INTERNATIONAL STANDARD

ISO 8626

First edition
1989-07-01

Servo-hydraulic test equipment for generating vibration — Method of describing characteristics

Moyens d'essais servo-hydrauliques utilisés pour la génération de vibrations — Méthodes de description des caractéristiques

Reference number
ISO 8626 : 1989 (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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8626 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Contents

Annexes

Servo-hydraulic test equipment for generating vibration — Method of describing characteristics

0 Introduction

This International Standard covers the characteristics of servo-hydraulic test equipment used for generating linear vibrations and serves as a guide for the selection of such equipment.

NOTE — For the purposes of this International Standard, servo-hydraulic test equipment is more simply referred to as "hydraulic test equipment".

The term "hydraulic" means that the vibratory movement produced results from the variable flow of a liquid which is generally ensured by means of an electrohydraulic control device fed by a hydraulic power system and acting on an actuator, using one or several control loops.

The hydraulic test equipment for generating vibration, a schematic diagram of which is shown in figures 6 and 7, comprises

- the complete hydraulic vibration generator system [hydraulic vibration generator(s), servovalve control device(s), hydraulic power system],
- control desks,
- auxiliary tables,
- other peripherals.

NOTE — Control desks will be dealt with in a future International Standards. Auxiliary tables are covered by ISO 6070.

Clauses 6, 7, 8 and 9 enable the user to specify separately individual components of a servo-hydraulic vibration test system if he chooses to assemble the system from components obtained from more than one source.

If the user chooses to acquire the complete servo-hydraulic vibration test system from a single source, he shall refer to clauses 6, 9 and 10.

1 Scope and field of application

The hydraulic test equipment used for generating vibration has a wide range of characteristics which can be evaluated in many different ways.

In order to enable the possibilities afforded by test equipment from different sources to be compared, this International Standard establishes

a) a list of the characteristics;

b) the standard method of obtaining certain of these characteristics.

This International Standard provides two levels of description to be used in describing the test equipment, as follows:

a) level 1 description;

b) level 2 description.

It gives, for each level of description, chosen by agreement between the user and the manufacturer, a list of the characteristics to be described by the manufacturer in his tender as well as a list of technical documents to be supplied with the equipment. Furthermore, the manufacturer's literature shall contain at least the characteristics corresponding to a level 1 description.

This International Standard applies to the following equipment:

- hydraulic vibration generators [actuators, servovalves, all or part of the position control device and, if fitted, the static force compensating device (see clauses 5, 6 and 7)];
- the servovalve control devices (see clauses 5, 6, and 8);
- the hydraulic power systems (see clauses 5, 6 and 9);
- the complete hydraulic vibration generator systems (see clauses 5, 6 and 10).

2 References

ISO 2041, *Vibrations and shock — Vocabulary.*

ISO 3746, *Acoustics — Determination of sound power levels of noise sources — Survey method.*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding level of contamination by solid particles.*

ISO 4413, *Hydraulic fluid power — General rules for the application of equipment to transmission and control systems.*

ISO 6070, *Auxiliary tables for vibration generators — Methods of describing equipment characteristics.*

3 Symbols

A	Useful cross-section
a	Acceleration
a_b	Maximum r.m.s acceleration under random conditions
a_g	Noise acceleration with the amplifier input in the absence of a control signal — being loaded with an impedance equivalent to the impedance of the signal source.
a_o	Maximum no-load acceleration
a_{max}	Maximum acceleration (see 5.5.7.2.1.1)
b	Viscous damping
c	Longitudinal velocity (see annex C)
d	Total distortion (see 5.5.10.1)
d_o	Rated total distortion (see 5.5.10.2)
D	Diameter of the test load
E	Longitudinal elasticity (Young's modulus)
f	Fundamental frequency
f_{min}	Minimum frequency used
f_{max}	Maximum frequency used
f_o	Smallest modal frequency of the load test (see annex C)
f_{oh}	Normal hydraulic mode frequency (see 5.5.6)
F_o	Rated force under sinusoidal conditions (see 5.5.7.2.1.2)
F_{ob}	Rated random force, broad-band (see 5.5.7.2.2)
F_{om_t}	Rated force under sinusoidal conditions for a test mass m_t (see 5.5.7.2.1.1) (the index t represents the various masses)
F_{st}	Static force (see 5.5.7.1)
g_n	Standard acceleration of free fall (due to gravity)
$H_h(s)$	Hydraulic transfer function
$H_I(f)$	Acceleration transfer characteristic at constant current (see clause B.1)
I_d	Servovalve input current
I_{so}	Rated r.m.s. current under sinusoidal conditions at the input of the servovalve
k_h	Linear hydraulic stiffness
L	Height of the test mass (see annex C)
m_e	Mass of the moving element (see 5.5.5)
m_t	Test masses (t = 0, 1, 2, 3, 4, 5) (see 5.4)
p_s	Supply pressure
$p_{s,max}$	Maximum supply pressure
q_V	Flow rate generated by the servovalve
q_{V_n}	Flow rate of the hydraulic power system
s	Laplacian operator
S	Dynamic amplification factor
U	Control voltage at the position loop amplifier input
U_{so}	Rated r.m.s. voltage under sinusoidal conditions at the input of the servovalve
v	Velocity
x	Displacement
x_b	R.M.S. value of displacement under random conditions
ε	Reduced damping factor
μ	Tranverse contraction coefficient (Poisson ratio) (see also annex C)
ν	Modal frequency
ϱ	Density
φ	Operational noise
$\Phi(f)$	Acceleration power spectral density (acceleration PSD)
$\theta(f)$	Displacement power spectral density (displacement PSD)

4 Units

When the manufacturer or the user gives values for the parameters required by this International Standard, he shall clearly define the units and state, where necessary, whether the values are r.m.s., peak or peak-to-peak values.

5 Definitions

For the purposes of this International Standard, the general definitions given in ISO 2041 and the following definitions apply.

5.1 hydraulic vibration generator: A test device in which the vibratory linear movement of the test table or power take-off[1] is produced by the action of a fluid on a piston.

A schematic diagram of the test table power take-off vibration generator is shown in figure 7.

1) Throughout the text, where for simplicity's sake "test table" has been used, read "test table or power take-off".

The hydraulic vibration comprises the constituent parts defined in 5.1.1 to 5.1.3.

5.1.1 moving element: Constituent part comprising the piston rod, the piston and, if fitted,

- the moving table,
- the connecting element between the piston rod and the power take-off, if it is other than part of the rod,
- the moving part of the position transducer,
- the moving parts of the anti-rotation system.

5.1.2 pedestal: Constituent part that connects the body of the actuator to the foundation, the reaction mass or baseplate, if fitted.

5.1.3 gravity compensation device: Constituent part fitted, in certain cases, to the hydraulic vibration generators in order to resist the static forces caused by the material under test.

5.2 servovalve control device: Device the function of which is to ensure

- the conditioning of the control signals under static and dynamic conditions,
- that the mean position of the moving element is maintained (see note 1), and
- that the harmonic distortion factors are minimized (see note 2).

NOTES

1 In certain cases or for certain servovalves, the valve may not include the hydromechanical position transducer; this should then be a function of the control system.

2 In order to minimize the harmonic distortion factors, this device may be fed with acceleration, velocity or pressure data in addition to the vibration signal and its slide valve position data.

5.3 hydraulic power supply: The complete hydraulic installation necessary for feeding the hydraulic vibration generators.

A schematic diagram is given in figure 8.

The hydraulic power supply designed for feeding the hydraulic vibration generator is generally made up of the elements defined in 5.3.1 to 5.3.8

5.3.1 hydraulic fluid: The power transfer agent between the hydraulic power supply and the vibration generator.

5.3.2 reservoir: Container for storing the hydraulic fluid and the capacity of which generally depends on the maximum flow rate of the hydraulic pump.

5.3.3 hydraulic pump: Equipment which produces the flow rate and pressure necessary for feeding the hydraulic vibration generator; it can have a constant or variable flow rate.

5.3.4 pressure regulator: Equipment which keeps the pressure between certain limits fixed by the vibration generator manufacturer; it may have a proportional or on-off action.

5.3.5 filtration system: Series of filters in the reservoir discharge and return circuits which keep the hydraulic circuits clean, as required for servovalve applications.

5.3.6 heat exchangers: Devices which maintain the temperature of the hydraulic fluid in the reservoir within the temperature range set by the manufacturer.

5.3.7 accumulator: Pressurized fluid reservoir which compensates for pressure surges in the hydraulic (discharge and return) circuits and attenuates hammering in the installation.

5.3.8 auxiliary equipment: Equipment comprising the accessories used, the device providing information, and the alarm and safety systems (see 10.3.2).

5.4 test masses, m_t: Mechanical masses selected by the manufacturer and used for the testing of hydraulic vibration generators.

NOTE — For requirements on shape, dimensions, flatness, surface roughness and fixing of the test mass, see annex C.

5.4.1 test mass m_0: The special case where the test mass is zero and only the moving table is driven.

5.4.2 test mass m_1: A load permitting a peak acceleration of approximately $1g$ under sinusoidal conditions.

5.4.3 test mass m_2: A load permitting a peak acceleration of approximately $4g$ under sinusoidal conditions.

5.4.4 test mass m_3: A load permitting a peak acceleration of approximately $10g$ under sinusoidal conditions.

5.4.5 test mass m_4: A load permitting a peak acceleration of approximately $20g$ under sinusoidal conditions.

5.4.6 test mass m_5: A load permitting a peak acceleration of approximately $40g$ under sinusoidal conditions.

5.5 Quantities

5.5.1 supply pressure, p_s: The pressure produced by the hydraulic power system at the flow rate q_{V_n}. The supply pressure is measured at the pressure regulator outlet in bars or pascals.

5.5.2 flow rate of the hydraulic system, q_{V_n}: The maximum flow rate which can be delivered by the power system at the supply pressure, p_s, measured at the pressure regulator output in litres per minute or cubic centimetres per second.

5.5.3 Travel

5.5.3.1 rated travel: The limits, in millimetres, within which the moving element of the vibration generator normally operates and beyond which the performance is no longer guaranteed by the manufacturer.

5.5.3.2 travel between stops: The rated travel plus the safety margins at each limit which are to be used for braking.

5.5.4 rated velocity, X_n: Maximum velocity amplitude of the moving element which can be obtained under sinusoidal conditions with test mass m_0 without the use of any resonance effect. The rated velocity is given in millimetres per second or metres per second.

5.5.5 mass of the moving element, m_e: The mass, in kilograms, of the moving element, as described in 5.1.1.

NOTE — This mass does not include the mass of the moving hydraulic fluid.

5.5.6 frequency of the normal hydraulic model, f_{oh}: The frequency given by the following formula:

$$f_{oh} = \frac{1}{2\pi}\sqrt{\frac{k_h}{m_e + m_t}}$$

Indeed the hydraulic generator has a behaviour similar to that of a single degree-of-movement system which has the following parameters:

— a total moving mass $m_e + m_t$

— a hydraulic stiffness k_h

NOTE — The viscous damping b may be disregarded.

5.5.7 force: For the purposes of this International Standard, the force in newtons or kilonewtons, developed by a hydraulic vibration generator which can be delivered to a load mounted on the test table or connected to the power take-off, i.e. output force.

5.5.7.1 static force, F_{st} (at zero velocity): The force of the moving element at zero velocity and supply pressure p_s; this is the product of the supply pressure p_s and the useful cross-section A:

$$F_{st} = p_s A$$

NOTE — If fitted, the gravity compensation device does not affect this definition (see 5.1.3 and 7.2.7).

5.5.7.2 dynamic forces: These are generally a function of the following two main variables:

a) the frequency;

b) the type of load on the moving element.

Practical loads may include spring forces and/or damper forces which will influence the performance of the generator. Characteristics of vibration generators are normally specified for mass loading which is the basis of this International Standard. A manufacturer should, however, be expected to give actuator performance with pure spring loading or pure damper loading, if required.

5.5.7.2.1 Dynamic forces under sinusoidal conditions

5.5.7.2.1.1 rated test force, F_{om_t}, **for a specific test mass,** m_t: This is the maximum force which can be introduced in a test mass, m_t, without use of any resonant effect.

$$F_{om_t} = F_o - m_e\, a_{max} = m_t\, a_{max}$$

The maximum acceleration a_{max} is defined in connection with the test loads (see 5.4). The frequency range in which a_{max} can be obtained is the rated frequency range for the test load m_t.

5.5.7.2.1.2 rated force, F_o: The rated dynamic force F_o that the vibration generator can supply for all the test masses m_t (see 5.4).

$$F_o = (m_e + m_t)\, a_{max}$$

NOTE — The rated dynamic force, F_o, may be different from the static load force, F_{st}, and should not cause any fatigue damage of the actuator.

5.5.7.2.2 rated random force, broad-band, F_{ob}: Minimum value of the force under random conditions in a broad band with test mass m_t. This force corresponds to a power spectral density (PSD) of uniform acceleration a_b within the frequency band f_3 to f_4 (see 5.5.8, 5.5.9 and figure 5).

$$F_{ob} = m_t\, a_b$$

5.5.8 Random displacement/acceleration power spectral density (PSD)

For test applications using servo-hydraulic vibration test equipment, both the acceleration power spectral density, $\Phi(f)$, and the related displacement power spectral density, $\theta(f)$, are significant.

5.5.8.1 acceleration power spectral density, $\Phi(f)$: The limiting value of $\frac{a_b^2}{\Delta f}$ when Δf tends towards zero, where a_b is the r.m.s. value of an acceleration waveform with Gaussian amplitude distribution and Δf is a frequency band centred about frequency f.

5.5.8.2 displacement power spectral density, $\theta(f)$: The limiting value of $\frac{x_b^2}{\Delta f}$ when Δf tends towards zero, where x_b is the r.m.s. value of a displacement waveform with Gaussian amplitude distribution and Δf is a frequency band centred about frequency f.

The graph of the acceleration and displacement power spectral density functions may be specified in terms of the lowest operating frequency f_1, a displacement-velocity transition frequency f_2, a velocity-acceleration transition frequency f_3, a cut-off frequency f_4, a second cut-off frequency f_5, if required, and the highest operating frequency, f_6. Between f_1 and f_2 the displacement power spectral density is constant, between f_3 and f_4 the acceleration power spectral density is constant.

The values for the displacement and acceleration PSDs for the various frequency ranges are listed in table 1.

Table 1 — Values for displacement and acceleration PSDs

Frequency band	Displacement PSD	Acceleration PSD
$f < f_1$	$\theta(f) = 0$	$\Phi(f) = 0$
$f_1 \leqslant f \leqslant f_2$	$\theta(f) = \theta_0$	$\Phi(f) = \dfrac{f^4}{(f_2 f_3)^2}\,\Phi_1$
$f_2 \leqslant f \leqslant f_3$	$\theta(f) = \dfrac{f_2^2}{f^2}\,\theta_0$	$\Phi(f) = \dfrac{f^2}{f_3^2}\,\Phi_1$
$f_3 \leqslant f \leqslant f_4$	$\theta(f) = \dfrac{(f_3 f_2)^2}{f^4}\,\theta_0$	$\Phi(f) = \Phi_1$
$f_4 \leqslant f \leqslant f_5$	$\theta(f) = \dfrac{(f_4 f_3 f_2)^2}{f^6}\,\theta_0$	$\Phi(f) = \dfrac{f_4^2}{f^2}\,\Phi_1$
$f_5 \leqslant f \leqslant f_6$	$\theta(f) = \dfrac{(f_5 f_4 f_3 f_2)^2}{f^8}\,\theta_0$	$\Phi(f) = \dfrac{(f_4 f_5)^2}{f^4}\,\Phi_1$
$f > f_6$	$\theta(f) = 0$	$\Phi(f) = 0$

In table 1

$$\theta_0 = \frac{1}{(2\pi f_2)^4}\,\Phi_0$$

5.5.9 R.M.S. values of displacement and acceleration

5.5.9.1 r.m.s. value of displacement, x_b: Value given by the following formula:

$$x_b = \theta_0^{1/2}\left[(f_2 - f_1) + f_2^2\left(\frac{1}{f_2} - \frac{1}{f_3}\right) + \frac{1}{3}(f_3 f_2)^2\left(\frac{1}{f_3^3} - \frac{1}{f_4^3}\right) + \frac{1}{5}(f_4 f_3 f_2)^2\left(\frac{1}{f_4^5} - \frac{1}{f_5^5}\right) + \frac{1}{7}(f_5 f_4 f_3 f_2)^2\left(\frac{1}{f_5^7} - \frac{1}{f_6^7}\right)\right]^{1/2}$$

5.5.9.2 r.m.s. value of acceleration, a_b: Value given by the following formula:

$$a_b = \Phi_1^{1/2}\left[\frac{1}{5(f_2 f_3)^2}(f_2^5 - f_1^5) + \frac{1}{3 f_3^2}(f_3^3 - f_2^3) + (f_4 - f_3) + f_4^2\left(\frac{1}{f_4} - \frac{1}{f_5}\right) + \frac{(f_4 f_5)^2}{3}\left(\frac{1}{f_5^3} - \frac{1}{f_6^3}\right)\right]^{1/2}$$

5.5.9.3 The formulae given in 5.5.9.1 and 5.5.9.2 are simplified where particular frequency bands are omitted. For example in the case where the highest operating frequency, f_6, is lower than the first cut-off frequency, f_4, the formulae become:

$$x_b = \theta_0^{1/2}\left[(f_2 - f_1) + f_2^2\left(\frac{1}{f_2} - \frac{1}{f_3}\right) + \frac{1}{3}(f_3 f_2)^2\left(\frac{1}{f_3^3} - \frac{1}{f_6^3}\right)\right]^{1/2}$$

$$a_b = \Phi_1^{1/2}\left[\frac{1}{5(f_2 f_3)^2}(f_2^5 - f_1^5) + \frac{1}{3 f_3^2}(f_3^3 - f_2^3) + (f_6 - f_3)\right]^{1/2}$$

The crest factor shall be at least 3.

The rated travel (see 5.5.3.1) shall be at least twice the r.m.s. value of the displacement, x_b, multiplied by the crest factor to avoid contacting the mechanical stops.

5.5.10 Distortion

There are two definitions with respect to distortion with different values for d, determined using the following formulae:

$$d = \frac{\sqrt{a^2 - a_1^2}}{a_1}$$

$$d = \frac{\sqrt{a^2 - a_1^2}}{a}$$

where a and a_1 are as defined in 5.5.10.1.

With respect to the operational noise φ, the distortion is often determined by the formula

$$d = \sqrt{\frac{\int_{f_{min}}^{f_1 - \Delta f/2} G_{XX}(f)\mathrm{d}f + \int_{f_1 + \Delta f/2}^{f_{max}} G_{XX}(f)\mathrm{d}f}{\int_{f_{min}}^{f_{max}} G_{XX}(f)\mathrm{d}f}}$$

where

$G_{XX}(f)$ is the PSD of the signal;

f is the frequency of the basic signal.

5.5.10.1 Total distortion, d (see figure 1)

5.5.10.1.1 acceleration distortion: An acceleration signal a may be considered as made up of components as given by the following formula:

$$a = \sqrt{\varphi^2 + a_1^2 + a_2^2 + a_3^2 + \ldots + a_n^2} = \sqrt{\varphi^2 + \sum_{i=1}^{n} a_i^2}$$

where

a is the r.m.s. value of the acceleration;

a_1 is the r.m.s. value of the component of acceleration at the fundamental frequency f, which is usually the only component desired;

$a_2, a_3, \ldots a_n$ are the r.m.s. values of the harmonic components at frequencies $2f, 3f, \ldots nf$, where n includes all components of significant value;

φ is the operational noise (see 5.5.11.2).

The total distortion, d, is the ratio between all of the undesired acceleration components and the desired acceleration, a_1:

$$d = \frac{\sqrt{\varphi^2 + a_2^2 + a_3^2 + \ldots + a_n^2}}{a_1} = \frac{\sqrt{\varphi^2 + \sum_{i=2}^{n} a_i^2}}{a_1} = \frac{\sqrt{a^2 - a_1^2}}{a_1}$$

5.5.10.1.2 velocity distortion: When the acceleration signal is integrated to obtain a velocity signal, each component is divided by its own frequency and the ratio between the harmonic components and the fundamental is deduced. If the harmonic components are much larger than the noise, as is usually the case, the velocity distortion will be much lower than the acceleration distortion. If velocity rather than acceleration distortion is intended, the words "velocity distortion" shall be clearly stated.

The velocity distortion is expressed by the following formula:

$$d_v = \frac{\sqrt{\left(\int_0^t \varphi_a \mathrm{d}t\right)^2 + \sum_{i=2}^{n} \left(\frac{a_i}{i\,2\pi f}\right)^2}}{\frac{a_1}{2\pi f}} = \frac{\sqrt{v^2 - v_1^2}}{v_1}$$

5.5.10.1.3 displacement distortion: When the velocity signal is integrated again to obtain a displacement signal, if the harmonic components of displacement are larger than the displacement noise, which may be the case, the displacement distortion will be less than the velocity distortion. If displacement distortion rather than acceleration distortion d is intended, the words "displacement distortion" shall be clearly stated.

The displacement distortion is expressed by the following formula:

$$d_x = \frac{\sqrt{\left(\int_0^t\int_0^t \varphi_a \mathrm{d}t\,\mathrm{d}t\right)^2 + \sum_{i=2}^{n} \left(\frac{a_i}{i^2\,4\pi^2 f^2}\right)^2}}{\frac{a_1}{4\pi^2 f^2}} = \frac{\sqrt{x^2 - x_1^2}}{x_1}$$

5.5.10.2 rated total distortion, d_o: The maximum value of the total distortion, d, determined at maximum acceleration in the rated frequency range, for a given test mass. See figure 2.

5.5.11 noise: Noise is caused by the measuring system as well as by the control loop.

5.5.11.1 background noise: The r.m.s. or peak-to-peak value of the vibratory motion, in a given frequency band, with the input signal of the system at zero.

NOTE — The background noise acceleration, a_g, is defined with the servovalve control device input loaded with an impedance equivalent to the signal source impedance and the control device adjusted for optimum control performances.

5.5.11.2 operational noise, φ: The residual value of the vibratory motion, in a given frequency band, with a control signal present.

φ is the r.m.s. value of the "noise", or non-harmonically related acceleration components, caused usually by:

— line frequency pick-up into the servovalve control,

— start-stop friction in the servovalve and/or the actuator (jack),

— impacting of loose parts in the specimen being tested,

— turbulence flow effect at controlling edges of servovalves.

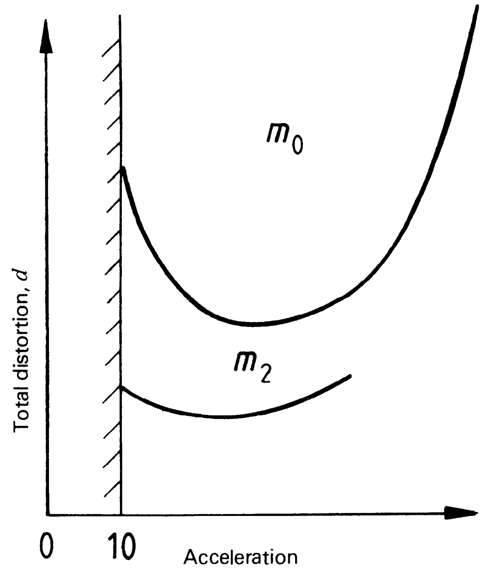


Figure 1 — Total distortion at a fixed frequency as a function of the acceleration

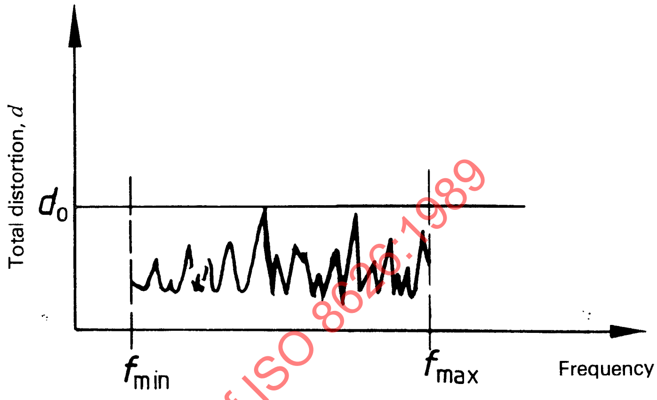


Figure 2 — Total distortion as a function of the frequency at maximum acceleration for a given test mass

5.5.11.3 signal-to-noise ratio: Value derived from technical causes, expressed in decibels, and given by the following formula:

$$20 \lg \frac{a}{a_g}$$

where

a is the maximum permissible acceleration under sinusoidal conditions at rated force F_{om_t} and test mass m_0;

a_g is the background noise acceleration (see 5.5.11.1).

5.5.12 dither: High frequency signal introduced into the signal in the servovalve control device to linearize the servovalve zero crossing region, and also to decrease the friction in order to improve the resolution of the valve and actuator.

5.5.13 transverse acceleration ratio: The ratio between the transverse acceleration and the axial acceleration; this may be related to test loads and frequency.

5.5.14 mean position deflection under load: Applying a load results in the first mean position being displaced, which is a function of the characteristics of the position control loop. The differential pressure on each side of the piston resulting from opening the servovalve statically balances the external forces. The opening of the servovalve therefore depends on the loads to be balanced, the leakage flow rate and the mean position error of the piston. It is controlled by the mean position control loop.

6 Characteristics to be supplied by the manufacturer for each level of description

Attention is drawn to the fact that the two levels of description adopted in this International Standard do not relate to the quality or size of the test equipment.

A level 1 description may be adequate for a large, high-quality test apparatus whereas, under certain circumstances, a level 2 description would be, for example, required for a small, medium-quality test apparatus.

The level of description required shall usually depend on the use to which the equipment is to be put.

This International Standard also gives the relevant characteristics for matching different components of the vibration generator system.

The characteristics indicated by an "X" in tables 2 to 5 shall be supplied when demanded by the particular level of description. The characteristics which are not required for a particular level of description, i.e. those which are not marked with an "X", may, however, be supplied if agreed between the manufacturer and the user.

NOTE — Attention is drawn to the need to specify these particular characteristics at the time of enquiry and when ordering because their cost, which can be high, has to be taken into consideration.

Tables 2, 3, 4 and 5 give a list of the characteristics to be described by the manufacturer as a function of the chosen level of description. Explanations of the listed characteristics are given in clauses 7, 8 and 9. Explanations of methods for measuring certain of these characteristics are given in annex B.

Table 2 — Vibration generator

Characteristic	Reference to corresponding clause	Level of description 1	Level of description 2
General characteristics			
Hydraulic supply conditions	7.1.1	X	X
Characteristics of the servovalve	7.1.2	X	X
Static force	7.1.3	X	X
Rated velocity	7.1.4	X	X
Rated frequency ranges	7.1.5	X	X
Limitations of characteristics under sinusoidal conditions	7.1.6	X	X
Limitation of characteristics under random conditions	7.1.7		
Rated force under sinusoidal conditions, F_{om_t}	7.1.8	X	X
Rated random force, broad-band, F_{ob}	7.1.9		
Uniformity of the acceleration field of the test table	7.1.10		
Transverse motion of the test table	7.1.11		
Limitation of characteristics	7.1.12		X
Moving element			
Mass	7.2.1	X	X
Rated travel	7.2.2	X	X
Travel between electrical safety devices	7.2.3		X
Travel between stops	7.2.4	X	X
Normal hydraulic mode frequency	7.2.5		X
Hydraulic stiffness	7.2.6		X
Gravity compensation device	7.2.7	X	X
Maximum transverse load	7.2.8.1		X
Rated static transverse load	7.2.8.2		X
Transverse static stiffness	7.2.9		X
Static friction of moving element	7.2.10		
Dimensions of the test table	7.2.11	X	X
Means of attaching the loads or the materials under test	7.2.12	X	X
Recommended torque on the threaded inserts or fixing elements in the table	7.2.13	X	X
Maximum permissible axial force on the threaded inserts or other fixing element	7.2.14		X
Flatness of the test table	7.2.15		X
Perpendicularity of the threaded inserts with respect to the plane of the test table	7.2.16		X
Perpendicularity of the plane of the test table with respect to the axis of the rod	7.2.17		X
Concentricity of axes (exciter power take-off)	7.2.18	X	X
Coupling tolerances of an auxiliary table	7.2.19	X	X
Auxiliary equipment			
Generator shaft position transducer	7.3.1.1	X	X
Pressure, force, velocity or acceleration transducer	7.3.1.2		X
Cooling system	7.3.2	X	X
Safety systems, alarm and cut-out devices	7.3.3	X	X
End of travel	7.3.3.1	X	X
Actuator force	7.3.3.2	X	X
Bearing temperatures	7.3.3.3	X	X
Oil flow rate	7.3.3.4	X	X
Clogging of the filter	7.3.3.5	X	X
Hoses and cables	7.3.4	X	X
Installation conditions			
General	7.4.1	X	X
Masses of the vibration generator	7.4.2	X	X
Vibration generator pedestal			
Orientation device	7.4.3 a)	X	X
Dynamic characteristics	7.4.3 b)		X
Fixing conditions	7.4.3 c)	X	X
Generated sound power level	7.4.4		
Heat dissipation	7.4.5		
Test table temperature	7.4.6		
Environmental and operating conditions			
Site	7.5.1	X	X
Combined tests	7.5.2		
Documents	7.6	X	X

Table 3 — Control system

Characteristic	Reference to corresponding clause	Level of description 1	Level of description 2
Servovalve control device			
Unmodulated input characteristics	8.1.1	X	X
Modulated input characteristics	8.1.2	X	X
A.C. source output characteristics	8.1.3	X	X
D.C. source output characteristics	8.1.4	X	X
Dither characteristics	8.1.5		X
Characteristics of output to servovalve	8.1.6	X	X
Characteristics of primary input (from signal sources)	8.1.7	X	X
Maximum input voltage	8.1.8	X	X
Transfer functions	8.1.9		
Total distortion, d	8.1.10		
Signal-to-noise ratio	8.1.11		
Stability of the output quantity for a zero input	8.1.12		X
Gain stability	8.1.13		
Limitation of characteristics	8.1.14		X
Control and protection panel	8.2	X	X
Auxiliary equipment	8.3	X	X
Installation conditions	8.4	X	X
Environmental and operating conditions	8.5		X
Documents	8.6	X	X

Table 4 — Hydraulic power system

Characteristic	Reference to corresponding clause	Level of description 1	Level of description 2
General characteristics			
Drive motor characteristics	9.1.1	X	X
Flow rate/pressure characteristics of the power system	9.1.2.1 9.1.2.2	X	X
Hydraulic fluid	9.2.1	X	X
Reservoir	9.2.2	X	X
Hydraulic pump	9.2.3	X	X
Pressure regulator	9.2.4		X
Filter system	9.2.5	X	X
Heat exchanger	9.2.6	X	X
Accumulators	9.2.7	X	X
Auxiliary equipment			
Accessories	9.3.1	X	X
Indicating equipment	9.3.2	X	X
Safety systems, alarms and cut-out devices	9.3.3	X	X
Installation conditions			
General	9.4.1	X	X
Masses of the main part of the hydraulic fluid power system	9.4.2	X	X
Power consumption	9.4.3	X	X
Connections	9.4.4	X	X
Start-up and maintenance	9.4.5	X	X
Generated sound power level	9.4.6		
Heat dissipation	9.4.7		
Cooling medium requirements	5.4.8	X	X
Environmental and operating conditions	9.5	X	X
Documents	9.6	X	X

Table 5 — Complete hydraulic vibration generator system

Characteristic	Reference to corresponding clause	Level of description	
		1	2
General characteristics			
Static force	10.1.1	X	X
Rated velocity	10.1.2	X	X
Rated frequency ranges	10.1.3	X	X
Limitations of characteristics under sinusoidal conditions	10.1.4	X	X
Limitations of characteristics under random conditions	10.1.5	X	X
Rated force under sinusoidal conditions, F_{om_t}	10.1.6		X
Rated random force, broad-band, F_{ob}	10.1.7		
Uniformity of the acceleration field of the test table	10.1.8		
Transverse motion of the test table	10.1.9		
Limitation of characteristics	10.1.10		
Total distortion, d			
No-load test	10.1.11.1		
Test under load	10.1.11.2		X
Background noise	10.1.12		X
Operational noise	10.1.13		X
Signal-to-noise ratio	10.1.14		
Dither	10.1.15		X
Input characteristics of the complete hydraulic vibration generator system	10.1.16	X	X
Output force stability	10.1.17		X
Transient motion of the moving element	10.1.18		
Servosystem stability	10.1.19		
Mean position deflection under load	10.1.20	X	X
Gravity compensation device	10.1.21		X
Moving element			
Mass	7.2.1	X	X
Rated travel	7.2.2	X	X
Travel between electrical safety devices	7.2.3		X
Travel between stops	7.2.4	X	X
Normal hydraulic mode frequency	7.2.5		X
Hydraulic stiffness	7.2.6		X
Gravity compensation device	7.2.7	X	X
Maximum transverse load	7.2.8.1	X	X
Rated static transverse load	7.2.8.2	X	X
Transverse static stiffness	7.2.9		X
Static friction of moving element	7.2.10		
Dimension of the test table	7.2.11	X	X
Means of attaching the loads or the materials under test	7.2.12		
Recommended torque on the threaded inserts or fixing elements in the table	7.2.13	X	X
Maximum permissible axial force on the threaded inserts or other fixing element	7.2.14	X	X
Flatness of the test table	7.2.15		X
Perpendicularity of the threaded inserts with respect to the plane of the test table	7.2.16		X
Perpendicularity of the plane of the test table with respect to the axis of the rod	7.2.17		X
Concentricity of axes (exciter power take-off)	7.2.18	X	X
Coupling tolerances of an auxiliary table	7.2.19	X	X
Auxiliary equipment			
Vibration generator transducers	10.3.1	X	X
Safety systems, alarm, cut-off and limitation devices	10.3.2	X	X
Failure of the electrical supply	10.3.2.1		
Failure of the hydraulic supply	10.3.2.2		
Electrical level of the input signal	10.3.2.3		
Manual emergency cut-off	10.3.2.4	X	X
Automatic cut-off by external signal	10.3.2.5		

Table 5 — Complete hydraulic vibration generator system (*concluded*)

Characteristic	Reference to corresponding clause	Level of description 1	Level of description 2
Installation conditions			
General layout	10.4.1	X	X
Masses of the main parts of the complete vibration generator system	10.4.2	X	X
Foundations for the complete vibration generator system			
Orientation device	7.4.3 a)	X	X
Dynamic characteristics	7.4.3 b)		X
Fixing conditions	7.4.3 c)	X	X
Power consumed	10.4.4	X	X
Cooling medium	10.4.5	X	X
External and internal connections	10.4.6	X	X
Start-up conditions	10.4.7	X	X
Generated sound power level	10.4.8		
Heat dissipation	10.4.9		
Test table temperature	10.4.10		
Environmental and operating conditions			
Installation site	10.5.1.1	X	X
Combined tests	10.5.1.2		
Servovalve control device	10.5.2		X
Hydraulic power supply	10.5.3	X	X
Documents	10.6	X	X

7 Hydraulic vibration generators

The hydraulic vibration generator comprises an actuator, a servovalve and, possibly, a static force compensation device. Schematic diagrams of a table and power take-off hydraulic vibration generator are given in figure 7 in annex A.

The manufacturer shall describe the configuration of the hydraulic vibration generator used to achieve the performance specified in 7.1.1 to 7.1.10. The description shall include the following information:

a) the type of generator, with table or power take-off;

b) the type of bearing for guiding the actuator rod;

c) the nature of the liaisons between the actuator body and the base plate;

d) the presence, or not, of a static force compensation;

e) the presence of an adjustable bypass;

f) the integrated and/or associated transducers;

g) the number of servovalve stages;

h) the number and type of elements constituting each of the stages;

i) the presence of accumulators, high pressure (HP) or low pressure (LP).

Furthermore, the manufacturer shall describe, in particular, the operation process of the servovalve.

7.1 General characteristics

The characteristics mentioned in this clause shall be measured with a large power supply which has a sufficient flow rate in order not to introduce any limit in the performance of the vibration generator, the delivered pressure being the rated supply pressure of the generator. Furthermore, there shall be low ripple (pressure noise at input and output of the vibration generation less than 1 % of the rated pressure) in order not to introduce any disturbance in the operation of the vibration generator.

7.1.1 Hydraulic supply conditions

The manufacturer shall specify the following hydraulic supply requirements for the servovalve input in order to obtain the characteristics described in 7.1:

a) the pressures and hydraulic flow rates for the various generator inputs and outputs (the different stages of the servovalve, bearings, etc.) and the corresponding ripple;

b) the hydraulic fluid temperature range;

c) the type and characteristics of the hydraulic fluid (in particular, its purity, water content and its viscosity) which can be used in the vibration generator without deterioration of performance. Its degree of cleanliness shall be specified in accordance with ISO 4406.

7.1.2 Characteristics of the servovalve

The manufacturer shall describe the type of servovalve supplied and any attached feedback transducers, with their characteristics in sufficient detail for the user to specify the requirements of the servovalve control device needed to drive the servovalve.

The manufacturer shall specify the following electrical characteristics of the servovalve in order to obtain the characteristics described in 7.1:

a) the input impedance, including the equivalent series resistance and inductance;

b) the maximum current, I_{so}, required to provide the rated performance of the vibration generator, and the voltage, U_{so}, required to obtain the current I_{so}; the manufacturer shall show the characteristic voltage and current as curves as a function of frequency, of which examples are shown in figure 3 for a single-stage valve spring return;

c) the breakdown voltage between any of the input terminals and metal body of the generator;

d) the characteristics and the transfer function of transducers used in the electrical feedback loops;

e) the manufacturer shall also state whether dither (see 5.5.12) is required to achieve the performance specified in 7.1.3 to 7.1.5, and, if it is required, how the dither requirement may be met.

7.1.3 Static force, F_{st}

The manufacturer shall specify the static force (see 5.5.7.1) within the rated conditions defined in 7.1.1 and 7.1.2.

7.1.4 Rated velocity

The manufacturer shall specify the rated velocity of the hydraulic vibration generator (see 5.5.4) within the rated supply conditions defined in 7.1.1 and 7.1.2 (see figure 4).

If the generator is fitted with an adjustable bypass, the rated velocity shall be defined for the regulation value of the bypass indicated by the manufacturer.

7.1.5 Rated frequency ranges

The manufacturer shall specify the frequency ranges corresponding to the rated force, F_{om_t}, (see 5.5.7) for the various test masses (see 5.4) chosen by the manufacturer.

7.1.6 Limitations of characteristics under sinusoidal conditions

The manufacturer shall specify the limits of the displacement, velocity and acceleration of the vibration generator for the different test masses (see 5.4), as a curve. Figure 4 gives an example of this curve.

NOTE — The use of the vibration generator may be limited at the lower frequencies by the following criteria:

a) harmonic distortion;

b) signal-to-noise ratio;

c) maximum piston travel (part of the curve placed on the left side of point 1).

The use of the vibration generator may be limited at the upper frequencies by the following criteria:

a) the servovalve characteristics;

b) the resonance frequency of the system;

c) the velocity limitations (part of the curve placed between points 1 and 2);

d) the acceleration limitations (part of the curve placed between points 2 and 3 established, when relevant, with account being taken of the leak flow in the bypass);

e) the servovalve limitations (part of the curve placed to the right side of point 3 or 4);

f) the hydraulic resonance frequencies of the complete system (part of the curve placed to the right side of point 4 or 3);

g) the transverse motion of the moving element.

7.1.7 Limitation of characteristics under random conditions

The manufacturer shall specify the limits of PSD acceleration which may be applied to different test masses, m_t, defined in 5.4, as a curve. Figure 5 gives an example of this curve.

7.1.8 Rated force under sinusoidal conditions, F_{om_t}

The manufacturer shall specify the amplitude of the rated force with the chosen test masses (5.4) for the frequency ranges given in clause 7.1.5, with the force of gravity being compensated

— either by an external system in the vibration generator,

— or by an internal system independant of the dynamic force generation.

If continuous operation is not possible in certain conditions, for example for certain test masses or certain frequency bands, these limits shall be clearly specified.

If rated force applies only to the vibration generator and not to the complete system, it shall be clearly specified.

7.1.9 Rated random force, broad-band, F_{ob}

The manufacturer shall specify, for all frequency ranges defined by frequencies f_3 and f_4 (see 5.5.8, 5.5.9 and figure 5), the rated random force (see 5.5.7.2.2) that the hydraulic vibration generator can produce in continuous operation.

7.1.10 Uniformity of the acceleration field of the test table

The manufacturer shall state the uniformity of the acceleration field of the unloaded test table as a function of the frequency giving the acceleration tolerance limits at the fixed points.

In the case of slotted test tables, at least the following two measuring points shall be selected on the radius:

— the best possible (as close to the centre as possible);

— the worst possible.

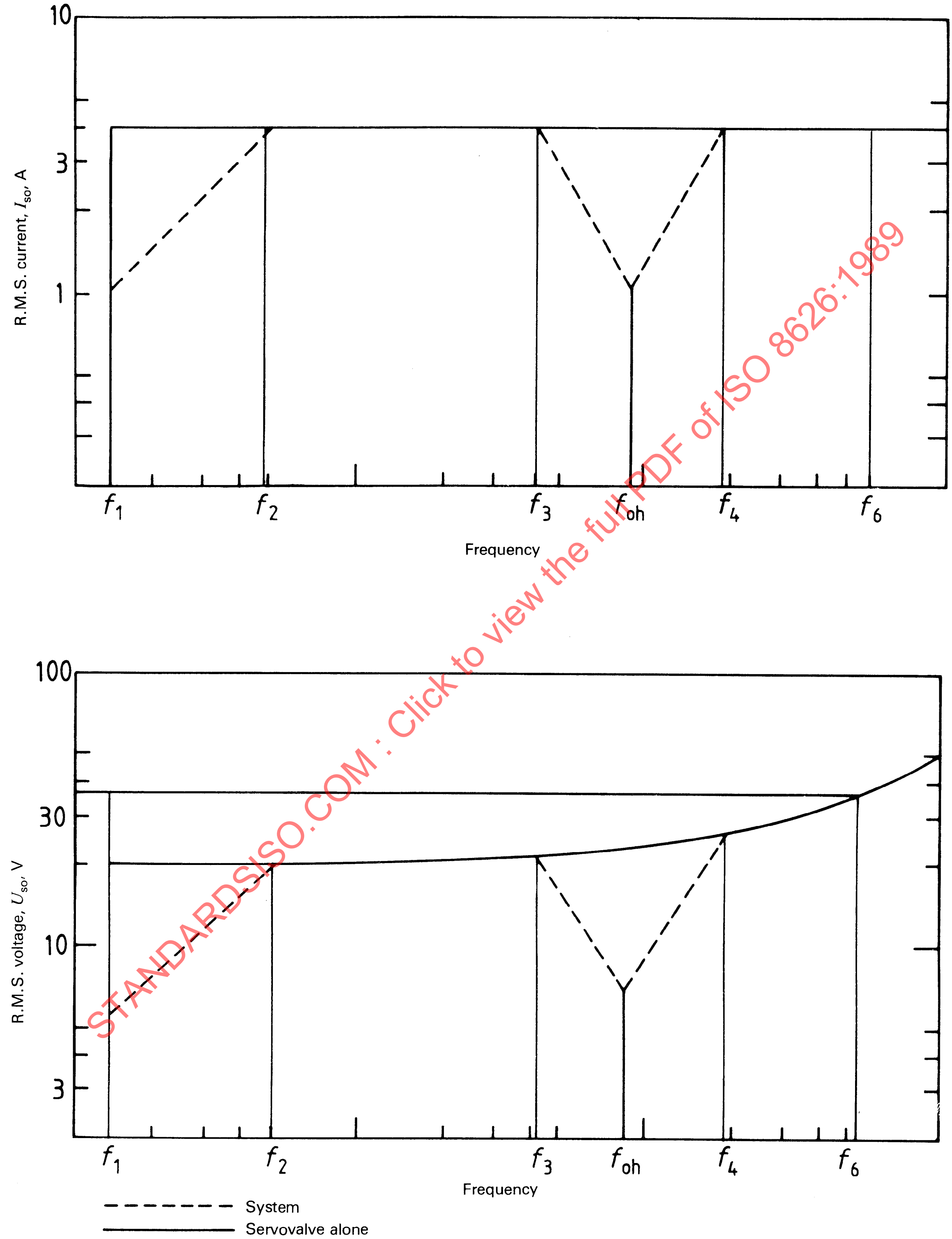


Figure 3 — Example of system and single hydraulic stage servovalve drive requirements

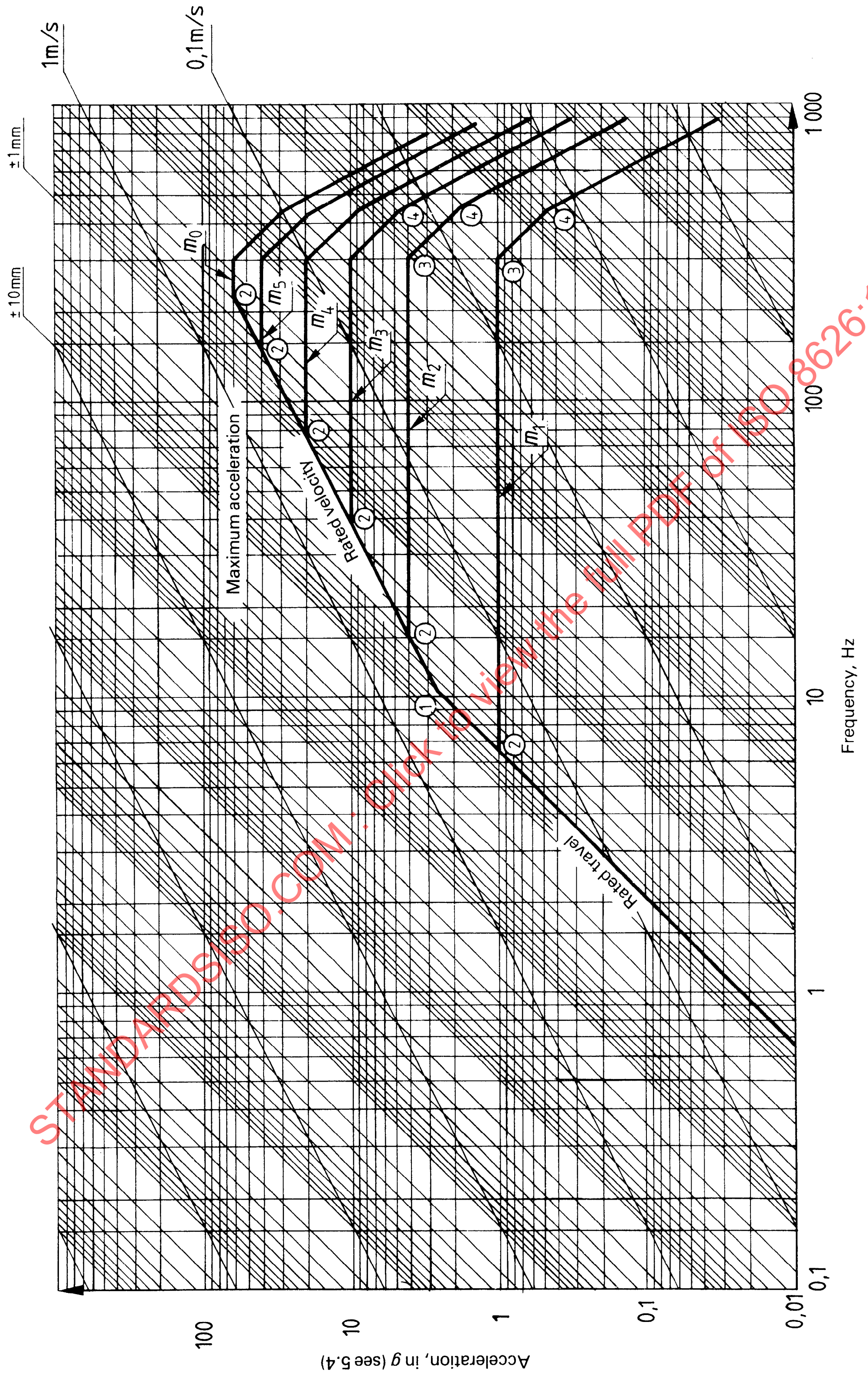


Figure 4 — Example of rated sinusoidal characteristics

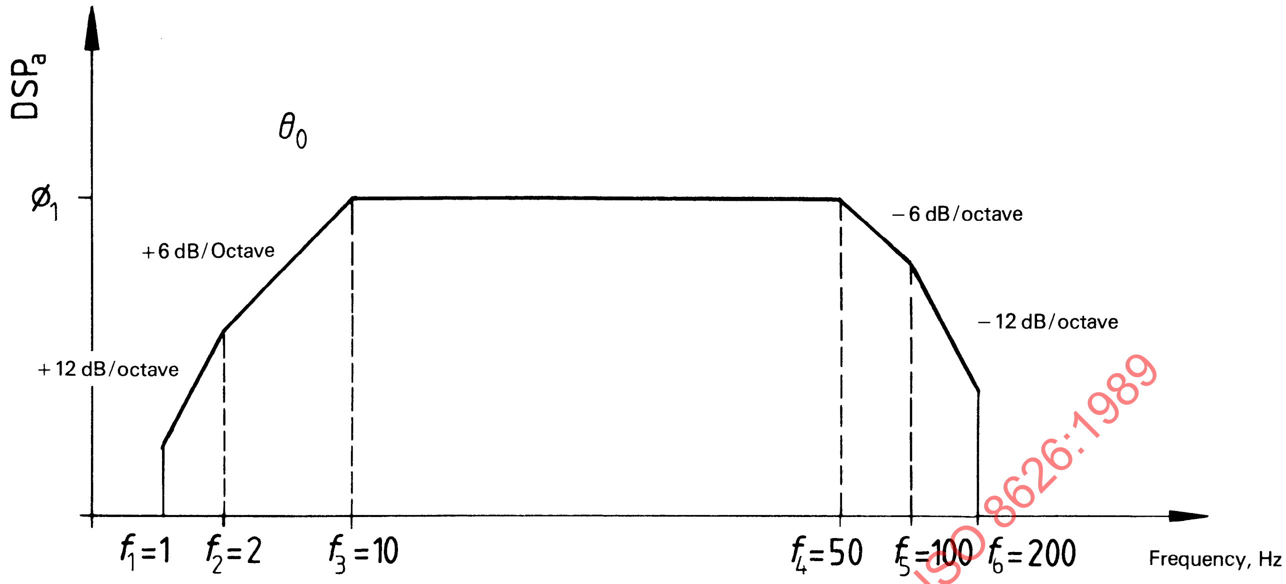


Figure 5 — Example of a power spectral density acceleration (PSD$_a$) profile

7.1.11 Transverse motion of the test table

The manufacturer shall specify the transverse motion of the test table or the power take-off as a function of the frequency by means of two curves representing the ratio between the transverse motions and the linear motion at the central fixing point. Each of the curves shall correspond to one of the two orthogonal directions perpendicular to the axis of the moving element.

If the central point is not accessible, the position of the reference point shall be indicated.

The measurements shall be made at no load and, if possible, at rated force; the manufacturer shall indicate the method employed and the value of the force.

Supplementary measurements of the transverse motion, such as measurements with test loads or measurements away from the central point, shall be carried out if agreed between the manufacturer and the user.

7.1.12 Limitation of characteristics

The manufacturer shall specify all factors limiting the characteristics of the hydraulic vibration generator provided they are not already made clear elsewhere.

7.2 Moving element

The moving element of a hydraulic vibration generator comprises

- a piston (1 in figure 7);
- a piston rod (4 in figure 7);
- a moving table (11 in figure 7);
- a test table (12 in figure 7) or power take-off (14 in figure 7).

7.2.1 Mass

The manufacturer shall specify the mass of the moving element (see 5.1.1).

7.2.2 Rated travel

The manufacturer shall specify the rated travel of the moving element (see 5.5.3.1).

7.2.3 Travel between electrical safety devices

The manufacturer shall specify the travel between the electrical safety devices, if fitted, or their control ranges.

7.2.4 Travel between stops

7.2.4.1 Simple mechanical stops

The manufacturer shall specify the travel between mechanical stops (see 5.5.3.2).

7.2.4.2 Mechanical stops with dampers

The manufacturer shall specify either the velocity decay, as a function of the displacement for different initial velocities and loads, or the modification of kinetic energy. The manufacturer shall specify if the damping is internal to the generator.

7.2.5 Normal hydraulic mode frequency

The manufacturer shall specify the normal hydraulic mode frequency with a specified test mass and the method by which it is derived (see 5.5.6.1). An example of the method for measuring the normal hydraulic mode frequency is given in clause B.1.

7.2.6 Hydraulic stiffness

The manufacturer shall specify the hydraulic stiffness and the method by which it is derived. An example of the method for measuring the hydraulic stifness is given in clause B.2.

7.2.7 Gravity compensation device

If the hydraulic generator contains an integrated gravity compensation device, the manufacturer shall specify the maximum load which can be compensated and the conditions for regulating the device over the frequency range given in 7.1.5 and the various conditions, such as adjustment of bypass and gravity compensation device.

7.2.8 Permissible loads on the guiding and positioning devices

7.2.8.1 Maximum transverse load

In order to avoid damage to the equipment the manufacturer shall specify the maximum permissible instantaneous transverse load, and state whether it is static, dynamic or a combination of the two.

The maximum transverse load perpendicular to the vibration axis, imparted at the level of the test table, shall be applied to at least three positions of the shaft (e.g. zero stroke, half stroke and full stroke).

7.2.8.2 Rated static transverse load

The manufacturer shall specify the static transverse load that the vibration generator can withstand permanently without any of its other characteristics being affected.

Its point of application is defined in 7.2.8.1.

7.2.9 Transverse static stiffness

The manufacturer shall specify the transverse static stiffness with respect to the actuator body, this stiffness being considered at the level of the test table.

Transverse static stiffness is made up of two elements: the transverse stiffness of the moving element guide mechanism and the bending stiffness of the actuator rod.

NOTE — In the case of long-travel linear vibration generators, the stiffness value should be given as a function of the position of the actuator rod.

7.2.10 Static friction of moving element

The manufacturer shall specify the forces necessary to overcome the friction forces when the moving element is started.

7.2.11 Dimensions of the test table

The manufacturer shall specify the test table dimensions and supply a dimensioned drawing indicating the fixing point tolerances and the constituent materials.

7.2.12 Means of attaching the loads or the materials under test

The manufacturer shall specify the means of attaching the loads to the moving element (test table or power take-off) and the maximum tightening torque of the screws.

In the case of test tables, the manufacturer shall state whether or not replaceable threaded inserts have been used and, if so, their position relative to the plane of the moving table.

7.2.13 Recommended torque on the threaded inserts or fixing elements in the table

The manufacturer shall specify the torque to be applied to the threaded inserts or fixing elements.

7.2.14 Maximum permissible axial force on the threaded inserts or other fixing element

The manufacturer shall specify the value of the maximum permissible axial force per threaded insert or fixing element.

7.2.15 Flatness of the test table

The manufacturer shall specify the overall and local tolerances with regard to the flatness of the test table under ambient conditions and stabilized thermal conditions (in accordance with 7.4.6).

If the inserts are below the plane of the table, the flatness of the whole surface of the table shall be specified.

If the test table has replaceable projecting inserts, the manufacturer shall specify both the flatness of the insert mounting surface and the thickness tolerance of the insert mounting heads.

7.2.16 Perpendicularity of the threaded inserts with respect to the plane of the test table

The manufacturer shall specify the perpendicularity tolerance of the threaded inserts with respect to the plane of the test table.

7.2.17 Perpendicularity of the plane of the test table with respect to the axis of the rod

The manufacturer shall specify the perpendicularity of the plane of the test table with respect to the axis of the rod.

7.2.18 Concentricity of axes (exciter power take-off)

The manufacturer shall specify the concentricity tolerances of axes of the exciter power take-off and the rod.

7.2.19 Coupling tolerances of an auxiliary table

The manufacturer shall specify the coupling tolerances between the auxiliary and the vibration generator.

7.3 Auxiliary equipment

7.3.1 Vibration generator transducers

7.3.1.1 Generator shaft position transducer

A vibration generator has at least one transducer used as a mean position feedback control unless position control is obtained mechanically. The manufacturer shall specify, for the shaft position transducer, the following:

a) the nominal input voltage;

b) the frequency of the input signal;

c) the nominal input current;

d) the sensitivity, i.e. the ratio of the maximum output signal (e.g. in millivolts) related to the input signal (e.g. in volts) to the position transducers at the rated travel of the moving element;

e) the minimum load impedance;

f) the relative phase between the output signal and the input signal, if necessary.

g) the breakdown voltage.

In the case of a transducer with incorporated electronics, the manufacturer shall also specify the transfer function between the transducer output and the displacement of the generator shaft.

7.3.1.2 Pressure force, velocity or acceleration transducer

If the vibration generator has one or more of these transducers, the manufacturer shall specify, for each, the following:

a) the nominal input voltage, if applicable;

b) the frequency of the input signal;

c) the input impedance, if applicable;

d) the minimum loading impedance;

e) the transfer function between the electrical output (voltage or current) and the mechanical input (pressure, force, velocity or acceleration);

f) the nominal input signal;

g) the sensitivity [as in 7.3.1.1 d)].

7.3.2 Cooling system

If there are cooling systems for the generator which are independent of the hydraulic power supply, the manufacturer shall specify their characteristics (see 9.2.6).

7.3.3 Safety systems, alarm and cut-out devices

Two systems may be distinguished according to how they function:

a) the alarm which attracts attention by means of a visual or audio signal as soon as an abnormal event occurs and which leaves the operator to take the necessary action, if any is required;

b) the cut-out system which brings the installation to a standstill.

The manufacturer shall specify the safety system used and, in each case, shall state whether an alarm or cut-out device is being used (in certain cases, the same detection system can activate an alarm for one threshold and a cut-out device for another).

The manufacturer shall also specify the procedure and characteristics of the shut-down. In general, this procedure should be such that a sudden shut-down which may damage the test specimen is avoided.

7.3.3.1 End of travel

This fixed or adjustable safety device may be independent of the generator shaft position measuring system (by means of end-of-travel contact), but it may also make use of it (as in threshold detection).

7.3.3.2 Actuator force

In order to prevent the actuator working at a greater force than its rated value, a safety device may be fitted which is activated, for example, when the threshold of the pressure difference acting on the piston has been exceeded.

In certain cases, this safety device can be adjusted to suit the application of the hydraulic vibration generator.

7.3.3.3 Bearing temperatures

The manufacturer shall describe a system, if supplied, to measure the bearing temperatures and activate an alarm or safety device when a set temperature threshold has been reached.

7.3.3.4 Oil flow rate

The manufacturer shall describe the flow limiter, if fitted to the generator or, if required, in the hydraulic power supply.

7.3.3.5 Clogging of the filter

In cases where the hydraulic vibration generator is fitted with filters, the manufacturer shall specify a system for detecting a clogged filter.

7.3.4 Hoses and cables

The manufacturer shall describe the interconnecting hoses and cables supplied with the hydraulic vibration generator.

7.4 Installation conditions

7.4.1 General

The manufacturer shall provide dimensioned and toleranced diagrams of the generator and the auxiliary devices (fluid and power supply systems, cabling, etc.) and shall specify if any special tools need to be used for installation.

7.4.2 Masses of the vibration generator

The manufacturer shall specify the following masses:

a) the total mass of the vibration generator;

b) the mass of the pedestal, if fitted;

c) the heaviest mass to be handled when dismantling a vibration generator;

d) the mass of the auxiliary devices, if fitted.

7.4.3 Vibration generator pedestal

If the system includes a pedestal, the manufacturer shall give the following information:

a) for the vibration generator orientation device: the positioning stops, the locking device and principle of operation;

b) the dynamic characteristics of the vibration generator pedestal for the two positions (vertical and horizontal);

c) the conditions for fixing the vibration generator pedestal on its foundations, with drawing if necessary.

NOTE — Attention is drawn to the importance of the dynamic characteristics of the foundations with respect to the efficiency of the installation, account being taken of the frequency range of the hydraulic generators, and, in particular, with respect to the quality of the mechanical connection between the foundation and the generator.

7.4.4 Generated sound power level

The manufacturer shall specify the maximum sound power level of the vibration generator and auxiliary equipment, if fitted, during operation under conditions of maximum no-load (load m_0) sinusoidal acceleration in the rated frequency range.

The manufacturer shall use the measuring method specified in ISO 3746. If it cannot be used, the manufacturer shall clearly explain the method used.

7.4.5 Heat dissipation

If requested by the user, the manufacturer shall specify the heat dissipation of the vibration generator, together with the thermal stabilization time, under rated conditions.

If auxiliary devices are used, the heat dissipation of these devices shall be specified separately.

7.4.6 Test table temperature

If requested by the user, the manufacturer shall specify the test table temperature for the stabilized conditions corresponding to the maximum temperature of the moving element.

7.5 Environmental and operating conditions

7.5.1 Site

The manufacturer shall specify the following permissible conditions under which the hydraulic generator may be used at rated site conditions without being damaged:

a) temperature and relative humidity ranges;

b) cleanliness of the area.

7.5.2 Combined tests

When the vibration generator is used in combined tests (vibration tests carried out jointly with a climatic or mechanical test), the manufacturer, if requested by the user, shall provide the following necessary information:

For the climatic conditions

a) temperature and relative humidity ranges;

b) permissible absolute pressure range, stating, where necessary, operation either, with a heat barrier or in a climatic chamber.

For centrifugal acceleration

a) maximum permissible continuous acceleration of the vibration generator for all three dimensions;

b) specification of the acceleration compensation system, if fitted.

7.6 Documents

The manufacturer shall list the documentation provided with the hydraulic vibration generator. Documentation might include the following items:

a) schematic diagram and description of the hydraulic generator with its auxiliary equipment);

b) characteristics;

c) operating mode and control;

d) layout conditions and diagram;

e) details on conditions for fixing the pedestal (see 7.4.3);

f) connecting and cabling diagram;

g) overall diagram and nomenclature of the spare parts;

h) assembly and dismantling instructions;

i) list of special tools, if necessary;

j) start-up and maintenance;

k) preferred list of spare parts recommended by the manufacturer;

l) environmental and operating conditions;

m) any other information.

8 Control system

In the context of this International Standard, the control system comprises

a) the hydraulic vibrator servovalve control device;

b) the control and protection panel;

c) auxiliary equipment;

d) all devices used to turn on and off, protect, and provide failure or other alarms for the complete hydraulic vibration generator system.

The components of the control system are normally mounted in a control console with signal sources, such as oscillators and displacement, velocity and acceleration display devices which are not covered by this International Standard.

Occasionally, some of the components of the control system may be mounted on the hydraulic fluid power supply or the hydraulic vibration generator. Some manufacturers provide the on-off control and protection functions on a panel separate from the servovalve control and other manufacturers integrate the on-off control and protection functions with the servovalve control functions into a single, panel-mounted chassis.

The user should refer to the whole of this clause, even though he may be specifying only one the devices included. Attention shall be given to the alarm transfer and interlock, if the hydraulic vibration generator system is supplied by different sources (manufacturers).

8.1 Servovalve control device

The manufacturer shall describe the operation of the servovalve control device, preferably in the form of a block diagram with a description of the operation of each of the blocks (see figure 10 in annex D).

The manufacturer shall specify the characteristics of the control device listed in 8.1.1 to 8.1.13.

8.1.1 Unmodulated input characteristics

Where applicable, the manufacturer shall specify the following characteristics for each unmodulated input:

a) minimum and maximum ranges of the input voltage;

b) range of the input sensitivity adjustment control;

c) gain stability, as a function of temperature and mains voltage;

d) range of zero shift adjustment;

e) zero stability, as a function of temperature and mains voltage;

f) frequency range, maximum and minimum, to d.c. if usable;

g) internal filter response;

h) input impedance;

i) common mode rejection;

j) input protection circuit level and adjustment possibilities.

8.1.2 Modulated input characteristics

Where applicable, the manufacturer shall specify the following characteristics for each modulated input:

a) maximum and minimum ranges of the input voltage in full scale (mV/V) for full output;

b) range of the input sensitivity adjustment control;

c) gain stability, as a function of temperature and mains voltage;

d) range of zero shift adjustment;

e) zero stability, as a function of temperature and mains voltage;

f) range of quadrature voltage compensation;

g) frequency range of the system, including the demodulator filter;

h) filter corner frequency adjusting range;

i) input impedance;

j) common mode rejection;

k) input protection circuit level and adjustment possibilities.

8.1.3 A.C. source output characteristics

For each a.c. source output to transducers, the manufacturer shall specify the following characteristics:

a) frequency;

b) range of frequency adjustment;

c) frequency stability;

d) voltage;

e) range of voltage adjustment;

f) voltage stability;

g) maximum continuous current;

h) output configuration, usually referenced to earth, balanced to earth, or a floating transformer secondary, with or without centretap;

i) any provisions for short-circuit protection.

8.1.4 D.C. source output characteristics

For each d.c. source output to transducers, the manufacturer shall specify the following characteristics:

a) voltage;

b) range of voltage adjustment;

c) voltage stability;

d) residual noise voltage;

e) maximum current;

f) output configuration, usually unidirectional (plus or minus only) or balanced to earth (equal plus and minus);

g) any provisions for short-circuit protection.

8.1.5 Dither characteristics (see 5.5.12)

If a dither oscillator is supplied in the servovalve control device to superimpose a dither signal on the servo-valve drive to reduce "stick friction" or "silting", the manufacturer shall specify the following characteristics:

a) dither frequency;

b) range of dither frequency adjustment;

c) dither amplitude;

d) range of dither amplitude adjustment;

e) circuitry to reduce automatically the dither as frequency increases, and if so, the frequency above which dither is absent.

8.1.6 Characteristics of output to servovalve

The manufacturer shall specify the following characteristics:

a) output current, both d.c. and a.c.;

b) output voltage, both d.c. and a.c.;

c) output impedance;

d) frequency range;

e) any provisions for short-circuit protection.

8.1.7 Characteristics of primary inputs (from signal sources)

The manufacturer shall specify the required control device input voltage range in order to obtain the current or voltage of the servovalve control device stated in 8.1.6, the feedback loops being on zero.

8.1.8 Maximum input voltage

The manufacturer shall specify the maximum voltage which may be applied to each input without deterioration in performance.

8.1.9 Transfer functions

The transfer functions from the primary and auxiliary inputs to the output shall be determined for the linear operation of the device.

If the gain is adjustable, the range shall be specified.

8.1.10 Total distortion, d

If requested by the user, the manufacturer shall specify the total distortion, d, for the rated output quantity, with the output loaded with a resistance which enables the rated quantities stated in 8.1.7 to be obtained.

8.1.11 Signal-to-noise ratio

If requested by the user, the manufacturer shall specify the signal-to-noise ratio, measured at the output of the control device, loaded with the rated impedance with the inputs themselves being loaded with their maximum source impedance.

8.1.12 Stability of the output quantity for a zero input

With the inputs loaded with the source maximum impedances and the output loaded with rated impedance, the manufacturer, if requested by the user, shall specify the deflection, expressed as a percentage, of the output quantity from the rated output value.

It shall be specified as a function of the temperature and the supply voltage of the control device, which shall be within the limits stipulated in the operating conditions (see 8.4).

8.1.4 Gain stability

For each input, the manufacturer, if requested by the user, shall specify the gain stability which shall be determined by the percentage variation of the output quantity as a function of the ambient temperature and the supply voltage under the following conditions:

a) with the control device loaded with rated source and output impedances;

b) with the stabilization devices, if required, having a specified value;

c) with the sources supplying signals of set frequencies and constant amplitudes corresponding to a rated output quantity;

d) with the temperature and supply voltage varying within the limits stipulated in 8.4.

8.1.14 Limitation of characteristics

The manufacturer shall specify all the factors limiting the characteristics of the servovalve control device provided they are not already made clear elsewhere.

8.2 Control and protection panel

The manufacturer shall describe the control and protection device stating what controls are provided to start and stop the system, turn off/on the coolant and what protective circuits and protective interlocks are provided.

8.3 Auxiliary equipment

The manufacturer shall describe the functions and characteristics of the auxiliary equipment necessary for the operation of the servovalve control device when such equipment is fitted.

8.4 Installation conditions

The manufacturer shall specify the following requirements for installing the control device:

a) the required power supply (voltage, current, frequency, power consumption, any cooling requirements, etc.);

b) space required;

c) connection methods (types of connection, length and type of cable, etc.);

d) environment which meets the conditions specified in 8.5.

8.5 Environmental and operating conditions

The manufacturer shall specify the permissible conditions in which the control device(s) may be used, by supplying the following information:

a) temperature and relative humidity ranges;

b) permissible electromagnetic disturbances;

c) variations in the mains power supply for which the rated operating conditions of the control device(s) are guaranteed.

8.6 Documents

The manufacturer shall list the documentation provided with the servovalve control device. Documentation might include the following items:

a) schematic diagram and description of the control device(s);

b) operating mode and control;

c) layout conditions and diagram;

d) connecting and cabling diagram;

e) installation conditions;

f) nomenclature of the spare parts;

g) preferred list of spare parts recommended by the manufacturer;

h) environmental and operating conditions;

i) any other information.

9 Hydraulic power system

A schematic diagram of the hydraulic power system is given in figure 8 in annex A.

9.1 General characteristics

The manufacturer shall describe the components supplied and shall state their characteristics.

The hydraulic power system shall be in accordance with the specifications laid down in ISO 4413.

9.1.1 Drive motor characteristics

The manufacturer shall specify the following characteristics:

a) the type of drive motor (electric motor, internal combustion engine, etc.);

b) its rated characteristics (speed, voltage, current and frequency for an electric motor, etc.).

9.1.2 Flow rate/pressure characteristics of the power system

9.1.2.1 The manufacturer shall specify the flow rate, q_{V_n} (see 5.5.2), and the supply pressure, p_s (see 5.5.1), for the hydraulic power system.

9.1.2.2 If requested by the user, the manufacturer shall provide the curve of the maximum flow rate available as a function of the supply pressure for the rated power of the motor.

9.2 Characteristics of the equipment

9.2.1 Hydraulic fluid

The hydraulic fluid, generally mineral oil, shall be compatible with the different components of the installation, in particular the seals.

The type of fluid shall be specified by its reference or the following physical characteristics:

a) dynamic or kinematic viscosity;

b) operating temperature;

c) density;

d) bulk modulus;

e) pH-value (compatible with the materials in contact with the fluid);

f) flash point;

g) de-aeration capability.

The manufacturer shall specify the types of hydraulic fluids which may be used in the hydraulic power system and state the types of fluids which are recommended in particular.

9.2.2 Reservoir

The fluid reservoir is characterized by its volume which shall be adequate to allow the oil to recover its characteristics during its passage through the system with particular attention being paid to its de-aeration (demulsification) and its cooling.

The manufacturer shall specify the following parameters affecting the fluid:

a) the useful volume of the reservoir, the latter complying with the local regulations;

b) the ratio between the maximum volume flow rate and the volume of the reservoir;

c) the minimum level of oil and the time it takes to pass through the reservoir.

The manufacturer shall also state if the reservoir has:

— a ventilation orifice with or without a filter;

— a filling hole with plug and possibly filter;

— one or several drainage holes and hatches to allow periodic cleaning of the reservoir.

9.2.3 Hydraulic pump

The manufacturer shall specify the type of hydraulic pump used (vane pump, gear pump or piston pump, depending on the desired pressure level), and whether the flow rate is fixed or variable. The manufacturer shall state if the high-pressure pump is supplied by a low-pressure (boost) pump, and, if so, the type.

9.2.4 Pressure regulator

The manufacturer shall state whether the regulator is incorporated in the pump or is separate from the pump and fitted on its discharge pipe. The manufacturer shall also specify the mode of control (manual or automatic) and action (proportional or on-off).

The pressure regulator shall be specified by the following characteristics:

a) pressure control range;

b) pressure stability, as a function of time and of flow rate fluctuations;

c) response time to a step change in flow rate.

9.2.5 Filter system

The filter system can be at one or several of the following levels specified by the manufacturer:

a) filling filter;

b) suction filter at the pump inlet;

c) high-pressure filter, in the pump discharge circuit;

d) return filter, at the reservoir inlet;

e) bypass filter.

The manufacturer shall specify the type and location of each filter provided. The manufacturer shall also specify the following characteristics, some of which depend on the type of fluid and its temperature:

a) maximum permissible flow rate;

b) maximum permissible pressure;

c) pressure drop;

d) filter mesh size.

The purity of the fluid shall be stated by the manufacturer with reference to ISO 4406; the purity of the fluid shall be compatible with that specified in accordance with 7.1.1.

9.2.6 Heat exchanger

The hydraulic fluid temperature shall be stable under the most severe operating conditions and in continuous operation.

The manufacturer shall specify

a) the optimum temperature level, and the upper and lower hydraulic fluid temperature limits;

b) the type of heat exchanger used (natural or forced convection, air-coolant, heat exchanger using a secondary fluid) and its mode of operation (continuous or two points);

c) the ranges of pressure for the fluids, upstream and downstream of the exchanger;

d) the maximum and mean permissible flow rates for the cooling fluid, at rated oil flow, as a function of input temperature of the cooling fluid;

e) characteristics of cooling medium to be used;

f) for air cooled units, the maximum ambient temperature;

g) the maximum amount of power dissipated as heat, which shall be function of the power absorbed by the hydraulic pump.

9.2.7 Accumulators

The manufacturer shall specify, for each accumulator,

a) maximum operating pressure;

b) capacity;

c) inflation pressure;

d) whether any periodical checks have to be made;

e) type of gas.

The accumulators shall satisfy the inspection criteria laid down by the regulations in force.

9.2.8 Interconnections

The manufacturer shall define the interconnection system (high-pressure supply, return and drainage pipework) between the hydraulic power system and the actuator.

9.3 Auxiliary equipment

9.3.1 Accessories

The manufacturer shall specify the accessories required:

a) the sampling equipment necessary for checking the degree of contamination of the hydraulic fluid in the circuit;

b) any thermostatic valve on the heat echanger;

c) various pumps for charging the main pump, if necessary, for making up leakages, etc.;

d) a filter, with or without desiccator, for air which has leaked into the reservoir.

e) de-aerator.

9.3.2 Indicating equipment

The manufacturer shall state whether the following equipment is provided and where the corresponding information is available (on site or in a remote location):

a) the high- and low-pressure gauges capable of isolation;

b) the reservoir level gauges;

c) the thermometer indicating the temperature of the hydraulic fluid in the reservoir.

9.3.3 Safety systems, alarms and cut-out devices

The manufacturer shall specify the safety system used and, in each case, shall state whether an alarm or cut-out device is being used (see 7.3.3), for example, by giving details about

a) thermostat;

b) pressure switch (hydraulic fluid pressure and, possibly, secondary fluid pressure in the heat exchanger);

c) maximum and minimum level (for example, a device for detecting any secondary fluid in the hydraulic fluid circuit in the heat exchanger);

d) filter clogging indicator;

e) a distributor permitting the hydraulic power system to be isolated from the generator by allowing it to drain into the reservoir;

f) a distributor permitting the vibration generator(s) to be isolated if there is damage to the pipe or break-down of the complete system.

9.4 Installation conditions

9.4.1 General

The manufacturer shall provide layout diagrams of the hydraulic power system, in particular the layout diagram specifying the fixing elements (sockets, anti-vibration mounts, etc.) and the dimensions of the fixing points. The manufacturer shall specify the space required around the power system to allow maintenance and repair.

9.4.2 Mass of the main parts of the hydraulic power system

The manufacturer shall specify the following masses:

a) the mass of the main parts of the complete hydraulic power system;

b) the heaviest mass to be handled when dismantling any part of the hydraulic power system.

9.4.3 Power consumption

If an electric motor is used, the manufacturer shall specify the power consumption of the system under stabilized conditions as a function of flow rate and supply pressure, p_s (see 5.5.1). The manufacturer shall also specify the peak start-up current and its duration. Where appropriate, the manufacturer shall supply curves of power consumption as a function of hydraulic fluid pressure and flow.

If an internal combustion engine is used for driving the pump(s) of the hydraulic power system, the manufacturer shall specify the hourly consumption of fuel and the electric power consumed by the auxiliary devices necessary for operation of the system.

9.4.4 Connections

The manufacturer shall provide references and dimensions of the following connections:

a) hydraulic fluid filling port;

b) hydraulic fluid outlet port;

c) return ports to the reservoir;

d) auxiliary ports (for example, drains);

e) electrical connections;

f) secondary fluid circuit connections (coolant, etc.).

9.4.5 Start-up and maintenance

Attention is drawn to the importance of the start-up procedure of the installation as well as the procedure for flushing and cleaning the circuits when starting up.

The manufacturer shall state how often the hydraulic power system is to be emptied, and shall specify the procedure for checking for pollution of the hydraulic fluid (with the intervals between checking), the procedure for checking the degree of clogging of the filters and the conditions for replacing the cartridges.

9.4.6 Generated sound power level

The manufacturer shall specify the generated sound power level for the maximum flow rate and pressure of the hydraulic power system.

The manufacturer shall use the measuring method specified in ISO 3746. If it cannot be used, the manufacturer shall clearly explain the method used.

9.4.7 Heat dissipation

The manufacturer shall specify the maximum thermal power discharged into the room for the rated flow rate and supply pressure, p_s.

9.4.8 Cooling medium requirements

The manufacturer shall specify:

a) the maximum quantity of cooling medium per time unit (in litres per minute) as a function of input temperature;

b) the temperature range for the required cooling medium input;

c) the pressure range for the cooling medium input;

d) the chemical requirements for the cooling medium (e.g. pH-value, hardness).

9.5 Environmental and operating conditions

The manufacturer shall specify the free space necessary around the hydraulic power system to allow operation under rated conditions. The manufacturer shall also specify the following characteristics:

a) permissible temperature-relative humidity range;

b) required air flow rate (independently of any flow rate in the heat exchanger);

c) limit altitude, where relevant;

d) permissible range of variation in the characteristics in the electrical supply (frequency and voltage);

e) in the case of an internal combustion engine,

— the flow rate of the air supply to the engine,

— the permissible temperature-relative humidity range of this air,

— the filtration conditions.

9.6 Documents

The manufacturer shall list the documentation provided with the hydraulic power system. Documentation might include the following items:

a) schematic diagram and description of the hydraulic power system;

b) characteristics of the system and equipment (see 9.1 and 9.2);

c) operating mode, control, start-up and maintenance (see 9.4.5);

d) layout conditions and diagram (see 9.4.1);

e) connecting and cabling diagram;

f) overall diagram and nomenclature of the spare parts;

g) assembly and dismantling instructions;

h) preferred list of spare parts recommended by the manufacturer;

i) environmental and operating conditions;

j) any other information.

10 Hydraulic vibration generator system

The hydraulic vibration generator system comprises a hydraulic vibration generator, a servovalve control device and a hydraulic power system.

The characteristics specified in this clause apply to the hydraulic vibration generator system and should not be applied to individual components. For each of its elements, the manufacturer shall specify the characteristics laid down in the corresponding clauses (see clauses 7, 8 and 9).

Hydraulic vibration generator systems shall be tested using the test masses, m_t (see 5.4).

10.1 General characteristics

10.1.1 Static force, F_{st}

The requirement laid down in 7.1.3 for generators also applies to the complete vibration generator system.

10.1.2 Rated velocity

The requirement laid down in in 7.1.4 for generators also applies to the complete vibration generator system.

10.1.3 Rated frequency ranges

The requirement laid down in 7.1.5 for generators also applies to the complete vibration generator system.

10.1.4 Limitations of characteristics under sinusoidal conditions

The requirement laid down in 7.1.6 for generators also applies to the complete vibration generator system.

10.1.5 Limitations of characteristics under random conditions

The requirement laid down in 7.1.7 for generators also applies to the complete vibration generator system.

10.1.6 Rated force under sinusoidal conditions, F_{omt}

The requirements laid down in 7.1.8 for generators also apply to the complete vibration generator system.

10.1.7 Rated random force, broad-band, F_{ob}

The requirement laid down in 7.1.9 for generators also applies to the complete vibration generator system.

10.1.8 Uniformity of the acceleration filed of the test table

The requirements laid down in 7.1.10 for generators also apply to the complete vibration generator system.

10.1.9 Transverse motion of the test table

The requirements laid down in 7.1.11 for generators also apply to the complete vibration generator system.

10.1.10 Limitation of characteristics

The requirement laid down in 7.1.12 for generators also applies to the complete hydraulic vibration generator system.

10.1.11 Total distortion, d (see 5.5.10.1)

The manufacturer shall specify the distortion and state whether it is displacement, velocity or acceleration distortion.

The manufacturer shall also specify the frequency band-width of the signal being analysed, including any filters used.

The total distortion, d, shall be measured at the operating limits of the hydraulic vibration generator (rated displacement, rated velocity and rated acceleration).

10.1.11.1 No-load test

The manufacturer shall specify the acceleration distortion of the unloaded, vibration-generator test table or the unloaded, exciter power take-off for the rated force characteristics and in the useful frequency range.

The distortion shall be indicated by means of curves as a function of the frequency at the rated force and at a tenth of this for the normal hydraulic mode damping value stipulated by the manufacturer. The limits of this curve are defined by the rated frequency ranges (see 7.1.5 and 7.1.6).

10.1.11.2 Test under load

The manufacturer shall specify the acceleration distortion under the same conditions as laid down in 10.1.11.1, but with different test loads. The distortion should be recorded at maximum values of displacement, velocity and acceleration and, in particular, at the velocity/acceleration breaking point corresponding to the maximum amount of power produced.

The manufacturer may also specify the acceleration distortion at a half and at a quarter of the maximum acceleration.

10.1.12 Background noise (see 5.5.11.1)

The manufacturer shall specify the acceleration and displacement background noise values as r.m.s. and peak values on the test table or power take-off. The manufacturer shall also specify the frequency band in which this measurement is to be taken under no-load conditions with zero signal input, the input being loaded with an impedance equivalent to the maximum source impedance.

10.1.13 Operational noise (see 5.5.11.2)

If requested by the user, the manufacturer shall specify the operational acceleration and displacement noise (spectral analysis) in addition to the frequency band in which this measurement is to be taken for the two types of test, i.e. with no-load and under load, at the rated values of displacement, velocity and acceleration.

10.1.14 Signal-to-noise ratio (see 5.5.11.3)

The manufacturer shall specify the signal-to-noise ratio as defined in 5.5.11.3.

10.1.15 Dither

The manufacturer shall specify whether dither (5.5.12 and 8.1.5) is required to achieve the characteristics specified in 10.1.1 to 10.1.7 and, if it is required, how the dither requirement may be met.

10.1.16 Input characteristics of the complete hydraulic vibration generator system

The manufacturer shall specify the input characteristics of the complete hydraulic vibration generator system.

The required input voltage and the minimum input impedance for the frequency range between f_{min} and f_{max} shall be given in particular.

10.1.17 Output force stability

The manufacturer shall specify the change in output force (F_{st} or F_{om_t}) for a 10 % variation in the supply voltage applied to the complete hydraulic vibration generator system.

10.1.18 Transient motion of the moving element

The manufacturer shall specify the maximum values and characteristics of transient motion of the moving element under the following conditions:

a) normal start-up conditions;

b) normal shut-down conditions;

c) operation of safety systems, if fitted;

d) in the case of a sudden disconnection of the supply to all or part of the complete hydraulic vibration generator system.

The measurements shall be carried out, with the test mass and the feedback loop control being specified.

10.1.19 Servosystem stability

The manufacturer shall specify the method used to obtain the servosystem stability.

If an adjustable leakage is used to obtain this stability or to reduce the distortion, the manufacturer shall specify the maximum leak rate for the maximum force and how it affects the maximum velocity.

If an electric stabilization method is used, the manufacturer shall describe how the signals to be provided from the transducers to the various feedback inputs are used (such as the actuator rod displacement, the actuator rod and pilot spool velocity, the slave spool displacement, the piston differential pressure and the table acceleration).

10.1.20 Mean position deflection under load

The manufacturer shall specify the mean position deflection defined in 5.5.14 under the permissible static load, F_{st}, defined in 5.5.7.1.

10.1.21 Gravity compensation device

The requirement laid down in 7.2.7 for generators also applies to the complete vibration generator system.

10.2 Moving element

The requirements laid down in 7.2 for generators also apply to the complete hydraulic vibration generator system.

10.3 Auxiliary equipment

10.3.1 Transducers built into the complete hydraulic vibration generator system

The requirements laid down in 7.3.1 for generators also apply to the complete hydraulic vibration generator system.

10.3.2 Safety systems, alarm, cut-off and limitation devices

In addition to the individual alarm and cut-off devices of the hydraulic vibration generator (see 7.3.3), the servovalve control device (see 8.2) and the hydraulic power system (see 9.3.3) and all limitation devices, the manufacturer shall specify the devices used for the complete hydraulic vibration generator system. The manufacturer shall specify in each case whether an alarm, a cut-off or a limitation device is used (see 7.3.3).

10.3.2.1 Failure of the electrical supply

The manufacturer shall specify the sequence of events in the case of a failure of the electrical supply.

10.3.2.2 Failure of the hydraulic supply

The manufacturer shall specify the sequence of events in the case of a failure of the hydraulic supply to the vibration generator.

10.3.2.3 Electrical level of the input signal

The manufacturer shall specify the maximum input signal level which could not cause the jack to operate beyond its rated characteristics. In certain cases, there is also a safety device for loss of input signal; the manufacturer shall state its mode of operation.

10.3.2.4 Manual emergency cut-off

The mode of operation of this safety device which may be activated by the operator shall be specified by the manufacturer.

10.3.2.5 Automatic cut-off by external signal

The manufacturer shall specify whether the user has the possibility of cutting in one or several extra safety devices, for example, on detection of a specimen response threshold. In this case, the operating conditions and the mode of operation shall be provided in the documentation (see 10.6).

10.4 Installation conditions

10.4.1 General layout

The manufacturer shall provide dimensioned and toleranced installation drawings of the complete vibration generator system and of the auxiliary devices (fluid and power supply systems, cables, etc.). The manufacturer shall specify the individual items, and preparations the user has to make, including items which the user has to supply.

He shall specify the necessary free space around the different parts of the whole system.

10.4.2 Masses of the main parts of the complete vibration generator system (see 7.4.2 and 9.4.2)

The manufacturer shall specify the following masses:

a) the mass of the main parts of the complete vibration generator system;

b) the heaviest mass to be handled when dismantling any part of the complete vibration generator system.

10.4.3 Foundations for the complete vibration generator system

The requirements laid down in 7.4.3 for generators also apply to the complete hydraulic vibration generator system. If necessary, the manufacturer shall specify the foundation requirements for the complete system.

10.4.4. Power consumed

When the complete hydraulic generator is being used under rated conditions, the manufacturer shall specify the electric power consumed under stabilized conditions and the peak start-up power of the hydraulic power system.

NOTE — If a thermal motor is used for driving the pump(s) of the hydraulic power system, the manufacturer should specify its hourly consumption of fuel as well as the electrical power required for the complete system.

10.4.5 Cooling medium

The manufacturer shall specify the cooling media requirements. The requirements laid down in 9.4.7 and 9.4.8 also apply to the complete hydraulic vibration system.

10.4.6 External and internal connections

The manufacturer shall specify the references and characteristics of the external electrical and hydraulic connections necessary for the complete generator and of the connections between the different parts of the system, including connections for the cooling medium.

NOTE — The attention of the user is drawn to the importance for correct operation of the dimensional characteristics (diameter, length, surface roughness, radius of curvature) and of the constituent materials of the hydraulic connections.

10.4.7 Start-up conditions

The manufacturer shall specify the start procedure of the complete hydraulic generator system and the cleaning procedure (rinsing, etc.) for the hydraulic circuits. This procedure applies to the first start-up following an intervention on the hydraulic system.

10.4.8 Generated sound power level

The manufacturer shall specify the maximum sound power level for each part of the complete generator for the maximum no-load sinusoidal acceleration of the moving element unloaded and with the vibration system being supplied at pressure p.

The manufacturer shall use the measuring method specified in ISO 3746. If it cannot be used, the manufacturer shall clearly explain the method used.

10.4.9 Heat dissipation

The manufacturer shall specify the maximum thermal power of the hydraulic power system (9.4.7) and the vibration generator (7.4.5) under rated conditions, in addition to the thermo-stabilization time.

If auxiliary devices are used, the thermal power of these devices shall be specified separately.

10.4.10 Test table temperature

If requested by the user, the manufacturer shall specify the test table temperature for stabilized conditions corresponding to the maximum temperature rise of the moving element.

10.5 Environmental and operating conditions

As the permissible environmental conditions may be different for each of the elements which constitute the vibration generator system, the manufacturer shall describe the precise operating conditions of each of these sub-units.

10.5.1 Hydraulic vibration generator

10.5.1.1 Installation site

The requirement laid down in 7.5.1 applies in this case.

10.5.1.2 Combined tests

The requirement laid down in 7.5.2 applies in this case.

10.5.2 Servovalve control device

The requirement laid down in 8.5 applies in this case.

10.5.3 Hydraulic power supply

The requirements laid down in 9.5 apply in this case.

10.6 Documents

The manufacturer shall list the documentation provided with the hydraulic vibration generator system. Documentation might include the following items:

a) schematic diagram and description including auxiliary equipment;

b) characteristics;

c) operating mode and control;

d) layout conditions and diagram;

e) details on site conditions of the foundations (see 7.4.3);

f) connection and cabling diagrams;

g) overall diagram and nomenclature of the spare parts;

h) assembly and dismantling instructions;

i) list of special tools, if necessary;

j) start-up and maintenance;

k) preferred list of spare parts recommended by the manufacturer;

l) environmental and operating conditions;

m) any other information.

Annex A

Schematic diagrams

(This annex forms an integral part of the standard.)

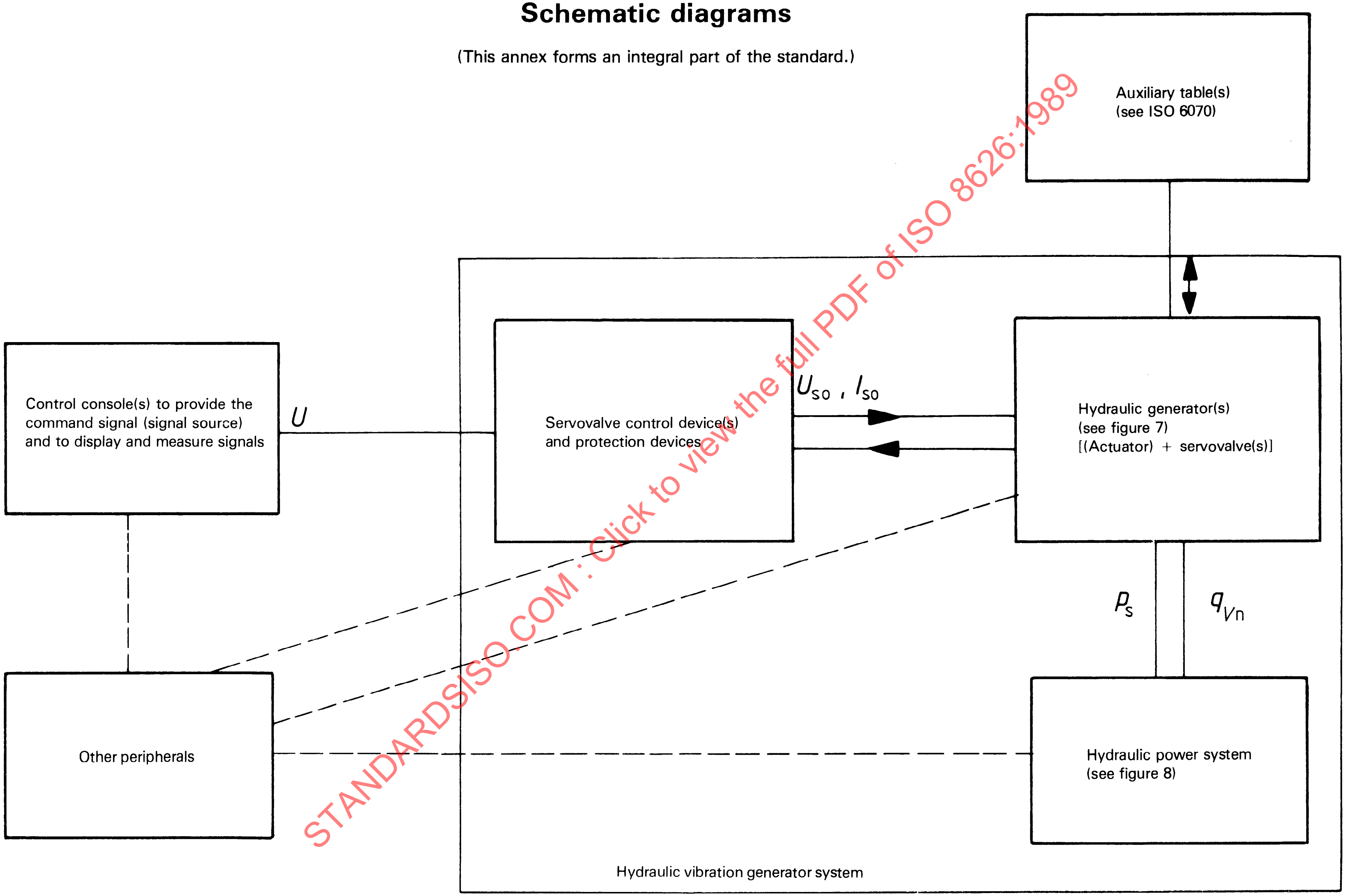
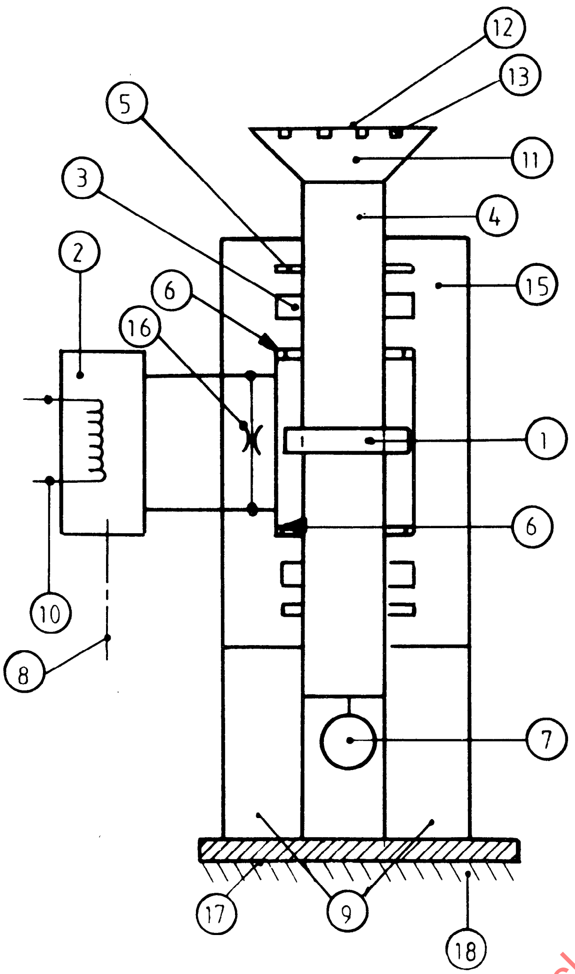


Figure 6 — Schematic diagram of hydraulic test equipment for generating vibrations

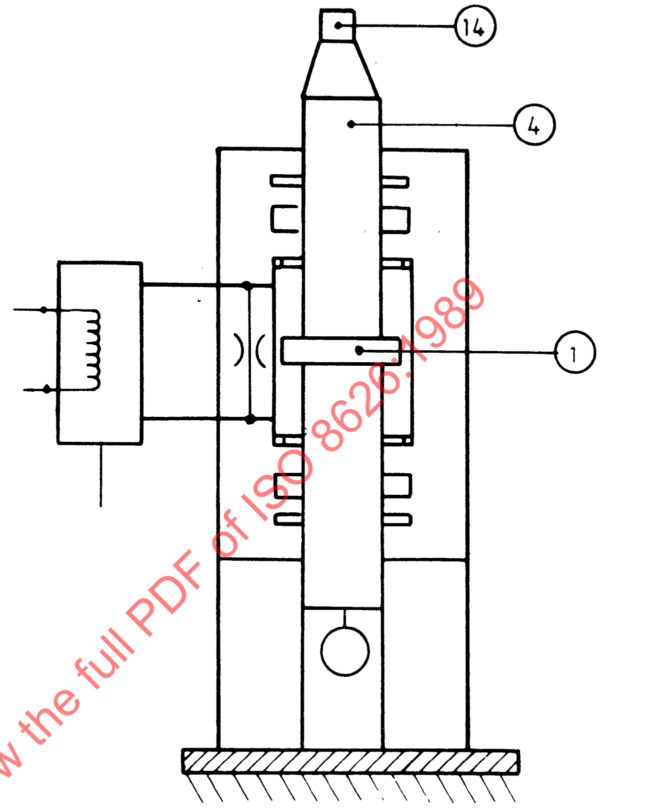


NOTES

1 The moving element is made up of the piston (1), the rod (4) and the moving table (11), including the test table.

2 The actuator body (15) and the pedestal (9) can be connected by means of trunnions or spherical mountings.

a) Hydraulic linear vibration generator with test table



NOTES

1 The moving element is made up of the piston (1), the rod (4) and the power take-off (14).

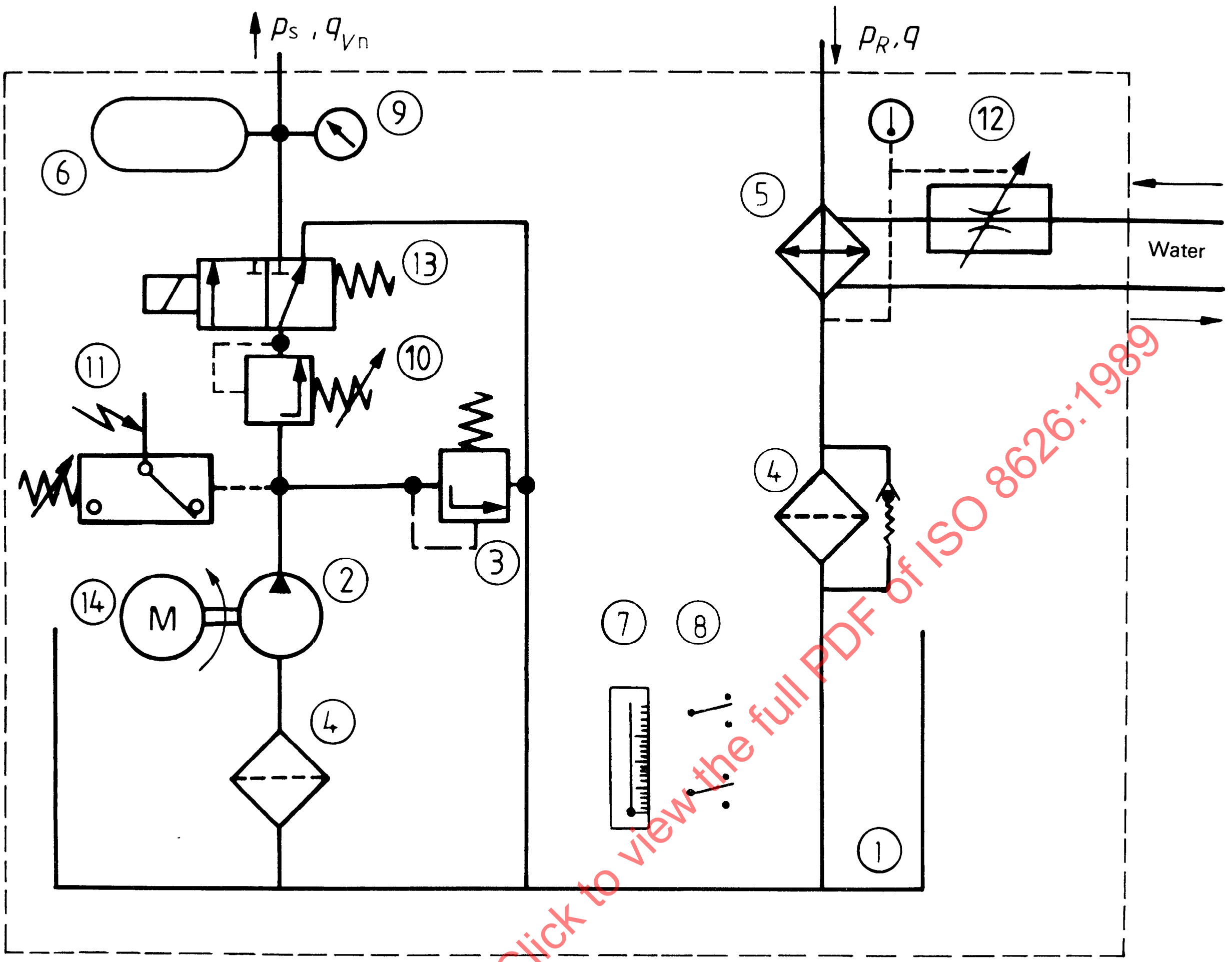
2 The actuator body (15) and the pedestal (9) can be connected by means of trunnions or spherical mountings.

b) Hydraulic linear vibration generator with power take-off

Key

(1) Piston (useful cross-section A)
(2) Servovalve
(3) Guide
(4) Rod
(5) Seal and leakage displacement transducer
(6) Snubbers
(7) Positional displacement transducer
(8) High-pressure supply
(9) Pedestal
(10) Servovalve control coil
(11) Moving table
(12) Test table
(13) Threaded insert
(14) Power take-off
(15) Body of the actuator
(16) Adjustable bypass
(17) Baseplate
(18) Foundations or reaction mass

Figure 7 — Hydraulic linear vibration generator



Key

1. Reservoir
2. Hydraulic pump
3. Pressure-relief valve (safety valve)
4. Filter
5. Heat exchanger
6. Accumulator
7. Level indicator and temperature indicator
8. Detector of minimum-maximum level
9. High-pressure gauge
10. Pressure regulator (adjustable)
11. Pressure switch
12. Thermostatic valve
13. Control valve (isolates the power system)
14. Motor

Figure 8 — Schematic diagram of a hydraulic power system (given as an example)

Annex B

Methods for measuring or calculating various vibration generator parameters

(This annex forms an integral part of the standard.)

B.1 Measuring the frequency of the normal hydraulic mode, f_{oh}

The generator, operating at no load ($m_t = m_0$), is supplied at constant pressure.

The generator of this mass, m_e, in motion is taken as a function of the frequency for a constant current (I_{sv}) in the servovalve coil.

The frequency of the hydraulic resonance, f_{oh}, may be derived from the response curve $H_I(f)$.

NOTES

1 If there is a hydraulic damping circuit between the two chambers of the generator, this may be removed for measurement purposes.

2 The relative velocity between the cylinder and the rod is measured preferably with a velocity transducer of the inductive type. It may also be measured by differentiation using an internal linear displacement transducer as long as the cut-off frequency of the displacement measuring range is at least twice the normal hydraulic frequency allowed for. Measuring the velocity with an acceleration transducer is only possible if the normal modes of the generator and seismic mass are known.

3 If the hydraulic frequency is adjacent to or outside the pass-band of the servovalve, it has to be taken into account and a correction made for determining the hydraulic transfer function, $H_h(s)$, as follows:

$$H_h(s) = \frac{H_I(s)}{q_V(s)}$$

where

s is the Laplacian operator;

$H_h(s)$ is the hydraulic transfer function;

q_V is the flow rate generated by the servovalve. This flow rate, q_V, is a function of I_d, where I_d is the servovalve current.

With the servovalve transfer function given by

$$H_d(s) = \frac{q_V(s)}{I_d}$$

by cancelling out q_V

$$H_h(s) = \frac{1}{I_d H_d(s)} H_I(s)$$

As I_d is constant, it is adequate to multiply $H_I(s)$ by the inverse of the servovalve transfer function.

In general, a servovalve current equal to one-tenth of the rated current is selected.

B.2 Measuring the hydraulic stiffness, k_h

It is not generally possible to measure the hydraulic stiffness directly. It is derived from measuring the frequency of the normal hydraulic mode, f_{oh}.

It is determined using the following equation:

$$k_h = (m_e + m_t)(2\pi f_{oh})^2$$