

# AFNOR ASSOCIATED STANDARDS

## Valid Standards.

### NF EN 1330-4

Non-destructive testing - Terminology - Part 4: Terms used in ultrasonic testing

### NF EN 16018

Non-destructive testing - Terminology - Terms used in ultrasonic testing with phased arrays

### NF EN ISO 16810

Non-destructive testing - Ultrasonic testing - General principles

### NF EN ISO 16811

Non-destructive testing - Ultrasonic testing - Sensitivity and range setting

### NF EN ISO 16823

Non-destructive testing - Ultrasonic testing - Transmission technique

### NF EN ISO 16826

Non-destructive testing - Ultrasonic testing - Examination for discontinuities perpendicular to the surface

### NF EN ISO 16827

Non-destructive testing - Ultrasonic testing - Characterization and sizing of discontinuities

### NF EN ISO 16828

Non-destructive testing - Ultrasonic testing - Time-of-flight diffraction technique as a method for detection and sizing of discontinuities

### NF EN ISO 2400

Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 1

### NF EN ISO 7963

Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 2

### NF EN 12668-1

Non-destructive testing - Characterization and verification of ultrasonic testing equipment - Part 1: Instruments

### NF EN 12668-2

Non-destructive testing - Characterization and verification of ultrasonic testing equipment - Part 2: Probes

### NF EN 12668-3

Non-destructive testing - Characterization and verification of ultrasonic testing equipment - Part 3: Combined equipment

### NF EN 16392-2

Non-destructive testing - Characterisation and verification of ultrasonic phased array equipment - Part 2: Probes

### EN ISO 18563-1

Non-destructive testing - Characterization and verification of ultrasonic phased array equipment - part 1: Instruments

### NF EN 17635

Non-destructive testing of welds - General rules for metallic materials

### ISO 5577

Non-destructive testing - Ultrasonic testing - Vocabulary

### EN ISO 18563-3

Non-destructive testing - Characterization and verification of ultrasonic phased array equipment - part 3: Combined systems

## NON-DESTRUCTIVE TESTING METHODS

ULTRASONIC  
TESTING



↳ Ultrasonic testing (UT) is one of the most widely used non-destructive test methods. It is based on the analysis of an ultrasound wave as it passes through the part being inspected.

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GOUVERNANCE  
DIRECTION



ORGANISATION  
PROFESSIONNELLE



CERTIFICATION ET  
QUALIFICATION



SCIENTIFIQUE  
ET TECHNIQUE



ÉVÉNEMENTIEL  
ET COMMUNICATION

## Principle

Ultrasonic testing works on the principle of an ultrasonic wave transmitted through a part to be tested, which is then analysed after it has interacted with the material. There are many specific techniques based on this general principle, depending on whether the wave is transmitted or reflected, whether the transmitter and receiver are combined or separate or according to the type and angle of the ultrasonic waves used.

The most common inspection method is the pulse echo method, similar to that used in medical imaging. The transmitter and receiver (combined or separate) are positioned on the same side of the part. The receiver collects the echoes reflected or diffracted from any obstacles encountered by the wave, such as flaws, interfaces between the materials or even the surface of the part.

The devices used for wave transmission/reception, called «ultrasonic probes» are generally based on the piezo-electric effect. The main element, the transducer, is composed of a piezo-electric element which converts an electric signal into a mechanical vibration and vice versa. Ultrasonic testing underwent a major development with the advances made in phased array techniques using electronically controlled arrays of piezo-electric probes in transmission or reception. This technology, which is now commonly used, adapts the characteristics of the transmitted wave, such as its focal point or its angle of incidence, by applying electronic delays to the various elements, calculated according to the purpose of the inspection. An area or volume may thus be scanned, or the ultrasonic beam can be focused on the material at varying depths using the same probe.

The frequency of the ultrasonic waves used will vary according to the materials tested and the applications within a range of around 100 kHz to 20 MHz. The frequency used is the result of a compromise between the spatial resolution (the higher the frequency the higher this will be) and the penetration depth (which decreases in proportion to the frequency due to signal attenuation). An inspection of a steel part will typically be performed at frequencies of between 1 and 5 MHz.

## Operating mode

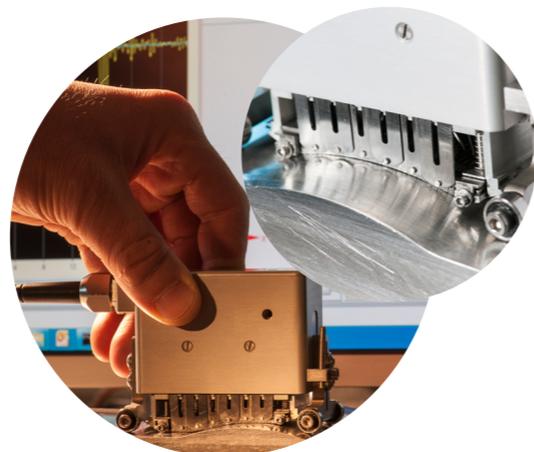
In reflection mode, this being the most common, the part is inspected by moving an ultrasonic probe which functions as both transmitter and receiver, along or above the surface and collecting then analysing the signals received.

A distinction is made between contact tests, where the ultrasonic probe is positioned on the surface of the part to which a couplant has been applied, and immersion tests, where the probe is moved at a certain distance from the part which is immersed in a fluid, generally water. The inspection may be either manual, where the probe is moved by an operator, or automatic.

The choice of probe, its size, the frequency of the waves transmitted by it and the specific settings to be used (delay laws for phased array probes) all determine the characteristics of the ultrasonic beam transmitted in the part, and the ensuing sensitivity and spatial resolution of the inspection. These characteristics are now often estimated by modelling at the design phase.

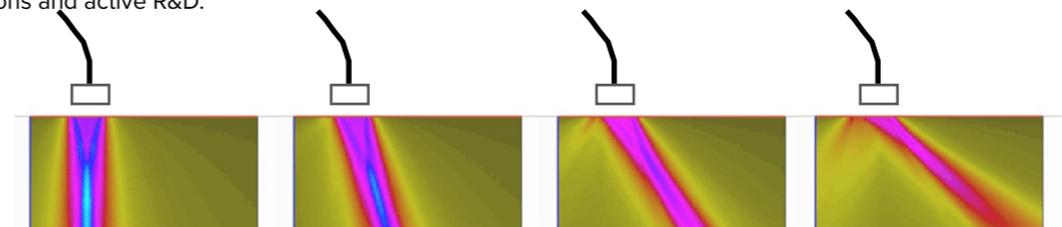
A diagnosis is made according to the analysis of the signals received: echoes received from the reflection or diffraction of the incident beam will indicate the presence of a flaw. The time between the reception of the echo and the energizing of the transmitter is called the time-of-flight. It indicates the location of the flaw, which is detected according to the amplitude. The acquisition time window is thus defined according to the area of the part being inspected for flaws.

According to the application, the diagnosis may be based on an amplitude exceeding a set threshold during scanning, or on a more in-depth analysis of the echographic images of the area inspected. The screen displays are of different types, B-Scan, C-Scan, etc. The amplitudes are always measured in comparison to a reference. The UT equipment is first calibrated on mock-ups containing reference reflectors in order to define the detection thresholds.

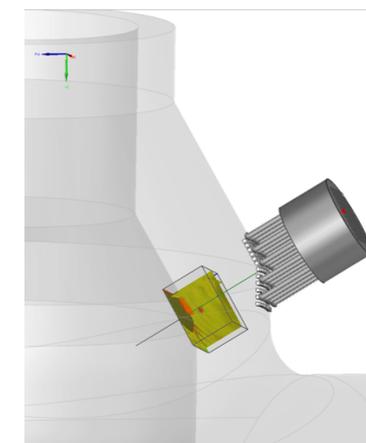


## ADVANTAGES OF THE MÉTHOD

- Volume method: as ultrasound penetrates deep into the material, the method can be used to inspect materials of all thicknesses;
- The settings (such as the frequency used) offer great sensitivity for a wide range of flaw dimensions and parts;
- A great number of modelling tools are available for the diagnosis and quantitative assessment of the efficiency of the method;
- The methods can be adapted to the materials and geometry of the parts. It can be used to inspect most materials, metals or composite materials;
- A great wealth of information is provided by the test: precise location and size of the flaws and an image of the region inspected;
- Phased array techniques available offering improved performance compared to conventional ultrasonic testing methods;
- Quick and simple to use;
- Access to the part is only required from one side;
- No chemical or radiological risks;
- A technique that is in constant evolution due to technological innovations and active R&D.



Phased array probe application  
Image of the ultrasonic beams transmitted by a phased array probe workin in continuous variable ange beam mode (results of a simulation)



Design of a robotized inspection method for laboratory use

## Fields of application

Ultrasonic testing is one of the most widely used NDE methods. It can be used for a wide range of materials and can be adapted to different part geometries. It can be used to detect any type of flaw representing a discontinuity in the mechanical properties (cracks, inclusions, porosities, etc.).

It is used for detecting cracks in metallic materials, weld inspection, composite materials testing (for the aeronautics sector in particular), porosity detection, etc.

It is not only used for flaw detection but also for dimensional analysis (thickness measurement), sorting and characterizing materials (steel grade identification) or characterizing surface treatments (such as heat treatment).

