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Non-destructive testing — Acoustic emission testing — Steel structures of overhead travelling cranes and portal bridge cranes

Essais non destructifs — Essais d'émission acoustique — Structures en acier des ponts roulants et des portiques

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 9, *Acoustic emission testing*.

Non-destructive testing — Acoustic emission testing — Steel structures of overhead travelling cranes and portal bridge cranes

1 Scope

This document describes the acoustic emission (AE) testing technique used to perform structural integrity evaluation on steel structures of overhead travelling cranes and portal bridge cranes.

This document applies to the testing of steel structures of in-service overhead travelling cranes and portal bridge cranes. Testing of other kinds of cranes can refer this document.

This testing method is not intended to be an alone NDT standard method for the evaluation of the structural integrity of overhead travelling cranes and portal bridge cranes. Other NDT methods are used to verify and supplement the AT results.

This document does not establish evaluation criteria.

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 4310, *Cranes — Test code and procedure*

ISO 12714, *Non-destructive testing — Acoustic emission inspection — Secondary calibration of acoustic emission sensors*

ISO 12716, *Non-destructive testing — Acoustic emission inspection — Vocabulary*

ISO/TR 13115, *Non-destructive testing — Methods for absolute calibration of acoustic emission transducers by the reciprocity technique*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12716 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
acoustic emission source
AE source
source point or spatial position in the material where transient elastic waves are generated by the release of energy

3.2
acoustic emission location source
AE location source
spatial area comprising one or more clusters associated with an *AE source* (3.1) and encompassing the true physical location of the AE events giving rise to the AE source

Note 1 to entry: Common location methods include zone location, computed location and continuous AE signal location.

3.3
activity
<of acoustic emission source> increasing total number of AE events in *AE location source (3.2)* with loading process or loading time

3.4
intensity
<of acoustic emission source> average elastic energy released by the AE events in the *AE location source (3.2)*

Note 1 to entry: Burst AE source intensity related parameters are, e.g. maximum amplitude, energy, signal strength and, to a certain extent, ring down counts. Continuous AE source intensity related parameters are, e.g. root mean square (RMS AE) signal voltage, average rectified signal voltage and average signal level (ASL).

3.5
maximum operating load
maximum operation load is the maximum load of the crane bearing in the last 6 months before the AE testing

4 General principles

The main purpose of acoustic emission testing (AT) is to detect the acoustic emission source generated in the parent metal of steel structures, weld surface and internally, and locate the acoustic emission source.

The acoustic emission testing shall be done during the loading process, which includes the loading, load holding and unloading. The acoustic emission sensors should be arranged on the surface of steel structure being detected, to receive the signals generated by the active source and transfer it into electric signals. The AE instrument is used to collect, handle, display, record and analyse the signals, and then provides the parameters and location of the acoustic emission source.

5 Qualification of personnel

It is assumed that AE testing is performed by competent personnel. In order to ensure that this is the case, it is recommended that the personnel meet the requirements of ISO 9712 or equivalent.

6 Equipment

6.1 AE testing system

AE testing employs an AE instrument, AE sensors, preamplifiers, and interconnecting cables.

This combination together with some mechanical equipment holding the sensors forms the AE testing system.

All essential parts of the system shall be defined in a written procedure agreed at the time of enquiry or order (see 10.2).

6.2 AE sensors

It is recommended to use sensors in the frequency range between 100 kHz and 400 kHz.

The minimum sensitivity shall be equivalent or greater than 60 dB referred to 1 V/(m·s-1) in surface wave sound field calibration, or in longitudinal wave calibration.

When sensors with other response frequencies are used, they shall provide enough sensitivity within its frequency band.

Sensors shall be shielded against radio frequency and electromagnetic noise interference by proper shielding practice or by differential element design, or both. The metallic case of each AE sensor shall be electrically isolated from a metallic test object.

The AE sensors shall be stable over the response frequency and temperature range of use, and shall not exhibit sensitivity changes greater than 3 dB over this range.

AE sensors mounted on the surface of a steel structure shall be insulation from each other.

For sufficient sensitivity, a pencil lead break of 0,5 mm diameter, hardness 2H, in 50 mm distance from the sensor, shall generate an amplitude of at least 95 dB_{AE}.

The calibration of the sensors shall be performed according to ISO 12714 or with ISO/TR 13115.

6.3 Signal cables

The signal cables connecting sensors and preamplifiers shall be shielded against electromagnetic interference. Its length shall not exceed 1 m, unless the length-depending signal loss is considered and acceptable.

This requirement may be omitted where the preamplifier is mounted in the shielded sensor housing.

6.4 Couplant

The used couplant should keep good sound transfer effect during testing.

6.5 Preamplifiers

The preamplifiers may be separate or may be mounted in the sensor housing.

The RMS voltage of preamplifiers circuit noise shall be less than 7 μV.

The preamplifiers shall be stable over the response frequency and temperature range of use, and shall not exhibit sensitivity changes greater than 3 dB over this range.

The preamplifiers response frequency shall match with that of the sensors, and the gain of the preamplifiers, usually 40 dB or 34 dB, shall not cause saturation of the measurement chain up to a 100 dB_{AE} signal amplitude.

If the preamplifiers are of differential design, a minimum of 40 dB of common-mode rejection shall be provided.

6.6 Power-signal cables

The cable providing power to the preamplifier and conducting the amplified signal to the main processor shall be shielded against electromagnetic noise. Signal loss shall be no more than 1 dB per 30 m of cable length. 150 m is the recommended maximum cable length to avoid excessive signal attenuation.

The cables providing power to the preamplifier and conducting the amplified signal to the main processor shall be shielded against electromagnetic noise.

The signal loss of cables depends on type of cable, frequency and length. With cable length above 10 m, the resulting attenuation and the voltage drop off the DC-supply shall be evaluated and considered in the data analysis. The signal loss shall be no more than 1 dB per 30 m of cable length.

To avoid excessive signal attenuation, the recommended maximum cable length is 150 m.

6.7 Filters

The response frequency of filters in the preamplifiers and the AE instrument shall match with that of the AE sensors.

6.8 AE instrument

The AE instrument shall have enough AE channels to cover the testing area. For each channel, the instrument shall provide as a minimum the following features: displaying and recording of arrival time, threshold, amplitude, count, energy, rise time, duration time, and hits. It is preferred that the instrument is able to receive and record also external electric signals, such as pressure, temperature.

The individual sampling frequency of each channel shall be not less than 10 times the sensors' centre response frequency.

The measurement inaccuracy for threshold above 40 dB_{AE} shall be better than ±1 dB.

The measurement inaccuracy for counts shall be better than ±5 %.

The instrument shall be capable to process, store and display at least 20 hits per second at all channels. The delay and display from the arrival of the AE hits shall not exceed 10 seconds. An alarm shall occur if the hit rate exceeds the capability of the instrument. A warning shall occur when the storage space runs short.

The measurement inaccuracy for peak amplitudes above 40 dB_{AE} shall be better than ±1 dB. Usable dynamic range shall be a minimum of 65 dB.

The measurement inaccuracy for energy above 40 dB_{AE} shall be better than ±5 %.

If delta-t source location is used, the resolution of rise time, duration and arrival time for each channel shall be better than 0,25 µs. The error of arrival time between each channel shall be better than ±3 µs.

The measurement inaccuracy for the external parametric inputs shall be better than 2 % of the full range.

During data acquisition, AE software shall be capable to display the following diagrams: any AE parameter versus time or load, one AE parameter versus another AE parameter, linear and planar locations. The real-time update time for all diagrams shall be not more than 5 s.

The AE analysis software shall provide functions to replay and to analyse the recorded AE testing data.

6.9 Maintenance and verification of test equipment

The performance of the testing system shall be verified at specified intervals in conformity with the methods provided by the manufacturer of the AE instrument, or refer to EN 13477-1 and EN 13477-2.

7 On-site operation

7.1 Preparation of documentation

7.1.1 Preliminary information

Prior to the definition of the testing, some or all of the following information is necessary:

— the purpose of the test;

— details of the crane to be tested;

— the physical location of the area where the test shall be performed;

— the requirements for surface preparation;

— the sensitivity of the test;

— the method used to verify the sensitivity;

— the acceptance criteria, if specified;

— other requirements in relation to the test report;

— details of qualification of personnel.

The following documents for the tested crane are required as a minimum before performing an AE test:

a) manufacturing documents of the crane to be tested, e.g. product certification, quality qualification document, as-built drawing;

b) operation recording documents of the crane, e.g. operating conditions and parameters, loading fluctuations, abnormal situation in operation;

c) previous inspection and testing report;

d) other documents, e.g. drawing and record showing repairs or modifications.

7.1.2 Site investigation

Prior to testing, it is necessary to carry out a site investigation to find all interference factors, such as friction of scaffold, electromagnetic interference, vibration. The interference of these factors shall be avoided during on-site testing.

7.1.3 Preparation of testing procedure and record sheets

The testing procedure and record sheets shall be prepared in accordance with the general testing procedure (see 10.2), crane and site conditions. The instrument, applicable sensors, testing place and surface conditions of the crane need to be specified.

7.1.4 Sensor array

A sufficient number of sensors shall be mounted on the steel structure of the crane to enable AE signal detection and source location, according to the dimension of the structure and the purpose of the testing. The allowed maximum sensor spacing can be determined by based on measured attenuation curve of AE amplitude. This can refer to EN 14584 and EN 15495. The spacing between sensors shall be the same as far as possible. All the sensors shall be numbered and indicated in the schematic diagram of the structure. Annex A provides guidelines for sensor placement for some structures of cranes.

7.1.5 Loading procedure

A loading procedure should be established according to the purpose of AE testing and the real condition of the crane.

The communication of the AE operator with the loading operator shall be included in the test procedure.

7.2 Mounting of sensor

The mounting of sensors shall meet with the following requirements:

a) The sensors shall be installed according to the specified sensor array. The sensors shall keep a distance to welding attachment such as supporting steel plate during the whole testing of the structure. For local testing, the testing area shall be in the centre of the sensor array.

b) The place for the mounting of a sensor on the structure shall be smooth and showing the metallic luster. The coating can be kept when it is smooth and compacted and measured attenuation is acceptable.

c) Efficient couplants such as vacuum grease, vaseline, are recommended.

d) Firmly fixing of the sensors with the structure shall be performed by a magnetic holding device, by an adhesive tape or other stuff, keeping the insulation.

7.3 Settings of the AE instrument

7.3.1 General requirements

Connects the sensors and preamplifiers with the main processor by cables, turn on the AE instrument and wait until the equipment is in proper working condition. Roughly set the instrument and then debug the AE system following steps 7.3.2 to 7.3.6.

7.3.2 Simulating of AE sources

Simulated AE sources are used to determine the sensitivity of each channel and to calibrate the localisation system of AE sources.

The simulated AE sources should be capable of producing a transient elastic wave having an amplitude representative of the AE signals.

The simulated AE source may be a breaking pencil lead or an electronically induced event or equivalent.

When using the pencil lead break technique, the simulated AE signals shall be generated by breaking 2H pencil leads (0,3 mm or 0,5 mm diameter) against the component surface at the prescribed points.

The pencil leads shall be broken at an angle of approximate 30° to the surface using about 2,5 mm pencil lead extension.

The detected peak amplitude of the simulated event should be at a fixed distance near the sensor, typically 100 mm ± 5 mm, and the responsive value shall be the average of more than 3 times.

7.3.3 Sensitivity setting

The sensitivity setting for all channels shall be done before and after the testing. The average peak amplitude of any sensor shall be within ±4 dB of the average of all sensors.

7.3.4 Determination of attenuation curve

The attenuation of acoustic emission signals for different steel structures shall be determined.