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TECHNICAL SPECIFICATION

HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

WELDING INSPECTION

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1. SCOPE

This specification covers inspection of welding work in Natural Gas Pipelines, Pipeline Installations, MR
Stations and Compressor Stations. For this inspection, the requirements of the following, in order of precedence, shall be fulfilled:

- This specification.
- ELOT EN 12732
- ELOT EN 1594
- Documents to which reference is made to the following.

2. REFERENCES

2.1. REFERENCE DOCUMENTS

- Tech. Spec. No. DSF-SPC-PIP-112 [Welding]

2.2. REFERENCE CODES AND STANDARDS

- EN ISO 19232-3 "Non-destructive testing - Image quality of radiographs - Part 3: Image quality classes»
- EN ISO 9712 "Non-destructive testing - Qualification and certification of NDT personnel - General principles"
- EN ISO 16810 "Non-destructive testing - Ultrasonic Testing General principles"
- EN ISO 16826 "Non-destructive testing. Ultrasonic testing. Examination for discontinuities perpendicular to the surface"
- EN ISO 16828 "Non-destructive testing. Ultrasonic testing. Time-of-flight diffraction technique as a method for detection and sizing of discontinuities”
- EN ISO 17640 “Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment”
- EN ISO 3452-1 “Non-destructive testing — Penetrant testing — Part 1: General principles”

- EN ISO 3452-2 “Non-destructive testing — Penetrant testing — Part 2: Testing of penetrant materials”
- P.D. 101/2018 Adaptation of Greek legislation to Council Directive 2013/59 / Euratom of December 5, 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618 / Euratom 90/641 / Euratom, 96/29 / Euratom, 97/43 / Euratom and 2003/122 /(EE L13 / 17.1.2014) - Establishment of radiation protection regulations
- EN ISO 17636-1 “Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film”
- EN ISO 11699-1 “Non-destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography”
- EN ISO 19232-1 “Non-destructive testing — Image quality of radiographs — Part 1: Determination of the image quality value using wire-type image quality indicators”
- EN ISO 19232-3 “Non-destructive testing — Image quality of radiographs — Part 3: Image quality classes”
- EN ISO 9934-1 “Non-destructive testing — Magnetic particle testing — Part 1: General principles”
- EN ISO 9934-2 “Non-destructive testing — Magnetic particle testing — Part 2: Detection media”
- EN ISO 9934-3 “Non-destructive testing — Magnetic particle testing — Part 3: Equipment”
- EN ISO 17638"Non-destructive examination of welds. Magnetic particle examination of welds"
- ELOT EN 1594 "Gas supply systems - Pipelines for maximum operating pressure over 16 bar - Functional requirements"
- EN ISO 3183 "Petroleum and natural gas industries. Steel pipe for pipeline
- transportation systems"
- ELOT EN 12732 "Gas supply systems - Welding steel pipework- Functional
- requirements"
- EN ISO 15626 " Non-destructive testing of welds - Time-of-flight diffraction technique (TOFD) - Acceptance levels"
- EN ISO 10863" Non-destructive testing of welds. Ultrasonic testing. Use of time-of-flight

diffraction technique (TOFD)"

- ASTM E-1961-2006 "Mechanized Ultrasonic Examination of Girth Welds using Zonal Discrimination with Focused Search Units"
- ISO/IEC 17020 "Conformity assessment — Requirements for the operation of various types of bodies performing inspection"
- ISO/IEC 17025 "Testing and calibration laboratories"
- ASME BPVC Section V "Nondestructive Examination"

3. GENERAL

All completed welding work shall be subject to series of examinations to control the quality of the work. The performance of examinations is to be allowed for in the work program. Examinations shall be rated with the same capacity as the welding work. Weld seams shall not be insulated or surface treated in any way before examinations have been made and weld clearance has been given by the Owner representative.

NDE for final acceptance shall be performed after any PWHT.

The Contractor shall plan, prepare, qualify, perform, evaluate, supervise and document all non-destructive examination (NDE).

All NDE will be performed by using written procedures that have been approved by a Level III Inspector as per EN ISO 9712, appointed in writing by the Contractor and declared to the Owner.

The procedures shall be detailed enough to provide the technique to be used to meet all codes requirements and must be approved by Owner.

Personnel performing and evaluating the above examinations shall be qualified in accordance with provisions of EN ISO 9712. All NDE reports, radiographic films and qualification records shall be available for Owner's Representative review.

All material equipment, personnel, procedures, documents and facilities necessary for NDE shall be provided by the Contractor and are in the scope of work of his contract with the Owner.

4. TEST METHODS

The following test methods shall be used:

- Radiography for all butt welds in the pipeline.

- Ultrasonic for butt welds in pipe with wall thickness exceeding 6.0 mm.

- Magnetic particle examination for welds which cannot be examined with radiography or ultrasonic. For checking that defects have been totally removed when repair welding is done and for testing of surfaces.

- Dye penetrant examination instead of magnetic particle examination, where this is not practicable.

- Destructive testing for certain girth production welds to be specified by the Client

- Representative.

5. NDE PROCEDURES

5.1. GENERAL

Six weeks before the start of any welding the Contractor shall submit to Owner for approval written detailed NDE-procedure specifications, including samples of reporting forms for each of the methods to be applied.

5.2. RADIOGRAPHIC EXAMINATION PROCEDURE

The procedure shall conform to the requirements of this Specification and EN 12732 and EN ISO 17636-1 for each technique used. Also included shall be complete equipment descriptions.

5.3. ULTRASONIC EXAMINATION PROCEDURE

The procedure shall conform to the requirements of EN 12732, EN ISO 16810, EN ISO 17640 and this Specification.

5.4. MAGNETIC PARTICLE EXAMINATION PROCEDURE

The procedure shall conform to the requirements of EN 12732, EN ISO 9934-1, EN ISO 17638 and this Specification.

5.5. LIQUID PENETRANT EXAMINATION PROCEDURE

The procedure shall conform to the requirements of EN 12732, EN ISO 3452 and this Specification. Type of cleaner, penetrant and developer shall be stated.

5.6. AUTOMATIC ULTRASONIC TESTING (AUT) PROCEDURE

Automatic Ultrasonic examination of welds may be applied as alternative to the radiographic technique under the terms that will be agreed in the contract. The Automatic Ultrasonic Testing (AUT) shall cover the requirements set in Appendix A of the present specification.

Automatic Ultrasonic Testing (AUT) shall be applied only if wall thickness is greater than 6 mm. The Contractor shall provide a detailed technical description of the equipment, testing methods, ultrasonic testing procedure set up and calibration/validation methods.

The Contractor shall engage the services of an independent automatic ultrasonic specialist to undertake assessment of the suitability of the equipment, system, testing methods and training/qualification/experience of the operators and interpreters proposed. Before the automatic ultrasonic testing is approved for use it shall be demonstrated to the complete satisfaction of the OWNER that the system and operators can reliably achieve detection, location, characterization and sizing of all anticipated flaws in welds, heat affected zones and weld repairs

The Contractor shall qualify the procedure using the requirements set in Appendix A of the present specification. The Contractor shall supply the necessary reference and calibration blocks for the qualification procedure.

The Contractor shall provide a quality assurance system, covering all aspects of development and automatic ultrasonic testing for company approval.

The Contractor shall prepare and submit a plan which provides details of contingency plan for periods when automatic ultrasonic testing systems do not perform properly. The plan shall provide for numbers of spare scanners and systems, spare parts to be retained at the jobsite and provision for replacement of equipment when systems must be shipped off-site for service or repair.

6. EXTENT OF TESTING

Butt Welds in Gas Pipelines

6.1. RADIOGRAPHY

100%

6.2. ULTRASONIC

6.2.1. INITIALLY

As a minimum the first 50 welds, shall be ultrasonically tested (100%) per each welding spread. Thereafter, the extent of US testing for line-up welds and tie-ins will be selected by the client representative based upon the welding quality. In general ultrasonic shall be used as back up for the

radiography in case of interpretation/ verification problems. However, guarantee welds shall always be ultrasonically tested. Guarantee welds are the welds which cannot be pressure tested for technical reasons (e.g. tie-ins between two pressure test sections).

Ultrasonic testing shall be performed full length, except for resolving interpretation problems in specific areas on radiographic films and for testing of repair welding where the testing shall extend 100 mm to each side of the repair.

6.2.2. BUTT WELDS IN CASING PIPES

Where casing pipes are installed under railways, the extent of testing shall be 100% RT and approx. 10% UT. In all other cases the extent of testing shall be 10% ultrasonic.

6.3. MAGNETIC PARTICLE

All fillet welds on pressure equipment and components shall be 100% tested with magnetic particles. Fillet welds on structural components shall be tested as required by the applicable technical code.

If it is necessary to extend the control on account of poor welding quality, the additional costs shall be paid by the Contractor. The costs of testing repair welding shall also be paid by the Contractor.

7. THE OWNER SUPERVISION

The Owner Representative and the Greek Authorities shall have free access to witness or verify all NDE, visit all working areas and review all documents pertinent to NDE.

The Owner Representative has the right to increase the amount of NDE to be performed by the Contractor.

The Contractor shall notify the Owner Representative before NDE is to be carried out. Notification time shall be agreed upon between the Owner Representative and the Contractor.

The Owner Representative has the final approval or rejection of all examinations.

8. QUALIFICATION OF PERSONNEL

NDE Company must be accredited as per ISO/IEC 17020 or ISO/IEC 17025 for the scope of the testing to be performed.

Personnel responsible for performing or evaluating NDE shall be qualified and certified in accordance with EN ISO 9712 requirements and as stated below.

Personnel responsible for supervising or evaluating NDE shall hold a current EN ISO 9712 Level II. Manual ultrasonic examination operator shall hold a current EN ISO 9712 Level II.

Automatic examination operator and the personnel responsible for supervising or evaluating automatic ultrasonic testing shall hold a current EN ISO 9712 Level II for phased arrays and/or TOFD ultrasonic testing as required based on the automatic system.

Records of the qualification supporting certificates shall be reviewed by the Owner Representative and retained on file by the Contractor.

All personnel shall be approved by the Owner Representative before commencement of work.

9. QUALIFICATION OF PROCEDURES

Qualification of welding procedures shall be as per ELOT EN 12732 and the relevant ELOT EN ISOs. Any required mechanical tests (including impact charpy tests) for the welding procedure and welder qualifications shall be performed in accordance with the applicable European codes by an accredited laboratory at Contractor's expense.

Each approved NDE-procedure technique shall be qualified and documented by the Contractor under site conditions in the presence of the Owner Representative before the technique is applied.

The qualification tests of NDE procedures shall be carried out on welds produced during qualification test welding or initial production welding (first 50 welds). The ultrasonic qualification test shall demonstrate that the technique is capable of detecting planar defects and cracks to the same extent as radiography. For automatic ultrasonic testing the procedure qualification shall be performed on validation specimens covering the requirements of ASME BPV sec V article 4. Qualification testing for the NDE operators for automatic ultrasonic methods shall include testing on specimens that the operators do not have any knowledge of the existing defects.

All Qualifications shall be approved by Owner before any welds can be released.

10. RADIOGRAPHIC EXAMINATION

10.1. SAFETY AND PROTECTION

All necessary safety precautions shall be fulfilled by the Contractor according to the requirements and Owner Representative Instructions.

The X-ray and Gamma-ray radioactive sources shall comply with the requirements of P.D. 101/2018

10.2. SURFACE PREPARATION

The surface shall be free of all irregularities that may cause spurious images on the film or difficulties in the interpretation.

10.3. LOCATION OF WELD ON RADIOGRAPHS

Where weld reinforcement does not exist, lead markers shall be used to identify the weld location.

10.4. IDENTIFICATION OF RADIOGRAPHS

Lead or barium figures shall be used for radiographic identification. Each film shall as a minimum be identified with the following information:

- Serial Pipe No. or Heat No.
- Weld identification number.
- Welder identification number.
- Field location.
- Project identification.
- The date.

The identification system shall not interfere with the weld interpretation.

For pipe diameters greater than 50 mm a lead number belt shall be used to verify circumferential weld coverage and to identify defect areas.

If the film has scratches in the area under examination, the radiography must be repeated. For diameters less than 50 mm lead letters or numbers shall be used to show exposure coverage.

Repair films shall be identified with a lead "R" as a suffix to the weld-identification number. The Owner reserves the right to introduce and utilize a permanent weld identification system.

10.5. OVERLAP OF FILMS

If a continuous length of weld is radiographed using several films, an overlap of at least 25 mm on each film shall be observed to ensure full weld coverage.

10.6. TECHNIQUE

The requirements of EN 12732 and EN ISO 17636-1 shall be fulfilled.

10.6.1. IMAGE QUALITY INDICATORS (PENETRAMETER)

Wire-type image quality indicator (as per EN ISO 12932-1) shall be used, as specified in EN ISO 19232-3, and shall be placed where possible on the source side. IQI sensitivity shall be according to EN ISO 17636-1 Class B.

10.6.2. RADIATION SOURCE

X-ray shall be the preferred source used.

However, where access or conditions are prohibitive for X-ray, a Gamma-ray technique with Se-75 or IR-192 may be used if approved by the Owner Representative. In such case the reduction of contrast due to the use of Gamma Source shall be compensate by a finer film sec film screen and cassettes.

10.6.3. SOURCE TO OBJECT DISTANCE

The minimum source to object distance shall be according to the requirements of EN ISO 17636-1 Class B.

10.6.4. POSITION OF FILM AND X-RAY TUBE

For radiography one of the following techniques shall be used:

- Technique II) film outside, source inside centrally placed (panoramic).
- Technique III): film outside, source outside (double wall, double image).
- Technique IV):film outside, source outside (double wall, single image).

Technique II is the required technique used for the main construction welds with an X-ray crawler.

Technique III shall be applied only on pipe diameters less than 2".

Technique IV shall be applied where the X-ray crawler cannot be used or no access to the inside of the pipe is possible.

10.6.5. FILM SCREENS AND CASSETTES

Film used shall be fine grained, corresponding to EN ISO 11699-1 C4 or better.

Film type EN ISO 11699-1 C3 is required for use with gamma rays.

Lead foil intensifying screens shall be used with a front screen thickness between 0.02 mm and 0.15 mm.

Use of prepacked film for tie-ins repairs will be permitted only when technique III is applied. Fluor -

metallic screens shall not be used.

10.6.6. FILM DENSITY

The density of the radiograph of the sound weld metal in the area under examination, including fog density shall be between 2.0 and 3.8. Higher densities may be used where the viewing light is sufficiently bright to permit adequate interpretation.

If the density anywhere throughout the area of interest varies by more than -15% +30% from the density throughout the body of the penetrameter, then an additional penetrameter shall be used for each exposure.

The unexposed density (fog density) of any film shall not exceed 0.30.

10.6.7. FILM PROCESSING

Films may be processed by manual or automatic methods.

Manual processing shall be in accordance with the manufacturer's recommendations.

Chemical temperatures shall be maintained according to the manufacturer's requirements.

A change log shall be maintained for chemicals used.

For handling of films a "dry" and "wet" film bench area shall be available in the dark room to prevent contamination.

Automatic processing equipment shall be operated and maintained in accordance with the manufacturer's recommendations.

Finished radiographs shall be processed to allow for an archival life without discoloration for a period of at least 10 years after the line has been handed over.

All radiographs shall be free from artifacts, blemishes, scratches etc. which might hinder future interpretations.

After processing the radiographs shall not contain a greater concentration of residual thiosulphate than specified in EN ISO 17636-1.

The Contractor shall perform a residual thiosulphate analysis on 5% of all production radiographs.

The data and test results shall be recorded in a logbook.

10.7. VIEWING OF RADIOGRAPHS

The radiographs shall be viewed in accordance with EN ISO 19232-3 (in a darkened room on an illuminated diffusing screen with the illuminated area masked to the minimum required for viewing the radiograph image).

The brightness of the viewing screen shall be adjustable so as to allow satisfactory reading of the radiographs up to and including the specified maximum density.

10.8. STANDARDS OF ACCEPTABILITY

Standards of acceptability shall be as specified in Tech. Spec. No. DSF-SPC-PIP-012

10.9. REPORTING

All report forms and reporting shall be accepted by the Owner Representative and shall contain the minimum information required by EN ISO 17636-1.

Each working day a test report shall be completed, covering the examination work performed.

The radiographer shall record the location(s) and type of all rejectable discontinuities in this report.

Films and test reports shall be presented if required to the Owner Representative for evaluation.

10.10. DOCUMENTATION AND STORAGE

Documentation shall be prepared, fixed and stored so that access and traceability can be achieved.

Films shall be stored individually and placed in suitable storage boxes. All documentation shall be stored under controlled conditions for humidity etc including safe protection.

Documentation system and storage shall be approved by the Owner Representative. All documentation shall be handed over to the Owner Representative before the hydrostatic testing of examined welds. The documentation shall be legible, indexed and filed according to consecutive weld identification numbers.

11. MANUAL ULTRASONIC EXAMINATION

11.1. EQUIPMENT

Ultrasonic equipment used for the weld examination shall be of a pulse-echo, CRT, A Scan type e.g. USL 32 or equivalent, capable of generating ultrasonic frequencies over a range of 2 MHz to 5 MHz.

Records of calibration, annual maintenance and adjustments, of the equipment shall be kept on file by the Contractor.

Probes shall range from 0° to 80 in steel, frequencies from 2 MHz to 10 MHz and sizes (crystal diameter) 6 mm to 12.7 mm. For wall thickness exceeding 15 mm larger probe sizes may be used.

Calibration blocks shall be IIW V1 and V2.

Reference blocks shall be plate of similar dimensions; material and surface finish as the actual pipe.

The reference standard shall be a side-drilled hole.

Couplant shall be of a water, glycerin, jelly or paste which will not cause any contamination of the material being examined, or problems of adherence the coating field joints.

11.2. SURFACE PREPARATION

The scanning surface of the pipe on each side of the weld shall be free of weld spatter, scale or dirt that could restrict the evaluation.

11.3. TECHNIQUE

11.3.1. CALIBRATION

A necessary warming-up period for the ultrasonic instrument shall precede any calibration operation.

Probe index and angle of refraction shall be checked on the IIW calibration block V1 orV2.

Sensitivity setting shall be established on a reference block provided with a 3 mm cylindrical side-drilled hole. A distance amplitude correction (DAC) curve based on the 3 mm hole shall be used. The indication from the reference hole shall be adjusted to reach the DAC curve.

All defect indications shall be compared with the level of the DAC curve.

During equipment calibration the type of coupling media should be the same as the one for inspection.

The equipment shall be calibrated at least once per shift in which it is being used, and whenever change of probe or other parameter changes occur. If the instrument is found to be functioning not satisfactorily, all welds examined since last calibration shall be re-examined.

Each calibration shall be recorded with reference to the number of the next weld to be examined.

11.3.2. LAMINATION EXAMINATION

An ultrasonic lamination examination of parent material adjacent to weld shall be performed and recorded before any shear wave examination.

11.3.3. SCANNING

Transfer correction and attenuation correction shall be carried out on all inspections, and gain shall be adjusted accordingly before establishing scanning level.

Scanning sensitivity shall be at least 6 dB higher than the reference level.

11.4. TIME LAPSE

For steel items with a yield strength corresponding to Grade L360 or higher no ultrasonic examination shall be made until 24 hours after the completion of the seam, unless an exception has been granted by the Owner Representative.

11.5. DEFECT EVALUATION

All indications that equal 25% of DAC shall be evaluated and recorded.

Additional NDE may be employed to resolve questions of interpretation of ultrasonic indications.

11.6. STANDARDS OF ACCEPTABILITY

Standards of acceptability shall be as specified in Tech. Spec. No. DSF-SPC-PIP-012

11.7. CLEANING OF SURFACES

The steel surface shall be cleaned of couplant on completion of examination.

11.8. REPORTING

All report forms and reporting shall be accepted by the Owner Representative and shall contain the minimum information required by EN ISO 17640.

Each working day a test report shall be completed, covering the examination work performed, and the report shall be presented if required to the Owner Representative for evaluation.

For each weld there must be clear statement whether the quality requirements are fulfilled or not. In case that are not fulfilled, the following details are to be reported:

- Defect location fromthe markedzeropoint.
- Defect length.
- Defect location indepth and sideposition.
- Echo height.

A sketch shall be produced and attached to the report.

12. MAGNETIC PARTICLE EXAMINATION

12.1. SAFETY AND PROTECTION

Care must be taken to avoid direct contact with the testing medium and to ensure that electric cables are safely positioned.

12.2. SURFACE PREPARATION

"As-welded" surfaces shall be power buffed and free of all surface debris before test.

12.3. EQUIPMENT

According to EN ISO 17638 and EN ISO 9934-3, with a minimum lifting power of 4.5 kg using alternating current.

12.4. MAGNETIC PARTICLE MATERIALS

Only water-suspended wet types may be used. Detection media shall comply with EN ISO 9934-2.

12.5. MAGNETIC TECHNIQUE

According to EN ISO 17638 and EN ISO 9934-1.

12.5.1. OTHER METHODS

Other magnetizing methods may also be used, such as the coil or the central conductor method.

In these cases it shall be verified that the magnetic field strength is at least 30 Oersted in the area to be tested.

12.5.2. DIRECTION OF MAGNETIZATION

At least two separate examinations shall be carried out on each area.

The second examination shall be with the lines of magnetic flux perpendicular to those of the first examination.

A different means of magnetization may be used for the second examination.

Examination shall be conducted with sufficient overlap to assure 100 percent coverage at the established test sensitivity.

12.5.3. WET METHOD

The suspension shall be applied by spraying during the magnetization.

The suspension shall be constantly agitated to prevent fall-out before application.

12.6. EVALUATION OF INDICATIONS

Discontinuities and defects will be identified by retention of the magnetic particles. All such indications shall be investigated.

12.7. DEMAGNETIZATION

Demagnetization following examination is required where residual magnetism interferes with

subsequent processes or usage. Demagnetization shall be performed prior to any post cleaning.

12.8. STANDARDS OF ACCEPTABILITY

Standards of acceptability shall be as specified in Tech. Spec. No. DSF-SPC-PIP-012.

12.9. REPORTING

All report forms and reporting shall be accepted by the Owner representative and shall contain the minimum information required by EN ISO 17638.

Every examination shall be followed by a report containing the following details:

- Description of the examined object, including location, identification, dimensions, surface conditions and extent of examination.
- Equipment, including apparatus data, magnetizing method, magnetic field strength.
- Examination procedure, including examination pattern, directions of magnetization, examination during and after repair.
- Examination results, each surface crack shall be reported with location and length. Depth shall be determined during removal of the crack.

For each weld or area, there shall be a clear statement whether or not the quality requirements are fulfilled.

Non-acceptable discontinuities shall be described with location and size and, if required, illustrated with a sketch.

The report shall be presented if required to the Owner Representative for evaluation.

13. LIQUID PENETRANT EXAMINATION

13.1. SAFETY AND PROTECTION

As penetrant inspection techniques may require the use of toxic, flammable and volatile materials, certain precautions have to be considered. Working areas shall be sufficiently ventilated and clear of heat sources, open fires and flames.

13.2. SURFACE PREPARATION

Surfaces to be examined and the adjacent area within at least 25 mm shall be free from scale, slag, burrs, oil, grease and adhering or embedded sand and other extraneous matter that would obscure surface openings or otherwise interfere with the examination.

13.3. EQUIPMENT

Visible dye penetrant system, solvent removable shall be used. Certification of penetrant materials

and cleaning solvents are required to show sulphur/halogen/chlorides content less than 1% of weight. Penetrant materials shall be according to EN ISO 3452-2.

13.4. TECHNIQUE

Penetrant examination shall meet the recommendations of EN ISO 3452-1 with the following additions:

- The excess penetrant shall be removed in such a manner as to ensure retention of penetrant in any discontinuity open to the surface, excluding washing directly with solvent.
- It should be noted that testing at temperatures other than those specified for the liquid penetrant materials may lead to erroneous results. Details of above operations shall be in accordance, with the penetrant system manufacturer's recommendations.

13.5. EXAMINATION

When developing time has elapsed, examination of the test surface shall be made under the appropriate viewing conditions. If the background is such that the interpretation of indications is impaired, the surface shall be completely retested. The location of indications shall be marked and associated discontinuities shall be evaluated.

13.6. STANDARDS OF ACCEPTABILITY

Standards of acceptability shall be as specified in Tech. Spec. No. DSF-SPC-PIP-012.

13.7. REPORTING

All report forms and reporting shall be accepted by the Owner representative and shall contain the minimum information required by EN ISO 3452-1.

Every examination shall be followed by a report containing all relevant information, including - but not limited to - the following details:

- Description of the examined object, including location, identification, dimensions, surface conditions, and extent of examination.
- Penetrant system.
- Examination procedure, including examination pattern, soaking time, development time, etc.
- For each weld or area examined, there shall be a clear statement whether the quality requirements are fulfilled or not.

In case they are not fulfilled the following details are to be reported:

- Defect location from the marked zero point.
- Defect length.

- Defect location in depth and side position.

A sketch shall be produced and attached to the report.

The report shall be presented if required to the client representative for evaluation.

14. OCCURRENCE OF CRACKS

If cracks occur repeatedly, the reason for the occurrence of cracks shall be investigated and disclosed.

The investigations shall include additional ultrasonic testing of at least 10 seams performed by each of the welder(s) having worked on the seams containing cracks (not withstanding that the seam may previously have been radiographically tested and accepted).

The specific welder's adaptation to the procedure shall be examined in order to disclose the origin of the occurrence of cracks. Should this not be determined as a welder's fault, the approved welding procedure or other factors shall be thoroughly examined, if necessary involving renewed procedure qualification tests or work procedure to ascertain whether the procedure can be used to produce sound welds.

15. DESTRUCTIVE TESTING

Owner's Representative is entitled to select some weld seams for destructive testing. He will also select the company that will perform these tests on behalf of the Contractor.

Contractor is responsible for cutting out the seams, beveling of the pipe ends, as well as to reweld the joint, preparing the test samples, and transporting the samples to the testing company / laboratory.

Contractor's Engineer and Owner's Representative shall be present during the testing of the specimen.

Destructive tests of production welds shall satisfy all the pipe mechanical properties including impact. The frequency of the production tests shall be at least:

- One production test during the first two days. Afterwards one production weld shall be selected by the Owner's representative for every 500 welds of line up including tie-ins.

- Two days after any change of welding crew. If the destructive test results are not acceptable then the Owner's Representative may select another joint for testing from the same date and of the same welder. In case that the results are still not acceptable the Owner Representative shall decide for the extension of the destructive testing (which is Contractor's obligation), with the aim of establishing the extent and cause of the problem.

APPENDIX A

REQUIREMENTS FOR AUTOMATIC ULTRASONIC TESTING (AUT)

A.1 SCOPE

This appendix provides recommendations for the automatic ultrasonic testing (AUT) of pipeline girth welds. It includes requirements for the AUT system, transducer configuration, reference blocks, sensitivity and system qualification.

Operator qualification for AUT is also addressed. This standard is applicable for a nominal wall thickness range from 6mm up to 25mm with a pipe diameter ranging from 2" to 60".
Other wall thicknesses and wall thickness tolerance may apply when it can be demonstrated that requirements for zonal discrimination and weld volume coverage can be met.

A.2 GENERAL REQUIREMENTS

This Appendix establishes the minimum requirements for the ultrasonic inspection of pipeline girth welds related to the system setup (ultrasonic equipment and transducers and recording system), calibration standards and field inspection performance. Phased array equipment shall meet the requirements of ASTM E 1961 and ToFD of EN ISO 10863.
The AUT system used shall provide an adequate number of inspection channels to ensure the complete volumetric inspection of the weld and heat affected zone in one (1) circumferential scan. This requirement may be deviated from in cases where full coverage in one scan cannot be obtained.
The inspection techniques, employed for the transmission of ultrasound, can be utilized using either multi probe / fixed angle or phased array probes. ToFD inspection shall be used as a supplementary technique to enhance the determination of imperfection dimensions and position.
An operating Quality Assurance system shall be in place documenting the AUT system in use in sufficient detail to ensure that the system is designed, assembled and operated to meet ISO 13487 standard requirements

A.2.1 Inspection Configuration

The weld shall be divided into vertical examination sections (zones) taking into account the specific weld bevel configuration and welding process. The height of each inspection zone is primarily dictated by vertical content of the weld bevel geometry, for instance in case of specific bevel orientation related to Root, Hot passes and/or LCP.

Remaining vertical bevel (Fill area) shall be divided into approximately equal vertical zones with heights between 2 and 4mm, taking into account the over trace requirements for adjacent zones. It is advised to create synergy, to the extent possible, between the inspection setup configuration and the welding process, for instance the number and height of used welding passes.

A.2.2 System Functionality

The system shall be capable of locating/detecting and accurately measuring the through wall height and circumferential length of imperfections that permits the use of the relevant acceptance criteria. System functionality shall be in accordance with ASTM E1961, Section 6, EN ISO 1863 and the following requirements:

A.2.2.1 TOFD Channel

The AUT system shall incorporate a Time of Flight (TOFD) configuration. With the TOFD technique, the entire weld volume is covered. A single TOFD configuration shall be used for wall thickness < 25mm, whereas a dual TOFD configuration shall be used for wall thickness >25mm. The TOFD technique provides additional information to assist in the evaluation of the overall AUT inspection result and offers the enhanced ability to determine the through-thickness dimension and the depth position of imperfections within the weld volume.

A.2.2.2 Transverse channels

The AUT system shall incorporate inspection techniques for the detection of transverse imperfections when the welding process, base material, application and environmental conditions identify a potential risk for transverse defects and when required by the Client

A.2.2.3 Digitization rate

The digitization rate shall be at least 4 times the nominal transducer frequency

A.2.3 Ultrasonic System Set up

Ultrasonic equipment set-up shall be in accordance with ASTM 1961 Sections7, 8 and 9 and EN ISO 1863 with the following additional requirements

A.2.3.1.TOFD

The TOFD frequency shall be between 6 and 10 MHz. TOFD transducers shall be optimised for the wall thickness to be tested and the refracted angle shall be the same for transmitter and receiver. Damping and incident angle shall be chosen to limit the dead zone formed by the lateral wave

For single TOFD channels, the transducer spacing shall be selected to place the theoretical crossing of beam centres at the weld centreline at 66 to 95% of the wall thickness. For double TOFD channels (recommended for wall thickness >50mm) the theoretical crossing of beam centres at the weld centreline shall be at 66 to 95% of the wall thickness for one channel and approximately 33% of the wall thickness for the other channel.

The time gate start should be at least 1 μs 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 of use 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 amplitude of the lateral wave shall be between 40 and 80% of full screen height (FSH). In cases when use of the lateral wave is not applicable, e.g. surface conditions and steep beam angles, the amplitude of the back wall signal shall be set at between 12 to 24 dB above FSH. When use of neither the lateral wave nor the back wall signal is applicable, the sensitivity should be set such that the noise level is between 5 and 10% of FSH.

A.2.3.2 Phased Array

Phased Array transducers shall be certified as meeting the performance requirements of the applicable standard.
Each phased array probe shall be marked to identify the manufacturer’s name and frequency

Phased array systems will simulate the conventional probe array system function for weld volume inspection. Phased array transducers shall have a minimum of 64 elements. Due to the large wedge footprint and therefore sensitivity to surface waviness, care must be taken to ensure the contact surface of the transducer is properly dressed to match the contour of the pipe surface.

Phased array transducers shall contain shaped elements in the passive none steered direction, radius of curvature 75 to 125 mm. Alternatively phased array transducers shall contain a suitable lens in the passive none steered direction.

Each focal law will provide for the maximum sound pressure at the target defined in the inspection design. The focus shall occur at the target ±10 mm of steel path and the beam height shall be

within ±25% of that required by the inspection design. A system preventing any unqualified alterations to agreed focal laws shall be implemented for the phased array AUT system.

A.2.3.4 Temperature

For AUT inspection at extreme temperatures, in very hot or very cold conditions, the calibration block may need to be heated or cooled so that the array is maintained within a 10 Celsius degrees variance when completing calibration in, weld scan, and calibration out cycles. The need for heating or cooling of the calibration standard shall be documented on all the hard copy calibration and weld printouts

A.2.5 Reference Block Standards

A.2.5.1 General

Reference standards shall be used to establish sensitivity qualify the system for field inspection and to monitor ongoing system performance. They shall be in accordance with ASTM E1961 Annex 3 and/or EN ISO 10863.

The principal calibration reflectors for fusion defects shall be 3 mm diameter flat bottom holes (FBH) and 1 mm deep surface notches. The central axis of each FBH calibration reflector shall coincide with the central axis of the sound-beam interrogating it. Where transver required two transverse notches are required, each measuring 10 mm long and 2 mm deep, with one on the ID and one on the OD surface. The principal reflector for porosity detection shall be a 1.5 mm FBH

TOFD notches shall not be deeper than 2 mm for the inside surface and 3 mm for the outside surface.

Besides the reference blocks mentioned above the Contractor shall prepare two circumferential joints with the same dimensions, material and welding process he is going to use on site, which will contain seven flaws at, or near the limit of the acceptance criteria. These joints shall be used during the AUT qualification procedure.

Other reference reflectors dimensions may be used to achieve the necessary probability of detection as determined by the smallest allowable imperfection height derived from the agreed

acceptance criteria.

A.2.6 Procedure (General and Specific)

A.2.6.1General

A detailed AUT Procedure shall be prepared for each weld joint geometry to be examined prior to the start of any welding. It is advised to establish a *General procedure* which describes the functionality of the AUT inspection system in use whereas the *Specific AUT procedure*(s) are to complement the general AUT procedure addressing the actual system configuration, set-up parameters and acceptance criteria for each pipe size, wall thickness and weld configuration. The general and specific procedures cover the use of Automatic Ultrasonic Testing (AUT) only. The AUT procedure(s) shall be submitted for acceptance.

A.2.6.2 General procedure

The purpose of the general procedure is to detail the methodology used for the Automatic Ultrasonic Testing (AUT) of circumferential pipeline girth welds (including repair welding)

- functional description of equipment
- reference standards and guidelines controlling equipment maintenance
- instructions for scanning device, ultrasonic instrument, ultrasonic electronics, hard- and software for recording, processing, display, presentation and storage of inspection data
- methodology for sensitivity setting and for fusion zone transducers; over trace (signal amplitude from adjacent zones) requirements consistent with the over trace used as basis for establishing height sizing corrections for amplitude sizing
- description/drawings of calibration block(s), including type, size and location of all calibration reflectors
- method for scanner alignment and maintenance of alignment
- verification of reference line and guide band positioning
- maximum allowed temperature range
- control of temperature differentials (pipe and calibrationblock)

A.2.6.3 Specific procedure

- number of examination zones for each wall thickness to be examined, as relevant
- transducer configuration(s), characteristics, types, coverage and/or focal law details
- gate settings
- equipment settings
- threshold settings
- acceptance criteria, or reference
- instructions for reporting including example of recorder chart and forms to be used

A.2.7 Operator Qualification

Ultrasonic operators shall be qualified and certified as a Level II in the “Ultrasonic” method in accordance with ISO 9712 and shall submit their current records of certification. In addition, operators shall have completed a minimum of 100 hours training in automatic testing, including practical and theoretical aspects pertinent to the equipment and general configurations to be examined. This training shall be documented and the records shall be provided on request.

Prior to their acceptance in a project the AUT system operators must be able to demonstrate their ability to detect and characterize typical weld indications and determine their acceptance in specimens whose defects are not known to them.

A.3 SPECIFIC REQUIREMENTS - ACCEPTANCE CRITERIA

A.3.1 Scope

This section defines the specific requirements for system qualification, system verification and calibration for ultrasonic systems where flaw acceptance is based on the response amplitude and length of the indication.

A.3.2 System qualification

Qualification of the system and procedure shall be by demonstration that an acceptable response is obtained for all reflectors in a reference standard block as specified in Section A.2.5

In addition, further verification of the performance of the system shall be demonstrated by the examination of at least two welded circumferential joints containing approximately seven flaws at, or near the limit of the acceptance criteria. The indications given by the system shall be compared with the results of radiography, manual ultrasonic examination and any other method requited by the Client. Discrepancies between the indications given by the system and by the other methods shall be resolved by sectioning the weld at the location of the indication and metallographic examination.

A.3.3 Acceptance criteria

A.3.3.1 Classification

Relevant indication: any indication related to a welding anomaly (imperfection / discontinuity / inclusion).

Not relevant indication: any indication not related to weld quality.

Imperfection: any welding anomaly.

Defects: imperfection exceeding the given acceptance criteria.

A.3.3.2 General

The reference level shall be based on 3mm flat bottomed hole and 1mm deep surface notches (Sect. A.2.5) All UT signals which produce a response over 40% of the reference level shall be evaluated to determine their cause. Based on this evaluation all relevant indications are considered imperfections. When doubt exists about indication being relevant or non-relevant verification may be obtained by using other non-destructive testing methods.

A.3.3.3 Flaw acceptance criteria

A.3.3.3.1 Cracks

Imperfections determined to be cracks (C) shall be considered defects

A.3.3.4 Linear surface (LS)

Linear surface (LS) imperfections (other than cracks) interpreted to be open to the I.D. or O.D. surface shall be considered defects should any of the following conditions exist:

a. The length of an individual indication exceeds 10 mm.

b. The aggregate length of indications exceeds 25 mm in any continuous 300 mm length of weld.

c. The aggregate length of indications exceeds 8 % of the weld length in any weld less than 300 mm in length.

A.3.3.5 Linear buried (LB)

Linear buried (LB) indications (other than cracks) interpreted to be subsurface within the weld and not I.D. or O.D. surface-connected shall be considered defects should any of the following conditions exist:

a. The length of an individual indication exceeds 25 mm.

b. The aggregate length of indications exceeds 25 mm in any continuous 300 mm length of weld.

c. The aggregate length of indications exceeds 8 % of the weld length.

A.3.3.6 Transverse (T)

Transverse (T) indications (other than cracks) shall be considered volumetric and evaluated using the criteria for volumetric indications. The letter T shall be used to designate all reported transverse

indications.

A.3.3.7 Volumetric cluster (VC)

Volumetric cluster (VC) indications shall be considered defects when the maximum dimension of VC indications exceeds 1/2 in. (13 mm).

A.3.3.8 Volumetric individual (VI)

Volumetric individual (VI) indications shall be considered defects when the maximum dimension of VI indications exceeds 1/8 in. (3 mm).

A.3.3.9 Volumetric Root (VR)

Volumetric root (VR) indications interpreted to be open to the I.D. surface shall be considered defects should any of the following conditions exist:

a. The maximum dimension of VR indications exceeds 1/4 in. (6 mm) or the nominal wall thickness, whichever is less.

b. The total length of VR indications exceeds 1/2 in. (13 mm) in any continuous 300 mm length.

A.3.3.10 Accumulation of imperfections (AR)

Any accumulation of relevant indications (AR) shall be considered a defect when any of the following conditions exist:

a. The aggregate length of indications above evaluation level exceeds 50 mm in any 300mm length of weld.

b. The aggregate length of indications above evaluation level exceeds 8% of the weld length.