# Gasunie Technical Standard

Construction Specification Mechanical

CSW-05-E

**Non-destructive testing**

Version 9 *08-11-2018*

© Copyright
N.V. Nederlandse Gasunie
Postbus 19, 9700 MA Groningen (Netherlands)
Telephone +31 50 5219111

## FOREWORD

This specification supersedes the eighth version of CSW-05-E.

With respect to the former version the following has been changed:

- clause 1:
  modified: the rules of the testing methods;
- subclause 2.2:
  adjusted: the reference standards;
- "construction management" has been changed to "project manager";
- various minor changes to implementation requirements;
- added: the acceptance criteria of CSW-01-N/E.

Alterations are marked with a left margin line.

**CONTENTS**

1. SCOPE AND APPLICATION 5
1.1 Standardisation 5
1.2 Dutch "Warenwetbesluit Drukapparatuur" 5
1.3 Transport media 5

2. REFERENCES 6
2.1 Gasunie specifications 6
2.2 Standards 6
2.3 Other references 8

3. DEFINITIONS, ABBREVIATIONS AND SYMBOLS 9
3.1 Definitions 9
3.2 Abbreviations 9
3.3 Symbols 10

4. APPROVAL OF CONTRACTORS 11
4.1 Scope of approval 11
4.2 Organisation 11
4.3 Certification of personnel 11
4.4 Qualification of NDT systems 11
4.5 Qualification of operators 12
4.6 Acceptance standards 12
4.7 Equipment 12
4.8 Quality, Health, Safety and Environment 12
4.9 Third Party Consultants 12

5. GENERAL REQUIREMENTS 13
5.1 Communication 13
5.2 Selection of NDT techniques 13
5.3 Procedures 13
5.4 Reporting 13
5.5 Equipment for verification by Gasunie 14
5.6 Pre-inspection meeting 14
5.7 Right to reassess NDT results 14

6. GUIDELINES TESTING CLAUSES 15

7. RADIOGRAPHIC TESTING 16
7.1 Application of NEN-EN-ISO 17636-1 (January 2013) 16
7.2 Application of NEN-EN-ISO 17636-2 (January 2013), digital radiography 18

8. ULTRASONIC TESTING OF BASE MATERIAL 20
8.1 General requirements 20
8.2 Application of NEN-EN-ISO 10893-8:2011 20

9. ULTRASONIC WALL THICKNESS MEASUREMENT 21
9.1 General requirements 21
9.2 Application of NEN-EN 14127 (February 2011) 21

10. ULTRASONIC TESTING OF WELDS, PULSE ECHO TECHNIQUE 22

10.1 General requirements 22
10.2 Application of NEN-EN-ISO 17640 (December 2017) 22

11. ULTRASONIC TESTING OF WELDS, TOFD TECHNIQUE 23
11.1 General requirements 23
11.2 Application of NEN-EN-ISO 10863 (September 2011) 23

12. ULTRASONIC TESTING OF WELDS, PHASED ARRAY TECHNIQUE 29
12.1 General requirements 29
12.2 Application NEN-EN-ISO 13588 (October 2012) 29

13. AUTOMATIC ULTRASONIC TESTING 32
13.1 Scope 32
13.2 Design of Automated Ultrasonic Testing systems 32
13.3 Signal evaluation multi-probe system 35

14. MAGNETIC PARTICLE TESTING 37
14.1 General requirements 37
14.2 The application of NEN-EN-ISO 17638 (November 2016) 37

15. LIQUID PENETRANT TESTING 38
15.1 General requirements 38
15.2 The application of NEN-EN-ISO 3452-1 (June 2013 –Cor. 2014-05) 38

16. SPECIAL TESTING METHODS 39

17. DOCUMENTATION 40

**ANNEXES**
**A QUALIFICATION OF AUTOMATED ULTRASONIC TESTING SYSTEMS** 41
**B QUALIFICATION OF PA ULTRASONIC TESTING SYSTEMS** 45
**C QUALIFICATION OF NDT OPERATORS** 48
**D MEASUREMENT OF THE DEPTH OF THE SCANNING SURFACE DEAD ZONE** 50
**E ACCEPTANCE REQUIREMENTS FOR WELDS** 53

# 1. SCOPE AND APPLICATION

This specification applies to the non-destructive testing of welds and base materials during the construction of pipelines, stations and installations for Gasunie.

This specification covers the following methods:
- radiographic testing;
- ultrasonic testing;
- magnetic particle testing;
- liquid penetrant testing;
- general validation rules for testing not mentioned in this specification.

This specification contains the following rules for the above mentioned testing methods:
- preparation of the testing;
- execution of the actual testing;
- reporting of the testing results;
- re-testing;
- acceptance criteria.

This specification also describes the rules and method for:
- qualification of equipment;
- qualification of NDT personnel.

## 1.1 Standardisation

This specification is in line with the requirements of NEN 3650-2, NEN 3651, NEN 3653 and EN 12732.

## 1.2 Dutch "Warenwetbesluit Drukapparatuur"

This specification is also applicable for pipelines and/or installations, which have to fulfil the requirements of the "Warenwetbesluit Drukapparatuur".

## 1.3 Transport media

Table 1 indicates the transport media for which this specification is applicable.

Table 1: Transport media

| Transport-medium[1] | Natural gas | Hydrogen | Carbon dioxide | Nitrogen | Hot water | Ammonia |
|---|---|---|---|---|---|---|
| | Applicable | Not judged[2] | Not judged[2] | Not judged[2] | Not judged[2] | Not judged[2] |

1 The table is based on suitability of the transport medium concerned.
The scope and media for which this specification is suitable are not automatically the same as the scope and media of underlying specifications. The scope and suitability for a medium are described for each specification.

2 Suitability shall be determined on the basis of an impact analysis. The requirements that do appear to be applicable shall be observed.

# 2. REFERENCES

This specification is subject to the requirements of the documents mentioned in this clause. If the documents in this specification are mentioned with a date, this specific edition will be applicable.

## 2.1 Gasunie specifications

In this specification reference is made to the following Gasunie specifications:

| | |
|---|---|
| CSA-38-N/E | Veiligheid, gezondheid en milieu op de bouwplaats (tweetalig) / Safety, health and environmental management at construction sites (bilingual). |
| CSW-01-N/E | Het lassen van pijpen, hulpstukken en constructie-elementen (tweetalig) / Welding of pipes, fittings and structural sections (bilingual). |
| CSW-20-N/E | Lassen die niet getest worden op dichtheid en sterkte (tweetalig) / Welds not tested for tightness and strength (bilingual). |
| GTS W-025 | Verification of calibration of the AUT systems. |
| NSW-04-N | Het lassen aan gasvoerende leidingen (Welding on in service pipelines) (internal Gasunie document). |
| OSW-01-N | Leidingklassen voor buisleidingsystemen t.b.v. aardgastransport; medium: aardgas en aardgas-condensaat (Pipework classification for piping systems serving natural gas transportation; medium: gas and gas condensate). |
| TVS 09.0027 | Qualification procedure AUT system. |
| VS 14.0375 | Qualification procedure PA system. |

## 2.2 Standards

In this specification reference is made to the standards[1] mentioned in this subclause. Any supplements and errata notices are also applicable.

| | |
|---|---|
| ASTM E 1961 (2016) | Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units. |
| NEN-EN 12668-1 | Non-destructive testing - Characterization and verification of ultrasonic examination equipment. Part 1: Instruments. |
| NEN-EN 12668-2 | Non-destructive testing - Characterization and verification of ultrasonic examination equipment. Part 2: Probes. |
| NEN-EN 12668-3 | Non-destructive testing - Characterization and verification of ultrasonic examination equipment. Part 3: Combined equipment. |
| NEN-EN 14127 (February 2011) | Non-destructive testing, ultrasonic thickness measurement. |
| NEN-EN-ISO 3452-1 (June 2013-cor 2014-05) | Non-destructive testing - Penetrant testing. Part 1: General principles. |

[1] Applicable for all NEN-EN standards: Depending on the country where the standard will be applied, DIN-EN or BS EN, for example, shall be chosen.

| | |
|---|---|
| NEN-EN-ISO 5817 | Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections. |
| NEN-EN-ISO 6520-1 | Welding and allied processes - Classification of geometric imperfections in metallic materials; Part 1: Fusion welding |
| NEN-EN-ISO 9712 | Non-destructive testing - Qualification and certification of NDT personnel. |
| NEN-EN-ISO 10675-1 | Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys. |
| NEN-EN-ISO 10893-8 (April 2011) | Non-destructive testing of steel tubes - Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections. |
| NEN-EN-ISO 10863 September 2011 | Non-destructive testing of welds - Ultrasonic testing - Use of time-of-flight diffraction technique (TOFD). |
| NEN-EN 12732 | Gas infrastructure - Welding steel pipework - Functional requirements. |
| NEN-EN-ISO 13588 (October 2012) | Non-destructive testing of welds - Ultrasonic testing - Use of automated phased array technology. |
| NEN-EN-ISO 16810 | Non-destructive testing - Ultrasonic testing - General principles. |
| NEN-EN-ISO 16828 | Non-destructive testing - Ultrasonic testing - Time-of-flight diffraction technique as a method for detection and sizing of discontinuities. |
| NEN-EN-ISO 17636-1 (January 2013) | Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film. |
| EN ISO 17636-2 (January 2013) | Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors. |
| NEN-EN-ISO 17638 (November 2016) | Non-destructive testing of welds - Magnetic particle testing. |
| NEN-EN-ISO 17640 (December 2017) | Non-destructive testing of welds - Ultrasonic testing; Techniques, testing levels and assessment. |
| NEN-EN-ISO/IEC 17020 | Conformity assessment - Requirements for the operation of various types of bodies performing inspection. |
| NEN-EN-ISO/IEC 17025 | General requirements for the competence of testing and calibration laboratories. |
| NEN 3650-2 (June 2012) | Eisen voor buisleidingsystemen - Deel 2: Aanvullende eisen voor leidingen van staal - (Requirements for pipeline systems - Part 2: Additional specifications for steel pipelines |
| NEN 3653 | Methods of determination of NDE acceptance criteria for defects in pipeline girth welds. |

## 2.3 Other references

Reference is made in this specification to the following document:

EPRG document "EPRG guidelines on the assessment of defects in transmission pipeline girth welds"; R Denys, R M Andrews, M Zarea and G Knauf, publication of the European Pipeline Research Group.

# 3. DEFINITIONS, ABBREVIATIONS AND SYMBOLS

## 3.1 Definitions

In this specification the following definitions are applicable:

| | |
|---|---|
| Gasunie management | The person or persons who is/are responsible, on behalf of Gasunie, for supervising the observance of the contract in general and the execution of the work in particular. |
| NDT contractor | The company awarded the contract for carrying out NDT for Gasunie or pipeline contractor. |
| Operator | Certified employee of NDT contractor, holding an appropriate level qualification for the technique employed. |
| Pipeline contractor | The contractor responsible for the planning, quality and documentation of the NDT contractor. |
| Level 3 | NDT expert certified according to NEN-EN-ISO 9712, for the technique applied. |
| Reference standard, calibration block | Material with defined reflectors and notches. |
| Tie-in weld | Welds not hydrostatically or pneumatically tested. |
| Transport medium | A gaseous or liquefied substance that is transported by and/or stored in a Gasunie transport network; limited to:<br>– natural gas;<br>– hydrogen;<br>– carbon dioxide;<br>– nitrogen;<br>– (hot) water;<br>– ammonia.<br>Additives and other substances used in the medium or in the processes are therefore expressly outside the scope. |

## 3.2 Abbreviations

In this specification the following abbreviations are applicable:

| | |
|---|---|
| AC | Alternating Current |
| AUT | Automated Ultrasonic Testing |
| DGS | Distance Gain Size (German: AVG = Abstand Verstärkung Größe) |
| DN | Diameter Nominal |
| DWDI | Double Wall Double Image |
| DWSI | Double Wall Single Image |
| HiLo | High - Low (= alignment) |
| FBH | Flat Bottom Hole |
| FSH | Full Screen Height |
| HAZ | Heat-Affected Zone |
| IQI | Image Quality Indicator |
| MT | Magnetic (particle) Testing |
| NDT | Non-Destructive Testing |
| PA | Phased Array |
| PAUT | Phased Array Ultrasonic Testing |
| PCS | Probe Centre Separation |

| | |
|---|---|
| PE | Pulse Echo |
| PIM | Pre-Inspection Meeting |
| PO | Purchase Order |
| POD | Probability Of Detection |
| QC | Quality Control |
| QHSE | Quality, Health, Safety and Environment |
| SWSI | Single Wall Single Image |
| ToFD | Time of Flight Diffraction |
| SDH | Side Drilled Hole |
| UT | Ultrasonic Testing |

## 3.3 Symbols

In this specification the following symbols are applicable:

| Symbol | Description | Unit |
|---|---|---|
| $a$ | depth of scanning surface dead zone | mm |
| $D$ | Density of the radiographic image | 1 |
| $h_{90\|50}$ | Defect height which is detected with 90 % probability and 50 % confidence | mm |
| $h_{90\|95}$ | Defect height which is detected with 90 % probability and 95 % confidence | mm |
| $h$ | Height | mm |
| $\Delta h$ | Difference in detected and actual defect height in radial direction (height) | mm |
| $h_{AUT}$ | Defect height determined by the AUT system | mm |
| $h_{do}$ | Actual defect height (after destructive testing) | mm |
| $h_{PA}$ | Defect height determined by the PA system | mm |
| $h_1$, $h_2$, $h_3$ | Maximum amplitude of lateral wave | % FSH |
| $l$ | Length | mm |
| $l_{max}$ | Maximum permitted length of the weld defect in circumferential direction. | mm |
| $\Delta l$ | Difference in detected and actual defect length in circumferential direction (length) | mm |
| $l_{AUT}$ | Defect length determined by the AUT system | mm |
| $l_{do}$ | Actual defect length (after destructive testing) | mm |
| $l_{PA}$ | Defect length determined by the PA system | mm |
| $m_1$, $m_2$ | Measuring point for determination dead zone | mm |
| $R_{e,max}$ | Maximum yield strength | MPa |
| $t$ | Wall thickness | mm |
| $t_{nom}$ | Nominal wall thickness | mm |
| $U_t$ | Tube potential | kV |

# 4. APPROVAL OF CONTRACTORS

All NDT shall be carried out by contractors approved by Gasunie.

## 4.1 Scope of approval

Following activities are subject to an approval:
1. phased array testing of welds, see clause 12;
2. automated ultrasonic testing of welds, see clause 13;
3. special testing methods, see clause 16.

## 4.2 Organisation

The NDT contractor shall have an accredited quality assurance system, with the relevant scope, to NEN-EN-ISO/IEC 17020 or NEN-EN-ISO/IEC 17025.

## 4.3 Certification of personnel

The NDT personnel employed by the NDT contractor performing work for Gasunie shall fulfil the requirements as stipulated in this subclause.

Requirements for NDT level 3:
- be familiar with the acceptance criteria set forth in the Gasunie Technical Standards, i.e. CSW-01-N/E / CSW-20-N/E and NSW-04-N;
- be a certified level 3 for the relevant technique according to NEN-EN-ISO 9712.
- be conversant in the Dutch language when in charge for interpretation of test results on Dutch territory.

Requirements for NDT level 2:
- be familiar with the approved NDT procedures;
- be a certified level 2 for the relevant technique according to NEN-EN-ISO 9712.
- be conversant in the Dutch language when responsible for interpretation of the test results on Dutch territory;
- possess a qualification certificate for the relevant level and "ID-card" or a Wallet card with:
  - surname, initials and date of birth;
  - method and level;
  - qualification or record number;
  - expiry date;
  - a passport photograph.

## 4.4 Qualification of NDT systems

AUT and PA systems shall be qualified by a third party, appointed by Gasunie (for details see annex A and B).

## 4.5 Qualification of operators

For operators charged with the execution and interpretation of manual UT, TOFD, PA and AUT an additional qualification test is required. The additional qualification shall be performed by Gasunie or a third party appointed by Gasunie. Except for UT wall thickness measurement and UT examination on segregation and/or laminations, for these activities an NEN-EN-ISO 9712 UT level 1 certificate is allowed (for details see annex C of this specification (CSW-05-E)).

## 4.6 Acceptance standards

The acceptance standards for girth welds in transmission pipelines and related facilities are mentioned in with annex E of this specification (CSW-05-E). The acceptance standards of in-service welding are mentioned in NSW-04-N.

## 4.7 Equipment

The NDT contractor shall have available all equipment, spare equipment and repair facilities needed to complete the contracted testing at the locations within the time agreed with Gasunie or the pipeline contractor.

Current certification/calibration certificates for all testing equipment shall be made available on request to Gasunie.

## 4.8 Quality, Health, Safety and Environment

Work shall be carried out in accordance with the applicable regulations as given in CSA-38-N/E and applicable national rules and regulations. QHSE checks as referred to this specification, will be carried out by persons appointed by Gasunie.

## 4.9 Third Party Consultants

Review of NDT systems, techniques, testing results, technical specifications or interviewing NDT personnel by third party personnel is not allowed without prior acceptance by Gasunie department "VGM Advisering" (HSE; Advice). No information regarding NDT results or NDT systems shall be given to third parties.

# 5. GENERAL REQUIREMENTS

## 5.1 Communication

Communication regarding project-related issues is through the responsible project manager of Gasunie.
Where NDT is subcontracted by the pipeline contractor, all communication between Gasunie and NDT contractor shall be done via the pipeline contractor or at least with notification to the pipeline contractor.

## 5.2 Selection of NDT techniques

Selection of the required testing techniques is specified in CSW-01-N/E.

## 5.3 Procedures

The NDT contractor shall prepare a procedure for each NDT method in Dutch which shall be approved by an NEN-EN-ISO 9712 level 3 operator.

The procedures and calibration records shall be submitted to Gasunie at least 10 working days prior to commencement of the work. Prior to commencement of welding, the non-destructive testing procedures shall be submitted to the NDT specialist of Gasunie department "VGM" (HSE) for acceptance.

## 5.4 Reporting

All NDT testing shall be reported daily in writing and before the operator leaves the site. Under the following circumstances, immediate reporting is required within no more than 4 hours to the Gasunie project manager:
- crossings;
- tie-in welds;
- non-acceptable welds and internal HiLo (misalignment) with values above 2,0 mm.

Reporting multiple drawings in one report is not allowed.

The pipeline contractor shall confirm the results by verifying, signing and stamping the reports prior to handing these over to Gasunie.

### *5.4.1 Report content*

As well as the information required by the NDT standards mentioned in this specification (CSW-05-E), the report shall contain the following additional information:
- name of the project;
- Gasunie project number;
- drawing number;
- type of material;
- welder's ID;
- any circumstances influencing the testing;
- weld numbers, identification and testing status shall be in accordance with CSW-01-N/E and related to the:
  - presence of (possible) weld imperfections;
  - dimensions.

### *5.4.2 Records and digital data*

During the project the NDT contractor shall store all NDT media in a safe place. When the project is finished, all these data shall be handed over to Gasunie on an appropriate means of digitalised storage.

## 5.5 Equipment for verification by Gasunie

To be able to verify the NDT results, the following equipment shall be made available to Gasunie (when applicable):

- In case of radiographic testing:
  - a film viewer;
  - a calibrated density meter.
- When software is required for evaluating NDT such as ToFD, PA, AUT, digital radiography and the like, a computer equipped with evaluation software.

## 5.6 Pre-inspection meeting

The contractor shall call for a PIM at least five working days prior to commencement of work. This meeting shall be attented by:

- project manager of Gasunie;
- department "VGM Inspectie" (HSE Inspections);
- NDT contractor.

During the PIM, further detailed agreements pertaining to NDT, other business and communication shall be stipulated.
As a minimum, the following shall be addressed:

1. Safety, e.g. radiation, electricity;
2. Quality control;
3. Report numbering and traceability;
4. Time lapse between testing and report;
5. Reference standard or calibration blocks;
6. Identification of testing records, radiographs, TOFD scans, AUT scans and the like.

## 5.7 Right to reassess NDT results

Gasunie reserves the right to reassess the NDT results. Gasunie will document the reassessment in the project documentation.

# 6. GUIDELINES TESTING CLAUSES

Notes concerning clauses 7 u/i 15:
- additional requirements are marked with "addition";
- substitutional requirements are marked with "substitution";
- choices are marked with "choice".

The numberings, clauses or subclauses in italics in this specification correspond to those in the specific standards where the subject is covered by that specification and any additional clauses or subclauses are numbered sequentially.

# 7. RADIOGRAPHIC TESTING

This clause is applicable to radiography on films and digital media. For film technique, NEN-EN-ISO 17636-1 (January 2013) is applicable. For digital technique, NEN-EN-ISO 17636-2 (January 2013) is applicable.

## 7.1 Application of NEN-EN-ISO 17636-1 (January 2013)

*5 Classification of radiographing techniques*

choice The required quality level is class B. When deviation from class B is necessary, the use of alternative testing methods or techniques shall be approved by Gasunie before commencement of the work.

*6.4 Identification of radiographs*

addition The radiographs shall be uniquely identified by means of identification characters recorded on the image. This shall be done simultaneously with the exposure by placing them on the surface of the parent metal outside the area of interest.

The following unique identification shall be placed by the NDT contractor on each radiograph as indicated in table 2 of this specification (CSW-05-E).

Table 2: Identification on the radiograph

| Item | NDT Contractor | |
|---|---|---|
| | pipelines (systems) | Stations |
| Monogram NDT contractor | X | X |
| Date[1)] | X | X |
| Pipeline number | X | |
| Drawing number | X | X |
| Weld number | X | X |
| Station number | | X |

1) Date is required in case of DN >100

The character size shall not be over 6 mm.

Gasunie will issue the identification number of the pipeline or station to the contractor. The pipeline contractor shall additionally issue the weld number of each weld as per CSW-01-N/E.

*6.5 Marking*

addition The markers shall be placed at least 10 mm from the weld.

addition Measuring tape

For the testing of welds on pipelines, the use of a number tape is mandatory. Gasunie shall specify the flow direction. The contractor shall indicate the flow direction on the pipe. This shall run clockwise round the pipe, looking in the direction of the gas flow (see figure 1).

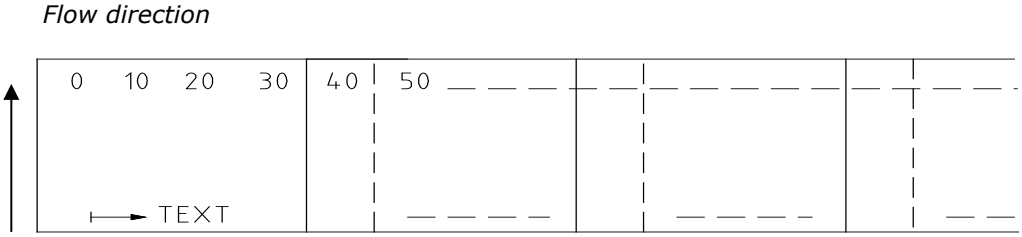



Figure 1: Use of a number tape

In other cases, the zero point and the direction of measurement shall be determined by the NDT contractor and clearly marked on the inspected object.

*6.7 Types and positions of image quality indicators (IQI)*

addition In case of SWSI radiographs, at least three wire IQI's shall be used, spaced at regular intervals. The maximum distance between two IQI's shall be 1 meter.

In case of DWSI radiographs for DN > 200, at least two wire IQI's shall be placed with the thinnest wire located on the outside of the exposure.
In case of DWSI or DWDI radiographs for DN ≤ 200, at least one wire IQI shall be placed at the centre of the exposure.

*7 Recommended techniques for making radiographs*

addition If the difference in thickness cannot be accommodated with a single exposure, at least two exposures shall be made with wall thickness values equivalent to the minimum and maximum thickness involved. A reasoned explanation of these values shall be included in the exposure report.

*7.2Choice of tube voltage and radiation source*

addition The use of an X-ray tube is mandatory.

*7.8 Density of radiograph*

addition The density shall be measured at the fusion of weld and base metal at the root side of the weld (see figure 2).

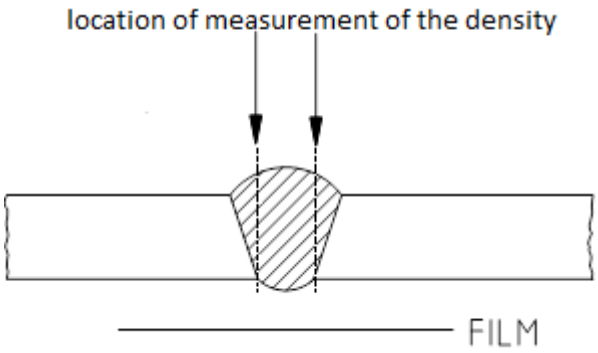



Figure 2: Location of measurement of the density

*8 Test report*

addition In addition to NEN-EN-ISO 17636-1 the test report shall also meet the requirements of subclause 5.4.1 of this specification (CSW-05-E).

## 7.2 Application of NEN-EN-ISO 17636-2 (January 2013), digital radiography

This specification applies to the non-destructive testing of welds and base material using radiography with digital radiographic detectors instead of film. The NEN-EN-ISO 17636-2 shall apply. This standard provides the minimum requirements and practice which permits to expose and acquire digital radiographs with equivalent sensitivity for detection of imperfections as film radiography. For digital radiographic testing X-ray by either computed radiography (CR) or radiography with digital detectors arrays (DDA) can be used.

### *7.2.1 Application of NEN-EN-ISO 17636-2 (January 2013)*

*5 Classification of radiographic techniques and compensation principles*

choice "The required quality level is class B".

*6.4 Identification of radiographs*

addition The radiographs shall be uniquely identified by means of identification characters recorded on the image. This shall be done simultaneously with the exposure by placing them on the surface of the parent metal outside the area of interest.

Gasunie will issue the identification number of the pipeline or station to the contractor. The pipeline contractor shall additionally issue the weld number of each weld as per CSW-01-N/E.

*6.5 Marking*

addition The markers shall be placed at least 10 mm from the weld.

addition Measuring tape
For the testing of welds on pipelines, the use of a number tape is mandatory. Gasunie shall specify the flow direction. The contractor shall indicate the flow direction on the pipe. This shall run clockwise round the pipe, looking in the direction of the gas flow (see figure 1).

In other cases the zero point and the direction of measurement shall be determined by the NDT contractor and clearly marked on the inspected object.

*6.6 Overlap of digital images*

addition The overlap of successive images shall be at least 10 mm if the useful weld length exceeds the film length used.

*6.7 Types and positions of image quality indicators (IQI)*

addition In case of SWSI radiographs, at least three wire IQI's shall be used, spaced at regular intervals. However, the distance between any two IQI's shall never exceed 1 m.
In case of DWSI radiographs for DN > 200, at least two wire IQI's shall be placed with the thinnest wire located on the outside of the exposure.
In case of DWSI or DWDI radiographs for DN $\leq$ 200, at least one wire IQI shall be placed at the centre of the exposure.

*7.2 Choice of tube voltage and radiation source*

addition The use of an X-ray tube is mandatory. Use of Gamma ray is subject to specific acceptance per project.

*8 Test report*

In addition to NEN-EN-ISO 17636-2 the test report shall also meet the requirements of subclause 5.4.1 of this specification (CSW-05-E).

# 8. ULTRASONIC TESTING OF BASE MATERIAL

## 8.1 General requirements

NEN-EN-ISO 10893-8: 2011 shall apply.

## 8.2 Application of NEN-EN-ISO 10893-8:2011

This clause describes the method for ultrasonic testing for laminar imperfections of uncoated pipe ends and pipe sections of carbon steel.

*5.3 Testing of welded steel tubes in the area adjacent to the weld seam*

choice Table 2 (NEN-EN-ISO 10893-8:2011): Acceptance level U1 shall be used

*9 Test report*

addition The UT operator shall submit a test report in accordance with NEN-EN-ISO 10893-8:2011 and subclause 5.4.1 of this specification (CSW-05-E).

# 9. ULTRASONIC WALL THICKNESS MEASUREMENT

## 9.1 General requirements

NEN-EN 14127 (February 2011) shall apply.

## 9.2 Application of NEN-EN 14127 (February 2011)

This clause describes the method for ultrasonic wall thickness measurement of uncoated pipe ends and pipe sections of carbon steel.

*4 Measurement modes*

choice Mode 1 or mode 3 shall be used to determine the wall thickness.

*5.2 Probes*

choice The probes mentioned in table 3 shall be used to determine the wall thickness.

Table 3: probes to be used to determine the wall thickness

| Type of probe | Frequency | Number of crystals | Min. wall thickness |
|---|---|---|---|
| Single element | 4 MHz | 1 | 6 mm |
| Dual element | 4 MHz | 2 | 2 mm |

*10 Test report*

addition The UT operator shall submit a test report in accordance with NEN-EN 14127 and subclause 5.4.1 of this specification (CSW-05-E).

# 10. ULTRASONIC TESTING OF WELDS, PULSE ECHO TECHNIQUE

## 10.1 General requirements

The NEN-EN-ISO 17640 (December 2017) shall apply.

## 10.2 Application of NEN-EN-ISO 17640 (December 2017)

*6 Information required prior to testing*

*6.1 Items to be specified*

The following is applicable:

a) Technique 2 (DGS) shall be used.
b) Evaluation level is as per technique 2 (DGS).
c) Acceptance criteria in accordance with annex E of this specification (CSW-05-E) or NSW-04-N.
d) Testing level B.
e) Testing is to be performed at girth welds of pipes or longitudinal welds in split tees or sleeves in final condition.
f) Operators are to be qualified to Level 2 UT, NEN-EN-ISO 9712 and to the requirements of annex C of this specification (CSW-05-E).
g) The complete weld is to be tested for transverse imperfections.
h) No additional requirements for tandem testing
i) Before the testing of the weld is performed, the adjacent base metal shall be scanned with a straight beam probe for imperfections which might influence the testing.
j) A written test procedure is required.
k) The written procedure shall meet NEN-EN-ISO 17640 and subclause 5.3 of this specification (CSW-05-E).

*6.2 Specific information required before testing*

The following is applicable:

a) The operator shall have the written test procedure at the site.
b) As specified in the NDT request.
c) As specified in the NDT request.
d) As specified in the NDT request.
e) As specified in the NDT request.
f) The pipeline contractor shall prepare the surface for the testing.
g) As specified in the NDT request.
h) As per clause 13 of NEN-EN-ISO 17640 and subclause 5.4.1 of this specification (CSW-05-E).
i) As per approved procedure.
j) As per approved procedure.
k) As per approved procedure.
l) As per approved procedure.
m) As per approved procedure.

# 11. ULTRASONIC TESTING OF WELDS, TOFD TECHNIQUE

## 11.1 General requirements

NEN-EN-ISO 10863 (September 2011) shall apply.

The performance of the use of TOFD systems shall be qualified as outlined in annex B of this specification (CSW-05-E).

## 11.2 Application of NEN-EN-ISO 10863 (September 2011)

*6 Information required prior to testing*

*6.1 Items to be defined by specification*

The following is applicable:

a) The purpose is to examine girth welds of pipes or longitudinal welds in split tees or sleeves. The extent is the weld and heat affected zone.
b) The required testing level is C; the written test procedure shall be in accordance with NEN-EN-ISO 16828 and NEN-EN-ISO 16810 and subclause 5.3 of this specification (CSW-05-E).
c) Reference blocks shall be produced from low carbon steels in a normalized condition.
d) Welds in final condition.
e) The pipeline contractor shall prepare the surface for the testing.
f) Reports shall be as per clause 13 of NEN-EN-ISO 10863 and subclause 5.4.1 of this specification (CSW-05-E).
g) Acceptance criteria in accordance with annex E of this specification (CSW-05-E) or NSW-04-N.
h) Operators are to be qualified to Level 2 TOFD, NEN-EN-ISO 9712 and to the requirements of annex C of this specification (CSW-05-E).

*6.2 Specific information required by the operator before testing*

The following is applicable:

a) The operator shall have the written test procedure at the site.
b) As specified in the NDT request.
c) As specified in the NDT request.
d) As specified in the NDT request.
e) The weld shall be in final condition.
f) Base metal may contain imperfections which might influence the examination. Therefore before the testing of the weld is performed, the adjacent base metal shall be examined for imperfections which might influence the testing.

## 10 Range and sensitivity settings

### 10.1 Settings

#### 10.1.1 General

addition The maximum height, measured with the PCS used in the testing of the weld, of the dead zone shall be 3,5 mm measured at the reference blocks. This can imply that two different set ups are required to examine the full weld volume. The set up for the lower part of the weld volume does not have the 3,5 mm dead zone requirement.
Determination of the dead zone shall be performed according the appropriate figure of annex D.

#### 10.1.2 Time window

addition In deviation of table 2, the depth range shall be chosen such that the time window shall include the mode converted signals. During testing all mode converted signals of i.e. high/low, misalignment shall be visible in the testing window.

### 10.3 Reference blocks

#### 10.3.1 General

addition A reference block according to figure 3 shall be used. This block is based on NEN-EN-ISO 10863, figure A.4, with additions as specified in 10.3.4.

#### 10.3.4 Reference reflectors (see figure 3)

addition The reflectors shall be situated in one line in the middle of the block.
A total of 5 reflectors shall be used for all reference blocks.

Specification of reflectors:

1) Side drill hole, diameter 2,0 mm, depth 30,0 mm, centre line at the end of the hole 4,0 mm below outer surface;.
2) Notch at the inner surface, depth 1,0 mm, width 0,2 mm, length equal to the wall thickness of the reference block;
3) Notch at the outer surface, depth 0,25 x wall thickness of reference block, width 2,5 mm length 30,0 mm, notch tip angle 60°;
4) Notch at the outer surface, depth 0,50 x wall thickness of reference block, width 2,5 mm length 30,0 mm, notch tip angle 60°;
5) Notch at the outer surface, depth 0,75 x wall thickness of reference block, width 2,5 mm length 30,0 mm, notch tip angle 60.

NDT contractor is responsible for proper conservation of the reference blocks. After acceptance, the reference block will be hard stamped by Gasunie. Part of the acceptance is the submission of a calculation of the length of the lateral wave and a measurement of the depth of the scanning surface dead zone, see annex D (CSW-05-E).

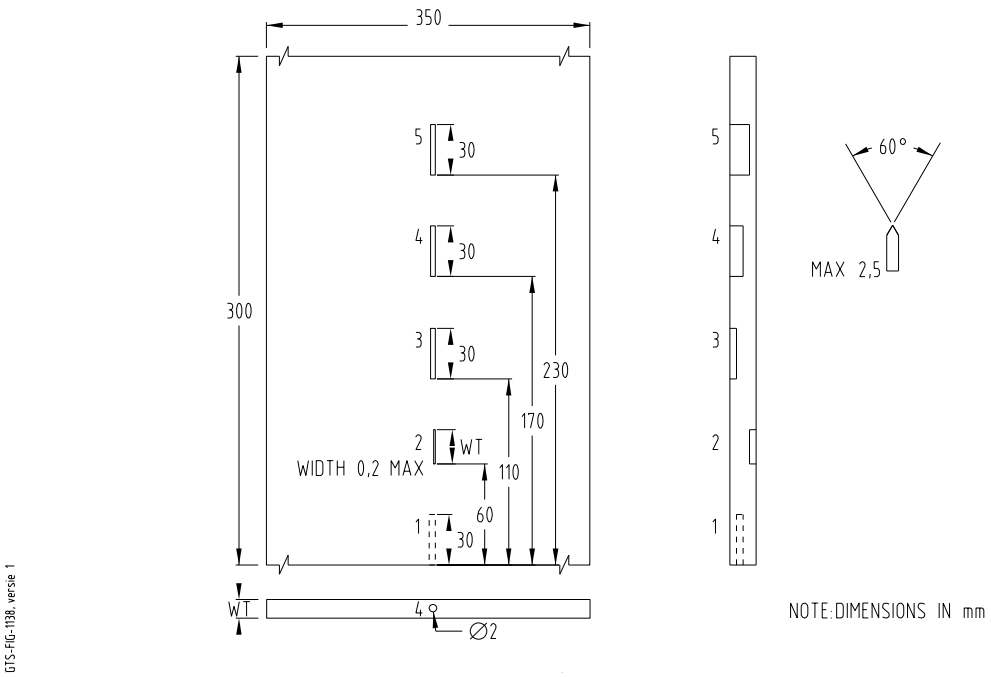



Figure 3: Location and sizing of reference reflectors in TOFD reference plates

*11 Weld testing*

addition The manipulator and recording system shall locate imperfections circumferential within an accuracy of ± 10,0 mm from the "0" mark.

*12 Interpretation and analysis of TOFD images*

*12.1 General*

addition Evaluation, characterisation and dimensioning imperfections
A distinction is made between surface breaking and embedded imperfections.

For TOFD testing, an imperfection is considered to be embedded if:
- for the internal surface, over the entire length, the diffraction signal is free from the bottom echo in accordance with figure 4 of this specification (CSW-05-E);
- for imperfections on the external surface, the lateral wave does not locally attenuate and/or become interrupted.

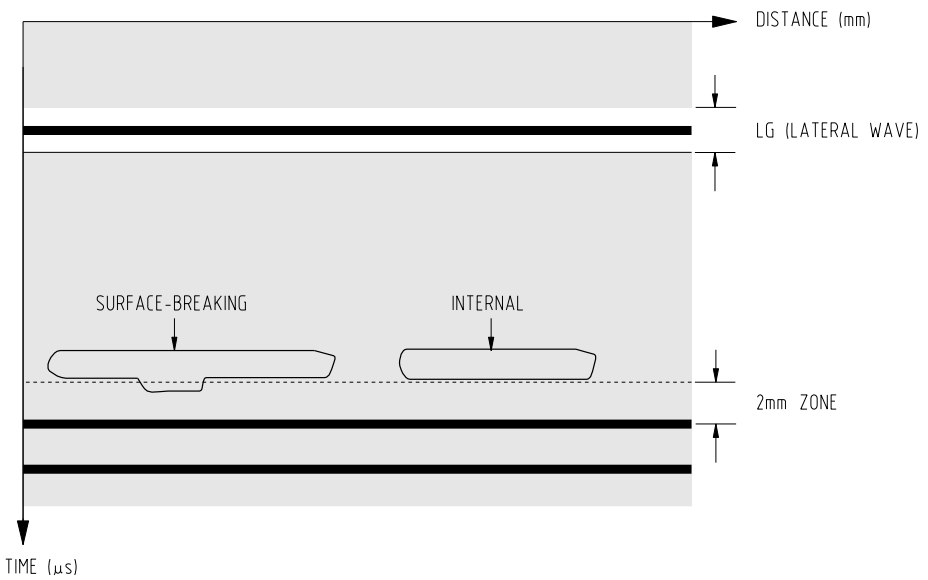



Figure 4: Schematic example of a surface-breaking imperfection and an embedded imperfection

*Relevant imperfections*

Imperfections are considered as representing relevant weld imperfections when:

a TOFD diffraction signals are distinguishable from the bottom reflection signal typical for the normal pattern of the root, or the pipe inner surface;
b TOFD diffraction signals are detected in conjunction with a local attenuation and/or interruption of the lateral wave typical for the pipe outer surface;
c TOFD diffraction signals are measurably distinguished by having height "in the thickness direction", combined with phase inversion;
d TOFD single diffraction signals occur in clusters or are evenly distributed;
e TOFD signals over a length *l* uninterrupted in delay time, represent a height of $h > 5$ mm, in accordance with figures 5 and 6 below.

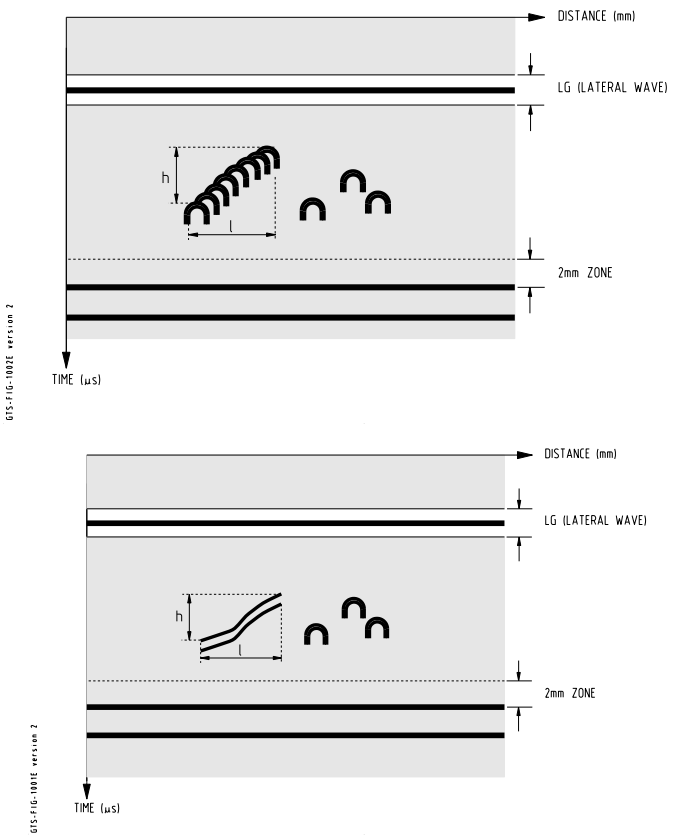



Figure 5 en 6: Schematic example of stacked imperfections and single diffraction signals

### *Sizing of imperfections*

Sizing of imperfections are given in terms of *l* and *h*, where:
- *l* is the length of the indication in mm in the circumferential direction;
- *h* is the height measurement in the through thickness direction of an indication in mm.

### *Alignment associated with an indication*

In conjunction with alignment (HiLo), the indication height is determined by the top of the indication and the lowest internal pipe surface at the location of the indication (see figure 7 of this specification (CSW-05-E)).

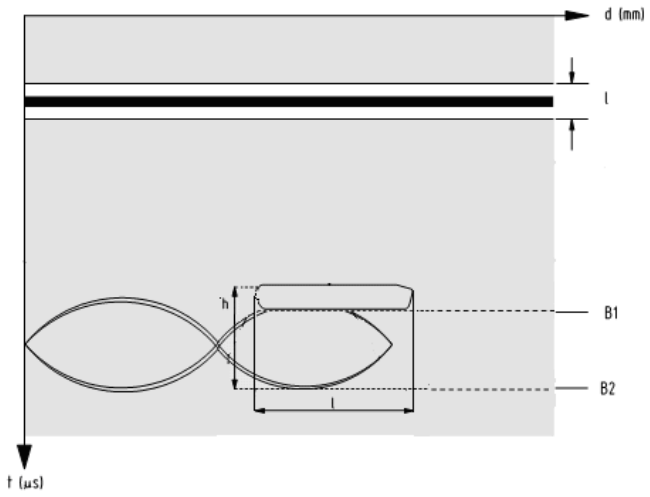



Figure 7: Schematic example for determining indication height in conjunction with HiLo.

The use of mode converted signals shall be used for the confirmation of misalignment. Details to be described in the NDT procedures.

Testing repair sleeves and split tees.
In the case of clarification of position and/or characterisation of detected weld flaws in the longitudinal weld seam, manual pulse-echo technique shall be used.

The acceptance criteria are specified in annex E of this specification (CSW-05-E) or NSW-04-N.

# 12. ULTRASONIC TESTING OF WELDS, PHASED ARRAY TECHNIQUE

## 12.1 General requirements

The NEN-EN-ISO 13588 (October 2012) shall apply.

The performance of the use of PA systems shall be qualified as outlined in annex B of this specification (CSW-05-E).

## 12.2 Application NEN-EN-ISO 13588 (October 2012)

*5 Information required prior to testing*

*5.1 Items to be defined prior to procedure development*

a Testing of carbon steel girth welds in pipes $R_{e,max}$ 245 MPa in the wall thickness range 4,5 mm – 8 mm and wall thicknesses difference $\leq$ 2 mm and/or tapering with a horizontal axial length of $\leq$ 12 mm.
b Table 2 – Description of testing levels:
- S-scan at fixed probe position to weld, two sides, testing level C.
- Skewed scan for detection of transverse imperfections.

c Acceptance criteria as specified in annex E of this specification (CSW-05-E).
d Reference blocks shall be produced from material delivered by Gasunie.
e Testing is to be performed at girth welds in final condition.
f Weld bevel to be specified by the contractor. The standard size of the HAZ shall be 3 mm from the weld bevel. Unless otherwise specified.
g The surface of the pipe, over 80 mm at both sides of the weld, shall be free of paint, weld spatters or other obstacles, which can influence the coupling of the ultrasound. The maximum allowed surface temperature is 50 °C.
h Operators are to be qualified to Level 2 UT and PAUT (NEN-EN-ISO 9712) and to the requirements of annex C of this specification.
i Reports shall be as per clause 15 of NEN-EN-ISO 13588 and subclause 5.4.1 of this specification (CSW-05-E).

*5.2 Specific information required by the operator before testing*

a The operator shall have an approved written test procedure at site;
b As per written NDT request;
c As per written NDT request;
d As per written NDT request;
e As per written NDT request;
f To be included in report.

*9 Range and sensitivity settings*

*9.1.3.4 Sensitivity settings for different modes of phased array testing*

addition The reference sensitivity of the system shall be set by adjusting the amplitude of the outside diameter center line notch reflector at 80 % screen height. Transfer correction shall only be determined on the pipe material of the existing gas pipeline.

*9.3.2 Material*

addition The diameter of the reference block shall be identical to the diameter of the weld to be tested.

*9.3.3 Dimensions and shape*

addition The wall thickness of the reference block shall be between 0,8 and 1,2 times the thickness of the test object.

*9.3.4 Reference reflectors (see figure 8 and 9)*

addition A minimum number of 10 reflectors shall be used for the reference block, being:

- 3 SDH;
- 2 transverse notches (root and cap);
- 5 circumferential notches (2 external, 2 internal and 1 in the middle of the wall thickness).

  After acceptance, the reference block will be hard stamped by Gasunie. NDT contractor is responsible for proper conservation of the reference blocks.

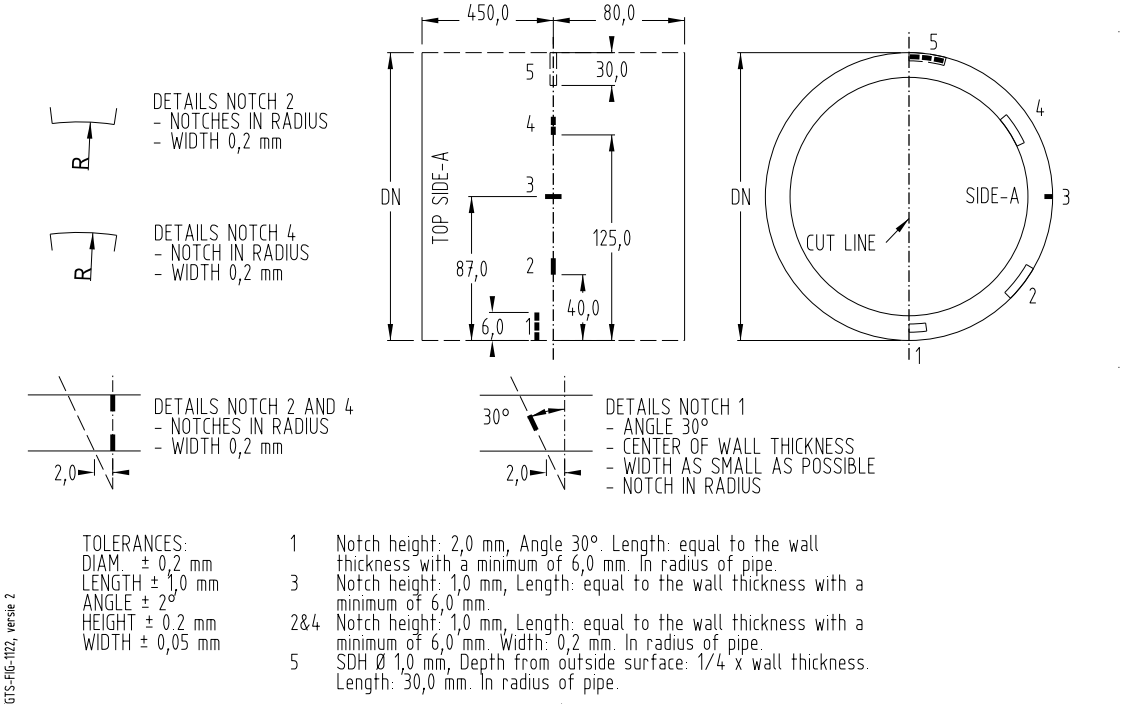



Figure 8: Specification of reflectors in reference plate, side A

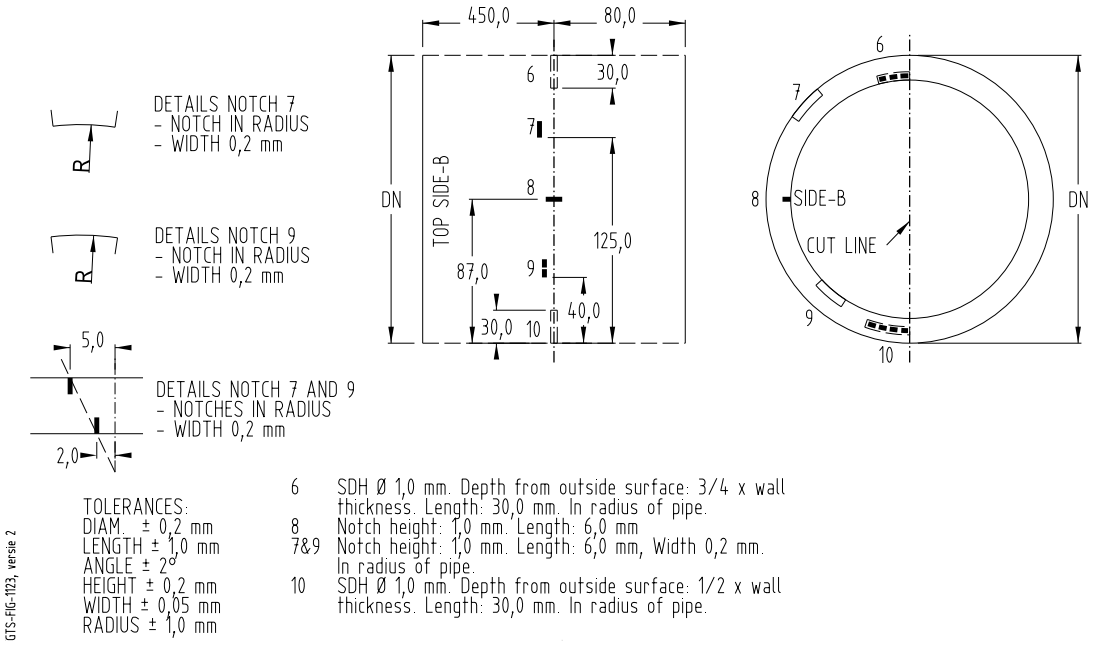



Figure 9: Specification of reflectors in reference plate, side B:

*12 Weld testing*

addition
- Girth welds ≥ DN 100 shall also be examined on transverse imperfections.
- Root imperfections at more than 1,25 skip distance shall not be reviewed, with exception of off-set scans in case of tapering.
- A control function for coupling shall be applied.

*15 Test report*

addition
- All not acceptable imperfections shall be reported.
- All acceptable imperfections with a height > 0,5 mm and with a length ≥ the wall thickness shall be reported.
- All reported imperfections shall include the % FSH of the indication.

# 13. AUTOMATIC ULTRASONIC TESTING

## 13.1 Scope

This clause is based on ASTM E 1961 (2016). Techniques designed not in accordance with ASTM E 1961 shall be qualified as special techniques, clause 16 of this specification (CSW-05-E).

This clause covers the use of automated ultrasonic testing (AUT) and applies to girth welds in carbon steel with a thickness from ($t$) 8,0 mm ≤ $t$ ≤ 30,0 mm.

## 13.2 Design of Automated Ultrasonic Testing systems

The system shall be designed in accordance with ASTM E 1961 and the requirements of this clause. Gasunie will deliver data of typical weld bevel preparation, dimensions and actual material or test material. The NDT contractor shall design an ultrasonic testing system to the typical weld configuration and material acoustics. All techniques, Pulse-Echo (can be Phased Array or multi probe), Mapping and TOFD shall be included in one system.

The system shall provide an adequate number of testing channels to ensure the complete testing in one circumferential scan of the weld. The scan will include all methods, Pulse-Echo, TOFD and Mapping.

### *13.2.1 Description and qualification of automated testing systems*

All systems shall be qualified as outlined in annex A of this specification (CSW-05-E).

### *13.2.2 Additional Requirements based on ASTM E 1961 (2016)*

Notes concerning this clause:
- additional requirements are marked with "addition";
- requirements for deletion are marked with "deletion";
- substitutional requirements are marked with "substitution";
- a choice is indicated as "choice".

Paragraphs mentioned are the paragraphs in ASTM E 1961

*4 Significance and Use*

*Paragraph 4.3*

addition The applicable wall thickness is ($t$) 8,0 mm ≤ $t$ ≤ 30,0 mm.

*Paragraph 4.4*

addition Maximum zone height is 3 mm.

*5 Basis of Application*

*Paragraph 5.2.1*

addition Operators need to be familiar with the equipment used and be qualified to Level 2 UT and Level 2 TOFD and to the requirements of annex C of this specification (CSW-05-E).

substitution *Paragraph 5.3 Qualification of Nondestructive Agencies*
The non destructive agency shall be qualified in accordance with this specification (CSW-05-E).

substitution *Paragraph 5.4 Procedures and Techniques*
The procedures and techniques shall be qualified in accordance with this specification (CSW-05-E).

substitution *Paragraph 5.8 Reporting Criteria/Acceptance Criteria*
Reporting criteria and acceptance criteria shall be in accordance with annex E of this specification (CSW-05-E).

substitution *Paragraph 5.9 Reexamination of Repaired/Reworked Items*
Repairs shall be rescanned over the full circumference with the same equipment as used for the original scan. When required, gate settings shall be adjusted, or off set scanning shall be used, i.e. in case of narrow gap weld configurations, a separate procedure shall be made and approved by Gasunie. This procedure shall contain the original scan and additional NDT methods related to the changed bevel configurations. When available AUT with V bevel set-up is the required method, if there is no AUT V-bevel available, manual PE, TOFD and MT shall be applied.

*7 Ultrasonic Equipment*

*Paragraph 7.1 Ultrasonic System*

addition The Automated Ultrasonic Testing system shall include TOFD and this technique shall meet the requirements according to NEN-EN-ISO 10863 and/or NEN-EN 12668-3 including the requirements as specified in clause 11 of this specification (CSW-05-E) unless otherwise specified in this clause 13.

Exception:
The maximum scan resolution shall be 2,0 mm. All scans shall be presented on one monitor.
Instead of the referenced ASTM practice, the applicable part of NEN-EN 12668 shall be used.
The minimum resolution of the monitors/displays shall be 800 by 600 pixels, monitor size minimum 19".

*7.4 Search Units:*

addition Probes shall meet the requirements of NEN-EN 12668-2.

*7.6 Ultrasonic Examination Procedure*

addition Additional to the requirements in ASTM E 1961, the following shall be included in the procedure;

- clause 4 and 5 of this specification (CSW-05-E);
- the requirements of annex E of this specification (CSW-05-E).

substitution *8.3 Evaluation Threshold*

Evaluation Threshold—The evaluation threshold for each detection channel shall be 20 % of full screen height. All signals above this amplitude will be evaluated in accordance with the qualified method as per annex A of this specification (CSW-05-E). Except for the multiprobe system; for this system reference is made to subclause 13.3 of this specification (CSW-05-E). Porosity detection channels may use a threshold for evaluation or patterns in mapping type channels and transit time may be used to characterise porosity.

substitution *Paragraph 9.3*

Acceptability of a system to produce a standardisation chart or record will be based on its ability to discriminate testing zones. This **shall** be demonstrated by signals from adjacent zones being at least 2 dB and not more than 10 dB lower than from the zone for which a search unit channel is standardised. Failure to ensure the 2 dB to 10 dB separation between zones **is** unacceptable and requires repositioning of the search unit or a complete search unit replacement.

*10 Field Examination*

addition The complete automated ultrasonic system design shall be qualified by calibration, to be witnessed and approved by Gasunie department "HSE; Specialists", at least ten working days before commencement of the welding activities. Details and findings shall be reported using GTS W-025. The reference standards shall be submitted with a dimensional control data sheet. This document shall be approved by the NDT contractor. For each reference standard a review shall be made.

substitution *10.2 Surface Condition*

The width to be cleared shall be in accordance with CSW-01-N/E.

*11 Report*

addition Reports shall be as per paragraph 11 of ASTM E 1961 and subclause 5.4.1 of this specification (CSW-05-E). TOFD shall be used to verify the extent of HiLo (misalignment). Any part with inner HiLo exceeding 2,0 mm shall be reported, including length and maximum value.

substitution *12 Standards of Acceptability*

Imperfections shall be evaluated according to annex E of this specification (CSW-05-E).

*Paragraph A3.2.1*

addition The reference standard (calibration block) shall be produced from project-specific line pipe material supplied by Gasunie. The pipeline contractor will provide the NDT contractor with details of the project-specific weld geometries. The NDT contractor shall specify the required project material for preparation of the reference standards.

*Paragraph A3.4 Identification*

addition During production of the reference standard, the hard stamping of the Gasunie PO number and pipe number with the Gasunie QC stamp shall be maintained.

substitution *Paragraph A3.5 Targets*

A3.5.1. Targets shall be arranged to allow zonal discrimination based on both weld profile and number of fill passes and shall be centred in the zone. (See Fig. A3.1). In the root zone at least two different angles shall be used with a difference of 10 degrees.

A3.5.2 Primary reference targets for fusion areas shall be 2 mm diameter flat-bottom holes (FBH).

A3.5.3 Square slots 1 mm deep and 2 mm wide shall be machined 10 mm long on the design fusion line to indicate locations where undercut or surface breaking non-fusion would occur on the pipe outer surface. The root slot shall be 10 mm long, 1 mm deep and 2 mm wide. For welds counterwelded internally, the root slots shall be 10 mm long and their depth and angular configuration should be identical to the root bevel used in the weld process being examined.

A3.5.4 A centreline through hole, 2 mm diameter, should be drilled to verify detectability of centreline flaws and to ensure gate length is sufficient to cover 1 mm past the weld centreline.

*Paragraph A3.7*

addition The following extra reference targets shall be present in the reference block:
Pulse-Echo, transverse direction;

- Slots at the inner and outer surface of the weld, 1,5 mm deep and 2 mm wide.
  - The slot on the inner surface shall have a length of 8,0 mm.
  - The slot on the outer surface shall have a length of 12 mm.
  - The slot shall be positioned in the centreline of the weld profile;
  - TOFD, longitudinal notches.

- Outer and inner surface notch for TOFD testing.
  - Length 10 mm.
  - The inner notch width is 0,2 mm and the depth is 1,0 mm.
  - The outer notch width is 0,5 mm and the depth is 2,5 mm.
  - These TOFD notches shall be produced by spark eroding, and have a notch tip of 60°.
  - Inner and outer TOFD notches shall be positioned at weld centre line.

## 13.3 Signal evaluation multi-probe system

*Relevant weld imperfections*

Imperfections are considered as representing relevant weld imperfections when:

(1) a Pulse Echo response of > 80 % FSH is obtained, based on an FBH of 2 mm;

(2) in three or more zones, irrespective of the position in the transversal direction and at the same position within 5 mm in the longitudinal direction, one or more Pulse Echo responses occur above 20 % FSH in one of the channels and a length in one or more channels of $\geq$ 8 mm;

(3) the sound transmission over a length of 8 mm or more is interrupted.

### *13.3.1 Determining "through the thickness" imperfection height*

Determining the height of a weld imperfection in the "through the thickness" direction shall primarily be undertaken by evaluating the focussed Pulse Echo response, after which correction/confirmation can be undertaken using TOFD. The following procedure is applicable for this:

- Weld imperfections detected using Pulse Echo are considered, as a minimum, as representing a "through the thickness" height, equivalent to the number of testing zones in which the imperfection is observed.
- These values can be corrected and/or confirmed by means of TOFD in the following way:
  - in the root layer zone (= root + zone height) a weld imperfection is, in principle, external, where the "through the thickness" measurements (*h*) from the pipe inner surface are rounded to 1,0 mm, 1,5 mm, 2,0 mm or 2,5 mm.
- In the zones between the root layer zone and the zone adjacent to the pipe outer surface, a detected weld imperfection has at least a height of the relevant zone height, unless a different value is established using TOFD.
- In the zone adjacent to the pipe outside surface, a weld imperfection is, in principle, external, with a minimum height of the relevant zone height, unless a different value is established using TOFD.
- It is permissible to inspect an imperfection further using a semi-mechanised ultrasonic TOFD system with a higher frequency (10 MHz - 15 MHz). This testing can be used to verify if the diffraction signals of an imperfection do not locally attenuate and/or interrupt the lateral wave, characteristic for the external surface.
- It is permissible to process the lateral wave electronically so that it can be established whether the top of the imperfection is touching the lateral wave. The signal from the top of the imperfection may not be attenuated when doing this. If, after this processing, the imperfection appears to be external then the imperfection height shall be the distance between the underside of the imperfection and the pipe surface.
  Every other analysis shall be stated in the NDT report and will be eligible for verification by the welding inspection of Gasunie department "HSE; Specialists".

# 14. MAGNETIC PARTICLE TESTING

## 14.1 General requirements

The testing shall be in accordance with NEN-EN-ISO 17638 (November 2016) and this clause.

## 14.2 The application of NEN-EN-ISO 17638 (November 2016)

*5 General*

*Paragraph 5.1 Information required prior to testing*
The following is applicable:
a) A test procedure is required.
b) NDT personnel to be certified in acordance with NEN-EN-ISO 9712, MT level 2.
c) Weld and/or weld bevel and 25 mm on each side.
d) Weld bevel after grinding/preparation, weld in final condition.
e) Electromagnetic AC yokes and magnetic particle suspensions with black or fluorescent particles are to be used.
f) Overall performance test is required after changes which could affect the the technical performance of the system.
g) Demagnitization is not required.
h) The acceptance criteria are specified in with annex E of this specification (CSW-05-E) or NSW-04-N.
i) When unacceptable imperfections are found these shall be reported, no further action is to be taken.

*Paragraph 5.2 Additional pre-test information*
The following is applicable:
a) As per NDT request.
b) As per NDT request.
c) As per NDT request.
d) As per NDT request.
e) Not applicable in case of repairs, full weld is to be re-examined.
f) As per NDT request.
g) As per NEN-EN-ISO 17638 paragraph 5.4 (Surface conditions and preparation).

Reporting shall be as per paragraph 5.14 (Test report) of NEN-EN-ISO 17638 and subclause 5.4.1 of this specification (CSW-05-E).

# 15. LIQUID PENETRANT TESTING

## 15.1 General requirements

The NEN-EN-ISO 3452-1 (June 2013-cor 2014-05) shall apply.

Notes concerning this clause:
- additional requirements are marked with "addition";
- requirements for deletion are marked with "deletion";
- substitutional requirements are marked with "substitution";
- choices are marked with "choice".

The numberings, clauses or subclauses in italics in this specification correspond to those in the NEN-EN-ISO 3452-1, where the subject is covered by that specification and any additional clauses or subclauses are numbered sequentially.

## 15.2 The application of NEN-EN-ISO 3452-1 (June 2013 –Cor. 2014-05)

*6 Products, sensitivity and designation*

*6.2 Testing Products*

choice Type II, method A, form d shall be used.

*9 Test report*

addition The imperfections shall be evaluated in accordance with annex E of this specification (CSW-05-E).

The test report shall include the information as specified in subclause 5.4.1 of this specification (CSW-05-E).

# 16. SPECIAL TESTING METHODS

The procedure to be followed and the requirements to be met by testing methods not specified in this specification (e.g. ultrasonic, leak detection, eddy current testing and acoustic emissions) shall be agreed in advance with Gasunie.

The following qualification steps shall be performed by the NDT contractor as a minimum:

1. description of the methods;
2. technical justification;
3. preliminary procedures;
4. qualification trials;
5. final procedures.

# 17. DOCUMENTATION

In this specification the following documentation is applicable:

1 NEN 3651: 2012
Aanvullende eisen voor buisleidingen in of nabij belangrijke waterstaatswerken (Additional requirements for pipelines in or nearby important public works).

# ANNEXES

# A QUALIFICATION OF AUTOMATED ULTRASONIC TESTING SYSTEMS

## A.1 Introduction qualification for AUT

Any automated ultrasonic testing system shall be qualified as laid down in the qualification procedure TVS 09.0027 which is based on NEN 3653.

It is the responsibility of the NDT contractor to make arrangements for the qualification in due time. The qualification includes a technical justification and the determination of probability of detection and sizing accuracy.

After final acceptance by Gasunie of the automated ultrasonic testing systems the NDT contractor shall review, revise where appropriate and provide final testing procedures for approval to Gasunie.

### *A.1.1 Probability of detection*

With reference to NEN 3650-2 (June 2012) annex C the POD shall be determined for planar imperfections on the bevel side. The required imperfection height $h_{90|95}$ , which is to be detected with a probability of at least 90 % with a confidence of 95 %, is maximum 3 mm. This requirement is schematically shown in figure 10.

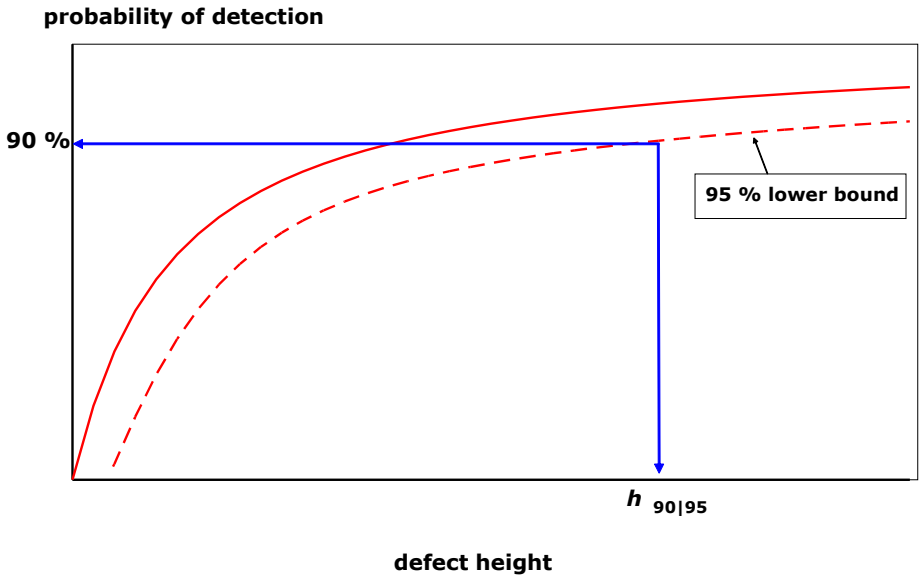



Figure 10 Lower bound (95 %) confidence probability of detection curve with explanation of $h_{90|95}$.

### *A.1.2 Sizing accuracy*

The size for planar imperfections shall be determined in the radial direction (height) and in the circumferential direction (length).

The sizing accuracy in height $\Delta h$ and length direction $\Delta l$ are defined as:

$$\Delta h = h_{\mathrm{AUT}} - h_{\mathrm{do}} \qquad \Delta l = l_{\mathrm{AUT}} - l_{\mathrm{do}}$$

where $h_{\mathrm{AUT}}$ and $l_{\mathrm{AUT}}$ are the imperfection sizes determined by the AUT system and $h_{\mathrm{do}}$ and $l_{\mathrm{do}}$ are the actual imperfection sizes in height and length directions. A negative sizing accuracy means that the AUT system underestimates the imperfection sizes. The sizing accuracy is assumed to be normal distributed, see figure 11.

The requirements for the sizing accuracies are:
- the probability of less than -0,5 mm sizing accuracy in height is maximum 50 %;
- the probability of less than -5 mm sizing accuracy in length is maximum 50 %.

Figures 11 and 12 give an explanation of the requirement.

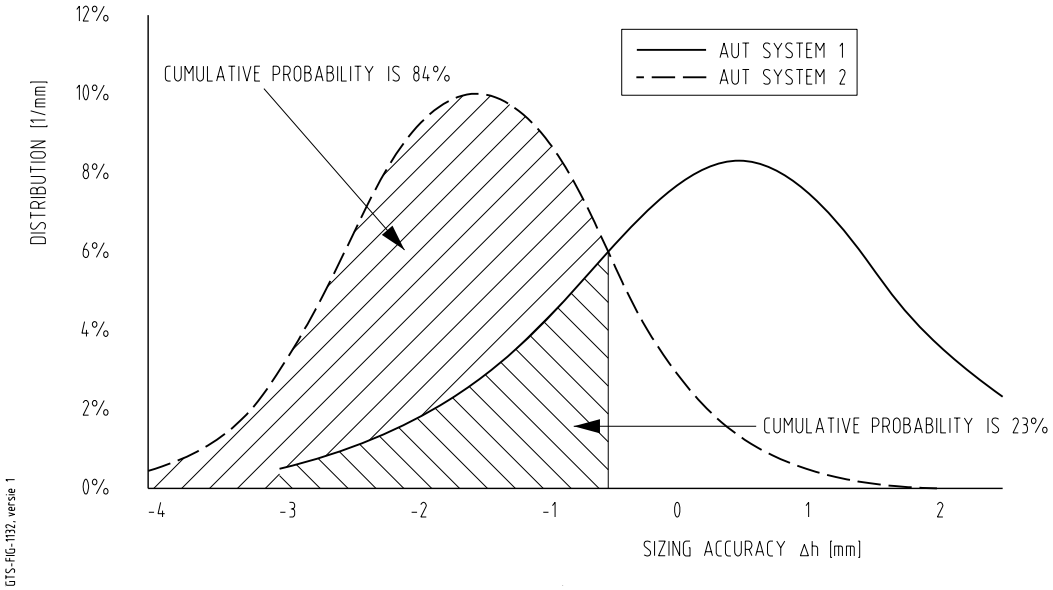



Figure 11: Probability density distribution

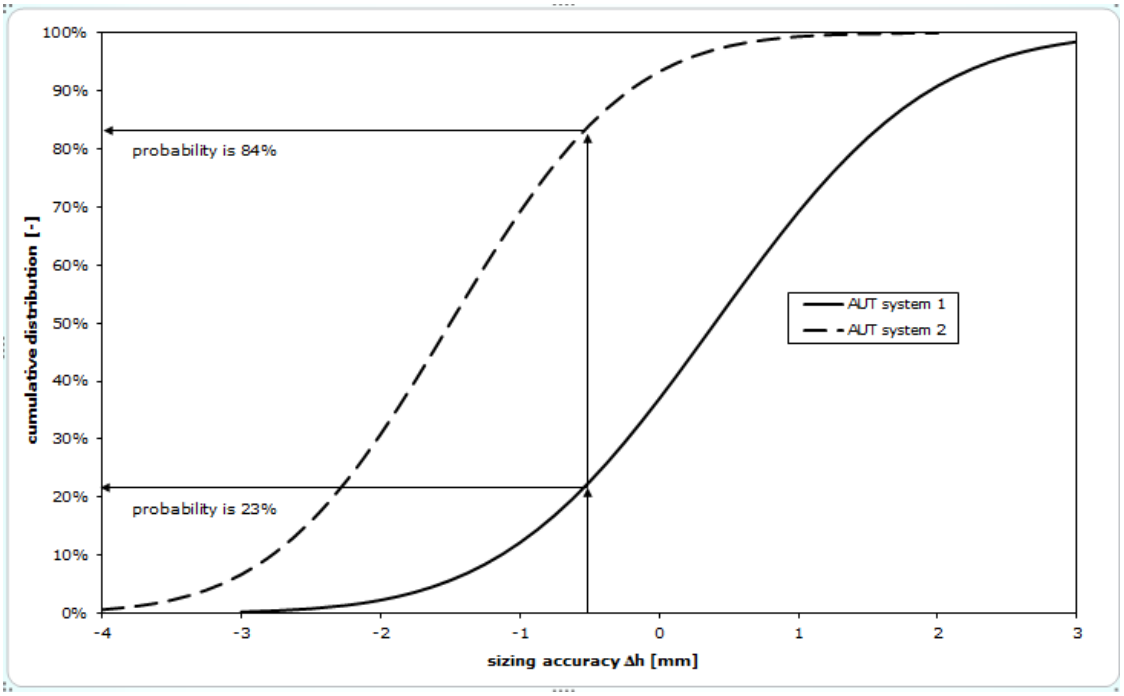



Figure 12: Cumulative distribution

Two examples of the sizing accuracy in height: figure 11 the probability density distribution of the sizing accuracy and figure 12 the cumulative distribution. AUT system 1 fulfils the requirement (cumulative probability 23 % at -0,5 mm) and AUT system 2 does not fulfil the requirement (cumulative probability 84 % at -0,5 mm) of the sizing accuracy in height.

### *A.1.3 Validity of qualification*

When the AUT system is qualified, the qualification is given for a limited wall thickness range, weld configuration, materials, welding parameters and equipment variables as specified hereafter.

#### *A.1.3.1 Pipe wall thickness*

A change in wall thickness outside the range as specified in table 4.

Table 4: Ranges of approval for qualification of AUT systems

| Nominal wall thickness of the blind trial (mm) | Type of line pipe | Validity range (mm) |
|---|---|---|
| 8,5 - 11,0 | High Frequency Induced or longitudinal welded | 8,0 – 15,0 |
| 17,0 - 24,0 | longitudinal welded | 15,0 – 30,0 |

### *A.1.3.2 Bevel angle deviation*

Table 5: Maximum deviation of bevel angle as applied in the qualification procedure

| Weld bevel angle qualified | Angle < 15° | 25° ≤ angle ≤ 35° |
|---|---|---|
| Qualifies | ± 5° | ± 10° |

### *A.1.3.3 NDT contractor*

A change in NDT procedure.

### *A.1.3.4 AUT system*

A. A change in trademark and type of NDT system components.
B. A change in software version for the pulse-echo, TOFD or Phased Array systems.
C. Any increase in scanning temperature above 50 °C.
D. An increase in scanning speed above qualified value.
E. A change in focussing technique.
F. Any addition or deletion of ultrasonic techniques as used during qualification
G. Materials other than specified in OSW-01-N.

# B QUALIFICATION OF PA ULTRASONIC TESTING SYSTEMS

## B.1 Introduction qualification for PA

Any PA ultrasonic testing system shall be qualified as laid down in the qualification procedure VS 14.0375 which is based on NEN 3653.
It is NDT contractor's responsibility to make arrangements for the qualification. The qualification includes a technical justification, the determination of probability of detection and sizing accuracy.

After Gasunie's final acceptance of the PA testing systems, the NDT contractor shall review/revise where appropriate and provide the final testing procedures for approval to Gasunie.

## B.2 Probability of detection

With reference to NEN 3650-2 (June 2012) annex C the POD shall be determined for planar imperfections on the bevel side. The required imperfection height $h_{90|95}$, which is to be detected with a probability of at least 90 % with a confidence of 95 %, is maximal 3 mm. This requirement is schematically shown in figure 13.

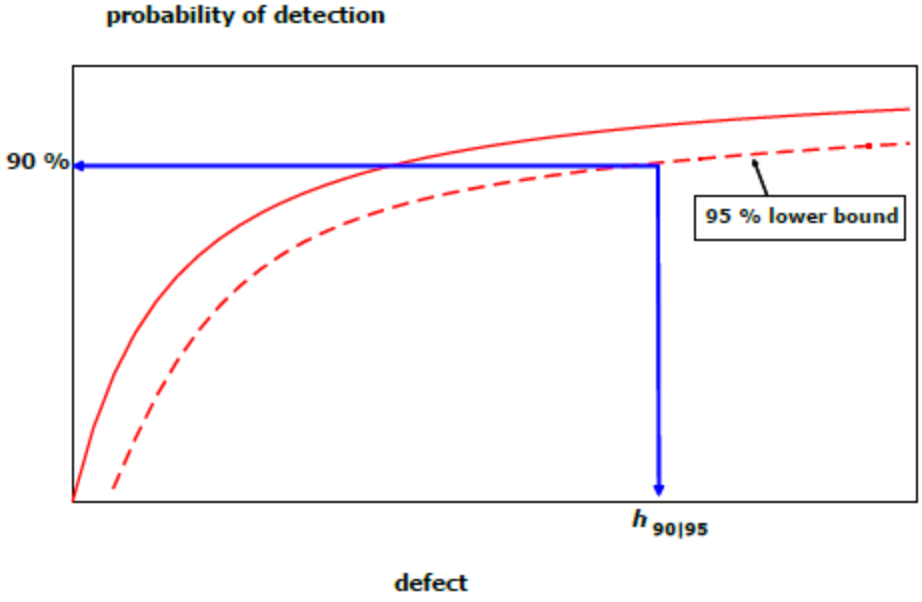



Figure 13: Lower bound (95 %) confidence probability of detection curve with explanation of $h_{90|95}$.

## B.3 Sizing accuracy

The size for planar imperfections shall be determined in the radial direction (height) and in the circumferential direction (length).
The sizing accuracy in height $\Delta h$ and length direction $\Delta l$ are defined as:
$\Delta h = h_{PA} - h_{do}$ and $\Delta l = l_{PA} - l_{do}$
where $h_{PA}$ and $l_{PA}$ are the imperfection sizes determined by the PA system and $h_{do}$ and $l_{do}$ are the actual imperfection sizes in height and length directions. A negative sizing accuracy means that the PA system underestimates the imperfection sizes. The sizing accuracy is assumed to be normal distributed (see figures 14 and 15).

The requirements for the sizing accuracies are:

- the probability of less than -0,5 mm sizing accuracy in height is maximal 50 %;
- the probability of less than -5 mm sizing accuracy in length is maximal 50 %.

Figures 14 and 15 gives an explanation of the requirement.

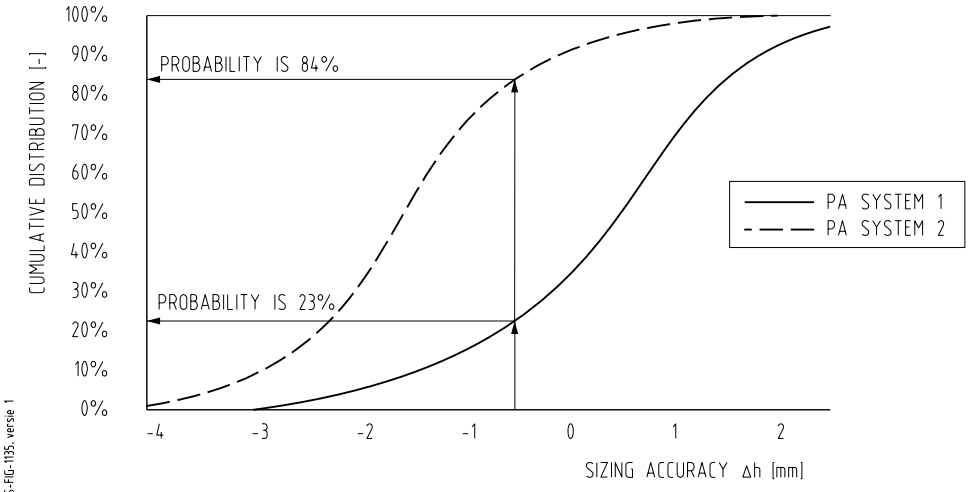



Figure 14: Cumulative distribution

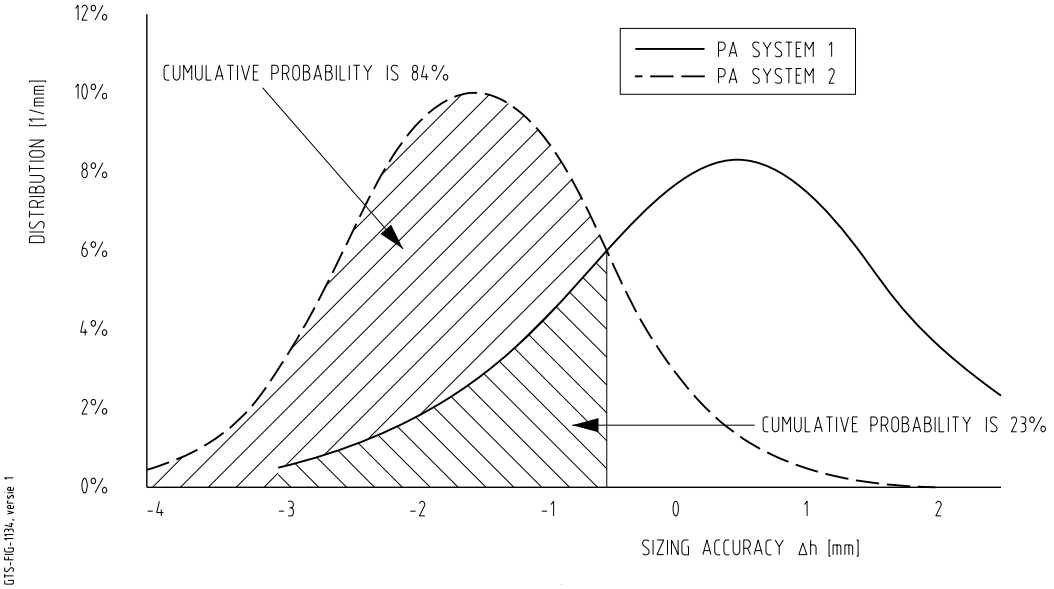



Figure 15: Probability density

Two examples of the sizing accuracy in height: figure 15, the probability density distribution of the sizing accuracy and figure 14, the cumulative distribution. PA system 1 fulfils the requirement (cumulative probability 23 % at -0,5 mm) and PA system 2 does not fulfil the requirement (cumulative probability 84 % at -0,5 mm) of the sizing accuracy in height.

## B.4 Range of qualification

When the PA system is qualified, the qualification is given for a limited wall thickness range, weld configuration, materials, welding parameters and equipment variables as specified in the following subclauses.

### *B.4.1 Pipe wall thickness*

A change in wall thickness outside the range as specified in table 6.

Table 6: Ranges of approval for qualification of PA systems

| Nominal wall thickness of the blind trial (mm) | Type of line pipe | Validity range (mm) |
|---|---|---|
| 5,0 | high frequency induced, longitudinal welded or seamless | 4,5 – 8,0 |

### *B.4.2 Bevel angle deviation*

Table 7: Maximum deviation of bevel angle as applied in the qualification procedure

| Weld bevel angle qualified | Angle 30° |
|---|---|
| Qualifies | ±5° |

### *B.4.3 NDT contractor*

A change in NDT procedure.

### *B.4.4 PA system*

1. A change in trademark and type of NDT system components.
2. A change in software version for the Phased Array systems.
3. Any increase in scanning temperature above 50 °C.
4. An increase in scanning speed above qualified value.
5. A change in focusing technique.
6. Any addition of ultrasonic techniques as used during qualification.
7. Materials other than specified in OSW-01-N.

# C QUALIFICATION OF NDT OPERATORS

The UT operator of the NDT contractor shall demonstrate by practical tests he is familiar with the assessment requirements and his equipment used for examination. The tests shall be performed in-house or on-site. Gasunie will verify such tests and shall be invited by the NDT contractor at least 5 days in advance. Time allowed for examination and reporting shall be not more than 2 hour per test.

## C.1 Pre requirements

Prior to the start of the qualification, the following items shall be made available by the operator who needs to be qualified:

- his/her certificate level 2 for the technique concerned according to NEN-EN-ISO 9712;
- his/her ID card, passport or driving license for identification;
- the applicable testing procedure.

## C.2 Qualification test

These qualifications will be performed on actual existing scans for AUT or actual welds for PA, ToFD or UT.

### *C.2.1 UT operators*

The operator shall examine one weld containing 10 imperfections. The operator shall report the imperfections found and report these according to with annex E of this specification (CSW-05-E).

### *C.2.2 ToFD operators*

The operator shall examine one weld containing 10 imperfections. The operator shall report the imperfections found and report these according to with annex E of this specification (CSW-05-E).

### *C.2.3 PA operators*

The operator shall examine one weld containing 10 imperfections. The operator shall report the imperfections found and report these according to with annex E of this specification (CSW-05-E).

### *C.2.4 AUT operators*

The practical tests will consist of a minimum of 5 actual welds, displayed in a computer format similar to that used in a work situation. During this test the program will allow all parameters to be evaluated as in an actual project scan. Reporting shall be done on a standard report.

The AUT Operator's evaluation shall be compared directly to the master copy.

### *C.2.4.1 Evaluation of the qualification and the result*

When the actual qualification is finished, the NDT specialist of Gasunie department "VGM" or approved third party shall check the NDT results against the master record.

The qualification will be considered successful if:
- 85 % of the imperfections on the master of the inspected weld are detected and reported;
- all reported imperfections are within the tolerances on the master.

In all other cases the qualification shall be considered not successful.

# D MEASUREMENT OF THE DEPTH OF THE SCANNING SURFACE DEAD ZONE

## D.1 Introduction figures presenting lateral wave

Near the scanning surface is a dead zone due to presence of the lateral wave. The depth "a" of the lateral wave shall be measured in the straightened image, between the points $m_1$ and $m_2$.

The maximum amplitude of total wave form shall be taken as reference to determine the crossing point $m_2$ of the signal at -6 dB or -12 dB level.

The measure point $m_1$ shall be taken after the 1st crossing with the base line.
In the case of figure 16, 17 and 19 the measure point $m_2$ is the last crossing – positive or negative- with the -6 dB line.
In the case of figure 18 the measure point $m_2$ is the last crossing- positive or negative- with the –12 dB line.
In the case of figure 20, where any crossing with a -6 dB line is absent, the measure point $m_2$ is with the base line.

Note:
The -12 dB crossing shall be taken only when a -6 dB crossing point is not present (see figure 18).

The signals can also occur in the opposite direction.

## D.2 Figures lateral wave

Key:

| | |
|---|---|
| $x$ | : amplitude |
| $y$ | : time |
| $a$ | : depth of scanning surface dead zone |
| $h_1$, $h_2$, $h_3$ | : one of these is the maximum amplitude of the TOFD signal in the lateral zone. |
| $m_1$ | : signal prime passing base line. |
| $m_2$ | : signal at -6 dB level before passing base line. |

Figure 16 is applicable if $h_3 \leq$ -6 dB of $h_1$.
Figure 17 is applicable if $h_3 >$ -6 dB of $h_1$.
Figure 18 is applicable if $h_3 \leq$-6 dB of $h_2$.
Figure 19 is applicable if $h_3 >$ 6 dB of $h_2$.
Figure 20 is applicable if $h_2 \leq$ -6 dB.

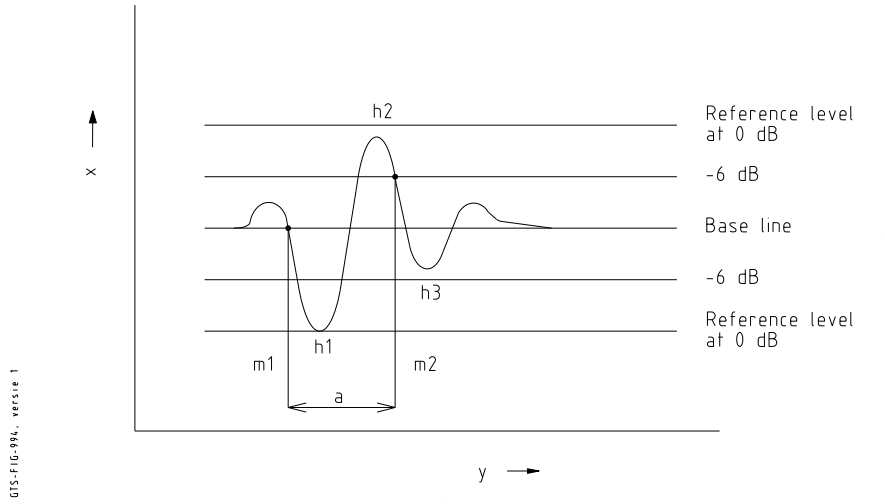



Figure 16: Schematic A-scan scanning surface dead zone

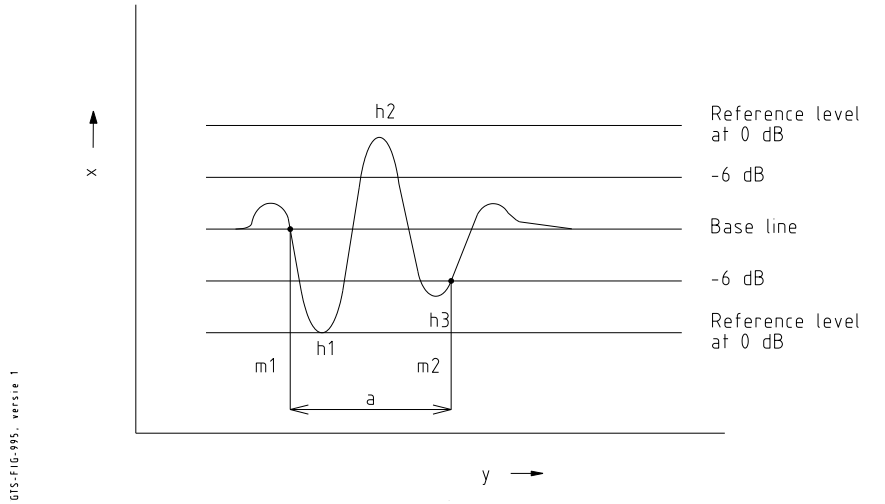



Figure 17: Schematic A-scan scanning surface dead zone with one extra maximum exceeding 50 %

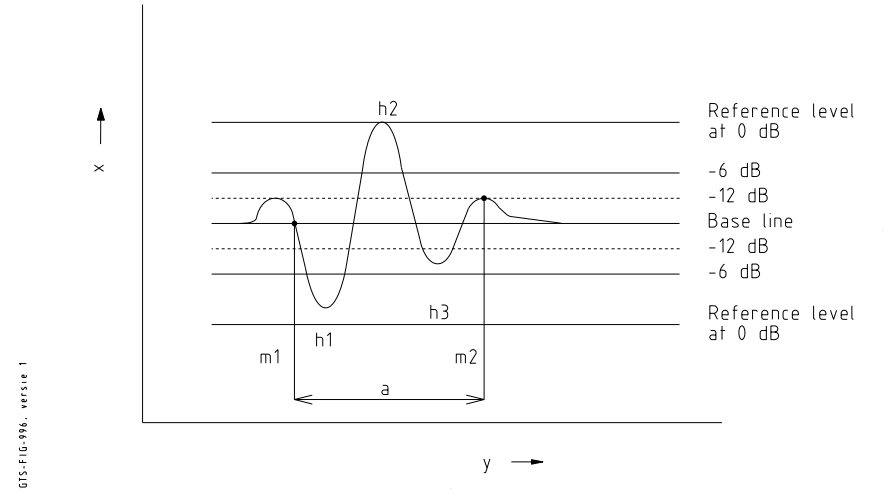



Figure 18: Schematic A-scan scanning surface dead zone with $h_2$ as maximum reference level

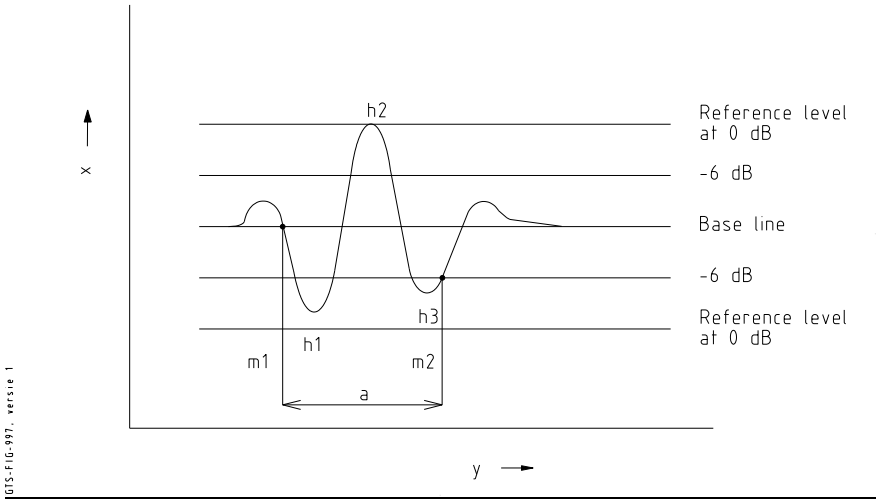



Figure 19: Schematic A-scan scanning surface dead zone with $h_2$ as maximum reference level

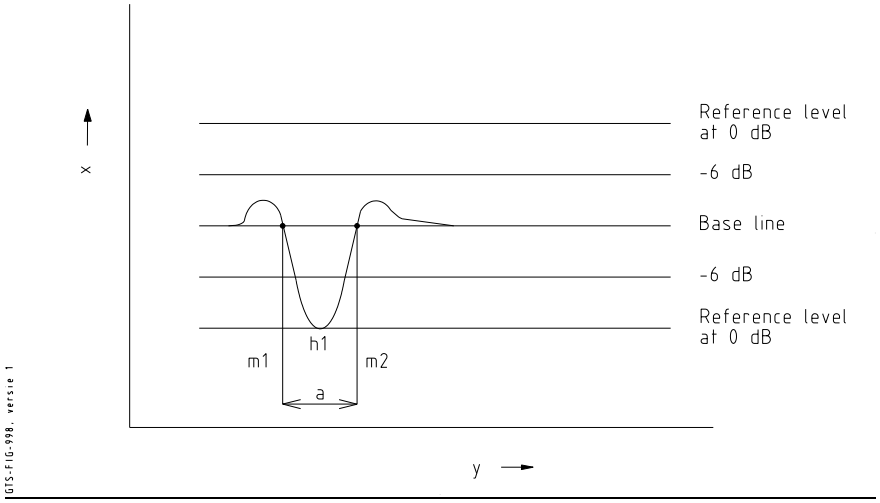



Figure 20: Schematic A-scan scanning dead zone with $h_1$ as maximum reference level. Due to the absence of a crossing with the -6 dB or -12 dB, $m_2$ measurement shall be at the crossing with the base line.

## D.3 Acceptance

The depth of the measured dead zone shall be less or equal than 3,5 mm.

# E ACCEPTANCE REQUIREMENTS FOR WELDS

This annex describes the acceptability requirements of welds as determined by means of non-destructive testing. The visual weld inspection acceptability requirements of welds are described in CSW-01-N/E.

## E.1 Radiographic testing in accordance with NEN-EN-ISO 5817 and NEN-EN 12732 (table G1 in the standard)

The symbols shown in this annex are taken from the standard, NEN-EN-ISO 5817, and may differ from the symbols shown in subclause 3.3.

| Symbol | Description | Unit |
|---|---|---|
| $A$ | Sum of projected areas of indications related to each $L \times W_p$ | % |
| $b$ | Width of excess penetration of weld | mm |
| $d$ | Diameter of a pore | mm |
| $d_A$ | Diameter of pore envelope area | mm |
| $d_{Ac}$ | Diameter of combined nest-shaped porosity | mm |
| $D$ | Distance between nest-shaped porosity | mm |
| $h$ | Width of indication, the width or height of surface imperfection | mm |
| $l$ | Length of indication | mm |
| $L$ | Any 100 mm of testing length | mm |
| $s$ | Nominal butt weld thickness | mm |
| $t$ | Base material thickness | mm |
| $W_p$ | Width of the weld | mm |
| $\Sigma l$ | Summary length of imperfections within $L$, in millimetres (indications shall not be divided into different ranges $L$). | mm |

## E.2 Imperfections

### *E.2.1 Internal imperfections*

Table 8: Acceptance criteria internal imperfections

| No. | Type of internal imperfection in accordance with NEN-EN-ISO 6520-1 | NEN-EN-ISO 10675-1 & NEN-EN 12732 table G1<br>No. 1, 3 to 11: Acceptance level 1<br>No. 2, 12: Acceptance level 2 |
|---|---|---|
| 1 | Cracks (100) | Not permitted |
| 2 | Porosity and gas pores (2011, 2012). Several layers | $A \leq 3$ % (see figure 21)<br>$d \leq 0{,}3 \cdot s$, max 4 mm<br>$L = 100$ mm |
| 3 | Clustered (localized) porosity (2013) | $d_A \leq W_p/2$, max. 15 mm (see figure 22 & 23)<br>$L = 100$ mm |
| 4 | Linear porosity (2014) | $l \leq s$, max 25 mm (see figure 26 & 27)<br>$d \leq 0{,}2 \cdot s$, max 2 mm<br>$L = 100$ mm |
| 5 | Elongated cavity (2015) and wormholes (2016) | $h < 0{,}2 \cdot s$, max 2 mm (see figure 28 & 29)<br>$\Sigma l \leq s$, max 25 mm<br>$L = 100$ mm |
| 6 | Shrinkage cavity (202) | Not permitted |
| 7 | Crater pipe (2024) | Not permitted |
| 8 | (Slag inclusions (301), flux inclusions (302) and oxide inclusions (303) | $h < 0{,}2 \cdot s$, max 2 mm<br>$\Sigma l \leq s$, max 25 mm<br>$L = 100$ mm |
| 9 | Metallic inclusions other than copper (304) | $l \leq 0{,}2 \cdot s$, max 2 mm |
| 10 | Copper inclusions (3042) | Not permitted |
| 11 | Lack of fusion (401) | Not permitted |
| 12 | Lack of penetration (402) | Not permitted |

Note:
Any two adjacent imperfections separated by a distance smaller than the major dimension of the smaller imperfection shall be considered as a single imperfection.

### *E.2.2 Imperfections appearing on the surface*

Imperfections appearing on the surface shall be assessed during the visual inspection. It is possible that the imperfections will also be visible on the radiographic images. The assessment made using radiography will be authoritative for the final assessment.

Table 9: Acceptance criteria surface imperfections

| No. | Type of surface imperfection in accordance with NEN-EN-ISO 6520-1 | NEN-EN-ISO 10675-1 & NEN-EN 12732 table G1<br>No. 13, 15, 16: Acceptance level 1<br>No. 14: Acceptance level 2 |
|---|---|---|
| 13 | Crater crack (104) | Not permitted |
| 14 | Stray arc (601) | Not permitted |
| 15 | Root concavity (515) | If the density in the weld material is more than the density in the adjacent base material than the assessment shall be Lack of penetration (402) |
| 16 | Poor restart (517) | Not permitted |

## E.3 Samples for the determination of imperfections

### *E.3.1 Porosity*

Figure 21 gives a image of a 3 % porosity percentages. This can be useful for the assessment of the porosity on the projected areas (radiographic) or cross section areas.

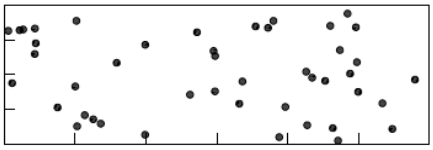


Figure 21: 3 % of the surface

### *E.3.2 Nest-shaped porosity*

Total of the acceptable ranges

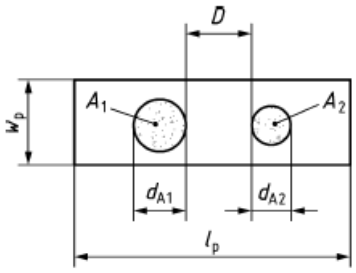



Figure 22: Nest-shaped porosity $D > d_{A2}$

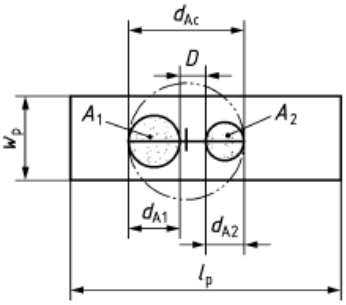



Figure 23: Nest-shaped porosity $D < d_{A2}$

The total of the various porosity ranges (*A1 + A2…*) in relation to the area to be evaluated $l_p \times W_p$ (figure 22).
If *D* is smaller than $d_{A1}$ or $d_{A2}$, regardless of which is smaller, the area within the surrounding $d_{Ac}$ shall be taken into consideration as a single imperfection (figure 23). The diameter of $d_{Ac} = d_{A1} + d_{A2} + D$.

### *E.3.3 Clustered porosity*

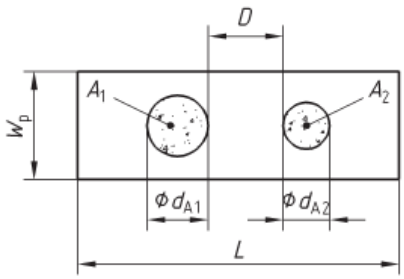



Figure 24:
Clustered porosity $D > d_{A2}$

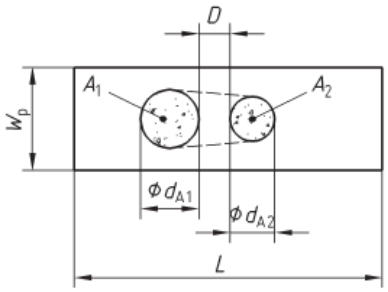



Figure 25:
Clustered porosity $D < d_{A2}$

The sum of the different pore envelope areas (A1 + A2 ...) related to the evaluation area, $L \times W_p$ (see figure 24), shall be calculated.
If $D$ is less than $d_{A1}$ or $d_{A2}$, whatever is smaller, an envelope surrounding the porosity areas, A1 + A2, shall be considered as one area of imperfection (see figure 25).

### *E.3.4 Linear porosity*

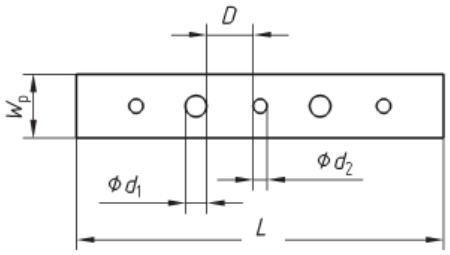



Figure 26:
Linear porosity $D > d_2$

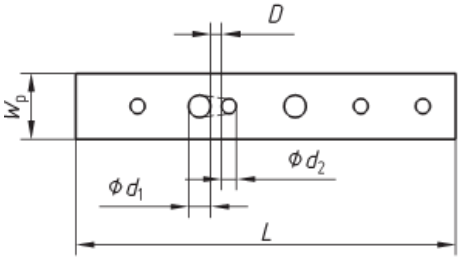



Figure 27:
Linear porosity $D < d_2$

The sum of the different pore areas related to the evaluation area, $L \times W_p$ (see figure 26), shall be calculated.
If $D$ is smaller than the smaller diameter of one of the neighbouring pores, the full connected area of the two pores shall be taken into the sum of imperfections (see figure 27).

### *E.3.5 Elongated cavities and wormholes*

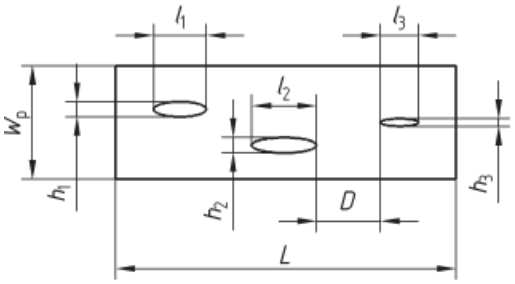



Figure 28: Elongated cavities and wormholes $D > l_3$

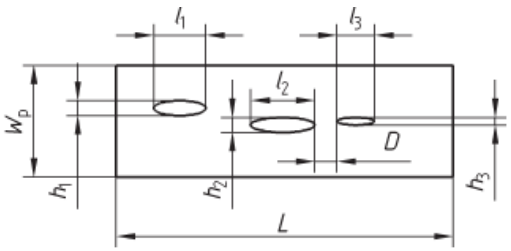



Figure 29: Elongated cavities and wormholes $D < l_3$

The sum of the length of indications, Σl, shall be determined for each testing length, *L* (see figure 28).
If *D* is smaller than the shorter length of one of the neighbouring imperfections, the full connection of the two imperfections is to be taken into the sum of imperfections (see figure 29).

## E.4 Evaluating manual (pulse echo) ultrasonic testing

### *E.4.1 Ultrasonic testing symbols*

| Symbol | Description | Unit |
|---|---|---|
| *d* | Wall thickness in accordance with construction drawing or dimension chart | mm |
| *H* | Echo height | * |
| $H_r$ | Comparison or reference echo height | * |
| *l* | Length of an inhomogeneity | mm |

Comment:
* expressed in percentages of the maximum screen height.

### *E.4.2 Acceptance criteria*

Indications on or in the vicinity (that is less than 2 mm) of the surface are permitted up to $H \leq H_r$ and $\bar{l} \leq 0{,}5 \cdot d$ with a maximum of 8 mm; $\bar{l}_{tot}$ not over 25 mm per 300 mm weld length, or proportionally less if the evaluated weld length is shorter.

Internal indications are permitted up to: $H \leq H_r$ and $\bar{l} \leq d$ with a maximum of 25 mm; $\bar{l}_{tot}$ not over 50 mm per 300 mm weld length; for a shorter evaluated weld length this is proportionally less.
6 dB drop method shall be used to determine flaw length.

### *E.4.3 Evaluation of transverse indications*

For transverse indications, surface grinding of the final weld layers is only permitted following consultation with Gasunie management.

One indication is permitted in the cross direction per 500 mm of weld length if the height is $H \leq H_r$ or less. The maximum permissible length of this indication is 6,0 mm.

## E.5 Evaluation ToFD testing

The evaluation standards are derived from NEN-EN 12732 (annex G Tier 2) and the revision of the EPRG tier 2 defect guidelines.

### *E.5.1 Validity range*

The acceptance criteria for weld imperfections described in this annex shall be applied if, for a wall thickness $d$, the following applies: 6,0 mm $\leq d \leq$ 30 mm.

For all other cases, specific acceptance criteria are determined by Gasunie "VGM" (HSE) department.

### *E.5.2 Acceptance criteria for ToFD*

Table 10: ToFD acceptance criteria wall thickness 6 mm < $d \leq$ 15 mm

| ToFD testing 6 mm < $d \leq$ 15 mm | | |
|---|---|---|
| | Permitted length<br>Surface breaking<br>Minimum distance to the surface < indications height<br>or touching lateral wave or the 2 mm zone on the inside of the pipe | Permitted length<br>Embedded<br>Minimum distance to the surface > indications height<br>and free from lateral wave |
| Indications height (mm) | Maximum length (mm) | Maximum length (mm) |
| $h \leq 1$ | 0,5·$D$ max 300 mm | *pipe circumference* |
| $1 < h \leq 1{,}5$ | 3·$d$ | 4,5·$d$ |
| $1{,}5 < h \leq 2$ | 2·$d$ | 4,5·$d$ |
| $2 < h \leq 2{,}5$ | 0,5·$d$ | 4·$d$ |
| $2{,}5 < h \leq 3$ | 0 | 4·$d$ |
| $3 < h$ | 0 | 0 |

Table 11: ToFD acceptance criteria wall thickness 15 mm < $d$ ≤ 30 mm

| ToFD testing 15 mm < $d$ ≤ 30 mm | | |
|---|---|---|
| | Permitted length Surface breaking Minimum distance to the surface < indications height[1)] | Permitted length Embedded Minimum distance to the surface > indications height and free from lateral wave |
| Indications height (mm) | Maximum length (mm) | Maximum length (mm) |
| $h$ ≤ 1 | 0,5·$D$ max 300 mm | pipe circumference |
| 1 < $h$ ≤ 1,5 | 3·$d$ | 5·$d$ |
| 1,5 < $h$ ≤ 2 | 2,5·$d$ | 5·$d$ |
| 2 < $h$ ≤ 2,5 | 2·$d$ | 4,5·$d$ |
| 2,5 < $h$ ≤ 3 | $d$ | 4,5·$d$ |
| 3 < $h$ ≤ 3,5 | 0,5·$d$ | 4·$d$ |
| 3,5 < $h$ ≤ 4,0 | 0 | 4·$d$ |
| 4,0 < $h$ | 0 | 0 |

1) If a indications affects the lateral wave or the 2 mm zone on the inside of the pipe, this indications shall always be considered as surface breaking.

### *E.5.2.1 Combined weld indications*

A group of indications, of which each individual indication is acceptable, is only acceptable provided **all** the following conditions are satisfied:

a The distance between consecutive indications in the circular/longitudinal direction of the weld is greater or equivalent to the average length of the indications.
b The distance between two consecutive indications in the height/thickness direction of the weld is greater than or equivalent to the height of the highest indication plus 50 %.
c The sum of the lengths of the individual indications, with a height > 1 mm is smaller or equivalent to 7·$d$ measured over any length of ½·$D$ to a maximum of 300 mm in the circular/longitudinal direction of the weld.
d For the merging of transverse indications: The weld does not contain two or more indications on top of each other, each with a height of more than 1,5 mm, irrespective of the position in the transverse/width wise direction of the weld.

### *E.5.2.2 Acceptance criteria where there is no ToFD signal*

If the ToFD signal fails, the following criterion applies:

– Lack of sound transmission over a length of 0,5·$d$ is permissible if the presence of a relevant indications is ruled out from a separate evaluation with a pulse echo technique.

### *E.5.2.3 Single diffraction signals*

If the ToFD scan detects single diffraction signals, the maximum permitted number of relevant indications per edge zone over a length of ½·$D$ to a maximum 300 mm weld length may not exceed the amounts stated in table 12. The height of the edge zone, measured from the surface, comes to ¼·$d$.

Table 12: Maximum permitted number of single diffraction signals per edge zone of ¼·*d*

| Nominal wall thickness *d* (mm) | Maximum permitted number of single diffraction signals per edge zone of ¼·*d* |
|---|---|
| 6,0 < *d* ≤ 9,0 | 20 |
| 9,0 < *d* ≤ 15,0 | 30 |
| 15,0 < *d* ≤ 30,0 | 40 |

A weld repair is required unless no excessive porosity is established by an X-ray; the evaluation standard for the X-ray is detailed in subclause E.1 of this specification (CSW-05-E).

#### *E.5.2.4 Evaluation of indications visible in ToFD and puls echo signals*

If an indication is detected with ToFD and puls echo signals, than for an embedded indication, the ToFD signals will be leading for the evaluation of the indication. If the indication is in the surface breaking zone, the puls echo signals will be leading for the evaluation of the indication.

#### *E.5.2.5 Evaluation of transverse indications*

Transverse indications can be observed both by ToFD probes and pulse echoe probes. Supplementary evaluation is necessary with ToFD testing. Surface grinding of the final weld layers is only permitted following approval from Gasunie management.

One indication is permitted per 500 mm weld length in the cross direction if the height is 1,5 mm or less. The maximum permissible length of this indication is 6,0 mm.

### *E.5.3 Evaluation of Phased Array testing*

The evaluation criteria are derived from NEN-EN 12732 (annex G, Tier 2 of EPRG document "EPRG guidelines on the assessment of defects in transmission pipeline girth welds"). Here, corrections are made based on the tolerances of testing that have been carried out and in line with good workmanship. By this means, the maximum permissible error-height/error-length combinations that are chosen are less than permitted by the EPRG-document.

### *E.5.4 Validity range*

For the use of PA testing, the following conditions shall be met:

- Wall thickness *d* shall be: 4,5 mm ≤ *d* ≤ 8 mm.
- The pipe diameter ≥ DN 50;
- The horizontal (axial) length of a tapering is 12 mm at the most (see CSW-01-N).
- De NDT inspector shall be informed about the weld that is to be inspected, in relation to, amongst other things, the location and dimensions of high-low and tapering.
- The cap of the weld shall not be removed.
- The Phased Array testing can only be used for pipeline material that has a $R_e$ ≤ 245 MPa (L245NB/MB, API Gr. B or equivalent).

### *E.5.5 Acceptance criteria for Phased Array*

If diffraction signals can be used to determine flaw height, the acceptance criteria of table 13 shall be used.

Table 13: based on height sizing

| Indications height | Wall thickness $4,5 \leq t \leq 8,0$ |
|---|---|
| $h$ (mm) | Maximum length[1)] (mm) |
| $h \leq 0,5$ | $0,5 \cdot D$ max 300 mm |
| $0,5 < h \leq 1$ | $3 \cdot t$ |
| $1 < h \leq 1,5$ | $2 \cdot t$ |
| $1,5 < h \leq 2,0$ | $1 \cdot t$ |
| $2 < h$ | 0 |

If diffraction signals cannot be used to determine flaw length height, the acceptance criteria of table 14 shall be used. The recording level for amplitude based is the acceptance level -4 dB.

Table 14: Based on amplitude

| Wall thickness (mm) | Maximum length[1)] (mm) |
|---|---|
| $4,5 \leq t \leq 8,0$ | 6 |

1) 6 dB drop method shall be used to determine flaw length

#### *E.5.5.1 Combined of indications*

A group of indications, individual indications of which are acceptable, shall only be acceptable if **all** the conditions below are met:

a) The distance between consecutive indications in the circular/longitudinal direction of the weld is greater than or the same as the average length of the indications.
b) The distance between two consecutive indications in the direction of height/direction of thickness of the weld is greater than or the same as the height of the highest indication plus 50 %.
c) The sum of the lengths of the individual indications, with a height > 1 mm, is smaller than or the same as 7.$t$ measured over a length of ½.$D$ up to a maximum of 300 mm in the circular/longitudinal direction of the weld.

#### *E.5.5.2 Evaluation of transverse indications*

Transverse indications can be observed using Phased Array. If a transverse indication is detected, contact shall be made with the Gasunie management. In the transverse direction, for every 500 mm of weld length, an indication with a height ≤ 1,5 mm is permitted. The maximum permissible length of a transverse indication is 4,0 mm.

## E.6 Evaluation of AUT testing

The evaluation standards are derived from NEN-EN 12732 (annex G Tier 2) and the revision of the EPRG tier 2 defect guidelines. The NIL "dunne plaat onderzoek" and the qualification tests for AUT in accordance with annex A of this specification (CSW-05-E) have caused corrections to be applied based on the tolerance of the relevant testing.

### *E.6.1 Validity range*

The acceptance criteria for weld imperfections described in this annex shall be applied if, for a wall thickness $d$, the following applies: 8,0 mm ≤ $d$ ≤ 30 mm.

For all other cases, specific acceptance criteria are determined by Gasunie "VGM" (HSE) department.

### *E.6.2 Acceptance criteria for AUT*

Table 15: AUT acceptance criteria wall thickness 8 mm < $d$ ≤ 15 mm

| AUT testing | | |
|---|---|---|
| 8 mm ≤ $d$ < 15 mm | Permitted length Surface breaking Minimum distance to the surface < indication height | Permitted length Embedded Minimum distance to the surface > indication height with a minimum of 2 mm |
| Indication height (mm) | Maximum length | Maximum length |
| $h$ ≤ 1 | 0,5·$D$ max 300 mm | *pipe circumference* |
| 1 < $h$ ≤ 1,5 | 3·$d$ | 4,5·$d$ |
| 1,5 < $h$ ≤ 2 | 2·$d$ | 4,5·$d$ |
| 2 < $h$ ≤ 2,5 | 0,5·$d$ | 4·$d$ |
| 2,5 < $h$ ≤ 3 | 0 | 4·$d$ |
| 3 < $h$ ≤ 3,5 | 0 | 0 |

Table 16: AUT acceptance criteria wall thickness 15 mm < $d$ ≤ 30 mm

| AUT testing with validated system | | |
|---|---|---|
| 15 < $d$ ≤ 30 mm | Permitted length Surface breaking Minimum distance to the surface < indication height | Permitted length Embedded Minimum distance to the surface > indication height with a minimum of 2 mm |
| Indication height (mm) | Maximum length | Maximum length |
| $h$ ≤ 1 | 0,5·$D$ max 300 mm | *pipe circumference* |
| 1 < $h$ ≤ 1,5 | 4·$d$ | 5,5·$d$ |
| 1,5 < $h$ ≤ 2 | 4·$d$ | 5,5·$d$ |
| 2 < $h$ ≤ 2,5 | 3·$d$ | 5,5·$d$ |
| 2,5 < $h$ ≤ 3 | 2·$d$ | 5·$d$ |
| 3 < $h$ ≤ 3,5 | 1·$d$ | 4,5·$d$ |
| 3,5 < $h$ ≤ 4 | 0 | 4·$d$ |
| 4 < $h$ ≤ 4,5 | 0 | 0 |

| AUT testing with multiprobe | | |
|---|---|---|
| 15 < *d* ≤ 30 mm | Permitted length Surface breaking Minimum distance to the surface < indication height | Permitted length Embedded Minimum distance to the surface > indication height with a minimum of 2 mm |
| Indication height (mm) | Maximum length | Maximum length |
| *h* ≤ 1 | 0,5·*D* max 300 mm | *pipe circumference* |
| 1 < *h* ≤ 2,5 | 2·*d* | 4·*d* |
| 1 < *h* ≤ 4 | 0 | 4·*d* |
| 1 < *h* ≤ 4,5 | 0 | 0 |

### *E.6.2.1 Combined indications*

A group of indications, of which each individual indication is acceptable, is only acceptable provided **all** the following conditions are satisfied:

a The distance between consecutive indications in the circular/longitudinal direction of the weld is greater or equivalent to the average length of the indications.

b The distance between two consecutive indications in the height/thickness direction of the weld is greater than or equivalent to the height of the highest indication plus 50 %.

c The sum of the lengths of the individual indications, with a height > 1 mm is smaller or equivalent to 7·*d* measured over any length of ½·*D* to a maximum of 300 mm in the circular/longitudinal direction of the weld.

d For the merging of transverse indications, the following applies: The weld does not contain two or more indications on top of each other, each with a height of more than 1,5 mm, irrespective of the position in the transverse/width wise direction of the weld.

Indications that do not comply with the above-mentioned conditions shall be treated as one indication. The indication dimensions ("*h*" and "*l*") shall be measured inclusive of the distance between the indications ("boxing");

### *E.6.2.2 Single diffraction signals*

If the ToFD scan detects single diffraction signals, the maximum permitted number of relevant indications per edge zone over a length of ½·*D* to a maximum 300 mm weld length may not exceed the amounts stated in table 17. The height of the edge zone, measured from the surface, comes to ¼·*d*.

Table 17: Maximum permitted number of single diffraction signals per edge zone of ¼·*d*

| Nominal wall thickness *d* (mm) | Maximum permitted number of single diffraction signals per edge zone of ¼·*d* |
|---|---|
| 6,0 < *d* ≤ 9,0 | 20 |
| 9,0 < *d* ≤ 15,0 | 30 |
| 15,0 < *d* ≤ 30,0 | 40 |

A weld repair is required unless no excessive porosity is established by an X-ray; the evaluation standard for the X-ray is detailed in subclause E.1 of this specification (CSW-05-E).

#### *E.6.2.3 Evaluation of transverse indications*

Transverse indications can be observed both by ToFD probes and pulse echoes. Supplementary evaluation is necessary with ToFD testing if the FSH of the transverse indications is more than 80 % FSH. Surface grinding of the final weld layers is only permitted following approval from Gasunie department "VGM" (HSE) testing.

One indication is permitted per 500 mm weld length in the cross direction if the height is 1,5 mm or less. The maximum permissible length of this indication is 6,0 mm.

## E.7 Evaluation of magnetic and/or penetrant weld testing

For the assessment of magnetic or penetrant testing, the following definitions shall be used:
- An indication shall be considered relevant if the minimum dimension is ≥ 1,5 mm.
- A linear indication has a length of at least 3 times its width.
- A round indication is an indication with a round or oval shape with a length of less than three times its width.

Any unclear indication, if necessary after the surface has been improved, shall be re-inspected with a view to determining whether or not it is relevant.
The use of penetrant testing shall be specifically approved by Gasunie department "VGM"(HSE) testing.

### *E.7.1 Acceptance criteria for weld bevel (magnetic/penetrant)*

The inspected surfaces of the weld bevel are free from:
- relevant linear indications;
- relevant round indications > 2 mm;
- more than three, in-line round indications ≥ 1,5 mm with a mutual distance of 1,5 mm, measured from edge to edge.

### *E.7.2 Acceptance criteria for weld testing (magnetic/penetrant)*

The inspected welds shall be free from:
- relevant linear indications;
- relevant round indications > 3 mm;
- more than three relevant circular indications larger than 2 mm diameter within a projected surface of 1 cm by 1 cm.