INTERNATIONAL STANDARD

ISO 10816-2

First edition
1996-02-15

Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts —

Part 2:

Large land-based steam turbine generator sets in excess of 50 MW

Vibrations mécaniques — Évaluation des vibrations des machines par mesurages sur les parties non tournantes —

Partie 2: Turboalternateurs installés sur fondation radier, excédant 50 MW

Reference number
ISO 10816-2:1996(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.

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.

International Standard ISO 10816-2 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

ISO 10816 consists of the following parts, under the general title *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts*:

— *Part 1: General guidelines*

— *Part 2: Large land-based steam turbine generator sets in excess of 50 MW*

— *Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ*

— *Part 4: Gas turbine driven sets excluding aircraft derivatives*

— *Part 5: Machine sets in hydraulic power generating and pumping plants*

— *Part 6: Reciprocating machines with power ratings above 100 kW*

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Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Annex A forms an integral part of this part of ISO 10816. Annexes B and C are for information only.

Introduction

ISO 10816-1 is the basic document which describes the general requirements for evaluating the vibration of various machine types when the vibration measurements are made on non-rotating parts. Measurements at such specified locations characterize reasonably well the overall state of vibration of steam turbine generator sets. This part of ISO 10816 applies to large steam turbine generator sets.

Two criteria are provided for assessing the machine vibration. One criterion considers the magnitude of the observed vibration; the second considers changes in the magnitudes. It must be recognized, however, that these criteria do not form the only basis for judging the severity of vibration. For steam turbine generator sets, it is also common to judge the vibration based on measurements taken on the rotating shafts. Shaft vibration measurement requirements and criteria are addressed in separate documents, ISO 7919-1 and ISO 7919-2.

Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts —

Part 2:
Large land-based steam turbine generator sets in excess of 50 MW

1 Scope

This part of ISO 10816 gives specific guidance for assessing the severity of vibration measured on the bearings of steam turbine generator sets.

It is applicable to steam turbine generator sets exceeding 50 MW with a normal operating speed of 1 500 r/min, 1 800 r/min, 3 000 r/min or 3 600 r/min. It includes steam turbines and generators which are directly coupled to a gas turbine (such as for combined cycle applications), but in such cases the criteria of this part of ISO 10816 apply only to the steam turbine and the generator.

NOTE 1 Evaluation of the gas turbine vibration should be carried out in accordance with ISO 10816-4.

The criteria apply to *in situ*, broad-band vibration measurements taken in the radial direction on the bearings under steady-state operating conditions at the normal operating speed. They also apply to axial vibration measured on thrust bearings.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10816. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10816 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7919-2:—[1], *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 2: Large land-based steam turbine generator sets.*

ISO 10816-1:1995, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines.*

3 Measurement procedures

The measurement procedures and instrumentation described in ISO 10816-1 shall be used. The measurement system shall be capable of measuring broad-band vibration over a frequency range from 10 Hz to at least 500 Hz. If, however, the instrumentation is also to be used for diagnostic purposes, or monitoring during machine run-up, run-down or overspeed, a wider frequency range may be necessary. Furthermore, in special cases where significant low-frequency vibration may be transmitted to the machine (e.g. in earthquake regions), it may be necessary to attenuate the low-frequency response of the instrumentation.

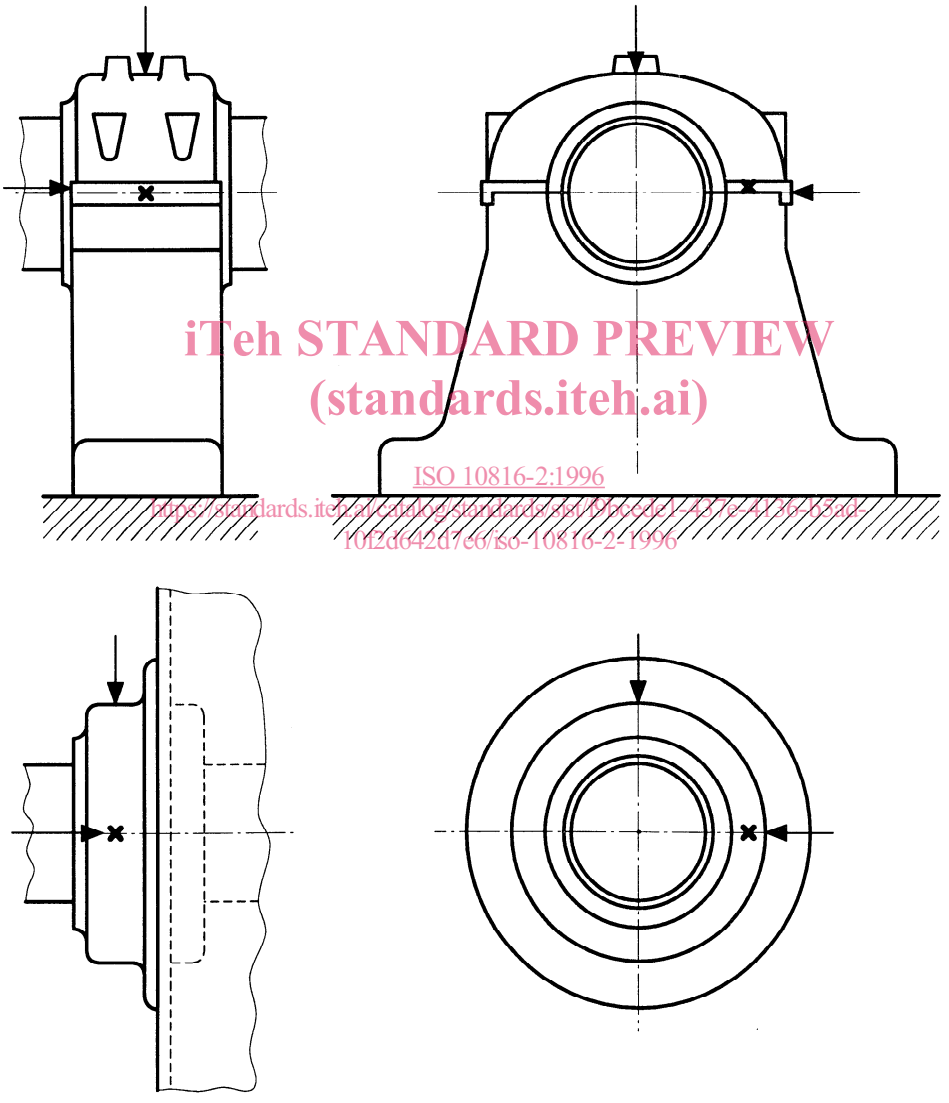
The locations of the vibration measurements shall be such that they provide adequate sensitivity to the dynamic forces of the machine. Typically, this will require measuring in two orthogonal radial directions on

1) To be published.

each bearing, as shown in figure 1. Although the transducers may be placed at any angular location on the bearings, vertical and horizontal directions are usually preferred.

A single transducer may be used on a bearing in place of the more typical pair of orthogonal transducers if it is known to provide adequate information on the magnitude of the machine vibration. In general, however, caution should be observed in evaluating vibration from a single transducer at a measurement plane since it may not be oriented to provide a reasonable approximation of the maximum value at that plane.

It is not common practice to measure axial vibration on main radial load-carrying bearings of steam turbine generators for continuous operational monitoring. Such axial measurements are used primarily during periodic vibration surveys, or for diagnostic purposes. Axial vibration criteria are not provided in this part of ISO 10816. However, when axial vibration is measured at thrust bearings, the severity may be judged using the same criteria as for radial vibration.



NOTE — Axial measurements refer to thrust bearings only.

Figure 1 — Recommended locations of vibration measurements on bearings

4 Evaluation

ISO10816-1 provides a general description of the two evaluation criteria used to assess vibration severity on various classes of machines. One criterion considers the magnitude of observed broad-band vibration; the second considers changes in magnitude, irrespective of whether they are increases or decreases.

4.1 Criterion I: Vibration magnitude

This criterion is concerned with defining limits for absolute vibration magnitude consistent with acceptable dynamic loads on the bearings and acceptable vibration transmission into the support structure and foundation. The maximum vibration magnitude observed at each bearing or pedestal is assessed against four evaluation zones established from international experience. The maximum magnitude of vibration measured is defined as the vibration severity.

4.1.1 Evaluation zones

The following evaluation zones are defined to permit a qualitative assessment of the vibration of a given machine and to provide guidelines on possible actions.

Zone A: The vibration of newly commissioned machines would normally fall within this zone.

Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Numerical values assigned to the zone boundaries are not intended to serve as acceptance specifications, which shall be subject to agreement between the machine manufacturer and customer. However, these values provide guidelines for ensuring that gross deficiencies or unrealistic requirements are avoided. In certain cases, there may be specific features associated with a particular machine which would require different zone boundary values (higher or lower) to be used. In such cases, it is normally necessary for the manufacturer to explain the reasons for this and, in particular, to confirm that the machine will not be endangered by operating with higher vibration values.

4.1.2 Evaluation zone limits

Values for the zone boundaries are given in table A.1. The zone boundary vibration values were established from representative data provided by manufacturers and users. Since the data showed significant spread, the zone boundary values should be considered only as guidelines. If it is known that the machine is not endangered, higher zone boundaries than those shown in table A.1 are permissible. The values in table A.1 apply to radial vibration measurements on all bearings and axial vibration on thrust bearings when taken under steady-state operating conditions at rated speed.

This part of ISO 10816 does not provide different evaluation zone values for turbine generators mounted on rigid and flexible foundations. This is consistent with ISO 7919-2 which deals with shaft vibration for the same class of machines. However, ISO 7919-2 may be revised in the future to give different criteria for turbine generators mounted on massive concrete foundations and those mounted on lighter, tuned steel foundations, if additional analysis of survey data on such machines shows it to be warranted.

The common measurement parameter for assessing machine vibration severity is velocity. Table A.1 presents the evaluation zone boundaries based on r.m.s. (root-mean-square) velocity measurements. In many cases, however, it was customary to measure vibration with instruments scaled to read peak rather than r.m.s. vibration velocity values. If the vibration wave form is basically sinusoidal, a simple relationship exists between the peak and r.m.s. values and the zone boundaries of table A.1 may be readily expressed in peak values.

For large steam turbine generators, it is common for the vibration to be predominantly at the running frequency of the machine. For such cases and when peak rather than r.m.s. values of vibration are being measured, a table equivalent to table A.1 can be constructed. The zone boundaries of table A.1 are multiplied by a factor of $\sqrt{2}$ to produce such an equivalent table for assessing peak vibration severity. Alternatively, the measured peak vibration values may be divided by $\sqrt{2}$ and judged against the r.m.s. criteria of table A.1.

4.2 Criterion II: Change in vibration magnitude

This criterion provides an assessment of a change in vibration magnitude from a previously established

reference value. A significant increase or decrease in broad-band vibration magnitude may occur which requires some action even though zone C of Criterion I has not been reached. Such changes can be virtually instantaneous or progressive with time and may indicate incipient damage or some other irregularity. Criterion II is specified on the basis of the change in broad-band vibration magnitude occurring under steady-state operating conditions. Such conditions allow for small changes in the generator power output at the normal operating speed.

When Criterion II is applied, the vibration measurements being compared shall be taken at the same transducer location and orientation, and under approximately the same machine operating conditions. Significant changes from the normal vibration magnitudes should be investigated so that a dangerous situation may be avoided. When an increase or decrease in vibration magnitude exceeds 25 % of the upper value of zone B, such changes should be considered significant. Diagnostic investigations should then be initiated to ascertain the reason for the change and to determine what further actions are appropriate.

NOTE 2 The 25 % value is provided as a guideline for a significant change in vibration magnitude, but other values may be used based on experience with a specific machine.

4.3 Operational limits

For long-term operation, it is common practice to establish operational vibration limits. These limits take the form of ALARMS and TRIPS.

ALARMS: To provide a warning that a defined value of vibration has been reached or a significant change has occurred, at which remedial action may be necessary. In general, if an ALARM situation occurs, operation can continue for a period whilst investigations are carried out to identify the reason for the change in vibration and define any remedial action.

TRIPS: To specify the magnitude of vibration beyond which further operation of the machine may cause damage. If the TRIP value is exceeded, immediate action should be taken to reduce the vibration or the machine should be shut down.

Different operational limits, reflecting differences in dynamic loading and support stiffness, may be specified for different measurement positions and directions.

4.3.1 Setting of ALARMS

The ALARM values may vary considerably, up or down, for individual machines. The values chosen will normally be set relative to a baseline value determined from experience for the measurement position or direction for that particular machine.

It is recommended that the ALARM value should be set higher than the baseline by an amount equal to 25 % of the upper limit of zone B. If the baseline is low, the ALARM may be below zone C.

Where there is no established baseline (for example with a new machine) the initial ALARM setting should be based either on experience with other similar machines or relative to agreed acceptance values. After a period of time, the steady-state baseline value will be established and the ALARM setting should be adjusted accordingly.

Where the baseline signal is non-steady and non-repetitive, some method of time averaging of the signal is required. This could be achieved with the aid of a computer.

It is recommended that the ALARM value should not normally exceed 1,25 times the upper limit of zone B.

If the steady-state baseline changes (for example after a machine overhaul), the ALARM setting should be revised accordingly. Different operational ALARM settings may then exist for different bearings on the machine, reflecting differences in dynamic loading and bearing support stiffnesses.

An example of establishing ALARM values is given in annex B.

4.3.2 Setting of TRIPS

The TRIP values will generally relate to the mechanical integrity of the machine and be dependent on any specific design features which have been introduced to enable the machine to withstand abnormal dynamic forces. The values used will, therefore, generally be the same for all machines of similar design and would not normally be related to the steady-state baseline value used for setting ALARMS.

There may, however, be differences for machines of different design and it is not possible to give clear guidelines for absolute TRIP values. In general, the TRIP value will be within zone C or D, but it is recommended that the TRIP value should not exceed 1,25 times the upper limit of zone C.

4.4 Supplementary procedures/criteria

The measurement and evaluation of vibration given in this part of ISO 10816 may be supplemented or replaced by shaft vibration measurements and the applicable criteria in ISO 7919-2. It is important to recognize that there is no simple way to relate bearing vibration to shaft vibration, or vice versa. The difference between the shaft absolute and shaft relative measurements is related to the bearing vibration but may not be numerically equal to it because of phase angle differences. Thus, when the criteria of this part of ISO 10816 and those of ISO 7919-2 are both applied in the assessment of machine vibration, independent shaft and bearing vibration measurements shall be made. If application of the different criteria leads to different assessments of vibration severity, the more restrictive classification generally applies.

4.5 Evaluation based on vibration vector information

The evaluation considered in this part of ISO 10816 is limited to broad-band vibration without reference to frequency components or phase. This will, in most cases, be adequate for acceptance testing and for operational monitoring purposes. However, for long-term condition monitoring purposes and for diagnostics, the use of vibration vector information is particularly useful for detecting and defining changes in the dynamic state of the machine. In some cases, these changes would go undetected when using only broad-band vibration measurements (see, for example, ISO 10816-1).

Phase- and frequency-related vibration information is being used increasingly for monitoring and diagnostic purposes. The specification of criteria for this, however, is beyond the present scope of this part of ISO 10816.