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Transnet Engineering

TRANSNET ENGINEERING

SPECIFICATION FOR THE SUPPLY OF HIGH CONDUCTIVITY RECTANGULAR COPPER CONDUCTORS WITH DRAWN OR ROLLED EDGES FOR ELECTRICAL PURPOSES TO TRANSNET ENGINEERING

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SUMMARY OF REVISION

First issue – 18 May 2010
Eighth issue – 15 July 2015
Ninth issue – 3 July 2018

The following revisions have been made in this version:

Change	Description
Clause 2	Updated revised specification
Clause 3	Added general tendering requirements
Clause 14	Added inspection requirements

Document Control

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1. SCOPE

This specification covers the requirements for the supply of high conductivity rectangular copper conductors with drawn or rolled edges for electrical proposes to Transnet Engineering.

2. REVELANT SPECIFICATIONS

BS EN 13601	Copper and Copper Alloys – Copper Rod, bar and wire for General Electrical Purposes
EN ISO 2626	Copper – Hydrogen embrittlement test
EN ISO 7438	Metallic materials – bend test
EN ISO 6892-1	Metallic materials – Tensile testing
ISO 8000-1	Quantities and units. General principles
BS EN 1655	Copper and copper alloys. Declarations of conformity
BS EN 10204	Metallic materials. Types of inspection documents

3. GENERAL TENDERING REQUIREMENTS

3.1 Tenderers must furnish with at the time of their offer, complete and detailed information as called for in this specification, to enable clear and satisfactory evaluation, comparison and adjudication of their offers.

3.2 Tenderers shall indicate, clause by clause, in Appendix C that their offers comply in every respect with the specification. Any deviations shall be disclosed in Appendix C. Failure to complete Appendix C shall result in disqualification of the tenderer.

3.3 Deviations from this specification shall not be accepted without written consent from Transnet Engineering, Product Development.

3.4 A broad statement to the effect that the copper conductors are in accordance with this specification is not acceptable.

3.5 Failure to comply with this document may preclude a tenderer from consideration.

3.6 Any material which deviates from this specification, but has superior properties to the material specified will be considered provided that the tenderer clearly communicates such deviations beforehand. All deviation will have to be assessed and approved in writing by Transnet Engineering, Product Development, prior to implementation.

3.7 In addition to this specification tenderers shall fully comply with the purchase order text of the relevant item number.

4. MATERIAL CONDITION, DIMENSIONS, CORNER AND EDGE CONDITIONS, SURFACE CONDITION, LENGTHS AND CUT LENGTHS, AND DELIVERY

The standard dimensions and lengths that will be ordered by Transnet Engineering are given in appendix A.

4.1 Material Condition

4.1.1 The conductor shall be manufactured from Oxygen Free Electrolytically Refined Copper (Cu-OF), as specified by specification BS EN 13601. Table 1 shows the chemical composition specified by BS EN 13601

4.1.2 The conductor shall be manufactured to the annealed condition (O). The material condition of the conductor shall be designated by H (material condition designated by minimum value of hardness requirement for the product with mandatory hardness requirements).

4.2 Dimensions and Tolerances

4.2.1 The thicknesses and widths of conductors as supplied shall be within the tolerances for the ordered thicknesses and widths specified by specification BS EN 13601 Table 4 and 5.

4.3 Corner and Edge Condition

4.3.1 The edge corners shall have a radius of half the thickness if the thickness of the strap is less than 1.2 mm. If the thickness of the strap is more than 1.2 mm then the edge corner radius shall be 0.65mm.

4.3.2 The tolerances of the corner radii shall be in accordance with specification BS EN 13601, Table 7 for the appropriate thickness.

4.4 Surface Condition

4.4.1 The conductors should be clean, and free from injurious defects. The conductors must further be free from any oxidation. Discoloration of the surface is permissible as long as it does not impair utilization and hardness.

4.4.2 The supplier shall be able to freely run his hand wrapped firmly around the bar at the rate of 1m/s without being cut on the copper edges.

4.5 Length and cut lengths

4.5.1 The conductors may be ordered by Transnet Engineering either per kg weight or per meter lengths and must be agreed upon between both Transnet Engineering and the supplier. The lengths of conductors supplied as fixed lengths shall be within the tolerances for the ordered lengths specified by specification BS EN 13601, Table 9. The lengths supplied will be in lengths equivalent to a multiple number of coils to obviate joints.

4.5.2 Transnet Engineering reserves the right to adjust the length of the copper roll for a particular type of field coil. The date of change is to be agreed upon with the supplier.

4.5.3 The deviation from squareness of the cut shall be a maximum of 2% of the width dimension of the conductor and is included in the fixed length tolerance.

4.6 Packing and Delivery

4.6.1 The conductor shall be packed in such a way that the quality as specified by sections 4.2 to 4.4 is not affected. The radius of packing will be circular and greater than 2 times the designated pole piece radius.

4.6.2 The supplier shall indicate, provide and design suitable lifting arrangements if the copper mass exceeds 80kg.

4.6.3 The supplier shall make sure that the pellets are strong enough to support 1 ton of copper without breaking. 1 ton is the maximum weight that should be placed on a pellet.

4.6.4 Each pancake on the stack should be protected in a way to separate them from each other for easier lifting when each roll is removed and also to prevent damage on the pancake. The supplier should design the type of protection which should be agreed upon by Transnet Engineering.

4.6.5 An identity tag should be put on each pancake clearly showing the following:

- ✓ Hardness
- ✓ Weight
- ✓ Material grade

5. ELECTRICAL RESISTIVITY

5.1 The electrical resistivity test shall be carried out in accordance with Section 8.5 of specification BS EN 13601. The electrical properties shall conform to the appropriate requirements in Table 3 of specification BS EN 13601.

5.2 The electrical resistivity shall be determined by direct measurement either at 20° C ± 1° C or at another temperature, the result shall be corrected to the equivalent value at 20° C, on the conductor in the as-delivered condition.

6 FREEDOM FROM HYDROGEN EMBRITTLEMENT

6.1 The conductors supplied shall show no evidence of cracking when tested and visually examined in accordance with Section 8.6 of BS EN 13601.

6.2 The conductor shall be subjected to the hydrogen embrittlement test which shall be carried out in accordance with EN ISO 2626.

6.3 Test samples shall be prepared according to specification BS EN 13601.

6.4 After heating the test samples in hydrogen as per specification EN ISO 2626, the test pieces shall be subjected to the close bend test described in specification EN ISO 7438.

6.5 Hydrogen embrittlement tests shall be performed on 1 of every 200 conductors supplied to Transnet Engineering. Traceable records of these tests must be kept by the supplier and the information be made available to Transnet Engineering on request.

6.6 The supplier must have a traceability system to clearly identify the sample taken for hydrogen embrittlement testing to ensure traceability to the conductor material from which the copper is manufactured.

7 CHEMICAL COMPOSITION

7.1 The composition of the conductor shall conform to the requirements shown in Table 1, as specified in BS EN 13601.

Table 1: Composition of Cu-OF (BS EN 13601)

Material Designation		Composition in % (mass in fraction)								
Symbol	**Number**	**Element**	**Cu**	**Ag**	**Bi**	**O**	**P**	**Pb**	**total**	**excluding**
Cu-OF	**CW008A**	Min	99.95[a]			-			-	Ag
		Max	-	-	0.0005	-[b]	-	0.005	0.03	

[a] *Including silver, up to a maximum of 0.015%*
[b] *The oxygen content shall be such that the material conforms to the hydrogen embrittlement requirements.*

7.2 The supplier must have a traceability system to clearly identify the copper sample taken for chemical analysis testing to ensure traceability to the conductor from which the copper is manufactured.

7.3 The supplier must supply a chemical composition certificate from the copper supplier representing each batch of copper from which the different conductors are manufactured upon delivery to Transnet Engineering.

8 MECHANICAL PROPERTIES

The mechanical properties shall conform to the appropriate requirements given in Table 2 of specification BS EN 13602, for material condition H035, annealed.

8.1 Hardness Test

8.1.1 Hardness tests must be performed using a Webster hardness tester (model BB-75). Three hardness measurements must be performed on both ends of each coil supplied for 1 turn (between 500 and 1500mm). The hardness values must have a Webster hardness number not greater than 7. ***This hardness requirement overrides the requirements in section 8.3 and Table 2 of specification BS EN 13601***. The hardness conversion table is provided in Appendix B of this specification.

8.2 Bend Characteristics

8.2.1 The test shall be carried out in accordance with EN ISO 7438.

9 SAMPLING

9.1 General

9.1.1 An inspection lot shall be sampled in accordance with clause 9.2 and 9.3.

9.2 Chemical analysis

9.2.1 The sampling shall be in accordance with Table 14 of BS EN 13601. A test sample, depending on the analytical technique to be employed, shall be prepared from each sampling unit and used for determination of composition.

Note: When preparing a test sample, care should be taken to avoid contamination or overheating the test sample. Carbide tipped tools are recommended; tool steels if used, should be made of magnetic material to assist in the subsequent removal of extraneous iron. If the test samples are in finely divided form (e.g. drillings, millings), they should be treated carefully with a strong magnet to remove any particles of iron introduced during preparation.

9.3 Mechanical and electrical tests

9.3.1 The sampling rate shall be in accordance with Table 14 of specification BS EN 13601. Sampling units shall be selected from the finished products. The test samples shall be cut from the sampling units. Test samples and test pieces prepared from them, shall not be subjected to any further treatment other than any machining operations necessary in the preparation of the test pieces.

10 RETESTS

10.1 If there is a failure of one, or more than one of the tests specified in this document, two test samples from the same inspection lot shall be permitted to be selected for retesting the failed property (properties). One of these test samples shall be taken from the same sampling unit as that from which the original failed test piece was taken, unless that sampling unit is no longer available, or has been withdrawn by the supplier.

10.2 If the test pieces from both test samples pass the appropriate test(s), then the inspection lot represented shall be deemed to conform to the particular requirement(s) of BS EN 13601. If a test piece fails a test, the inspection lot represented shall be deemed not to conform to BS EN 13601.

11 EXPRESSION OF RESULTS

11.1 For the purpose of determining conformity to the limits specified in standard BS EN 13601, an observed or a calculated value obtained from a test shall be rounded in accordance with the following procedure, which is based upon the guidance given in ISO 80000-1. It shall be rounded in one step to the same number of figures used to express the specified limit in specification BS EN 13601, except that for the tensile strength and 0.2% proof strength the rounding interval shall be 10 N/mm² and for elongation the value shall be rounded to the nearest 1%.

11.2 **The following rules shall be used for rounding:**

a) If the figure immediately after the last figure to be retained is less than 5, the last figure shall be kept unchanged;
b) If the figure immediately after the last figure to be retained is equal or greater than 5, the last figure to be retained shall be increased by one.

12 INFORMATION TO BE KEPT AND SUPPLIED BY THE SUPPLIER

12.1 **The following information must be supplied to Transnet Engineering upon delivery of the conductors**

- ✓ Hardness Characteristics (See section 8.1)
- ✓ Chemical Composition (See section 7)

12.2 **The following records should be kept by the supplier and made available to Transnet Engineering upon request**

- ✓ Electrical Resistivity (See section 5)
- ✓ Freedom of Hydrogen Embitterment (See section 6)
- ✓ Bend Characteristics (See section 8.2)

13 DECLARATION OF CONFORMITY AND INSPECTION DOCUMENTATION

13.1 **Declaration of conformity**

13.1.1 Transnet Engineering requests the supplier to issue for the products/conductors the appropriate declaration of conformity in accordance with BS EN 1655.

13.2 **Inspection documentation**

13.2.1 Transnet Engineering requests the supplier to issue for the products/conductors the appropriate inspection document in accordance with EN 10204.

14 INSPECTION

14.1 Transnet Engineering, Product Development reserves the right to undertake inspection at anytime during manufacturing.

14.2 All suppliers shall be subjected to a technical audit by Transnet Engineering, Product Development prior to any contract being awarded. It is the responsibility of the Procurement Office to inform Product Development of potential suppliers.

15 ADDITIONAL/SPECIAL REQUIREMENTS

15.1 Upon awarding of a contract, a supplier shall be required to submit a meter length copper sample for each contract item for testing to Transnet Engineering.

15.2 If a supplier cannot submit a sample and is awarded a contract, a copper sample will be tested on the first batch of order. Should the copper not comply with any of the requirements stipulated in this document, then the order batch shall be rejected and the supplier shall bear the responsibility to replace the rejects.

15.3 The supplier shall be required to replace the defective copper within 14 days and shall be given only two chances to do so. Should the supplier fail to deliver the replacement copper to requirements on the second attempt, then Transnet Engineering reserve the right to terminate the contract at no cost to Transnet Engineering.

16 GUARANTEE

16.1 The supplier shall guarantee the copper conductors for an in-service period of twelve months, against any defect imputable to manufacture and not revealed during acceptance at the works. In such instances the supplier's liability shall be restricted to the replacement of the defective copper conductors only.

DOCUMENT AUTHORITIES

COMPILER	**Emma Molobi**
DESIGNATION	**Snr Engineer**
SIGNATURE	

APPROVER	**Andile Nqodi**
DESIGNATION	**Principal Engineer**
SIGNATURE	

APPENDIX A

Ordered Dimensions

Copper constant = 0.001
Copper density = 8.94
Kg/m = width x thickness x copper constant x copper density

		Size (mm)			
Item no.	**Description**	**W**	**T**	**Roll size (kg)**	**Roll length (m)**
061041019	6E1 IP	36.33	4.19	99	72.7
061002228	6E1 Field	35.56	4.06	86	66.6
061006808	5M2 Field Early series	22.22	4.19	84	100.9
061004025	5M2 IP Early series	31.75	2.54	77	106.8
761038072	5M2 Field Later series	46.8	1.65	73	105.7
785072880	5M2 IP Later series	20	2.9	100	192.9
061014414	7E IP	18	7	113	100.3
485000215	7E Series Field	25	4.6	98	95.3
485000216	7E Exciter Field	18.5	3.2	121	228.6
085300151	D29 Field	25.4	4.366	74	74.6
085300152	D31 Field	25.4	4.76	79	73.1
	EMD IP	28.9	3.83		
085801546	9E Separate Field	36.3	1.5	89	182.8
085808243	9E IP	31	4.32	82.32	70
085807681	GE 764 Field	18	7	63.8	56.6
085807680	GE 764 IP	30	4.95	85	64
085807681	GE 761 (A1-17,A19,A21,A22) Field	18	7	63.8	56.6
085829177	GE 761 (A18,A20,A23,A24) Field	19.3	7	68.4	56.6
085807680	GE 761 IP	30	4.95	85	64

APPENDIX B

COMPARITIVE HARDNESS SCALES

934-1	Brinell	Vickers	Rockwell B	Rockwell E	Rockwell P	Rockwell H	Webster
35		23				32	
36		23				33	
37		24				37	
38		24				40	
39		25				43	
40	25	25				45	
41	26	26				47	
42	26	27				49	
43	27	27				52	
44	27	28				54	
45	27	29				56	
46	28	30				58	
47	29	32		24		61	2
48	30	33		25		63	
				26			3
49	31	34		28		64	
50	32	35		30		66	4
51	33	36		33		68	
				35			5
52	34	38		36		70	
				38			6
53	35	39		39	29	72	
54	37	41		42	33	73	7
55	38	42		44	38	75	
56	39	44		46	40	76	8
57	40	45		48	43	78	
				50			9
58	42	47		51	47	80	
59	44	48		52	49	81	
60	45	49		53	51	82	
				56			10
61	47	51		57	54	84	
62	48	53		59	56	86	
				60			11
63	50	55		62	58	88	
64	52	57		64	61	89	
934-1	**Brinell**	**Vicker**	**Rockwell**	**Rockwell**	**Rockwell**	**Rockwell**	**Webster**

		s	B	E	P	H	
65	54	58		65	63	90	
				66			12
66	56	60		67	65	91	
67	58	62		69	67	92	
				70			13
68	60	64		71	69	94	
69	62	67		73	71	95	
70	64	69	18	74	73	96	
71	67	72	19	76	75	98	14
72	69	74	28	77	77	99	
73	71	76	33	79	79	100	
				80			15
74	73	81	39	81	81	101	
75	76	85	45	82	83	102	
76	80	88	48	84	84	103	16
77	84	92	52	86	86	104	
78	87	95	58	88	87	105	
79	90	99	60	89	88	106	
80	94	103	63	90	89	107	17
81	97	108	65	91	90	108	
82	100	111	69	92	91	108	
83	100	116	72	94	92	109	18
84	108	122	75	95	93	109	
85	110	127	77	96	94	110	
86	112	133	80	97	95	111	
87	122	137	83	98	96	111	19
88	126	142	86	99	97	112	
89	131		89	100	97	112	
90	135		91	101	98	113	
91	139			102	99	113	
92	145			103	100		
93				104	101		
94				104	102		
95				105	102		
96				106	103		
97				107			
98				108			
99				109			
100							

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