INTERNATIONAL STANDARD

ISO 8528-9

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 9:

Measurement and evaluation of mechanical vibrations

Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —

Partie 9: Mesurage et évaluation des vibrations mécaniques

Reference number
ISO 8528-9:1995(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 8528-9 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 2, *Performance and tests*.

ISO 8528 consists of the following parts, under the general title *Reciprocating internal combustion engine driven alternating current generating sets*:

— *Part 1: Application, ratings and performance*

— *Part 2: Engines*

— *Part 3: Alternating current generators for generating sets*

— *Part 4: Controlgear and switchgear*

— *Part 5: Generating sets*

— *Part 6: Test methods*

— *Part 7: Technical declarations for specification and design*

— *Part 8: Requirements and tests for low-power generating sets*

— *Part 9: Measurement and evaluation of mechanical vibrations*

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— *Part 10: Measurement of airborne noise by the enveloping surface method*

— *Part 11: Dynamic uninterruptible power supply systems*

— *Part 12: Emergency power supply to safety services*

Annexes A, B, C, D and E of this part of ISO 8528 are for information only.

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 9:
Measurement and evaluation of mechanical vibrations

1 Scope

This part of ISO 8528 describes a procedure for measuring and evaluating the external mechanical vibration behaviour of generating sets at the measuring points stated in that International Standard.

It applies to RIC engine driven AC generating sets for fixed and mobile installations with rigid and/or resilient mountings. It is applicable for land and marine use, excluding generating sets used on aircraft or those used to propel land vehicles and locomotives.

For some specific applications (essential hospital supplies, high rise buildings, etc.) supplementary requirements may be necessary. The provisions of this part of ISO 8528 should be regarded as a basis.

For generating sets driven by other reciprocating-type prime movers (e.g. sewage gas engines, steam engines), the provisions of this part of ISO 8528 should be regarded as a basis.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8528. 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 8528 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 2041:1990, *Vibration and shock — Vocabulary.*

ISO 5348:1987, *Mechanical vibration and shock — Mechanical mounting of accelerometers.*

ISO 8528-5:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 5: Generating sets.*

IEC 34-7:1992, *Rotating electrical machines — Part 7: Classification of types of constructions and mounting arrangements (IM Code).*

3 Definitions

For the purposes of this part of ISO 8528, the definitions given in ISO 2041 and the following definition apply.

3.1 vibration severity: A generic term that designates a value or set of values, such as a maximum value, average value or rms value, or other parameter that is descriptive of the vibration.

NOTES

1 It may refer to instantaneous values or average values.

2 ISO 2041 includes two notes in the definition. These notes do not apply in this part of ISO 8528.

4 Symbols and abbreviations

For the purposes of this part of ISO 8528 the following symbols apply.

a	Acceleration
$\hat{a}$	Peak value of acceleration
f	Frequency
s	Displacement
$\hat{s}$	Peak value of displacement
t	Time
v	Velocity
$\hat{v}$	Peak value of velocity
x	Axial co-ordinate
y	Transverse co-ordinate
z	Vertical co-ordinate
ω	Angular velocity

The following subscripts are used in conjunction with the vibration quantities v, s and a.

rms	Value of vibration quantity
x	Measured value of vibration quantity in the axial direction
y	Measured value of vibration quantity in the transverse direction
z	Measured value of vibration quantity in the vertical direction
1, 2 ... n	Progressive values

The following abbreviation is used.

IMB	Type or construction and mounting arrangement of generators according to IEC 34-7

5 Regulations and additional requirements

5.1 For a.c. generating sets used on board ships and offshore installations which have to comply with rules of a classification society, the additional requirements of the classification society shall be observed. The classification society shall be stated by the customer prior to placing the order.

For a.c. generating sets in unclassed equipment, such additional requirements are in each case subject to agreement between the manufacturer and customer.

5.2 If special requirements from regulations of any other authority, e.g. inspecting and/or legislative authorities, have to be met, the authority shall be stated by the customer prior to placing the order.

Any further additional requirements shall be subject to agreement between the manufacturer and customer.

6 Measured values

Acceleration, velocity and displacement are measured variables for the vibrations (see clause 10).

In the general case of any vibration over time interval t_1 to t_2, the rms velocity is given by

$$v_{\text{rms}} = \sqrt{\frac{\int_{t_1}^{t_2} v^2 \mathrm{d}t}{t_2 - t_1}} \qquad \text{... (1)}$$

In the particular case of sinusoidal vibration the rms velocity is given by

$$v_{\text{rms}} = \frac{\hat{s}\omega}{\sqrt{2}} = \frac{\hat{v}}{\sqrt{2}} = \frac{\hat{a}}{\omega} \times \frac{1}{\sqrt{2}} \qquad \text{... (2)}$$

If the vibration characteristics are analysed and if for angular frequencies ω_1, ω_2, ..., ω_n, the vibration velocities $\hat{v}_1$, $\hat{v}_2$ ... $\hat{v}_n$ are available, then the following relationships can be used to determine the rms velocity:

$$v_{\text{rms}} = \frac{\sqrt{\hat{v}_1^2 + \hat{v}_2^2 + ... + \hat{v}_n^2}}{\sqrt{2}} \qquad \text{... (3)}$$

$$v_{\text{rms}} = \sqrt{v_{\text{rms}1}^2 + v_{\text{rms}2}^2 + ... + v_{\text{rms}n}^2} \qquad \text{... (4)}$$

NOTE 3 For acceleration and displacement rms values are calculated in the same manner.

7 Measuring devices

The measuring system shall provide the rms values of displacement, velocity and acceleration with an accuracy of ± 10 % over the range 10 Hz to 1 000 Hz and an accuracy of $^{+10}_{-20}$ % over the range 2 Hz to 10 Hz. These values may be obtained from a single sensor whose signal is either integrated or differentiated, depending on the outcome of the measuring device, to derive the quantities not directly measured, provided the accuracy of the measuring system is not adversely affected.

NOTE 4 The accuracy of measurement is also affected by the method of connection between the transducer and

the object being measured. Both the frequency response and the measured vibration are affected by the method of attaching the transducer. It is especially important to maintain good attachment between the transducer and the point on the generating set being measured when vibration levels are high.

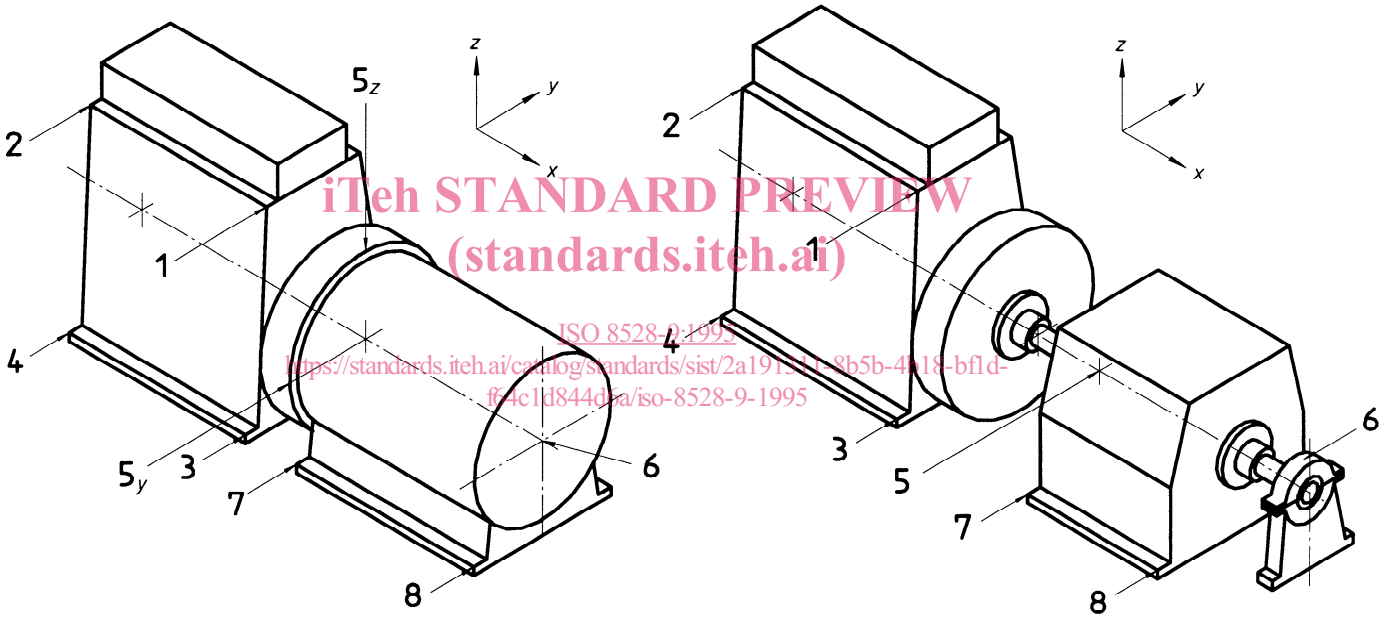
Refer to ISO 5348 for guidance on the mounting of accelerometers.

8 Location of measuring points and direction of measurements

Figure 1 shows the recommended points of vibration measurement in generating sets. The specifications apply as appropriate for other types of design. If possible, measurements shall be taken at these points in the three main directions, defined by x, y and z.

Figure 1 shows the approximate positions of the measuring points which have to be located on the solid engine block and on solid areas of the generator frame in order to avoid measuring local structural vibrations.

If experience with similar generating sets has shown at which points the maximum vibration severity is to be expected, not all the points given in figure 1 need necessarily be measured.



a) Generating set driven by a vertical in-line engine with flange housing coupled generator with integral bearings.

b) Generating set driven by a vertical in-line engine and a generator with pedestal bearings

Key

1, 2 Front end top edge and back end top edge
3, 4 Front and rear end of engine base
5, 6 Generator main bearing housing
7, 8 Generator base

NOTE — The vertical in-line engine shown is given as an example only. Measuring points 1 to 4 are applicable as appropriate for other types of engine, e.g. V-engines, horizontal engines.

Figure 1 — Arrangement of measuring points

9 Operating conditions during measurement

The measurements shall be taken with the generating set at its operating temperature and rated frequency, at both zero power and rated power. If the rated power of the generating set is not attainable, it should be tested at the maximum power that can be attained.

10 Evaluation of results

The main excitation frequencies of the RIC engine itself are found in the range 2 Hz to 300 Hz. However, when considering the overall generating set structure and components, a range of 2 Hz to 1 000 Hz is required to evaluate the vibration.

Additional testing may be necessary to ensure that no local structural resonances contribute to the measurement result.

Assessment of the potential effects of vibration are made by reference to table C.1 which gives rms values of vibration displacement, velocity and acceleration. These values can be used as guidelines for evaluating the measured vibration levels.

Experience has shown that with a standard design of generating set structure and components, damage would not be expected if vibration levels remain below value 1.

If the vibration levels fall between values 1 and 2, assessment of the generating set structure and components may be required along with an agreement between the generating set manufacturer and the component supplier in order to ensure reliable operation.

In some cases vibration levels can be above value 2 but only if individual special designs of generating set structure and components are applied.

In all cases the generating set manufacturer remains responsible for the compatibility with each other of the generating set components (see ISO 8528-5:1993, 15.10).

11 Test report

The indicated measurement results shall include the main data of the generating set and the measuring equipment used. These data are to be recorded using annex D.

Annex A
(informative)

Typical generating set configurations

There are a number of possibilities for the assembly of a reciprocating internal combustion engine and a generator. Figures A.1 to A.6 show examples of typical configurations.

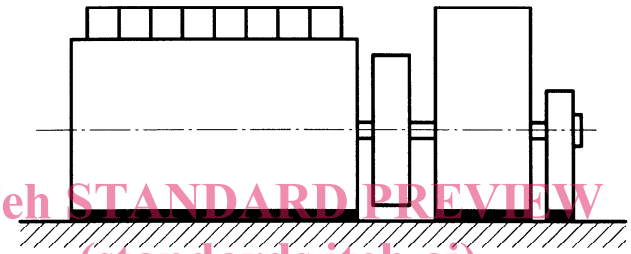


Figure A.1 — Engine and generator rigidly mounted

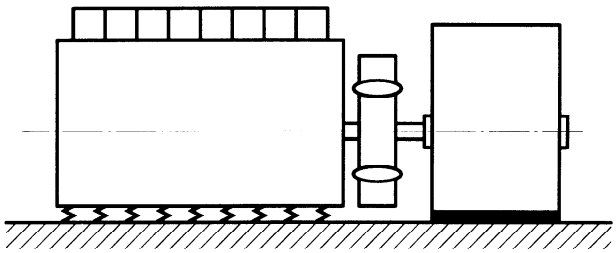


Figure A.2 — Engine resiliently mounted, generator rigidly mounted, flexible coupling

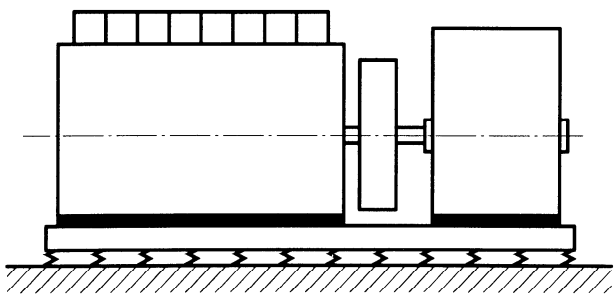


Figure A.3 — Engine and generator rigidly mounted on resiliently mounted base frame