



BSI Standards Publication

Fluid power systems — O-rings

Part 2: Housing dimensions for general applications

National foreword

This British Standard is the UK implementation of ISO 3601-2:2025. It supersedes BS ISO 3601-2:2016, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/18/-/3, Cylinders.

A list of organizations represented on this committee can be obtained on request to its committee manager.

The UK committee notes that the formatting of the term ‘Rz’ is not consistent; in Subclause 5.2.5, Table 2 and Table 7 it is in italic characters, and in Figure 4, Figure 6 and Figure 7 it is in roman characters. It is the opinion of the UK committee that this difference has the potential to cause users confusion.

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Part 2:
Housing dimensions for general
applications**

*Transmissions hydrauliques et pneumatiques — Joints
toriques —*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 7, *Sealing devices*.

This third edition cancels and replaces the second edition (ISO 3601-2:2016), which has been technically revised.

The main changes are as follows:

- comprehensive extension of listed housing dimensions for metric bore sizes ([Tables 4](#) and [6](#));
- volumetric calculation of housing fill instead of calculation with cross-sectional areas ([Annex B](#));
- correction in calculation of the cross-sectional reduction for the effective compression ([5.6.2](#)).

A list of all parts in the ISO 3601 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In fluid power systems, power is transmitted and controlled through a fluid (liquid or gas) under pressure within an enclosed circuit. To avoid leakage or to seal different chambers of a component from each other sealing devices are used. O-rings are one type of sealing devices. To seal properly, an O-ring has to be used in an appropriate housing for the application.

Fluid power systems — O-rings —

Part 2: Housing dimensions for general applications

1 Scope

This document specifies the housing dimensions for class A O-rings for general industrial applications conforming to ISO 3601-1, as well as housing dimensions for class B O-rings used on selected metric-dimensioned hardware, e.g. fluid power cylinder bores and piston rods. These O-rings are for use in general hydraulic and pneumatic applications without and with anti-extrusion rings (back-up rings). The dimensions of the O-rings (d_1 and d_2), size codes (SC) and tolerances conform to ISO 3601-1.

This document also addresses different design approaches in industry, and this is reflected in the table structures for hardware dimensions. Using the O-ring as a starting point to design the optimal hardware dimensions is reflected in [Tables 3, 5, and 8](#). Using fixed hardware dimensions (i.e. bore/rod) and choosing the most appropriate O-ring to fit is reflected in [Tables 4 and 6](#).

Housing dimensions for the O-rings intended for aerospace applications that are specified in ISO 3601-1 are addressed in [Annex A](#).

NOTE 1 It is expected that O-ring housing dimensions for special applications be agreed upon between the O-ring manufacturer and the user.

NOTE 2 The term “housing”, in this document, is used to describe the groove or cavity, into which the O-ring is fitted, and the mating surface, which between them confine the O-ring.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3601-1, *Fluid power systems — O-rings — Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 5598, *Fluid power systems and components — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Symbols

The following letter symbols are used in this document.

Table 1 — Symbols and definitions

Symbol	Definition
b_x	width of the O-ring housing
b_1	width of the O-ring housing without an anti-extrusion ring (back-up ring)
b_2	width of the O-ring housing with one anti-extrusion ring (back-up ring)
b_3	width of the O-ring housing with two anti-extrusion rings (back-up rings)
b_4	width of the O-ring axial (face seal) housing
C	percentage of effective O-ring cross-section compression
d_1	O-ring inside diameter
d_2	O-ring cross-section diameter
d_2^*	effective cross-section of installed O-ring
d_3	housing inside diameter for piston application
d_4	bore diameter for piston application
d_5	rod diameter
d_6	housing outside diameter for rod application
d_7	outside diameter of housing for axial (face) sealing
d_8	inside diameter of housing for axial (face) sealing
d_9	piston diameter
d_{10}	bore diameter for rod application
F	percentage of housing fill
f	housing radius (also known as edges of undefined shape)
g	extrusion gap or radial gap
h	depth of seal groove
j	length from piston chamfer to seal groove edge
k	length from housing chamfer to seal groove edge
m	roughness of the side surface of the O-ring housing
n	surface roughness of the O-ring housing base
p	roughness of the mating surface of the O-ring
q	surface roughness of lead-in chamfer
R	percentage of O-ring cross-sectional reduction resulting from diametral stretch
Ra	arithmetic mean height of the surface roughness profile
R_{mr}	relative material ratio of the surface roughness profile
Rz	maximum height of the surface roughness profile
S	percentage of inside diameter stretch
SC	O-ring size code from ISO 3601-1
t	total radial housing depth
t_x	approximate radial housing depth
V_H	volume of O-ring housing
V_{OR}	volume of the O-ring
Y	maximum run-out tolerance
z	length of lead-in chamfer
$\emptyset$	diameter

5 O-ring housings

5.1 Typical O-ring applications

[Figure 1](#) shows a typical O-ring as presented in ISO 3601-1.

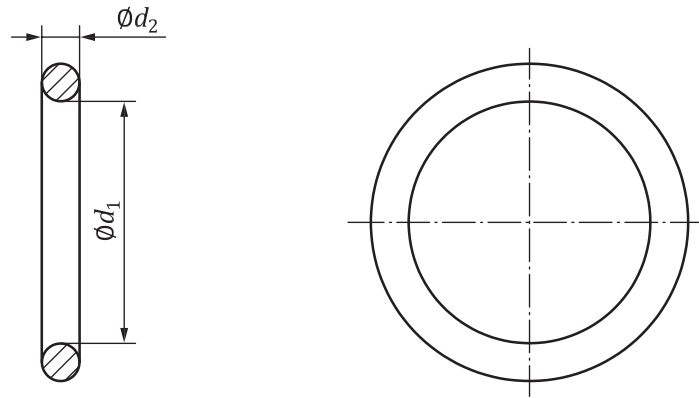


Figure 1 — Typical O-ring configuration

[Figure 2](#) shows the features of an O-ring housing for use in dynamic rod and piston applications.

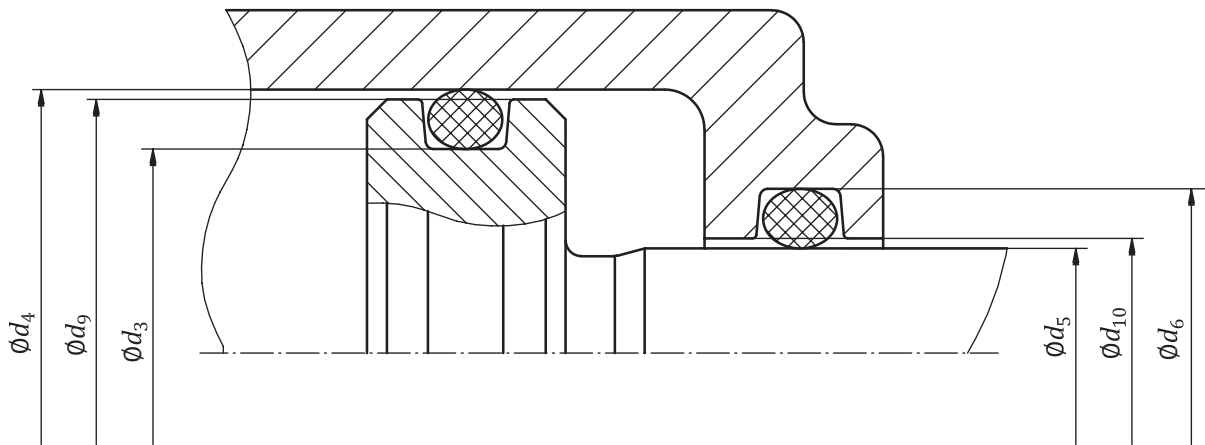


Figure 2 — Features of housings for dynamic rod and piston applications

[Figure 3](#) shows the features of O-ring housings used in static rod and piston applications. It also shows an example of a face (axial) seal.

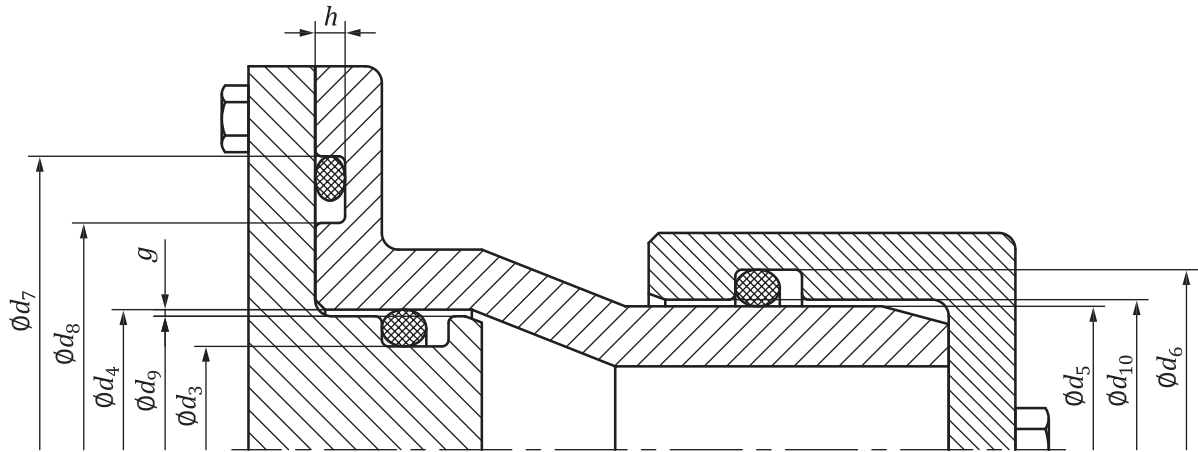
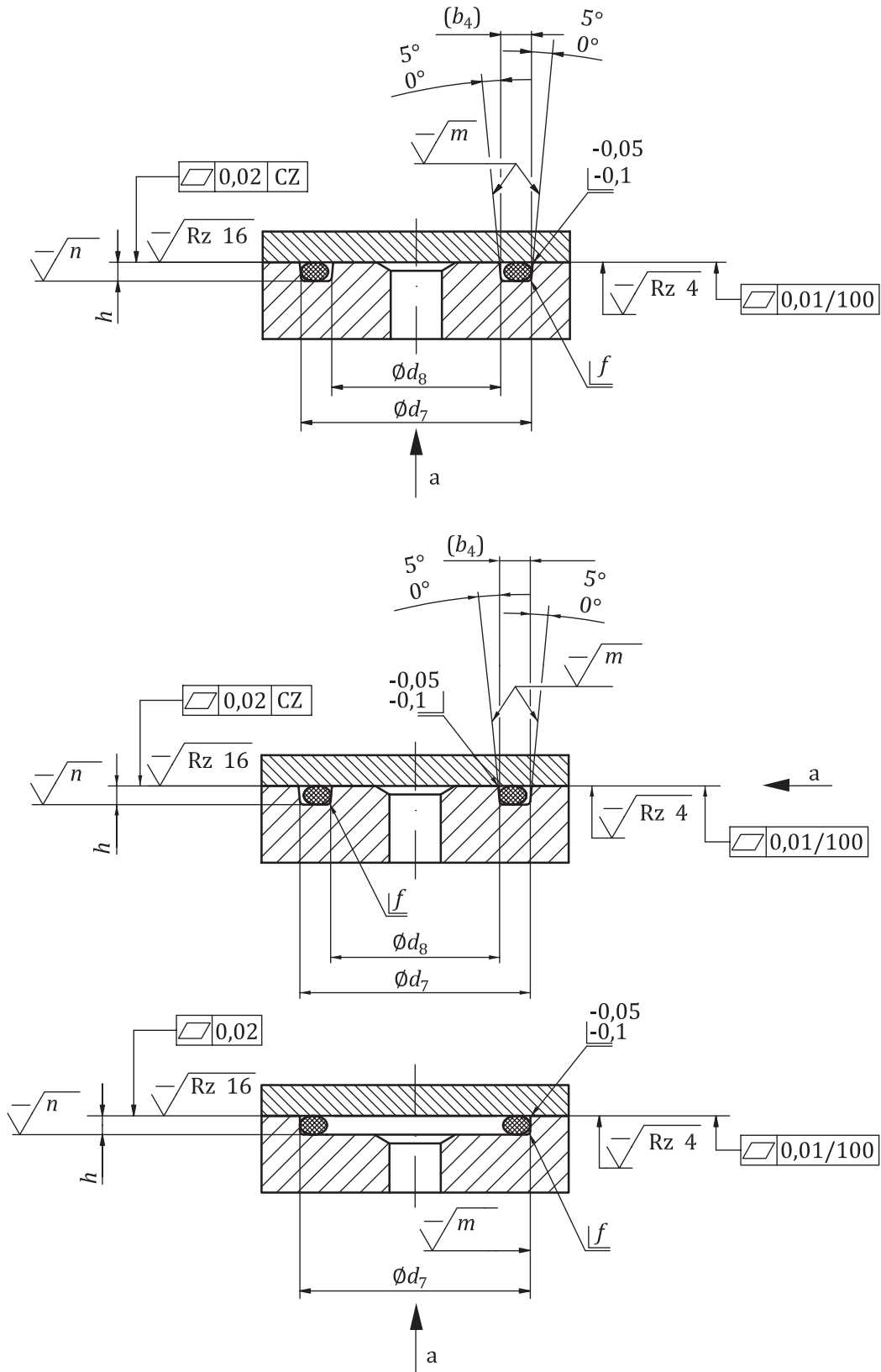


Figure 3 — Features of housings for static rod and piston applications

5.1.4 O-ring housings for face seal applications have different dimensional requirements depending upon whether the pressure is internal or external to the system. See [Figure 4](#) for illustrations.



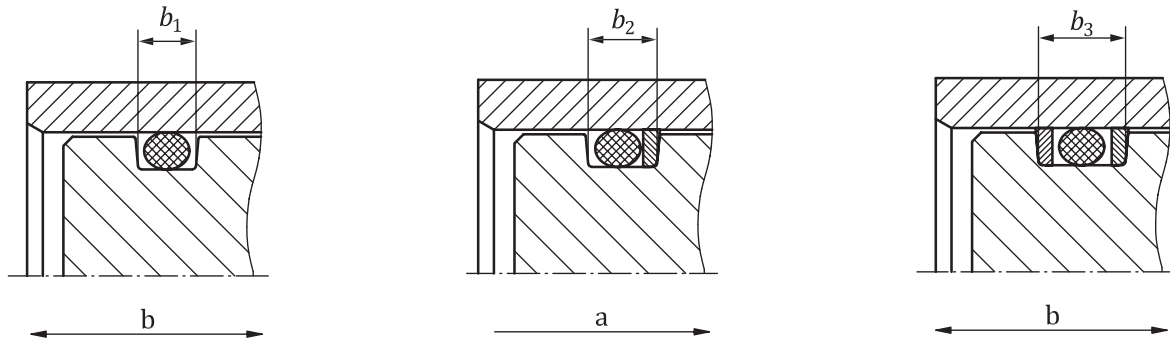
Key

- m, n surface roughness; see [Table 7](#)
- b_4 housing width; see [Table 7](#)
- f housing radius; see [Table 7](#)
- a Direction of pressure.

NOTE Tolerancing is in accordance with ISO 8015.

Figure 4 — Illustrations of housings for face seal applications

Figure 5 shows examples of widths of O-ring housings for use with or without anti-extrusion rings (back-up rings). Recommendations for the use of anti-extrusion rings are given in ISO 3601-4.



a) Without anti-extrusion rings b) With one anti-extrusion ring c) With two anti-extrusion rings

- a Pressure acting in one direction.
b Pressure acting in alternating directions.

Figure 5 — Widths of O-ring housings, for use with or without anti-extrusion rings (back-up rings)

5.2 Surface roughness

5.2.1 The surface roughness of the O-ring housing and any mating part has a significant impact on the life and sealing performance of the O-ring.

5.2.2 Unless otherwise agreed, surface roughness values shall be in accordance with Table 2. Surface roughness values of the housings for the O-rings intended for aerospace applications that are specified in ISO 3601-1 are addressed in Annex A.

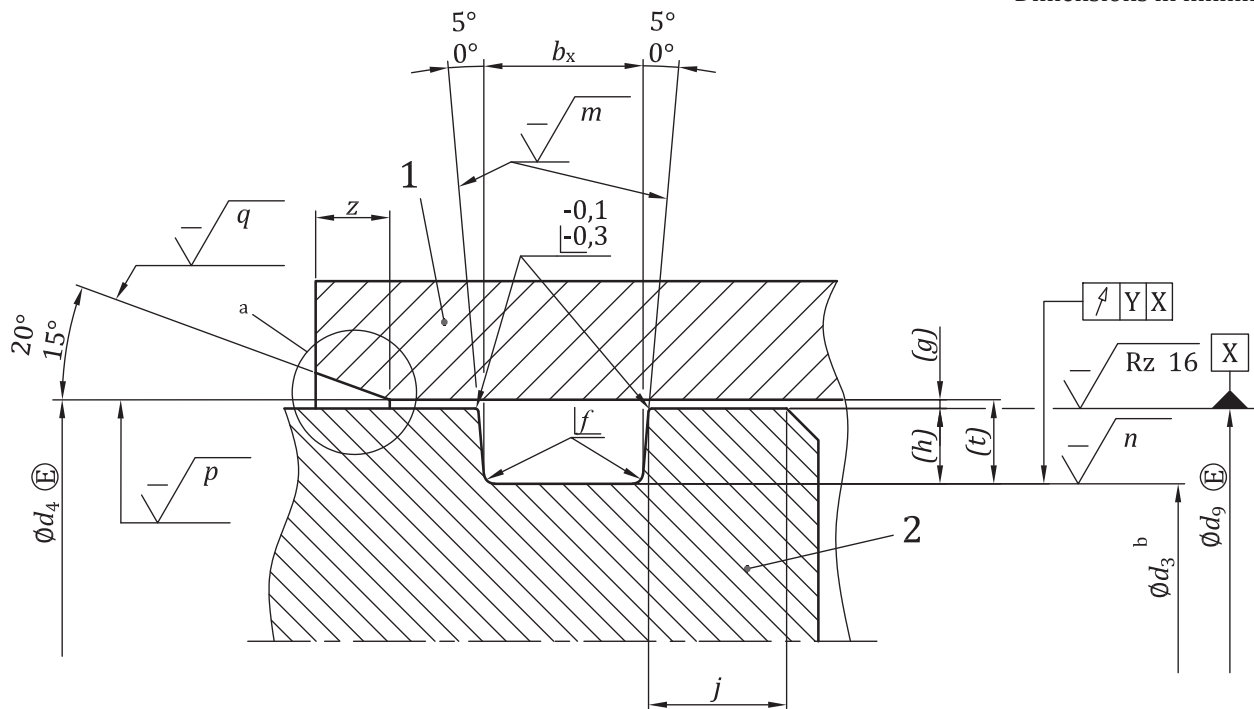
5.2.3 All surfaces against which a seal operates should be free from scratches, burrs, gouges, scores, nicks, tool chatter, spiral machining marks (circumferential marks), or other defects along the operating axis of the seal as these may reduce sealing efficiency and the life of the seal.

5.2.4 The latest International Standards for surface roughness measurement require new statements for roughness requirements. Because of the short measuring length, an exact roughness is not measurable. In these cases, a visual inspection using master parts is permitted.

5.2.5 Unless otherwise agreed the material ratio, $R_{mr}(p, d_c)$, of housing surfaces that are in mating contact with the seal should be between 50 % and 80 % at a profile depth (d_c) of 25 % of R_z from a reference material ratio $p = 5$ % (in accordance with ISO 21920-2).

5.3 Housing dimensions

Figure 6 shows a cross-section of a typical piston housing, illustrating the housing width, b_x , seal groove depth, h , the total distance between the sealing surface and the radial housing depth, t , the radial gap, g , between the piston, d_g , and the bore, d_a , the edges of undefined shape, f , and the surfaces for which surface roughness requirements are specified. All of these features have different values depending on the application.



Key

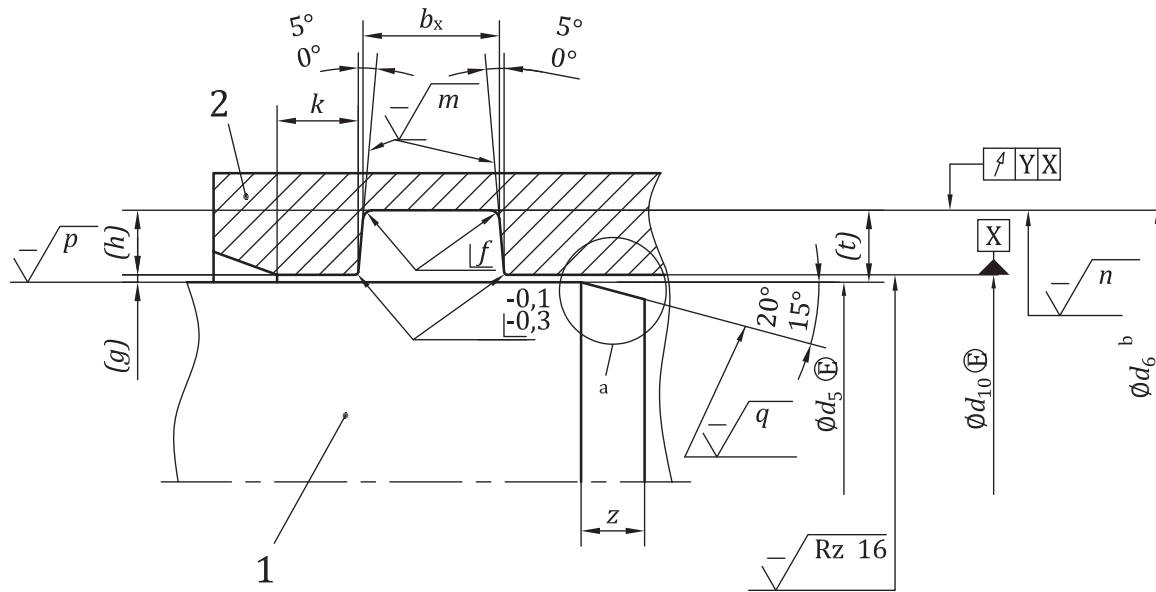
- 1 bore
- 2 piston
- m, n, p, q surface roughness; see [Table 2](#)
- f housing radius; see [Table 2](#)
- b_x width of O-ring housing
- a No burrs are permitted in this area; the edge shall be rounded.
- b Housing diameter $d_3 \leq 50$: maximum run-out tolerance $Y = 0,025$;
housing diameter $d_3 > 50$: maximum run-out tolerance $Y = 0,05$.

NOTE Tolerancing is in accordance with ISO 8015.

The length from the piston chamfer to the seal groove edge, j , should be greater than the length of the lead-in chamfer, z .

Figure 6 — Dimensions of piston seal housings

[Figure 7](#) shows a cross-section of a typical rod housing, illustrating the housing width, b_x , seal groove depth, h , the total distance between the sealing surface and the radial housing depth, t , the radial gap, g , between the rod, d_5 and bore, d_{10} , edges of undefined shape, f , and the surfaces for which surface roughness requirements are specified. All these features have different values depending on the application.



Key

- | | |
|--------------|--|
| 1 | rod |
| 2 | bore |
| m, n, p, q | surface roughness; see Table 2 |
| f | housing radius; see Table 2 |
| b_x | width of O-ring housing |
| a | No burrs are permitted in this area; the edge shall be rounded. |
| b | Housing diameter $d_6 \leq 50$: maximum run-out tolerance $Y = 0,025$;
housing diameter $d_6 > 50$: maximum run-out tolerance $Y = 0,05$. |

NOTE Tolerancing is in accordance with ISO 8015.

The length from the housing chamfer to the seal groove edge, k , should be greater than the length of the lead-in chamfer, z .

Figure 7 — Dimensions of rod seal housings

5.4 Corners and edges of undefined shape

Values for inside corner edge, f , that depend on the cross-sections of housings and rods are specified in [Table 2](#). Values for the undefined edge of the housing outside corner are specified in [Figures 6](#) and [7](#).

5.5 Lead in chamfer

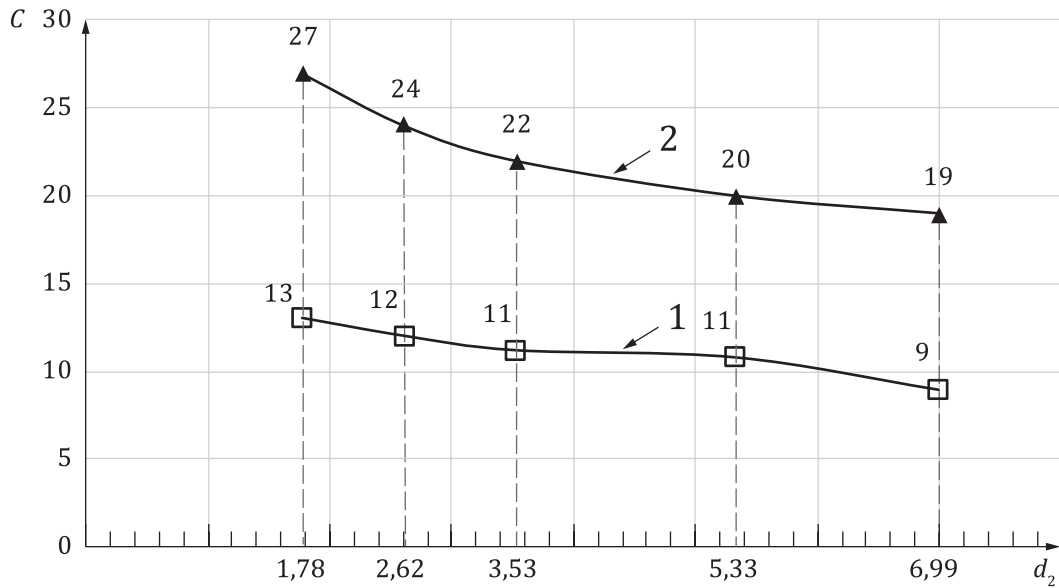
5.5.1 A lead-in chamfer with an angle of 15° to 20° shall be used to prevent damage to the O-ring by either the rod or the piston upon assembly into the cylinder bore. Chamfer edges shall be rounded. [Figures 6](#) and [7](#) illustrate lead-in chamfers for piston and rod housings, respectively.

5.5.2 Values for the lengths of lead-in chamfers, dimension z , for the cross-sections of housings and rods are specified in [Table 2](#).

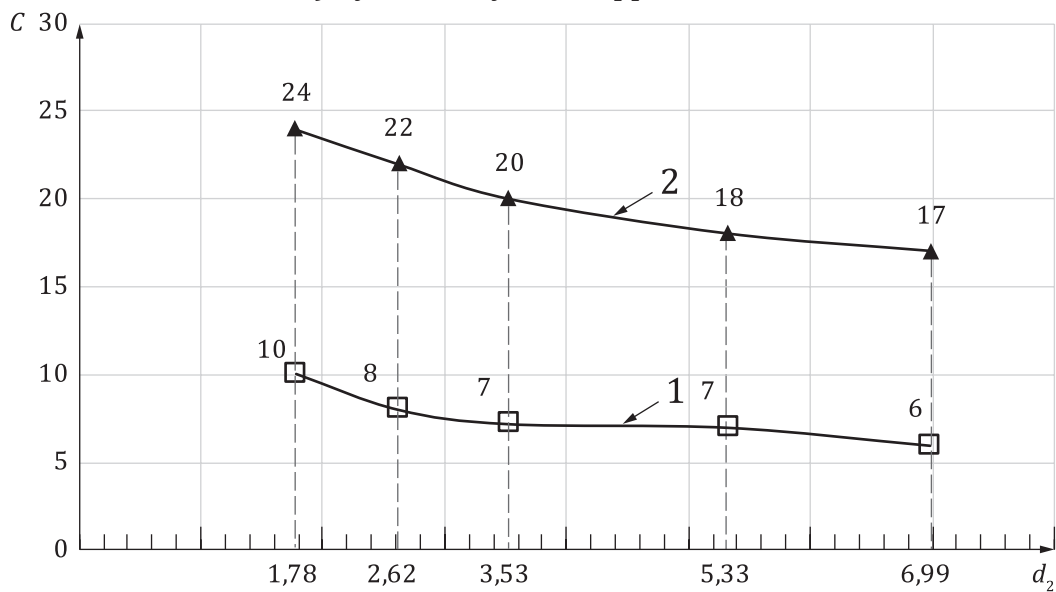
5.6 Calculation of housing dimensions for radial sealing applications

5.6.1 For the basic dimensions of housings for O-rings, see [Tables 3](#) through [6](#). Dimensions d_3 (for piston sealing applications) and d_6 (for rod sealing applications) and the depth of the housing apply if the

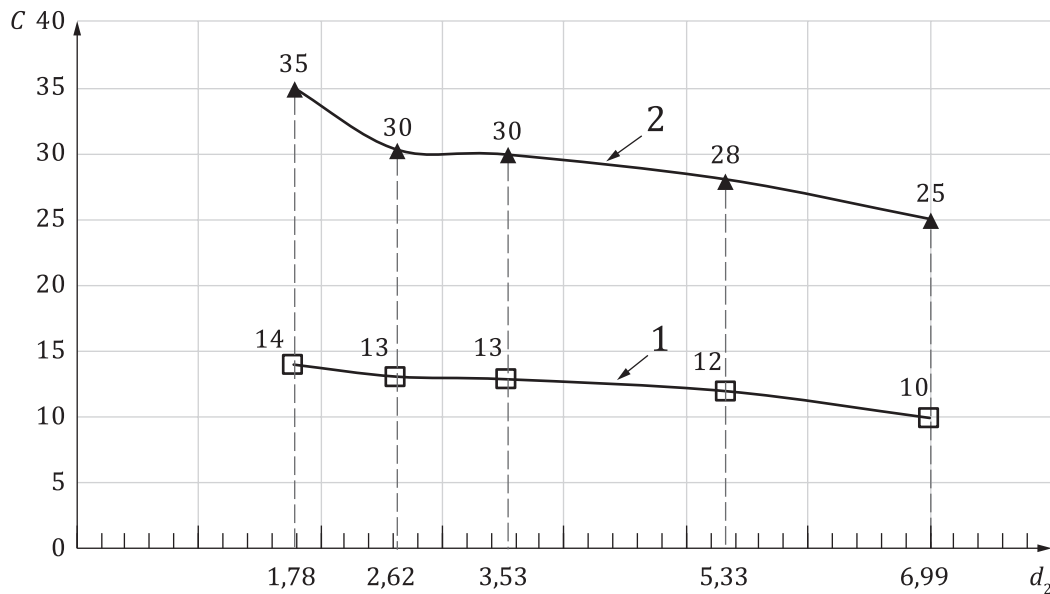
percentage of effective O-ring cross-sectional compression is within the limits given in [Figure 8](#), depending on the application and O-ring cross-section.



a) Hydraulic dynamic applications



b) Pneumatic dynamic applications



c) Static radial and axial applications

Key

- d_2 O-ring cross-section, expressed in millimetres
- C compression, expressed in percent
- 1 minimum value
- 2 maximum value

Figure 8 — Limits of compression for ISO 3601-1 O-rings

5.6.2 Percent effective compression, C

5.6.2.1 When an O-ring is stretched, as occurs when installed in the housing, its cross-section, d_2 , is reduced, flattened, and is no longer circular. This affects the effective compression, C , of the installed O-ring. The minimum effective compression, $C_{\min}$, of the installed O-ring is represented by the difference between the minimum effective cross-section of the installed O-ring, $d_{2,\min}^*$, and the maximum total radial housing depth, $t_{\max}$. The maximum effective compression, $C_{\max}$, of the installed O-ring is represented by the difference between the maximum effective cross-section of the installed O-ring, $d_{2,\max}^*$, and the minimum total radial housing depth, $t_{\min}$.

5.6.2.2 The percentage that d_2 is reduced depends on the percentage that the O-ring's inside diameter, d_1 , is stretched, S . S needs to be calculated to determine the effective, or installed, cross-section, d_2^* . For piston applications, S is calculated in accordance with [Formulae \(1\)](#) and [\(2\)](#):

$$S_1 = \left[\frac{d_{3,\max} - d_{1,\max}}{d_{1,\max}} \right] \times 100 \% \quad \text{Use this value for } R_1, \text{ and hence } C_{\max} \quad (1)$$

$$S_2 = \left[\frac{d_{3,\min} - d_{1,\min}}{d_{1,\min}} \right] \times 100 \% \quad \text{Use this value for } R_2, \text{ and hence } C_{\min} \quad (2)$$

For rod applications, S is calculated in accordance with [Formulae \(3\)](#) and [\(4\)](#):

$$S_1 = \left[\frac{d_{5,\max} - d_{1,\max}}{d_{1,\max}} \right] \times 100 \% \quad \text{Use this value for } R_1, \text{ and hence } C_{\max} \quad (3)$$

$$S_2 = \left[\frac{d_{5,\min} - d_{1,\min}}{d_{1,\min}} \right] \times 100 \% \quad \text{Use this value for } R_2, \text{ and hence } C_{\min} \quad (4)$$

5.6.2.3 The percent of cross-sectional reduction resulting from diametral stretch, R , for an O-ring whose inside diameter is stretched 0 % to 3 % (inclusive) is calculated in accordance with [Formula \(5\)](#):

$$R = 0,01 + 1,06(S) - 0,1(S)^2 \quad (5)$$

NOTE [Formulae \(5\)](#) and [\(6\)](#) are also given in SAE MAP 3440.

EXAMPLE For an O-ring whose inside diameter is stretched 2,5 %, the percent of cross-sectional reduction is

$$\begin{aligned} R &= 0,01 + 1,06(2,5) - 0,1(2,5)^2 \\ &= 2,04 \% \end{aligned}$$

5.6.2.4 The percent of cross-sectional reduction resulting from diametral stretch, R , for an O-ring whose inside diameter is stretched more than 3 % but less than 25 % is calculated in accordance with [Formula \(6\)](#):

$$R = 0,56 + 0,59(S) - 0,0046(S)^2 \quad (6)$$

5.6.2.5 The effective cross-section, d_2^* , range for the stretched O-ring is in accordance with [Formulae \(7\)](#) and [\(8\)](#):

$$d_{2,\min}^* = d_{2,\min} - \left(\frac{R_2}{100} \right) \times d_{2,\min} \quad (7)$$

where R_2 is calculated according to [Formula \(5\)](#) or [Formula \(6\)](#) using S_2 .

$$d_{2,\max}^* = d_{2,\max} - \left(\frac{R_1}{100} \right) \times d_{2,\max} \quad (8)$$

where R_1 is calculated according to [Formula \(5\)](#) or [Formula \(6\)](#) using S_1 .

The range in the percent effective compression, C , is in accordance with [Formulae \(9\)](#) and [\(10\)](#):

$$C_{\min} = \left[\frac{(d_{2,\min}^* - t_{\max})}{d_{2,\min}^*} \right] \times 100 \% \quad (9)$$

$$C_{\max} = \left[\frac{(d_{2,\max}^* - t_{\min})}{d_{2,\max}^*} \right] \times 100 \% \quad (10)$$

NOTE Percent effective compression has been considered in the development of this document. Eccentricity can affect effective compression.

6 Requirements

6.1 Housing dimensions

6.1.1 Housing for piston sealing in hydraulic and pneumatic applications

6.1.1.1 The nominal O-ring inside diameter, d_1 , should be stretched between 2 % and 5 % for dynamic applications and 2 % and 8 % for static applications. For O-rings with a diameter d_1 smaller than 20 mm, this is not always possible, which can result in a wider range of stretch. To minimize this range and the maximum stretch, it is necessary to minimize the tolerances of the housing diameter, d_3 , and have a less stringent requirement for the minimum O-ring stretch. Ideally, the stretch of the maximum value of d_1 by the diameter d_3 should be at least 2 %.

In dynamic applications, it is important to keep the maximum stretch to 5 % or less to avoid detrimental effects on sealing performance.

NOTE Some static applications can require higher stretch (e.g. for assembly issues). In this case the O-ring and the stretch are to be agreed upon between the O-ring manufacturer and the user.

6.1.1.2 The general housing dimensions and tolerances and housing diameter tolerances are given in [Tables 3](#) and [4](#). The depth of the housing, t , can be calculated in accordance with [Formulae \(11\)](#) and [\(12\)](#):

$$t_{\min} = \frac{d_{4,\min} - d_{3,\max}}{2} \quad \text{Use for } C_{\max} \quad (11)$$

$$t_{\max} = \frac{d_{4,\max} - d_{3,\min}}{2} \quad \text{Use for } C_{\min} \quad (12)$$

6.1.1.3 For the key dimensions related to piston sealing, see [Figure 6](#).

6.1.1.4 Actual housing dimensions for the standard O-rings specified in ISO 3601-1 are given in [Table 3](#). Housing dimensions for selected metric bore sizes are given in [Table 4](#) along with the suggested standard O-rings. For other metric bore sizes not given in [Table 4](#), [Annex B](#) should be used for guidance to calculate hardware dimensions.

6.1.1.5 After an O-ring is installed in the housing, sufficient time should be given for it to relax and recover back to size before assembling the piston into the bore to avoid damaging the O-ring during installation.

6.1.1.6 To avoid situations where the O-ring inside diameter, d_1 , has to be stretched more than 50 % during installation into the housing, which can potentially damage the seal, consideration should be given to the use of split housing and / or use of a suitable O-ring material compound with sufficient minimum elongation at break for the installation.

6.1.2 Housings for rod sealing in hydraulic and pneumatic applications

6.1.2.1 The O-ring outside diameter ($d_1 + 2d_2$) shall be at least equal to or larger than the housing outside diameter, d_6 , to give interference on the outside diameter. The O-ring outside diameter shall not exceed the housing outside diameter by more than 3 % for O-rings with a diameter d_1 greater than 250 mm, or 5 % for O-rings with a diameter d_1 smaller than 250 mm. For O-rings with a diameter d_1 smaller than 20 mm, this is not always possible due to tolerance issues, which can result in a greater outside diameter interference.

NOTE The calculation is based on the minimum O-ring outside diameter and the maximum housing diameter, d_6 .