Eskom	Standard	Asset Management

Title: **Procurement of Seamless Steel High Pressure Pipework and Boiler Tubing Material Standard in the Generation Division**

Unique Identifier:	**240-87733094**
Alternative Reference Number:	**N/A**
Area of Applicability:	**Generation**
Documentation Type:	**Standard**
Revision:	**3**
Total Pages:	**13**
Next Review Date:	**April 2026**
Disclosure Classification:	**CONTROLLED DISCLOSURE**

APPROVED FOR AUTHORISATION
☑ GENERATION ENGINEERING
DOCUMENT CENTRE ☎ x4962

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Date: 7 April 2021	Date: 09/04/2021	Date: 09/04/2021

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1. INTRODUCTION

Variations in material properties are a significant contributor to scatter in material behaviour for various failure mechanisms and a major cause of premature failures and exhaustion in the power generation industry. To allow for safe and reliable operation and plant life management within predictable boundaries of material scatter, it is important to adhere to international manufacturing standards when material is ordered.

Globalisation and growth of developing economies has created access to numerous manufacturers and especially suppliers, who can compete on cost but are not always capable of repeatedly delivering quality HP pipework and boiler tubing materials. Without careful control of technical quality, Eskom is at risk of receiving substandard material that can lead to premature failures compromising plant safety and availability. To limit this risk, it is necessary to standardise the specifications for HP pipework and boiler tubing materials in Eskom within the limits of international standards as well as engineering best practice, and control quality during manufacture by assessing and approving manufacturing plants instead of suppliers.

These will, in some cases, result in special requirements for material procurement in Eskom which will be more stringent than those contained in harmonised international material technical delivery standards and/or code requirements. It is costly for Eskom to physically assess and approve manufacturing plants and to ensure only manufacturing plants with proven capabilities are assessed; mandatory requirements are introduced, which if not supplied with the tender documents, will result in disqualification of the supplier from the tender process.

This standard covers the materials that can be ordered both via the European Norm (EN) or American Society of Mechanical Engineers (ASME) codes/standards. It must be noted however that ordered material must be in accordance with the design base of the station in question. Most Eskom plants are designed and built to EN codes while Kendal is designed and built according to ASME codes.

2. SUPPORTING CLAUSES

2.1 SCOPE

This standard covers the ordering of all seamless tubing and piping material to be used in high pressure applications.

2.1.1 Purpose

The purpose of this standard is to ensure that seamless HP pipework and boiler tubing material purchased by, and manufactured for Eskom is of desirable quality.

2.1.2 Applicability

This document shall apply throughout Eskom's Generation Division in relation to materials of construction and repair for use on high pressure pipework and boiler tubing.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 NORMATIVE

[1] 32-1034 - Eskom Procurement and Supply Chain Management Procedure, Rev.4.

[2] ISO 9001 Quality Management Systems.

[3] 97/23/EC (PED) – European Pressure Directive

[4] EN 764-5: Pressure Equipment – Part 5: Inspection Documentation of metallic materials and compliance with the materials specification.

[5] AD 2000-Merkblatt W 0

[6] EN 10216: Seamless steel tubes for pressure purposes – Technical delivery conditions – All parts

[7] EN 10204: Metallic Products – Types of inspection documents

[8] ASME Boiler Pressure Vessel Code Section II: Materials - Part A (Ferrous Material Specification) and Part D (Properties)

[9] ASME B31.1: Power Piping

[10] BS EN 12952: Water-tube boilers and auxiliary installations

[11] BS EN 13480: Metallic industrial piping

[12] 240-56239129: High Energy Pipework Standard for Power Generation Plants

[13] VdTÜV WB560/2 (03.2009) - *VM 12*

[14] VdTÜV WB547 (06.2003) – *DMV 347 HFG*

Note: In all cases, the latest version of the codes/standards/procedures shall be applicable.

2.2.2 INFORMATIVE

[15] VGB Specification VGB-R 109

[16] VdTÜV WB511 (03.2009) - *for X10CrMoVNb9-1 and T/P 91 impact properties only*

[17] Guidelines and Specifications for High-Reliability Fossil Power Plants, 2nd Edition—Best Practice Guideline for Manufacturing and Construction of Grade 91 Steel Components. (Report No: 3002006390)

2.3 DEFINITIONS

Definition	Description
High Pressure Pipework and Tubing	Pipes and fittings in such systems for the conveyance of steam, water, gases or other fluids whose design pressure equals or exceeds 4.0 MPa **or** whose design temperature equals or exceeds 250 °C.

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
ASME	American Society of Mechanical Engineers
BPVC	Boiler Pressure Vessel Code
EN	Euro Norm
EPRI	Electric Power Research Institute
HP	High Pressure
MPa	Mega Pascal
OD	Outside Diameter
PED	Pressure Equipment Directive
PWHT	Post Weld Heat Treatment

2.5 ROLES AND RESPONSIBILITIES

The Engineering Manager is both accountable and responsible for ensuring that the relevant system engineers include the provisions of this standard in all procurement requests for HP piping and boiler tubing.

The procurement manager is responsible for ensuring that the provisions of this standard are adhered to when an order for HP pipework and boiler tubing is placed.

2.6 PROCESS FOR MONITORING

Not applicable

2.7 RELATED/SUPPORTING DOCUMENTS

Not applicable

3. TECHNICAL REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 APPLICABLE MATERIAL STANDARDS

HP pipework and boiler tubing material shall be procured in accordance with the requirements of EN 10216 (latest version and whichever part is relevant) for boilers and pipework systems designed according to EN design codes (e.g. EN 12952, BS 1113, EN 13480, BS 806, TRD 301). Boilers and piping systems designed to the ASME BPVC shall be procured in accordance with the requirements of Section II Part A, in conjunction with Part D (material properties in metric units), of the ASME Boiler and Pressure Code (BPVC).

For all piping and tubing procured in accordance with EN 10216, test category 2 (TC2) of Table 13 (Part 2), Table 15 (Parts 3 & 5) and Table 10 (Part 4) shall apply including all optional tests with the exception of option 5 (Part 2) and option 23 (Part 5).

For piping and tubing procured according to Section II of the ASME BPVC, similar tests to those in EN 10216 TC 2 (above) shall apply, while ensuring that all applicable tests and requirements specified in the ASME BPVC Section II are observed. Any apparent conflicts between the tests prescribed in EN 10216 TC2 and those prescribed in ASME BPVC Section II Part A shall be referred to Eskom for clarification.

NOTE: Material standards and specifications must be utilised according to the design base of the particular plant/plant area. No mixing of codes (i.e. ASME/ASTM material on an EN-designed station) will be permitted without an approved design modification being in place.

3.1.2 MANDATORY REQUIREMENTS

The information listed below shall be included in the tender submission for each material grade and dimension group. Failure to supply the required information will result in automatic disqualification of the tenderer.

a. EN Materials: A valid (and current) certificate of conformity by a Third Party/Notified Body (in accordance with EN 764-5 (Clause 4) or AD 2000-Merkblatt W 0), to demonstrate that the ***material manufacturing plant*** has been audited and authorised as having a quality assurance system for material manufacture in accordance with PED 97/23/EC or 2014/68/EU (Pressure Equipment Directive), to produce the material grades and dimension ranges tendered for. This certificate should be accompanied by the Appendices containing all material, size ranges and harmonised standards approved. Where CE marking is available, the EU declaration of conformity for each product type (material grades and dimensions) tendered for must be included. It will be mandatory to provide the name, address and contact number of the Third Party/Notified Body that carried out the conformity assessment upon contract award.

   ASME Materials: A valid (and current) ASME Certificate of Authorisation by a Third Party/Notified Body (in accordance with ASME requirements), to demonstrate that the ***material manufacturing plant*** is an ASME Authorised Organisation that has been audited and authorised to produce the material grades and dimension ranges tendered for with the ASME Certification Mark. This certificate should be accompanied by the Appendices containing all material, size ranges and harmonised standards approved. Where ASME materials are approved for CE marking, the information required for EN Materials will also be acceptable for ASME materials. It will be mandatory to provide the name, address and contact number of the Third Party/Notified Body that carried out the conformity assessment upon contract award.

3.1.3 SPECIFIC REQUIREMENTS

The following requirements shall apply in addition to the requirements stipulated in the relevant international material specifications mentioned in 3.1.1 of this document.

3.1.3.1 Details of Manufacturing Plant

The following information shall be provided to Eskom as part of the tender submission:

Formal business name of the manufacturing plant, street and postal address, contact names and telephone numbers of senior plant managers, along with their organisational roles. The manufacturing plant is the *site of manufacturing, inspection, testing, and release. If any activity is carried out at a different location or facility other than the main manufacturing plant, this shall be duly disclosed in the tender submission (showing clearly the scope/activities that will be done at a different plant location) and the same information shall be provided for the plant/site where other activities will be performed*.

Note: It is Eskom's intent to conduct an evaluation or assessment of the manufacturing plants as part of the tender evaluation process (or to arrange for an audit by a third party). Under no circumstances can material be manufactured elsewhere without Eskom's written approval.

3.1.3.2 History of Previous Supply

A list of material manufactured at the plant, with particular regard to the materials required as part of the tender, shall be supplied. This should include a reference list with contact details of the end users, dates of delivery, material grade, dimensions, harmonised standards applied and tonnage.

3.1.3.3 Steel Making Process

The foundries (if different from the material manufacturing plant) that will be used to supply cast billets for the manufacture of HP pipework and boiler tubing shall be listed in the tender returnable documents.

The manufacturer shall provide Eskom (also in tender returnables) with a short technical description of its process to ensure the production of “clean” steel within the limits of this Standard. Raw material and scrap control by foundries must demonstrate low contamination levels with trace impurities and dangerous (i.e. poisonous and radioactive) elements. Only fully killed steels will be acceptable.

For austenitic stainless steels supplied in accordance to EN 10216-5, option 1 shall apply.

Manufacturers shall also provide details of raw material suppliers along with relevant certification of the suppliers’ quality management system/process, such as a valid or current ISO9001 certificate or comprehensive quality manuals (where an ISO certificate is not available). This information shall be provided with the tender submission.

3.1.3.4 Heat Treatment

The following heat treatment requirements shall apply:

a. A valid or current calibration certificate(s) for the facilities used for the heat treatment shall be provided with the tender submission. The actual current calibration certificate for the Eskom order shall be furnished in the data books.

b. Suppliers shall provide a detailed heat-treatment record (certified temperature/time record) for each product (component or lot of components processed as a single batch) purchased.

c. Loading of piping and tubing in the furnace shall be carried out to avoid non-uniform heating and cooling which could result in non-uniform material properties. A furnace packing plan and short description of heat treatment measures that are or will be in place in order to achieve this shall be included with the tender submission. Detailed procedures must be available for review during site audits by Eskom.

d. Suppliers must provide a short description of the heat treatment facilities and procedures to demonstrate how heat treatment will be controlled within parameters/requirements as evidence in the form of the latest heat treatment survey of the facilities. All calibration certificates and procedures must be made available for review by Eskom (when site visits are planned).

Note: After contract award but before execution of the Eskom order, suppliers shall demonstrate that the thermocouples that are used to control the temperature can be maintained within a 3°C of the target temperature and that the largest variation in temperature between any two points in the work zone of the furnace (the volume holding the components) does not exceed 20°C. This shall be demonstrated by placing thermocouples on metal samples that are placed in the furnace in order to accurately indicate the temperatures in the work zone. For resistance-type heaters, the heat-treatment supplier shall demonstrate that the temperature at the control thermocouple can be maintained within 3°C of the target temperature. The heat-treatment supplier should demonstrate that for a given component the temperature is controlled within the specified temperature range through placement of properly installed thermocouples at a sufficient number of locations along the length and around the circumference of tubular-shaped components. For other types of heating, such as induction heating, the heat-treatment supplier must demonstrate the ability to maintain the temperature at all points on the component within the required temperature range for the appropriate amount of time.

e. The fully annotated heat treatment schedule for each material tendered for shall be supplied with the tender documents. The heat treatment schedule shall as a minimum contain methods of heating and cooling, heating and cooling rates, holding temperature ranges and holding times. These heat treatment schedule may be provided in the form of a schematic heat treatment dummy chart.

Special note for the heat treatment of grade 91 steel tubes and pipes:

Normalizing
For all product forms, normalizing is to be carried out using a suitable furnace within the temperature range of 1050°C–1100°C to produce a fully martensitic microstructure. Once the full thickness of the component has reached the target *normalizing* temperature, the time at temperature shall be a minimum of 10 minutes. The product shall be air cooled outside of the furnace and away from any source of heat that would retard the rate of cooling. Care must be taken to ensure that all areas of the component are allowed to cool uniformly. In cases where multiple components are processed as part of a single heat-treatment cycle, the individual pieces must be separated in such a way that each piece will cool without interference from an adjoining piece. Cooling shall be continuous down to at least 90°C at the hottest location before tempering. Note that for components greater in thickness than 75 mm, forced air cooling or oil quenching or the equivalent from the normalizing temperature to an internal work piece temperature below 540°C may be necessary to achieve the required mechanical properties. Heating using resistance heating pads or induction heating is not permitted for normalizing.

Tempering
For all product forms, tempering is to be performed within the temperature range of 730°C–780°C. Note that because of the risk of stress corrosion cracking that exists when Grade 91 material is in the fully hardened condition, once the normalizing heat treatment has been completed, the material shall not be allowed to remain at a temperature below 80°C for more than eight (8) hours before the tempering heat treatment is begun, unless precautions are taken to keep the material dry on both the inner and outer surfaces. The tempering temperature selected and the time at the *tempering* temperature shall be controlled to satisfy the specified hardness requirement. The product may be cooled in still air from the *tempering* temperature, as long as excessive distortion or excessive thermal stress is avoided, or, as an alternative, where expedient, furnace cooling is acceptable provided that the cooling rate exceeds 55°C/hour until the internal temperature is below 650°C.

3.1.3.5 Chemical Composition

The following chemical composition shall apply when producing material for an Eskom tender (after contract award):

a. Cast/melt and product analysis will be required for all materials. This shall be performed on the same heat / sample used for mechanical testing.

b. For all steel grades the following trace elements shall be controlled and reported (on mill material certificates) with adherence to the following limits:
   Phosphorus (P) ≤ 0,015%
   Sulphur (S) ≤ 0,005%

c. The following trace elements shall be reported on mill material certificates
   Arsenic (As)
   Antimony (Sb)
   Lead (Pb)
   Tin (Sn)

d. The following special requirements, for both cast and product analysis, within but more stringent than the code limits, must be adhered to for the steels listed in Table 1 (below):

Table 1: List of Special Chemical Requirements.

Material	Ni (%)	Al (%)	N (%)	N/Al Ratio	Si (%)	Mn (%)	Cu (%)
X20CrMoV11-1	0,50 max	0,02 max					0,10 max
X10CrMoVNb9-1	0,20 max	0,015 max	0.035 min	> 4	0,40 max	0,50 max	0,10 max
7CrWVMoNb9-6							0,10 max
7CrMoVTiB10-10							0,10 max

e. Control of Delta Ferrite will be maintained by adherence to the following formulas:

X20CrMoV11-1:
(Cr + 6Si + 4Mo + 1,5W +11V + 5Nb + 9Ti + 12Al) – (40C +30N + 4Ni +2Mn +1Cu) < 12

X10CrMoVNb9-1 (P/T91):
(Cr + 6Si + 4Mo + 1,5W +11V + 5Nb + 9Ti + 12Al) – (40C +30N + 4Ni +2Mn +1Cu) < 12

The chemical analysis results and techniques used shall be reported for the above elements on the respective test certificates for each product and/or batch.

For VM12-SHC and X10CrWVMoNb9-2 material, the manufacturer shall demonstrate how delta ferrite was controlled during the manufacturing process.

3.1.3.6 Mechanical Properties

All mechanical testing shall be carried out in accordance with the relevant codes or standards. The following requirements shall apply for material manufacture to be supplied to Eskom (after contract award). All results of mechanical properties testing shall be recorded on the Certified Material Test Report.

(a) *Tensile Testing*

Tensile testing shall be done at room temperature and in the transverse direction except where the dimensions do not allow. The sample direction must be noted on the test report. Tensile properties

shall comply with the respective codes. Yield strength (or 0.2% proof strength), ultimate tensile strength, elongation and reduction in area shall be reported.

High temperature tensile tests shall be carried out for all materials used in time-independent designs. The temperature to be used shall be the highest listed proof strength value for each material in the respective code. Testing shall be in the transverse direction except where the dimensions do not allow. The sample direction must be noted on the test report. Tensile properties shall comply with the respective codes. Yield strength (or 0.2% proof strength), ultimate tensile strength, elongation and reduction in area shall be reported.

(b) *Hardness Testing*

Hardness testing (macro-Vickers with 10kg load) shall be carried out on a cross section, close to the outside surface (0,5 - 1mm), in the centre and close to the inside surface (0,5 - 1mm) of each sample. Care must be taken to polish away the cold work effects from cutting of the samples.

For X10CrMoVNb9-1 (T/P91), manufactured tubes/pipes must be in the hardness range of 215HV – 260HV. The hardness range after bending and forming (followed by normalisation heat treatment) must be 210HV – 260HV. For X20CrMoV11-1, X10CrWVMoNb9-2 and VM12-SHC materials, the hardness values shall be recorded.

(c) *Impact Testing*

All impact testing shall be done in the transverse direction except where dimensions do not allow. The sample orientation must be noted on the test report. In addition longitudinal impact testing of 15NiCuMoNb5-6-4 is required. In the case of X10CrMoVNb9-1, X10CrWMoVNb9-2, and VM12-SHC the values contained in the latest VD TÜV data sheets shall be applicable. In all other cases impact properties shall comply with the relevant codes.

3.1.3.7 Creep Data

In line with the provisions of Appendix B of EN 12952-2, the material manufacturer shall furnish to Eskom verification of the creep test results for materials intended for operation in the creep range (≥ 450^{o}C). This requirement includes materials covered by both EN and ASME specifications. The creep tests results shall be based on tests conducted by the material manufacturer from heats of a given material produced from its own plant and procedures. The creep tests results shall be based on actual data for each material grade tendered for or quoted in ***tender returnable documents***. The minimum test duration for the actual creep test shall be 40 000 hrs.

The material manufacturer shall provide this data with the tender submission or provide a written declaration that the data exists and will be made available to Eskom personnel during a factory or site assessment or at any stage (when arrangements are made and communicated) prior to contract award.

3.1.3.8 Non-Destructive Testing (NDT)

(a) *ASME materials:*

All non-destructive testing shall be carried out as per the relevant requirements of the Section V of the ASME code.

(b) *EN materials:*

All testing shall be carried out in accordance with EN 10216 (all Parts) Test Category 2 (TC 2) or the relevant Test Category 2 for any other part of EN 10216 to which tubing is manufactured and delivered.

For all pipe products (OD > 100mm), additional NDT in the form of ultrasonic testing (UT) must be carried out in the transverse direction, and for the detection of laminar imperfections.

For ferritic steel pipes and tubes Magnetic particle (MT) shall be carried out on all tubes/pipes. Should electromagnetic testing be used (in the case of tubing) it must be fully capable of detecting longitudinal defects.

In all cases (ASME and EN) leak tightness testing shall be by electromagnetic testing for ferritic steels and eddy current testing according to EN ISO 10893-1 for austenitic steels.

3.1.3.8 Certification

Certification shall be in accordance with the latest version of EN 10204: “Types of Inspection Documents” for EN and preferably also ASME materials. Should this not be possible (in the case of ASME materials), a certificate of compliance in accordance with the relevant material code shall be supplied.

Certification shall be in accordance with EN 10204 3.2 in all cases.

3.1.3.9 Protection against Corrosion

All pipes and tubes must be dry, free of corrosion, and a temporary protective coating must be applied on each tube to protect it for long-term storage in outside atmospheric conditions (open storage). Tube ends shall be covered with tight fitting end caps and desiccant bags or suitable inhibitor must be placed on the inside of each pipe or tube to protect it for long term storage under atmospheric conditions (outside storage). The manufacturer must supply details of the coating and desiccant /inhibitor with the tender submission.

3.1.3.10 Marking

Standard and clear legible marking must be applied on both ends of each tube/pipe. All marking shall be in accordance with the relevant technical delivery conditions specification / standard.

3.1.3.11 Surface Condition

The surface of all tubes/pipes shall be of such a nature that all required NDT testing can be carried out without any limitations.

All pipes/tubes shall be delivered free of external and internal scale.

The component wall thickness after removal of any non-representative surface layer shall be greater than or equals to the specified wall thickness.

3.1.4 DELIVERY

Upon completion, technical data books shall be supplied containing as a minimum:

(a) Order requirements and specifications (including declaration of conformity stating that all technical conditions were met or fulfilled) in line with the requirements of this document or as agreed at the time of purchase or contract award.

(b) PED certification or ASME Certificate of Authorisation

(c) Signed quality control documentation

(d) Steel making processes and foundry material certificates.

(e) Certificates according to EN 10204 including all detailed results for destructive, mechanical and non-destructive testing.

(f) Heat treatment records (clearly showing austenitizing and tempering soak temperatures, times, heating and cooling rates of all heat treatment processes of each product/batch)

(g) Details or records of descaling, surface finish and corrosion protection applied.

(h) All approved concessions where applicable.

4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

Date	Rev.	Compiler	Remarks
March 2016	0.1	A Downes	New standard governing the procurement of HP pipework material in the Generation Division
May 2016	0.2	A Downes	Draft Document for Comments Review
June 2016	0.3	A Downes	Updated comments into document
July 2016	1	A Downes	Final Document for Authorisation and Publication
Nov 2016	1.1	A Downes	Update heat treatment and additional requirements to be unambiguous
February 2017	1.2	A. Downes	Updated document
February 2017	1.3	A. Downes	Final Draft Document for Comments Review
March 2017	2	A. Downes	Final Document for Authorisation and Publication (Rev 2)
	x		Revision 2 Document was Cancelled in lieu of recompiling
March 2021	2.1	A Downes	Final updated new Draft Document for Comments Review
March 2021	2.2	A Downes	Final Draft after Comments Review Process
April 2021	3	A Downes	Final Rev 3 Document for Authorisation and Publication

6. DEVELOPMENT TEAM

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

- A Downes
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7. ACKNOWLEDGEMENTS

- None