UDC 621.882.54-034.14 : 621.882.2 : 620.1

October 1987

Fasteners

Technical delivery conditions
Steel spring washers for bolt/nut assemblies

DIN 267 Part 26

Mechanische Verbindungselemente; technische Lieferbedingungen;
Federelemente aus Federstahl für Schraubenverbindungen

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

1 Scope and field of application

This standard applies to steel spring washers for use with bolt/nut assemblies and dealt with in the following standards:

DIN 127 Spring lock washers with tang ends and square ends

DIN 128 Curved and wave spring lock washers

DIN 137 Curved and wave spring washers

DIN 6796 Conical spring washers for bolt/nut assemblies

DIN 6904 Spring washers for screw assemblies

DIN 6905 Spring lock washers for screw assemblies

DIN 6908 Conical spring washers for screw assemblies

DIN 6913 Spring lock washers with safety ring

DIN 7980 Spring lock washers for cheese head bolts

It is recommended that this standard also be applied for steel spring washers for bolt/nut assemblies which have not been standardized.

Spring washers made from materials other than spring steel are not the subject of this standard.

Note. Steel spring washers serve to counteract the loss in inherent tension caused by setting or creep of a bolt/nut assembly provided that they are sufficiently resilient to increase the overall resilience of the assembly and that their inherent springiness can compensate for any loss in tension so that the clamping force required to ensure the reliability of the assembly is maintained.

There may be a relative movement between bolt and nut if the friction between the clamped components is overcome by transverse forces. If this does occur, loosening of the assembly cannot be prevented by spring washers.

Thus, when using these components, it should be checked whether the spring washers may usefully be applied as the elements maintaining the clamping force.

2 General requirements

The effectiveness of spring washers in bolt/nut assemblies depends on the material (see clause 3) and on whether the test criteria specified in clause 4 are complied with.

Spring washers shall have a smooth surface and be free from scale and burrs. The surface roughness should be specified in the product standards where required. In the as delivered condition, spring washers shall have a rust protection.

DIN 267 Part 1 shall apply for the surface finish of spring washers in the as delivered condition, unless otherwise specified in the relevant product standard (e.g. by specifying "phosphated and oiled", denoted by Znphr . . . f), or particular agreements have been made.

DIN 267 Part 9 shall apply for electroplated coatings.

Note. Hydrogen-induced embrittlement cannot be ruled out when employing current methods of applying metal coatings from aqueous solutions (see DIN 267 Part 9). As there is even an increased risk of embrittlement in the case of components with a hardness of 400 HV or more, particular care is to be taken when selecting the material, and in connection with heat treatment and surface treatment.

3 Material

Spring washers shall be made of spring steel (FSt) complying with the specifications of DIN 17 221 or DIN 17 222, or of spring steel with equivalent properties, the grade being at the manufacturer's discretion. This requirement shall also apply where the documentation does not specify any material. Spring washers for bolt/nut assemblies, in the hardened and tempered condition, shall have a hardness as specified in table 1.

Table 1. **Hardness**

Type of spring washer	Hardness
Spring lock washers	HV 430 to 530
Spring washers	HV 430 to 530
Conical spring washers	HV 420 to 510

4 Testing

4.1 Testing for accuracy to size and finish

The specifications of DIN 267 Part 5 shall apply for acceptance inspection with respect to the accuracy to size of spring washers.

Table 2 shall apply for the characteristics and the AQL values.

Table 2. **AQL values**

Characteristic	AQL value
Internal diameter Width of spring lock washers Washer thickness Free height External diameter of spring washers and conical spring washers	1,5

Continued on pages 2 to 10

4.2 Testing the mechanical properties and materials

The mechanical properties shall be tested as specified in subclauses 4.2.1 to 4.2.5.

4.2.1 Hardness testing

DIN 50 133 shall apply for the Vickers hardness test, DIN 50 103 Part 1 for the Rockwell hardness test, and DIN 50 150 for the conversion of hardness values.

In the case of spring washers, the value shall be measured, where possible, in the middle of the washer surface at the point of contact with the supporting surface.

In the case of conical spring washers, the value shall be measured, where possible, in the middle of the washer surface. The supporting surface on which the measurement is made shall be hard.

In the case of spring lock washers, a number of washers shall be threaded, with the gap facing downwards, on a bolt, and clamped. The spring lock washer assembly shall then be placed in a V-block and ground down in preparation for hardness testing.

4.2.2 Test for permanent set

The spring washer to be tested shall be compressed between hardened, flat ground washers (with a hardness of not less than 60 HRC) for two minutes using the compression loads specified in tables 3 to 5 (and determined in accordance with VDI 2230 Part 1, assuming a coefficient of friction in the thread, μ_G, of 0,12), and applying

- proof loads corresponding to those for bolts of property class 6.8 in the case of spring lock washers,
- proof loads corresponding to those for bolts of property class 5.8 in the case of spring washers, and
- proof loads corresponding to those for bolts of property class 8.8 in the case of conical spring washers.

The free height of the washers (height after release of pressure) shall not be less than the values specified in tables 3 to 5.

4.2.3 Permanent load test for spring lock washers and spring washers

Ten spring lock washers or spring washers, threaded on a bolt and separated from one another by parallel-faced washers (hardened to at least 500 HV), shall not be fractured or cracked after 48 hours conditioning at ambient temperature under the compression loads specified in tables 3 and 4.

Table 3. **Test for permanent set of spring lock washers**

Nominal size (= bolt thread size)		2	2,5	3	3,5	4	5	6
Compression load, in N		700	1160	1760	2370	3050	5050	7050
Minimum free height, in mm	DIN 127	0,8	1	1,3	1,3	1,4	1,9	2,6
	DIN 128 (type A)	0,6	0,7	0,85	0,85	0,95	1,2	1,5
	DIN 6905[1]	–	0,7	0,85	0,85	0,95	1,2	1,5
	DIN 6913	[2]	[2]	[2]	[2]	[2]	[2]	[2]
	DIN 7980	–	–	1,6	1,6	1,9	2,5	2,6

Nominal size (= bolt thread size)		7	8	10	12	14	16	18
Compression load, in N		9000	12900	20600	30000	41300	56300	69000
Minimum free height, in mm	DIN 127	2,6	3,2	3,5	4	4,8	5,6	5,6
	DIN 128 (type A)	1,5	2	2,25	2,65	3	3,6	3,6
	DIN 6905[1]	1,5	2	2,25	–	–	–	–
	DIN 6913	[2]	[2]	[2]	[2]	[2]	[2]	[2]
	DIN 7980	–	3,2	4	4	4,8	5,6	5,6

For [1] and [2], see page 3.

Table 3 (concluded).

Nominal size (= bolt thread size)		20	22	24	27	30	33	36
Compression load, in N		88000	110000	127000	167000	204000	255000	298000
Minimum free height, in mm	DIN 127	6,4	6,4	8	8	9,6	–	9,6
	DIN 128 (type A)	4,2	4,2	5,3	5,3	7,6	–	7,6
	DIN 6905[1]	–	–	–	–	–	–	–
	DIN 6913	[2]	[2]	[2]	[2]	[2]	[2]	[2]
	DIN 7980	7,2	7,2	8	8	9,6	9,6	9,6

1) As a deviation from the specifications of the product standards for washers and lock washers for screw assemblies, the bolt thread size instead of the inside diameter shall be used as the relevant nominal size.
2) No values specified at present.

Table 4. **Test for permanent set of spring washers**

Nominal size (= bolt thread size)		3	3,5	4	5	6
Compression load, in N		1540	2070	2700	4400	6150
Minimum free height, in mm	DIN 137 (type B)	0,8	0,9	1	1,1	1,3
	DIN 6904[1]	0,9	1	1,5	1,6	1,85

Nominal size (= bolt thread size)		7	8	10	12	14	16	18
Compression load, in N		9000	11300	18000	26300	36100	49200	60000
Minimum free height, in mm	DIN 137 (type B)	1,5	1,5	2,1	2,5	3	3,2	3,3
	DIN 6904[1]	2,2	2,2	2,4	2,9	–	–	–

Nominal size (= bolt thread size)		20	22	24	27	30	33	36
Compression load, in N		78000	97000	111000	146000	178000	223000	261000
Minimum free height, in mm	DIN 137 (type B)	3,7	3,9	4,1	4,7	5	5,3	5,8
	DIN 6904[1]	–	–	–	–	–	–	–

For [1], see table 3.

4.2.4 Permanent load test for conical spring washers

Ten conical spring washers, threaded with alternating orientation on a bolt and separated from one another by parallel-faced washers (hardened to at least 500 HV), shall not be fractured after 48 hours conditioning at a temperature of + 100 °C under the compression loads specified in table 5, nor shall the free height be more than 2 % below the values specified in table 5.

Table 5. **Test for permanent set of conical spring washers**

Nominal size (= bolt thread size)		2	2,5	3	3,5	4	5	6
Compression load, in N		920	1540	2350	3160	4050	6700	9400
Minimum free height, in mm	DIN 6796	0,5	0,6	0,7	0,9	1,1	1,3	1,7
	DIN 6908 [1)]	–	1	1,2	1,2	1,5	1,8	2

Nominal size (= bolt thread size)		7	8	10	12	14	16	18
Compression load, in N		13700	17200	27500	40000	55000	75000	95000
Minimum free height, in mm	DIN 6796	2	2,2	2,8	3,4	4	4,6	5,1
	DIN 6908 [1)]	2,3	2,8	2,8	3,3	–	–	–

Nominal size (= bolt thread size)		20	22	24	27	30
Compression load, in N		122000	152000	175000	230000	280000
Minimum free height, in mm	DIN 6796	5,6	6,1	6,8	7,3	8
	DIN 6908 [1)]	–	–	–	–	–
For [1)], see table 3.						

4.2.5 Twist test for spring lock washers

Spring lock washers shall not fracture when twisted through 90° (see figure 1).

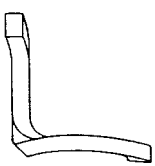


Figure 1.

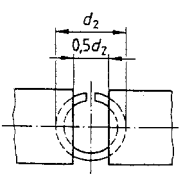


Figure 2.

Bend the spring lock washer slowly and gradually, taking precautions to prevent injuries from any flying splinters. The clamping jaws shall be approximately $0{,}5\,d_2$ apart, their edges shall be slightly rounded (see figure 2).

4.2.6 Spring force test

A spring force test may be carried out in order to assess the springiness of spring washers, this test permitting the residual spring force to be determined.

Place the washer to be tested in a test device and apply the compression load specified in table 7, 8 or 9, the test device being designed to permit as uniform an application of the load as possible. The pressure platen shall have a surface hardness of at least 60 HRC. After two minutes, the load applied to the spring washer shall be slowly and steadily released through a travel of 20 µm, which shall be measured using a precision measuring device (see Explanatory notes).

The residual spring force shall reach the values specified in table 7, 8 or 9, due allowance being made for any deformation of the test device.

The Explanatory notes describe a suitable test device and include examples of spring characteristics.

The residual spring force values represent provisional specifications, with which experience has to be gained. Table 6 summarizes the residual spring forces required for all washer types.

Table 6.

Type of washer	As specified in	Compression load corresponding to the proof load for property class	Residual spring force after release through travel of 20 µm, as a percentage of the compression load
Spring lock washer	DIN 127 DIN 128, type A DIN 6905 DIN 6913 DIN 7980	6.8[1]	20% for nominal sizes 4 to 5 30% for nominal sizes 6 to 12 40% for nominal sizes 14 to 20 50% for nominal sizes above 22
Spring washer	DIN 137, type B DIN 6904	5.8	10% for nominal sizes 4 to 6 15% for nominal sizes 7 to 12 25% for nominal sizes above 12
Conical spring washer [2]	DIN 6796 DIN 6908	8.8	35% for nominal sizes 4 to 5 45% for nominal sizes 6 to 16 60% for nominal sizes 18 to 22 70% for nominal sizes above 22

[1] Spring lock washers which are only intended for bolt/nut assemblies involving fasteners of a property class less than 6.8 are also to be tested at compression loads corresponding to property class 6.8 proof loads.

[2] The residual spring force values have been determined on conical spring washers complying with DIN 6796.

Table 7. **Spring lock washers as specified in DIN 127, DIN 128 (type A), DIN 6905 *), DIN 6913, DIN 7980**

Nominal size	4	5	6	8	10	12	14	16	18
Compression load [1], in N	3050	5050	7050	12900	20600	30000	41300	56300	69000
Minimum residual spring force, in N	600	1000	2100	3900	6200	9000	16500	22500	27600

Nominal size	20	22	24	27	30	33 [2]	36
Compression load [1], in N	88000	110000	127000	167000	204000	255000	298000
Minimum residual spring force, in N	35200	55000	63000	83000	102000	127000	149000

[1] Corresponding to property class 6.8.

[2] Nominal size not included in DIN 127 and DIN 128 (type A).

*) As a deviation from the specifications of the product standards for washers and lock washers for screw assemblies, the bolt thread size instead of the washer or lock washer inside diameter shall be used as the relevant nominal size.

Table 8. **Spring washers as specified in DIN 137 (type B), DIN 6904 *)**

Nominal size	4	5	6	7	8	10	12	14	16
Compression load [1], in N	2700	4000	6150	9000	11300	18000	26200	36100	49200
Minimum residual spring force, in N	270	400	615	1350	1700	2700	3900	9000	12300

Nominal size	18	20	22	24	27	30	33	36
Compression load [1], in N	60000	78000	97000	111000	146000	178000	223000	261000
Minimum residual spring force, in N	15000	19500	24200	27800	36500	44500	55700	65200

[1] Corresponding to property class 5.8.

Table 9. **Conical spring washers as specified in DIN 6796, DIN 6908 *)**

Nominal size	4	5	6	7	8	10	12	14	16
Compression load [1], in N	4050	6700	9400	13700	17200	27500	40000	55000	75000
Minimum residual spring force, in N	1400	2300	4200	6200	7700	12400	18000	25000	34000

Nominal size	18	20	22	24	27	30
Compression load [1], in N	95000	122000	152000	175000	230000	280000
Minimum residual spring force, in N	57000	73000	91000	122000	161000	196000

[1] Corresponding to property class 8.8.

5 Form of supply

Steel spring washers shall be packed to give adequate protection against mechanical damage during transport.

The packages shall be marked with the standard designation specified in the relevant product standard, e.g.:

DIN 127 – A 8 – FSt

The number of units in the package and the manufacturer's symbol shall also be stated on the package.

*) As a deviation from the specifications of the product standards for washers and lock washers for screw assemblies, the bolt thread size instead of the washer or lock washer inside diameter shall be used as the relevant nominal size.

Standards and other documents referred to

DIN	127	Spring lock washers with tang ends and square ends
DIN	128	Curved and wave spring lock washers
DIN	137	Curved and wave spring washers
DIN	267 Part 1	Fasteners; technical delivery conditions, general requirements
DIN	267 Part 5	Fasteners; technical delivery conditions; acceptance inspection (modified version of ISO 3269, 1984 edition)
DIN	267 Part 9	Fasteners; technical delivery conditions; electroplated fasteners
DIN	6796	Conical spring washers for bolt/nut assemblies
DIN	6904	Spring washers for screw assemblies
DIN	6905	Spring lock washers for screw assemblies
DIN	6908	Conical spring washers for screw assemblies
DIN	6913	Spring lock washers with safety ring
DIN	7980	Spring lock washers for cheese head bolts
DIN 17 221		Hot rolled steels for quenched and tempered springs; quality specifications
DIN 17 222		Cold rolled steel strips for springs; technical delivery conditions
DIN 50 103 Part 1		Testing of metallic materials; Rockwell hardness testing, C, A, B, F scales
DIN 50 133		Testing of metallic materials; Vickers hardness testing; HV 0,2 to HV 100
DIN 50 150		Testing of steel and cast steel; conversion tables for Vickers, Brinell and Rockwell hardness, and tensile strength
VDI 2230 Part 1		Calculation of high-strength bolt/nut assemblies; cylindrical single bolt/nut assemblies

Explanatory notes

Specifications relating to technical delivery conditions which include component testing are already to be found in a number of DIN Standards dealing with steel spring washers for bolt/nut assemblies. Such tests, however, did not provide sufficient information with regard to the function and effectiveness of washers in service. Information on function in service is, however, required in the standards as part of product information and in respect of the manufacturer's liability. The standards concerned have thus been revised and the technical delivery conditions collated in this standard. The revision of the standards relating to washers for use with screw assemblies had not been completed at the time this standard was published.

Most of the specifications relating to material and hardness, which only apply to washers made of spring steel, have been left unchanged. In the case of spring washers made from materials other than spring steel, they shall be checked to ensure that with regard to the mechanical properties and corrosion behaviour (incompatibility of materials, crevice corrosion, pitting corrosion) they are suitable for the given application.

The residual spring forces specified are based on tests and the relevant technical literature, but are not as yet sufficiently substantiated for them to be made mandatory for acceptance inspection at present. Before mandatory data can be specified, further experience and test results are needed to obtain a statistically substantiated evaluation.

The same compression loads used for the permanent set and permanent load tests apply as for the spring force test.

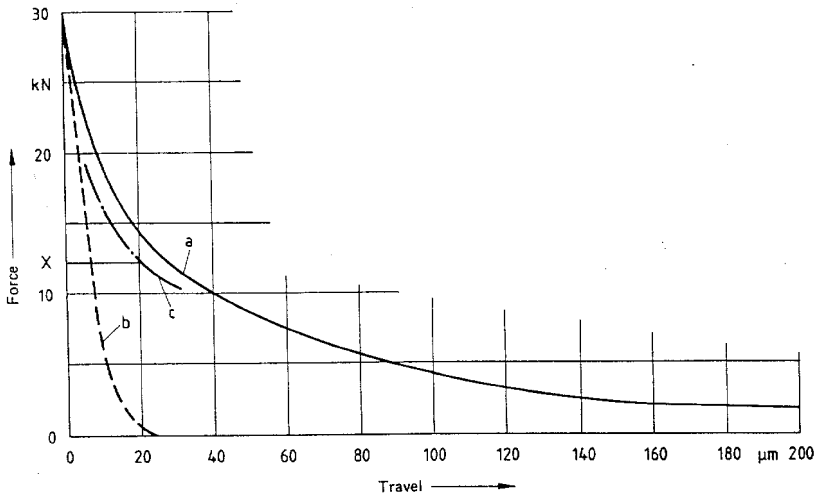
When determining the spring characteristic of spring washers as part of the spring force test, the effect of the elastic deformation of the test device is to be allowed for by deducting the spring travel originating in the test device from the overall travel (i.e. that of spring washer and test device). The relief characteristic for the test device is to be determined as follows.

Place a plain washer instead of a spring washer in the test device (see figure 4 for example), the plain washer being lapped on both sides and having a tolerance on parallelism not exceeding 1 µm and a hardness of not less than 700 HV. The washer dimensions (inside diameter, outside diameter and thickness) shall be identical to those of the spring washer to be tested. Plot the relief characteristic of the test device starting at the compression loads specified in tables 7 to 9. It is essential that parallel-faced washers having the same dimensions as the spring washers to be tested be used when recording the relief characteristic of the test device, as different-sized washers will give different characteristics.

In figure 3, the continuous line represents the total relief characteristic of spring lock washer plus test device for a DIN 127 – A 12 – FSt spring lock washer measured under a compression load of 30 kN, and the dashed line, the relief characteristic of the device only. A segment of the relief characteristic of the spring lock washer obtained by subtraction of the two curves is plotted as a chain line.

To avoid any reversibility error of the force measuring device and the travel gauge, the values of compression load specified in tables 2 to 4 may be exceeded by 5 % when applying the load. The starting point for measuring the 20 µm travel shall, however, be the compression load specified.

Although the 20 µm travel is in most cases larger than the probable amount of setting of a bolt/nut assembly due to surface roughness and coatings, this travel can be reproduced in the test with relatively greater accuracy



a = total relief curve;
b = relief characteristic of test device;
c = relief characteristic of spring lock washer;
X = residual spring force recorded when spring lock washer has been released by through travel of 20 µm.

Figure 3. Determination of spring characteristic (relief characteristic) for a DIN 127 – A 12 – FSt spring lock washer (using a compression load of 30 kN)

than a 5 µm or 10 µm travel. Thus, the residual spring forces given in tables 7 to 9 represent lower limit values for the clamping forces of bolt/nut assemblies exhibiting an exceptionally high degree of setting at parting lines. The free height of spring washers after removal of the proof load, which was previously the sole spring characteristic specified, gives only little indication of the ability of a spring lock washer to counteract the loosening of a bolt/nut assembly, as the greatest relief travels are in the very flat segment of the characteristic where the forces are very small. The curve plotted in figure 3, which covers a relief travel of 0,2 mm does not reach zero force until after a total relief travel of approximately 3,5 mm.

This shows that, though basically simple, the test device must satisfy a number of requirements if valid, reproducible and repeatable results are to be obtained. Figure 4 illustrates a test device suitable for both electrical and mechanical measurements of travel. The numbers given in brackets below indicate for which component(s) of the test device the following specifications apply.

1 Low resilience and, if possible, only (elastic) compressive deformation without flexural deformation of the complete test device, in particular in the zone where the force is transmitted from the pressure platen (1) to the bearing plate (2) and the upper part of the pedestal (6).

2 Centric bore in the pedestal permitting the passage of the measuring pin (4) of the travel gauge (8) and that of the sleeve (7) specified under item 3.

3 Fastening of travel gauge (8) using a sleeve (7) exactly at the same height as the upper face of the bearing plate (2), so as to ensure that the error resulting from the inherent formation of the gauge is as small as possible.

4 Bearing plate (2) and sleeve (7) removable, so that bearing plates for different washer diameters can be used.

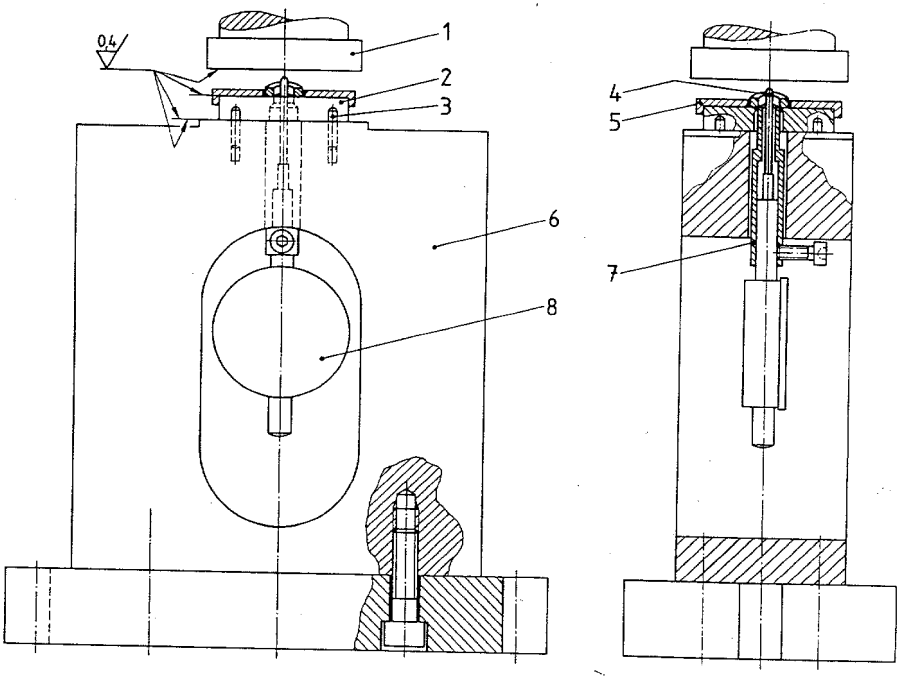
5 All surfaces via which the force is applied and the deformations of which are included in the travel measurements shall have a roughness, R_a, not exceeding 0,4 (corresponding to R_z not exceeding 1,6).

6 The bearing plate (2) and the pressure platen (1) shall have a hardness of not less than 60 HRC.

7 The pressure platen (1) shall be guided so as to be parallel to the bearing plate, a useful feature being a play of some tenths of a millimetre in the plane of the bearing plate to compensate for small elastic forces (this is generally provided for in universal testing machines).

8 The compression load shall be adjustable to within 2%, and it shall be possible to read the residual spring force to within 2%.

9 The dial indicator, the inductive travel gauge or any other travel gauge (8) used may only have a relative repeatability error and reversibility error not exceeding 1 µm for any partial measuring range of 40 µm, the direction of movement of the measuring pin being away from the gauge (see DIN 879 Part 1 for definitions).



1 Pressure platen (hardness not less than 60 HRC)
2 Bearing plate (hardness not less than 60 HRC)
3 Centring pins
4 Measuring pin
5 Centring device
6 Pedestal
7 Sleeve
8 Travel gauge

Figure 4. Example of a test device

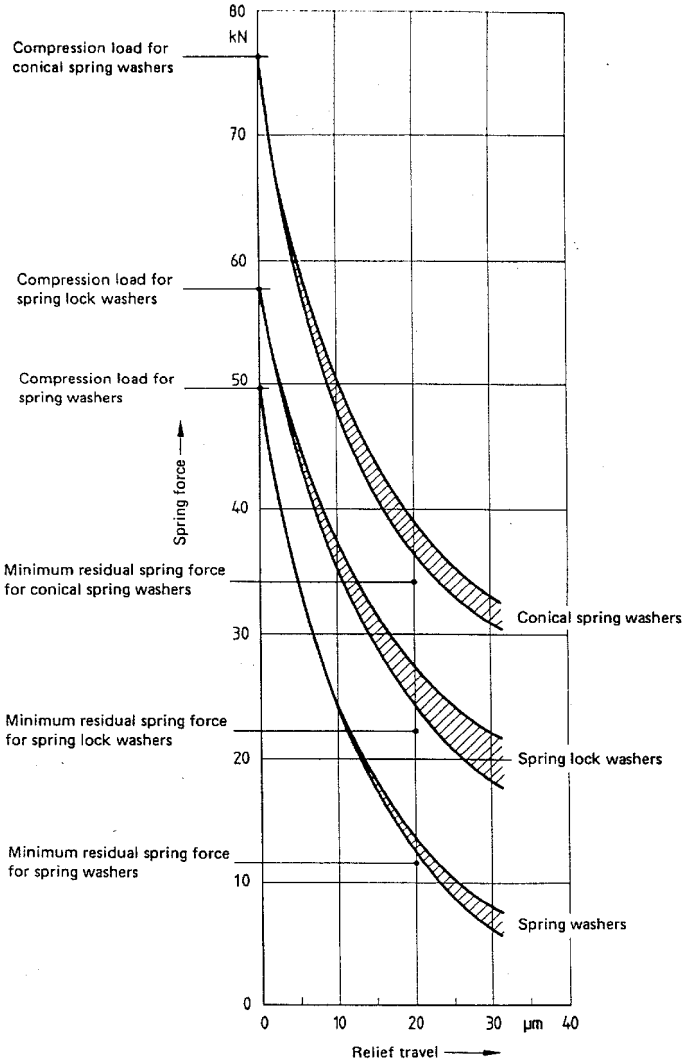


Figure 5. Graphs representing relief travels and residual spring forces for various spring washers (of nominal size 16)

International Patent Classification

F 16 B 39/24
G 01 M 19/00
G 01 N 3/00