INTERNATIONAL STANDARD

ISO 24497-2

First edition
2007-11-01

Non-destructive testing — Metal magnetic memory —

Part 2: General requirements

Essais non destructifs — Mémoire magnétique des métaux —

Partie 2: Exigences générales

Reference number
ISO 24497-2:2007(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 24497-2 was prepared by the International Institute of Welding, Commission V, *Quality control and quality assurance of welded products*, recognized as an international standardizing body in the field of welding in accordance with Council Resolution 42/1999.

Requests for official interpretations of any aspect of this part of ISO 24497 should be directed to the ISO Central Secretariat, who will forward them to the IIW Secretariat for an official response.

ISO 24497 consists of the following parts, under the general title *Non-destructive testing — Metal magnetic memory*:

— *Part 1: Vocabulary*

— *Part 2: General requirements*

— *Part 3: Inspection of welded joints*

Non-destructive testing — Metal magnetic memory —

Part 2: **General requirements**

1 Scope

This part of ISO 24497 specifies the general requirements for the application of the method of metal magnetic memory of components, units, equipment, and structures for various application purposes. It covers non-destructive testing.

The purposes of the method are the following.

- Determination of heterogeneity of the stress/strain state of equipment and structures and revealing of stress concentration zones as the main sources of damage.
- Determination of locations to perform metal sampling in stress concentration zones for assessment of the microstructural-mechanical state.
- Early diagnostics of fatigue damage and evaluation of equipment and structure life.
- Reduction of testing and material costs with its utilization in combination with conventional methods of non-destructive testing.
- Quality control of welded joints of various types and embodiment (including contact and spot welding).
- Very quick sorting of new and used machine-building products by their microstructural heterogeneity.

2 Abbreviated terms

The following abbreviations are used in this part of ISO 24497:

- IO: Inspection Object;
- SMLF: Self-Magnetic-Leakage Field;
- MMM: Metal Magnetic Memory;
- NDT: Non-Destructive Testing;
- SCZ: Stress Concentration Zone.

NOTE The Stress Concentration Zone (SCZ) is characterized by an abrupt local change of magnetization in the test object. Under examination SCZ is indicated as an abrupt local change of the SMLF. SCZ is formed in places of defect concentration, heterogeneity of metal microstructure; i.e., along welded joints or in zones of steady dislocation slip band caused by static or cyclic loads.

3 General information

3.1 The MMM method refers to non-destructive magnetic-flux leakage testing by using magnetic-field-sensitive probes, but with no active magnetization of the IO.

3.2 The MMM method is based on measurement and analysis of the distribution of self-magnetic-leakage fields of metal components. Self-magnetic-leakage fields reflect the microstructural and technological history of metal components, including welded joints. Natural magnetization formed in the Earth's magnetic field during the process of the product fabrication is used during testing. For the equipment in operation, the magnetic memory appears in the irreversible change of the magnetization of the material in the direction of maximal stresses due to working loads.

3.3 The MMM method determines SCZ, presence of imperfections, and heterogeneity of metal and welded joints microstructures.

NOTE For components and machine-building products, SCZ in metal is conditioned by the technology of their fabrication (fusion, forging, rolling, turning, press forming, thermal treatment, etc.).

3.4 For operating equipment in service, the MMM method gives the definition of SCZ specified by the complex action of technological factors, the unit's design philosophy, and operating loads.

3.5 The MMM method is used on products made of ferromagnetic and austenitic steels and alloys, and cast iron with unlimited test sizes and thicknesses, including welded joints.

NOTE Austenitic steels can be inspected if their microstructure is sensitive for $\gamma-\alpha$ phase transformation under static or cyclic loads.

3.6 The temperature range of the MMM method application is according to the normal and safe working conditions of the operator (NDT inspector). Inspection tools shall be operable at temperatures from −20 °C to +60 °C.

4 Requirements of the inspection object

4.1 During the application of the MMM method, equipment and structures are inspected both in the in-service state (under load) and during maintenance (after removal of operating loads).

4.2 Surface dressing and preparation are not required. It is recommended to remove insulation. In individual cases, non-magnetic insulation is allowed during inspection. The maximum permissible insulation layer thickness shall be determined experimentally.

4.3 The range of metal thicknesses in inspection zones is specified in techniques used for this inspection object.

4.4 The limiting factors for the application of the MMM method are the following:

— artificial magnetization of the metal;

— influence of foreign ferromagnetic products on the inspection object, near the inspection region of interest;

— presence of the source of an external magnetic field or an electric-welding current flow near (closer than 1 m) to the IO.

4.5 Acoustic noise from the IO and mechanical vibration of the IO do not influence the inspection results.

5 Requirements of the inspection means

5.1 For equipment inspection using the MMM method, specialized magnetometric instruments are used. The typical technique of the SCZ determination shall be documented in the manual of the instruments mentioned.

5.2 The principle of the operation of these instruments is based on the registration of induced electrical voltage pulses in the sensor coil of a flux-gate meter at its placement into the self-magnetic-leakage field (SMLF) of the near-surface area of the IO. A flux-gate meter or other magnetic-sensitive transformers (field meters or gradiometers) can be used as sensors for measuring the SMLF intensity.

5.3 Instruments shall have a screen for the graphical representation of the inspection parameters, a recorder based on a microprocessor, a storage unit, and scanner assemblies depending on the form of the individual specialized sensors. The possibility of an information swap from the instrument to an external computer and data printout shall be provided. Special software for computer processing of the inspection results should be supplied with the instrument.

5.4 Specialized sensors are supplied with the instrument. The sensor type is determined by the method and the specific inspection tasks. The sensor shall have not less than two measurement channels, one of them for the instrument and another for tuning out the influences of the Earth's external magnetic field.

5.5 The sensor housing shall be equipped with an electronic unit for the measured field amplification and a sensor for measuring the length of the scanned inspection path length.

5.6 On the IO, where it is difficult to use scanning devices, it is permitted to apply magnetometric instruments with a digital display of the magnetic field intensity.

5.7 The following factors influence the error of SMLF measurements:

— IO surface finish;

— sensor lift-off from the IO surface;

— sensor scanning rate along the IO surface;

— sensor sensitivity;

— the permissible error of measurement shall be indicated in the techniques depending on the individual inspection object.

5.8 The instruments should have the following metrological characteristics:

— the relative error of the measured magnetic field for each instrument channel not more than ± 5 %;

— the error of the measured length not more than ± 5 %;

— instrument measurement range not less than ± 1 000 A/m;

— minimal scanning step (distance between the two adjacent inspection points) of 1 mm;

— electronic noise level conditioned by the processor and operation of the micro-electronics not more than ± 5 A/m.

6 Pre-testing procedure

6.1 The pre-testing procedure is part of the following basic stages:

— analysis of the technical documentation of the IO and preparation of the IO chart (logfile, inspection plan);

— selection of sensors and test instrument types;

— setting and calibration of the instruments and sensors according to the instruction indicated in the manual;

— segmentation of the inspection object into individual inspection areas and inspection units having their own design philosophy and their indication in the IO logfile.

6.2 Analysis of technical documentation for the inspection object includes the following:

— indication of the steel grades and the dimensions of the selected inspection units;

— analysis of the IO operation modes and reasons of failures (damages);

— indication of the inspection units' design philosophy, and locations of welded joints.

7 Inspection procedure

7.1 The normal and/or tangential component of the self-magnetic-leakage field, H_p, is measured at the IO surface by continuous or spot scanning with the instrument sensor. At the same time, positions with extreme H_p field changes are determined and registered at the IO surface. The zero value of the normal component corresponds to the maximal value of the tangential component of the field.

7.2 For quantitative assessment of the residual stress concentration level, the coefficient, K_{in}, indicating the intensity of the normal and/or tangential component of the magnetic field gradient, is determined by the formula:

$$K_{in} = \frac{|\Delta H_p|}{l_K}, \text{ A/m}^2 \tag{1}$$

where

ΔH_p is the difference of the H_p fields between the two adjacent scanning points;

l_K is the distance between these adjacent points.

The zone of maximal concentration of residual stress corresponds to the maximum gradient of the normal and/or tangential component of the field.

7.3 The inspection results are recorded in the instrument's memory unit and then, using the software, the SCZ with a maximum $K_{max, in}$ value of the normal and/or tangential component of the field is determined. Then, using the software, an average value $K_{med, in}$ of the normal and/or tangential component of the field is determined for all SCZ revealed on the inspection object.

7.4 After determination of $K_{med, in}$ and $K_{max, in}$ values for all zones revealed during inspection, two or three SCZ with the highest $K_{max, in}$ values are selected and the ratio m is calculated:

$$m = \frac{K_{max, in}}{K_{med, in}} \tag{2}$$

At the same time, the value m is calculated separately for the ratio of gradients of the normal component of the field and separately for the ratio of gradients of the tangential component of the field.

If m, calculated for the ratio of gradients of the normal and/or tangential components of the field, exceeds a limiting threshold value, m_{lim}, a conclusion is made about the material state in the next period of life preceding an IO damage.

The magnetic index, m_{lim}, characterizes the metal deformation capability by strengthening before failure and is determined in the laboratory and under industrial conditions using a special calibration method.

7.5 Additional testing by destructive and non-destructive methods is carried out in the SCZ with maximum $K_{in, max}$ values for normal and/or tangential components of the field, and the most representative material sample is selected for studying the material microstructure and its mechanical properties.

8 Recording of inspection results

8.1 Inspection results are recorded in a report, and the following data shall be indicated:

- names of inspection units and segments where SCZ were detected;
- H_p field values and the extreme values of the field gradient K_{in} in SCZ;
- results of additional inspection in SCZ by other NDT methods;
- visual examination;
- IO non-failure operating time from its start-up;
- type of instrument used at inspection;
- résumé according to inspection results;
- date of inspection and name and surname of the inspector.

8.2 The IO logfile with indications of the inspection areas and detected SCZ shall be attached to the report.

8.3 The conclusion of the analysis of the results, characterizing the state of the IO, is made on the basis of inspection results.

8.4 Inspection results shall be stored till the next IO examination.

9 Safety requirements

9.1 Only persons trained in the MMM method and certified according to level I and II qualification levels are allowed to perform the inspection.

9.2 Persons performing the MMM inspection shall follow the safety requirements established for the industrial environment where the inspection is performed.

9.3 Before starting with the inspection performance, all involved persons shall pass an appropriate safety instruction and training of which the content shall be recorded in a special logfile.

Training of the inspectors shall be performed at each changing of the working conditions. The person responsible for training the operators shall be qualified according to an engineering level (level III).

9.4 During inspection, the appropriate Personal Protective Equipment for the specific industrial environmental conditions shall be worn.

9.5 When working at a height, an appropriate scaffold, cradle, and rope access system, which meets the requirement of the safety standard, shall be used. Scaffold, ladder, and cradle constructions shall meet the requirements of safety standards.

ICS 25.160.40

Price based on 5 pages