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REPORT OF THE SUB-COMMITTEE ON STANDARDIZATION OF OVERHEAD LINE MATERIAL.

Submitted to the Annual Meeting of the Managers' Section of the Association at Birmingham, 16th June, 1920.

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Municipal Tramways Association (Incorporated).

REPORT OF THE SUB-COMMITTEE ON STANDARDIZATION OF OVERHEAD LINE MATERIAL.

1 We believe that the formation of this Sub-Committee was due in the first place to a letter, dated 27th April, 1917, from Messrs. Brecknell, Munro and Rogers, of Bristol, to the Hon. Secretary of the Association, drawing attention to the enormous number and variety of sections and sizes of trolly wire, and to the multiplicity of fittings which were then manufactured and stocked in order to suit the particular requirements of Engineers of Tramway Undertakings. The firm named suggested that if some standardization of overhead material could be agreed upon, the delivery of fittings would be more quickly made, and the cost of them would be materially cheapened, inasmuch as manufacturers would not have to stock the large number of patterns necessitated by small orders for separate undertakings. With standard fittings, they could stock large quantities and effect delivery at considerably reduced prices.

2 As a consequence, the Sub-Committee was appointed, consisting of :—Messrs. W. Boot (Nottingham), H. Dudgeon (Birmingham), L. E. Harvey (Ilford), J. F. Simpson (Preston), S. W. A. Sturman (Sheffield), H. Western (Salford), and R. H. Wilkinson (Bradford). Subsequently the Tramways and Light Railways Association was asked to appoint representatives, and Messrs. J. B. Tippitts (British Electrical Federation, Ltd.), W. Nairn (Bristol), C. J. Jewell (Wakefield), and J. F. Bennett (Metropolitan Electric Tramways), were appointed. Mr. Bennett was unable to attend the meetings. Later, Messrs. J. Ferguson (Glasgow) and J. J. McMahon (Manchester) were appointed upon the Sub-Committee. Mr. L. E. Harvey was appointed Chairman, and Mr. S. W. A. Sturman Hon. Secretary.

3 Since the Sub-Committee was appointed 30 meetings have been held—Birkenhead (1), Birmingham (4), Bristol (3), Bradford (1), Preston (2), Leicester (1), Leeds (7), Manchester (1), Nottingham (2), Sheffield (2), Salford (5), West Ham (1).

4 At an early meeting it was recognized that the first duty of the Committee would be to obtain from every Tramway Undertaking a complete description of the trolley wire, and fittings then in use, so that the members could judge of the scope of their work. Accordingly, a detailed questionnaire was sent out to all the Municipal Undertakings. At a later date, with the co-operation of the Secretary of the Tramways and Light Railways Association, the questionnaire was also sent to the Company Undertakings. The replies thereto were made by almost every Undertaking. The answers received disclosed an extraordinary state of affairs, establishing the fact of the widest divergence of practice, and serving to emphasize the necessity for securing some measure of simplification. From the fact that there were upwards of 30 different sizes and sections of trolley wire in use in this country and that one firm manufactured as many as 50 different sizes of insulated bolts, whilst another had over a thousand different patterns of line ears, the importance of the investigations will be realized. Messrs. Brecknell, Munro and Rogers, Bristol; Messrs. British Insulated and Helsby Cables, Ltd., Prescot; and Messrs. Alfred Wiseman, Ltd., Birmingham, submitted to the Sub-Committee a large variety of exhibits of overhead line fittings then in use.

5 The Sub-Committee, in the first instance, confined their attention chiefly to the consideration of the section of trolley wire to be recommended for ultimate standardization, being of opinion that the size and type of trolley wire was the fundamental basis of their investigations. It was recognized from the first that it was not our duty to lay down any hard and fast rule that a certain size of round wire or grooved wire should be used by any Tramway Undertaking, but that our object was to suggest that if Tramway Undertakings would adopt certain standard sizes in trolley wire and a certain shape in grooved wire, they would then reap the advantage of quick delivery and lower costs of fittings and wire. If, on the other hand, any Manager or Engineer desires to use any type of wire fittings which is not standard, there will be no obstacle in his way, except that the manufacturer will charge more for the special patterns and will keep him waiting longer for delivery by reason of not having stocks on hand. It is not suggested in this Report that Undertakings should scrap their present equipment, but that gradually, as and when renewals take place, a standard construction should be adopted.

6 We had very little difficulty in deciding on the sizes of round trolley wire, and ultimately the standard wire gauges of 1/0 to 4/0 were adopted. From the answers to the questionnaire, it was obvious to us that these sizes would be generally acceptable. When we dealt with the question of the section of grooved trolley wire to be recommended, considerable difficulty was experienced. For the purpose of enabling us to consider adequately the strongest and most suitable section to adopt, a great number of tests was carried out by Mr. Dudgeon (Birmingham) and Mr. Jewell (Wakefield). Messrs. British Insulated and Helsby Cables, Ltd. (Prescot).

Thomas Bolton and Sons (Oakamoor), Frederick Smith and Co. (Salford), and Messrs. Craddock and Co. (Wakefield) were also consulted upon the matter. With the view to ascertaining the effect of fatigue on trolley wire, vibrating tests have been carried out by Mr. Dudgeon (Birmingham). Although the testing Machine was specially designed to eliminate, as far as possible, all sources of error, no satisfactory or conclusive results could be obtained—the fatigue of copper apparently being a very variable factor. It was eventually agreed to adopt a standard section of grooved wire corresponding to Standard Wire Gauge sectional area. At several meetings the Wire Manufacturers named above sent representatives to consult with us on numerous debatable points, and visits have been made to their works to view the processes of manufacture. The specification was finally submitted to the manufacturers and approved of by them. The specification for trolley wire has been arrived at after careful deliberation, and is printed in the Appendix No. 2.

7 A specification has been prepared for steel Span and Guard Wires, and is printed in the Appendix No, 3.

8 A general specification for overhead fittings has been prepared, and is also printed in the Appendix No. 4. It has been decided to recommend porcelain insulators, as well as moulded insulators. We have been in communication with the Institution of Electrical Engineers, which has appointed a panel that is now engaged in considering the queston of porcelain insulators, but their inquiry is not yet completed, and we are therefore unable to submit their specification for tramway porcelain insulators.

9 The designs of the various overhead fittings have been considered at great length, the dimensions standardized, and patterns and samples prepared. Messrs. Dudgeon (Birmingham), Sturman (Sheffield), and Weston (Salford) undertook to prepare the necessary detailed drawings, and the other members of the Sub-Committee desire to thank these gentlemen for the arduous and valuable work done by them. They have prepared the drawings named in the Appendix No. 1. We propose to exhibit at the meeting all the drawings mentioned in the Appendix, as well as a considerable number of samples of overhead fittings. The question of the publication of the drawings for the use of the various undertakings and manufacturers is one for the Association to determine.

10 We suggest that the Association should consider the desirability of appointing a Permanent Sub-Committee, to investigate any matters that may, from time to time, arise in connection with the overhead equipment of Tramways.

11 We have not approached the Engineering Standards Committee in any matter connected with this Report, preferring to leave matters of further procedure to your Executive Council.

12 On behalf of the Association, we beg to offer our cordial thanks to the General Managers of Tramways in the towns where we have met, for the facilities they have provided for us and for the information they have so readily supplied for the use of the Sub-Committee.

(Signed) L. E. HARVEY (Chairman)
W. BOOT.
H. DUDGEON.
C. J. JEWELL.
J. FERGUSON.
J. J. McMAHON.
W. NAIRN.
J. B. TIPPETTS.
J. F. SIMPSON.
H. WESTON.
R. H. WILKINSON.

S. W. A. STURMAN,
Hon. Secretary of the Sub-Committee.

APPENDIX No. 1.

LIST OF DRAWINGS.

Drawing No.	DESCRIPTION,
1.	10 times enlarged section of standard grooved trolley wire, gauges 1/0 to 4/0.
2.	10 times enlarged section of 1/0 standard grooved trolley wire and base of line ear.
3.	10 times enlarged section of 2/0 standard grooved trolley wire and base of line ear.
4.	10 times enlarged section of 3/0 standard grooved trolley wire and base of line ear.
5.	10 times enlarged section of 4/0 standard grooved trolley wire and base of line ear.
5a.	10 times enlarged section of 1/0 standard grooved trolley wire and base of splicing ear and section insulator.
5b.	10 times enlarged section of 2/0 standard grooved trolley wire and base of splicing ear and section insulator.
5c.	10 times enlarged section of 3/0 standard grooved trolley wire and base of splicing ear and section insulator.
5d.	10 times enlarged section of 4/0 standard grooved trolley wire and base of splicing ear and section insulator.
6.	6" Mechanical line ear for 1/0 to 4/0 grooved trolley wire.
7.	12" ,, ,, ,, ,, ,,
8.	18" ,, ,, ,, ,, ,,
9	24" ,, ,, ,, ,, ,,
10.	Anchor ear for 1/0 to 4/0 ,, ,,
11.	12" Mechanical feeder ear for 1/0 to 4/0 ,, ,,
12.	18" Splicing ear for 1/0 to 4/0 ,, ,,
13.	24" ,, ,, ,, ,, ,,
14.	30" ,, ,, ,, ,, ,,
15.	36" ,, ,, ,, ,, ,,
16.	Section insulator (centre suspension) for 1/0 to 4/0 grooved trolley wire.
17.	Section insulator (end suspension) for 1/0 to 4/0 grooved trolley wire.
18.	Top suspension attachment for section insulators.
19.	Left hand poker frog.
20.	Right ,, ,,
20a.	Details of left and right hand poker frogs.
21.	Left hand mechanical switch frog } For shunting, trolley reversers, hand and automatic pulls.
22.	Right hand ,, ,, }
23.	Left hand trailing frog.
24.	Right hand ,.
25.	Porcelain insulators.
26.	12" Mechanical line ear for round trolley wire, 1/0 to 4/0.
27.	18" ,, ,, ,, ,, ,,
28.	24" ,, ,, ,, ,, ,,
29.	12" ,, feeder ,, ,, ,,

Drawing No.	DESCRIPTION.
30.	18", 24", 30" and 36" Splicing ears for round trolley wire, 1/0 to 4/0.
31.	Section insulator (centre suspension) for round trolley wire, 1/0 to 4/0
32.	Section insulator (end suspension) for round trolley wire, 1/0 to 4/0.
33.	12" Clinch feeder ear for round trolley wire, 1/0 to 4/0.
34.	12" ,, line ,, ,, ,, ,,
35.	18" ,, ,, ,, ,, ,, ,,
36.	24" ,, ,, ,, ,, ,, ,,
37.	36" ,, ,, ,, ,, ,, ,,
38.	Dimensions of standard trolley wheel groove.
39.	Anchor ear for round trolley wire, 1/0 to 4/0.
40.	Double pull off. (For use with insulated bolts).
41.	Single ,, (,, ,, ,,).
42.	Straight line hanger. (,, ,, ,,).
43.	Insulated bolt.
44.	Bridge hanger.
45.	Trolley wire terminal clamp.
46.	Turnbuckle.
47.	Clevis and Porcelain reel insulator for bowstring suspension.
48.	Flexible span bracket arm fittings.
49.	25° Crossings. for 1/0 to 4/0 trolley wire.
50.	45° ,, ,, ,, ,,
51.	90° ,, ,, ,, ,,
52.	*Straight line hanger, double pull-off and single pull-off. With porcelain insulation.
53.	Double and single pull-offs, uninsulated type.
54.	Emergency splicing ear.
55.	Pole strap, bull rings, eye bolt, hook bolt and connecting links.
56.	Giant strain insulators.
57.	Span carrier for section insulator where end suspension is used.
58.	Diagonal Anchor plate.
59.	Pole crank lever and spindle for switch frog pull.
60.	Pole strap with porcelain reel insulator.

*Not yet complete.

APPENDIX No. 2.

SUGGESTED SPECIFICATION

FOR

STANDARD COPPER TROLLEY WIRE.

1.—MATERIAL.

The wire shall consist of Hard Drawn Electrolytic Copper.

2.—SIZE OF WIRE.

The wire shall be truly and fully up to the section specified. It shall be perfectly symmetrical, and no variation from the approved cross section greater than 1% plus or minus on any dimension will be permitted.

3.—FINISH.

The wire shall be drawn direct from the solid rod made from billets of not less than 250 pounds in weight.

The joints shall be made in the soft rod with hard silver and shall afterwards be drawn three times through a die to the finished size. The wire at a joint shall conform to the same tests and electrical conductivity as is hereafter specified for its particular section.

The wire must be free from kinks and inequalities and it shall not contain any scale, flaws, cold shuts, seams or other defects.

4.—TESTS.

The tests which are described in the following paragraphs shall be made in the presence of the Purchasers' Engineer, the necessary apparatus for making such test being furnished by the Contractor, The Purchasers, however, shall have the right of furnishing any part of the apparatus as they may think fit.

The apparatus furnished by the Contractor shall be examined and approved by the Purchasers' Engineer. Failing agreement on this point the test shall be taken by a recognized standard testing institution.

The tensile strength, elongation, and torsion tests specified shall be determined by taking samples from each reel 36 ins. in length. Should the first sample selected fail to come up to the specification, the Engineer shall take two more samples at his discretion. If the results from the second and third tests shall be within the Specification, the reel shall be accepted. If they shall not be within the Specification, the reel may be rejected. A Certificate shall be supplied by the Contractor to the Purchaser showing actual test results made on each reel of wire supplied.

The following tests shall be made :—

5.—TENSILE STRENGTH AND ELONGATION.

A sample length shall be tested for tension and elongation by breaking the same in a testing machine. The elongation shall be measured by marking the wire in two places, 10 ins. apart, which shall coincide with the distance between the jaws of the machine. The fracture must take place between these marks and at a point not less than one inch away from either mark.

The samples shall show a minimum tensile strength in accordance with the following table :—

Gauge Number S.W.G.	Area of Cross Section. Sq. Inches.	Circular Wire.	Grooved Wire.
1/0	·08245	24.5 tons per sq. in.	23.5 tons per sq. in.
2/0	·09511	24.0 ,, ,,	23.0 ,, ,,
3/0	·10869	24.0 ,, ,,	23.0 ,, ,,
4/0	·12566	23.5 ,, ,,	22.5 ,, ,,

The elongation on fracture for all forms of wire shall be not less than the following :—

No. 1/0 S.W.G. 2 per cent in the 10 in. length.
No. 2/0 S.W.G. 2½ ,, ,, 10 ,, ,,
No. 3/0 S.W.G. 3 ,, ,, 10 ,, ,,
No. 4/0 S.W.G 3 ,, ,, 10 ,, ,,

6.—TORSION TEST.

For the purpose of developing and exposing defects in trolley wire the following tests shall be made :—

A sample of the wire shall be placed between the holders of the machine and shall be twisted to destruction.. The length tested shall be 10 inches between the grips. If any seams, pits, slivers, or surface imperfections shall be revealed the wire may be rejected. The samples shall withstand the following number of turns without breaking :—

Gauge No.	Circular Wire.	Grooved Wire,
1/0	11 twists.	10 twists.
2/0	10 ,,	9 ,,
3/0	9 ,,	8 ,,
4/0	8 ,,	7 ,,

The rate of twisting shall not be more than 10 turns per minute.

7.—WEIGHT.

The weight of the wire per mile shall be as follows :—

Area of Cross Section equivalent to	Weight per Mile.
No. 1/0 S.W.G.	1,678 lbs. per mile.
No. 2/0 S.W.G.	1,935 ,, ,,
No. 3/0 S.W.G.	2,212 ,, ,,
No. 4/0 S.W.G.	2,558 ,, ,,

A variation of 2 per cent on either side of these figures will be permitted.

8.—ELECTRICAL RESISTANCE.

The resistance of the finished wire shall not exceed the following :—

Standard Wire Gauge.	Resistance in ohms per 1000 yds. at 15.5°C. (equals 60°F.)
No. 1/0	.2997
No. 2/0	.2601
No. 3/0	.2275
No. 4/0	.1968

9.—PACKING FOR SHIPMENT.

The wire shall be put on reels of approved design and of sufficient size to prevent sharp bends, and shall be properly protected so that it shall not be injured in transportation. The Committee suggest that the dimensions of the reels shall be as follows :—

24 inches diameter of barrel.
24 inches wide between the inside of flanges.
36 inches diameter over flanges.
2 inch clear square hole through centre.

Care shall be exercised in winding grooved sections of wire on to the drums to ensure complete absence from twist when being unrolled.

Each reel shall have its gross, net and tare weights, together with the length and size of wire, plainly and indelibly marked on the outside of the reel.

10.—GROOVED TROLLEY WIRE.

It is recommended that the grooved wire adopted shall be as shown on the drawing No. 1.

APPENDIX No. 3.

SUGGESTED SPECIFICATION

FOR

STEEL SPAN AND GUARD WIRES.

The wire shall be of mild steel uniformly annealed, pliable, free from all flaws and other defects and galvanized with zinc and spelter before being stranded together.

The steel shall have a tensile strength of 28/35 tons per square inch, with an elastic limit of not less than 35% of the breaking stress.

The breaking stresses of the various wire shall be as follows :—

Gauge.		Minimum.		Maximum.
No. 8 S.W.G.	...	1,261 lbs.	...	1,576 lbs.
,, 7/12 ,,	...	3,500 ,,	...	4,375 ,,
,, 7/14 ,,	...	2,100 ,,	...	2,625 ,,
,, 7/16 ,,	...	1,400 ,,	...	1,750 ,,

Samples taken from the coils and plunged into a saturated solution of sulphate of copper at 60° F. for one minute, then dipped and wiped a further three times, must not show any sign of a reddish deposit of metallic copper on the wire.

The wire, both stranded and single (with the exception of the No. 8 gauge) must stand being bent round a horse collar thimble, measuring 1" external diameter over the largest breadth, and after being so bent, must pass the last named dipping test.

No. 8 S.W.G. single wire shall stand the last test after being bent round a 2" thimble.

The size of the coils shall be to the satisfaction of the Purchasers' Engineer.

APPENDIX No. 4.

SUGGESTED SPECIFICATION

FOR

OVERHEAD WIRE FITTINGS.

METAL.

The gun metal shall be of the following mixture :—

Copper	88 per cent.
Tin	10 per cent.
Zinc	2 per cent.

A test piece of the metal having a sectional area of 1 sq. inch. shall be capable of withstanding a tensile stress of not less than 15 tons with an elongation on fracture of between 15 per cent and 20 per cent measured on an 8in. length.

The malleable iron shall be made from the best quality malleable pig iron, and be well and properly annealed. A standard test piece of form "B" 2in. wide x $\frac{3}{8}$in. thick, called for by the Engineering Standards Committee, shall stand being bent through an angle of 90 degrees over a radius of one inch without sign of fracture. It shall have an ultimate tensile strength of not less than 17 tons per sq. inch with an elongation of 4 per cent in a length of 2 inches.

Where galvanizing is called for, the casting shall be well cleaned and the hot process applied, best quality spelter being used. All threads are to be hot brushed.

The steel must be dropped-forged and of the best quality. A standard test piece of the form of "C" of quarter sq. inch area by two inches gauge line, called for by the Engineering Standards Committee, machined cold lengthwise from each of the forgings selected must, without heating or any other manipulation whatever, show a tensile breaking strength of not less than 25 tons or more than 32 tons per sq. inch, with an elongation of not less than 27 per cent and 20 per cent in 2in. respectively. The total sum of the tensile strengths and corresponding elongations must be not less than 52 in each case.

COMPOSITE INSULATED FITTINGS.

These are to be thoroughly waterproof and homogeneous, Five per cent of the quantity ordered shall be tested by being soaked in water at a temperature not exceeding 80 degrees F. for a period of 24 hours, and then taken out and wiped dry, after which the fittings shall be capable of withstanding 2,500 volts, alternating current, for five minutes applied between the metal parts which are insulated from each other. Before delivery, each fitting shall be subjected to a flash test of 2,500 volts alternating current.

THREADS.

All threads shall be of Whitworth's standard, full and clean out, and shall be a good running fit.

THE FOLLOWING FITTINGS shall be of the design and sizes recommended on the drawings :—

EARS.

The grooves shall be of the approved profile and of smooth finish tinned if required, so as properly to fit the wire to be supported.

DOUBLE PULL-OFFS.

These shall be of the metal specified, capable of withstanding a straight pull of 1,500 lbs. at the bottom of the arms, without being distorted in the body so as to prevent the bolt being put in. They shall withstand a tensile stress of 4,000 lbs. without showing signs of fracture. The hole before testing must not be more than 1/32in. larger in diameter than the size of the insulated bolt used.

SINGLE PULL-OFFS.

These shall be capable of withstanding the same stresses as those specified for double pull-offs, but the test shall be applied between the end of the bolt and the arm.

STRAIGHT LINE HANGERS.

These shall be capable of withstanding a stress of 3,500 lbs. on the span wire without showing any signs of distortion or fracture.

LOCKING CAP FOR PULL-OFFS AND HANGERS.

This shall be a proper fit and interchangeable, and arranged so that it can be used repeatedly without being destroyed. A leather washer at least 1/16in. thick shall be inserted in the cap.

GLOBE INSULATORS.

These must be capable of withstanding a tensile stress of 5,000 lbs. without fracturing when heated to a temperature of 100 degrees Fahr.

INSULATOR BOLTS.

These are to be made in one piece of drop-forged steel of smooth finish, evenly finished so that the bolt is truly central with the insulation,

PORCELAIN INSULATORS.

Where porcelain is called for, it shall be made of carefully selected materials combined in proportions to give the best electrical and mechanical strength, and the final product must be dense, impervious to moisture, and be thoroughly vitrified. It must not depend upon the glaze for its insulating qualities. Each insulator shall withstand a pressure of 5,000 volts, alternating current, between adjacent metal parts.