Eskom	Standard	Technology

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Compiled by

G. Meredith
Eskom NDT Level 3
Date: 10 Aug 2017

Approved by

M. Maroga
Corporate Specialist - Materials, NDT & Welding
Date: 10/08/2017

Authorised by

D. Odendaal
General Manager (Acting) – Plant Engineering
Date: 11/8/2017

Supported by SCOT/SC/TC

S. Govender
SCOT/SC/TC Chairperson
Date: 15/08/2017

PCM Reference: **240-53459108**
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1. INTRODUCTION

Ultrasonic wall thickness (WT) testing is used as one of the inspection methods whenever a question arises regarding a components true thickness. This could be either for purposes of confirmation of an actual thickness versus a design thickness or for purpose of actively searching for wall thickness reductions due to various wall loss mechanisms in order to establish the location of the thinnest section on the component and report the corresponding thickness. These measurements are critically important in order to maintain confidence in the safe and reliable operation of the component.

2. SUPPORTING CLAUSES

2.1 SCOPE

This standard stipulates the Eskom minimum, mandatory requirements for ultrasonic wall thickness testing.

2.1.1 Purpose

The purpose of this standard is to standardise operations in the performance of wall thickness measurement carried out on Eskom plant. These requirements shall be considered as a minimum requirement, and Eskom may specify more stringent requirements for specific sites or applications.

2.1.2 Applicability

This standard is a mandatory requirement and is applicable to ultrasonic wall thickness performed on Eskom Plant or components, by Eskom, or contracted NDT service providers. It applies to the measurements on all types of ferritic, martensitic and austenitic steels as well as to both pre-service inspections (PSI) and in-service inspections (ISI).

This standard should be read in conjunction with other relevant Standards referenced in the Informative references.

This standard does not apply to Tube-SOLO testing.

2.2 NORMATIVE/INFORMATIVE REFERENCES

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

2.2.1 Normative

[1] ISO 9001 Quality Management Systems.

[2] BS EN 14127 - Ultrasonic thickness measurement.

[3] 240-83539994 – Standard for Non-destructive testing (NDT) on Eskom plant.

2.2.2 Informative

[4] BS EN ISO 2400 - Non-destructive testing. Ultrasonic testing. Specification for calibration block No. 1.

[5] BS EN ISO 7963:2010 - Non-destructive testing. Ultrasonic testing. Specification for calibration block No. 2.

[6] BS EN 12668-1 – Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 1: Instrument.

[7] BS EN 12668-2 – Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 2: Probes.

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[8] BS EN 12668-3 – Non-destructive testing – Characteristic and verification of ultrasonic examination equipment - Part 3: Combined Equipment.

[9] ASTM E797 - Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method.

[10] ASME 5 – Non-destructive Examination.

[11] GGA 1182 – The Control of Chemical Products in a Power Plant.

[12] 240-75114345 – Standard for metallographic replication applicable to high temperature, high pressure turbine and generator components on Eskom plant.

[13] 240-7510974 – Standard for Metallographic Replication Application to High Temperature Pressure Components on Eskom Plants.

[14] 240-60238156 – Standard for management of Flow Accelerated Corrosion (FAC) at Fossil Fired Power Plant.

2.3 DEFINITIONS

Definition	Description
Boiler Health Care System	An electronic system for the management of the condition of boiler pressure parts. All inspection instructions from the Mater Test and Inspection Plan have been detailed in inspection area detailed reports. The results of historic and current condition are captured and analysed with the use of the system and repair instructions are issued from the system.
Boundary of the measurement position	The defined limit of the area on a component, with a drawing, within which the lowest wall thickness is to be located, measured and reported.
Calibration block	A standardisation device used to ensure the equipment used to take measurements is set up in such a way as to ensure minimum accuracy requirements are met.
Fraudulent	The act of wilfully compromising results for any reason. Eskom reserves the right to take the requisite action where such act can be proven.
Inspection Instruction	A scope of work supplied to the NDT service provider to clearly identify the component to be inspected and locations on that component that requires testing. It includes the inspection of a percentage of the original full inspection instruction scope requirements e.g. cross checks.
Reporting	The act of submitting documentation of the inspection results in a format acceptable to Eskom.
Scanning	The act of locating the area of thinnest wall thickness on a component, or section of a component, by taking individual spot readings in grid formation before recording the lowest wall thickness result.
Service provider	An entity or organisation approved to provide a service to Eskom.
Transducer	Piezoelectric element that converts mechanical energy into electrical energy and vice versa, used in for pulse echo contact inspections to measure wall thickness. Interchangeable with crystal and probe.
Visual inspection	For this procedure this is the act of verifying the condition of the inspection area as being in a condition suitable to couple a transducer to take reliable and accurate wall thickness readings.

2.3.1 Disclosure Classification

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

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2.4 ABBREVIATIONS

Abbreviation	Description
ASTM	American Society for Testing and Materials
BS EN	British Standard European Norm
BWE	Back Wall Echo
CRAC	Chemical Restriction and Control
FAC	Flow Accelerated Corrosion
FSH	Full Screen Height
ISI	In-service Inspection
ISO	International Standards Organisation
NDT	Non-Destructive Testing
PSI	Pre-service Inspection
RE	Reference Echo
RT&D	Research Test & Development
SOC	State Owned Company
UT	Ultrasonic Testing
WT	Wall Thickness

2.5 ROLES AND RESPONSIBILITIES

2.5.1 Eskom Level 3

The Eskom NDT Level 3 is the custodian of this document and it is his/her responsibility for ensuring that the requirements of this standard are implemented and maintained.

2.5.2 Eskom Site System Engineer

The relevant System Engineer shall ensure that this standard is referenced as a minimum requirement when compiling an enquiry for the procurement of WT performed by NDT service providers.

2.5.3 NDT Service Providers

[1] NDT service providers shall ensure that they meet the requirements of this standard.

[2] NDT service providers shall ensure that they submit their wall thickness procedure for review and acceptance by the Eskom NDT Level 3

[3] NDT service providers shall ensure that they submit request for approval of all technicians (as required by 240-83539994) to be performing ultrasonic wall thickness measurements on Eskom Plant to the Eskom NDT Level 3 for Eskom approval.

[4] The NDT service provider's Level 3 shall be responsible to ensure that a full scope of inspection has been conducted to meet Eskom's requirements, as well as issuing an end of inspection report.

2.5.4 Boiler Health Care System Service Provider

[1] The BHC System Service Provider shall ensure that they meet the minimum requirements of this standard.

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2.6 PROCESS FOR MONITORING

This implementation of this standard shall be monitored via periodic assessments or audits.

3. PROCESS FOR INSPECTIONS

3.1 PREREQUISITES

[1] NDT service providers shall have their own wall thickness procedure. This procedure, as well as the WT technicians shall have Eskom approval in accordance with the requirements of Eskom Standard 240-83539994.

[2] The NDT WT supervisor shall be Eskom Approved to a minimum of UT level 2 in accordance with the requirements of Eskom Standard 240-83539994.

[3] For boiler inspections the NDT service provider shall:

- Provide their own data capturers to capture the results of the inspections onto the Boiler Health Care (BHC) system and print reports as required.
- Ensure that any person employed for data capture onto the BHC system has been trained, tested and declared competent in this regard by the service provider for the BHC system, on behalf of Eskom.
- Ensure that all wall thickness technicians undergo plant specific training on the following and have been tested and declared competent in this regard by the service provider for the BHC system, on behalf of Eskom.
  - Plant component locations and access considerations.
  - Component inspection requirements with distinct reference to area boundaries, numbering philosophies, expected damage mechanisms and inspection positions as detailed in the "Inspection Area detailed Reports" from the BHC system.

[4] The NDT service provider's UT Level 3 shall perform a minimum of one site documented audit per week during FAC, boiler inspection and metallurgical surveys. He/she shall submit a project close out report after the outage (as per the requirements of 240-83539994).

3.2 EQUIPMENT AND INSPECTION VARIABLES

3.2.1 Instruments

[1] The instrument shall have a numeric display and be capable of displaying thickness measurement to the second decimal (1/100).

[2] The accuracy of measurement instrumentation is subject to a range of external conditions as well as the capability of the equipment. This directly affects the measurement uncertainty. Measurement accuracy generally improves with increasing thickness value. Generally speaking measurement accuracy and repeatability of readings shall not deviate beyond 0,1mm of measured values (either calibration standard and/or cross referenced values).

[3] The instrument shall be capable of transmitting and receiving synchronised sound energy in the 1 – 10MHz range.

[4] For purposes of all WT measurements on boiler tubing (where the wall thickness is generally $0.8mm \leq t \leq 10mm$), the instrument shall have numerical display showing the measured value, as well as an A-scan or waveform presentation.

[5] All instruments shall be sent for calibration to the manufacturer, or his agent, or a laboratory on annual intervals to verify the performance of the ultrasonic instrument during its lifetime.

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[6] All instruments shall meet the applicable requirements of the standard referenced in 2.2.2[6].

3.2.2 Transducers

3.2.2.1 Transducer Identification

[1] The type, frequency and diameter (individual crystal dimensions for twin crystal transducers) shall be clearly marked on all transducers. Such marking should be robust enough to ensure that it can at all times be clearly distinguished.

[2] Since the physical size of these transducers is limited it is recommended that a simple coding system be applied e.g. 10/T/6 could be used to signify a 10 MHz, twin crystal transducer of 6 mm diameter.

[3] All transducers shall meet the applicable requirements of the standard referenced in 2.2.2[7].

3.2.2.2 Transducer Wear Face Depth

[1] The wear face of the transducer shall be visually examined by the technician on a continuous basis to confirm the absence of mechanical damage and to assess the remaining wear face depth.

[2] The wear face shall at all times stand proud of the manufacturers wear face allowance marks.

3.2.2.3 Transducer Wear Face Flatness

[1] The flatness of the wear face of the transducer shall be visually examined by the technician on at least a daily basis to ensure that it is flat.

[2] This must be done by setting a piece of fine emery paper on a flat surface and gently rotating the transducer and visually examine the wear face to verify that the entire face has come into contact with the abrasive medium on the paper.

3.2.2.4 Non-conforming transducers

Transducers suffering from any of the above defects shall immediately be removed from service until the defect has been corrected.

3.2.3 Combined systems

[1] All equipment shall meet the applicable requirements of the standard referenced in 2.2.2[8].

[2] A transducer from one supplier may only be used together with an instrument from the same supplier and may not be used together with an instrument from another supplier.

3.2.4 Calibration Blocks

[1] Calibration blocks must be of an ultrasonically similar material to the item being tested (i.e. separate calibration blocks are required for austenitic materials).

[2] Calibration blocks shall be hard stamped with a serial number and material type (CS, SS), specifically to differentiate between carbon steel and stainless steel. Such serial number should be traceable to a manufacturing certificate which shall include the material the block is manufactured from.

[3] Flat calibration blocks are acceptable for pipe diameters exceeding 100mm.

[4] Curved calibration blocks are required for tube diameters below 100mm.

[5] For boiler tubing measurements and for purposes of uniformity within Eskom such curved calibration blocks shall be in accordance with the following specification:

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- Outside diameter of the thickest section of the step wedge shall be 60mm.
- Inside diameter shall be 36mm
- The step wedge shall have 7 machined steps. The step thicknesses of 1mm, 1.5mm, 2mm, 4mm, 6mm, 10mm and 12mm.

[6] For all other measurements at least two standard thicknesses shall be used. One should have a thickness near the maximum of the range to be measured and the other near the minimum of this range.

[7] All calibration blocks to be machined to a tolerance of 0.02 mm.

3.2.5 Couplants

[1] Couplants in nuclear application shall be CRAC approved in accordance with the requirements of GGA 1182

[2] The same couplant used during calibration shall be used during inspection

3.2.6 Temperature

[1] Conventional Ultrasonic wall thickness measurements shall not be performed on components where the temperature exceeds 60°C.

[2] High temperature transducers and couplants shall be used with temperatures ranging from 60°C up to 260°C. In such instances temperature measurements shall be taken and recorded on the inspection report. Calibration block and component temperatures shall be within 25°C of each other.

3.2.7 Surface Finish

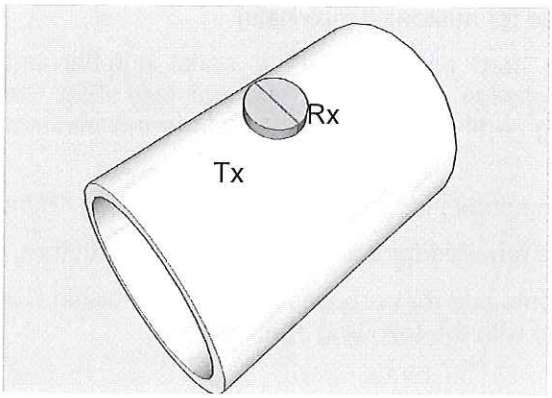
The test surface shall be free of weld spatter, scale, rust, etc. which could otherwise impair the transmission of ultrasound. Should the surface finish of the component requiring wall thickness measurement not be suitable for accurate/reliable measurement of the minimum thickness, this shall be brought to the attention of the supervisor of the NDT service provider. If it cannot be resolved it shall be escalated to the relevant NDT Level 3's. No wall thickness data may be reported at such location until the surface finish has been rectified and deemed fit for inspection by the WT technician.

3.3 PROCEDURE

3.3.1 General Requirements

[1] When obtaining measurements, the reading on the digital readout shall be allowed to stabilise before recording the thickness.

[2] When testing curved surfaces the transducer shall be placed with the acoustic barrier perpendicular to the pipe/tube axis as illustrated as below:



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[3] When performing boiler tube inspections the "A scan" waveform shall be assessed.

[4] In the event that the procedural requirements cannot be met for, any reason, such as rough surface, ash deposits weld splatter or physical obstructions such as pipe clamps or adjacent pipe insulation, the limitation shall be appropriately reported, escalated and resolved. No data shall be recorded or reported until appropriate remedial action has been taken to allow the inspection to continue.

[5] In the event that the matter cannot be resolved this shall be escalated to the Eskom Level 3 and an acceptance letter from Eskom shall be part of the report.

[6] For boiler tubing inspections where inspection scope has been issued by Eskom from the Boiler Health Care System, the NDT contractor:

- Shall be issued with inspection instructions that will contain detailed and clear information pertaining to the areas to be inspected and the naming of each measure position requiring thickness measurement to be reported.
- Shall be issued with Eskom templates per inspection area. These are intended to further clarify the format (element and tube numbers in matrix with measure positions) that have been defined in the inspection instruction and require values to be measured and reported accordingly.
- Shall not visibly mark the location of the minimum thickness or the measured value on the tube.

  For information purposes only this requirement is intended to:

  - *Ensure that technicians performing backups will also scan the area and verify the location of the thinnest point, not just measure at the marked location since that would defeat the first intent of the inspection and add no real confidence in the data set.*
  - *Ensure that technicians performing backups at this location will in fact measure the wall thickness and not be led astray by the indicated thickness value. Any marking of the original thickness value on the tube will defeat the second intent of the inspection and again add no real confidence in the data set.*
- Shall be responsible for the capture of all data to the electronic system.
- Shall be required to verify that the data captured onto the Boiler Health Care system is a true reflection of the actual boiler condition as established through the inspection by signing off the hardcopy version of the data as printed from the electronic system. These signed copies are to be checked against the rough work by the technician having executed the original inspection, signed and included in the contractors report on the inspection.

3.3.2 Transducer Selection

[1] The following maximum crystal diameters shall apply:

Nominal Pipe Size Diameter (mm)	Maximum Crystal Diameter (mm)
≤100	≤6
>100 to 150	10
>150 to 600	15
>600	≥20

Note[1]: In general probe dimensions shall be chosen based on the size limits of the thinned sections measured this is based on size and inspection area profile.

Note[2]: For pipes with diameters indicated the probe size should not exceed the values listed

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[2] The following probe frequency selection shall apply:

Component wall thickness (mm)	Probe Frequency (MHz)	Probe Type
0.8 to 12	10	Twin Crystal
12 to 50	5	Single/Twin Crystal
≥ 50	1 to 4	Single Crystal

3.3.3 Calibration Requirements

[3] Calibration shall be conducted in accordance with the instruction manual of the manufacturer.

[4] There shall at all times be a WT calibration block/step wedge available for each of the WT technicians performing inspections in order to periodically verify, and if required, correct the calibration.

[5] When inspecting components with both ferritic and austenitic steels two clearly identifiable step wedges will be required for calibration purposes.

[6] Calibration shall generally be conducted on at least one thickness on either side of the design/installed wall thickness of the components to be inspected.

[7] The design/installed wall thickness for the component shall be supplied by the Eskom on the inspection instruction and shall be reported on the WT report.

[8] For boiler tubing, calibrations shall always be done at the minimum step wedge thickness of 1mm and at the next step on the gauge greater than the design/installed wall thickness. This requirement is based on the knowledge that it is possible to have boiler tubes anywhere in the boiler which have not failed in operation but only have remaining wall thicknesses in the order of 1mm or even less (reheater tubing) at the time of inspection.

[9] Each WT technician shall complete his/her own equipment calibration.

[10] Calibration shall be performed at the following intervals:

- At the start and end of the test
- Every half hour during continuous operation
- If any wear on the transducer wear face is identified.

[11] The calibration checks should be recorded and included as part of the inspection report.

[12] Equipment that is out of calibration or fails during routine operation shall be tagged and removed from service until such time as corrective action has been performed to restore the equipment to its certified state.

[13] If there is any difference greater than ±0,2mm between initial and post calibration readings for boiler tubing and components tested with a thickness of ≤ 12mm, then all measurements pertaining to that calibration shall be marked void and the entire inspection shall be redone.

[14] If there is any difference greater than 0,5mm between initial and post calibration readings for components tested with a thickness of > 12mm, then all measurements pertaining to that calibration shall be marked void and the entire inspection shall be redone.

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3.3.4 Scanning Requirements

Should an inspection instruction define a boundary of an inspection area to be "scanned" the following shall apply:

[1] The probe shall not be dragged across the surface of the component being inspected. This will lead to premature failure of the probe due to excessive wear of the probe shoe.

[2] The test shall be executed by performing a series of spot thickness measurements in grid formation until the area with the lowest wall thickness has been located.

[3] The WT technician shall always purposefully look for signs of external wear and feel, by hand, for irregular contouring before performing any wall thickness measurements.

[4] Should such erosion pattern be visible, it shall be considered as a guide to locate the area with the greatest wall loss. The wall thickness technician shall then systematically execute multiple readings in grid formation over the local area of concern until the location and wall thickness of the thinnest area, within the boundaries of the measure position, has been positively identified.

[5] Should no evidence of such erosion patterns be evident, the technician shall execute a series of measurements in the longitudinal direction of the tube. This shall be done until an area of the lowest remaining wall thicknesses within the boundaries of measure position has been located. The wall thickness technician shall then systematically execute multiple readings in a grid formation over the local area of concern until the location and wall thickness of the thinnest area, within the boundaries of the measure position, has been positively identified.

[6] In the event that wall loss is visually identified outside the boundaries of the measure position, the technician shall not deviate from recording the lowest thickness in the measure position in question. Any wall loss at the other location shall be noted and recorded as an additional measurement, with a clear note that the location of such reading is outside of the boundaries measure position.

3.3.5 Cross Check Requirements

[1] For all wall thickness measurements the NDT service provider:

- Shall execute at least a 10% cross check as part of their own quality control system.
- Shall flag any anomalies where the difference between the initial wall thickness and the cross checks exceeds 0,2mm. Any such anomalies shall be verified by a third WT operator using another wall thickness instrument. These wall thickness readings shall be compared to both the initial and cross check readings in order to confirm the correct reading.

[2] For boiler tubing inspections, where the inspection scope has been issued by Eskom, from the Boiler Health Care System, the NDT contractor shall be issued with a specific list of at least 10% cross checks to be executed. The results of these inspections shall also be captured in the Boiler Health Care system. These cross checks will be used to analyse the integrity of the data. The following rules will apply:

- The inspection data set for a specific inspection instruction will be accepted if at least 80% cross checks are within ±0.2mm of the reported thickness and no more than 5% are greater than ±0.5mm of the reported thickness. The latter 5% shall however be reissued for verification.
- If results are suspected to be fraudulent (for e.g. more than 50% of the cross checks are within ± 0.05mm of the measured value) the inspection data set for the specific inspection instruction will be rejected.
- If more than 25% of the wall thickness data for an inspection area shows an increase in thickness since the last wall thickness survey in that area additional cross checks will be issued.

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- If any anomalies exist during cross checks, an additional 10% cross check per area shall be conducted. In the event that more anomalies are noted, the inspection shall be repeated.

[3] The WT supervisor shall investigate reasons for the anomalies and assess whether it is due to human error or equipment error after which he/she shall take the appropriate corrective actions, which might include recalibration/ replacement of equipment, retraining of personnel, redoing of wall thickness inspection and possible disciplinary action.

[4] The contractor NDT UT Level 3 shall inform the Eskom NDT level 3 of the investigation results during the project.

[5] The Eskom NDT level 3 may elect to revoke the Eskom Approvals of the WT operator or if the Eskom NDT level 3 determines that the problem lies with the NDT service provider, he/she may revoke the Eskom Approval of the NDT service provider.

[6] The NDT UT level 3 of the NDT contractor shall sign off on the investigation findings of the supervisor and shall include it in his/her project report.

[7] For thick walled components where no wall loss mechanisms are suspected to be active, and initial measurement in any area is found to be in excess of ±15% of the design thickness of a component, this must be brought to the attention of the site supervisor, included in the NDT service providers own cross checks.

3.4 REPORTING

[1] The following shall be the minimum detail supplied on the report sheet:

- Wall thickness measured on the thinnest section of a component, or within the limits of a defined measure position on a component. Results presented in the format prescribed by Eskom.
- Material
- Location
- Description and identification of component/part and area tested
- Date of test
- Procedure and revision number
- Equipment used, including calibration dates and serial numbers
- Transducer used, including serial numbers
- Couplant type
- As tested surface condition.
- Resolved limitations.
- Serial number of calibration block used.
- Reference sensitivity (in dBs) when using A scan equipment.
- Name, qualification and signature of technician having conducted the thickness testing.

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4. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Andrew Downes	Chief Metallurgist
Ronnie Scheepers	Corporate Specialist – Turbine
Thobeka Pete	Chief Metallurgist
Marthinus Bezuidenhout	Corporate Specialist – Materials
Shandre Brown	Senior Supervisor Technical Maintenance - Koeberg

5. REVISIONS

Date	Rev.	Compiler	Remarks
September 2015	0	A.C Prins	New Document
17 July 2017	0.1	Zakhele Bhayi	Draft Document – updated by Connie Bunce
04 August 2017	1	Grant Meredith	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

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

- Andrew Downes
- Grant Meredith
- Zakhele Bhayi
- Mark Breetzke

7. ACKNOWLEDGEMENTS

- None.

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