UDC 621.887.6 : 621.824 : 001.4 : 003.62 : 620.1

September 1981

Lock washers
(retaining washers)
for shafts

DIN
6799

Sicherungsscheiben (Halteschеiben) für Wellen

Supersedes May 1963 edition

As it is current practice in standards published by the International Organization for Standardization (ISO), the comma has been used throughout as a decimal marker.

Dimensions in mm

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1 Concept

Lockwashers within the context of this standard are retaining washers for the axial retention of components on shafts. They are inserted radially in grooves and enclose the groove base under spring tension with segments.

2 Dimension lettering, formula symbols

a width of the opening of the unloaded lock washer
d_1 shaft diameter
d_1' shaft diameter to which F_N refers
d_2 groove diameter = nominal size
d_3 max. external diameter when seated in the groove with nominal diameter
E modulus of elasticity
F_N load bearing capacity of the groove with shaft diameter d_1' at a yield point of the grooved material of 200 N/mm² (see subclause 7.1)
F_s load bearing capacity of the lock washer with sharp-edged abutment
F_{sg} load bearing capacity of the lock washer with edge chamfering distance g
R_{el} yield point
g edge chamfering distance
m groove width
n edge margin
n_{abl} detachment speed
s thickness of the lock washer

Continued on pages 2 to 7

3 Dimensions, designation, constructional data

The lock washers need not conform to the pictorial representation; only the dimensions specified are to be adhered to.

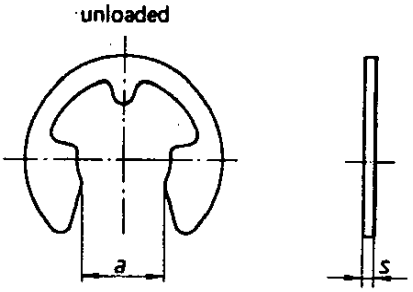


Figure 1.

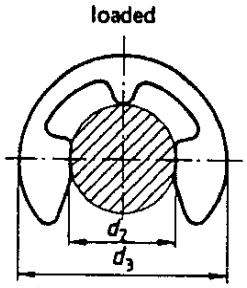


Figure 2.

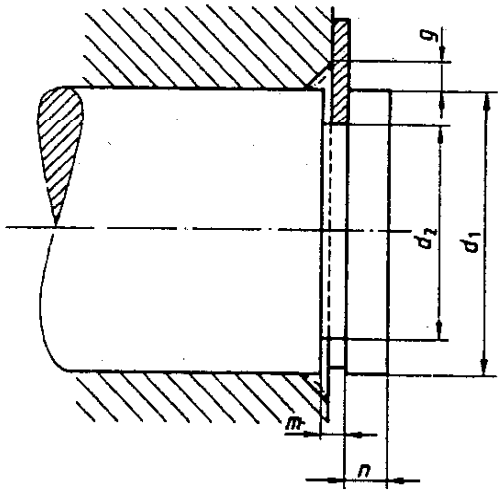


Figure 3.

Designation of a lock washer for groove diameter (nominal size) d_2 = 4 mm:

Lock washer DIN 6799 – 4

Table 1.

Groove diameter d_2	Shaft diameter range d_1		Lock washer					Groove					Supplementary data						
			s		a		Weight per 1000 pieces in kg	d_2		m [1]		n	d_3	F_N		F_S	g	F_{St}	n_{abl}
Nominal size	from	to		per. dev.		per. dev. (±IT 10)	≈		per. dev. (h11)		per. dev.	min.	max.	kN	at d_1'	kN		kN	min.$^{-1}$
0,8	1	1,4	0,2	±0,02	0,58	±0,04	0,003	0,8	0 −0,04	0,24	+0,04 0	0,4	2,25	0,03	1,2	0,08	0,3	0,04	50 000
1,2	1,4	2	0,3		1,01		0,009	1,2	0 −0,06	0,34		0,6	3,25	0,04	1,5	0,12	0,4	0,06	47 000
1,5	2	2,5	0,4		1,28		0,021	1,5		0,44		0,8	4,25	0,07	2	0,22	0,6	0,11	43 000
1,9	2,5	3	0,5		1,61		0,040	1,9		0,54	+0,05 0	1	4,8	0,10	2,5	0,35	0,7	0,17	40 000
2,3	3	4	0,6		1,94		0,069	2,3		0,64		1	6,3	0,15	3	0,50	0,9	0,24	38 000
3,2	4	5	0,6		2,70		0,088	3,2	0 −0,075	0,64		1	7,3	0,22	4	0,65	0,9	0,32	35 000
4	5	7	0,7		3,34	±0,048	0,158	4		0,74		1,2	9,3	0,25	5	0,95	1	0,47	32 000
5	6	8	0,7		4,11		0,236	5		0,74		1,2	11,3	0,90	7	1,15	1	0,60	28 000
6	7	9	0,7		5,26		0,255	6		0,74		1,2	12,3	1,10	8	1,35	1,1	0,70	25 000
7	8	11	0,9		5,84		0,474	7	0 −0,09	0,94		1,5	14,3	1,25	9	1,80	1,3	1,00	22 000
8	9	12	1	±0,03	6,52	±0,058	0,660	8		1,05	+0,08 0	1,8	16,3	1,42	10	2,50	1,5	1,25	20 000
9	10	14	1,1		7,63		1,09	9		1,15		2	18,8	1,60	11	3,00	1,6	1,50	17 000
10	11	15	1,2		8,32		1,25	10		1,25		2	20,4	1,70	12	3,50	1,8	1,75	15 000
12	13	18	1,3		10,45	±0,07	1,63	12	0 −0,11	1,35		2,5	23,4	3,10	15	4,70	1,9	2,30	13 000
15	16	24	1,5		12,61		3,37	15		1,55		3	29,4	7,00	20	7,80	2,2	3,30	11 000
19	20	31	1,75		15,92		6,42	19		1,80		3,5	37,6	10,00	25	11,00	2,5	3,60	7 600
24	25	38	2		21,88	±0,084	8,55	24	0 −0,13	2,05		4	44,6	13,00	30	15,00	3	4,00	5 500
30	32	42	2,5		25,80		13,5	30		2,55		4,5	52,6	16,50	36	23,00	3,5	5,30	4 200

[1] See clause 9

4 Material

Spring steel C 60, C 67 or C 75 according to DIN 17 222 (at manufacturer's discretion).

The hardness shall be:

460 to 580 Vickers hardness (corresponding to 46 to 54 Rockwell C hardness)

Hardness values converted according to DIN 50 150

Other materials by agreement.

5 Finish

Lock washers must be free from burr.

Lock washers shall normally be supplied with a corrosion protection according to table 2 (at manufacturer's discretion).

No special details are required concerning this form on delivery in the designation of a lock washer.

Table 2. Corrosion protection of lock washers

Serial No.	Type of corrosion protection	Corrosion resistance
1	Phosphated and oiled according to DIN 50942 Symbol: Znphr . . . f	No sign of corrosion permissible after 8 hours exposure to salt spray DIN 50021 – SS
2	Black oxide and oiled (thermal or chemical)	
3	Black finish and oiled according to DIN 50938 Process class A Symbol: br Af	Testing of protection value according to DIN 50938, December 1973 edition, subclause 5.2

If a particular corrosion protection is required which is different from table 2, the designation of the lock washer must be supplemented accordingly. For electroplated coatings, designation or identifying marks apply as in DIN 267 Part 9, e.g.:

Lock washer DIN 6799 – 4 A 3 K

In the bulk electroplating of lock washers in a drum or bell, it is not possible to maintain closely toleranced plating thicknesses.

Attention is drawn to DIN 267 Part 9 regarding the danger of hydrogen-induced delayed brittle fractures in lock washers with electroplated surface protection.

The upper limiting dimension of the lock washer thickness s may be allowed to be exceeded according to the film thickness of the coating required in the case of washers with electroplated surface protection. This must be taken into account when designing the groove.

6 Testing

6.1 Testing the material

Vickers hardness test according to DIN 50133 Part 1.

Rockwell hardness test according to DIN 50103 Part 1.

In cases of doubt, the Vickers hardness test shall apply.

6.2 Bend and fracture test

The lock washer shall be fitted radially onto a hardened pin with a diameter of 1,1 d_2 (nominal size) and kept at ambient temperature for 48 hours. The lock washer must not break.

6.3 Testing of flatness

The lock washer must fall through two parallel, perpendicular plates spaced 1,1 s apart (nominal size).

6.4 Testing the function (permanent set and grip test)

The lock washer shall be fitted five times onto a hardened pin with groove diameter (minimum dimension) and removed four times. It must remain in position still under tension also on the occasion of the fifth fitting.

6.5 Acceptance testing

The basic principles for testing and acceptance according to DIN 267 Part 5 shall apply for the acceptance testing.

Table 3 applies to the features, while table 4 applies in respect of the acceptable quality level.

Table 3.

Features
Lock washer thickness s
Aperture width a
Flatness (deformation)
Function (set and grip)

Table 4.

Acceptable quality level AQL [1]	
for testing of features	for testing for faulty parts
1	1,5

[1] See DIN 40080

If other plans for sample testing are to be applied this shall be agreed at the time of ordering.
Hardness testing shall be in accordance with DIN 267 Part 5, April 1968 edition, clause 5.
With lock washers, the hardness testing shall be regarded as a destructive test.

7 Load bearing capacity

A lock washer connection requires separate calculations for the load bearing capacities of the groove F_N and for the load bearing capacity of the lock washer F_S. In each case the weaker part is that which shall apply. The load bearing capacities (F_N, F_S, F_{Sg}) listed in clause 3 contain no safeguards against plastic flow under static load nor against fatigue fracture under fluctuating load. There is at least twice the level of reliability against fracture under static loading.

7.1 Load bearing capacity of the groove F_N

The F_N values in table 1 (load bearing capacity of the groove) apply to grooves in parts of materials up to 200 N/mm² yield point, edge margins n and refer to the shaft diameter d_1'.

Load bearing capacity F_N' for materials with a yield point R_{eL}' (previously σ_s') deviating from 200 N/mm² is directly proportional to the yield point.

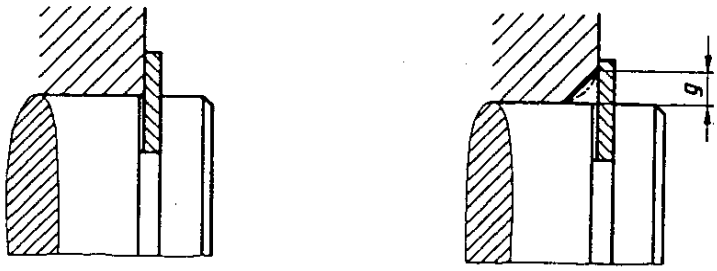
$$F_N' = F_N \cdot \frac{R_{eL}'}{200}.$$

Where the shaft diameter d_1 deviates from d_1', the load bearing capacity of the groove F_N' is calculated from

$$F_N' = F_N \cdot \frac{d_1 - d_2}{d_1' - d_2}.$$

7.2 Load bearing capacity of the lock washer F_S

The load bearing capacity of the lock washer F_S according to clause 3 applies to a sharp-edged abutment of the pressure machine part (see figure 4 a).



a) Sharp-edged abutment

b) Abutment with edge chamfering (chamfering or rounding)

Figure 4. Abutment of the lock washer

The values F_{Sg} apply to an abutment with edge chamfering distance g (see clause 3).
The two values F_S and F_{Sg} apply to lock washer materials with a modulus of elasticity of 210 000 N/mm². With the use of lock washers of a different material with a different elastic modulus E', then, for conversion, the load bearing capacity of the washer is directly proportional to the modulus of elasticity.

$$F_S' = F_S \cdot \frac{E'}{210\,000}$$

$$F_{Sg}' = F_{Sg} \cdot \frac{E'}{210\,000}$$

If the edge chamfering distance g' deviates from the values in clause 3, then, for conversion, the load bearing capacity of the lock washer is indirectly proportional to the edge chamfering distance.

$$F_{Sg}' = F_{Sg} \cdot \frac{g}{g'}$$

Note: If F_{Sg}' with small values of g' is greater than F_S, then F_S applies.

8 Detachment speed

The application of lock washers is limited by those rotational speeds which could cause the washers to spring out of their seatings.

In clause 3, therefore, detachment speeds n_{abl} are given at which the washers may spring out. The values apply only to lock washers of spring steels according to clause 4.

9 Finish of the groove

The dimensions given in table 1 for the groove width m apply to standard cases. In the case of high precision or alternate-sided loading, narrower groove widths can be selected and, in the case of reduced accuracy requirements, wider groove widths can also be selected.

Standards referred to

DIN 267 Part 5	Bolts, screws, nuts and similar threaded and formed parts; technical delivery conditions; testing and acceptance
DIN 267 Part 9	Fasteners; technical delivery conditions; electroplated coatings
DIN 17 222	Cold rolled steel strip for springs; technical delivery conditions
DIN 40 080	Procedures and tables for random testing using qualitative features (inspection by attributes)
DIN 50 021	Corrosion tests; spray tests with different sodium chloride solutions
DIN 50 103 Part 1	Testing of metallic materials; Rockwell hardness test; C, A, B, F methods
DIN 50 133 Part 1	Testing of metallic materials; Vickers hardness test; test load range: 49 to 980 N (5 to 100 kp)
DIN 50 150	Testing of steel and steel castings; conversion table for Vickers hardness, Brinell hardness, Rockwell hardness and tensile strength
DIN 50 938	Alkaline blackening (black finishing) of iron material; principles of methods, symbols, testing
DIN 50 942	Phosphating of metals; general directions, symbols and methods of testing

Previous editions

DIN 6799: 11.50, 11.54, 05.63

Amendments

Compared with the May 1963 edition the following amendments have been made:

a) contents of the standard revised and extended.

b) technical delivery conditions and principles of calculation included.

Explanations

The present revised edition of DIN 6799 replaces the May 1963 edition. It has been extended to cover the technical delivery conditions and principles of calculation in order to provide a whole and complete standard which can be applied without the inclusion of additional standards. The following explanations are given with respect to this standard.

Re title

The term "retaining washers" has been added to the title of the standard. The old designation "lock washer" has been retained, although these elements are used only for the axial retention of components on shafts and have no locking action. The organizational problems associated with a general change in designation desirable for the sake of clarity were, because of the wide distribution of these standards, also rated as more important than the danger of misunderstood information on the part of the standards user due to an inappropriate title.

Re clause 1 Concept

This clause was included in order to prevent possible errors in the application and function of the parts resulting from the designation.

Re clause 2 Dimension lettering, formula symbols

Clause 2 lists and describes the dimension lettering and formula symbols used in the standard.

Re clause 3 Dimensions, designation, constructional data

The clause contains the dimensions of the lock washers. Required constructional data have been added. The dimensions of the lock washers or their tolerances have been corrected slightly in a few cases without any danger thereby of replacement difficulties.

Re clause 4 Material

Details of the material have been modified. Three materials have been selected as the most usual from DIN 17 222. Other materials shall be the subject of agreement between the parties concerned.

Re clause 5 Finish

Details of the finish have been extended and adapted to present conditions. With electroplated lock washers, the danger of hydrogen embrittlement is relatively great and requires special attention within the context of DIN 267 Part 9. Particular reference has therefore been made to DIN 267 Part 9. According to this standard, the situation is approximately as follows:

In order to avoid hydrogen-induced delayed brittle fractures in the electroplated surface protection of lock washers, the electroplating treatment and heat treatment before and after electroplating shall be selected so that only a small amount of hydrogen is taken up in the pickling and electroplating treatment and this hydrogen is furthermore driven off again to a large extent.

Normally, delayed brittle fractures can be avoided by these measures. If brittle fractures have to be avoided with specific, statistical certainty, the taking of appropriate quantities of random samples is recommended followed by fatigue testing of these samples over 48 hours at ambient temperature according to subclause 6.2.

Re clause 6 Testing

Clause 6 about the testing of lock washers is new to the standard. It details tests which are required for the assessment of the mechanical and functional properties of lock washers. The contents of this clause result from the experience of manufacturers and users and correspond to the general applications of lock washers.

This also applies to the details of acceptance testing given in subclause 6.5. These details are based on DIN 267 Part 5. Special agreements are not thereby excluded.

Re clause 7 Load bearing capacity

Clause 7 contains details of the calculations of the load bearing capacities of lock washers and indicates how the extended data given in table 1 have arisen. These data refer only to normal applications, but clause 7 states the principles for calculating the load bearing capacities also for other applications.

Re clause 8 Detachment speed

Clause 8 is supplementary to clause 7 and explains the detachment speeds in table 1.

Re clause 9 Finish of the groove

Appropriate details are given in clause 9 for the finish of the grooves for lock washers and these apply to general applications.