



Exploration & Production

## GENERAL SPECIFICATION

### PIPELINES - RISERS

GS EP PLR 430

|                                                                   |
|-------------------------------------------------------------------|
| <b>Automated Ultrasonic Testing (AUT) of pipeline girth welds</b> |
|-------------------------------------------------------------------|

|      |         |                                            |
|------|---------|--------------------------------------------|
|      |         |                                            |
|      |         |                                            |
| 03   | 01/2011 | General review                             |
| 02   | 10/2005 | Addition of "EP" root to GS identification |
| 01   | 10/2004 | General review                             |
| 00   | 09/2003 | First issue                                |
| Rev. | Date    | Notes                                      |

|                   |                                 |
|-------------------|---------------------------------|
| Owner: EP/TDO/TEC | Managing entity: EP/TDO/TEC/PLR |
|-------------------|---------------------------------|



## Contents

|                                                                                                   |           |
|---------------------------------------------------------------------------------------------------|-----------|
| <b>1. Scope .....</b>                                                                             | <b>5</b>  |
| 1.1 General .....                                                                                 | 5         |
| <b>2. Purpose of scanning.....</b>                                                                | <b>5</b>  |
| <b>3. Reference documents.....</b>                                                                | <b>5</b>  |
| <b>4. General.....</b>                                                                            | <b>7</b>  |
| 4.1 Definitions .....                                                                             | 7         |
| 4.2 Quality Assurance/Quality Control.....                                                        | 8         |
| 4.3 Sub-Contractor approval.....                                                                  | 9         |
| 4.4 Development of AUT procedure .....                                                            | 9         |
| 4.5 Pipes with large tolerance on wall thickness .....                                            | 9         |
| <b>5. Equipment.....</b>                                                                          | <b>10</b> |
| 5.1 Generality .....                                                                              | 10        |
| 5.2 Power supply .....                                                                            | 10        |
| 5.3 Ultrasonic equipment.....                                                                     | 10        |
| <b>6. Personnel qualification.....</b>                                                            | <b>14</b> |
| 6.1 Operator.....                                                                                 | 14        |
| 6.2 Interpreter .....                                                                             | 14        |
| <b>7. Calibration .....</b>                                                                       | <b>15</b> |
| 7.1 Calibration blocks .....                                                                      | 15        |
| 7.2 Ultrasonic examination set-up (static calibration) .....                                      | 17        |
| <b>8. Qualification of UT procedures .....</b>                                                    | <b>20</b> |
| 8.1 Generality .....                                                                              | 20        |
| 8.2 Preliminary statements .....                                                                  | 20        |
| 8.3 Qualification of the system efficiency.....                                                   | 21        |
| 8.4 Qualification of equipment particular arrangement/scanning procedure for each pipe size ..... | 21        |
| 8.5 Description of tests .....                                                                    | 21        |
| <b>9. Field examination - Production scanning .....</b>                                           | <b>26</b> |
| 9.1 General requirements .....                                                                    | 26        |



|            |                                                                                                                           |           |
|------------|---------------------------------------------------------------------------------------------------------------------------|-----------|
| 9.2        | Qualified equipment.....                                                                                                  | 26        |
| 9.3        | Static calibration .....                                                                                                  | 26        |
| 9.4        | Dynamic calibration .....                                                                                                 | 27        |
| 9.5        | Preliminary verification of scanning system calibration .....                                                             | 27        |
| 9.6        | Setting of parameters for production scanning .....                                                                       | 27        |
| 9.7        | Reference line.....                                                                                                       | 27        |
| 9.8        | Surfaces and coupling conditions .....                                                                                    | 27        |
| 9.9        | Pipe surface temperature .....                                                                                            | 28        |
| 9.10       | Accelerated cooling of welds .....                                                                                        | 28        |
| 9.11       | Traceability - Weld identification and scanning marking.....                                                              | 28        |
| 9.12       | Dynamic calibration frequency in production scanning.....                                                                 | 28        |
| 9.13       | Interpretation of scanning results.....                                                                                   | 28        |
| 9.14       | Inspector survey .....                                                                                                    | 29        |
| 9.15       | Re-examination.....                                                                                                       | 29        |
| <b>10.</b> | <b>Examination of welding repairs .....</b>                                                                               | <b>29</b> |
| <b>11.</b> | <b>Philosophy of weld quality and Imperfection Acceptance Criteria.....</b>                                               | <b>30</b> |
| 11.1       | Workmanship of good standard.....                                                                                         | 30        |
| 11.2       | Conditions to the implementation of ECA based AC (EC) in production .....                                                 | 30        |
| 11.3       | Engineering Critical Assessment .....                                                                                     | 31        |
| <b>12.</b> | <b>Inspection by the Company .....</b>                                                                                    | <b>32</b> |
| 12.1       | General.....                                                                                                              | 32        |
| 12.2       | Inspector's training.....                                                                                                 | 32        |
| <b>13.</b> | <b>Third Party .....</b>                                                                                                  | <b>33</b> |
| <b>14.</b> | <b>Documentation .....</b>                                                                                                | <b>33</b> |
| 14.1       | At the bid stage.....                                                                                                     | 33        |
| 14.2       | Reporting in production.....                                                                                              | 33        |
| 14.3       | Upon completion of pipe production .....                                                                                  | 35        |
| <b>15.</b> | <b>Other references .....</b>                                                                                             | <b>35</b> |
| Appendix 1 | Development of AUT procedure definition .....                                                                             | 36        |
| Appendix 2 | Additional requirements for pipes with a Wall Thickness Range "WTR" over 1.5 mm and sound path difference over 3 mm ..... | 37        |



|             |                                                                               |    |
|-------------|-------------------------------------------------------------------------------|----|
| Appendix 3  | Joint assembled as per WPS specification (Before machining of shrinkage) .... | 40 |
| Appendix 4  | JIG for reference line scribing .....                                         | 41 |
| Appendix 5  | Evaluation of defect length .....                                             | 42 |
| Appendix 6  | Test "T5" tack welded joint design .....                                      | 43 |
| Appendix 7  | Recommendation for "C3" coupling monitoring (phased array system).....        | 44 |
| Appendix 8  | Qualification stage - Synopsis of qualification and Inspector scope .....     | 45 |
| Appendix 9  | Production stage - Company inspector scope .....                              | 56 |
| Appendix 10 | Reserve form .....                                                            | 58 |



## 1. Scope

### 1.1 General

**Company reminds that specifications [GS EP PLR 420](#) and [GS EP PLR 421](#) require inspection of pipeline girth welds by x-ray. Inspection by automatic UT (AUT), when so proposed by Contractor, is subject to derogation request. Company may accept provided that the conditions and the requirements specified herein are fully met.**

This specification defines the Company requirements for the Automated Ultrasonic Testing (AUT) of any girth (field butt) welds of onshore or offshore transmission pipelines operating in sweet or sour service.

It applies to carbon steel pipelines of wall thickness 7 mm minimum, OD 4.5" minimum, and to pipes made from rolled plates or rolled coils.

It does not apply to seamless pipes or to welded pipes that have a Wall Thickness Range (WTR) which exceeds 1.5 mm or which affects the sound path in any channel of more than 3 mm. However, Company may accept derogation where AUT procedure is found to be specially designed for and really suitable. Refer to the relevant paragraph 4.5 and Appendix 2.

This specification covers multiple probe technique or phased array probe technique or a combination of these.

This specification shall be used in conjunction with a Project Particular Specification (PPS), if any, detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the pipeline project.

The automatic UT procedure proposed by Contractor shall conform to the present specification. It shall remind the here-included requirements, qualification tests and the acceptance criteria. It shall specify clearly the procedure of flaw evaluation, in such a way that Company Representative can understand and can counter check the UT interpretation. It shall be approved by the Third Party approved by Company and then, submitted to Company final approval. Procedure qualifications shall not begin until Company has accepted the procedure(s). The procedure validations are submitted to the hereafter qualifications.

## 2. Purpose of scanning

The system shall be capable to detect, to identify, to locate and to size in the through thickness and in the circumferential direction, and to size any longitudinal or transverse, planar or volumetric discontinuity.

It is Contractor responsibility to specify the equipment and the procedures so as to achieve such a capability.

## 3. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

The order of precedence of the applicable documents shall be:

- The Contract
- The Particular Specification if any



- The present Specification
- The codes and standards in reference.

Applicable Codes and Standards that are to be used in conjunction with this specification are stated in paragraphs hereafter.

Unless otherwise specifically indicated in writing by the Company, the Contractor shall work in accordance with the requirements specified herein and the applicable requirements of the latest editions at date of Contract award of the referenced Codes and Standards, whenever asked in the present specification.

Where this specification states no overriding requirements, the referenced Codes and Standards shall apply in full.

Standards equivalent to those referred to herein shall not be substituted without written approval from the Company. Approval of equivalent standards will not, in any way, remove responsibility from Contractor to meet the requirements of the Standards referred to and amended herein, in the event of conflict.

The Contractor shall equip himself with copies of all the reference specifications referred to in this specification and shall make them readily available to all fabrication, testing and inspection personnel involved on the work.

### Standards

| Reference      | Title                                                                                                                                                   |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| API 5L         | Specification for line pipe                                                                                                                             |
| API 1104       | Welding of pipelines and related facilities                                                                                                             |
| ASTM A 578     | Straight-beam ultrasonic examination of plain and clad steel plates of special application                                                              |
| ASTM E 317     | Practice for evaluating performance characteristics of ultrasonic Pulse-echo testing system without the used of electronic measurement instruments      |
| ASTM E 1961-98 | Standard practice for mechanised ultrasonic examination of girth welds using zonal discrimination with focused search units                             |
| BS 7910        | Guide on methods for accessing the acceptability of flaws on metallic structures                                                                        |
| DNV-OS-F101    | Submarine pipeline systems - 2000                                                                                                                       |
| EN 1435        | Non-destructive examination of welds. Radiographic examination of welded joints.                                                                        |
| ENV 583-6      | Non-destructive testing - Ultrasonic examination - Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities |
| ISO 9002       | Quality systems - Model for quality assurance in production and installation                                                                            |



## Professional Documents

| Reference | Title                                                                                    |
|-----------|------------------------------------------------------------------------------------------|
| EN 473    | Qualification and certification of NDT personnel – General principles                    |
| COFREND   | Comité français des essais non-destructifs (French Committee of non-destructive testing) |

## Regulations

| Reference      | Title |
|----------------|-------|
| Not applicable |       |

## Codes

| Reference   | Title                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------|
| ASME B 31.4 | Liquid transportation systems for hydrocarbons, liquid petroleum gas, anhydrous ammonia, and alcohols |
| ASME B 31.8 | Gas transmission and distribution piping systems                                                      |

## Other documents

| Reference      | Title |
|----------------|-------|
| Not applicable |       |

## Total General Specifications

| Reference     | Title                                                                                           |
|---------------|-------------------------------------------------------------------------------------------------|
| GS EP PLR 420 | Site welding of carbon steel pipelines to API 1104 (sweet service)                              |
| GS EP PLR 421 | Site welding of carbon steel pipelines to API 1104 (mild, intermediate and severe sour service) |

## 4. General

### 4.1 Definitions

**Company** TOTAL or agents acting on its behalf, shall be referred to herein as the "Company".

**Contractor** Shall be the Company appointed by the Company to carry out the work but shall also include his Sub-Contractors and Vendors.



|                         |                                                                                                                                                                                                                                                                                                                                                              |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Third Party (TP)</b> | Shall be any recognised authority appointed by Contractor, as defined in chapter 13 of this specification.                                                                                                                                                                                                                                                   |
| <b>Inspector</b>        | The Company's representatives or members from a Company's elected Inspection Agency for the time being or from time to time duly appointed in writing by the Company to act as its representatives for the purpose of the Contract shall be referred to herein as the "Inspector".                                                                           |
| <b>Operator</b>         | Is a Contractor's technician who is qualified and trained to manipulate in practice the AUT equipment.                                                                                                                                                                                                                                                       |
| <b>Interpreter</b>      | Is a Contractor's technician qualified and trained and whose expertise is deemed sufficient to apply properly the AUT procedure in regard of the present specification requirements.                                                                                                                                                                         |
| <b>Contract</b>         | All documents such as requisitions, specifications, etc. issued by Company and attached to the contract or the purchase order are referred to herein as the "Contract".                                                                                                                                                                                      |
| <b>Approval</b>         | Authorisation in writing given by the Company to the Contractor on a procedure or to proceed with the performance of a specific part of the work without releasing in any way the Supplier from any of his obligations to conform with the technical specifications, requisitions, etc. "approve", "approved" and "approval" shall be construed accordingly. |
| <b>Search units</b>     | Means also <b>Transducers or Probes</b> .                                                                                                                                                                                                                                                                                                                    |
| <b>Indication</b>       | Evidence of an imperfection obtained by non-destructive testing.                                                                                                                                                                                                                                                                                             |
| <b>Mapping</b>          | An image of weld cross section where indication(s) may be localised along the weld.                                                                                                                                                                                                                                                                          |
| <b>TOFD</b>             | Time Of Flight Diffraction techniques.                                                                                                                                                                                                                                                                                                                       |
| <b>Imperfection</b>     | A discontinuity or irregularity that is detectable by methods outlined in this specification.                                                                                                                                                                                                                                                                |
| <b>Defect</b>           | An imperfection or discontinuity of sufficient magnitude to warrant rejection based on the stipulations of the present specification.                                                                                                                                                                                                                        |
| <b>Repair</b>           | Any rework on a weld that is required to correct a weld defect. The defect is beyond this specification's limits of acceptability.                                                                                                                                                                                                                           |
| <b>To Detect</b>        | To make evidence of an imperfection on weld examination chart.                                                                                                                                                                                                                                                                                               |
| <b>PUS</b>              | Probability of under-sizing.                                                                                                                                                                                                                                                                                                                                 |
| <b>May</b>              | Used to indicate that a provision is optional.                                                                                                                                                                                                                                                                                                               |
| <b>Shall</b>            | Used to indicate that a provision is mandatory.                                                                                                                                                                                                                                                                                                              |
| <b>Should</b>           | Used to indicate that a provision is not mandatory but is recommended as good practice.                                                                                                                                                                                                                                                                      |

## 4.2 Quality Assurance/Quality Control

The Supplier shall operate a Quality Assurance system in accordance with [ISO 9002](#), or equivalent, approved by a recognised authority.



Three months prior to commencement of weld inspection, the Supplier shall prepare and submit to the Company a written Quality Control Plan (or otherwise called Inspection and Test Plan) which describes all the required information hereafter. The Quality Control Plan shall set forth "Witness", "Hold", "Review" and "Monitor" points.

Moreover, the interface between weld inspection and welding quality monitoring shall be described in the Contractor Quality plan. It shall ensure the transmission of scanning results to the welding line in terms of corrective actions to keep a good quality standard.

#### 4.3 Sub-Contractor approval

The following Sub-Contractors shall be submitted to Company for approval:

- The laboratories selected to perform the ECA associated tests
- The supplier of ECA calculation
- The AUT Sub-Contractor
- Contractor's Third Party.

#### 4.4 Development of AUT procedure

The AUT procedure shall be specifically developed for the Project job. It shall be detailed on the basis of technical specificity and of purpose/requirements to meet.

Consequently, as a minimum, the following data shall be provided to the AUT Sub-Contractor early enough to allow him to define and issue adequately his procedure:

- Profile and dimensions of weld preparation, together with its tolerances
- Welding process
- Thickness standard deviation of pipes
- Weld shrinkage
- Acceptance criteria of defects issued from the ECA, when so accepted by Company.

Company keep its rights to amend or modify the requirements stated in the present specification, in view of the above data.

**Contractor shall strictly conform his development to the Appendix 1 of the present specification.**

#### 4.5 Pipes with large tolerance on wall thickness

As stated in the paragraph 1, the AUT inspection of pipeline girth welds of which wall thickness range (WTR) exceeds 1.5 mm is not allowed.

However, it may be accepted under the following conditions:

- The effect of tolerance on the thickness, considering  $\pm$  "WTR/3", does not affect the ultrasonic path of more than 3 mm in any pulse echo/tandem channel (e.g. V bevel where tandem is not applied). In such conditions, the AUT scanning of girth welds is acceptable and the above requirements shall apply for equipment, calibration block, qualification and production scanning

- The effect of tolerance on the thickness, considering  $\pm$  "WTR/3", affects the ultrasonic path of more than 3 mm in any pulse echo/tandem channel. Then, X-ray radiography and the requirements of the relevant specification [GS EP PLR 420](#) or [GS EP PLR 421](#) shall apply. However, if Contractor maintains his request to perform AUT on girth welds, the additional requirements of the Appendix 2 shall apply.

## 5. Equipment

### 5.1 Generality

The system shall be capable to identify and to size (height and length) all imperfections identified herein and in the [API 1104](#) Chapter 9.6, and shall clearly identify the specific zone in which they are located.

### 5.2 Power supply

The ultrasonic system shall have its own power supply. There shall be provisions for an alternative power supply in case of failure in the main power supply. There shall be no loss of inspection data as a result of a power failure.

### 5.3 Ultrasonic equipment

#### 5.3.1 General

The system shall provide an adequate number of examination channels to cover the examination of the complete volume of the weld through thickness and heat-affected zone in a single circumferential scan. The system shall be designed such that the weld volume is divided into elementary examination zones of height in the through thickness direction not exceeding 3 mm in the fill region.

In case phased array equipment is used and work as multi-probes equipment, each individual ultrasonic channel produced by the phased array transducer shall have a predefined focal law.

#### 5.3.2 A-Scan

The instrument shall provide a linear A-scan presentation for each channel selected.

#### 5.3.3 B-scan

The instrument shall provide a TOFD and a B-scan image. TOFD shall complete pulse-echo techniques but shall not replace pulse-echo techniques.

B-scan display will be used for volumetric imperfection detection and characterisation.

#### 5.3.4 Scanner

The details of the probes required to inspect the weld will be defined for the specific application in a technique described in the Contractor procedure.

The system shall allow to carry out properly the static calibration, i.e. the UT scanning frame shall have an approach speed slow enough (or declutchable) to allow a perfect positioning of probes on the relevant reflector(s) and the computer display shall allow to show individually each channel.



### 5.3.5 Transducers

#### 5.3.5.1 Generality

A single pair or multiple pair of phased array probes or a combination of phased array and conventional ultrasonic transducers may be used. Each weld configuration shall require the development of a unique inspection procedure based on the parameters of weld bevel and expected possible imperfection position and orientation. Acceptable performance of the probes used for the zonal discrimination will be demonstrated by signals from adjacent zones being at least 6 dB and not more than 12 dB lower than the zone a probe or array is calibrated for. All transducer wedges shall be contoured to match the curvature of the pipe surface.

#### 5.3.5.2 Actual characteristics

As a minimum, the following parameters for each transducer shall be reported:

- Identification
- Beam angle
- Wedge characteristics
- Beam size
- Pulse shape
- Frequency
- Pulse length
- Signal to noise
- Focus point and length in case focused beams are used
- Focus laws in case phased arrays are used.

The whole of these parameters is not always applicable to phased array transducers.

The transducers with array design shall be indicated at the bid stage.

#### 5.3.6 Actual arrangement of the system

After AUT Sub-Contractor has carried out his "in house" adjustments for the system optimisation, the following data shall be duly reported before qualification starting:

- "Actual characteristics" as stated above
- Number of transducers
- Arrangement of transducers.

After qualification test(s) has been found satisfactory, Inspector and Third Party shall sign this report. This report shall be attached to AUT procedure as the actual qualified configuration.

Prior to start any calibration, qualification or production examination, the actual configuration shall be checked and reported. Once qualified, there shall not be any change made without prior agreement of Company.

### 5.3.7 Acoustic Coupling

Two types of coupling control shall be available on the system:

- Transmission type between probes symmetrical from the weld centre line (C1)
- Level coupling control type (surface condition control) (C2) shall consist of a scanning zero degree on both upstream and downstream, on the circumferential area of the farthest receiver probe. The probe area shall be of similar size as the weld scanning probes. The reference level shall be the back wall signal on calibration block
- For Phased Array system, a coupling control (C3), of "C2" type, may be sufficient, providing that the full scanning area is covered as shown on the attached sketch.

### 5.3.8 Software

The software and the particular executable programs (sequenced focal laws) from the software to be used for each scanning procedure shall be identified by a unique version number which will be specified in the procedure. These specific numbers shall be clearly indicated on all displays and printouts of calibration and production scanning.

All recording, data handling, software and weld examination chart system shall be covered by the Quality Assurance system.

**The specific programs of the software shall be exactly the same for dynamic calibrations as for production scanning. Software, programs, etc. shall not display information on indications or reflectors from theoretical pre-set data. The display shall be such as found really by the UT scanning, based on the commonly used method of UT interpretation.** E.g. a planar indication at root shall not be displayed automatically at the pre set theoretical root face location but it shall be shown at the actual location it is.

### 5.3.9 Recording system

The scanning direction shall be clockwise as regard to the fluid direction through the pipe. "Upstream" and "downstream" side shall refer to the flow fluid direction. The AUT procedure shall include a sketch of site laying, showing the flow(s) direction(s) and the scanning direction(s). The "0" datum shall always be referenced on the top of the pipe (12 o'clock in 5G scanning position).

The recording system shall clearly indicate the locations of imperfections from 12 o'clock position with a + 10 mm accuracy along weld length.

Each transducer (or symmetrical couple of transducers) shall exhibit a separate recording channel for imperfection evaluation and confirmation of acoustic coupling.

The numerisation frequency shall be between 6 and 10 times the transducer frequency

Distance markers shall be provided on the recording at intervals not exceeding 100 mm of circumferential weld length.

For TOFD technique, the recording system shall be capable of a 64 level greyscale display and be capable of recording full R-F waveforms for the TOFD transducer pairs.



### 5.3.10 Reporting and data storage

#### 5.3.10.1 Weld examination chart

The examination data produced as a permanent record should consist of a complete strip chart type showing the weld number, the reference point "O", the direction of scanning, date and time of examination, and the name of operator and interpreter. The examination zone identified in each channel should also be recorded.

Colour palettes or grey scales used for B-scan mapping channels shall be set to display all pertinent signals. It shall provide a rapid mean to identify the concerned areas and to aid the characterisation of flaws.

#### 5.3.10.2 Electronic data storage

All weld inspections shall be stored automatically at the end of each inspection cycle (each production weld) on two hard drives in the inspection computer. Calibration parameters (gains, threshold levels, etc.) shall be recorded and stored as well, prior to start each production shift and every time when any parameter is changed.

Periodic data back up will be made to back up data master.

#### 5.3.10.3 Graphical print-out

Calibration parameters (gains, threshold levels, etc.) shall be printed out prior to start each production shift and every time when any parameter is changed. Strip chart of any weld showing defect shall be prints out.

### 5.3.11 Spares

There shall be a sufficient number of spare parts available at the place of examination to ensure that the work can proceed without interruptions. Type and number of spares shall be agreed with Company. The AUT Contractor shall evaluate the necessity to provide spare calibration blocks in regard of the quantity of joints to be scanned in production.

### 5.3.12 Display for Company supervision

The Contractor shall include in the system, slave equipment computer/monitor/software which will allow, in real time, Inspector to carry out inspection at his own convenience:

- The display of production and calibration scanning
- The return back to any previous scanning
- The verification of any pre-set parameters
- The supervising of any indication evaluation in terms of size, signal amplitude, location in weld cross section and position on the circumference.

All facilities, computer software tools, available for AUT interpreter shall be available as well on Inspector slave equipment without any restriction.

### 5.3.13 JIG for scribing the reference line

For an accurate positioning of UT probe holder, a specific jig shall be used. The device shall allow scribing a positioning reference line on pipe external surfaces, the jig being tacked against the **bevel root face, which shall be the reference plan.**



Jig shall be qualified at the stage of procedure qualification and then shall be used for production scanning. The AUT procedure shall specify at which pipe end (upstream or downstream with respect to the flow direction) of the joint, the reference line must be scribed.

The tolerance on UT head positioning shall not exceed + 0.5 mm against the bevel root face. However, because of the difficult conditions on site/barge, the scanning system shall remain fully efficient with a deviation of  $\pm 2$  mm from the stated theoretical position, unless Contractor can demonstrate that better accuracy of band positioning can be achieved.

The procedure shall include instructions to AUT operator:

- To place the band on minimum 3 points at 120° each other around the circumference
- To verify on the scanning display that UT head is well centred
- When the band is incorrectly centred, to instruct the technicians responsible to “reposition the band” for a rescanning
- To check periodically (at least twice a shift), the scribe line proper position
- To call for a corrective action when recurrent deviation is found.

## 6. Personnel qualification

The credentials of each AUT operator and interpreter shall be submitted to Company acceptance 3 weeks minimum prior to start of weld examination.

Company shall have the right to verify the operators and interpreters qualifications before final approval.

Operators and interpreters who are not accepted by Company shall not work on the project.

The Contractor shall designate one of them to be the lead operator and interpreter and also the responsible of the ultrasonic personnel, the good order of equipment, spare parts availability, and inspection work, including reports and records. The interpreters shall have technical support from an “AUT-expert-interpreter” at any time during execution of the examination work.

### 6.1 Operator

The operator, who operates the scanner mechanism shall be trained in using mechanised UT manipulator.

### 6.2 Interpreter

AUT interpreters shall have at least one previous experience of AUT on pipe laying. This previous experience as AUT interpreters shall include the use of the same AUT system and same AUT software.

Interpreters shall be qualified for manual UT to level 2 minimum by a recognised independent authority, **EN 473** or equivalent.

They shall be able to demonstrate their capabilities with regard to calibrating the equipment, performing an operational test under field conditions and evaluating type, size, nature and location of imperfections.

## 7. Calibration

### 7.1 Calibration blocks

#### 7.1.1 Specificity

Pipe section for calibration blocks shall be taken from the Project pipes. The pipe shall be selected to have a wall thickness corresponding to the average  $[(W_{tmax} + W_{tmin})/2]$  of values found by pipe mill inspection or by plate/coil rolling mill. The pipe number and the pipe section shall be selected based on the manufacturing mill data, as stated in the Appendix 2 of the present specification. However, the selected pipe and section shall be taken off for calibration block sampling, only after the blasting at coating stage.

One calibration block shall be required for each pipe size.

A specific calibration block shall be required for any difference in the Essential Variables hereunder listed:

- Pipe diameter
- Wall thickness
- Steel source
- Plates (or coils) sources and/or manufacturing process
- Steel grade
- As delivery condition of base material
- Heat treatment condition of weld
- Welding Procedure Specification (WPS)
- Welding Procedure Qualification Test (WPQ)
- Bevel profile and dimensions (including root face)
- Preparation root gap.

The steel acoustic isotropy shall be checked by scanning a weld bevel over 360° using the tandem channels. The steel isotropy will be satisfactory if the signal variation does not exceed 3 dB (i.e.  $\pm 1.5$  dB). Otherwise a special procedure for calibration shall be applied.

Moreover, in case of doubt concerning the base material homogeneity in a same batch (as defined above), acoustic velocity and attenuation measurements shall be performed to compare the behaviour of the various materials. These measurements shall be performed according to [DNV-OS-F101-Appendix E-Annexe B](#) or [ASTM E 1961-Annexe A1](#). If significant differences in acoustic velocity are found, then specific calibration blocks shall be made.

#### 7.1.2 Design

Calibration blocks shall be used to calibrate, qualify the inspection equipment and procedure, and to monitor the production scanning calibration.

The drawings of the calibration blocks used shall be appended to the Contractor procedure. Calibration reflectors shall be checked by the Contractor for conformance to design drawings.

Results of prints or metrology will be kept in file for each calibration block and submitted to Company on request.

Reference Standards or calibration blocks shall be in accordance with “[DNV-OS-F101-Appendix E-Chapter B §412 to §422](#)” or “[ASTM E 1961-Annexe A3](#) (block types A3-1 and A3-2)” and the hereafter requirements.

The calibration block shall be designed with sufficient length and width so that total number of transducers including array system will run across the target areas in a single pass.

The calibration block shall be identified and hard stamped using a unique serial number. Records of the serial number, wall thickness, diameter, item, batch, bevel design, welding procedure and ultrasound velocity shall be kept and be made available to Inspector review.

Contractor shall submit also to Company the details and sketches of:

- The specific weld geometry
- The ultrasonic path associated to each reflector.

For the inspection of SAW welds (e.g. double jointing), a welded joint shall be used for the manufacture of calibration blocks. Weld reinforcements shall be let as they are after welding.

### 7.1.3 Reflectors

The type and the position of each reflector shall be the most suitable to simulate the expected imperfections in the relevant zone, in regard of the joint preparation (bevels) and of the welding process.

At the bevel opposite to the reference line scribed at pipe end (refer to 5.3.13), the positioning of reflectors shall take into account the transverse weld shrinkage expected or previously measured by the Contractor. This parameter (i.e. the expected weld shrinkage) shall be specified in the AUT procedure.

The following shall be required, as a minimum, for calibration:

- Height of scanning zones in weld fill: 3 mm max.
- Flat Bottom Hole (FBH) reflectors shall be 2 mm max in diameter
- Reflectors for longitudinal scanning calibration shall consist of notches with depth between 0.8 mm and 1 mm, with maximum length of 15 mm. For TOFD, the Contractor shall specify the dimensions of reflectors
- Reflectors for transverse scanning calibration shall consist of one transverse notch, 1 mm deep and 5 mm width, on external and internal surfaces. Each couple of probes shall detect, at the minimum, 80% FSH for the dedicated notch and 30% FSH for the opposite surface notch. Otherwise, alternative calibration could be based on one FBH, diameter 3 mm, drilled at both block ends, designated as (Ht), longitudinally to the weld direction, at mid thickness. These calibrations will allow demonstrating that full through thickness scanning is achieved
- For volumetric defects (such as porosity), on upstream (US) and downstream (DS), one FBH diameter 1.5 mm designated as (Hp), 45° from the vertical, every 7 mm of thickness



- Through thickness longitudinal slot, located either side, at weld centre line for gate positioning
- Reflectors simulating high-low of 1 mm max (low side alternatively at Upstream and at Downstream).

The machining tolerances shall be in accordance with [ASTM E 1961](#), Chapter A3.8. However, where ASTM specifies a tolerance of 0.1 mm, 0.2 mm will be acceptable.

Lateral positioning of the reflectors should be such as to allow for independent signals. The beam of each transducer shall include the reflector without any part of the beam encountering adjacent reflector.

The calibration block may be inserted and only tack-welded on the circumference of the calibration pipe.

Any modification to the above requirements shall be duly justified and submitted to Company prior approval.

#### 7.1.4 Storage of calibration blocks

The Contractor shall ensure preservation and storage of calibration blocks.

They shall be stored and made available to the Company for 30 days minimum after the inspection completion.

### 7.2 Ultrasonic examination set-up (static calibration)

The system shall be optimised for any inspection and particularly for qualification and for field inspection using the relevant calibration block(s).

#### 7.2.1 TOFD

To the extent that is applicable, [ENV 583-6](#) will be used as a guide for setting up the TOFD arrangement.

The TOFD emitter-receiver elements shall be optimised for the wall thickness to be tested using the same refracted angle for emitter and receiver. Probe centre spacing will be selected so as to allow the theoretical crossing point of the beam centres to occur on the weld centreline at approximately 66% to 95% of the wall thickness. Probe parameters of frequency, damping, filtering and incident angle will be selected so as to limit the dead-zone formed by the lateral wave.

When a phased array equipment is used and the pair of arrays is not able to produce an acceptable signal, a dedicated TOFD transducer pair shall be used.

The amplitude of the lateral wave shall be between 40% and 80% full screen height (FSH). In cases where the use of the lateral wave is not appropriate (e.g. inappropriate surface conditions, use of steep beam-angles), the sensitivity shall be set such that the amplitude of the back wall signal is between 18 dB and 30 dB above FSH. When the use of neither a lateral wave, nor a back wall signal is appropriate, sensitivity should be set such that the material grain noise is between 5% and 10% FSH. In any case, the sensitivity shall be verified by the use of an appropriate reference block.

The time start of gate shall be at least 1  $\mu$ s prior to the time of arrival of the lateral wave, and shall at least extend up to the first back wall echo. Because mode converted echoes can be

used in identifying defects, it is recommended that the time gate also includes the time of arrival of the first mode converted back wall echo. The time gate shall cover at least the depth of region of interest.

For TOFD, the recording threshold shall be the calibration threshold. It is normally not recommended to change it. However, a change of threshold may be specified in the procedure in post processing mode but it shall not exceed  $\pm 6$  dB.

## 7.2.2 Mapping Channels

In addition to the strip chart (linear C-scan) channels, digitised waveforms will be used to generate B-scan mapping channels. Dedicated separate transducers or focal laws or a re-firing of dual purpose probes (e.g. root probe for amplitude on one firing and mapping on another firing) will be used to generate volumetric/mapping channels for both the weld fill area and the root area.

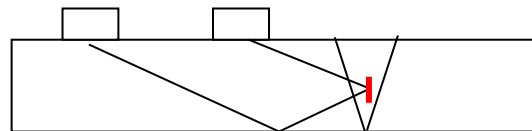
The mapping sensitivity shall allow to detect a spherical porosity of diameter 20% x w.t. and 3 mm max, wherever its location in the weld. As a minimum, gain will be approximately 6 -10 dB over that required achieving an 80% FSH signal from a 1.5 mm FBH (Hp) but should not be so great as to cause electrical interfering or geometric noise.

Colour palettes used in the B-scan mapping channels shall be set to display all pertinent signals over the noise level and indicate signal amplitude with respect to threshold and reference levels.

Using the calibration block, each mapping gate shall be set to cover a sound path distance which starts at least 7 mm before the weld preparation (in HAZ) and long enough to encompass 3 mm after the weld axis bevel on opposite side of weld centreline.

## 7.2.3 Pulse Echo and Tandem mode

### TANDEM MODE



**Note:** The tandem mode technique is used to detect imperfections perpendicular to the scanning surface. Both probes are set on the same side of the weld, one working as emitter and the other as receiver.

### 7.2.3.1 Static Calibration

**Gate widths:** Gates shall be set 5 mm min before the fusion line (in HAZ), and 3 mm minimum after the weld axis (except at root where 1 mm minimum is required). Moreover, gate adjustment shall take into account the extent of possible signal position due to the difference between the minimum and the maximum of ultrasonic time flight. This difference shall be relating to a band positioning error of 1 mm and to a difference of wall thickness equal to 2 times the standard deviation.

**Reference signal** from reflectors shall be set 80% FSH min.

**Detection thresholds:** Threshold shall be set at 20% FSH. Any imperfection which send a signal higher than 20% FSH shall be considered as a defect. Its length shall be that corresponding to the part of signal over 10% FSH (the 6 dB drop method). No indication of "go/no go" type will be displayed on screen. Only colour/signal height type is allowed.