British Standard

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BRITISH STANDARD

BS EN 13913:2003

Railway applications — Rubber suspension components — Elastomer-based mechanical parts

The European Standard EN 13913:2003 has the status of a British Standard

ICS 45.040

British Standards

National foreword

This British Standard is the official English language version of EN 13913:2003.

The UK participation in its preparation was entrusted by Technical Committee RAE/3, Railway rolling stock material, to Subcommittee RAE/3/-/4, Suspension components, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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Bahnanwendungen - Elastomer-Federungselemente - Mechanische Bauteile auf Elastomerbasis

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 13913:2003) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

— Council Directive 96/48/EEC of 23 July 1996 on interoperability of the European high-speed train network[1];

— Council Directive 93/38/EEC of 14 June 1993 co-ordinating the procurement procedures of entities operating in the water, energy, transport and telecommunications sectors[2];

— Council Directive 91/440/EEC of 29 July 1991 on the development of the community's railways[3].

The annexes A, B, C, D and E are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

[1] Official Journal of the European Communities N° L 235 of 17.09.96

[2] Official Journal of the European Communities N° L 199 of 09.08.93

[3] Official Journal of the European Communities N° L 237 of 24.08.91

Introduction

Designing an elastomer-based mechanical part requires knowledge of the mechanical system of which it forms part. Specific characteristics are therefore needed for each case, which only the customer can specify.

This European Standard is the result of the studies and research to improve the performances and quality of elastomer-based mechanical parts in order to meet the requirements of railway rolling stock.

This European Standard is designed for the railway operators, the manufacturers and equipment suppliers of the railway industry as well as for the suppliers of elastomer-based mechanical parts.

1 Scope

This European Standard defines:

- characteristics that elastomer-based mechanical parts shall achieve, together with applicable inspection and test methods to be carried out for verification;
- approval procedure to be implemented by the customer;
- guidelines for qualification of the product with specified requirements;
- quality monitoring of elastomer-based mechanical parts in manufacture.

This European Standard applies to elastomer-based mechanical parts designed to be fitted on railway vehicles and similar vehicles running on dedicated tracks with permanent guide systems, whatever the type of rail and the running surface.

Typical applications of elastomer-based mechanical parts include:

- vehicle suspension systems;
- equipment mounting systems;
- joints (e.g.: end-mountings of dampers, elastomer-based bearings, elastomer-based parts used on mechanical couplings);
- limit stops.

These parts can be:

- made entirely of elastomer, operating on their own or in combination with other elastic parts;
- made up of elastomer and other materials, adherent together or not.

This European Standard does not apply to:

- rubber diaphragms for pneumatic suspension springs;
- elastic parts of buffing and drawgear springs;
- diaphragms, bellows and seals;
- hoses and tubings;
- transmission belts.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO 31-1, *Quantities and units – Part 1: Space and time.*

ISO 31-3, *Quantities and units – Part 3: Mechanics.*

ISO 188, *Rubber, vulcanized or thermoplastic – Accelerated ageing and heat-resistance tests.*

ISO 471, *Rubber – Temperatures, humidities and times for conditioning and testing.*

ISO 1382, *Rubber – Vocabulary.*

ISO 1817, *Rubber, vulcanised – Determination of the effect of liquids.*

ISO 2781, *Rubber, vulcanised – Determination of density.*

ISO 4649, *Rubber, vulcanized or thermoplastic – Determination of abrasion resistance using a rotating cylindrical drum device.*

ISO 9227, *Corrosion test in artificial atmospheres – Salt spray tests.*

ISO 10209-1, *Technical product documentation – Vocabulary – Part 1: Terms relating to technical drawings: general and types of drawings.*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this European Standard, the following terms and definitions and those given in ISO 1382 apply.

3.1.1
component
elastomer-based mechanical part

NOTE Clause 1 describes them.

3.1.2
static creep
displacement increase, occurring after a specified period of time, of a component subjected to a constant static force

3.1.3
dynamic creep
displacement increase, occurring after a specified period of time, of a component subjected to a dynamic force oscillating about a constant static force

3.1.4
static relaxation
force decrease, occurring after a specified period of time, of a component subjected to a constant displacement

3.1.5
dynamic relaxation
force decrease, occurring after a specified period of time, of a component submitted to a dynamic displacement oscillating about a constant static displacement

3.1.6
phase angle
difference in phase between the transmitted force and the deformation at a specific sinusoidal amplitude and frequency

3.2 Symbols and abbreviations

The majority of the symbols, used in this standard and defined in this sub-clause, are in accordance with ISO 31-1 and ISO 31-3.

Decimal multiples and submultiples of units defined below can be used.

Table 1 — Symbols and abbreviations

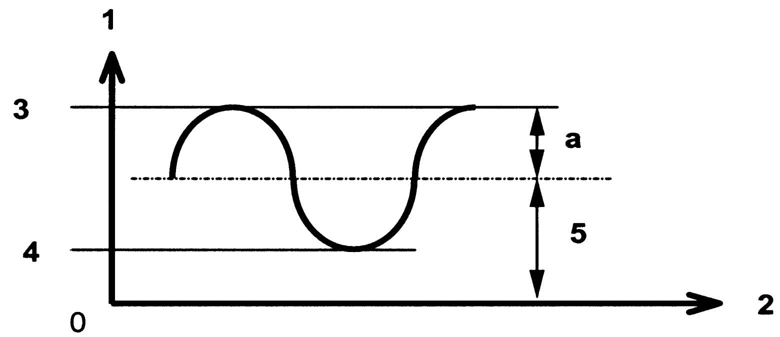
Symbol Abbreviation	Unit	Explanation
a	m or rad	Amplitude of the movement  **Key** 1 Displacement (d or Θ) 2 Time (t) 3 d_{max} (or Θ_{max}) 4 d_{min} (or Θ_{min}) 5 d_P or Θ_P **Figure 1 — Amplitude of the movement**

Table 1 *(continued)*

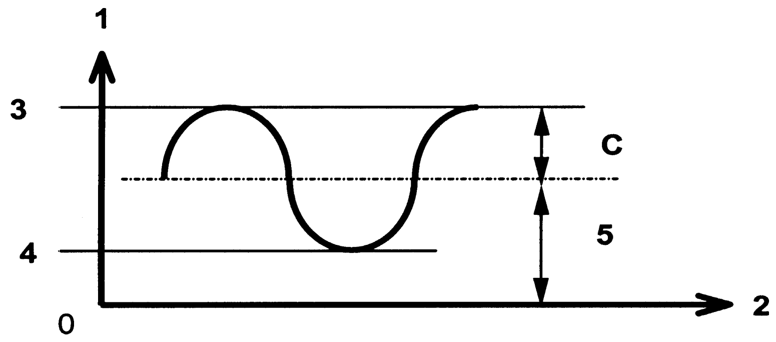
Symbol Abbreviation	Unit	Explanation
C	N or Nm	Amplitude of the force (or the moment)  **Key** 1 Force (***F***) or moment (***M***) 2 Time (***t***) 3 F_{max} (or M_{max}) 4 F_{min} (or M_{min}) 5 F_P (or M_P) **Figure 2 — Amplitude of the force (or the moment)**
d	m	Linear displacement, with: d_J : displacement (d_1; d_2; etc.) corresponding to a force F_J with d_0<d_J<d_M; d_0 : lower data limit for the definition of the stiffness characteristics; d_M : upper data limit for the definition of the stiffness characteristics; d_{min} : minimum displacement on a sinusoidal motion (see Figure 1); d_{max} : maximum displacement on a sinusoidal motion (see Figure 1); d_P : mean displacement (see Figure 1).
F	N	Static force, with: F_J : force (F_1; F_2; etc.) corresponding to a displacement d_J with F_0<F_J<F_M; F_0 : lower data limit for the definition of the stiffness characteristics; F_M : upper data limit for the definition of the stiffness characteristics; F_{min} : minimum force on a sinusoidal motion (see Figure 2); F_{max} : maximum force on a sinusoidal motion (see Figure 2); F_P : mean force (see Figure 2); F_C : reference force taken into account for the creep test (static and dynamic); F_L : reference force taken into account for the definition of the dimensions of the component under load.
f	Hz	Frequency.
kdyn	N/m	Stiffness under sinusoidal motion. Characteristic of the component measured along an axis, under a sinusoidal motion.

Table 1 *(continued)*

Symbol Abbreviation	Unit	Explanation
ks	N/m	Characteristic ″force as a function of linear displacement″ at constant velocity. Characteristic of the component measured along an axis, at constant velocity.
kΘdyn	Nm/rad	Rotational stiffness under sinusoidal motion. Characteristic of the component measured around an axis, under a sinusoidal motion.
kΘs	Nm/rad	Characteristic ″moment as a function of rotational displacement″ at constant velocity. Characteristic of the component measured around an axis, at constant velocity.
L	m	Dimension of the component, with: L_J : dimension (L_1; L_2; etc.) under a static force F_J ; L_0 : dimension at F_0 (or M_0); L_D : reference dimension taken into account for the definition of the force given by the component under deformation ; L_M : dimension at F_M (or M_M); L_R : reference dimension taken into account for the relaxation test (static and dynamic).
M	Nm	Moment applied around an axis of the component, with: M_J : moment (M_1; M_2; etc.) corresponding to an angle of displacement Θ_J with $M_0 < M_J < M_M$; M_0 : lower limit value for the definition of the stiffness characteristics; M_M : upper limit value for the definition of the stiffness characteristics; M_{min} : minimum moment on a sinusoidal motion (see Figure 2); M_{max} : maximum moment on a sinusoidal motion (see Figure 2); M_P : mean moment (see Figure 2).
R_C	m/decade	Creep rate NOTE It is permissible to use % / decade instead of m/decade.
Te	°C	Ambient temperature (temperature of the air surrounding the component) in extreme and exceptional situation, with: Te_{min} : lower temperature; Te_{max} : higher temperature.
To	°C	Ambient temperature (temperature of the air surrounding the component) for normal vehicle operation, with: To_{min} : lower limit of the range of normal operating temperatures; To_{max} : higher limit of the range of normal operating temperatures.

Table 1 *(concluded)*

Symbol Abbreviation	Unit	Explanation
Θ	rad	Angle of displacement in a plane around an axis of the component, with: Θ_J : angle of displacement (Θ_1; Θ_2; etc.) corresponding to a moment M_J with $\Theta_0<\Theta_J<\Theta_M$; Θ_0 : lower limit value for the definition of the stiffness characteristics; Θ_M : upper limit value for the definition of the stiffness characteristics; Θ_{min} : minimum angle of displacement on a sinusoidal motion (see Figure 1); Θ_{max} : maximum angle of displacement on a sinusoidal motion (see Figure 1); Θ_P : mean angular displacement (see Figure 1); NOTE It is permissible to use angular units of degrees instead of radians.
β		Coefficient for the definition of the dynamic creep and the dynamic relaxation.
δ	rad unit	Phase angle

3.3 Three dimensional definition of characteristics

In the absence of any reference system and specific co-ordinates in the definition documents, the following arrangements shall be made.

Using the **X**-**Y**-**Z** axes to orientate the vehicle in space, a Cartesian reference point $\mathbf{O}_{xyz}$, related to the vehicle and with a supposedly fixed point within the mechanical system to which the component belongs as origin, is established as follows:

— axis $\mathbf{O}_x$ parallel to the longitudinal axis of vehicle **X**;

— axis $\mathbf{O}_y$ parallel to the transverse axis of vehicle **Y**;

— axis $\mathbf{O}_z$ parallel to the vertical axis of vehicle (or normal axis) **Z**.

The displacements corresponding to the degrees of freedom are:

— displacement parallel to axis $\mathbf{O}_x$: d_x

— displacement parallel to axis $\mathbf{O}_y$: d_y

— displacement parallel to axis $\mathbf{O}_z$: d_z

— rotation around axis $\mathbf{O}_x$: Θ_x

— rotation around axis $\mathbf{O}_y$: Θ_y

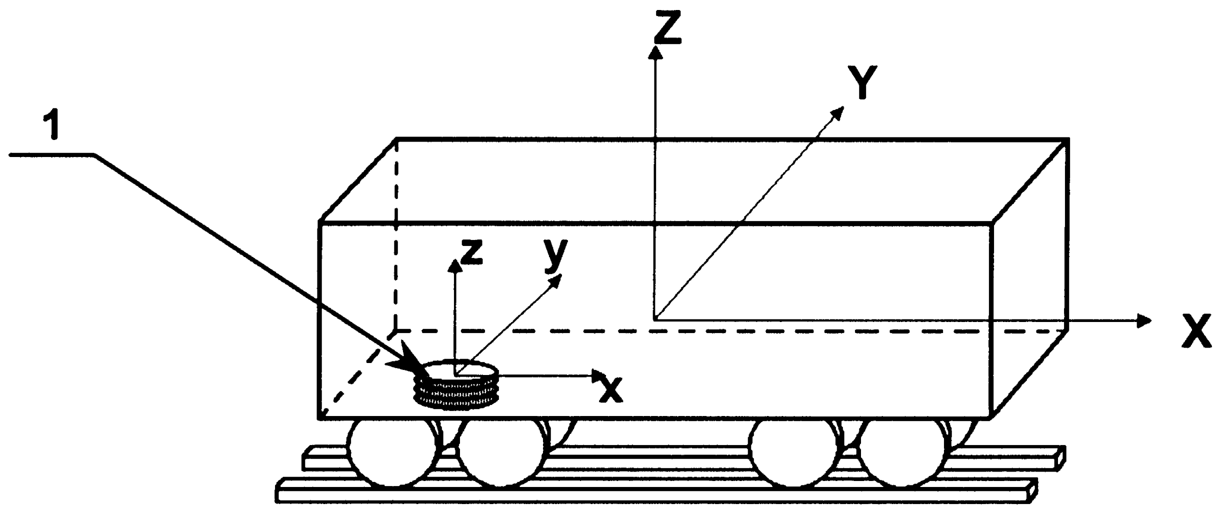
— rotation around axis $\mathbf{O}_z$: Θ_z

The positive direction of rotation is clockwise looking from the origin.

The mechanical characteristics associated with the displacements are:

- for d_x : stiffnesses ks_x and $kdyn_x$; force F_x
- for d_y : stiffnesses ks_y and $kdyn_y$; force F_y
- for d_z : stiffnesses ks_z and $kdyn_z$; force F_z
- for Θ_x : stiffnesses $k\Theta s_x$ and $k\Theta dyn_x$; moment M_x
- for Θ_y : stiffnesses $k\Theta s_y$ and $k\Theta dyn_y$; moment M_y
- for Θ_z : stiffnesses $k\Theta s_z$ and $k\Theta dyn_z$; moment M_z

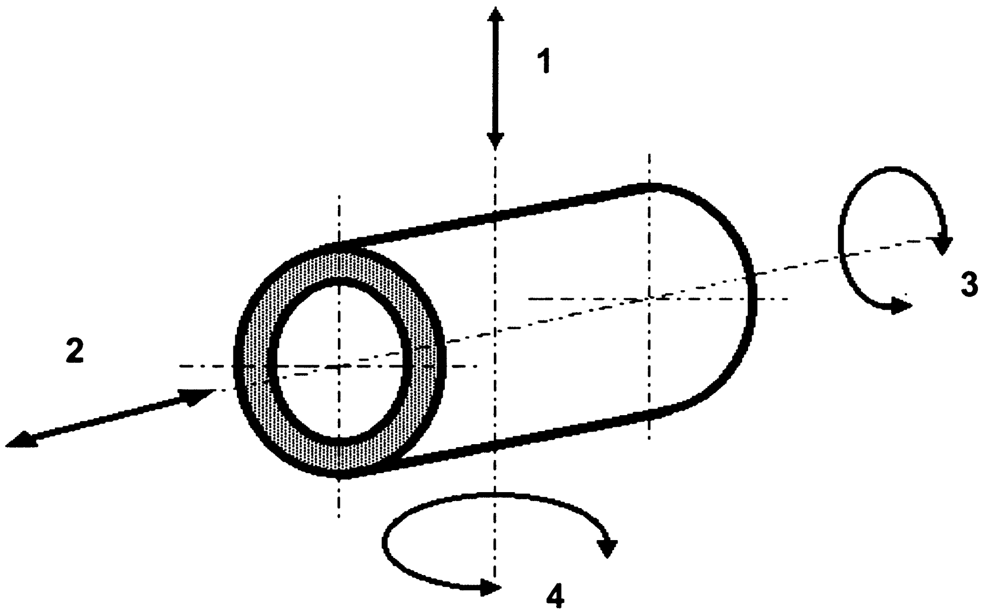
These provisions are illustrated by Figure 3.



Key

1 Component

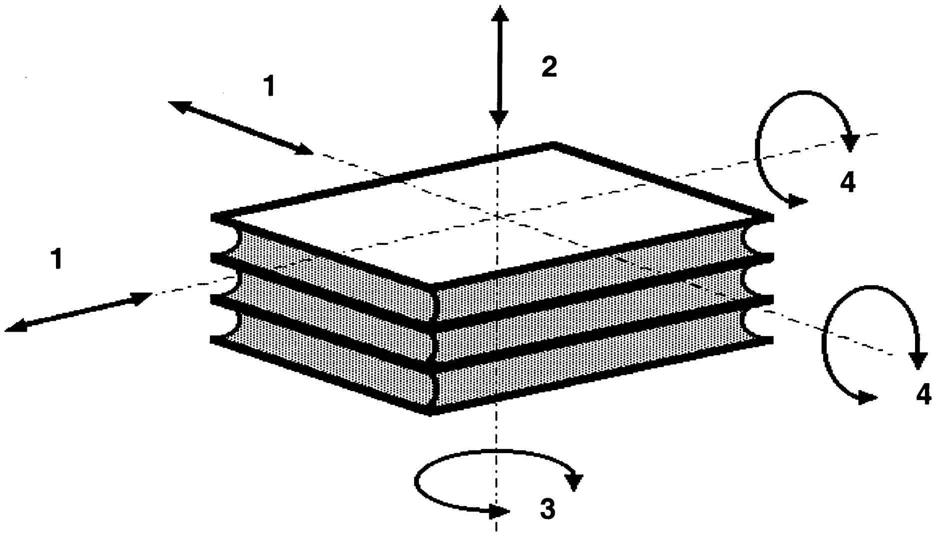
Figure 3 — Three dimensional definition of characteristics



Key

1 Radial
2 Axial
3 Torsional
4 Conical

Figure 4 — Main directions defining the characteristics of a joint (example: elastic bush)



Key

1 Radial
2 Axial
3 Torsional
4 Conical

Figure 5 — Main directions defining the characteristics of a spring (example: layer spring)

4 Definition documents

4.1 Introduction

The component shall be defined in a technical specification which consists of the following documents (see 4.2 and 4.3).

The definition of type of drawing is given in ISO 10209-1.

4.2 Documents to be provided by the customer

The customer shall provide a technical specification including:

a) Interface drawing (possibly, a general assembly drawing of the mechanical system or a sub-assembly drawing) showing at least:

   — space envelope;

   — functional dimensions and tolerances.

b) Technical data detailing at least:

   — conditions of utilisation (forces, movements, temperatures, assembly, environment, maintenance, storage, etc.);

   — requirements (characteristics of the product, tolerances and expected service life);

   — approval procedure and type test requirements (e.g.: characteristics to be checked and tests to be carried out, order of tests and checks).

4.3 Documents to be provided by the supplier

The supplier shall provide documentation describing the component and detailing:

— information required for use of the component (for example fitting, maintenance and storage instructions);

— definition drawing including overall dimensions and tolerances;

— any information required by the technical specification of the customer.

5 Conditions of utilisation

5.1 Environmental conditions

According to position on the vehicle and its service conditions, the component may be subject to attack from sources such as:

— chemical products (cleaning products for example);

— organic wastes;

— oil sprays;

— climate.

These conditions shall be defined in the customer's technical specification.

5.2 Operating temperatures

The operating temperature range (To_{min} to To_{max}) shall be defined in the technical specification.

If no values are specified, the following limits shall be taken into account:

— To_{min} = - 25 °C;

— To_{max} = + 50 °C.

5.3 Operating conditions

During its service life the component is subjected to forces and displacements (linear and angular), due to the function of the mechanical system to which it is fitted.

These forces and displacements shall be taken into consideration for the definition of the component and therefore shall be defined in the technical specification by the customer.

5.4 Recycling

The customer may specify requirements relating to the final disposal of the component.

Any requirement shall be specified in the technical specification.

The supplier of the component shall inform the customer of the recycling of the materials used.

6 Definition of the product

6.1 General

6.1.1 Definition of characteristics

The customer shall specify in the technical specification the necessary characteristics for the definition of the component according to its usage and operating conditions.

These characteristics shall be selected among those specified in Tables 2 and 3.

Any characteristic selected shall be defined according to instructions of the present European Standard.

The component shall comply with the specified criteria.

Recommended tolerances are given in annex C.

6.1.2 Mounting conditions

Any mounting conditions which may have an influence on the characteristics (e.g.: component prestressed when installed) shall be defined in the technical specification.

6.1.3 Ambient conditions

Unless otherwise specified, the characteristics of the component are defined with an ambient temperature of (23 ± 2) °C.

Specific characteristics may be defined in different conditions. In this case, the technical specification shall specify:

— the concerned characteristics;

— the temperature;

— the criteria.

Table 2 — Component characteristics

CHARACTERISTIC	Characteristic definition (sub-clause)	Inspection and test method (sub-clause)
Resistance to environmental conditions		
Low temperature	6.2.2	7.2.2
High temperature	6.2.3	7.2.3
Ozone	6.2.4	7.2.4
Oil and petroleum products	6.2.5	7.2.5
Chemical product	6.2.6	7.2.6
Abrasion	6.2.7	7.2.7
Fire behaviour	6.2.8	7.2.8
Corrosion	6.2.9	7.2.9
Other conditions	6.2.10	7.2.10
Resistance to operating conditions		
Fatigue resistance	6.3.1	7.3.1
Static creep	6.3.2	7.3.2
Dynamic creep	6.3.3	7.3.3
Static relaxation	6.3.4	7.3.4
Dynamic relaxation	6.3.5	7.3.5
Other conditions	6.3.6	7.3.6
Physical characteristics		
Materials	6.4.1	7.4.1
Mass	6.4.2	7.4.2
Geometrical and dimensional characteristics		
Space envelope	6.5.1	7.5.1
Dimensions	6.5.2	7.5.2

Table 3 — Component characteristics

FUNCTIONAL CHARACTERISTIC	Characteristic definition (sub-clause)	Inspection and test method (sub-clause)
Characteristics ″force as a function of displacement″ at constant velocity		
In a new condition	6.6.3.2	7.6.3.2
After test	6.6.3.3	7.6.3.3
Stiffnesses under sinusoidal motion		
In new condition	6.6.4.2	7.6.4.2
After test	6.6.4.3	7.6.4.3
Damping		
In new condition	6.6.5.2	7.6.5.2
After test	6.6.5.3	7.6.5.3
Other characteristics		
Dimensions under load	6.6.1	7.6.1
Force under deformation	6.6.2	7.6.2

6.2 Resistance to environmental conditions

6.2.1 General

Some characteristics are defined on test pieces (see 7.2.1). Results obtained on test pieces may differ from the actual performances of the component. This shall be taken into account when defining these characteristics.

6.2.2 Low temperature

Where the characteristic is selected, the component shall be able to withstand low temperature.

The extreme temperature $\boldsymbol{Te}_{\mathbf{min}}$ shall be defined in the technical specification. If no value is specified, $\boldsymbol{Te}_{\mathbf{min}}$ shall be taken equal to - 25 °C.

When the component operates at extreme temperature $\boldsymbol{Te}_{\mathbf{min}}$, criteria may be specified on characteristics (e.g.: impact resistance). If required, the technical specification shall specify:

— the concerned characteristics;

— the criteria.

6.2.3 High temperature

Where the characteristic is selected, the component shall be able to withstand high temperature.

The extreme temperature $\boldsymbol{Te}_{\mathbf{max}}$ shall be defined in the technical specification. If no value is specified, $\boldsymbol{Te}_{\mathbf{max}}$ shall be taken equal to + 70 °C.

Criteria may be specified on characteristics:

- when the component operates at extreme temperature $\boldsymbol{Te}_{\mathbf{max}}$;
- after heat ageing according to the test method defined in 7.2.3.

If required, the technical specification shall specify:

- the concerned characteristics;
- the criteria.

Requirements on the characteristics ″force as a function of displacement″ of the component, after heat ageing, are defined in 6.6.3.3 and 6.6.4.3.

6.2.4 Ozone

In general, the ozone action on the products defined by the present standard does not generate significant damages which would negatively affect the function of the product (small surfaces of elastomer exposed, elastomer compressed).

If severe exposure is expected to be a problem, then the technical specification shall specify requirements regarding the effect of ozone on the component, and shall define the criteria and corresponding test method (see 7.2.4).

6.2.5 Oil and petroleum products

Where the characteristic is selected, the component shall not be damaged by occasional oil sprays.

If severe exposure is expected to be a problem, then the technical specification shall specify the permissible variation of the characteristics after the test defined in 7.2.5, in relation to those measured on the component in a new condition.

In this case, the technical specification shall specify:

- the concerned characteristics;
- the criteria.

6.2.6 Chemical products

Where the characteristic is selected, the component shall not be damaged by occasional chemical products sprays.

If severe exposure is expected to be a problem, then the technical specification shall specify the permissible variation of the characteristics after the test defined in 7.2.6, in relation to those measured on the component in a new condition.

In this case, the technical specification shall specify:

- the concerned characteristics;
- the criteria.

6.2.7 Abrasion

Where the characteristic is selected, the technical specification shall define:

- the surfaces which shall be able to withstand abrasion;

— the criteria corresponding to the test method defined in 7.2.7.

Recommended acceptance criteria are given in Table C.1.

6.2.8 Fire behaviour

Where the characteristic is selected, the customer shall inform the supplier of its requirements regarding effect of fire on the component (see 7.2.8).

If required, the component shall be classified with regard to fire reaction, opacity of smoke and toxicity of gas given off.

6.2.9 Corrosion

Where the characteristic is selected, the non-elastomeric parts shall be protected against corrosion.

The technical specification shall specify the kind of protection and the corresponding surfaces to protect.

There are two kinds of corrosion protection system:

a) Temporary protection

   The specified surfaces shall be protected against corrosion prior to installation of the component on the vehicle, as minimum.

b) Permanent protection

   The specified surfaces shall be protected against corrosion during a specified period of service of the component.

   Unless otherwise specified, the characteristics of the protection system are those given by the salt spray test, defined in 7.2.9.

   The criteria, corresponding to this test method, shall be specified in the technical specification.

   Recommended acceptance criteria are given in Table C.1.

The chosen protection systems shall be defined on the definition drawing of the component.

6.2.10 Other conditions

The customer may specify any other environmental conditions of the component, in the technical specification.

6.3 Resistance to operating conditions

6.3.1 Fatigue resistance

The component shall be able to withstand stresses and forces to which it is subject when operating.

Where the characteristic is selected, the fatigue resistance of the component can be evaluated by a fatigue test simulating the movements and the forces encountered in service.

The test programme (see 7.3.1) and the acceptance criteria shall be completely defined in the technical specification.

Examples of acceptance criteria are given in annex B.

6.3.2 Static creep

Where the characteristic is selected, the technical specification shall specify:

— the value of the admissible static creep during a specific time (expressed in metre per decade or percentage per decade);

— the value of the force $\boldsymbol{F}_C$.

6.3.3 Dynamic creep

Where the characteristic is selected, the technical specification shall specify the permissible dynamic creep of the component and the conditions in which the dynamic creep will be determined, according to 7.3.3.

6.3.4 Static relaxation

Where the characteristic is selected, the technical specification shall specify the permissible static relaxation of the component and the conditions in which the static relaxation will be determined, according to 7.3.4.

6.3.5 Dynamic relaxation

Where the characteristic is selected, the technical specification shall specify the permissible dynamic relaxation of the component and the conditions in which the dynamic relaxation will be determined, according to 7.3.5.

6.3.6 Other conditions

The customer may specify any other operating conditions of the component, in the technical specification.

6.4 Physical characteristics

6.4.1 Materials

Materials used for elastomerics and other elements shall be defined.

6.4.2 Mass

Criteria on the mass of the component may be specified in the technical specification.

6.5 Geometrical and dimensional characteristics

6.5.1 Space envelope

Where the characteristic is selected, the space envelope available for the component shall be defined for given functioning conditions.

The overall dimensions of the component shall always remain within the specified space envelope.

6.5.2 Dimensions

The overall dimensions of the component in a free state (component not fitted and not submitted to an external stress) shall be defined in the technical specification.

6.6 Functional characteristics

6.6.1 Dimensions under load

Where the characteristic is selected, the technical specification shall define:

— the magnitude and the direction of the reference force F_L;

— the dimensions of the component under F_L, with their tolerances;

— the method of measurement (see 7.6.1).

6.6.2 Force under deformation

This is the force given by the component deformed to the reference dimension L_D.

Where the characteristic is selected, the technical specification shall define:

— the reference dimension L_D;

— the force given by the component deformed to the dimension L_D, with its tolerances;

— the method of measurement (see 7.6.2).

6.6.3 Characteristics ″force as a function of displacement″ at constant velocity

6.6.3.1 Definition

6.6.3.1.1 Conditions

Typically, the characteristics ″force as a function of displacement″ at constant velocity can be defined in terms of displacements corresponding to either:

— uniaxial cycles;

— multiaxial cycles, one of the forces remaining constant both in magnitude and direction.

6.6.3.1.2 Data limits

For any characteristic ″force as a function of displacement″ at constant velocity specified in the technical specification, the definition limits of this characteristic shall be defined.

These limits are:

— F_0 and F_M when data are forces;

— M_0 and M_M when data are moments;

— d_0 and d_M when data are linear displacements;

— Θ_0 and Θ_M when data are angular displacements.

6.6.3.1.3 Methods of definition

Characteristics ″force as a function of displacement″ at constant velocity can be defined in the technical specification according to one of the following methods:

NOTE Characteristics ″force as a function of displacement″ at constant velocity can be defined in the technical specification without criteria (indicative values). In that case, only the data limits should be defined.

a) Force (or moment) as a function of displacement curves.

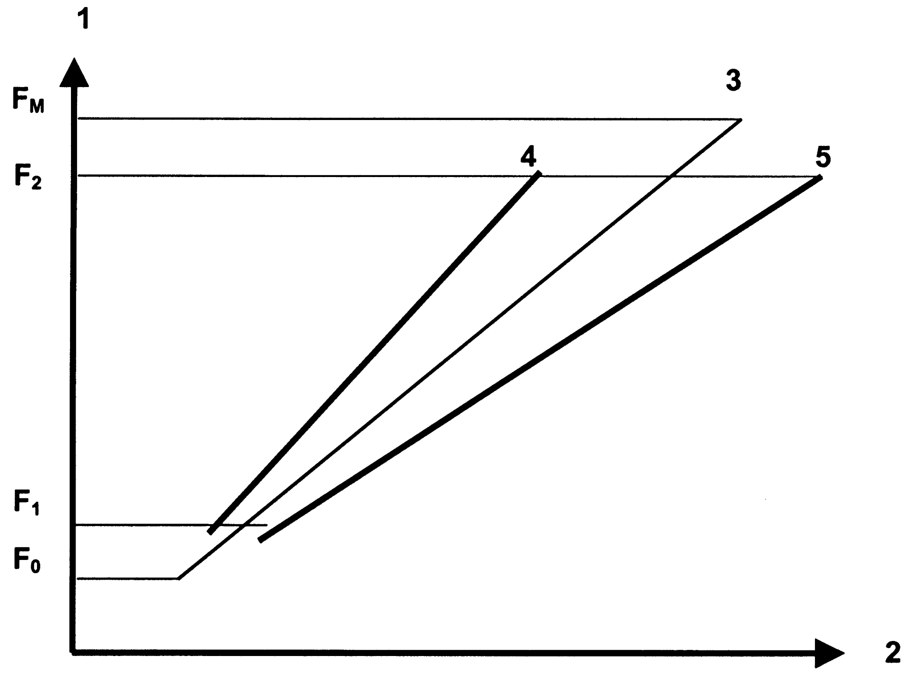
Figures 6 and 7 illustrate an example of ″force as a function of linear displacement″ curve.

If required, tolerances shall be defined between the two data limits:

— either by envelope curves (see Figure 6);

— or by target values established for discrete data (see Figure 7).

Recommended tolerances are given in Table C.4.



Key

1 Force ***F*** (data)

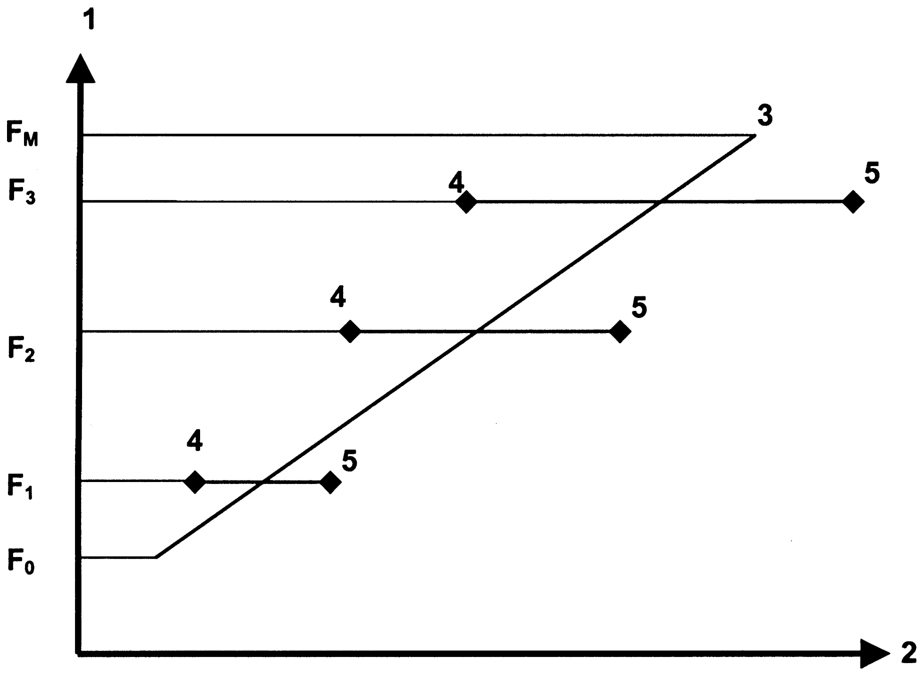
2 Displacement ***d***

3 Theoretical curve

4 Maximum

5 Minimum

Figure 6 — Envelope curves (example)



Key

1 Force ***F*** (data)
2 Displacement ***d***
3 Theoretical curve
4 Maximum
5 Minimum

Figure 7 — Target values (example)

b) Ratio of change of force (or moment) to the corresponding change of displacement.

Figure 8 illustrates an example for the calculation of the stiffness of the ″force as a function of linear displacement″ curve.

The technical specification shall specify:

— the data (F_1, F_2) and (d_1, d_2) or (M_1, M_2) and (Θ_1, Θ_2) ;

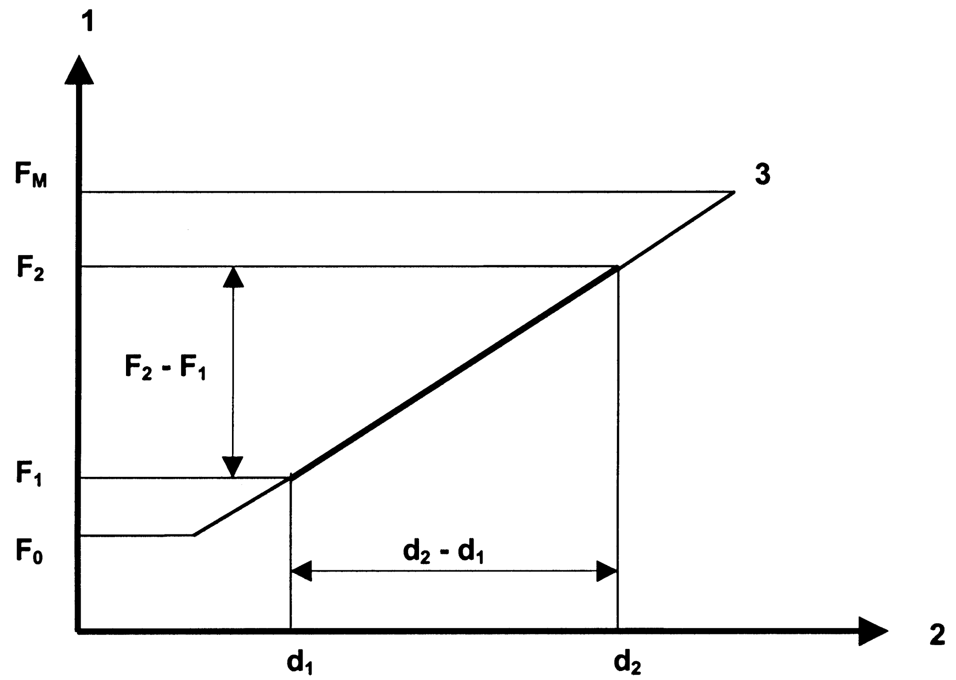
— the tolerances, if required.

Recommended tolerances are given in Table C.4.

Characteristics ″force as a function of displacement″ at constant velocity are determined using the following formulas:

$ks = (F_2 - F_1) / (d_2 - d_1)$ with : $F_0 < F_1 < F_2 < F_M$

$k\Theta s = (M_2 - M_1) / (\Theta_2 - \Theta_1)$ with : $M_0 < M_1 < M_2 < M_M$



Key

1 Force ***F*** (data)

2 Displacement ***d***

3 Theoretical curve

Figure 8 — Change of force as a function of change of displacement (example)

6.6.3.2 Characteristics ″force as a function of displacement″ at constant velocity in a new condition

Where the characteristic is selected, characteristics ″force as a function of displacement″ at constant velocity shall be defined in the technical specification, according to the prescription of 6.6.3.1.

6.6.3.3 Characteristics ″force as a function of displacement″ at constant velocity after test

Where the characteristic is selected, characteristics ″force as a function of displacement″ at constant velocity, after test (for example: static creep, dynamic creep, dynamic relaxation, heat ageing), shall be defined in the technical specification according to the prescription of 6.6.3.1.

The permissible variation of the characteristics ″force as a function of displacement″ at constant velocity after the specified test, in relation to those measured on the component in a new condition, may be defined in the technical specification.

Recommended permissible variations are given in Table C.2.

6.6.4 Stiffnesses under sinusoidal motion

6.6.4.1 Definition

6.6.4.1.1 Introduction

There are three principal definition methods:

— characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of amplitude of the displacement″;

- characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of amplitude of the force (or the moment)″;
- characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of frequency″.

Stiffnesses under sinusoidal motion may be defined in the technical specification without criteria (indicative values).

In that case, only the data limits shall be defined.

If required, tolerances shall be defined:

- either by envelope curves (see example on Figure 6);
- or by target values established for discrete data (see example on Figure 7).

NOTE Recommended tolerances are given in Table C.4. It is recommended that these characteristics are defined for frequencies above 0,1 Hz.

6.6.4.1.2 Stiffnesses under sinusoidal motion (*kdyn*) as a function of amplitude of the displacement

Each characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of amplitude of the displacement″ is defined for a specific frequency.

If the characteristic is defined by a curve, then the range of amplitudes of the displacement shall be specified in the technical specification together with the value of the frequency.

If the characteristic is defined at particular amplitudes of the displacement, then the value of these amplitudes shall be specified in the technical specification together with the value of the frequency.

6.6.4.1.3 Stiffnesses under sinusoidal motion (*kdyn*) as a function of amplitude of the force (or moment)

Each characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of amplitude of the force (or moment)″ is defined for a specific frequency.

If the characteristic is defined by a curve, then the range of amplitudes of the force (or moment) shall be specified in the technical specification together with the value of the frequency.

If the characteristic is defined at particular amplitudes of the force (or moment), then the value of these amplitudes shall be specified in the technical specification together with the value of the frequency.

6.6.4.1.4 Stiffnesses under sinusoidal motion (*kdyn*) as a function of frequency

Each characteristic ″stiffness under sinusoidal motion (***kdyn***) as a function of frequency″ is defined for a specific amplitude of the displacement or force (or moment).

If the characteristic is defined by a curve, then the range of frequencies shall be specified in the technical specification together with the value of the amplitude of the displacement or force (or moment).

If the characteristic is defined at particular frequencies, then the value of these frequencies shall be specified in the technical specification together with the value of the amplitude of the displacement or force (or moment).

6.6.4.2 Stiffnesses under sinusoidal motion in new condition

Where the characteristic is selected, stiffnesses under sinusoidal motion shall be defined in the technical specification, according to the prescription of 6.6.4.1.

6.6.4.3 Stiffnesses under sinusoidal motion after test

Where the characteristic is selected, stiffnesses under sinusoidal motion after test (for example: static creep, dynamic creep, dynamic relaxation, heat ageing), shall be defined in the technical specification according to the prescription of 6.6.4.1.

The permissible variation of the stiffnesses under sinusoidal motion after the specified test, in relation to those measured on the component in a new condition, may be defined in the technical specification.

Recommended permissible variations are given in Table C.3.

6.6.5 Damping

6.6.5.1 Definition

6.6.5.1.1 Introduction

The phase angle δ is given as a value for the elastomer damping.

NOTE It is recommended that these characteristics should be defined for frequency above 0,1 Hz. Other damping parameters can be specified, if required.

The damping characteristic is generally defined according to one of the following:

6.6.5.1.2 Characteristic ″phase angle δ (or other parameter) as a function of amplitude of the displacement″

Each characteristic ″phase angle δ (or other parameter) as a function of amplitude of the displacement″ is defined for a specific frequency.

If the characteristic is defined by a curve, then the range of amplitudes of the displacement shall be specified in the technical specification together with the value of the frequency.

If the characteristic is defined at particular amplitudes of the displacement, then the value of these amplitudes shall be specified in the technical specification together with the value of the frequency.

6.6.5.1.3 Characteristic ″phase angle δ (or other parameter) as a function of amplitude of the force (or the moment)″

Each characteristic ″phase angle δ (or other parameter) as a function of amplitude of the force (or moment)″ is defined for a specific frequency.

If the characteristic is defined by a curve, then the range of amplitudes of the force (or moment) shall be specified in the technical specification together with the value of the frequency.

If the characteristic is defined at particular amplitudes of the force (or moment), then the value of these amplitudes shall be specified in the technical specification together with the value of the frequency.

6.6.5.1.4 Characteristic ″phase angle δ (or other parameter) as a function of frequency″

Each characteristic ″phase angle δ (or other parameter) as a function of frequency″ is defined for a specific amplitude of the displacement or force.

If the characteristic is defined by a curve, then the range of frequencies shall be specified in the technical specification together with the value of the amplitude of the displacement or force.

If the characteristic is defined at particular frequencies, then the value of these frequencies shall be specified in the technical specification together with the value of the amplitude of the displacement or force.

6.6.5.2 Damping in new condition

Where the characteristic is selected, damping characteristics shall be defined in the technical specification, according to the prescription of 6.6.5.1.

6.6.5.3 Damping after test

Where the characteristic is selected, damping characteristics after test (for example: static creep, dynamic creep, dynamic relaxation, heat ageing) shall be defined in the technical specification, according to the prescription of 6.6.5.1.

The permissible variation of the damping characteristics after the specified test, in relation to those measured on the component in a new condition, may be defined in the technical specification.

7 Inspection and test methods

7.1 General

7.1.1 General test conditions

7.1.1.1 Introduction

The test methods and extent of the tests shall be defined by the customer in the technical specification and shall be documented by the supplier following completion. Any deviations from the tests which have been defined in the technical specification shall only be made with the agreement of the customer.

7.1.1.2 Temperature

The measurements and the tests shall be carried out at the temperatures specified in the technical specification of the component.

Tests may be required at particular temperatures according to the prescriptions of 7.2.2 and 7.2.3.

Unless otherwise specified, tests shall be carried out with an ambient temperature of (23 ± 2) °C, in accordance with ISO 471.

The applicable tolerance on a particular temperature is ± 2 °C.

For any test, the temperature shall be recorded and given with the measurement results.

7.1.1.3 Force, displacement, velocity and frequency

Tests shall be performed within the specified parameter tolerances and actual values declared.

Uncertainties of measure have to be determined.

The relationship between the accuracy of the test equipment in use and the specified tolerance (on a test parameter or result) shall be agreed between the customer and the supplier.

Unless otherwise specified, the applicable tolerances are:

- time: ± 2 min;
- velocity: ± 10 % of the value;
- frequency: ± 10 % of the value;

— force: ± 2 % of the maximum value applied for the measurements;

— moment: ± 2 % of the maximum value applied for the measurements;

— displacement: ± 2 % of the maximum value applied for the measurements.

7.1.2 Instrumentation

When the mounting conditions have an influence on the characteristics of the component, tests shall be carried out on a component fastened in a device reproducing its assembly on the mechanical system for which it is designed.

The test device shall be defined in the technical specification, according to the instructions given in annex A.

Details of the test devices and measuring systems shall be submitted to the customer for approval.

7.1.3 Definition and preparation of test pieces

For all tests, unless otherwise specified, the test piece shall be the complete component.

The piece shall be kept at ambient temperature for at least 72 h before starting tests and taking measurements.

The piece shall be left in a location at the specified test temperature for at least 24 h before the tests.

7.2 Resistance to environmental conditions

7.2.1 General

For the characteristics defined in 7.2.4, 7.2.5, 7.2.6 and 7.2.7, moulded test pieces may be used. The test pieces shall be representative of the surface exposed to the environmental conditions described.

7.2.2 Low temperature

The test method shall be agreed between the customer and the supplier and defined in the technical specification of the component.

7.2.3 High temperature

7.2.3.1 Heat ageing

The component shall be submitted to heat ageing during 14 days at the specified temperature $\boldsymbol{Te}_{max}$ according to the prescriptions the ISO 188.

Subsequent to this treatment, the component shall be left for 24 h at the ambient temperature.

Then, the characteristics designed in the technical specification, shall be measured according to the test methods defined in the present standard.

7.2.3.2 Other tests

Any other test method shall be agreed between the customer and the supplier, and defined in the technical specification of the component.

7.2.4 Ozone

The test method shall be agreed between the customer and the supplier, and defined in the technical specification of the component.

7.2.5 Oil and petroleum products

Oil and petroleum product resistance shall be tested in conformance with ISO 1817.

Test details shall be as follows:

— oil: IRM 902;

— test temperature: (70 ± 1) °C;

— immersion time: 72 h (0; - 2) h.

7.2.6 Chemical products

Chemical product resistance shall be tested in accordance with ISO 1817.

Tests details shall be as follows:

— aqueous solution of oxalic acid with concentration by weight of 5%;

— test temperature: (50 ± 1) °C;

— immersion time: 72 h (0; - 2) h.

7.2.7 Abrasion

Abrasion resistance shall be tested in accordance with ISO 4649 method A.

The relative density of the elastomer shall be measured in accordance with ISO 2781.

7.2.8 Fire behaviour

Test methods shall be agreed between the customer and the supplier, and defined in the technical specification of the component.

7.2.9 Corrosion

Corrosion resistance shall be tested in accordance with ISO 9227.

7.2.10 Other conditions

Test methods shall be agreed between the customer and the supplier, and defined in the technical specification of the component.

7.3 Resistance to operating conditions

7.3.1 Fatigue resistance

7.3.1.1 Introduction

The test shall be carried out in accordance with the following procedure.

7.3.1.2 Test machine

The test machine shall be designed to reproduce the critical forces and movements to which the component is submitted when operating.

7.3.1.3 Test procedure

The fatigue test shall consist in repeating specified sequences of forces and movements, such as those indicated as examples in annex B.

The test procedure shall be defined in the technical specification.

7.3.1.4 Test procedure validation

When it is possible, the test shall be validated by applying it to a component that has the same or a similar function, and which has a known operating performance.

7.3.1.5 Inspections

Before and after the test:

— the component shall be subject to a visual inspection;

— the specified characteristics shall be checked.

7.3.2 Static creep

7.3.2.1 General

The technical specification shall specify:

— the magnitude and the direction of the static force ***F*c**;

— the dimension to measure;

— the ambient temperature, if particular (see 7.1.1).

Before the test, the component shall be subjected to a static force ***F*c**, at the specified ambient temperature, and the dimension of the component shall be measured according to 7.6.1.

Then, the component shall be subjected to the static force ***F*c,** maintained constant, and the variation of the selected dimension shall be recorded, without releasing the force ***F*c**, as a function of the time.

During the test, the variation of the ambient temperature shall be recorded.

7.3.2.2 Determination of the creep rate

The static force shall be applied from 0 to ***F*c** within the first 30 seconds of the test.

The selected dimension shall be measured at times (including the loading time):

— t_0 1 min;

— t_2 100 min.

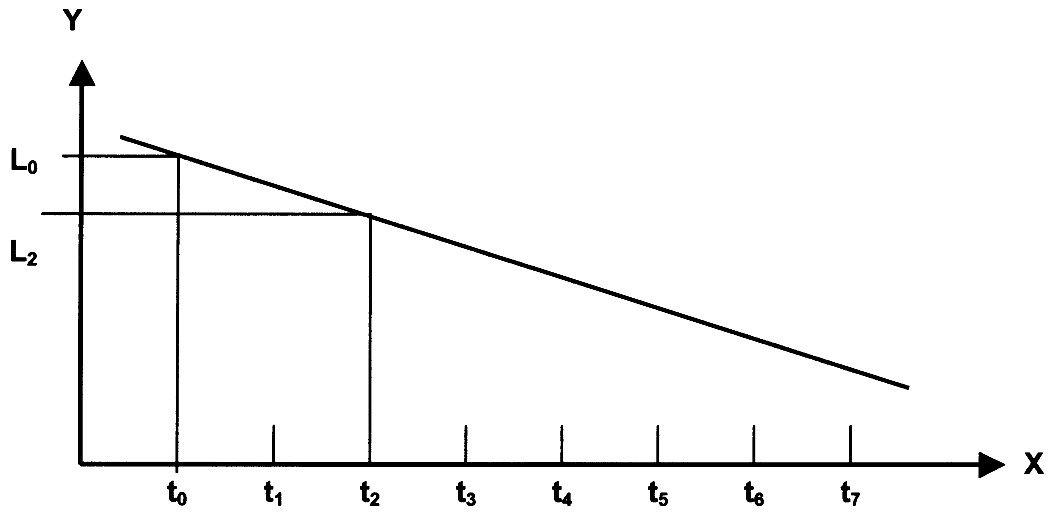
The result is that: $t_2 - t_0$ = 1 h 39 min.

Time $(t_2 - t_0)$ shall be divided into the two logarithmic decades of 9 min and 90 min.

The creep rate R_C (expressed in meter per decade) shall be calculated by using the formula:

$$R_C = (L_0 - L_2) / 2$$

The ambient temperature between t_0 and t_2 shall not vary more than 2 °C.



Key

X Time

Y Dimension

t_0 1 min

t_1 10 min

t_2 1 h 40 min

t_3 16 h 40 min

t_4 6 days and 22 h 40 min

t_5 69 days and 10 h 40 min

t_6 694 days and 10 h 40 min (≈ 2 years)

t_7 6 944 days and 10 h 40 min (≈ 19 years)

Figure 9 — Static creep in function of the logarithm of time

The value of the static creep shall be calculated at the time specified in the technical specification.

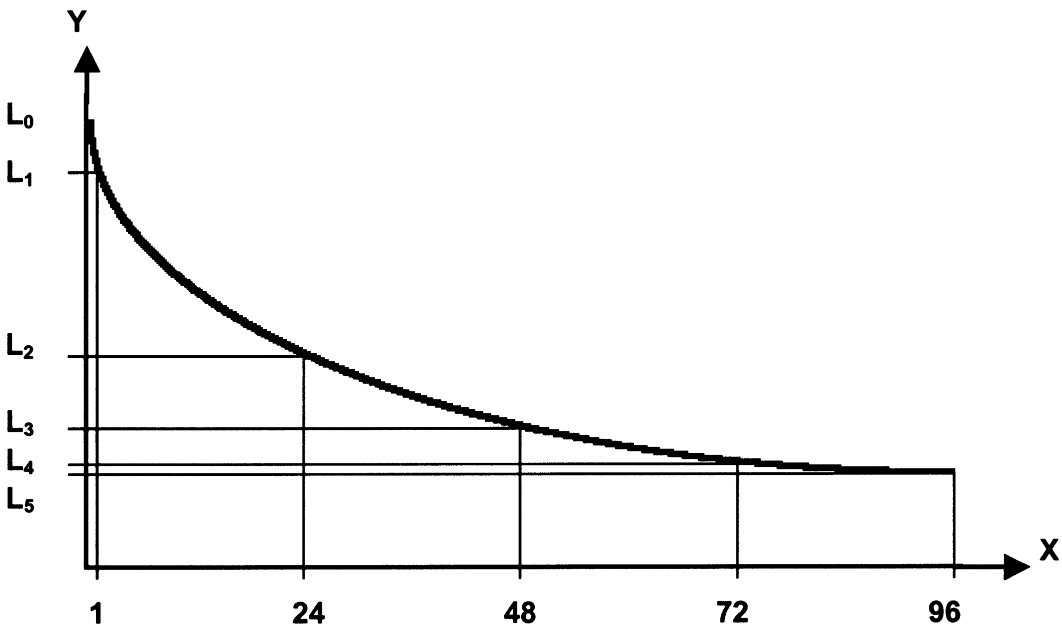
NOTE The linear creep characteristic shown above is not applicable for components which possess non-linear force displacement characteristics. In such cases the value of static creep cannot be extrapolated after a short time period. Testing over an increased time period can be required.

7.3.2.3 Stabilisation test

The test defined in 7.3.2.2 shall be continued until the stabilisation of the component.

The component is deemed stabilised when the change of length over 24 h is less than one tenth of the change of length between t equal to 1 h and t equal to 24 h.

Figure 10 gives an example of a component stabilised after a test duration of 96 h.



$$L_4 - L_5 < 0{,}1 \times (L_1 - L_2)$$

Key

X Time (h)

Y Dimension

Figure 10 — Stabilisation test (example)

The characteristics of the component, specified in the technical specification, shall be measured just after this test.

The force F_C shall not be released between the stabilisation test and the measurements.

7.3.3 Dynamic creep

Before the test, the component shall be stabilised under a static force F_C, at a specific ambient temperature, and the dimension of the component shall be measured according to 7.6.1.

The technical specification shall specify:

— the magnitude and the direction of the static force F_C;

— the ambient temperature, if particular (see 7.1.1).

Then, the component shall be subjected to a sinusoidal force F_{Csin}, such that:

$$F_{Csin} = F_C + (\beta \times F_C \times \sin (2 \times \pi \times f \times t)) \qquad \text{with:}$$

— f : Frequency taken as equal to (10 ± 0,5) Hz if no other value is specified in the technical specification;

— β : Coefficient taken as equal to 0,1 if no other value is specified in the technical specification.

It is recommended that during the test, the component surface temperature does not exceed 40 °C. Otherwise, the frequency value will have to be reduced.

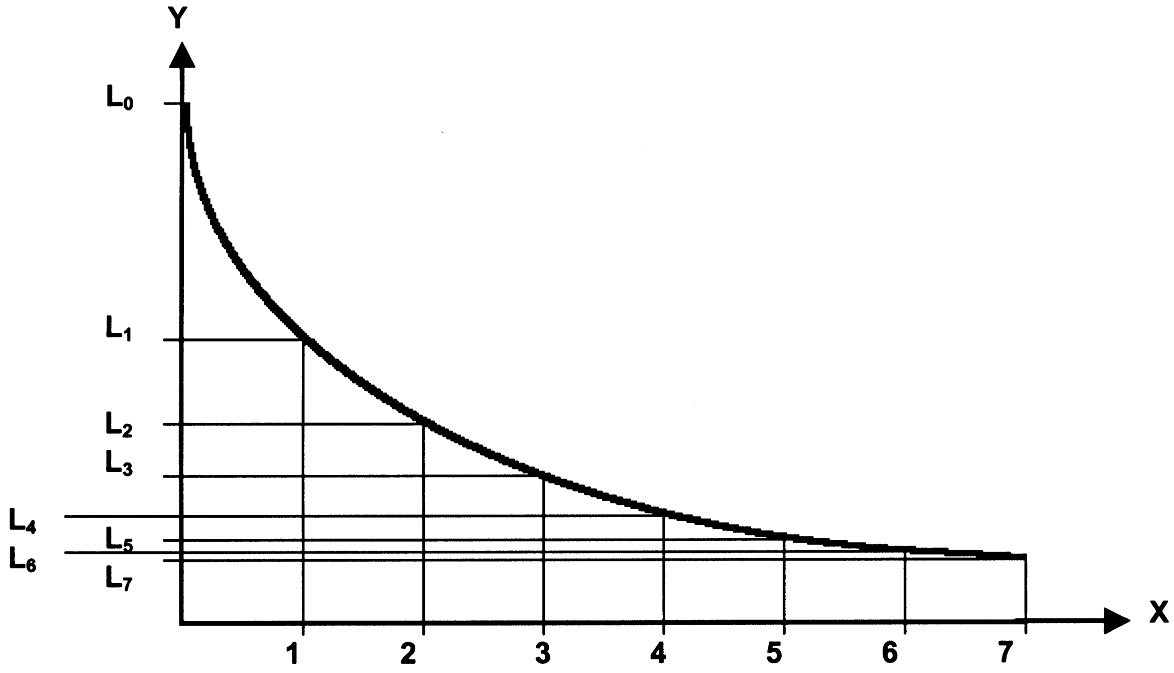
The variation of the length of the component, under a static force F_C, shall be recorded as a function of the time.

When the component is stabilised, the test shall be stopped.

The component is deemed stabilised when the change of length over 1 h is less than one tenth of the change of length between ***t*** equal to 1 h and ***t*** equal to 2 h.

The value of the dynamic creep is the difference between the dimension of the component recorded before and at the end of the test under static force ***F*c**.

Figure 11 gives an example of a component stabilised after a test duration of 7 h.



Key

X Time (h)

Y Dimension

Figure 11 — Dynamic creep (example)

7.3.4 Static relaxation

The component shall be deflected at a constant dimension L_R, at a specific ambient temperature, and the force given by the component shall be measured according to 7.6.2.

The technical specification shall specify:

— the dimension L_R;

— the ambient temperature, if particular (see 7.1.1).

Then, the variation of the force given by the component, deflected at a constant dimension L_R, shall be recorded as a function of the time.

When the component is stabilised, the test shall be stopped.

The component is deemed stabilised when the change of force over 24 h is less than one tenth of the change of force between ***t*** equal to 1 h and ***t*** equal to 24 h.

The value of the static relaxation is the difference between the force recorded before and at the end of the test.

7.3.5 Dynamic relaxation

The component shall be deflected at a constant dimension L_R, at a specific ambient temperature, and the force given by the component shall be measured according to 7.6.2.

The technical specification shall specify:

— the dimension L_R;

— the ambient temperature, if particular (see 7.1.1).

Then, the component shall be deflected sinusoidally such that:

$$L_{Rsin} = L_R + (\beta \times (L_0 - L_R) \times \sin (2 \times \pi \times f \times t))$$ with:

— f : Frequency taken as equal to (10 ± 0,5) Hz if no other value is specified in the technical specification;

— β : Coefficient taken as equal to 0,1 if no other value is specified in the technical specification.

It is recommended that during the test, the component surface temperature does not exceed 40 °C. Otherwise, the frequency value will have to be reduced.

The variation of the mean force given by the component, compressed at a constant dimension L_R , shall be recorded as a function of the time.

When the component is stabilised, the test shall be stopped.

The component is deemed stabilised when the change of force over 1 h is less than one tenth of the change of force between t = 1 h and t = 2 h.

The value of the dynamic relaxation is the difference between the mean force recorded before and at the end of the test.

7.3.6 Other conditions

Tests methods shall be agreed between the customer and the supplier, and defined in the technical specification of the component.

7.4 Physical characteristics

7.4.1 Materials

Measurements of the material characteristics shall be carried out by appropriate test relevant to the kind of material.

Test methods shall be agreed between the customer and the supplier.

7.4.2 Mass

The mass shall be measured using test instruments adapted to the precision level required.

7.5 Geometrical and dimensional characteristics

7.5.1 Space envelope

The geometrical and dimensional characteristics shall be measured using test instruments adapted to the size of the component and to the precision level required.

7.5.2 Dimensions

The geometrical and dimensional characteristics shall be measured using test instruments adapted to the size of the component and to the precision level required.

7.6 Functional characteristics

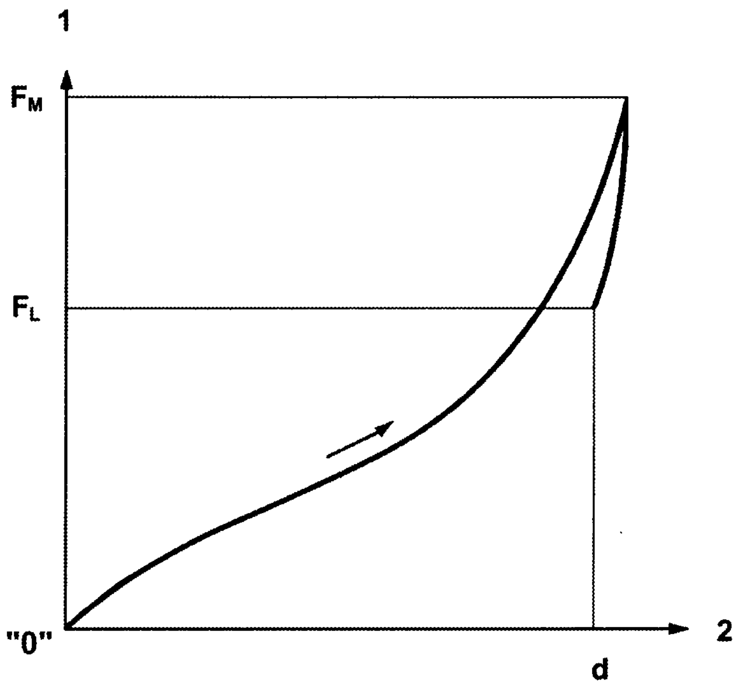
7.6.1 Dimensions under load

The dimensions of the component, under a specific load, shall be measured according to one of the following methods:

Four cycles shall be applied successively at a constant velocity between 0 and F_M.

a) Method A.

During the load decreasing phase of the fourth cycle, the component shall be held under a constant force F_L.



Key

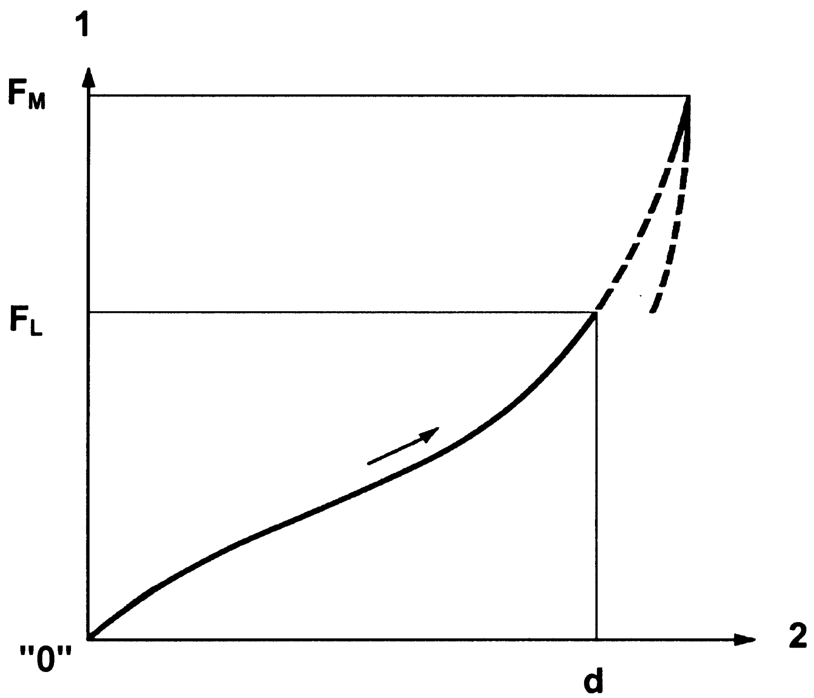
1 Force

2 Displacement

Figure 12 — Dimensions under load (method A)

b) Method B.

During the load increasing phase of the fourth cycle, the component shall be held under a constant force F_L.



Key

1 Force

2 Displacement

Figure 13 — Dimensions under load (method B)

The dimensions of the component, which are specified in the technical specification, shall be recorded after a stabilisation period of (10 ± 2) s.

The technical specification shall define:

— the method to be used;

— the forces F_M and F_L with $F_M > F_L$;

— the velocity to be used.

NOTE The dimensions can be determined on a fourth cycle executed just after those carried out for the measurement of force as a function of displacement characteristic at constant velocity (see 7.6.3). In this case, the velocity used for the fourth cycle need not be the same as that used for the first three.

7.6.2 Force under deformation

The force given by the component when it is deformed to a reference dimension, shall be measured according to one of the following method.

Four cycles of displacement shall be applied successively at a constant velocity between L_0 and L_M.

a) Method A.

During the displacement decreasing phase of the fourth cycle, the component shall be held at a constant dimension $\boldsymbol{L}_{\mathbf{D}}$.

b) Method B.

During the displacement increasing phase of the fourth cycle, the component shall be held at a constant dimension $\boldsymbol{L}_{\mathbf{D}}$.

The force given by the component shall be recorded after a stabilisation period of (10 ± 2) s.

The technical specification shall define:

— the method to be used;

— the dimensions $\boldsymbol{L}_{\mathbf{0}}$, $\boldsymbol{L}_{\mathbf{D}}$ and $\boldsymbol{L}_{\mathbf{M}}$;

— the velocity to be used.

NOTE The force under deformation can be determined on a fourth cycle executed just after those carried out for the measurement of force as a function of displacement characteristic at constant velocity (see 7.6.3). In this case, the velocity used for the fourth cycle need not be the same as that used for the first three.

7.6.3 Characteristics ″force as a function of displacement″ at constant velocity

7.6.3.1 Measurements

7.6.3.1.1 Method

According to the selected method for the definition of the characteristic (see 6.6.3.1.3), measurements shall be carried out by applying:

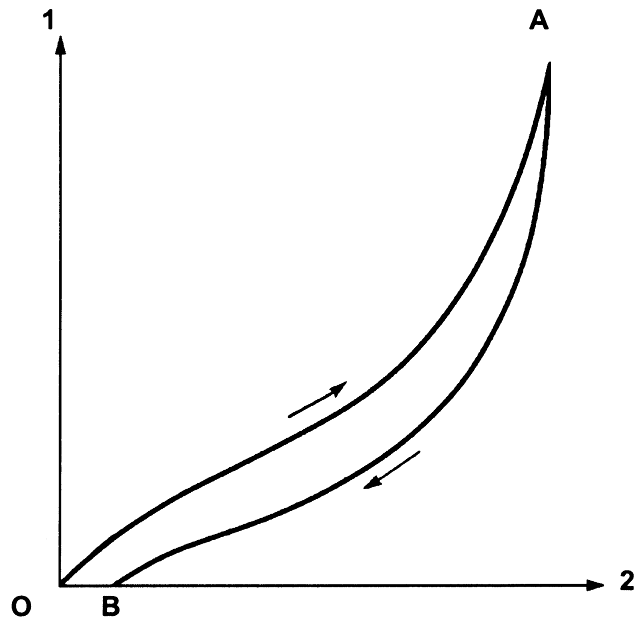
— either a force (or a moment) and recording the corresponding displacement (linear or angular);

— or a displacement (linear or angular) and recording the corresponding force (or a moment).

For each configuration, three cycles shall be carried out successively at a constant velocity of displacement, without interruption. The third cycle shall be recorded.

7.6.3.1.2 Determination of a characteristic ″force as a function of displacement″ at constant velocity on a nonalternating cycle (see example on Figure 14)

The characteristic shall be determined on the part of the recording corresponding to the increasing force (curve OA on the Figure 14).



Key

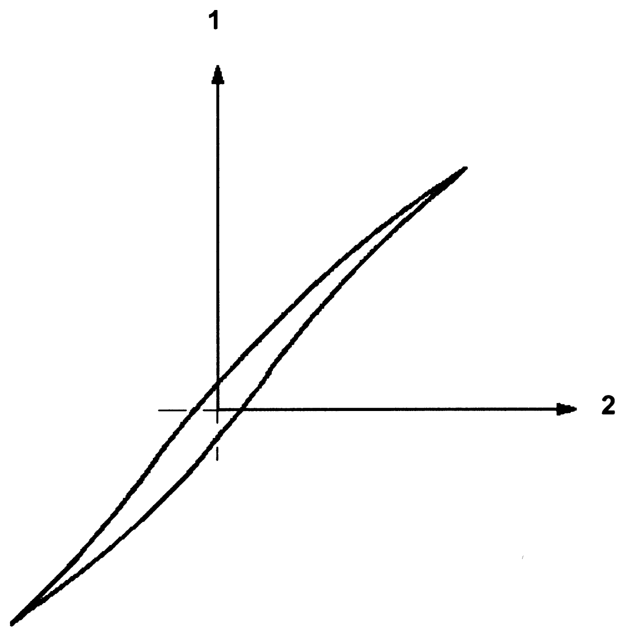
1 Force

2 Displacement

Figure 14 — Diagram force as a function of displacement (example of a non alternating cycle)

7.6.3.1.3 Determination of a characteristic ″force as a function of displacement″ at constant velocity on an alternating cycle (see example on Figure 15)

The method of measurement and interpretation of results shall be clearly defined in the technical specification.



Key

1 Force

2 Displacement

Figure 15 — Diagram force as a function of displacement (example of an alternating cycle)

7.6.3.1.4 Velocity

The measurement velocity shall be specified in the technical specification.

Recommended velocities are given in annex D.

During the test, the velocity shall remain constant.

7.6.3.2 Characteristics ″force as a function of displacement″ at constant velocity in a new condition

Measurements shall be carried out according to the prescriptions of the technical specification of the component and of 7.6.3.1.

7.6.3.3 Characteristics ″force as a function of displacement″ at constant velocity after test

Measurements shall be carried out just after the specified test, according to the prescriptions of the technical specification of the component and of 7.6.3.1.

7.6.4 Stiffnesses under sinusoidal motion

7.6.4.1 Definition

7.6.4.1.1 Stiffnesses under sinusoidal motion (*kdyn*) as a function of amplitude of the movement

The test consists in applying a dynamic oscillation ***d*** **(*t*)** or ***Θ*** **(*t*)** to the component at:

— the frequency specified in the technical specification;

— the various amplitudes of the movement specified in the technical specification;

and of recording the corresponding force ***F*** **(*t*)** or moment ***M*** **(*t*)**.

At every amplitude of the movement specified in the technical specification, the excitation shall be applied for at least ten cycles before recording.

Stiffnesses ***kdyn*** shall be measured from the displacements that cause movements of the form:

— When the oscillation is a linear displacement,

$$d(t) = (a \times \sin(2 \times \pi \times f \times t)) + d_P \qquad \text{where}$$

— $d(t)$: instantaneous movement;

— d_P : mean displacement;

— a : amplitude of the displacement;

— f : frequency;

— t : time.

Stiffness ***kdyn*** is defined as being equal to the ratio of the force variation to the displacement variation:

$$kdyn = (F_{max} - F_{min}) / (2 \times a)$$

— When the oscillation is an angular displacement,

$$\Theta(t) = (a \times \sin(2 \times \pi \times f \times t)) + \Theta_P \qquad \text{where}$$

— $\Theta(t)$: instantaneous movement;

— Θ_P : mean angular displacement;

— a : amplitude of the angular displacement;

— f : frequency;

— t : time.

Stiffness ***kΘdyn*** is defined as being equal to the ratio of the moment variation to the displacement variation:

$$k\Theta dyn = (M_{max} - M_{min}) / (2 \times a)$$

7.6.4.1.2 Stiffnesses under sinusoidal motion (*kdyn*) as a function of amplitude of the force (or moment)

The test consists in applying a dynamic oscillation ***F*** **(*t*)** or ***M*** **(*t*)** to the component at:

— the frequency specified in the technical specification;

— the various amplitudes of the force (or moment) specified in the technical specification;

and of recording the corresponding displacement ***d*** **(*t*)** or ***Θ*** **(*t*)**.

At every amplitude of the force (or moment) specified in the technical specification, the excitation shall be applied for at least ten cycles before recording.

Stiffnesses ***kdyn*** shall be measured from the forces (or moments) that cause movements of the form:

— When the oscillation is a force,

$$F(t) = (C \times \sin(2 \times \pi \times f \times t)) + F_P$$ where

- $F(t)$: instantaneous force;
- F_P : mean force;
- C : amplitude of the force;
- f : frequency;
- t : time.

Stiffness ***kdyn*** is defined as being equal to the ratio of the force variation to the displacement variation:

$$k_{dyn} = (2 \times C) / (d_{max} - d_{min})$$

— When the oscillation is a moment,

$$M(t) = (C \times \sin(2 \times \pi \times f \times t)) + M_P$$ where

- $M(t)$: instantaneous moment;
- M_P : mean moment;
- C : amplitude of the moment;
- f : frequency;
- t : time.

Stiffness ***kΘdyn*** is defined as being equal to the ratio of the moment variation to the displacement variation:

$$k\Theta dyn = (2 \times C) / (\Theta_{max} - \Theta_{min})$$

7.6.4.1.3 Stiffnesses under sinusoidal motion (*kdyn*) as a function of frequency

The test consists in applying a dynamic oscillation $d(t)$, $\Theta(t)$, $F(t)$ or $M(t)$ to the component at:

— the amplitude of the dynamic oscillation specified in the technical specification;

— the various frequencies specified in the technical specification;

and of recording the corresponding force $F(t)$, moment $M(t)$, displacement $d(t)$, or angular displacement $\Theta(t)$.

At every frequency specified in the technical specification, the excitation shall be applied for at least ten cycles before recording.

According to the mode of oscillation, stiffnesses ***kdyn*** shall be measured with the corresponding method (see 7.6.4.1.1 and 7.6.4.1.2).

7.6.4.2 Stiffnesses under sinusoidal motion in new condition

Measurements shall be carried out according to the prescriptions of the technical specification of the component and of 7.6.4.1.

7.6.4.3 Stiffnesses under sinusoidal motion after test

Measurements shall be carried out just after the specified test, according to the prescriptions of the technical specification of the component and of 7.6.4.1.

7.6.5 Damping

7.6.5.1 Definition

7.6.5.1.1 Characteristic ″phase angle δ (or other parameter) as a function of amplitude of the movement″

The test consists in applying a dynamic oscillation $d(t)$ or $\Theta(t)$ to the component at:

— the frequency specified in the technical specification;

— the various amplitudes of the movement specified in the technical specification;

and of recording together the variation of the deformation applied ($d(t)$ or $\Theta(t)$) and the variation of the transmitted force $F(t)$ or moment $M(t)$.

The difference in phase between the transmitted force and the deformation (phase angle δ), shall be determined.

7.6.5.1.2 Characteristic ″phase angle δ (or other parameter) as a function of amplitude of the force (or the moment)″

The test consists in applying a dynamic oscillation $F(t)$ or $M(t)$ to the component at:

— the frequency specified in the technical specification;

— the various amplitudes of the force (or moment) specified in the technical specification;

and of recording together the variation of the deformation applied ($d(t)$ or $\Theta(t)$) and the variation of the transmitted force $F(t)$ or moment $M(t)$.

The difference in phase between the transmitted force and the deformation (phase angle δ), shall be determined.

7.6.5.1.3 Characteristic ″phase angle δ (or other parameter) as a function of frequency″

The test consists in applying a dynamic oscillation $d(t)$, $\Theta(t)$, $F(t)$ or $M(t)$ to the component at:

— the amplitude of the dynamic oscillation specified in the technical specification;

— the various frequencies specified in the technical specification;

and of recording together the variation of the deformation applied ($d(t)$ or $\Theta(t)$) and the variation of the transmitted force $F(t)$ or moment $M(t)$.

The difference in phase between the transmitted force and the deformation (phase angle δ), shall be determined.

7.6.5.2 Damping in new condition

Measurements shall be carried out according to the prescriptions of the technical specification of the component and of 7.6.5.1.

7.6.5.3 Damping after test

Measurements shall be carried out just after the specified test, according to the prescriptions of the technical specification of the component and of 7.6.5.1.

8 Marking

The customer shall specify any marking requirements.

For example:

— supplier's logo;

— production plant code, if there is more than one plant;

— product reference;

— manufacturing date (month and year);

— additional indications, if required by the customer.

When it is possible, these markings shall be placed in a position where they are not likely to come into contact with surrounding parts.

If necessary, the prohibited areas for marking shall be defined in definition documents established by the customer.

The location of the above markings shall be clearly identified on the part drawing established by the supplier.

To ensure traceability (see annex E), these marks shall be readable throughout the working life of the component.

Annex A
(informative)

Design of the test devices and analysis of the parasitic deformations during stiffness measurements

A.1 Design of the test devices

The design of the test devices can have a decisive impact on the results of the measurements of the stiffnesses of the component.

Therefore, it is important to define the essential characteristics of the test devices.

For example, for an elastic joint comprising an outer ring and an axis, the following characteristics of the test device shall be defined:

— the minimum length of the bore;

— the toleranced diameter of the bore;

— the surface texture of the bore;

— the minimal thickness of material.

All these parameters determine the tightening of the outer ring on the component and therefore the strain on the elastomer, which can substantially affect the stiffness characteristics of the component.

A.2 Analysis of the parasitic deformations

Experience shows that the stiffness of a component should be greater than that of the measurement equipment (test machine, force sensor and test device).

In any case the deformations of this assembly are rarely negligible and should never be ignored.

The test laboratory in charge of carrying out the measurements (test machine, force sensor and test device) therefore clearly states the method used to allow for these parasitic deformations.

The stiffness of the measurement equipment is measured and taken into account in the stiffness measurements of the component.

Annex B
(informative)

Examples of fatigue test programme

B.1 Object

This annex details two fatigue test methods, which can be used as a basis to draw up the fatigue test programme defined in the technical specification (see 7.3.1).

B.2 "Staircase" method

B.2.1 Test principle

The test consist in applying loading sequences to the component, which are the addition of quasi-static forces ($\boldsymbol{F}_q$) and dynamic forces ($\boldsymbol{F}_d$) varying with time (see Figure B.1).

The total number of cycles of dynamic variations (N1 + N2 + N3) is generally equal to 10×10^6 (see Figure B.2).

The values of $\boldsymbol{F}_q$, $\boldsymbol{F}_s$ and $\boldsymbol{F}_d$ as well as the frequencies are defined in the technical specification.

During the test, ensure that the component surface temperature does not exceed 40 °C. Otherwise, the frequency value will be reduced.

In the absence of any indication, the following values are used:

a = $(F_q + F_d)$;

b = $1{,}2 \times (F_q + F_d)$;

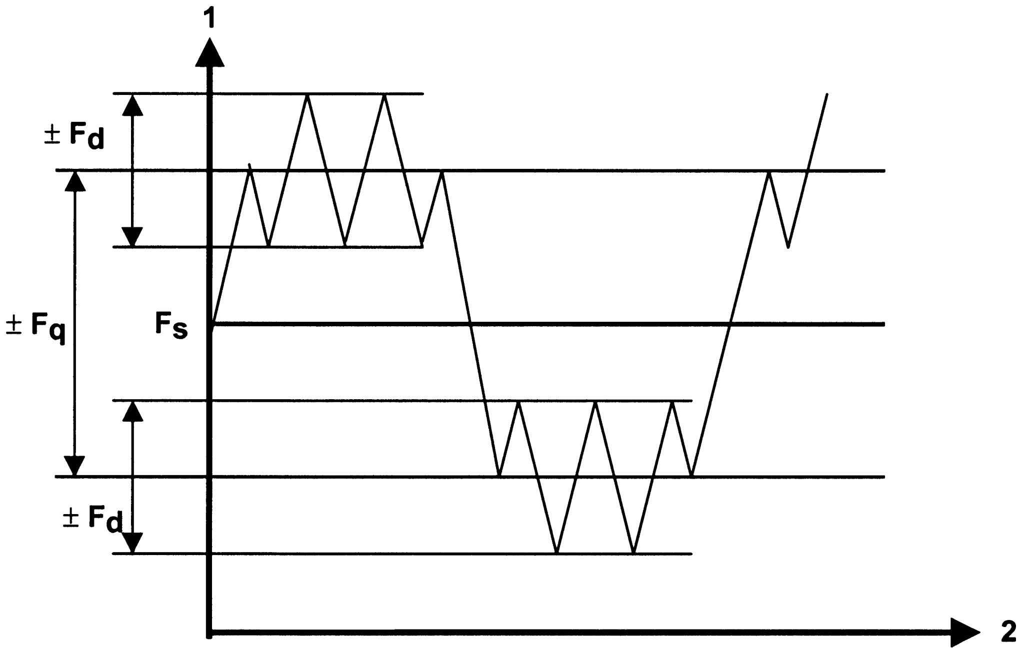
c = $1{,}4 \times (F_q + F_d)$;

N1 = 6×10^6;

N2 = 2×10^6;

N3 = 2×10^6

This test can be carried out by applying displacement instead of forces (or moment) with the same procedure.

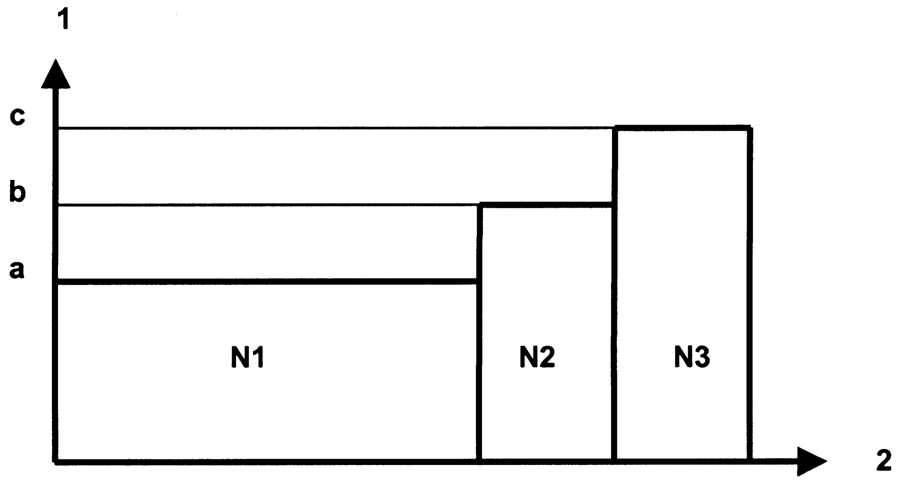


Key

1 Force

2 Time

Figure B.1 — Loading sequences (example with forces)



Key

1 Loading sequences

2 Cycles

Figure B.2 — Stages

The variation of the characteristics ″force as a function of displacement″ and the state of the component is recorded during the fatigue test.

The characteristics ″force as a function of displacement″ to observe and the criteria are defined in the technical specification.

B.2.2 Results

The component meets the requirements of the technical specification.

In the absence of indications in the technical specification, the checks are carried out as follows:

— Variation of the characteristics ″force as a function of displacement″.

  Unless otherwise specified, characteristics ″force as a function of displacement″ do not differ from the values recorded in the initial state by more than:

  5 % after the first stage (N1);

  10 % after the second stage (N2);

  15 % after the third stage (N3).

— Deterioration

  Final assessment of the component (destructive test):

  Location and extent of the visual abnormalities of the elastomer, condition of the other materials.

B.3 ″Programmed blocks″ method

This fatigue test consists of the following stages:

B.3.1 Line test

Measurement of the loads to which the component is submitted when operating.

B.3.2 Loads distribution

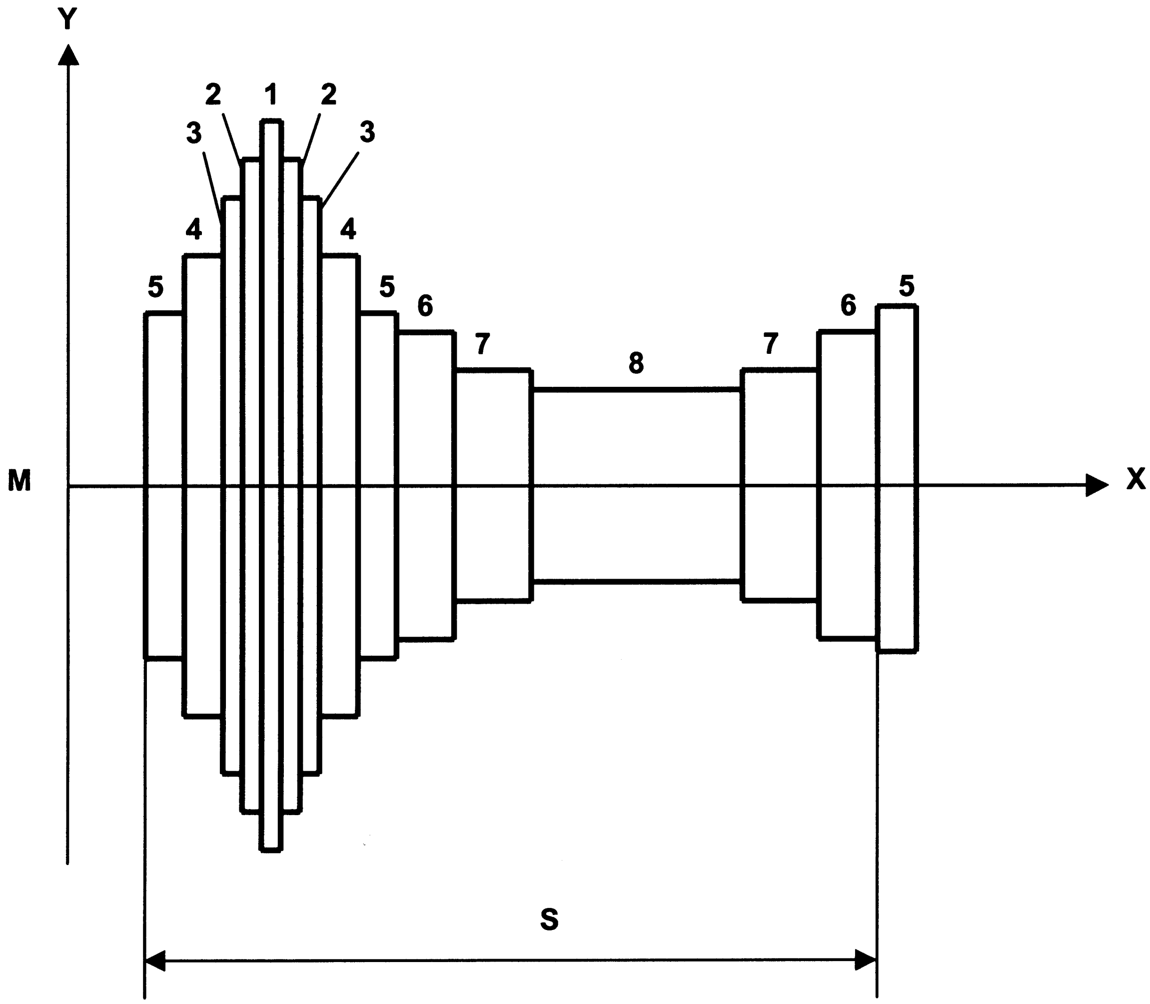
Making up of the loads distribution, using the method of "peak counting" between two zero crossing (in general, the mean value is zero).

B.3.3 Blocks

Classification of the loads into eight blocks (number recommended).

B.3.4 Sequence

Determination of the fatigue test program in sequences, as shown on Figure B.3.



Key

Y Loadings

X Cycles

M Mean load

S 1 sequence (8 blocks) is equivalent to a given distance covered.

Figure B.3 — Definition of a sequence (example)

B.3.5 Test principle

Each sequence is reproduced on a component submitted for testing.

The number of sequences is determined beforehand so as to obtain the expected number of kilometres.

The test can be continued until destruction of the component to estimate its life expectancy.

During the test, ensure that the component surface temperature does not exceed 40 °C. Otherwise, the frequency value will be reduced.

The variation of the characteristics ″force as a function of displacement″ and the state of the component are recorded during the fatigue test.

The characteristics ″force as a function of displacement″ to observe and the criteria are defined in the technical specification.

B.3.6 Results

The component meets the requirements of the technical specification.

In the absence of indications in the technical specification, the checks are carried out as follows:

— Variation of the characteristics "force as a function of displacement″

  Unless otherwise specified, characteristics ″force as a function of displacement″ do not differ from the values recorded in the initial state by more 15 % after the fatigue test.

— Deteriorations

  Final assessment of the component (destructive test):

  Location and extent of the visual abnormalities of the elastomer, condition of the other materials.

Annex C
(informative)

Recommended tolerances and acceptance criteria to characteristics of components

C.1 Object

The present annex is a guide for the definition of tolerances and acceptance criteria applying on the functional characteristics of components.

NOTE The closest tolerances and acceptance criteria should be specified only where the application requires it. Closer tolerances and acceptance criteria demand stricter control during manufacture and, consequently, the cost of the product is increased.

C.2 Tolerances and acceptance criteria

Tolerances and acceptance criteria are identified in the technical specification of the component.

Practical limits are shown in Tables C.1, C.2, C.3, C.4 and wherever possible these should not be exceeded.

Where different tolerances and acceptance criteria are to be specified, these ones are agreed between the supplier and the customer.

Table C.1 — Acceptance criteria on resistance characteristics to environmental conditions

Characteristic	Close Criteria	Normal Criteria
Corrosion (salt spray) resistance	≥ 360 h	≥ 240 h
Abrasion resistance loss of volume of test sample	< 100 mm^3	< 200 mm^3

Table C.2 — Acceptance criteria on functional characteristics

Permissible variation [a] of characteristics ″force as a function of displacement″ after:	Close Criteria	Normal Criteria
static creep	± 10 %	± 20 %
dynamic creep	± 15 %	± 20 %
static relaxation	± 10 %	± 20 %
dynamic relaxation	± 15 %	± 20 %
heat ageing	± 15 %	± 20 %
[a] in relation to that measured in new condition		

Table C.3 — Acceptance criteria on functional characteristics

Permissible variation [a] of stiffnesses under sinusoidal motion after:	Close Criteria	Normal Criteria
static creep	± 15 %	± 20 %
dynamic creep	± 15 %	± 20 %
static relaxation	± 15 %	± 20 %
dynamic relaxation	± 15 %	± 20 %
heat ageing	± 20 %	± 25 %
[a] in relation to that measured in new condition		

Table C.4 - Tolerances on functional characteristics

Characteristic	Close Tolerance	Normal Tolerance
Characteristics ″force as a function of displacement″ at constant velocity	± 15 %	± 20 %
Stiffnesses under sinusoidal motion	± 15 %	± 20 %

Annex D
(informative)

Recommended measurement velocities

The present annex is a guide for the definition of measurement velocities of stiffnesses at constant velocity and length under load.

Measurement velocities are preferably selected among those indicated in Table D.1, in such a way that the total time of each cycle falls between thirty and sixty seconds.

Where different velocities are to be specified, these velocities are agreed between the supplier and the customer.

Table D.1 — Measurement velocities

Linear displacement (mm / min)	Angular displacement (rad / min)
1	0,080
2	0,160
5	0,320
10	0,640
20	1
50	

Annex E
(informative)

Traceability, qualification and quality surveillance

E.1 Traceability

Suppliers establish an identification and traceability system of the product according to definition given in EN ISO 9000.

Traceability is the subject of a contractual document between the customer and the supplier.

E.2 Supplier production plant qualification

The various manufacturing operations of the component, including the manufacturing of its component parts, are only performed by qualified suppliers, according to definition given in EN ISO 9000, and possessing a certified quality assurance system according to EN ISO 9001.

E.3 Approval and qualification of the product

E.3.1 Approval

Before it is fitted to a vehicle, a component could be subject to approval (according to definition in EN 45020) by the customer.

When such an approval is required, all condition and procedures for approval are agreed between customer and supplier.

E.3.2 Qualification

E.3.2.1 General

The definitions given in EN ISO 9000 apply.

Before being used on a vehicle, every new component (of a new or known supplier), or every existing component used for a new application (new technical specification), is qualified.

The characteristics and properties of the component are be verified (type test) according to the customer requirements.

The extent of testing is defined in the technical specification and agreed between customer and supplier.

E.3.2.2 Test pieces

The definition and the preparation of test pieces are defined in 7.1.3.

All components taken as test pieces for qualification tests are taken from the same production batch and delivered together.

Test pieces are representative of the production technology, the materials employed and all the characteristics for which qualification is requested.

The number of test samples and the distribution of tests and inspections on tests samples, are specified in the technical specification.

E.3.2.3 Qualification procedure

The qualification procedure consists of verification of the conformity of the product to the stated requirements.

All the characteristics specified in the technical specification are verified on the product submitted for qualification.

The qualification procedure of the component, with the exception of those supplied by a new supplier, can be simplified in accordance with the quality system in force with the supplier.

The verification of known characteristics can be optional.

A simplified qualification process is , in any case, subject to a separate agreement between customer and supplier.

The checks are performed in accordance with the requirements of the technical specification.

The laboratory/laboratories that perform the qualification tests is/are designated after agreement of the customer.

E.3.2.4 Validity of the product qualification

After the qualification of the product, any modification in design, technology, composition, changes in manufacturing process or modifications in the manufacturing plant, is reported to the customer for approval before implementation.

The customer can in this case question the validity of the product qualification.

Qualification can also be thrown into doubt after:

— interruption of the manufacturing process for more than two years;

— operating incidents that throw doubt on the component's quality.

E.4 Inspection and quality surveillance

For the purposes of the present clause, the definitions given in EN ISO 9000 apply.

The supplier proposes the methods for checking the manufacturing quality of his products within a quality plan submitted for the approval of the customer.

The customer can require verification of specific characteristics, according to Table 2.

In that case, the test procedure and the check proportions are defined in the technical specification.

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EN ISO 9000, *Quality management systems – Fundamentals and vocabulary (ISO 9000:2000).*

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EN 45020*, Standardization and related activities – General vocabulary (ISO/IEC Guide 2:1996).*

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