Eskom	Standard	Technology

Title: **Standard for Metallographic Replication Applicable to High Temperature High Pressure Components in Eskom Plant**

Unique Identifier:	**240-75109745**
Alternative Reference Number:	**474-51**
Area of Applicability:	**Engineering**
Documentation Type:	**Standard**
Revision:	**1**
Total Pages:	**23**
Next Review Date:	**March 2017**
Disclosure Classification:	**CONTROLLED DISCLOSURE**

APPROVED FOR AUTHORISATION
☑ TECHNOLOGY ENGINEERING
DOCUMENT CENTRE ☎ X4962

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CONTENTS

Page

FIGURES

1. INTRODUCTION

This procedure details the process to be adhered to when performing metallographic replication on Eskom components. The document details how metallographic replication work is to be performed on high temperature, high pressure components, but can also be used as a guideline for all metallographic replication on other Eskom plant. The procedure also lists the roles and responsibilities of Eskom role players and suppliers of metallographic services involved in the taking of the replicas.

2. SUPPORTING CLAUSES

2.1 SCOPE

The scope of this procedure covers the process of taking metallographic replicas on Eskom pipework. The responsibilities of suppliers and Eskom role players are stipulated in the procedure. The correct use of etchants and which etchants to use on which alloy, is included to ensure consistency of results. To ensure that damage to components is prevented, a directive with regards to minimum wall constraints and post cleaning is detailed.

2.1.1 Purpose

The Purpose of this procedure is to specify the in-situ metallographic replica technique used on high-pressure and principles may be applied on other high temperature components after consulting the Eskom's Metallurgical group.

2.1.2 Applicability

- The following procedure details techniques of surface examination in which a plastic film or fluid lacquer material is used to record images of inhomogenities, both mechanical and metallurgical, as well as the condition of the metal microstructure.
- These techniques have the advantage of being suitable for locations where access is restricted or where the removal of the component is difficult or impossible. The main use within Eskom is the in-situ inspection of highly stressed components on high-pressure turbine components and associated equipment, critical components, components with long replacement lead times and major leading components.
- The technique can also be carried out on the inside of the components where accessible, especially in areas where thermal fatigue is suspected.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

[1] ISO 9001: Quality Management Systems.

[2] EST 32-631: Eskom Approval of Personnel Performing Quality Related Special Processes on Eskom Plant

[3] EST 32-632: Requirements for Non Destructive Testing (NDT) on Eskom Plant

2.2.2 Informative

[4] Metallography Principles and Procedures, Leco Corporation 1977

[5] ASTM E3-11

2.3 DEFINITIONS

Definition	Description
Company	A supplier/contractor approved by Physical Metallurgy section to perform the duties of taking metallographic replicas on Eskom plants
High Alloy Steel	CrMoV all alloys containing >5% Cr but < 12.5% Cr
Low Alloy Steel	CMoV steel, all alloys containing < 5% Cr, < 2% Ni, < 3% Mo
Replica	Replica film mounted on a glass slide and labelled as per this procedure
Replica Film	Acetate film 30 - 50 micron thickness is recommended
Site Rep	An Eskom appointed Metallurgical Engineer / Technologist / Advisor that is responsible for advising a Power Station with regard to remaining life analysis of high temperature high pressure components
Stainless Steel	All alloys containing > 12% chromium

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
BMW	Bi-metallic weld
DM	Departmental Manager
DQR	Division Quality Representative
ESMQR	Eskom Metallographic Quality Representative
FA	Functional Administrator
HAZ	Heat Affected Zone
LM	Laboratory Manager
METALL	Metallographer
MSV	Materials, Stress & Vibration
MSVM	Materials, Stress & Vibration Manager
MT	Material Technology
NDE	Non-destructive examination
PSM	Power Station Manager
SR	Metallurgical Site Representative
WT	Wall Thickness

2.5 ROLES AND RESPONSIBILITIES

2.5.1 Action by the Power Station

- The Power Station Manager will ensure that this procedure is implemented on site

The Power Station will ensure that only Eskom approved suppliers (https://hyperwave.eskom.co.za/0x936e3246 0x0225ba7a) are used to perform metallographic replication.

The Power Station will ensure that all suppliers adhere to this procedure.

The relevant Power Station project manager will ensure that the correct flow of replicas is followed.

Quality related issues rose by the ESMQR or Metallurgical Site Representative will be managed and addressed by the Power Station and the Company.

2.5.2 Action by the DM/Section

- Give the Power Station advice on area/SOW where replication should be carried out.
- The DM shall ensure that all staff in the Research Testing and Development section implements this procedure in full.
- The Physical Metallurgy section personnel are responsible for maintenance of this procedure.
- An Eskom approved Metallurgist (ESMQR) shall be responsible for ensuring that the metallographic replica technique is performed according to this procedure.

2.5.3 Action by Site Representative

- Confirm the geographical area (Middelburg/Rosherville) where the replicas should be delivered with the Power Station and Company. Arrange with FA when to receive the replicas. The SR is responsible for correct flow of replicas between the Company and FA/METALL as well as information between FA/METALL and the Power Station/Company
- Action all concerns from METALL to the system engineer or Power Station project management
- Involve the ESMQR in resolving replica quality/flow problems with the replica taking company
- Carry out remaining life assessments on replicated components
- Assists the ESMQR in ensuring that the metallographic replica technique is carried out according to this procedure
- Review replicas with damage/defects by own evaluation

2.5.4 Action by Eskom quality representative

- Perform replica taking training of staff.
- Ensure replica taking procedure is adhered to by all suppliers
- Approve all replica taking suppliers. Need to ensure that the list in HyperWave is kept updated for record purposes.
- Keep record of all the replicas evaluated and record all rejected replicas as a percentage of total replicas evaluated per supplier.
- Liaising with suppliers in case of quality problems.
- Confirming of positions replicated and re-taking of replicas as a round robin study.
- Site visits to power stations to ensure compliance to the procedure.

2.5.5 Action by FA (Principle Clerk)

- All replica boxes to be received by one of the Principle Clerks at Rosherville or in Middelburg
- No replicas will be accepted without a transmittal sheet. Transmittals will not be accepted without thickness measurements.
- The Principle Clerk must check the number of replica boxes against the transmittal sheets.

- The transmittal sheets must be signed by both parties and the date and time the boxes are received must be on the transmittal sheets.
- The Company must keep the copy of the transmittal sheets signed by the Principle Clerk.
- The Principle Clerk must keep the copy of the transmittal sheets signed by the Company.
- The Principle Clerk will check the labelling of the replica boxes and slides and confirm the number of slides in the boxes against the transmittal sheet.
- When boxes are found to have been labelled incorrectly, they will be rejected and the Company must re-lift those replicas.
- The Company must correct any faulty transmittals immediately.
- The replica boxes must then be taken to the Replica Evaluators.

When the company wants to deliver replica boxes after hours or over weekends,

- The Company must contact the Site Rep supporting that Power Station to make special arrangements on when and where deliveries will happen and how signing of transmittal forms will be effected. Replicas left by security will only be checked and signed when FA or SR receive them from security – even if it is some days after delivery to security.

All Transmittals are to be scanned and loaded on HyperWave (https://hyperwave.eskom.co.za/0x936e32460x01e8c85e) for record purposes.

2.5.6 Action by the Company

- The Company is responsible for the quality and integrity of the replicas taken by their employees and ensuring that the replicas are taken and labelled in accordance with this procedure. A competent supervisor/ Metallurgist who will be responsible for quality of replicas must be appointed by all Companies and approved by the ESMQR.
- The Company shall ensure that its employees have been approved by Eskom. The Company shall ensure that all quality control is done at a magnification of 400/500:1 by the Eskom approved supervisor.
- The Metallurgist must ensure that his staff will adhere to this procedure. Any deviation from this procedure must be communicated and approved by the Eskom SR.
- The Company will be responsible for the delivery of all the replicas to the Rosherville and/or Middelburg laboratory. The company will be advised by the SR where the replicas must be delivered.
- The company will ensure that all replicas sent to Eskom will be of the required quality i.e.
  - Level of scratches
  - Level of etching
  - Size of film that can be evaluated – minimum size of 10mm X 40mm
  - At least 15mm Parent Metal and 10mm WM must be visible in case of replication on welds
  - Replicas are correctly labelled
  - Transmittal forms are correct and complete
  - Lines are walked with drawings and all components are correctly labelled (confirm with SR)
- The company must provide a delivery or transmittal sheet with all replicas. It is also recommended that the company take note of any visual anomalies such as macro cracking, weld anomalies or any geometric anomalies and report to the ESMQR or SR.

- The company to provide a list of all the areas replicated with the wall thickness measurements taken before and after replication
- The system engineer and the contractor should sign on prior to the job and after the job is completed.
- Should a company use an in-house procedure, this procedure must be approved by the ESMQR. In case of any disputes, the Eskom procedure shall prevail

2.6 PROCESS FOR MONITORING

It is the responsibility of the Eskom Materials quality representative (ESMQR), to monitor performance of contractors by arranging quality spot checks as and when required. It is expected that the Company will do its own process monitoring in the form of spot checks of which the results are shared with the ESMQR.

2.7 RELATED/SUPPORTING DOCUMENTS

Document Code	Document Title
474-268	Metallographic Replication Procedure Applicable to High Temperature High Pressure Turbine Components on Eskom Plant

3. METALLOGRAPHIC REPLICATION PROCESS

3.1 METALLOGRAPHIC REPLICATION PROCESS

In high pressure pipework systems, there are various areas which are susceptible to creep, fatigue or a combination of the two. The components examined will ultimately be governed by a holistic approach, as directed by the SR and captured in scopes of work.

- The scope of the inspection shall be negotiated with, and agreed to by SR prior to inspection. Recommendations from the OEM and other relevant sources, own experience and the specific plant design must also be considered when compiling the final scope of inspection.
- When a component is re-replicated, the area that is examined shall be as near as possible to the area of the previous examination, subject to minimum wall thickness not being violated and component integrity.
- In all cases the depth of grinding to remove the oxide layer shall be restricted to the minimum. The minimum wall thickness must at no time be violated and during investigative grinding, frequent thickness measurements must be taken. The maximum allowable depth of grinding and minimum allowable thickness in the replica area shall be clarified through consultation with the SR in charge. If NDE was performed, the examination will reveal where additional replicas must be taken. These must be confirmed with the SR. Other areas that are also examined are those where geometry changes occur, where the component is thinnest, and where there is the possibility of external loads on a component.
- Only personnel qualified by this procedure are allowed to carry out any replica taking duties on Eskom site

3.2 LEVELS OF APPROVAL FOR PERSONNEL

The following personnel, in accordance with their specified qualifications are allowed to perform metallographic replica taking of high temperature turbine components at Eskom plant.

3.2.1 Preparation Technician

An individual approved to this level:

- Shall be qualified to carry out grinding and/or polishing of surfaces as per the approved Company procedure
- Shall understand drawings allocating positions where replicas must be taken
- All work and reports generated by a preparation technician will be reported to, agreed with and countersigned by an approved replica supervisor

3.2.2 Wall Thickness Technician

An individual approved to this level:

- Shall have a minimum requirement of UT Wall thickness at an ISO approved training facility
- Shall be approved by Eskom's NDT Level lll
- Results reported by Level l must be countersigned by a Level ll/lll in that discipline
- UTWT shall not be conducted, under any circumstances, by non –approved personnel

3.2.3 Replica Technician (Level 1)

An individual approved to this level:

- Shall be qualified to perform all replication tasks as per the approved Company procedure excluding evaluation of replicas. They must mark replicas correctly by writing component and position information on the slide.
- Shall supervise, train and assist the replica surface preparation technicians.

Shall complete report forms for evaluation (sketches showing replica positions included)

3.2.4 Replica Supervisor (Level 2)

An individual approved to this level must be a Metallurgical engineer or technologist and:

- Shall be qualified to undertake full responsibility for all that concerns the taking of replicas for and on behalf of Eskom.
- Shall be responsible for:
    - the correct marking of components and areas to be replicated as per the drawing. All deviations must be agreed with the SR and Power Station systems engineer and drawings must be updated to reflect the correct status
    - etchants were prepared correctly and correct etchants were used
    - ensure that minimum wall thickness tolerances are not violated during the replica process
    - the evaluation of all replica to ensure the correct quality before delivery
    - the correct labelling of replicas, boxes and transmittals with correct wall thickness data
    - report preparation, with respect to the quality and integrity of the replicas taken prior to transmittal of replicas for further evaluation
    - shall regularly assess the performance of all replica personnel during the actual replica operations, in order to establish whether correct operating procedures are being adhered to.

  - shall ensure that replicas are delivered on time and at the agreed location and that the transmittal forms are signed off correctly
  - shall arrange to resolve enquiries and re-work
- Shall regularly assess the performance of all replica personnel during the actual replica operations, in order to establish whether correct operating procedures are being adhered to.
- Shall ensure that minimum wall thickness tolerances are not violated during the replica process
- Shall be accountable for the choice of etchants, communication with Eskom's Chief Metallurgists, work flow, quality control, cleanliness and safety of replication activities on the turbine components

Note: It is preferable that supervision is direct; however Eskom recognises that this is not always possible. A supervisor's presence is mandatory at the start up and at the completion of an inspection activity. The maximum interval between contacts shall not exceed two working days and communication shall be possible by radio, telephone or other agreed means.

3.3 POSITIONS TO BE REPLICATED

The size of the areas that are prepared for replication must be polished and etched without any rejectable defects to ensure that the following metallographic evaluation is possible on a slide/film:

- Size of film that can be evaluated – minimum size of 10mm X 40mm

- At least 15mm Parent Metal and 10mm WM must be visible if the replica is taken across a weld.

➢ **Pipe Bend**

Unless stated otherwise, following applies to routine replication:

- On pipe bends and elbows, the critical zone for the initiation of creep damage is the exterior surface of the bend. To ensure that a representative evaluation of the bend is obtained, four sets of two replicas (eight in total) shall be taken. Bends are typically replicated in locations on the extrados at position A (U/S), D (Mid) and G (D/S) and one position on the intrados at position D (Mid). See Figure 1a in appendix A for detail.
- Replicas are placed longitudinally in the direction of flow on the extrados and intrados, see Figure 1b & c in appendix A for details. US and DS must be clearly noted.

When non- routine inspections are called for, i.e. premature life exhaustion assessment or for other reasons, the replication scope could be extended by the responsible SR to include the neutral axis of the bend, or the intrados or any other areas as determined by him/her.

➢ **Branch, Stub and Attachments Welds**

Unless stated otherwise, the following applies to routine replication

- Two areas per stub or attachment weld which must be both flanks as per Figure 2a in Appendix A, the two flanks will be 9 o'clock and 3 o'clock positions for this example. If the stub is <15mm thick, only replicate on the pipe side (or header side) of the weldment. Otherwise, replicate the stub side of the weldment as well. On attachment blocks, always do the pipe side replicas only. ***Note:*** *Stub means that the welded component can freely move with the main pipe or header- no line is attached to the stub.*
- Four areas per branch weld (Internal diameter greater than 50 mm on both flanks & crotches). As per Figure 2a in Appendix A, the four areas will be 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock

positions. If the branch is <15mm thick, only replicate on the pipe side (or header side) of the weldment. Otherwise, replicate the branch side of the weldment as well. ***Note:*** *Branch means that the welded component cannot freely move with the main pipe or header as another line is attached to the main pipe via branch connection*

- Replicas must be taken across the weld and HAZ including part of the parent metal (min 15mm), see Figure 2b in Appendix A for detail.

When non-routine inspections are called for, i.e. premature life exhaustion assessment or for other reasons, the replication scope could be extended or changed to be different to the standard discussion above by the responsible SR.

➢ **Butt Weld**

Unless stated otherwise, the following applies to routine replication:

- Four areas are done per butt weld (12:00, 3:00, 6:00 & 9:00), see Figure 3a for detail.
- One area consists of four replicas (2 U/S & 2 D/S), see Figure 3b for detail.
- Replicas must be taken across the weld and HAZ including part of the parent metal (min 15mm), see Figure 3b in Appendix A for detail.

When non-routine inspections are called for, i.e. premature life exhaustion assessment or for other reasons, the replication scope could be extended or changed to be different to the standard discussed above by the responsible SR.

➢ **Seam Weld**

Unless stated otherwise, the following applies to routine replication:

- Three areas are done per seam weld (two triple points and one on the mid-point between the triple points), Replication to be carried out across the seam weld/ parent metal interface as well as the triple point. The mid-point consists of four slides, two on each opposite side of the seam weld as per Figure 4a in Appendix A. The numbering of these slides should be as per Figure 4c in Appendix A. To avoid mix-up of transverse replicas, additional indications must be used to describe the positions, i.e. right hand side, unit 1 side, etc.
- Replicas must be taken across the weld and HAZ including part of the parent metal.

When non-routine inspections are called for, i.e. premature life exhaustion assessment or for other reasons, the replication scope could be extended or changed to be different to the standard discussed above by the responsible SR.

3.4 SURFACE PREPARATION

When a decision has been made regarding which components are to be replicated, the appropriate areas shall be marked by the level 2 Replica Supervisor (agreed by the systems engineer and SR) and then prepared using the following procedure:

3.4.1 Depth of Replication

The following replication depths must be adhered to:

- 0.5 – 0.8 mm on all low alloy areas not yet replicated;
- 0.5 – 1.0 mm on all X20 components with WT <25 mm, for areas not yet replicated;

- 1.5 – 1.8 mm on all X20 components with WT >25 mm, for areas not yet replicated;
- 0.3 – 0.5 mm on previously replicated areas if replicating again.
- Depth of replication on components <15mm must be provided in writing and specifically by the SR
- No replication to be done on the stub/branch side of a stub/branch with WT<10mm. In this case, replication should be done on pipe/header side only

Depth control grooves or punch marks must be made over the entire replication area before any grinding, to ensure a homogeneous and correct depth.

Wall thickness (WT) measurements must be taken in thinnest areas before replication of the area and after replication, to indicate approximate depth and minimum WT remaining. On areas where before and after replication wall thicknesses are not possible due to geometry, grinding should only be done after consultation with SR.

The WT and depth measurements must be recorded in the transmittal sheets and submitted with the replicas. Replica Technicians may use profiling technique to manage the material removal during grinding.

3.4.2 Rough Grinding

- Before grinding, the actual and calculated minimum wall thickness must be established, and during preparation the minimum wall thickness may not be violated without prior approval in writing by the SR in charge.
- Rough grinding is carried out using a light angle grinder with the main objective being to remove heavy oxide deposits from the surface and to expose bare metal. Care shall be taken to ensure that the surface is not over heated or burnt, and that sufficient material is removed to eliminate residual oxide.

3.4.3 Intermediate and Fine Grinding

- This operation is generally carried out in two steps, firstly using an electrically powered tool with fanned grinding segments (flap wheels) of successively finer grades from 80 to 320 grit followed by silicon carbide grinding (using a “transpol” or other light grinding unit) paper of successively finer grades i.e. 320, 500, 800 and 1200. It is important to use at least 6 progressively finer grinding steps to ensure ease of removal of previous deformed layer. More steps can be advantageous.
- To ensure optimum quality, it is important to use SLIGHT pressure and speed during grinding. For intermediate grinding, a speed of no more than 3000 rpm is recommended. For fine grinding, the speed of not more than 600 rpm is recommended. Change the direction of polishing or grinding after each grinding step and ensure that the old deformed layer is removed each time. It is also important to clean each area before the next grinding or polishing step commences. Especially for polishing media, it is recommended that high quality products be used.
- Ensure an adequate area is cleaned and free of dust and white background paint, if MT was carried out prior to replication.
- Care must be taken to ensure that all grinding marks from the preceding grade are removed before moving to the next grade.
- Adequate lighting is essential for satisfactory results.

3.4.4 Polishing

The polishing operation is aimed at producing a smooth, uniform, mirror-like surface finish similar to that produced in a metallographic laboratory.

- The procedure describes the use of Struers “transpol” unit. Though other power units and polishing methods may be employed, the basic procedure shall remain the same.
- In each instance the polishing step is lubricated with a suitable polishing extender (most diamond paste solutions already contain polishing extender).
- Thoroughly clean the surface with Methanol and a cotton wool swab; flush the surface with Methanol.
- Polishing cloths should be changed on a regular basis, old and slightly warn cloths introduce lots of artefacts and leads to uneven polishing and under polishing.
- Using a polishing cloth (mol or felt type cloth), moderate pressure and 6 µm diamond paste/suspension, all polishing marks from the preceding 1200 grit (equivalent to 15 µm surface finish) grinding step should be removed (3 minutes is a good guide to achieve this).
- Flush and swab the area clean using Methanol, ensure that it is dry before proceeding.
- Using a polishing cloth (mol or felt type cloth), light pressure and 3 µm diamond paste/suspension to remove any marks from the preceding 6 µm diamond paste/suspension (2 minute is a good guide to achieve this).
- Flush and swab the area clean using Methanol and ensure that it is dry before proceeding.
- Using a suitable etching solution (3-5% Nital for low alloy steels) the area shall be etched using a swab or by continuously wetting the area with the etch solution for approximately 20 - 30 seconds and methanol should then be used to flush and dry the area. This is to check for scratches that must not be carried to the subsequent stages
- Using a polishing cloth (felt type cloth), moderate pressure and 1 µm diamond paste/suspension, all polishing marks from the preceding 3 µm step should be removed (1-2 minutes is a good guide to achieve this). The etched structure should be removed at this stage.
- Flush and swab the area clean using Methanol, ensure that it is dry before proceeding to final etching.
- The area is now ready for etching.
- During the polishing process the polishing direction must be changed every 30 seconds to ensure that directional polishing is not introduced into the surface.

3.4.5 Etching

Etching is a controlled preferential attack on the material surface for the purpose of revealing the microstructure. For optimum etch quality, fresh etchant must be mixed every two days and chemicals used in etchant must be kept constant to avoid varying quality. For Villella’s vital reagent the etchant must be freshly made every day.

Etching time is dependent upon several variables i.e. material temperature, material composition, etchant concentration, etchant age and quality of the polished surface. For this reason it is not always possible to assign a fixed etching time etc. Etching can be done using a fixed time as a guide but should still be judged visually by experienced technicians. The surface is etched until it is an even, dull, blue/grey colour. The correct degree of etching is best judged by experience, not by timing only.

The following two stages of etching is recommended as guide line for low alloy steel as explained partly in the polishing section (times stated below should be used as a guideline and must be subjected to the judgement of an experienced technician):

- Etch for at least 30 seconds after the first 3 µm diamond paste/solution polishing step.
- Final etching for 30-60 seconds after 1 µm diamond paste/ solution polishing step

The following three stages of etching is recommended as a guideline for X20CrMoV121 and P91 (times stated below should be used as a guideline and must be subjected to the judgement of an experienced technician):

- Etch at least for 30 seconds after the first 3 µm diamond paste/solution polishing step.
- First etch for 45-60 seconds after the 1 µm diamond paste/solution polishing step. Proceed to take the replica, clearly marking as first etch.
- When acetate films of first etch has dried, remove film and clean area using Methanol.
- Progressive etch for 10-15 seconds after removing acetate film placed on first etch and take second replicas. Proceed to take a replica clearly marking second etch.

When a BMW is replicated it is important to first etch the low alloy side (etch with Nital), take first replica then the X20CrMoV121 side (double etch with Villelas reagent), and take second replica on the X20CrMoV121 side only

After replication, no evidence of any polishing consumables or etching solutions must remain in the polished area. Marks must be removed by light grinding with 400 grit paper and cleaning with alcohol. The entire component should be clean and dry from any etching and polishing consumables.

➢ Etchants

Ensure that the polished area is clear of any polishing compound or oils by cleaning with acetone.

The etchant to be used will be determined by the requirements and is not restricted to the list as stated below. The etchants listed below are the standard etchants to be used on the various steels. Any deviations from this list must be discussed with the Chief Metallurgist. Damage mechanisms like stress corrosion cracking can be initiated if incorrect chemicals are used, if the components are not properly cleaned and if the etching is not controlled so as to contain it only on the area of interest. From the few last years, pitting induced by aggressive echants was noted on coil retaining rings on Eskom plant.

- For Low Alloy Steels

  3-5 % Nital = 3-5ml Nitric Acid (HNO_3) + 97-95ml Methyl Alcohol

- For High Alloy Steels X20CrMoV121 & P91

  Villelas reagent = saturated solution of picric acid in high purity propanol mixed with HCl. Saturation is obtained by stirring the picric acid in propanol (at least 10g picric for 100ml propanol) at a temperature of 30 - 40°C for at least 2 hours. For every 100ml of saturated alcoholic picric solution, 5ml of HCl should be added. A good indication to ensure that a saturated solution of Picric acid has been achieved is when a thin gel forms when HCl is added.

- For Stainless Steel (Get SR approval before using this)

  Mixed acids = 1 part Hydrofluoric Acid (HF), 1 part Nitric Acid (HNO_3), 2 parts demineralised water (H_2O).

  Marble's Reagent = 4 gram of copper sulphate, 20ml of hydrochloric acid (HCl) & 20 ml of water (H_2O).

  Other electrolytic etching techniques will most likely be preferred by the SR and must be prescribed in writing when Stainless steels and other materials are replicated.

3.5 APPLICATION AND REMOVAL OF THE REPLICA FILM

Ensure that all etchants have been cleared from the surface by cleaning with methanol (wet cotton wool swab is normally required). Clearing etchants with acetone is not recommended prior to replica film removal because it is aggressive and can be the cause for surface contamination and poor washing.

- Prior to use, acetate film must be cut into suitably sized pieces. (Minimum 50mmX15mm). The acetate film must be free from dust.
- To apply the film, a strip is dipped into acetone for approximately 2 seconds. The film is then applied without pressure to the polished surface. Care shall be taken to minimise the amount of air trapped under the film. The replica is carefully peeled off after it has completely dried and secured impression face upwards to a glass microscope slide.
- The film must be applied in such a way that will prevent bubbles and ripples on the side. It is known however that usage of 30-50 micron acetate film and due to the porous nature of some castings, ripples and some small bubbles that cannot be prevented are formed respectively.
- The film must be correctly mounted on the glass slide (not upside down) and care should be taken not to touch the impression side of the replica at any time during the mounting process. (the structure and voids can easily be flattened leading to a non-representative sample)
- After mounting the replica, the minimum information must be written in pen on sellotape to correctly identify the replica.
- The area and component replicated should be left clean and dry.

Note: *Dependent upon the ambient/material temperature, the film will detach itself from the surface which might lead to a loss of the replica.*

After polishing and etching, it is critical that the replicas are taken immediately to prevent pitting of the surface. Once polishing started, a break cannot be taken by the technician until the replica is lifted. If a break was taken, commence at least with fine grinding and ensure that the area is left dry during the break.

3.6 POST REPLICATION CLEANING

The polishing and etching compounds can be detrimental to components replicated and the environment. The Company should ensure that their employees do not leave any traces of metallographic preparation consumables after replication on the components. Polishing compounds/consumables as well as etchants should be cleaned with methanol and acetone immediately after the replication has been completed. Marks must be removed by light grinding with 400 grit paper and cleaning with alcohol. The entire component should be clean and dry from any etching and polishing consumables.

The Company should ensure that the cleanliness is consistence with each component replicated.

3.7 COMPONENT IDENTIFICATION, LABELLING & TRANSMITTALS

Before work commences, the systems must be walked and visually examined. All the components must be correctly marked as per the inspection drawings supplied. If anomalies exist between the system and the drawings, the drawings must be updated to reflect the true situation, before replication commences. The SR must be informed of any changes.

The component numbers on the replicas must at all times be correct and be reflected on the updated drawing used during the replication process and supplied after the outage.

To avoid mix-up of areas, If replication is done on a previously replicated area, the replica label & transmittal must indicate “old” after the replicated position unique number to clearly identify the history of the area.

Care must be taken not to touch the replica film during labelling, and to work meticulously to ensure correct numbering.

The replicas shall be stored in conventional microscope slide storage boxes, away from dust, damp and extreme variations in temperatures.

When a replica is lifted, the component and area and the unique number, i.e. Inner Casing RT 3, must be written in pen on the mounting tape. During this step absolute care must be taken to use the correct component and area description.

The following information must be shown on each slide:

- Power Station, Unit, System – *Duvha, U6,MS Pipes*
- Date – *Sep 2012*
- Component No/Name. – *Butt weld RA 11.1011*
- Replica unique No – *3:00 (U5 side), U/S, No.1(old)*

The areas of a specific component must not be mixed between boxes.

The replicas of different systems (Rotor & Steam Chest) must not be together in one box.

Each box must have a unique number and must contain the following information:

- Unique Box No., Date – *Box MS 1, 12 September 2012*
- Power Station, Unit, System – *Duvha, U6, MS Pipes*
- Component No. – *RA11.101 1*

The boxes in which repeated replicas (either due to poor quality or additional work) are submitted should reflect the box number of the original component. For example – if unique No RT3 from Box TC26 was rejected due to dust, the replica box should be labelled TC26-R1, and if additional work was requested on unique No RT3, the replica box should be labelled TC26-E1.

Each box must be indicated on a transmittal sheet. Transmittal sheets must contain the following information:

- Power Station, Unit, System – *Duvha, U6, MS Pipes*
- Date – *16 September 2012*
- List the following in table format:
    - Box No.
    - Component type (Butt weld, bend, stub weld, etc.)
    - Component No.
    - Area description (3:00, U5 side, U/S, old)
    - WT before replication
    - WT after replication
    - Depth of replication
    - Comments (no access due to flange, MT defect, etc.)

The boxes of different systems (Rotor & Steam chest) must not be listed together on one transmittal.

3.8 FLOW AND DELIVERY OF REPLICAS

All replicas taken on day 1 must be labelled and transmittals prepared on day 2. The replicas, with FULLY COMPLETED transmittals (WT included if possible) must be handed over to Rosherville or Middelburg not later than 7:00 on day 3 (it can be done on day 2 if it is ready).

Company must ensure good quality before labelling and delivery of replicas

It is the Company's responsibility to hand over the labelled boxes together with the transmittals and wall thickness results to the Rosherville or Middelburg offices.

Daily records of areas replicated, handed over and not yet done must be kept by the Company. Daily progress must be reported in the morning meetings.

Quality problems will be handled via the System Engineer and must be addressed immediately after the problems are detected. All rework due to quality will be repeated on the Company's cost.

Boxes and slides that are incorrectly labelled or requested for re-labelling during or after the outage will not be accepted. Should this happen, boxes and slides will be rejected and the issue will be addressed as a quality issue (Company to retake all at own cost)

Safety, environmental and quality control of the replication process is the full responsibility of the replica Company. Project management of the replication process is also the company's responsibility, they must attend daily meetings to discuss and solve problems.

3.9 REJECTION OF REPLICAS

Metallographic replicas can be rejected for the following reasons:

1. Bubbles – none (treated case by case)
2. Dust – limited to 10 particles/mm^2
3. Scratches - none
4. Etch and cleaning artefacts - none
5. Size of film - refer to minimum size of PM visible
6. Incorrect marking – not acceptable
7. Replicas not mounted correctly (upside down) – not acceptable
8. Replica not flat – not acceptable
9. No transmittal Sheet – not acceptable
10. No evidence of WT measurement – not Acceptable (treated case by case)
11. Damaged Slides – not acceptable
12. Under and Over-polishing or etching – not acceptable

4. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
MEJ Bezuidenhout	Corporate Consultant
M van Dalen	Eskom NDE level 3
E van Zyl	Corporate Consultant (HP Pipework – GBE)
D Bhimma	Generation Fleet and Technology Manager (GBE)
All	Portfolio Engineering Managers
All	Engineering Managers

5. REVISIONS

Date	Rev.	Compiler	Remarks
January 2014	0.1	T. Ngoasheng	Draft Document
January 2014	0.2	T. Ngoasheng	Draft Document for Comments Review
February 2014	1	T. Ngoasheng	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

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

- O. Netshifamadi
- T. Ngoasheng
- Y. Maharaj
- T. Masilela
- A. Snell

7. ACKNOWLEDGEMENTS

Special thanks to everyone who contributed in compilation of this document

APPENDIX A: DRAWINGS

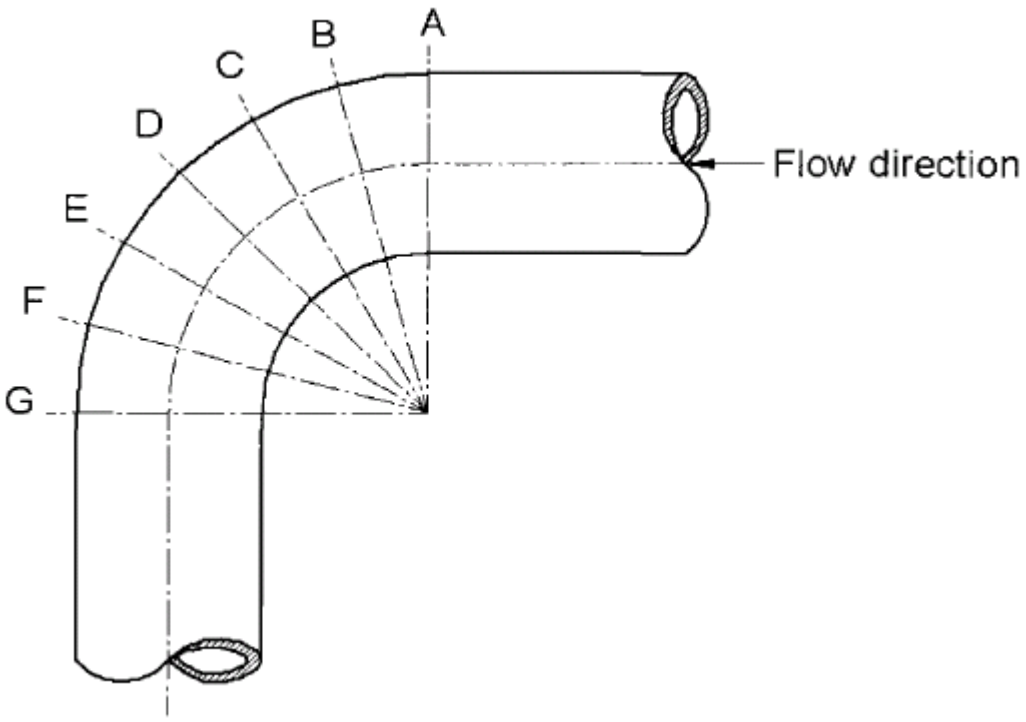

Figure 1a: Bend Location diagram

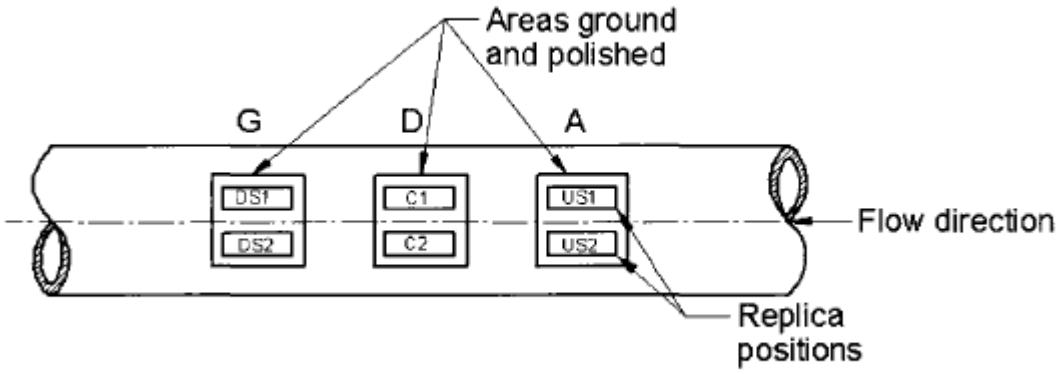

Figure 1b: Replica positions on the Extrados of a Bend. At least 400mm between areas are applicable for bends with an OD of at least 200mm.

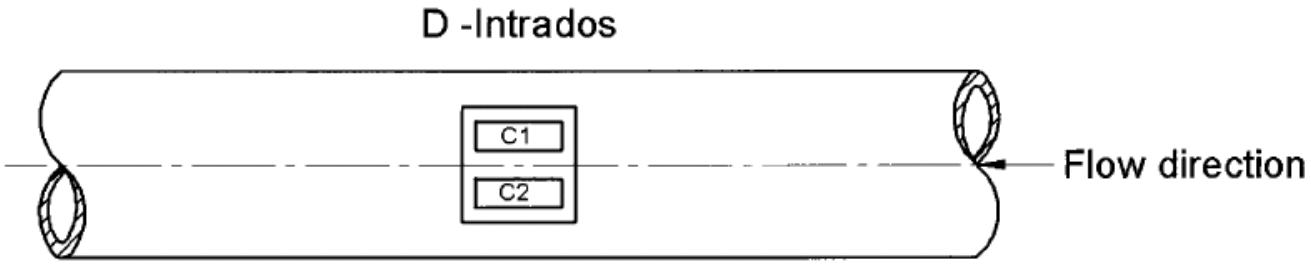

Figure 1c: Replica positions on the Intrados of a Bend

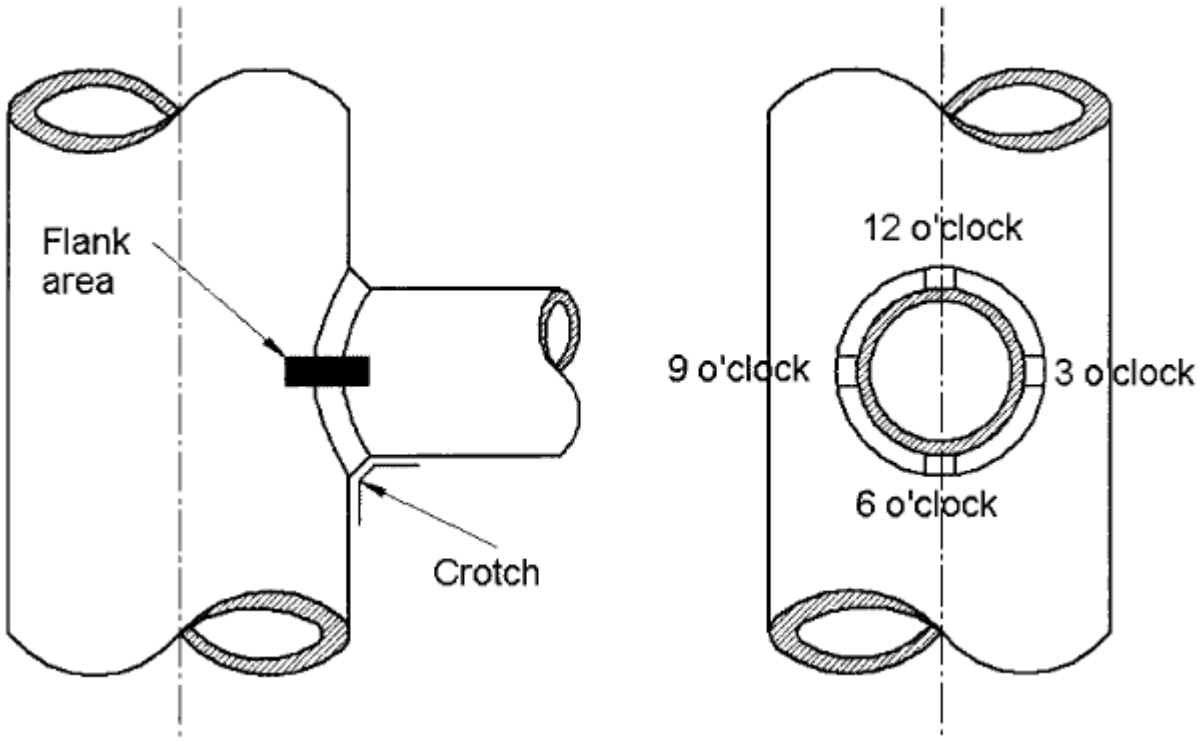

Figure 2a: Typical Branch, Stub & Attachment Weld positions to be replicated.

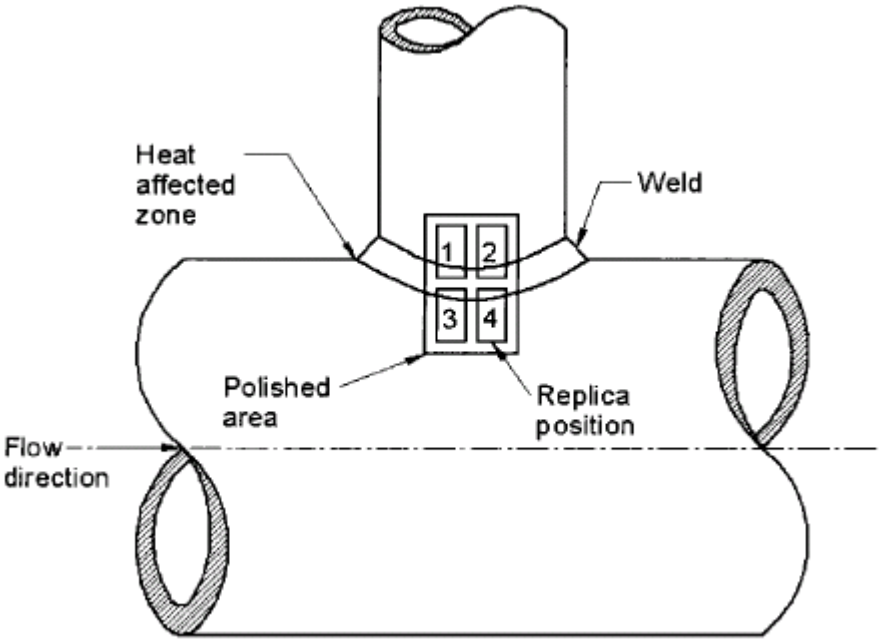

Figure 2b: Replica position on flank side of a branch/attachment weld. Note: If the branch or stub is less than 15mm thick, only do pipe side replicas (#3 and #4)

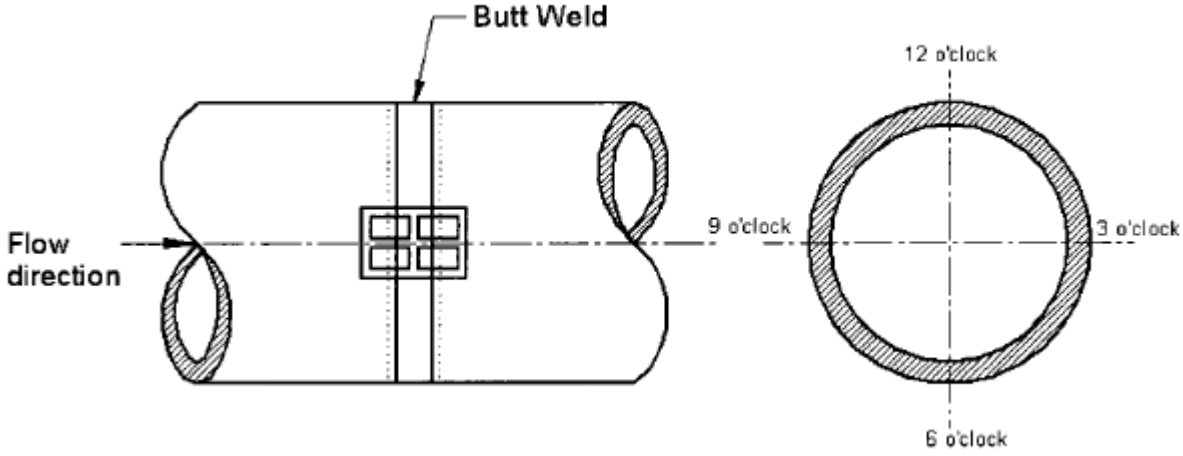

Figure 3a: Typical Butt Weld positions to be replicated.

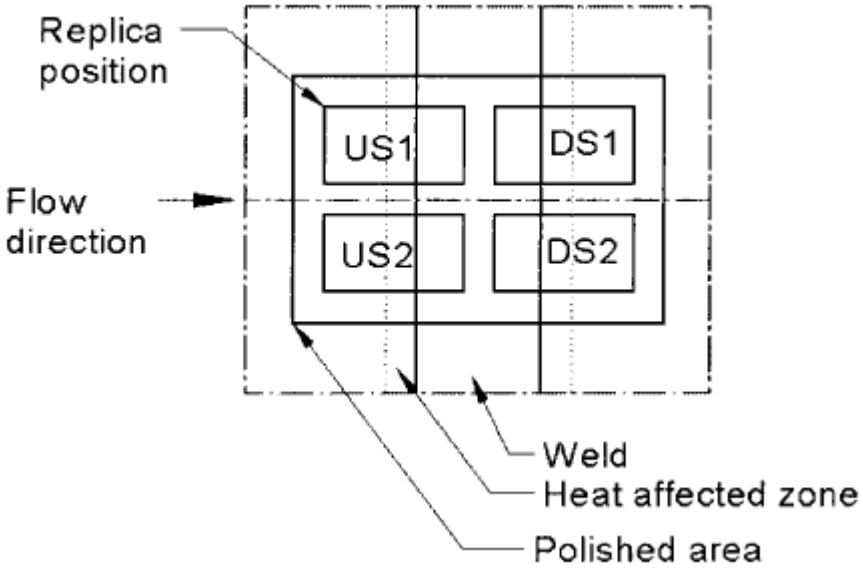

Figure 3b: Typical replica positions across a weld, note inclusion of Weld, HAZ & PM.

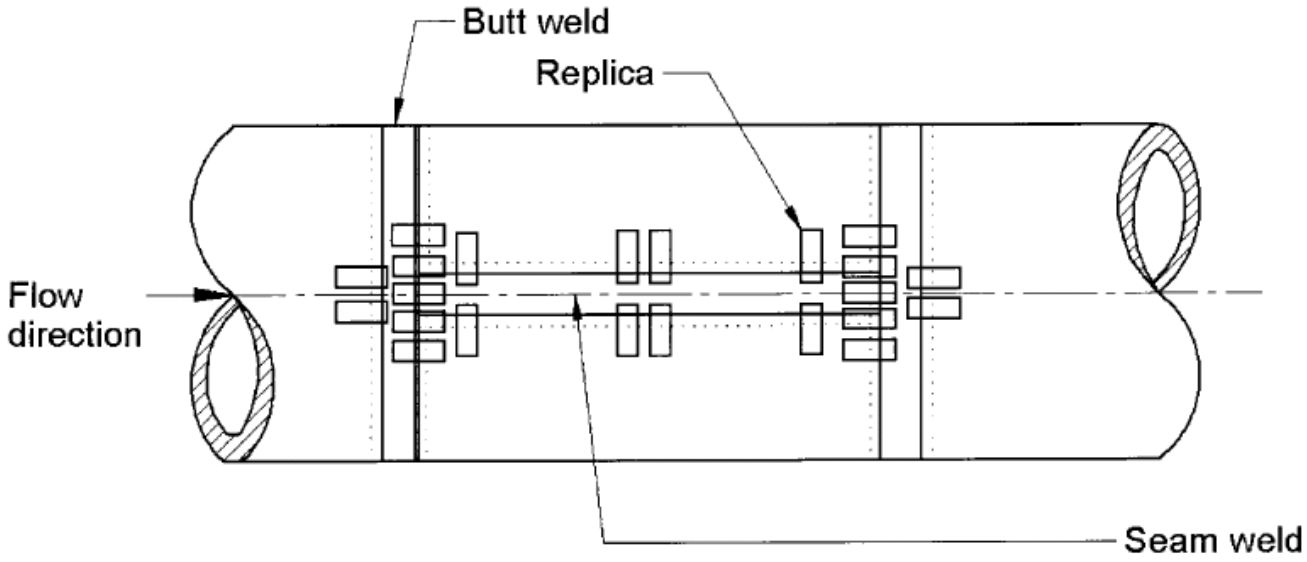

Figure 4a: Typical replica positions on a seam weld.

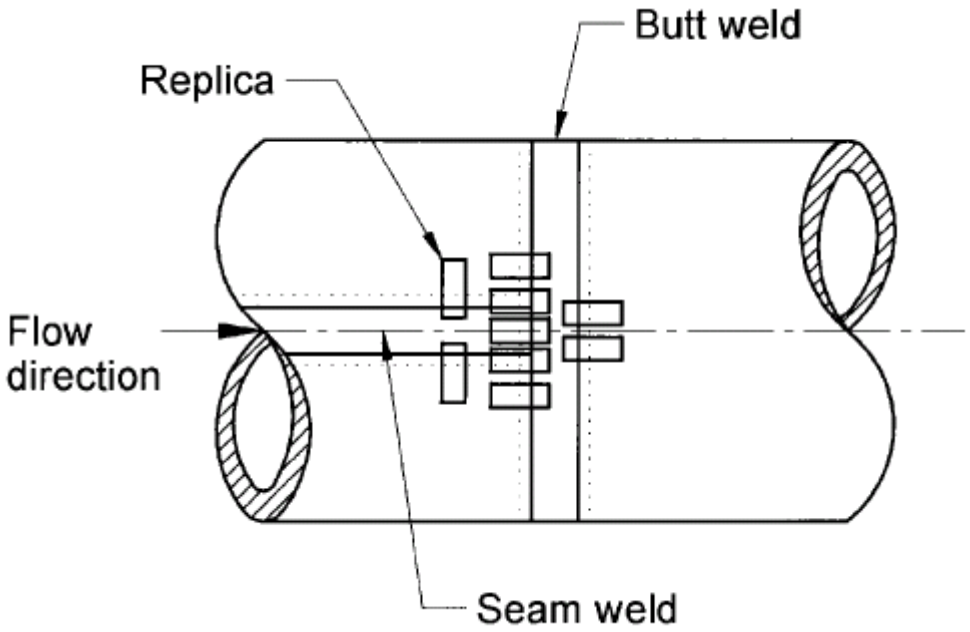

Figure 4b: Triple-Point replica positions on seam weld

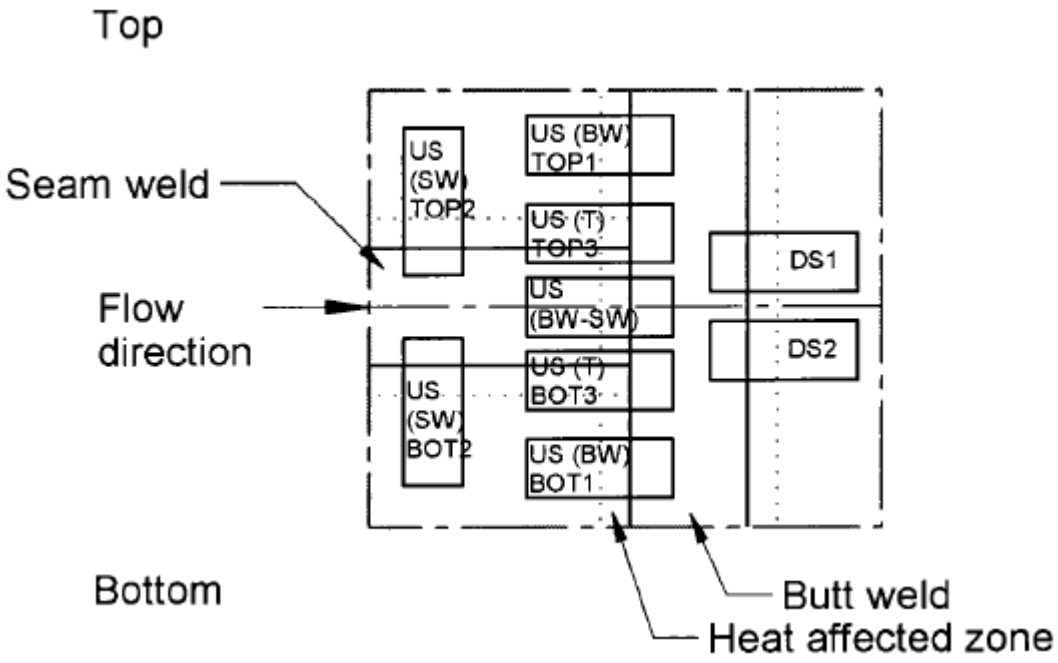

Figure 4c: Triple-Point replica positions and numbering on a seam weld