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Temperature Tube and Pipework
Standard**

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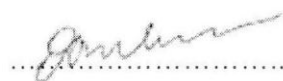
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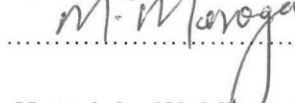
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1. INTRODUCTION

None

2. SUPPORTING CLAUSES

2.1 SCOPE

This standard defines unambiguous, regulatory and fit-for-purpose requirements for high pressure tube and pipework welding during construction, repair and/or maintenance activities on Eskom plant. While considering relevant national and international standards, this standard states Eskom's mandatory requirements for and provides details pertinent to welding, heat treatment and quality control for design, construction and maintenance of high pressure tube and pipework on power stations as defined in Eskom Standard 240-56239129 [39] .

This document represents a prominent part of a range of a family of documents that constitutes the Eskom Welding Rule Book (WRB) which is a collection of Eskom Standards, Procedures and Guidelines for welding on Eskom plant, and contains documents key to support Eskom's position on all welding related issues and disputes, improve the quality of welding and reducing the weld repair rate. The principle objective of this document is to impose good basic welding practices of high quality levels while conforming to the construction code. Ensuring a safe and healthy working environment conformance to the requirements of the OHS Act [34] is another important objective.

2.2 PURPOSE

None

2.2.1 Applicability

This document shall apply throughout Eskom SOC Holdings Limited Divisions.

It applies to all Eskom high pressure tube and pipework plant during execution of construction phase, as well as for subsequent maintenance and repair welding activities. Any anomalies/disputes that fall outside this standard or that appear to be in conflict with it may be resolved with the proper weld engineering and/or metallurgical inputs. Actions and situations that fail to meet these requirements may be assessed to determine the nature and significance of the shortcomings. Eskom will consider the applicability of proposed remedial actions for application with the necessary concessions.

This standard is applicable to all Eskom plant involving high pressure tube and pipe welding activities and to be applied within the following contexts:

- During formal contractor engagement phases, in particular: procurement, reviewing and placing construction, maintenance and repair contracts with vendors for welding and related activities on Eskom high pressure tube and pipework plant by the relevant Eskom procurement departments. The procurement team shall ensure that the WRD, which contains this standard, is included in the inquiry documentation package as a specific Eskom technical requirement.
- Routine weld repair and maintenance work on high pressure tube and pipework performed by Eskom personnel also fall within the requirements of this document.
- It will serve as the standard to support Eskom's position on all Eskom high pressure tube and pipework welding related issues and disputes. Any disputes that fall outside this standard or that appear to be in conflict with it may be resolved with the proper weld engineering and/or metallurgical inputs.
- Contractors that fail to meet these requirements may be assessed to determine the nature and significance of the shortcomings, after which they may be considered for the contract with the

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necessary concessions which shall be documented and submitted to Eskom during the course of the contract as required by the Eskom Quality Standard QM58 [38].

- The Eskom Standard 240-56239129 [39] defines High Pressure Pipework.

2.3 NORMATIVE/INFORMATIVE REFERENCES

The following documents contain provisions that, through reference in the text, constitute requirements of this document. At the time of publication, the editions indicated were valid. These documents are subject to revision and users are responsible to ensure that the most recent editions of the documents listed below are referenced. Parties using this document shall use the most recent editions of the documents listed in this section.

INTERNATIONAL STANDARDS

- [1] **BS EN 13480:** Metallic industrial piping Parts 1 to 8
- [2] **BS 12952 :** Water-tube boilers and auxiliary plant – Parts 1 to 17
- [3] **BS EN 10216:** Seamless steel tubes for pressure purposes – Technical delivery conditions – Parts 1 to 5
- [4] **PD 5500:** Unfired fusion welded pressure vessels
- [5] **ASME Boiler and Pressure Vessel Construction Code:** Section I: Power Boilers; Section II: Material Specifications: Part A – ferrous materials, Part C – Welding rods, electrodes and filler metals; Section VIII: Pressure vessels, Division 1, Division 2 – alternative rules; Section IX: Welding
- [6] **ASME B 31.1:** Power piping
- [7] **TRD Series:** 100; 200; 300
- [8] **AD 2000 Merkblatt**
- [9] **BS EN 1011:** Welding- Recommendations for welding of metallic materials – Part 1 General guidance for arc welding; Part 2 (2001) Arc welding of ferritic steels; Part 3 (2000) Arc welding of stainless steels
- [10] **BS EN ISO 15607:** Specification and qualification of welding procedures for metallic materials - General rules
- [11] **BS EN ISO 15613:** Specification and qualification of welding procedures for metallic materials – Qualification based on pre-production welding test
- [12] **BS EN ISO 5817:** Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections
- [13] **BS EN ISO 17663:** Welding – Quality requirements for heat treatment in connection with welding and allied processes
- [14] **BS 2633:** Specification for Class I arc welding of ferritic steel pipework for carrying fluids
- [15] **EN 10204:** Metallic products: Types of inspection documents
- [16] **EN ISO 13916:** Welding – guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature
- [17] **PD CEN ISO/TR 15608:** Welding – Guidelines for a metallic material grouping system
- [18] **ISO 14731:** Welding co-ordination. Tasks and responsibilities

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- [19] **VGB-R 109** - VGB Directive – Material specification for components under pressure in fossil-fired power plants; Second Edition 2008
- [20] **V&M Material Data Sheet MDS 439** – High Temperature CrWCoVNb-Steel with 12% Cr for Tubes; Rev. 1; 29.01.2008
- [21] **AWS A 5.01 (ISO 14344 : 2002 MOD)** : Procurement Guidelines for Consumables – Welding and Allied Processes – Flux and Gas Shielded Electrical Welding Processes
- [22] **EN ISO 3580**: Welding Electrodes for Manual Metal Arc Welding of creep resisting Steels - Classification
- [23] **EN ISO 21952**: Welding consumables – Wire Electrodes, Wires, Rods and deposits for Gas Shielded Arc Welding of Creep Resisting Steel - Classification
- [24] **EN ISO 14175**: Welding Consumables – Gases and Gas Mixtures for Fusion Welding and Allied Processes
- [25] **BS EN 17640**: Non-destructive Testing of welds – Ultrasonic testing - Techniques, testing levels and assessment
- [26] **BS EN ISO 23279**: NDT of Welds – Ultrasonic testing – Characterisation of indications in welds

NATIONAL STANDARDS

- [27] **SANS 15614** Specification and qualification of welding procedures for metallic materials - Welding procedure test; Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys; Part 7: Overlay welding
- [28] **SANS 15609-1** Specification and qualification of welding procedures for metallic materials - Welding procedure specification Part 1: Arc welding
- [29] **SANS 9606-1** Approval testing of welders - Fusion welding Part 1: Steels
- [30] **SANS ISO 3834**: Quality requirements for Welding Part 1 Guidelines for selection and use; Part 2 Comprehensive quality requirements; Part 3 Standard quality requirements; Part 4 Elementary quality requirements
- [31] **Pressure Equipment Regulations (PER)**
- [32] **SANS 347**: Specification for categorization and assessment criteria for all pressure equipment in dangerous service
- [33] **SANS 17025**: General requirements for the competence of testing and calibration laboratories
- [34] **Occupational Health and Safety Act 85 of 1993 (OHS-Act)**

Eskom standards, specifications and procedures

- [35] **240-56241933** Control of Welding during Plant Construction, Repair and Maintenance Activities
- [36] **240-83540088** Requirements for NDT on Eskom plant
- [37] **240-83539994** Eskom approval of personnel performing quality related special processes on Eskom plant
- [38] **QM 58** Supplier Contract Quality Requirements Specification
- [39] **240-56239129** High Pressure Pipework for fossil fired Power stations
- [40] **240-56246601** Qualification, Certification and Accreditation Requirements for Personnel and Entities Performing Welding Related Work on Eskom Plant Standard
- [41] **36-1255** Material procurement standard

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[42] **240-72273656** Power generation Asset criticality classification standard

[43] **240-77196678** Heat treatment of welded components

2.4 DEFINITIONS

| Definition | Description |
|---|--|
| Procedure Qualification Record | A record comprising all relevant data from the welding of a test piece needed for the approval of a welding procedure specification as described in the ASME Boiler and Pressure Vessel Code Section IX [5]. |
| Welding Procedure Qualification Record: | A record comprising all relevant data from the welding of a test piece needed for the approval of a welding procedure specification as described in the welding specification SANS 15614 [27]. |
| Welding Procedure Specification: | A document meeting the requirements of SANS 15609 [28] or ASME Boiler and Pressure Vessel Code Section IX [5] and derived from the WPQR/PQR that sets out in detail the required variables for a specific application to assure repeatability. |
| Welder Qualification Record: | A document meeting the requirements of SANS 9606 [29] or ASME Boiler and Pressure Vessel Code Section IX [5], which presents the results of the approval testing of a welder to perform a fusion welding process. |
| Eskom Welding Co-ordinator | A Welding Engineer/Technologist appointed in writing for a specific business unit or project to oversee all welding activities within Eskom Holdings SOC Ltd. |
| High Pressure Equipment: | Equipment for the conveyance of steam, water, gases or other fluids whose design pressure equals or exceeds 2.0 MPa and/or whose design temperature equals or exceeds 200 °C. |
| Eskom Engineer: | The Engineer/Technologist responsible for the plant or component. Applicable to the contents and intentions of this standard, his decisions may be based on support and recommendations from the applicable Eskom welding, metallurgy, NDT and structural integrity specialists. |
| Thin-walled pipe: | Pipework with an OD and Wall thickness in which the design code does not require special consideration w.r.t the specific PWHT heat treatment of the material, joint design and weld sequence. |
| Thick-walled pipe: | Pipework with an OD and Wall thickness in which the design code requires special consideration w.r.t the specific PWHT heat treatment of the material, joint design and weld sequence. |

2.4.1 Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.5 ABBREVIATIONS

| Abbreviation | Description |
|--------------|---|
| AWS | American Welding Society |
| BS EN | British Standard European Norm |
| EFEC-W | Eskom Framework for Effective Coordination of Welding |
| ISO | International Organization for Standardization |
| ITP | Inspection and test plan |
| IW | International Welder registered with the International Institute of Welding |

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| | |
|---------|---|
| IWE | International Welding Engineer registered with the International Institute of Welding |
| IWS | International Welding Specialist registered with the International Institute of Welding |
| IWT | International Welding Technologist registered with the International Institute of Welding |
| NDT | Non-destructive testing |
| OD | Outside diameter |
| OHS Act | Occupational Health and Safety Act of 1993 |
| PER | Pressure Equipment Regulations of 2009 |
| PQR | Procedure Qualification Record |
| PWHT | Post weld heat treatment |
| QCP | Quality control plan |
| SAQA | South African Qualification authority |
| TCA | Technical capability assessment |
| TEPPI | Toolkit for Eskom Power Plant Inspector |
| TPI | Third Party Inspector |
| TRD | Technische Regeln für Dampfkessel |
| WA | Welding administrator / coordinator |
| WPQR | Welding Procedure Qualification Record |
| WPS | Welding Procedure Specification |
| WQR | Welder Qualification Record |

2.6 ROLES AND RESPONSIBILITIES

None

2.7 PROCESS FOR MONITORING

None

2.8 RELATED/SUPPORTING DOCUMENTS

None

3. REQUIREMENTS

3.1 GENERAL WELDING REQUIREMENTS

3.1.1 Statutory Requirements

Welding activities on high pressure tube and pipework, as defined in the PER [31] and SANS 347 [32], shall be governed by the latest version of the plant design code and applied according to the requirements of the Eskom Welding Standard 240-56241933 [35] and the Eskom High Pressure Pipework Standard 240-56239129 [39].

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3.1.2 Basic Welding Principles

The principle aim shall be for welds to be in the best possible condition for safe and reliable operation for at least the contractually agreed design life of Eskom plant. Obtaining minimum specified mechanical properties, corrosion resistance and creep life are of particular importance.

Basic welding rules for construction and maintenance work on high temperature tube and pipe components are contained in BS 2633 [14]. This specification provides details for arc welding using manual, semi-automatic or automatic processes, base materials, welding consumables, preparation for welding, joint configurations, inspection techniques, acceptance criteria, heat treatment methodologies, welding procedure and welder approval tests. Furthermore, BS EN 1011 [9] provides general guidance principles and controls required for good quality weldments in ferritic and stainless steels. Low hydrogen welding principles shall be applied on all Eskom boiler and high temperature systems, minimum requirements are set out in BS EN 1011-2 Annex C.

3.1.3 AIA Requirements

Tasks and responsibilities for the AIA pertinent to the High pressure temperature Eskom plant will apply as required by the PER [31] with Eskom specific detail stipulated in welding standard 240-56241933 [35].

3.2 WELDING PROCEDURE QUALIFICATION

3.2.1 PQR/WPQR for Butt Welds

For plant designed to ADM [8], TRD [7], PD5500 [4]; BS EN 13480 [1]; BS 12952 [2]; all WPS's shall be supported by a valid WPQR conforming to SANS 15614 Part 1 [27] as stipulated in Eskom Welding Standard 240-56241933 [35] according to the relevant plant design codes, unless written concessions have been approved by Eskom where specific situations arise. For plant designed to ASME B31.1 [6] or ASME BPVC Section VIII [5], all WPS's shall be supported by a valid PQR conforming to ASME BPVC Section IX [5]. Prior to commencement of fabrication, the principal Contractor shall submit all welding procedures and procedure qualifications for approval by the plant responsible Eskom Welding Engineer.

During the review processes, the range of applicability regarding material grouping needs to be considered for the intended application.

3.2.2 PQR/WPQR for Weld Repairs

Where repairs of defect excavations require weld preparations not representative of butt welds, a procedure shall be qualified to meet the requirements for a PQR/WPQR as prescribed in Par. 3.2.1, and in addition incorporate the geometry of the weld preparations as prescribed in BS EN 15613 [11]. If the repair requires a significant amount of weld build-up, the relevant butt weld procedure qualification shall be supported by the test requirements listed in SANS 15614 Part 7 [27].

3.2.3 WPS

The WPS shall contain all the data as required by Eskom weld standard 240-56241933 [35].

3.2.4 Weld location

3.2.4.1 Weld joint map

Welding procedures submitted to Eskom shall be accompanied by documentation clearly identifying the specific item and contract number to which they refer and shall be indicated on a weld joint map showing an isometric lay-out of the plant stipulated in the contract. Where practically possible, the weld map should as a minimum include welder stamp number, WPS number, NDT report numbers, consumable certificate, etc. applicable to the individual welds on the isometric drawings for the pipe system

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3.2.4.2 New welds

When new welds are introduced to high pressure tube and pipe systems, these shall be uniquely identified according to the same numbering convention used for the relevant plant, and the position recorded on revisions of the drawings as part of the contract documentation package.

3.3 WELDER QUALIFICATIONS

3.3.1 Construction Code

Welders employed in the fabrication of all items covered by this document shall be coded, unless the Contractor can produce valid welder qualification records to the satisfaction of the Eskom Welding Engineer/Technologist.

3.3.2 Control of WQR

The principal Contractor shall have under its control all facilities, labour and materials required for the examination and testing of welders, and their re-testing from time to time during the course of the contract, in accordance with the code of construction. All materials required for qualification of both weld procedures and welders shall be certified to the relevant BS EN 10216 [3] or ASME BPV Section II [5] seamless wrought tube/pipe material specification and supplied by the contractor.

No material assigned to the same group but not intended for use on high temperature and pressure tube and pipework, shall be allowed.

3.3.3 Validity of WQR

Only welders who have passed the qualifying tests in accordance with the relevant plant code of construction shall be employed for welding of HP tube and pipework, pressurized systems and associated stressed attachments. Unless it can be proven by the Contractor that the individual welders have been practicing their trade continuously since qualifying, they shall be re-tested to the requirements of the code.

3.3.4 Performance Records

The principal contractor shall keep performance records of each welder operating on high pressure and temperature tube and pipework on Eskom Level I plant, traceable to the national identification number (or passport number) of each individual. This information shall be included in the final contract document package, and as a minimum show the individual's weld repair and production rates.

3.3.5 Training of Welders

Each welder, irrespective of his recent site experience on tube and pipe plant, shall be tested on a mock-up (so-called jungle gym) of the relevant plant configuration before the contract commences. For tube welding contracts under challenging site conditions the welder shall prove his skill in out-of-position manipulations to a similar degree of difficulty expected during the contract. For large-bore thick-walled pipework, the welders shall demonstrate the skill required to perform balanced out of position welding on site. Special attention shall be placed on the correct techniques for successful application of pipe root welds.

3.4 DESIGN FOR WELDING

3.4.1 Weld Joint Designs

Before fabrication starts, the contractor shall submit to Eskom welding procedures complying with the plant design code, showing the weld joint configuration to be used in the fabrication or for the repair to be performed on the tube or pipework. For thick walled pipes the proposed configuration shall aim to

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minimise weld metal volumes through the use of U-preparations instead of V-preparations in order to reduce the levels of weld residual stresses while confirming with the welders identified to execute the weld, that full access will be possible. The weld joint shall also be fully inspectable by conventional volumetric NDT techniques.

3.4.2 Permanent Attachments

Welding of attachments to piping shall not be permitted without Eskom approval on the contract design. The location, geometry and size of all attachments shall be accurately indicated on the contract weld map and flagged for the full NDT requirements as for pressure boundary welds. Welds joining load-bearing attachments to high temperature pipes shall have full penetration weld joint preparations and be continuously welded for the full length of the weld preparation. Fillet reinforcement size and profiles shall be strictly according to low stress design principles., and flagged for grinding to a smooth finish and to eliminate all undercut or stress concentration notches. All load-bearing attachment welds shall be heat treated according to the design code and material requirements.

3.4.3 Socket Welds

Socket welds shall not be permitted unless specifically approved by Eskom on case by case basis for systems not subjected to vibration or frequent thermal cycling. Great care shall be exercised in the fit-up for such joints in ensuring that the pipe does not butt up against the inner end of the socket.

3.4.4 Acceptable Welding Processes

One or a combination of the following processes may be used for welding on high pressure and temperature tube and pipework:

- Manual Metal Arc Welding (MMAW)/shielded metal arc welding (SMAW) (not to be used for full penetration butt welds where the root back side is inaccessible);
- Manual and automated Tungsten Inert Gas Welding (TIG)/gas tungsten inert welding (GTAW);
- Mechanised Submerged Arc Welding (SAW).

Manual metal inert gas (MIG)/metal active gas (MAG)/flux cored arc welding (FCAW)/gas metal arc welding (GMAW) processes are not allowed for tube/pipe overlay and joining. Mechanised/automated MIG/MAG/FCAW/GMAW pressure boundary applications executed in controlled workshop conditions are not excluded, but will require sufficient motivation and technical justification to be considered for Eskom plant application. These proposals/justifications will be evaluated and approved on a case by case basis and not as a general acceptable group of welding processes.

Other welding processes shall only be used with prior specific approval by Eskom where applicable, for example the case of attachment of fins to economiser tubes where the resistance welding process is commonly used.

3.4.5 Backing Rings

The use of permanent backing rings shall not be permitted.

3.4.6 Weld Contour

Welding parameters shall be optimally set within the range allowed by the WPS to provide sufficiently contoured weld bead profiles to permit complete fusion at the sides of the weld end preparations and to avoid slag entrapment. Weld reinforcement, penetration and finish shall be applied as required by the applicable code and design requirements while aiming for minimum post weld cleaning and profiling by grinding. Weld dimensions as calculated by the designer shall be closely followed, over-welding by more

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than 25% which may be conducive to the creation of unnecessary high weld residual stresses shall be avoided as far as practically possible.

3.4.7 Proximity of Welds

Positioning of the toes of adjacent butt welds, branch welds and attachment welds shall meet the requirement of the design and application codes. If not specified, it shall not be nearer than a distance equalling four times the wall thickness of the pipe concerned while allowing adequate access for the deposition of sound weld metal and for the application of any post-weld operation such as heat treatment and NDT.

3.4.8 Tack Welds

Shall be designed to the requirements of the construction code. Where the construction code allows for incorporation of tack welds into the joint weld, the tack welds shall be of sufficient size to withstand the thermal stresses associated with the installation of the weld root.

Areas to be tack welded must be preheated evenly to the same temperature (as specified for welding in the WPS) over an area up to minimum 150 mm away. The cross section size, length and spacing tack welds depend on the physical size of the pipe, but a minimum of 25 mm long where practically possible on large-bore thick-walled pipes and be cleaned of slag prior to welding the main weld beads. The leg length (weld size as measured with a weld gauge) shall be a maximum of 6mm as far as practically possible on the specific pipe size. All tack welds must be ground smooth prior to completion of the joint fill weld beads.

3.4.9 Bridge Pieces

Bridge pieces for weld joint alignment shall not be welded directly to the outside surface of tubes /pipes. Purpose designed bolted clamps or strong-backs, to which bridge pieces may be welded, shall be used. Where required, bridge pieces may be welded to the weld preparation surface in cases where the attachment weld will eventually be incorporated into the completed tube/pipe weld.

3.4.10 Cold Pull

For cases where cold pull are used to reduce reaction forces at terminations and anchors, careful and comprehensive evaluation of system layout, supports and geometry shall be performed by competent pipe design engineers to determine the correct cold pull required for a rigid closing weld as required by the Eskom High pressure pipework Standard 240-56239129 [39]. Where it is necessary to fit straining gear for a cold pull at a joint, such gear shall remain in position during welding and until all repair work, stress relief and subsequent cooling have been completed.

3.4.11 Identification of Welds on Pipework

All welds on thick walled piping shall have the weld unique number mark which correlates with the approved contract weld map, using low stress stamping or with a round nosed stamp, within the heat treatment zone of the weld (but not in the heat affected zone). Identification methods of welds where required on thin wall piping shall be subject to approval by Eskom.

3.4.12 Valves and Fittings

All valves, fittings and terminal points equal to or greater than 150 mm nominal bore, shall be fitted with transition pieces so that all site welds where practically possible are between the same materials. The material for the transition pieces and welding qualification shall be provided by the principal Contractor or pipework sub-contractor to the valve supplier for welding to the valve in the works of the valve supplier. Care shall be exercised to install transition pieces of correct length, weld built-up shall not be employed to make up for ill fittings transitions pieces.

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The WPS for the weld joint between the valve and the transition piece shall be agreed upon between the main Contractor, the pipework sub-contractor, the valve supplier and Eskom. For valves, fittings and terminal points of less than 150mm nominal bore, the provision of the welding procedure and its qualification, if required, shall be the responsibility of the pipework contractor.

3.5 PRESSURE BOUNDARY MATERIALS

3.5.1 Tube and Pipe base Material

New material for use on high-temperature components shall be ordered to the requirements of the Eskom standard 36-1255 [41] which references EN 10216 [3]; the VGB Document VGB-R 109 [19] or ASME BPV Section II [5], depending on the relevant plant design code. For material VM12-SHC not yet listed in the said specifications, the manufacturer's material data sheet V&M Material Data Sheet MDS 439 [20] shall be referenced until listed in the current pipe material specification. The table in the Annex B shows various high pressure and temperature ferritic and martensitic steels currently allowed for use on Eskom plant.

Any other material proposed for use which is listed in specifications BS EN 10216 [3] or ASME BPV Section II [5] may be considered for use when sufficiently motivated by design calculations. Newly developed alloys may be considered for application on Eskom plant with sufficient support documentations from the supplier pertaining to mechanical properties, creep life properties and workability data.

Substitution of materials installed on existing plant as selected by the original design with another grade is not allowed unless approved through the relevant Eskom intervention process (Concession/Modification). The approval will be based on supporting design calculation documents that address mechanical properties, creep properties, weldability issues, workability issues, heat treatment requirement, material mass (effects on hanger and support system).

3.5.2 Weld consumables

Details of acceptable consumable specifications are listed in paragraph 3.6.1

3.5.3 Base materials and weld consumables non-conforming to design codes and specifications

Base materials and weld consumables not conforming to the requirements of Eskom Standard 240-56241933 and paragraphs 3.5.1 and 3.6.1 of this document may be considered for use through sufficient technical motivation. Examples of these are:

- New designed material grades not yet accepted on the current revision of the permissible material specifications
- Material deemed proprietary by the OEM of the plant
- Trademarked materials

Any proposed non-standard material grade shall be considered for use after evaluation by Eskom technical team of sufficient technical data supporting the motivation.

Pertaining to EN designed plant; a strong argument for unconditional use of a material not listed in the international specifications may be for the use of the non-standard material grade to be supported by well-known research organisations such as VGB who published extensive technical data sheets for certain grades.

For ASME BPV designed plant, material not listed in ASME BPV Code Section II shall be handled as required for unassigned grades during welding related activities as provided for in clauses QW 420 to QW 433.

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3.6 WELDING CONSUMABLE REQUIREMENTS

Guidelines for the handling and storage of weld consumables are contained in the Welding Standard 240-56241933 [35]. Important points pertinent to consumables for use on high pressure and temperature tube and pipework are emphasised in this document.

3.6.1 Specification for Consumables

Welding consumables for high pressure and temperature tubes and pipework, in particular those intended for use in the creep range, shall be ordered from manufacturers which have evidence and have demonstrated that the properties of their products are suitable for long-term high temperature use. Consumable approval shall conform to the national standard requirements of the country of origin as a minimum. It is recommended that consumables with approval according to BSEN family of consumable specifications, in particular EN ISO 3580 [22] and EN ISO 21952 [23] be used on Level 1 and 2 Eskom plant. Published creep data shall be made available for scrutiny. The basis for the evaluation of test results is creep and rupture properties of the base metals to be joined.

Consumables marketed by companies opting for certification to AWS A5.X family of specifications will be acceptable if supplied with a test report confirming compliance with the applicable AWS standard or the reference to this AWS standard contained in ASME II, Part C [5]. The test report shall correspond to "Schedule F" of AWS A5.01 [21] if no further elements are specified. This test report is comparable with a works certificate "2.2" as regards content. Evidence of creep testing shall be available at the point of ordering.

ANNEX C tables the recommended consumable grades for materials used on Eskom plants.

3.7 PREPARATION FOR WELDING

3.7.1 Supervision of Welding Activities

The principle contractor shall appoint an adequate number of supervisors to control all welding activities at site level during the full life cycle of the contract. They shall have the necessary practical experience with supervising contracts on high pressure and temperature tube and pipework and at least be a certified IWS as required by Eskom Standards 240-56241933 [35] and 240-56246601 [40].

3.7.2 Inspection and Test Plans

Inspection and test plans/QCP's shall be prepared and submitted to Eskom in accordance with QM58 [38].

3.7.3 Inspection of Weld Preparation

Tube and pipe weld preparations shall be inspected before application of preheat for cleanliness, fit-up, alignment, geometry and access. Each weld preparation for joints on pipes with outside diameter larger than 150 mm shall be inspected according to the check-list in Annex A which shall be completed by the authorised persons and included in the contract work package.

3.7.4 Weld Joint Preparation

Weld joint preparation by workshop machining will be preferred where practically possible. Where portable machining equipment is not available, on-site weld preparations shall be done by abrasive disk cutting and grinding. Base material dedicated grinding consumables shall be used, no indiscriminate mixing between low alloy/carbon steel and stainless steel materials shall be allowed.

Prepared surfaces shall be inspected by thorough visual examination for flaws, cracks, laminations and other defects. When pipes or fittings have to be internally machined for internal diameters to match

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adjoining components, this process shall not reduce the thickness at the weld preparation to below the minimum calculated design thickness, in which case a proposal for remedial action shall be submitted to Eskom for approval. Buttering or including the thickness of the weld cap shall not be considered acceptable rectification practices, but may be considered by Eskom with sufficient motivation.

Thermal cut weld preparations shall be allowed on the following materials without evidence of formal work procedures. [BSEN 10216 (ASME Section II)/alternative]

- 14MoV6-3 (660);
- 15NiCuMoNb5-6-4 (WB 36;
- 7CrMoVTiB10-10 (P24);
- 7CrWVMoNb9-6 (P23);
- X20CrMoV12-1;
- X10CrMoVNb9-1 (P91);
- X10CrWMoVNb9-2 (92);
- VM12-SHC.

These grades require pre-heat for welding and shall be pre-heated in the same manner before thermal cutting or gouging. Where thermal cutting by plasma arc or by the oxy-fuel technique is required/proposed, a procedure shall be presented by the contractor specifying the following minimum critical parameters pertaining to the base material:

- Pre-heating rate and maintained temperature,
- Cutting travel speed,
- Process gas type,
- Type of flame: Neutral, oxidising or carburising
- Gas pressure
- Gas supply rate
- In the case of plasma cutting the volts and amperage settings.

3.7.5 Residual Magnetism

Before any welding commences, the weld joint preparation shall be checked for any magnetism that might have resulted from the initial NDT and weld preparation activities, de-gaussing may be required for preventing arc blow to occur during welding.

3.7.6 Installation of Tack Welds

These shall be applied to the requirements of the applicable WPS with respect to allowable weld parameters, preheat and only by qualified welders. Where the construction code allows for incorporation of tack welds into the joint weld, the tack welds shall be of sufficient size to withstand the thermal stresses associated with the installation of the weld root. Visibly cracked tacks shall not be fused into the root weld; these shall be excavated and re-welded.

3.7.7 Temporary Attachments

Where approved, temporary attachments shall be welded to tube and pipe surfaces as per the requirements of the relevant WPS with regard to preheat, weld parameters, welder qualification and PWHT.

3.7.8 Root weld Backing Gas

Backing gas is mandatory for high alloyed ferritic steels and martensitic/austenitic stainless steels sorting under groups 4, 6, 8, 9... (EN13480 Part 4 Par 9) [1]. Open ends of tube/pipe sections to be joined shall be sealed off to provide an enclosed environment through which the root side of the weld joint can be flooded with the grade of inert gas for shielding the root against high temperature oxidation. For the cases where these sections are excessively long requiring large quantities of gas to excavate the air from the root side of the joint, other more practical solutions may be used. Temporary purge dams constructed from inflatable pipe plugs, rice paper, or spiral wound refractory tape may be considered. These devices must be readily extractable through the root gap just before the last section is welded close. Under these circumstances the purging gas can be administered through a small bore tube directly through the weld preparation root gap or through pipe nozzles or gamma-bosses in close proximity to the weld joint. Before welding commences the efficacy of the root purge shall be checked with an oxygen analyser.

The use of backing gas containing mixtures of hydrogen shall not be permitted on martensitic stainless steel tube or pipe welds.

3.7.9 Chimney Effect

For all welds in pipes of internal diameter of 50 mm and greater, the root runs shall be made by the TIG/GTAW process. Care shall be exercised to ensure that the purging gas inside the pipe is not swept away by the chimney effect. Any flow of air through the pipeline during welding shall be prevented by closing in-line valves in close proximity, blanking the ends of the pipes and plugging all other openings such as gamma-ray bosses and branch connections. The plugs shall be readily removable.

3.7.10 Scaffolding and Shelter

Adequate and safe scaffolding shall be available to provide welders and the best possible environment to execute a successful weld in a safe manner.

Tents or screens shall be erected for full protection of the complete weld area against the elements, notably wind and rain during the full period of preparation, welding and PWHT activities, as well as during cooling down of the welded joint afterwards.

3.8 PREHEATING

3.8.1 Heating Methods

Preheating shall be carried out using induction or resistance heating elements, except for cases where heating by gas is permitted due to practical considerations.

3.8.2 Temperature Recording

Temperatures shall be recorded on calibrated and certificated equipment using at least four thermocouples on thick-walled large-bore pipes. Less thermocouples will be acceptable on small-bore thin-walled tubes as dictated by practical factors. Care shall be taken when working with thick materials, that the temperatures recorded are representative of those existing at the inner surface before tacking or making the root runs.

3.8.3 Gas Preheating

Where contractors propose the use of gas preheating, it shall be motivated by a suitable procedure that adequately addresses control and repeatability of the technique, and the contractor has to justify gas preheating with the necessary controls in the form of a method statement. This will be considered by Eskom for implementation on the specific jobs assessed. Gas heating may be used on boiler internals (boiler tubes that will not result in safety critical failures). However, even on boiler tubes, contractors must demonstrate adequate controls, especially when welding alloyed steels.

Preheating by gas shall be permitted under the following general conditions:

- Only propane or butane or mixtures thereof shall be permitted as fuel gas on ring burners or torches of the “rosebud” type. Oxygen-acetylene torches are not permitted. . When temperature indicating crayons are used, at least three ranges shall be employed, while heating, to give progressive forewarning as the correct temperature is approached
- For small bore pipes and tubes of carbon steel, gas preheating may be used in the works and on site.
- Gas preheating may be used on site for the welding of 15Mo3 when the dimensions are 250 mm OD or less and a thickness of 12 mm or less
- Regarding large bore piping, headers and shells, gas preheating may be used in the shop only for welds in carbon steels and 15Mo3 , including tacking and local repairs for which post weld heat treatment is not required
- Gas preheating of large bore pipes and tubes outside the boiler shall not be used for the welding of the following materials [BSEN 10216 (ASME Section II)/alternative]] :
 - 13CrMo4-4 (P21);
 - 10CrMo9-10 (P22);
 - 14MoV6-3 (660)
 - 15NiCuMoNb5-6-4 (WB36);
 - 7CrMoVTiB10-10 (P24);
 - 7CrWVMoNb9-6 (P23);
 - X20CrMoV12-1;
 - X10CrMoVNb9-1 (P91);
 - X10CrWMoVNb9-2 (P92)and
 - VM12-SHC.

3.9 EXECUTION OF WELDS

3.9.1 Weld Progression

Pipes with OD larger than 150 mm shall be welded simultaneously from opposite halves by two welders. The welders shall match each other layer by layer in order to achieve a thermally balanced weld. For pipes with long axis orientated horizontally, the starting positions shall be at the six-o'clock position. For each subsequent layer, the start and stop position for the respective welders shall be shifted by at least 25 mm towards or away from that of the previous layer in order to stagger the starts and stops and not positioning it on the same plane radial to the pipe centre line.

For pipe sizes where access limitations prohibit the use of multiple welders, the contractor shall provide a method statement before the job commences where detail such as balanced welding techniques is clearly stated. Waiving or relaxing these requirements shall only be considered on a case by case basis

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when the contractor provides specific welding procedure(s) that detail an acceptable welding sequence which will result in a thermally balanced weld. These procedures shall be approved by Eskom prior to welding.

3.9.2 Joint Root Welding

Root runs shall be completed without interruption except for changing of position by the welder or weld consumable changes. Confirmation of full penetration welded from one side only, root inside profile acceptance check shall be performed by an assistant to the welder by observing through the root gap at a position conveniently away from the welder. Before final closure the weld supervisor shall confirm by visual inspection that no gross weld defects deemed outside the acceptance criteria exist on the weld root inside surface. The weld root hot pass shall commence immediately after closure of the root gap. Temporary attachments for weld joint alignment shall be kept in place until at least 20% of the thickness of the final weld has been laid down. If welding is interrupted at this critical stage due to a power failure or other emergency event and allowed to cool below the minimum pre-heat temperature an investigation /evaluation will be required to decide on the merits of removing the weld and starting again.

Measurement of temperature shall be in accordance with EN ISO 13916 [16]. More specific to tube and pipe welding, each welder shall be issued with at least two temperature indicating crayons, one rated at the minimum preheat temperature as required by the WPS, and the other rated at the maximum interpass temperature value. The rating of the crayon shall be a permanent marking by indelible ink. After completion of each weld layer both temperature values shall be checked to be within the WPS requirements at a position 5 mm away from the weld groove preparation edge. In the event that the crayons indicate temperature excursions, the temperature value shall be confirmed by a calibrated digital contact thermometer and recorded. Non-contact infra-red type thermometers shall only be used for non-procedural comparative temperature measurement, not for checking and confirmation purposes.

3.9.3 Interruption of Welding

The welding cycle shall not be interrupted for an unlimited time unless the weld can be maintained at the pre-heat temperature. In the event of a power failure during welding of the root, where the duration of the failure is such that the weld area cools below the pre-heat temperature, the weld operation shall be halted and the situation investigated.,

In the event of a power failure during any stage of the welding of readily hardenable alloys such as [BSEN 10216 (ASME Section II)/alternative]]:

- 14MoV6-3 (660);
- 15NiCuMoNb5-6-7 (WB36);
- 7CrMoVTiB10-10 (P24);
- 7CrWVMoNb9-6 (P23);
- X20CrMoV12-1;
- X10CrMoVNb9-1 (P91);
- X10CrWMoVNb9-2 (P92);
- VM12-SHC

Where the duration of the failure is such that the weld area cools below the pre-heat temperature, the weld operation shall be halted, an investigation /evaluation will be required to decide on the merits of removing the weld and re-starting. If weld removal is required, the tube/pipe ends shall be ground back to re-introduce the original weld preparation, NDT inspected and re-prepared before the welding operating shall start again.

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If the construction code permit an interruption in welding, the preheat temperature shall be maintained until welding can be re-started.

3.9.4 Attachment Welds

All attachments shall be welded by welders appropriately qualified and according to the relevant WPS. Welding arc parameters shall be set at the lowest practical values within the range stipulated by the WPS in order to minimise the possibility of penetration through the tube/pipe wall. Weld geometries and sizes shall be strictly according to the design requirements. Oversizing or welds more than 25% above the dimensions required by the design shall be cause for rejection. No weld shall be started or terminated at high stress intensity positions such as at the ends of attachments, but positioned at least 15 mm away (keep on welding around the corner).

3.9.5 Interpass Cleanliness

Flux, weld spatter and slag shall be removed from the weld joint preparation with parent material dedicated wire brushes (for example stainless steel tubes and pipes require matching brushes) before starting to deposit successive passes. Superficial pneumatic needle peening shall only be permitted to the extent necessary to clean the welds, or where called for in an approved welding procedure. In cases where a pneumatic peener is used, the air release aperture shall be positioned as to ensure that the exhaust air stream is directed completely away from the work surface, supply air shall be completely dry and free of contaminants such as lubrication oil therefore confirmation of the functionality of filters and traps shall be included in the QC checklist.

Under no circumstances will the practice of so-called slag 'burn-out' of a previous weld-stop after changing to a new covered electrode be allowed, chipping or grinding to remove slag of each weld stop before commencing with the next run start shall be performed.

After completion of each weld layer, the completed weld surface shall be smoothly and evenly ground to bare metal.

3.10 DIFFICULT-TO-WELD JOINTS

Welds which from previous experience are known to have a high level of difficulty to perform and low success rate due to practical issues such as welder access limitations shall be identified a focus area for drastic weld effort improvement. Attempting to perform these welds through conventional welding techniques will inadvertently lead to unacceptable high defect rates. Eskom issued a Technical Bulletin to clarify the standpoint on such scenario.

These welds are typical candidates for application of new weld technologies and innovations when economically justified. Automated welding processes in many cases provide the solution for most of these welds and development of suitable repeatable techniques by contractors for Eskom acceptance are strongly recommend.

3.11 DRESSING OF WELDS

3.11.1 Preparation for Inspection

All welds in high pressure pipework and components shall be subject to in-service inspection and dressing of welds shall be such as to enable ultrasonic testing to be carried out.

To achieve the best possible quality NDT, welds shall be dressed before final PWHT, flush with the adjacent pipe outside diameter level to check for transverse and longitudinal indications in the following materials: [BSEN 10216 (ASME Section II)/alternative]]:

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- 14MoV6-3 (660);
- 15NiCuMoNb5-6-4 (WB36);
- 7CrMoVTiB10-10 (P24);
- 7CrWVMoNb9-6 (P23);
- X20CrMoV12-1;
- X10CrMoVNb9-1 (P91);
- X10CrWMoVNb9-2 (P92);
- VM12-SHC.

For cases where the weld caps are not required to be dressed flat, weld edges shall be smoothed by grinding to blend the weld cap to the pipe and to eliminate undercut. Welds on form pieces shall be dressed by grinding to a smooth contour. When the weld reinforcement is fully dressed, wall thickness checks shall be carried out and recorded. The minimum weld thickness shall not be less than the minimum wall thickness. For grinding after final heat treatment, local overheating due to inefficient techniques shall be avoided. The correct size grinding wheel shall be used for this purpose. All grinding shall be supervised to reduce heat input.

3.11.2 Dressed Weld Profile Requirements

To permit an Examination Level 2 according to BS EN 17640 [25], all welds in HP pipework with OD of 100 mm or greater shall be ground as follows:

- In all cases the weld cap and the parent metal shall be blended to eliminate undercut.
- Welds on pipes for carbon steel and 15Mo3, shall be ground to a partially dressed near-flat surface profile category SP3 according to BS EN 17640 [25].
- All welds for the following alloys [BSEN 10216 (ASME Section II)/alternative)] :
 - 14MoV6-3 (660);
 - 15NiCuMoNb5-6-4 (WB36).
 - 7CrMoVTiB10-10 (P24);
 - 7CrWVMoNb9-6 (P23);
 - X20CrMoV12-1;
 - X10CrMoVNb9-1 (P91);
 - X10CrWMoVNb9-2 (P92);
 - VM12-SHC;

Shall be ground to a fully dressed surface profile category SP4 according to BS EN 17640 [25].

- Fillet welds as on branch pieces, stubs and nipples of greater than 100 mm shall be ground to a profile category SP7 according to BS EN 17640 [25];
- Fillet welds of load-bearing attachments shall be ground to a dressed flat surface profile category SP7 according to BS EN 17640 [25];
- The welds of pipework of less than 100 mm OD shall be ground to remove undercut, and to permit an adequate level of NDT;

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- Each wheel used for grinding alloy welds shall be reserved for grinding one composition only, and shall be so marked. The surface finish on the ground area shall conform to BS EN 17640 [25];
- Butt welds which have been fully dressed to category SP4 shall be checked for remaining thickness if the area of the weld has been ground below the level of the parent metal either side. Such welds shall be delineated by light centre punch marks at 100 mm spacing round the circumference 25 mm away from the centre of the weld.

3.12 POST WELD HEAT TREATMENT

Heat treatment procedures shall be based on the basic guidelines provided in the Eskom Heat treatment Standard 240-77196678 [43] and the specification BS EN ISO 17663 [13].

In addition to these documents and pertinent to the heat treatment of high pressure and temperature tubes and pipes, the following clauses shall apply:

3.12.1 Base Material PWHT Requirements

The construction codes provide minimum mandatory requirements for different alloys. Carbon steel (as defined in ISO 15608 for Group 1 materials, Group 11 materials excluded) and 15Mo3 are exempted from PWHT for wall thicknesses up to 30 mm; however Eskom will reserve the right to require stress relief of thick section ISO15608 Group 1 material [17] components for very specific cases. For ferritic grades alloyed higher than 10CrMo9-10, PWHT for tempering purposes of the HAZ for all components inside and outside the boiler regardless of wall thickness shall be required by default. For alloys 10CrMo9-10 and 13CrMo4-4 refer to the Eskom Technical Bulletin (WCG 006) for PWHT requirements.

3.12.2 Cooling Down for Transformation

Weld joints involving ferritic/martensitic grades [BSEN 10216 (ASME Section II)/alternative)] X20CrMoV12-1; X10CrMoVNb9-1 (P91); X10CrWMoVNb9-2 (P92) and VM12-SHC shall be cooled down from minimum interpass temperature to between 90 and 100°C (or specific temperature calculated from accepted empirical formulae) to ensure full martensite transformation before commencing with PWHT. Considering that temperature is generally measured at the outer surface, the component should be held at this temperature for a sufficient amount of time as to ensure that through thickness transformation occurs.

3.12.3 Heating and Cooling Rates

Guidelines as provided in the applicable construction code, BS EN 1011 [9] and BS2633 [14] shall be followed as required by material geometries. For weld joints involving components with more than 100 000 accumulated operating hours constructed from 13CrMo4-4 (P21) and all higher alloyed grades, the maximum heating and cooling rates shall be 50°C per hour.

Where practicality and time constraints exist, Eskom may consider relaxing this requirement for thin walled components on a case by case basis when adequate technical information and justification is available.

3.13 INSPECTION OF COMPLETED WELDS

3.13.1 General NDT Requirements

The contractor is responsible for ensuring that NDT contractors and their equipment operators are correctly qualified and on the approval list as required by the Eskom Standards 32-631 [37]. All NDT shall be performed to meet the requirements of Eskom NDT Standard 32-632 [36].

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For the material grades [BSEN 10216 (ASME Section II)/alternative] 14MoV6-3 (660); 7CrMoVTiB10-10 (P24); 7CrWVMoNb9-6 (P23);; X20CrMoV12-1; X10CrMoVNb9-1 (P91); X10CrWMoVNb9-2 (P92) and VM12-SHC, final inspection of welds shall be delayed and performed at least 48 hours after cooling down from welding and PWHT (where applicable all welds shall be visually inspected after completion).

All weld surfaces shall be free from defects indicative of poor workmanship and shall be cleaned of all foreign material after completion of welding.

3.13.2 Main Inspection

Inspections shall be performed as required by Eskom weld standard 240-56241933 [35].

3.14 WELD REPAIRS

3.14.1 Authority to Repair

Repairs on completed welds shall not be affected without approval of the Eskom Welding Engineer. These repairs shall be made as soon as possible after inspection of a weld.

3.14.2 Removal of Defects

- Defects shall be completely removed by gouging, grinding or other approved methods (for the type of material being repaired) to clean metal. The excavated area shall be examined by an accepted method to ensure complete removal of the defect.
- A pneumatic hammer or chisel shall not be used while further welding is in progress on the pipe length.
- Portable grinders may be employed on all types of steel. Care shall be taken to avoid overheating and contamination of the pipe material by the grinding wheels.
- Carbon arc air gouging shall not be permitted on 14MoV6-3 (660); X20CrMoV12-1; X10CrMoVNb9-1 (P91); X10CrWMoVNb9-2 (P92) and VM12-SHC. On all other materials, an appropriate preheat shall be used if air gouging is carried out.
- All gouged surfaces of welds, prior to repair, shall have a minimum of 2 mm of metal ground away in order to ensure complete removal of any oxidised material before re-welding commences.

3.14.3 Weld Repair Procedure

- Weld repairs in areas where defects have been correctly removed, shall be made using the same welding procedure used for the original weld, referenced in a concise job specific repair method statement.
- The repaired areas shall be re-examined using the same inspection procedures by which the defects were originally detected.
- Only two repair attempts shall be allowed on any one weld areas. No further attempts shall be carried out with-out approval.
- The Contractor shall submit, for Eskom's review and approval, a repair method statement that details the corrective action in each instance of rejection of a major component due to faulty/defective welding.
- For very limited excavations, temper bead repairs without subsequent heat treatment may be considered by Eskom on some grades of tubes/pipes. ANNEX D illustrates the concept of temper bead technique.

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4. RECORDS AND CERTIFICATES

4.1 GENERAL REQUIREMENTS

4.1.1 Retention Period

The Contractor shall retain all relevant signed off inspection and test records in hardcopy and electronic format for a minimum of 12 years after commissioning of the plant or for the time specified in the contract after which time the records shall be offered to Eskom before destruction.

4.2 SPECIFIC DOCUMENTS FOR RECORD KEEPING

- Welder qualifications and procedure qualifications test certificate.
- Charts recording the weld preheating and post-weld stress relieving treatment.
- All radiographs together with the relevant means of identification.
- Weld defect reports.
- Records of location and extent of all weld repairs.
- Full test reports on magnetic particle-, ultrasonic-, liquid-penetrant- or radiographic examination in accordance with the relevant Eskom procedure.
- Full test reports on destructive testing.
- Material test certificates for welding consumables.
- Quality Control Plans (Verified and signed).

5. AUTHORISATION

This document has been seen and accepted by:

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6. REVISIONS

| Date | Rev. | Compiler | Remarks |
|---------------|-------------|-----------------|--|
| November 2012 | 0.1 | P. Doubell | Draft Document for review created from Welding of High Pressure, Temperature Tube and Pipework |
| March 2013 | 1 | P. Doubell | Final Document Authorised for Publication |
| October 2014 | 1.1 | P. Doubell | Revision of Document |
| October 2014 | 1.2 | P. Doubell | Draft Document for Comments Review |

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| | | | |
|---------------|-----|-------------------------|--|
| December 2014 | 1.3 | P. Doubell & D. Moll | Consolidation of M. Maroga comments |
| January 2015 | 1.4 | P. Doubell & D. Moll | Consolidation of M. Maroga comments |
| January 2015 | 1 | P. Doubell & D. Moll | Final Document for Authorisation and Publication Rev 2 |

7. DEVELOPMENT TEAM

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

- Philip Doubell
- Donovan Govender
- Hennie Coetzer
- Michael Mkize
- Nanda Chabula
- Papy Mwilambwe
- Sma Msomi
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- Eliza Dlamini
- Prenola Naidoo
- Phathu Nemakhavhani
- Marcel Rabie
- DeVilliers Moll


8. ACKNOWLEDGEMENTS

None

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APPENDIX A: LARGE BORE PIPE WELD PREPARATION CHECK LIST

|  | | Doc ID: <u>TEPPI 01-2013 Rev 0</u> | |
|---|-----------------------|--|-------------------|
| POWER STATION: | | | |
| QC Check Sheet for large bore pipe welds | | | |
| No | Activity | Information | Page 1 of 5 Sign. |
| 1. | Weld Identification | 1.1 Unit: _____ 1.2. Identification Number: _____ 1.3 System: _____ 1.4 Weld orientation (vertical /horizontal): _____ | |
| 2. | Base material | 2.1 Material 1 _____ 2.2 Material 2 _____ | |
| 3. | Welder Identification | 3.1. Name 1: _____ 3.2. Identification No 1: _____ Name 2: _____ Identification No 2: _____ | |
| 4. | Ambient conditions | 4.1. Possible interferences (Vibrations, bumps, moisture, draughts) with negative influence? _____ 4.2. Other work in close proximity with potential negative influence? _____ _____ | |

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| | | | |
|----|--|---|--|
| 5. | Weld Preparation / Weld fit up. | <p>5.1. Weld preparation geometry according to WPS design (record anomalies) :</p> <hr/> <p>5.2. Blocking structures in place:</p> <hr/> <p>5.2.1 Torque settings on bolts as per method statement: _____</p> <p>5.2.2 Was adjustments on bolts required during heat treatment:</p> <hr/> <p>5.2.3 Hot fit-up temperature:</p> <hr/> <p>5.2.4 Torque settings after possible adjustments:</p> <hr/> | |
| | Attach orientation drawing. | <p>5.3. Alignment:</p> <p>5.3.1 Cold fit-up Minimum measurement: _____ Maximum measurement: _____</p> <p>5.3.2 Hot fit-up Minimum measurement: _____ Maximum measurement: _____</p> <p>5.3.3 Hot fit-up temperature:</p> <hr/> | |

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| | | | |
|-----------|-----------------------------|--|--------------------|
| | Attach orientation drawing. | 5.4. Root Gap Reading: 5.4.1 Cold fit-up Minimum reading: _____ Maximum reading: _____ 5.4.2 Hot fit-up Minimum reading: _____ Maximum reading: _____ 5.4.3 Hot fit-up temperatures: _____ | |
| No | Activity | Information | Page 2 of 5 |
| 4 | Attach orientation drawing. | 4.5. Strong backs used (Half pipe, pipe, Solid or "C" bracket e.g.) 4.5.1. Type: _____ 4.5.2. Size: _____ 4.5.3. Number off: _____ 4.5.4. Installation positions: _____ | |
| | To be available on request | 4.6. Prep profile taken and recorded: _____ | |

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| | | | |
|----|--------------------------------------|--|-------------------|
| 5 | Welding | <p>5.1. Welding Machine Identification:</p> <p>5.1.1. Identification number: _____</p> <p>5.1.2. Type of welding machine (Transformer or Inverter): _____</p> <p>5.1.3. Brand of welding machine: _____</p> <p>5.2. Root weld tungsten electrode:</p> <p>5.2.1. Angle measure (should be 30°±5 inclusive): _____</p> <p>5.2.2. Tungsten Electrode type: _____</p> <p>5.2.3. Grinding marks orientated parallel to electrode along axis: _____</p> <p>5.2.4. Welding electrode diameter (measure): _____</p> <p>5.2.5. TIG torch fitted with gas lens? _____</p> | |
| No | Activity | Information | Page 3 of 5 Sign. |
| | Procedure to be available on request | 5.3. Welding Procedure No (WPS): | |
| | Procedure to be available on request | 5.4. Pre-heat procedure followed: | |
| | | 5.5. Ergonomics, welder access to the weld: | |
| | | 5.6. Purging Plug installed and tested: | |

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| | | | |
|--|--|---|--|
| | | 5.7 Purging Gas: 5.7.1. Batch number / cylinder identification: <hr/> 5.7.2. Brand: | |
| | | 5.8 Welding consumables used to weld the ROOT. 5.8.1. Batch No: <hr/> 5.8.2. Brand: | |
| | | 5.9. Welding technique/ process followed to weld the ROOT. (Describe): <hr/> | |
| | | 5.10. Interpass temperature during the ROOT welding process: <hr/> 5.11. Sequence of ROOT weld: 5.11.1 Orientation started: <hr/> 5.11.2. Welding direction: | |
| | | 5.12. Weld duration of the ROOT:(Pre-heat complete) 5.12.1. Staring time: <hr/> 5.12.2. Completion time: <hr/> 5.12.3. Actual welding duration: | |

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| | | | |
|-----------|-----------------------------|---|--------------------------|
| | | 5.13. Did the ROOT gap close during the welding process: _____ If, how much: | |
| | Attach orientation drawing. | 5.14. Was any grinding done during the ROOT welding process: | |
| | | 5.15. Interruptions during welding of the root up to closure? (Corrections to root gap, Magnetism, Inspections e.g.) If, what: | |
| | | 5.16. Magnetism: (ROOT) 5.16.1. Magnetism present: _____ 5.16.2. Residual magnetism measured by Gauss meter: _____ | |
| No | Activity | Information | Page 4 of 5 Sign. |
| | | 5.16.3. How did you manage the magnetism: _____ _____ | |
| | | 5.17. Was the welder satisfied with the ROOT weld: | |
| | | 5.18. Who inspected the welding of the ROOT (Names): _____ _____ | |
| | | 5.19. Will the same welder / welders weld the HOTPASS: | |
| | | 5.20 Welding consumables used to weld the HOTPASS. 5.20.1. Batch No: _____ 5.20.2. Brand: | |

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| | | | |
|--|-----------------------------|---|--|
| | | 5.21. Welding technique/ process followed to weld the HOTPASS. (Describe): | |
| | | 5.22. Interpass temperature during the HOTPASS welding process: | |
| | | 5.23. Weld duration of the HOTPASS: (After ROOT welding) | |
| | | 5.23.1. Staring time: | |
| | | | |
| | | 5.23.2. Completion time: | |
| | | | |
| | | 5.23.3. Actual welding duration: | |
| | Attach orientation drawing. | 5.24. Was any grinding done during the HOTPASS welding process: | |
| | | 5.25. Magnetism: (HOTPASS) | |
| | | 5.25.1. Magnetism present: | |
| | | | |
| | | 5.25.2. Residual magnetism measured by Gauss meter: | |
| | | | |
| | | 5.25.3. How did you manage the magnetism: | |
| | | 5.26. Will the same welder / welders complete the weld: | |
| | | 5.27 Welding consumables used to fill the weld to completion. | |
| | | 5.27.1. Batch No: | |
| | | | |
| | | 5.27.2. Brand: | |

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| | | | |
|-----------|-----------------------------|--|--------------------|
| | | 5.28. Welding technique/ process followed to fill the weld to completion (Describe): | |
| | | 5.29. Interpass temperature during the fill welding process: | |
| No | Activity | Information | Page 5 of 5 |
| | | 5.30. Weld duration of the fill process: (After HOTPASS welding) | |
| | | 5.30.1. Staring time: | |
| | | 5.30.2. Completion time: | |
| | | 5.30.3. Actual welding duration: | |
| | Attach orientation drawing. | 5.31. Was any grinding done during the fill welding process: | |
| | | 5.25. Magnetism: (Fill process) | |
| | | 5.25.1. Magnetism present: | |
| | | 5.25.2. Residual magnetism measured by Gauss meter: | |
| | | 5.25.3. How did you manage the magnetism: | |
| 6 | Weld Results | 6.1. NDT Technique used: | |
| | | 6.2. Duration from completing the weld up to NDT: | |

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| | | | |
|--|--|--|--|
| | | 6.3. NDT Result (Accept or Fail) : _____ If failed, identify the failure mechanism: | |
| | | 6.4. Any cross checks done: | |
| | | | |

Note: This form should be completed for each individual weld.
Complete a new form for every weld or weld repair.
Attach any support document / information to this document to assist with investigations.
The information on this form will be used to identify good and bad practices and to improve the weld repair rate.

This document was completed by (Welding Supervisor):

Name: _____ **Signature:** _____ **Date:** _____

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APPENDIX B: TABLE OF ESKOM PLANT MATERIALS

| DIN 17175/17459 | BS 3059 / 3602 / 3604 Gr: | Also known as | BSEN 10216 | ASME II | Werkstof |
|-----------------|---------------------------|-------------------|-----------------|--------------------------|-----------------|
| St35.8 | 320; HFS320; HFS360 | Carbon steel | P235GH | A106 Grade A | 1.0305 / 1.0345 |
| St45.8 | 440; HFS430 | Carbon steel | P265GH | A106 Grade B | 1.0405 / 1.0425 |
| 15Mo3 | ~243 | ½Mo | 16Mo3 | A335 Grade P1 | 1.5415 / 1.5423 |
| 15NiCuMoNb5 | 591 | 15NiCuMo and WB36 | 15NiCuMoNb5-6-4 | | 1.6368 |
| 13CrMo4 4 | ~ 620 | 1Cr-½Mo | 13CrMo4-4 | A213 / A335 Grades T/P12 | 1.7335 |
| 10CrMo9 10 | 622 | 2¼Cr-1Mo | 10CrMo9-10 | A213 / A335 Grades T/P22 | 1.7380 |
| 14MoV6 3 | ~ 660 | ½Cr-½Mo-¼V | 14MoV6-3 | | 1.7715 |
| X20CrMoV12 1 | 762 | 12Cr or X20 | X20CrMoV12-1 | | 1.4922 |
| | | P24 | 7CrMoVTiB10-10 | A405 Grade P24 | 1.7378 |
| | | P23 | 7CrWVMoNb9-6 | | 1.8201 |
| | | T/P91 | X10CrMoVNb9-1 | A213 / A335 Grades T/P91 | 1.4903 |
| | | P92 | X10CrWMoVNb9-2 | | 1.4901 |
| | | VM12 | VM12-SHC | | |
| X6CrNi18 11 | 304S25 | 304H | X6CrNi18-10 | A213 Grade TP 304H | 1.4948 |
| X10CrNiNb18 9 | 347S18 | 347H | X6CrNiNb18-10 | A213 Grade TP347H | 1.4550 |

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APPENDIX C:TABLE OF RECOMMENDED WELD CONSUMABLES

Recommended filler metals for welding of materials operated at high temperature including corresponding product standards

| Base Material | Recommended filler acc. to standard | |
|-----------------|---------------------------------------|----------------------|
| | MMA electrodes | Bare wires/rods |
| | EN ISO 3580 (EN 1599) | EN 12070 |
| 13CrMo4-5 | E CrMo1 B | W CrMo1Si |
| 10CrMo9-10 | E CrMo2 B | W CrMo2Si |
| 15NiCuMoNb5-6-4 | E 50 4 Mo B 42 E 50 4 1 Mo B 42 H5 | W MoSi |
| 7CrMoVTiB10-10 | E ZCrMo2VNb B 4 2 H5 | W ZCrMo2VNb |
| 7CrWVMoNb9-6 | E ZCrWV2 1,5 B 4 2 H5 | E ZCrWV2 1,5 |
| X20CrMoV11-1 | E CrMoWV12 B 4 2 H5 | W CrMoWV12Si |
| X10CrMoVNb9-1 | E CrMo9 B 4 2 H5 | W CrMo91 |
| X10CrWMoVNb9-2 | E ZCrMoWVNb 9 0,5 2 B 4 2 H5 | W ZCrMoWVNb9 0.5 1.5 |
| VM12-SHC | E Z CrCoW12 2 2 | WCrCoW12 2 2 |

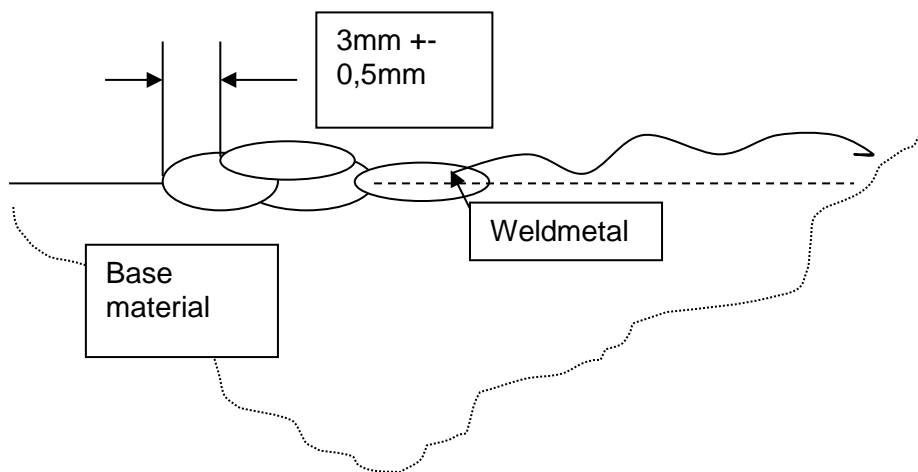
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APPENDIX D:TEMPER BEAD TECHNIQUE

APPLICATION OF TEMPER BEAD WELDS

Apply a temper bead to the outer edge of the last stringer weld deposit as indicated in the diagram. The edge of the temper bead must be placed as accurately as possible 3mm away from the edge last weld bead.



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