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

**Part 7:
Rotodynamic pumps for industrial
applications, including measurements on
rotating shafts**

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

*Partie 7: Pompes rotodynamiques pour applications industrielles, y
compris mesurages sur les arbres tournants*



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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 10816-7 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*, in collaboration with ISO/TC 115 *Pumps*.

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: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min*
- *Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ*
- *Part 4: Gas turbine sets with fluid-film bearings*
- *Part 5: Machine sets in hydraulic power generating and pumping plants*
- *Part 6: Reciprocating machines with power ratings above 100 kW*
- *Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts*

Introduction

Vibration measurements on rotodynamic pumps can be useful for many purposes, e.g. for the operational monitoring, acceptance test and for diagnostic or analytic investigation (condition monitoring).

General descriptions of the principles to be applied for the measurement and assessment of vibration on coupled industrial machines are given for vibration on non-rotating parts in ISO 10816-1 and for shaft vibration in ISO 7919-1.

This part of ISO 10816 is based on vibration data gathered from a survey of about 1 500 pumps operating both *in situ* and at various test facilities. This survey included pumps of different types, speed and power, operating over a wide range of flows. Due to the large number of vibration measurements, these data are considered to be representative of pumps that are operating satisfactorily, though there is a lack of information about the mean time between failure and operating conditions for the measured values.

Statistical evaluation of these data has been made for the preferred operating region, i.e. 70 % to 120 % of the best efficiency point (BEP), as well as evaluations of the flow and power dependency.

This vibration survey showed no significant differences between rigid and flexible supports, or between horizontal and vertical orientations of the pumps when measured at the positions defined in this part of ISO 10816. This is in contrast to other standards dealing with vibration measurements (e.g. ISO 10816-1, ISO 10816-3 and ISO 13709^[10]) which do make these distinctions.

The statistical analysis showed a slight dependency of the vibration values with the power consumption of a pump. Consequently, this part of ISO 10816 distinguishes between pumps up to and above 200 kW.

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

Part 7:

Rotodynamic pumps for industrial applications, including measurements on rotating shafts

1 Scope

This part of ISO 10816 gives instructions for the evaluation of vibration on rotodynamic pumps for industrial applications with nominal power above 1 kW. It defines the special requirements for evaluation of vibration when the vibration measurements are made on non-rotating parts (bearing housing vibration). It provides specific guidance for assessing the severity of vibration measured on bearing housings of rotodynamic pumps *in situ* and for the acceptance test at the manufacturer's test facility or in the plant. This part of ISO 10816 also gives general information and guidelines for assessing relative shaft vibration of the rotating shaft.

This part of ISO 10816 specifies zones and limits for the vibration of horizontal and vertical pumps irrespective of their support flexibility. The general evaluation criteria are valid for operational monitoring of rotodynamic pumps and for acceptance tests¹⁾ *in situ* or at the manufacturer's test facility if specified. For the acceptance test at the manufacturer's test facility, special conditions are given.

For monitoring the vibration values during long-term operation, two criteria are provided for assessing the machine vibration. One criterion considers the magnitude of the observed vibration and the second considers changes in magnitude. The evaluation criteria are applicable for the vibration produced by the pump itself and not for vibration which is transmitted to the pump from external sources. The criteria mainly serve to ensure a reliable, safe long-term operation of the pump, simultaneously minimizing harmful effects on connected devices. Additionally, recommendations are given for defining operational limits and setting alarm and trip values.

For pump units with integrated electrical motors (impeller directly on the motor shaft or impeller shaft rigidly connected to the motor shaft), this part of ISO 10816 applies to the whole coupled unit.

For flexibly coupled motors, this part of ISO 10816 is applicable for the pump only. Also, separately mounted drivers are not within the scope of this part of ISO 10816. Those drivers are dealt with in ISO 10816-3.

The following types of pumps are excluded from this part of ISO 10816:

- reciprocating and rotating positive displacement pumps;
- reciprocating engine driven pumps;

1) Wherever acceptance tests are mentioned in this part of ISO 10816 it should be taken into account that all the details about place, size and form of those test procedures are optional and need to be specified and agreed between both parties of a contract.

- pumps in hydraulic power generating and pumping plants with power above 1 MW (see ISO 7919-5^[4] and ISO 10816-5);
- solids handling, slurry and submersible pumps.

Torsional vibration is not dealt with in this part of ISO 10816.

2 Normative references

The following referenced documents are indispensable for the application 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 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 7919-1, *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 1: General guidelines*

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

3 Vibration measurement

3.1 Measurement quantity and procedure

The measurement quantity to be used for measuring the vibration of non-rotating parts²⁾ of rotodynamic pumps is the root-mean-square (r.m.s.) vibration velocity in mm/s. For speeds below 600 r/min, it is additionally required to measure the peak-to-peak displacement in μm . The measurement procedure to be followed is specified in ISO 10816-1.

3.2 Measuring instrumentation and frequency range

3.2.1 General

The measuring instrumentation shall conform to the requirements set out in ISO 10816-1. The instrumentation shall be capable of measuring the r.m.s. vibration velocity in a broad frequency range reaching from at least 10 Hz to 1 000 Hz and shall be in accordance with the requirements of ISO 2954.

For pumps with operating speeds below 600 r/min, the lower frequency limit of the measuring instrumentation shall normally be 2 Hz so that the frequency of the vibration component at operating speed is well within the measured frequency range. In addition, the measuring instrumentation shall measure both r.m.s. vibration velocity (in millimetres per second) and peak-to-peak displacement (in micrometres).

Owing to the fact that the broad-band peak-to-peak displacement in the low-frequency range can be strongly influenced by stochastic, impulsive excitations due to the fluid flow, sometimes higher than normal values might occur and should then be analysed and explained e.g. by frequency filtering. In accordance with this it is recommended to measure the peak-to-peak displacement for the filtered values at 0,5 times, 1 times and 2 times the operating speed with a bandwidth of 1 Hz or less to evaluate the quality of a pump.

For very high-speed pumps or for diagnostic purposes (see e.g. ISO 13373-1^[8] which specifies a more detailed analysis), it may be required to use measuring instrumentation which covers a wider frequency range, usually up to 2,5 times the blade-passing frequency so that the blade-passing frequency components are adequately accounted for.

2) For measurements on rotating shafts, see Annex B.