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Non-destructive testing — Ultrasonic testing — General use of full matrix capture/total focusing technique (FMC/TFM) and related technologies

Essais non destructifs — Contrôle par ultrasons — Utilisation générale de l'acquisition de la matrice intégrale/technique de focalisation en tous points (FMC/FTP) et de techniques associées

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by the IIW, *International Institute of Welding*, Commission V, *NDT and Quality Assurance of Welded Products*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Non-destructive testing — Ultrasonic testing — General use of full matrix capture/total focusing technique (FMC/TFM) and related technologies

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document gives general provisions for applying ultrasonic testing with arrays using FMC/TFM techniques and related technologies. It is intended to promote the adoption of good practice either at the manufacturing stage or for in-service testing of existing installations or for repairs.

Some examples of applications considered in this document deal with characterization and sizing in damage assessment.

Materials considered are low-alloyed carbon steels and common aerospace grade aluminium and titanium alloys, provided they are homogeneous and isotropic, but some recommendations are given for other materials (e.g. austenitic ones).

This document does not include acceptance levels for discontinuities.

For the application of FMC/TFM to testing of welds, see ISO 23864.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 18563-1, *Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 1: Instruments*

ISO 18563-2, *Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 2: Probes*

ISO 23243, *Non-destructive testing — Ultrasonic testing with arrays - Vocabulary.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 23243 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
full matrix capture/total focusing technique
FMC/TFM
assembly of a data acquisition scheme and imaging scheme, whereby the acquisition scheme involves a full matrix capture, and the imaging scheme involves a total focusing technique, and where the data acquisition and imaging scheme may be performed with several similar technologies.

Note 1 to entry: TFM is often indicated as "total focusing method" but, in this document, the term "method" in NDT is reserved for applying a physical principle (see ISO 9712).

3.2
FMC/TFM setup
probe arrangement defined by probe characteristics (e.g. frequency, probe element size, wave mode), probe position, and the number of probes.

Note 1 to entry: Unless stated otherwise, in this document “TFM” and “FMC” refer to the techniques as defined in ISO 23243, and to all related technologies see for example Annex B and ISO 23243.

4 Principle of the technique

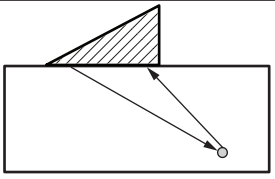
4.1 General

Both FMC/TFM and phased array ultrasonic testing (PAUT) use an array probe where each element of the array is independent of the others. Physical characteristics related to the propagation of waves from the elements of the array govern the capabilities of both techniques in a similar way. In standard PAUT, as in ISO 13588, the active aperture is used to generate sound beams for testing.

In comparison, the FMC/TFM approach typically uses the entire array in order to achieve the best possible focused imaging performance because for effective focusing the test volume should be within the near-field region of the array, which is maximized by using the entire array. In the PAUT technique, the beams can also be "focused" in a similar way to FMC/TFM by using large apertures or the entire array to create beams that concentrate the sound pressure to specific points, by ensuring that these focal points are within the near-field region of the aperture.

Various imaging paths as described in Table 1 may be used.

Table 1 — - Description of the imaging paths

Imaging path	Examples	Description
	T-T L-L	transmitter path direct, receiver path direct

NOTE 1 All figures are schematic, not to scale. Due to the principle of reciprocity, transmitter and receiver can be swapped, meaning that the whole path can be followed in the opposite direction. The direction of the arrows for the paths shown in this table is arbitrary. Drawings are intended to illustrate the assumptions made on the imaging path for calculation of the image and do not intend to imply beam forming or focusing of ultrasonic waves.

NOTE 2 The use of indirect imaging paths, especially those aiming at producing an image representative of the reflectors shape, require an accurate assessment of the actual component physical properties, such as ultrasonic wave velocity, wall thickness or non-flat surfaces. This can be compensated for in post-processing or by using an adaptive imaging algorithm.

NOTE 3 L corresponds to longitudinal wave mode and T to transversal wave mode.