

Railway applications — Rubber suspension components — Rubber diaphragms for pneumatic suspension springs

The European Standard EN 13597:2003 has the status of a
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National foreword

This British Standard is the official English language version of EN 13597:2003.

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.

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Foreword

This document (EN 13597:2003) 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of an identical text or by endorsement, at the latest by August 2003, and conflicting national standards shall be withdrawn at the latest by August 2003.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 coordinating 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 B and D are normative.

The annexes A and C 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 a suspension diaphragm 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.

The requirements of the European Standard should operate in conjunction with the conditions for the supply of air spring suspension diaphragms.

This European Standard is the result of studies and research to improve the performances and quality of rubber diaphragms for pneumatic suspension springs 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 rubber diaphragms for pneumatic suspensions springs.

1 Scope

This European Standard specifies:

- characteristics that suspension diaphragms achieves, 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 diaphragms in manufacture;
- supply requirements.

This European Standard applies to suspension diaphragms 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.

The European Standard does not detail the other components of pneumatic suspension assemblies or control systems such as air reservoirs, frames, stiffeners, emergency suspension systems or elastic supports (such as series springs), etc., which will affect the diaphragm performance.

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).

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

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

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

ISO 36, *Rubber, vulcanized or thermoplastic – Determination of adhesion to textile fabric*.

ISO 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD ⁴⁾)*.

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

ISO 1382, *Rubber – Vocabulary*.

ISO 1431-2, *Rubber, vulcanized or thermoplastic – Resistance to ozone cracking – Part 2: Dynamic strain test*.

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

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

⁴⁾ IRHD : International Rubber Hardness Degrees

ISO 2921, *Rubber, vulcanized – Determination of low-temperature characteristics – Temperature – Retraction procedure (TR test)*.

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

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 terms and definitions in ISO 1382 together with the following apply.

3.1.1

bead

end feature of the diaphragm which enables it to be secured and sealed to the surrounding structure

NOTE A diaphragm has two beads.

3.1.2

bead core

reinforcing core, vulcanized in at both ends of the carcass

NOTE It assures permanent seating on a conical or other specifically shaped mounting part.

3.1.3

carcass

structure of reinforcing material, typically consisting of heavy duty fabric plies arranged crosswise, embedded in the elastomer for flexible force transmission

3.1.4

diaphragm

the term "diaphragm" herein applies to the finished product, comprising of carcass and beads for use as part of pneumatic suspension system

NOTE Different types of diaphragms are illustrated in annex A.

3.1.4.1

new diaphragm

diaphragm in new condition and never yet used

3.1.4.2

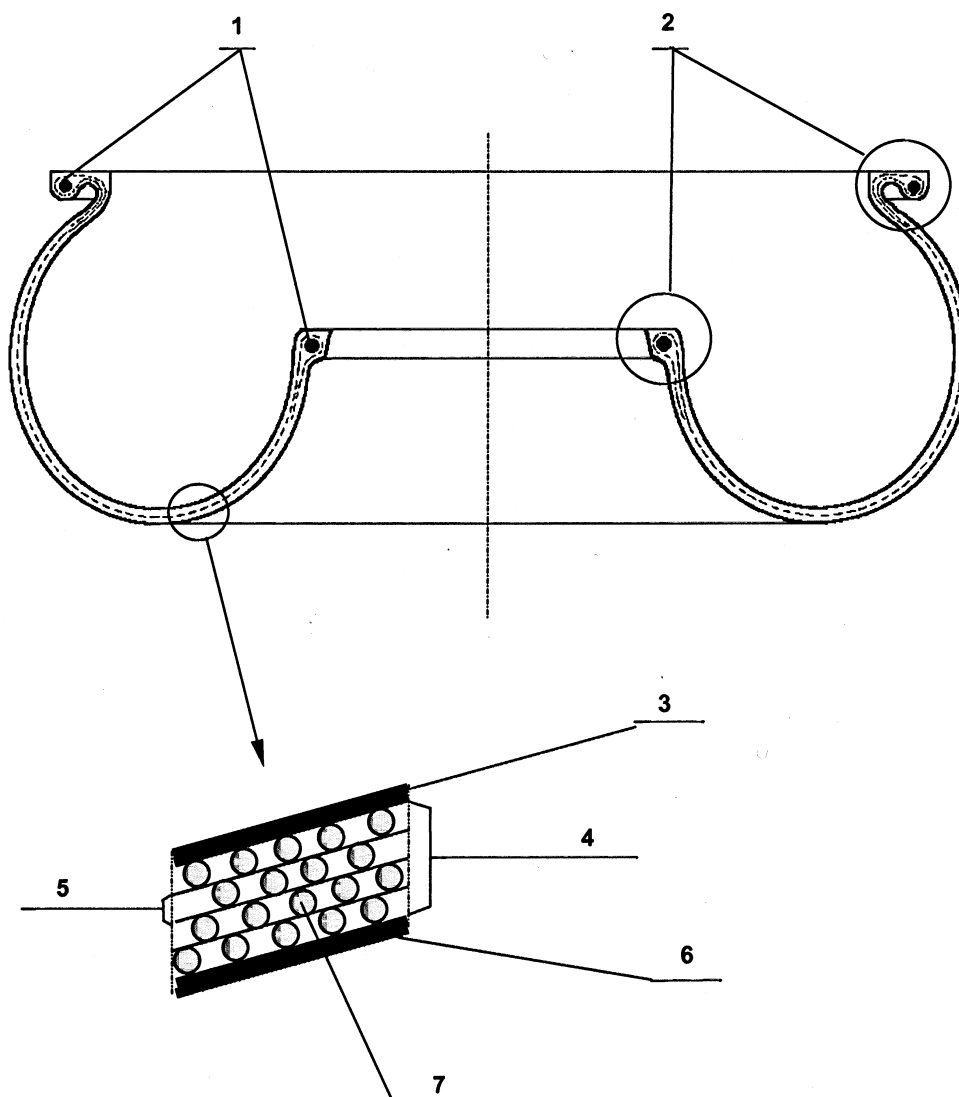
grown diaphragm

diaphragm which has been in use and, as a result, has changed dimensionally

3.1.5

ply

layer typically made up of rubberized fabric



Key

- 1 Bead cores
- 2 Beads
- 3 Inner layer of rubber
- 4 Carcass
- 5 Ply
- 6 Outer layer of rubber
- 7 Rubberized fabric

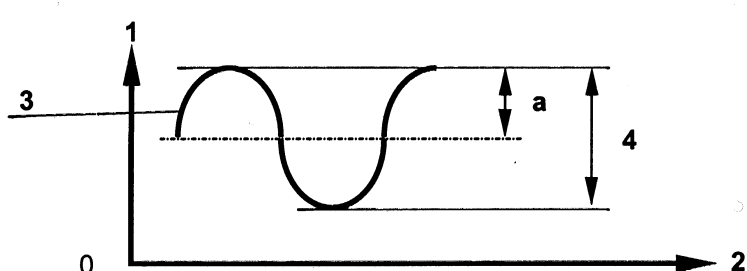
Figure 1 — Different parts of a diaphragm

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 in Table 1 can be used.

Table 1 — Symbols and abbreviations

Symbol Abbreviation	Unit	Explanation
A_e	m^2	Effective area of the diaphragm, with: — $A_e = F / p$ — $\Delta A_e / \Delta d$: Variation of the effective area in function of axial displacement. $\Delta A_e / \Delta d = ((F_{(j+1)} - F_j) / p) / (d_{(j+1)} - d_j)$
a	m or rad	Amplitude of the movement, with $a = \Delta d / 2$ or $a = \Delta \theta / 2$.  Key 1 Displacement (d or θ) 2 Time (t) 3 $d(t)$ or $\theta(t)$ 4 Δd or $\Delta \theta$ Figure 2 — Amplitude definition
D	m	Outer diameter of diaphragm (see Figures 5, A.1, A.2, A.3 and A.4), with: D_{pi}: Outer diameter of diaphragm for a given internal pressure (see explanation symbol p).
d	m	Linear displacement, with: d_M: Maximum operational displacement; Δd: Difference between peak movements measured on the "force versus linear displacement" diagram (see Figures 2 and 14). NOTE The above symbols state the direction of the displacement (see 3.3). For example, d_{Mx} corresponding to a maximum displacement parallel to axis O_x.
e	m	Thickness of test sample for verification of low temperature resistance (see 7.2.1).
F	N	Static force applied on the diaphragm, with: F_j: Various operational forces (F_1, F_2, F_3, etc.), with: $0 \leq F_0 < F_j < F_M$; F_0: Minimum operational force; F_M: Maximum operational force; ΔF: Difference between peak forces measured on the "force versus linear displacement" diagram (see Figure 14). NOTE The above symbols state the direction of the force (see 3.3). For example, F_{z0} corresponding to the minimum operational force applied on the diaphragm along axis O_z.

to follow

Table 1 (continued)

Symbol Abbreviation	Unit	Explanation
f	Hz	Frequency
H	m	Height of the diaphragm (see Figures 5, 6, A.1, A.2, A.3 and A.4), with: H_1 : Maximum overall dimension of the diaphragm in relation to its upper surface (supporting face of the upper bead) when the diaphragm is submitted to a radial displacement. H_2 : Minimum overall dimension of the diaphragm in relation to its upper surface (supporting face of the upper bead) when the diaphragm is submitted to a radial displacement. H_{pj} : Height of the diaphragm for a given internal pressure (see explanation symbol p).
h_N	m	Height of levelling of the diaphragm. Distance between the thrust surfaces of the diaphragm beads (see Figures 5, 6, A.1, A.2, A.3 and A.4). This dimension is essential when setting the height of pneumatic springs and shall be specified in the definition documents.
ks	N/m	Stiffness at constant velocity. Stiffness of the diaphragm measured along an axis, at constant velocity. NOTE 1 The above symbol states the direction of the characteristic (see 3.3). For example, ks_y corresponding to constant velocity stiffness measured about axis O_y . NOTE 2 It is permitted to define a flexibility at constant velocity instead of a stiffness at constant velocity, where flexibility is the inverse of stiffness ($1/ks$).
$k\theta s$	N·m/rad	Rotational stiffness at constant velocity. Stiffness of the diaphragm measured around an axis, at constant velocity. NOTE 1 The above symbol states the direction of the characteristic (see 3.3). For example, $k\theta s_z$ corresponding to rotational stiffness at constant velocity measured around axis O_z . NOTE 2 It is permitted to define a rotational flexibility at constant velocity instead of a rotational stiffness at constant velocity, where flexibility is the inverse of stiffness ($1/k\theta s$).
k_{dyn}	N/m	Stiffness under sinusoidal motion. Stiffness of the diaphragm measured along an axis, under a sinusoidal motion. NOTE 1 The above symbol states the direction of the characteristic (see 3.3). For example, k_{dyn_z} corresponding to stiffness measured about axis O_z under a sinusoidal motion. NOTE 2 It is permitted to define a flexibility under a sinusoidal motion instead of a stiffness under a sinusoidal motion, where flexibility is the inverse of stiffness ($1/k_{dyn}$).

to follow

Table 1 (continued)

Symbol Abbreviation	Unit	Explanation
$k\theta_{dyn}$	N·m/rad	Rotational stiffness under sinusoidal motion. Stiffness of the diaphragm measured around an axis, under a sinusoidal motion. NOTE 1 The above symbol states the direction of the characteristic (see 3.3). For example, $k\theta_{dyn_z}$ corresponding to rotational stiffness measured around axis O_z under a sinusoidal motion. NOTE 2 It is permitted to define a rotational flexibility under a sinusoidal motion instead of a rotational stiffness under a sinusoidal motion, where flexibility is the inverse of stiffness ($1/k\theta_{dyn}$).
L_B	m	Half of the distance between the bogie pivots of the vehicle to which the diaphragm is fitted.
L_b	m	Distance from the diaphragm centre line to the bogie pivot.
l_0	m	Reference length of test piece for verification of low temperature resistance (see 7.2.1).
M	N·m	Moment applied around an axis of the diaphragm, with: M_j : Various operational moments (M_1, M_2, M_3 , etc.), with : $0 < M_j < M_M$. M_M : Maximum operational moment corresponding to a maximum angular displacement θ_M . ΔM : Difference between peak moments measured on the "moment versus angular displacement" diagram (see Figure 14). NOTE The above symbols state the axis of rotation (see 3.3). For example, M_{Mz} corresponding to the maximum moment applied around axis O_z .
p	Pa	Diaphragm relative internal pressure (above atmospheric pressure), with: p_i : Various internal pressures (p_1, p_2 , etc.) when diaphragm is submitted to an axial static force F_i , with: $0 \leq p_0 < p_i < p_M$. p_0 : Internal pressure when diaphragm is submitted to the minimum axial static force F_0 . p_M : Internal pressure when diaphragm is submitted to the maximum axial static force F_M . p_B : Diaphragm bursting pressure. NOTE 1 1 Pa = 1 N/m ² ; 1 bar = 100 kPa. NOTE 2 Use of this symbol as a suffix indicates a parameter which varies with internal pressure (which should be defined according to the above definitions).
R_1	m	Maximum overall dimension of the diaphragm in relation to the axis of the fixed section of the diaphragm when radially displaced (see Figure 6).
R_2	m	Minimum overall dimension of the diaphragm in relation to the axis of the fixed section of the diaphragm when radially displaced (see Figure 6).
R_c	m	Radius of the track curve.
r	%	Percentage of retraction of test piece for verification of low temperature resistance (see 6.2.1).

to follow

Table 1 (concluded)

Symbol Abbreviation	Unit	Explanation
t	s	Time, with: Δt : Period of oscillation ($1/f$).
V_D	m^3	Diaphragm air volume. Volume defined by the shell of the inner carcass surface and the two parallel planes formed by the inner edge of the beads (see Figures 3 and 4).
V_{AUX}	m^3	Auxiliary air volume. Any volume increase or reduction of V_D for testing (see Figures 3 and 4).
V_T	m^3	Total air volume Volume applied for testing, with: $V_T = V_D + V_{AUX}$ (see Figures 3 and 4).
Δm_A	g/m^2	Variation in weight by surface unit of test piece for verification of oil and petroleum product resistance (see 6.2.3).
θ	rad	Angle of displacement in a plane around an axis of the diaphragm, with: θ_M : Maximum operational angular displacement around a clearly defined axis. $\Delta\theta$: The difference between peak movements measured on the "moment versus angle of displacement" diagram (see Figures 2 and 14). NOTE 1 The above symbols state the axis of rotation (see 3.3). For example, θ_{Mz} corresponding to a maximum angular displacement around axis O_z . NOTE 2 It is permissible to use angular units of degrees instead of radians.

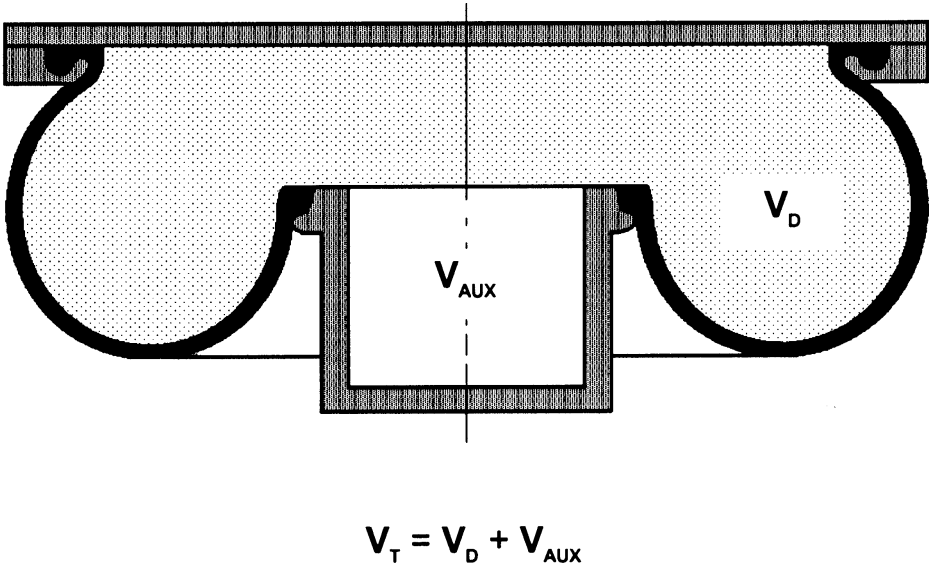
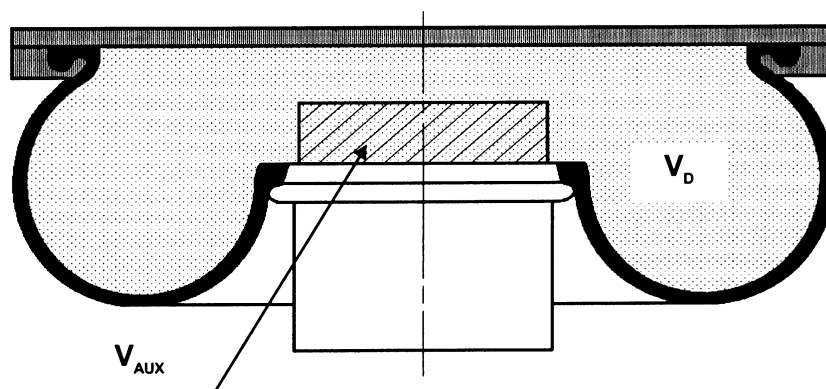


Figure 3 — Definition of air volumes (example with positive auxiliary air volume)



$$V_T = V_D - V_{AUX}$$

Figure 4 — Definition of air volumes (example with negative auxiliary air volume)

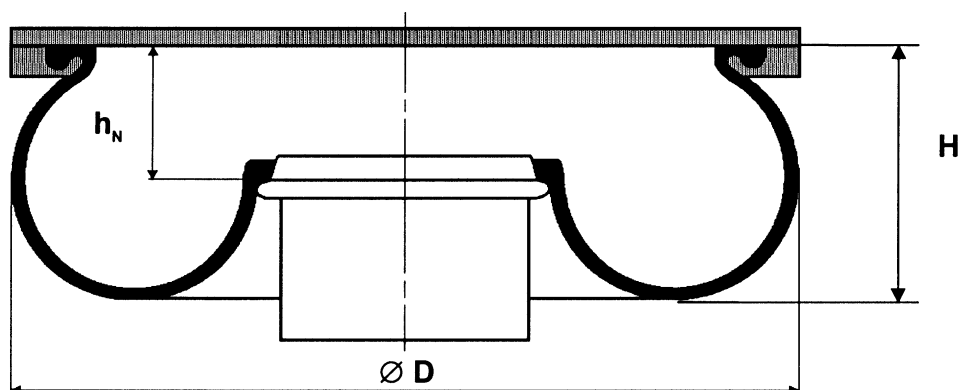
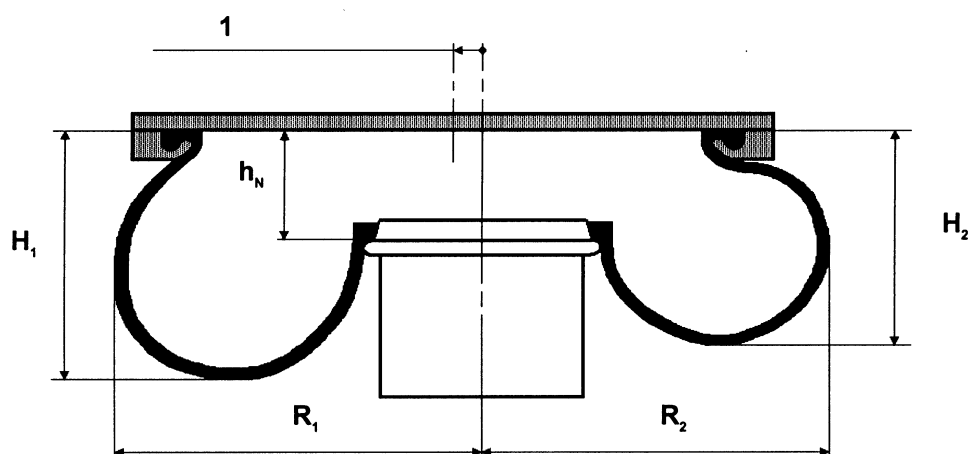


Figure 5 — Main dimensions when diaphragm is in a centred position



Key

- 1 Setting over

Figure 6 — Main dimensions when diaphragm is radially displaced

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 O_{xyz} , related to the vehicle and with a supposedly fixed point within the mechanical system to which the diaphragm belongs as origin, is established as follows:

- axis O_x parallel to the longitudinal axis of vehicle X;
- axis O_y parallel to the transverse axis of vehicle Y;
- axis 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 O_x : d_x ;
- displacement parallel to axis O_y : d_y ;
- displacement parallel to axis O_z : d_z ;
- rotation around axis O_x : θ_x ;
- rotation around axis O_y : θ_y ;
- rotation around axis O_z : θ_z ;

The positive direction of rotation is clock wise 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 7.

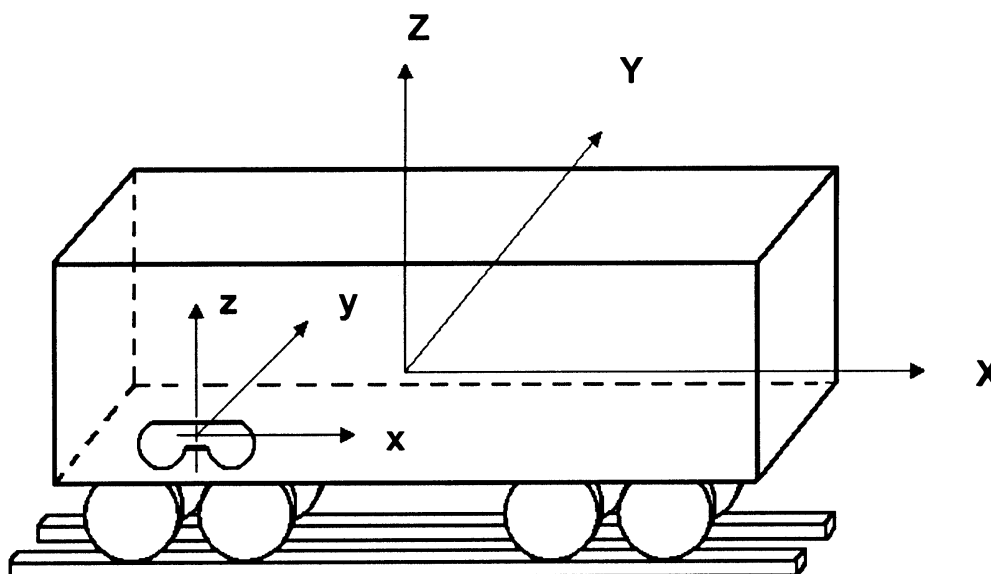


Figure 7 — Three dimensional definition of characteristics

4 Definition documents

4.1 General

Diaphragms 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 suspension or a sub-assembly drawing) showing at least:
 - space envelope;
 - functional dimensions and tolerances;
 - position of marking.
- 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 diaphragm and detailing at least:

- information required for use of the diaphragm (e.g.: performance data, mounting instruction, etc.);
- definition drawing including overall dimensions (diaphragm held in a centred position and during peak movements).

5 Conditions of utilisation

5.1 General

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

5.2 Climatic and atmospheric conditions

The range of atmospheric temperatures (ambient temperature outside of the vehicle) to consider shall normally be “– 25 °C to + 50 °C”.

However, a different range of atmospheric temperatures can be selected in case of special service conditions or particular geographical situation.

5.3 Environmental conditions

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

- chemical products (cleaning products for example);
- organic wastes;
- oil sprays;
- flying ballast;
- etc.

5.4 Mechanical conditions

During its life the diaphragm is subjected to forces and displacements (axial, radial, angular), due to the functional conditions of the vehicle to which it is fitted.

These forces and displacements shall be taken into consideration for the definition of the diaphragm and therefore have to be defined in the technical specification.

The technical specification, provided by the customer, shall specify at least:

- a) axial static forces F_0 , F_j (F_1 , F_2 , F_3 , ...) and F_M .
- b) displacements:
 - the maximum axial displacement in compression ($- d_M$) and extension ($+ d_M$) of the mechanical system, of which the diaphragm is a part, relative to height of levelling h_N ;

- the maximum radial displacement d_M as function of the axial static force F_j applied to the mechanical system, of which the diaphragm is a part;
- the maximum angular deformation Θ_M as function of the axial static force F_j applied to the mechanical system, of which the diaphragm is a part.

6 Definition of the product

6.1 General

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

These characteristics shall be selected among those specified in Table 2.