International Standard

ISO 29821

Condition monitoring and diagnostics of machine systems — Ultrasound — General requirements, guidelines, procedures and validation

Surveillance des conditions et diagnostic d'état des machines — Ultrasons — Exigences générales, lignes directrices, procédures et validation

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Foreword

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This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 5, *Condition monitoring and diagnostics of machine systems*.

This second edition of ISO 29821 cancels and replaces the first edition (ISO 29821:2018) which has been technically revised.

The main changes are as follows:

— Clause 5 has been revised to include Formula (1) describing the decibel level;

— Clause 5 has been revised to include MEMS sensors and a reference to ISO 1683;

— Subclause 5.3 has an additional note describing parabolic reflectors;

— Figures B.1 to B.4 have been improved;

— Minor editorial changes have been made.

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.

Introduction

This document provides specific guidance on the interpretation of ultrasonic readings and wave files or frequency and time domain printouts (sometimes called sound characteristics) as part of a programme for condition monitoring (CM) and diagnostics of machines.

Airborne (AB) and structure-borne (SB) ultrasound can be used to detect abnormal performance or machine anomalies. The anomalies are detected as high frequency acoustic events caused by turbulent flow, ionization events, impacts and friction which are caused by incorrect machinery operation, leaks, improper lubrication, worn components, and/or electrical discharges.

Airborne and structure-borne ultrasound is based on measuring the high frequency sound that is generated by either turbulent flow, friction, impacts or ionization created from the anomalies. Personnel carrying out ultrasonic inspections or measurements therefore require an understanding of ultrasound and how it propagates through the atmosphere and through structures as a prerequisite to the creation of an airborne and/or structure-borne ultrasound programme.

Ultrasonic energy is present with the operation of all machines. It can be in the form of friction, turbulent flow, impacts and/or ionization as a property of the process or produced by the process itself. As a result, ultrasonic emissions are created which are a useful parameter for monitoring machine condition and detecting anomalies.

Condition monitoring and diagnostics of machine systems — Ultrasound — General requirements, guidelines, procedures and validation

1 Scope

This document

— gives guidelines for establishing severity assessment criteria for anomalies identified by airborne (AB) and structure-borne (SB) ultrasound,

— specifies methods and requirements for carrying out ultrasonic inspection, testing, measurement and monitoring of machines, including safety recommendations and sources of error, and

— provides information relative to data interpretation, assessment criteria and reporting.

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 13372, *Condition monitoring and diagnostics of machines — Vocabulary*

ISO 13379-1, *Condition monitoring and diagnostics of machine systems — Data interpretation and diagnostics techniques — Part 1: General guidelines*

ISO 13381-1, *Condition monitoring and diagnostics of machine systems — Prognostics — Part 1: General guidelines and requirements*

ISO 17359, *Condition monitoring and diagnostics of machines — General guidelines*

ISO 18436-8, *Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personnel — Part 8: Ultrasound*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13372 and the following apply.

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

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

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

3.1
airborne and structure-borne ultrasound
non-destructive test method detecting airborne and structure-borne ultrasound above 20 kHz created from or through a medium

3.2
background noise
unwanted noise present in a signal which cannot be attributed to a specific cause

Note 1 to entry: This ultrasonic noise can emanate from the area surrounding the measurement position which can cause false indications.

3.3
scanning
moving a receiving transducer or an array of transducers around a suspected source of ultrasound to verify its location

3.4
sonic reflection
airborne ultrasound reflected off a solid surface possibly indicating a false reading

3.5
contact module
waveguide in the form of a rod attached to an ultrasonic transducer conducting ultrasound through physical contact with the structure or machine

4 Principle of the airborne and structure-borne method

4.1 General

Airborne and structure-borne ultrasound is a physical wave that occurs within the test subject (material or machinery component) or in the atmosphere and is detected externally either close to or at a distance from the test subject and is based on the detection of high-frequency sounds.

Most ultrasonic instruments are used to monitor equipment detect frequencies above 20 kHz which is above the range of human hearing (20 Hz to 20 kHz). The differences in the way low-frequency and high-frequency sounds travel help to explain why this technology can be effective for condition monitoring since

— low-frequency sounds maintain a high intensity of sound volume and travel further than high-frequency sounds, and

— high-frequency sounds are more directional. As high-frequency sound waves propagate from the point of generation, their intensity level decreases rapidly with distance depending on the elasticity and density of the medium traversed which helps to identify the origin of a sound source.

Airborne ultrasound is propagated through an atmosphere (air or gas) and detected with an ultrasonic microphone while structure-borne ultrasound is generated within and propagated through the structure and is usually detected with a contact module, although other sensors may be used. These contact modules do not require any coupling agent, as the detection frequencies are low enough that, unlike traditional pulse-echo ultrasound, small air gaps between the contact probe and the structure under test do not significantly attenuate the received signal. If permanently mounted sensors are used, careful mounting techniques should be utilized to avoid signal attenuation or resonances, or both. The structure can be a machine or any component of a machine or a system.

4.2 Application of airborne and structure-borne ultrasound within condition monitoring programmes

Ultrasound is a non-invasive measurement technique which can identify a range of faults in many applications.

Table 1 shows typical examples of ultrasound applications for machine condition monitoring.

4.3 Correlation with other technologies

Airborne and structure-borne ultrasonic is often used in a condition-monitoring programme to detect failure modes that have been previously identified by another technology. There are instances where airborne or structure-borne ultrasound is the first indicator of a failure mode, such as in the detection of faulty slow-speed bearings and/or insufficient lubrication in rolling element bearings. Airborne or structure-borne ultrasound can also be used to identify a potential safety hazard to a practitioner using an alternate technology, for example, in the inspection of enclosed electrical systems. Airborne and structure-borne ultrasound can be used to determine if an arc flash hazard is present before opening the cabinet for an infrared thermographic inspection.

Acoustic emission is the phenomenon of radiation of acoustic (elastic) waves in solids that occurs when a material undergoes irreversible changes in its internal structure. Acoustic emission is traditionally utilized to monitor items that are under stress to detect the formation and location of cracks including structures, pressure vessels and pipelines. Many of the acoustic emission applications are similar to the structure-borne ones described in this document.

NOTE For information on the use of acoustic emission for condition monitoring refer to ISO 22096.

Table 1 — Ultrasonic application examples

Machine description	Pressure or vacuum leak detection[a]	Mechanical[a]	Electrical[a]
Heat exchangers	AB	—	—
Boilers	AB	—	—
Condensers	AB	—	—
Control air systems	AB	—	—
Valves	SB	—	—
Steam traps	SB	—	—
Motors	—	SB	SB
Pumps	AB	SB	SB
Gears/gear boxes	—	SB	—
Fans	—	SB	—
Compressors	AB	SB	SB
Conveyors	—	SB and AB	SB
Switchgear	—	AB and SB	AB and SB
Transformers	—	SB	AB/SB
Insulators	—	—	AB
Junction boxes	—	—	SB
Circuit breaker	—	—	SB
Turbines	AB	SB	—
Generators (utility)	AB	SB	AB/SB
Lubrication	—	SB	—
High-speed bearings	—	SB and AB	—
Low-speed bearings	—	SB and AB	—

[a] AB: airborne; SB: structure-borne.