Eskom	Standard	Technology

Title: **EXOTHERMIC WELD CONNECTIONS FOR SUBSTATION EARTHING**

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Compiled by	Approved by	Authorized by
Gavin Strelec	**Theunus Marais**	**Naresh Hari**
Chief Engineer	**Chief Engineer, Substation Engineering**	**General Manager, Transmission Engineering**
Date: 12 April 2022	Date: 12/04/2022	Date: 22/04/2022

Supported by SCOT/SC

Type text here

Subhas Maharaj

Substation SC Chairperson

Date: 21/4/2022

PCM Reference: **Substation Design**

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1. Introduction

"Exothermic welding", also referred to as "thermite welding" is a process where metallic components such as earthing conductors are fused together in molten copper metal in a pre-machined graphite mould to form a joint between the components. A high temperature is created through the exothermic reaction of the weld-metal, which is in excess of 2000 °C, and fuses the components at a molecular level. The absence of an interface between the two components prevents electrical arching, oxidation and galvanic corrosion thereby ensuring a maintenance free connection with a service life of several decades under normal conditions. Even normal continuity tests at connections are rendered superfluous. This has an impact on life cycle cost and reduced risk exposure of personnel to touch voltages during maintenance in energised substations.

The exothermic welding process ensures that the components can be considered electrically and mechanically continuous and viewed as a single element after the welding is completed. The joint will present a golden copper surface and the weld volume will be free of porosity. This will ensure high mechanical and electrical integrity. As the cross section of metal at the joint is larger than the conductor, the current capacity at the joint will exceed that of the conductor itself.

As an effective measure to mitigate against copper theft, copper and steel concentrically composite conductors will be introduced. These conductors, due to higher conductivity of copper compared to steel, the standard copper-clad steel (CCS) conductors have lower overall conductivity, of up to a maximum of 40% of equivalent copper cross-sectional area. This lower current capacity necessitates larger temperature rises during fault conditions in order to manage the conductor area required. In this regard exothermic connections are ideal as these joints permit a temperature rise to the fusing temperature of the conductor, unlike other conventional connections such as crimped or bolted connection which are limited to several hundred degrees.

Due to the steel centre core, CCS conductors are substantially more rigid than equivalent diameter copper conductors. The state of temper of metals can significantly influence the material ductility. In order to facilitate the installation of CCS, the conductor shall be fully annealed or "Dead Soft Annealed" (DSA), which returns the metals to their native crystal structure and renders them in their "softest state". The annealing also affects the material conductivity by up to about 1 percent which improves the conductor capacity slightly.

The high content copper alloy in the joint created by the exothermic weld, has a larger cross-sectional area than the conductors themselves and results in the connection being the strongest link in the fault current path.

Another feature of exothermic welding is that it is suitable for joining dissimilar metals such as copper and steel. In the context of this standard exothermic welds will be used for the following connections:

a) CCS conductors to CCS conductors (refer to D-DT-6365)

b) CCS conductors to copper conductors (refer to D-DT-6365, D-DT-6044 and D-DT-6045)

c) CCS conductors to galvanised steel structures

1.1 Standardisation philosophy

The overall philosophy is to rationalise the exothermic welds as far as practicable for the benefits of reduced engineering design effort, reduced installation complexity, simplified procurement and material management and lower supply costs due to larger volumes of fewer items.

The consumable items that are used to perform exothermic weld connections for earthing systems are comprised of two main components that are specified in this standard, namely the mould and weld-metal. Hardware items that are used with the moulds comprise of handle clamps, crucible scrapers, conductor cleaning brush, mould cleaning brush, conductor clamps etc which are re-usable items, all being part of the installer's tools and equipment.

The joints have been designed with adequate margins in order to minimise on site risks which may result in avoidable extra costs due to poor workmanship and rework.

2. Supporting clauses

2.1 Scope

This standard covers the Eskom specific technical requirements for exothermic weld kits for the purpose of performing earthing conductor connections. This standard must be used in conjunction with the normative references listed.

2.1.1 Purpose

This standard specifies the Eskom specific technical requirements for exothermic welding kits and weld-metals for earthing conductor connections.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/Informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 32-1034, Eskom Procurement and Supply Management Procedure

[2] 240-48929482, Tender Technical Evaluation Procedure

[1] D-DT-6367, MOULD, THERMAL WELD

[2] D-DT-6368, WELDING POWDER: EXOTHERMIC

[3] IEEE Std 837, IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

[4] ISO 9001, Quality Management Systems.

[5] NRS 102, Theft Deterrent Earthing Materials

2.2.2 Informative

[6] 240-170000153, Copper Conductors Used for Earthing in Substations

[7] 240-170000349, Copper Cladded Steel Conductors used for Earthing

[8] D-DT-6044, BAR:ROUND;DIA 10 MM;CU;ANNEALED

[9] D-DT-6045, STRIP:FLAT;WD 50 MM;THK 3.15 MM;CU

[10] D-DT-6365, BAR ROUND, 40% CCS

2.3 Definitions

2.3.1 General

Definition	Description
Anneal	To subject to great heat and then slow cooling, and sometimes reheating and further cooling, for the purpose of rendering the material less brittle, to temper or to toughen.
Cardboard	A heavy paper used in the manufacture of small boxes.

Definition	Description
Conductivity	A material's ability to conduct electric current. It is the inverse of its volume resistivity. Unit of measurement is "Siemens per metre."
Copper-clad steel	Bimetallic conductor that is manufactured by a thermo-mechanical bonding process that produces a metallurgical bond between a solid oxygen-free copper layer and a steel core.
Corrugated fibreboard	A material consisting of a fluted corrugated sheet and one or two flat linerboards.
Dead Soft Annealed (or "Fully Annealed")	Metal is heated to above the critical range and appropriately cooled to develop the greatest possible commercial softness or ductility.
Exothermic welding	Also known as exothermic bonding, thermite or thermite welding. It is a welding method that employs molten metal to mechanically and electrically fuse two earth rods, or an earth conductor to an earth rod, or conductor to conductor. The process employs an exothermic reaction of a thermite composition to heat the metal and requires no external source of heat or current.
Longitudinal Test	The lengthwise axis of the weld is parallel or inline to the direction of the applied load.
Paperboard	A thick paper or thin cardboard.
Transverse Test	The lengthwise axis of the weld is at right angles to the direction of the applied load.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
Ω·m	ohm metre
°C	degree Celsius
CCS	Copper Clad Steel
Cu	Copper
DSA	Dead Soft Annealed
g	gram
IEC	International Electrotechnical Commission
m	metre
mm	millimetre
NRS	National Rationalised Standard
RTS	Rated Tensile Strength
SANS	South African National Standard

2.5 Roles and responsibilities

This standard is to be complied with by all manufacturers and suppliers of exothermic welding kits and weld-metals to be used in Eskom. Applicable Eskom staff to ensure compliance on all equipment installed at Eskom sites.

2.6 Process for monitoring

Compliance will be confirmed during the supporting documents provided during tender submissions.

2.7 Related/Supporting documents

This document is the first edition and must be used in conjunction with the normative references.

3. Exothermic weld kit technical requirements

This section covers the requirements that the exothermic weld kits and components used to perform the weld shall comply with.

There are two components required for performing exothermic connections:

1) Exothermic weld-metal

2) Graphite mould

3.1 Exothermic weld-metals

The weld-metals used for the exothermic connections used in Eskom substations shall comply with the specifications stipulated in this section.

3.1.1 Introduction

The weld-metal shall be manufactured from component material(s) that result in a high copper alloy weld.

The weld-metals usually come in two parts, a main weld-metal and a starter. The two mixtures contain similar ingredients, however the particles vary in grain size and the proportion of constituents. The starter is formulated to facilitate ignition.

The main weld-metal usually contains primarily three ingredients, copper oxide, copper fines and aluminium flake. The copper oxide supplies an abundance of oxygen for the exothermic reaction. The aluminium fines which is oxidised in the exothermic reaction (the oxygen being supplied by the copper oxide). The exothermic reaction produces a temperature that is typically in the range of 2200 °C to 2400 °C. The aluminium is converted to aluminium oxide slag. The reaction is described by the following reaction:

Copper Oxide + Aluminium → Aluminium Oxide + Copper + Heat

Other ingredients in the mixture are welding fluxes, which are formulated to inhibit the formation of oxides and other unwanted contamination by-products in the weld, thereby improving the quality of the weld by reducing porosity.

The exact proportions and ingredients of the main weld-metal and starter are proprietary and are formulated to provide the correct yield of copper metal for the particular joint concerned.

3.1.2 Weld-metal specification

The quantity of weld-metal for a particular mould is supplied in accordance with a “size”, for the purposes of this discussion, the number “90” is used as an example. This “size” is not the mass in grams but should be quite close to the actual mass. This number can be referred to as “size 90” or size “Cu90” which refers to the approximate resulting copper content of the weld-metal. The “size 90” is not standardised between suppliers, although the copper yield generated into the weld will be similar. Therefore, it is not advisable to use weld-metal from “Company A” in a mould from “Company B”, even if it is the correct size weld-metal e.g. “size 90”.

The nugget produced when conducting a flash test on the Cu90 weld-metal shall have a minimum copper yield of 90%.

3.1.3 Weld-metal compatibility between suppliers

Moulds and weld-metal from different suppliers should not be used together.

Moulds and weld-metal from the same supplier shall therefore be used in combination.

3.1.4 Standardisation of weld-metals for specific joints

The weld-metal size have been rationalised to a single standard weld-metal for all exothermic welds required in this standard, except for the “Cross” joint which will require two standard weld-metals. The standard weld-metal has been determined for the most common weld volume. This means that some welds will be slightly oversized, but this is a minor trade-off for the numerous benefits of standardisation.

The design of the “Cross” connection is such that both conductors at the joint can run continuously without the need for cutting of a conductor to ensure that both conductors are on the same plane. This is achieved by joining the two conductors with one above the other crossing perpendicularly; this is referred to as a “lapped” connection. That is that the “Tee” and the “Run” conductors cross one another on separate horizontal planes. Due to this lapped configuration, a relatively large joint volume is required. Therefore, the cross joint is designed for twice the standardised volume used compared to all the other welds. Therefore, there will only be a single weld-metal specified for all welds except for the cross joint which will utilise two standard weld-metals.

3.1.5 Weld-metal for use in Eskom

The weld-metal to be used for all connections is specified in Table 1.

Table 1: Exothermic weld-metal for use in Eskom substation applications (D-DT-6368)

SAP number	UM	SAP description	Requirements
0703779	Box of 10	WLDG PWDR:EXOTHERMIC;10XCU90	Box of ten Cu90 weld-metals. Also contains starter for ten welds. Standardised exothermic weld-metal for all Eskom moulds for substation applications. High copper yield. Mass approximately 90 g. Supplied in a secure plastic container.

3.2 Exothermic weld moulds

3.2.1 Graphite material specification for exothermic mould production

Moulds shall be fabricated from a material that is suitable for at least 85 welds (but preferably more than 100) if used in accordance with manufacturer’s instructions. The tenderer must supply the contact details of at least three (3) contractors to be contacted to verify the average mould longevity.

The graphite used in the mould manufacture shall NOT be of the “nuclear grade”. The manufacturer/supplier/end-user of the graphite mould shall not require any licence as may be required by the ‘Department of Labour and Energy’ in the case of graphite exceeding a density of >1.76 g/cm^3.

The minimum specification for graphite to be used to produce the moulds for exothermic connections is given in Table 2.

These properties are adequate to ensure the appropriate material quality for this application.

The manufacturer shall exercise all relevant quality control in the purchase of raw material and the manufacture of the moulds.

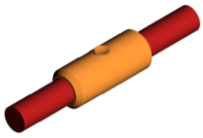
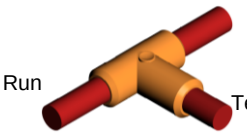
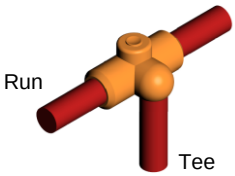
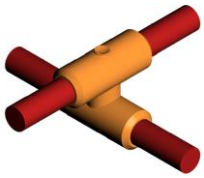
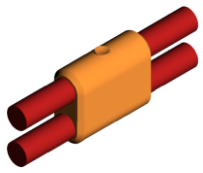
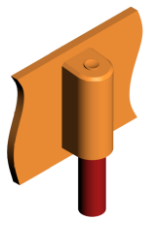
Table 2: Graphite mould material specification

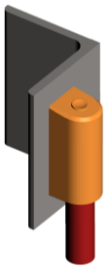
Property	Specification value	Unit
Maximum Grain Size	≤ 2	mm
Bulk Density	1.63 – 1.76	g/cm^3
Compressive Strength	≥ 25	MPa
Ash Content	≤ 0.3	%

3.2.2 Exothermic moulds to be used in Eskom

The exothermic moulds specified for use in Eskom are listed in Table 3.

Table 3: Exothermic weld moulds for use in Eskom substation applications (D-DT-6367)

Mould	SAP material number	SAP material description	Weld-metal (1)	Drawing (2)
1	0703781	MOULD THRML WLD:STRAIGHT;8.5-8.5 MM	1 x Cu90	
2	0703783	MOULD THRML WLD:STRAIGHT;8.5-10 MM	1 x Cu90	
3	0703785	MOULD THRML WLD:TEE;RUN8.5;TEE8.5 MM	1 x Cu90	
4	0703784	MOULD THRML WLD:TEE;RUN10;TEE8.5 MM	1 x Cu90	
5	0703788	MOULD THRML WLD:TEE;RUN 8.5;TEE14.2 MM	1 x Cu90	
6	0703786	MOULD THRML WLD:CROSS;8.5-8.5 MM;LAPPED	2 x Cu90	
7	0703790	MOULD THRML WLD:MULTI;2 X 8.5 MM;DOUBLE	1 x Cu90	
8	0703789	MOULD THRML WLD:STRIP;1 X 8.5 MM;SINGLE	1 x Cu90	

Mould	SAP material number	SAP material description	Weld-metal (1)	Drawing (2)
9	0703787	MOULD THRML WLD:STRUCTURE;8.5 MM;SINGLE	1 x Cu90	

Notes: 1) The weld-metal listed refers to the specified quantity of weld-metals to be used to make the joint.

2) Drawings are indicative only and not for manufacturing purposes.

Moulds listed in Table 3 will be used for the following connections:

- Moulds 1 - 7: Connect 8.5 mm CCS conductors to 8.5 mm CCS or 10 mm Cu conductors,
- Mould 8: Connects 8.5 mm CCS conductors to 50 x 3.15 mm Cu or 80 x 6 mm galvanised mild steel flat strip,
- Mould 9: Connects 8.5 mm CCS conductors to galvanised steel structure members varying in thickness to a maximum of 14.5 mm.

3.3 Packaging and storage

3.3.1 Weld-metals

The weld-metal must be completely dry and packaged immediately after processing. The weld-metal shall be packaged “tightly” with minimal empty volume in an appropriately sized plastic container. This is to avoid particle separation based on the differing constituent densities due to vibration during transport and handling.

The unit of measure when purchasing weld-metals will be per box of 10 individual containers, i.e. “BOX OF 10”.

The size Cu90 weld-metals shall be supplied in boxes with 10 containers each containing main weld-metal for a joint requiring Cu90. Each box shall also contain sufficient starters to perform 10 exothermic welds.

This BOX containing the 10 individually packed containers must as a minimum be manufactured from corrugated fibreboard. Plain cardboard or paperboard boxes are not acceptable.

In addition, the BOX containing the 10 individual containers must be wrapped in plastic film to inhibit moisture absorption during transport and storage. The Safety Data Sheet must be followed for transport, storage and site use.

The required storage instructions must be printed on the outside of the box.

Sample packaging including storage instructions must be submitted with each tender, both for the individual containers and for the “BOX OF 10”.

3.3.2 Weld moulds

As a minimum the moulds shall be packaged in suitably sized, appropriately robust corrugated fibreboard boxes that would protect the moulds against damage under normal reasonable handling and transport conditions.

Sample mould packaging must be submitted with each tender.

3.4 Labelling

3.4.1 Weld-metal

As a minimum every weld-metal and starter container shall be labelled to denote the manufacturer's name, part number and the size of the weld-metal. Note that the size of the weld-metal is not necessarily the mass of the container/tube contents and must be aligned with this standard.

Each container/box of 10 weld-metals shall also be labelled with the manufacturer's name, part number and the size of the weld-metal.

Sample labels for the individual weld-metal containers as well as for the "BOX OF 10" must be submitted with each tender.

3.4.2 Weld moulds

As a minimum every mould shall have a metal label that depicts the manufacturer's name, and part number, applicable conductor sizes and the required weld-metal size and quantity to be used.

The mould connection type must be clearly indicated on the outside of the box.

Sample mould labels for each type of mould must be submitted with each tender.

3.5 Tests

A series of tests to evaluate performance of the exothermic connections are specified below. The main tests are classified as type tests. Type tests are intended to establish design characteristics. They are normally only made once and repeated only when the design, manufacturing process or the material used is changed. The results of type tests are recorded as evidence of compliance with design requirements.

A series of type tests to evaluate the performance of the exothermic connections are specified below. These tests are divided into three categories, viz. material composition, electrical and mechanical type tests.

Manufacturers shall comply with all test requirements stated in this document and any other test that they may deem necessary.

All testing shall be done by an independent testing laboratory or witnessed by an independent testing authority if done in-house.

Manufacturers / Suppliers are required to provide evidence confirming that the products supplied are in conformance with the tests listed below. The equivalence of alternate tests will be determined by the relevant subject matter expert at Eskom or the technical evaluation team.

Should alternative tests be submitted / not required, the supplier must provide Eskom with a detailed explanation from the manufacturer detailing the reasons why equivalent tests are valid or not required (if applicable). Regardless, all deviations from this standard must be stated in the supplied deviation schedule.

In addition, routine quality tests as stipulated are required on the exothermic weld-metals.

3.5.1 Type test certificates and reports

Copies of all type-test reports and certificates shall be submitted to Eskom in electronic format at the tender stage. Manufacturers shall retain copies of routine test reports for a period of at least 2 years.

Type test reports and certificates will be acceptable as long as the exothermic connection's design, material composition, manufacturing process and weld-metals stay unchanged. ***Should any of these change Eskom must be informed and the applicable exothermic connection/s shall be retested and the test certificates resubmitted to Eskom.***

Type test reports shall contain, as a minimum, the following information:

- Name and address of test facility.
- Contact details of test facility.

- Details and validity of accreditation of test facility.
- Date of test.
- Type of exothermic connection tested.
- Description of the test equipment used, including test equipment serial number and last date of calibration.
- Description of test set-up, including photographs of the set-up.
- Description of test procedure.
- Test results.
- Analysis of test results.
- A statement that the exothermic connection conforms, or does not conform, to the requirements of this specification.
- Description of the condition of the exothermic connection after testing (include photographs).
- Names and titles of personnel who conducted the test.

3.5.2 Weld-metal material composition type test

Proof is required indicating that the minimum copper yield in a “nugget” produced from a flash test based on the specified Cu90 weld-metal is more than 90%. A minimum of two “nuggets” shall be tested.

The type test shall be performed by an independent and accredited laboratory.

3.5.3 Mould graphite material type test

A certificate shall be provided indicating compliance to the requirements set in Table 2, Graphite mould material specification, must be tested.

The type test shall be performed by an independent and accredited laboratory.

3.5.4 Electrical type tests

The following electrical tests shall be performed in accordance with IEEE 837. A minimum of two samples per connection type shall pass all tests as verification of compliance.

3.5.4.1 Current-temperature cycling test

The test shall be performed as described in IEEE 837 section 8 with a minimum test current of 337 A applied for the 8.5 mm diameter single strand CCS conductor.

The test is passed when the final measured resistance corrected value (R_{Final}) does not exceed 1.5 times the initial (R_{Total}) value for each sample tested.

3.5.4.2 Fault-current test

The test shall be performed as described in IEEE 837 section 11 with a minimum 90% test currents of 3.1 kA applied for the 8.5 mm diameter single strand CCS conductor.

The test is passed when the final measured resistance corrected value (R_{Final}) does not exceed 1.5 times the initial (R_{Total}) value for each sample tested.

3.5.5 Mechanical type test

Mechanical integrity of joints shall be tested by “tensile testing” of the connection/joint to confirm that the joint breaks in the conductor heat affected zone. The failure should not occur in the joint but should occur in the conductor adjacent to the weld joint which was exposed to the high temperature of the exothermic weld. This test is to be performed as a type test on all joint type connections. The type test shall be performed by an independent and accredited laboratory.

3.5.5.1 Test scope

The test method covers the procedure and definitions for the mechanical testing of exothermic welds performed for the purpose of making earthing conductor connections, specifically for copper clad steel wire.

As indicated, the mechanical test herein described is used as a type test to determine the integrity of welds based on the mould design and weld procedure as prescribed by the supplier. The test is based on a pass-fail criteria.

3.5.5.2 Test orientation

The terms “longitudinal test” and “transverse test” are used to describe the direction of load application with regards to the type of weld that is tested.

The following definitions apply:

- Longitudinal Test: The lengthwise axis of the weld is parallel or inline to the direction of the applied load. Load to be applied to the “connections” of the weld. Refer to Figure 1 (a) – (d).
- Transverse Test: The lengthwise axis of the weld is at right angles (90 degrees) to the direction of the applied load. Load to be applied to the “connections” of the weld. Refer to Figure 1 (e) – (f).

3.5.5.3 Specimen dimensions and quantities

A minimum of 2 samples shall be supplied for each joint type. If the two samples do not fail within a tolerance of 5% of the rated tensile strength (RTS), no additional test is to be performed to confirm repeatability.

To allow sufficient gripping and subsequent deformation of the copper cladded wire during testing the minimum length of copper cladded wire ends per connection as illustrated in Figure 1 (a) to (f) is to be 300 mm (± 20 mm).

For the galvanised structure joint, Figure 1 (d) one of the following two options can be used for the test:

- 100 x 100 x 12 mm galvanised angle member with the back angle cut off, or
- 50 x 12 mm galvanised flat bar.

3.5.5.4 Test speed

The test is to be performed in load control mode. The rate of increase of load shall be uniform during testing. The time required to reach 30% of the RTS of the copper cladded wire shall not be less than 1 min nor more than 2 min. The same rate of loading shall thereafter be maintained throughout the tests performed for additional test samples.

3.5.5.5 Test criteria

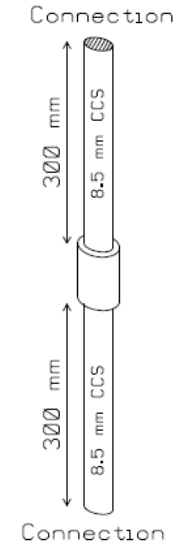
The test is to be performed to failure of either the weld or copper cladded wire.

- Pass = The recorded maximum tensile load exceeds 95% of the RTS of the copper cladded wire under testing.
- Fail = The recorded maximum tensile load is below 95% of the RTS of the copper cladded wire.

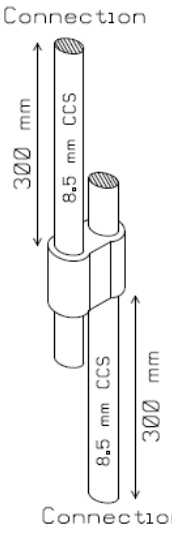
NRS 102 lists the RTS for 8.54 mm diameter single strand CCS conductor as 15.48 kN.

3.5.5.6 Certificate of compliance

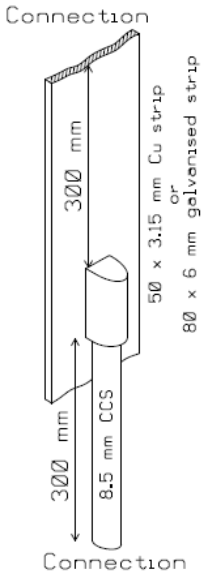
The manufacturer shall supply the purchaser with a certificate giving the obtained results for all tests carried out on the welds, including photographs depicting the untested weld and the area/location of failure on the tested weld. Where weld failures or "pull out" of the copper cladder wire occurred, the certificate is to include photographs of the dissected weld.



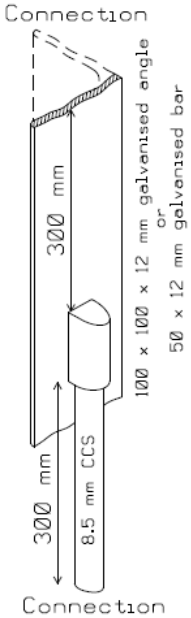
(a) Straight joint



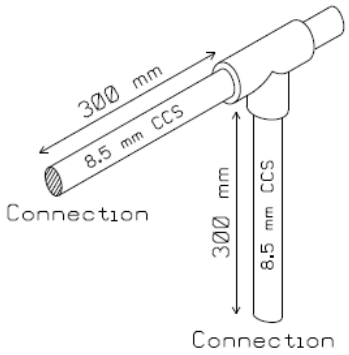
(b) Multi-purpose joint



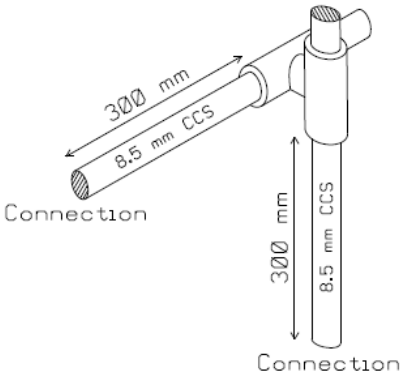
(c) Flat joint



(d) Galvanised structure joint



(e) Tee and Earth rod joints



(f) Cross joint

Figure 1: Test samples and connection points

3.5.6 Routine quality tests for exothermic weld-metal

Tests for weld-metals are not standardised and depend on the supplier. Notwithstanding, routine and batch tests should be carried out by the supplier to ensure the required consistent quality and traceability of product. Manufacturers shall retain copies of these routine test reports for a period of at least 2 years.

The following description is a suggested typical test regimen, and it is understood that this may vary between suppliers. The supplier is to submit their test protocol as part of a tender submission for technical and quality evaluation by Eskom. Whilst Eskom appreciates that certain information may be proprietary and the supplier may not wish to share specifics, the test plan submitted should contain sufficient detail to permit reasonable determination of adequacy.

The weld-metal should be batch tested in order to ensure consistent quality. The batch size should be limited to 60 kg.

There should be one test for metal recovery and porosity per every 20 kg maximum of the main weld-metal formulated mix. Tests for metal recovery and porosity in the weld should be performed by making an actual joint and then cutting the connection to ensure that no porosity exists in the weld, and to confirm that the conductors are properly covered by the metal of the joint. This sample weld should be performed for every batch using finished packed product. Therefore, there should 3 sample tests per batch, which would typically produce typically 500 – 600 weld-metal.

Two tests for burn rates are to be performed per kg of the starters.

The specifics of copper recovery percentage and burn rate are parameters developed by the supplier to ensure quality and competitive advantage. These parameters are therefore proprietary information and cannot be specified. The manufacturer shall exercise all relevant quality control in the purchase of raw material and in the manufacture of the weld-metal.

Test results of all batches should be retained in quality control records. These test results should be traceable to each individual box of weld-metals that is part of that particular batch. Batch samples and test results are to be retained for at least two years to cover the warranty period of the weld-metal.

3.5.7 Visual inspection of the weld

Joints shall be well formed with a shiny copper surface (Figure 2), indicating a sound weld. Surface discolouration (“Blueing”) of conductors adjacent to the weld area is a positive indication that sufficient heat was generated and that the weld should be sound.

Figure 2: Example of acceptable exothermic weld connection

The joint shall be free of slag inclusions and porosity. Minor surface inclusions and pores may be accepted if not greater than 0.5 mm across. The joints indicated In Figure 3 are not acceptable.

A sample of a finished joint of each connection type must be submitted with the tender. It may be required to cut the joint to allow inspection of the internal joint volume for voids. Minor voids are permitted if they are subjectively determined not to affect the mechanical integrity or electrical performance.

(a) Weld with insufficient volume to cover conductors

(b) Weld with excessive slag

Figure 3: Examples of unacceptable exothermic weld connections

3.6 Training and certification

All contractors must be trained and certified to perform exothermic welds by the company whose welding items are being used. The Supplier shall provide first-hand training of an international standard on the supplied exothermic welds by OEM accredited instructors.

3.7 Tender returnable documents and samples

All returnables shall be in English. The following documents and samples shall be submitted for evaluation during a tender enquiry:

- Completed Technical Schedule B, refer to Annex A and B.
- Deviations and Declarations report, refer to Annex C.
- Type Test Schedule, refer to Annex D.
- Sample packaging for weld-metals and moulds in accordance with 3.3.
- Sample labels for weld-metals and moulds in accordance with 3.4.
- Test certificates and reports in accordance with the requirements stipulated in Section 3.5 verifying the listed technical requirements.
- Details of training and certification process offered.
- At least one sample of a finished joint for each connection type offered.
- Contact details of at least three (3) contractors to be contacted to verify the average mould longevity.

4. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Alex Ndlela	Senior Manager, Distribution Division, Engineering
Subhas Maharaj	Senior Manager, Transmission Division, Substation Engineering
Braam Groenewald	Corporate Specialist, Transmission Division, Substation Engineering
Athelene Gouws	Senior Engineer, Distribution Division, Gauteng Cluster
Best Khoza	Engineer, Distribution Division, Cape Coastal Cluster
Christy Thomas	Senior Engineer, Transmission Division, Substation Engineering
Derrick Delly	Chief Engineer, Transmission Division, Substation Engineering

Name and surname	Designation
Dickey van Eeden	Senior Technician, Distribution Division, CentralEast Cluster
Enderani Naicker	Chief Engineer, Transmission Division, Substation Engineering
Jacques Calitz	Senior Consultant, RT&D
Jason Blaauw	Senior Engineer, Distribution Division, Cape Coastal Cluster
Mark Peffer	Chief Engineer, Transmission Division, Substation Engineering
Mohamed Khan	Senior Engineer, Distribution Division, CentralEast Cluster
Payoyo Bukhosini	Senior Technician, Transmission Division, Substation Engineering
Percy Seboco	Chief Technologist, Transmission Division, Substation Engineering
Rukesh Ramnarain	Chief Engineer, Transmission Division, Substation Engineering
Sipho Zulu	Chief Engineer, Transmission Division, Substation Engineering
Stefan Terblanche	Senior Advisor, Distribution Division, Cape Coastal Cluster

5. Revisions

Date	Rev	Compiler	Remarks
April 2022	1	GJ Strelec	First issue

6. Development team

The following people were involved in the development of this document:

- Gavin Strelec — Chief Engineer, Research Department
- Jacques Calitz — Senior Consultant, Research Department
- Theunus Marais — Chief Engineer, Substation Engineering

7. Acknowledgements

The compiler would like to acknowledge Julian Venter for the exothermic joint connection isometric drawings used in this standard.

Annex A – Technical Schedules A and B for Exothermic Weld-metals

This section must be read together with Section 3 of this document.

Schedule A: Eskom's particulars requirements

Schedule B: Technical particulars of conductor offered

A separate technical schedule shall be completed per mould as per the table below.

SAP MATERIAL NO	SAP MATERIAL DESCRIPTION	SELECT ITEM
0703779	WLDG PWDR:EXOTHERMIC;10XCU90	

ITEM	DESCRIPTION	SCHEDULE B
1	**Manufacturer's details**	
1.1	Manufacturer	
1.2	Manufacturer's local agent/supplier	
1.3	Manufacturer's type reference	

ITEM	DESCRIPTION	UNIT	SCHEDULE A	SCHEDULE B
2	**Weld-metal material**			
2.1	Cu90 weld-metal flash test minimum copper yield (verify on test report)	%	> 95	
3	**Packaging**			
3.1	Material used for individual Cu90 weld-metal containers		Mandatory	
3.2	Quantity of individual containers per box?		10	
3.3	Material used for the box		Mandatory	
3.4	Is the container wrapped in a plastic film?		Mandatory	
3.5	Are storage instructions printed on the box?		Mandatory	
4	**Labelling**			
4.1	List the manufacturer's name as indicated on each individual weld-metal		Mandatory	
4.2	List the part number as indicated on each individual weld-metal		Mandatory	
4.3	List the size of the weld-metal as indicated on individual weld-metal containers		Mandatory	
4.4	List the manufacturer's name as indicated on each individual starter		Mandatory	
4.5	List the part number as indicated on each individual starter		Mandatory	
4.6	Manufacturer's name, part number and the size of the weld-metal printed on the box?		Mandatory	

Annex B – Technical Schedules A and B for Exothermic Weld Moulds

This section must be read together with Section 3 of this document.

Schedule A: Eskom's particulars requirements

Schedule B: Technical particulars of conductor offered

A separate technical schedule shall be completed per mould as per the table below.

MOULD	SAP MATERIAL NO	SAP MATERIAL DESCRIPTION	SELECT ITEM
1	0703781	MOULD THRML WLD:STRAIGHT;8.5-8.5 MM	
2	0703783	MOULD THRML WLD:STRAIGHT;8.5-10 MM	
3	0703785	MOULD THRML WLD:TEE;RUN8.5;TEE8.5 MM	
4	0703784	MOULD THRML WLD:TEE;RUN10;TEE8.5 MM	
5	0703788	MOULD THRML WLD:TEE;RUN 8.5;TEE14.2 MM	
6	0703786	MOULD THRML WLD:CROSS;8.5-8.5 MM;LAPPED	
7	0703790	MOULD THRML WLD:MULTI;2 X 8.5 MM;DOUBLE	
8	0703789	MOULD THRML WLD:STRIP;1 X 8.5 MM;SINGLE	
9	0703787	MOULD THRML WLD:STRUCTURE;8.5 MM;SINGLE	

ITEM	DESCRIPTION	SCHEDULE B
1	**Manufacturer's details**	
1.1	Manufacturer	
1.2	Manufacturer's local agent/supplier	
1.3	Manufacturer's type reference	

ITEM	DESCRIPTION	UNIT	SCHEDULE A	SCHEDULE B
2	**Mould material** (verified on test report)			
2.1	Material	-	Mandatory	
2.2	Maximum Grain Size	mm	Mandatory	
2.3	Bulk Density	g/cm^3	Mandatory	
2.4	Compressive strength	MPa	Mandatory	
2.5	Ash Content	%	Mandatory	

ITEM	DESCRIPTION	UNIT	SCHEDULE A	SCHEDULE B
3	**Weld-metal**			
3.1	Weld-metal used in mould	Quantity & size	Mandatory	
4	**Mould longevity**			
4.1	Number of connections made per mould (under normal correct use)	ea.	Mandatory	
5	**Packaging**			
5.1	Material used for protective boxes		Mandatory	
6	**Labelling**			
6.1	Mould label material		Mandatory	
6.2	Manufacturer's name as indicated on label		Mandatory	
6.3	Part number as indicated on label		Mandatory	
6.4	Conductor sizes as indicated on label		Mandatory	
6.5	Mould connection type indicated on box		Yes / No	
6.6	Is manufacturer's name, part number and conductor sizes also printed on the box?		Yes / No	

Annex C – Deviations and Declarations

The following must be noted:

1) All deviations to any requirement in this technical schedule and associated specification must be listed below with clear explanations/justification.

2) All documents to be provided in hard copy in addition to any soft copies offered, in accordance with tender requirements.

3) If no deviations/modifications/alternatives are offered, this schedule must be marked N/A and signed.

SPECIFICATION / SCHEDULE PAGE NUMBER	SPECIFICATION / SCHEDULE CLAUSE NUMBER	PROPOSED DEVIATIONS / MODIFICATIONS / ALTERNATIVES

Declaration by supplier:

With the exception of the above deviations, this standard, associated technical schedules, and annexures together with the requirements contained within, will be fully complied with in the manufacture, testing, supply, provision of drawing and documents, packaging, labelling, transport, and delivery of the product being offered, amongst others. Further, it is declared that all information provided has been checked and is correct.

Full name of authorised representative: _____

Designation of authorised representative: _____

Signature: _____ Date: _____

Annex D – Test Report Schedule

D1 Weld-metal test report

SAP MATERIAL NO	SAP MATERIAL DESCRIPTION	SELECT ITEM
0703779	WLDG PWDR:EXOTHERMIC;10XCU90	

ITEM	DESCRIPTION	REPORT NO.
1	Weld-metal material composition test	

D2 Mould test reports

The following must be noted:

1) This section must be read together with Section 3.5 of this document.

2) A separate type test schedule shall be completed per mould / joint offered.

3) Select the appropriate mould from the table below.

4) List all the type test report numbers applicable to the mould / joint offered.

MOULD	SAP No	SAP DESCRIPTION	SELECT ITEM
1	0703781	MOULD THRML WLD:STRAIGHT;8.5-8.5 MM	
2	0703783	MOULD THRML WLD:STRAIGHT;8.5-10 MM	
3	0703785	MOULD THRML WLD:TEE;RUN8.5;TEE8.5 MM	
4	0703784	MOULD THRML WLD:TEE;RUN10;TEE8.5 MM	
5	0703788	MOULD THRML WLD:TEE;RUN 8.5;TEE14.2 MM	
6	0703786	MOULD THRML WLD:CROSS;8.5-8.5 MM;LAPPED	
7	0703790	MOULD THRML WLD:MULTI;2 X 8.5 MM;DOUBLE	
8	0703789	MOULD THRML WLD:STRIP;1 X 8.5 MM;SINGLE	
9	0703787	MOULD THRML WLD:STRUCTURE;8.5 MM;SINGLE	

ITEM	DESCRIPTION	REPORT NO.
1	Mould graphite material test	
2	Current-temperature cycling test	
3	Fault-current test	
4	Mechanical test	