

PETRONAS TECHNICAL STANDARDS

MAINTENANCE MANAGEMENT

PROCEDURAL SPECIFICATION

ULTRASONIC EXAMINATION

PTS 71.00.08.31

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This revision of PTS **71.00.08.31 – ULTRASONIC EXAMINATION (Sep 2009, Revision 1)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **50.015 (December 1983)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

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The specification contained herein sets out the standard requirements and procedures to be complied with by CONTRACTORS carrying out work directly or indirectly for PETRONAS.

For a given project, the Contract Documents related thereto may specify requirements and procedures which deviate from or qualify those set out in this standard specification.

The CONTRACTOR shall be responsible for identifying any and all such deviations and qualifications and ensuring that the work is completed in strict accordance therewith.

GENERAL SPECIFICATION FOR ULTRASONIC EXAMINATION

1. SCOPE

This is a general specification describing the techniques and methods which are to be used for manual ultrasonic examinations of all types of welding work parts, components, materials and thickness determination.

2. REQUIREMENTS

2.1 All work shall be in accordance with approved standards as required by the Company.

2.2 The Contractor shall supply all ultrasonic equipment & accessories ([see Appendix I](#)).

2.3 Maintenance of the equipment will be the Contractor's responsibility. Suitable storage will be provided by the Company.

2.4 Sufficient spare equipment will be made available by the Contractor in order to be able to replace any item immediately and thus avoid any disruption of the work programme.

2.5 The Contractor shall carry out all work required in order to obtain a definite accept/reject result. However, the Company reserves the right to be able to evaluate these results at any time with their own qualified personnel.

2.6 Contractors personnel may be required periodically to demonstrate to the Company's satisfaction that a high standard of quality and integrity is being maintained in the field. They may also be required to demonstrate that they are proficient in their task regardless of personal qualification.

2.7 The Company reserves the right to reject the component under examination at any time regardless of the Contractor's conclusion if in the Company's, opinion, irregularities exist that may be detrimental to that component's performance.

2.8 SUMMARY OF CHANGES SINCE PREVIOUS EDITION

The previous edition of this PTS was dated December 1983; no changes are made since the last edition.

3. EQUIPMENT

3.1 Ultrasonic sets

3.1.1 Flaw detection shall be conducted using an ultrasonic pulsed reflection system generating frequencies in the ranges ½ -10 MHz.

3.1.2 Flaw detection shall be carried out with a rectified 'A' scan display. The trace shall be well defined, easy to read and associated with permanent graticule scale markings covering both range and amplitude.

3.1.3 The ultrasonic apparatus must possess the following properties:

- a) To be able to transmit high amplitude sound
- b) To produce a short duration pulse for high resolution
- c) A calibrated attenuator with steps not greater than 2 DB.

3.1.4 The overall performance of ultrasonic flaw detectors shall satisfy minimum Company requirements prior to field use and at specified intervals thereafter. ([See Appendix II](#)).

3.1.5 Documentation of the aforementioned equipment performance will be required prior to commencement of a project and submitted at specified intervals thereafter. ([See Appendix III](#)).

3.1.6 The ultrasonic set shall have both single & double transducer functions.

3.1.7 The flaw detector model shall have a flat screen which may be viewed at varying angles & distances without distortion of the time base.

3.2 Ultrasonic Probes

3.2.1 The material of Piezo-electric transducer shall be synthetic ceramic preferably of the following kind unless otherwise permitted by the Company

- a) Lead zirconate titanate
- b) Lead metaniobate (also suitable for high temperature)
- c) Lithium sulphate
- d) Barium titanate

3.2.2 Probes will be examined visually prior to use to confirm freedom from mechanical damage & excess shoe wear. Probe's shoe flatness shall be checked by setting a straight edge across the centre of the probe successively in two mutually perpendicular directions. Slightly concavity or convexity may be removed by lightly rubbing with fine sandpaper (This obviously does not apply for special purpose probes especially contoured to compliment the component test surface).

3.2.3 All ultrasonic probes shall be checked and monitored for performance and integrity according to British Standard 4331 Part 3.

3.2.4 Any internal noise from probes shall not be so great as to interfere with interpretation of results at the working sensitivity used for the examination.

3.2.5 Accurate beam profiles shall be plotted out using the institute of Welding (IOW) Beam Profile Block or suitable equivalent as follows:

- a) In a vertical plane only, for shear wave angle probes
- b) For twin crystal 0° compression wave probes the index point of emission of the beam profile axis shall be at 90° to the transmit/receive crystal interface.

3.2.6 All probes shall be checked before each individual inspection and prior to the plotting of reflectors for index pt and beam angle. Should there be a deviation of 1° or greater from the original angle of refraction then the beam profile shall be suitably re-adjusted by replotting off the relevant calibration block.

3.3 Calibration and Reference Blocks

3.3.1 The following calibration blocks shall be available:

- a) I.I.W. V1 calibration block (A2 block/BS 2704)
- b) I.I.W. V2 calibration block (Din 54 122)
- c) The Welding Institute, U.K. (I.O.W.) Beam profile with BS 4331, Part 3
- d) Reference blocks according to the specified code.

3.3.2 Reference blocks shall be fabricated from either:

- a) An offcut of the material after identical treatment of which the component to be inspected is constructed.

or

- b) Material which is of similar metallurgical structure and the same or the equivalent of the P-number (ASME) grouping of the finished component.

The material to be used for reference blocks should be similar in its acoustic attenuation to the material which is to be inspected. The grain size, heat treat condition, physical and chemical composition, surface finish and manufacturing procedure (rolling forging, etc.) are variables to be considered in matching acoustic responses.

3.3.3 Reference blocks shall be manufactured as required by the reference code section or as stated lay the Company in order to be representative of the geometry of the component under examination.

3.3.4 Block quality: All blocks shall be free of significant unwanted surface irregularities and the scanning surfaces shall be machined to a smooth finish.

The calibration block material shall be completely examined in all possible directions with a straight beam search unit. Blocks that contain reflectors which exceed the remaining backwall reflection will not be acceptable.

3.4 Couplant

3.4.1 A suitable non corrosive couplant of good (high) acoustic impedance shall be used.

3.4.2 Components shall be examined using the same couplant as that used for sensitivity calibration.

4. STANDARD ULTRASONIC EXAMINATION PROCEDURE

4.1 For all major projects, the Company shall require a written site ultrasonic testing procedure enveloping all possible configurations to be submitted for approval prior to commencement of the project.

4.2 For ultrasonic examinations not related to a site procedure, the Company reserves the right, at the Contractor's cost, to demand re-inspection of the component if the examination technique is assessed to be inadequate.

4.3 Scanning sensitivities and technical information not contained herein shall be as specified in the applicable reference code as required by the Company. Reference codes will be used as a supplementary to this specification and not vice versa.

4.4 Accept/reject parameters will be according to the reference code as required by the Company.

4.5 Sizing of Defects

4.5.1 For cross-sectional face width either the 20 dB drop technique, the maximum amplitude technique or a combination of both shall be used.

4.5.2 For length a 60 dB drop technique i.e. half intensity drop shall be used. Personnel will be alert to the factors which influence amplitude when using the 6 dB drop method. It is not safe assumption that amplitude is dropping because the beam is scanning past the end of the defect. Factors to be taken into consideration are:-

- a) Area of defect surface: The defect may taper in section giving a reduction in cross-sectional area within the beam, if this is enough to drop the signal by 6 dB, the defect cut-off point could be plotted well before the true end of the defect.
- b) Orientation: The defect may vary considerably in orientation from point where maximised response is received. (See para. 4.7).
- c) Range: There may be dog-leg in the run of the defect, putting part of its length in an unfavourable position (See para 4.6).
- d) Probe Rotation: Inadvertently twisting the probe during scanning may lead to a false result.
- e) Change in surface roughness or complaint may alter intensity of transmitted sound.

4.6 Evaluation and assessment of indications will be carried out where possible as follows:

- a) Lateral Scan: Scanning motion parallel to the indication at 90° to it, for evaluation and length (6 dB drop)
- b) Transverse Scan: Probe movement forward and back at 90° to the reflector axis i.e. zig-zag pattern for evaluation and cross-sectional dimensions (20 dB drop and maximum amplitude).
- c) Rotational Scan: The probe is rotated about its axis by about 60° in each direction for defect echo evaluation.
- d) Orbital Scan: The probe is orbited at a constant radius from the indication for evaluation.

4.7 Reflectors shall be sized using those probes which receive the optimum response.. If necessary, the defect will be plotted with more than one probe to accurately position and size cross-sectional width and length of reflector.

4.8 The surface finish of the scanning area shall be conditioned in a proper manner, i.e. shall be free from surface irregularities, grit, scale, etc. that would interfere with free movement of the search unit or impair the transmission of ultrasonic vibration. Good transducer contact is essential for critical ultrasonic examination.

4.9 Transfer Method

4.9.1 Transfer methods are used to correlate the responses from the basic reference block and from the component. Transfer is accomplished by noting the difference between responses received from a standard reflector in the basic reference block and an equivalent reflector in the component and correcting for the difference. ([See Appendix IV](#)).

4.9.2 Transfer values will not be necessary in instances where an off-cut of the material, as specified in [Para. 3.3.2a](#), is used as a reference block. However the reference block may only be representative at one stage of manufacture. If the component is further treated and then submitted for further ultrasonic examination a transfer value must be obtained.

4.10 For the examination transducers of the following frequency range shall be employed:

- a) For generating compression waves (0°) in the material probes in the frequency range 1 - 5 MHz shall be used.
- b) For generating shear waves in the material probes in the frequency range 2-6 MHz shall be used.

Choice of frequency in conjunction with transducer diameter and probe type i.e. single or twin crystal shall be governed by the characteristics of the component in order to obtain optimum test results. ([See Appendix V](#)).

4.11 Angles of transmission employed shall be dependent on the geometry of the component to be examined, in order to carry out a suitably thorough examination.

4.12 Final ultrasonic examination shall be done as far as possible after final heat treatment. No ultrasonic testing on mild steel (Y.S. less than 40 ksi) should be carried out less than 24 hours after welding has been completed. For higher strength steel the time delay should be minimum 48 hours.

4.13 Recalibration shall be made after a change of operators, each 30 minute maximum time interval, or when the electrical circuitry is disturbed in any way includes the following:

- 1) Transducer change
- 2) Battery change
- 3) Electrical outlet change
- 4) Coaxial cable change
- 5) Power failure

5. WELDS

5.1 Lamination Scanning

5.1.1 All scanning surfaces shall be 100% examined with 0° compressional wave to ensure freedom from parent material defects e.g. segregates or laminar indications which would impair critical examination of the weld.

5.1.2 If material flaws are discovered, their influence on the inspection shall be considered and the technique of scanning adjusted accordingly, if possible.

5.2 The extent of the ultrasonic examination shall guarantee the inspection of the entire volume of weld and heat affected zone.

5.3 Root Scanning

5.3.1 A critical root scan at stand-off distance of 1/2 skip from near root preparation face shall be carried out on all full penetration constant configuration joints.

5.3.2 Probe angles employed for critical root scans shall be as follows:

- a) 12.5 mm and under: 70° nominal angle
- b) Thickness between 12.5mm and 25mm: 70° & 60° nominal angles.
- c) 25 mm and above: 60° & 45° nominal angles.

5.4 Choice of angle(s) of refraction for scanning weld body sidewall and reinforcement shall depend on the following factors:

- a) Characteristics and orientation of defects likely to occur i.e. welding process
- b) Weld preparation geometry
- c) Height of reinforcement
- d) Width of reinforcement in relation to wall thickness
- e) Wall thickness - Poor resolution of shallow angle probes at extensive beam path lengths

5.5 Overall examination techniques shall be consistent with providing optimum test results.

5.6 Flaw detection slides are only suitable for constant configuration joints if misalignment is not present. Accurate profiles shall be taken with wire type profile gauges, or if joint angle is acute, a suitable pliable material able to maintain its shape under normal conditions i.e. excessively soft material such as plasticine is unsuitable.