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1. INTRODUCTION

This standard represents a guiding part of a range of a family of documents that constitutes the Eskom Welding Rule Book (WRB) containing a collection of Eskom Standards, Procedures and Guidelines for welding on Eskom plant. These documents are key to support Eskom's position on all welding related issues and disputes, endeavouring to improve the quality of welding and reducing the weld repair rate and at the same time improve efficiencies. The principle objective of this document is to impose good basic welding practices of high quality levels while conforming to construction codes. Another important objective is to ensure a safe and healthy working environment as required by the Occupational Health and Safety Act including compliance with the applicable requirements of the PER in the case of pressurised equipment.

2. SUPPORTING CLAUSES

2.1 SCOPE

The requirements contained in this standard shall apply in 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 plant by the relevant Eskom procurement departments. The procurement team shall ensure that the WRB, which contains this standard, is included in the inquiry documentation package as a specific Eskom technical requirement.
- Routine weld repair and maintenance work by Eskom personnel also fall within the requirements of this document.
- It will serve as the standard to support Eskom's position on all 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 welding 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 necessary concessions which shall be documented and submitted to Eskom during the course of the contract as required by the Eskom Quality Standard QM58 [35].

2.1.1 Purpose

This standard defines unambiguous, fit-for-purpose requirements for welding during construction, repair and/or maintenance activities on Eskom plant. Measures have been put in place which aims to oblige all contractors to supply Eskom with high quality product. This directly apply to Eskom's control and quality requirements for construction and maintenance welding of high integrity safety critical plant which are captured in the Eskom Weld Rule Book

2.1.2 Applicability

This document shall apply to plant and components located in workshops off site and on sites throughout Eskom Holdings SOC Limited Divisions where welding activities are involved.

2.2 NORMATIVE REFERENCES

Parties using this document shall use the most recent editions of the documents listed in this section.

[1] ASME Boiler and Pressure Vessel Construction Code: Sections V, VIII and IX: (Including Addenda)

[2] BS EN 1011: Welding- Recommendations for welding of metallic materials – Part 1 General guidance for arc welding

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[3] BS EN 1011: Welding- Recommendations for welding of metallic materials – Part 2 Arc welding of ferritic steels

[4] BS EN 1011: Welding- Recommendations for welding of metallic materials – Part 3 Arc welding of stainless steels

[5] BS EN ISO 15607: Specification and qualification of welding procedures for metallic materials - General rules

[6] BS EN ISO 15613: Specification and qualification of welding procedures for metallic materials – Qualification based on pre-production welding test

[7] BS EN ISO 5817: Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections

[8] BS EN ISO 17663 : Welding – Quality requirements for heat treatment in connection with welding and allied processes

[9] BS 2633: Specification for Class I arc welding of ferritic steel pipework for carrying fluids

[10] BS EN 10204: Metallic products: Types of inspection documents

[11] EN ISO 13916: Welding – guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature

[12] PD CEN ISO/TR 15608: Welding – Guidelines for a metallic material grouping system

[13] BS EN ISO 14731: Welding co-ordination. Tasks and responsibilities

[14] EN 14732: Welding personnel. Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials

[15] BS EN ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories

[16] SANS 15614-1 (identical to BS EN ISO 15614-1): 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

[17] SANS 15614-7 (identical to BS EN ISO 15614-7): Specification and qualification of welding procedures for metallic materials - Welding procedure test Part 7: Overlay welding

[18] SANS 15609-1 (identical to BS EN ISO 15609-1): Specification and qualification of welding procedures for metallic materials - Welding procedure specification Part 1: Arc welding

[19] SANS 9606-1 (identical to BS EN ISO 9606-1): Approval testing of welders - Fusion welding Part 1: Steels

[20] BS EN ISO 9606-4: Approval testing of welders. Fusion welding. Nickel and nickel alloys

[21] SANS ISO 3834-1 (identical to BS EN ISO 3834-1): Quality requirements for Welding Part 1 Guidelines for selection and use

[22] SANS ISO 3834-2 (identical to BS EN ISO 3834-2): Quality requirements for Welding Part 2 Comprehensive quality requirements

[23] SANS ISO 3834-3 (identical to BS EN ISO 3834-3): Quality requirements for Welding Part 3 Standard quality requirements

[24] SANS ISO 3834-4 (identical to BS EN ISO 3834-4): Quality requirements for Welding Part 4 Elementary quality requirements

[25] SANS 10269: Welding of thermoplastics – Testing and approval of welders

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[26] SANS 10270: Welding of thermoplastics – Approval of welding procedures and welds

[27] SANS 10268: Welding of thermoplastics – Welding Processes Part 10: Weld defects

[28] Pressure Equipment Regulations (PER)

[29] Occupational Health and Safety Act 85 of 1993 (OHS-Act)

[30] SANS 10227: Specification for the criteria for the operation of Inspection authorities performing Inspection in terms of the Pressure Equipment Regulations

[31] SANS 347: Specification for categorization and assessment criteria for all pressure equipment

[32] SANS 10238: Welding and thermal cutting processes —Health and safety

[33] 240-83540088 Requirements for NDT on Eskom Plant Standard

[34] 240-83539994 Eskom NDT Personnel Approval (NPA) for Quality Related Special Processes on Eskom Plant Standard

[35] QM 58 Supplier Contract Quality Requirements Specification

[36] 240-56239129 High pressure pipework for fossil fired power stations

[37] 240-56355225: Welding of high temperature and pressure tube and pipework

[38] 240-56246601 Qualification, Certification and Accreditation Requirements for Personnel and Entities Performing Welding Related Work on Eskom Plant Standard

[39] 240-72273656 Power generation Asset criticality classification standard

[40] 240-77196678 Heat treatment of welded components

[41] EN ISO 14175: Welding Consumables – Gases and Gas Mixtures for Fusion Welding and Allied Processes

[42] 240-56247788 Weld Defect Classification and Reporting Work Instruction

[43] BS EN ISO 23279: NDT of Welds – Ultrasonic testing – Characterisation of indications in welds

[44] BS EN ISO 17640: Non-destructive Testing of welds – Ultrasonic testing - Techniques, testing levels and assessment

[45] 240-53114002 Engineering Change Management Procedure

2.3 DEFINITIONS

Definition	Description
Eskom Welding Co-ordinator	A Welding Engineer/Technologist appointed by Eskom to oversee all welding activities within Eskom SOC Holdings Ltd.
Procedure Qualification Record (PQR)	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
Welding Procedure Qualification Record (WPQR)	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 BS EN ISO 15614
Welding Procedure Specification (WPS)	A document meeting the requirements of BS EN 15609 or ASME Boiler and Pressure Vessel Code Section IX and derived from the WPQR/PQR that sets out in detail the required variables for a specific application to assure repeatability
Welder Qualification Record (WQR)	A document meeting the requirements of SANS 9606 or ASME Boiler and Pressure Vessel Code Section IX, that presents the results of the approval

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Definition	Description
	testing of a welder to perform a fusion welding process.

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
AIA	Approved Inspection Authority
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
BS EN	British Standard European Norm
EFEC-W	Eskom Framework for Effective Coordination of Welding
ISO	International Organization for Standardisation
ITP	Inspection and test plan
IW	International Welder registered with the International Institute of Welding
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
OHS Act	Occupational Health and Safety Act of 1993
PER	Pressure Equipment Regulations of 2009
PWHT	Post weld heat treatment
QCP	Quality control plan
SANAS	South African National Accreditation System
SCOT	Study committee of Technology
TCA	Technical capability assessment
TEPPI	Toolkit for Eskom Pressure Plant Inspection
TPI	Third Party Inspector employed by an Eskom appointed AIA company
WRB	Welding rule book

3. REQUIREMENTS

3.1 GENERAL

3.1.1 Welding Requirements

Eskom as owner and operator of safety critical equipment takes full responsibility for safe operation of plant as well as for proven integrity maintenance and repair work during the lifecycle of the plant.

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Although Eskom's responsibilities might be limited during certain contracts for new plant construction, the following statutory requirements, governing rules, standards and specifications related to welding will always apply:

- OHS-Act [29];
- SANS 347 [31];
- Relevant plant design and /or construction codes;
- WRB and other Eskom Standards.

These requirements shall be fulfilled during execution of welding activities, dispositioning of defects and engineering interventions for evaluation anomalies.

In addition to fulfilling the regulatory and plant safety requirements, entities performing welding work will be obliged to achieve good quality welds as intended by the correct design through:

- Sufficient and appropriate welding documentation approval, verification and control;
- the requirement of ISO 3834 Part 2 [22] certification of companies that will work on Safety Critical Plant as described in 240-72273656 [39] for Level 1 plant;
- material and welding consumable control;
- optimised heat treatment;
- maintained calibration of equipment;
- optimised NDT;
- completed data packages and record keeping

Furthermore, arc welding in general shall be performed to the requirements of BS EN 1011 Parts 1[2], 2[3] and 3 [4] which provide general guidance on how to achieve and control basic good quality welds in ferritic and stainless steels with emphasis on sound welding principles whilst fulfilling metallurgical and mechanical requirements.

3.1.2 Weld coordination

Welding is an inherently difficult process to effectively manage and maintain control of during the manufacturing process. There are many variables to control starting from the preparatory stages, during the welding process and through to the heat treatment phase and the final inspection.

A significant feature of SANS ISO 3834 [22] is the requirement for a manufacturer/contractor to have responsible welding coordinators according to ISO 14731[13] – individuals who can competently coordinate and apply good practice in the welding activities carried out by the manufacturer. This is an important requirement included to ensure that welding problems are identified in time, corrected and lessons learned are subsequently applied to avoid re-occurrence in future. ISO 14731 [13] links the competence of its responsible welding coordinators to the International Institute of Welding (IIW) diploma qualifications. All Eskom and contractor weld coordination personnel tasks shall be assigned based on the requirements of ISO 14731 [13]. The minimum qualifications required for weld coordination staff is stipulated in Eskom standard 240-56246601 [38].

3.1.3 Approval of documents and processes

New plant construction weld package approval is subjected to the Eskom established project management processes. Eskom weld specialist involvement is required during the contract negotiation and review phase.

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Maintenance and repair weld contract package approval is the task of the Eskom system engineer or delegate (site weld coordinator).

Approval of QCP/ITP's of welding contracts shall be done by an Eskom welding coordinator.

3.1.4 Independent third party inspector (TPI) specific to pressure parts

Safety of high temperature and pressure power generation plant and personnel is the sole responsibility of the user. As a consequence Eskom is obliged by legislation to appoint competent contractors applying suitable design and manufacturing codes, to provide a safe to operate product. For every Eskom weld construction and maintenance project, the Eskom approved inspection authority (AIA) is tasked to verify legislative compliance of the plant with regulations contained in the OHS-Act and PER during the operating life of the plant. Only AIA companies assessed and accepted by Eskom shall be utilised. As proof of this compliance the OSH-Act demands that a suitably licensed AIA be closely involved with the construction process. Third party inspectors employed by the AIA is typically also an Inspectors of Pressurized Equipment (IPE), a qualification certified by South African Qualification and Certification Committee for inspectors of pressurized equipment (SAQCC). The TPI assures compliance to the PER through reviews, witnessing, crosschecks and audits. Minimum tasks and responsibilities of a TPI employed by the contract AIA Company are included in SANS 10227 [30]; surveillance of the manufacturing or maintenance programme shall include but are not limited to aspects such as the following:

- Verify quality control plan (however named);
- Witness material certification and identification;
- Witness mechanical testing of weld qualification and verification of weld procedures;
- Verification of validity of qualifications for welders and operators;
- Examination of material cut edges, preparation, fit-up and quality of welding;
- Acceptance of non-destructive testing procedures and test results;
- Verify and witness heat treatment;
- Witness pressure testing;
- Final examination to verify as-built dimensions for conformance to design ;
- Nameplate and hard stamping;
- Acceptance of documentation; and
- Issue certificate of manufacture or repair or modification
- Report non-compliance of health and safety regulations

3.1.5 Technical capability assessment of contractors

Companies (main contractor and those subcontracted) aspiring to performing welding work on high value and safety critical Eskom plant shall be evaluated for acceptance on the Eskom vendor list for companies approved for selected contracts on Level 1 and 2 plant as defined in Eskom Standard 240-72273656 [39] through a technical capability assessment (TCA), convened and coordinated by the Eskom Quality Department. Furthermore, these assessments shall be specific to asset type e.g. valves, pumps etc. The assessment team shall as a minimum consist of:

- IWE/IWT
- NDT specialist
- Quality specialist
- Eskom component/plant specialist (PEIC)

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- Relevant Eskom site plant engineer (In case of a generic Eskom contract, the relevant plant engineer shall be delegated by the by the SCOT chairman)

Subsequent to each TCA a full report with findings shall be compiled by the TCA team chairman/ convener and submitted to the SCOT chairman for distribution and future reference by the relevant Eskom line groups. The list of approved Level 1 and 2 vendors, for specific plant types, shall be maintained and kept updated by the Eskom Quality Department and distributed to the Eskom procurement departments. Follow up TCA's should ideally be conducted at 2 year intervals but not later than a three year interval, or:

- When a contractor company is subjected to major structural changes (e.g. company mergers, take-overs etc.)
- When a major breakdown in a contracting company's capabilities is suspected, in which case a TCA can be motivated at any time by the responsible Eskom plant engineer.

3.1.6 Code, standard and specification requirements

For all level I and II plant as defined in standard 240-72273656 [39], welding procedure qualification for metallic arc weldments shall be in accordance with the appropriate combination of EN and ISO/EN family of specifications; BS EN ISO 15607 [5], SANS 15609 [18], SANS 15614-1 [16], SANS 15614-7 [17], BS EN ISO 15613 [6] and ISO 15608 [12]; as is applicable to the relevant plant and to the Eskom quality Level requirements stipulated in Table 1 of Annexure A.

An exception to this shall apply to Eskom plant at sites constructed to the ASME Boiler and Pressure Vessel Codes [1] in which case the requirements stipulated in Section IX of the code shall be met. Any other possible exceptions shall be motivated for approval by the responsible Eskom plant engineer through a concession.

Combining different families of codes specification i.e. mixing of different code families is not allowed for the complete design to weld execution path.

Welding procedure qualification for thermoplastic welds shall be in accordance with SANS 10270 [26].

3.1.6.1 Construction of new plant

All welding required for construction of new level 1 and 2 plant/components shall be performed according to an approved and accepted design. This shall be presented in weld map drawings clearly showing the location of each weld.

Construction by welding of new plant shall be performed to welding procedures qualified to the requirements of the latest version of the applicable construction code.

3.1.6.2 Maintenance welding on existing plant

Replacement of existing welds or the introduction of new welds on previously commissioned plant shall conform to the weld requirements of the latest version of the applicable construction code. Any deviations from the original design code and specification requirements resulting from technological advancement of equipment, processes and techniques shall be noted and submitted for approval by Eskom. For this type of application the original PQR/WPQR can be used but the WPS must be re-written to reflect the latest weld specification format. Dated/original procedures are only eligible for use if accompanied by the required supporting documents such as the heat treatment chart and report from the mechanical test laboratory. Failure to meet this requirement will necessitate the requalification of the procedure in question, although concessions might be allowed by Eskom in certain cases.

An important aspect for the procedure reviewer to consider during maintenance and repair situations is that weld specifications such as SANS 15609 [18], ISO 15613 [6] and SANS 15614 [16] were developed with the primary purpose being the execution of welding as required by the construction codes for new

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plant. Weld maintenance (or repairs) during the life cycle of a component are not specifically addressed in these construction codes, therefore it is important to apply the correct principles pertinent to maintenance /repair situations.

For plant designed to ASME BPVC the Section IX [1] requirements for weld repairs need to be fulfilled.

3.1.6.3 Refurbishment and/or repair work to existing plant

Refurbishment and/or repair work on existing plant that require non-standard weld preparations to repair defect excavations shall be supported by suitably qualified welding procedures that accommodate the geometry of the intended repairs. In the majority of cases this will require overlay or built-up type welding techniques. It is recommended that the basic rules stipulated in SANS 15614 Part 1 [16] be complemented by elements of SANS 15614 Part 7 [17] and BS EN 15613 [6]. For this approach the welding procedure will closely reflect the geometry, sequence and technique required for the production weld. Weld procedures meeting the requirements of BS EN 15614 Part 7 [17] only, shall not be eligible for use for weld repairs other than for situations requiring corrosion and hard metal overlays.

For plant designed to ASME BPVC the Section IX [1] requirements for weld repairs need to be fulfilled.

All weld build-ups shall be subjected to the approval of Eskom. Repairs by weld overlay of areas on base material surfaces or existing welds require careful consideration to clarify the intention and acknowledge the clear differences that exist between inherently different weld overlay types. These can be grouped as:

- build-up of ligaments worn or wasted by process medium effects,
- overlays with resistance to environmental attack and
- overlays with tribological properties.

Each of these cases is described in the next sub-paragraphs 3.1.6.3.1 to 3.1.6.3.3:

3.1.6.3.1 Build-up of worn/wasted surfaces to restore pressure boundary ligaments

When the sole objective of the build-up/overlay is to restore fitting/sealing tolerances in areas not impacting on the component pressure boundary, a BSEN15614 Part 7 [17] qualification for the WPQR/PQR will suffice. However, if the intention is to restore pressure boundary ligament to reduce the stress increase caused by a wall cross section loss, a specification BSEN15614 Part 1 [16] WPQR/PQR qualification is required to create test coupons on which the strength and integrity of the weld joint can be proven with the selected weld parameters applied for the production weld. This implies a butt joint test.

To supplement the practicality aspects of an overlay weld configuration, Eskom may in specific cases require the contractor to also perform BSEN15614 Part 7 [17] and BSEN15613 specified tests to ensure the overlay weld provides the required metallurgical properties, for example the tempering effects of one versus multi-layer build-ups.

For plant designed to ASME BPVC the Section IX [1] requirements stated in clause QW 202 for repairs and weld build-ups need to be fulfilled.

3.1.6.3.2 Corrosion resistance overlays

The application of corrosion resistant weld overlays shall not be applied indiscriminately. The effect of the thickness and the mechanical properties of the overlay need to be considered in the design calculations for the pressure boundary, such as for a pump casing, in order to demonstrate the stress lowering effect of the applied thickness of the corrosion resistant overlay on a pressure boundary. A weld procedure qualified to both BSEN15614 Part 1 [16] and BSEN15614 Part 7 [17] shall apply.

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If it can be established beyond any doubt that the area where the corrosion resistant weld consumable is applied is not part of the pressure boundary, then without any further engineering intervention only BSEN15614 Part 7 [17] principles applies here during the weld procedure qualification process.

For plant designed to ASME BPVC the Section IX [1] requirements for corrosion resistant overlays stated in clauses QW 214 and QW453 need to be fulfilled.

3.1.6.3.3 Impact, sliding and fretting wear resistant layers

No credit for weld overlay thickness may be claimed for hard and brittle wear resistant layers when pressure boundary load carrying capabilities are calculated. Specification BSEN15614 Part 7 [17] applies to procedure qualifications.

For plant designed to ASME BPVC the Section IX [1] requirements for wear resistant overlays as stated in clauses QW 216 and QW453 shall be fulfilled

3.1.6.4 Modification work to existing plant

Modification welding work to existing plant shall be supported by the necessary design modification process as stated in Eskom Standard 240-53114002 [45]. Subsequent welding shall be performed to welding procedures qualified to the welding requirements of the latest version of the applicable construction code. Typical conditions that constitute a design modification are:

- Change of a specific base material grade from the original design as allowed by the base material grouping system described in specification ISO 15608 [12].
- Change in base material product type, e.g. exchanging from a wrought for a forged product form
- Application of a weld overlay for corrosion resistance and/or wear resistance purposes on a component where the layer was not included in the original design
- Changing of a weld consumable grade from a lower to a higher alloyed composition and vice-versa (under matching and overmatching of mechanical properties and/or weld chemistry)

For cases where reverse engineering processes apply to modification projects with no direct involvement of the plant or equipment OEM, the requirements in the Eskom policy on reverse engineering shall be adhered to.

3.1.7 Inspection and Non Destructive Testing (NDT)

All weld NDT shall be performed according to the requirements of Eskom standards 240-83539994 [34] and 240-83540088 [33].

NDT requirements for new technology not yet fully addressed in the Eskom NDT standards will require specific attention if to be included in the contract requirements. Examples of this is digital radiographic testing (RT), micro phased array ultrasonic testing (PAUT) and time of flight diffraction (TOFD) UT. Acceptance criteria for these techniques will be referenced from research and investigating project results reporting until such time that Eskom NDT standards specifically address each of these techniques.

For each project a concise dedicated inspection scope is required to avoid the tendency for subjectivity that can affect judgement if conditions meet minimum requirements or not.

3.1.7.1 Visual Weld Inspection

The Eskom or contractor welding inspector responsible for inspection of welding set-ups, welding preparations and completed weldments shall have a minimum qualification as stipulated in Eskom Standard 240-56246601 [38]. Any other qualification acquired from another country that is considered to

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be equivalent shall be evaluated by the Eskom Welding Coordinator for maintenance and repair projects or his delegate during the time of contract placement negotiations.

Typical activities specifically linked to quality-related duties in accordance with SANS ISO 3834 [21] is specified in EN ISO 14731 [13]. Acceptance criteria to be used are those referenced in the Eskom approved quality and inspection plans and job specific check-sheets from the Toolkit for Eskom Pressure Plant Inspection (TEPPI). Inspection personnel must ensure before the job commences that only calibrated and validated measuring, inspection and testing equipment are used

3.1.8 Main Inspection

3.1.8.1 Characterisation and Recording of Indications

All recordable indications shall be characterised as indicated in ASME BPVC Section V [1] or BS EN ISO 23279 [43] as required by the plant design code, in conjunction with Eskom procedure 240-56247788 [42] for further evaluations.

3.1.8.2 Assessment of Indications

All recordable indications shall be assessed as per ASME BPVC [1] or BS EN ISO 17640 [44] where applicable.

3.1.8.3 Acceptance Criteria

When required or specified, weld examination procedures and acceptance criteria shall be in accordance with the applicable construction codes, ISO 5817 [7], ASME BPV Code Section V [1] and BS 2633 [9] in addition to agreement by Eskom.

3.1.8.4 Acceptance levels for flaws for metallic welds

Acceptance levels for weld flaws B,C or D as described in BSENISO 5817 [7] as required for specific weldments shall be prescribed to the contractor before production commences, preferably at the inquiry or order stage. Any case that appears to be non-conforming may be evaluated for acceptance through the Eskom Integrity analysis process. Such an intervention is typically a calculation for flaw acceptance outside the specified acceptance criteria based on engineering principles. All legal protocols shall be observed with respect to accountability when no requirements are specified; the construction code minimum requirements shall apply by default. For special purposes additional conditions and details may be prescribed. The quality levels refer to production quality and not to fitness for purpose of the situation.

For projects relating to ASME BPVC designs, evaluation methods and acceptance criteria stipulated in Sections V and VIII of the code apply.

3.1.8.5 Quality levels and assessment class for flaws in plastic welds

Quality levels and assessment class for imperfections as described in SANS 10268 [27] for thermoplastic welds shall be prescribed to the contractor before production commences, preferably at the inquiry or order stage. For special purposes additional conditions and details may be prescribed. The quality levels refer to production quality and not to fitness for purpose of the situation.

3.1.8.6 Inspection Records and Reporting of defects

An inspection record shall be kept in conjunction with the welding schedule which shall be updated as soon as a welding location, as indicated in the welding schedule, is completed. It shall indicate all repairs carried out and non-destructive examination performed on the weld or group of welds. Defect rates shall be as required by Eskom Standard 240-56247788 [42].

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Pertinent to maintenance and refurbishment projects, flaws exceeding the acceptance criteria after the completion of the standard evaluation process and classified as a defect, shall be eligible for further engineering assessment. Significant flaws shall first be subjected by the contractor's formal internal evaluation process before being declared as not meeting the acceptance criteria. Significant flaws are those deemed more economical from a time and cost perspective to repair than to do a complete re-weld.

The contractor NDT Level III specialist next submits the NDT report to the Eskom Level III specialist for agreement before being classified as a defect.

In order for efficient assessment to be performed, the NDT level III or his designate shall prepare a clear and accurate sketch to the engineering evaluating showing the dimensions and geometry of the defect based on the verified test data recorded in the NDT reports. This will prevent uncertainty and wasting of valuable outage time due to the general assumption that the raw data recorded in standard NDT reports can be readily interpreted by engineering personnel with no or little NDT background.

3.1.8.7 Defect assessment process

A formal defect report shall be submitted to the Eskom Engineer for his recommendation for further action which can be one of three:

- Request a full engineering assessment of the flaw to determine if the flaw can be left as is or whether a weld repair will be required.
- Authorise a defect repair process to commence.
- Reject the weld and request a complete re-weld.

3.1.9 Health and safety

3.1.9.1 Statutory safety requirements

All sites and workshop establishments involved with the execution of welding projects and contracts shall meet the mandatory statutory health requirements as contained in the OSHAct of 1993 [29].

3.1.9.2 Eskom specific safety requirements

In addition to this, the Eskom health and safety policies shall be strictly adhered to with special emphasis on:

- Observing the Eskom lifesaving rules at all times
- Work area safety zoning classification
- Awareness of special plant safety requirements e.g. for dust/pulverised fuel particles, fuel oil, live steam leaks, hydrogen leaks, casual water etc.
- Risk assessments and continued improvement on safety
- Personnel wearing correct personal protective equipment (PPE) at all times
- Regular safety debriefs and lessons learned

3.1.9.3 Welding safety

The basics on welding health and safety requirements are stipulated in SABS 10238 [32]. Special additional points of importance are:

- Personnel performing welding and the support staff in close proximity to the point of welding must wear welding helmets with minimum shade rating 10.

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- The welding helmet inner clear shield shall always be of a shatter resistant polycarbonate type plastic to prevent eye injuries in the event of impact by debris during grinding operations. The outer clear shield covering the welding shade glass can be of normal glass to protect the shade glass from weld spatter, thereby preventing reduced UV shielding efficiency of the shade glass.
- Personnel performing welding and the support staff in close proximity to wear long sleeve tops and covered neck areas to prevent skin burn by ultraviolet (UV) radiation.
- Safety glasses worn in close proximity of welding (closer than 15 meter) will absorb up to 60 % of welding arc emitted UV radiation and effectively reduce the occurrence of accidental “arc eyes”.
- The use of thorium containing TIG electrodes should be avoided where practically possible. When grinding thorium containing electrodes, respiratory devices must be worn to prevent inhalation of the mildly radioactive substance thorium.
- Prolonged exposure to certain heavy metals constituents such as hexavalent chromium present in welding fumes may cause severe respiratory diseases. These species are more prevalent during shielded metal arc welding and flux cored arc welding of Cr-Mo stainless steel and high alloy welding operations.
- Arc welding and cutting produce intense electromagnetic fields which may affect electronic prosthesis such as pacemakers. Welding personnel with such implants should consult medical practitioners to establish whether they can expect health risks when exposed to such welding environments. (See AWS Fact Sheet 16 for more information).
- High frequency (HF) arc starting modules can also be a source of health concerns regarding electromagnetic field effects on medical devices. Furthermore, HF signals may also effect the operation of sensitive safety critical electronic equipment such as gas monitors if such devices are not adequately screened.
- Work in confined spaces shall be conducted according to the Eskom Plant Safety Regulations

3.2 HEAT TREATMENT

Heat treatment of welds shall be performed to the requirements of the Eskom heat treatment standard 240-77196678 [40].

3.3 QUALIFICATIONS OF WELDING PROCEDURES

3.3.1 Basic requirements

A WPS shall be supported by a valid WPQR/PQR for all Level I and II plant work, while this is recommended in the case of Level III plant work as set out in Table 1 of Appendix A. The PQR/WPQR shall be approved by a registered IWE or IWT with minimum qualifications as defined in Eskom Standard 240-56246601 [38].

3.3.2 WPQR/PQR

3.3.2.1 Preparation for the WPQR/PQR process

A preliminary WPQR/PQR shall be generated containing perceived welding parameters based on previous experience, welding consumable manufacturer recommendations, base material limitations, welding equipment capabilities and project requirements. This document will guide the welding team with a range of weld equipment settings available for scrutiny before the execution of the WPQR/PQR.

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3.3.2.2 Execution of WPQR/PQR

The following shall be recorded/verified by the reviewers:

- Preparation of samples and weld set-up
  - Base material and weld consumable test certificates and transfer of stamp numbers (where applicable)
  - Weld position and reference point showing the orientation of the weld set-up
  - Purge integrity for open root welds (when applicable)
  - Cleanliness of weld preparation
  - Dried condition of the consumables

- Welding of the test sample
  - Preheat measured on the weld preparation
  - Weld parameter settings – amperage, voltage for each layer
  - Weld progress speed
  - Method of inter-run cleaning
  - Maximum interpass temperature

3.3.2.3 Heat treatment of WPQR/PQR test piece

The actual temperature measured by calibrated thermocouples placed directly on the test weld shall be recoded on a time versus temperature chart. This document shall be part of the permanent record on the WPQR/PQR.

3.3.2.4 NDT of WPQR/PQR test piece

Performed to the requirements of the weld specification

3.3.2.5 NDT and Mechanical tests of WPQR/PQR test piece

Mechanical tests shall be performed at an accredited mechanical test laboratory conforming to the requirements of BS EN ISO/IEC 17025 [15]. Witnessing the mechanical tests and verification of accuracy of the test data is mandatory for the appointed TPI employed by an Eskom approved AIA Company. As a minimum the following shall be addressed:

- Calibration of test equipment to be verified
- Removal of test pieces according to the orientation and geometric requirements of the weld specification
- Numbering/identification of the test samples in accordance with the protocol of the test application standard
- Machining of test samples in accordance with the weld specification
- Tensile test verification:
  - Gauge length marked correctly
  - Correct placement of extension gauge directly on the test sample (measuring extension on machine head movement only is not acceptable)

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- Strain rate within mechanical test allowable range
- Recording test temperature
- Test certificate to report for each sample cross section area before and after test; total extension as measured on the change in gauge length, maximum force at failure, calculated and report ultimate tensile strength, calculated and report yield strength
- It is recommended that the force versus extension graph is included in the PQR permanent record.

- Impact energy test verification:
  - Broaching of notch according to test specification dimensions and positioning according the weld joint orientation requirements
  - Recording test temperature
- Hardness tests verification:
  - Sample surface prepared correctly for type of test (micro versus macro)
  - Correct position of indentations according to weld specification
  - Correct number of tests per location
- Chemical analysis as per weld specification requirements

3.3.2.6 Compilation of WPQR/PQR

A template shall be used to capture minimum essential and non-essential variables as required by the applicable weld specification. ASME BPVC Section IX Par QW-483 [1] and EN 15614 Part 1 [16] Annex A. show examples of templates to capture the minimum required data. The WPQR/PQR document shall clearly reflect in the heading the name and address of the relevant company taking responsibility of the outcome of the procedure. A suitably qualified TPI employed by an Eskom appointed AIA Company shall verify that the data listed in the WPQR/PQR are those recorded during the weld test and reported by the test laboratory.

The following information shall appear on the WPQR/PQR:

- Heat input (defined in BS EN 1011-1 [2]): the speed of weld progression shall be recorded in mm/s; the weld current range shall be measured with a clip-on gauge/ tong tester; the open circuit voltage of the welding machine and the weld voltage range shall be measured with a volt-meter (multi meter). (Provide practical range and elaborate around arc energy, HI equipment characteristic etc.). Welding machines with pulsed mode may be used; in which case the heat input as calculated by the equipment needs to be recorded.
- Commercial trade name of the welding consumable.
- The tensile strength of the coupons as recorded during the tensile tests. It is recommended that a copy of the actual graph generated during execution of the tensile tests shall be part of the permanent record package for the reviewer to check on the results.
- The heat treatment chart (where applicable) shall form part of the permanent record of the WPQR/ PQR.
- Material certificates for both filler and parent material(s) shall be part of the permanent record of the WPQR/PQR.
- The mechanical test samples shall be preserved against corrosion and mechanical damage, and retained for at least six months after completion of the tests for evaluation/examination by Eskom when required.

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3.4 WPS

Welding performed on plant built to a code or standard of manufacture shall be done in accordance with a valid WPS reflecting the requirements of the applicable design code. The principal Contractor shall be responsible for generating a relevant welding procedure specification to the requirements of SANS 15609 [18] or ASME BPVC Section IX [1] for each joint configuration, showing drawings and parameter details pertinent to each case of application, generic WPS's only showing a range of weld preparations will not be allowed. An exception will be for the case where multiple joints on tubes of identical geometry are required, one WPS will suffice. This is typical for tube applications of the same outside diameter, wall thickness and weld preparation geometries. However, for thick walled pipe applications where nominal pipe dimensions could be of identical design , in practice, variations in tolerances can lead to non-standard/custom preparations in order to compensate for exaggerated ovality or small wall thickness variations requiring local machining such as counter-boring to match ID's. For accurate NDT interpretation purposes and future reference, a dedicated WPS will thus be required. Geometry welds will always require dedicated WPS's.

Eskom reserve the right to review a WPS already verified by the AIA, prior to commencement of fabrication.

3.4.1 Compilation of WPS

The heading of the WPS document template shall clearly reflect the name and address of the relevant company taking responsibility of the outcome of the procedure. Minimum essential and non-essential variables required by the applicable weld specification shall be listed.

3.4.2 WPS approval for use

The information on the WPS shall accurately reflect the parameter ranges as reported on the WPQR/PQR, to be approved for use on Eskom equipment. A suitably qualified TPI employed by an Eskom appointed AIA Company shall verify that the data listed in the WPQR/PQR is correctly transferred to the WPS.

Approval of this document by an IWE/IWT is mandatory, with emphasis on the critical evaluation of the technical content suiting the circumstances and requirements of the intended applications.

The following shall be considered as a minimum:

- Review of the geometry and dimensions of the weld joint provided by an accurate drawing
- Base material (Grade, operating history, integrity)
- Site access limitations (weld position, space for torch manipulation)
- Environmental aspects (draughts, moisture)
- In-service engineering aspects for application of the weld.

3.4.3 Welding Schedule/Technique Sheet

If a WPS is not issued to each individual welder, a welding schedule or technique sheet shall as a minimum be generated for all weld joints. This document shall list the parameters of importance to the welder:

- Principal welding parameters:
  - weld process, current, voltage, heat input,
  - Welding machine set-up: electrical characteristics (AC, DC- or DC+); pulsing etc.
  - Base material and welding consumable specifications

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- Sketch clearly showing weld joint geometry and bead stacking layout
- Minimum preheat and maximum interpass temperatures;
- Reference procedure number,
- Weld consumable specification and batch number,
- Welder stamp number,
- Weld number or group of welds and a reference weld map drawing number locating the welds,
- Type and extent of special NDT requirements e.g. hot MT by iron powder after each weld layer for areas under non-routine repairs.

3.4.4 Approval of Weld Documentation

Before commencing with the work the principal contractor shall submit to the responsible Eskom Welding Engineer/Technologist for approval, verified copies of weld procedures for conformance to the requirements listed in paragraph 3.4.2 and shall, take into consideration practical site anomalies which might exist (difficult access, environmental conditions etc.) and covering all forms of welding which will apply to the contract. Verified copies of all WPS's used during the course of the contract shall be included in the maintenance records.

3.5 WELDER AND WELD OPERATOR QUALIFICATION

WQR testing for metallic materials shall be performed in accordance to SANS 9606 [19]. For welding activities on plant constructed to the ASME Boiler and Pressure Vessel Code Section IX [1] of the code applies.

Welders and welding operators working within the scope of this guideline shall be qualified in-accordance with the requirements of the latest construction code relevant to the plant and have the minimum IW qualifications specified in Eskom Standard 240-56246601 [38]. Manual welder qualification shall be in accordance with SANS 9606 [19] while for weld operators specification EN 14732 [14] applies.

An important aspect to be addressed during roll-out of the EFEC-W will be to address the status quo with existing qualifications. Those qualifications perceived not to be in line with the Eskom move towards standardisation of welding coordination based on the IIW standards and qualifications, need to be evaluated on merit as to not exclude competent / experienced people. Recognition of Prior Learning (RPL) is paramount to smooth transition; it will be based on the objectives for RPL specified by SAQA. Contractors may propose transition arrangements regarding minimum qualifications for experienced coded welders with a proven track record, but without the motivation or incentives for furthering their qualifications due to advanced age, for Eskom's consideration and allowed to continue work on Eskom plant trough the necessary concessions.

Welder qualification pertinent to thermoplastic materials shall be performed in accordance to SANS 10269 [25].

3.6 WELD QUALITY SYSTEM

3.6.1 SANS ISO 3834 [21]

A proven quality assurance system which manifests through sufficient quality control measures is critical for reproducible, defect-free results. Eskom aims to achieve this scenario by insisting that all weld related activities on Eskom plant shall be controlled by a quality system based on the requirements of SANS ISO 3834 [21]. This standard provides the framework for quality levels pertinent to the welding process. Exemptions from this requirement will be acknowledged for plant built in accordance with the

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ASME BPVC [1] in which cases a quality system related or referenced to this construction code may be used as stated in the ASME BPVC, Section VIII Division 1 Appendix 10. The contractor shall clearly define the welding function, its control and interaction with the rest of the company's production functions in the quality manual.

3.6.2 Welding Quality Requirements

The welding quality requirements will depend on:

- The category level of Eskom plant being worked on as defined in Eskom standard 240-72273656 [39]
- The contract requirements as agreed on between Eskom and contracting party
- Any unusual conditions such as emergency repairs.

The different quality requirements as described in ISO 3834 [21] are summarised in Table 1 of Appendix A.

Repair and maintenance work on Level I Category components shall confirm to ISO 3834-2 for comprehensive quality requirements where European construction rules apply. This by implication requires the contractor to be an SANS ISO 3834 Part 2 [22] certified company.

For components built to the ASME BPVC [1], the requirements applicable to that code shall apply. For work on Level II and Level III components a quality level will be decided on by the Eskom project manager or his delegate.

3.6.3 Quality assurance function

3.6.3.1 Minor repairs and maintenance

The Eskom site welding co-ordinator/welding administrator shall perform the quality assurance function at this level.

3.6.3.2 Major repairs and maintenance

The authorised principal contractor shall employ a suitably qualified person to perform the quality assurance function. The Eskom appointed site welding co-ordinator/administrator or his delegate shall maintain a monitoring presence and report any concerns to the Eskom project manager or the senior person responsible for quality at the plant.

Quality of welding activities performed on pressurised equipment, particularly pipework and boiler components, shall be monitored and verified by the Eskom appointed AIA as required by the PER and Eskom Standard 240-56239129 [36].

The authorised principal contractor shall appoint an AIA for any off-site repair and or refurbishment done on pressure equipment if required by SANS 347 [31]. The tasks and duties of the AIA are stipulated in SANS 10227 [30].

The contractor shall prepare quality control documentation as required by Eskom Quality Standard QM58 [35] and submit it to the Eskom welding co-ordinator for approval before commencing with any contract or welding work.

3.6.4 Project quality audits for the construction of pressure equipment

The Eskom welding co-ordinator or his delegate shall carry out spot checks on the overall welding activities of a major contract with emphasis on:

- Compliance with the Eskom Generation quality standard QM58 and SANS ISO 3834 [21] quality level requirements as stated in the contract documents

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- Conformance of the contractor to the welding quality system as presented to the Eskom Corporate Audit team during the vendor approval phase.
- Application of sound welding principles
- Adherence to PER [28]
- NDT

These checks should also form part of technical capability assessments follow-ups when vendor companies are evaluated for acceptance on the Eskom vendor list for selected contracts on Eskom Level 1 and 2 plants.

3.6.5 Reporting of non-conformances

All issues shall be addressed through the reporting system as required by the contract.

Issues that might jeopardise the integrity of Eskom plant, transgressing the requirements of the applicable construction code and/or the OHSAct [29] and/or the rules set out by the PER [28] and QM 58 shall be investigated as required by these authorities.

3.6.6 NCR'S and concessions

An important mechanism of quality assurance/control to inform welding contractors of conditions not conforming to the contract is to issue non-conformance reports (NCR's), request suitable corrective actions and approving non-conforming products that through analysis proved to be benign to plant performance, safety and availability by issuing concessions to accept. It is important for Eskom and welding contractors to acknowledge the potential positive influence of NCR's to successful application of EFEC-W. For this the inherent benefits of continuous system improvement must be fully exploited through a workable and mutually accepted NCR/Corrective action/Concession system.

3.6.6.1 Non Conformance Reports

Eskom Quality Standard QM58 describes the process to be followed when issuing welding contractors with Non Conformance Reports (NCR's), which are issued by Eskom for defects, non-conforming materials, parts, workmanship or documentation which form part of the permanent quality records. NCR's are submitted to the Contractor Project Manager for the attention of the QA representative or inspection authority. The Contractor is obliged to respond by stating the:

- Cause
- Corrective Action
- Action taken to prevent Recurrence
- Effective date

The Contractor consequently has to apply for a concession or production permit when non-conforming materials, components or workmanship are suitable for repair, rework or use as is. The Eskom project manager/QA Representative or its authority then issues a concession or production certificate if the materials, components or workmanship are suitable for repair, rework or use as is.

All issues shall be addressed through the reporting system as required by the contract.

Issues that might jeopardise the integrity of Eskom plant, transgressing the requirements of the applicable construction code and/or the OHSAct [29] and/or the rules set out by the PER shall be investigated as required by these authorities

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3.6.6.2 Concessions

A concession is required whenever a situation arises that requires deviation from the Eskom WRB. The contractor's welding coordinator/project manager compiles the concession request and submits it to Eskom only after being influenced by the contractor's welding technologist/engineer. Important aspects to be captured (when applicable) in such a concession and made available to the Eskom approving personnel are:

- Concise problem definition
- Technical justification
- Essential basic information:
    - Component design code
    - Component drawings
    - Plant operating parameters: pressure, temperature
    - Process medium (steam, water, oil etc.)
    - Material specification: base material, weld consumables
    - Operating history of anomalies, transient conditions and accumulated hours
    - Photographic evidence of affected component
    - Welding procedure qualification records, Welding procedure specifications and welder qualifications that will be applied.
- Minimum standing requirements (contractual, design, standards, etc.)
- Required action
- Risk of failure assessment
- Future actions log:
    - Data package amendments
    - Drawing revisions;
    - procedure revisions,
    - Operating manual changes
    - Future intervention requirements for temporary cases
- Technical involvement for the approval of the concession shall involve the following individuals as a minimum:
    - Eskom System Engineer
    - Contractor's welding Engineer
    - The responsible AIA representative
    - The responsible Eskom IWE/IWT
    - On site Eskom welding administrator (if applicable)

Signatures of the above mentioned individuals shall appear on all WRB concessions. Any deviations shall be discussed with and agreed to by the Eskom Welding Care Group Chairman or his delegate. It is recommended that the concession should be applied for by using the Concession template provided in the Eskom Quality Manual "QM-58".

3.7 MATERIAL CONTROL

Prescriptions of the Quality Standard relevant to the contract shall be adhered to including the following basic requirements that are pertinent to all welding related tasks:

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3.7.1 Material to be used for fabrication or for weld repairs

Material to be used for fabrication or for weld repairs shall be identified by a material test or mill test certificate.

All high pressure valves, fittings, tubes and pipe work must be supplied with an EN 10204: Type 3.2 [10] material certificate. Since this is a certificate concerning a delivery-related test according to information supplied by the purchaser, it is imperative that the scope of testing be made clear at the time of ordering or even at the enquiry stage.

All other components may be supplied at least with an EN 10204: Type 3.1 [10] material certificate.

3.7.2 Unidentified material

Unidentified material shall be isolated/quarantined and identified by a full chemical analysis and mechanical testing as required by the relevant material specification, before being considered for further use.

3.7.3 Positive Material Identification

Refer to PED requirements and ASME BPVC clause UG 10 [1]. For construction materials a full wet chemical analysis is required (if financially warranted).

3.7.4 Marking of removed material

Any pieces or parts removed from original material shall be clearly marked with low stress hard stamps in the presence of the WA/TPI before any cutting is performed.

3.7.5 Protection of sectioned faces

Sectioned faces shall be inspected for material defects and then protected from atmospheric conditions and contamination and stored in a clean and dry environment until required for use.

3.7.6 Surface Cleanliness

Any surfaces to be welded shall be clean and free from oil, dirt, scale, oxides and paint; the latter being subject to approval in the case of a primer. For removal of surface contamination by oil or grease, an approved (from health and safety and environmental perspective) degreaser shall be applied. Weld spatter releasing agent shall not be applied to any part of the weld preparation.

3.7.7 Arc Strikes

Deliberate arc strikes away from a weld joint on the parent material is strictly prohibited, separate sacrificial plate material shall be used for this. In case of accidental strikes, these areas shall be ground to smooth contours and surface crack testing shall be carried out in the areas. The same applies to accidental gouge marks away from weld joints. The need for repair welding after grinding of arc strikes and gouge marks for cases where minimum allowed remaining wall thickness is affected, shall be determined by Eskom and shall be subject to approval.

3.8 WELDING CONSUMABLE CONTROL

The prescriptions of the Quality Standard relevant to the contract shall be adhered to including the following basic requirements that are pertinent to all welding related tasks.

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3.8.1 Consumable approval

Consumables shall be approved by the national standard requirements of the country of origin as a minimum. It is recommended that consumables with approval according to AWS A5.X family of specifications and/or BSEN family of consumable specifications be used on Level 1 and 2 Eskom plant.

3.8.2 Consumable identification

Batch identification numbers shall be clearly marked on each individual package.

3.8.3 Consumable storage

Consumables shall be stored in a clean atmosphere with humidity kept below 50% and a minimum of at least 30ºC above atmospheric dew point shall be maintained inside the original packaging as long as possible.

A comprehensive procedure for identifying, drying, storing and handling of electrodes and filler wires related to the electrode manufacturer's recommendations shall be implemented by the Contractor. The batch numbers of the specified welding consumables shall be recorded for permanent record keeping. The quality control system shall cover the issue of the correct rods for the weld to be made, and the return of surplus rods to their correct material group and batch.

If dew point measurement devices are not available then 100% humidity at sea level conditions will be assumed, and the holding temperature shall be chosen as100°C. For Cr-Mo and Cr-Mo-V base materials, low hydrogen potential welding consumables rated at below 5 milligrams of diffusible hydrogen per 100 ml weld metal shall be used. Only sufficient electrodes for a shift's work shall be issued to welders from the holding oven and transferred directly to a pre-heated hot box/quiver which shall be kept at a minimum temperature of 100ºC at all times. Consumables not used during any one shift shall be returned to the consumable storage area and considered for re-baking as per the contractors established marking and maximum allowable re-baking works procedure.

3.8.4 Damaged or contaminated consumables

All consumables showing signs of damage to coatings, rust or contamination by any carbonaceous (paint, oil, polymers etc.) substance shall be promptly removed from storage or circulation and properly disposed of.

3.8.5 Identification on consumables

Consumable grade markings/stamps shall be visible on each individual wire or rod. There shall be no mixing of different class/grade consumables in one container.

3.8.6 Baking/drying of consumables

Baking or drying temperature and duration shall be at least in accordance with the supplier's minimum requirements.

3.8.7 Holding of baked/dried consumables

After baking/drying, the consumables shall be promptly transferred to a holding oven and stored at 120°C to 150°C for a maximum of one week prior to use.

3.8.8 Hot boxes for consumables

Consumables shall be issued to welding personnel in hot boxes and the temperature shall be maintained at a minimum of 100°C.

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3.8.9 Unused consumables

After each working shift the unused consumables shall be accounted for by the welding supervisor or a properly trained delegate and returned to the holding oven until issued for a next working shift. These unused consumables shall be the first to be issued on the next working shift.

3.8.10 Consumable Integrity

Electrodes showing signs of flaked and cracked flux coatings shall not be used. Wires with flaking protective coatings or showing traces of rust, oil and other carboniferous contamination shall not be considered for use. Correct storage of flux cored and metal cored wire products in a sufficiently dry environment are of particular importance due to possible moisture pick-up through non-tight long wire seams.

Weld shielding gas regulators and transmission tubes shall be kept dry and free of any traces of oil and grease on the inside surfaces.

3.8.11 Permitted re-baking cycles

The number of permitted re-baking cycles shall be in accordance with the supplier recommendations. If this is not clearly specified, the maximum number of baking cycles shall be three.

3.8.12 Selection of Consumables

Consumable core wires shall be selected so that the principal elements in the deposited weld metal, joining base metal to base metal, shall be of the same nominal composition as the base metal. The choice of the weld consumables and the welding technology should therefore be to fulfil the requirements of the parent metal used and must be matched to its behaviour.

The use on weld consumables not designed to match the mechanical properties and chemistry of the base material needs specific technical motivation for Eskom approval. Typical examples are:

- Consumables under matching the strength of the base material e.g. low carbon steel electrodes for welding high strength materials
- Low alloyed consumables used to join stainless steel base materials in order to avoid weld root back purging
- High alloyed austenitic consumables used to join ferritic and martensitic base materials in order to avoid heat treatment (See paragraph 3.8.14 for more detail)

For ferritic weld deposits, filler wire for automatic welding processes shall contain the principal alloying elements in the wire, not added through the flux.

3.8.13 Dissimilar Weld Joint Consumables

For welds between dissimilar base materials the weld consumables selected shall be such as to ensure compatibility with regards to metallurgical integrity and quality of the joint. This selection must be made so that, where possible, the weld metal arising should not be too hard, brittle and susceptible to cracks allowing for dilution with the different materials. For high temperature applications the objective shall be for weld metal creep properties as supported by the suppliers creep test data be retained after dilution with the different base materials.

3.8.14 Austenitic Weld Consumables used on Ferritic/Martensitic Base Materials

The merits of using austenitic stainless steel or nickel based consumables in particular, for joining ferritic or martensitic base material grades, shall be thoroughly motivated and not used as a perceived quick – fix joining technique or catch-all technical solution.

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Any situation involving high pressure tube and pipework with a previously Eskom approved design where austenitic weld consumables were applied as overlay or used for joining ferritic/martensitic base materials do not need any further discussion, this statement holds true only where maintenance and repair welding involves application of consumables of the same nominal composition on existing welds.

In the case of evaluation of the proposed application on non-approved designs where austenitic weld consumables are applied as overlay or used for joining ferritic/martensitic base materials, careful consideration of the technical merits will be required and weighted against possible long-term disadvantages. Factors that need to be considered and evaluated before applying austenitic weld consumables are:

- Detrimental effects of difference in coefficients of thermal expansion on joint integrity, in particular the introduction of localised stresses during thermal transients for heavy wall components
- Difficulty level to perform and interpret the results of volumetric NDT such as UT due to changes in microstructures and material physical properties.
- Surface crack detection by MT is very difficult if not impossible and cannot be applied with repeatable results; therefore the only option will be the using of a less sensitive technique such as PT.
- Welding with nickel based consumable requires a welder with specific experience that mastered the techniques to avoid problems such as hot cracking and lack of fusion due to a sluggish weld pool.
- Using nickel-based weld consumables may provide lower weld residual stress, but without PWHT the parent material heat affected zones remain untempered and susceptible to degradation by mechanisms such as hydrogen cracking and stress corrosion cracking.
- In addition to the NDT required in the contract, weld joints welded with austenitic consumables and not subsequently subjected to PWHT on materials that normally required PWHT shall be inspected for micro cracks in the base material by surface replication, as well as having hardness measured on at two positions on the base material HAZ
- These joints shall be rated as temporary and flagged to be replaced at the earliest opportunity, not later than 20 k hours of operation. Application of temper beads on the weld re-informant must be considered where practically possible. Refer to appendix D for a description of this technique.

Based on these factors, austenitic weld consumables used on ferritic/martensitic base materials should be avoided and only used where the situation warrants it. Prior approval by the Eskom Engineer shall be motivated before using this type of consumables, supported by a solid engineering argument.

3.8.15 Welding in austenitic temperature range

PQR's qualified with high preheats to facilitate welding in the austenite temperature range (typically for X20CrMoV11-1) must only be used for good technical reasons. It shall not be used for joining other grades in the same material grouping e.g. X10CrMoVNb9-1 as allowed by application range of the welding specifications.

3.8.16 Welding and cutting gasses

All gases used for welding and cutting tasks shall be clearly identifiable and accompanied by an analysis certificate. All grades of shielding and backing gas shall be supplied with supporting documents for certification to EN ISO 14175 [41].

3.9 CALIBRATION OF EQUIPMENT

The prescriptions of the Quality Standard relevant to the contract shall be adhered to including the following basic requirements that are pertinent to all welding related tasks.

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The principal Contractor shall provide the necessary calibrated equipment for the preparation, execution and testing of welds, the pre-heating and post-weld heat treatment of welds, and the thermocouples and recorders required to record the temperatures achieved. Where inverter type welding machines with high frequency arc starting capabilities are used, these will be fitted with the required radio wave interference suppressors. All TIG torches shall be fitted with gas lenses for improved shielding efficiency. Earth cables shall be placed as close as practically possible to the weld joints.

3.9.1 Equipment identification

Each welding machine, heat treatment power source and plasma cutter shall be identifiable by a unique number. Machines shall be serviced and calibrated at least once a year when in constant use and proper records shall be kept. In case of infrequent use longer inspection and calibration cycles may be motivated by the vendor. Periodic checks by using a calibrated tong tester shall be performed to ensure that a reasonable level of accuracy is maintained.

3.9.2 Calibration of temperature measuring equipment

All temperature measuring and recording equipment must be calibrated by a SANAS approved metrology test laboratory, with traceable document proof, to national calibration standard requirements. Minimum frequency of calibration will be at least once a year and a record shall be kept to this effect. Other inspection and calibration cycles may be motivated and agreed between Eskom and the vendor.

3.9.3 Calibration of furnaces, holding ovens and hot boxes

Consumable baking furnaces, holding ovens and hot boxes shall be calibrated at least once a year and a record shall be kept. In case of infrequent use longer inspection and calibration cycles may be motivated by the vendor.

3.9.4 Calibration of chart recorders for heat treatments

Chart recorders used for heat treatment shall be calibrated at least once a year and a record shall be kept. In case of infrequent use longer inspection and calibration cycles may be motivated by the vendor.

3.9.5 Proof of calibration

Proof of calibration status of the calibration and test equipment itself shall be included on each calibration certificate.

3.10 RECORDS AND DATA PACKAGES

Records pertaining to any manufacture, repairs or modifications shall be compiled and/or updated and stored as required by Regulation 14 of the PER and QM 58. All documents required by the applicable codes, standards and specifications shall be included in the contract/project data package.

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4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

This revision cancels and replaces Revision No. 0 of Standard No. 240-56241933 Previous versions were as follows:

Date	Rev.	Compiler	Remarks
July 1988	OPS5368 rev 2	C.L Ross	Title : Control of repair and maintenance welding
June 2002	ESKASABI9	P Doubell	Title: Control of repair and maintenance welding activities
June 2006	GGG1407	P Doubell	Control of erection, repair and maintenance welding activities
April 2007	GGS 1407	P Doubell	Control of plant erection, repair and maintenance welding activities
November 2011	36-775 rev 0	P Doubell	Control of plant construction, Repair and Maintenance welding activities
February 2012	36-775 rev 1	P Doubell	Control of plant construction, Repair and Maintenance welding activities
March 2013	240-56241933 rev 0	P Doubell	Control of plant construction repair and maintenance welding activities standard
March 2013	1	P Doubell	Final Document for Authorisation and Publication
September 2014	1.2	P Doubell	Draft Document for Comments Review
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	2	P Doubell & D Moll	Final Document for Authorisation and Publication Rev 2

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6. DEVELOPMENT TEAM

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

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APPENDIX A:

A.1 SUMMARY OF SANS ISO 3834 QUALITY REQUIREMENTS

ELEMENTS	SANS ISO 3834-2 (Comprehensive quality requirements) – ESKOM LEVEL 1 PLANT	SANS ISO 3834-3 (Standard Quality requirements) – ESKOM LEVEL 2 PLANT	SANS ISO 3834-4 (Elementary quality requirements) – ESKOM LEVEL 3 PLANT
CONTRACT REVIEW	Full documented review	Less extensive review	Establish that capability and information is available
DESIGN REVIEW	Design for welding can be reviewed		
SUB-CONTRACTOR	Treat like main contractor		Shall comply with standard
WELDERS, OPERATORS	Approved to SANS 9606 (Metallic weldments); SANS10269 (Thermoplastics)		
WELDING COORDINATION	Welding co-ordination personnel with appropriate technical knowledge according to ISO14731, or persons with similar knowledge		Not demanded but responsibility of contractor
INSPECTION PERSONNEL	Sufficient and competent personnel to be available		Sufficient and competent, access for third parties, as needed
PRODUCTION EQUIPMENT	Required to prepare, cut, weld, transport, lift, together with safety equipment and protective clothes		No specific demand
EQUIPMENT MAINTENANCE	Has to be carried out, maintenance plan necessary	No specific demand. Shall be adequate	No demands
PRODUCTION PLAN	Necessary	Restricted plan necessary	No demands
WPS	Instructions to be available to welder (BS EN 15609)		No specific demands
WELDING PROCEDURE APPROVAL	In accordance with BS EN15614 series(for metallics), approved as application standard or contract demands For thermoplastic weldments refer to SANS 10270		No demands
WORK INSTRUCTIONS	WPS or dedicated work instructions to be available		No demands
DOCUMENTATION	Necessary	Not specified	No demands
BATCH TESTING OF CONSUMABLES	Only if specified in contract	Not specified	No demands
STORAGE AND HANDLING OF WELDING CONSUMABLES	In accordance with supplier recommendation as minimum		

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STORAGE OF PARENT MATERIALS	Protection required from influence by the environment		No demands
POST WELD HEAT TREATMENT	Specification and complete record necessary	Confirmation to specification necessary	No demands
INSPECTION BEFORE, DURING, AFTER WELDING	As required for specific operations		Responsibilities as specified in contract
NON-CONFORMANCES	Procedures shall be available		
CALIBRATION	Procedures shall be available	Not specified	
IDENTIFICATION	Required when appropriate	Required , when necessary	Not specified
TRACEABILITY			Not specified
QUALITY RECORDS	Shall be available to meet the rules for product liability		As required by contract
	Retained for five years minimum 5 years (or as contractually required)		

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