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China Disc Springs, Inc.

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China Disc Springs, Inc.

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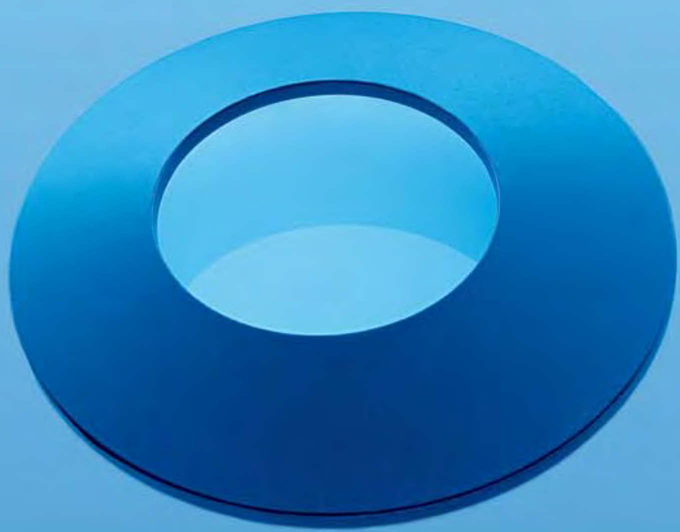
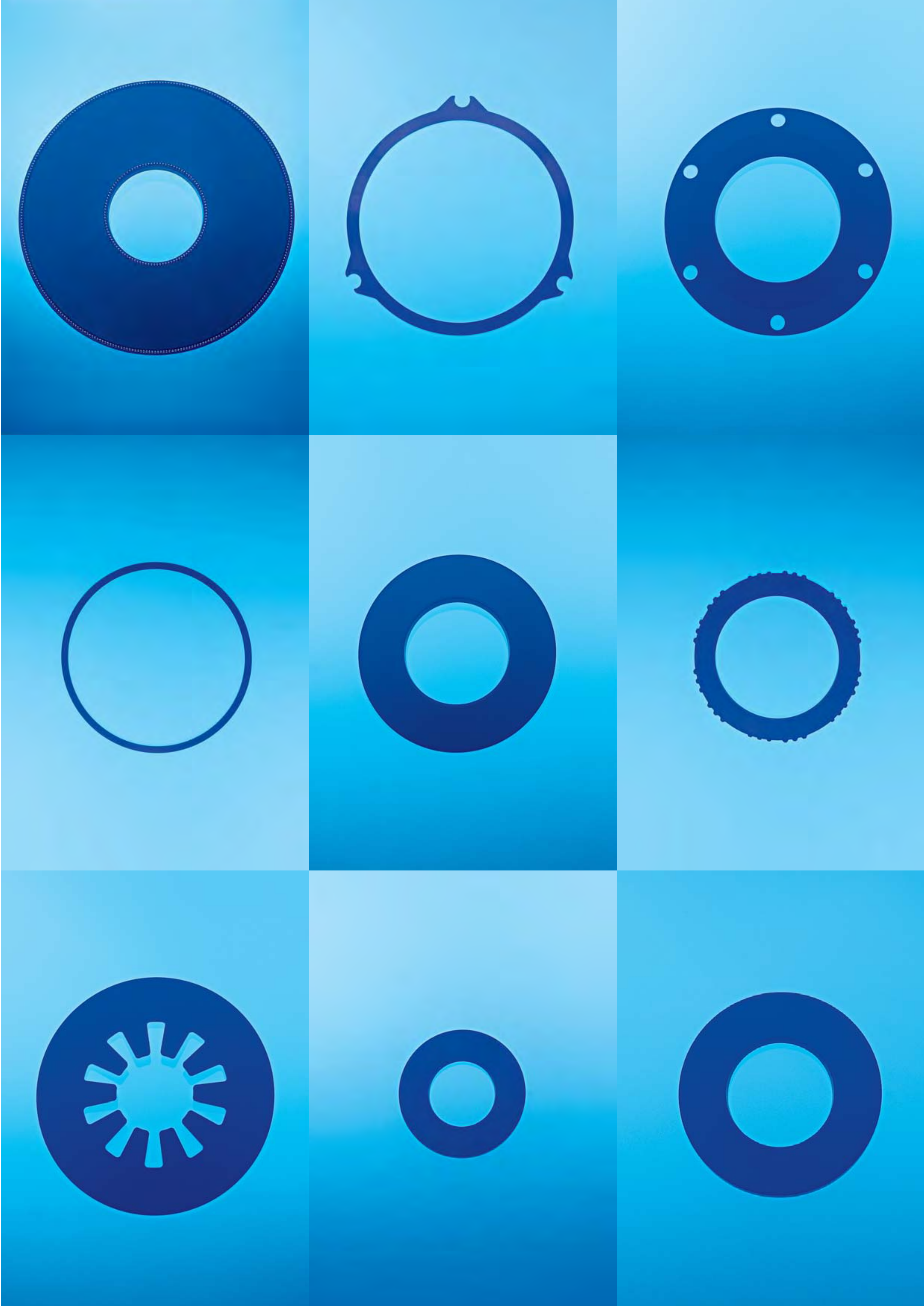
Engineering for mobility: As an international partner of the automobile industry, China Disc Springs, Inc. develops and manufactures high-quality disc springs, suspension springs, stabiliser bars, engine valve springs, hose clamps, belt tensioning systems and other highly-stressed components.

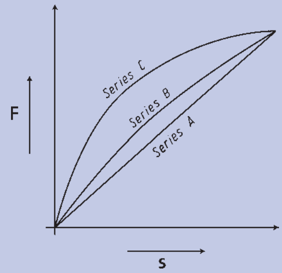


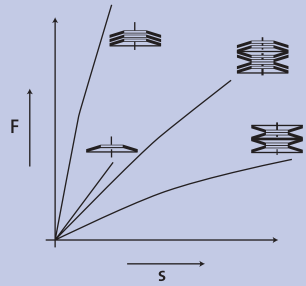


2.1 Disc Spring Product Overview

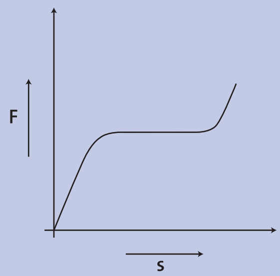
Spring Type | **Appearance** | **Spring characteristics**

CONVENTIONAL
DISC SPRINGS

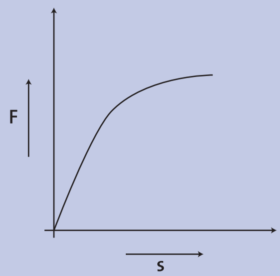




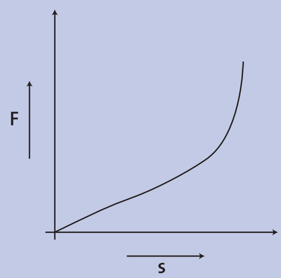
SLOTTED
DISC SPRINGS [1)]



SPECIAL SPRINGS [1)]



WAVE SPRINGS [1)]



Typical applications

| Boiler suspension systems in power plants
| Safety valves
| Overload protection in electric transformers
| Couplings
| Aerial cable cars
| Machine tool clamping components
| Safety brakes for lifts and elevators
| Brakes for construction and railway vehicles
| Backlash compensation for ball bearings
| Vibration isolation, etc.

| Automatic transmissions
| Overload clutches
| Clutches, etc.

| Adapted to the specific installation requirements in
  | Clutches
  | Gearboxes, transmissions, etc.

| Automatic transmissions
| Backlash compensation, etc

[1] custom designed parts

Conventional disc springs

| Disc springs to DIN 2093 (Group 1, Group 2, Group 3 ...)

| Disc springs to China Disc Springs, Inc. Factory Standards or other as required

| Size range: outside diameter 8.0 mm to 800 mm

| Materials to DIN 2093 (DIN 17 221, DIN 17 222) and special materials (*Section 5.1*)

| Disc springs with a thickness of 0.5 mm and greater are shot-peened to improve fatigue life

| Standard corrosion protection is phosphate oiling *(Other coatings are possible as noted in Section 5.2)*

Disc spring stacks

On request, China Disc Springs, Inc. can deliver disc springs pre-assembled in stacks or on a guiding device.

Advantages include:

| Ability to provide stack specific load-deflection diagrams (our load testing machines can measure loads up to 1000 kN)

| Small load tolerances possible

| 100% load testing can be used to verify proper stacking

| Assembly is more efficient with pre-assembled stacks

Internally or externally slotted disc springs

| Size range: outside diameter 20 to 300 mm
| Slotted disc springs are typically developed in close collaboration with customers for specific applications
| Special production processes are used to maintain extremely tight load tolerances and to achieve the maximum possible fatigue life.

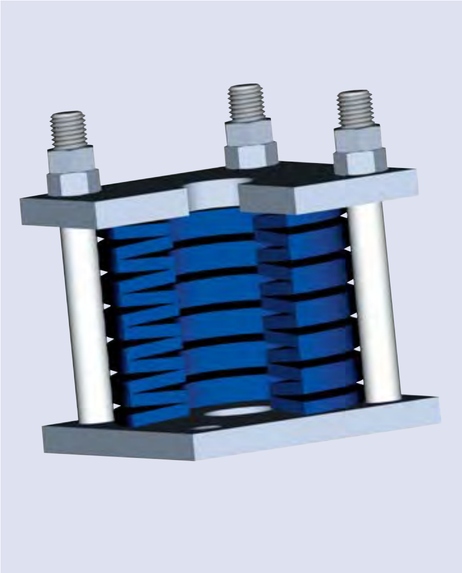
Special springs

As necessary, China Disc Springs, Inc. will work with the customer to develop special springs to meet the requirements of specific applications.

Wave springs

China Disc Springs, Inc. produces wave springs with outside diameters ranging from 20 mm to 300 mm. Wave springs are often used to improve shift quality in automatic transmissions. Wave springs are designed per the specific requi-rements of each customer.

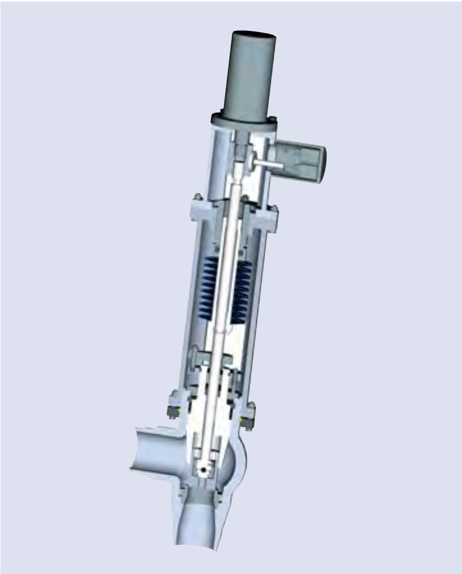
2.2 Application examples



Pre-assembled spring stacks

Plant construction, power station construction, machine construction

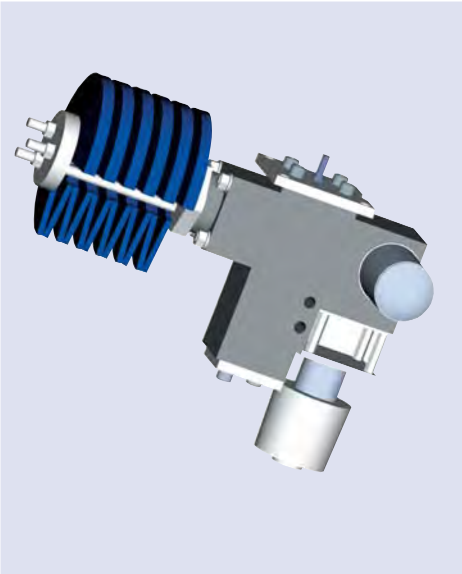
Spring stacks are used for boiler suspension systems. The spring assemblies compensate for localised deflections in the bearing surface and thus guarantee an even lowering of the boiler with load fluctuations due to thermal expansion.



Valves

Plant construction, machine construction, chemical industry

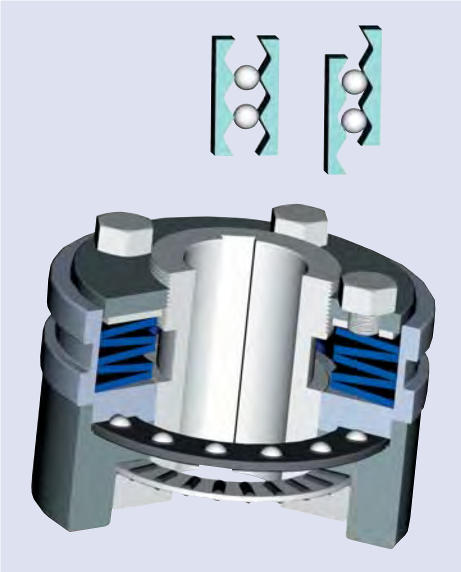
In quick-action stop valves the disc spring stack is hydraulically preloaded when in the open position. If a failure occurs, the hydraulic pressure drops and the disc spring stack is released, closing the valve and thus interrupting the flow. Often ball-centered disc spring stacks are used for this purpose.



Energy storage for safety systems

Circuit breakers, machine construction

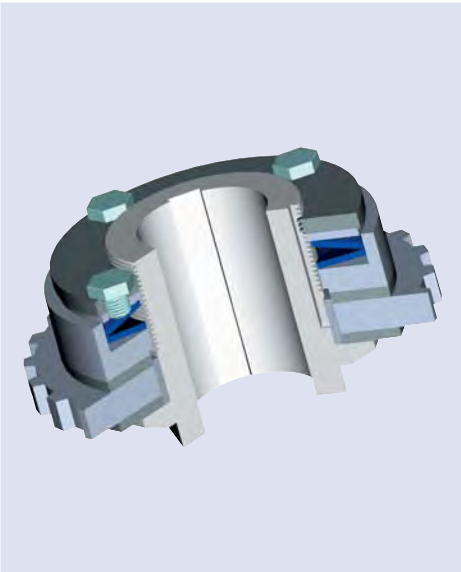
In hydraulic spring mechanisms, energy storage is often achieved by means of a disc spring stack.



Overload clutches

Plant construction, machine construction, motor vehicle construction

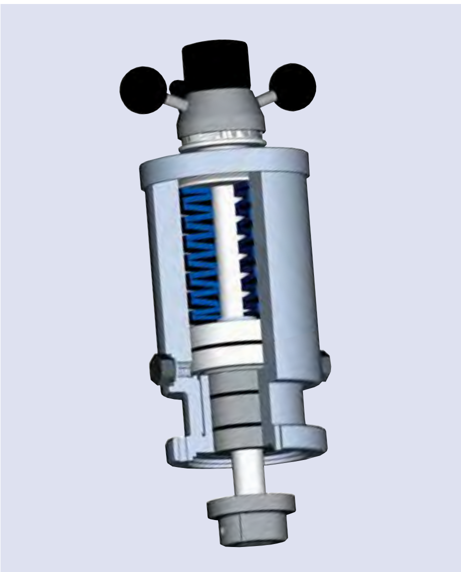
In overload clutches, disc springs provide the load required to maintain sufficient friction to transmit the torque. The load level can be regulated with adjuster nuts. If overload occurs the transmission of torque is interrupted.



Slip clutches

Plant construction, machine construction, motor vehicle construction

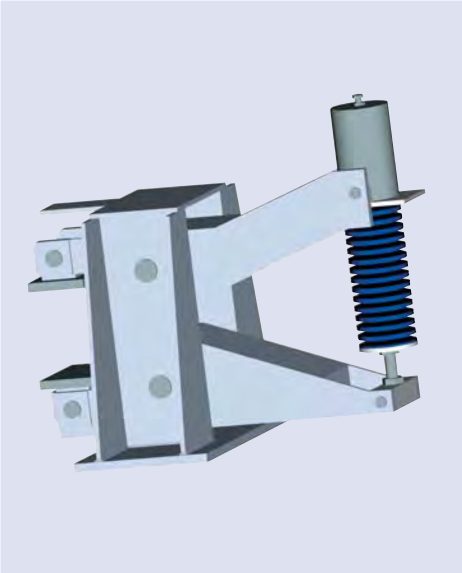
In slip clutches the disc spring provides a defined axial pressure on the friction linings. Wear on the friction linings over the life of the clutch is compensated for by the disc spring, thereby maintaining a constant torque level. Slotted disc springs with a flat load curve are especially well suited to this type of application.



Piston return springs

Off road and automotive transmissions

The disc spring ensures that the hydraulically actuated piston returns to its original position after the load on the coupling is released. Tolerances and wear on the coupling components are compensated for by the horizontal characteristic of the load curve in the working range of the disc spring. This results in consistent shift quality.



Spring-actuated brakes (Fail safe brakes)

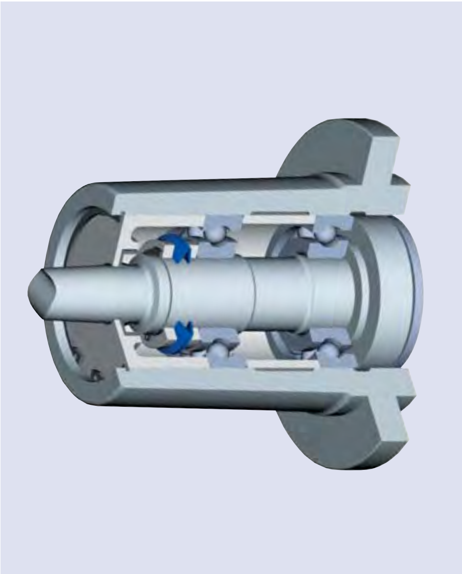
Plant construction, machine construction, motor vehicle construction

The braking load is generated by the disc springs when the hydraulic pressure is reduced to a predetermined level.

Tool clamping components

Machine construction, toolmaking

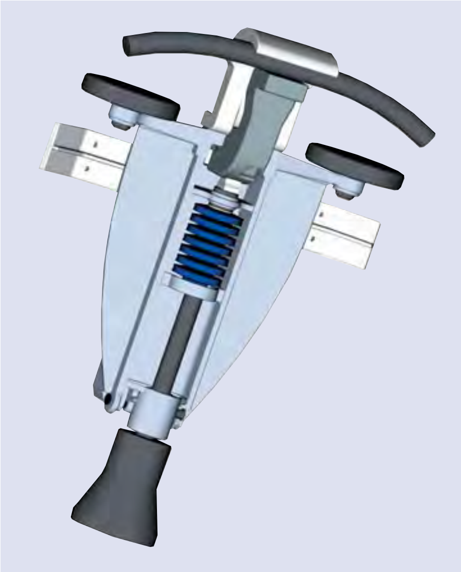
In tool clamping components, the function of the disc spring stack is to hold the tool securely in the tapered holder.



Backlash compensation

Plant and machine construction

Disc springs are often used to compensate for geometric tolerances in component assemblies.



Cableway grip

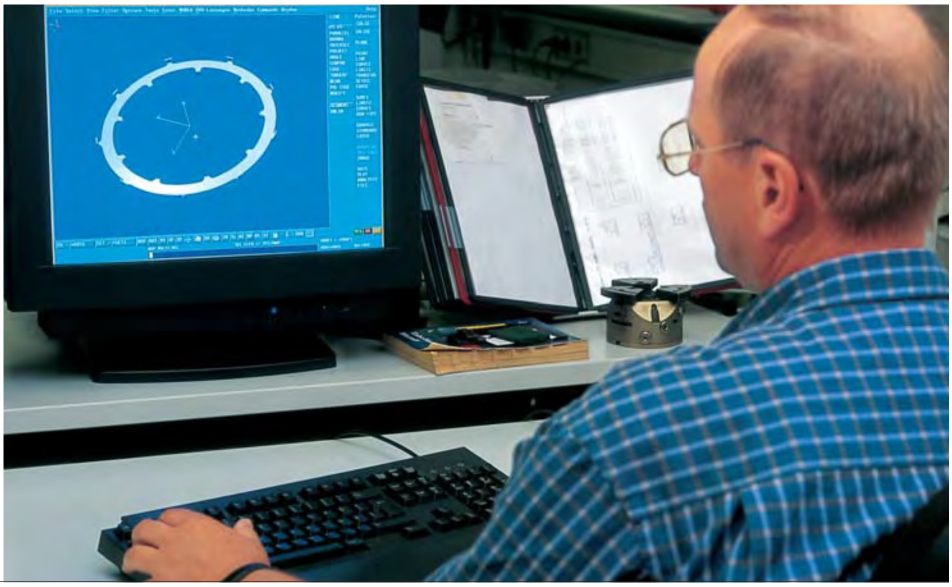
Plant construction

On cableways a disc spring stack generates a friction lock between the cable grip and wire cable. Depending on the type of grip, the load can be static or dynamic.

2.3 Production

China Disc Springs, Inc. sets high internal standards to ensure superior quality at a reasonable cost by using innovative and extremely efficient production methods, starting with the production of the raw material.

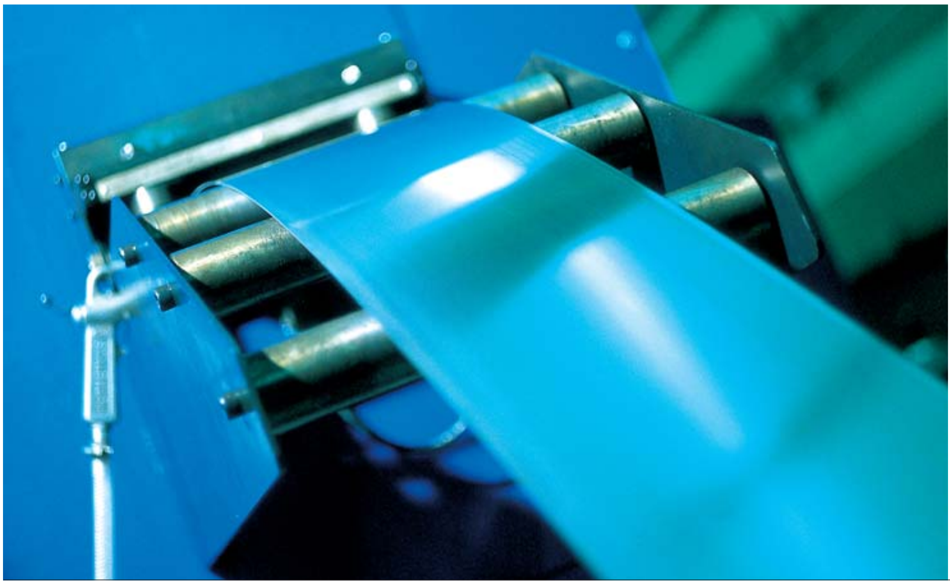
The majority of strip material used is produced to very tight tolerances. Depending on the disc thickness, the disc blanks are manufactured by stamping (Group 1), fine blanking (Group 2) or plasma arc/flame cutting (Group 3). Disc springs of greater material thickness are machined all over to remove surface imperfections. Depending on the application, disc springs can be heat-treated with either a martempering or austempering process to extremely tight hardness tolerances. Subsequent shot-peening improves the fatigue life of the springs. Our standard corrosion protection, phosphating and oiling, is done in our own facility. Complete monitoring of the various production stages guarantees the high quality of China Disc Springs, Inc. disc springs. Mubea's quality system is certified to DIN EN 9001, VDA 61 and QS 9000 and to the environmental guideline DIN EN ISO 14000.



Development

Tool making

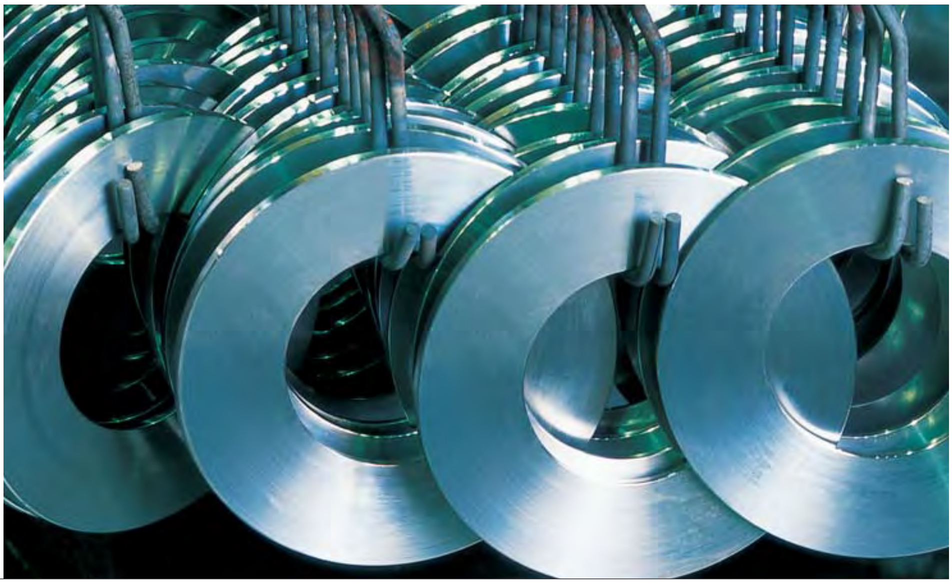
Raw material



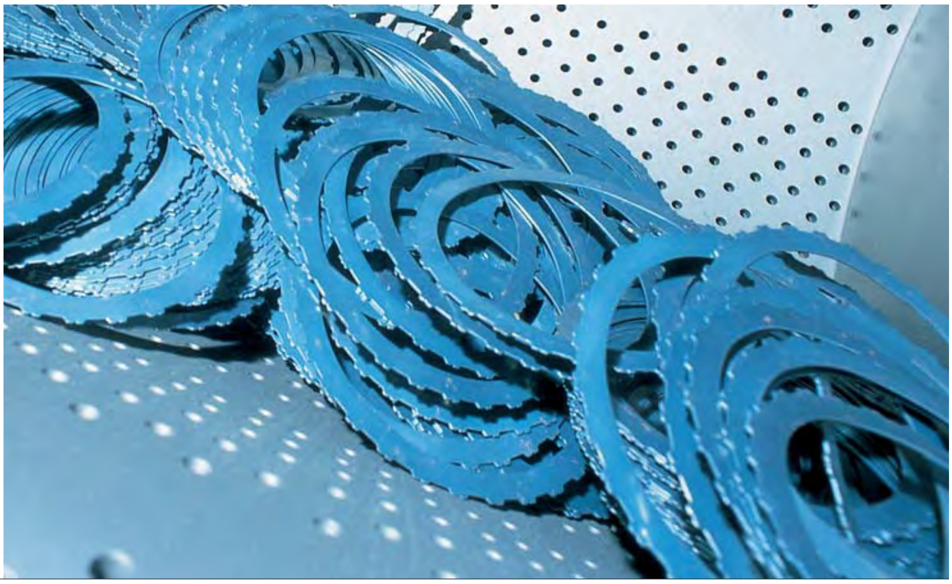
Fine blanking

Flame cutting

Deburring



Heat treating



Shot peening

Corrosion protection

Quality assurance

Final product

Design and Theory

3

Chapter 3

Design and Theory

3.1. Design

3.1.1 Quick selection guide

Disc springs can be designed to meet the specific requirements of a variety of applications. These requirements can typically be met with springs from Mubea's standard product line. Our standard product line includes disc springs designed per the requirements of DIN 2093, our own internal factory standards, as well as other special sizes. Disc springs from our standard product line are typically available from stock for immediate delivery.

Disc springs can also be designed with non-standard dimensions. Depending upon the availanility of material and tooling requirements, delivery times may be longer. In such cases one should consider whether the additional cost and longer delivery is justifiable. Below is a brief guide to support quick and accurate disc spring design.

As a minimum, the following information about the application is required:

- available mounting space
- required spring loads
- type of load
- required number of load cycles
- operating conditions (operating temperature, operating medium, corrosion protection)

Mubea's Datasheet for the Design of Disc Springs shown in Fig. 3.1 provides a good basis for summarising the requirements of a given application.

For a majority of applica tions, the materials specified in DIN 2093 or Mubea's Factory Standard (Ck 67, 50 CrV 4) are sufficient. As a standard, Mubea's springs are phosphated and oiled. Other available surface coatings are listed in Section 5.2. Applications requiring a high level of corrosion resistance, operation at extreme temperatures, antimagnetism etc. require the use of special materials, which is explained in greater detail in Section 5.1. Please contact China Disc Springs, Inc. regarding spring designs for applications requiring special materials.

If the desired mounting space is fixed, it first needs to be determined if disc springs from our standard productline can beused. The dimensions for these disc springs can be obtained from Section 6. The tables also specify the loads for the respective spring at varying deflections. Furthermore, detailed spring characteristics can be found in the section containing graphs for springs per DIN 2093. The graphs also enable the fatigue life to be estimated. Refer to Section 6.2 for an explanation of the graphs. If a standard spring will not work for an application, disc springs can also be custom designed with the aid of the China Disc Springs, Inc. Calculation Program described in Section 3.1.2. Please contact China Disc Springs, Inc. if additional assistan-ce is required. It is preferable that the design of disc spring stacks should be done with the China Disc Springs, Inc. Calculation Program.

Datenblatt | Datasheet | Données techniques

DATENBLATT ZUR AUSLEGUNG VON TELLERFEDERN (Bitte ausfüllen bzw. Zutreffendes ankreuzen)
DATA SHEET FOR THE DESIGN OF DISC SPRINGS (please fill in/check off where applicable)
DONNÉES TECHNIQUES (S.v.p. remplir ou mettre une croix)

1| **Art der Maschine bzw. Anlage**: ______________________________
Kind of machine/plant:
Type de machine/application:

2| **Zweck der Federn:** ______________________________
Purpose of the springs:
Usage des rondelles:

3| **Einbauraum:** Durchmesser D_{max} = ______________ D_{min} = ______________ mm
Mounting space: Diameter
Dimensions: Diamètre
Länge/length/longueur L_{max} = ______________ L_{min} = ______________ mm

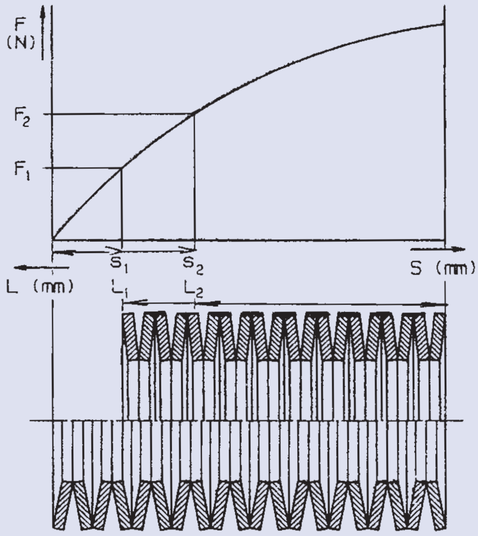
4| **Schichtungsart**/Method of stacking/Mode d'empilage: ______________________________

5| **Kräfte und Federwege**/Forces and deflections/Forces et courses:

L_1 = ________ mm s_1 = ________ mm F_1 = ________ N Tol: + ________ % Tol: - ________ %
L_2 = ________ mm s_2 = ________ mm F_2 = ________ N Tol: + ________ % Tol: - ________ %
L_3 = ________ mm s_3 = ________ mm F_3 = ________ N Tol: + ________ % Tol: - ________ %

6| **Art der Belastung**/Type of load/Mode de fonctionnement:
☐ statisch/static/statique ☐ dynamisch/dynamic/dynamique

7| **Belastungsverlauf**/Application of load/Allure de courbes:
☐ stoßartig/shock/amortissement ☐ sinusförmig/sinusoidal/sinusoïdale



8| **Erwünschte Lebensdauer:** ______________________________
Requested fatigue life:
Durée de vie souhaitée:

9| **Betriebstemperatur (an der Feder):** ______________________________
Working temperature (at spring):
Température de fonctionnement (au ressort):

10| **Führung:** ☐ innen ☐ außen
Guide method: inside outside
Guide: intérieur extérieur

11| **Lage der Feder bzw. Säule:** ☐ vertikal ☐ horizontal
Location of spring/stack: horizontal vertical
Position de la rondelle ressort/d'empilage: horizontal vertical

12| **Ist ein besonderer Korrosionsschutz erforderlich?** ______________________________
Is a special protection against corrosion required?
A-t-on besoin d'une protection particulière contre la corrosion?

13| **Angreifendes Medium**/Agressive medium/A quoi est dû la corrosion: ______________________________

14| **Bemerkungen**/Remarks/Remarques: ______________________________

Sachbearbeiter/Responsable/Responsable Produit: ______________________________

Telefon/Phone/Téléphone: ______________________________ **Telefax**/Fax/Téléfax: ______________________________

Datum/Date/Date: ______________________________ **Unterschrift**/Signature/Signature: ______________________________

Design and Theory

3.1.2 Mubea's Calculation Program

Detailed design calculations can be made with the aid of the **Calculation Program for the Design of Disc Springs** available from China Disc Springs, Inc.. This program aids in the optimum selection of either individual springs or combinations of stacked springs based upon available moun-ting space and fatigue life requirements. This program can also evaluate springs made from a variety of materials.

The Calculation Program can be obtained from the enclosed CD or downloaded from the internet Operation instructions for the program are provi-ded on the CD and Mubea's website. The program can estimate fatigue life for:

| spring stacks containing up to 60 individual disc springs stacked in series
| spring stacks consisting of up to 15 spring packs containing 2 springs stacked in parallel
| for springs less than 16mm thick
| for springs stressed within allowable limits.

Applications with requirements outside of those listed above should be discussed with China Disc Springs, Inc..

3.2 Disc spring theory

Disc springs are shallow conical rings that are subjected to axial loads (*Fig. 3.2*). Normally the ring thickness is constant and the applied load is evenly distributed over the upper inside and lower outside edges. Disc springs are generally manufactured from spring steel and can be subjected to static loads, rarely alternating loads, and dynamic loads. Disc springs can meet the most stringent fatigue life and set loss requirements.

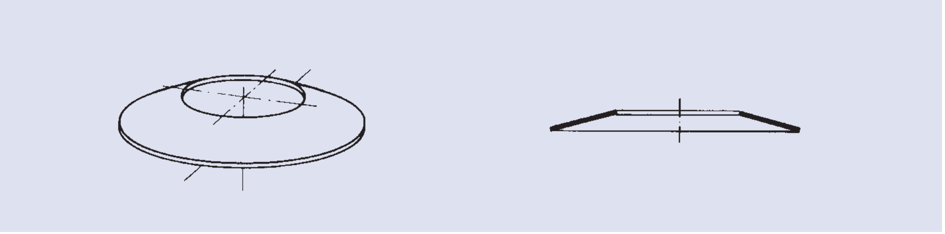


Fig. 3.2: Single disc spring

Disc springs are distinguished from other spring types by the following characteristics:

| high load capacity with a small spring deflection
| high space utilisation when compared with other types of springs
| high fatigue life and low set loss/creep when properly sized
| different combinations of springs can be designed to achieve the desired load characteristics
| a variety of special materials and surface coatings can be used
| cost-effective, as a result of standardised sizes.

3.2.1 Properties and construction

The characteristic load curve is a representation of the force-deflection behaviour of the spring. Depending upon the dimensional ratios, the characteristic load curve of a disc spring is more or less digressive up to the flat position (*Fig. 3.3*). In special cases, disc springs can be designed so that deflection beyond the flat position is possible. Typically, disc springs are used as modular components. A group of individual disc springs stacked facing the same way is called a parallel spring stack. A group of individual disc springs or parallel spring stacks that are stacked facing alternate ways is called a series spring stack (*Fig. 3.4/3.5*). In a parallel spring stack, the deflection of the stack is equal to that of the individual spring. The load at a given deflection is proportional to the number of individual springs in the stack. In a series spring stack, the deflection of the stack is the sum of the deflections of the individual springs. The load of the stack is equal to the load on the individual spring. When calculating the spring deflection and load capacity of a stack composed of individual springs or spring packs these facts must be taken into consideration (*Fig. 3.6*).

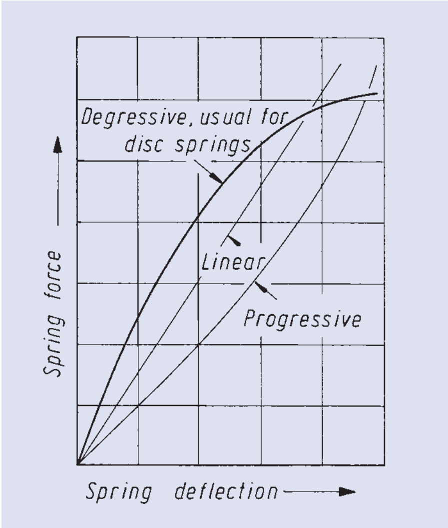


Fig. 3.3: Typical characteristic curves

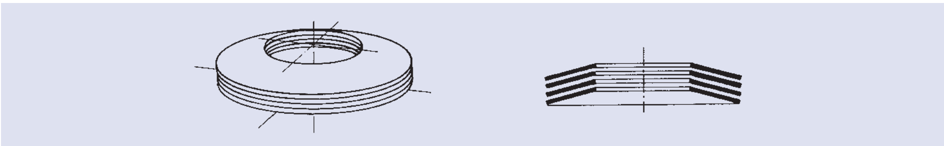


Fig. 3.4: Stack consisting of four individual springs arranged in parallel

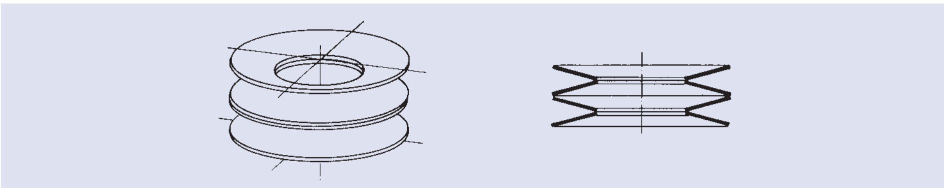
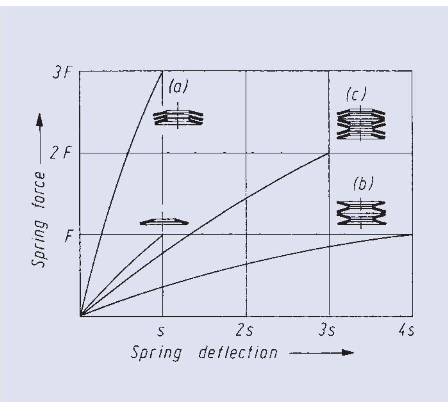


Fig. 3.5: Stack consisting of four individual springs arranged in series

It is possible to generate progressive characteristic curves by combining paralell spring stacks containing different numbers of disc springs or single disc springs of varying thickness to form a stack. In these cases the packs or single discs with the lower load capacity do not contribute to the deflection of the stack after reaching the flat position or their upper stroke limits, with the result that the total spring rate of the stack rises *(Fig. 3.7)*.



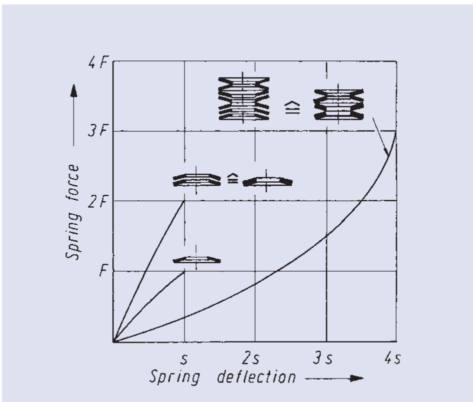


Fig. 3.6, left: Various combinations of disc springs:
a) stack of 3 individual disc springs in paralell: force multiplied by 3
b) stack of 4 individual disc springs in series: deflection multiplied by 4
c) series stack consisiting of 3 paralell stacks, each paralell stack contains 2 individual disc springs: deflection multiplied by 3, force multiplied by 2

Fig. 3.7, right: Combination of disc-springs designed to yield a progressive characteristic load curve

3.2.2 Classification according to DIN 2093

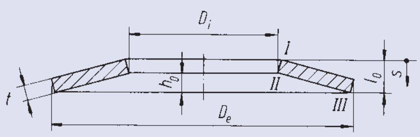
Disc spring design, sizing, and manufacture have been standardised according to DIN 2092 (Disc springs, Calculation) and DIN 2093 (Disc springs, Calculation, Dimensions, Quality requirements). Disc springs in accordance with DIN 2093 are classified into 3 groups:

| Group 1: Disc thickness, t, less than 1.25 mm

| Group 2: Disc thickness, t, from 1.25 mm to 6 mm

| Group 3: Disc thickness, t, over 6 mm up to 14 mm

Group 1 and 2 springs are manufactured without contact surfaces (*Fig. 3.8*), Group 3 springs are manufactured with contact surfaces (*Fig. 3.9*).



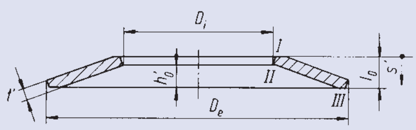


Fig. 3.8, left: Group 1 and 2 springs without contact surfaces

Fig. 3.9, right: Group 3 springs with contact surfaces

The requirements of springs manufactured to DIN 2093 are summarised in the table below (*Table 3.1*).

Group	Production Method	Surface Finish**) Upper and lower surfaces µm	Surface Finish**) Inner and outer edges µm
1	stamped, cold-formed, edges rounded	R_a < 3,2	R_a < 12,5
2*)	stamped, cold-formed, D_e and D_i turned, edges rounded	R_a < 6,3	R_a < 6,3
	fine-blanked, cold-formed, edges rounded	R_a < 6,3	R_a < 3,2
3	cold- or hot-formed, turned on all sides, edges rounded	R_a < 12,5	R_a < 12,5

*) Unless otherwise specified, the manufacturing process is left to the discretion of the manufacturer *(see Section 5 in DIN 2093)*.
**) The specified values do not apply to shot-peened disc springs.

Table 3.1 Production method and permissible surface finish

Other production methods, such as laser-beam cutting or water-jet cutting etc. may be used for the production of special disc springs. In addition to disc springs with a rectangular cross-section and rounded edges, there are the following types:

| disc springs with a trapezoidal cross-section and

| disc springs with slots

Slotted disc springs are used extensively in couplings and transmissions while those with a trapezoidal cross section are not typically used. These types of springs are not covered in this catalog. However, China Disc Springs, Inc. can assist in the selection of slotted springs.

3.2.3 Evaluation of individual disc springs

Although more accurate analytical equations exist for the evaluation of disc spring behaviour, the simplified equations of DIN 2092 are sufficiently accurate. The equations in DIN 2092 are essentially derived from calculations developed by ALMEN and LÁSZLÓ.

According to these equations, the deformation behaviour of the disc spring is treated as a one-dimensional inversion of a circular ring of rectangular cross-section about a center of inversion S. The resulting inverted stress condition is overlaid by a bending stress condition caused by the change in the cone angle resulting from the deflection. The cross-section of the disc spring remains rectangular, so that force is always applied at the edges I and III. The behaviour of the material is regarded as linear-elastic without limit. Residual stresses are not taken into account. The calculated stresses are nominal stresses. China Disc Springs, Inc. has com-puter-aided calculation programs available for the design of disc springs (*see Section 3.1*).

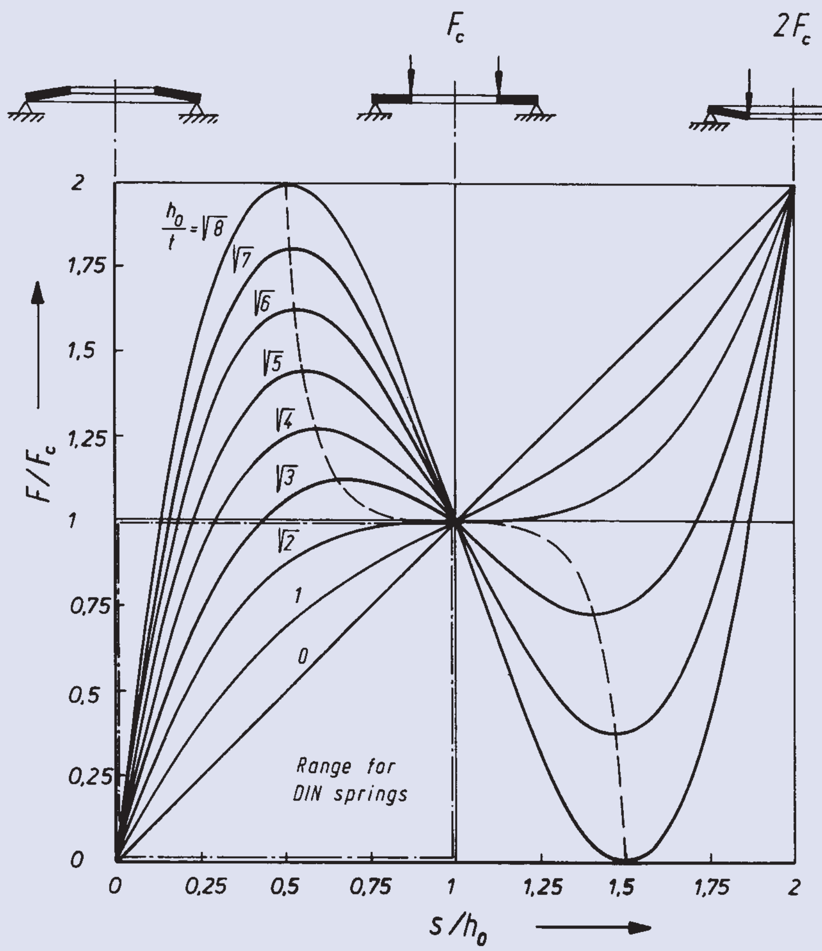


Fig. 3.10:
Relative calculated characteristic load curves. Deflection: refers to the spring deflection up to flat position $s = S_C = h_O$. Spring force: refers to the spring force in the flat position $F_C = F(h_O)$

Disc springs without contact surfaces with force application per DIN

Specifications

The characteristic load curve for a disc spring is defined by the h_0/t ratio. Assuming unrestricted spring deformation and adherence to permissible load limits, the characteristic load curves shown in *Fig. 3.10* are obtained. The characteristic curves shown in Fig. 3.11 are specifically for Series A, B and C springs standardised according to DIN 2093.

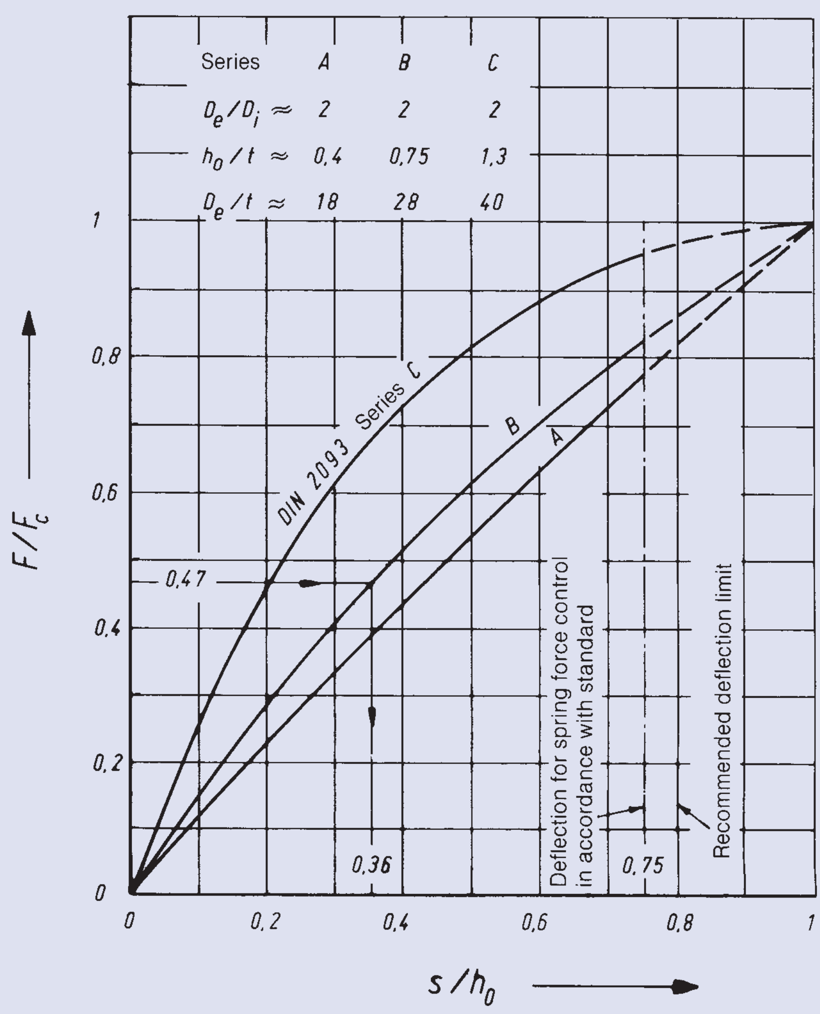


Fig. 3.11: Calculated characteristic load curves for disc springs to DIN 2093, Series A, B and C, as well as the recommended deflection limit. The upper section of the graph shows the average spring parameters for the standard spring series

Load stresses

The fatigue life of the disc spring is dependant upon the stresses that run tangentially, while the stresses running radially are negligibly small. Typically, compressive stresses act on the upper side of the disc and tensile stresses on the lower side.

The calculated stresses do not correspond to the actual stresses in the spring. This is due to residual stresses caused by shot-peening and presetting. The actual stresses are a combination of the residual stresses and the load stresses *(Fig. 3.12)*. The dynamic strength of the spring is dependant upon the tensile stresses on the underside of the disc. Due to the residual stresses introduced in our production process, the calculated stress levels are higher than the actual stress levels.

Depending on the h_0/t ratio, the maximum tensile stress will occur at cross-section point II (inner diameter bottom) or III (outer diameter bottom).

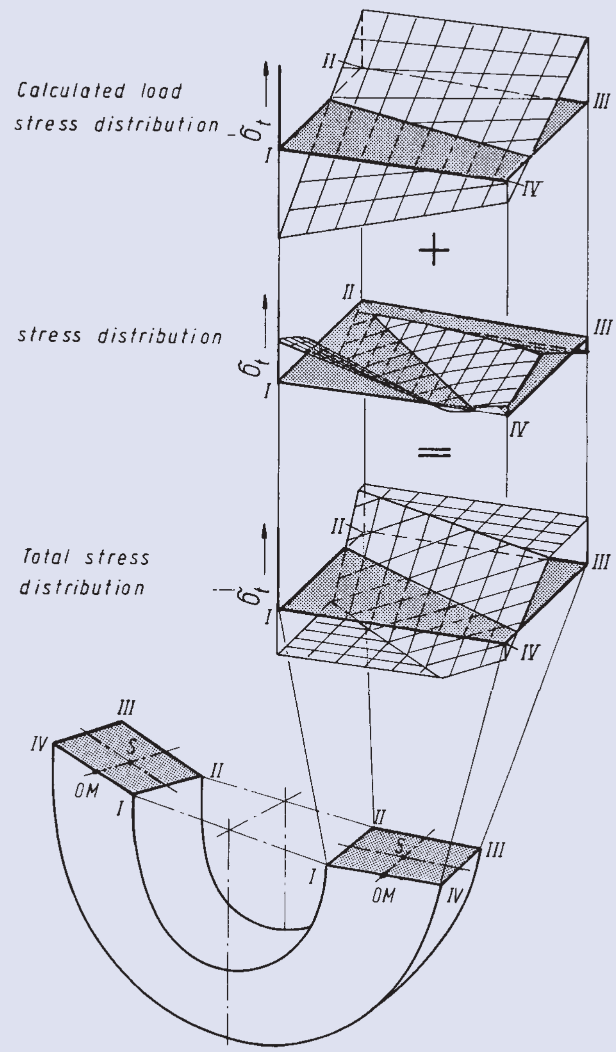


Fig. 3.12: Overlay of load stresses and residual stresses to give total stresses

On the upper side of the spring, the maximum compressive stress occurs on the inside edge of the spring at cross-section point I. This stress determines the set loss of the spring. Setting is caused by plastic deformation of the disc spring due to high deflections that exceed the elastic limit of the material. This results in a reduction in the free height of the spring.

Disc springs without contact surfaces with force application through shortened lever arms

For the deformation model typically used, the moment required to achieve a given deflection when force is applied through shortened lever arms, is of exactly the same magnitude as the moment required when the load is applied at points I and III of the spring cross section.

Because of the shortened lever arm a greater load F’ > F is required to achieve the same spring deflection. The result is a steeper characteristic load curve when compared with a spring subjected to normal loading. The calculated load stress is not influenced by the location of load application. It depends only on the variation of the cone angle *(Fig. 3.13)*.

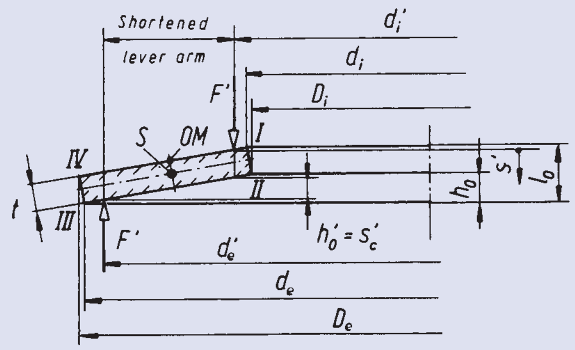


Fig. 3.13: Dimensional relationships when load is applied via a shortened lever arm

Disc springs with contact surfaces

Contact surfaces are used for disc springs with a thickness greater than 6 mm (Group 3 of DIN 2093). This provides a larger area for load application thereby reducing the friction on the guide elements. The location of the applied force is shifted from d_e to d_e' on the outside and from d_i to d_i' on the inside. This results in a shortening of the lever arm and an increase in the characteristic load curve *(Fig. 3.14)*.

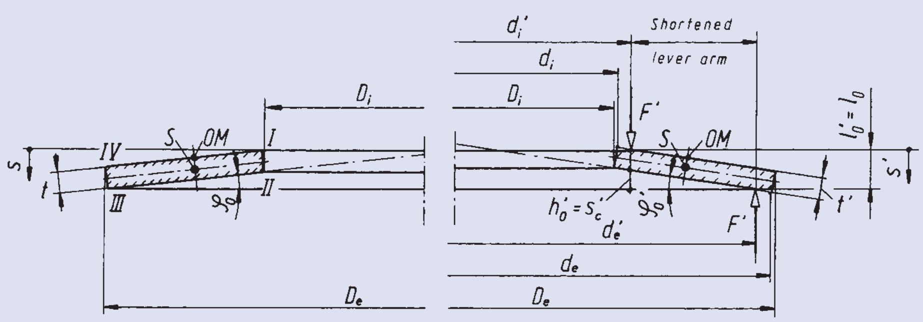


Fig. 3.14: Comparison of a disc spring without contact surfaces (left) and a disc spring with contact surfaces (right)

Disc springs with contact surfaces have the same design force F (at a deflection $s = 0.75 \cdot h_0$) as disc springs without contact surfaces with the same dimensions D_e, D_i and l_0.
The resulting increase in force is counteracted by a reduction in the disc thickness. Due to the requirement for identical overall height l_0, the disc spring with contact surfaces will have a greater cone angle $\varphi_0' > \varphi_0$. This results in a characteristic curve which, with the exception of the common design point F‘ (s=0,75 h_0) = F (s=0,75 h_0), deviates slightly from that for the standard disc spring *(Fig. 3.15)*.

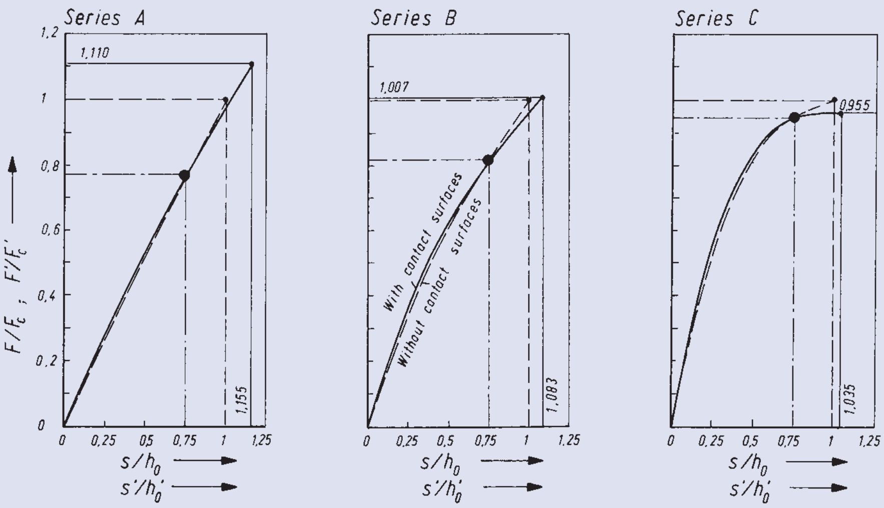


Fig. 3.15: Comparison of the calculated characteristic curves of disc springs with and without contact surfaces

The reduction of the disc thickness from t to t' is specified in DIN 2093. The average ratio of disc thickness between t' and t is .938 for Series A and B springs, and .995 for Series C springs. The load stresses are calculated for the corner points I ... IV of the cross section, which no longer exist because of the contact surfaces. Therefore the calculated stresses are somewhat higher than the values that would be obtained for the actual corner areas with a more precise calculation. Since these are only nominal values, the error is insignificant.

Special cases

Conversions when using special materials

The characteristic equations applicable to a sharp-edged rectangular cross section yield forces which are 8 % to 9 % too high for spring steel where E = 206000 N/mm² and μ = 0.3. This is compensated for by the shortening of the lever arm due to the radii at points I and III. Therefore the calculated and measured loads for steel springs correlate closely. This is no longer true if special materials, especially ones with higher POISSON ratio μ, are used.

Extremely thin disc springs

In the case of disc springs where $D_e/t \gg 40$ the characteristic equation yields a force which is too high. In this case, the cross section of the spring is no longer rectangular and deflection over the spring cross section must be taken into consideration (especially if a finite element analysis is made).

Extremely small diameter ratio

In the case of disc springs with $D_e/D_i < 1.8$, the shortening of the lever arm due to the corner radii must be taken into consideration when calculating the characteristic load curve. Otherwise the calculated load will be too low.

3.2.4 Disc spring combinations

As already mentioned at the beginning of this section, disc springs can be combined in many different ways to form parallel or series stacks or a combination thereof. The following information is only for disc springs without contact surfaces. It can also be applied to disc springs with contact surfaces. However it must be noted that the reduction of the disc thickness from t to t' results in a shortening of the parallel spring stack or series spring stack containing groups of parallel spring packs.

Spring stack design

Stack of the disc springs in parallel

For spring stacks consisting of n identical discs springs arranged in parallel, the force calculated for a single spring is multiplied by a factor n for a constant spring deflection *(Fig. 3.16)*.

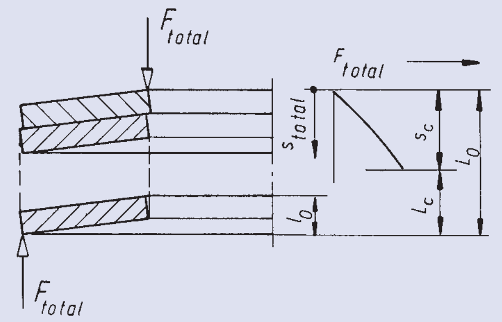


Fig. 3.16: Parallel spring stack consisting of n individual discs springs (the deflection is enlarged for clarity)

The length L_0 of the unloaded spring pack is calculated as $L_0 = l_0 + (n-1)\ t$.

If friction is disregarded, the following equations are obtained:

| deflection: $s_{tot} = s$

| spring force: $F_{tot} = n \cdot F$

Stack of disc springs in series

For spring stacks consisting of i individual disc springs arranged in series, the deflection is multiplied by a factor of i for a constant load *(Fig. 3.17)*.

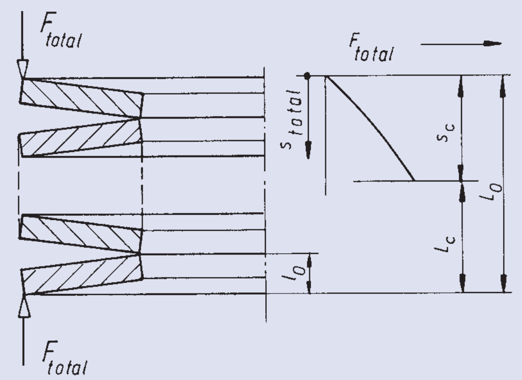


Fig. 3.17: Series spring stack consisting of i individual disc springs

The length of the unloaded series spring stack of single springs is calculated as $L_O = i \cdot l_O$. If friction is disregarded, the following equations are obtained:

| deflection: $s_{total} = i \cdot s$
| spring force: $F_{total} = F$

Progressive characteristic load curves

Progressive characteristics load curves can be obtained with the use of parallel stacks with different numbers of disc springs combined to yield compound series stacks (high friction) or series stacks comprised of individual disc springs of varying thickness and overall height (low friction) as shown in Fig. 3.7. The progression is achieved because the weaker stack – or weaker spring – is cancelled out and thus no longer contributes to the compression of the stack after reaching either the flat position or the deflection limiter *(Fig. 3.18)*.

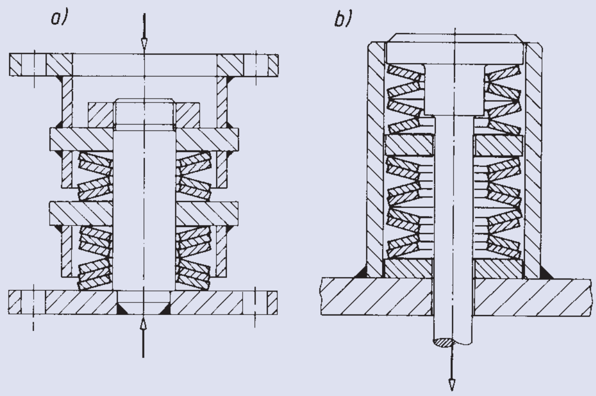


Fig. 3.18: Spring stacks with progressive characteristic load curves and stroke limiters to avoid overload
a) Bell b) Stop

Spring stack design guidelines

The following guidelines should be considered in the design of disc spring stacks:

| Individual springs stacked in series are used if the deflection of the individual spring is not sufficient.
| Single springs stacked in parallel are used if high loads have to be obtained in a limited mounting space.
| A large spring diameter enables a low overall height to be achieved.
| Normally no more than 2 ... 4 springs should be stacked in parallel since the discrepancies between the calculated and measured characteristic load curves increase with an increasing number of discs due to friction (the influence of friction is not taken into consideration in the calculation program).

Spring stack guides

Both series and parallel spring stacks should be guided. This is done with a guide element such as

| a guide rod *(internal guidance, Fig. 3.19 a)*
| a guide sleeve *(external guidance, Fig. 3.19 b)* or by
| self-centering devices *(balls, Fig. 3.19 c)*
or by hardened wire segments.

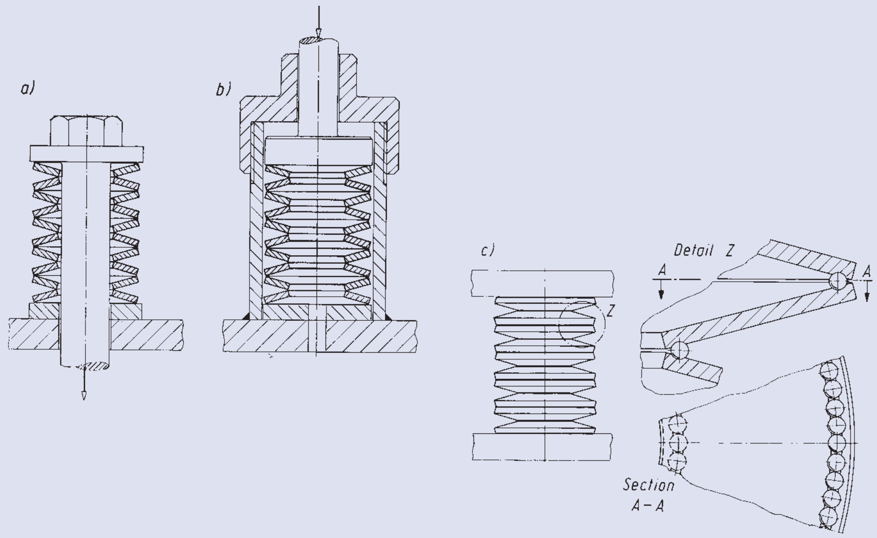


Fig. 3.19:
Different types of spring stack guides

Both internal and external guides should be polished over their entire length and hardened to at least 55 HRC.

In the case of purely static or rarely alternating loads, an un-hardened guide element can be used. In spring stacks, the load can be applied via either the inner or the outer diameter. If the load is applied via the inner diameter the contact pressures will be higher.

Both internal and external guides require some clearance, T, between the spring stack and guide element *(Fig. 3.20)*. This allows adequate room for the displacement of the lubricant while ensuring proper guidance. Table 3.2 shows the total clearance, T, for both types of guides, depending on the disc inner diameter D_i (in the case of internal guides) or the disc spring outer diameter D_e (in the case of external guides).

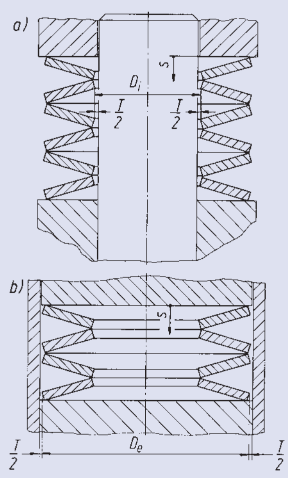


Fig. 3.20:
Spring stack guides (a) internal (b) external, clearance, T, between springs and guide element

Table 3.2: Total clearance between the disc spring and guide element

D_i or D_e (mm)			Total clearance T (mm)
–	up to	16,0	0,2
over 16	up to	20,0	0,3
over 20	up to	26,0	0,4
over 26	up to	31,5	0,5
over 31,5	up to	50,0	0,6
over 50	up to	80,0	0,8
over 80	up to	140,0	1,0
over 140	up to	250,0	1,6
over 250	–		2,0

Self-centering disc spring stacks

A guide element is not required for self-centering spring stacks. In practice, 3 types of self-centering disc spring stacks are currently used.

a) Ball-centered disc spring stacks

The disc springs have flat annular grooves on the inner and outer diameter, into which hardened steel balls are inserted. This type of guidance is virtually friction-free. Ball-centering is primarily used on stacks of large disc springs.

Fig. 3.21: Ball-centered stack

b) Wire-centered disc spring stacks

A wire-centered disc spring stack is a more cost-effective alternative to the ball-centered stack. In this arrangement, wire segments are substituted for the steel balls. However, the friction is slightly higher than with ball centering.

Fig. 3.22: Wire-centered stack

c) Alternative stack guide

A retaining ring or T-ring may also be used for centring disc spring stacks.

Fig. 3.23: Retaining ring centered stack

3.2.5 Calculating allowable load stresses

The allowable stresses depend upon the type of loading that the spring is subjected to *(Fig. 3.24)*.

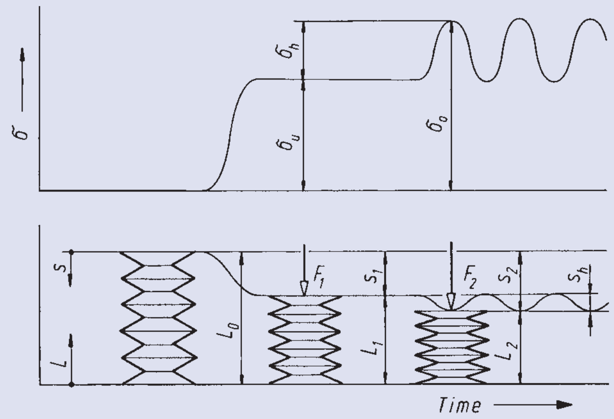


Fig. 3.24: Representation of motion as a function of time during dynamic loading
Top: stress - versus - time function
Bottom: deflection - versus - time function

3 types of loading are considered:

a) Static or rarely alternating loads with fewer than 10^4 load cycles over the required life of the spring

b) Alternating loads with $10^4 < N < 2 \cdot 10^6$ load cycles over the required life of the spring

c) Alternating loads with $N > 2 \cdot 10^6$ load cycles over the required life of the spring

a) For applications with a static or rarely alternating load, the highest calculated stress at the upper inner edge of the single spring (cross-sectional point I) is the most critical. The stress at cross-sectional point I has the highest magnitude and thus determines the set loss of the spring. For springs made of high grade steel as specified by DIN 17221 and DIN 17222, the compressive stress calculated for point I should not exceed the values specified in Table 3.3 in the flat position $s_c = h_0$.

In the case of higher compressive stresses the spring may undergo a high degree of setting. If the maximum permissible calculated compressive stresses are exceeded in the case of special sizes, such springs can also undergo a high degree of setting.

Tabelle 3.3: Maximum permissible stresses in the flat condition

D_e/D_i	σ_{Ic} (N/mm²)
1,5	-2600
2,0	-3400
2,5	-3600

b) and c): For applications with dynamic loading, the maximum tensile stresses on the lower side of the disc spring are critical. Fatigue fracture always begins on the lower side of the spring. Fracture will begin at cross-section II or III depending upon which position has the higher cyclical stress level.

Minimum preload

For springs subjected to dynamic loading, the disc spring must be installed with sufficient preload to prevent fracture at the upper inside edge (cross-sectional point I). Radial surface cracks may occur at the upper inside edge due to residual tensile stresses caused by the pre-setting process.

Experience shows that the minimum compressive stress σ_I should be about -600 N/mm² for DIN springs. This corresponds to a preload deflection of $s_u \approx 0{,}15 \cdot h_0 \ldots 0{,}20 \cdot h_0$.

While springs with lower stresses in the flat condition can have a lower preload deflection, a larger preload deflection is needed for springs with very high stresses in the flat condition.

Fatigue strength values

The fatigue strength graphs provided here are based upon many years of testing *(Fig. 3.25, 3.26, 3.27)*. They show the permissible calculated stress on the underside of the disc spring that is decisive for fatigue failure. The fatigue strength graphs have been calculated for disc springs of varying size and thickness and with varying numbers of load cycles.

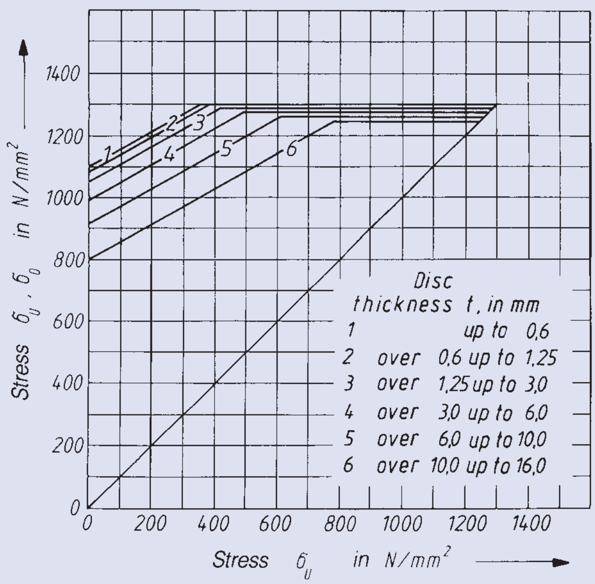


Fig. 3.25: Fatigue strength diagram for N = 10⁵ load cycles

The graphs apply to Group 2 and 3 disc springs made of 50 Cr V 4 and Group 1 disc springs made of Ck 67. The maximum fatigue life can be achieved with a statistical probability of 99 % under the following conditions:

a) Spring stacks must be limited to a maximum of 10 individual disc springs arranged in series
b) The spring or spring stack must be subjected to a sinusoidal deflection-versus-time function with a constant deflection at a constant frequency below the permissible thermal limit *(see Fig. 3.24)*
c) Spring stacks must be assembled on guide elements (rod or sleeve) per the requirements noted in section 3.2.4. The load must be applied via hardened and polished plates at the stack ends.

d) proper lubrication

e) operation at room temperature and normal atmosphere
(i.e. no excessive humidity, no corrosive chemicals, etc.)

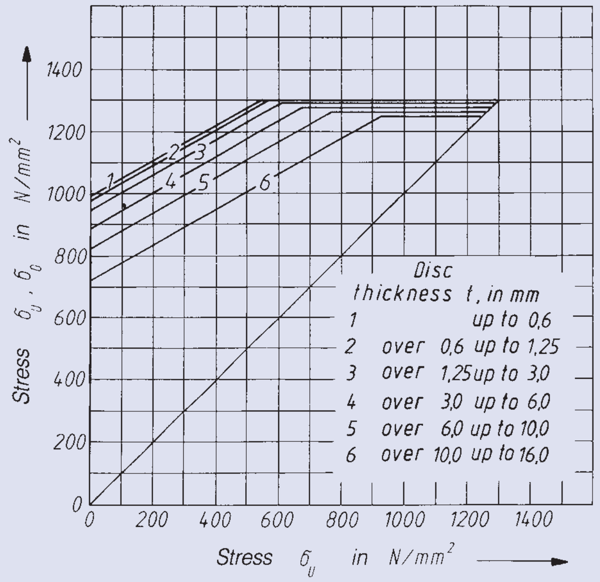


Fig. 3.26: Fatigue strength diagram for N = 5 · 10⁵ load cycles

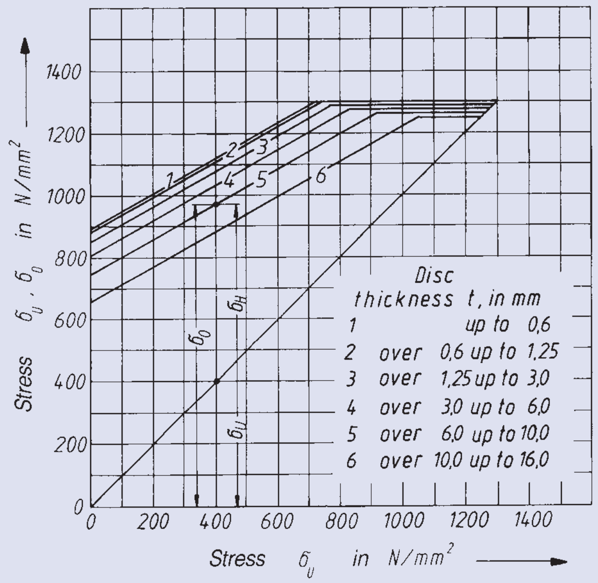


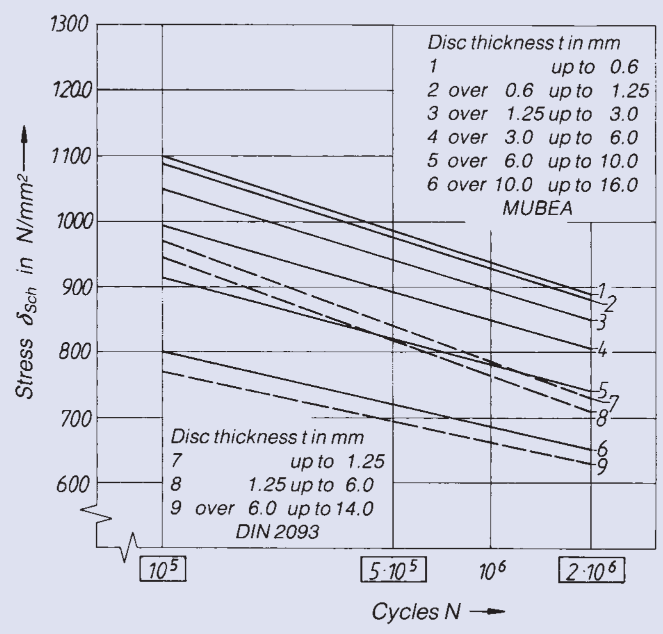
Fig. 3.27: Fatigue strength diagram for N = 2 · 10⁶ load cycles

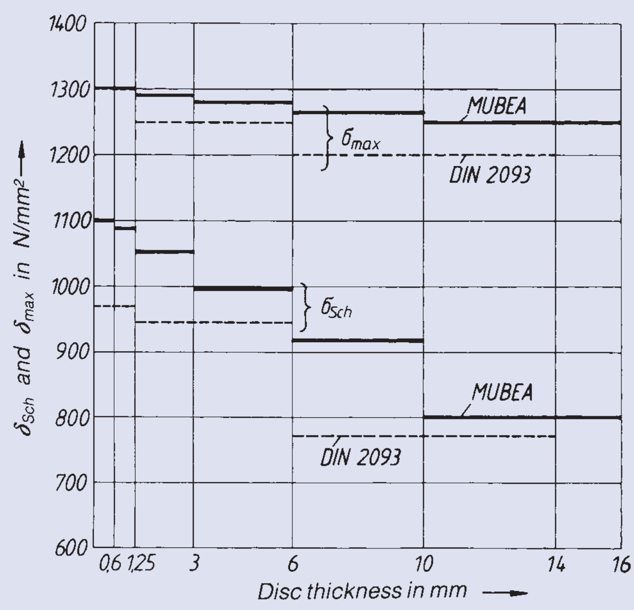
Deviations from these test conditions may reduce the number of load cycles that can be achieved. This applies especially to sudden loads that can occur during operation in the case of faulty lubrication, or when corrosion and surface imperfections are present.
As the number of disc springs in a stack increases, the number of load cycles that can be achieved are reduced in comparison to a single disc spring. One reason is the varying deflection of the individual springs within the stack.

This is influenced by:

| friction between the springs and guide rod

| friction between the springs in parallel stacks





China Disc Springs, Inc. disc springs can accept higher dynamic stress levels, or operating cycles, compared to the requirements of the DIN 2093 standard. This is shown in the fatigue strength diagrams where the dynamic stresses and the allowable stresses are compared to the corresponding values in DIN 2093 *(fig. 3.28 / 3.29)*.

3.2.6 Relaxation and creep

Over time, all springs undergo a loss of elasticity. Depending on the type of load imposed on the spring, this loss of elasticity results in either relaxation or creep.

Relaxation is the decrease of force, ΔF, seen over time if a spring is compressed to a constant length.

Creep is the decrease in spring height, Δl, seen over time if the spring is subjected to a constant load.

The amount of relaxation or creep is effected by the following factors:

1) The load stresses, especially σ_I
2) The residual stresses resulting from the presetting process
3) The operating temperature
4) The material strength, especially at high temperatures (heat strength)
5) The duration of load application

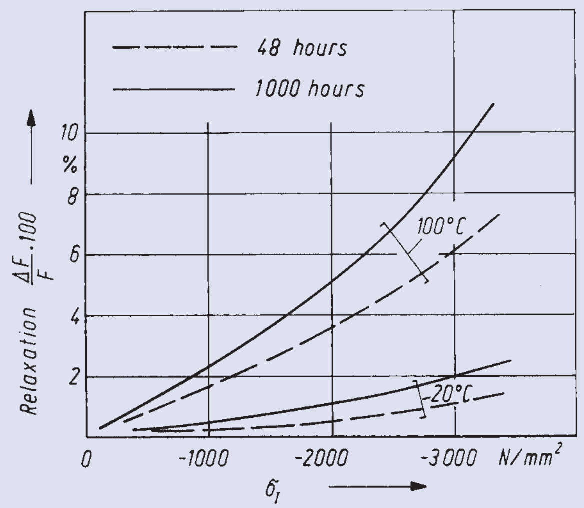


Fig. 3.30: Permissible relaxation for disc springs made of Ck steels (carbon steels) per DIN 17 222

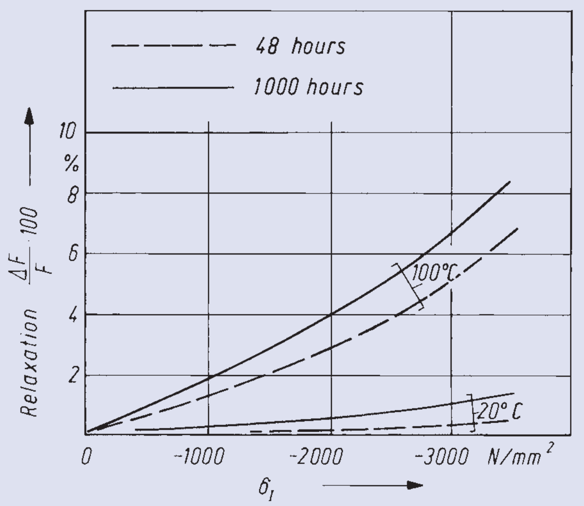


Fig. 3.31: Permissible relaxation for disc springs made of chrome vanadium-alloy steels per DIN 17221 and DIN 17222

Hot-preset springs have approximately the same residual stresses at the surface as cold-preset springs. However, the zone of plasticity extends more deeply into the material, and therefore the slope of the residual stress is less steep. This results in lower set loss when compared with cold-preset springs. The permissible relaxation for cold-preset springs is shown in Fig. 3.30 and 3.31. For operating temperatures higher than 100 °C, please contact China Disc Springs, Inc..

3.2.7 Friction

Depending upon the spring arrangement, frictional forces arise during the compression and extension of springs between individual springs, between the springs and the guide element, and at the edges of the spring where load is applied. This results in a variation bet-ween the calculated characteristic load curve and the actual loading and unloading cha-racteristic load curves for a given application.

Friction for an individual disc spring

As shown in Fig. 3.32, during compression frictional forces $\mu_R \cdot F(\mu_R)$ create a moment that counteracts the moment of the applied load and thus increases the required compression force $F(\mu_R)$.

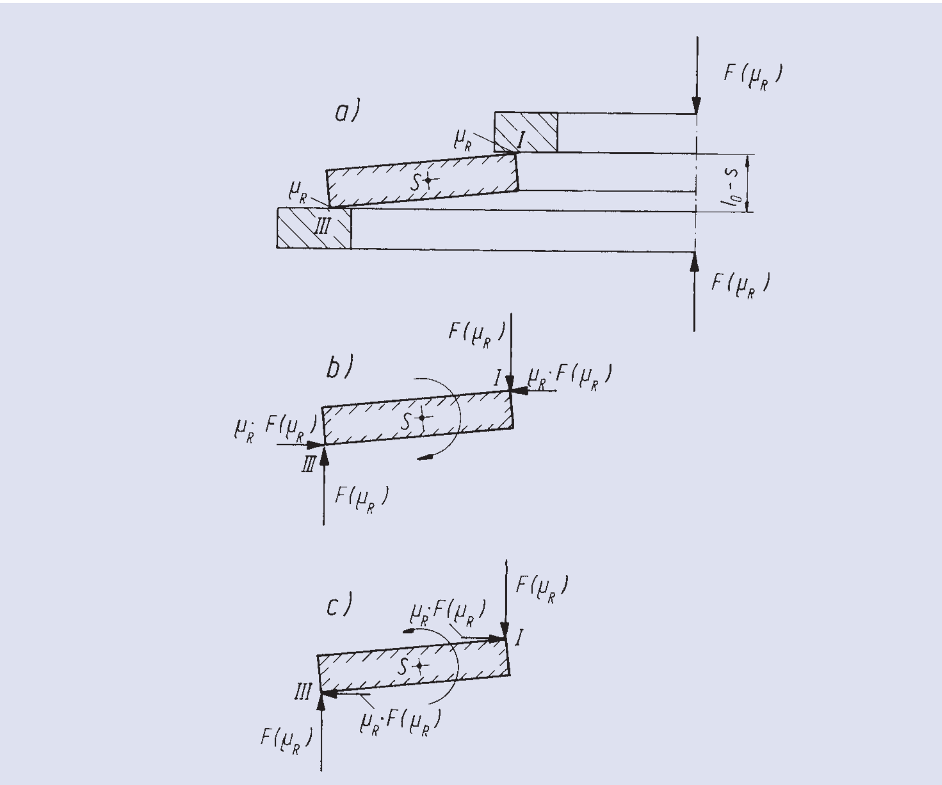


Fig. 3.32 Individual disc spring with edge friction
a) Overall view
b) Compression
c) Extension

During extension, frictional forces create a moment acting in the same direction as the load moment and therefore reduce the required retaining force.

The actual coefficients of friction depend upon the surface finish of the components through which the load is applied, the radii at edges I and III of the disc spring, and the lubricant used.

Friction in stacks of disc springs arranged in parallel

When a parallel spring stack consisting of n discs is compressed, radial frictional forces $\mu_M \cdot F(n, \mu_M)$ acting in opposing directions occur on the surfaces of contacting disc springs *(Fig. 3.33)*. These frictional forces are in addition to those created at the edges where the load is applied to the spring stack. This results in n frictional moments which counteract the moment of the applied load and thus increase the required compression force. During the release stroke, frictional forces reduce the required retaining force.

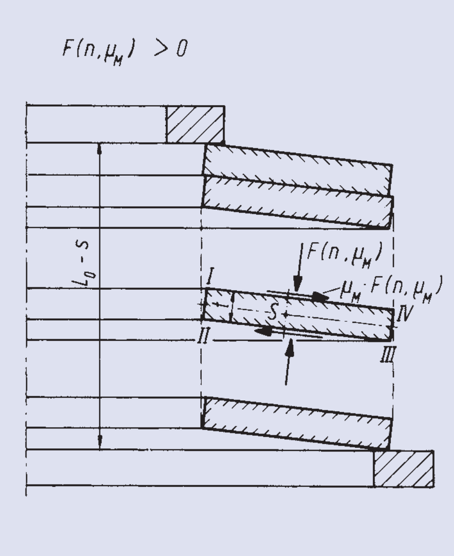


Abb. 3.33: Friction forces on a parallel stack of disc springs

The actual deviation in load is independent of the spring deflection. The use of thicker disc springs (Series A) results in a greater damping effect.

Experience shows that the characteristic load curve deviates more from the characteristic load curve as the numbers of springs arranged in parallel increases *(Fig. 3.34)*. This is due to the accumulation of the geometrical variations of the individual disc springs from their ideal shape, particularly out-of-roundness on the surface area of the cone and deviations in the overall height l_0.

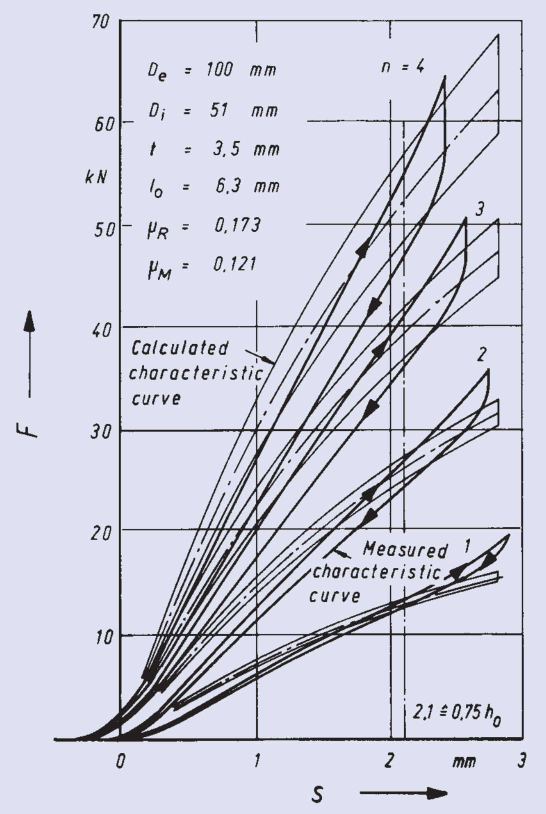


Fig. 3.34: Comparison of measured and calculated characteristics load curves for an individual disc spring and a parallel stack comprised of 2 to 4 disc springs

If springs are moved or even rotated within a stack, slightly different characteristic load curves will occur. In general, however, over time a steady state loading and unloading characteristic curve is established.
For safety reasons, even a single stack of springs arranged in parallel should be provided with internal or external guidance. If disc springs with a low friction design are used, the resulting frictional forces are usually negligible.

Friction in stacks of disc springs in series
In series spring stacks, it is assumed that disc springs of low friction design are used. For example, the springs are designed with a special inner edge contour that minimises the friction between the guide rod and disc spring stack. This results in the uniform deflection of the disc springs in a stack of individual springs arranged in series. The risk of premature spring fracture from over-stressing the springs at the moving end of the stack is thereby reduced.

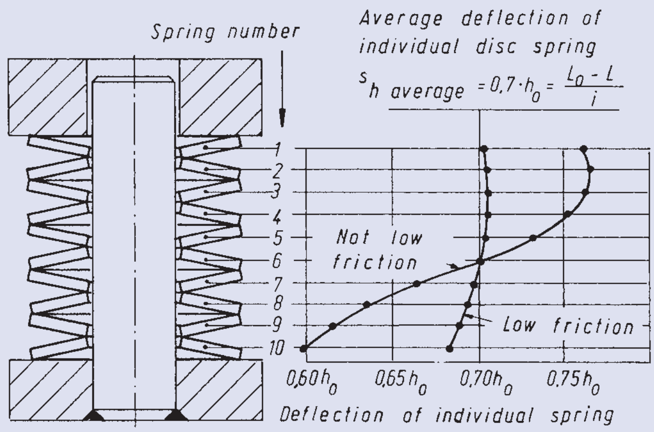
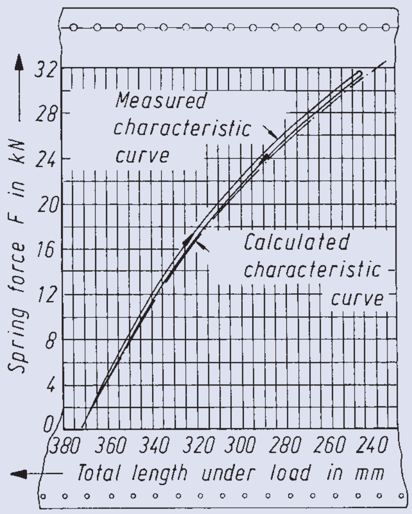


Fig. 3.35: Deflection of individual disc springs in a series stack



Ab. 3.36: Comparison between the measured and the calculated characteristic load curves for a spring stack consisting of 10 springs arranged in series

Fig. 3.35 shows the difference in deflection of the individual disc springs in both low friction and high friction spring stacks. The characteristic load curves measured during loading and unloading for series stacks of disc springs of low friction design differ slightly from one another as well as the calculated characteristic load curve *(Fig. 3.36)*.
If parallel stacks of disc springs are used in the series stack, these almost ideal conditions no longer apply.
Deviations in the ideal geometry of the individual disc springs result in an uneven transmission of load from one spring to the next in parallel stacks. This results in

lateral displacement of the springs, which are then pressed with great force against the guide element. If such laterally displaced springs are located at the moving end of the stack, the lateral forces generate a high amount of friction because of the large spring deflection. Therefore, it should be emphasised that the use of parallel stacks of disc springs in a series stack can result in non-uniform deflection of the individual springs and in a higher operating temperature at high frequency. This results in a reduction of the fatigue life of the spring stack.

3.3 Symbols, signs, denominations and units

D_e	Outside diameter in mm	Δl	Loss of length due to creep in mm
D_i	Inside diameter in mm	N	Number of load cycles prior to failure
D_o	Diameter of the circle of inversion in mm	R	Spring rate in N/mm
E	Modulus of elasticity in N/mm²	T	Total clearance in mm
F	Spring force for an individual disc spring without contact surfaces in N	W	Spring work in Nmm
F_1, F_2, F_3	Spring forces corresponding to the deflections s_1, s_2, s_3 in N	h_o	Maximum deflection for disc springs without contact surfaces $h_o = l_o - t = s_c$ in mm
F_c	Calculated spring force in flat condition in N	i	Number of individual springs or parallel spring stacks in a series spring stack
F_{tot}	Spring force for an individual spring with friction or for a parallel or series spring stack in N	l_o	Free height of the individual disc spring in mm
ΔF	Decrease in force due to relaxation in N	n	Number of individual disc springs in a parallel spring stack
L_o	Length of an unloaded parallel or series spring stack in mm	s	Deflection of the individual disc spring without contact surfaces in mm
L_1, L_2, L_3	Assigned lengths of the parallel or series spring stack, corresponding to the loads F1,F2, F3 in mm	s_1, s_2, s_3	Deflections corresponding to the spring forces F_1, F_2, F_3, in mm
L_c	Calculated length of the parallel or series spring stack in the flat condition in mm	s_{tot}	Total deflection for the parallel or series spring stack. Recommended max. value: $s_{total} = 0{,}8 \cdot (L_o - L_c)$ in mm
		t	Thickness of the individual disc spring without contact surfaces in mm

t'	Reduced thickness of the individual disc spring with contact surfaces in mm
φ_o	Cone angle
μ	POISSON's ratio
μ_M, μ_R	COULOMB's coefficients of friction
$P_ü$	Survival probability
σ	Calculated stress in N/mm²
σ_{max}	Maximum load stress in N/mm²
σ_{Sch}	Pulsating stress in N/mm²
σ_I, σ_{II}, σ_{III}, σ_{IV}, σ_{OM}	Calculated stresses for the cross-sectional points I,II, III,IV and OM in N/mm²
σ_o	Calculated maximum allowable stress for disc springs subject to dynamic loading in N/mm²
σ_{Ic}	Calculated stress at cross-sectionalpoint I in flat position in N/mm²
σ_u	Calculated minimum required stress for disc springs subject to dynamic loading in N/mm²
σ_h	Calculated stress amplitude $\sigma_h = \sigma_o - \sigma_u$, corresponding to the working stroke for disc springs subject to dynamic loading in N/mm²
σ_O	Maximum allowable upper stress according to the fatigue strength diagrams in N/mm²
σ_U	Minimum allowable lower stress according to the fatigue strength diagrams in N/mm²
σ_H	Allowable stress amplitude $\sigma_H = \sigma_O - \sigma_U$ according to the fatigue strength diagrams in N/mm²
σ_t	Tangential stress in N/mm²
( )‘	All values marked with an ‘ ie. F‘, s‘, h_o‘, t‘, d_e‘, d_i‘ etc. refer to disc springs with contact surfaces
W	Spring work in Nmm

Tolerances

4

Chapter 4

Tolerances

4.1 General tolerances

Tolerances for spring geometry, load, and hardness are specified in Tables 4.1 and 4.2. These tolerances are valid for Mubea's entire product range.

In the case of the springs manufactured per DIN 2093, the tolerances for the outside and inside diameter correspond to h_{12} or H_{12}. If tighter tolerances are required, China Disc Springs, Inc. should be consulted.

	Material thickness t or t' (mm)	allowable tolerance in material thickness t (mm)	allowable tolerance in free height l_o (mm)	allowable tolerance in spring force F at l_o-s during loading with s = 0.75 h_o (%)	Hard-ness (HRC)
Group 1 springs without contact surfaces	0,2 to 0,6	+ 0,02 - 0,06	+ 0,10 - 0,05	+ 25 - 7,5	42-52
	> 0,6 but < 1,25	+ 0,03 - 0,09			
Group 2 springs without contact surfaces	1,25 to 2,0	+ 0,04 - 0,12	+ 0,15 - 0,08	+ 15 - 7,5	
	> 2,0 to 3,0		+ 0,20 - 0,10		
	> 3,0 to 3,8		+ 0,30 - 0,15	+ 10 - 5	
	> 3,8 to 6,0	+ 0,05 - 0,15			
Group 3 springs with contact surfaces	> 6,0 to 15	± 0,10	± 0,30	± 5	
	> 15 to 25	± 0,12	± 0,50*		
	> 25 to 40	± 0,15	± 1,0*		

* applies only to disc springs with a ratio $D_e/t \leq 20$

Table 4.1: Allowable tolerances for material thickness, free height, spring force and spring hardness

When the ratio $D_e/t > 20$, a larger tolerance for the free height is typically required. In this case, actual tolerances should be reviewed with China Disc Springs, Inc..

Outside diameter D_e, Inside diameter D_i			
D_e or D_i (mm)	Allowable tolerance D_e h_{12} (mm)	Allowable tolerance D_i H_{12} (mm)	Concentricity tolerance for D_e (mm)
3 to 6	0 to −0,12	0 to +0,12	0,15
> 6 to 10	0 to −0,15	0 to +0,15	0,18
> 10 to 18	0 to −0,18	0 to +0,18	0,22
> 18 to 30	0 to −0,21	0 to +0,21	0,26
> 30 to 50	0 to −0,25	0 to +0,25	0,32
> 50 to 80	0 to −0,30	0 to +0,30	0,60
> 80 to 120	0 to −0,35	0 to +0,35	0,70
> 120 to 180	0 to −0,40	0 to +0,40	0,80
> 180 to 250	0 to −0,46	0 to +0,46	0,92
> 250 to 315	0 to −0,52	0 to +0,52	1,04
> 315 to 400	0 to −0,57	0 to +0,57	1,14
> 400 to 500	0 to −0,63	0 to +0,63	1,26
> 500 to 600	0 to −0,68	0 to +0,68	1,36

Table 4.2: Allowable tolerances for spring diameters and concentricity

4.2 Load testing of disc springs

Individual disc spring

Unless otherwise agreed, the static load F of an individual spring is checked at a deflection $l = 0{,}75 \cdot h_0$.

Typically, testing is performed while the spring is being loaded. The plates used to apply the load to the spring must be hardened, ground, polished and lightly oiled. For most applications, the allowable deviation from the rated force F ($0{,}75\ h_0$) as noted in table 4.1 is acceptable. If tighter load tolerances are required, China Disc Springs, Inc. should be consulted. For diameter ratios

less than $D_e/D_i \sim 1.8$ (special size), load tolerances higher than those given in Table 4.1 are required. For non-standard dimensions the load tolerances should be reviewed with China Disc Springs, Inc..

Series spring stacks

The deviation in force between the characteristic loading and unloading curves is tested using a spring stack consisting of 10 individual springs arranged in series. The springs must be assembled on a guide rod as noted in Section 3.2.4.

During the stacking process, the individual springs must be shifted alternately to the left and right on the guide rod. This will create the maximum amount of friction and therefore provide the maximum expected force deviation between the characteristic loading and unloading curves. This does not apply to special sizes for which the center of inversion, S, is situated below the plane described by the cross section point II. In this case please refer to Patent No. 1 273 267 granted to China Disc Springs, Inc.. In such cases mutual agreement is required.

The plates used to apply the load to the spring stack must be hardened, ground, polished and lightly oiled.

For load testing, the spring stack must be compressed to at least $L_0 - 8 \cdot h_0$. For $L_0 - 7{,}5 \cdot h_0$ the

[illegible] us [illegible] ;

Group	Series		
	A	B	C
1	90,0		85,0
2	92,5		87,5
3	95,0		90,0

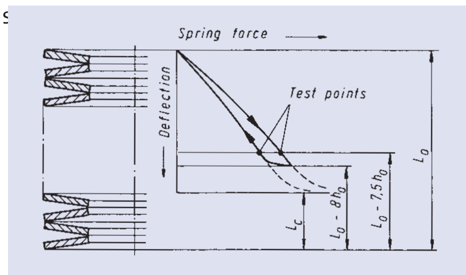


Table 4.3: Minimum value in percent, of the spring force measured during unloading relative to the force measured during loading

Fig. 4.1: Test points on the characteristic loading and unloading curves

Materials and Corrosion Protection

Materials and Corrosion Prevention

5.1 Materials

China Disc Springs, Inc. disc springs are manufactured to meet the most demanding fatigue life require-ments while exhibiting a minimum amount of relaxation. The choice of material directly influences these properties. For standard applications, the spring materials Ck 67 and 50 CrV 4 are used. These materials are very economical and commonly used for springs in Group 1 (Ck 67) and in Group 2 and 3 (50 CrV 4). Furthermore, special materials can be used for applications requiring

| high corrosion resistance

| operation at low/high temperature

| antimagnetic properties.

The properties of the materials used by China Disc Springs, Inc. are listed in the following tables.

In general, it should be noted that the moduli of elasticity provided in Tables 5.1 and 5.3 are experimentally obtained values and are only for reference. However, they do indicate how the spring characteristics will vary as the operating temperature changes. Table 5.2 lists the chemical composition of the various materials used by China Disc Springs, Inc..

For Tables 5.1, 5.2 and 5.4 see inside flap

Application profile	Material designation	DIN Material number	Modulus of elasticity at 20 °C (N/mm²)	Max. material thickness (mm)
Standard material	Ck 67 50 CrV 4	1.1231 1.8159 [1]	206.000 206.000	1,25 25
High material thickness	51 CrMoV 4	1.7701	206.000	40
Corrosion resistant	X 12 CrNi 17 7 [3] X 7 CrNiAl 17 7 X 5 CrNiMo 18 10	1.4310 1.4568 1.4401	190.000 200.000 190.000	2 2,5 1,6
Thermally stable	X 35 CrMo 17 X 30 WCrV 5 3 X 22 CrMo V 12 1	1.4122 1.2567 1.4923	209.000 206.000 209.000	8 20 8
Antimagnetic and corrosion-resistant	CuBe 2 NiBe 2	2.1247 2.4132	135.000 200.000	3 3
High temperature	Inconel 718 Inconel X 750 ~~Nimonic 90~~	2.4668 2.4669 ~~2.4969~~	200.000 214.000 ~~206.000~~	8 8 ~~8~~

[1] Material no. 1.8159 also includes 51 CrV 4 [2] with hot pre-setting this material may be used at temperatures up to approx. 200° C [3] Material no. 1.4310 also includes X 10 CrNi 18 8
* typically in stock ** 12–14 weeks, *** 14–16 weeks

Material designation	DIN material number	Chemical composition in percent by mass (reference values)							
		C	Si	Mn	P ≤	S ≤	Cr	Mo	Ni
Ck 67	1.1231	0,69	0,25	0,75	0,035	0,035			
50 CrV 4	1.8159	0,51	0,28	0,90	0,035	0,035	1,05		
51 CrMo 4	1.7701	0,52	0,28	0,90	0,035	0,035	1,05	0,20	
X 12 CrNi 17 7	1.4310	≤ 0,12	≤ 1,0	≤ 2,0	0,045	0,030	17,00		8,00
X 7 CrNiAl 17 7	1.4568	≤ 0,09	≤ 1,0	≤ 1,0	0,045	0,030	17,00		7,13
X 5 CrNiMo 18 10	1.4401	≤ 0,07	≤ 1,0	≤ 2,0	0,045	0,030	17,50	2,25	12,00
X 35 CrMo 17	1.4122	0,38	≤ 1,0	≤ 1,0	0,045	0,030	16,50	1,10	≤ 1,0
X 30 WCrV 5 3	1.2567	0,30	0,25	0,30	0,035	0,035	2,35		
X 22 CrMoV 12 1	1.4923	0,22	0,30	0,50	0,035	0,035	12,00	1,00	0,50
Cu Be 2	2.1247								*
Ni Be 2	2.4132								> 96
Inconel 718 (Ni Cr 19 Nb Mo)	2.4668	0,03	≤ 0,35	≤ 0,35	0,015	0,015	17,00	2,80	50,00
Inconel X 750 (Ni Cr 15 Fe 7 Ti Al)	2.4669	≤ 0,08	≤ 0,5	≤ 1,0			15,50		≤ 70
~~Nimonic 90 (Ni Cr 20 Co 18 Ti)~~	~~2.4969~~	~~0,09~~	~~≤ 1,0~~	~~≤ 1,0~~		~~0,015~~	~~19,50~~		~~Rest~~

* = Ni + Co 0,2-0,6%

DIN		International standards			
Material designation	DIN material number	France AFNOR	Great Britain B.S.	Soviet Union GOST	Italy UNI
Ck 67	1.1231	XC 68	060 A 67	70	C 70
50 CrV 4	1.8159	50 CV 4	735 A 50	50ChGFA	50 CrV 4
51 CrMo 4	1.7701	51 CDV 4	-	-	51 CrMoV 4
X 12 CrNi 17 7	1.4310	Z 12 CN 17.07	301 S 21	-	X 12 CrNi 1707
X 7 CrNiAl 17 7	1.4568	Z 8 CNA 17.07	301 S 81	09Ch17N7Ju1	-
X 5 CrNiMo 18 10	1.4401	Z 6 CND 17.11	316 S 16 316 S 31	-	X 5 CrNiMo 1712
X 35 CrMo 17	1.4122	-	-	-	X 35 CrMo 17
X 30 WCrV 5 3	1.2567	-	-	-	-
X 22 CrMoV 12 1	1.4923	-	-	-	X 22 CrMoV 121
Cu Be 2	2.1247	-	-	-	-
Ni Be 2	2.4132	-	-	-	-
Inconel 718 (Ni Cr 19 Nb Mo)	2.4668		-	-	-
Inconel X 750 (Ni Cr 15 Fe 7 Ti Al)	2.4669	NC 15 TNbA	HR505	-	-
~~Nimonic 90 (Ni Cr 20 Co 18 Ti)~~	~~2.4969~~	~~NC 20 KTA~~	~~2HR2~~ ~~2HR202~~	-	-

Operating temperature range (°C)	Lead time to obtain raw material	Typical application
-10 to 100 -20 to 150 2)	* *	Plant construction, machine tools automotive
-20 to 150	*	Plant construction
-150 to 200 -200 to 200 -200 to 200	* ** ***	Food processing industry, chemical industry
-60 to 300 -60 to 350 -60 to 350	*** *** ***	Boilers, power plant construction, industrial furnaces and ovens, chemical industry
-250 to 150 -200 to 350	*** ***	Electrical equipment, low-temperature applications, superconductors, satellites
-200 to 500 -200 to 500 ~~-200 to 600~~	** *** ***	Boilers, industrial furnaces and ovens, chemical industry

Table 5.1: Reference data for disc spring materials

V	W	Al	Ti	Be	Cu	Co	Fe	Nb
0,15								
0,10								
		1,13						
0,60	4,25							
0,30								
				1,95	Rest	*		
				1,75				
		0,40	0,65		≤ 0,1	≤ 1,0		4,75
		0,70	2,50		≤ 0,5		7,00	0,95
		~~1,40~~	~~2,35~~		~~≤ 0,2~~	~~16,50~~	~~≤ 2,0~~	

Table 5.2: Reference values for the chemical composition of various materials

	Japan JIS	Sweden SS	Spain UNE	USA AISI/SAE
	-	1770	-	1070
	SUP 10	2230	F.1430	6150
	-	-	-	-
	SUS 301	2331	F.3517	301
	SUS 631	2388	-	631
	SUS 316	2347	F.3543 F.3534	316
	-	-	-	-
	-	-	-	-
	-	-	-	-
	-	-	-	-
	-	-	-	-
	-	-	-	- -
	-	-	-	AMS 5598A
	-	-	-	~~AMS 5829~~

Table 5.4: Cross-reference table for material designations per DIN and various international standards

Material designation	DIN material number	Modulus of elasticity (kN/mm²) at 20°C	100°C	200°C	300°C	400°C	500°C	600°C	700°C
Ck 67	1.1231	206	202						
50 CrV 4	1.8159	206	202	196					
51 CrMo 4	1.7701	206	202	196					
X 12 CrNi 17 7	1.4310	190	185	178					
X 7 CrNiAl 17 7	1.4568	200	195	190					
X 5 CrNiMo 18 10	1.4401	190	185	178					
X 35 CrMo 17	1.4122	209	205	199	192				
X 30 WCrV 5 3	1.2567	206	202	196	189	178			
X 22 CrMoV 12 1	1.4923	209	205	200	193				
Cu Be 2	2.1247	135	131	126					
Ni Be 2	2.4132	200	195	189	182	176			
Inconel 718 (Ni Cr 19 Nb Mo)	2.4668	200	196	190	186	179	172		
Inconel X 750 (Ni Cr 15 Fe 7 Ti Al)	2.4669	214	207	198	190	179	170		
~~Nimonic 90 (Ni Cr 20 Co 18 Ti)~~	~~2.4969~~	~~206~~	~~201~~	~~195~~	~~189~~	~~181~~	~~175~~	~~167~~	~~160~~

Table 5.3:
Effects of temperature on modulus of elasticity (recommended values for design purposes)

Plating process	Coating composition	Coating thickness (µm)	Stability in salt-spray testing per DIN 50 021
Phosphating	Zinc phosphate + oil	10–15	
Phosphating	Zinc phosphate + wax	10- 40	
Electro-galvanising	Zinc	> 8	
Electro-galvanising	Zinc	> 12	
Electro-galvanising + yellow chromate	Zinc + yellow chromate	> 8	
Electro-galvanising + yellow chromate	Zinc + yellow chromate	> 12	
Mech. zinc plating	Zinc	> 12	
Mech. zinc plating + yellow chromate	Zinc + yellow chromate	> 12	
Delta Tone	Zinc phosphate + Zinc powder coating	10–15	
Delta Seal	Zinc phosphate + org. coat + oil	10–15	
Dacromet 500-A	Chromated zinc flakes	> 5	
Dacromet 500-B	Chromated zinc flakes	> 8	
Chem. nickel plating	Nickel	approx. 25	

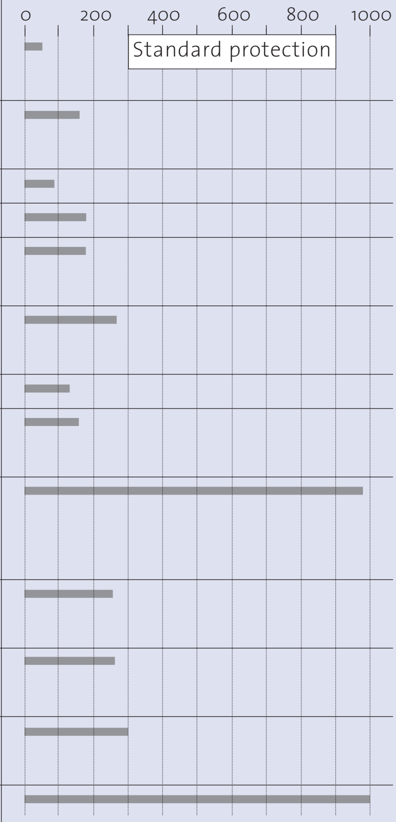


Table 5.5:
Comparison of various corrosion prevention processes (recommended values)

5.1.1 Standard materials

Ck 67 (DIN 1.1231)

Ck 67 is the most economical spring steel for low stress applications.Per DIN 2093, this material is only used for Group 1 springs (material thickness < 1.25 mm). In special cases it may also be used for disc springs with a thickness of up to 4 mm.

50 CrV 4 (DIN 1.8159)

50 CrV 4 is the most commonly used material for disc springs. Because of its high alloy content, it offers the best spring properties in the temperature range of - 15 °C to + 150 °C. If a reduction in durability is acceptable, this material can be used at temperatures down to - 25 °C. With hot-presetting the material may also be used at temperatures up to + 200 °C. It has a lower level of relaxation when compared to non-alloy steels.

51 CrMoV 4 (DIN 1.7701)

51 CrMoV 4 has properties similar to 50 CrV 4. Due to the addition of molybdenum, parts with a material thickness of up to 40 mm can easily be through-hardened. 51 CrMoV 4 also has a higher ductility than 50 CrV 4, making it more suitable for applications with operating temperatures in the range 0 °C to -20 °C.

5.1.2 Corrosion-resistant materials

Because of their high nickel alloy content, corrosion-resistant materials have an austenitic crystal lattice in their initial state. In other words, they cannot be martempered or austempered as is done with standard materials. In contrast, corrosion-resistant spring steels obtain their strength by mixed crystal formation, cold working during rolling (see DIN 17 224) and by precipitation hardening (X 7 CrNiAl 17 7). A strength sufficient for springs is achieved only after a certain degree of cold working. Consequently, narrow limits are set for the maximum material thickness of the material. Springs made from corrosion-resistant materials can also be used at extremely low temperatures. However, the strength obtained by cold rolling is lost at temperatures above + 200 °C.

X 12 CrNi 17 7 (DIN 1.4310)

X 12 CrNi 17 7 to DIN 17 224 is a chrome-nickel alloy commonly used for corrosion-resistant disc springs. This material obtains its strength by cold rolling. Therefore, the maximum material thickness that can be used for disc springs is limited to 2.0 mm. Cold rolling also magnetises the parts to a certain degree.

X 7 CrNiAl 17 7 (DIN 1.4568)

X 7 CrNiAl 17 7 per DIN 17224 is a precipitation-hardened, corrosion-resistant spring steel. It obtains its strength both by cold rolling and by precipitation hardening. X 7 CrNiAl 17 7 steel is highly magnetic in the soft state. Cold working makes the material even more magnetic.

X 5 Cr Ni Mo 18 10 (DIN 1.4401)

X 5 Cr Ni Mo 18 10 per DIN 1.4401 is highly corrosion resistant and typically can not be magnetised.

5.1.3 Thermally stable materials

Most thermally stable materials are martempered steels. Because of their high alloy content, they exhibit a lower level of creep in the higher temperature ranges when compared with standard materials. The upper operating temperatures stated in Table 5.1 are based on long term exposure to high temperatures. The springs may also be exposed to temperatures around 100 °C higher than those listed for short periods (up to about 1 hour) without affecting their properties. When designing disc springs, it must be kept in mind that the modulus of elasticity decreases as the temperature rises and increases as the temperature falls. Therefore, a disc spring will have a lower force at temperatures above room temperature and a higher force at temperatures below room temperature. For springs manufactured from thermally stable materials premature failure due to brittle-fracture is possible.

X 35 CrMo 17 (DIN 1.4122)

X 35 CrMo 17 has a high thermal stability due to the addition of molybdenum. This material is also corrosion-resistant when used in some applications. However, its corrosion-resistance is limited at the material strengths required for disc springs. In sea-water or similar environment this material is not corrosion-resistant.

X 22 CrMoV 12 1 (DIN 1.4923)

This material is a heat-treatable molybdenum and vanadium steel containing thermally stable chrome for applications with operating temperatures of - 60° C to 350° C. X 22 CrMoV 12 1 may fail prematurely due to brittle-fracture.

5.1.4 Antimagnetic and corrosion-resistant materials

These materials obtain their strength by precipitation hardening. They are both antimagnetic and corrosion-resistant.

CuBe 2 (DIN 2.1247)

CuBe 2 is precipitation-hardened copper-beryllium alloy that can be used at extremely low temperatures. Due to its low modulus of elasticity when compared with other materials, springs made of CuBe 2 generate much lower spring forces. CuBe 2 also has good electrical conductivity.

NiBe 2 (DIN 2.4132)

In addition to the properties mentioned above, NiBe 2 is suitable for use at elevated temperatures. The temperatures listed in Table 5.1 can be exceeded by approx. 100 °C for short periods without affecting the properties of the material.

5.1.5 High temperature materials

A number of precipitation-hardenable materials from the group of nickel-base alloys are used for disc springs operating at elevated temperatures. They are highly ductile and have very high fatigue strength. When designing springs made of high temperature materials, the lower tensile strength and unfavourable elastic limit - tensile strength ratio must be taken into account. Otherwise, a high degree of setting loss is possible.

Materials and Corrosion Prevention

It is not possible to specify an upper operating temperature limit. The overall height of the spring decreases under load due to creep. The actual level of creep is a function of temperature, time and stress. For example, a spring can be used at elevated temperatures if either a lower load is applied or the duration at the elevated temperature is short. Therefore, the values in Table 5.1 can serve only as guide for the maximum temperatures at which the disc springs will exhibit the same behaviour as at room temperature.
It must be kept in mind that the modulus of elasticity is somewhat lower in the upper temperature limit of the material. Taking this into account, disc springs made of thermally stable materials can be used at temperatures up to approx. 150 °C higher than those stated in Table 5.1.
The lead times for thermally stable materials are typically very long. If material is in stock, the delivery times for production orders are the same as for normal steel springs. Nimonic 90 is better suited for extremely high temperatures than Inconel X 750 (or Inconel 718). It should also be noted that thermally stable materials are typically very expensive.

5.2 Corrosion protection

China Disc Springs, Inc. disc springs are capable of withstanding severe loads while operating at very high stress levels. Therefore, suitable measures must be taken to protect the disc spring surfaces from chemical or electrochemical corrosion. There are a variety of coating processes to pre-vent corrosion. Table 5.5 lists some of the corrosion resistant surface coatings and processes available as well as their relative corrosion resistance when subjected to a salt spray test per the requirements of DIN 50 021.
The values for the coating thickness listed for galvanising and nickel-plating are examples of the protection values attainable. It is also possible in some cases to use a greater coating thickness. In the case of mechanical galvanising and chemical nickel-plating it is possible to obtain a coating thickness up to 50 μm. For disc springs stacked in parallel, there may be problems with the coatings especially on the lateral surfaces of the spring where there is relative motion between the springs. In such cases China Disc Springs, Inc. should be consulted.

5.2.1 Phosphate coatings

Zinc phosphate + oiling/waxing

Zinc phosphating and oiling is the standard corrosion protection used for disc springs according to DIN 2093 and Mubea's Factory Standards. During phosphating, fine-crystalline structures of metallic phosphate are deposited on the base metal. A more durable corrosion resistant coating is achieved if an additional protective coating such as oil or wax is applied. Due to production limitations, waxing can only be used on springs with an outside diameter of 100 mm and greater. This type of corrosion prevention is suitable for indoor applications and properly weatherproofed outdoor installations.

Manganese phosphate

On request, China Disc Springs, Inc. can also offer a manganese phosphate coating for disc springs. Manganese phosphate coatings do not offer any corrosion protection. They only serve as a lubricant. A small degree of protection against corrosion can be achieved by oiling prior to transport and storage.

5.2.2 Galvanising

When metal coatings are precipitated from aqueous solutions, there is a possibility that hydrogen will diffuse into the surface of the spring. This is particularly the case with the high-strength spring steels used for disc springs. A hydrogen-induced, delayed brittle-fracture (hydrogen embrittlement) may occur. The risk of hydrogen embrittlement can be reduced by a suitable thermal treatment process after galvanising (effusion annealing), but not completely eliminated. Where possible, coatings applied by electrolytic galvanising should be avoided because of the risk of hydrogen embrittlement.

Electro-galvanising

Zinc is chemically more basic than steel. Zinc protects itself by reacting with the atmosphere to form passive protective coatings. If the zinc coating is damaged, it protects steel cathodically. The level of protection against corrosion is roughly proportional to the thickness of the zinc coating. Additional protection can be provided by adding a chromate finish. Chromate coatings are available in various colours. A subsequent thermal treatment is required to expel the hydrogen. Galvanic coatings are applied mostly for decorative purposes and are used for both indoor and outdoor purposes.

5.2.3 Mechanical zinc plating

Mechanical zinc plating offers the same level of corrosion protection as electro-galvanising, but without the risk of hydrogen embrittlement. In the mechanical zinc plating process a zinc powder is applied to the disc spring by the barrelling method. It is recommended that a subsequent chromate coating also be applied. Mechanically zinc-plated springs can be used for same range of applications as for springs that are electro-galvanised.

5.2.4 Delta Tone/Delta Seal coating

Delta Tone is an inorganic coating, consisting of zinc and aluminium compounds. Bright silver coatings with high corrosion-preventive properties are obtained through a baking process. The coating is electrically conductive and thus protects the spring against corrosion cathodically. There is no risk of hydrogen embrittlement.
Delta Seal is an organically based coating. A strongly adhesive, chemical-resistant coating is produced after a suitable application and baking process. Delta Seal can also be applied “with internal lubrication” that serves as a long-lasting dry lubrication. Delta Tone and Delta Seal are heavy-metal-free. This high-quality corrosion preventive medium is used mostly to protect springs against corrosion in outdoor applications.

5.2.5 Dacromet coating

Dacromet is an inorganic, strongly adhesive coating consisting of zinc and aluminium in a chromate compound. This type of coating offers a high degree of protection against corrosion. It also provides a high heat resistance and a low coefficient of friction with no risk of hydrogen embrittlement.

The Dacromet coating is applied by dip-centrifuging in an aqueous solution of zinc chromate (with a low aluminium content), dried, and subsequently baked. Individual springs with an outside diameter < 40 mm can sometimes stick together. Dacromet-coated springs are primarily used for outdoor applications requiring a high degree of corrosion protection.

5.2.6 Chemical (Electroless) nickel plating

Chemical nickel plating also known as electroless nickel plating is a high quality coating that is wear-resistant and decorative while providing protection against corrosion. Because of the nature of the chemical nickel-plating process, hydrogen embrittlement may occur. The chemical nickel-plating of disc springs is done in dipping units. Nickel-plated disc springs are typically used in applications where they are exposed to high mechanical and chemical stresses.

Product Range and Characteristic Graphs

6.1 The China Disc Springs, Inc. disc spring product lines

Mubea's standard product lines of disc springs include:

The Standard Product Range of disc springs (sizes to DIN 2093 and China Disc Springs, Inc. Factory Standards) includes 246 sizes with outside diameters between 8 and 250 mm. These springs are manufactured from Ck 67 and 50 CrV 4, and are typically available ex stock (*Table 6.1*; dimensions to DIN 2093 are marked with the corresponding DIN series). The standard corrosion protection is zinc phosphating and oiling .

The Special Range of non-standard disc springs includes 153 sizes with outside diameters from 70 to 600 mm *(also shown in Table 6.1)*. These springs are typically available ex stock. Production tooling is available for these sizes. The standard corrosion protection is zinc phosphating and oiling.

The Stainless Steel Product Range of disc springs made from X 12 Cr Ni 17 7 (Material No. 1.4310) and X 7 Cr Ni Al 17 7 (Material No. 1.4568), are typically available ex stock *(Table 6.2)*.

Disc Springs for Ball Bearings are available in 68 sizes *(Table. 6.3)*.

Other sizes and materials are available upon request.

Ordering informations

Ordering standard springs

Example 1:

100 disc springs with the following dimensions are required	Order:
D_e = 70 mm	100 disc springs
D_i = 30,5 mm	size 70 x 30,5 x 2,5
t = 2,5 mm	Part no. 180 074

Example 2:

200 disc springs are required for pre-loading ball bearings with the designation 6020. The springs are to be located on the outer race of the ball bearing	Order: 200 disc springs size 149 x 106 x 1,5 Part no. 200 044

Ordering special sizes

Orders for disc springs with non-standard dimensions should include the following: D_e, D_i, t, l_0 and the required load characteristics. Orders for Group 3 disc springs should also include the value t'.

6.2 Tables of disc spring dimensions

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_0				
			D_e	D_i	t	t'	l_0	h_0	h_0/t	s	F	σ_I	σ_{II}	σ_{III}
17 0001			8,00	3,20	0,30		0,55	0,25	0,833	0,062	45,6	883	207	401
17 0002			8,00	3,20	0,40		0,60	0,20	0,500	0,050	69,2	797	365	350
17 0003			8,00	3,20	0,50		0,70	0,20	0,400	0,050	128,4	943	511	408
17 0004	C		8,00	4,20	0,20		0,45	0,25	1,250	0,062	21,2	696	8	409
17 0005	B		8,00	4,20	0,30		0,55	0,25	0,833	0,062	51,6	872	184	501
17 0006	A		8,00	4,20	0,40		0,60	0,20	0,500	0,050	78,2	784	343	439
17 0007			10,00	3,20	0,30		0,65	0,35	1,166	0,087	51,1	979	90	378
17 0008			10,00	3,20	0,40		0,70	0,30	0,750	0,075	75,1	938	285	348
17 0009			10,00	3,20	0,50		0,85	0,35	0,700	0,087	165,3	1336	447	492
17 0010			10,00	4,20	0,40		0,70	0,30	0,750	0,075	79,3	860	241	405
17 0011			10,00	4,20	0,50		0,75	0,25	0,500	0,062	109,8	789	359	361
17 0012			10,00	4,20	0,60		0,85	0,25	0,416	0,062	181,5	904	473	410
17 0013	C		10,00	5,20	0,25		0,55	0,30	1,200	0,075	30,4	654	21	380
17 0014	B		10,00	5,20	0,40		0,70	0,30	0,750	0,075	87,8	857	224	485
17 0015	A		10,00	5,20	0,50		0,75	0,25	0,500	0,062	121,5	782	343	435
17 0016			12,00	4,20	0,40		0,80	0,40	1,000	0,100	85,1	936	149	385
17 0017			12,00	4,20	0,50		0,90	0,40	0,800	0,100	142,6	1072	285	432
17 0018			12,00	4,20	0,60		1,00	0,40	0,666	0,100	224,1	1208	421	480
17 0019			12,00	5,20	0,50		0,90	0,40	0,800	0,100	150,4	1015	251	493
17 0020			12,00	5,20	0,60		0,95	0,35	0,583	0,087	195,9	957	372	455
17 0021			12,00	6,20	0,50		0,85	0,35	0,700	0,087	133,5	845	249	475
17 0022			12,00	6,20	0,60		0,95	0,35	0,583	0,087	213,6	955	358	531
17 0023	C		12,50	6,20	0,35		0,80	0,45	1,285	0,112	83,5	903	2	506
17 0024	B		12,50	6,20	0,50		0,85	0,35	0,700	0,087	120,0	775	231	420
17 0025	A		12,50	6,20	0,70		1,00	0,30	0,428	0,075	239,4	804	403	425
17 0026			14,00	7,20	0,35		0,80	0,45	1,285	0,112	68,0	723	-11	418
17 0027			14,00	7,20	0,50		0,90	0,40	0,800	0,100	120,1	745	173	419
17 0028			14,00	7,20	0,80		1,10	0,30	0,375	0,075	283,8	712	390	386
17 0029			15,00	5,20	0,40		0,95	0,55	1,375	0,137	101,2	957	3	401
17 0030			15,00	5,20	0,50		1,00	0,50	1,000	0,125	132,8	939	151	383
17 0031			15,00	5,20	0,60		1,05	0,45	0,750	0,112	170,8	908	269	361
17 0032			15,00	5,20	0,70		1,25	0,55	0,785	0,137	340,2	1317	362	526
17 0033			15,00	6,20	0,50		1,00	0,50	1,000	0,125	138,1	895	129	424
17 0034			15,00	6,20	0,60		1,05	0,45	0,750	0,112	177,6	863	243	400
17 0035			15,00	6,20	0,70		1,10	0,40	0,571	0,100	222,4	818	328	373
17 0036			15,00	8,20	0,70		1,10	0,40	0,571	0,100	256,3	819	311	479
17 0037			15,00	8,20	0,80		1,20	0,40	0,500	0,100	366,8	900	391	523
17 0038	C		16,00	8,20	0,40		0,90	0,50	1,250	0,125	83,7	693	10	399
17 0039	B		16,00	8,20	0,60		1,05	0,45	0,750	0,112	172,0	751	197	420
17 0040	A		16,00	8,20	0,90		1,25	0,35	0,388	0,087	362,5	721	386	391
17 0041			18,00	6,20	0,40		1,00	0,60	1,500	0,150	84,6	759	-30	319
17 0042			18,00	6,20	0,50		1,10	0,60	1,200	0,150	129,9	851	61	350
17 0043			18,00	6,20	0,60		1,20	0,60	1,000	0,150	191,1	942	152	382
17 0044			18,00	6,20	0,70		1,40	0,70	1,000	0,175	354,1	1282	207	520
17 0045			18,00	6,20	0,80		1,50	0,70	0,875	0,175	479,5	1388	313	556
17 0046			18,00	8,20	0,70		1,25	0,55	0,785	0,137	254,6	858	216	434
17 0047			18,00	8,20	0,80		1,30	0,50	0,625	0,125	308,9	823	292	411
17 0048			18,00	8,20	1,00		1,50	0,50	0,500	0,125	559,0	963	432	475
17 0049	C		18,00	9,20	0,45		1,05	0,60	1,333	0,150	120,7	763	-14	440
17 0050	B		18,00	9,20	0,70		1,20	0,50	0,714	0,125	233,4	756	216	421
17 0051	A		18,00	9,20	1,00		1,40	0,40	0,400	0,100	450,6	728	382	394
17 0052			20,00	8,20	0,50		1,15	0,65	1,300	0,162	128,3	739	11	355
17 0053			20,00	8,20	0,60		1,30	0,70	1,166	0,175	214,4	907	63	432
17 0054			20,00	8,20	0,70		1,35	0,65	0,928	0,162	261,5	890	161	416
17 0055			20,00	8,20	0,80		1,40	0,60	0,750	0,150	315,0	865	244	398
17 0056			20,00	8,20	0,90		1,50	0,60	0,666	0,150	423,2	934	313	427
17 0057			20,00	8,20	1,00		1,60	0,60	0,600	0,150	555,6	1003	382	455
17 0058			20,00	10,20	0,40		0,90	0,50	1,250	0,125	53,4	443	6	254

Spring force F in N										Stress σ in N/mm²					Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
0,125	79,1	1669	511	750	0,187	104,3	2359	912	1046	0,250	125,5	2952	1409	1290	0,099
0,100	130,1	1533	792	666	0,150	185,5	2207	1281	949	0,200	238,0	2820	1832	1198	0,133
0,100	246,4	1824	1083	782	0,150	357,4	2643	1717	1123	0,200	464,9	3401	2413	1430	0,166
0,125	33,3	1294	114	753	0,187	39,2	1794	319	1034	0,250	42,0	2195	622	1251	0,057
0,125	89,3	1646	467	938	0,187	117,9	2322	847	1312	0,250	141,8	2900	1326	1620	0,086
0,100	147,0	1504	749	837	0,150	209,5	2162	1218	1194	0,200	268,9	2757	1750	1511	0,114
0,175	81,6	1831	308	697	0,262	98,3	2556	652	957	0,350	108,0	3154	1123	1158	0,166
0,150	132,9	1782	663	652	0,225	179,1	2533	1134	913	0,300	219,6	3191	1698	1130	0,221
0,175	296,1	2544	1021	925	0,262	404,0	3626	1721	1299	0,350	500,4	4580	2549	1614	0,277
0,150	140,3	1632	570	760	0,225	189,1	2316	988	1066	0,300	231,8	2911	1495	1322	0,203
0,125	206,3	1516	778	688	0,187	294,0	2182	1260	981	0,250	377,3	2786	1803	1239	0,254
0,125	347,2	1746	1008	785	0,187	502,3	2526	1604	1125	0,250	652,0	3245	2262	1432	0,304
0,150	48,2	1217	133	702	0,225	57,5	1691	336	965	0,300	62,6	2074	628	1169	0,112
0,150	155,3	1623	539	912	0,225	209,3	2299	943	1281	0,300	256,5	2884	1439	1591	0,180
0,125	228,3	1502	749	829	0,187	325,3	2159	1218	1182	0,250	417,5	2753	1749	1495	0,225
0,200	141,4	1760	411	714	0,300	178,3	2472	786	988	0,400	205,6	3071	1272	1205	0,311
0,200	249,0	2032	683	809	0,300	331,4	2879	1193	1130	0,400	401,7	3614	1815	1395	0,389
0,200	404,9	2303	954	904	0,300	556,8	3286	1600	1273	0,400	694,1	4157	2358	1585	0,467
0,200	262,7	1921	611	923	0,300	349,6	2717	1080	1291	0,400	423,8	3404	1658	1596	0,360
0,175	361,2	1830	828	863	0,262	506,1	2620	1367	1222	0,350	640,7	3326	1990	1534	0,432
0,175	239,2	1605	582	894	0,262	326,4	2280	1001	1259	0,350	404,2	2869	1506	1569	0,325
0,175	393,8	1824	801	1007	0,262	551,7	2608	1329	1429	0,350	698,5	3307	1943	1795	0,390
0,225	129,8	1677	134	932	0,337	151,2	2323	393	1278	0,450	160,2	2840	782	1542	0,254
0,175	215,1	1473	539	791	0,262	293,4	2093	925	1114	0,350	363,4	2635	1389	1388	0,363
0,150	456,8	1550	864	814	0,225	659,5	2240	1382	1167	0,300	854,9	2872	1957	1484	0,508
0,225	105,7	1343	103	770	0,337	123,2	1860	309	1055	0,450	130,5	2273	619	1274	0,311
0,200	209,8	1408	428	787	0,300	279,2	1990	764	1101	0,400	338,4	2490	1182	1363	0,444
0,150	547,2	1377	826	743	0,225	796,8	1997	1308	1071	0,300	1040,0	2571	1836	1369	0,711
0,275	154,4	1777	142	735	0,412	175,5	2462	417	1002	0,550	180,7	3010	828	1202	0,488
0,250	220,6	1766	414	711	0,375	278,2	2480	790	983	0,500	320,9	3082	1279	1199	0,610
0,225	302,1	1725	630	678	0,337	407,2	2451	1082	949	0,450	499,0	3085	1625	1176	0,732
0,275	596,4	2497	861	985	0,412	796,5	3541	1496	1376	0,550	968,6	4449	2268	1701	0,854
0,250	229,4	1680	368	787	0,375	289,4	2356	716	1089	0,500	333,7	2923	1173	1331	0,575
0,225	314,2	1638	574	752	0,337	423,5	2323	994	1054	0,450	519,0	2921	1503	1307	0,690
0,200	411,1	1567	727	707	0,300	577,5	2245	1195	1002	0,400	732,6	2854	1734	1258	0,805
0,200	473,9	1566	694	909	0,300	665,6	2240	1150	1291	0,400	844,4	2841	1679	1624	0,681
0,200	689,3	1727	856	997	0,300	982,3	2482	1392	1423	0,400	1261,0	3164	2002	1800	0,778
0,250	131,2	1289	117	735	0,375	154,3	1786	322	1009	0,500	165,4	2186	624	1220	0,465
0,225	304,3	1423	474	790	0,337	410,0	2016	830	1109	0,450	502,5	2530	1264	1377	0,698
0,175	697,0	1394	820	751	0,262	1013,0	2019	1301	1080	0,350	1319,0	2596	1831	1379	1,047
0,300	126,1	1406	52	583	0,450	138,6	1940	247	791	0,600	136,7	2361	555	944	0,704
0,300	205,7	1588	234	646	0,450	245,4	2213	520	885	0,600	267,0	2725	920	1070	0,880
0,300	317,3	1770	416	708	0,450	400,3	2486	794	980	0,600	461,6	3090	1284	1195	1,056
0,350	588,0	2410	567	964	0,525	741,7	3384	1080	1333	0,700	855,2	4205	1748	1627	1,232
0,350	821,6	2622	779	1037	0,525	1072,0	3703	1399	1443	0,700	1277,0	4630	2173	1774	1,408
0,275	446,2	1624	523	815	0,412	596,0	2298	922	1141	0,550	724,7	2881	1413	1412	1,108
0,250	563,8	1570	660	777	0,375	782,6	2242	1104	1098	0,500	983,5	2837	1624	1375	1,266
0,250	1051,0	1849	939	904	0,375	1497,0	2660	1523	1289	0,500	1921,0	3395	2182	1629	1,582
0,300	185,8	1415	83	809	0,450	213,7	1957	291	1106	0,600	222,9	2387	610	1333	0,664
0,250	416,6	1434	509	792	0,375	566,4	2035	879	1114	0,500	699,4	2560	1326	1387	1,033
0,200	865,0	1406	814	757	0,300	1254,0	2035	1295	1088	0,400	1631,0	2615	1826	1387	1,476
0,325	198,8	1375	126	652	0,487	230,8	1906	345	892	0,650	243,4	2333	668	1074	1,026
0,350	342,1	1694	246	797	0,525	412,0	2360	550	1095	0,700	453,0	2905	974	1327	1,231
0,325	442,0	1675	426	775	0,487	568,5	2356	795	1076	0,650	668,0	2934	1269	1320	1,436
0,300	557,3	1640	576	748	0,450	751,0	2328	998	1048	0,600	920,5	2926	1507	1300	1,641
0,300	764,5	1779	715	804	0,450	1051,0	2535	1205	1133	0,600	1311,0	3203	1784	1413	1,846
0,300	1020,0	1917	853	861	0,450	1424,0	2743	1413	1218	0,600	1798,0	3480	2062	1527	2,051
0,250	83,7	824	75	468	0,375	98,5	1142	206	642	0,500	105,5	1398	400	777	0,730

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_0				
			D_e	D_i	t	t'	l_0	h_0	h_0/t	s	F	σ_I	σ_{II}	σ_{III}
17 0059	C		20,00	10,20	0,50		1,15	0,65	1,300	0,162	141,3	734	-4	422
17 0060	B		20,00	10,20	0,80		1,35	0,55	0,687	0,137	304,3	759	230	421
17 0061			20,00	10,20	0,90		1,45	0,55	0,611	0,137	411,7	821	292	452
17 0062			20,00	10,20	1,00		1,55	0,55	0,550	0,137	543,6	882	354	484
17 0063	A		20,00	10,20	1,10		1,55	0,45	0,409	0,112	548,2	733	379	397
17 0064			22,50	11,20	0,60		1,40	0,80	1,330	0,200	240,4	865	-14	488
17 0065			22,50	11,20	0,80		1,45	0,65	0,812	0,162	306,3	751	171	412
18 0001			22,50	11,20	1,25		1,75	0,50	0,400	0,125	693,1	726	383	384
17 0066			23,00	8,20	0,70		1,50	0,80	1,142	0,200	279,4	940	87	397
17 0067			23,00	8,20	0,80		1,55	0,75	0,937	0,187	332,0	925	175	384
17 0068			23,00	8,20	0,90		1,70	0,80	0,888	0,200	485,7	1086	233	449
17 0069			23,00	10,20	0,90		1,65	0,75	0,833	0,187	463,1	944	213	469
17 0070			23,00	10,20	1,00		1,70	0,70	0,700	0,175	538,2	919	282	451
17 0071			23,00	12,20	1,00		1,60	0,60	0,600	0,150	474,7	753	271	429
18 0002			23,00	12,20	1,25		1,85	0,60	0,480	0,150	863,4	881	399	497
18 0003			23,00	12,20	1,50		2,10	0,60	0,400	0,150	1432,0	1009	527	565
17 0072	C		25,00	12,20	0,70		1,60	0,90	1,285	0,255	331,2	902	4	499
17 0073	B		25,00	12,20	0,90		1,60	0,70	0,777	0,175	366,8	724	181	389
18 0004	A		25,00	12,20	1,50		2,05	0,55	0,366	0,137	1040,0	761	425	393
17 0074			28,00	10,20	0,80		1,75	0,95	1,187	0,237	347,9	870	62	375
17 0075			28,00	10,20	1,00		2,00	1,00	1,000	0,250	615,2	1061	165	451
18 0005			28,00	10,20	1,25		2,25	1,00	0,800	0,250	1030,0	1214	319	507
18 0006			28,00	10,20	1,50		2,20	0,70	0,466	0,175	1003,0	863	424	346
17 0076			28,00	12,20	1,00		1,95	0,95	0,950	0,237	589,9	947	156	467
18 0007			28,00	12,20	1,25		2,10	0,85	0,680	0,212	843,8	934	300	451
18 0008			28,00	12,20	1,50		2,25	0,75	0,500	0,187	1149,0	900	406	426
17 0077	C		28,00	14,20	0,80		1,80	1,00	1,250	0,250	434,8	904	13	515
17 0078	B		28,00	14,20	1,00		1,80	0,80	0,800	0,200	476,4	744	174	414
18 0009			28,00	14,20	1,25		2,10	0,85	0,680	0,212	907,4	931	287	513
18 0010	A		28,00	14,20	1,50		2,15	0,65	0,433	0,162	1033,0	747	371	403
17 0079	C		31,50	16,30	0,80		1,85	1,05	1,312	0,262	384,3	771	-9	448
18 0011	B		31,50	16,30	1,25		2,15	0,90	0,720	0,225	790,5	797	224	449
18 0012			31,50	16,30	1,50		2,40	0,90	0,600	0,225	1260,0	899	326	501
18 0013	A		31,50	16,30	1,75		2,45	0,70	0,400	0,175	1391,0	729	382	399
18 0014			31,50	16,30	2,00		2,75	0,75	0,375	0,187	2199,0	879	481	480
17 0080			34,00	12,30	1,00		2,20	1,20	1,200	0,300	587,2	938	63	403
18 0015			34,00	12,30	1,25		2,45	1,20	0,960	0,300	946,4	1063	188	448
18 0016			34,00	12,30	1,50		2,70	1,20	0,800	0,300	1447,0	1188	313	493
18 0017			34,00	14,30	1,25		2,40	1,15	0,920	0,287	912,8	964	177	461
18 0018			34,00	14,30	1,50		2,55	1,05	0,700	0,262	1224,0	953	297	447
18 0019			34,00	16,30	1,50		2,55	1,05	0,700	0,262	1291,0	942	283	495
18 0020			34,00	16,30	2,00		2,85	0,85	0,425	0,212	2097,0	877	445	449
17 0081	C		35,50	18,30	0,90		2,05	1,15	1,277	0,287	457,7	737	2	427
18 0021	B		35,50	18,30	1,25		2,25	1,00	0,800	0,250	730,9	724	168	409
18 0022	A		35,50	18,30	2,00		2,80	0,80	0,400	0,200	1864,0	749	393	409
18 0023			40,00	14,30	1,25		2,65	1,40	1,120	0,350	904,4	961	98	406
18 0024			40,00	14,30	1,50		2,80	1,30	0,866	0,325	1188,0	962	218	398
18 0025			40,00	14,30	1,75		3,05	1,30	0,742	0,325	1722,0	1061	316	433
18 0026			40,00	14,30	2,00		3,05	1,05	0,525	0,262	1800,0	878	393	349
18 0027			40,00	16,30	1,50		2,80	1,30	0,866	0,325	1224,0	928	199	430
18 0028			40,00	16,30	1,75		3,10	1,35	0,771	0,337	1881,0	1076	290	494
18 0029			40,00	16,30	2,00		3,10	1,10	0,550	0,275	1972,0	897	375	402
18 0030			40,00	18,30	2,00		3,15	1,15	0,575	0,287	2182,0	933	365	466
17 0082	C		40,00	20,40	1,00		2,30	1,30	1,300	0,325	565,3	734	-4	422
18 0031	B		40,00	20,40	1,50		2,65	1,15	0,766	0,287	1109,0	774	196	431
18 0032			40,00	20,40	2,00		3,10	1,10	0,550	0,275	2175,0	882	354	484
18 0033	A		40,00	20,40	2,25		3,15	0,90	0,400	0,225	2336,0	746	392	403
18 0034			40,00	20,40	2,50		3,45	0,95	0,380	0,237	3351,0	864	470	466

Spring force F in N								Stress σ in N/mm²							Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
0,325	218,9	1363	98	776	0,487	254,1	1887	305	1063	0,650	268,0	2305	617	1283	0,912
0,275	546,8	1442	536	793	0,412	748,2	2050	917	1118	0,550	929,0	2582	1374	1394	1,460
0,275	754,0	1566	659	856	0,412	1050,0	2235	1102	1212	0,550	1323,0	2829	1621	1520	1,642
0,275	1010,0	1689	783	920	0,412	1425,0	2421	1288	1307	0,550	1815,0	3077	1868	1646	1,824
0,225	1050,0	1416	809	761	0,337	1521,0	2048	1290	1093	0,450	1976,0	2630	1821	1393	2,007
0,400	369,9	1605	98	897	0,600	425,4	2219	336	1227	0,800	443,9	2708	699	1478	1,409
0,325	533,4	1420	425	771	0,487	707,4	2006	762	1079	0,650	855,1	2508	1182	1335	1,878
0,250	1330,0	1403	815	737	0,375	1929,0	2031	1296	1059	0,500	2509,0	2610	1825	1350	2,935
0,400	448,4	1758	295	733	0,600	543,6	2454	626	1007	0,800	601,9	3028	1078	1221	1,993
0,375	560,0	1743	457	714	0,562	718,5	2453	846	991	0,750	842,4	3057	1343	1214	2,277
0,400	829,2	2051	589	837	0,600	1078,0	2894	1066	1164	0,800	1279,0	3615	1665	1430	2,561
0,375	801,9	1784	531	877	0,562	1058,0	2520	953	1225	0,750	1273,0	3151	1480	1512	2,357
0,350	964,2	1746	655	849	0,525	1315,0	2483	1119	1195	0,700	1629,0	3129	1673	1487	2,619
0,300	871,7	1436	612	813	0,450	1217,0	2052	1020	1152	0,600	1536,0	2598	1498	1446	2,343
0,300	1630,0	1692	868	949	0,450	2331,0	2436	1404	1356	0,600	3000,0	3110	2010	1718	2,929
0,300	2748,0	1948	1124	1085	0,450	3986,0	2820	1788	1560	0,600	5184,0	3622	2522	1990	3,514
0,450	514,6	1675	136	919	0,675	599,6	2320	396	1259	0,900	635,4	2837	785	1519	2,055
0,350	644,3	1371	440	730	0,525	862,3	1940	776	1023	0,700	1050,0	2432	1190	1268	2,642
0,275	2007,0	1473	898	757	0,412	2926,0	2138	1419	1091	0,550	3821,0	2755	1988	1395	4,403
0,475	552,5	1624	239	692	0,712	661,5	2264	532	950	0,950	722,7	2787	940	1149	3,354
0,500	1022,0	1994	459	837	0,750	1289,0	2798	880	1158	1,000	1486,0	3475	1429	1414	4,191
0,500	1799,0	2300	765	949	0,750	2394,0	3258	1340	1326	1,000	2902,0	4089	2042	1637	5,238
0,350	1899,0	1663	911	660	0,525	2723,0	2401	1461	943	0,700	3511,0	3076	2074	1193	6,286
0,475	991,7	1781	425	870	0,712	1268,0	2502	807	1208	0,950	1482,0	3111	1302	1480	3,914
0,425	1519,0	1777	691	849	0,637	2083,0	2529	1172	1196	0,850	2590,0	3191	1743	1491	4,893
0,375	2159,0	1729	883	812	0,562	3077,0	2488	1431	1157	0,750	3949,0	3176	2049	1462	5,872
0,500	681,0	1680	154	950	0,750	801,4	2330	422	1304	1,000	858,8	2852	817	1577	2,872
0,400	832,0	1406	429	776	0,600	1107,0	1986	765	1086	0,800	1342,0	2486	1183	1344	3,590
0,425	1634,0	1770	667	968	0,637	2240,0	2516	1138	1365	0,850	2785,0	3171	1701	1703	4,486
0,325	1970,0	1440	795	772	0,487	2841,0	2080	1274	1106	0,650	3680,0	2665	1806	1407	5,386
0,525	593,8	1430	94	825	0,787	686,8	1978	308	1130	1,050	721,6	2415	633	1363	3,583
0,450	1409,0	1512	530	844	0,675	1913,0	2145	917	1187	0,900	2359,0	2696	1386	1478	5,599
0,450	2314,0	1716	734	950	0,675	3230,0	2451	1223	1346	0,900	4077,0	3104	1795	1689	6,717
0,350	2669,0	1408	814	766	0,525	3871,0	2038	1296	1102	0,700	5036,0	2619	1826	1405	7,839
0,375	4239,0	1702	1020	924	0,562	6173,0	2467	1615	1331	0,750	8054,0	3176	2267	1701	8,956
0,600	930,0	1751	250	742	0,900	1110,0	2439	563	1018	1,200	1208,0	3002	1001	1231	6,194
0,600	1587,0	2001	500	833	0,900	2024,0	2814	938	1154	1,200	2359,0	3502	1501	1412	7,743
0,600	2527,0	2251	750	923	0,900	3363,0	3190	1313	1290	1,200	4076,0	4003	2001	1593	9,280
0,575	1546,0	1816	466	858	0,862	1993,0	2555	868	1193	1,150	2347,0	3182	1382	1464	7,330
0,525	2192,0	1813	687	841	0,787	2990,0	2579	1172	1183	1,050	3704,0	3250	1750	1472	8,799
0,525	2313,0	1790	660	933	0,787	3155,0	2543	1131	1313	1,050	3908,0	3203	1696	1635	8,233
0,425	4003,0	1692	952	860	0,637	5783,0	2446	1520	1234	0,850	7498,0	3138	2150	1570	10,978
0,575	712,4	1370	108	786	0,862	831,9	1897	320	1078	1,150	883,8	2319	637	1302	5,134
0,500	1277,0	1369	416	766	0,750	1699,0	1935	743	1073	1,000	2059,0	2421	1149	1329	7,131
0,400	3576,0	1448	837	785	0,600	5187,0	2095	1332	1128	0,800	6747,0	2692	1878	1439	11,410
0,700	1459,0	1799	319	750	1,050	1780,0	2514	664	1033	1,400	1984,0	3105	1132	1253	10,755
0,650	2040,0	1818	542	743	0,975	2668,0	2568	973	1034	1,300	3184,0	3212	1510	1271	12,905
0,650	3051,0	2015	739	813	0,975	4119,0	2863	1268	1139	1,300	5056,0	3605	1904	1412	15,056
0,525	3363,0	1688	855	664	0,787	4769,0	2427	1387	943	1,050	6096,0	3098	1988	1188	17,207
0,650	2102,0	1752	503	802	0,975	2749,0	2472	911	1118	1,300	3281,0	3088	1422	1376	12,339
0,675	3309,0	2040	692	926	1,012	4435,0	2891	1207	1297	1,350	5410,0	3631	1834	1606	14,396
0,550	3663,0	1719	825	764	0,825	5169,0	2467	1349	1084	1,100	6580,0	3141	1948	1364	16,499
0,575	4030,0	1785	810	883	0,862	5656,0	2556	1338	1252	1,150	7171,0	3246	1946	1573	15,599
0,650	875,8	1363	98	776	0,975	1017,0	1887	305	1063	1,300	1072,0	2305	617	1283	7,299
0,575	1953,0	1465	474	810	0,862	2621,0	2073	835	1136	1,150	3201,0	2599	1278	1410	10,948
0,550	4041,0	1689	783	920	0,825	5701,0	2421	1288	1307	1,100	7258,0	3077	1868	1646	14,590
0,450	4481,0	1441	835	774	0,675	6500,0	2086	1328	1112	0,900	8456,0	2680	1871	1419	16,422
0,475	6453,0	1673	997	896	0,712	9390,0	2424	1579	1290	0,950	12243,0	3120	2219	1649	18,246

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_0				
			D_e	D_i	t	t'	l_0	h_0	h_0/t	s	F	σ_I	σ_{II}	σ_{III}
18 0035	C		45,00	22,40	1,25		2,85	1,60	1,280	0,400	1041,0	883	4	497
18 0036	B		45,00	22,40	1,75		3,05	1,30	0,742	0,325	1524,0	795	214	433
18 0037	A		45,00	22,40	2,50		3,50	1,00	0,400	0,250	2773,0	726	383	384
18 0038			48,00	16,30	1,50		3,00	1,50	1,000	0,375	1048,0	832	135	333
18 0039			50,00	18,40	1,25		2,85	1,60	1,280	0,400	756,9	742	24	325
18 0040			50,00	18,40	1,50		3,15	1,65	1,100	0,412	1166,0	855	93	370
18 0041			50,00	18,40	2,00		3,65	1,65	0,825	0,412	2229,0	1013	251	428
18 0042			50,00	18,40	2,50		4,15	1,65	0,660	0,412	3870,0	1171	409	486
18 0043			50,00	18,40	3,00		4,20	1,20	0,400	0,300	4179,0	891	488	357
18 0044			50,00	20,40	2,00		3,50	1,50	0,750	0,375	1966,0	865	244	397
18 0045			50,00	20,40	2,50		3,85	1,35	0,540	0,337	3008,0	876	373	393
18 0046			50,00	22,40	2,00		3,60	1,60	0,800	0,400	2247,0	932	228	466
18 0047			50,00	22,40	2,50		3,90	1,40	0,560	0,350	3261,0	904	364	442
18 0048	C		50,00	25,40	1,25		2,85	1,60	1,280	0,400	853,7	717	2	410
18 0049			50,00	25,40	1,50		3,10	1,60	1,066	0,400	1242,0	789	74	447
18 0050	B		50,00	25,40	2,00		3,40	1,40	0,700	0,350	1949,0	777	230	430
18 0051			50,00	25,40	2,25		3,75	1,50	0,666	0,375	2905,0	921	292	508
18 0052			50,00	25,40	2,50		3,90	1,40	0,560	0,350	3473,0	903	355	494
18 0053	A		50,00	25,40	3,00		4,10	1,10	0,366	0,275	4255,0	762	424	409
18 0054	C		56,00	28,50	1,50		3,45	1,95	1,300	0,487	1458,0	843	-4	483
18 0055	B		56,00	28,50	2,00		3,60	1,60	0,800	0,400	1910,0	744	173	415
18 0056			56,00	28,50	2,50		4,20	1,70	0,680	0,425	3638,0	931	287	515
18 0057	A		56,00	28,50	3,00		4,30	1,30	0,433	0,325	4142,0	747	371	404
18 0058			60,00	20,50	2,00		4,20	2,20	1,100	0,550	2528,0	1082	125	440
18 0059			60,00	20,50	2,50		4,70	2,20	0,880	0,550	4151,0	1233	276	491
18 0060			60,00	20,50	3,00		5,20	2,20	0,733	0,550	6434,0	1384	426	543
18 0061			60,00	25,50	2,50		4,40	1,90	0,760	0,475	3447,0	949	259	451
18 0062			60,00	25,50	3,00		4,65	1,65	0,550	0,412	4495,0	889	369	414
18 0063			60,00	30,50	2,50		4,50	2,00	0,800	0,500	4059,0	1012	236	564
18 0064			60,00	30,50	2,75		4,75	2,00	0,727	0,500	5125,0	1075	299	596
18 0065			60,00	30,50	3,00		4,70	1,70	0,566	0,425	5083,0	917	356	502
18 0066			60,00	30,50	3,50		5,00	1,50	0,428	0,375	6591,0	874	437	472
18 0067	C		63,00	31,00	1,80		4,15	2,35	1,305	0,587	2364,0	961	-4	536
18 0068	B		63,00	31,00	2,50		4,25	1,75	0,700	0,437	2942,0	763	227	410
18 0069			63,00	31,00	3,00		4,70	1,70	0,566	0,425	4524,0	830	324	441
18 0070	A		63,00	31,00	3,50		4,90	1,40	0,400	0,350	5399,0	726	383	380
18 0071			70,00	24,50	3,00		5,30	2,30	0,766	0,575	5080,0	1070	306	430
18 0072			70,00	24,50	3,50		6,00	2,50	0,714	0,625	8446,0	1324	421	529
18 0073			70,00	25,50	2,00		4,50	2,50	1,250	0,625	2408,0	938	43	406
18 0074			70,00	30,50	2,50		4,90	2,40	0,960	0,600	3755,0	961	153	475
18 0075			70,00	30,50	3,00		5,10	2,10	0,700	0,525	4676,0	895	276	433
18 0076			70,00	35,50	3,00		5,10	2,10	0,700	0,525	5028,0	891	264	493
18 0077			70,00	35,50	3,50		5,30	1,80	0,514	0,450	6077,0	809	347	440
18 0078			70,00	35,50	4,00		5,80	1,80	0,450	0,450	8757,0	891	430	482
18 0079			70,00	35,50	4,00	3,75	5,80	1,80	0,450	0,450	9167,0	977	357	535
18 0080			70,00	40,50	4,00		5,70	1,70	0,425	0,425	9025,0	858	424	521
18 0081			70,00	40,50	4,00	3,75	5,70	1,70	0,425	0,425	9423,0	942	354	579
18 0082			70,00	40,50	5,00		6,40	1,40	0,280	0,350	13646,0	807	513	484
18 0083			70,00	40,50	5,00	4,70	6,40	1,40	0,280	0,350	14004,0	886	457	537
18 0084	C		71,00	36,00	2,00		4,60	2,60	1,300	0,650	2861,0	932	-5	532
18 0085	B		71,00	36,00	2,50		4,50	2,00	0,800	0,500	2894,0	723	169	402
18 0086	A		71,00	36,00	4,00		5,60	1,60	0,400	0,400	7379,0	748	393	402
18 0087			71,00	36,00	4,00	3,75	5,60	1,60	0,400	0,400	7685,0	821	334	447
18 0088			80,00	30,50	2,50		5,30	2,80	1,120	0,700	3664,0	943	91	421
18 0089			80,00	31,00	3,00		5,50	2,50	0,833	0,625	4531,0	890	212	393
18 0090			80,00	31,00	4,00		6,10	2,10	0,525	0,525	7319,0	856	378	366
18 0091			80,00	31,00	4,00	3,75	6,10	2,10	0,525	0,525	7717,0	933	308	406
18 0092			80,00	35,50	4,00		6,20	2,20	0,550	0,550	8118,0	884	364	428

Spring force F in N					Stress σ in N/mm²										Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σI	σII	σIII	s	F	σI	σII	σIII	s	F	σI	σII	σIII	in kg
0,800	1620,0	1641	134	914	1,200	1891,0	2273	389	1253	1,600	2007,0	2779	770	1514	11,739
0,650	2701,0	1507	512	814	0,975	3646,0	2135	892	1144	1,300	4475,0	2681	1355	1421	16,434
0,500	5320,0	1403	815	737	0,750	7716,0	2031	1296	1059	1,000	10037,0	2610	1825	1350	23,478
0,750	1740,0	1564	370	618	1,125	2195,0	2197	704	855	1,500	2531,0	2730	1138	1043	18,850
0,800	1178,0	1381	151	597	1,200	1375,0	1918	380	817	1,600	1459,0	2352	712	984	16,657
0,825	1890,0	1602	294	684	1,237	2319,0	2239	605	942	1,650	2600,0	2768	1024	1144	19,988
0,825	3868,0	1918	610	800	1,237	5114,0	2713	1079	1116	1,650	6163,0	3400	1656	1377	26,651
0,825	7002,0	2234	926	916	1,237	9643,0	3187	1552	1291	1,650	12038,0	4032	2288	1609	33,314
0,600	8018,0	1725	1033	685	0,900	11630,0	2500	1636	983	1,200	15128,0	3219	2296	1251	39,977
0,750	3478,0	1642	578	745	1,125	4687,0	2330	1000	1045	1,500	5745,0	2929	1510	1295	25,695
0,675	5601,0	1680	817	746	1,012	7919,0	2412	1334	1060	1,350	10098,0	3072	1922	1335	32,118
0,800	3924,0	1763	556	872	1,200	5222,0	2493	985	1220	1,600	6329,0	3123	1514	1509	24,639
0,700	6044,0	1730	806	838	1,050	8510,0	2480	1324	1190	1,400	10817,0	3152	1920	1496	30,799
0,800	1328,0	1332	106	755	1,200	1550,0	1845	312	1035	1,600	1646,0	2256	621	1251	14,294
0,800	2028,0	1476	250	828	1,200	2512,0	2061	528	1145	1,600	2844,0	2543	909	1397	17,153
0,700	3491,0	1476	537	810	1,050	4762,0	2097	923	1140	1,400	5898,0	2639	1388	1421	22,871
0,750	5249,0	1752	675	959	1,125	7217,0	2494	1147	1353	1,500	8997,0	3145	1709	1690	25,730
0,700	6437,0	1728	789	938	1,050	9063,0	2474	1301	1332	1,400	11519,0	3143	1891	1677	28,589
0,550	8214,0	1476	897	787	0,825	11976,0	2142	1418	1135	1,100	15640,0	2759	1987	1451	34,306
0,975	2259,0	1565	112	889	1,462	2622,0	2165	350	1218	1,950	2766,0	2645	709	1470	21,489
0,800	3335,0	1406	428	778	1,200	4438,0	1987	765	1090	1,600	5379,0	2486	1183	1349	28,653
0,850	6550,0	1770	666	972	1,275	8978,0	2517	1138	1369	1,700	11164,0	3173	1701	1709	35,816
0,650	7895,0	1441	795	775	0,975	11388,0	2080	1274	1110	1,300	14752,0	2666	1806	1412	42,979
1,100	4097,0	2028	386	812	1,650	5026,0	2837	784	1119	2,200	5636,0	3509	1320	1358	39,208
1,100	7102,0	2330	688	916	1,650	9255,0	3289	1237	1273	2,200	11008,0	4112	1923	1564	49,009
1,100	11429,0	2631	990	1019	1,650	15465,0	3742	1690	1428	2,200	19022,0	4716	2527	1771	58,811
0,950	6081,0	1799	616	847	1,425	8175,0	2551	1072	1187	1,900	9997,0	3204	1627	1471	45,465
0,825	8352,0	1704	812	787	1,237	11784,0	2445	1330	1117	1,650	15002,0	3111	1922	1405	54,557
1,000	7088,0	1914	583	1058	1,500	9432,0	2704	1041	1481	2,000	11433,0	3384	1610	1834	41,149
1,000	9117,0	2039	708	1122	1,500	12356,0	2892	1228	1576	2,000	15217,0	3634	1860	1961	45,264
0,850	9407,0	1754	793	953	1,275	13226,0	2511	1309	1353	1,700	16792,0	3188	1906	1703	57,608
0,750	12574,0	1685	937	905	1,125	18153,0	2434	1499	1297	1,500	23528,0	3121	2123	1650	57,608
1,175	3658,0	1785	130	986	1,762	4238,0	2470	402	1351	2,350	4463,0	3018	811	1629	33,381
0,875	5270,0	1449	531	773	1,312	7189,0	2059	912	1088	1,750	8904,0	2592	1368	1355	46,362
0,850	8373,0	1587	721	838	1,275	11772,0	2273	1190	1189	1,700	14946,0	2886	1731	1495	56,635
0,700	10359,0	1403	815	729	1,050	15025,0	2030	1296	1047	1,400	19545,0	2609	1826	1335	64,907
1,150	8948,0	2031	721	806	1,725	12007,0	2883	1245	1128	2,300	14663,0	3626	1878	1396	79,526
1,250	15076,0	2519	971	994	1,875	20495,0	3585	1650	1395	2,500	25309,0	4522	2458	1733	92,781
1,250	3771,0	1748	214	748	1,875	4437,0	2431	512	1024	2,500	4755,0	2985	939	1235	52,401
1,200	6297,0	1807	422	883	1,800	8031,0	2538	806	1225	2,400	9360,0	3153	1306	1501	61,186
1,050	8376,0	1701	640	814	1,575	11426,0	2418	1093	1145	2,100	14152,0	3048	1634	1426	73,423
1,050	9007,0	1694	617	928	1,575	12287,0	2407	1060	1307	2,100	15218,0	3029	1593	1628	67,319
0,900	11384,0	1551	760	837	1,350	16177,0	2228	1239	1193	1,800	20714,0	2839	1784	1507	78,539
0,900	16634,0	1716	925	921	1,350	23923,0	2476	1486	1319	1,800	30919,0	3169	2114	1675	89,759
0,900	17018,0	1877	790	1022	1,350	23923,0	2701	1299	1460	2,050	33656,0	3831	2244	2045	84,149
0,850	17230,0	1654	910	1000	1,275	24889,0	2388	1459	1435	1,700	32274,0	3059	2069	1827	80,388
0,850	17604,0	1813	779	1108	1,275	24889,0	2611	1277	1588	1,950	35467,0	3731	2215	2246	75,364
0,700	26719,0	1572	1068	938	1,050	39410,0	2295	1665	1364	1,400	51911,0	2975	2303	1760	100,485
0,700	27059,0	1722	963	1040	1,050	39410,0	2509	1518	1509	1,700	61324,0	3841	2680	2289	94,456
1,300	4432,0	1730	125	980	1,950	5144,0	2394	388	1342	2,600	5426,0	2924	784	1620	46,177
1,000	5054,0	1366	417	754	1,500	6725,0	1931	744	1055	2,000	8152,0	2416	1150	1306	57,722
0,800	14157,0	1445	837	772	1,200	20535,0	2091	1332	1109	1,600	26712,0	2687	1877	1415	92,355
0,800	14445,0	1583	727	857	1,200	20535,0	2286	1179	1230	1,850	29661,0	3302	2039	1755	86,582
1,400	5911,0	1765	303	778	2,100	7211,0	2464	637	1070	2,800	8039,0	3042	1093	1299	84,305
1,250	7847,0	1682	520	735	1,875	10352,0	2378	926	1025	2,500	12451,0	2978	1428	1265	100,598
1,050	13677,0	1644	823	695	1,575	19394,0	2363	1338	989	2,100	24791,0	3014	1920	1246	134,130
1,050	14049,0	1788	694	771	1,575	19394,0	2564	1159	1094	2,350	26327,0	3566	1989	1495	125,747
1,100	15083,0	1693	802	812	1,650	21280,0	2428	1314	1154	2,200	27093,0	3089	1901	1452	126,750

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm (s = 0,25 h_0)				
			D_e	D_i	t	t'	l_0	h_0	h_0/t	s	F	σ_I	σ_{II}	σ_{III}
18 0093			80,00	35,50	4,00	3,75	6,20	2,20	0,550	0,550	8577,0	964	289	474
18 0094			80,00	36,00	3,00		5,70	2,70	0,900	0,675	5401,0	964	181	487
18 0095	C		80,00	41,00	2,25		5,20	2,95	1,311	0,737	3698,0	942	-9	544
18 0096	B		80,00	41,00	3,00		5,30	2,30	0,766	0,575	4450,0	774	196	434
18 0097			80,00	41,00	4,00		6,20	2,20	0,550	0,550	8726,0	883	354	486
18 0098			80,00	41,00	4,00	3,75	6,20	2,20	0,550	0,550	9220,0	965	278	538
18 0099	A		80,00	41,00	5,00		6,70	1,70	0,340	0,425	11821,0	755	439	407
18 0100			80,00	41,00	5,00	4,70	6,70	1,70	0,340	0,425	12211,0	827	385	452
18 0101	C		90,00	46,00	2,50		5,70	3,20	1,280	0,800	4232,0	886	2	509
18 0102	B		90,00	46,00	3,50		6,00	2,50	0,714	0,625	5836,0	756	216	421
18 0103	A		90,00	46,00	5,00		7,00	2,00	0,400	0,500	11267,0	728	382	394
18 0104			90,00	46,00	5,00	4,70	7,00	2,00	0,400	0,500	11713,0	796	327	437
18 0105			100,00	41,00	4,00		7,20	3,20	0,800	0,800	8715,0	944	238	437
18 0106			100,00	41,00	4,00	3,80	7,20	3,20	0,800	0,800	9215,0	1004	173	470
18 0107			100,00	41,00	5,00		7,75	2,75	0,550	0,687	12345,0	896	374	404
18 0108			100,00	41,00	5,00	4,70	7,75	2,75	0,550	0,687	13013,0	973	303	446
18 0109	C		100,00	51,00	2,70		6,20	3,50	1,296	0,875	4779,0	853	-3	490
18 0110	B		100,00	51,00	3,50		6,30	2,80	0,800	0,700	5624,0	715	167	399
18 0111			100,00	51,00	4,00		7,00	3,00	0,750	0,750	8673,0	854	225	476
18 0112			100,00	51,00	4,00	3,80	7,00	3,00	0,750	0,750	9156,0	912	165	513
18 0113			100,00	51,00	5,00		7,80	2,80	0,560	0,700	13924,0	903	355	496
18 0114			100,00	51,00	5,00	4,70	7,80	2,80	0,560	0,700	14689,0	983	281	546
18 0115	A		100,00	51,00	6,00		8,20	2,20	0,366	0,550	17061,0	763	424	411
18 0116			100,00	51,00	6,00	5,60	8,20	2,20	0,366	0,550	17753,0	843	361	461
19 0001			100,00	51,00	7,00	6,55	9,20	2,20	0,314	0,550	27374,0	950	457	516
18 0117	C		112,00	57,00	3,00		6,90	3,90	1,300	0,975	5834,0	843	-4	483
18 0118	B		112,00	57,00	4,00		7,20	3,20	0,800	0,800	7639,0	744	173	415
18 0119			112,00	57,00	4,00	3,75	7,20	3,20	0,800	0,800	8192,0	805	107	454
18 0120	A		112,00	57,00	6,00		8,50	2,50	0,416	0,625	15800,0	712	363	384
18 0121			112,00	57,00	6,00	5,60	8,50	2,50	0,416	0,625	16536,0	786	302	431
18 0122			125,00	51,00	4,00		8,50	4,50	1,125	1,125	10096,0	980	86	463
18 0123			125,00	51,00	4,00	3,80	8,50	4,50	1,125	1,125	10705,0	1031	19	492
18 0124			125,00	51,00	5,00		8,90	3,90	0,780	0,975	13063,0	913	241	420
18 0125			125,00	51,00	5,00	4,75	8,90	3,90	0,780	0,975	13804,0	972	179	452
18 0126			125,00	51,00	6,00		9,40	3,40	0,566	0,850	17027,0	859	349	386
18 0127			125,00	51,00	6,00	5,65	9,40	3,40	0,566	0,850	17944,0	931	282	426
18 0128			125,00	61,00	5,00		9,00	4,00	0,800	1,000	14615,0	930	220	500
18 0129			125,00	61,00	5,00	4,75	9,00	4,00	0,800	1,000	15455,0	990	155	538
18 0130			125,00	61,00	6,00		9,60	3,60	0,600	0,900	19789,0	908	334	481
18 0131			125,00	61,00	6,00	5,60	9,60	3,60	0,600	0,900	21079,0	996	249	535
19 0002			125,00	61,00	8,00	7,50	10,90	2,90	0,362	0,725	34434,0	937	415	492
18 0132	C		125,00	64,00	3,50		8,00	4,50	1,285	1,125	8514,0	907	0	522
18 0133	B		125,00	64,00	5,00		8,50	3,50	0,700	0,875	12238,0	778	229	433
18 0134			125,00	64,00	5,00	4,70	8,50	3,50	0,700	0,875	13031,0	842	163	475
18 0135			125,00	64,00	6,00		9,60	3,60	0,600	0,900	20348,0	912	331	504
18 0136			125,00	64,00	6,00	5,60	9,60	3,60	0,600	0,900	21674,0	1000	246	560
19 0003			125,00	64,00	7,00	6,55	10,00	3,00	0,428	0,750	25528,0	886	335	489
19 0004	A		125,00	64,00	8,00	7,50	10,60	2,60	0,325	0,650	31118,0	825	391	450
18 0137			125,00	71,00	6,00		9,30	3,30	0,550	0,825	19538,0	835	328	504
18 0138			125,00	71,00	6,00	5,60	9,30	3,30	0,550	0,825	20725,0	919	250	561
19 0005			125,00	71,00	8,00	7,45	10,90	2,90	0,362	0,725	38416,0	974	408	587
19 0006			125,00	71,00	10,00	9,30	11,80	1,80	0,180	0,450	42821,0	674	409	398
18 0139	C		140,00	72,00	3,80		8,70	4,90	1,289	1,225	9514,0	856	-2	495
18 0140	B		140,00	72,00	5,00		9,00	4,00	0,800	1,000	12014,0	745	173	419
18 0141			140,00	72,00	5,00	4,70	9,00	4,00	0,800	1,000	12847,0	803	109	457
19 0007	A		140,00	72,00	8,00	7,50	11,20	3,20	0,400	0,800	31903,0	846	343	467
18 0142			150,00	61,00	5,00		10,30	5,30	1,060	1,325	15292,0	976	114	458
18 0143			150,00	61,00	5,00	4,75	10,30	5,30	1,060	1,325	16221,0	1029	48	488

Spring force F in N								Stress σ in N/mm²							Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
1,100	15512,0	1843	664	899	1,650	21280,0	2637	1124	1274	2,450	28564,0	3638	1945	1731	118,828
1,350	9196,0	1817	474	909	2,025	11919,0	2557	879	1265	2,700	14106,0	3186	1396	1556	94,401
1,475	5715,0	1749	117	1000	2,212	6613,0	2419	379	1370	2,950	6950,0	2953	778	1652	65,460
1,150	7838,0	1466	474	814	1,725	10518,0	2074	835	1142	2,300	12844,0	2600	1278	1417	87,281
1,100	16213,0	1690	783	924	1,650	22874,0	2422	1288	1314	2,200	29122,0	3078	1868	1655	116,374
1,100	16674,0	1843	642	1021	1,650	22874,0	2634	1094	1448	2,450	30703,0	3630	1906	1970	109,100
0,850	22928,0	1465	924	786	1,275	33559,0	2130	1453	1135	1,700	43952,0	2750	2028	1456	145,468
0,850	23296,0	1602	822	871	1,275	33559,0	2324	1312	1255	2,000	50035,0	3434	2269	1834	136,740
1,600	6585,0	1646	130	938	2,400	7684,0	2280	385	1286	3,200	8157,0	2787	766	1553	92,231
1,250	10416,0	1434	509	792	1,875	14161,0	2035	879	1114	2,500	17487,0	2560	1326	1387	129,124
1,000	21617,0	1406	814	757	1,500	31354,0	2035	1295	1088	2,000	40786,0	2615	1826	1387	184,463
1,000	22035,0	1535	712	837	1,500	31354,0	2217	1153	1201	2,300	45141,0	3188	1979	1707	173,395
1,600	15219,0	1788	577	818	2,400	20251,0	2530	1017	1144	3,200	24547,0	3172	1557	1414	205,153
1,600	15683,0	1898	457	880	2,400	20251,0	2681	851	1228	3,400	24574,0	3503	1501	1577	194,896
1,375	22937,0	1717	823	767	2,062	32361,0	2464	1346	1089	2,750	41201,0	3136	1944	1370	256,441
1,375	23561,0	1862	691	846	2,062	32361,0	2665	1164	1198	3,050	43381,0	3669	1933	1622	241,055
1,750	7410,0	1584	116	902	2,625	8609,0	2192	357	1235	3,500	9091,0	2678	721	1491	123,164
1,400	9823,0	1351	411	749	2,100	13070,0	1909	734	1049	2,800	15843,0	2389	1136	1298	159,657
1,500	15341,0	1618	540	894	2,250	20674,0	2292	944	1255	3,000	25338,0	2877	1439	1559	182,465
1,500	15789,0	1724	429	962	2,250	20674,0	2437	792	1348	3,200	25555,0	3198	1394	1747	173,342
1,400	25810,0	1728	789	942	2,100	36339,0	2475	1301	1337	2,800	46189,0	3144	1891	1683	228,081
1,400	26525,0	1877	651	1036	2,100	36339,0	2682	1111	1468	3,100	48503,0	3676	1923	1987	214,397
1,100	32937,0	1477	897	790	1,650	48022,0	2143	1418	1139	2,200	62711,0	2760	1987	1457	273,698
1,100	33589,0	1629	778	885	1,650	48022,0	2358	1253	1273	2,600	71153,0	3483	2207	1858	255,451
1,100	52454,0	1843	972	996	1,650	75840,0	2679	1543	1439	2,650	115982,0	4053	2729	2152	298,787
1,950	9038,0	1565	112	889	2,925	10489,0	2165	350	1218	3,900	11064,0	2645	709	1470	171,917
1,600	13341,0	1406	428	778	2,400	17752,0	1987	765	1090	3,200	21518,0	2486	1183	1349	229,222
1,600	13855,0	1518	305	850	2,400	17752,0	2139	595	1188	3,450	21468,0	2816	1114	1542	214,896
1,250	30215,0	1373	777	737	1,875	43707,0	1985	1239	1058	2,500	56737,0	2548	1752	1348	343,833
1,250	30906,0	1513	662	824	1,875	43707,0	2182	1081	1181	2,900	62863,0	3152	1894	1685	320,911
2,250	16265,0	1832	299	856	3,375	19817,0	2556	640	1178	4,500	22060,0	3153	1109	1431	321,182
2,250	16830,0	1924	176	908	3,375	19817,0	2680	471	1249	4,700	21268,0	3394	994	1554	305,123
1,950	22931,0	1730	579	787	2,925	30669,0	2451	1012	1102	3,900	37342,0	3076	1541	1363	401,478
1,950	23619,0	1838	463	847	2,925	30669,0	2599	852	1183	4,150	37492,0	3405	1492	1524	381,404
1,700	31514,0	1645	770	733	2,550	44307,0	2358	1264	1039	3,400	56254,0	2999	1832	1306	481,773
1,700	32369,0	1779	647	806	2,550	44307,0	2544	1095	1140	3,750	58923,0	3482	1868	1535	453,700
2,000	25526,0	1758	542	938	3,000	33965,0	2485	965	1312	4,000	41170,0	3111	1489	1624	366,953
2,000	26305,0	1869	421	1007	3,000	33965,0	2637	799	1407	4,250	41217,0	3439	1428	1811	348,605
1,800	36336,0	1734	749	911	2,700	50722,0	2479	1247	1290	3,600	64028,0	3141	1827	1619	440,343
1,800	37539,0	1897	592	1011	2,700	50722,0	2703	1031	1429	4,000	66696,0	3701	1831	1929	410,987
1,450	65305,0	1812	893	945	2,175	93577,0	2625	1432	1359	3,400	138144,0	3856	2486	1972	550,429
2,250	13231,0	1684	129	961	3,375	15416,0	2331	388	1318	4,500	16335,0	2849	777	1591	248,775
1,750	21924,0	1477	537	816	2,625	29908,0	2099	923	1149	3,500	37041,0	2641	1387	1432	355,393
1,750	22661,0	1596	415	893	2,625	29908,0	2262	754	1254	3,800	37673,0	3017	1350	1651	334,069
1,800	37362,0	1741	746	955	2,700	52155,0	2487	1243	1352	3,600	65836,0	3150	1823	1697	426,471
1,800	38599,0	1905	587	1059	2,700	52155,0	2714	1024	1497	4,000	68579,0	3713	1825	2022	398,040
1,500	47615,0	1706	738	935	2,250	67216,0	2458	1208	1338	3,450	95795,0	3521	2099	1893	465,564
1,300	59520,0	1599	833	867	1,950	85926,0	2322	1326	1252	3,100	129972,0	3477	2322	1854	533,039
1,650	36302,0	1598	728	959	2,475	51217,0	2288	1201	1363	3,300	65207,0	2905	1746	1718	391,515
1,650	37411,0	1754	583	1065	2,475	51217,0	2504	1001	1511	3,700	68887,0	3464	1776	2067	365,414
1,450	72705,0	1882	883	1128	2,175	103964,0	2723	1424	1623	3,450	154927,0	4042	2537	2384	486,131
0,900	84082,0	1322	845	779	1,350	124124,0	1943	1306	1141	2,500	223282,0	3413	2605	1986	606,848
2,450	14773,0	1590	119	911	3,675	17195,0	2201	362	1249	4,900	18199,0	2690	728	1508	337,734
2,000	20982,0	1408	428	787	3,000	27920,0	1990	764	1101	4,000	33843,0	2490	1182	1363	444,388
2,000	21756,0	1518	310	856	3,000	27920,0	2136	601	1196	4,300	33792,0	2807	1117	1551	417,724
1,600	59967,0	1631	747	895	2,400	85251,0	2355	1213	1284	3,700	123137,0	3402	2098	1832	666,581
2,650	25021,0	1829	352	848	3,975	31041,0	2559	712	1171	5,300	35207,0	3165	1196	1426	578,881
2,650	25883,0	1925	228	903	3,975	31041,0	2688	542	1245	5,550	34160,0	3422	1088	1557	549,937

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_o				
			D_e	D_i	t	t'	l_o	h_o	h_o/t	s	F	σ_I	σ_{II}	σ_{III}
18 0144			150,00	61,00	6,00		10,80	4,80	0,800	1,200	19560,0	946	239	435
18 0145			150,00	61,00	6,00	5,70	10,80	4,80	0,800	1,200	20684,0	1006	174	463
19 0008			150,00	61,00	7,00	6,55	11,80	4,80	0,685	1,200	30593,0	1135	245	525
18 0146			150,00	71,00	6,00		10,85	4,85	0,808	1,212	21067,0	943	221	494
18 0147			150,00	71,00	6,00	5,60	10,85	4,85	0,808	1,212	22703,0	1023	131	544
19 0009			150,00	71,00	8,00	7,50	12,05	4,05	0,506	1,012	35885,0	983	321	510
19 0010			150,00	81,00	8,00	7,50	12,00	4,00	0,500	1,000	38230,0	982	315	572
19 0011			150,00	81,00	10,00	9,40	13,40	3,40	0,340	0,850	57601,0	950	438	544
18 0148	C		160,00	82,00	4,30		9,90	5,60	1,302	1,400	12162,0	852	-6	491
18 0149			160,00	82,00	4,30	4,15	9,90	5,60	1,302	1,400	12653,0	880	-45	510
18 0150	B		160,00	82,00	6,00		10,50	4,50	0,750	1,125	17203,0	751	197	420
18 0151			160,00	82,00	6,00	5,60	10,50	4,50	0,750	1,125	18496,0	818	125	464
19 0012	A		160,00	82,00	10,00	9,40	13,50	3,50	0,350	0,875	50547,0	857	390	469
19 0013			160,00	82,00	11,00	10,20	14,50	3,50	0,318	0,875	66678,0	943	434	515
18 0152	C		180,00	92,00	4,80		11,00	6,20	1,291	1,550	14646,0	828	-2	476
18 0153			180,00	92,00	4,80	4,60	11,00	6,20	1,291	1,550	15352,0	861	-48	498
18 0154	B		180,00	92,00	6,00		11,10	5,10	0,850	1,275	16558,0	705	144	396
18 0155			180,00	92,00	6,00	5,60	11,10	5,10	0,850	1,275	17866,0	765	76	435
19 0014	A		180,00	92,00	10,00	9,40	14,00	4,00	0,400	1,000	46850,0	796	327	437
19 0015			180,00	92,00	13,00	12,10	16,50	3,50	0,269	0,875	84574,0	849	438	460
18 0173			200,00	82,00	5,00	4,80	10,50	5,50	1,100	1,375	9700,0	600	26	290
18 0174			200,00	82,00	6,00	5,80	13,00	7,00	1,1767	1,750	22300,0	940	22	450
19 0016			200,00	82,00	8,00	7,50	14,20	6,20	0,775	1,550	35519,0	977	162	458
19 0041		*	200,00	82,00	8,50	8,10	14,50	6,00	0,706	1,500	38500,0	960	220	440
19 0017			200,00	82,00	10,00	9,40	15,50	5,50	0,550	1,375	52053,0	973	303	446
19 0018			200,00	82,00	12,00	11,25	16,60	4,60	0,383	1,150	67868,0	898	393	404
19 0042			200,00	82,00	13,00	12,10	16,50	3,50	0,269	0,875	62100,0	700	370	310
19 0019			200,00	92,00	10,00	9,40	15,60	5,60	0,560	1,400	55657,0	980	289	498
19 0020			200,00	92,00	12,00	11,25	16,80	4,80	0,400	1,200	74572,0	930	385	465
19 0021			200,00	92,00	14,00	13,05	18,10	4,10	0,292	1,025	95817,0	877	441	433
18 0156	C		200,00	102,00	5,50		12,50	7,00	1,272	1,750	19817,0	861	5	494
18 0157			200,00	102,00	5,50	5,30	12,50	7,00	1,272	1,750	20659,0	892	-37	514
19 0022	B		200,00	102,00	8,00	7,50	13,60	5,60	0,700	1,400	33367,0	845	160	475
19 0043		*	200,00	102,00	8,30	7,80	14,30	6,00	0,723	1,500	40500,0	950	170	530
19 0044		*	200,00	102,00	9,00	8,60	14,60	5,60	0,622	1,400	44100,0	890	240	500
19 0023			200,00	102,00	10,00	9,40	15,60	5,60	0,560	1,400	58756,0	983	281	546
19 0045		*	200,00	102,00	11,00	10,30	15,00	4,00	0,364	1,000	49500,0	700	300	380
19 0024	A		200,00	102,00	12,00	11,25	16,20	4,20	0,350	1,050	66983,0	792	357	432
19 0025			200,00	102,00	14,00	13,05	18,20	4,20	0,300	1,050	103986,0	904	441	491
18 0175		*	200,00	112,00	6,00	5,80	12,00	6,00	1,000	1,500	19700,0	770	50	470
19 0026			200,00	112,00	12,00	11,25	16,20	4,20	0,350	1,050	71671,0	809	359	480
19 0027			200,00	112,00	14,00	13,05	17,50	3,50	0,250	0,875	90576,0	745	397	438
19 0046		*	200,00	112,00	15,00	14,00	18,00	3,00	0,200	0,750	93500,0	660	390	390
19 0028			200,00	112,00	16,00	14,80	19,80	3,80	0,237	0,950	146464,0	927	493	545
19 0029	C		225,00	112,00	6,50	6,20	13,60	7,10	1,092	1,775	23582,0	794	15	446
19 0030	B		225,00	112,00	8,00	7,50	14,50	6,50	0,812	1,625	32870,0	812	104	450
19 0047		*	225,00	112,00	9,00	8,45	15,50	6,50	0,722	1,625	43600,0	880	160	480
19 0048		*	225,00	112,00	10,00	9,40	16,20	6,20	0,620	1,550	52800,0	880	220	480
19 0049		*	225,00	112,00	10,80	10,00	16,50	5,70	0,528	1,425	58100,0	850	240	470
19 0031	A		225,00	112,00	12,00	11,25	17,00	5,00	0,416	1,250	64497,0	772	304	415
19 0032			225,00	112,00	16,00	14,90	20,50	4,50	0,281	1,125	128407,0	864	438	458
19 0033			250,00	102,00	10,00	9,40	18,00	8,00	0,800	2,000	58157,0	1017	160	476
19 0034			250,00	102,00	12,00	11,25	19,00	7,00	0,583	1,750	75052,0	971	276	445
19 0035	C		250,00	127,00	7,00	6,70	14,80	7,80	1,114	1,950	26895,0	767	10	438
19 0050		*	250,00	127,00	7,50	7,00	16,50	9,00	1,200	2,250	41900,0	1000	53	580
19 0036			250,00	127,00	8,00	7,50	16,00	8,00	1,000	2,000	38439,0	877	30	500
19 0051		*	250,00	127,00	9,00	8,45	16,60	7,60	0,844	1,900	45900,0	880	98	500
19 0052		*	250,00	127,00	9,20	8,60	17,40	8,20	0,891	2,050	55200,0	990	80	560

Spring force F in N							Stress σ in N/mm²								Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
2,400	34161,0	1791	579	814	3,600	45456,0	2535	1020	1138	4,800	55098,0	3178	1562	1406	694,658
2,400	35204,0	1901	459	875	3,600	45456,0	2686	855	1221	5,100	55161,0	3510	1506	1569	659,925
2,400	53294,0	2156	604	986	3,600	70442,0	3062	1079	1385	5,250	89248,0	4119	1919	1830	758,335
2,425	36714,0	1782	545	926	3,637	48749,0	2518	973	1295	4,850	58978,0	3152	1503	1602	645,829
2,425	38235,0	1930	379	1017	3,637	48749,0	2721	743	1420	5,250	58662,0	3591	1408	1846	602,774
2,025	65655,0	1884	725	969	3,037	91060,0	2702	1212	1378	4,550	124679,0	3769	2094	1895	807,287
2,000	70060,0	1881	713	1088	3,000	97319,0	2697	1195	1549	4,500	133637,0	3764	2074	2136	737,000
1,700	109889,0	1839	938	1049	2,550	158300,0	2668	1498	1512	4,000	236018,0	3941	2593	2211	923,710
2,800	18832,0	1581	111	904	4,200	21843,0	2188	350	1238	5,600	23022,0	2672	712	1494	500,409
2,800	19288,0	1632	38	938	4,200	21843,0	2256	250	1284	5,750	22250,0	2797	634	1572	482,953
2,250	30431,0	1423	474	790	3,375	41008,0	2016	830	1109	4,500	50260,0	2530	1264	1377	698,246
2,250	31633,0	1547	341	870	3,375	41008,0	2186	646	1218	4,900	50562,0	2908	1203	1599	651,696
1,750	96216,0	1658	836	902	2,625	138331,0	2403	1338	1299	4,100	204958,0	3533	2310	1889	1094,000
1,750	127338,0	1827	925	994	2,625	183518,0	2655	1474	1436	4,300	284160,0	4078	2686	2179	1187,000
3,100	22731,0	1537	115	877	4,650	26442,0	2128	350	1201	6,200	27966,0	2600	703	1450	708,337
3,100	23387,0	1597	30	916	4,650	26442,0	2208	233	1255	6,400	26839,0	2747	612	1540	678,822
2,550	28552,0	1331	368	742	3,825	37502,0	1875	672	1035	5,100	44930,0	2340	1057	1278	885,421
2,550	29767,0	1440	243	812	3,825	37502,0	2024	499	1132	5,500	44355,0	2654	974	1464	826,393
2,000	88141,0	1535	712	837	3,000	125417,0	2217	1153	1201	4,600	180562,0	3188	1979	1707	1387,000
1,750	163392,0	1653	922	892	2,625	237883,0	2412	1452	1294	4,400	381593,0	3811	2664	2021	1786,000
2,750	15400,0	1130	130	530	4,125	18400,0	1570	310	730	5,700	20100,0	1980	620	910	980,000
3,500	35000,0	1750	170	830	5,250	41200,0	2440	450	1140	7,200	44200,0	3050	900	1400	1190,000
3,100	60470,0	1847	431	857	4,650	78034,0	2611	806	1198	6,700	95329,0	3458	1466	1558	1539,000
3,000	67200,0	1810	540	830	4,500	89300,0	2580	960	1170	6,400	112100,0	3400	1620	1520	1660,000
2,750	94245,0	1862	691	846	4,125	129445,0	2665	1164	1198	6,100	173523,0	3669	1993	1622	1928,000
2,300	128082,0	1735	847	774	3,450	182737,0	2512	1361	1111	5,350	266449,0	3662	2345	1594	2308,000
1,750	120000,0	1360	780	600	2,625	174800,0	1990	1220	870	4,400	280300,0	3150	2240	1360	2480,000
2,800	100501,0	1873	665	943	4,200	137688,0	2677	1130	1336	6,200	183777,0	3673	1946	1806	1828,000
2,400	140170,0	1794	836	890	3,600	199269,0	2591	1354	1276	5,550	287825,0	3747	2335	1819	2187,000
2,050	184267,0	1706	931	837	3,075	267227,0	2485	1471	1211	5,050	418519,0	3846	2649	1850	2537,000
3,500	30882,0	1599	131	910	5,250	36111,0	2216	381	1247	7,000	38423,0	2709	752	1507	1004,000
3,500	31663,0	1655	54	946	5,250	36111,0	2289	274	1296	7,200	37138,0	2845	671	1590	967,970
2,800	57955,0	1601	409	892	4,200	76378,0	2268	747	1254	6,100	96202,0	3031	1347	1654	1368,000
3,000	70000,0	1790	440	1000	4,500	91800,0	2530	810	1400	6,500	114600,0	3370	1470	1840	1420,000
2,800	78800,0	1700	570	940	4,200	107100,0	2420	980	1330	6,000	138600,0	3220	1640	1750	1570,000
2,800	106099,0	1877	651	1036	4,200	145357,0	2682	1111	1468	6,200	194014,0	3676	1923	1987	1716,000
2,000	93900,0	1350	660	730	3,000	134500,0	1950	1050	1050	4,700	198700,0	2870	1840	1530	1880,000
2,100	127401,0	1532	766	831	3,150	183020,0	2221	1227	1196	4,950	272297,0	3282	2136	1747	2053,000
2,100	199671,0	1755	935	948	3,150	289181,0	2554	1481	1371	5,150	450249,0	3931	2667	2085	2381,000
3,000	32200,0	1430	200	880	4,500	39700,0	2000	450	1210	6,200	45100,0	2530	850	1520	980,000
2,100	136317,0	1564	772	923	3,150	195830,0	2266	1238	1330	4,950	291355,0	3345	2160	1944	1904,000
1,750	175719,0	1452	832	850	2,625	256758,0	2121	1306	1236	4,450	418407,0	3394	2414	1959	2209,000
1,500	183100,0	1290	810	750	2,250	269700,0	1900	1260	1100	4,000	465200,0	3200	2400	1840	2370,000
1,900	284370,0	1808	1032	1059	2,850	415725,0	2644	1616	1542	5,000	699348,0	4368	3106	2521	2505,000
3,550	37417,0	1482	136	825	5,325	44580,0	2063	364	1137	7,400	48614,0	2608	764	1418	1455,000
3,250	55412,0	1531	301	842	4,875	70749,0	2158	591	1176	7,000	85127,0	2836	1110	1524	1761,000
3,250	75300,0	1660	410	910	4,875	98800,0	2350	760	1270	7,050	123300,0	3130	1370	1670	1980,000
3,100	93900,0	1680	520	910	4,650	126700,0	2400	910	1290	6,800	164800,0	3240	1590	1720	2200,000
2,850	105200,0	1630	560	880	4,275	144400,0	2340	960	1250	6,500	197000,0	3290	1720	1740	2350,000
2,500	120738,0	1488	666	794	3,750	171016,0	2146	1084	1137	5,750	244783,0	3080	1872	1612	2641,000
2,250	247489,0	1680	923	886	3,375	359590,0	2449	1456	1283	5,600	569897,0	3829	2651	1983	3498,000
4,000	98485,0	1922	432	889	6,000	126387,0	2713	817	1241	8,600	152967,0	3574	1487	1605	3019,000
3,500	134524,0	1854	640	842	5,250	182962,0	2648	1093	1190	7,750	242024,0	3630	1894	1603	3613,000
3,900	42527,0	1430	123	810	5,850	50466,0	1989	340	1116	8,100	54733,0	2506	718	1388	1915,000
4,500	64400,0	1860	40	1060	6,750	73500,0	2580	270	1460	9,500	75100,0	3260	740	1820	2000,000
4,000	61836,0	1641	173	928	6,000	74819,0	2292	429	1284	8,500	83455,0	2947	908	1628	2144,000
3,800	76800,0	1650	300	930	5,700	97300,0	2330	600	1290	8,150	115600,0	3040	1150	1670	2420,000
4,100	91000,0	1860	280	1050	6,150	113400,0	2620	600	1460	8,800	132000,0	3410	1200	1870	2460,000

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_o				
			D_e	D_i	t	t'	l_o	h_o	h_o/t	s	F	σ_I	σ_{II}	σ_{III}
19 0037	B		250,00	127,00	10,00	9,40	17,00	7,00	0,700	1,750	51871,0	842	163	471
19 0053		*	250,00	127,00	10,50	9,90	18,00	7,50	0,714	1,875	64800,0	950	180	530
19 0054		*	250,00	127,00	11,00	10,40	18,80	7,80	0,709	1,950	77000,0	1030	200	580
19 0038			250,00	127,00	12,00	11,25	19,30	7,30	0,608	1,825	87633,0	1011	251	563
19 0055		*	250,00	127,00	13,00	12,20	19,60	6,60	0,508	1,650	93900,0	940	300	520
19 0056		*	250,00	127,00	13,50	12,60	19,60	6,10	0,452	1,525	94200,0	880	310	480
19 0039	A		250,00	127,00	14,00	13,10	19,60	5,60	0,400	1,400	93239,0	813	328	444
19 0057		*	250,00	127,00	14,50	13,60	20,00	5,50	0,379	1,375	100400,0	820	350	440
19 0058		*	250,00	127,00	15,00	14,10	21,00	6,00	0,400	1,500	122500,0	930	380	510
19 0040			250,00	127,00	16,00	14,90	21,80	5,80	0,362	1,450	141529,0	949	406	517
19 0059		*	250,00	127,00	16,80	15,65	22,00	5,20	0,310	1,300	142800,0	870	410	470
19 0060		*	250,00	127,00	17,50	16,35	22,00	4,50	0,257	1,125	136000,0	750	400	400
19 0061		*	250,00	127,00	18,50	17,30	23,00	4,50	0,243	1,125	159700,0	790	440	420
19 0062		*	270,00	127,00	10,65	10,00	18,00	7,35	0,690	1,838	53800,0	800	160	420
19 0063		*	270,00	142,00	22,00		26,90	4,90	0,223	1,225	248700,0	780	550	430
19 0064		*	280,00	127,00	12,00	11,40	21,40	9,40	0,783	2,350	95400,0	1110	190	560
19 0065		*	280,00	127,00	19,00	18,00	25,00	6,00	0,316	1,500	178200,0	880	450	430
19 0066		*	280,00	142,00	12,00	11,30	21,00	9,00	0,750	2,250	95100,0	1060	180	590
19 0067		*	280,00	142,00	15,00	14,10	21,40	6,40	0,427	1,600	105700,0	800	310	440
19 0068		*	280,00	142,00	16,60	15,60	23,25	6,65	0,401	1,663	146600,0	910	370	490
19 0069		*	280,00	142,00	17,45	16,40	23,90	6,45	0,370	1,613	162300,0	910	400	490
19 0070		*	280,00	142,00	18,00	16,90	24,00	6,00	0,333	1,500	162600,0	860	400	460
19 0071		*	280,00	142,00	18,90	17,80	24,60	5,70	0,302	1,425	175800,0	830	420	450
19 0072		*	280,00	142,00	20,30	19,10	25,40	5,10	0,251	1,275	190600,0	780	430	420
19 0073		*	280,00	142,00	22,00	20,65	26,35	4,35	0,198	1,088	202800,0	700	430	370
19 0074		*	280,00	152,00	12,80	11,90	19,80	7,00	0,547	1,750	82100,0	820	220	480
19 0075		*	280,00	152,00	15,00	14,00	21,40	6,40	0,427	1,600	111300,0	820	300	480
19 0076		*	280,00	152,00	18,50	17,40	23,60	5,10	0,276	1,275	152700,0	730	380	420
19 0077		*	300,00	127,00	12,00	11,30	21,00	9,00	0,750	2,250	76300,0	930	170	440
19 0078		*	300,00	127,00	13,00	12,30	20,50	7,50	0,577	1,875	70900,0	770	230	360
19 0079		*	300,00	127,00	14,00	13,30	21,00	7,00	0,500	1,750	78300,0	740	270	340
19 0080		*	300,00	127,00	15,30		22,80	7,50	0,490	1,875	104600,0	800	370	370
19 0081		*	300,00	127,00	16,00	15,20	24,30	8,30	0,519	2,075	140200,0	1010	350	470
19 0082		*	300,00	127,00	17,00	16,10	23,80	6,80	0,400	1,700	128400,0	830	360	380
19 0083		*	300,00	127,00	17,40	16,45	22,65	5,25	0,302	1,313	101100,0	620	320	280
19 0084		*	300,00	152,00	8,50	8,25	16,80	8,30	0,976	2,075	31300,0	640	60	360
19 0085		*	300,00	152,00	10,00	9,40	20,00	10,00	1,000	2,500	64900,0	950	40	540
19 0086		*	300,00	152,00	12,00	11,30	21,00	9,00	0,750	2,250	82800,0	920	150	520
19 0087		*	300,00	152,00	13,00	12,20	22,00	9,00	0,692	2,250	101200,0	970	190	540
19 0088		*	300,00	152,00	14,00	13,20	22,00	8,00	0,571	2,000	102500,0	880	250	480
19 0089		*	300,00	152,00	14,50	13,60	22,00	7,50	0,517	1,875	103400,0	830	260	460
19 0090		*	300,00	152,00	15,00	14,10	23,00	8,00	0,533	2,000	123100,0	920	280	510
19 0091		*	300,00	152,00	15,50	14,60	23,50	8,00	0,516	2,000	134100,0	940	300	520
19 0092		*	300,00	152,00	16,10	15,10	23,70	7,60	0,472	1,900	139200,0	910	320	500
19 0093		*	300,00	152,00	16,50		23,00	6,50	0,394	1,625	117500,0	700	370	380
19 0094		*	300,00	152,00	17,00	16,00	24,40	7,40	0,435	1,850	155600,0	920	350	500
19 0095		*	300,00	152,00	18,00	16,80	25,00	7,00	0,389	1,750	170900,0	910	370	490
19 0096		*	300,00	152,00	18,50	17,40	25,00	6,50	0,351	1,625	167900,0	840	380	450
19 0097		*	300,00	152,00	19,50	18,30	26,20	6,70	0,344	1,675	202200,0	910	420	490
19 0098		*	300,00	152,00	20,00	18,80	25,50	5,50	0,275	1,375	173000,0	730	390	390
19 0099		*	300,00	152,00	20,50	19,30	26,50	6,00	0,293	1,500	204700,0	820	420	440
19 0100		*	300,00	182,00	12,00	11,10	18,00	6,00	0,500	1,500	54400,0	590	170	380
19 0101		*	320,00	172,00	8,10	7,60	16,30	8,20	1,012	2,050	26200,0	560	10	340
19 0102		*	320,00	172,00	9,00	8,50	19,00	10,00	1,111	2,500	47000,0	790	10	470
19 0103		*	320,00	172,00	13,00	12,20	20,00	7,00	0,538	1,750	64400,0	620	180	360
19 0104		*	320,00	172,00	15,00	14,10	21,00	6,00	0,400	1,500	77600,0	570	230	330
19 0105		*	340,00	172,00	9,20	8,65	19,40	10,20	1,109	2,550	43700,0	720	10	410
19 0106		*	340,00	172,00	9,50	8,90	20,80	11,30	1,189	2,825	57000,0	850	40	490

Spring force F in N					Stress σ in N/mm²										Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
3,500	90206,0	1595	415	886	5,250	119053,0	2260	755	1244	7,600	149964,0	3014	1350	1638	2687,000
3,750	112500,0	1800	460	1000	5,625	148100,0	2550	840	1400	8,100	185500,0	3380	1500	1840	2830,000
3,900	133900,0	1950	520	1080	5,850	176900,0	2760	940	1520	8,400	222000,0	3660	1650	1990	2970,000
3,650	156021,0	1926	599	1063	5,475	210806,0	2743	1045	1502	8,050	275879,0	3730	1839	2016	3216,000
3,300	171800,0	1800	680	990	4,950	238300,0	2580	1150	1400	7,400	325800,0	3590	1980	1930	3490,000
3,050	174400,0	1700	700	930	4,575	244700,0	2440	1150	1320	7,000	345300,0	3480	2010	1860	3600,000
2,800	175145,0	1568	715	851	4,200	248828,0	2264	1160	1221	6,500	360229,0	3281	2018	1748	3745,000
2,750	189700,0	1570	750	850	4,125	270800,0	2280	1210	1220	6,400	395600,0	3310	2090	1760	3890,000
3,000	230500,0	1790	830	970	4,500	327900,0	2580	1350	1390	6,900	472100,0	3720	2310	1980	4030,000
2,900	267853,0	1833	875	993	4,350	383017,0	2655	1408	1428	6,900	570770,0	3944	2500	2096	4260,000
2,600	273500,0	1680	880	900	3,900	395400,0	2440	1390	1310	6,350	611600,0	3740	2510	1980	4470,000
2,250	263600,0	1460	850	780	3,375	384900,0	2140	1330	1140	5,650	619500,0	3390	2410	1780	4670,000
2,250	310400,0	1530	910	820	3,375	454300,0	2240	1420	1190	5,700	739800,0	3590	2600	1890	4950,000
3,675	93700,0	1520	410	790	5,513	123900,0	2150	740	1110	8,000	156700,0	2880	1320	1460	3500,000
2,450	490700,0	1530	1130	830	3,675	728300,0	2250	1750	1210	4,900	963500,0	2930	2400	1580	7150,000
4,700	163100,0	2090	500	1060	7,050	211600,0	2950	940	1480	10,000	258300,0	3860	1650	1900	4380,000
3,000	342600,0	1710	950	830	4,500	496800,0	2490	1510	1200	7,000	741600,0	3670	2550	1740	6910,000
4,500	163400,0	2000	470	1110	6,750	212900,0	2820	880	1560	9,700	262900,0	3730	1590	2030	4060,000
3,200	197600,0	1540	680	840	4,800	279500,0	2220	1120	1200	7,300	396800,0	3160	1910	1690	5060,000
3,325	275800,0	1750	810	950	4,988	392300,0	2530	1310	1360	7,650	564800,0	3640	2260	1930	5600,000
3,225	307600,0	1760	860	950	4,838	440400,0	2540	1380	1360	7,500	645100,0	3700	2380	1960	5890,000
3,000	310600,0	1660	860	890	4,500	447900,0	2400	1370	1290	7,100	672000,0	3570	2370	1890	6070,000
2,850	338300,0	1620	890	870	4,275	491000,0	2350	1410	1250	6,800	748700,0	3540	2450	1870	6390,000
2,550	370300,0	1510	903	810	3,825	542100,0	2210	1410	1170	6,300	862700,0	3460	2510	1820	6860,000
2,175	397600,0	1360	880	720	3,263	586300,0	2000	1360	1060	5,700	996900,0	3330	2550	1740	7410,000
3,500	148000,0	1560	520	910	5,250	202500,0	2230	890	1290	7,900	273200,0	3110	1590	1780	4060,000
3,200	207500,0	1580	670	910	4,800	292700,0	2270	1100	1300	7,400	418700,0	3260	1930	1850	4770,000
2,550	295400,0	1420	800	810	3,825	430600,0	2060	1270	1170	6,200	671500,0	3170	2230	1780	5930,000
4,500	131000,0	1750	440	830	6,750	170700,0	2480	810	1170	9,700	210800,0	3280	1440	1520	5150,000
3,750	127800,0	1460	530	680	5,625	174900,0	2090	900	970	8,200	231100,0	2840	1520	1290	5600,000
3,500	144200,0	1410	600	660	5,250	201400,0	2030	980	930	7,700	273700,0	2790	1630	1260	6060,000
3,750	197000,0	1540	800	700	5,625	281200,0	2210	1290	1000	7,500	361400,0	2830	1840	1270	6970,000
4,150	257000,0	1930	790	900	6,225	357400,0	2770	1310	1270	9,100	482200,0	3790	2170	1720	6920,000
3,400	242200,0	1600	780	730	5,100	345500,0	2310	1260	1050	7,700	492600,0	3280	2100	1470	7330,000
2,625	194800,0	1200	690	550	3,938	283000,0	1750	1080	790	6,200	428200,0	2620	1840	1160	7490,000
4,150	51500,0	1200	200	670	6,225	64100,0	1680	420	930	8,550	73700,0	2130	760	1160	3400,000
5,000	104500,0	1780	190	1000	7,500	126600,0	2480	470	1390	10,600	141500,0	3180	990	1750	3880,000
4,500	142200,0	1740	410	970	6,750	185300,0	2460	760	1350	9,700	228900,0	3250	1380	1770	4660,000
4,500	176200,0	1850	480	1020	6,750	232800,0	2620	880	1440	9,800	294200,0	3500	1580	1900	5030,000
4,000	184700,0	1670	580	920	6,000	252700,0	2380	980	1300	8,800	335200,0	3250	1690	1750	5440,000
3,750	188600,0	1590	590	870	5,625	260900,0	2280	1000	1240	8,400	355300,0	3170	1730	1700	5610,000
4,000	223900,0	1770	650	970	6,000	308900,0	2530	1090	1370	8,900	417100,0	3490	1880	1870	5820,000
4,000	245200,0	1800	690	990	6,000	339900,0	2590	1150	1400	8,900	461800,0	3570	1970	1910	6020,000
3,800	257000,0	1750	710	960	5,700	359500,0	2520	1180	1360	8,600	500100,0	3550	2030	1890	6230,000
3,250	225600,0	1350	790	720	4,875	327600,0	1960	1260	1040	6,500	426400,0	2520	1770	1320	6810,000
3,700	290300,0	1760	770	960	5,550	410000,0	2540	1270	1370	8,400	578800,0	3600	2160	1920	6600,000
3,500	321700,0	1750	800	950	5,250	457700,0	2520	1300	1360	8,200	669000,0	3690	2280	1960	6930,000
3,250	319600,0	1620	820	870	4,875	459500,0	2350	1300	1250	7,600	679600,0	3440	2250	1820	7180,000
3,350	385200,0	1760	890	950	5,025	554200,0	2550	1420	1360	7,900	826600,0	3770	2480	1990	7550,000
2,750	334500,0	1420	810	760	4,125	487600,0	2070	1280	1100	6,700	761900,0	3190	2260	1680	7750,000
3,000	394700,0	1600	900	860	4,500	573800,0	2330	1410	1240	7,200	881200,0	3530	2460	1860	7960,000
3,000	99100,0	1130	390	730	4,500	136900,0	1620	660	1030	6,900	189600,0	2290	1210	1450	3890,000
4,100	42000,0	1050	100	630	6,150	50600,0	1470	260	870	8,700	56200,0	1890	570	1100	3410,000
5,000	73900,0	1470	90	880	7,500	87100,0	2050	302	1210	10,500	93500,0	2590	690	1510	3820,000
3,500	117000,0	1190	420	690	5,250	161000,0	1710	720	980	7,800	217100,0	2360	1250	1330	5480,000
3,000	146100,0	1100	510	630	4,500	207900,0	1590	820	900	6,900	299300,0	2290	1410	1280	6330,000
5,100	68600,0	1350	90	760	7,650	80700,0	1870	280	1050	10,750	86300,0	2380	640	1320	4590,000
5,650	87900,0	1590	50	900	8,475	100800,0	2200	250	1240	11,900	104000,0	2790	650	1550	4720,000

Table 6.1

Ref. Nr.	DIN Series	not stocked	Dimensions in mm							Spring deflection s in mm				
										s = 0,25 h_o				
			D_e	D_i	t	t'	l_o	h_o	h_o/t	s	F	σ_I	σ_{II}	σ_{III}
19 0107		*	340,00	172,00	10,50	9,90	22,50	12,00	1,143	3,000	78300,0	980	20	560
19 0108		*	340,00	172,00	11,00	10,40	22,40	11,40	1,036	2,850	78300,0	930	30	530
19 0109		*	340,00	172,00	11,50	10,80	22,90	11,40	0,991	2,850	87000,0	970	40	550
19 0110		*	340,00	172,00	12,50	11,80	23,00	10,50	0,840	2,625	90800,0	900	110	510
19 0111		*	340,00	172,00	13,50	12,70	23,50	10,00	0,741	2,500	101300,0	890	150	500
19 0112		*	340,00	172,00	13,70	12,90	24,30	10,60	0,774	2,650	115000,0	970	150	550
19 0113		*	340,00	172,00	14,20	13,30	24,40	10,20	0,718	2,550	118800,0	950	170	530
19 0114		*	340,00	172,00	14,60	13,70	25,10	10,50	0,719	2,625	132700,0	1010	180	560
19 0115		*	340,00	172,00	15,30	14,40	24,70	9,40	0,614	2,350	126200,0	900	220	500
19 0116		*	340,00	172,00	15,80	14,80	25,50	9,70	0,614	2,425	144000,0	960	230	530
19 0117		*	340,00	172,00	16,20	15,20	25,60	9,40	0,580	2,350	146700,0	940	250	520
19 0118		*	340,00	172,00	17,00	16,00	25,30	8,30	0,488	2,075	140300,0	820	280	450
19 0119		*	340,00	172,00	17,30	16,30	26,10	8,80	0,509	2,200	158700,0	900	290	490
19 0120		*	340,00	172,00	18,00	16,90	26,00	8,00	0,444	2,000	156400,0	820	310	450
19 0121		*	340,00	172,00	20,00	18,70	28,00	8,00	0,400	2,000	209500,0	900	360	490
19 0122		*	340,00	172,00	22,00	20,60	28,00	6,00	0,273	1,500	195500,0	690	360	370
19 0123		*	360,00	182,00	15,50	14,60	23,50	8,00	0,516	2,000	93000,0	650	210	360
19 0124		*	360,00	182,00	20,00	18,80	28,30	8,30	0,415	2,075	194800,0	830	330	450
19 0125		*	360,00	182,00	21,00	19,70	28,00	7,00	0,333	1,750	182000,0	700	330	380
19 0126		*	360,00	182,00	21,50	20,20	29,50	8,00	0,372	2,000	227700,0	840	370	460
19 0127		*	360,00	182,00	23,00	21,60	30,20	7,20	0,313	1,800	243300,0	780	380	420
19 0128		*	370,00	202,00	25,00	23,20	31,40	6,40	0,256	1,600	271200,0	710	370	410
19 0129		*	370,00	202,00	26,00	24,20	32,80	6,80	0,262	1,700	324500,0	790	410	450
19 0130		*	380,00	152,00	19,00	18,00	29,00	10,00	0,526	2,500	174600,0	920	310	410
19 0131		*	380,00	192,00	13,50	12,70	26,20	12,70	0,941	3,175	120300,0	990	70	560
19 0132		*	380,00	192,00	25,00	23,40	33,00	8,00	0,320	2,000	313100,0	860	410	460
19 0133		*	380,00	202,00	12,00	11,50	25,00	13,00	1,083	3,250	98100,0	940	20	560
19 0134		*	380,00	202,00	15,00	14,10	27,00	12,00	0,800	3,000	144400,0	990	130	580
19 0135		*	380,00	212,00	18,00	16,70	27,00	9,00	0,500	2,250	158000,0	790	240	480
19 0136		*	400,00	202,00	10,00	9,60	22,00	12,00	1,200	3,000	50100,0	680	10	390
19 0137		*	400,00	202,00	12,00	11,30	26,50	14,50	1,208	3,625	107500,0	1000	40	570
19 0138		*	400,00	202,00	14,00	13,20	27,00	13,00	0,929	3,250	122400,0	940	70	530
19 0139		*	400,00	202,00	16,00	15,10	28,00	12,00	0,750	3,000	146600,0	920	160	510
19 0140		*	400,00	202,00	19,00	17,90	30,00	11,00	0,579	2,750	198900,0	920	260	510
19 0141		*	400,00	202,00	20,30	19,10	31,10	10,80	0,532	2,700	230900,0	950	290	520
19 0142		*	400,00	202,00	21,20	19,90	31,40	10,20	0,481	2,550	240700,0	910	310	500
19 0143		*	400,00	202,00	22,50	21,20	32,50	10,00	0,444	2,500	274900,0	930	350	500
19 0144		*	400,00	202,00	30,00	28,20	37,20	7,20	0,240	1,800	422500,0	790	450	420
19 0145		*	440,00	212,00	18,50		32,00	13,50	0,730	3,375	190400,0	910	250	480
19 0146		*	440,00	252,00	25,00	23,20	33,00	8,00	0,320	2,000	257500,0	670	300	400
19 0147		*	450,00	202,00	25,50	24,00	34,10	8,60	0,337	2,150	241500,0	670	320	330
19 0148		*	450,00	252,00	21,00	19,50	33,00	12,00	0,571	3,000	251200,0	910	230	550
19 0149		*	450,00	252,00	25,00	23,30	33,80	8,80	0,352	2,200	269500,0	700	300	420
19 0150		*	470,00	237,00	33,00	31,00	42,00	9,00	0,273	2,250	516100,0	800	430	430
19 0151		*	480,00	252,00	20,30	19,00	33,00	12,70	0,626	3,175	207400,0	820	190	470
19 0152		*	480,00	252,00	20,70		36,60	15,90	0,768	3,975	285500,0	1030	260	590
19 0153		*	500,00	202,00	37,00	35,00	44,40	7,40	0,200	1,850	466200,0	630	400	270
19 0154		*	500,00	242,00	32,00	30,00	41,00	9,00	0,281	2,250	408400,0	690	360	360
19 0155		*	500,00	252,00	19,00		34,50	15,50	0,816	3,875	200100,0	860	190	480
19 0156		*	600,00	282,00	22,00		44,00	22,00	1,000	5,500	340100,0	1070	140	560
19 0157		*	600,00	282,00	24,00		46,00	22,00	0,917	5,500	413600,0	1120	200	590

*) $s_c = h_o = l_o - t$ for disc springs without contact surfaces
$s_c = h_o = l_o - t'$ for disc springs with contact surfaces

Spring force F in N					Stress σ in N/mm²										Weight
s = 0,50 ho					s = 0,75 ho					s_c*					per 1000 pcs.
s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	in kg
6,000	122200,0	1830	100	1030	9,000	142500,0	2540	350	1420	12,600	150800,0	3210	830	1780	5250,000
5,700	125400,0	1750	180	980	8,550	151000,0	2440	450	1360	12,000	167000,0	3110	940	1710	5520,000
5,700	140300,0	1810	200	1020	8,550	170400,0	2530	490	1410	12,100	191000,0	3250	1020	1790	5730,000
5,250	152500,0	1700	330	950	7,875	194000,0	2390	650	1320	11,200	231400,0	3120	1200	1700	6260,000
5,000	174300,0	1690	400	940	7,500	227600,0	2390	750	1310	10,800	282100,0	3160	1360	1720	6740,000
5,300	196200,0	1840	410	1020	7,950	253900,0	2600	780	1430	11,400	310700,0	3420	1420	1860	6840,000
5,100	205200,0	1800	440	1000	7,650	268900,0	2550	810	1400	11,100	336100,0	3410	1480	1850	7050,000
5,250	229400,0	1910	470	1060	7,875	300900,0	2700	870	1480	11,400	376100,0	3590	1570	1950	7270,000
4,700	224700,0	1700	540	940	7,050	303700,0	2430	930	1320	10,300	396100,0	3290	1630	1770	7640,000
4,850	255900,0	1830	560	1010	7,275	345200,0	2600	980	1420	10,700	450700,0	3540	1730	1910	7850,000
4,700	263200,0	1790	590	980	7,050	358400,0	2550	1020	1390	10,400	474600,0	3480	1780	1870	8060,000
4,150	258300,0	1580	630	860	6,225	360400,0	2270	1050	1230	9,300	496100,0	3160	1790	1690	8490,000
4,400	290800,0	1720	660	940	6,600	403900,0	2460	1110	1330	9,800	550500,0	3410	1900	1820	8640,000
4,000	291000,0	1580	680	860	6,000	409800,0	2280	1110	1230	9,100	577300,0	3230	1910	1720	8960,000
4,000	393500,0	1730	790	940	6,000	558900,0	2500	1280	1340	9,300	809800,0	3630	2230	1920	9920,000
3,000	377900,0	1330	760	710	4,500	550600,0	1950	1190	1030	7,400	869300,0	3020	2130	1590	10900,000
4,000	170000,0	1250	480	680	6,000	235700,0	1800	800	970	8,900	320300,0	2480	1370	1330	8680,000
4,150	365200,0	1600	730	870	6,225	518000,0	2310	1180	1240	9,400	739800,0	3310	2020	1750	11200,000
3,500	347500,0	1370	700	730	5,250	501000,0	1980	1120	1060	8,300	752700,0	2950	1960	1560	11700,000
4,000	431200,0	1630	790	880	6,000	617000,0	2350	1270	1260	9,300	902900,0	3430	2190	1810	12000,000
3,600	466700,0	1520	810	810	5,400	675700,0	2210	1290	1180	8,600	1027000,0	3320	2250	1750	12800,000
3,200	525000,0	1390	780	790	4,800	765700,0	2030	1220	1160	8,200	1252000,0	3260	2290	1840	13700,000
3,400	628000,0	1530	860	880	5,100	915500,0	2240	1350	1270	8,600	1480000,0	3550	2490	2010	14300,000
5,000	319100,0	1760	710	780	7,500	442400,0	2520	1180	1100	11,000	596100,0	3460	1960	1490	13500,000
6,350	196600,0	1850	260	1040	9,525	242400,0	2600	570	1440	13,500	277600,0	3350	1130	1840	8420,000
4,000	599300,0	1660	870	890	6,000	865600,0	2410	1380	1290	9,600	1318000,0	3640	2440	1910	15500,000
6,500	156300,0	1760	170	1040	9,750	187300,0	2450	440	1430	13,500	205700,0	3100	920	1780	7350,000
6,000	244600,0	1860	380	1080	9,000	313900,0	2630	730	1510	12,900	379900,0	3450	1360	1960	9000,000
4,500	288300,0	1520	540	910	6,750	398700,0	2180	920	1290	10,300	551200,0	3070	1650	1800	10200,000
6,000	77900,0	1260	70	710	9,000	90400,0	1750	250	980	12,400	95200,0	2190	560	1210	7050,000
7,250	165400,0	1860	50	1060	10,875	189200,0	2580	290	1450	15,200	194700,0	3250	760	1800	8300,000
6,500	200800,0	1760	260	990	9,750	248900,0	2470	560	1370	13,800	286700,0	3190	1100	1750	9700,000
6,000	252100,0	1735	410	960	9,000	328800,0	2450	770	1350	12,900	406200,0	3240	1390	1750	11100,000
5,500	357700,0	1760	600	960	8,250	488200,0	2510	1020	1360	12,100	645800,0	3420	1760	1830	13200,000
5,400	420300,0	1810	670	990	8,100	580100,0	2590	1120	1400	12,000	783300,0	3570	1930	1910	14000,000
5,100	443500,0	1750	700	950	7,650	619200,0	2510	1160	1360	11,500	857100,0	3520	2000	1880	14600,000
5,000	512000,0	1780	770	960	7,500	722000,0	2560	1270	1380	11,300	1014000,0	3610	2150	1920	15600,000
3,600	822700,0	1540	930	820	5,400	1206000,0	2250	1460	1190	9,000	1945000,0	3570	2620	1860	20700,000
6,750	338500,0	1720	600	900	10,125	458400,0	2440	1040	1270	13,500	564300,0	3060	1570	1570	17000,000
4,000	491700,0	1290	640	780	6,000	708500,0	1870	1030	1120	9,800	1094000,0	2870	1870	1700	18600,000
4,300	461200,0	1300	690	630	6,450	665000,0	1890	1090	900	10,100	991000,0	2800	1880	1320	23900,000
6,000	449800,0	1740	540	1050	9,000	610900,0	2480	940	1480	13,500	814900,0	3430	1700	2030	16700,000
4,400	511400,0	1360	650	800	6,600	733000,0	1970	1050	1160	10,500	1099000,0	2940	1870	1710	20000,000
4,500	999000,0	1560	900	830	6,750	1456000,0	2280	1410	1210	11,000	2282000,0	3520	2490	1840	31500,000
6,350	367200,0	1560	460	890	9,525	493500,0	2220	810	1250	14,000	641300,0	3010	1440	1680	19600,000
7,950	502600,0	1950	630	1110	11,925	674300,0	2760	1100	1550	15,900	823100,0	3460	1690	1930	21300,000
3,700	914900,0	1240	830	530	5,550	1350000,0	1820	1280	770	9,400	2233000,0	2950	2310	1240	45100,000
4,500	788400,0	1350	760	690	6,750	1147000,0	1960	1200	1000	11,000	1794000,0	3030	2120	1520	35400,000
7,750	348100,0	1630	480	900	11,625	461300,0	2310	870	1250	15,500	557200,0	2880	1350	1550	21900,000
11,000	564800,0	2000	420	1050	16,500	712400,0	2810	8201	1450	22,000	821500,0	3480	1360	1780	38000,000
11,000	701300,0	2110	530	1100	16,500	905000,0	2970	990	1530	22,000	1066000,0	3700	1580	1880	41500,000

Table 6.2

	Dimensions in mm							Spring deflection s in mm						
								$s = 0{,}25\ h_o$					$s = 0{,}50$ ho	
Ref. Nr.	D_e	D_i	t	t'	l_o	h_o	h_o/t	s	F	σ_I	σ_{II}	σ_{III}	s	F
171 005	8,0	4,20	0,30		0,50	0,20	0,666	0,05	33,8	593	187	337	0,100	61,0
171 006	8,0	4,20	0,40		0,60	0,20	0,500	0,05	72,2	723	317	405	0,100	136,0
171 014	10,0	5,20	0,40		0,65	0,25	0,625	0,063	61,9	618	213	347	0,125	113,0
171 015	10,0	5,20	0,50		0,70	0,20	0,400	0,05	85,1	545	286	300	0,100	163,3
171 016	12,0	4,20	0,40		0,80	0,40	1,000	0,10	78,6	864	138	355	0,200	130,4
171 017	12,0	4,20	0,50		0,80	0,30	0,600	0,075	85,9	674	265	265	0,150	157,7
171 024	12,5	6,20	0,50		0,85	0,35	0,700	0,088	110,8	715	213	387	0,175	198,4
171 025	12,5	6,20	0,70		0,95	0,25	0,357	0,063	178,0	592	336	310	0,125	344,3
171 027	14,0	7,20	0,50		0,90	0,40	0,800	0,10	110,8	687	160	387	0,200	193,5
171 028	14,0	7,20	0,80		1,10	0,30	0,375	0,075	261,8	656	360	356	0,150	504,7
171 037	15,0	8,20	0,80		1,20	0,40	0,500	0,10	338,3	830	361	482	0,200	635,8
171 039	16,0	8,20	0,60		1,05	0,45	0,750	0,113	158,7	693	182	388	0,225	280,7
171 220	16,0	8,20	0,80		1,20	0,40	0,500	0,10	284,2	720	317	395	0,200	534,1
171 040	16,0	8,20	0,90		1,25	0,35	0,388	0,088	334,4	665	356	360	0,175	642,9
171 050	18,0	9,20	0,70		1,20	0,50	0,714	0,125	215,3	697	199	388	0,250	384,3
171 051	18,0	9,20	1,00		1,40	0,40	0,400	0,10	415,7	671	353	363	0,200	797,5
171 052	20,0	8,20	0,50		1,15	0,65	1,300	0,163	118,4	682	10,2	327	0,325	183,4
171 056	20,0	8,20	0,90		1,50	0,60	0,667	0,15	390,4	861	289	394	0,300	705,2
170 159	20,0	10,20	0,60		1,20	0,60	1,000	0,15	163,3	663	83	375	0,300	271,1
171 060	20,0	10,20	0,80		1,35	0,55	0,687	0,138	280,7	700	212	388	0,275	504,4
170 158	20,0	10,20	0,90		1,40	0,50	0,555	0,125	333,5	668	265	366	0,250	618,8
171 062	20,0	10,20	1,00		1,55	0,55	0,550	0,138	501,5	814	326	446	0,275	931,7
171 063	20,0	10,20	1,10		1,55	0,45	0,409	0,113	506,0	676	350	366	0,225	969,0
171 065	22,5	11,20	0,80		1,45	0,65	0,812	0,163	282,6	693	158	380	0,325	492,0
181 001	22,5	11,20	1,25		1,75	0,50	0,400	0,125	639,3	670	353	354	0,250	1227,0
171 072	25,0	12,20	0,70		1,60	0,90	1,285	0,225	305,5	832	3,5	460	0,450	474,7
171 073	25,0	12,20	0,90		1,60	0,70	0,777	0,175	338,4	668	167	359	0,350	594,3
181 004	25,0	12,20	1,50		2,00	0,50	0,333	0,125	859,4	625	369	322	0,250	1669,0
171 074	28,0	10,20	0,80		1,75	0,95	1,187	0,238	320,9	802	57	346	0,475	509,6
181 005	28,0	10,20	1,25		2,05	0,80	0,640	0,200	679,3	830	301	340	0,400	1235,0
171 078	28,0	14,20	1,00		1,80	0,80	0,800	0,200	439,4	685	160	382	0,400	767,4
181 010	28,0	14,20	1,50		2,15	0,65	0,433	0,163	953,1	689	342	372	0,325	1817,0
181 011	31,5	16,30	1,25		2,15	0,90	0,720	0,225	729,1	735	207	414	0,450	1300,0
181 013	31,5	16,30	1,75		2,45	0,70	0,400	0,175	1283,0	672	353	368	0,350	2462,0
181 021	35,5	18,30	1,25		2,25	1,00	0,800	0,250	674,2	668	155	377	0,500	1178,0
181 031	40,0	20,40	1,50		2,65	1,15	0,768	0,288	1023,0	714	181	398	0,575	1802,0
181 036	45,0	22,40	1,75		3,05	1,30	0,742	0,325	1406,0	733	198	400	0,650	2491,0

*) $s_c = h_o = l_o - t$ for disc springs without contact surfaces
$s_c = h_o = l_o - t'$ for disc springs with contact surfaces

Spring force F in N			Stress in N/mm²											Weight
			s = 0,75 h_0					s_c*						per 1000 pcs.
σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}	s	F	σ_I	σ_{II}	σ_{III}		in kg
1128	431	636	0,150	83,9	1605	734	897	0,20	105,0	2023	1095	1121		0,087
1388	691	722	0,150	193,0	1994	1124	1102	0,20	248,0	2543	1615	1393		0,115
1178	483	656	0,188	156,9	1680	812	928	0,25	197,2	2124	1198	1163		0,181
1053	608	576	0,150	237,0	1524	968	827	0,20	308,1	1957	1365	1055		0,226
1624	379	659	0,300	164,5	2280	725	911	0,40	189,7	2832	1174	1112		0,313
1289	589	502	0,225	220,1	1846	971	710	0,30	277,9	2344	1411	888		0,390
1359	497	730	0,263	270,7	1930	854	1027	0,35	335,2	2430	1282	1280		0,365
1148	708	598	0,188	502,6	1667	1117	862	0,25	657,1	2149	1563	1104		0,511
1299	395	725	0,300	257,5	1835	705	1016	0,40	312,1	2296	1091	1258		0,445
1270	762	686	0,225	735,0	1842	1206	988	0,30	958,9	2371	1693	1263		0,715
1593	789	920	0,300	906,0	2289	1284	1312	0,40	1162,6	2918	1846	1660		0,783
1313	437	729	0,338	378,2	1859	765	1023	0,45	463,6	2333	1166	1270		0,702
1383	691	753	0,300	761,2	1988	1123	1074	0,40	976,7	2535	1613	1358		0,940
1286	756	693	0,263	934,2	1862	1200	997	0,35	1217,0	2395	1688	1272		1,060
1323	469	731	0,375	522,4	1877	811	1028	0,50	645,2	2361	1223	1279		1,040
1297	751	698	0,300	1157,0	1877	1195	1003	0,40	1505,0	2412	1684	1279		1,485
1268	116	601	0,488	212,9	1758	318	822	0,65	224,6	2152	617	991		1,030
1641	659	742	0,450	969,6	2339	1112	1045	0,60	1209,0	2954	1646	1304		1,858
1244	249	698	0,450	342,0	1741	498	968	0,60	394,4	2156	830	1184		1,101
1330	494	732	0,413	690,1	1891	846	1031	0,55	856,9	2382	1267	1286		1,470
1278	588	696	0,375	872,0	1831	968	989	0,50	1109,0	2326	1405	1245		1,650
1558	722	848	0,413	1315,0	2233	1188	1206	0,55	1674,0	2838	1723	1519		1,840
1306	746	702	0,338	1403,0	1889	1190	1008	0,45	1823,0	2426	1679	1285		2,020
1310	392	712	0,488	653,0	1850	703	995	0,65	789,0	2314	1090	1231		1,890
1294	751	680	0,375	1779,0	1874	1195	977	0,50	2314,0	2408	1684	1245		2,950
1545	125	847	0,675	553,1	2140	365	1161	0,90	586,1	2617	724	1401		2,070
1265	406	674	0,525	795,3	1790	716	944	0,70	968,9	2243	1098	1170		2,660
1213	775	621	0,375	2445,0	1765	1218	897	0,50	3204,0	2281	1696	1151		4,430
1498	221	638	0,713	610,2	2088	491	876	0,95	666,7	2571	867	1060		3,480
1584	678	642	0,600	1709,0	2263	1130	906	0,80	2142,0	2866	1658	1131		5,270
1296	395	715	0,600	1021,0	1832	706	1001	0,80	1238,0	2293	1091	1240		3,610
1328	734	712	0,488	2620,0	1918	1175	1021	0,65	3394,0	2459	1665	1298		5,420
1394	488	779	0,675	1764,0	1978	846	1095	0,90	2176,0	2486	1279	1363		5,630
1299	751	707	0,525	3571,0	1880	1195	1016	0,70	4645,0	2415	1685	1296		7,890
1263	383	707	0,750	1567,0	1784	685	990	1,00	1899,0	2233	1060	1225		7,180
1351	437	747	0,863	2418,0	1912	770	1048	1,15	2953,0	2397	1179	1300		11,020
1390	472	751	0,975	3363,0	1970	823	1055	1,30	4128,0	2473	1250	1311		16,540

Table 6.2

	Dimensions in mm							Spring deflection s in mm						
								s = 0,25 h_o					s = 0,50 ho	
Ref.Nr.	D_e	D_i	t	t'	l_o	h_o	h_o/t	s	F	σ_I	σ_{II}	σ_{III}	s	F
180 880	31,5	16,30	1,25		2,00	0,75	0,600	0,188	590,0	606	220	338	0,375	1083,0
180 881	31,5	16,30	1,75		2,30	0,55	0,314	0,138	1023,0	528	320	286	0,275	1992,0
180 882	35,5	18,30	2,00		2,65	0,65	0,325	0,163	1423,0	565	337	306	0,325	2767,0
180 883	40,0	20,40	1,50		2,45	0,95	0,633	0,238	810,8	580	197	320	0,475	1477,0
180 884	40,0	20,40	2,00		2,80	0,80	0,400	0,200	1416,0	572	301	309	0,400	2716,0
180 885	40,0	20,40	2,25		2,95	0,70	0,311	0,175	1698,0	534	326	285	0,350	3308,0
180 886	45,0	22,40	1,75		2,80	1,05	0,600	0,263	1085,0	579	212	312	0,525	1992,0
180 887	45,0	22,40	2,50		3,30	0,80	0,320	0,200	2080,0	537	324	281	0,400	4048,0
180 888	50,0	25,40	1,50		3,10	1,60	1,066	0,400	1206,0	766	72	434	0,800	1969,0
180 889	50,0	25,40	2,00		3,15	1,15	0,575	0,288	1431,0	581	222	318	0,575	2643,0
180 890	50,0	25,40	2,50		3,50	1,00	0,400	0,250	2207,0	572	301	308	0,500	4234,0
180 891	50,0	25,40	3,00		3,85	0,85	0,283	0,213	3088,0	543	347	288	0,425	6043,0
180 892	56,0	28,50	2,00		3,40	1,40	0,700	0,350	1510,0	602	178	333	0,700	2705,0
180 893	56,0	28,50	3,00		4,05	1,05	0,350	0,263	3124,0	558	319	299	0,525	6050,0
180 894	63,0	31,00	2,50		3,95	1,45	0,580	0,363	2186,0	577	220	307	0,725	4033,0
180 895	71,0	36,00	2,50		4,25	1,75	0,700	0,438	2288,0	585	173	323	0,875	4099,0
180 896	80,0	41,00	3,00		4,90	1,90	0,633	0,475	3253,0	581	197	322	0,950	5925,0

*) $s_c = h_o = l_o - t$ for disc springs without contact surfaces
$s_c = h_o = l_o - t'$ for disc springs with contact surfaces

Spring force F in N			Stress in N/mm²											Weight
			$s = 0{,}75\ h_0$					s_c*						per 1000 pcs.
σI	σII	σIII	s	F	σI	σII	σIII	s	F	σI	σII	σIII		in kg
1157	495	641	0,563	1512,0	1652	825	907	0,75	1909,0	2093	1210	1139		5,630
1026	670	553	0,413	2926,0	1494	1049	801	0,55	3841,0	1933	1458	1030		7,89
1097	706	590	0,488	4058,0	1596	1107	854	0,65	5322,0	2063	1542	1097		11,480
1106	449	606	0,713	2046,0	1576	756	856	0,95	2568,0	1992	1117	1072		11,020
1106	640	594	0,600	3940,0	1600	1019	853	0,80	5125,0	2056	1436	1088		14,680
1037	681	552	0,525	4861,0	1512	1066	799	0,70	6385,0	1956	1481	1028		16,530
1106	476	592	0,788	2780,0	1581	793	838	1,05	3510,0	2003	1163	1051		16,540
1044	678	544	0,600	5940,0	1521	1063	787	0,80	7796,0	1967	1479	1011		23,630
1433	243	804	1,200	2439,0	2001	513	1112	1,60	2761,0	2469	882	1356		17,260
1110	495	604	0,863	3710,0	1589	820	856	1,15	4704,0	2016	1196	1077		23,020
1105	640	591	0,750	6141,0	1600	1018	850	1,00	7989,0	2055	1435	1084		28,770
1058	722	559	0,638	8910,0	1545	1125	812	0,85	11734,0	2004	1556	1047		34,520
1143	416	628	1,050	3690,0	1623	715	884	1,40	4570,0	2043	1074	1102		28,840
1081	672	576	0,788	8842,0	1571	1060	832	1,05	11568,0	2026	1481	1066		43,250
1102	491	582	1,088	5654,0	1577	812	826	1,45	7162,0	2001	1185	1038		46,660
1110	404	608	1,313	5592,0	1577	695	856	1,75	6925,0	1985	1044	1067		58,090
1106	449	609	1,425	8210,0	1577	756	861	1,90	10301,0	1993	1117	1078		87,840

Table 6.3

	Dimensions in mm						Spring deflection s in mm	Spring force F in N				
							$s = 0{,}25\ h_o$		$s = 0{,}50\ h_o$		$s = 0{,}75\ h_o$	
Ref. Nr.	D_e	D_i	t	l_o	h_o	h_o/t	s	F	s	F	s	F
200 001	9,8	6,2	0,2	0,4	0,2	1,000	0,050	11	0,1	18,3	0,150	23,1
200 002	12,8	7,2	0,25	0,5	0,25	1,000	0,062	13,9	0,125	23,2	0,187	29,3
200 003	15,8	8,2	0,25	0,55	0,3	1,200	0,075	12,1	0,150	19,2	0,225	23
200 004	18,8	9,2	0,3	0,65	0,35	1,166	0,087	16,3	0,175	26	0,262	31,3
200 005	18,8	10,2	0,35	0,7	0,35	1,000	0,087	24,2	0,175	40,1	0,262	50,6
200 006	21,8	12,3	0,35	0,75	0,4	1,142	0,100	23,8	0,200	38,2	0,300	46,3
200 007	23,7	14,3	0,4	0,9	0,5	1,250	0,125	43,7	0,250	68,4	0,375	80,6
200 008	25,7	14,3	0,4	0,9	0,5	1,250	0,125	34,4	0,250	53,9	0,375	63,4
200 009	27,7	17,3	0,4	1,0	0,6	1,500	0,150	48,8	0,300	72,7	0,450	80
200 010	29,7	17,4	0,4	1,1	0,7	1,750	0,175	56,2	0,350	80,2	0,525	82,8
200 011	31,7	20,4	0,4	1,1	0,7	1,750	0,175	54,9	0,350	78,5	0,525	81
200 012	34,6	20,4	0,4	1,1	0,7	1,750	0,175	41,6	0,350	59,5	0,525	61,4
200 013	34,6	22,4	0,5	1,2	0,7	1,400	0,175	69	0,350	104,7	0,525	118,3
200 014	36,6	20,4	0,5	1,3	0,8	1,600	0,200	70,3	0,400	102,8	0,600	110,2
200 015	39,6	25,5	0,5	1,3	0,8	1,600	0,200	70,1	0,400	102,5	0,600	109,8
200 016	41,6	25,5	0,5	1,4	0,9	1,800	0,225	78,3	0,450	111	0,675	113,30
200 017	46,5	30,5	0,6	1,5	0,9	1,500	0,225	93,7	0,450	139,5	0,675	153,4
200 018	51,5	35,5	0,6	1,5	0,9	1,500	0,225	82,7	0,450	123,2	0,675	135,4
200 019	54,5	40,5	0,6	1,5	0,9	1,500	0,225	86,3	0,450	128,5	0,675	141,3
200 020	61,5	40,5	0,7	1,8	1,1	1,571	0,275	110,6	0,550	162,7	0,825	175,6
200 021	67,5	50,5	0,7	1,7	1,0	1,428	0,250	95,3	0,500	143,9	0,750	161,2
200 022	71,5	45,5	0,7	2,1	1,4	2,000	0,350	137,4	0,700	189,6	1,050	184,8
200 023	71,5	50,5	0,7	2,1	1,4	2,000	0,350	162,3	0,700	223,9	1,050	218,3
200 024	74,5	55,5	0,8	1,9	1,1	1,375	0,275	121,8	0,550	185,8	0,825	211,2
200 025	79,5	60,5	0,8	2,3	1,5	1,875	0,375	161,8	0,750	226,9	1,125	227,5
200 026	79,5	55,5	0,8	2,3	1,5	1,875	0,375	187,4	0,750	262,7	1,125	263,4
200 027	84,5	60,5	0,9	2,5	1,6	1,777	0,400	246	0,800	349,8	1,200	358,7
200 028	89,5	60,5	0,9	2,5	1,6	1,777	0,400	197,3	0,800	280,6	1,200	287,7
200 029	89,5	65,5	0,9	2,5	1,6	1,777	0,400	229,9	0,800	326,9	1,200	335,2
200 030	94,5	75,5	1,0	2,2	1,2	1,200	0,300	171,8	0,600	272,1	0,900	324,7
200 031	99	65,5	1,0	2,6	1,6	1,600	0,400	186,5	0,800	272,8	1,200	292,3
200 032	99	70,5	1,0	2,6	1,6	1,600	0,400	212	0,800	310,1	1,200	332,2
200 033	109	70,5	1,25	2,7	1,45	1,160	0,362	185,2	0,725	296	1,087	357,1
200 034	109	75,5	1,25	2,7	1,45	1,160	0,362	206,3	0,725	329,7	1,087	397,9
200 035	114	90,5	1,25	2,45	1,2	0,960	0,300	186,1	0,600	312,2	0,900	398,1
200 036	119	75,5	1,25	2,8	1,55	1,240	0,387	172,7	0,775	271,1	1,169	319,9
200 037	119	85,5	1,25	2,8	1,55	1,240	0,387	211,9	0,775	332,7	1,162	392,5
200 038	124	90,5	1,25	3,0	1,75	1,400	0,437	259,4	0,875	393,8	1,312	444,7
200 039	129	85,5	1,25	3,2	1,95	1,560	0,487	254,1	0,975	374,2	1,462	405,1
200 040	129	95,5	1,25	3,2	1,95	1,560	0,487	313,6	0,975	461,9	1,462	500
200 041	139	90,5	1,25	3,25	2,0	1,600	0,500	225,6	1,000	330	1,500	353,6
200 042	139	101	1,25	3,25	2,0	1,600	0,500	273,9	1,000	400,7	1,500	429,3
200 043	149	95,5	1,5	3,2	1,7	1,133	0,425	194,1	0,850	312,1	1,275	379,4
200 044	149	106	1,5	3,2	1,7	1,133	0,425	230,3	0,850	370,4	1,275	450,2
200 045	159	101	1,5	3,5	2,0	1,333	0,500	233	1,000	358,5	1,500	412,2
200 046	159	111	1,5	3,5	2,0	1,333	0,500	269,8	1,000	415	1,500	477,3
200 047	169	111	1,5	3,8	2,3	1,533	0,575	291,5	1,150	431,4	1,725	470,2
200 048	169	121	1,5	3,8	2,3	1,533	0,575	338,6	1,150	501,1	1,725	546,2
200 049	179	121	2,0	4,2	2,2	1,100	0,550	434,5	1,100	704,2	1,650	864
200 050	179	126	2,0	4,2	2,2	1,100	0,550	466,8	1,100	756,5	1,650	928,2
200 051	189	121	2,0	4,3	2,3	1,150	0,575	391,5	1,150	627,2	1,725	758,8
200 052	189	131	2,0	4,3	2,3	1,150	0,575	442,8	1,150	709,4	1,725	858,3
200 053	198	131	2,0	4,5	2,5	1,250	0,625	440,5	1,250	689,9	1,875	811,8
200 054	198	141	2,0	4,5	2,5	1,250	0,625	500,7	1,250	784,2	1,875	922,8
200 055	213	151	2,25	4,5	2,25	1,000	0,562	449,3	1,125	746,1	1,687	941,1

Stress σ in N/mm²					Weight	Bearings							
s = ho					per 1000 pcs.	Dimensions				Bearing Ref. Nr.			
s	F	σ_I	σ_{II}	σ_{III}	in kg	d_e	d_i						
0,2	26,7	1182	435	787	0,071	10	3			623		
0,25	33,7	1014	382	608	0,173	13	4			624		
0,3	25	830	252	468	0,281	16	5	4		625	634	
0,35	34,4	808	259	432	0,497	19	6	5		626	635	
0,35	58,4	911	346	529	0,538	19	7			607		
0,4	51,2	819	260	495	0,699	22	8	7		608	627	
0,5	86,3	1055	287	679	0,881	24	9			609		
0,5	68	864	241	518	1,124	26	10	9		6000	629	
0,6	78,9	1018	186	680	1,154	28	12			6001		
0,7	74,7	1060	119	674	1,429	30		10			6200	
0,7	73	993	104	684	1,452	32	15	12		6002	6201	
0,7	55,3	783	88	501	1,926	35			10			6300
0,7	120,8	953	203	655	2,144	35	17	15		6003	6202	
0,8	104,9	939	151	570	2,846	37			12			6301
0,8	104,6	874	130	601	2,830	40		17			6203	
0,9	100,3	903	86	598	3,331	42	20		15	6004		6302
0,9	151,3	848	151	591	4,557	47	25	20	17	6005	6204	6303
0,9	133,6	732	127	532	5,149	52		25	20		6205	6304
0,9	139,4	738	124	572	4,920	55	30			6006		
1,1	168,9	708	110	495	9,244	62	35	30	25	6007	6206	6305
1,0	163	619	118	482	8,657	68	40			6008		
1,4	151,7	720	28	494	13,128	72			30			6306
1,4	179,1	811	24	607	11,057	72		35			6207	
1,1	217,4	624	131	484	12,182	75	45			6009		
1,5	195,8	690	49	472	18,594	80			35			6307
1,5	226,6	766	48	566	15,980	80	50	40		6010	6208	
1,6	320,1	824	72	622	19,309	85		45			6209	
1,6	256,8	679	63	488	24,137	90			40			6308
1,6	299,2	763	65	586	20,641	90	55	50		6011	6210	
1,2	353,4	597	160	491	19,914	95	60			6012		
1,6	278,4	574	84	404	33,975	100			45			6309
1,6	316,4	631	88	473	29,782	100	65	55		6013	6211	
1,45	393,4	464	139	316	53,285	110			50			6310
1,45	438,3	500	147	362	47,632	110	70	60		6014	6212	
1,2	464	466	172	380	37,035	115	75			6015		
1,55	343,9	419	114	281	65,203	120			55			6311
1,55	422	485	127	363	52,795	120		65			6213	
1,75	454	542	110	413	55,377	125	80	70		6016	6214	
1,95	391,3	511	81	360	71,907	130			60			6312
1,95	483	600	89	464	57,959	130	85	75		6017	6215	
2,0	336,8	448	66	311	85,779	140			65			6313
2,0	408,8	517	71	394	70,283	140	90	80		6018	6216	
1,7	421,3	343	107	232	120,968	150			70			6314
1,7	499,9	388	118	288	101,402	150	100	85		6020	6217	
2,0	430,2	374	89	252	139,457	160			75			6315
2,0	498,1	414	95	303	119,851	160	105	90		6021	6218	
2,3	458,5	414	69	289	150,184	170			80			6316
2,3	532,7	463	74	348	128,729	170	110	95		6022	6219	
2,2	968,8	429	138	304	214,549	180			85			6317
2,2	1041	452	144	332	199,321	180	120	100		6024	6220	
2,3	838,5	387	118	261	259,925	190			90			6318
2,3	948,4	421	126	305	228,852	190		105			6221	
2,5	870	407	107	284	271,799	200			95			6319
2,5	988,9	447	115	332	238,260	200	130	110		6026	6222	
2,25	1085,3	360	129	265	313,056	215		120	100		6224	6320

Table 6.3

	Dimensions in mm						Spring deflection s in mm Spring force F in N					
							s = 0,25 h_o		s = 0,50 ho		s = 0,75 h_o	
Ref. Nr.	D_e	D_i	t	l_o	h_o	h_o/t	s	F	s	F	s	F
200 056	223	161	2,25	4,6	2,35	1,040	0,587	460,5	1,175	756,4	1,762	942,4
200 057	228	161	2,25	4,95	2,7	1,200	0,675	548,4	1,350	868,4	2,025	1036,2
200 058	238	161	2,25	5,25	3,0	1,330	0,750	577	1,500	887,8	2,250	1020,9
200 059	248	171	2,5	5,0	2,5	1,000	0,625	479,7	1,250	796,5	1,875	1004,7
200 060	258	171	2,5	5,5	3,0	1,200	0,750	585,5	1,500	927,2	2,250	1106,4
200 061	268	181	2,5	5,7	3,2	1,280	0,800	636,1	1,600	989,7	2,400	1155
200 062	278	181	2,5	6,0	3,5	1,400	0,875	673,8	1,750	1022,7	2,625	1154,9
200 063	288	191	2,75	5,75	3,0	1,090	0,750	573,2	1,500	931	2,250	1145,2
200 064	298	191	2,75	6,35	3,6	1,310	0,900	730,1	1,800	1128,9	2,700	1306,9
200 065	308	202	3,0	6,1	3,1	1,030	0,775	631,5	1,550	1040,1	2,325	1299,9
200 066	318	212	3,0	6,2	3,2	1,070	0,800	643,7	1,600	1051,5	2,400	1302,1
200 067	338	232	3,0	6,6	3,6	1,200	0,900	748,7	1,800	1185,6	2,700	1414,6
200 068	358	242	3,0	7,2	4,2	1,400	1,050	892	2,100	1353,8	3,150	1528,9

Stress σ in N/mm²					Weight	Bearings						
s = ho					per 1000 pcs.	Dimensions				Bearing Ref. Nr.		
s	F	σ_I	σ_{II}	σ_{III}	in kg	d_e	d_i					
2,35	1073,6	358	121	268	330,257	225	150		105	6030		6321
2,7	1127,9	398	111	294	361,538	230		130			6226	
3,0	1065,3	399	93	284	426,180	240			110			6322
2,5	1158,5	315	114	226	497,270	250		140			6228	
3,0	1204,2	355	100	248	575,259	260			120			6324
3,2	1226,1	367	92	261	602,078	270		150			6230	
3,5	1178,9	371	79	256	686,233	280			130			6326
3,0	1287,5	303	99	211	787,747	290		160			6232	
3,6	1374,5	351	86	239	887,100	300			140			6328
3,1	1485,4	290	102	200	999,872	310		170			6234	
3,2	1474,1	289	97	202	1039,083	320		180	150		6236	6330
3,6	1539,7	310	87	223	1117,504	340		190	160		6238	6332
4,2	1560,6	335	70	239	1287,294	360		200			6240	

6.3 Explanation of disc spring diagrams

All graphs are based upon a modulus of elasticity of $E = 2{,}06 \times 10^5$ N/mm² and a POISSON ratio of $\mu = 0{,}3$. For simplifying the selection of the proper disc spring, load deflection curves are provided for all standard disc springs. The goal is to provide information to simplify the selection of the proper disc spring. In addition to the dimensioned cross-sectioned drawing of the disc spring, each diagram has a table with pertinent data and specifications for parallel spring stacks.

The following information is plotted on the diagram:

| the theoretical characteristic load curve F(s),

| the calculated spring work, W(s), due to elastic deformation of the material, and

| the fatigue strength specifications based upon varying numbers of load cycles.

The fatigue strength specifications apply to spring stacks with up to 10 individual disc springs stacked in series, a sinusoidal compression - time curve, and a survival probability of $P_Ü = 99$ %. Disc springs should not be loaded beyond $s_2 = 0{,}8 \cdot h_O$ for dynamic applications. Therefore this value is specified as the upper deflection limit , even if higher deflections are theoretically permissible. A lower limit of $s_1 = 0{,}15 \cdot h_O$ is specified as the minimum deflection for fatigue strength calculations.

Some springs have a curved line at $N = 10^5$, $5 \cdot 10^5$ or $2 \cdot 10^6$ load cycles. This is due to the fact that the cross-sectional point that is decicive for the fatigue strength changes depending upon the spring deflection.

Experience shows that the calculated spring characteristic load curve F(s) deviates from the measured characteristic load curve. If the measurement is taken between two flat plates, higher forces are typically measured for compressions $s_2 > 0{,}8 \cdot h_O$. This deviation is lower for disc springs with contact surfaces, as they have not yet reached the flat condition for the deflection $S = h_O$ due to their higher cone angle.

Example for use of spring diagrams:

A disc spring stack consisting of 10 springs of the size 100 x 51 x 5.0 is arranged in series and assembled on a guide rod. The stack is subjected to a maximum load of $F_2 = 29{,}1$ kN and the stroke length is to be maximised. The following items are to be determined:

1) the deflections s_1 and s_2 of the individual spring as well as the deflection for the entire stack

2) the spring force, F_1

3) the allowable number of load cycles, N

For item 1) The maximum deflection, ho = 2,8 mm, is taken from the upper table of the diagram for the disc spring of the size 100 x 51 x 5.

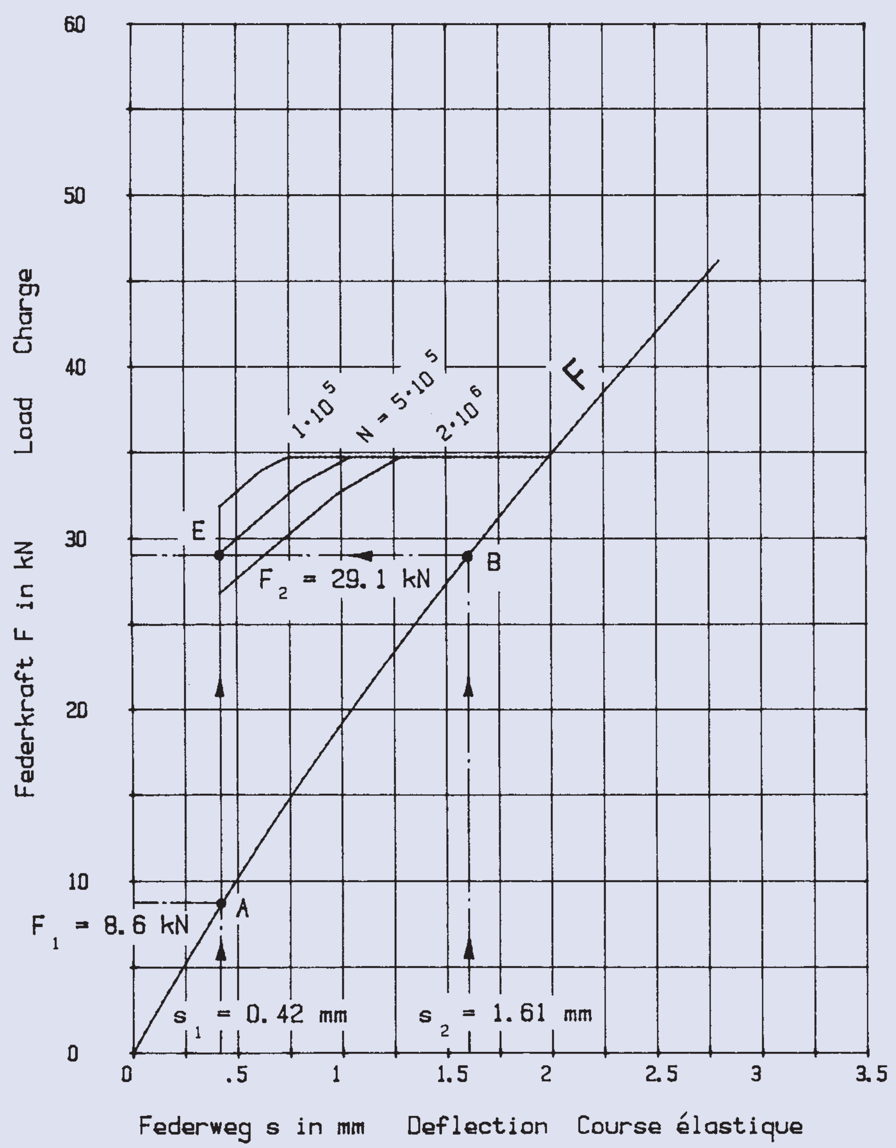
The minimum preload deflection $s_u = s_1 = 0{,}15\ h_O = 0{,}15 \cdot 2{,}8$mm = 0,42 mm.

The maximum deflection for $F_2 = 29{,}1$ kN is found on the x-axis below Point B; $s_2 = 1{,}61$ mm.

The deflection for the entire stack is $(s_2\text{-}s_1) \cdot 10 = 11{,}9$ mm.

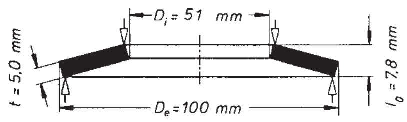
For item 2) From the diagram, the value $F_1 = 8{,}6$ kN (Point A) is obtained for $s_1 = 0{,}42$ mm.

For item 3) From the diagram, the point of intersection, E, is obtained by drawing a vertical line through point A and the horizontal line through point B, the value $N \approx 5 \cdot 10^5$, is obtained. In other words, the disc spring will sustain $5 \cdot 10^5$ load cycles without failure with a 99 %

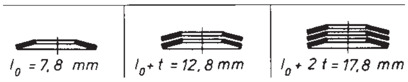


100 x 51 x 5,0

GR 2



h_0 = 2,8 mm	D_e/D_i = 1,96
t = 5,0 mm	D_e/t = 20
h_0/t = 0,56	m = 228,081 g

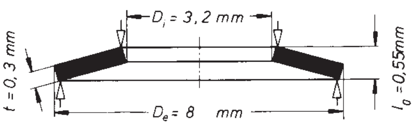


probability. It can also be shown from the diagram that a preload deflection of s_1 = 0,64 mm = 0,23 · h_0 is required to achieve the fatigue life of N = 2 · 10^6 load cycles while maintaining a deflection of s_2 = 1,61 mm.

Diagramme | Diagrams | Diagrammes

8 x 3,2 x 0,3

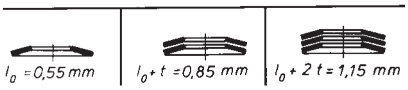
GR 1

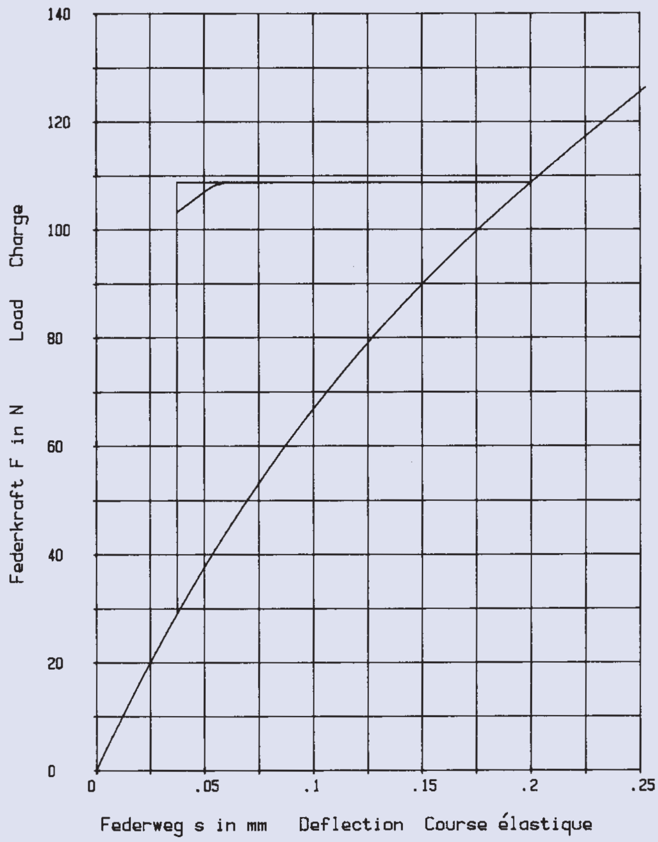


h_0 = 0,25mm D_e/D_i = 2,5

t = 0,3 mm D_e/t = 26,666

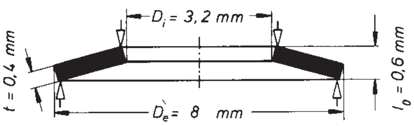
h_0/t = 0,833   m = 0,099 g





8 x 3,2 x 0,4

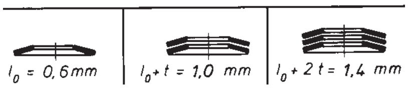
GR 1

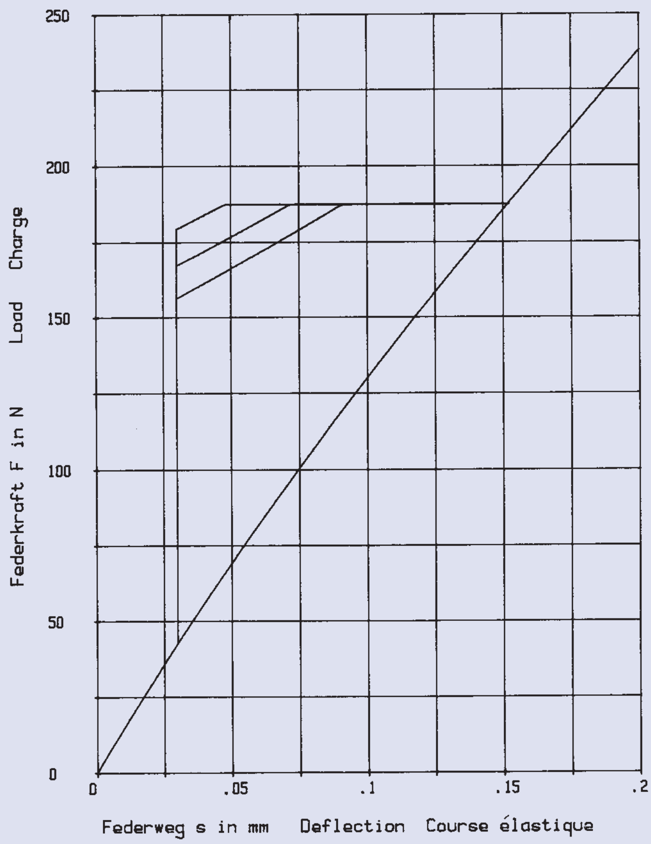


h_0 = 0,2mm D_e/D_i = 2,5

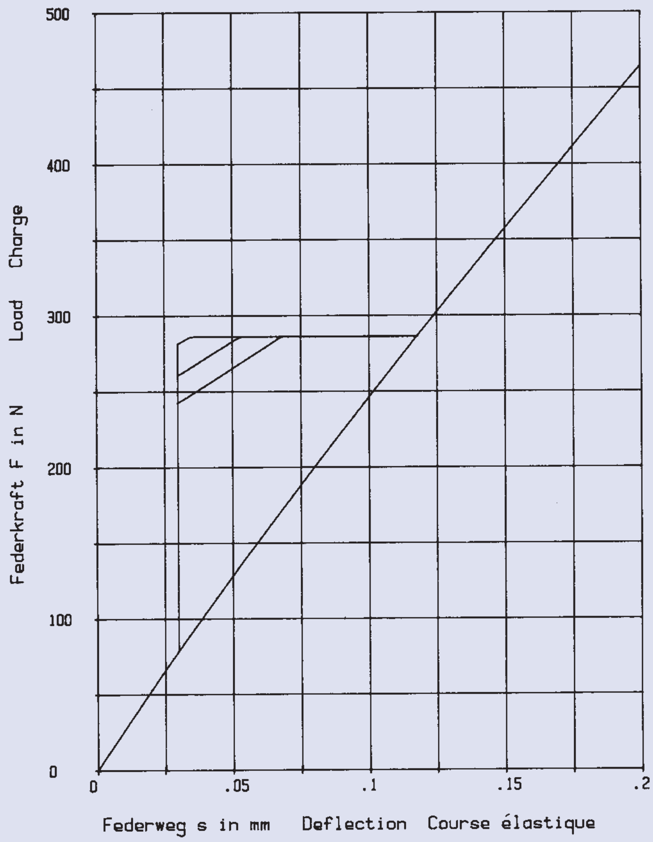
t = 0,4 mm D_e/t = 20

h_0/t = 0,5   m = 0,133 g

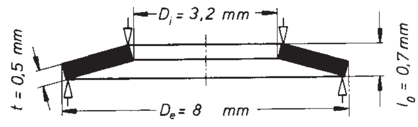




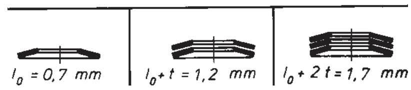
8 x 3,2 x 0,5



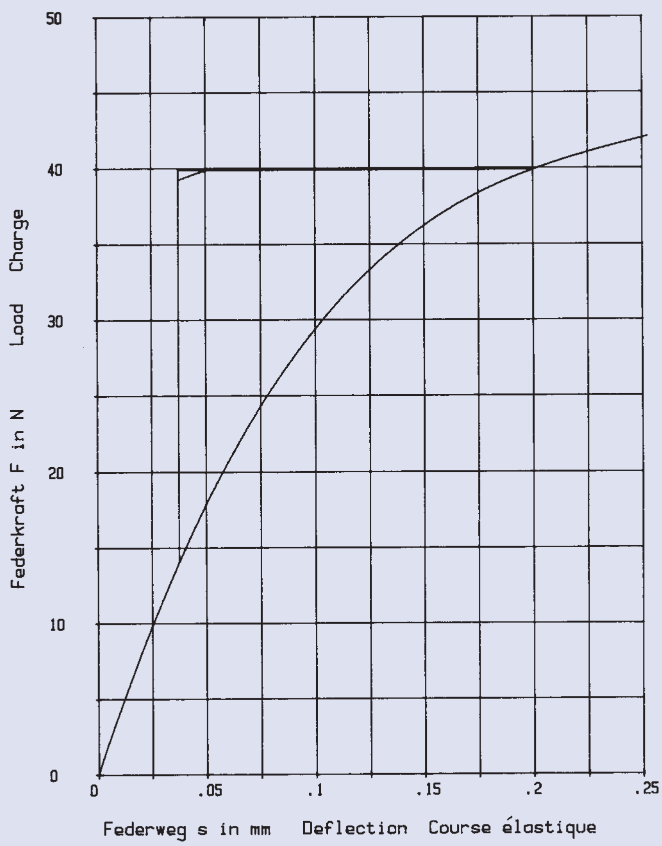
GR 1



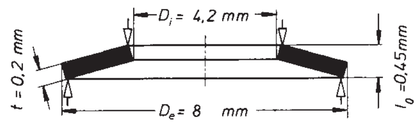
h_0 = 0,2 mm	D_e/D_i = 2,5
t = 0,5 mm	D_e/t = 16
h_0/t = 0,4	m = 0,166 g



8 x 4,2 x 0,2



GR 1, DIN 2093 – C 8



h_0 = 0,25mm	D_e/D_i = 1,904
t = 0,2 mm	D_e/t = 40
h_0/t = 1,25	m = 0,057 g

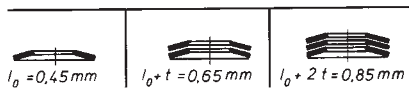
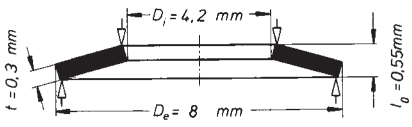


Diagramme | Diagrams | Diagrammes

8 x 4,2 x 0,3

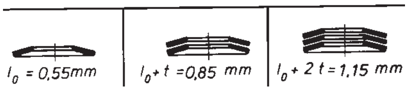
GR 1, DIN 2093 – B 8

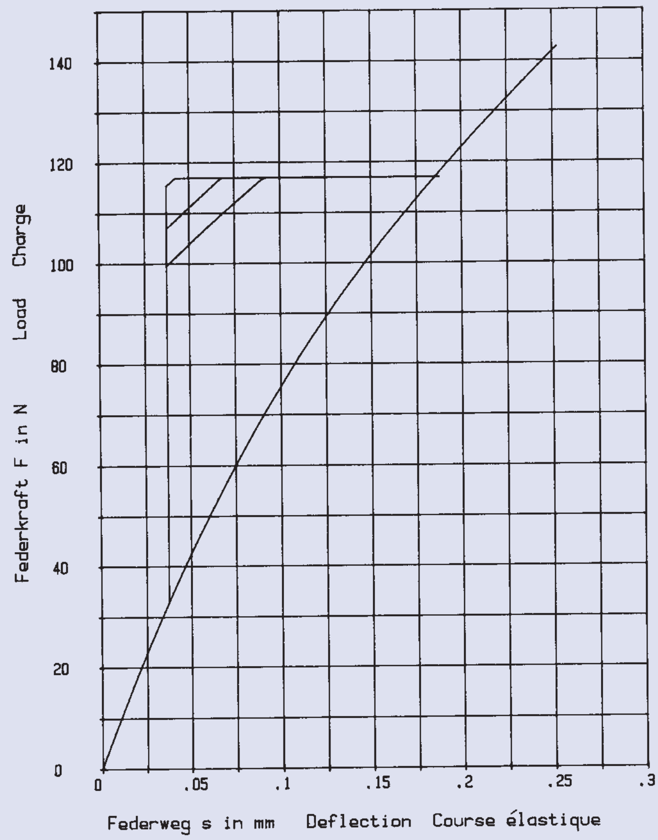


h_0 = 0,25mm D_e/D_i = 1,904

t = 0,3 mm D_e/t = 26,666

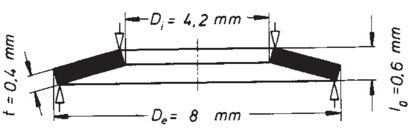
h_0/t = 0,833 m = 0,086 g





8 x 4,2 x 0,4

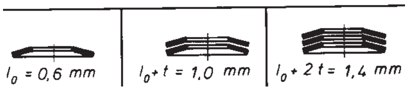
GR 1, DIN 2093 – A 8

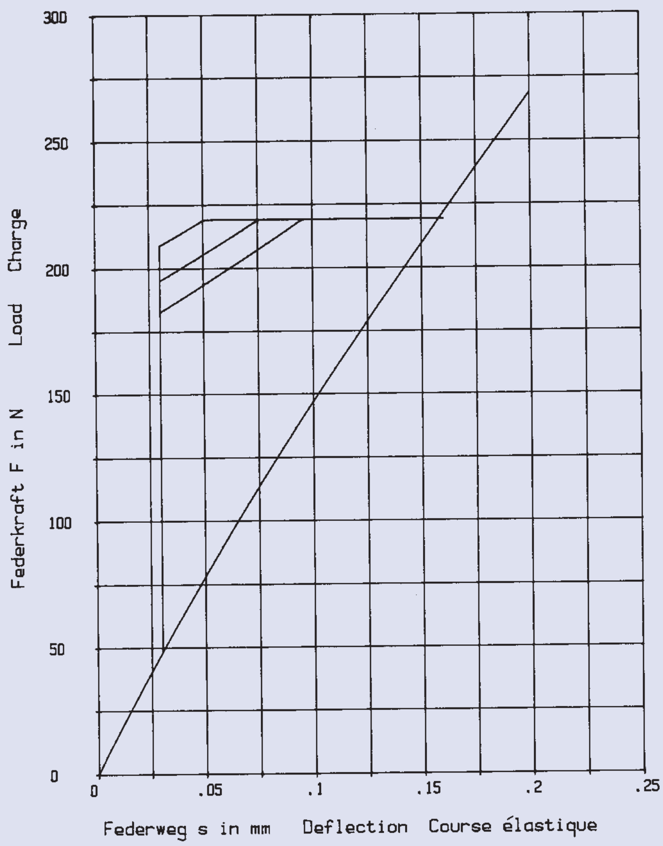


h_0 = 0,2 mm D_e/D_i = 1,904

t = 0,4 mm D_e/t = 20

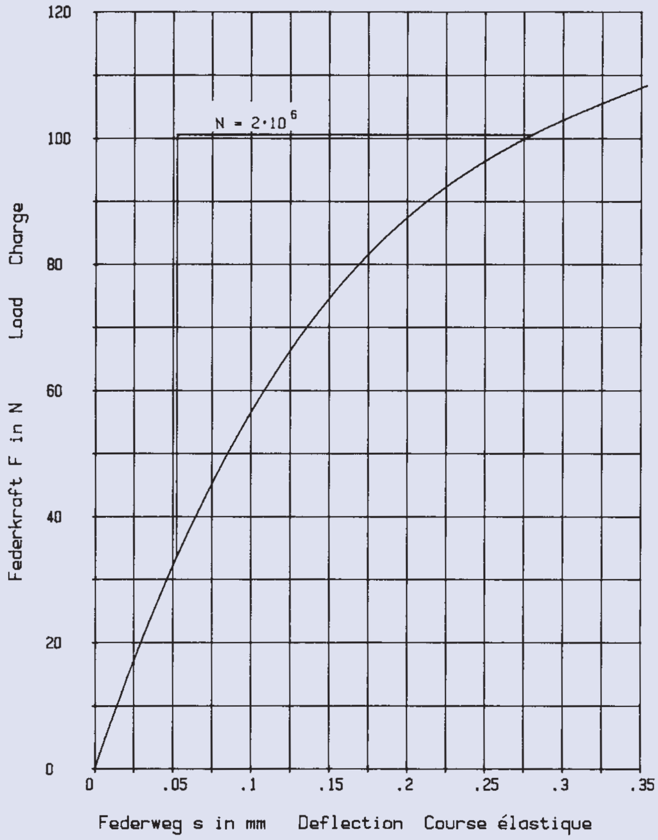
h_0/t = 0,5 m = 0,114 g

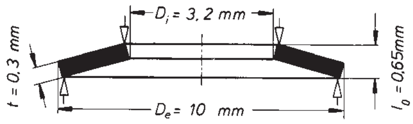




10 x 3,2 x 0,3

GR 1

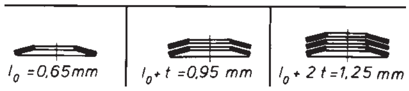




h_0 = 0,35mm D_e/D_i = 3,125

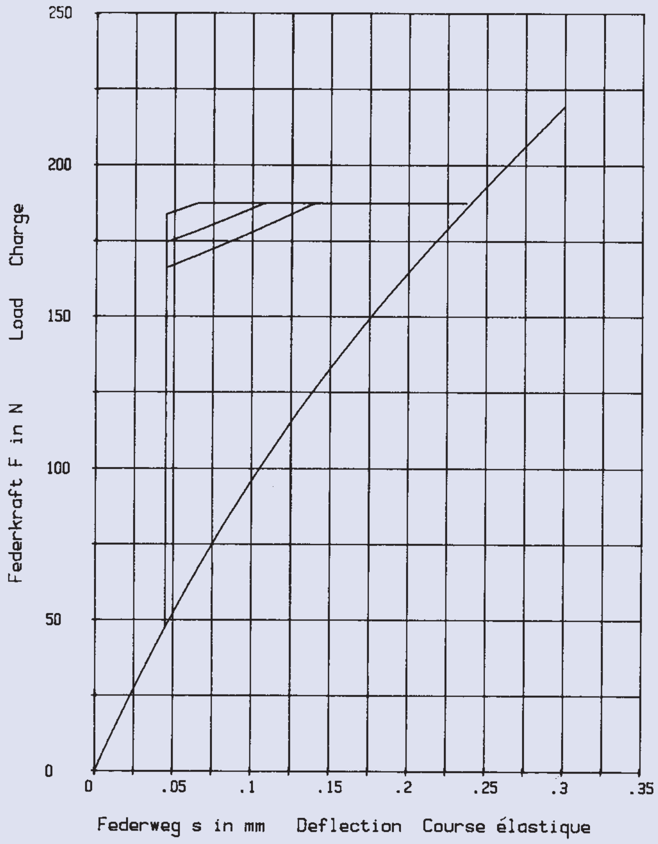
t = 0,3 mm D_e/t = 33,333

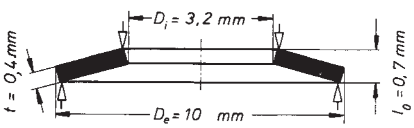
h_0/t = 1,166   m = 0,166 g



10 x 3,2 x 0,4

GR 1





h_0 = 0,3 mm D_e/D_i = 3,125

t = 0,4 mm D_e/t = 25

h_0/t = 0,75   m = 0,221 g

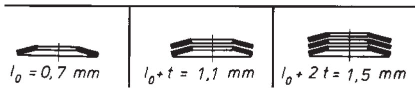
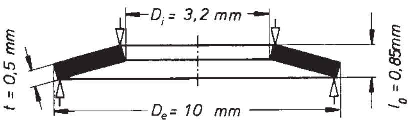


Diagramme | Diagrams | Diagrammes

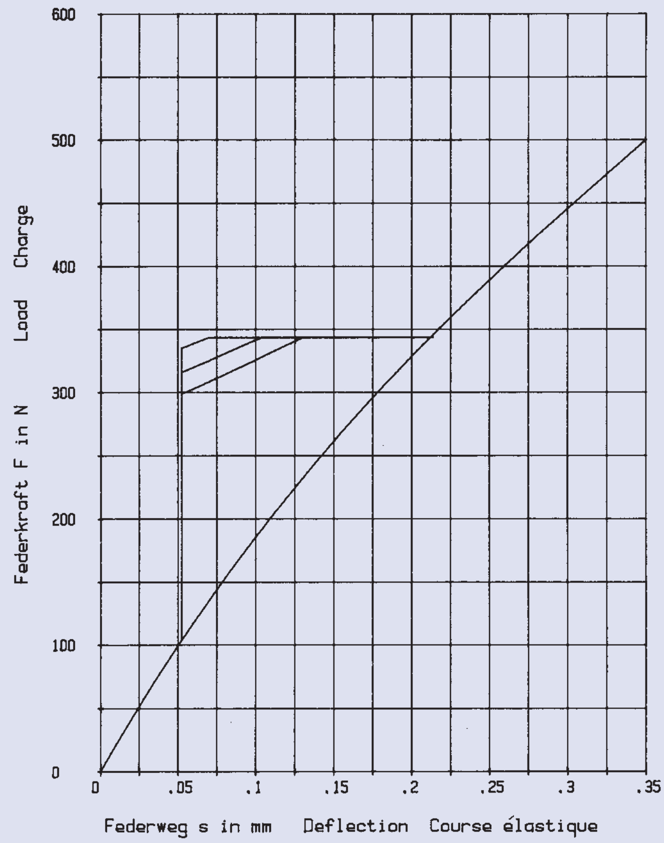
10 x 3,2 x 0,5

GR 1



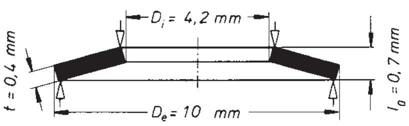
h_0 = 0,35mm	D_e/D_i = 3,125
t = 0,5 mm	D_e/t = 20
h_0/t = 0,7	m = 0,277 g

l_0 = 0,85mm	$l_0 + t$ = 1,35 mm	$l_0 + 2t$ = 1,85 mm



10 x 4,2 x 0,4

GR 1



h_0 = 0,3mm	D_e/D_i = 2,38
t = 0,4 mm	D_e/t = 25
h_0/t = 0,75	m = 0,203 g

l_0 = 0,7 mm	$l_0 + t$ = 1,1 mm	$l_0 + 2t$ = 1,5 mm

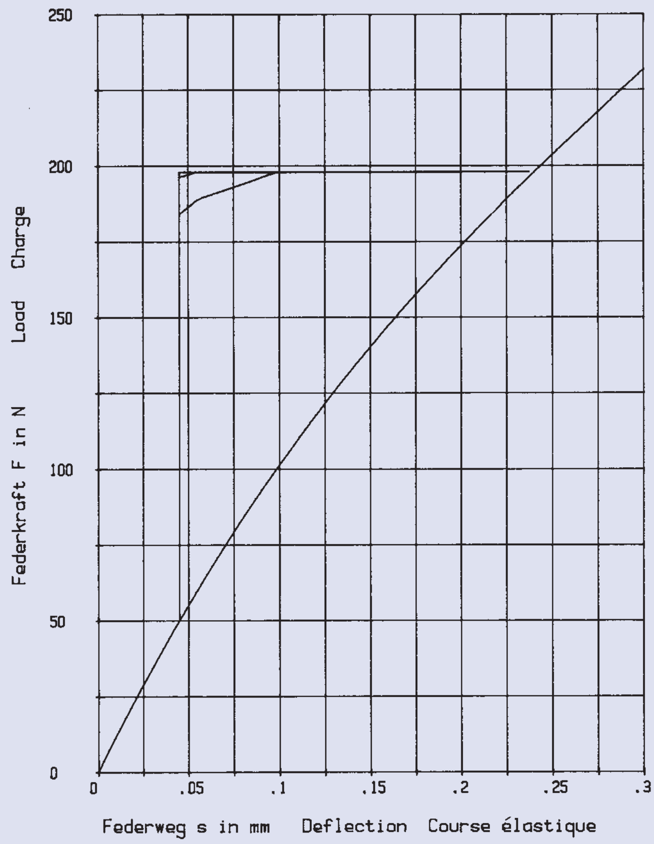
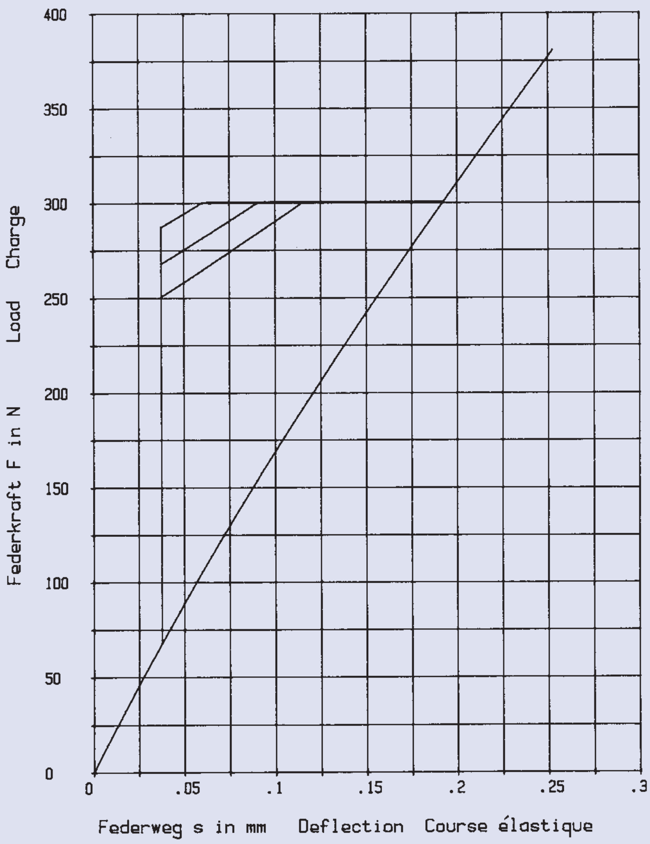
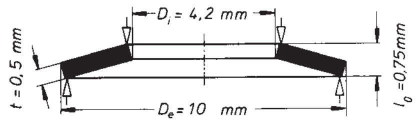


Diagramme | Diagrams | Diagrammes

10 x 4,2 x 0,5

GR 1

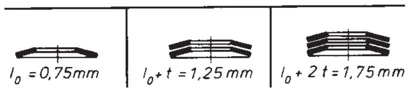




h_0 = 0,25 mm D_e/D_i = 2,38

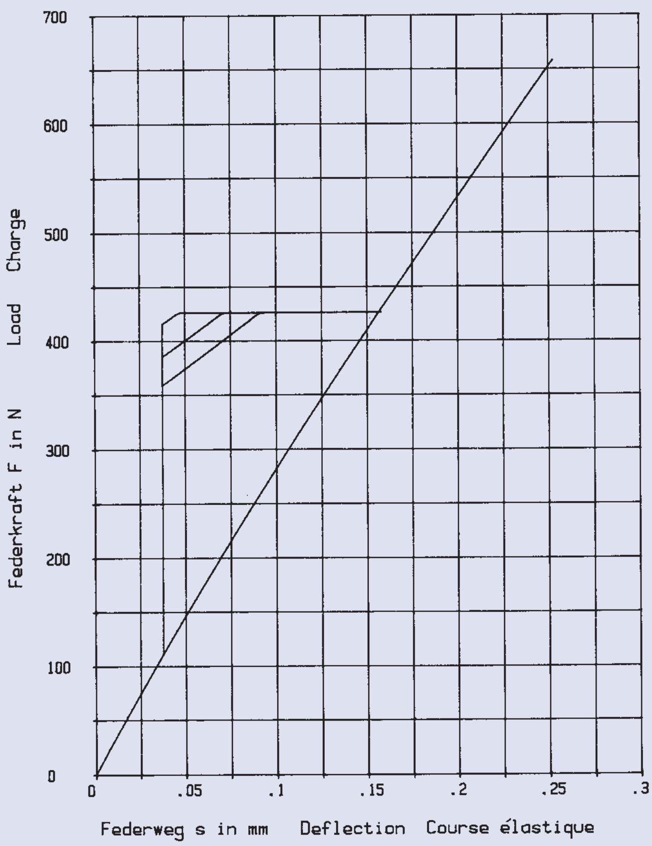
t = 0,5 mm D_e/t = 20

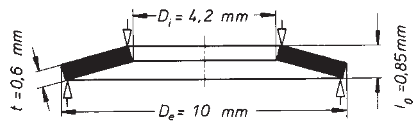
h_0/t = 0,5   m = 0,254 g



10 x 4,2 x 0,6

GR 1





h_0 = 0,25 mm D_e/D_i = 2,38

t = 0,6 mm D_e/t = 16,666

h_0/t = 0,416   m = 0,304 g

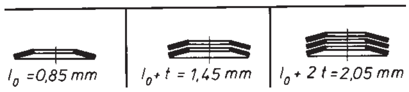
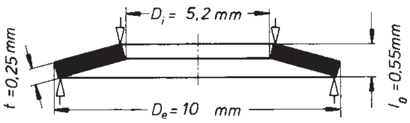


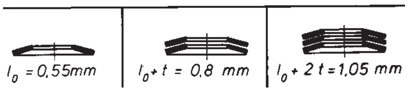
Diagramme | Diagrams | Diagrammes

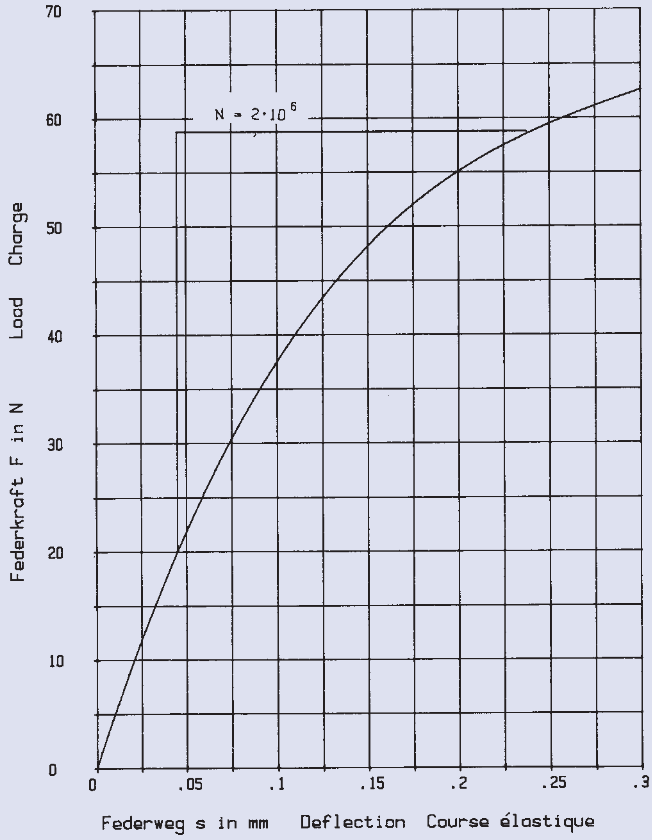
10 x 5,2 x 0,25

GR 1, DIN 2093 – C 10



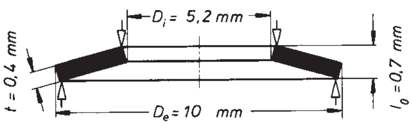
h_0 = 0,3 mm	D_e/D_i = 1,923
t = 0,25mm	D_e/t = 40
h_0/t = 1,2	m = 0,112 g



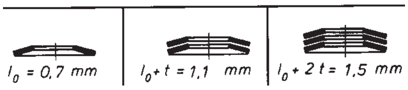


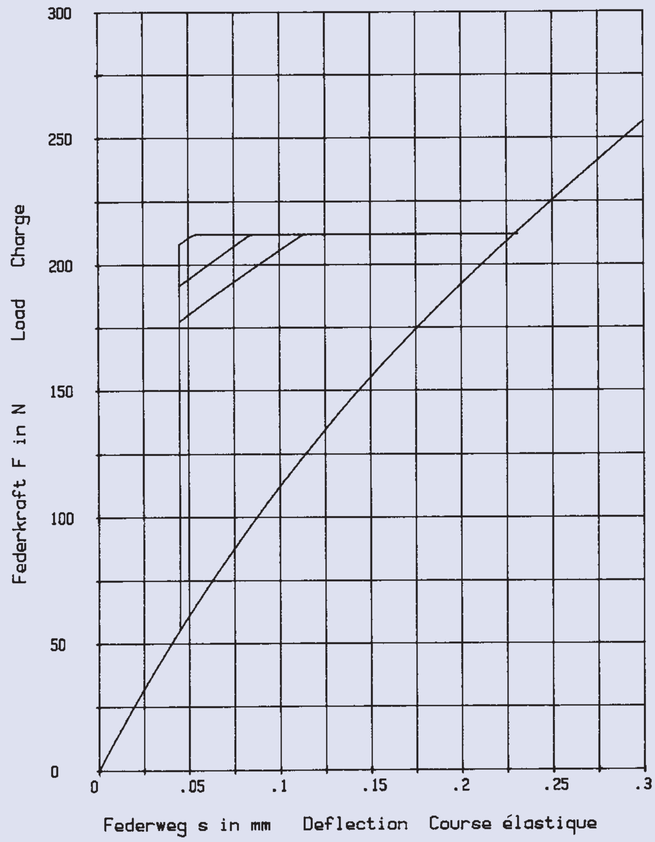
10 x 5,2 x 0,4

GR 1, DIN 2093 – B 10



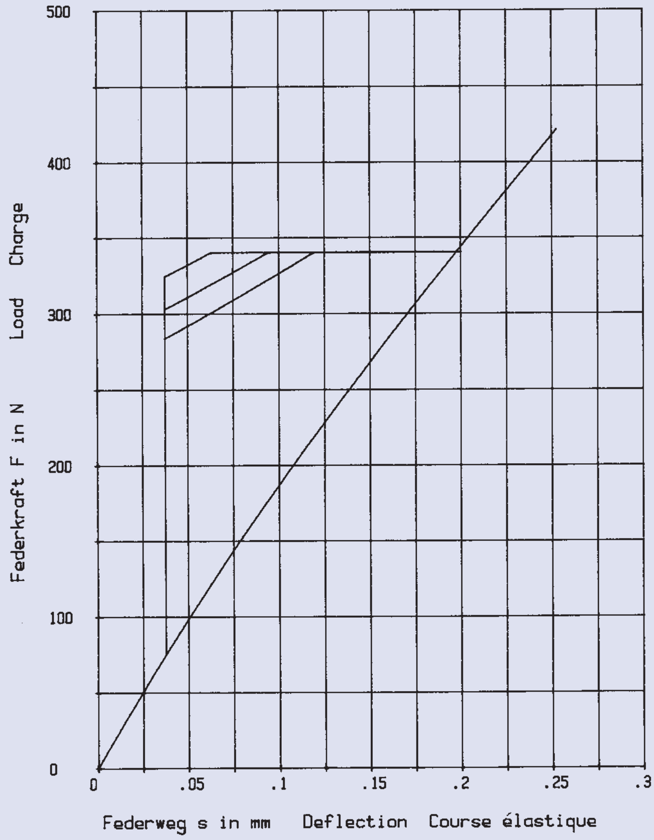
h_0 = 0,3 mm	D_e/D_i = 1,923
t = 0,4 mm	D_e/t = 25
h_0/t = 0,75	m = 0,18 g

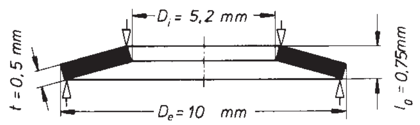




10 x 5,2 x 0,5

GR 1, DIN 2093 – A 10





h_0 = 0,25 mm

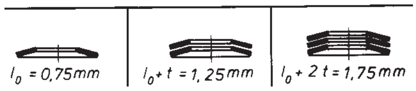
t = 0,5 mm

h_0/t = 0,5

D_e/D_i = 1,923

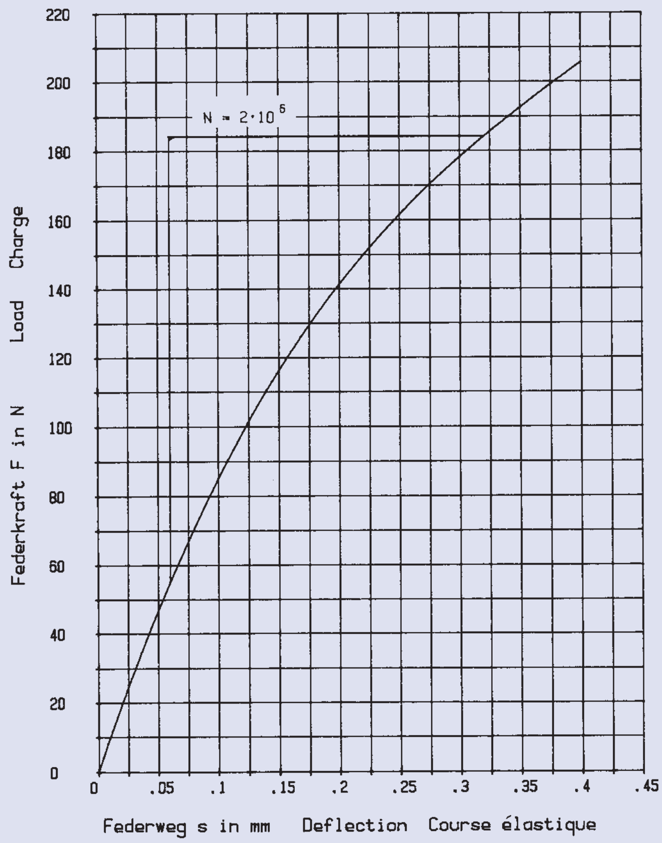
D_e/t = 20

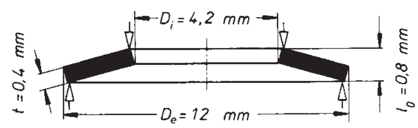
m = 0,225 g



12 x 4,2 x 0,4

GR 1





h_0 = 0,4 mm

t = 0,4 mm

h_0/t = 1

D_e/D_i = 2,857

D_e/t = 30

m = 0,311 g

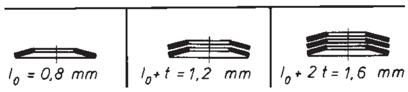
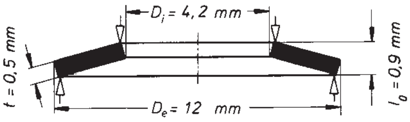


Diagramme | Diagrams | Diagrammes

12 x 4,2 x 0,5

GR 1

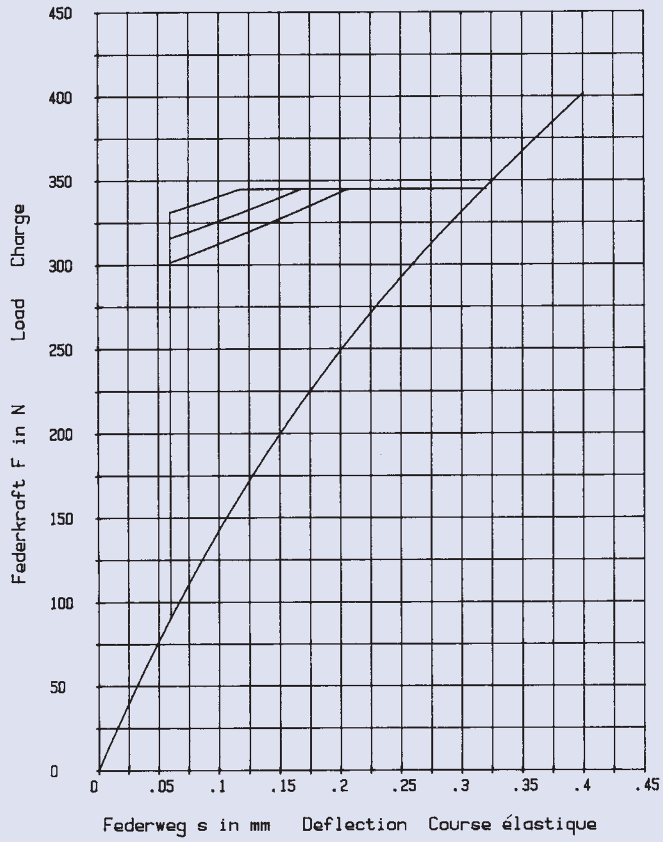


h_0 = 0,4 mm — D_e/D_i = 2,857

t = 0,5 mm — D_e/t = 24

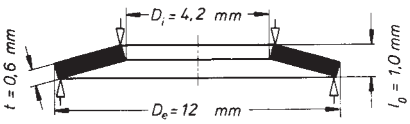
h_0/t = 0,8 — m = 0,389 g

l_0 = 0,9 mm	l_0 + t = 1,4 mm	l_0 + 2 t = 1,9 mm



12 x 4,2 x 0,6

GR 1

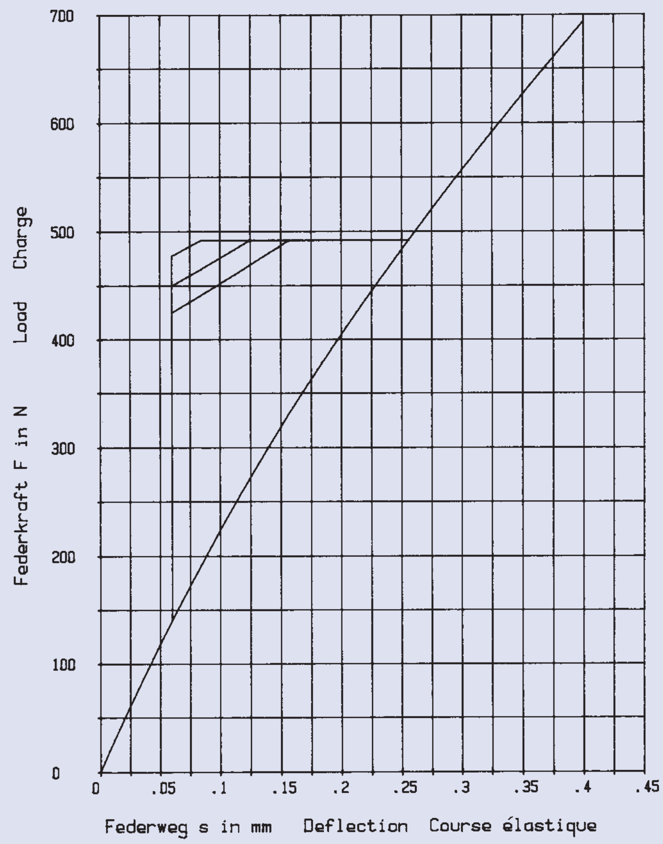


h_0 = 0,4 mm — D_e/D_i = 2,857

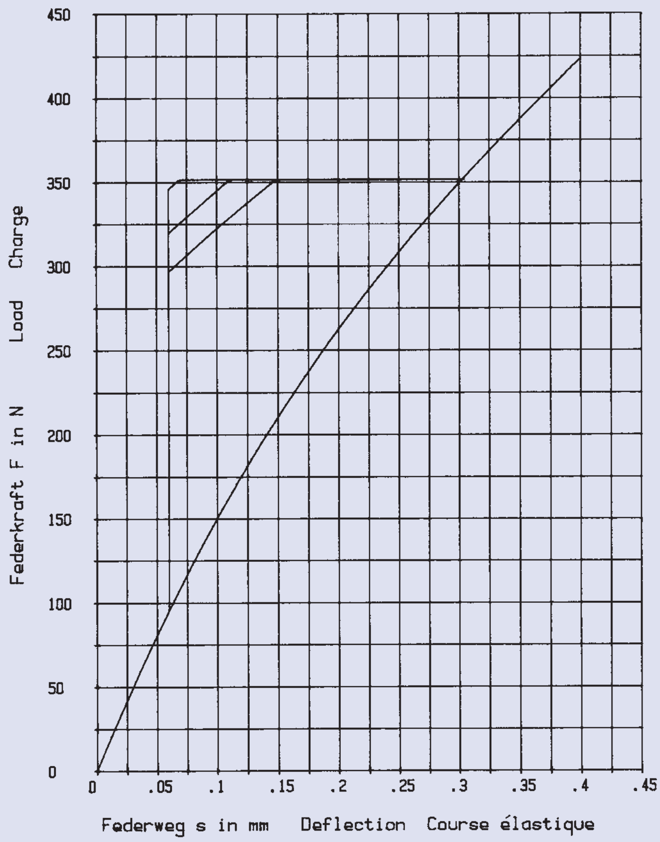
t = 0,6 mm — D_e/t = 20

h_0/t = 0,666 — m = 0,467 g

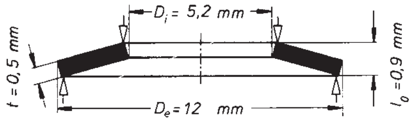
l_0 = 1,0 mm	l_0 + t = 1,6 mm	l_0 + 2 t = 2,2 mm



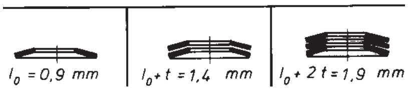
12 x 5,2 x 0,5



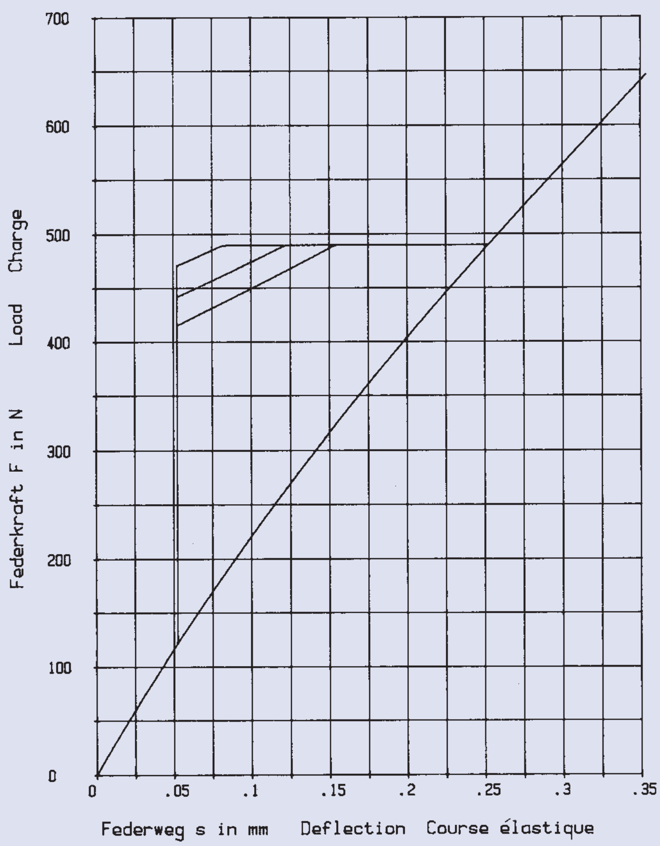
GR 1



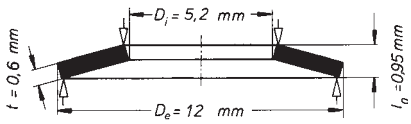
h_0 = 0,4 mm	D_e/D_i = 2,307
t = 0,5 mm	D_e/t = 24
h_0/t = 0,8	m = 0,360 g



12 x 5,2 x 0,6



GR 1



h_0 = 0,35 mm	D_e/D_i = 2,307
t = 0,6 mm	D_e/t = 20
h_0/t = 0,583	m = 0,432 g

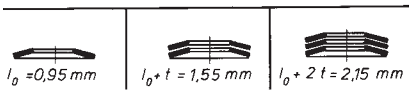
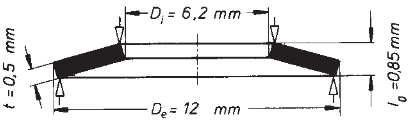


Diagramme | Diagrams | Diagrammes

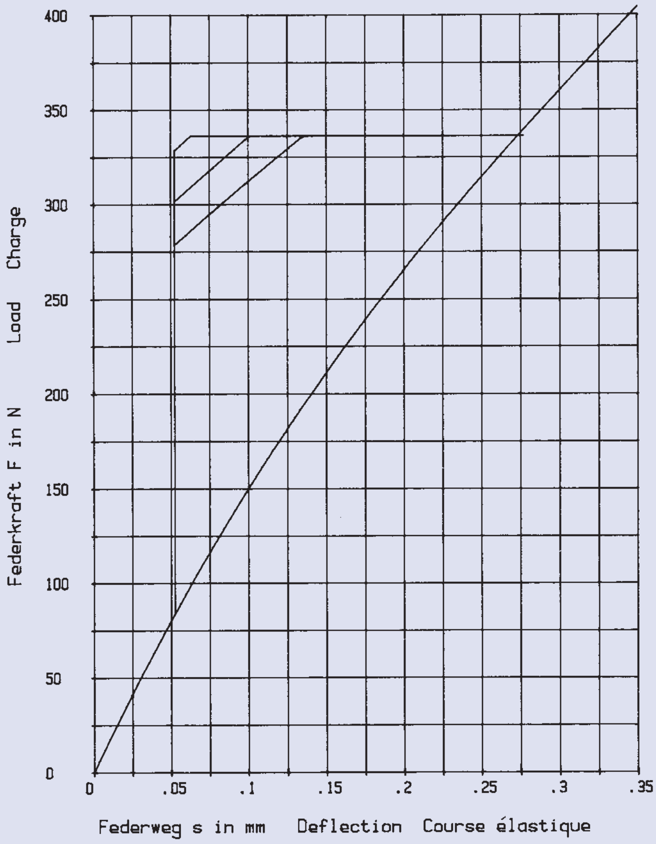
12 x 6,2 x 0,5

GR 1



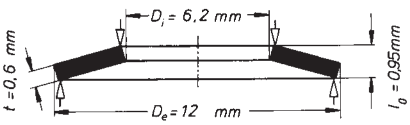
h_0 = 0,35mm	D_e/D_i = 1,935
t = 0,5 mm	D_e/t = 24
h_0/t = 0,7	m = 0,325 g

l_0 = 0,85 mm	l_0 + t = 1,35 mm	l_0 + 2 t = 1,85 mm



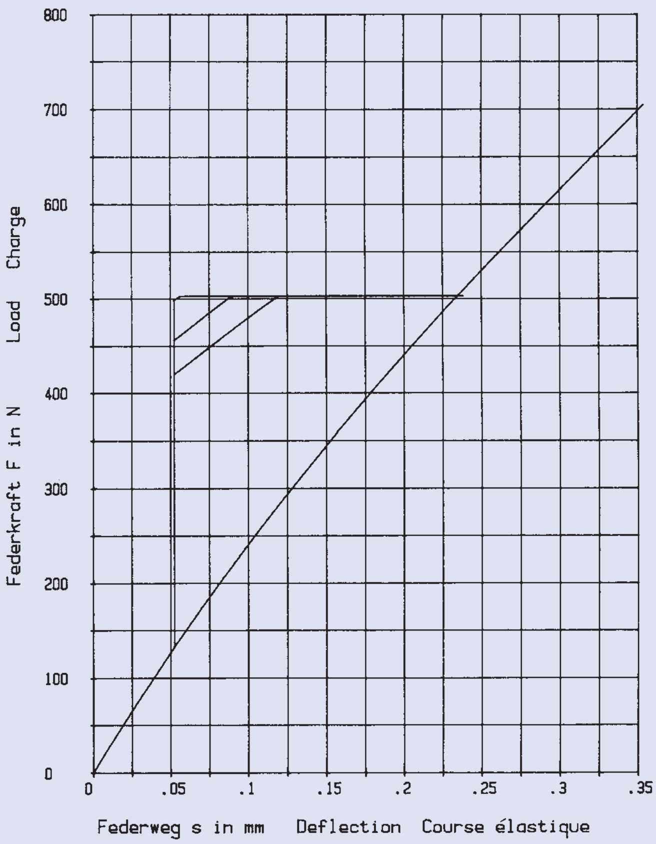
12 x 6,2 x 0,6

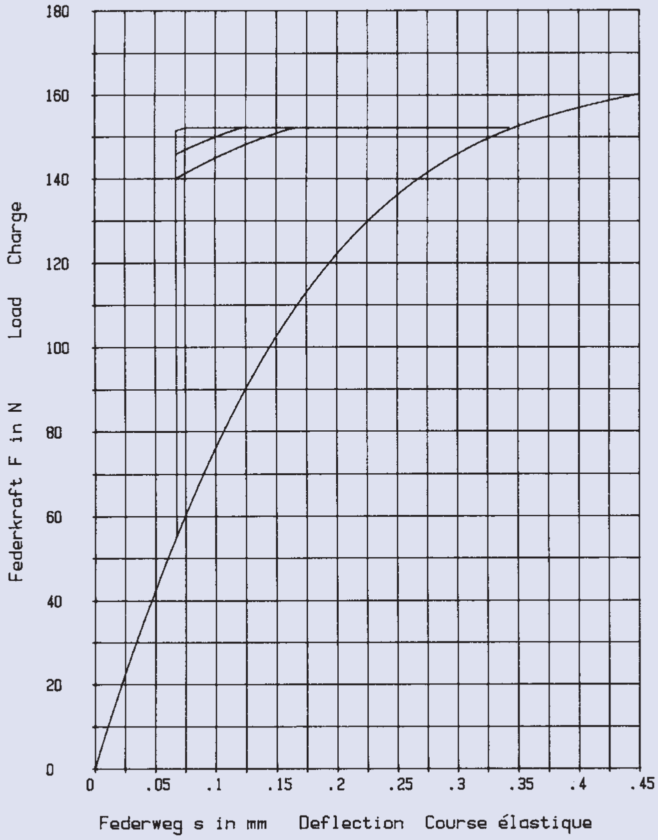
GR 1



h_0 = 0,35 mm	D_e/D_i = 1,935
t = 0,6 mm	D_e/t = 20
h_0/t = 0,583	m = 0,390 g

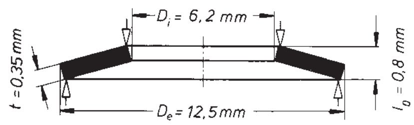
l_0 = 0,95 mm	l_0 + t = 1,55 mm	l_0 + 2 t = 2,15 mm



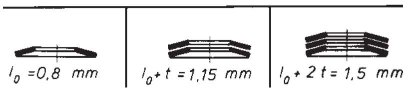


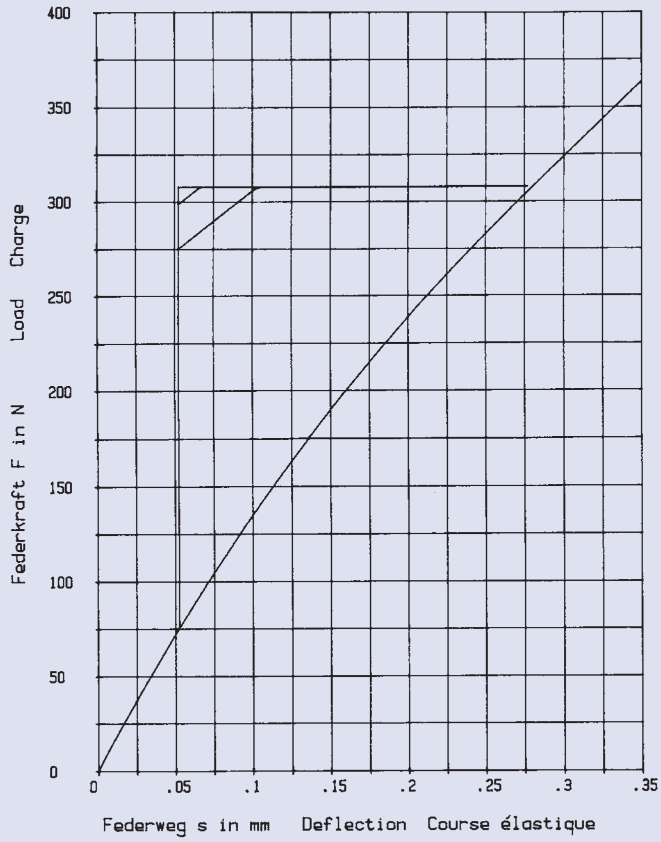
12,5 x 6,2 x 0,35

GR 1, DIN 2093 – C 12,5



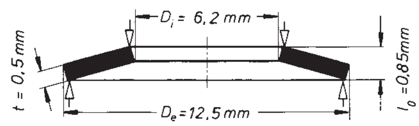
h_0 = 0,45mm	D_e/D_i = 2,016
t = 0,35mm	D_e/t = 35,714
h_0/t = 1,285	m = 0,254 g





12,5 x 6,2 x 0,5

GR 1, DIN 2093 – B 12,5



h_0 = 0,35mm	D_e/D_i = 2,016
t = 0,5 mm	D_e/t = 25
h_0/t = 0,7	m = 0,363 g

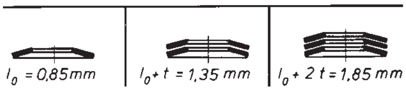
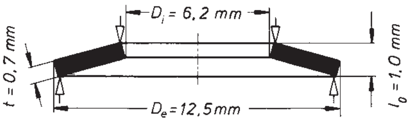


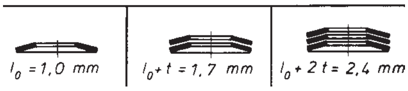
Diagramme | Diagrams | Diagrammes

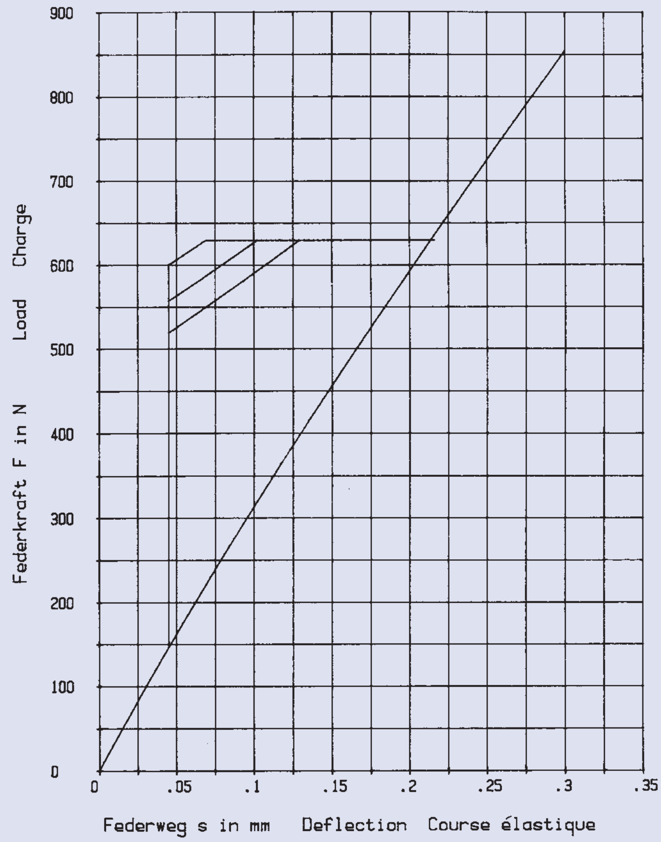
12,5 x 6,2 x 0,7

GR 1, DIN 2093 – A 12,5



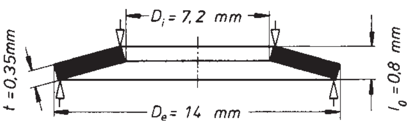
$h_0 = 0,3$ mm	$D_e / D_i = 2,016$
$t = 0,7$ mm	$D_e / t = 17,857$
$h_0 / t = 0,428$	$m = 0,508$ g



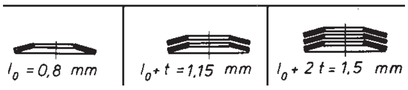


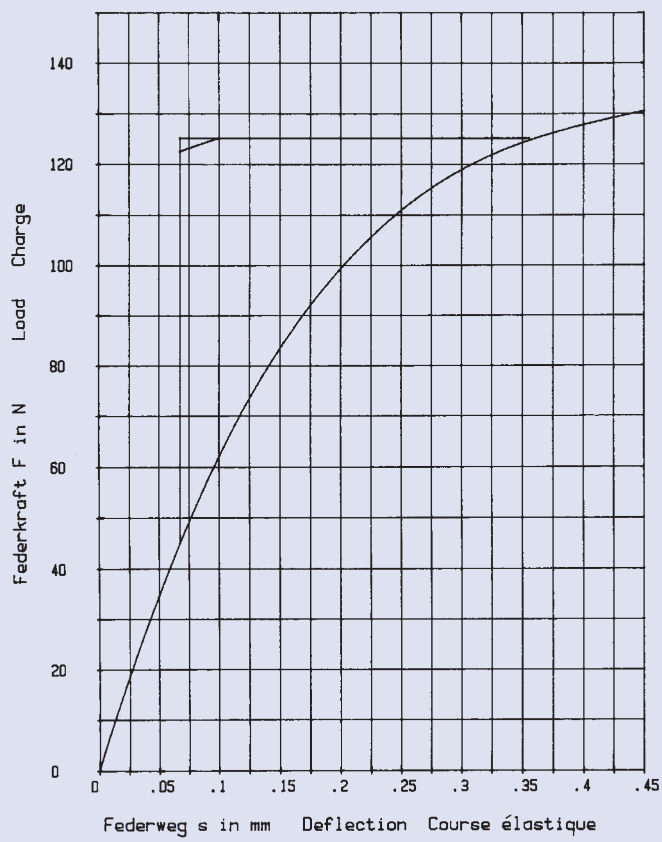
14 x 7,2 x 0,35

GR 1, DIN 2093 – C 14



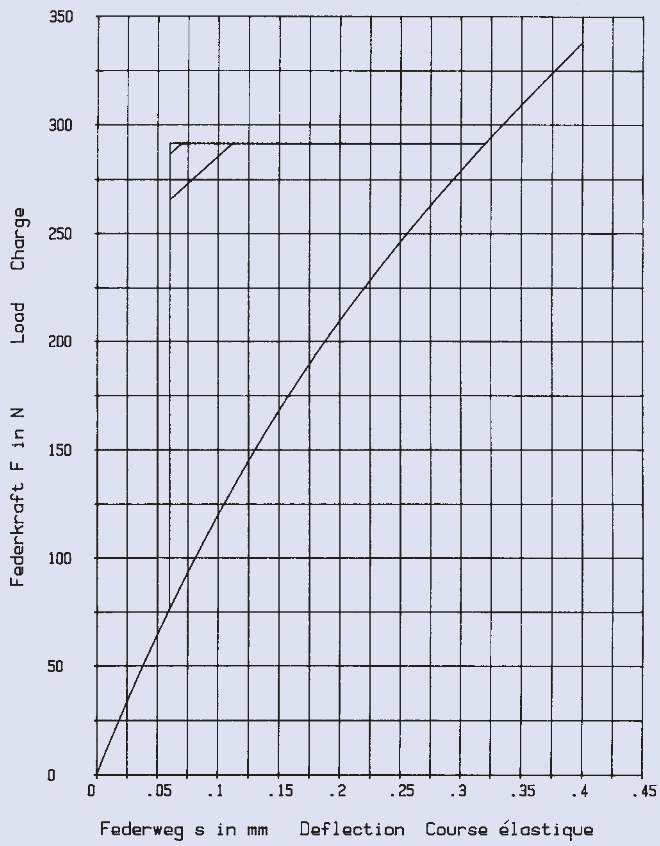
$h_0 = 0,45$mm	$D_e / D_i = 1,944$
$t = 0,35$mm	$D_e / t = 40$
$h_0 / t = 1,285$	$m = 0,311$ g

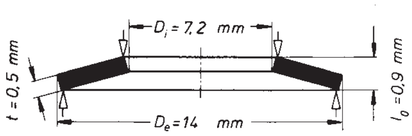




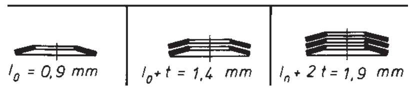
14 x 7,2 x 0,5

GR 1, DIN 2093 – B 14



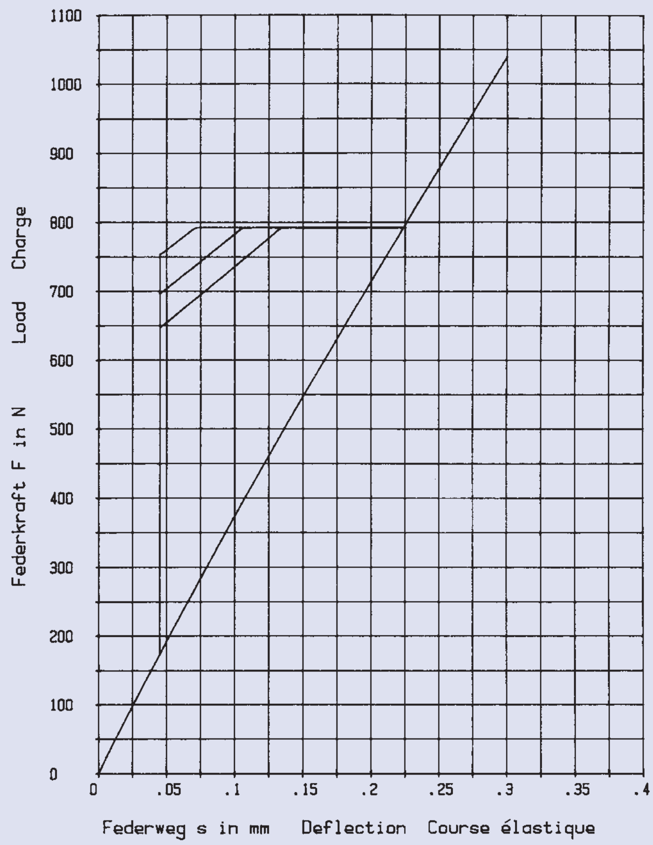


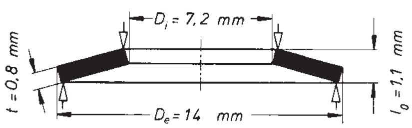
h_0 = 0,4 mm	D_e/D_i = 1,944
t = 0,5 mm	D_e/t = 28
h_0/t = 0,8	m = 0,444 g



14 x 7,2 x 0,8

GR 1, DIN 2093 – A 14





h_0 = 0,3 mm	D_e/D_i = 1,944
t = 0,8 mm	D_e/t = 17,5
h_0/t = 0,375	m = 0,711 g

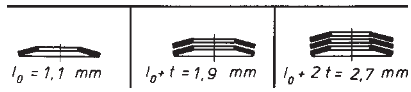
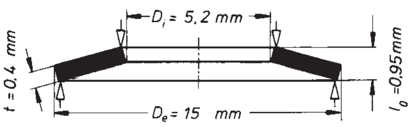


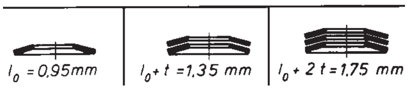
Diagramme | Diagrams | Diagrammes

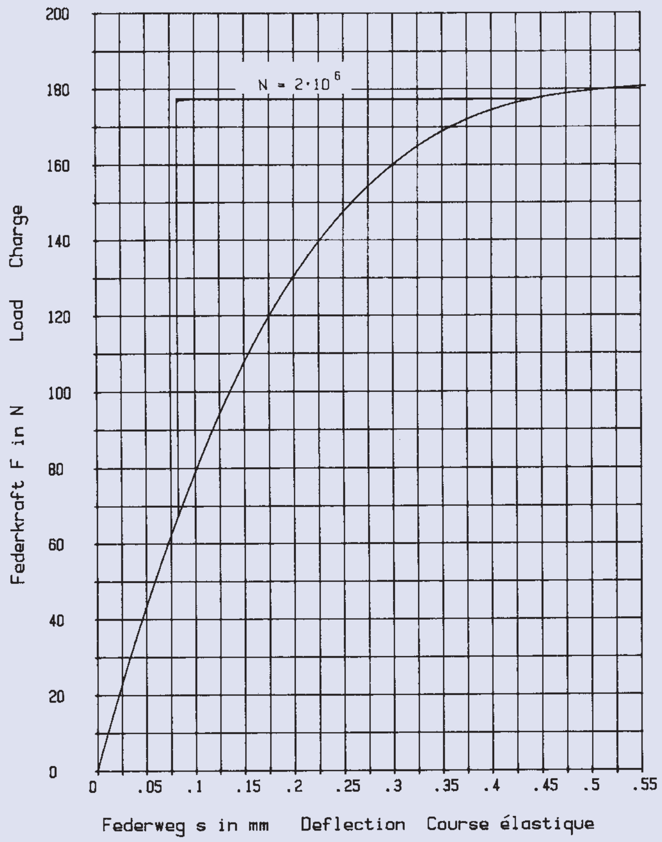
15 x 5,2 x 0,4

GR 1



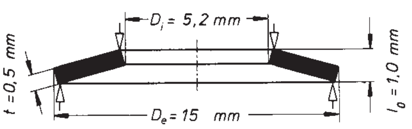
h_0 = 0,55mm	D_e/D_i = 2,884
t = 0,4 mm	D_e/t = 37,5
h_0/t = 1,375	m = 0,488 g



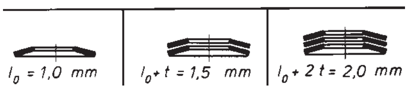


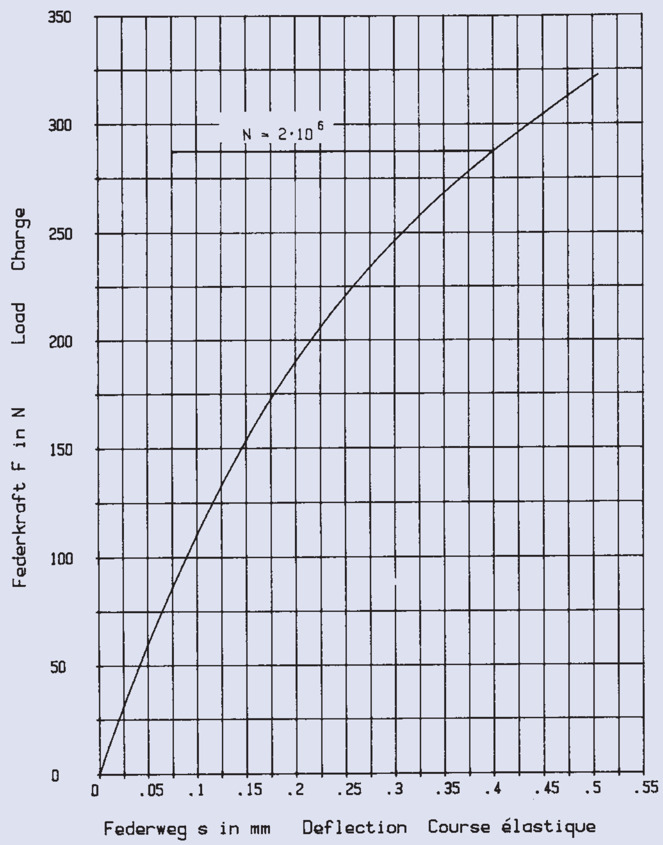
15 x 5,2 x 0,5

GR 1



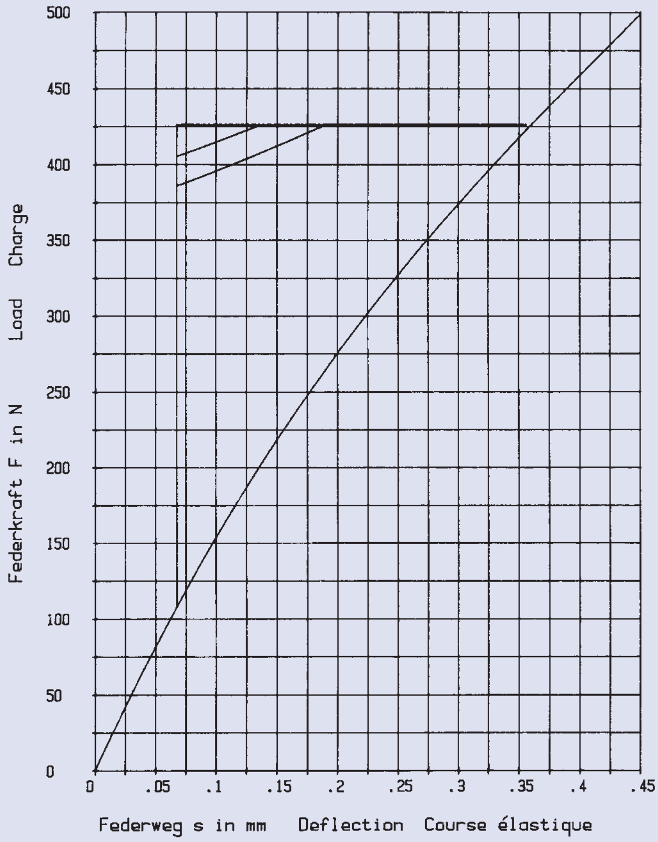
h_0 = 0,5 mm	D_e/D_i = 2,884
t = 0,5 mm	D_e/t = 30
h_0/t = 1,0	m = 0,610 g

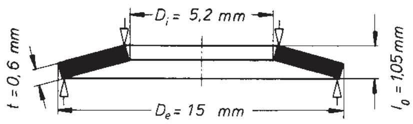




15 x 5,2 x 0,6

GR 1

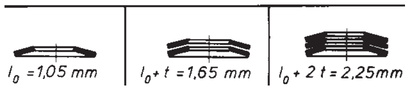




h_0 = 0,45 mm D_e/D_i = 2,884

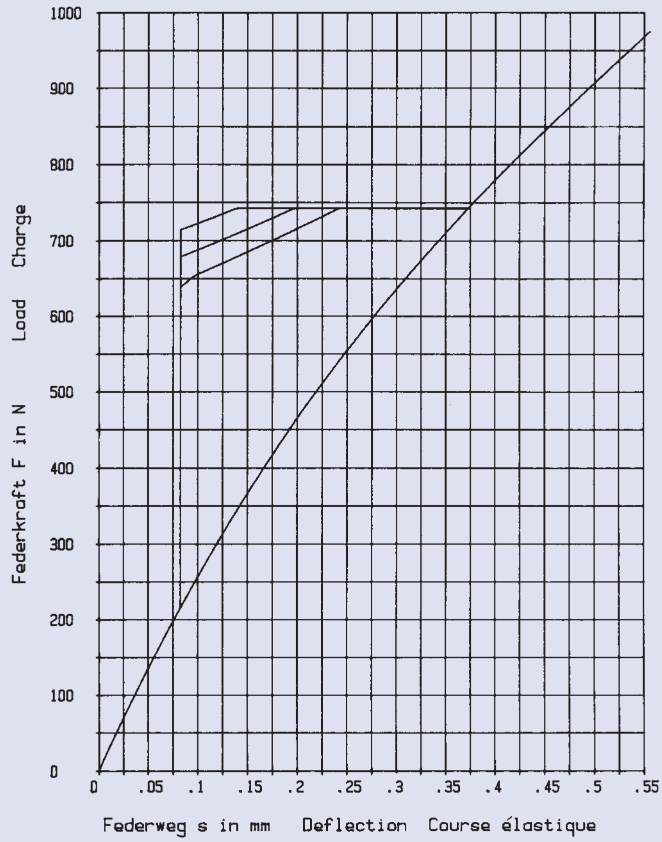
t = 0,6 mm D_e/t = 25

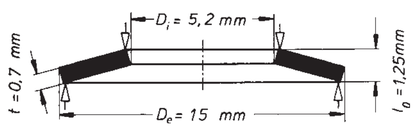
h_0/t = 0,75 m = 0,732 g



15 x 5,2 x 0,7

GR 1





h_0 = 0,55 mm D_e/D_i = 2,884

t = 0,7 mm D_e/t = 21,428

h_0/t = 0,785 m = 0,854 g

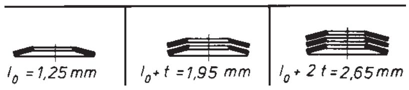
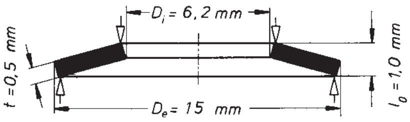


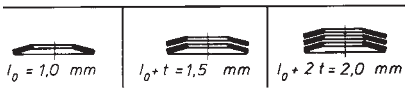
Diagramme | Diagrams | Diagrammes

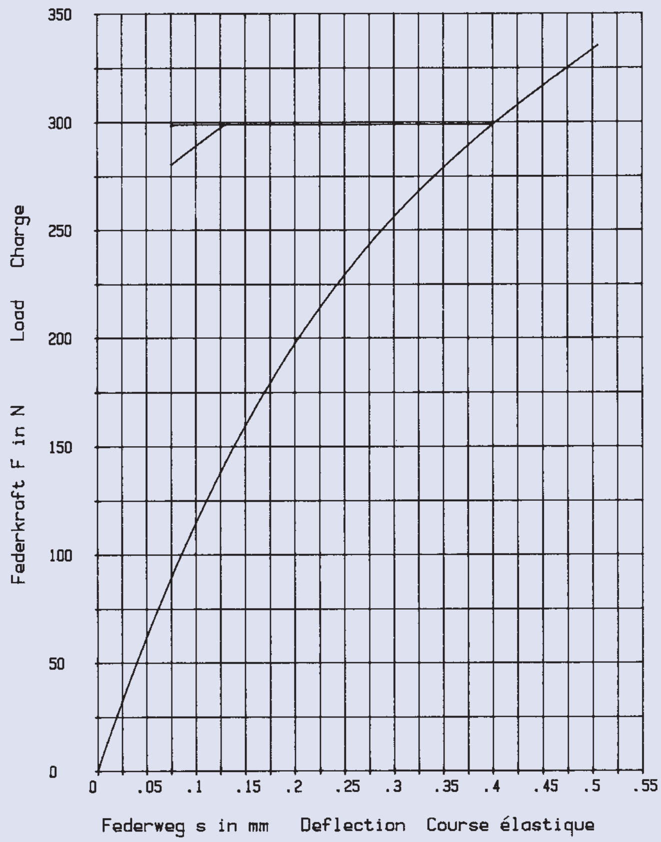
15 x 6,2 x 0,5

GR 1



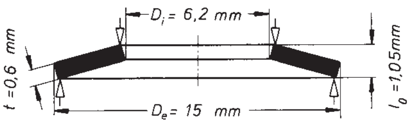
h_0 = 0,5 mm	D_e/D_i = 2,419
t = 0,5 mm	D_e/t = 30
h_0/t = 1,0	m = 0,575 g



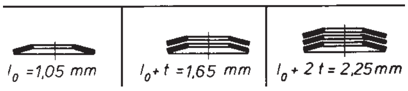


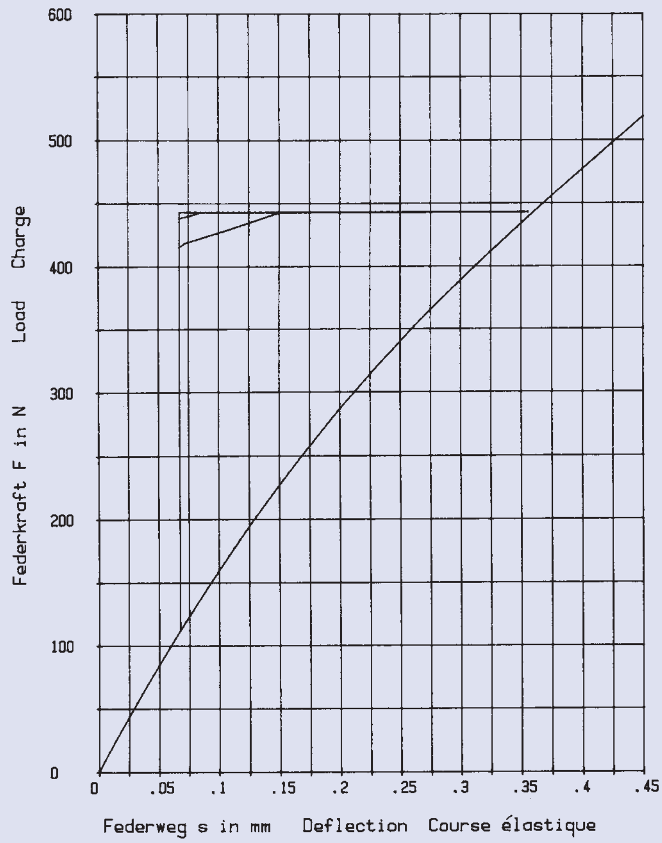
15 x 6,2 x 0,6

GR 1

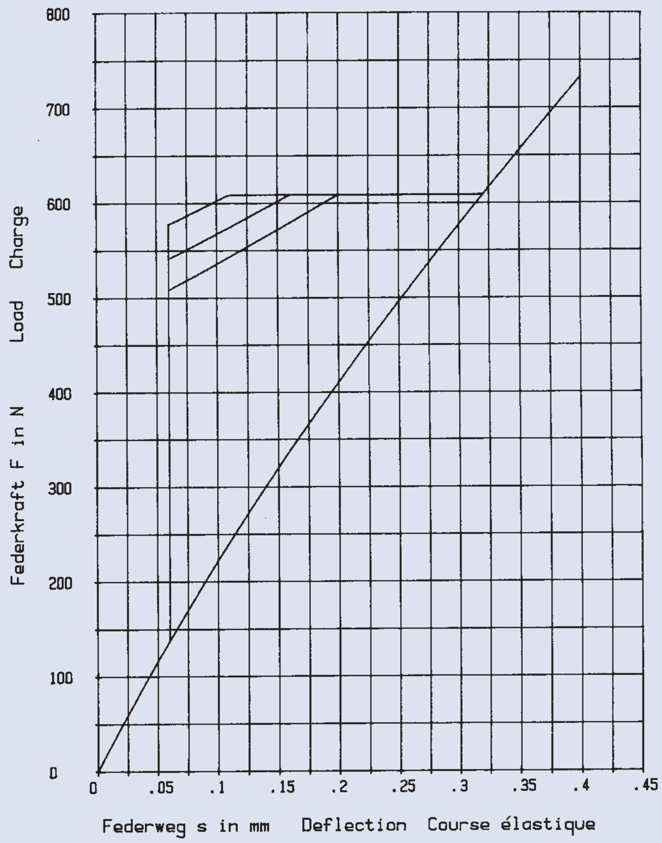


h_0 = 0,45 mm	D_e/D_i = 2,419
t = 0,6 mm	D_e/t = 25
h_0/t = 0,75	m = 0,690 g

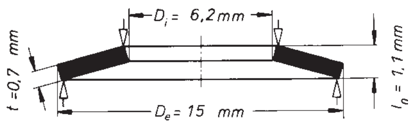




15 x 6,2 x 0,7



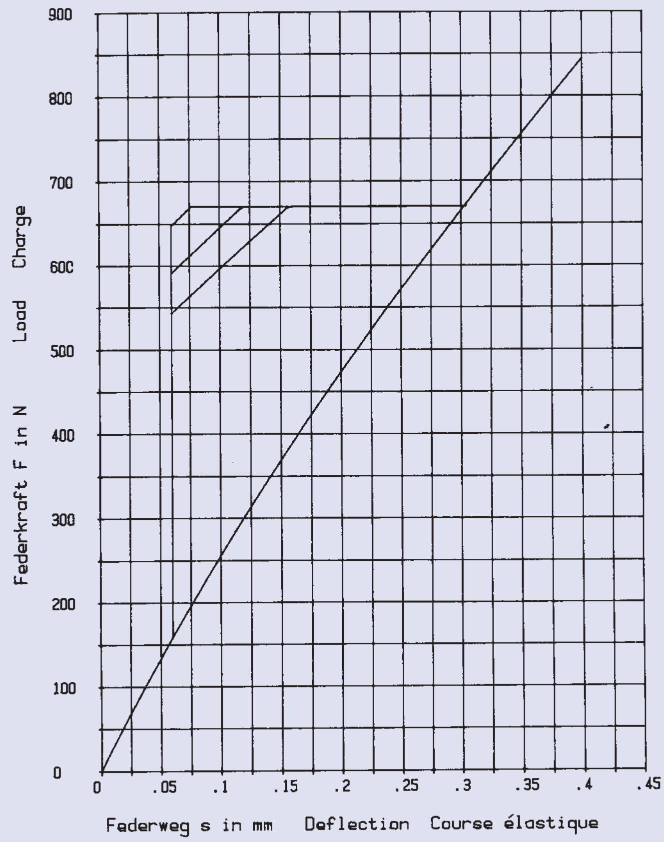
GR 1



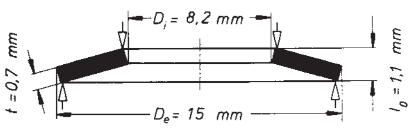
h_0 = 0,4 mm	D_e/D_i = 2,419
t = 0,7 mm	D_e/t = 21,428
h_0/t = 0,571	m = 0,805 g

l_0 = 1,1 mm	l_0 + t = 1,8 mm	l_0 + 2 t = 2,5 mm

15 x 8,2 x 0,7



GR 1



h_0 = 0,4 mm	D_e/D_i = 1,829
t = 0,7 mm	D_e/t = 21,428
h_0/t = 0,571	m = 0,681 g

l_0 = 1,1 mm	l_0 + t = 1,8 mm	l_0 + 2 t = 2,5 mm

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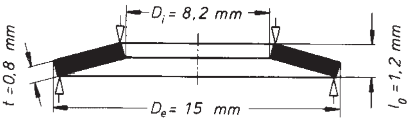
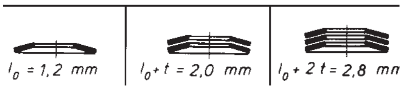
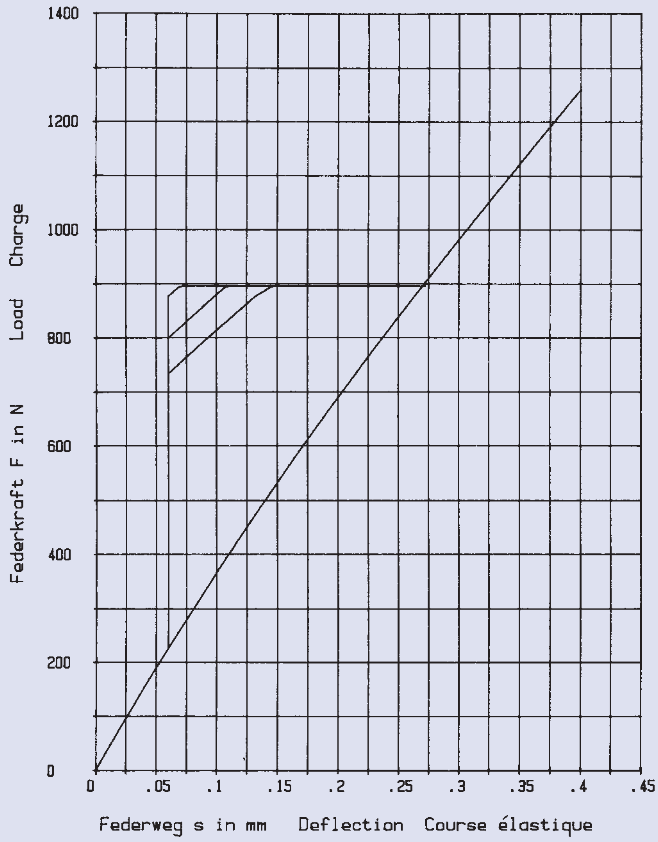
15 x 8,2 x 0,8

GR 1



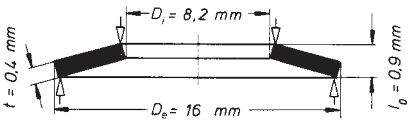
h_0 = 0,4 mm	D_e/D_i = 1,829
t = 0,8 mm	D_e/t = 18,75
h_0/t = 0,5	m = 0,778 g



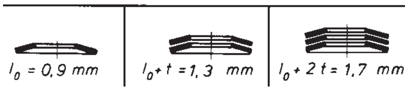


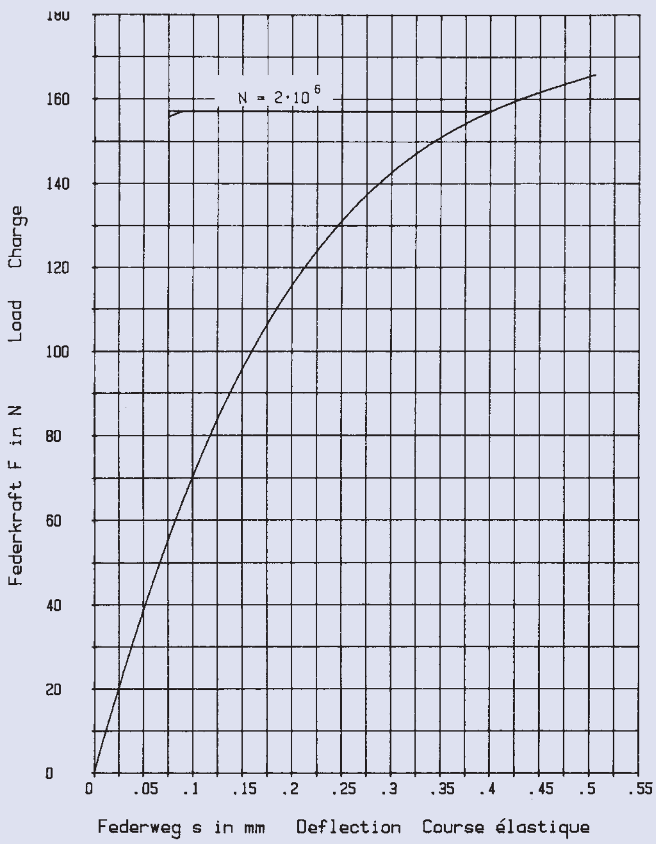
16 x 8,2 x 0,4

GR 1, DIN 2093 – C 16



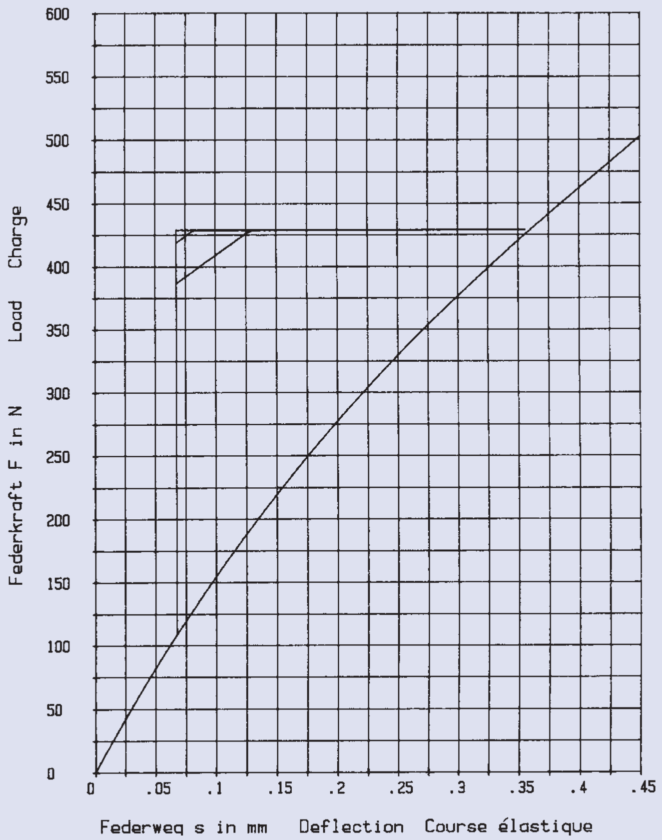
h_0 = 0,5 mm	D_e/D_i = 1,951
t = 0,4 mm	D_e/t = 40
h_0/t = 1,25	m = 0,465 g

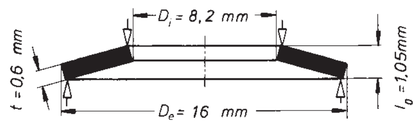




16 x 8,2 x 0,6

GR 1, DIN 2093 – B 16

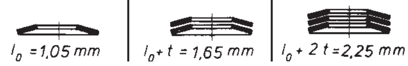




$h_0 = 0{,}45$ mm — $D_e/D_i = 1{,}951$

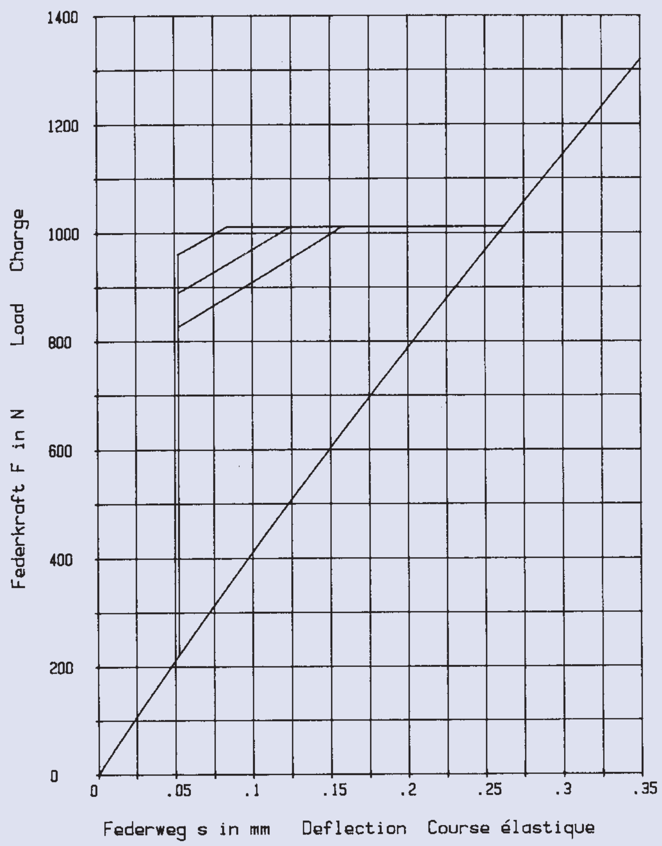
$t = 0{,}6$ mm — $D_e/t = 26{,}666$

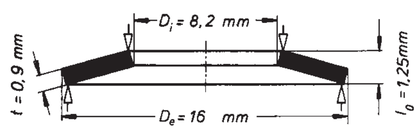
$h_0/t = 0{,}75$ — $m = 0{,}698$ g



16 x 8,2 x 0,9

GR 1, DIN 2093 – A 16





$h_0 = 0{,}35$ mm — $D_e/D_i = 1{,}951$

$t = 0{,}9$ mm — $D_e/t = 17{,}777$

$h_0/t = 0{,}388$ — $m = 1{,}047$ g

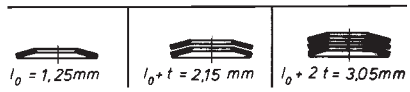
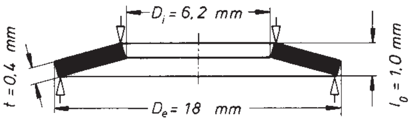


Diagramme | Diagrams | Diagrammes

18 x 6,2 x 0,4

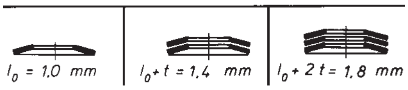
GR 1

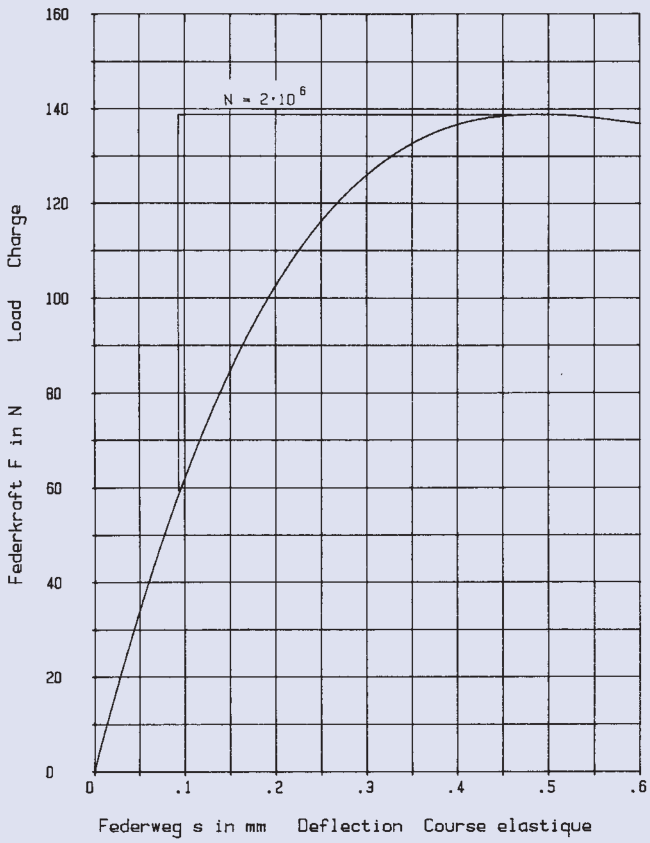


h_0 = 0,6 mm D_e/D_i = 2,903

t = 0,4 mm D_e/t = 45

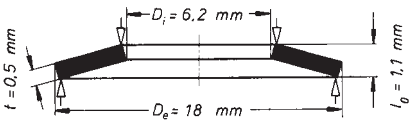
h_0/t = 1,5 m = 0,704 g





18 x 6,2 x 0,5

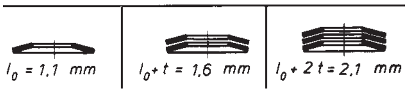
GR 1



h_0 = 0,6 mm D_e/D_i = 2,903

t = 0,5 mm D_e/t = 36

h_0/t = 1,2 m = 0,88 g



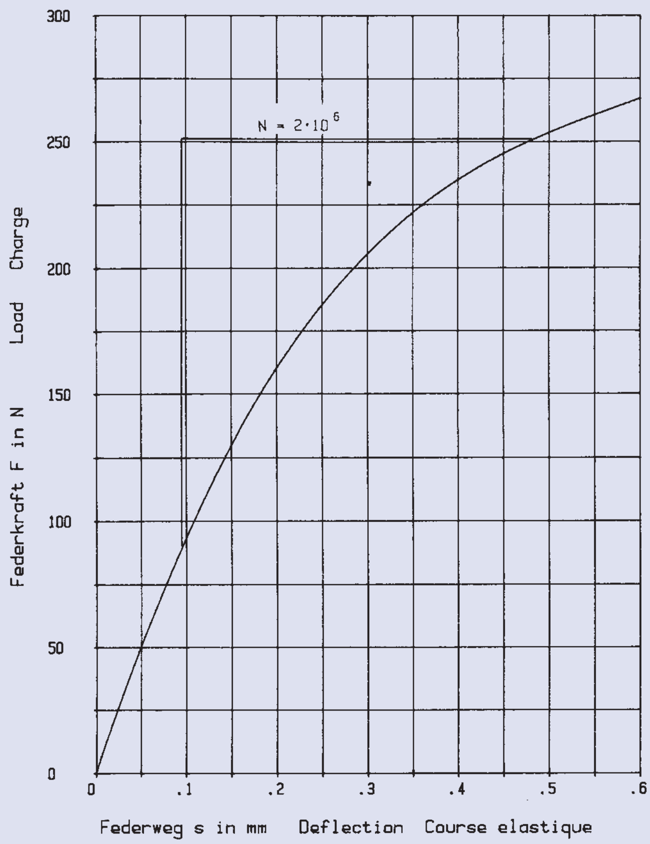
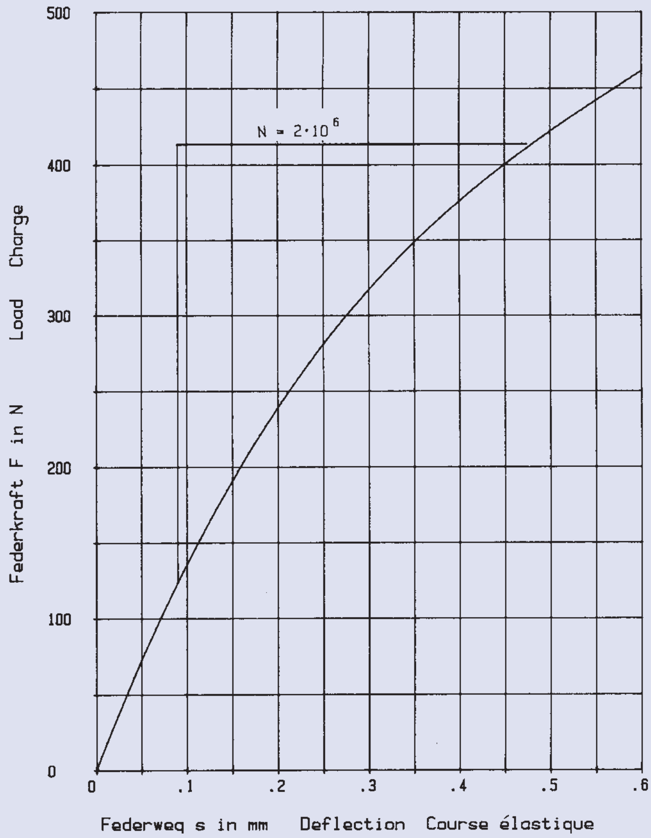
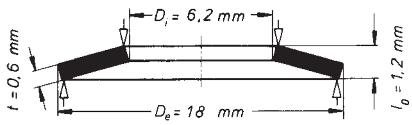


Diagramme | Diagrams | Diagrammes

18 x 6,2 x 0,6

GR 1

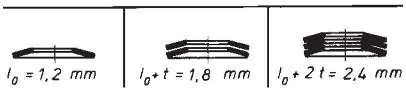




h_0 = 0,6 mm — D_e/D_i = 2,903

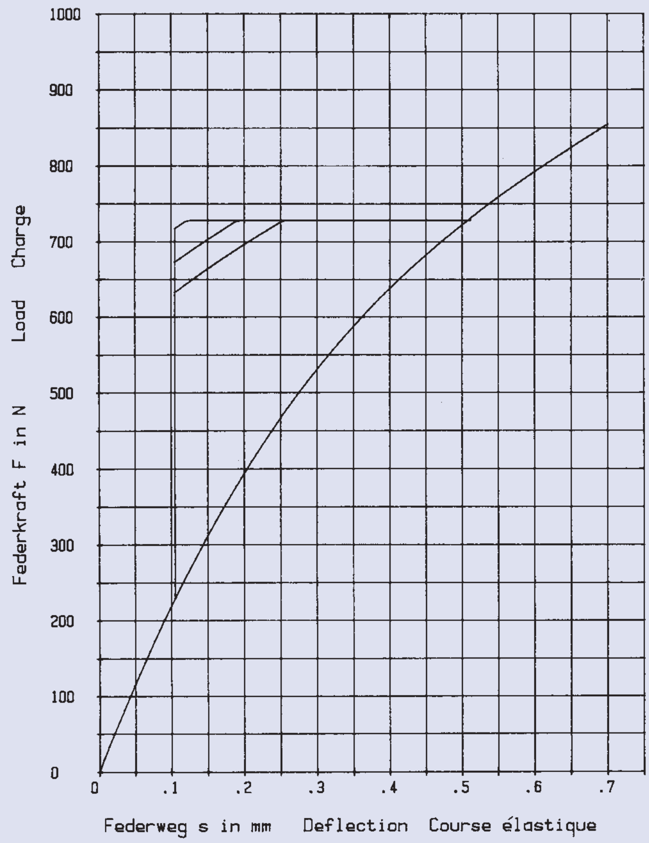
t = 0,6 mm — D_e/t = 30

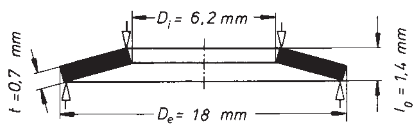
h_0/t = 1,0 — m = 1,056 g



18 x 6,2 x 0,7

GR 1





h_0 = 0,7 mm — D_e/D_i = 2,903

t = 0,7 mm — D_e/t = 25,714

h_0/t = 1,0 — m = 1,232 g

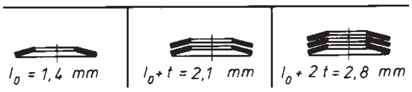
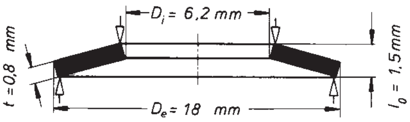


Diagramme | Diagrams | Diagrammes

18 x 6,2 x 0,8

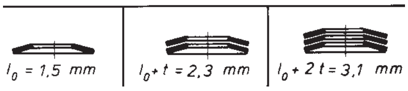
GR 1

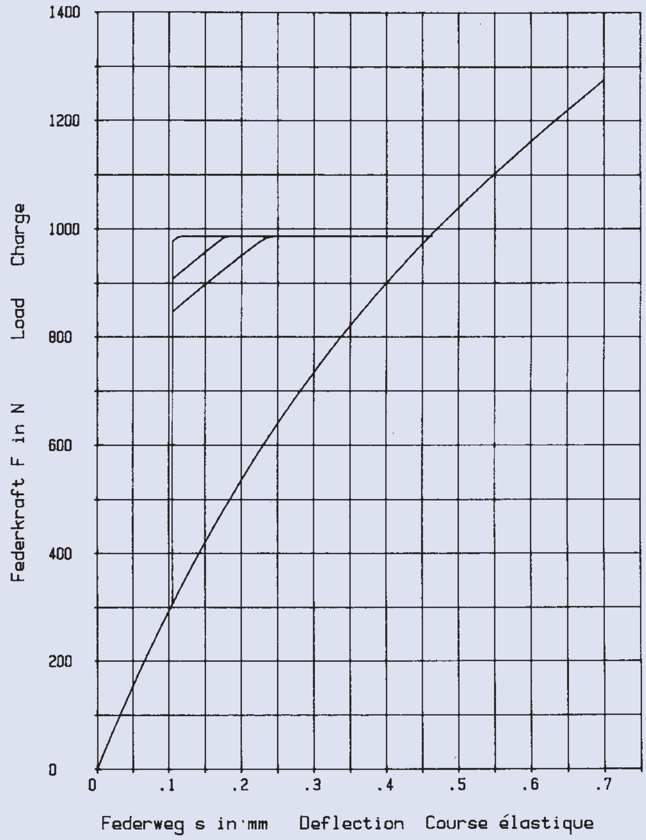


h_0 = 0,7 mm D_e/D_i = 2,903

t = 0,8 mm D_e/t = 22,5

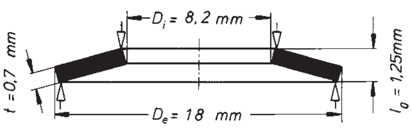
h_0/t = 0,875 m = 1,408 g





18 x 8,2 x 0,7

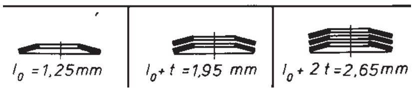
GR 1

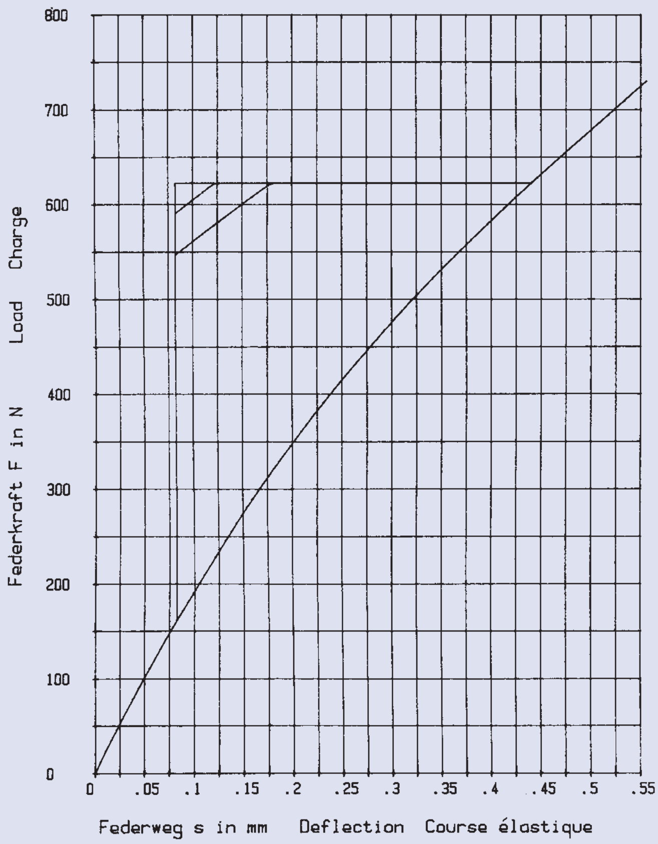


h_0 = 0,55 mm D_e/D_i = 2,195

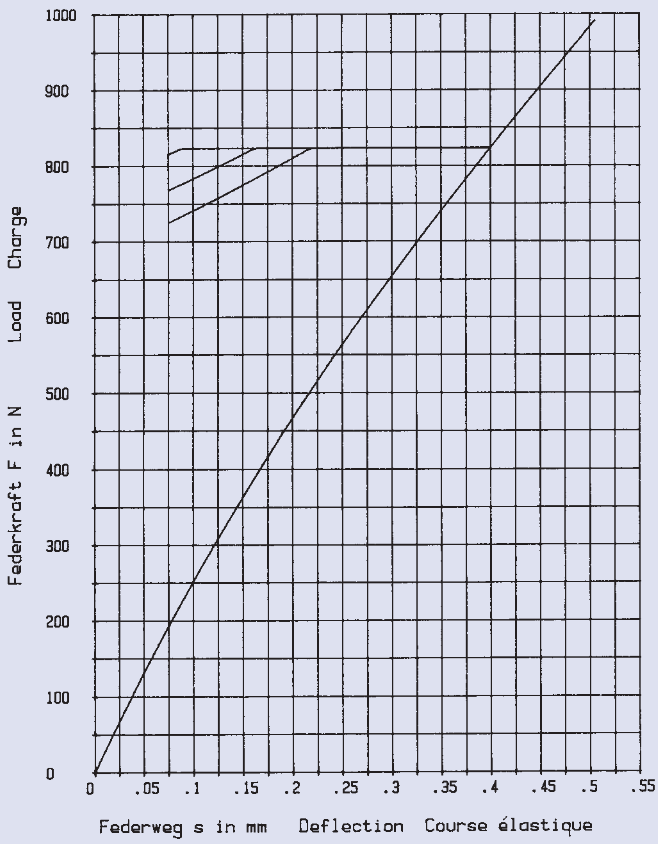
t = 0,7 mm D_e/t = 25,714

h_0/t = 0,785 m = 1,108 g

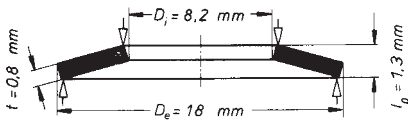




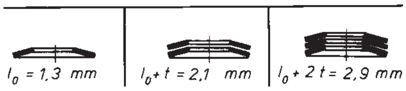
18 x 8,2 x 0,8



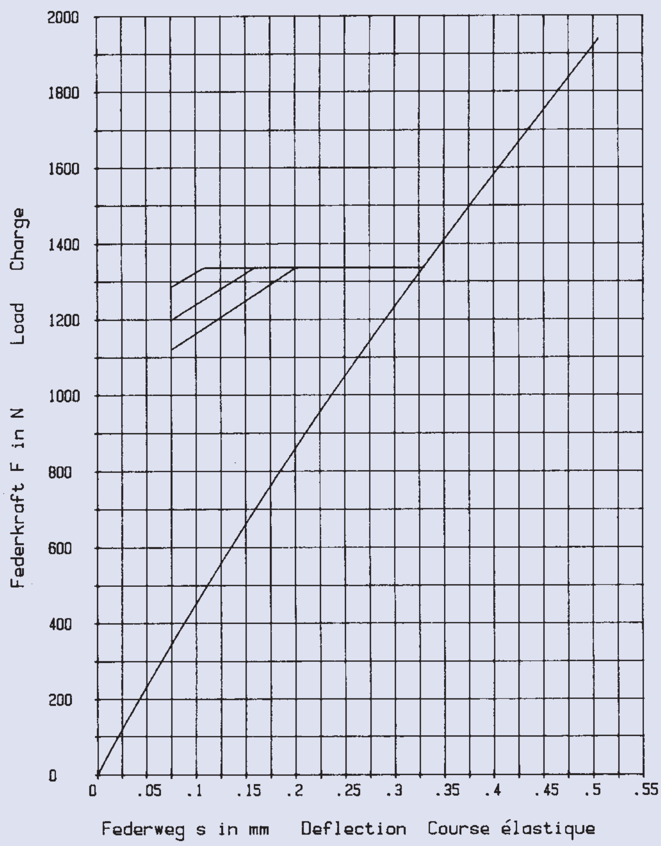
GR 1



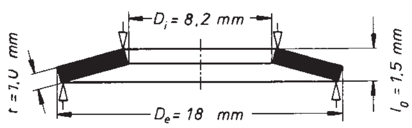
h_0 = 0,5 mm	D_e/D_i = 2,195
t = 0,8 mm	D_e/t = 22,5
h_0/t = 0,625	m = 1,266 g



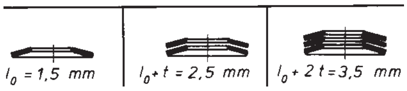
18 x 8,2 x 1,0



GR 1



h_0 = 0,5 mm	D_e/D_i = 2,195
t = 1,0 mm	D_e/t = 18
h_0/t = 0,5	m = 1,582 g



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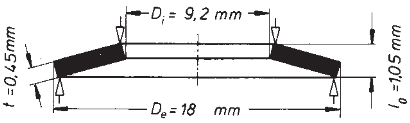
18 x 9,2 x 0,45

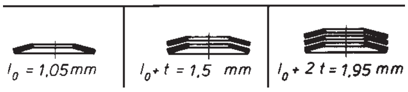
GR 1, DIN 2093 – C 18

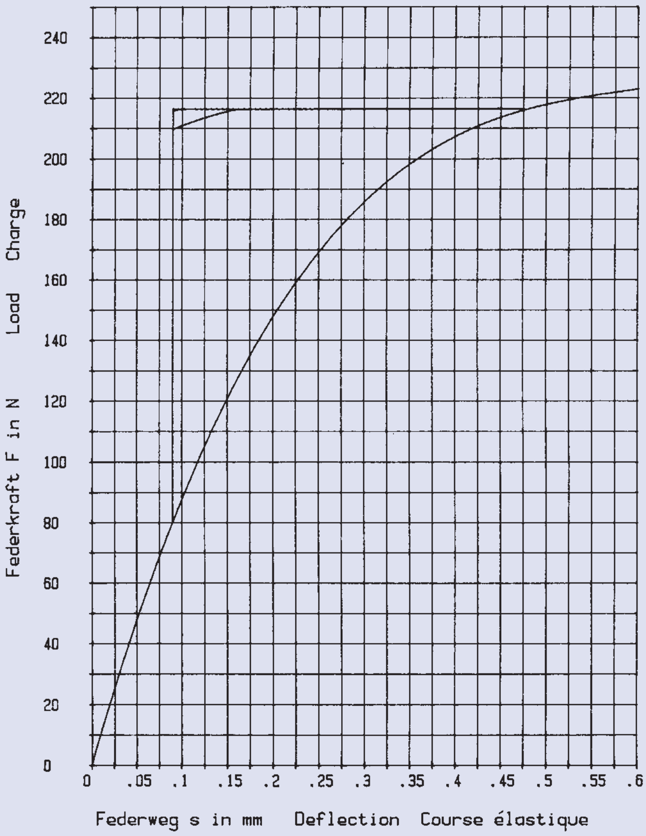


h_0 = 0,6 mm D_e/D_i = 1,956

t = 0,45mm D_e/t = 40

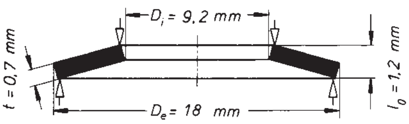
h_0/t = 1,333 m = 0,664 g





18 x 9,2 x 0,7

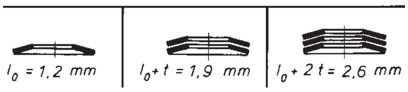
GR 1, DIN 2093 – B 18

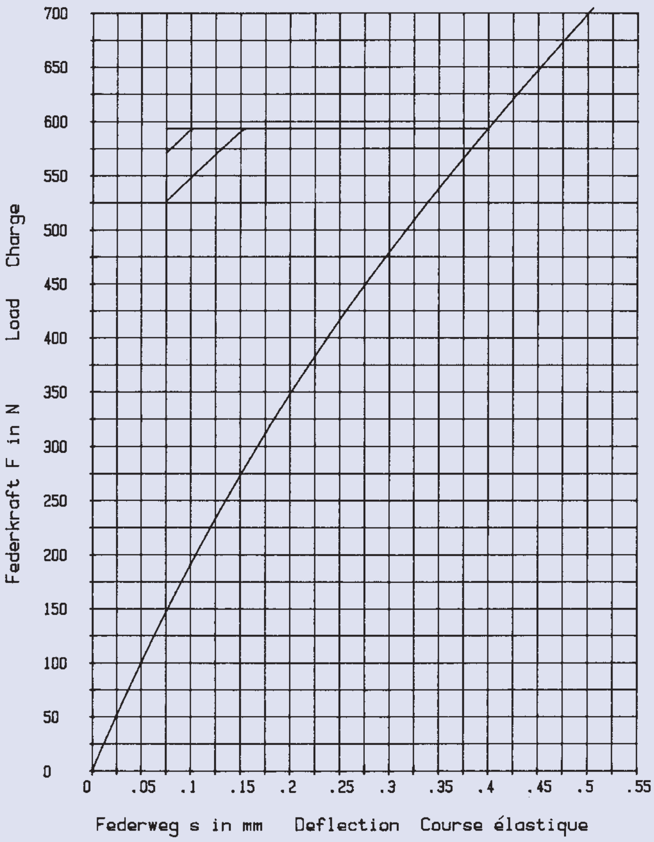


h_0 = 0,5 mm D_e/D_i = 1,956

t = 0,7 mm D_e/t = 25,714

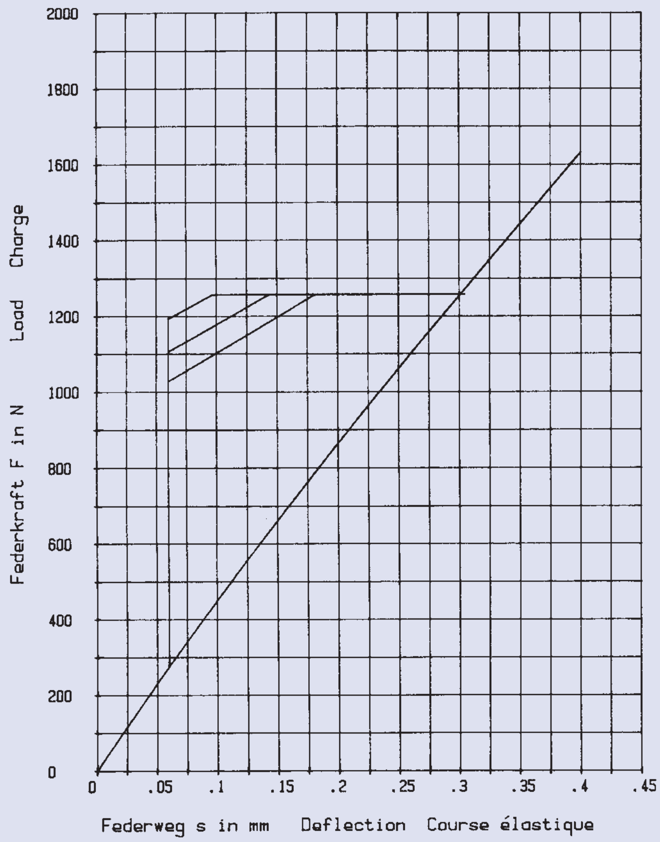
h_0/t = 0,714 m = 1,033 g

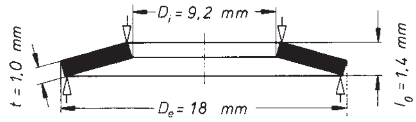




18 x 9,2 x 1,0

GR 1, DIN 2093 – A 18





h_0 = 0,4 mm D_e/D_i = 1,956

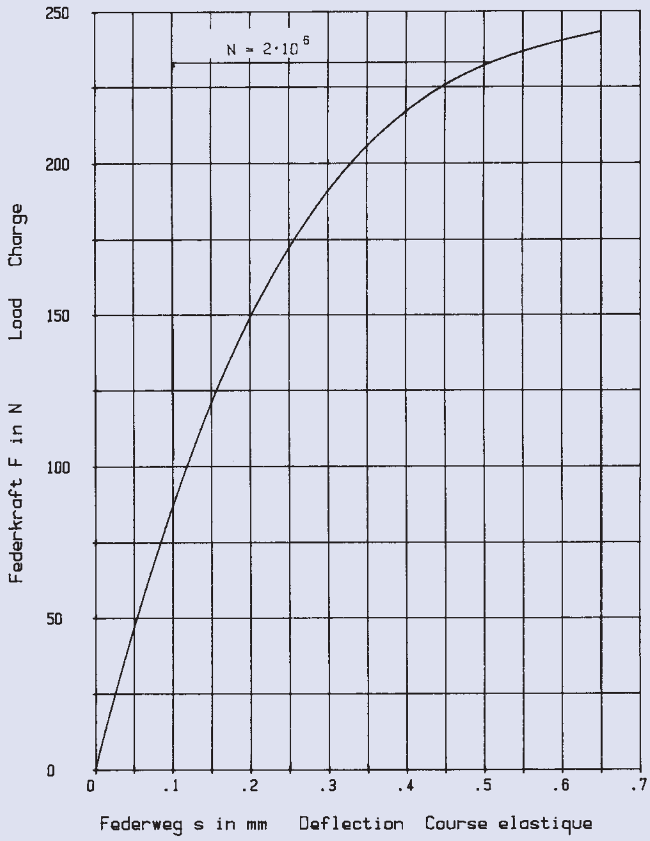
t = 1,0 mm D_e/t = 18

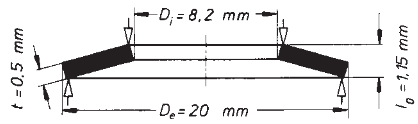
h_0/t = 0,4 m = 1,476 g

l_0 = 1,4 mm | $l_0 + t$ = 2,4 mm | $l_0 + 2t$ = 3,4 mm

20 x 8,2 x 0,5

GR 1





h_0 = 0,65 mm D_e/D_i = 2,439

t = 0,5 mm D_e/t = 40

h_0/t = 1,3 m = 1,026 g

l_0 = 1,15 mm | $l_0 + t$ = 1,65 mm | $l_0 + 2t$ = 2,15 mm

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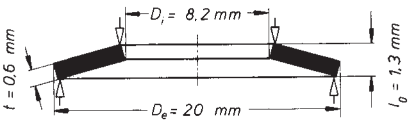
20 x 8,2 x 0,6

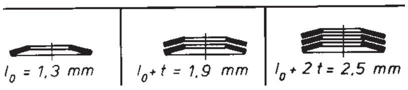
GR 1

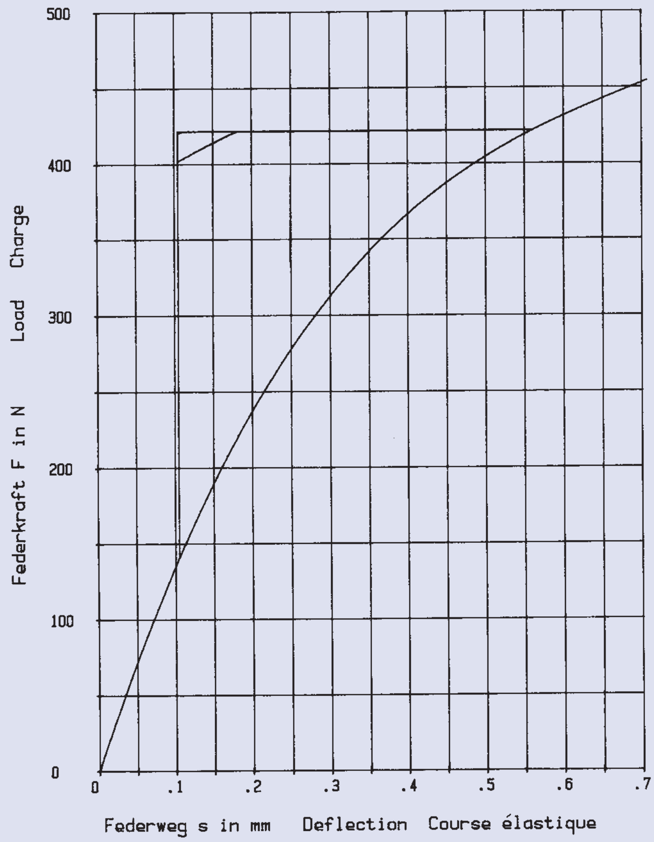


$h_0 = 0{,}7$ mm $D_e / D_i = 2{,}439$

$t = 0{,}6$ mm $D_e / t = 33{,}333$

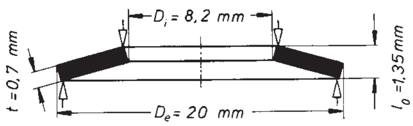
$h_0 / t = 1{,}166$ $m = 1{,}231$ g





20 x 8,2 x 0,7

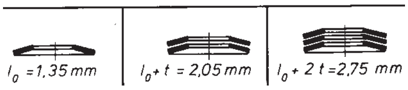
GR 1

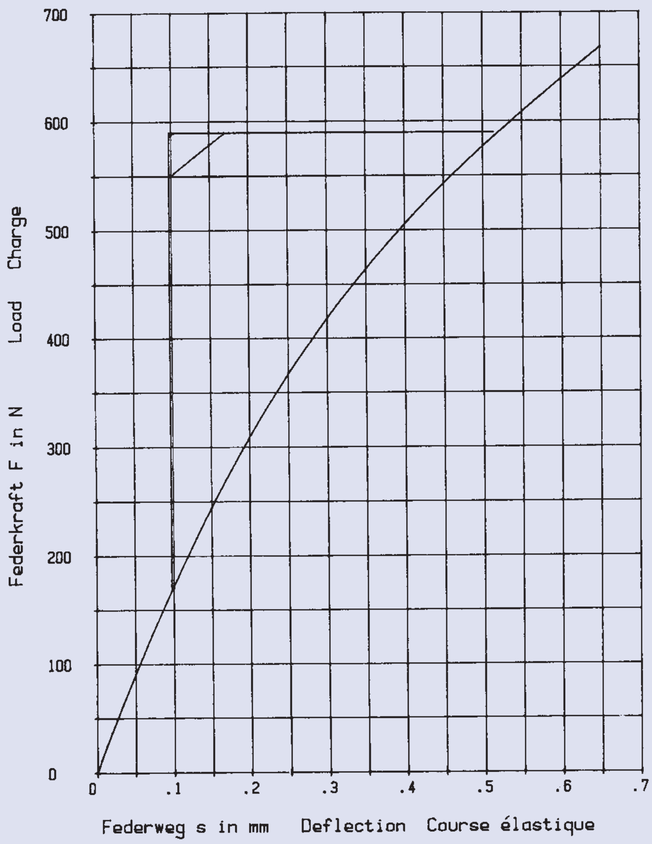


$h_0 = 0{,}65$ mm $D_e / D_i = 2{,}439$

$t = 0{,}7$ mm $D_e / t = 28{,}571$

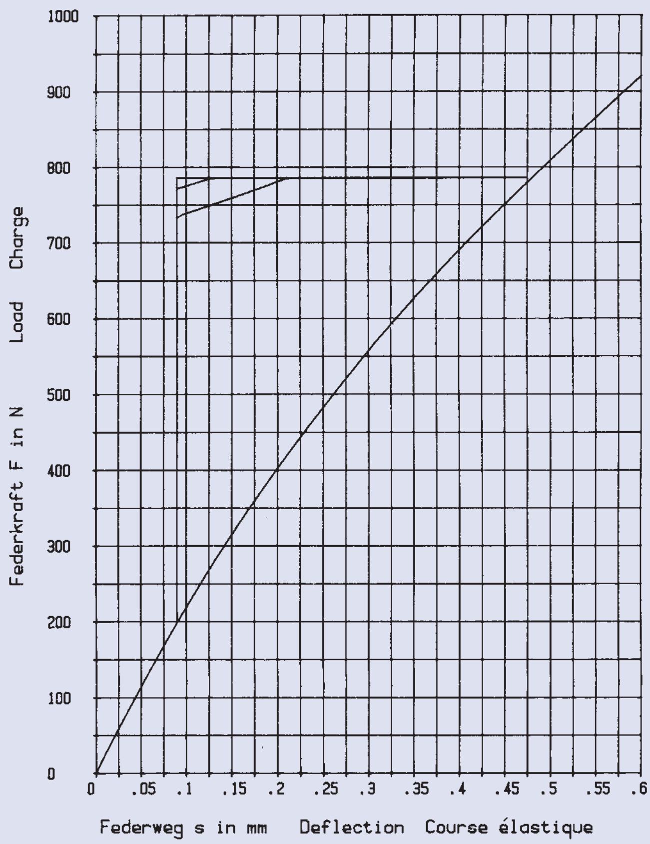
$h_0 / t = 0{,}928$ $m = 1{,}436$ g

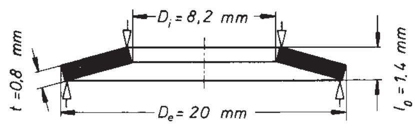




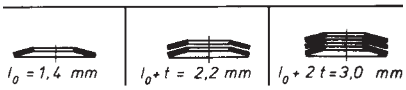
20 x 8,2 x 0,8

GR 1



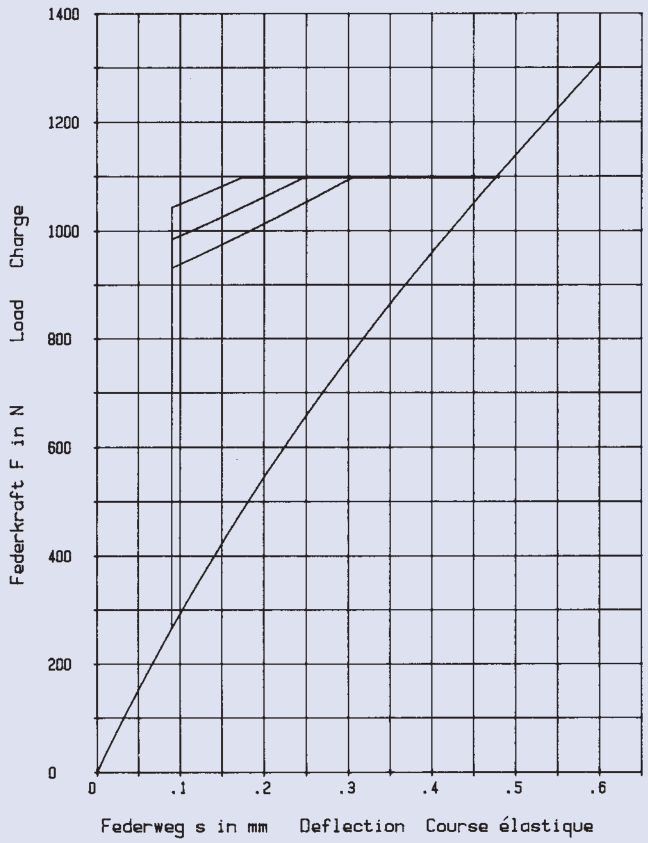


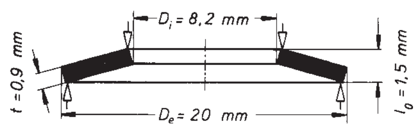
h_0 = 0,6 mm	D_e/D_i = 2,439
t = 0,8 mm	D_e/t = 25
h_0/t = 0,75	m = 1,641 g



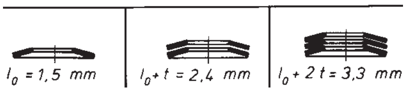
20 x 8,2 x 0,9

GR 1





h_0 = 0,6 mm	D_e/D_i = 2,439
t = 0,9 mm	D_e/t = 22,222
h_0/t = 0,666	m = 1,846 g



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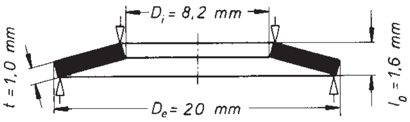
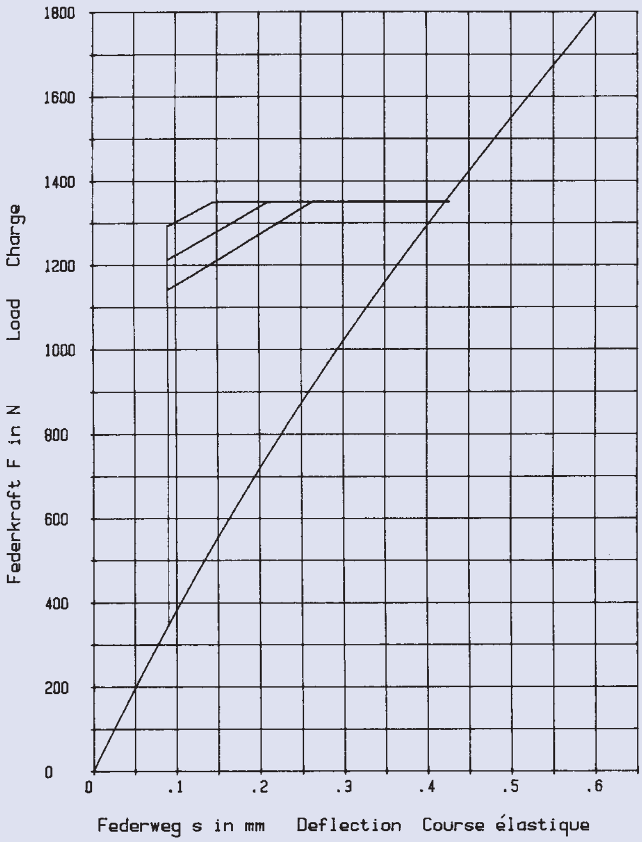
20 x 8,2 x 1,0

GR 1



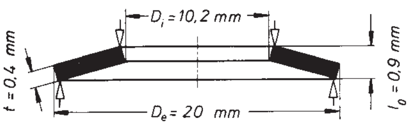
h_0 = 0,6 mm	D_e/D_i = 2,439
t = 1,0 mm	D_e/t = 20
h_0/t = 0,6	m = 2,051 g

l_0 = 1,6 mm	l_0 + t = 2,6 mm	l_0 + 2 t = 3,6 mm



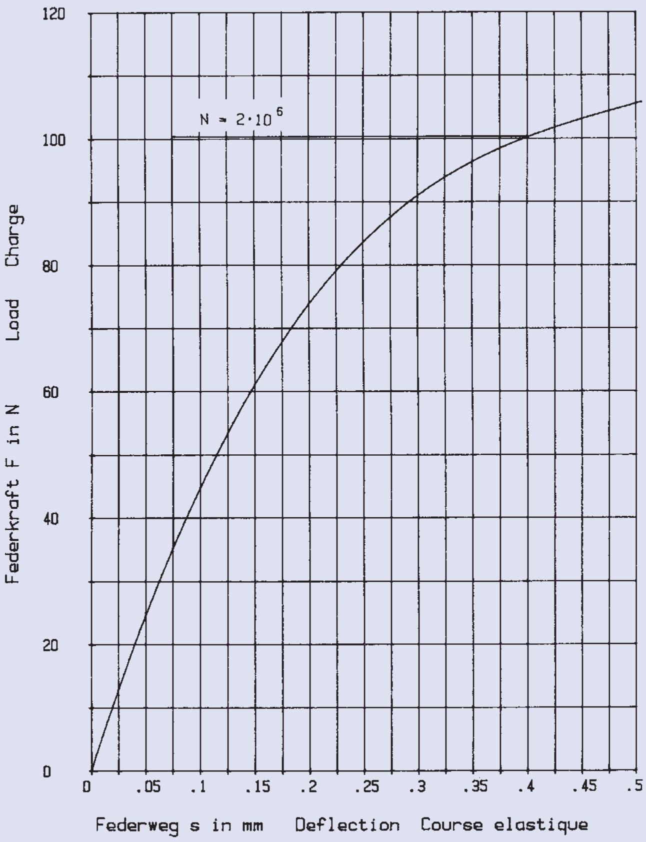
20 x 10,2 x 0,4

GR 1



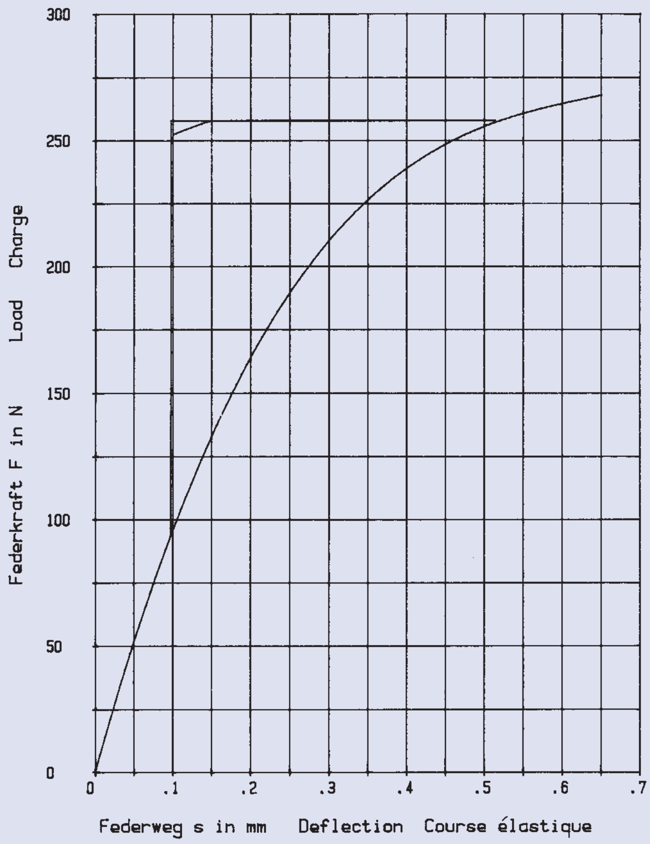
h_0 = 0,5 mm	D_e/D_i = 1,96
t = 0,4 mm	D_e/t = 50
h_0/t = 1,25	m = 0,73 g

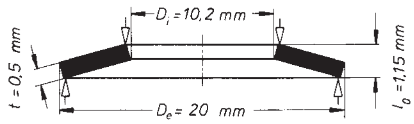
l_0 = 0,9 mm	l_0 + t = 1,3 mm	l_0 + 2 t = 1,7 mm



20 x 10,2 x 0,5

GR 1, DIN 2093 – C 20

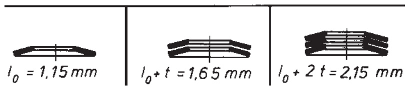




$h_0 = 0{,}65$ mm $D_e / D_i = 1{,}96$

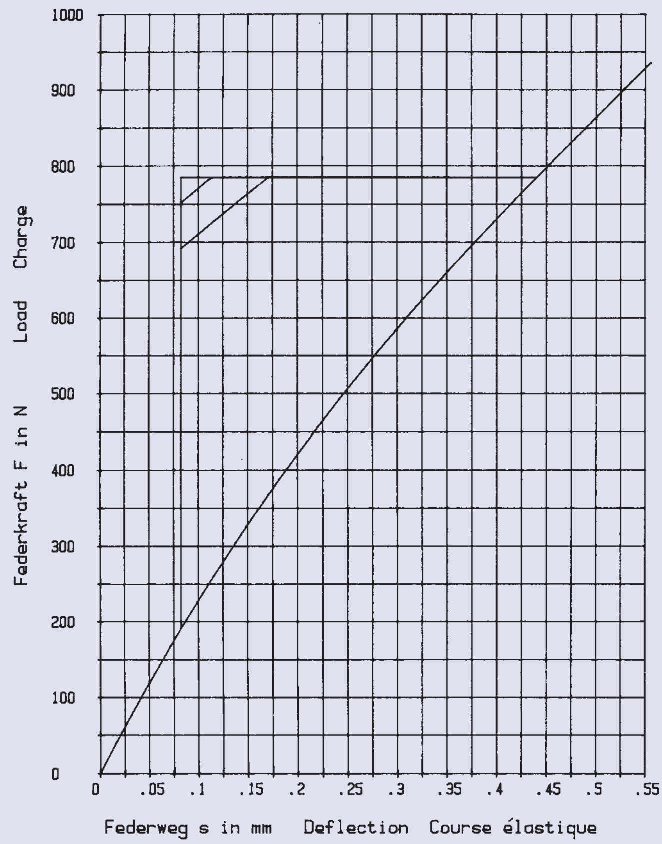
$t = 0{,}5$ mm $D_e / t = 40$

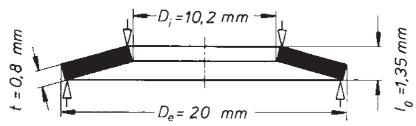
$h_0 / t = 1{,}3$ $m = 0{,}912$ g



20 x 10,2 x 0,8

GR 1, DIN 2093 – B 20

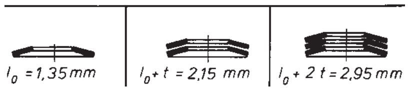




$h_0 = 0{,}55$ mm $D_e / D_i = 1{,}96$

$t = 0{,}8$ mm $D_e / t = 25$

$h_0 / t = 0{,}687$ $m = 1{,}46$ g



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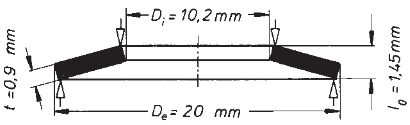
20 x 10,2 x 0,9

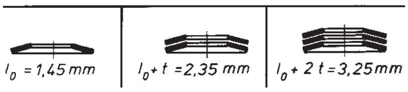
GR 1

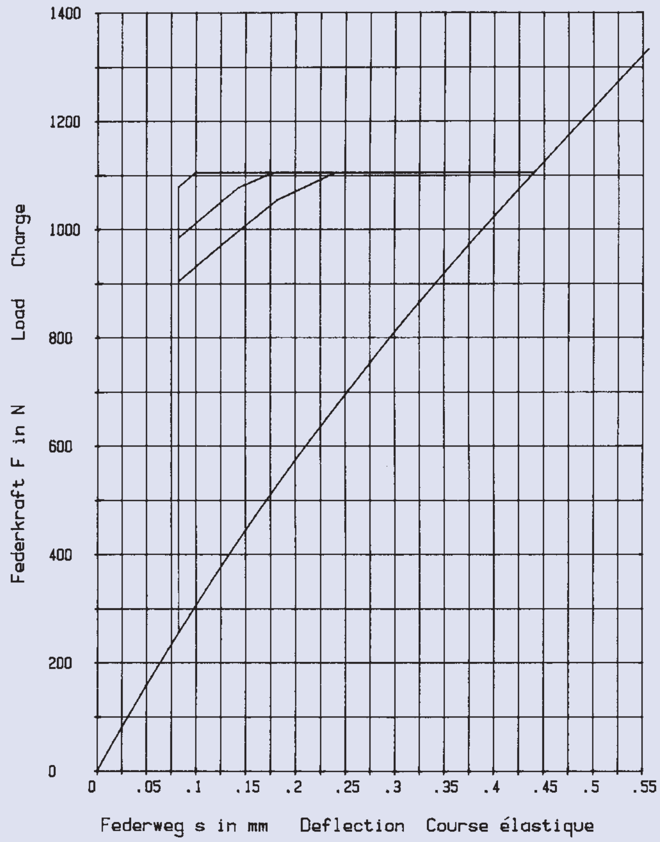


$h_0 = 0,55mm$ — $D_e / D_i = 1,96$

$t = 0,9\ mm$ — $D_e / t = 22,222$

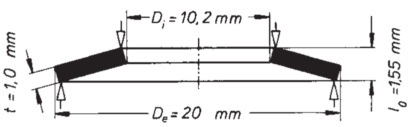
$h_0 / t = 0,611$ — $m = 1,642\ g$





20 x 10,2 x 1,0

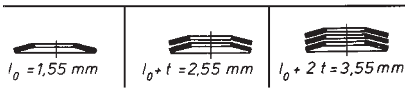
GR 1

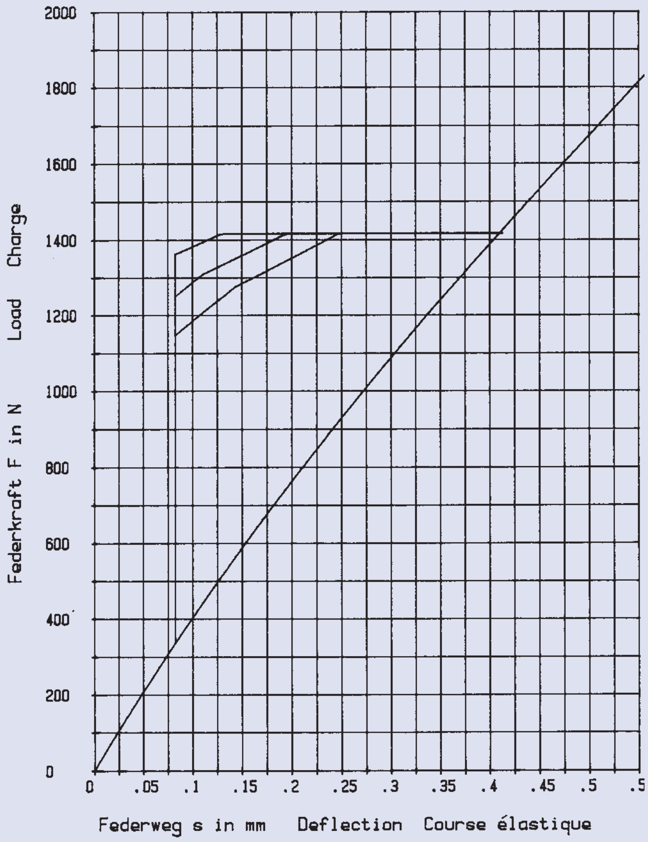


$h_0 = 0,55mm$ — $D_e / D_i = 1,96$

$t = 1,0\ mm$ — $D_e / t = 20$

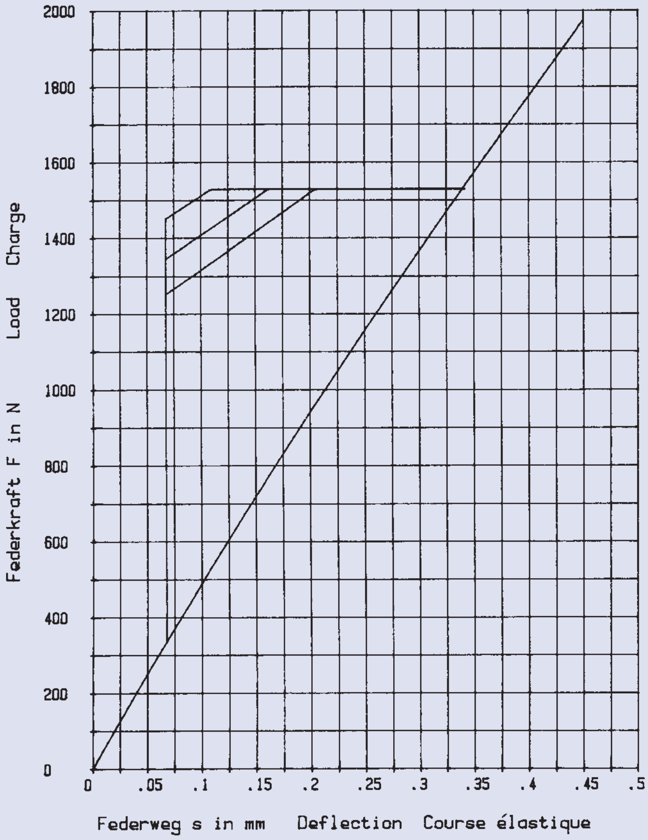
$h_0 / t = 0,55$ — $m = 1,824\ g$

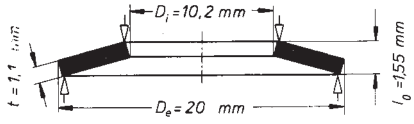




20 x 10,2 x 1,1

GR 1, DIN 2093 – A 20

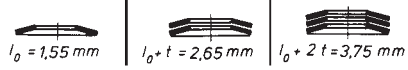




$h_0 = 0{,}45$ mm $\quad D_e/D_i = 1{,}96$

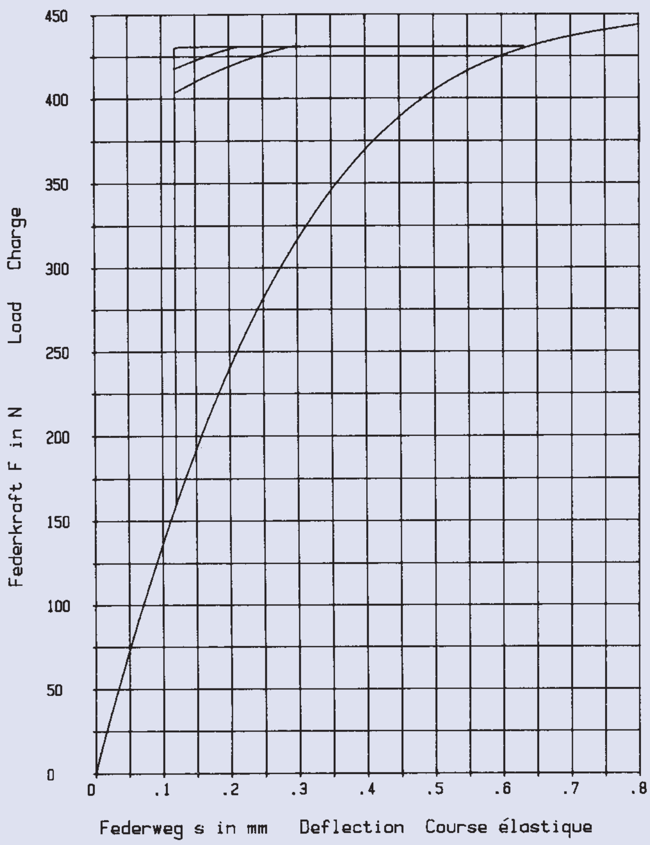
$t = 1{,}1$ mm $\quad D_e/t = 18{,}181$

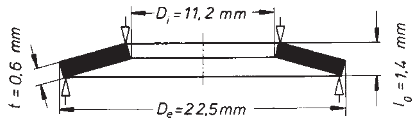
$h_0/t = 0{,}409 \quad m = 2{,}007$ g



22,5 x 11,2 x 0,6

GR 1, DIN 2093 – C 22,5

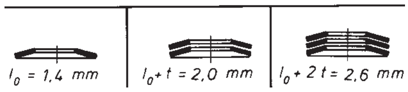




$h_0 = 0{,}8$ mm $\quad D_e/D_i = 2{,}008$

$t = 0{,}6$ mm $\quad D_e/t = 37{,}5$

$h_0/t = 1{,}333 \quad m = 1{,}409$ g



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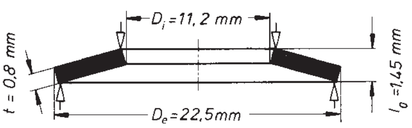
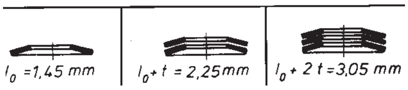
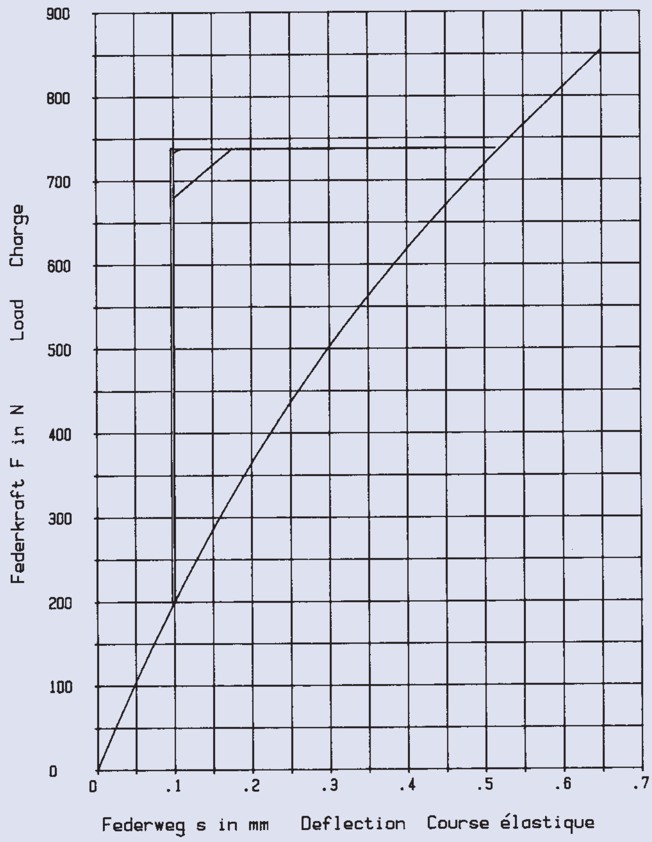
22,5 x 11,2 x 0,8

GR 1, DIN 2093 – B 22,5



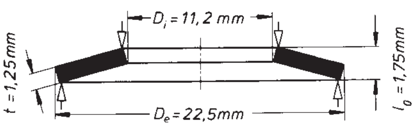
h_0=0,65mm | D_e/D_i = 2,008
t = 0,8 mm | D_e/t = 28,125
h_0/t=0,812 | m = 1,878 g



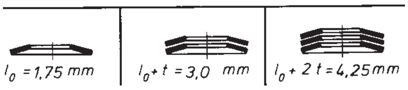


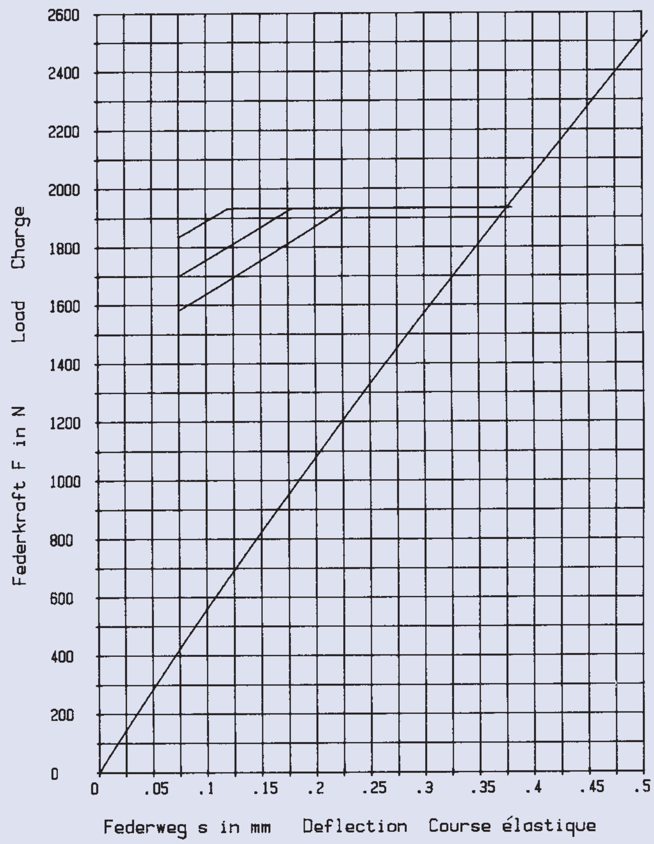
22,5 x 11,2 x 1,25

GR 1, DIN 2093 – A 22,5



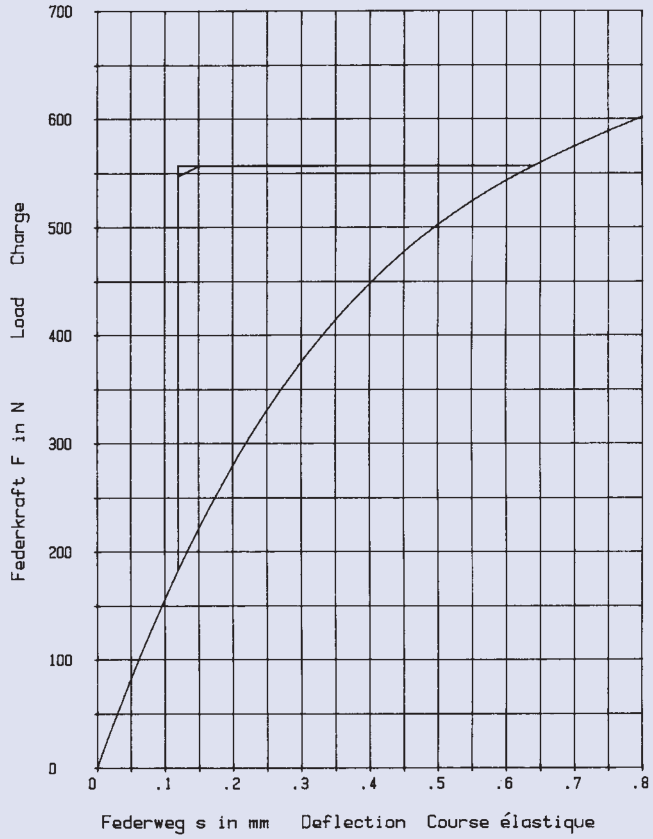
h_0= 0,5 mm | D_e/D_i = 2,008
t =1,25mm | D_e/t = 18
h_0/t= 0,4 | m = 2,935 g

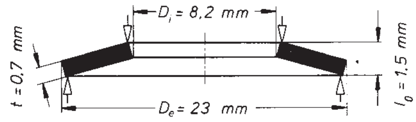




23 x 8,2 x 0,7

GR 1

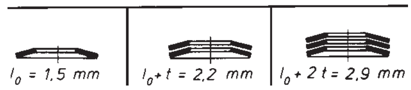




h_0 = 0,8 mm — D_e/D_i = 2,804

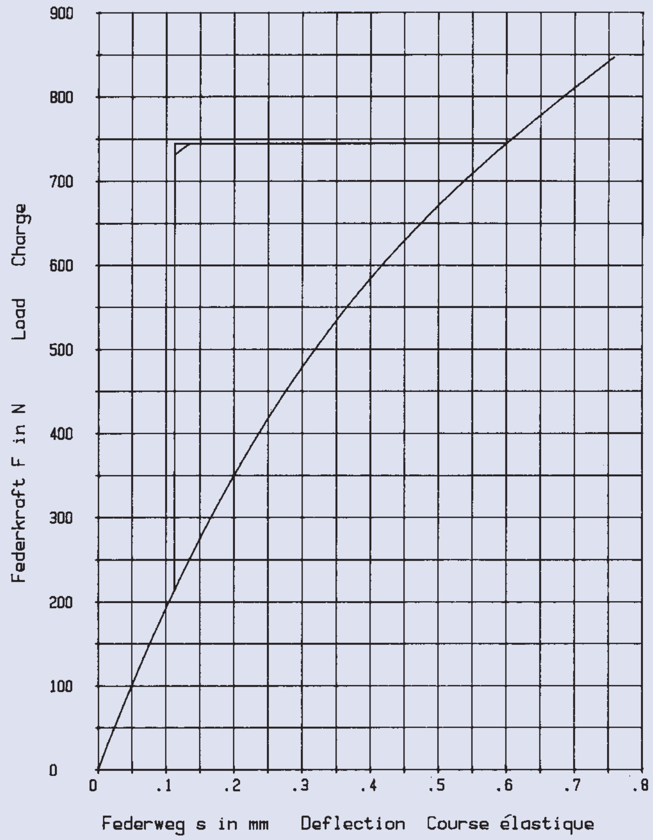
t = 0,7 mm — D_e/t = 32,857

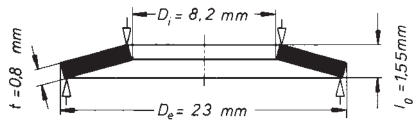
h_0/t = 1,142 — m = 1,993 g



23 x 8,2 x 0,8

GR 1





h_0 = 0,75 mm — D_e/D_i = 2,804

t = 0,8 mm — D_e/t = 28,75

h_0/t = 0,937 — m = 2,277 g

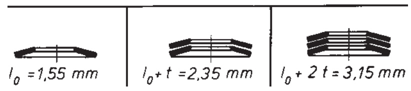
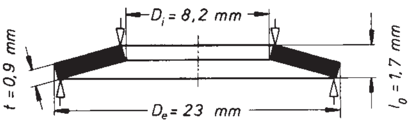


Diagramme | Diagrams | Diagrammes

23 x 8,2 x 0,9

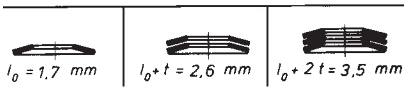
GR 1

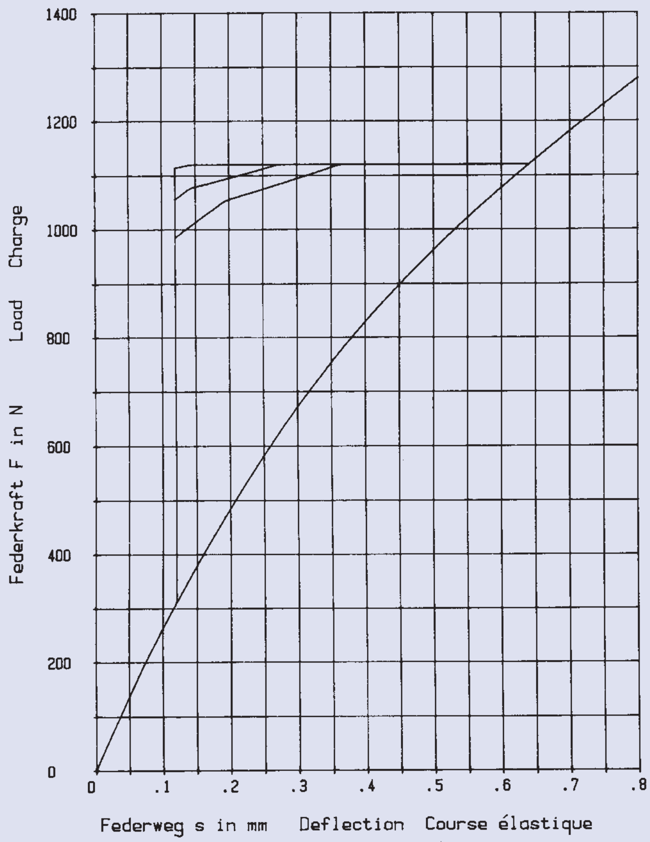


h_0 = 0,8 mm — D_e/D_i = 2,804

t = 0,9 mm — D_e/t = 25,555

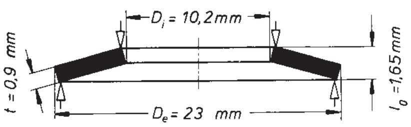
h_0/t = 0,888 — m = 2,561 g





23 x 10,2 x 0,9

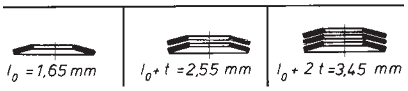
GR 1

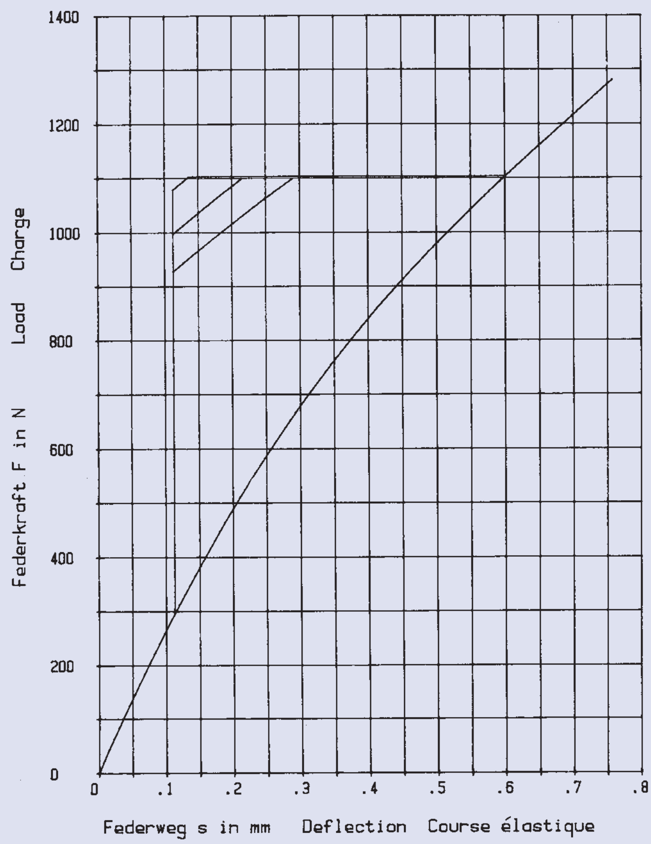


h_0 = 0,75 mm — D_e/D_i = 2,254

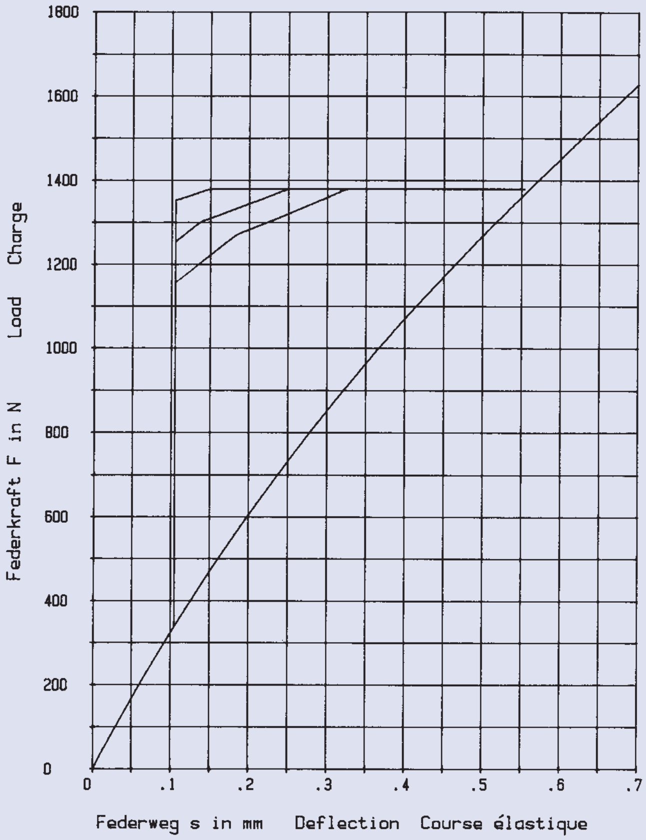
t = 0,9 mm — D_e/t = 25,555

h_0/t = 0,833 — m = 2,357 g

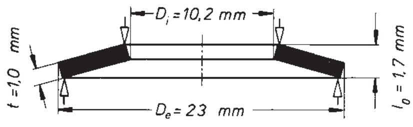




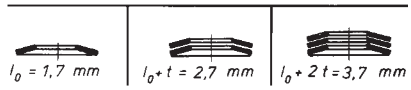
23 x 10,2 x 1,0



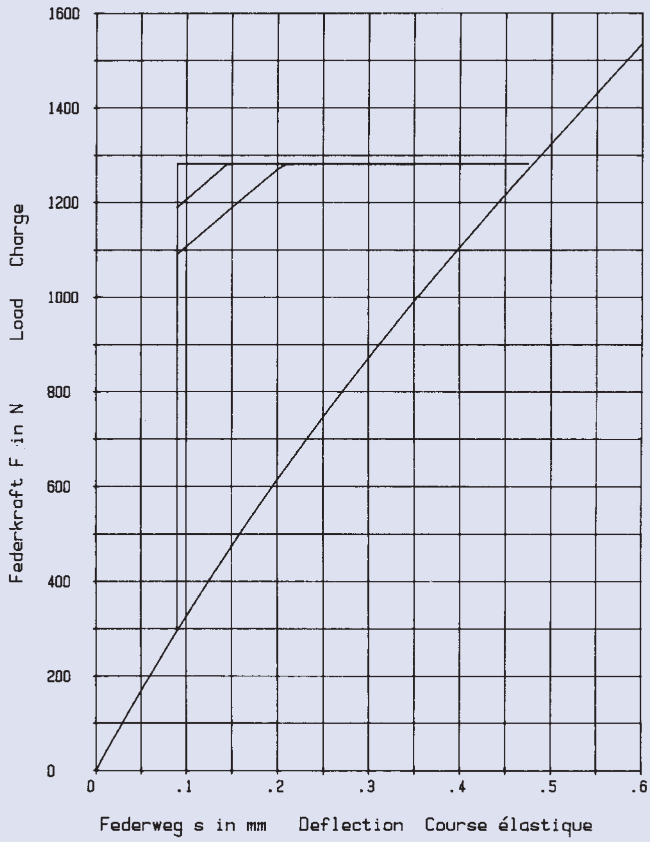
GR 1



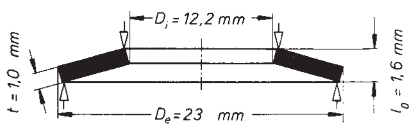
h_0 = 0,7 mm	D_e/D_i = 2,254
t = 1,0 mm	D_e/t = 23
h_0/t = 0,7	m = 2,619 g



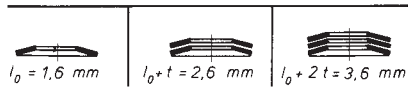
23 x 12,2 x 1,0



GR 1

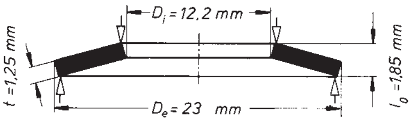


h_0 = 0,6 mm	D_e/D_i = 1,885
t = 1,0 mm	D_e/t = 23
h_0/t = 0,6	m = 2,343 g

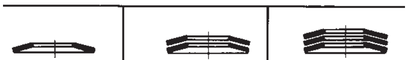


23 x 12,2 x 1,25

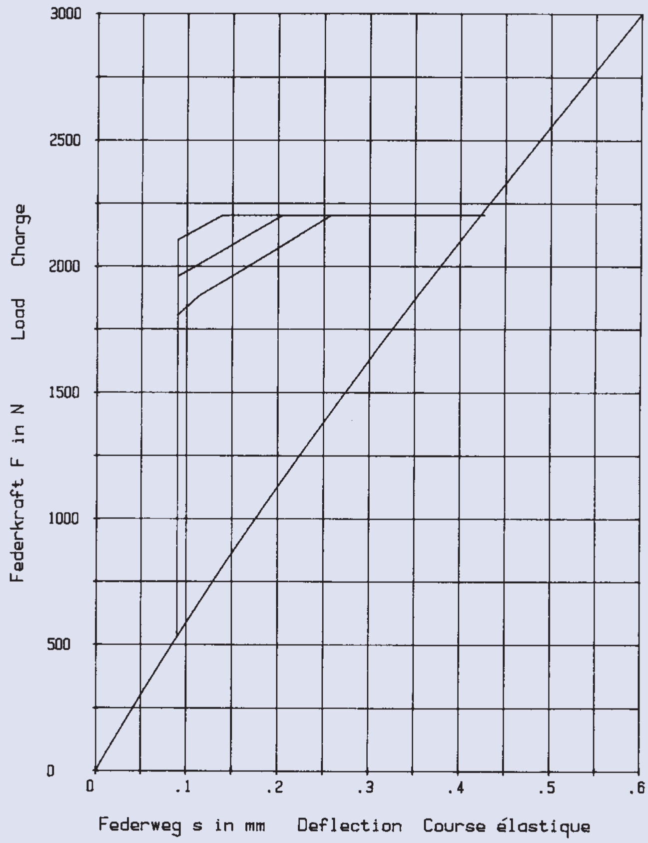
GR 2



$h_0 = 0,6$ mm	$D_e / D_i = 1,885$
$t = 1,25$ mm	$D_e / t = 18,4$
$h_0 / t = 0,48$	$m = 2,929$ g

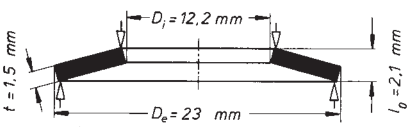


$l_0 = 1,85$ mm	$l_0 + t = 3,1$ mm	$l_0 + 2t = 4,35$ mm



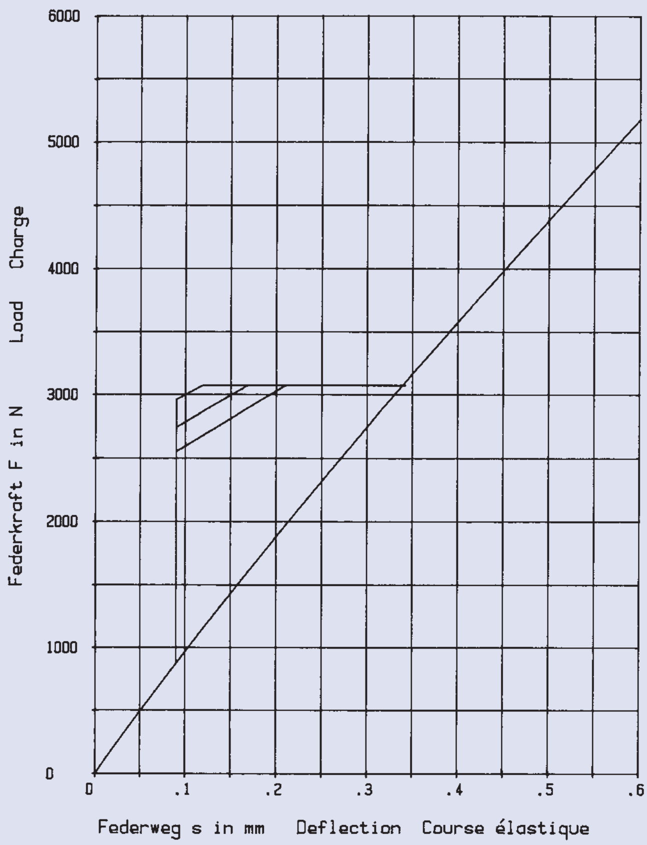
23 x 12,2 x 1,5

GR 2



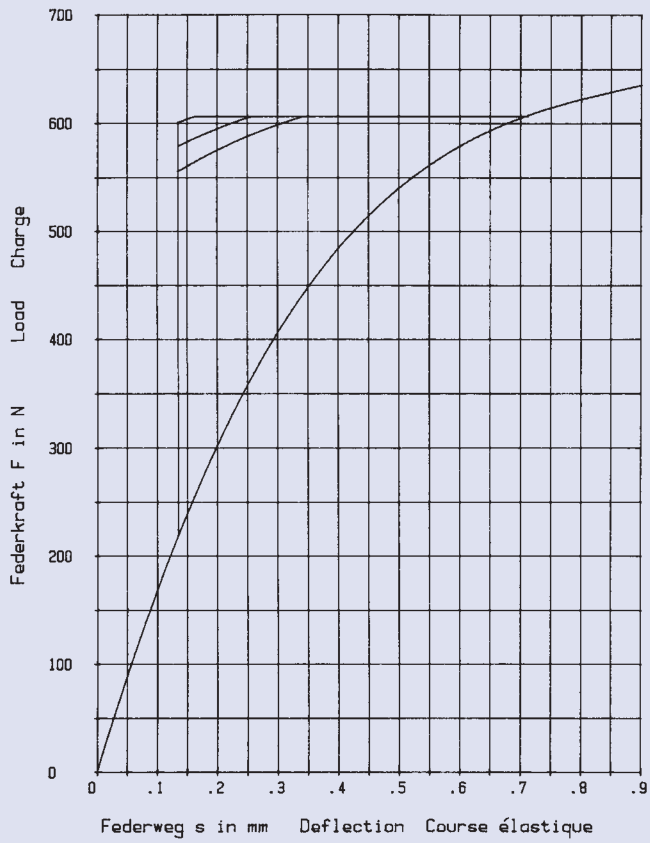
$h_0 = 0,6$ mm	$D_e / D_i = 1,885$
$t = 1,5$ mm	$D_e / t = 15,333$
$h_0 / t = 0,4$	$m = 3,514$ g

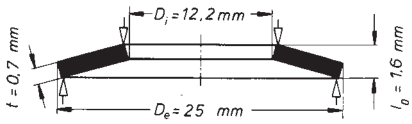
$l_0 = 2,1$ mm	$l_0 + t = 3,6$ mm	$l_0 + 2t = 5,1$ mm



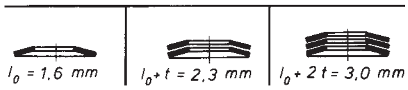
25 x 12,2 x 0,7

GR 1, DIN 2093 – C 25



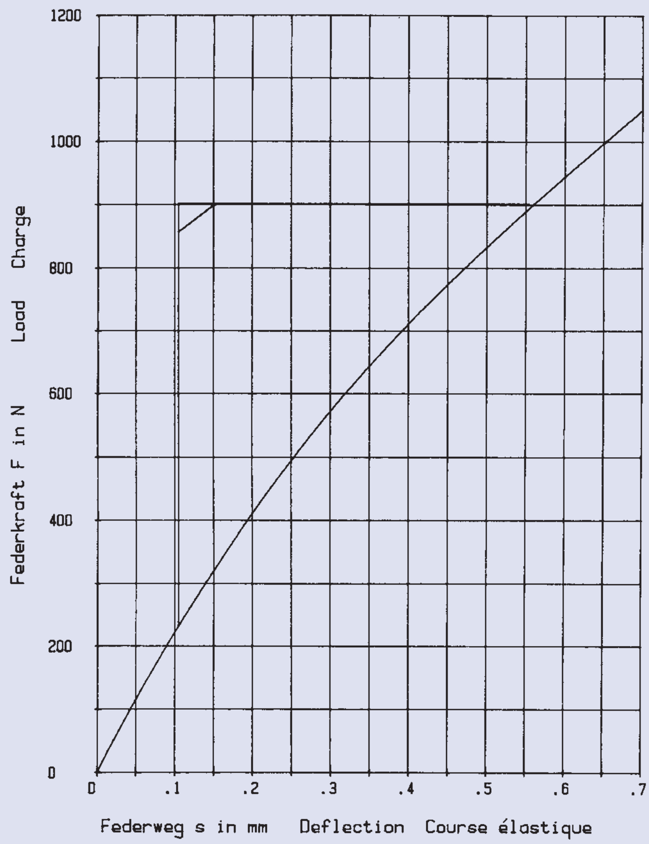


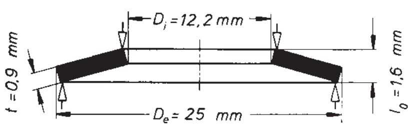
h_0 = 0,9 mm	D_e/D_i = 2,049
t = 0,7 mm	D_e/t = 35,714
h_0/t = 1,285	m = 2,055 g



25 x 12,2 x 0,9

GR 1, DIN 2093 – B 25





h_0 = 0,7 mm	D_e/D_i = 2,049
t = 0,9 mm	D_e/t = 27,777
h_0/t = 0,777	m = 2,642 g

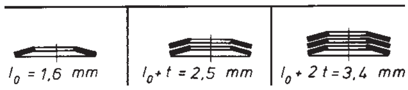
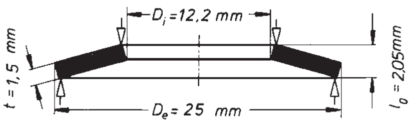


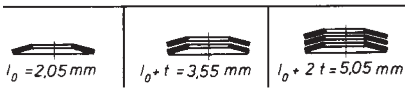
Diagramme | Diagrams | Diagrammes

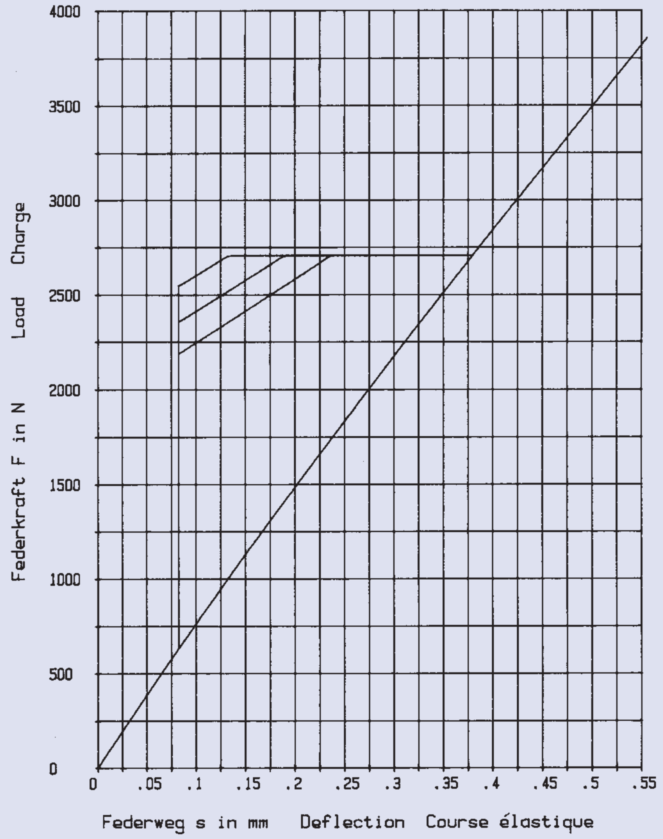
25 x 12,2 x 1,5

GR 2, DIN 2093 – A 25



h_0 = 0,55mm	D_e/D_i = 2,049
t = 1,5 mm	D_e/t = 16,666
h_0/t = 0,366	m = 4,403 g

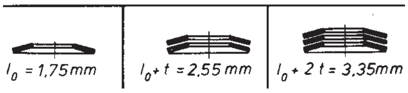


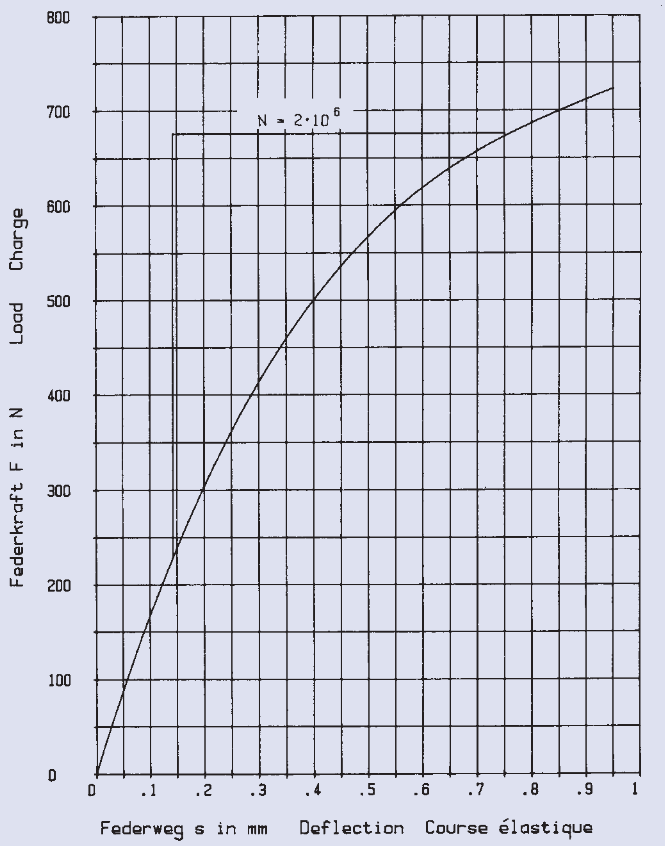


28 x 10,2 x 0,8

GR 1

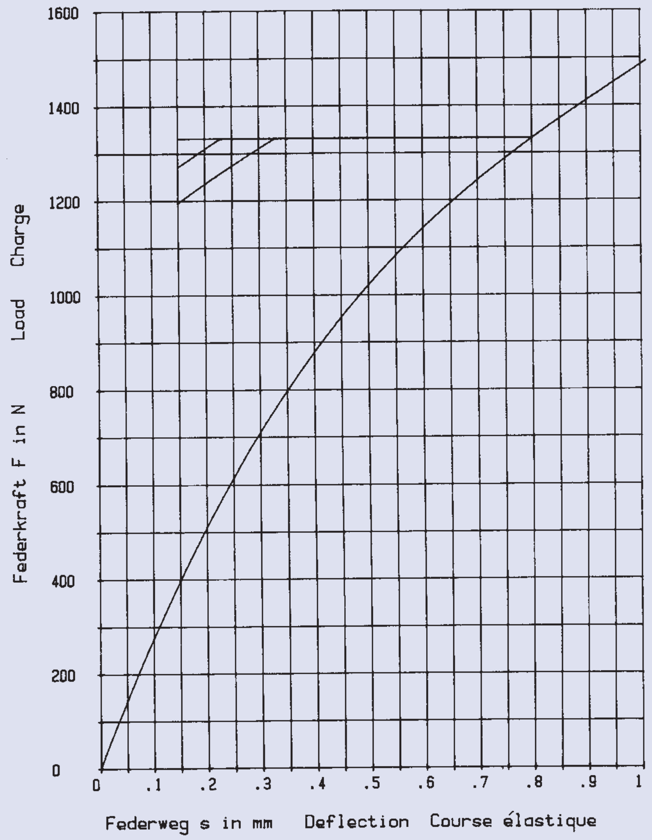
h_0 = 0,95mm	D_e/D_i = 2,745
t = 0,8 mm	D_e/t = 35
h_0/t = 1,187	m = 3,354 g

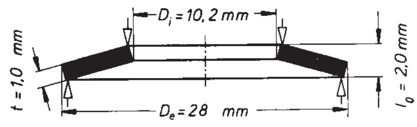




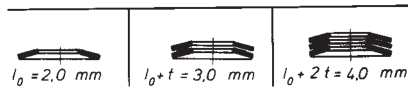
28 x 10,2 x 1,0

GR 1



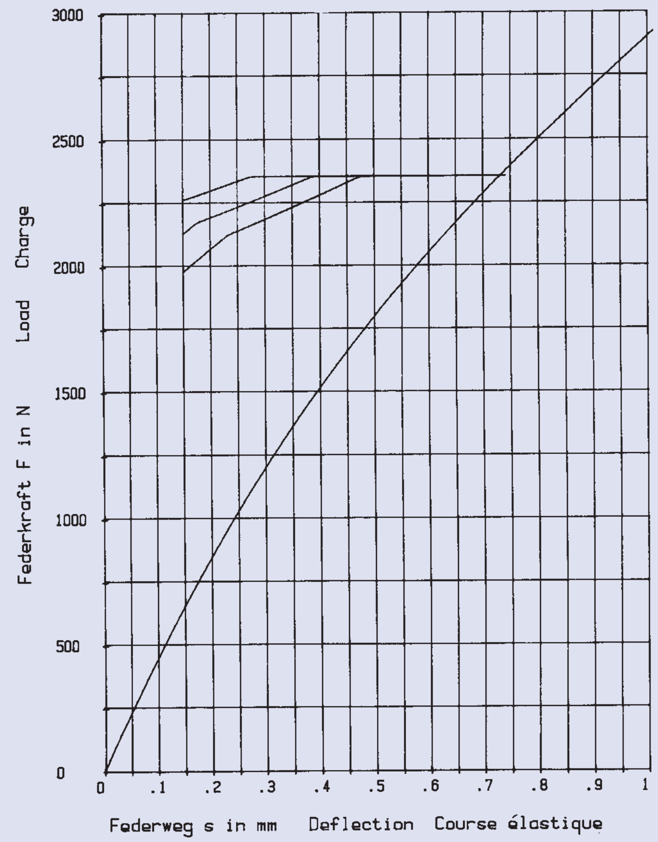


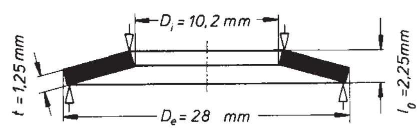
h_0 = 1,0 mm
D_e/D_i = 2,745
t = 1,0 mm
D_e/t = 28
h_0/t = 1,0
m = 4,191 g



28 x 10,2 x 1,25

GR 2





h_0 = 1,0 mm
D_e/D_i = 2,745
t = 1,25 mm
D_e/t = 22,4
h_0/t = 0,8
m = 5,238 g

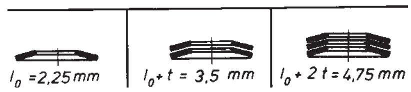
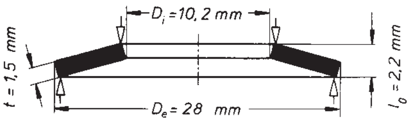


Diagramme | Diagrams | Diagrammes

28 x 10,2 x 1,5

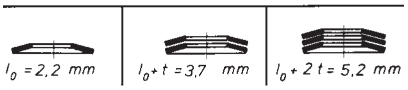
GR 2

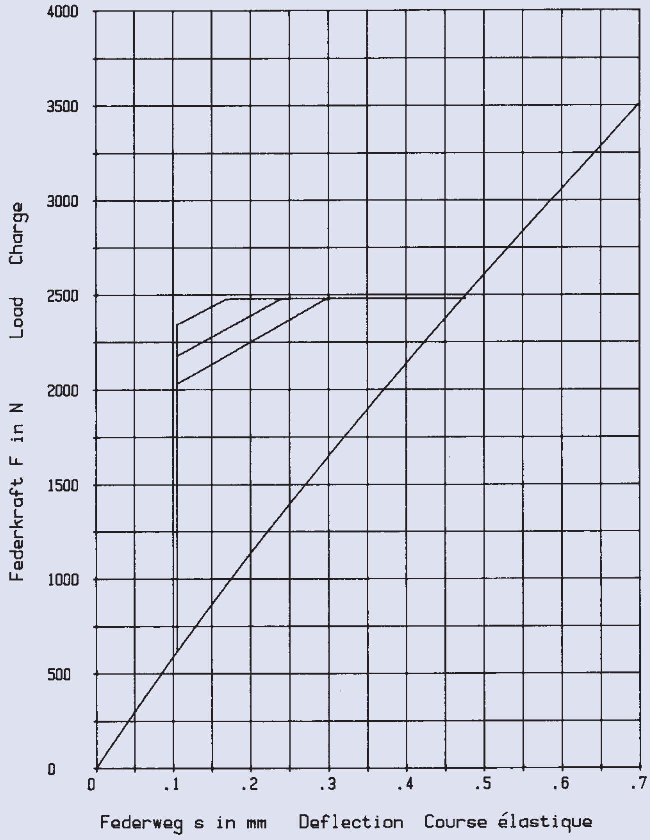


h_0 = 0,7 mm D_e/D_i = 2,745

t = 1,5 mm D_e/t = 18,666

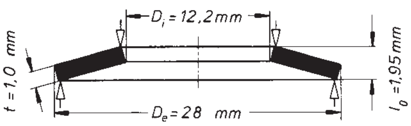
h_0/t = 0,466 m = 6,286 g





28 x 12,2 x 1,0

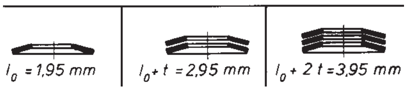
GR 1



h_0 = 0,95 mm D_e/D_i = 2,295

t = 1,0 mm D_e/t = 28

h_0/t = 0,95 m = 3,914 g



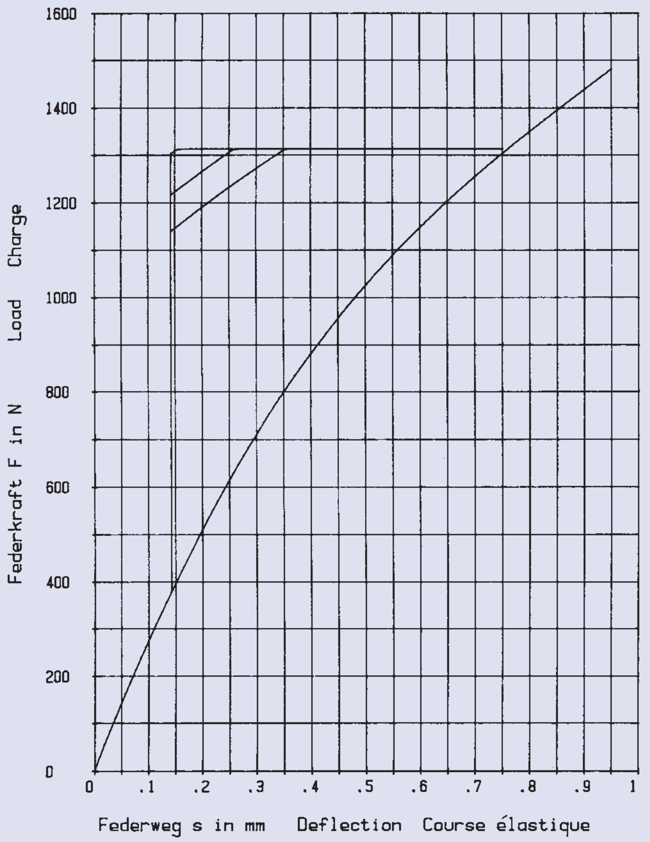
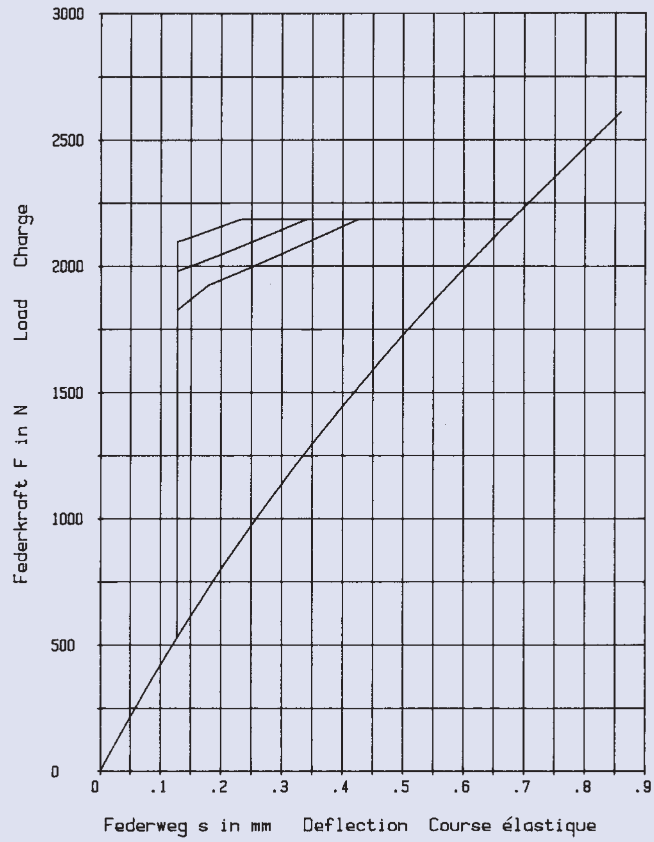
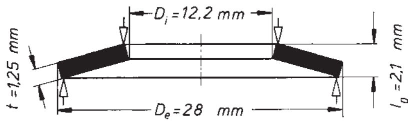


Diagramme | Diagrams | Diagrammes

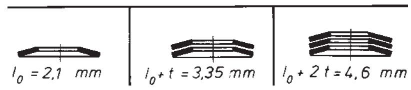
28 x 12,2 x 1,25

GR 2



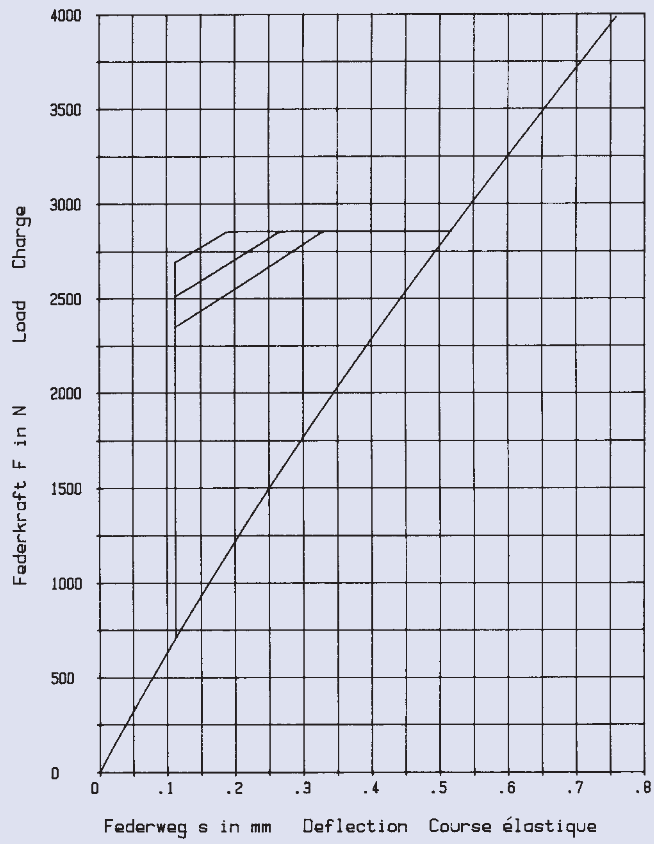


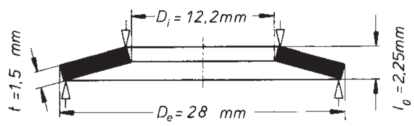
h_0 = 0,85 mm	D_e/D_i = 2,295
t = 1,25 mm	D_e/t = 22,4
h_0/t = 0,68	m = 4,893 g



28 x 12,2 x 1,5

GR 2





h_0 = 0,75 mm	D_e/D_i = 2,295
t = 1,5 mm	D_e/t = 18,666
h_0/t = 0,5	m = 5,872 g

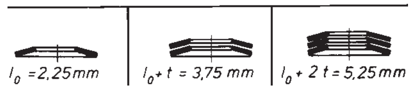
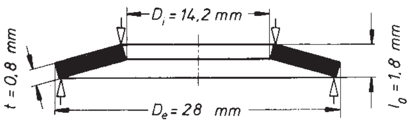


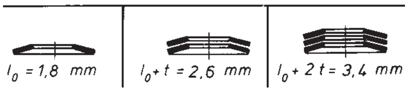
Diagramme | Diagrams | Diagrammes

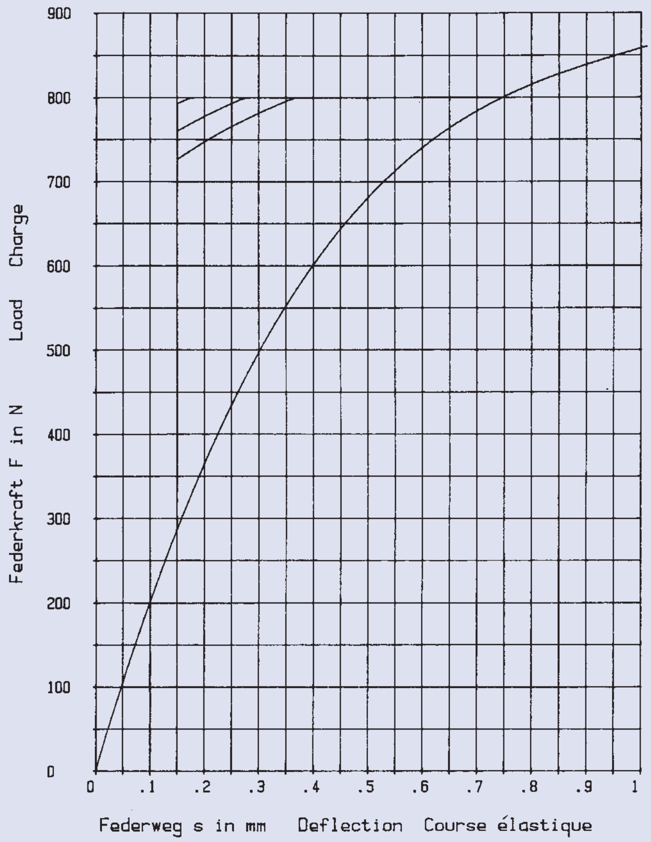
28 x 14,2 x 0,8

GR 1, DIN 2093 – C 28



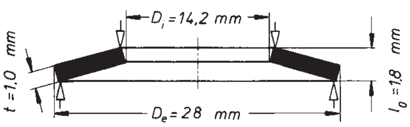
h_0 = 1,0 mm	D_e/D_i = 1,971
t = 0,8 mm	D_e/t = 35
h_0/t = 1,25	m = 2,872 g



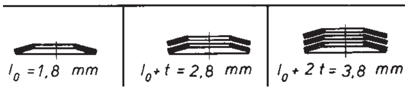


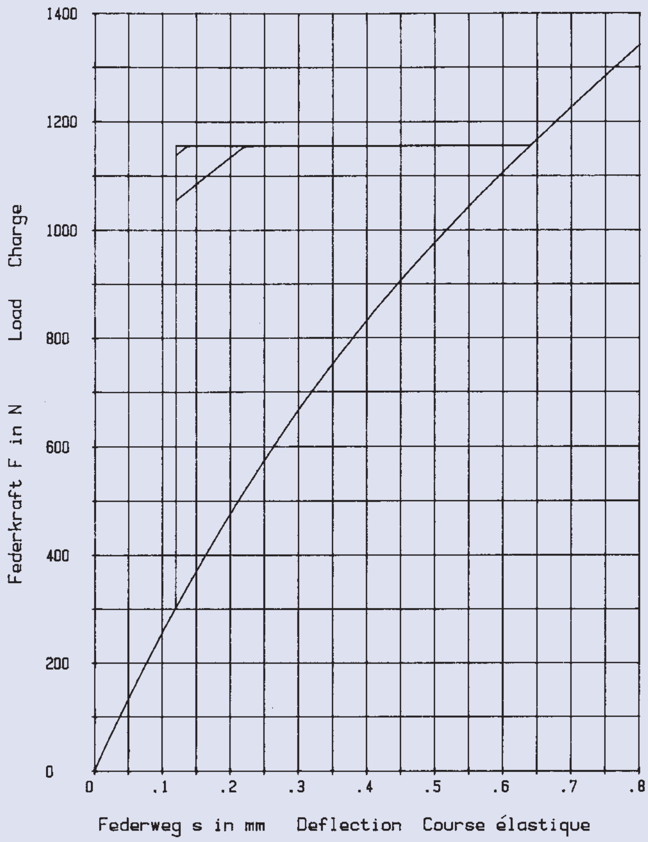
28 x 14,2 x 1,0

GR 1, DIN 2093 – B 28



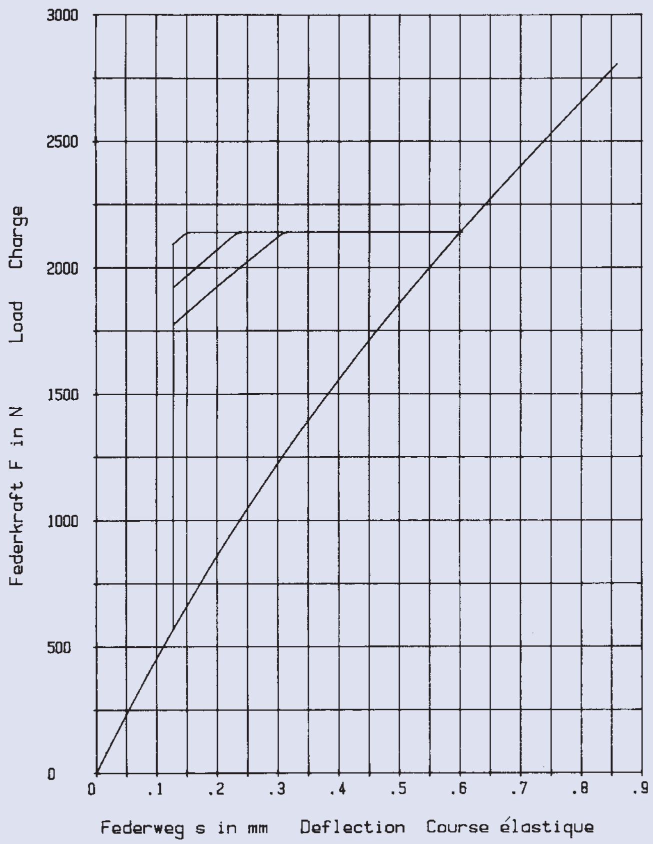
h_0 = 0,8 mm	D_e/D_i = 1,971
t = 1,0 mm	D_e/t = 28
h_0/t = 0,8	m = 3,59 g

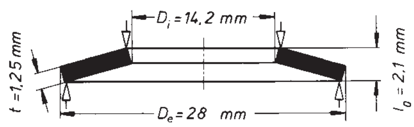




28 x 14,2 x 1,25

GR 2



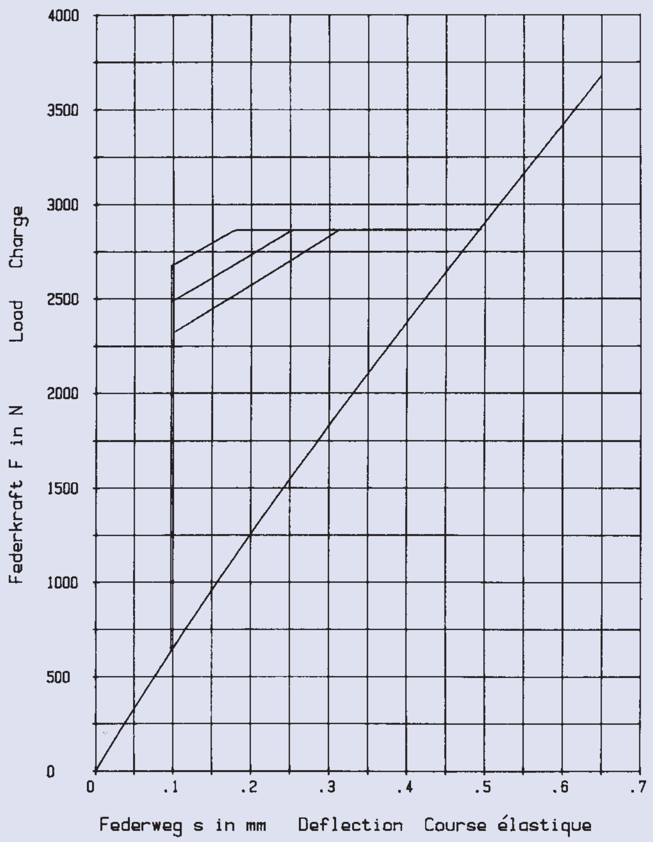


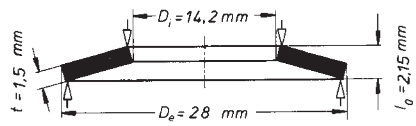
h_0 = 0,85 mm	D_e/D_i = 1,971
t = 1,25 mm	D_e/t = 22,4
h_0/t = 0,68	m = 4,486 g

l_0 = 2,1 mm	l_0 + t = 3,35 mm	l_0 + 2 t = 4,6 mm

28 x 14,2 x 1,5

GR 2, DIN 2093 – A 28





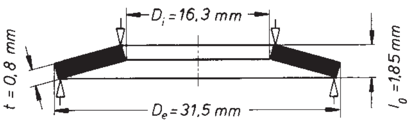
h_0 = 0,65 mm	D_e/D_i = 1,971
t = 1,5 mm	D_e/t = 18,666
h_0/t = 0,433	m = 5,386 g

l_0 = 2,15 mm	l_0 + t = 3,65 mm	l_0 + 2 t = 5,15 mm

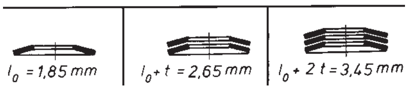
Diagramme | Diagrams | Diagrammes

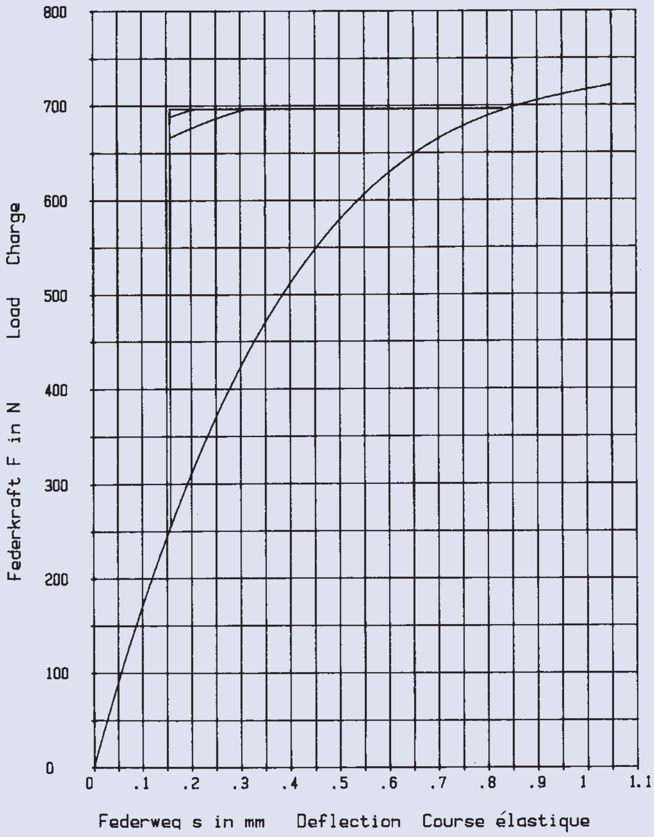
31,5 x 16,3 x 0,8

GR 1, DIN 2093 – C 31,5



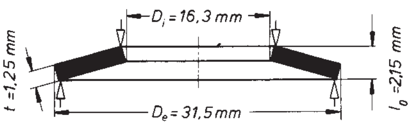
h_0 = 1,05 mm D_e/D_i = 1,932
t = 0,8 mm D_e/t = 39,375
h_0/t = 1,312   m = 3,583 g



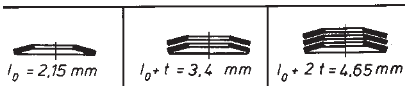


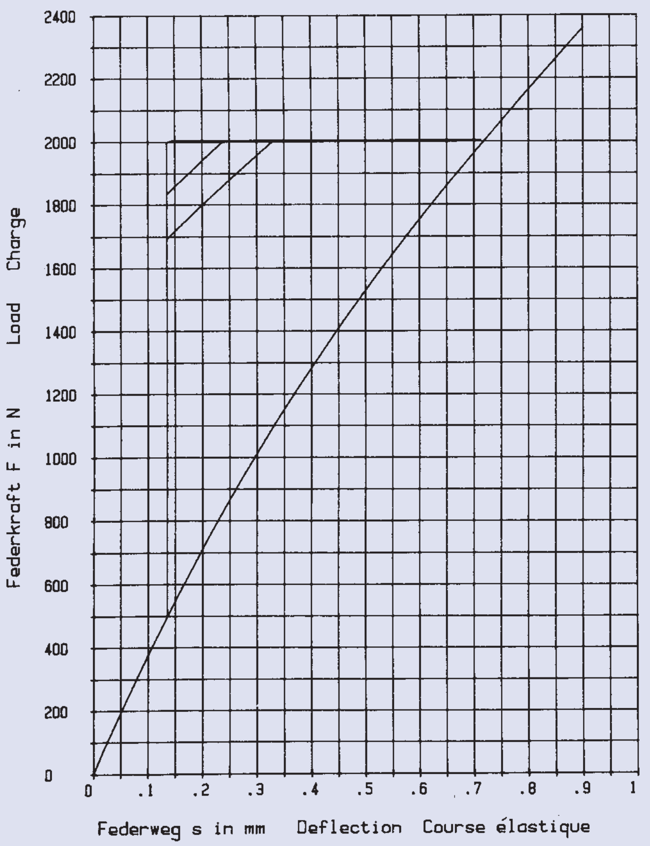
31,5 x 16,3 x 1,25

GR 2, DIN 2093 – B 31,5



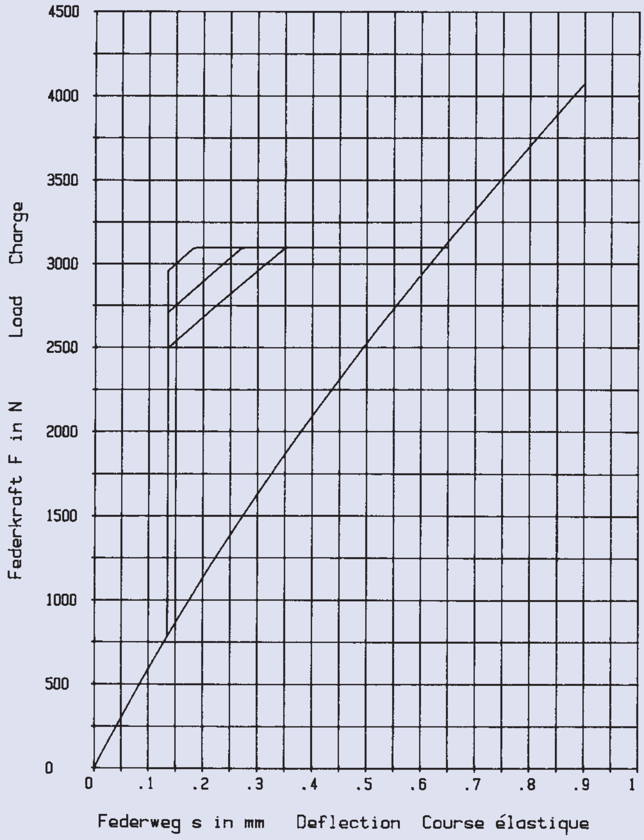
h_0 = 0,9 mm D_e/D_i = 1,932
t = 1,25 mm D_e/t = 25,2
h_0/t = 0,72   m = 5,599 g

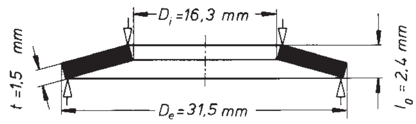




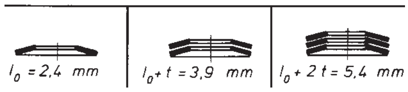
31,5 x 16,3 x 1,5

GR 2



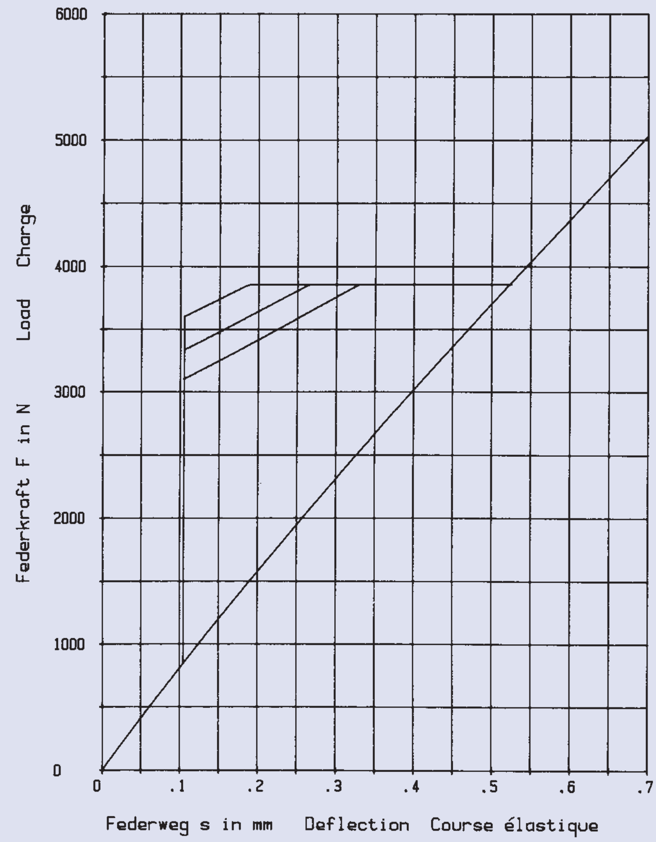


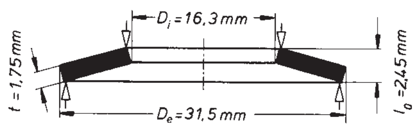
h_0 = 0,9 mm	D_e/D_i = 1,932
t = 1,5 mm	D_e/t = 21
h_0/t = 0,6	m = 6,717 g



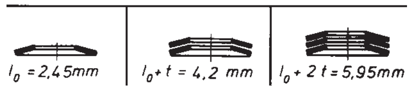
31,5 x 16,3 x 1,75

GR 2, DIN 2093 – A 31,5





h_0 = 0,7 mm	D_e/D_i = 1,932
t = 1,75 mm	D_e/t = 18
h_0/t = 0,4	m = 7,839 g



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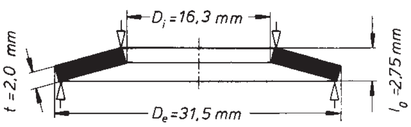
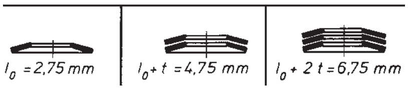
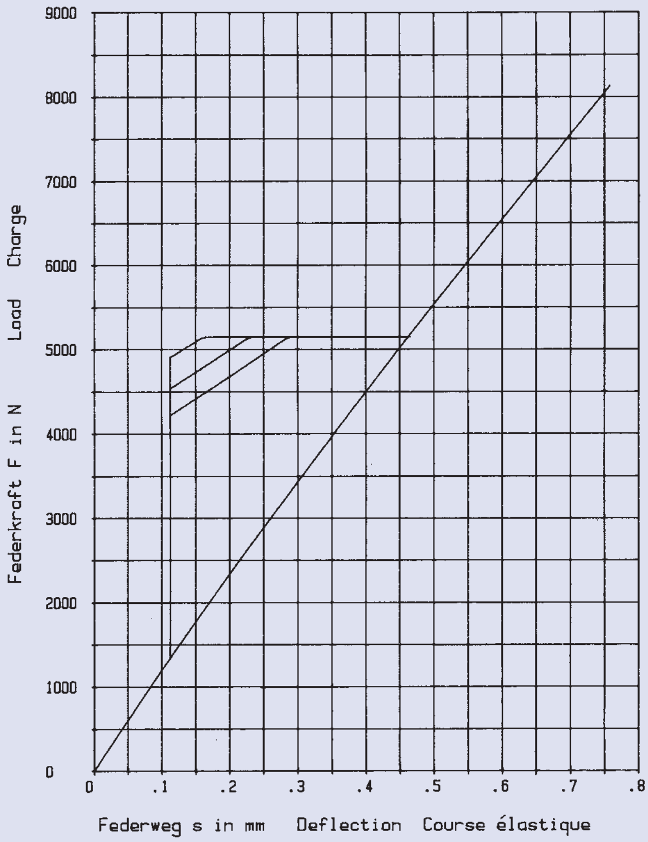
31,5 x 16,3 x 2,0

GR 2



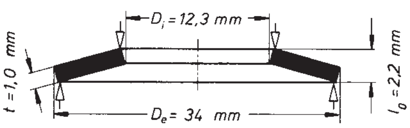
h_0 = 0,75 mm	D_e/D_i = 1,932
t = 2,0 mm	D_e/t = 15,75
h_0/t = 0,375	m = 8,956 g



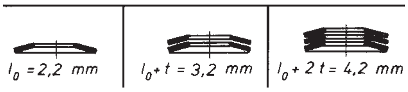


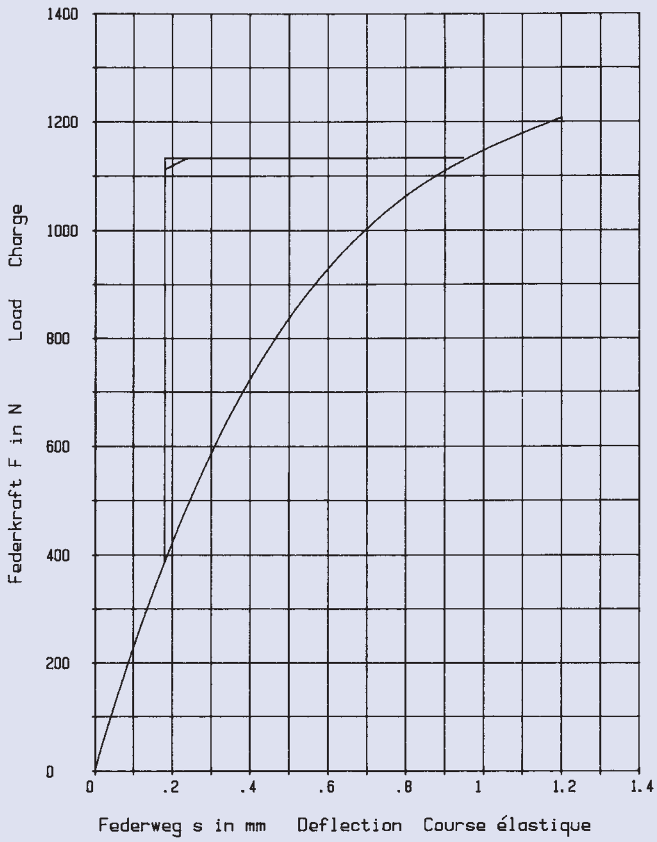
34 x 12,3 x 1,0

GR 2

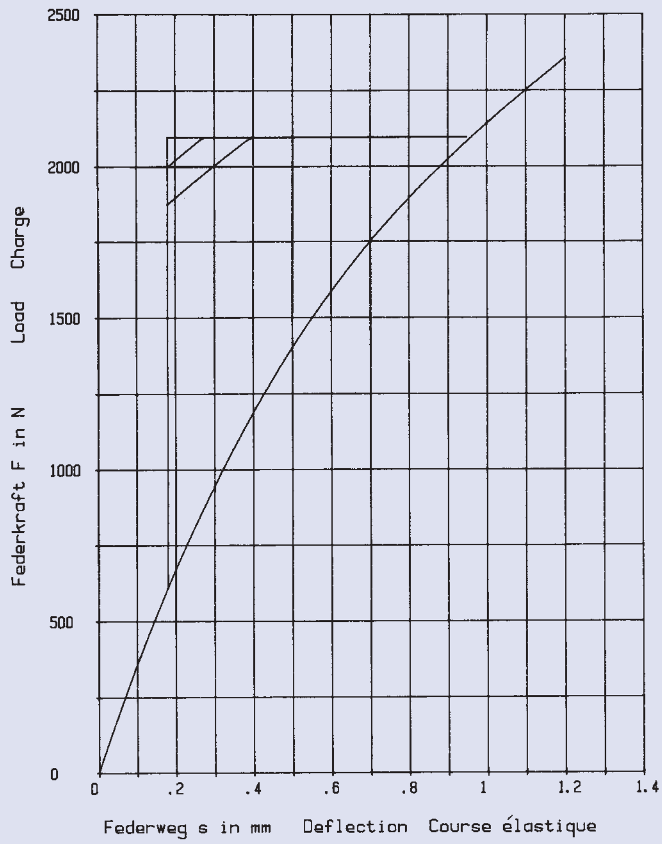


h_0 = 1,2 mm	D_e/D_i = 2,764
t = 1,0 mm	D_e/t = 34
h_0/t = 1,2	m = 6,194 g

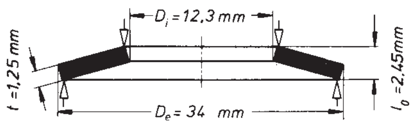




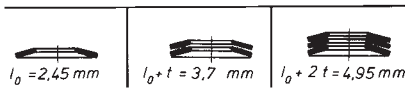
34 x 12,3 x 1,25



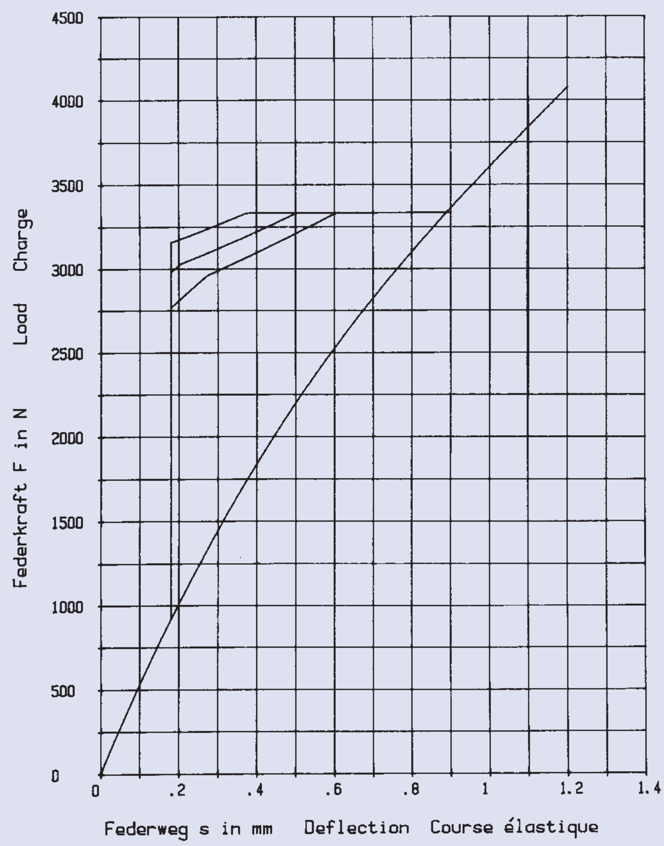
GR 2



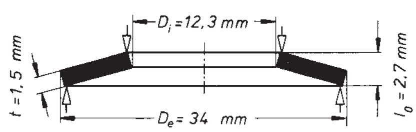
h_0 = 1,2 mm	D_e/D_i = 2,764
t = 1,25mm	D_e/t = 27,2
h_0/t = 0,96	m = 7,743 g



34 x 12,3 x 1,5



GR 2



h_0 = 1,2 mm	D_e/D_i = 2,764
t = 1,5 mm	D_e/t = 22,666
h_0/t = 0,8	m = 9,288 g

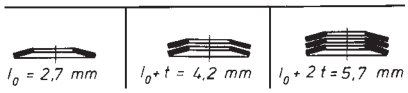
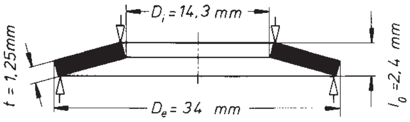


Diagramme | Diagrams | Diagrammes

34 x 14,3 x 1,25

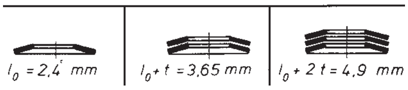
GR 2

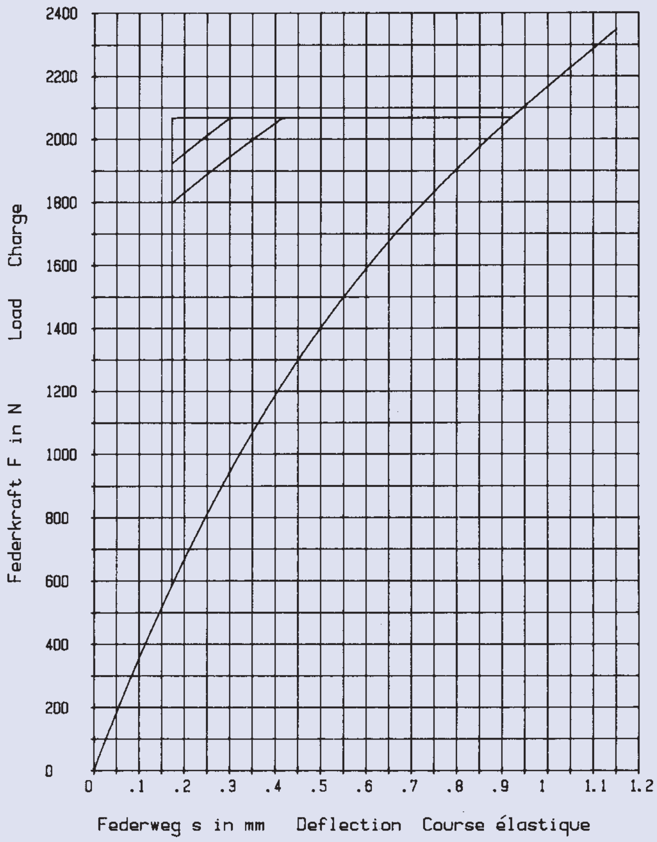


h_0 =1,15 mm — D_e/D_i = 2,377

t =1,25 mm — D_e/t = 27,2

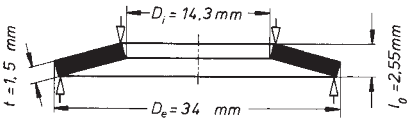
h_0/t = 0,92 — m = 7,33 g





34 x 14,3 x 1,5

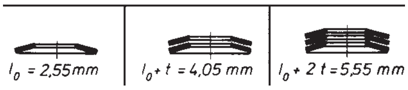
GR 2

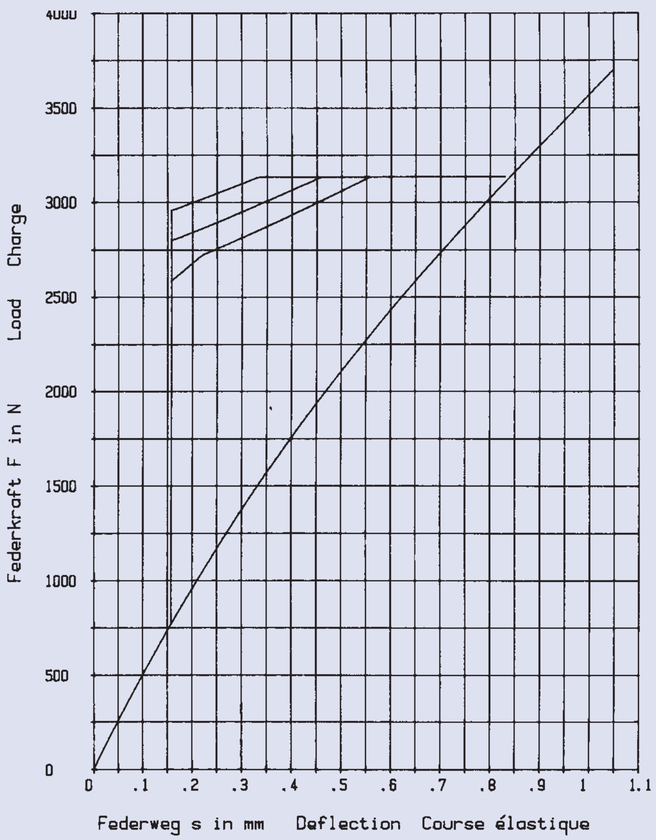


h_0 =1,05 mm — D_e/D_i = 2,377

t = 1,5 mm — D_e/t = 22,666

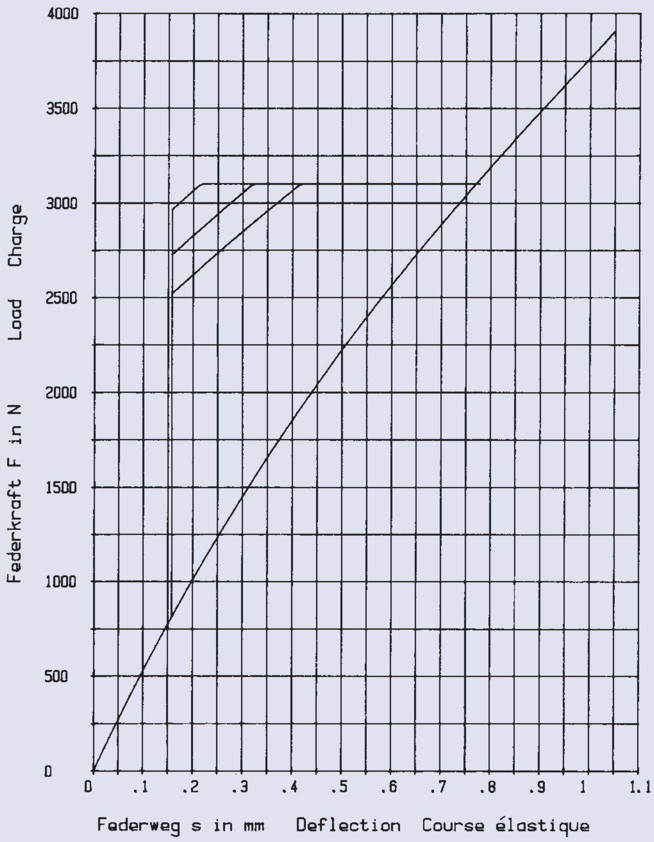
h_0/t = 0,7 — m = 8,799 g

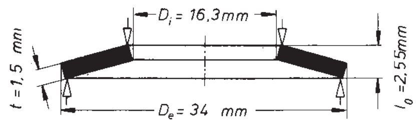




34 x 16,3 x 1,5

GR 2

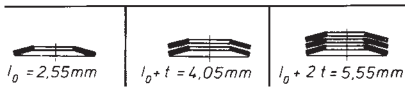




h_0 = 1,05 mm — D_e/D_i = 2,085

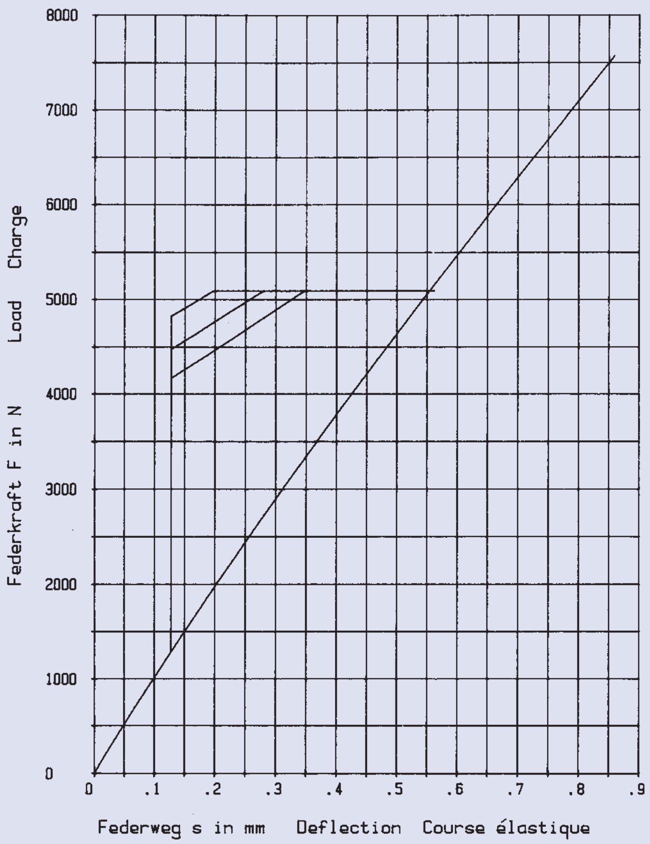
t = 1,5 mm — D_e/t = 22,666

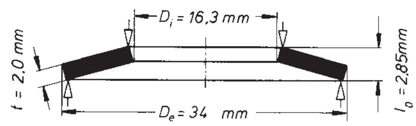
h_0/t = 0,7 — m = 8,233 g



34 x 16,3 x 2,0

GR 2

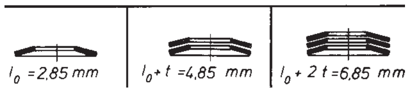




h_0 = 0,85 mm — D_e/D_i = 2,085

t = 2,0 mm — D_e/t = 17

h_0/t = 0,425 — m = 10,978 g



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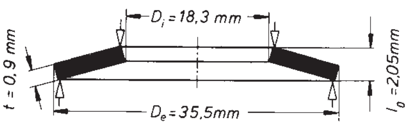
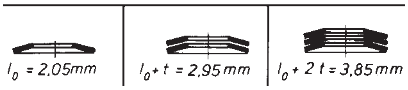
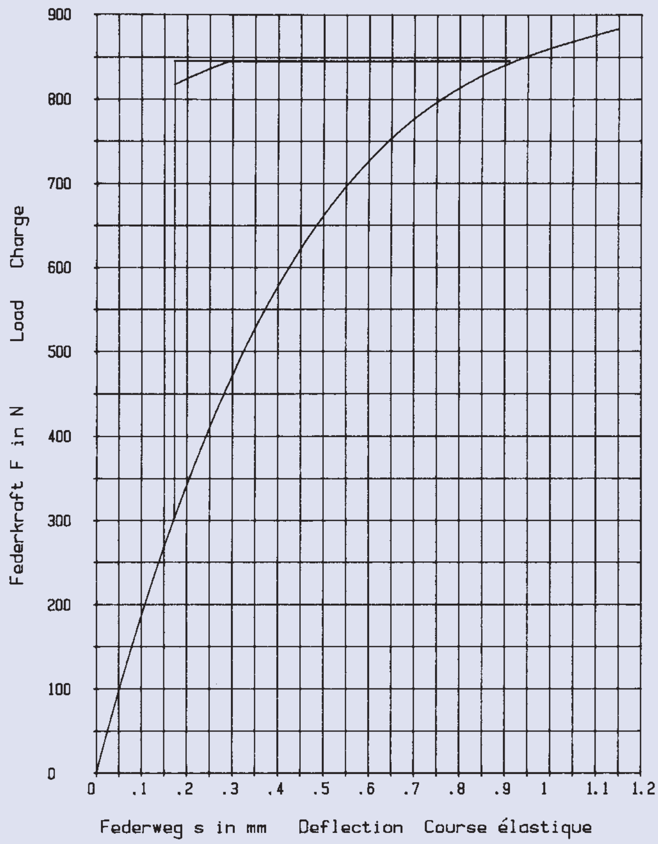
35,5 x 18,3 x 0,9

GR 1, DIN 2093 – C 35,5



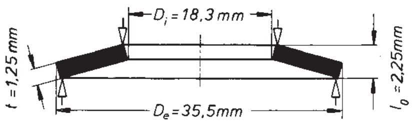
$h_0 = 1{,}15$ mm	D_e/D_i = 1,939
t = 0,9 mm	D_e/t = 39,444
$h_0/t = 1{,}277$	m = 5,134 g



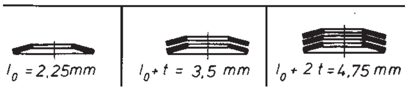


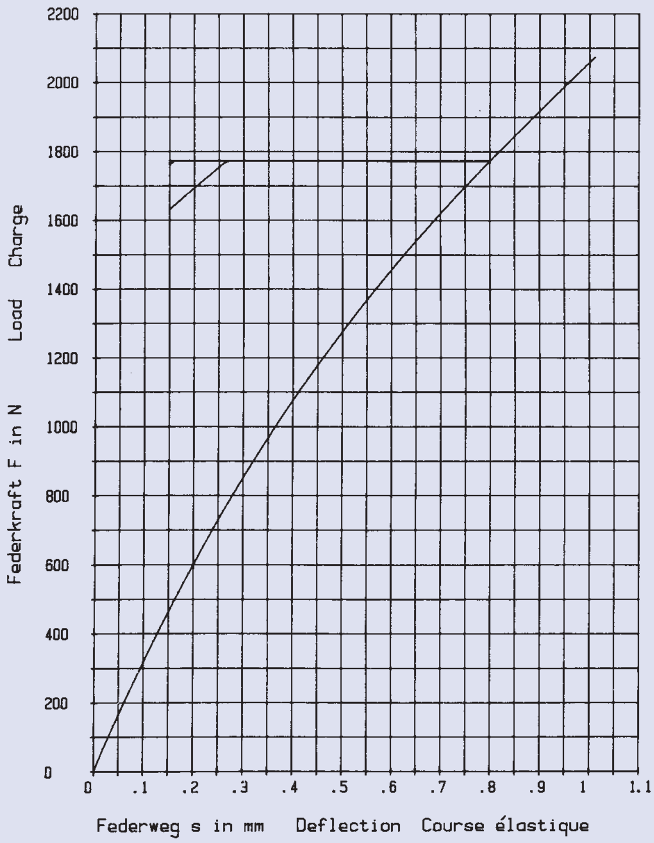
35,5 x 18,3 x 1,25

GR 2, DIN 2093 – B 35,5



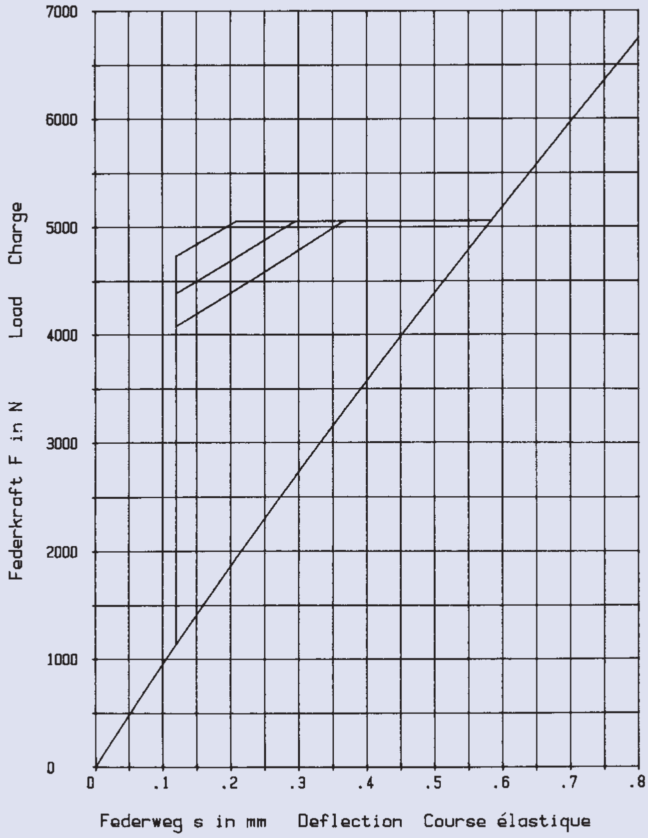
$h_0 = 1{,}0$ mm	D_e/D_i = 1,939
t = 1,25mm	D_e/t = 28,4
$h_0/t = 0{,}8$	m = 7,131 g

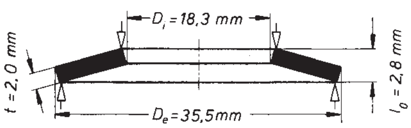




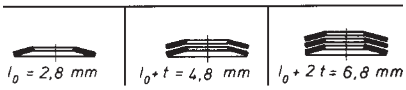
35,5 x 18,3 x 2,0

GR 2, DIN 2093 – A 35,5



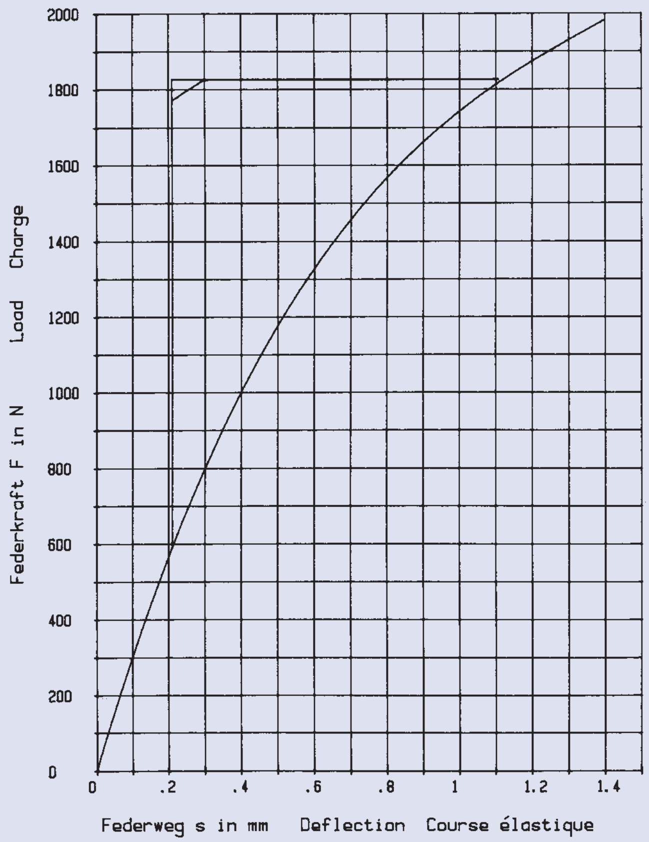


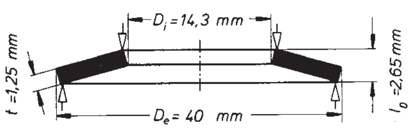
$h_0 = 0,8$ mm	D_e/D_i = 1,939
t = 2,0 mm	D_e/t = 17,75
h_0/t = 0,4	m = 11,41 g



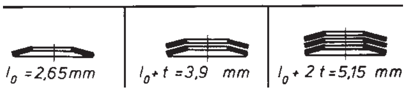
40 x 14,3 x 1,25

GR 2





$h_0 = 1,4$ mm	D_e/D_i = 2,797
t = 1,25 mm	D_e/t = 32
h_0/t = 1,12	m = 10,755 g



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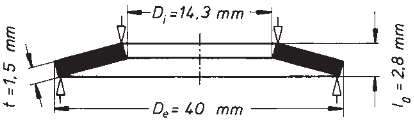
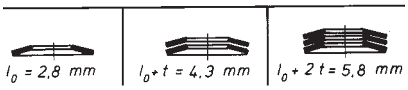
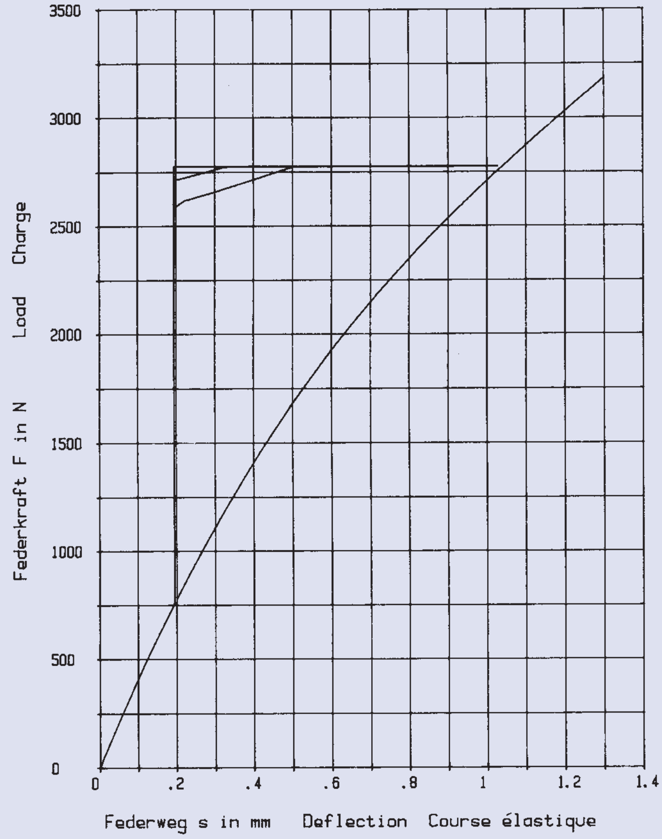
40 x 14,3 x 1,5

GR 2



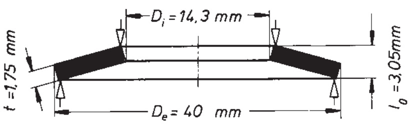
h_0 = 1,3 mm	D_e/D_i = 2,797
t = 1,5 mm	D_e/t = 26,666
h_0/t = 0,866	m = 12,905 g



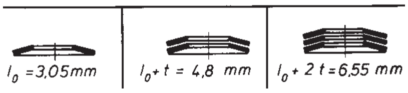


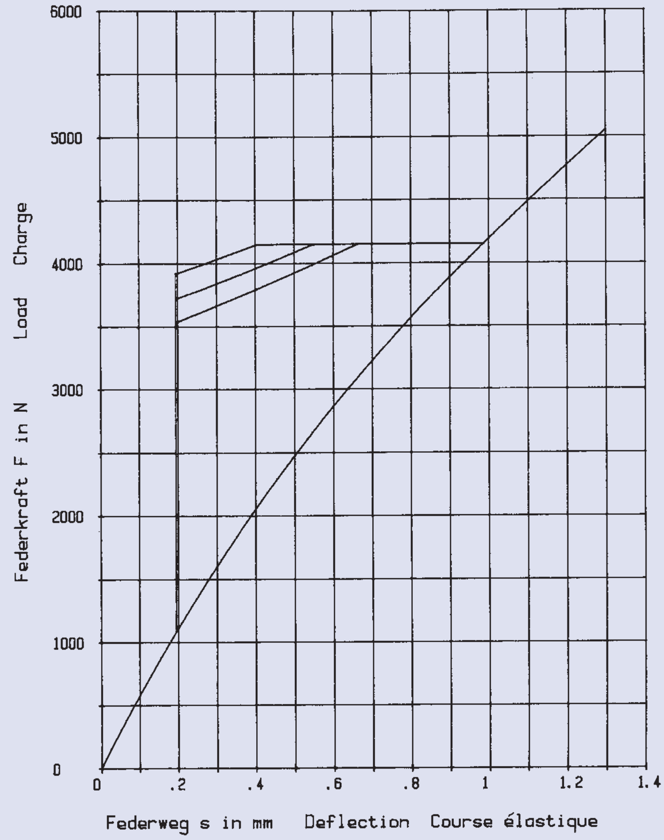
40 x 14,3 x 1,75

GR 2



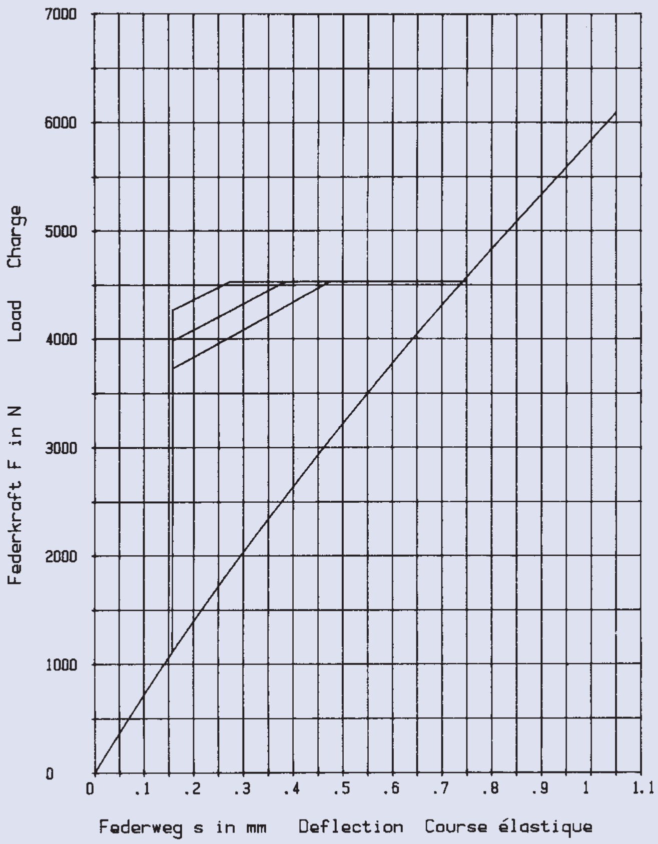
h_0 = 1,3 mm	D_e/D_i = 2,797
t = 1,75 mm	D_e/t = 22,857
h_0/t = 0,742	m = 15,056 g

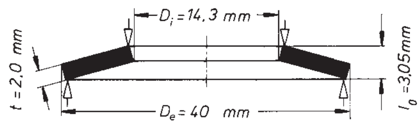




40 x 14,3 x 2,0

GR 2



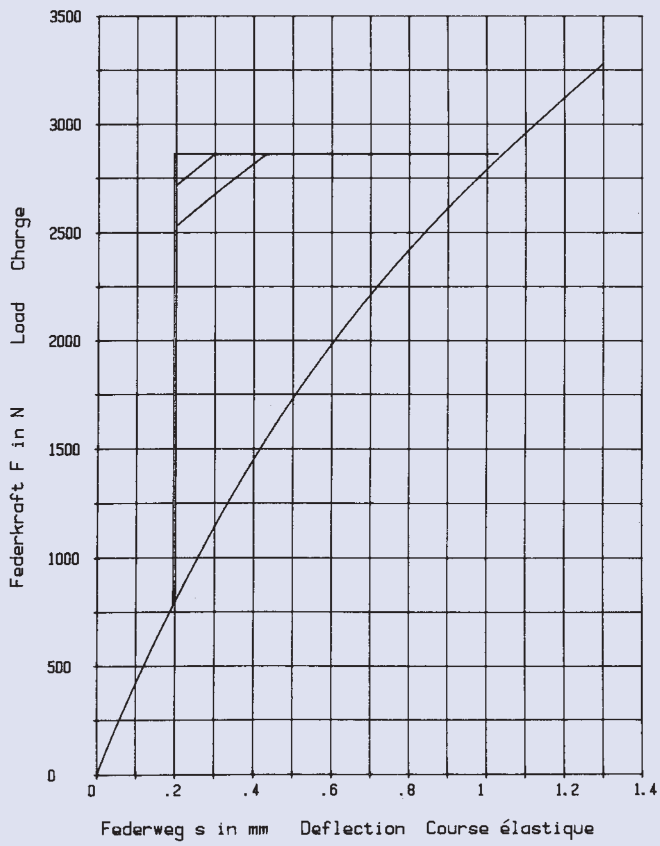


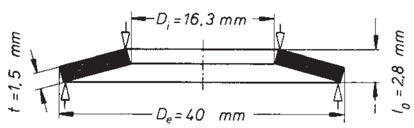
h_0 = 1,05 mm	D_e/D_i = 2,797
t = 2,0 mm	D_e/t = 20
h_0/t = 0,525	m = 17,207 g

l_0 = 3,05mm | l_0 + t = 5,05 mm | l_0 + 2 t = 7,05 mm

40 x 16,3 x 1,5

GR 2





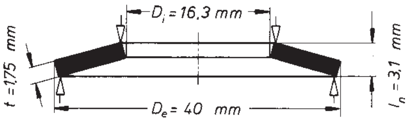
h_0 = 1,3 mm	D_e/D_i = 2,453
t = 1,5 mm	D_e/t = 26,666
h_0/t = 0,866	m = 12,339 g

l_0 = 2,8 mm | l_0 + t = 4,3 mm | l_0 + 2 t = 5,8 mm

Diagramme | Diagrams | Diagrammes

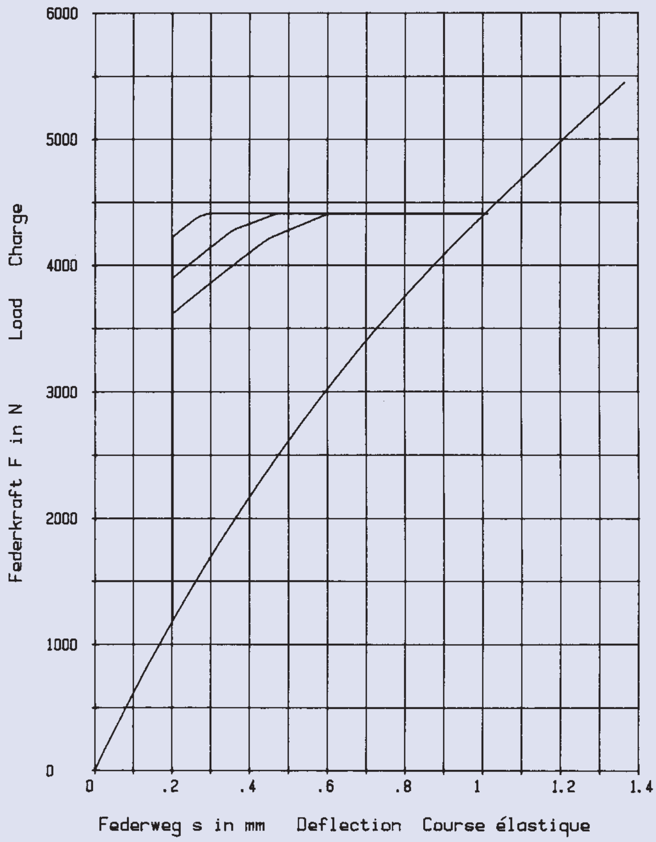
40 x 16,3 x 1,75

GR 2



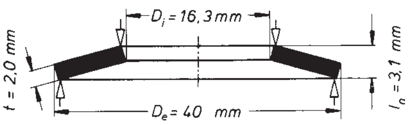
h_0 = 1,35 mm | D_e/D_i = 2,453
t = 1,75 mm | D_e/t = 22,857
h_0/t = 0,771 | m = 14,396 g

l_0 = 3,1 mm	$l_0 + t$ = 4,85 mm	$l_0 + 2t$ = 6,6 mm



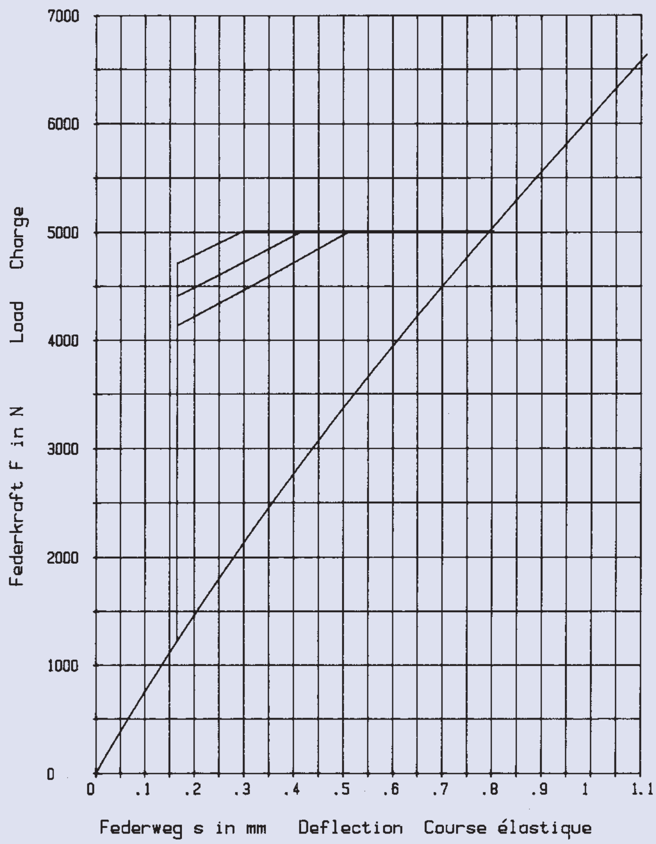
40 x 16,3 x 2,0

GR 2

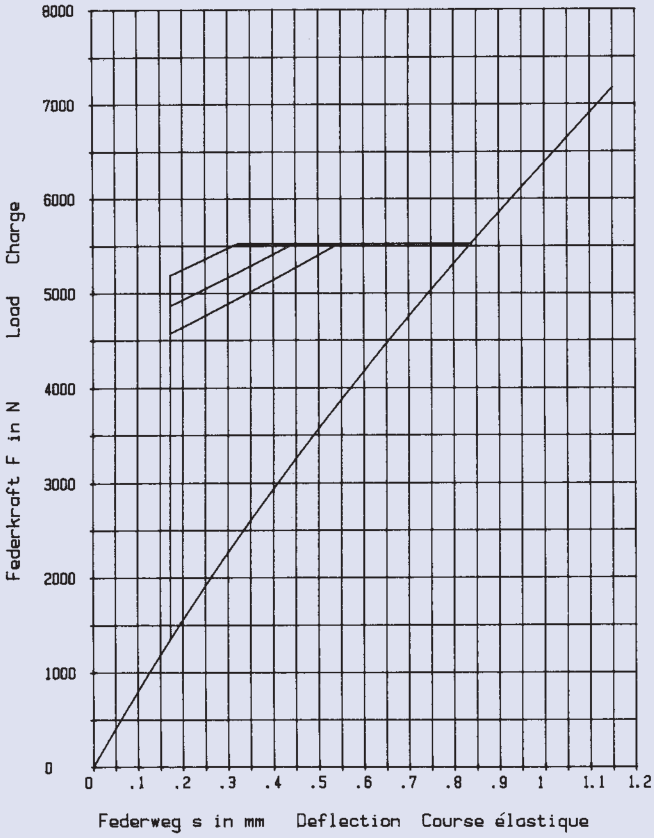


h_0 = 1,1 mm | D_e/D_i = 2,453
t = 2,0 mm | D_e/t = 20
h_0/t = 0,55 | m = 16,499 g

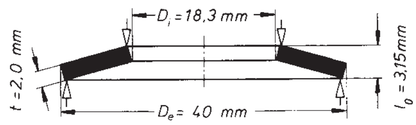
l_0 = 3,1 mm	$l_0 + t$ = 5,1 mm	$l_0 + 2t$ = 7,1 mm



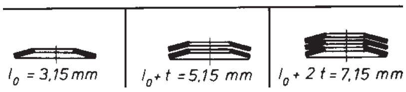
40 x 18,3 x 2,0



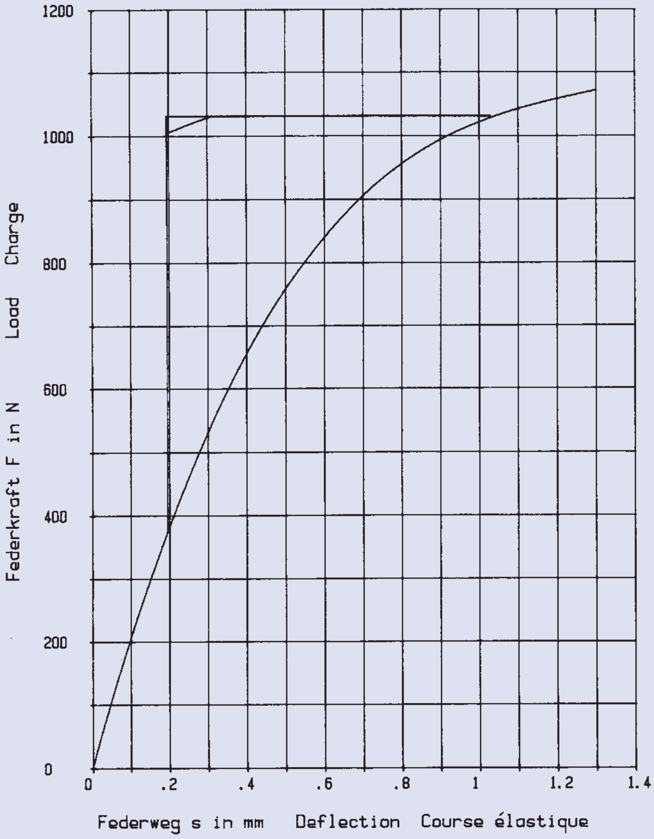
GR 2



h_0 = 1,15 mm	D_e / D_i = 2,185
t = 2,0 mm	D_e / t = 20
h_0 / t = 0,575	m = 15,599 g



40 x 20,4 x 1,0



GR 1, DIN 2093 – C 40

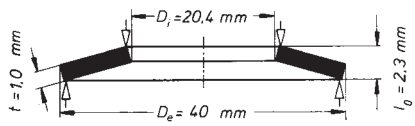
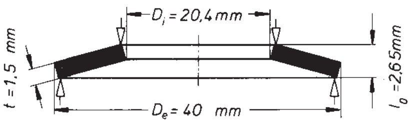


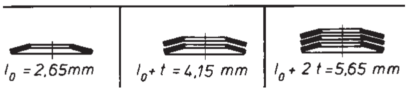
Diagramme | Diagrams | Diagrammes

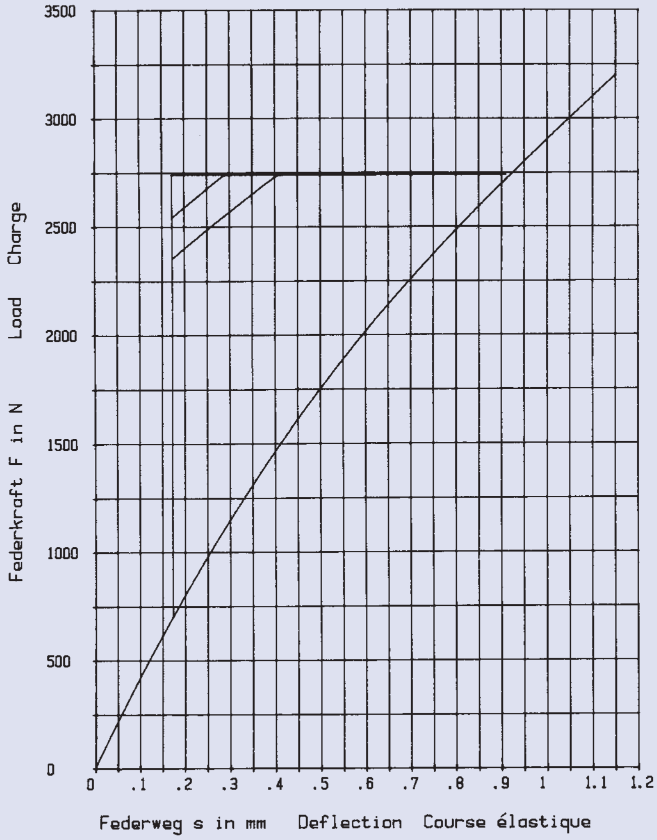
40 x 20,4 x 1,5

GR 2, DIN 2093 – B 40



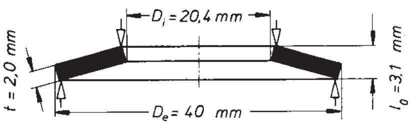
h_0 = 1,15 mm D_e/D_i = 1,96
t = 1,5 mm D_e/t = 26,666
h_0/t = 0,766   m = 10,948 g



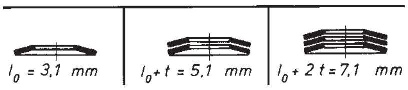


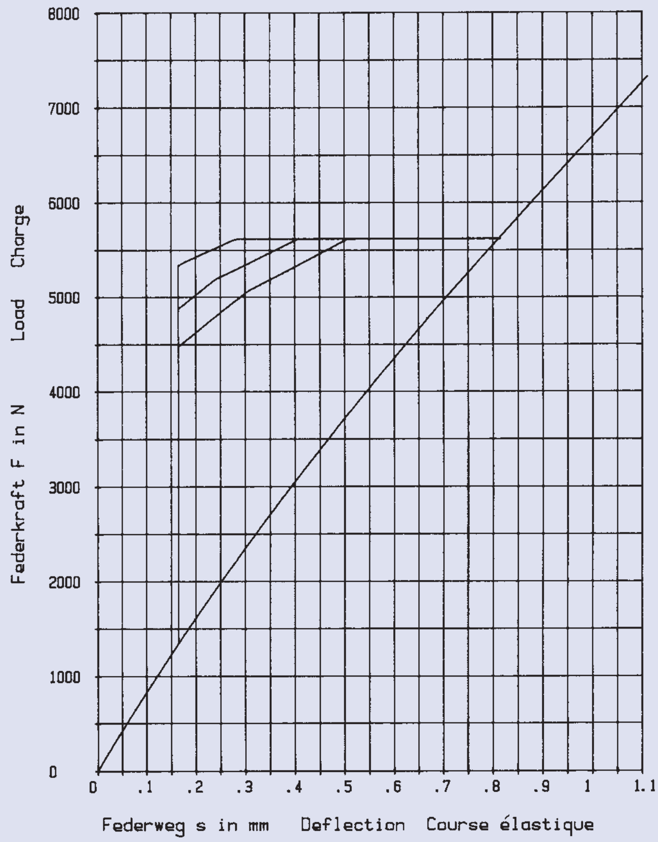
40 x 20,4 x 2,0

GR 2



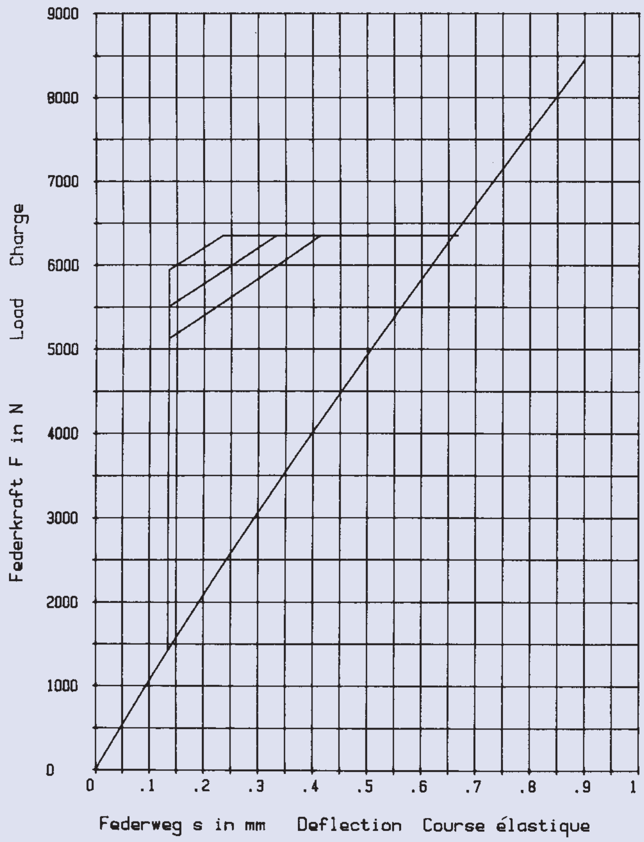
h_0 = 1,1 mm D_e/D_i = 1,96
t = 2,0 mm D_e/t = 20
h_0/t = 0,55   m = 14,597 g

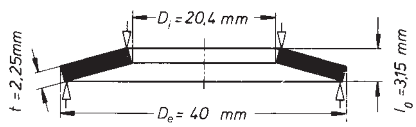




40 x 20,4 x 2,25

GR 2, DIN 2093 – A 40

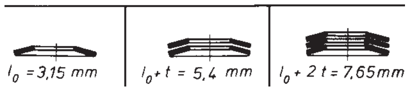




h_0 = 0,9 mm D_e/D_i = 1,96

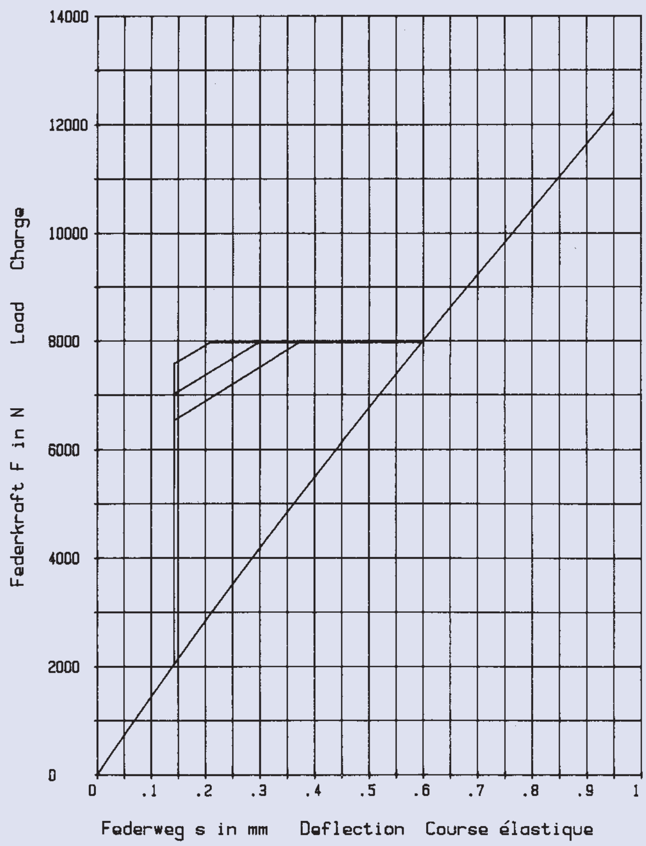
t = 2,25mm D_e/t = 17,777

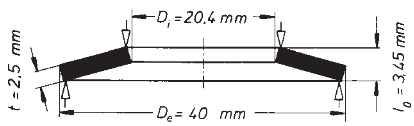
h_0/t = 0,4 m = 16,422 g



40 x 20,4 x 2,5

GR 2





h_0 = 0,95 mm D_e/D_i = 1,96

t = 2,5 mm D_e/t = 16

h_0/t = 0,38 m = 18,246 g

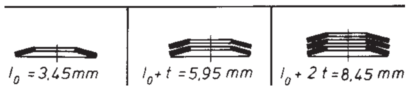
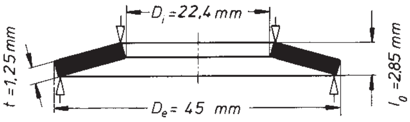


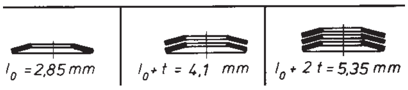
Diagramme | Diagrams | Diagrammes

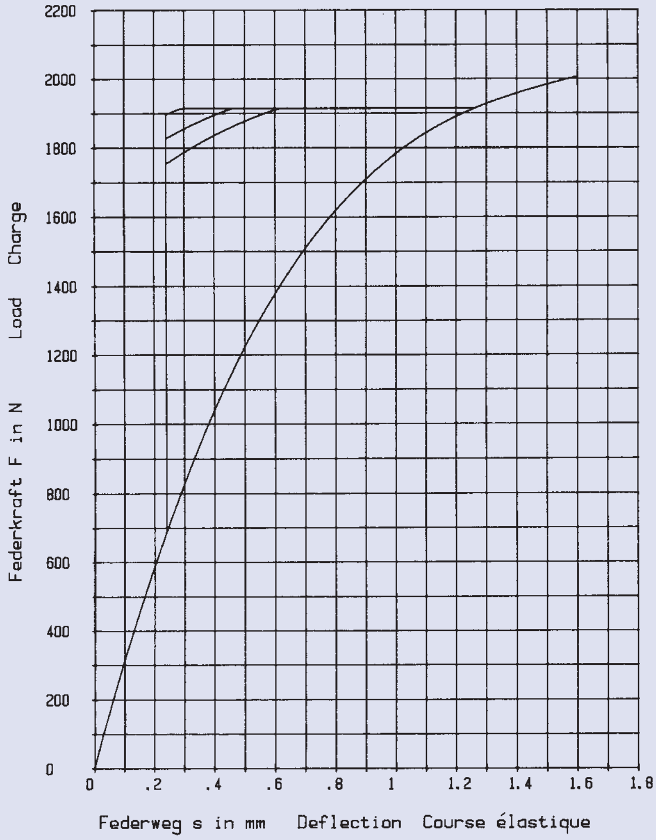
45 x 22,4 x 1,25

GR 2, DIN 2093 – C 45



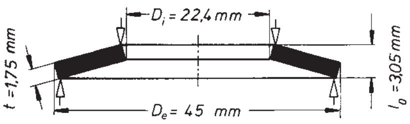
h_0 = 1,6 mm	D_e / D_i = 2,008
t = 1,25 mm	D_e / t = 36
h_0 / t = 1,28	m = 11,739 g



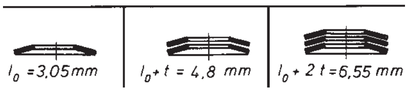


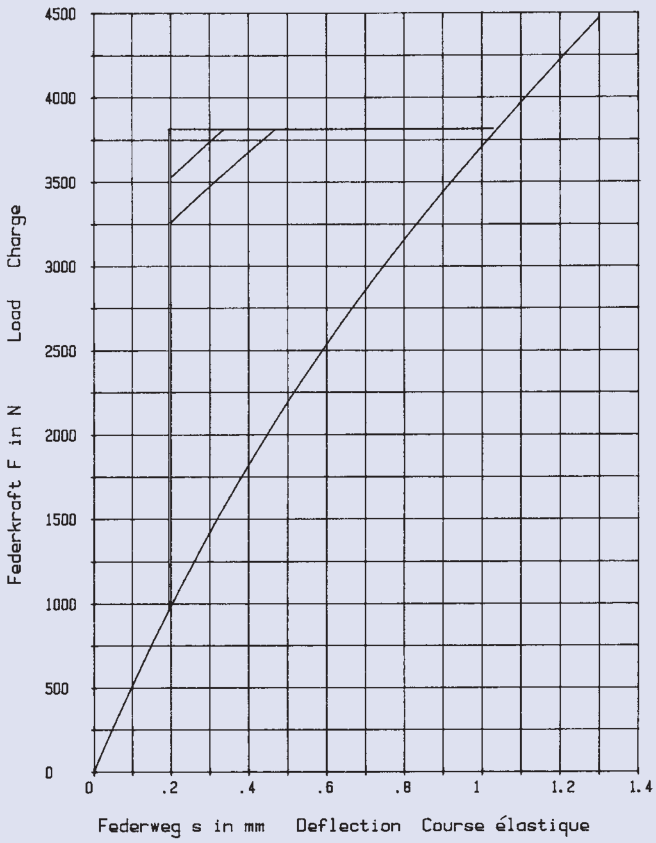
45 x 22,4 x 1,75

GR 2, DIN 2093 – B 45



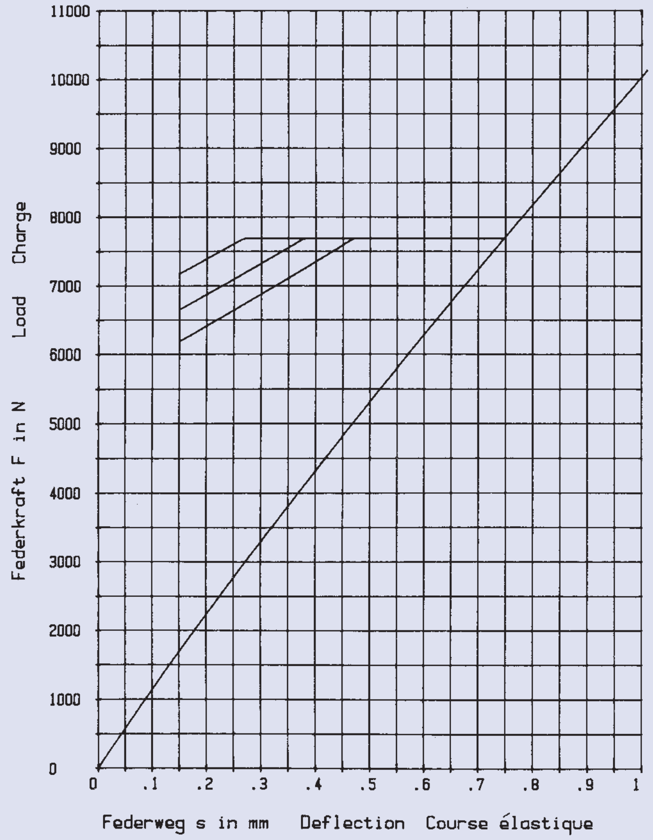
h_0 = 1,3 mm	D_e / D_i = 2,008
t = 1,75 mm	D_e / t = 25,714
h_0 / t = 0,742	m = 16,434 g

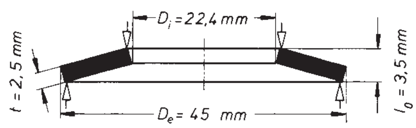




45 x 22,4 x 2,5

GR 2, DIN 2093 – A 45





h_0 = 1,0 mm

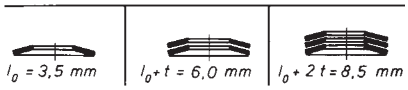
t = 2,5 mm

h_0/t = 0,4

D_e/D_i = 2,008

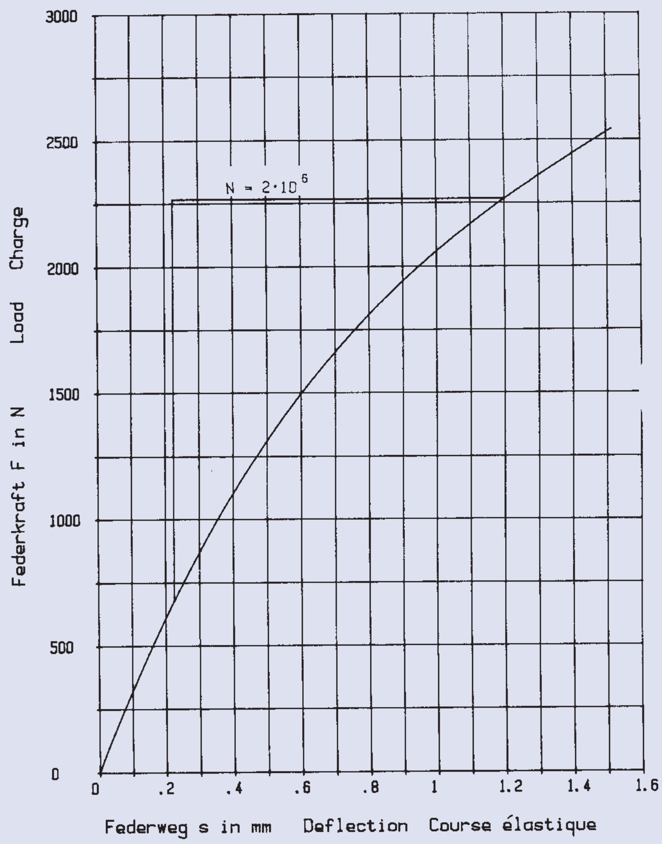
D_e/t = 18

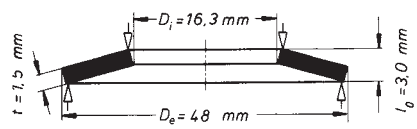
m = 23,478 g



48 x 16,3 x 1,5

GR 2





h_0 = 1,5 mm

t = 1,5 mm

h_0/t = 1,0

D_e/D_i = 2,944

D_e/t = 32

m = 18,85 g

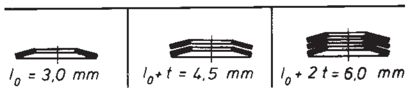
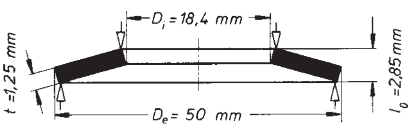


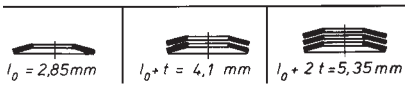
Diagramme | Diagrams | Diagrammes

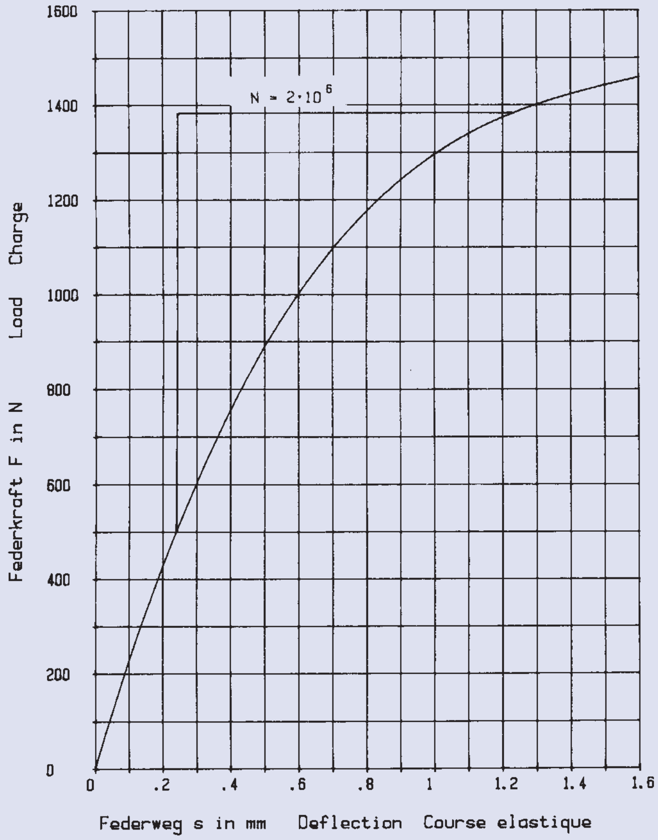
50 x 18,4 x 1,25

GR 2



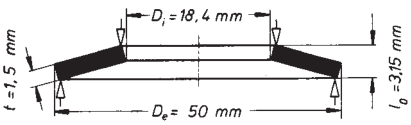
h_0 = 1,6 mm	D_e / D_i = 2,717
t = 1,25 mm	D_e / t = 40
h_0 / t = 1,28	m = 16,657 g



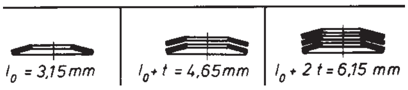


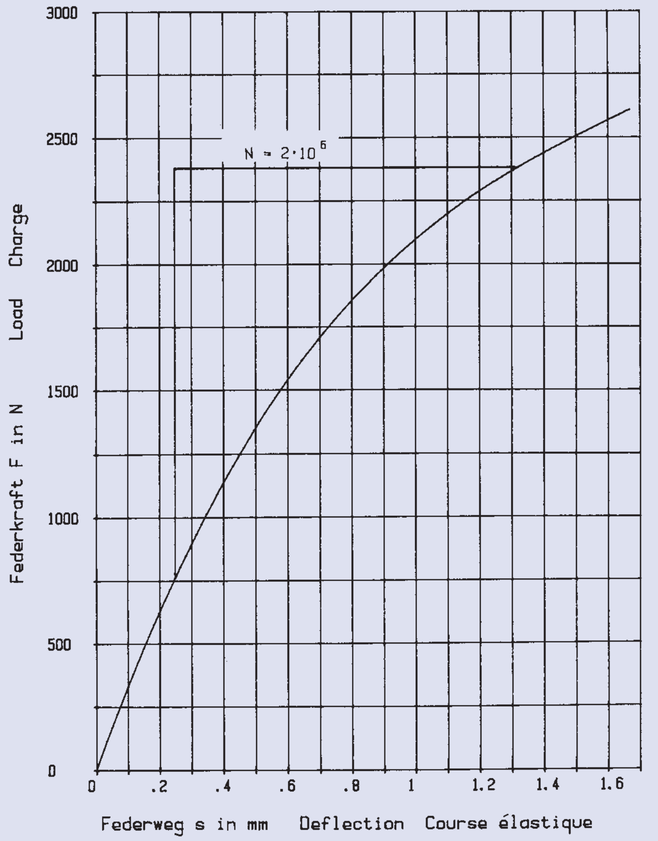
50 x 18,4 x 1,5

GR 2



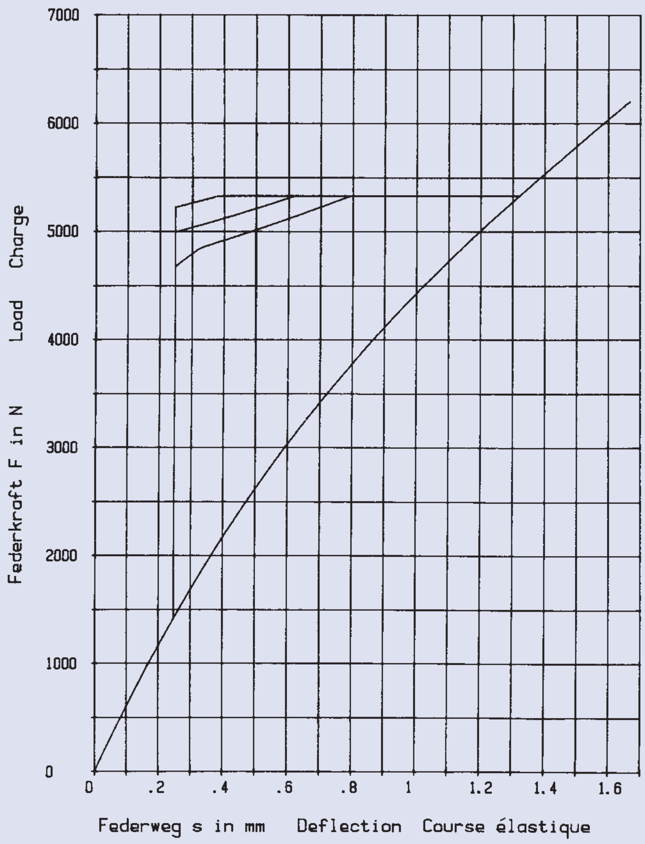
h_0 = 1,65 mm	D_e / D_i = 2,717
t = 1,5 mm	D_e / t = 33,333
h_0 / t = 1,1	m = 19,988 g

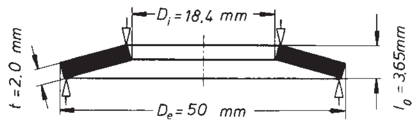




50 x 18,4 x 2,0

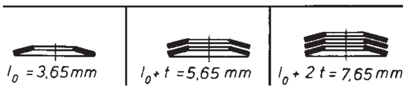
GR 2





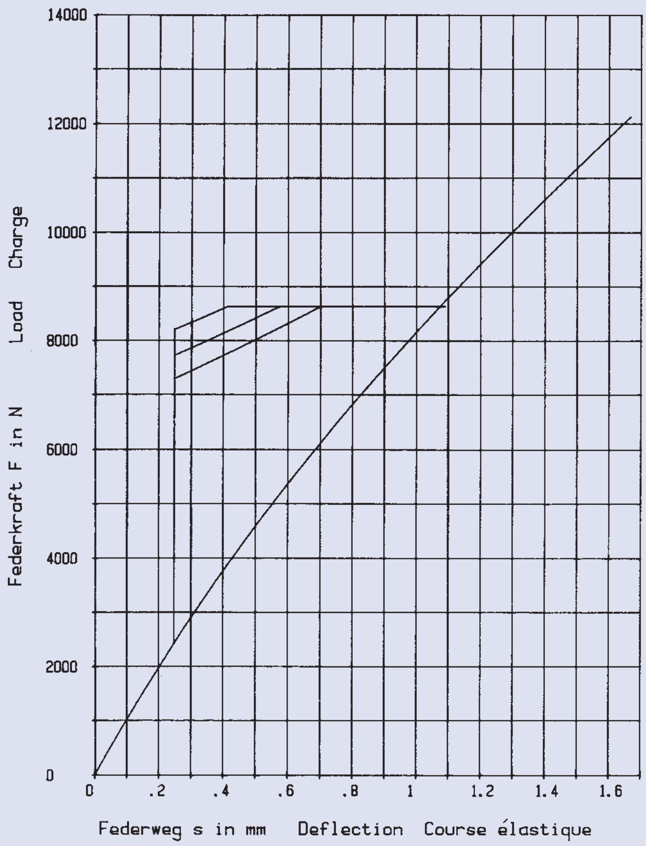
h_0 = 1,65 mm
t = 2,0 mm
h_0/t = 0,825

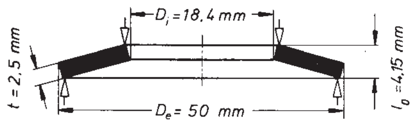
D_e/D_i = 2,717
D_e/t = 25
m = 26,651 g



50 x 18,4 x 2,5

GR 2





h_0 = 1,65 mm
t = 2,5 mm
h_0/t = 0,66

D_e/D_i = 2,717
D_e/t = 20
m = 33,314 g

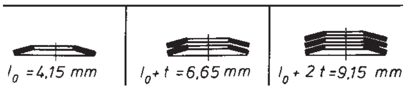
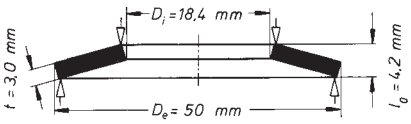


Diagramme | Diagrams | Diagrammes

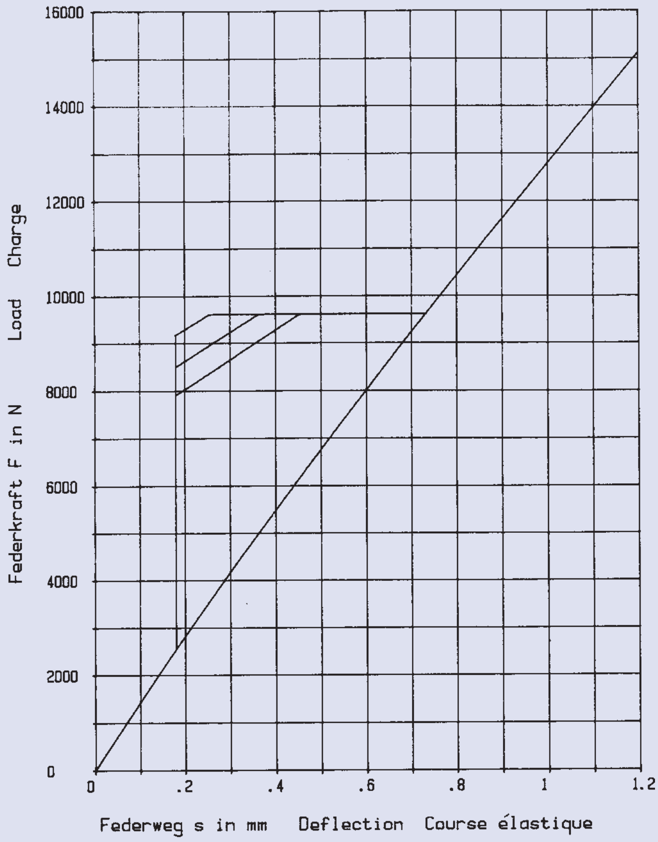
50 x 18,4 x 3,0

GR 2



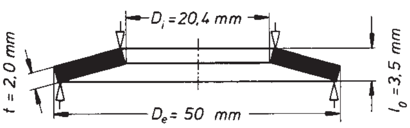
h_0 = 1,2 mm	D_e/D_i = 2,717
t = 3,0 mm	D_e/t = 16,666
h_0/t = 0,4	m = 39,977 g

l_0 = 4,2 mm	l_0 + t = 7,2 mm	l_0 + 2 t = 10,2 mm



50 x 20,4 x 2,0

GR 2



h_0 = 1,5 mm	D_e/D_i = 2,45
t = 2,0 mm	D_e/t = 25
h_0/t = 0,75	m = 25,695 g

l_0 = 3,5 mm	l_0 + t = 5,5 mm	l_0 + 2 t = 7,5 mm

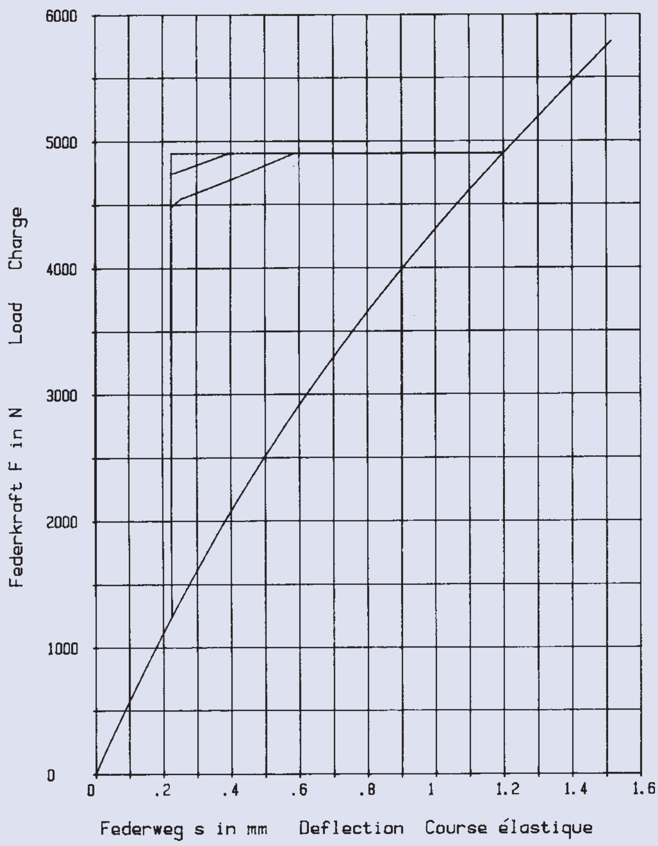
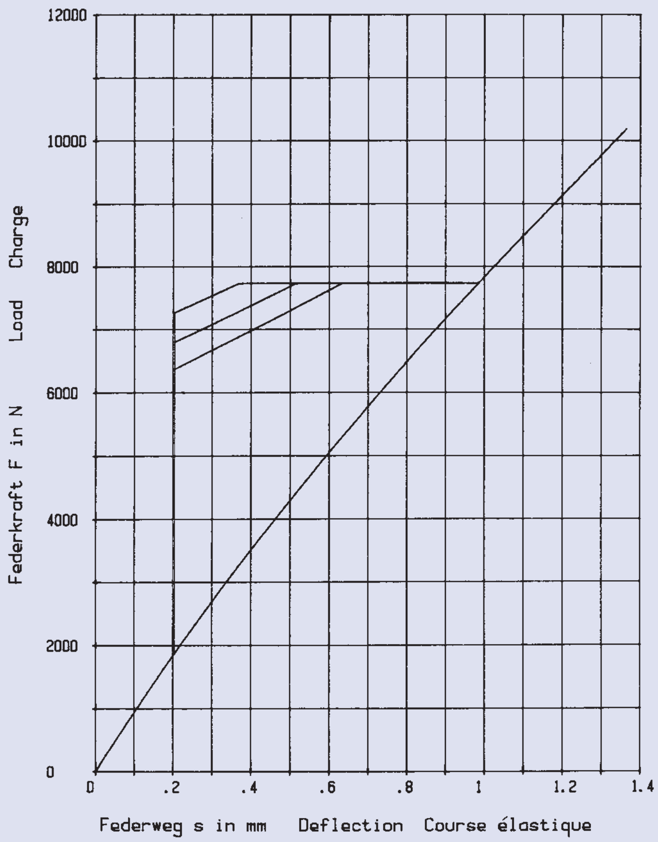
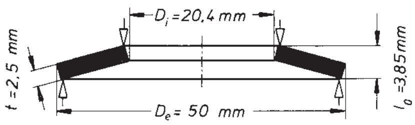


Diagramme | Diagrams | Diagrammes

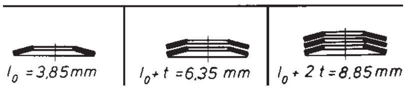
50 x 20,4 x 2,5

GR 2



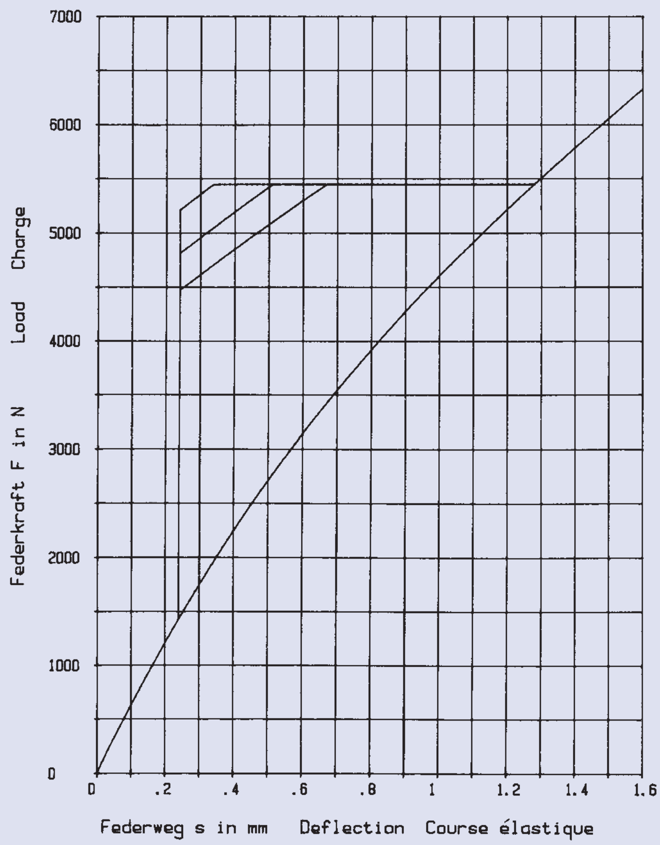


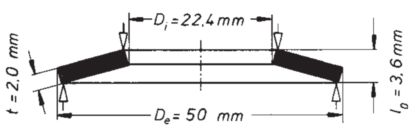
$h_0 = 1{,}35\,mm$	$D_e / D_i = 2{,}45$
$t = 2{,}5\,mm$	$D_e / t = 20$
$h_0 / t = 0{,}54$	$m = 32{,}118\,g$



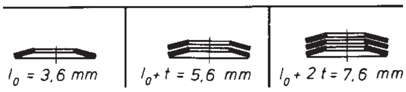
50 x 22,4 x 2,0

GR 2



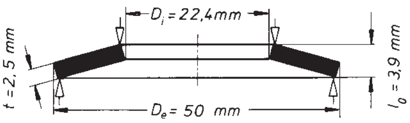


$h_0 = 1{,}6\,mm$	$D_e / D_i = 2{,}232$
$t = 2{,}0\,mm$	$D_e / t = 25$
$h_0 / t = 0{,}8$	$m = 24{,}639\,g$



50 x 22,4 x 2,5

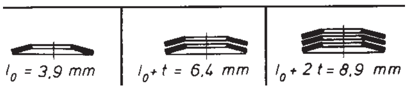
GR 2

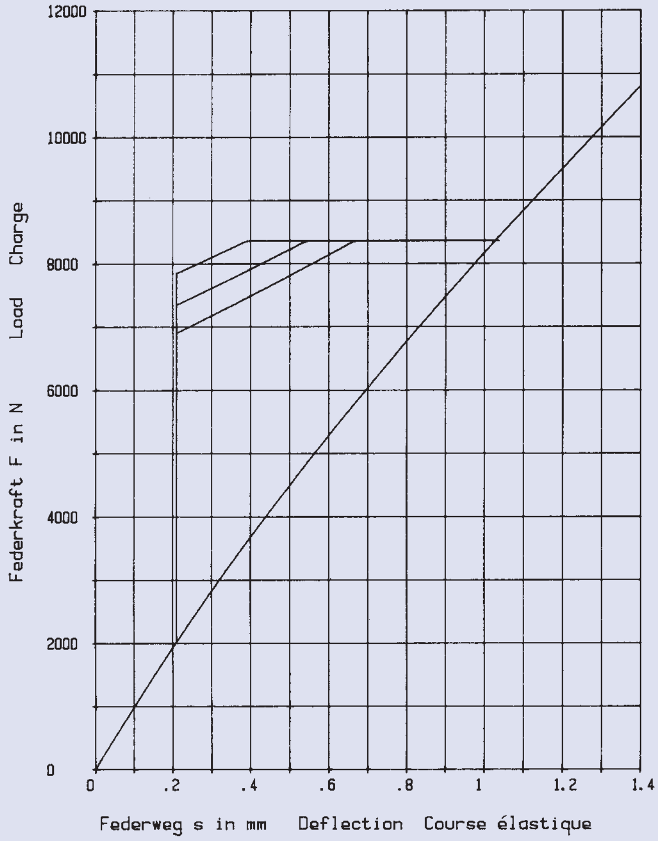


h_0 = 1,4 mm D_e/D_i = 2,232

t = 2,5 mm D_e/t = 20

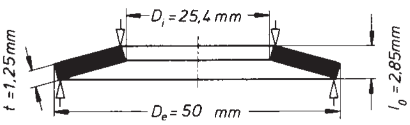
h_0/t = 0,56 m = 30,8 g





50 x 25,4 x 1,25

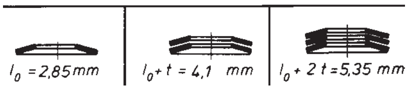
GR 2, DIN 2093 – C 50

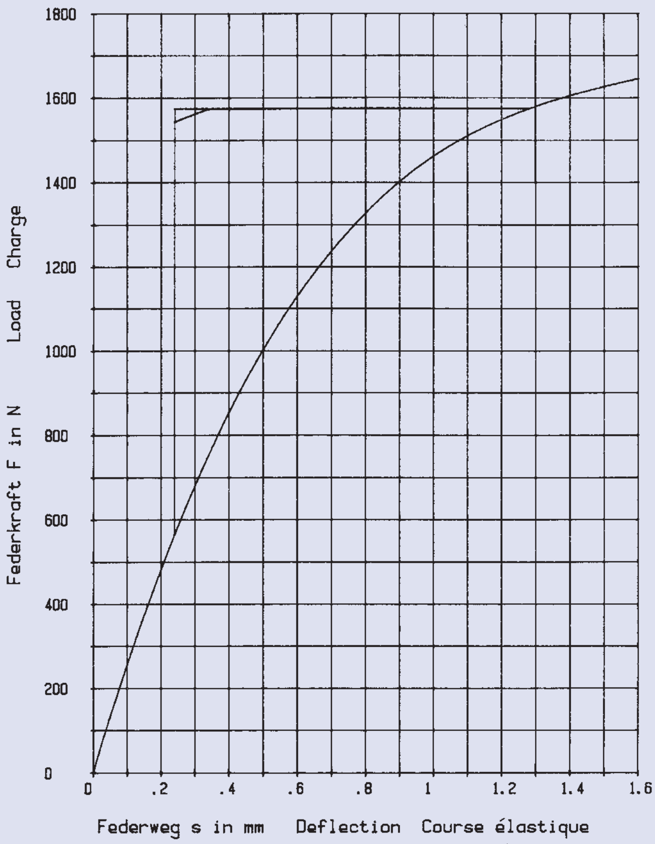


h_0 = 1,6 mm D_e/D_i = 1,968

t = 1,25 mm D_e/t = 40

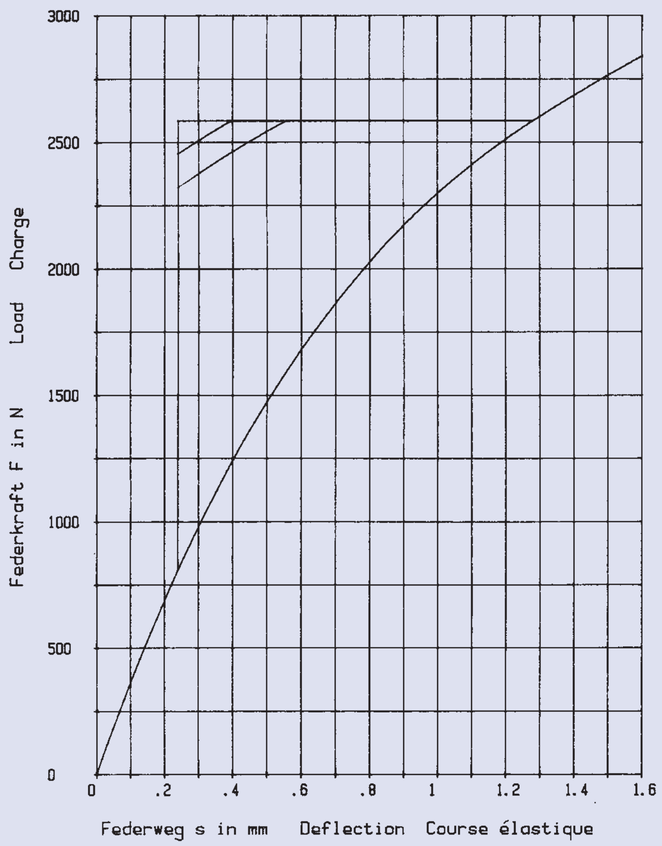
h_0/t = 1,28 m = 14,294 g

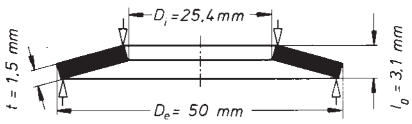




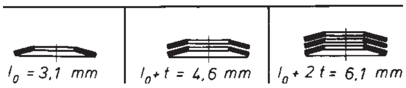
50 x 25,4 x 1,5

GR 2





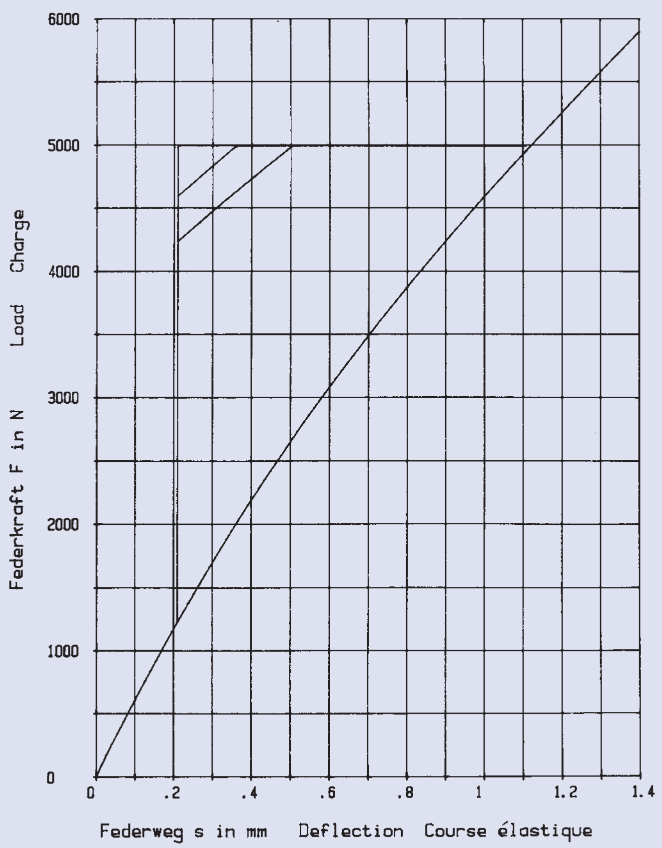
h_0 = 1,6 mm	D_e/D_i = 1,968
t = 1,5 mm	D_e/t = 33,333
h_0/t = 1,066	m = 17,153 g

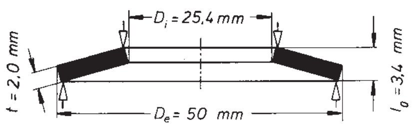


l_0 = 3,1 mm	l_0 + t = 4,6 mm	l_0 + 2 t = 6,1 mm

50 x 25,4 x 2,0

GR 2, DIN 2093 – B 50





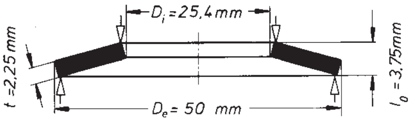
h_0 = 1,4 mm	D_e/D_i = 1,968
t = 2,0 mm	D_e/t = 25
h_0/t = 0,7	m = 22,871 g

l_0 = 3,4 mm	l_0 + t = 5,4 mm	l_0 + 2 t = 7,4 mm

Diagramme | Diagrams | Diagrammes

50 x 25,4 x 2,25

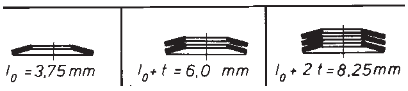
GR 2

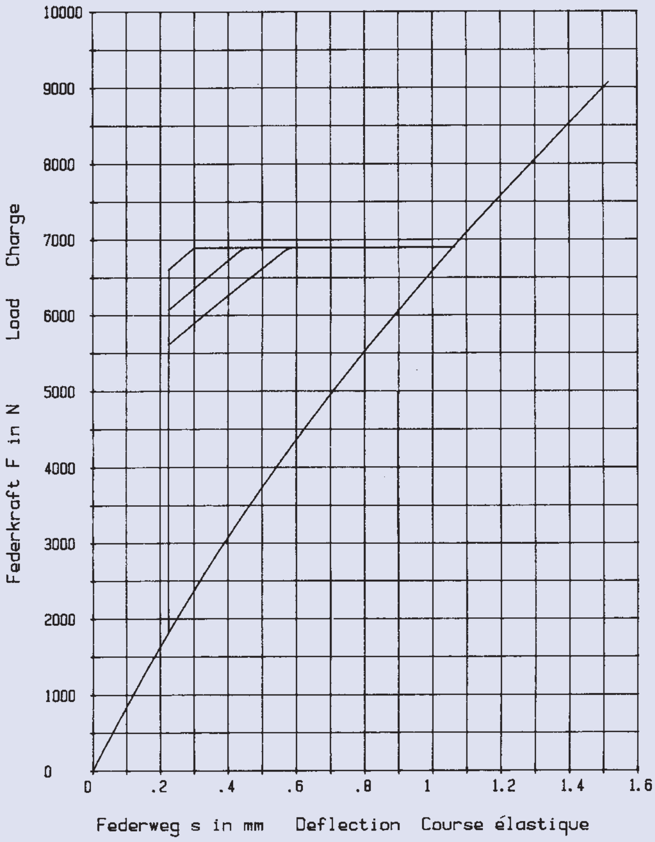


h_0 = 1,5 mm D_e / D_i = 1,968

t = 2,25 mm D_e / t = 22,222

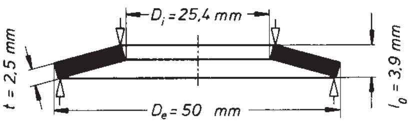
h_0 / t = 0,666 m = 25,73 g





50 x 25,4 x 2,5

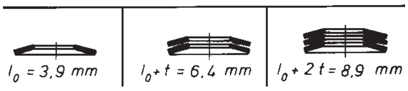
GR 2

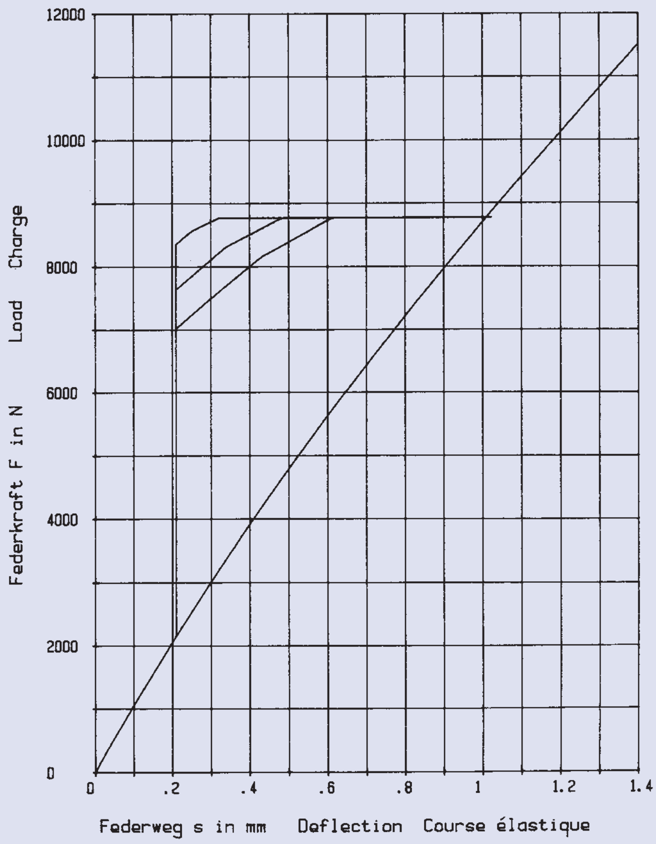


h_0 = 1,4 mm D_e / D_i = 1,968

t = 2,5 mm D_e / t = 20

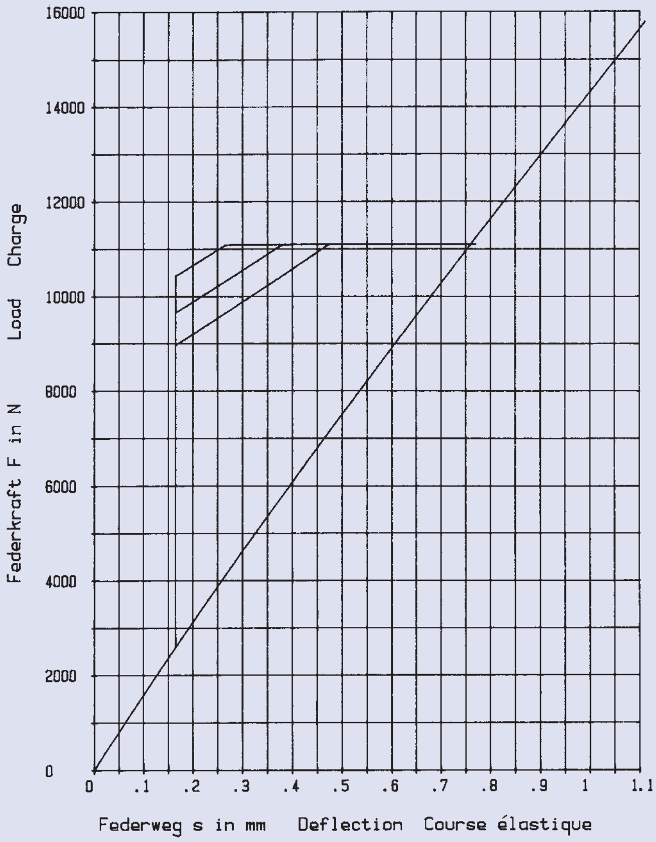
h_0 / t = 0,56 m = 28,589 g

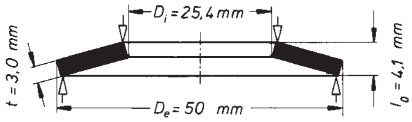




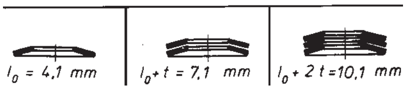
50 x 25,4 x 3,0

GR 2, DIN 2093 – A 50



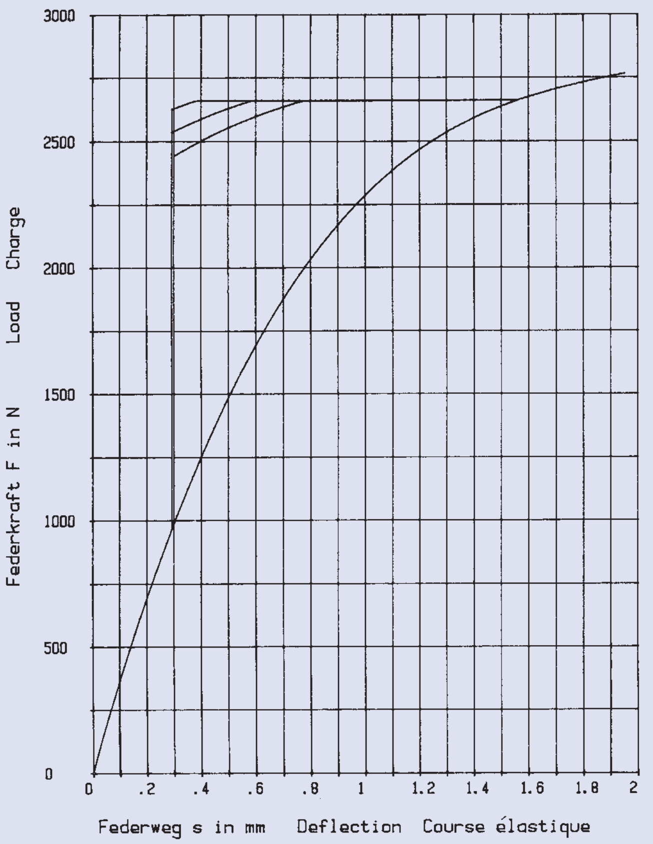


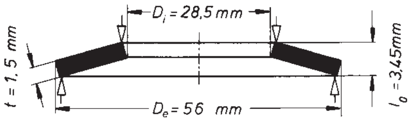
h_0 = 1,1 mm D_e/D_i = 1,968
t = 3,0 mm D_e/t = 16,666
h_0/t = 0,366   m = 34,306 g



56 x 28,5 x 1,5

GR 2, DIN 2093 – C 56





h_0 = 1,95mm D_e/D_i = 1,964
t = 1,5 mm D_e/t = 37,333
h_0/t = 1,3   m = 21,489 g

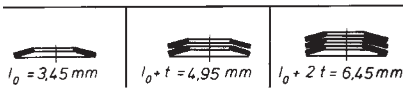
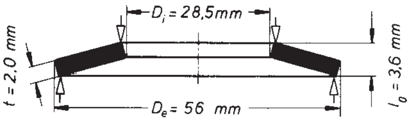


Diagramme | Diagrams | Diagrammes

56 x 28,5 x 2,0

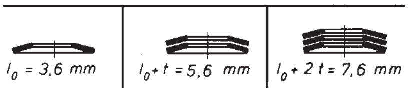
GR 2, DIN 2093 – B 56

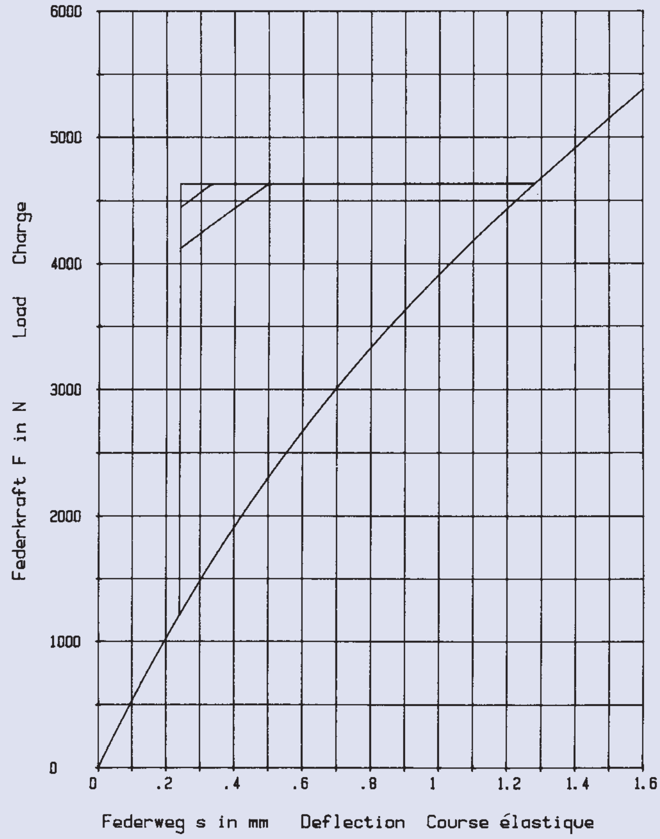


h_0 = 1,6 mm D_e/D_i = 1,964

t = 2,0 mm D_e/t = 28

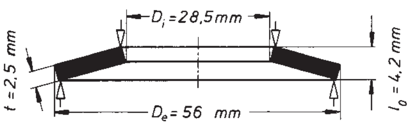
h_0/t = 0,8 m = 28,653 g





56 x 28,5 x 2,5

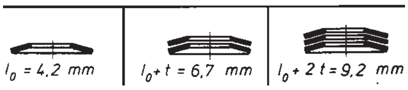
GR 2



h_0 = 1,7 mm D_e/D_i = 1,964

t = 2,5 mm D_e/t = 22,4

h_0/t = 0,68 m = 35,816 g



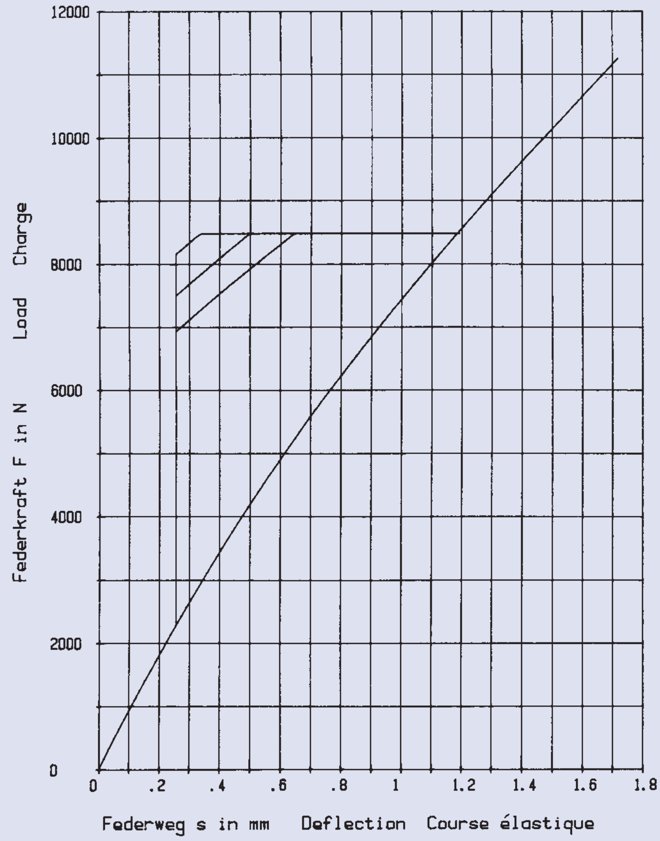
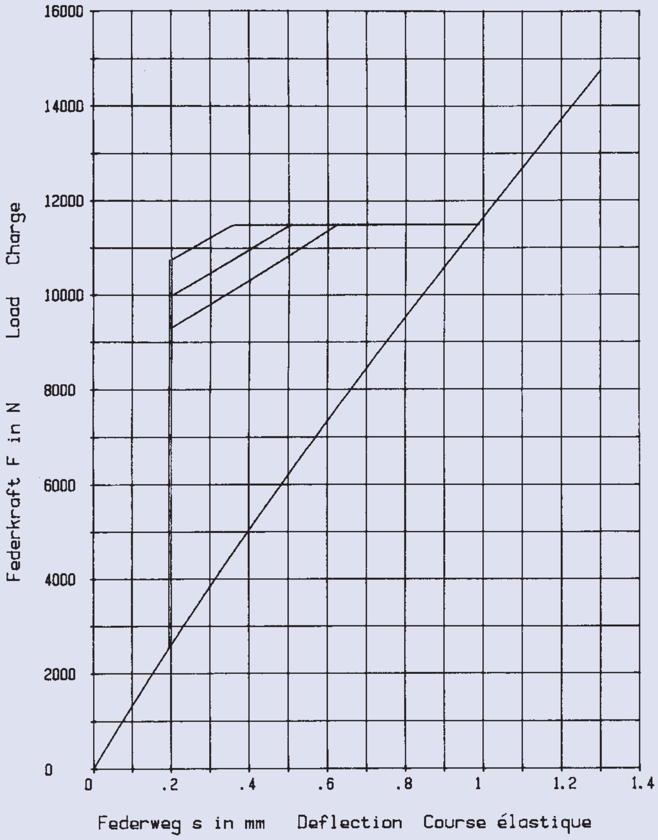
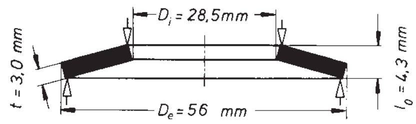


Diagramme | Diagrams | Diagrammes

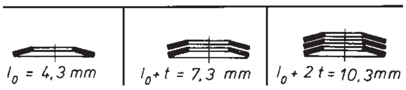
56 x 28,5 x 3,0

GR 2, DIN 2093 – A 56



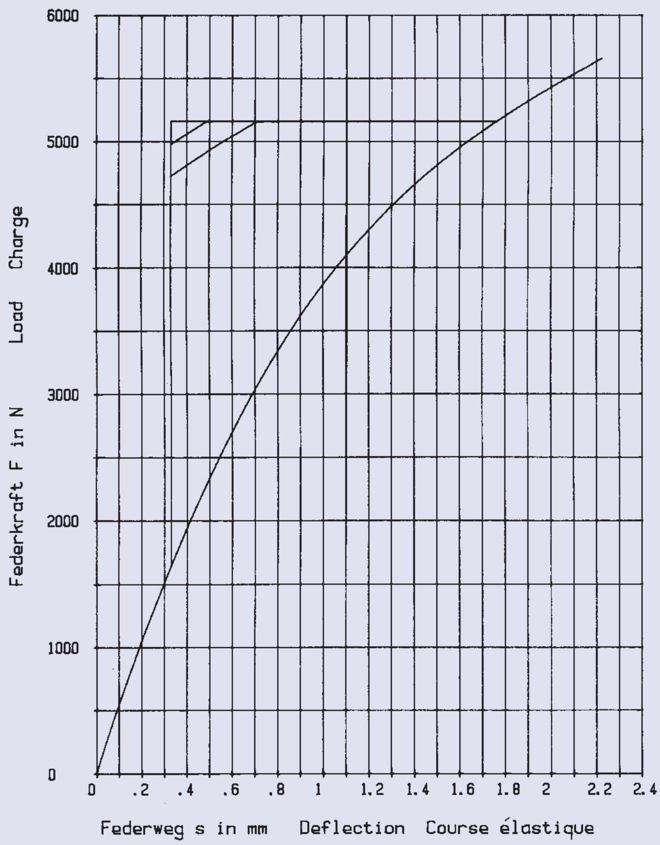


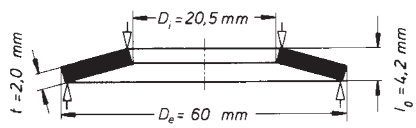
h_0 = 1,3 mm
D_e/D_i = 1,964
t = 3,0 mm
D_e/t = 18,666
h_0/t = 0,433
m = 42,979 g



60 x 20,5 x 2,0

GR 2





h_0 = 2,2 mm
D_e/D_i = 2,926
t = 2,0 mm
D_e/t = 30
h_0/t = 1,1
m = 39,208 g

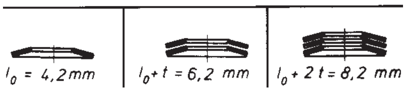
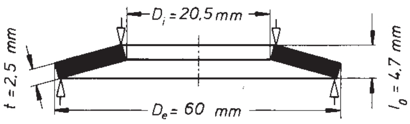


Diagramme | Diagrams | Diagrammes

60 x 20,5 x 2,5

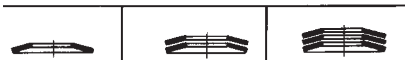
GR 2



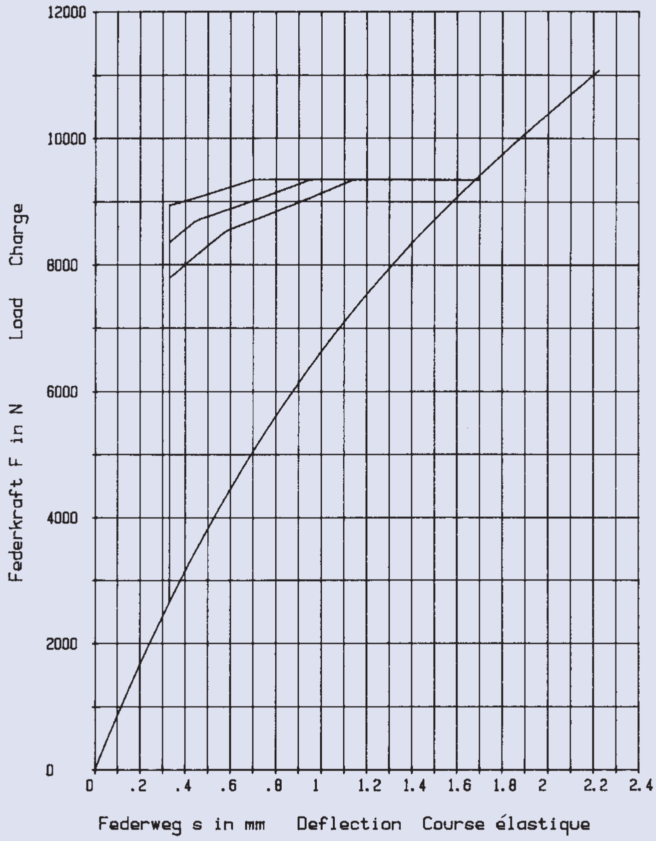
h_0 = 2.2 mm　　D_e/D_i = 2.926

t = 2.5 mm　　D_e/t = 24

h_0/t = 0.88　　m = 49.0 g

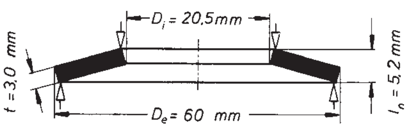


l_0 = 4.7 mm　　l_0 + t = 7.2 mm　　l_0 + 2 t = 9.7 mm



60 x 20,5 x 3,0

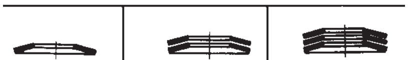
GR 2



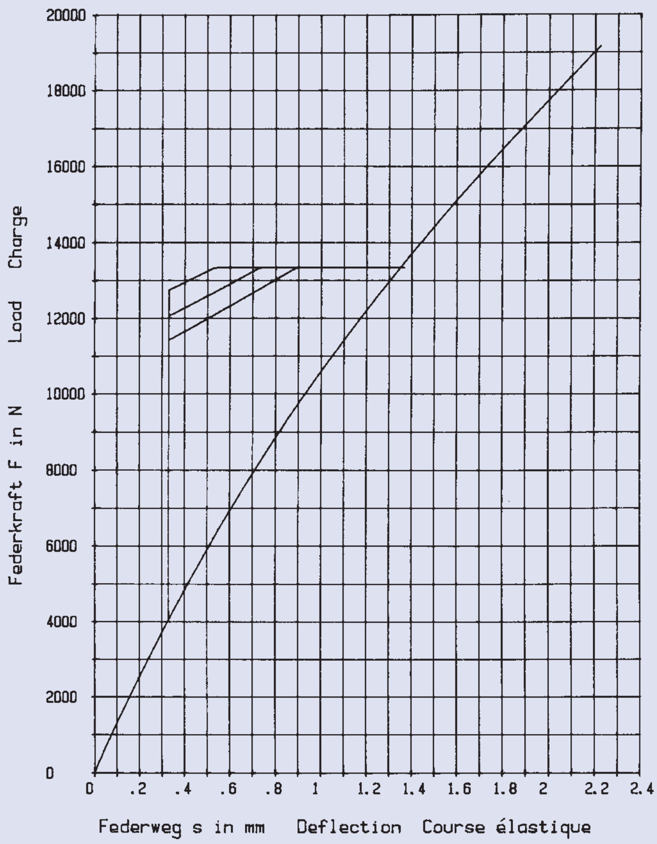
h_0 = 2.2 mm　　D_e/D_i = 2.926

t = 3.0 mm　　D_e/t = 20

h_0/t = 0.733　　m = 58.811 g

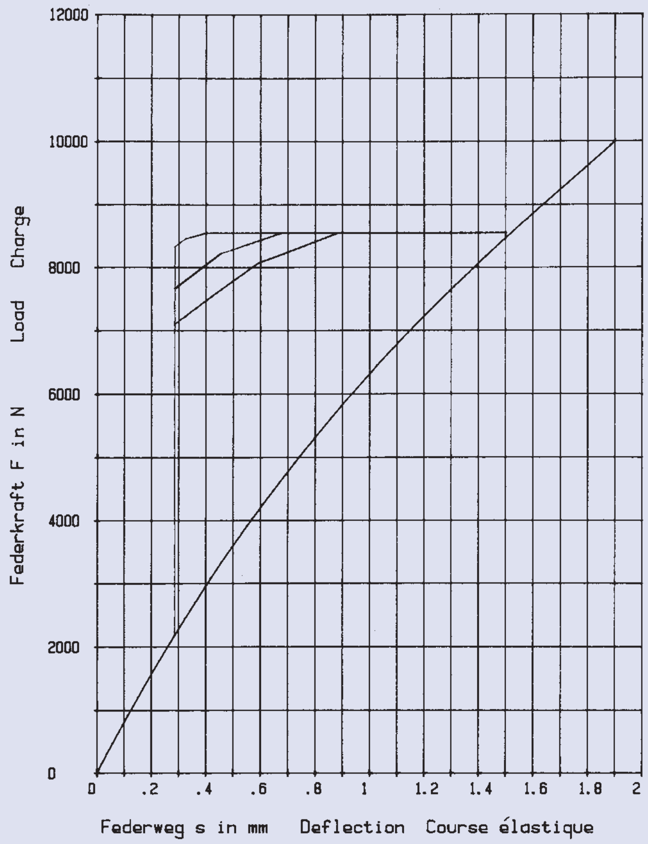


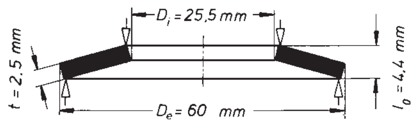
l_0 = 5.2 mm　　l_0 + t = 8.2 mm　　l_0 + 2 t = 11.2 mm



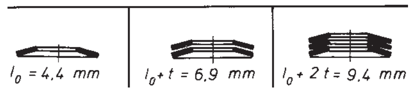
60 x 25,5 x 2,5

GR 2



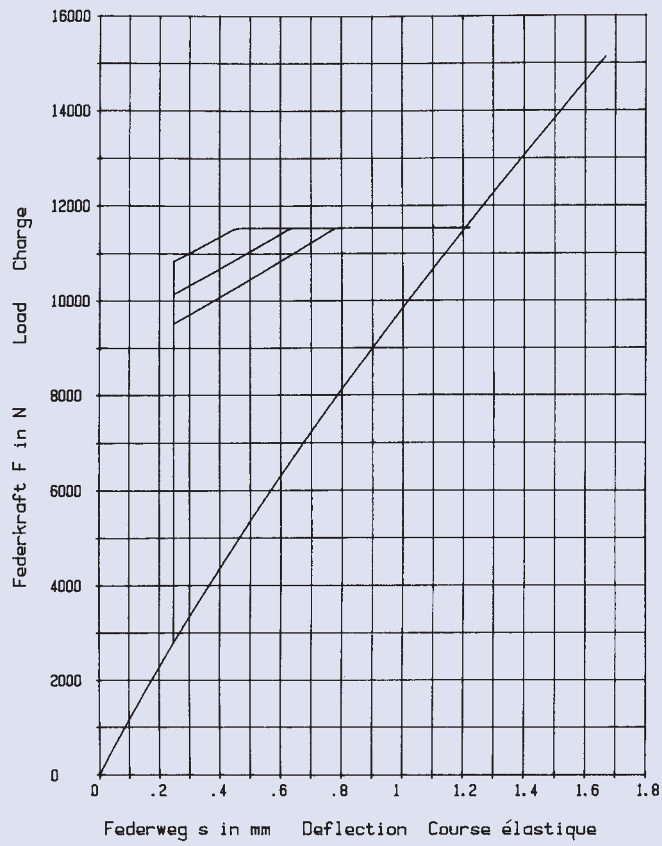


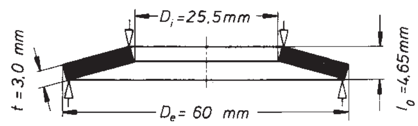
h_0 = 1,9 mm	D_e/D_i = 2,352
t = 2,5 mm	D_e/t = 24
h_0/t = 0,76	m = 45,464 g



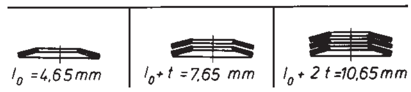
60 x 25,5 x 3,0

GR 2





h_0 = 1,65 mm	D_e/D_i = 2,352
t = 3,0 mm	D_e/t = 20
h_0/t = 0,55	m = 54,557 g



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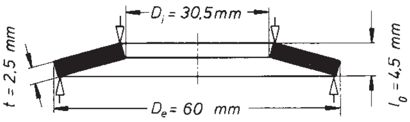
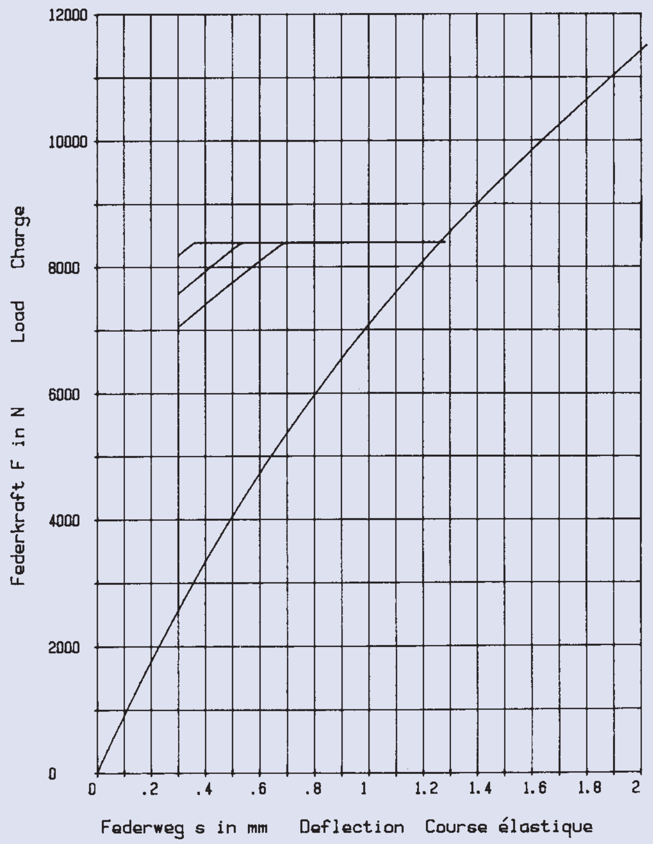
60 x 30,5 x 2,5

GR 2



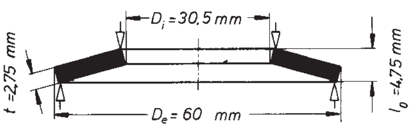
h_0 = 2,0 mm	D_e/D_i = 1,967
t = 2,5 mm	D_e/t = 24
h_0/t = 0,8	m = 41,149 g

l_0 = 4,5 mm	l_0 + t = 7,0 mm	l_0 + 2 t = 9,5 mm



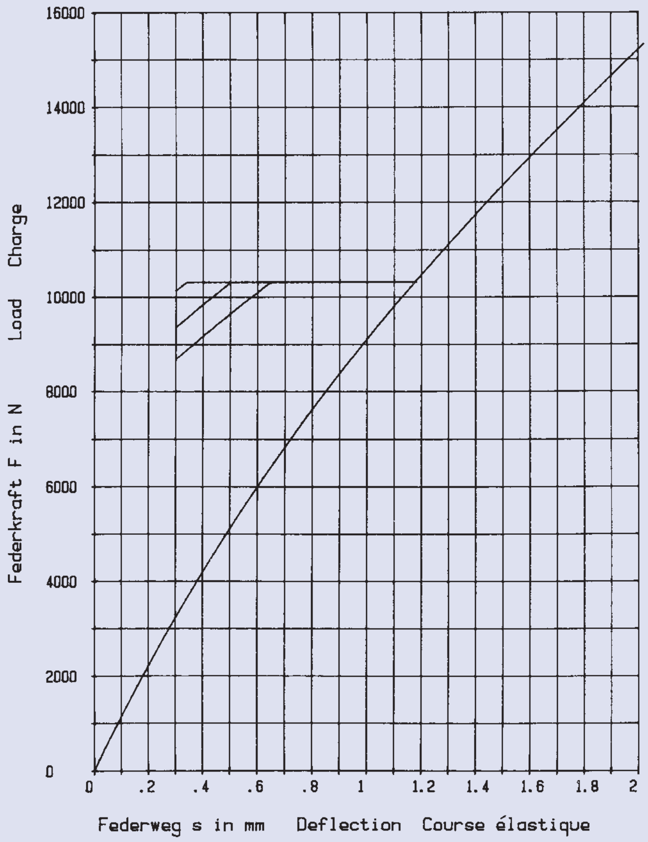
60 x 30,5 x 2,75

GR 2

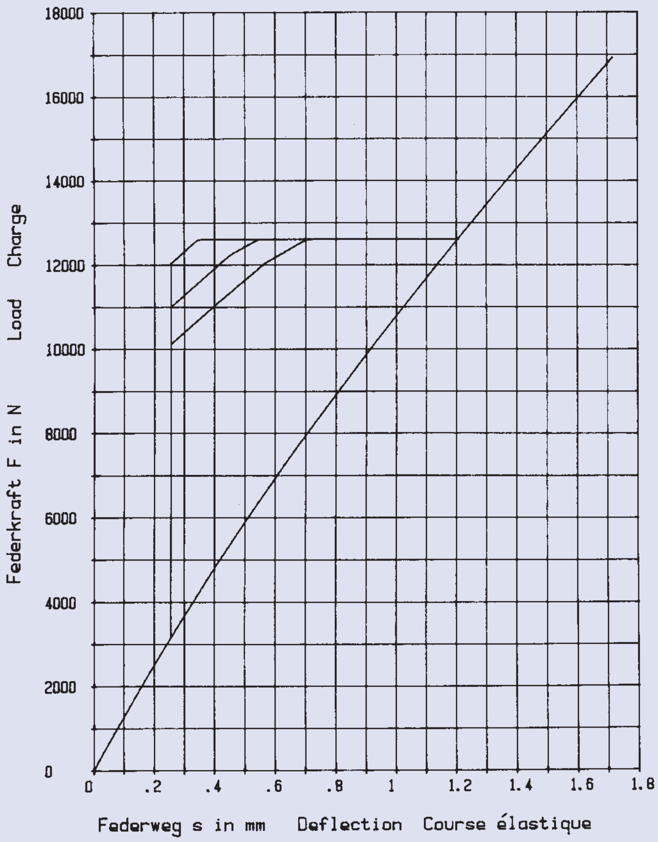


h_0 = 2,0 mm	D_e/D_i = 1,967
t = 2,75 mm	D_e/t = 21,818
h_0/t = 0,727	m = 45,264 g

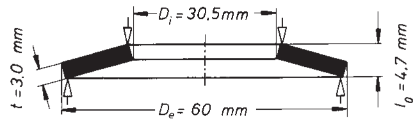
l_0 = 4,75 mm	l_0 + t = 7,5 mm	l_0 + 2 t = 10,25 mm



60 x 30,5 x 3,0



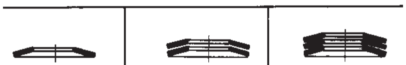
GR 2



h_0 = 1,7 mm D_e/D_i = 1,967

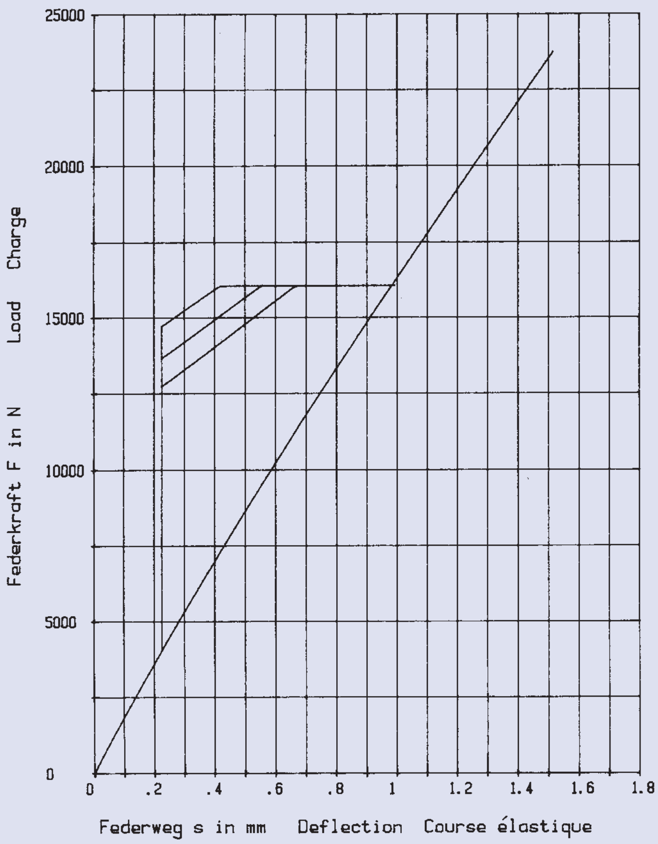
t = 3,0 mm D_e/t = 20

h_0/t = 0,566 m = 49,379 g

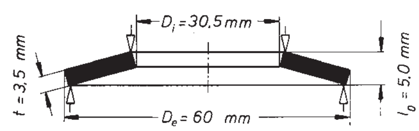


l_0 = 4,7 mm | $l_0 + t$ = 7,7 mm | $l_0 + 2t$ = 10,7 mm

60 x 30,5 x 3,5



GR 2



h_0 = 1,5 mm D_e/D_i = 1,967

t = 3,5 mm D_e/t = 17,142

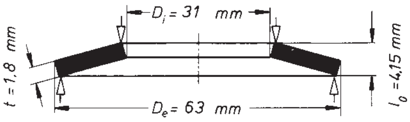
h_0/t = 0,428 m = 57,608 g

l_0 = 5,0 mm | $l_0 + t$ = 8,5 mm | $l_0 + 2t$ = 12 mm

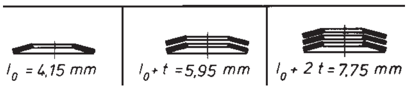
Diagramme | Diagrams | Diagrammes

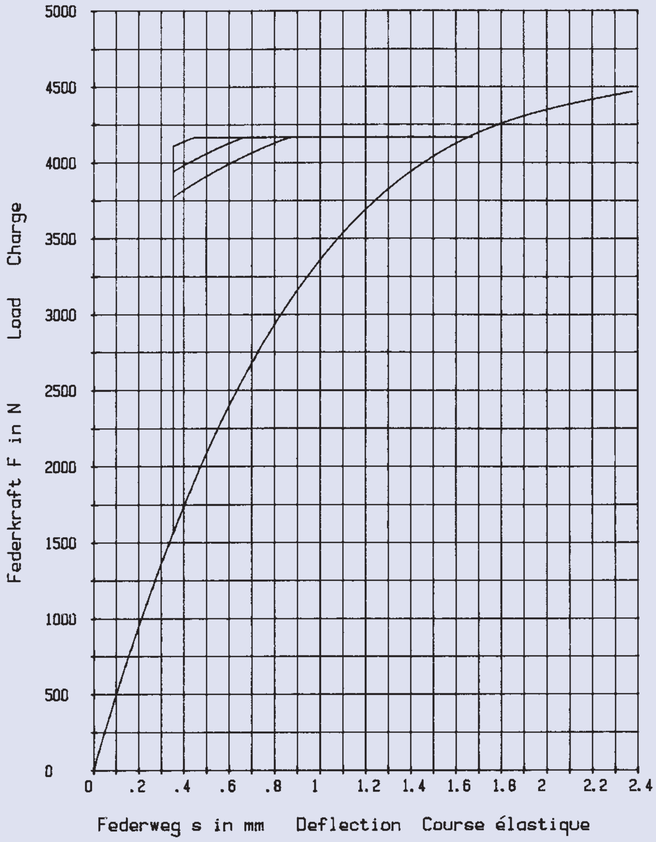
63 x 31 x 1,8

GR 2, DIN 2093 – C 63



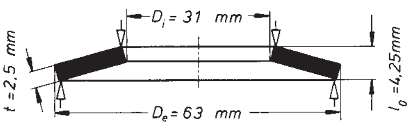
h_0 = 2,35mm	D_e/D_i = 2,032
t = 1,8 mm	D_e/t = 35
h_0/t = 1,305	m = 33,381 g



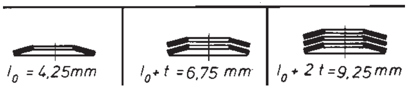


63 x 31 x 2,5

GR 2, DIN 2093 – B 63



h_0 = 1,75mm	D_e/D_i = 2,032
t = 2,5 mm	D_e/t = 25,2
h_0/t = 0,7	m = 46,362 g



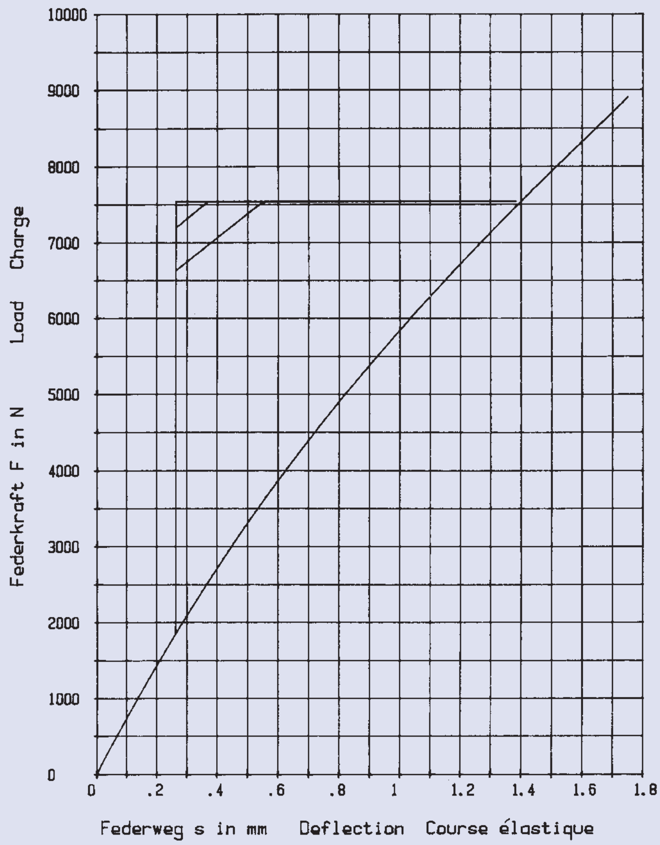
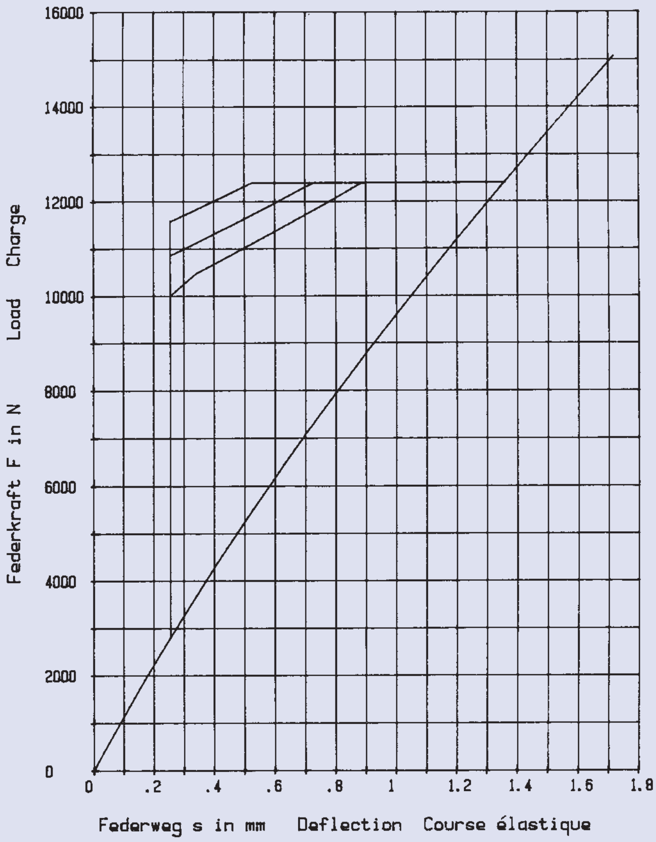
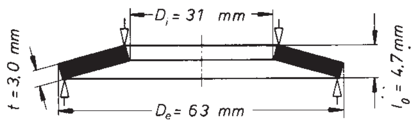


Diagramme | Diagrams | Diagrammes

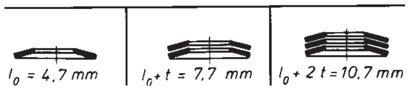
63 x 31 x 3,0

GR 2



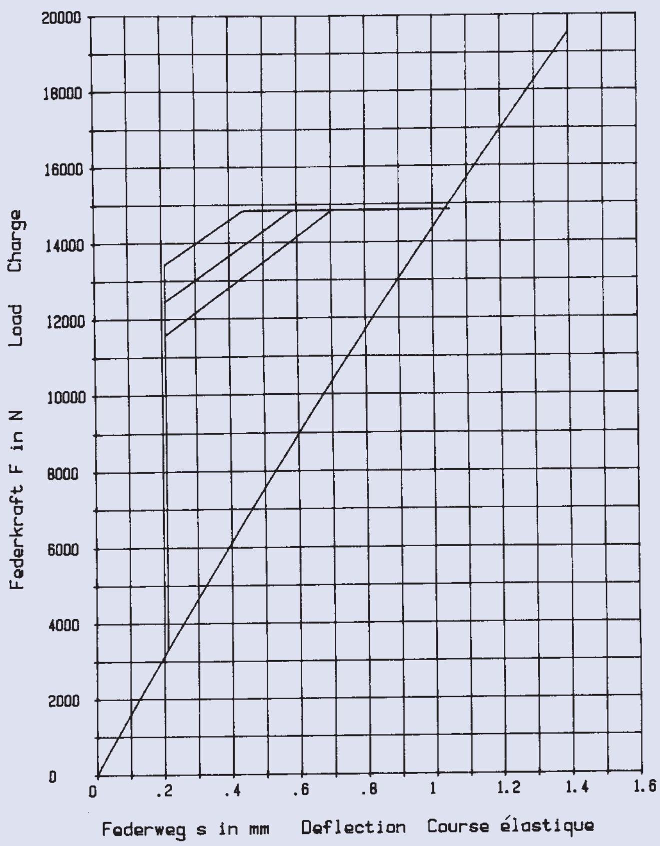


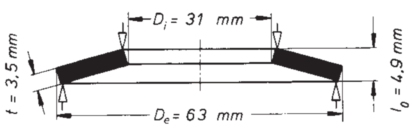
h_0 = 1,7 mm	D_e/D_i = 2,032
t = 3,0 mm	D_e/t = 21
h_0/t = 0,566	m = 55,635 g



63 x 31 x 3,5

GR 2, DIN 2093 – A 63





h_0 = 1,4 mm	D_e/D_i = 2,032
t = 3,5 mm	D_e/t = 18
h_0/t = 0, 4	m = 64,907 g

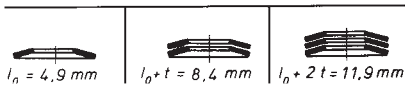
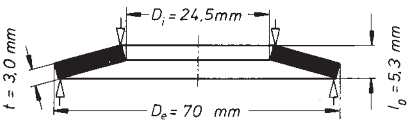


Diagramme | Diagrams | Diagrammes

70 x 24,5 x 3,0

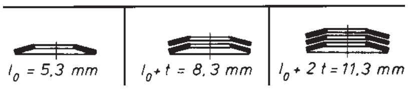
GR 2

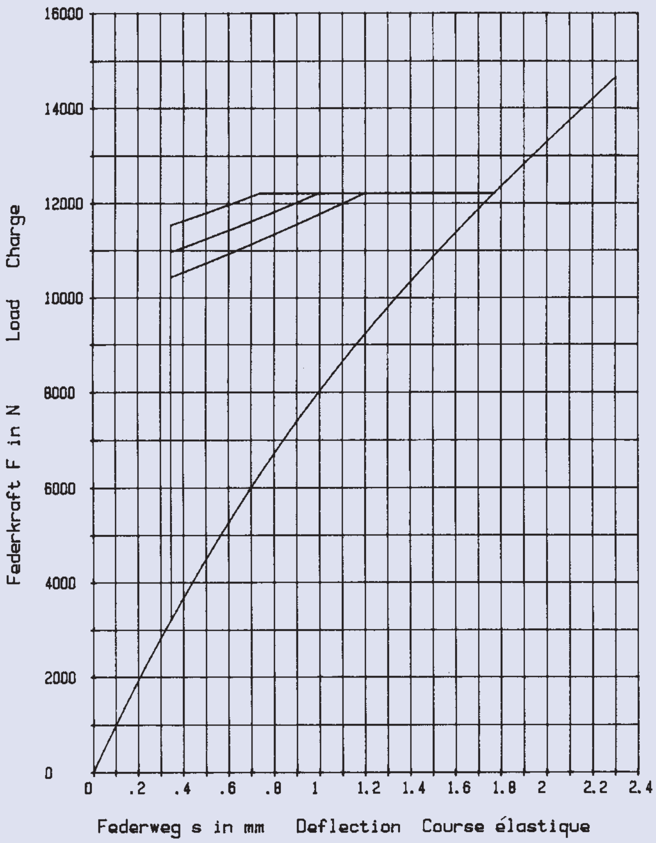


$h_0 = 2,3 mm$ — $D_e / D_i = 2,857$

$t = 3,0 mm$ — $D_e / t = 23,333$

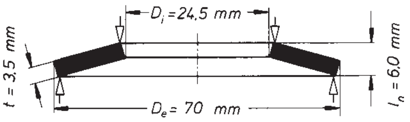
$h_0 / t = 0,766$ — $m = 79,526 g$





70 x 24,5 x 3,5

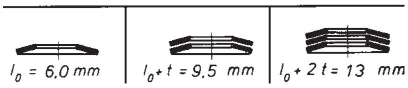
GR 2

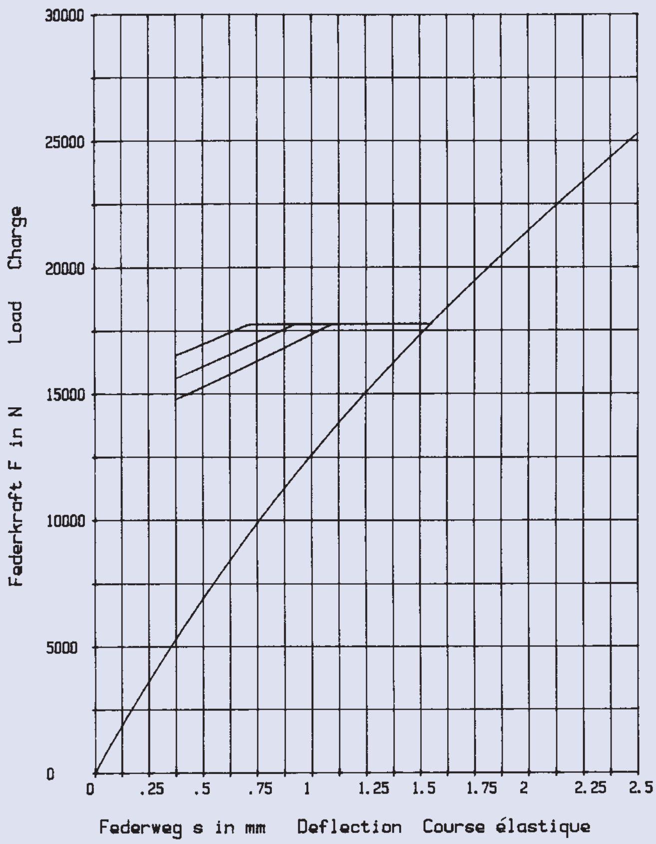


$h_0 = 2,5 mm$ — $D_e / D_i = 2,857$

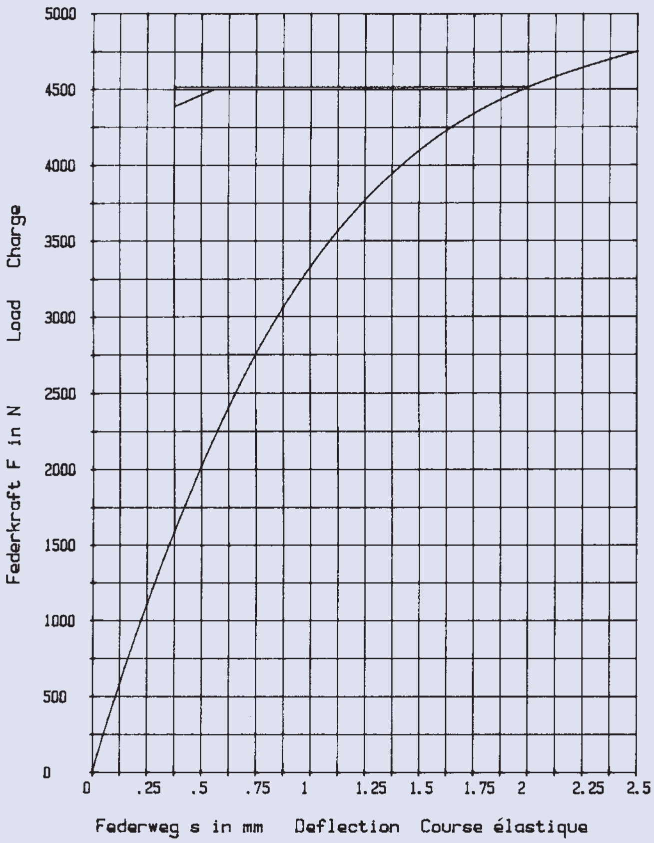
$t = 3,5 mm$ — $D_e / t = 20$

$h_0 / t = 0,714$ — $m = 92,781 g$

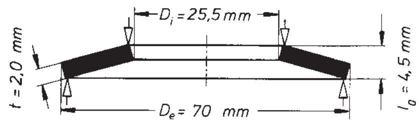




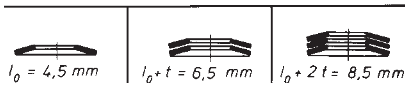
70 x 25,5 x 2,0



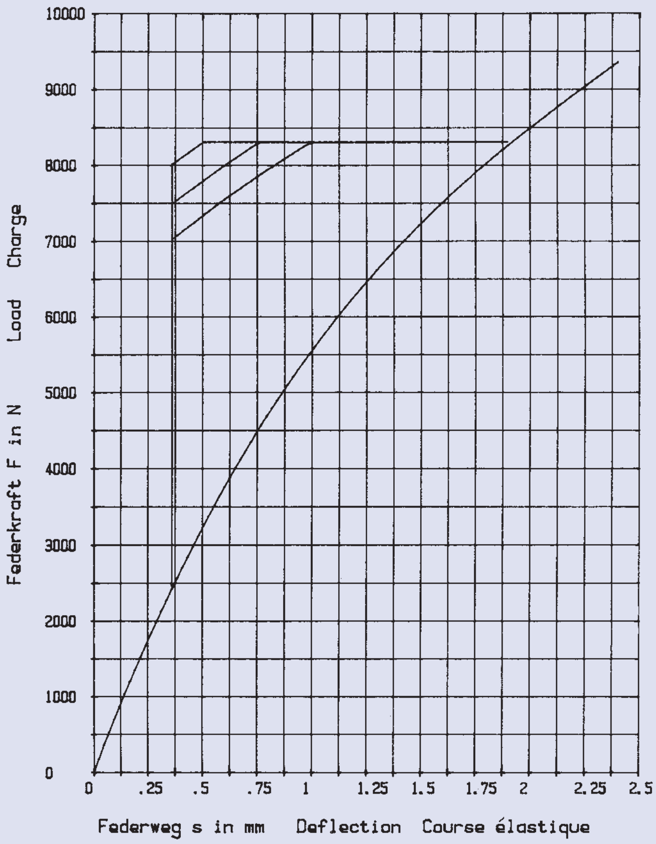
GR 2



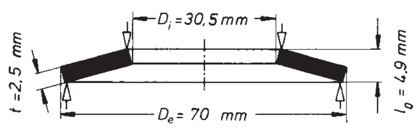
h_0 = 2,5 mm D_e/D_i = 2,745
t = 2,0 mm D_e/t = 35
h_0/t = 1,25 m = 52,401 g



70 x 30,5 x 2,5



GR 2



h_0 = 2,4 mm D_e/D_i = 2,295
t = 2,5 mm D_e/t = 28
h_0/t = 0,96 m = 61,186 g

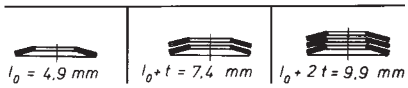
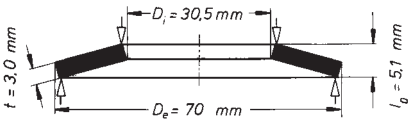


Diagramme | Diagrams | Diagrammes

70 x 30,5 x 3,0

GR 2



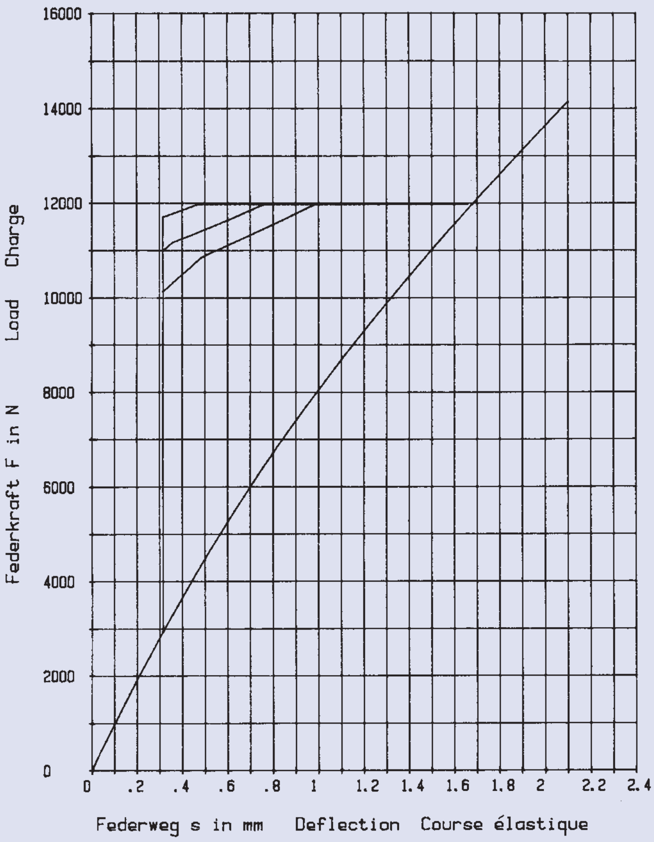
h_0 = 2,1 mm
t = 3,0 mm
h_0/t = 0,7

D_e/D_i = 2,295
D_e/t = 23,333
m = 73,423 g

l_0 = 5,1 mm

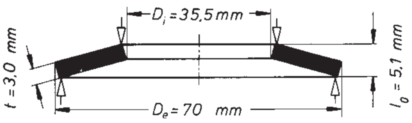
l_0 + t = 8,1 mm

l_0 + 2 t = 11,1 mm



70 x 35,5 x 3,0

GR 2



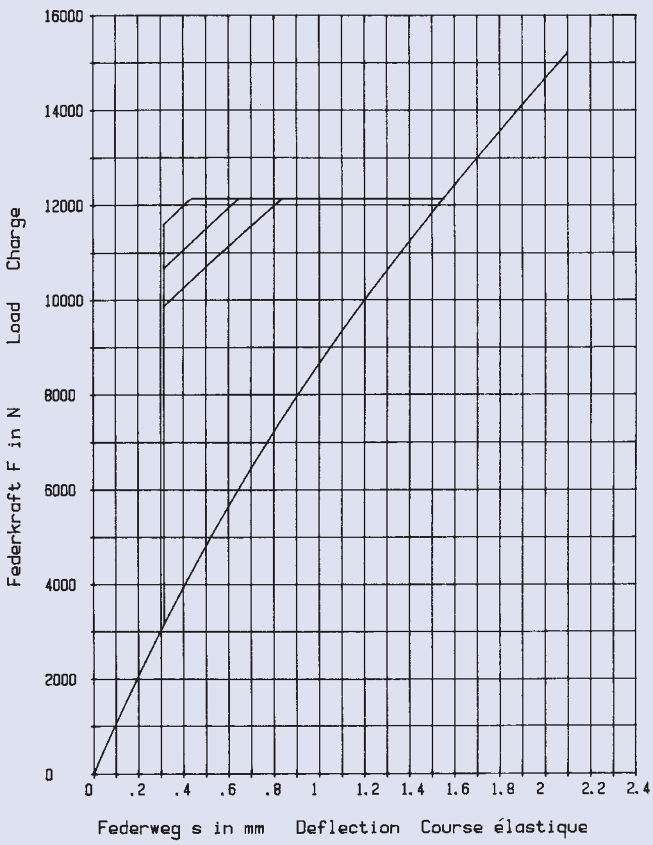
h_0 = 2,1 mm
t = 3,0 mm
h_0/t = 0,7

D_e/D_i = 1,971
D_e/t = 23,333
m = 67, 319 g

l_0 = 5,1 mm

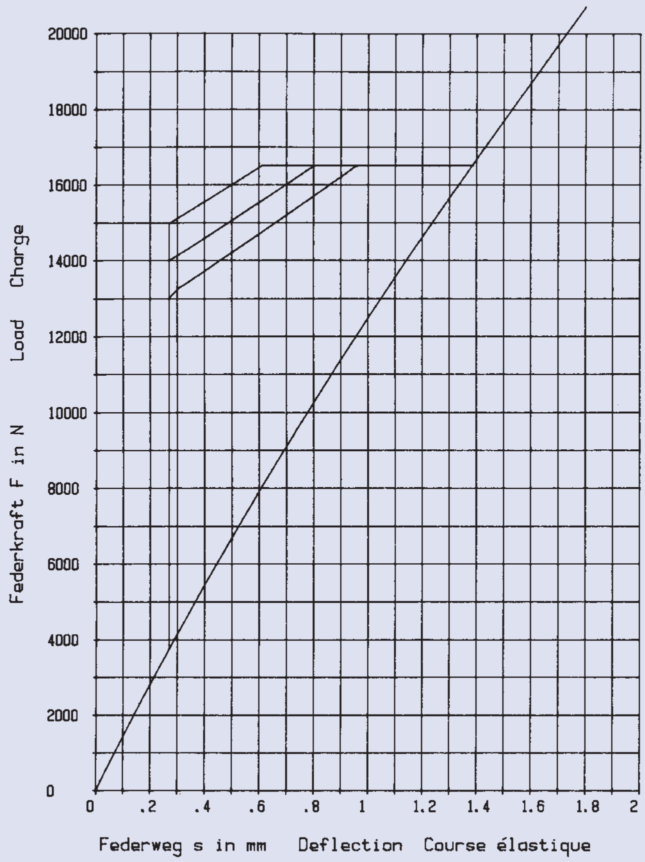
l_0 + t = 8,1 mm

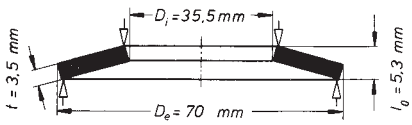
l_0 + 2 t = 11,1 mm



70 x 35,5 x 3,5

GR 2

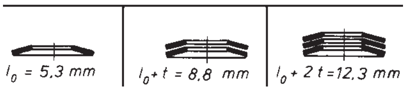




h_0 = 1,8 mm D_e/D_i = 1,971

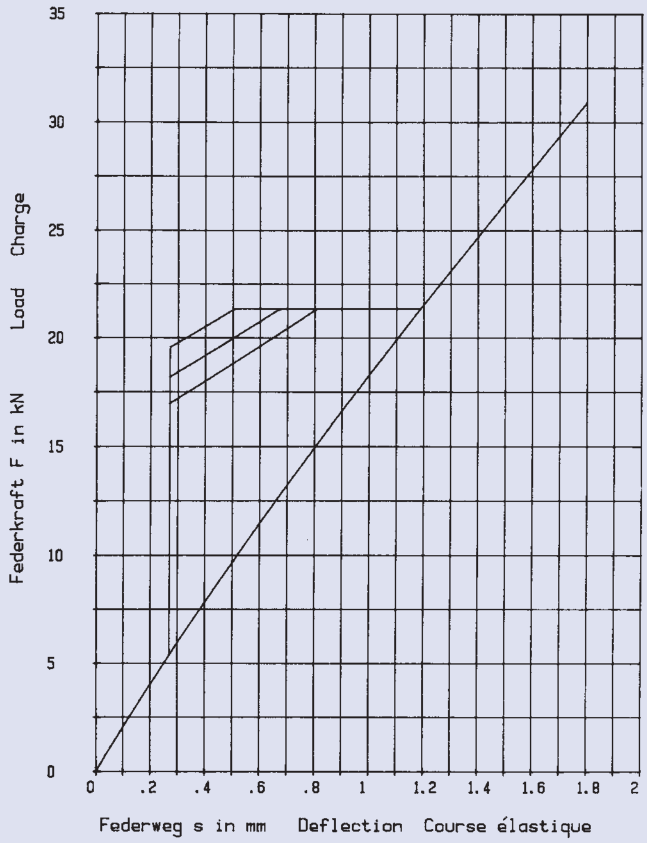
t = 3,5 mm D_e/t = 20

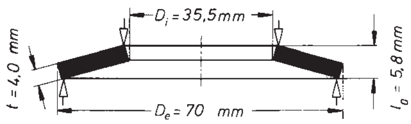
h_0/t = 0,514 m = 78,539 g



70 x 35,5 x 4,0

GR 2





h_0 = 1,8 mm D_e/D_i = 1,971

t = 4,0 mm D_e/t = 17,5

h_0/t = 0,45 m = 89,759 g

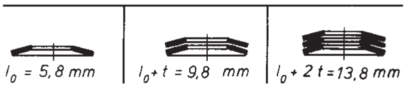
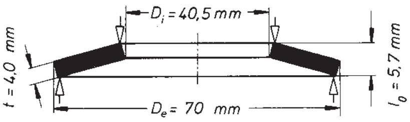


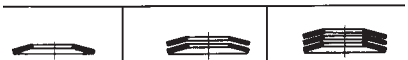
Diagramme | Diagrams | Diagrammes

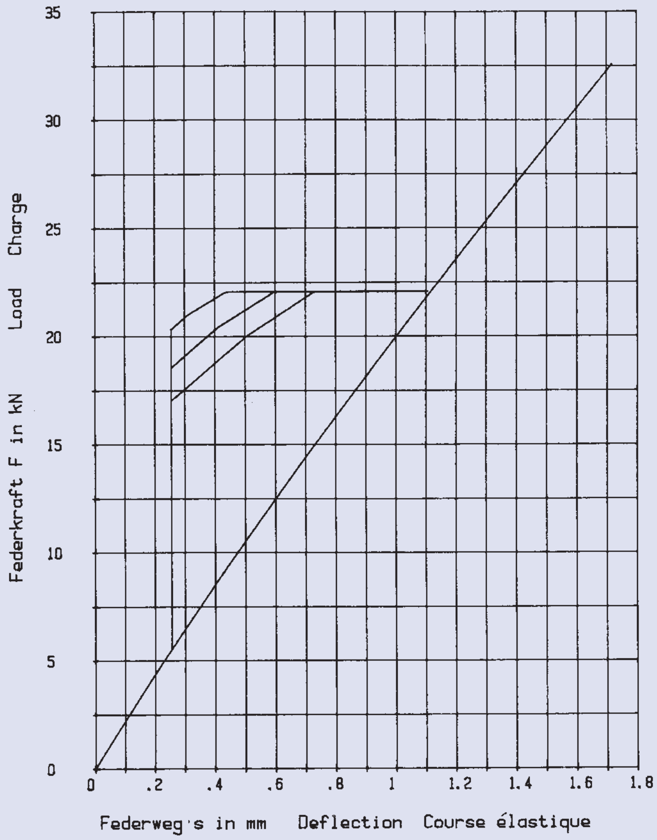
70 x 40,5 x 4,0

GR 2



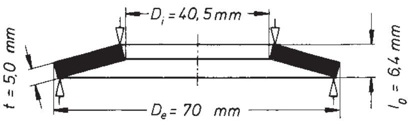
h_0 = 1,7 mm	D_e/D_i = 1,728
t = 4,0 mm	D_e/t = 17,5
h_0/t = 0,425	m = 80,388 g



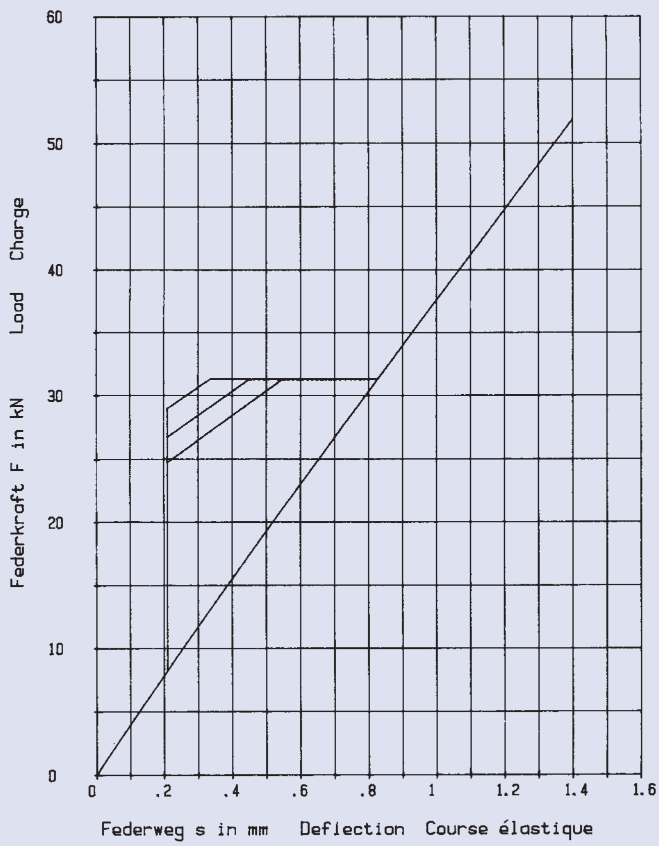


70 x 40,5 x 5,0

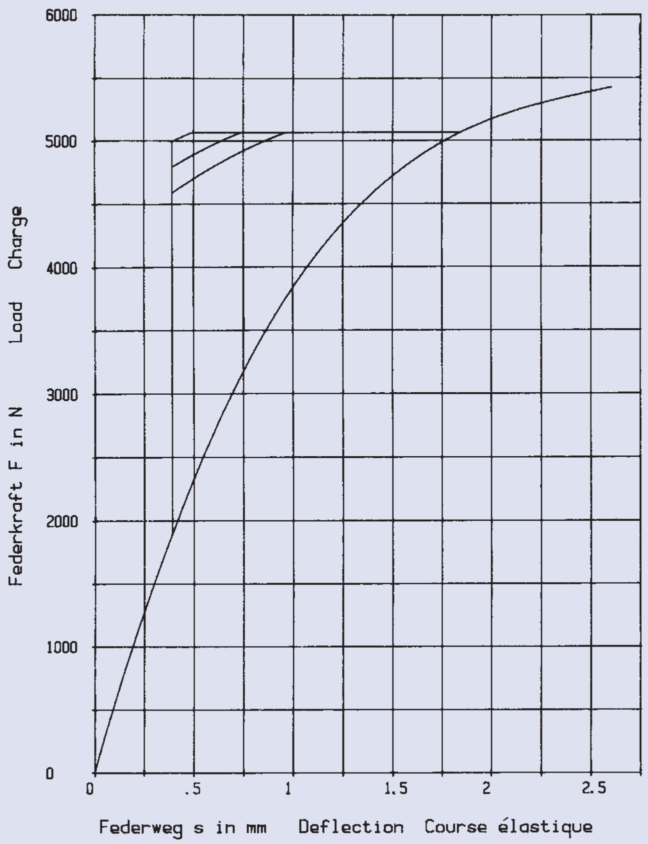
GR 2



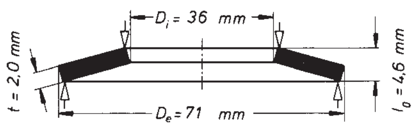
h_0 = 1,4 mm	D_e/D_i = 1,728
t = 5,0 mm	D_e/t = 14
h_0/t = 0, 28	m = 100,485 g



71 x 36 x 2,0



GR 2, DIN 2093 – C 71

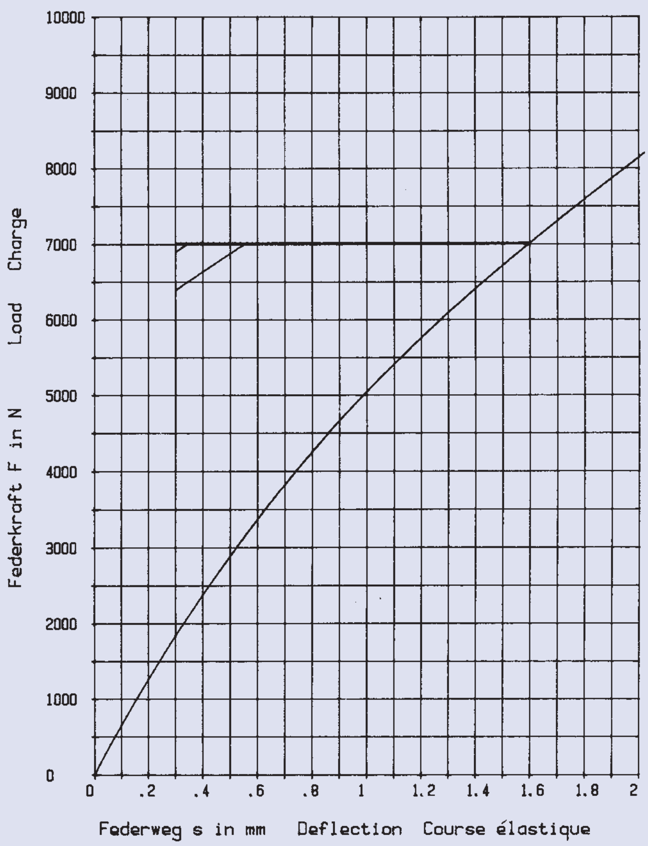


h_0 = 2,6 mm
t = 2,0 mm
h_0/t = 1,3

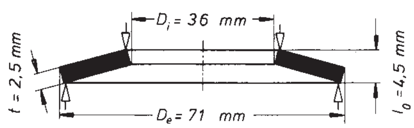
D_e/D_i = 1,972
D_e/t = 35,5
m = 46,177 g

l_0 = 4,6 mm	$l_0 + t$ = 6,6 mm	$l_0 + 2t$ = 8,6 mm

71 x 36 x 2,5



GR 2, DIN 2093 – B 71



h_0 = 2,0 mm
t = 2,5 mm
h_0/t = 0,8

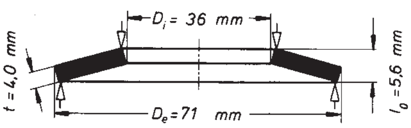
D_e/D_i = 1,972
D_e/t = 28,4
m = 57,722 g

l_0 = 4,5 mm	$l_0 + t$ = 7,0 mm	$l_0 + 2t$ = 9,5 mm

Diagramme | Diagrams | Diagrammes

71 x 36 x 4,0

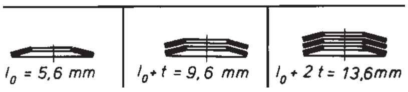
GR 2, DIN 2093 – A 71

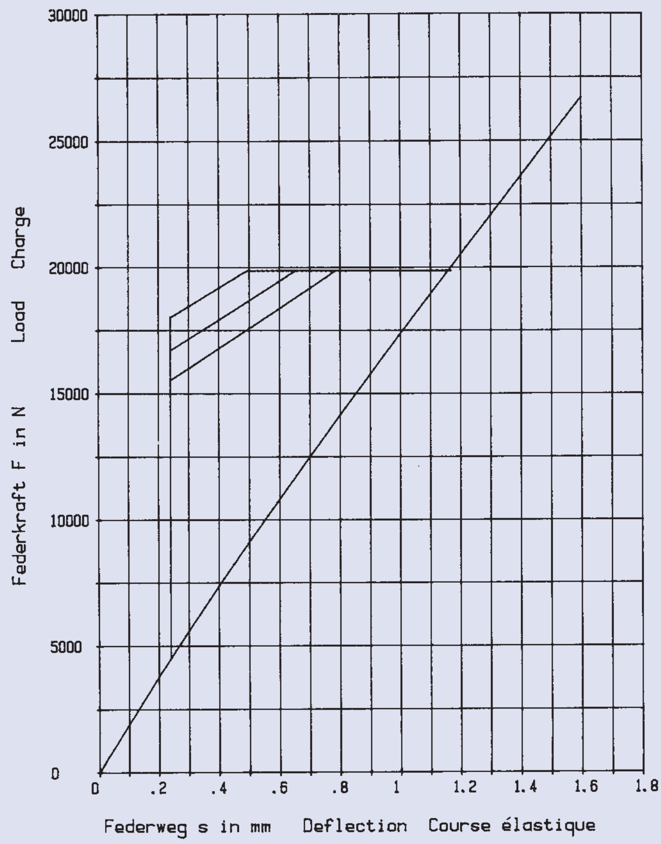


$h_0 = 1,6$ mm — $D_e/D_i = 1,972$

$t = 4,0$ mm — $D_e/t = 17,75$

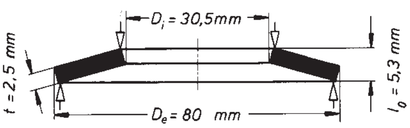
$h_0/t = 0,4$ — $m = 92,355$ g





80 x 30,5 x 2,5

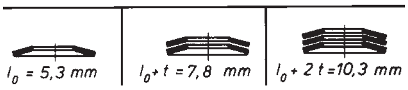
GR 2

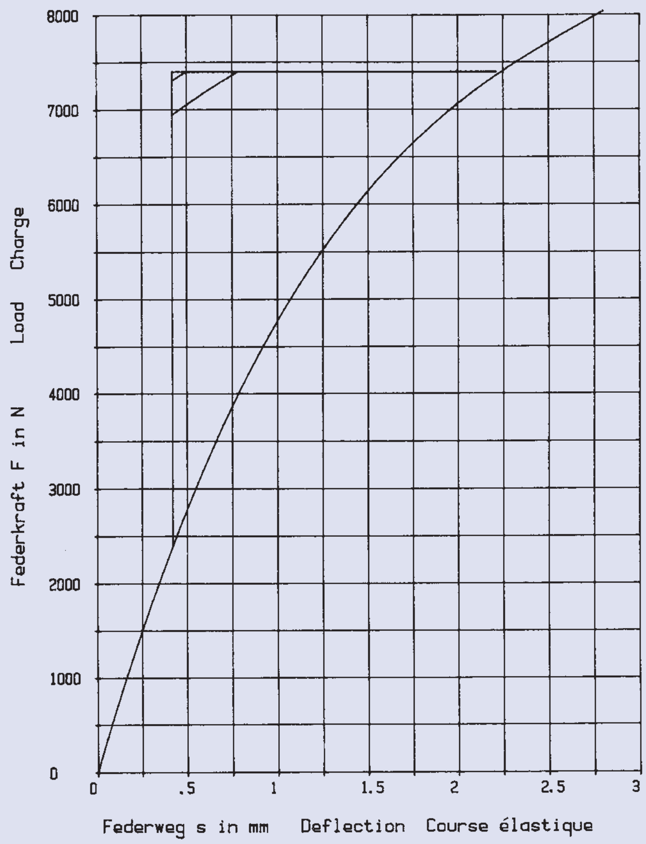


$h_0 = 2,8$ mm — $D_e/D_i = 2,622$

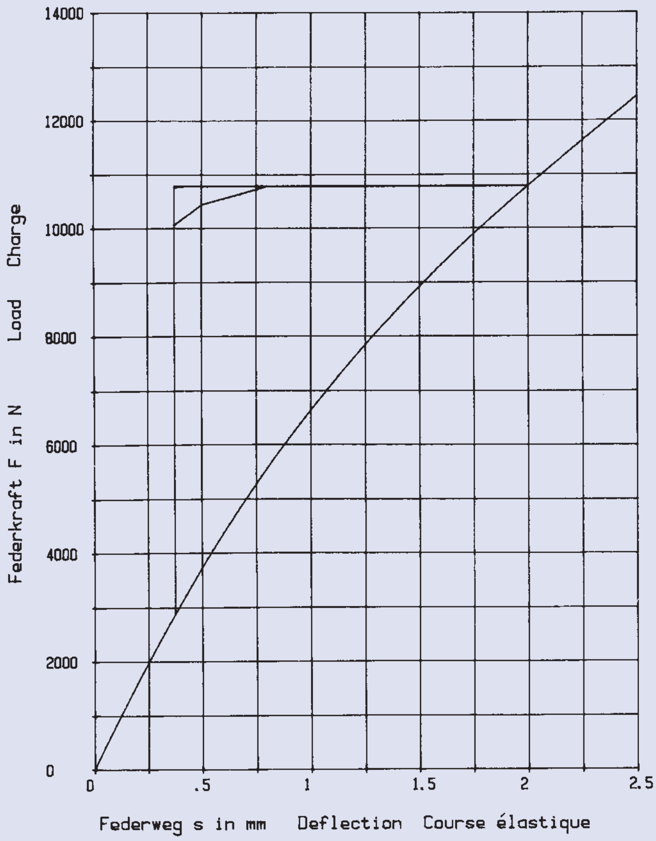
$t = 2,5$ mm — $D_e/t = 32$

$h_0/t = 1,12$ — $m = 84,305$ g

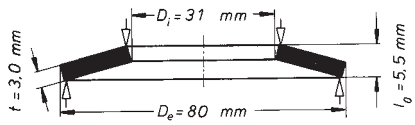




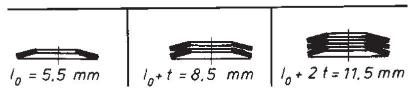
80 x 31 x 3,0



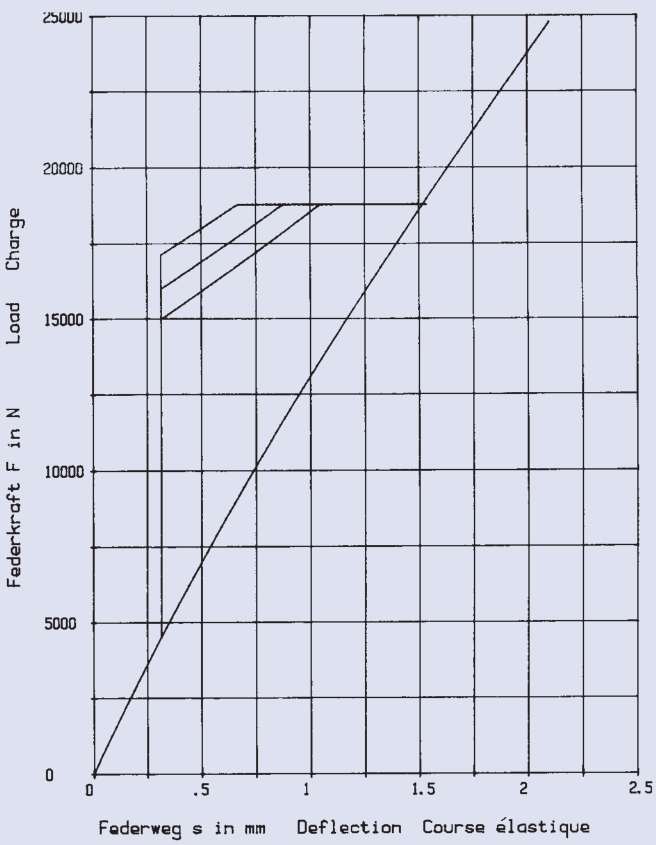
GR 2



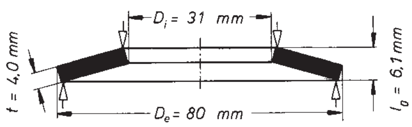
h_0 = 2,5 mm	D_e/D_i = 2,58
t = 3,0 mm	D_e/t = 26,666
h_0/t = 0,833	m = 100,60 g



80 x 31 x 4,0



GR 2



h_0 = 2,1 mm	D_e/D_i = 2,58
t = 4,0 mm	D_e/t = 20
h_0/t = 0,525	m = 134,13 g

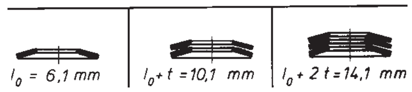
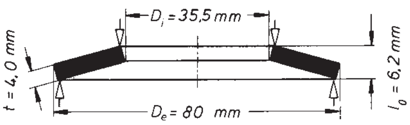


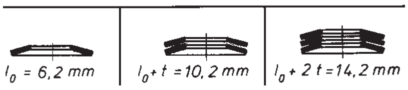
Diagramme | Diagrams | Diagrammes

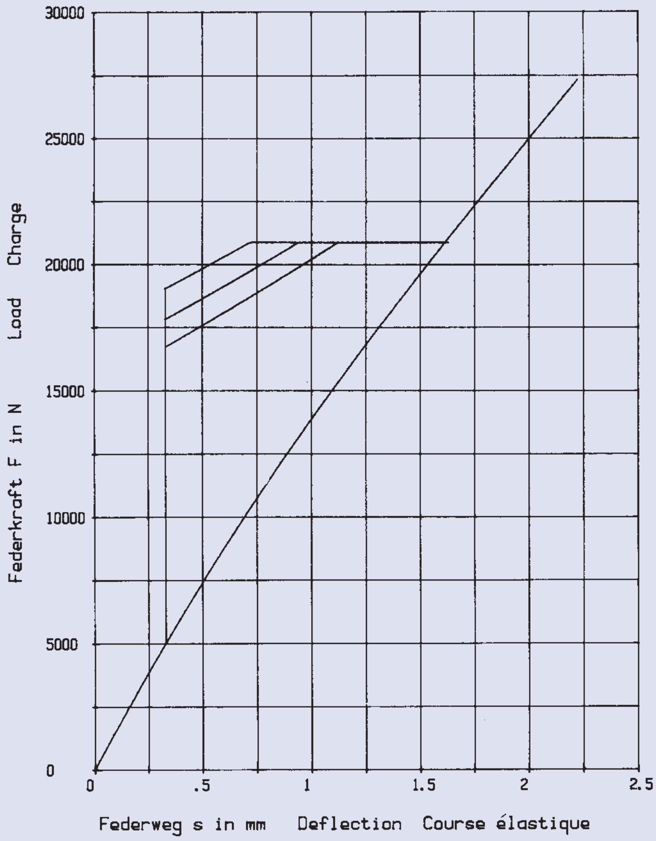
80 x 35,5 x 4,0

GR 2



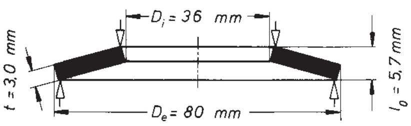
$h_0 = 2{,}2$ mm	$D_e/D_i = 2{,}253$
$t = 4{,}0$ mm	$D_e/t = 20$
$h_0/t = 0{,}55$	$m = 126{,}75$ g



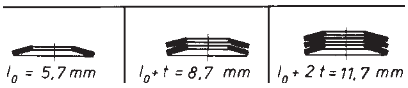


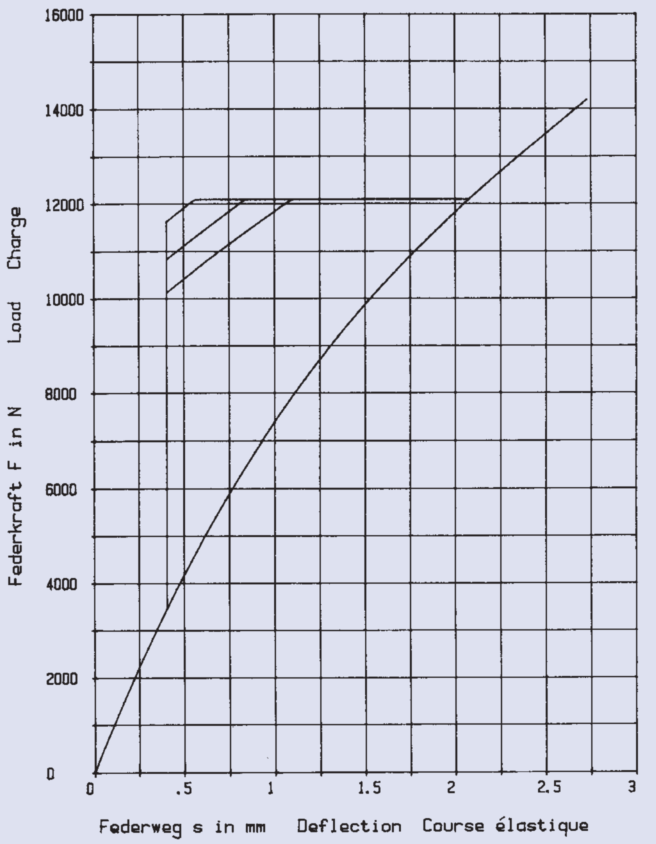
80 x 36 x 3,0

GR 2



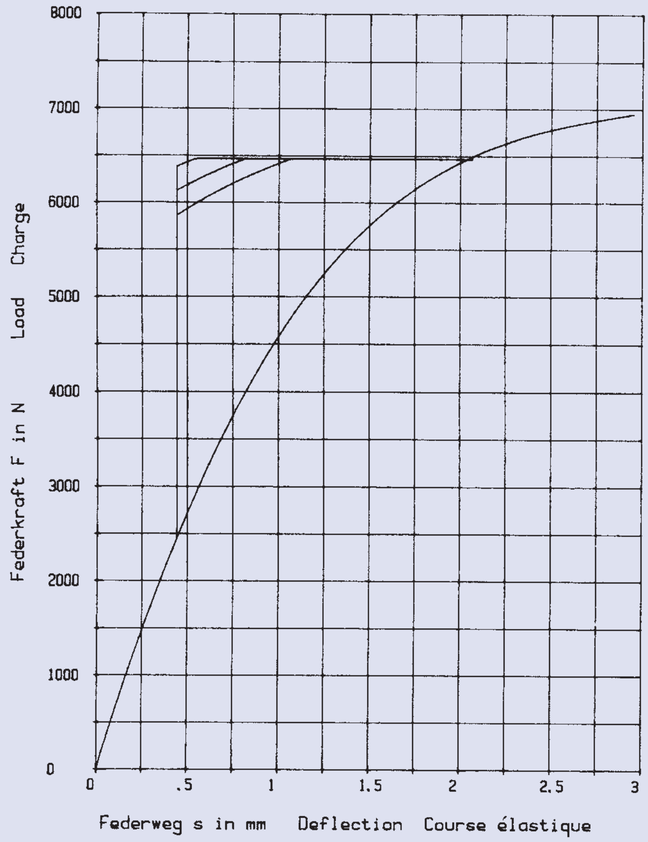
$h_0 = 2{,}7$ mm	$D_e/D_i = 2{,}222$
$t = 3{,}0$ mm	$D_e/t = 26{,}666$
$h_0/t = 0{,}9$	$m = 94{,}401$ g

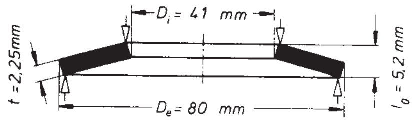




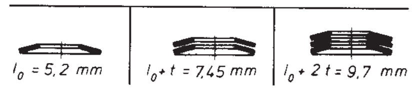
80 x 41 x 2,25

GR 2,DIN 2093 – C 80



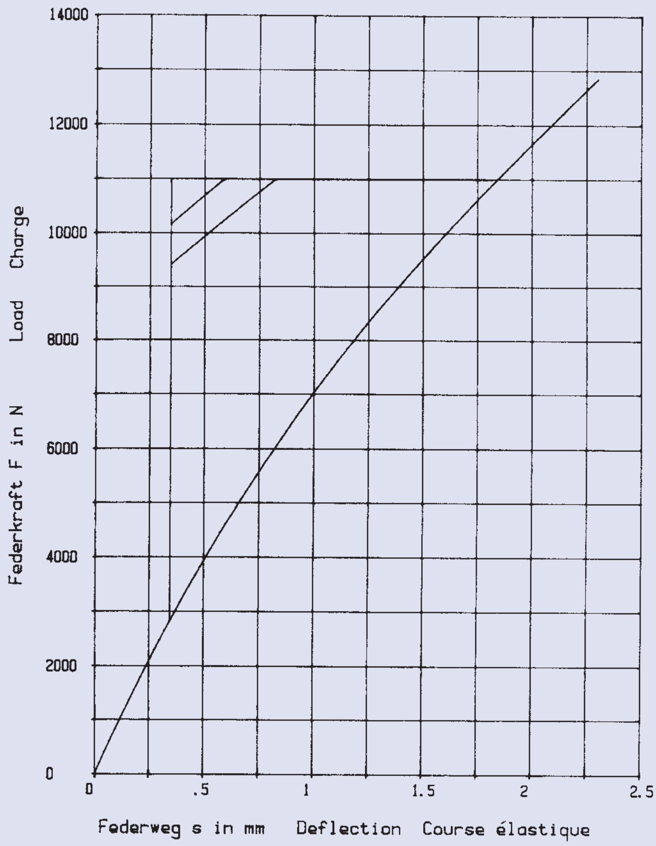


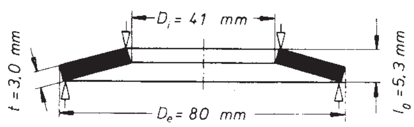
h_0 = 2,95mm	D_e/D_i = 1,951
t = 2,25mm	D_e/t = 35,555
h_0/t = 1,311	m = 65,460 g



80 x 41 x 3,0

GR 2, DIN 2093 – B 80





h_0 = 2,3mm	D_e/D_i = 1,951
t = 3,0 mm	D_e/t = 26,666
h_0/t = 0,766	m = 87,281 g

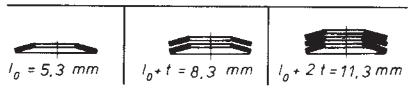
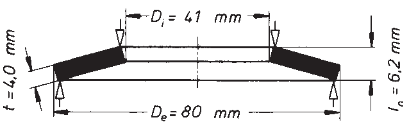


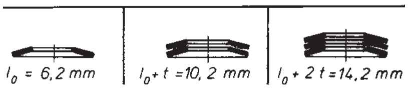
Diagramme | Diagrams | Diagrammes

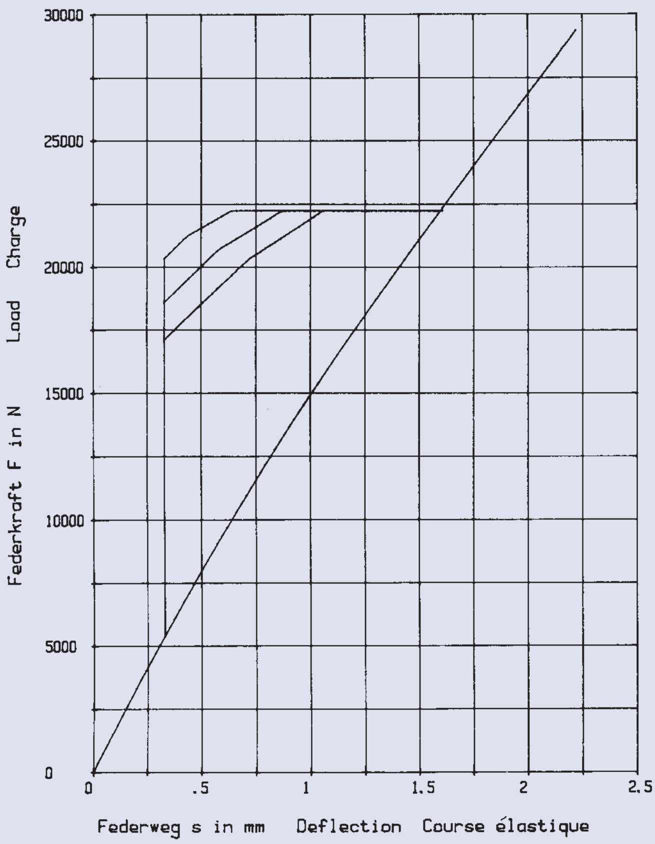
80 x 41 x 4,0

GR 2



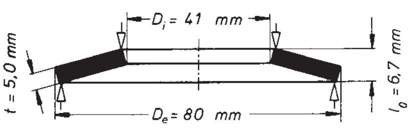
h_0 = 2,2 mm	D_e / D_i = 1,951
t = 4,0 mm	D_e / t = 20
h_0 / t = 0,55	m = 116,374 g



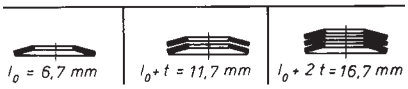


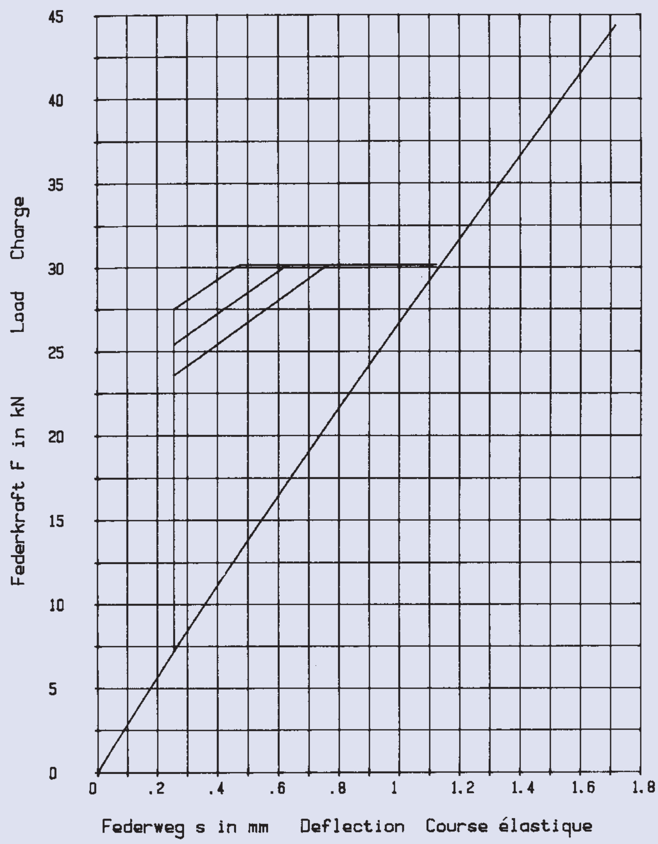
80 x 41 x 5,0

GR 2, DIN 2093 – A 80

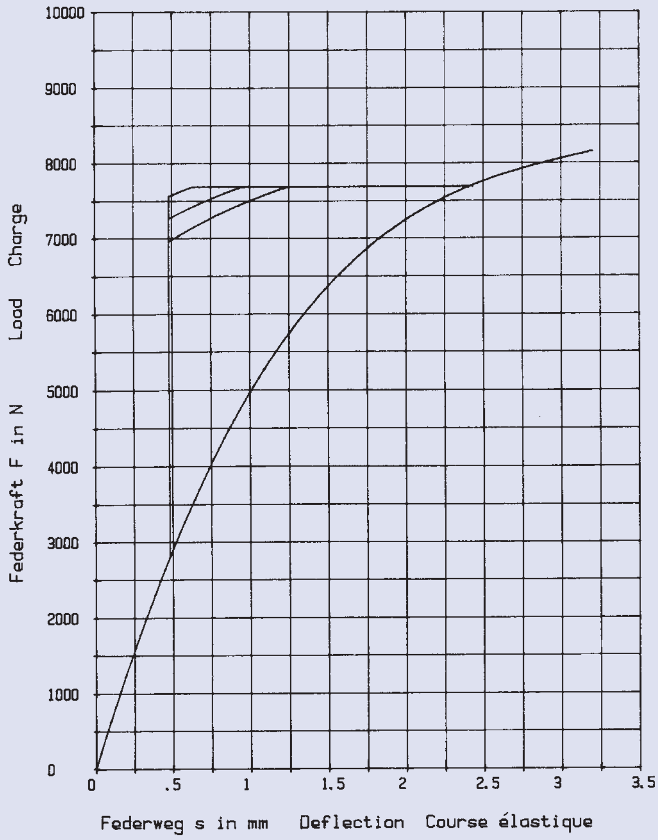


h_0 = 1,7 mm	D_e / D_i = 1,951
t = 5,0 mm	D_e / t = 16
h_0 / t = 0, 34	m = 145,468 g

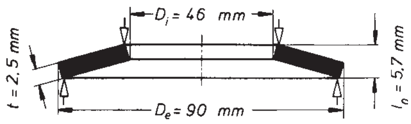




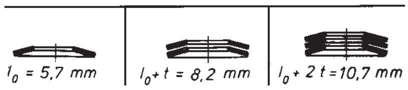
90 x 46 x 2,5



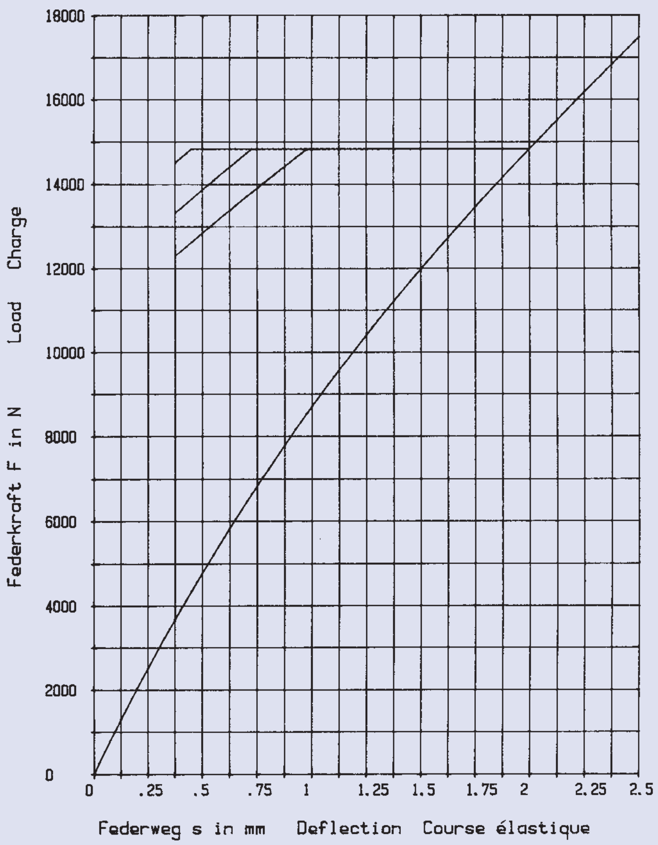
GR 2, DIN 2093 – C 90



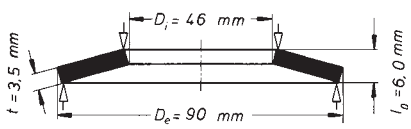
h_0 = 3,2 mm	D_e/D_i = 1,956
t = 2,5 mm	D_e/t = 36
h_0/t = 1,28	m = 92,231 g



90 x 46 x 3,5



GR 2, DIN 2093 – B 90



h_0 = 2,5 mm	D_e/D_i = 1,956
t = 3,5 mm	D_e/t = 25,714
h_0/t = 0,714	m = 129,124 g

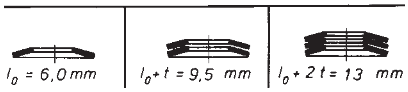
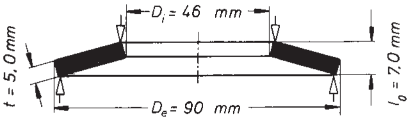


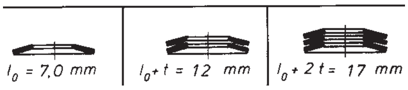
Diagramme | Diagrams | Diagrammes

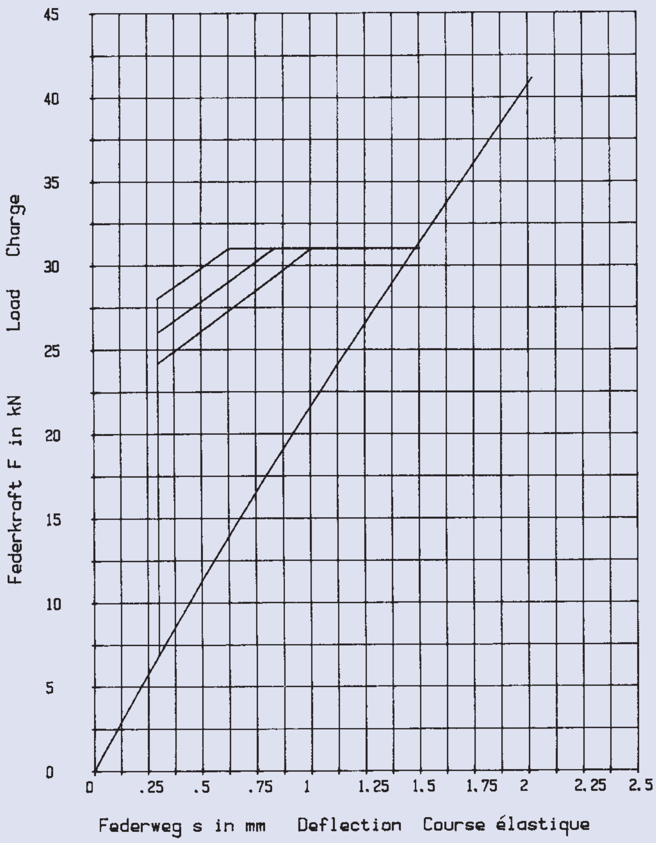
90 x 46 x 5,0

GR 2, DIN 2093 – A 90



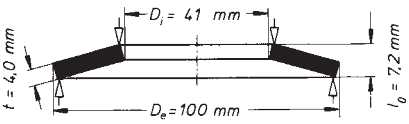
h_0 = 2,0 mm D_e / D_i = 1,956
t = 5,0 mm D_e / t = 18
h_0 / t = 0,4   m = 184,463 g



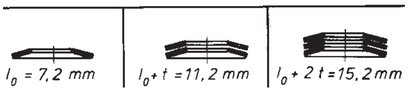


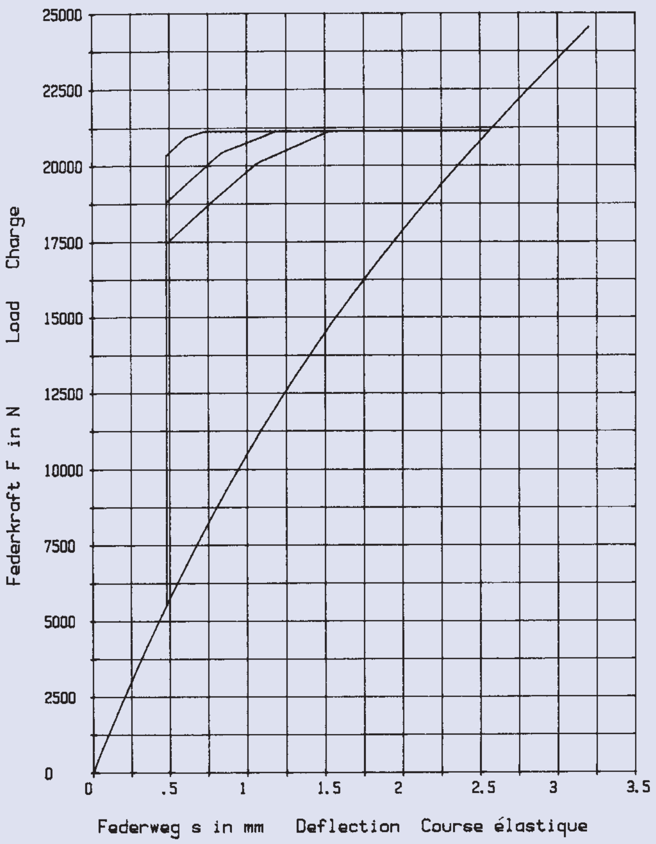
100 x 41 x 4,0

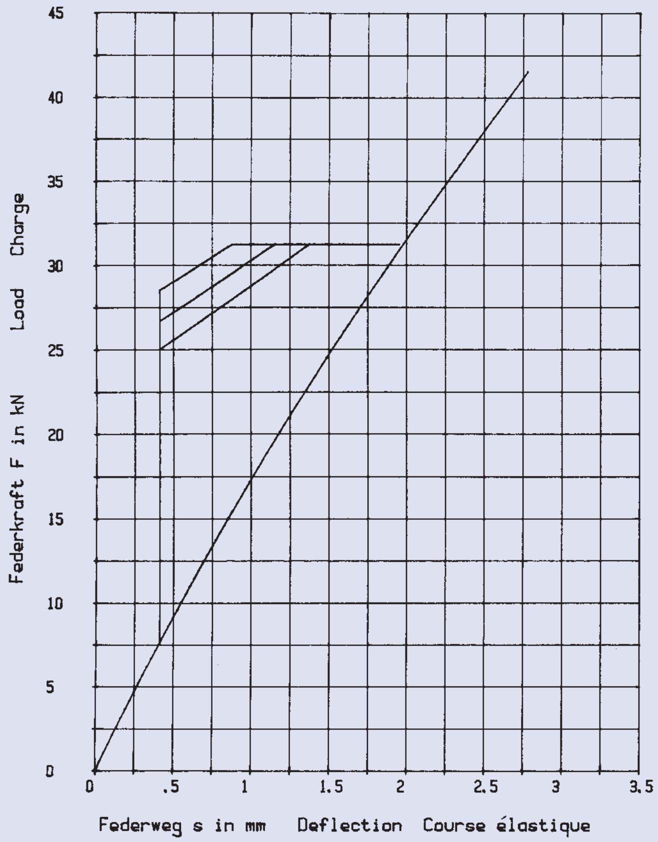
GR 2



h_0 = 3,2 mm D_e / D_i = 2,439
t = 4,0 mm D_e / t = 25
h_0 / t = 0,8   m = 205,153 g

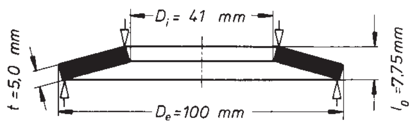






100 x 41 x 5,0

GR 2



h_0 = 2,75 mm

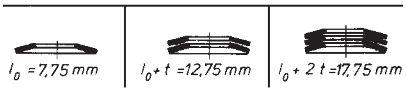
t = 5,0 mm

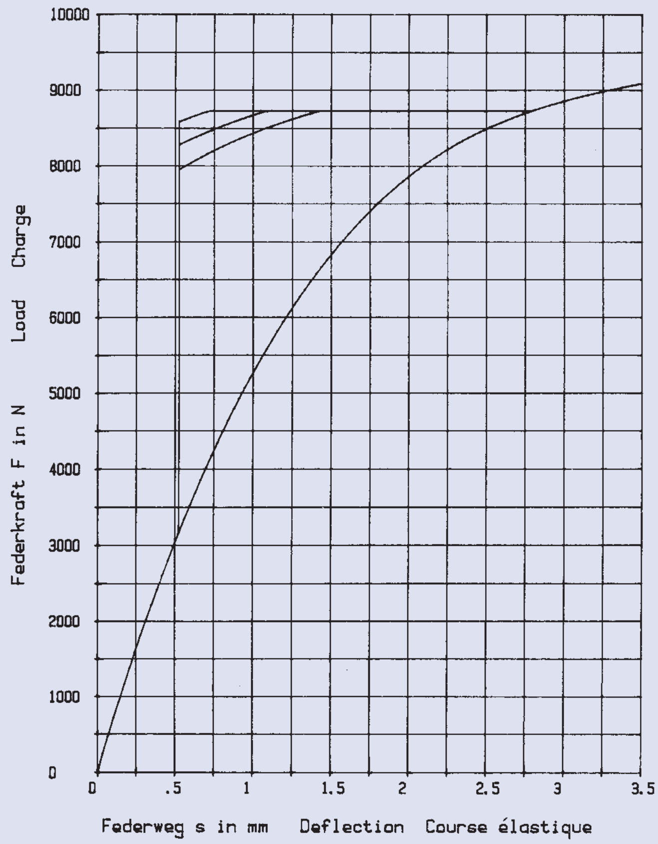
h_0/t = 0,55

D_e/D_i = 2,439

D_e/t = 20

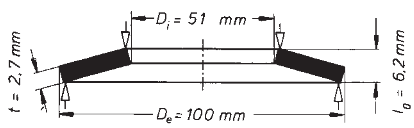
m = 256,441 g





100 x 51 x 2,7

GR 2, DIN 2093 – C 100



h_0 = 3,5 mm

t = 2,7 mm

h_0/t = 1,296

D_e/D_i = 1,96

D_e/t = 37,037

m = 123,164 g

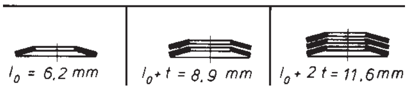
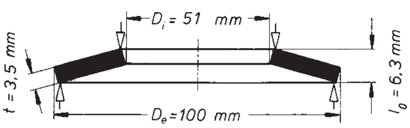


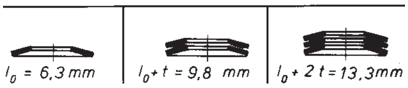
Diagramme | Diagrams | Diagrammes

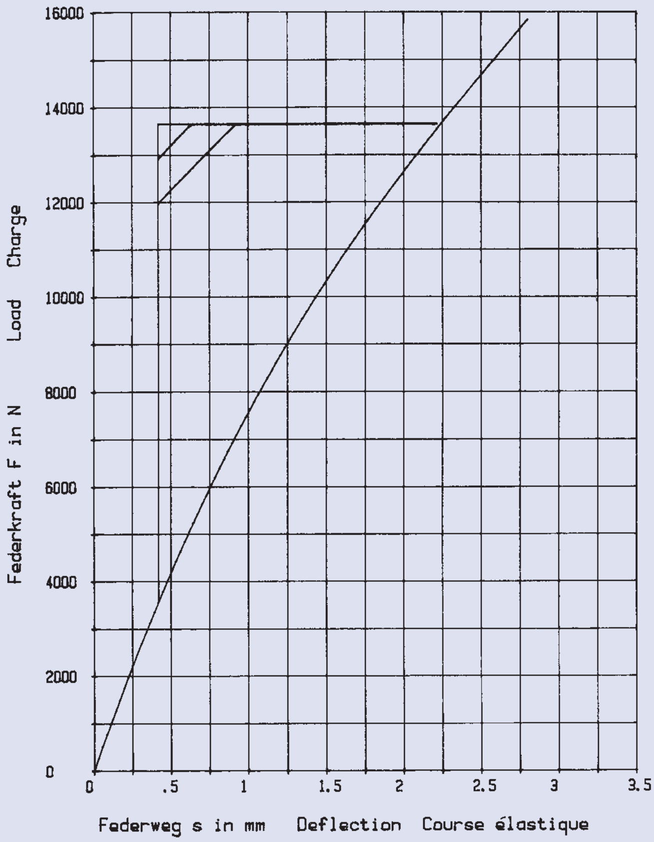
100 x 51 x 3,5

GR 2, DIN 2093 – B 100



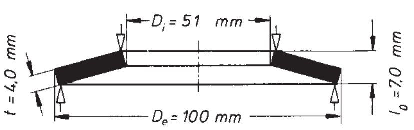
$h_0 = 2{,}8$ mm	$D_e / D_i = 1{,}96$
$t = 3{,}5$ mm	$D_e / t = 28{,}571$
$h_0 / t = 0{,}8$	$m = 159{,}657$ g



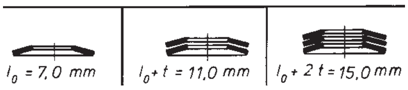


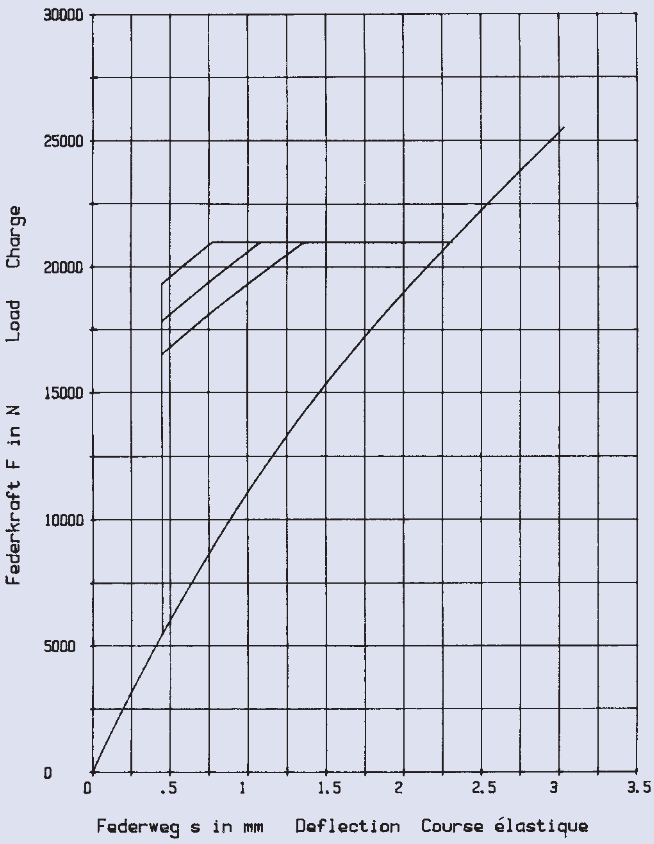
100 x 51 x 4,0

GR 2

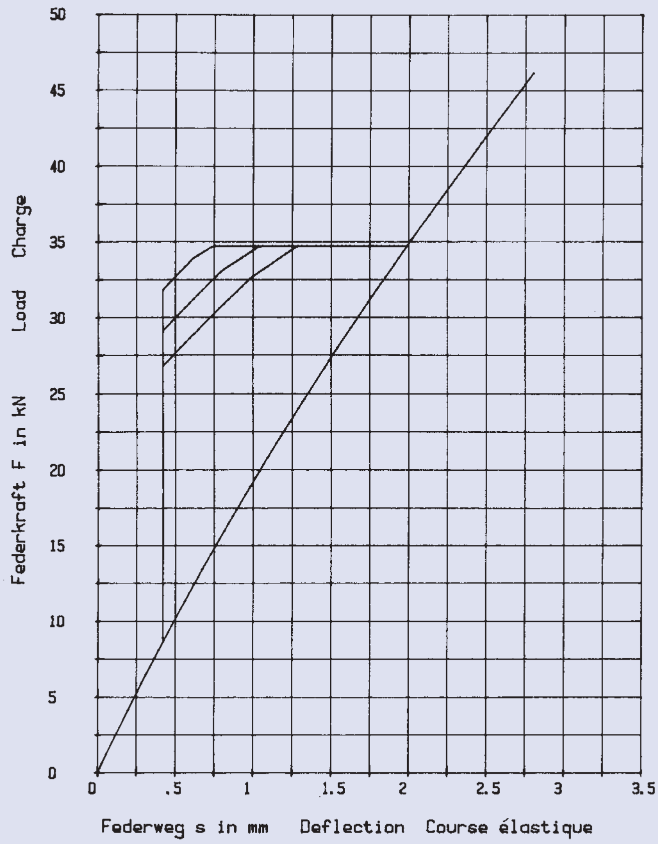


$h_0 = 3{,}0$ mm	$D_e / D_i = 1{,}96$
$t = 4{,}0$ mm	$D_e / t = 25$
$h_0 / t = 0{,}75$	$m = 182{,}465$ g

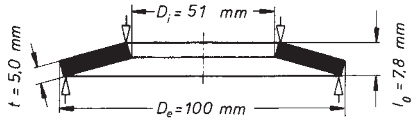




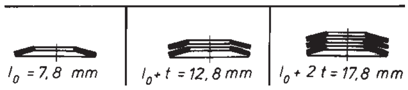
100 x 51 x 5,0



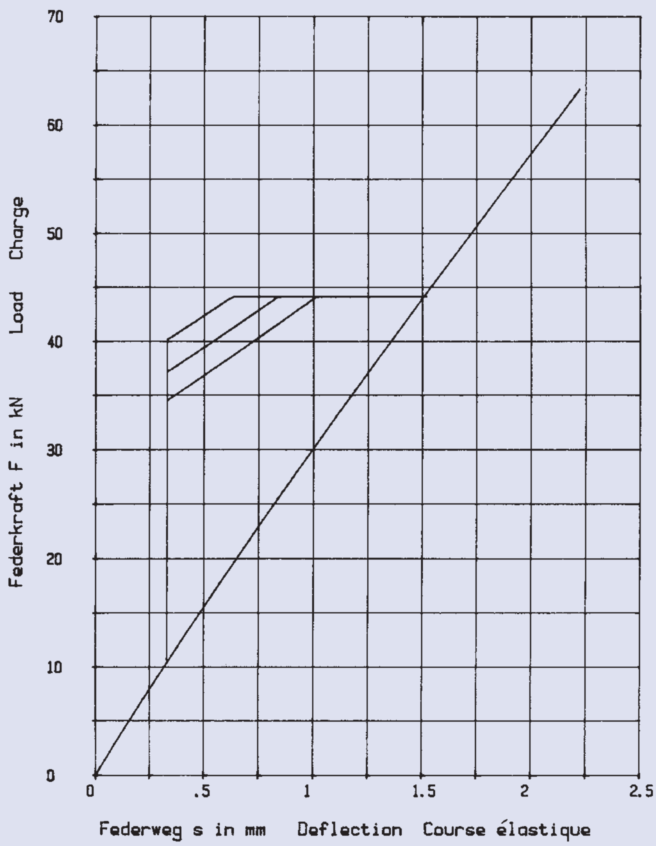
GR 2



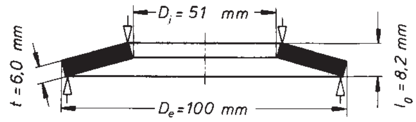
h_0 = 2,8 mm	D_e/D_i = 1,96
t = 5,0 mm	D_e/t = 20
h_0/t = 0,56	m = 228,081 g



100 x 51 x 6,0



GR 2, DIN 2093 – A 100



h_0 = 2,2 mm	D_e/D_i = 1,96
t = 6,0 mm	D_e/t = 16,666
h_0/t = 0,366	m = 273,698 g

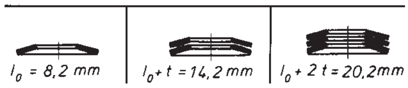
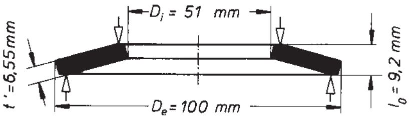


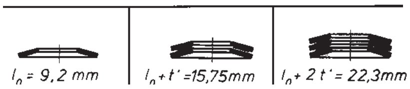
Diagramme | Diagrams | Diagrammes

100 x 51 x 7,0

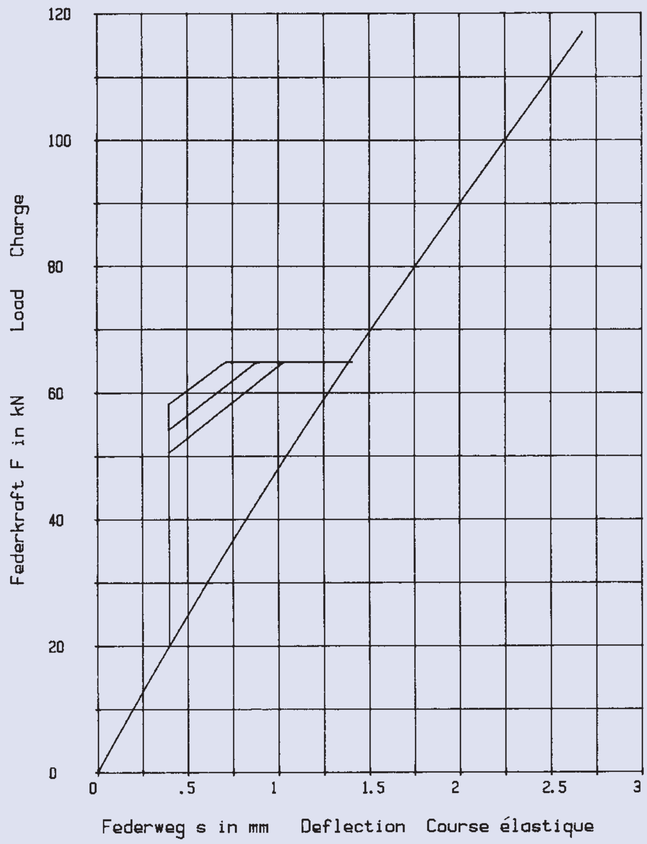
GR 3



h_0 = 2,2 mm	D_e / D_i = 1,96	h_0' = 2,65mm
t = 7,0 mm	D_e / t = 14,285	t'/t = 0,935
h_0 / t = 0,314	m = 298,79 g	h_0' / t' = 0,405

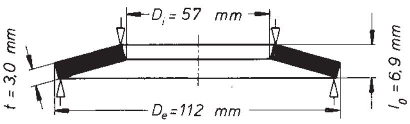


l_0 = 9,2 mm	l_0 + t' = 15,75mm	l_0 + 2 t' = 22,3mm



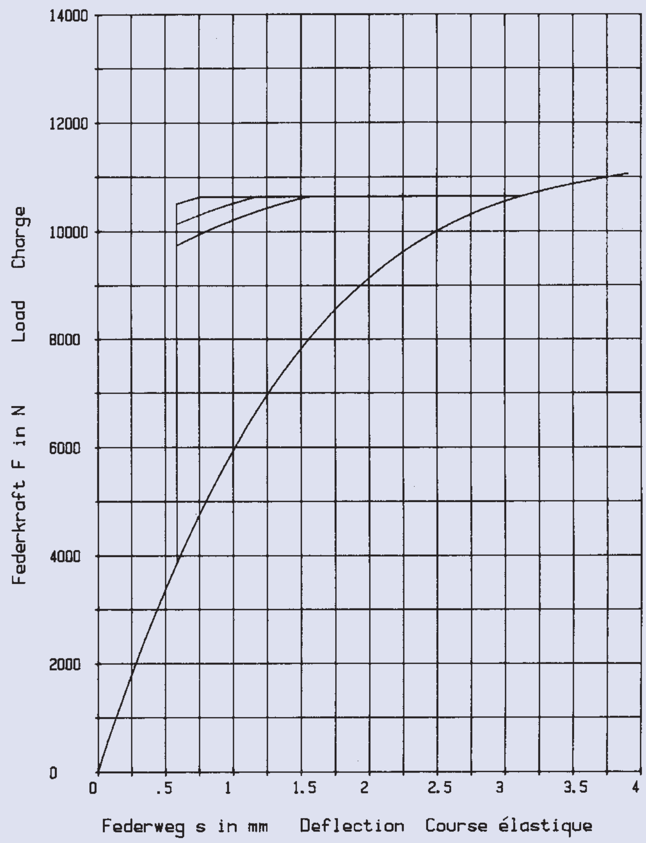
112 x 57 x 3,0

GR 2, DIN 2093 – C 112



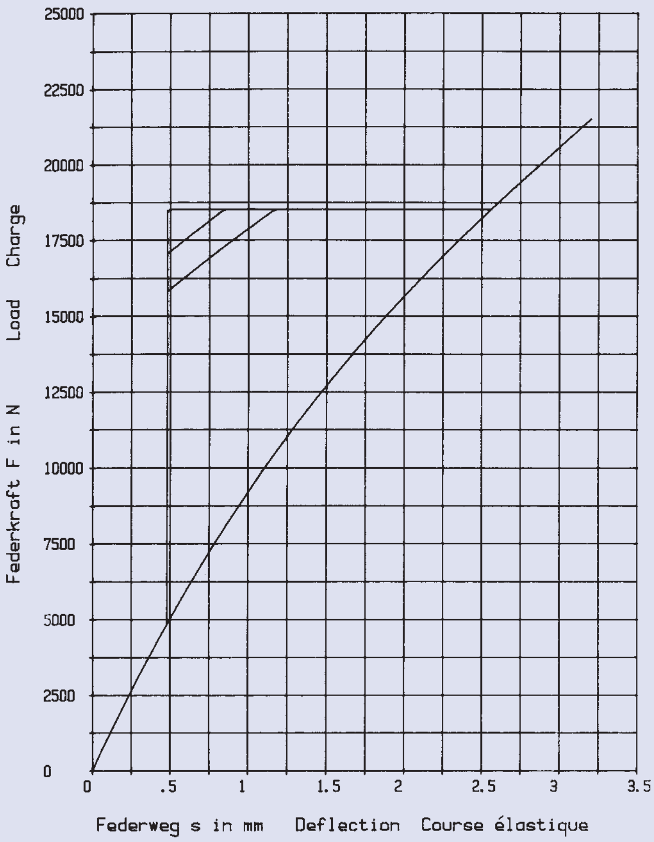
h_0 = 3,9 mm	D_e / D_i = 1,964
t = 3,0 mm	D_e / t = 37,333
h_0 / t = 1,3	m = 171,917 g

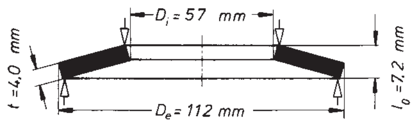
l_0 = 6,9 mm	l_0 + t = 9,9 mm	l_0 + 2 t = 12,9mm



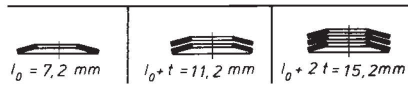
112 x 57 x 4,0

GR 2, DIN 2093 – B 112



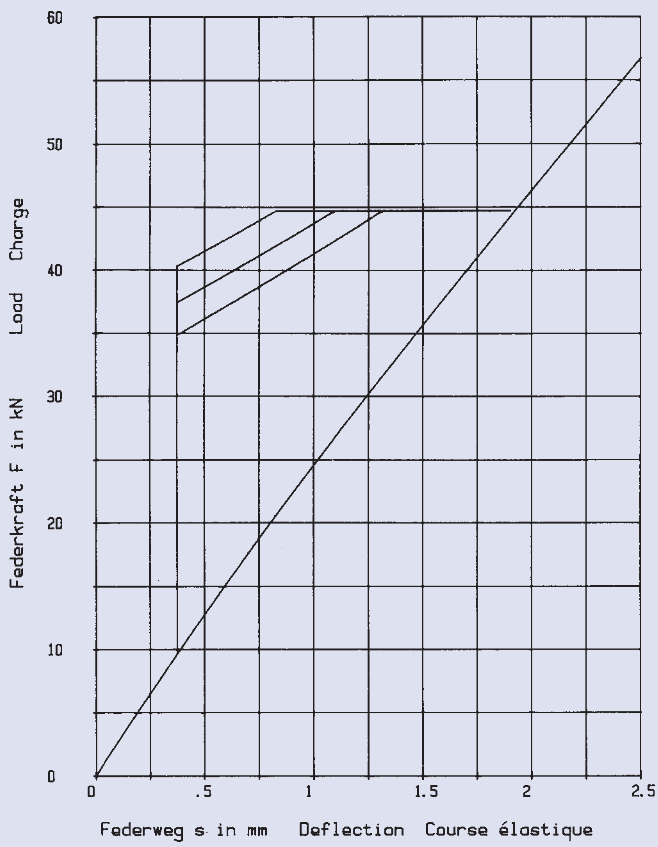


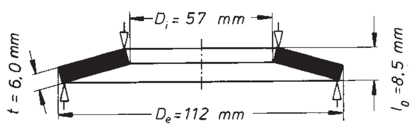
h_0 = 3,2 mm	D_e/D_i = 1,964
t = 4,0 mm	D_e/t = 28
h_0/t = 0,8	m = 229,222 g



112 x 57 x 6,0

GR 2, DIN 2093 – A 112





h_0 = 2,5 mm	D_e/D_i = 1,964
t = 6,0 mm	D_e/t = 18,666
h_0/t = 0,416	m = 343,833 g

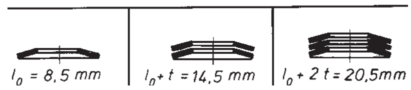
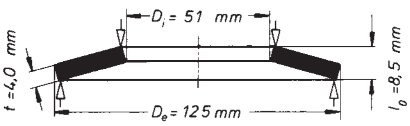


Diagramme | Diagrams | Diagrammes

125 x 51 x 4,0

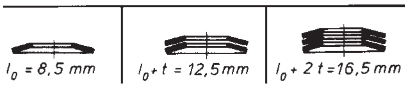
GR 2

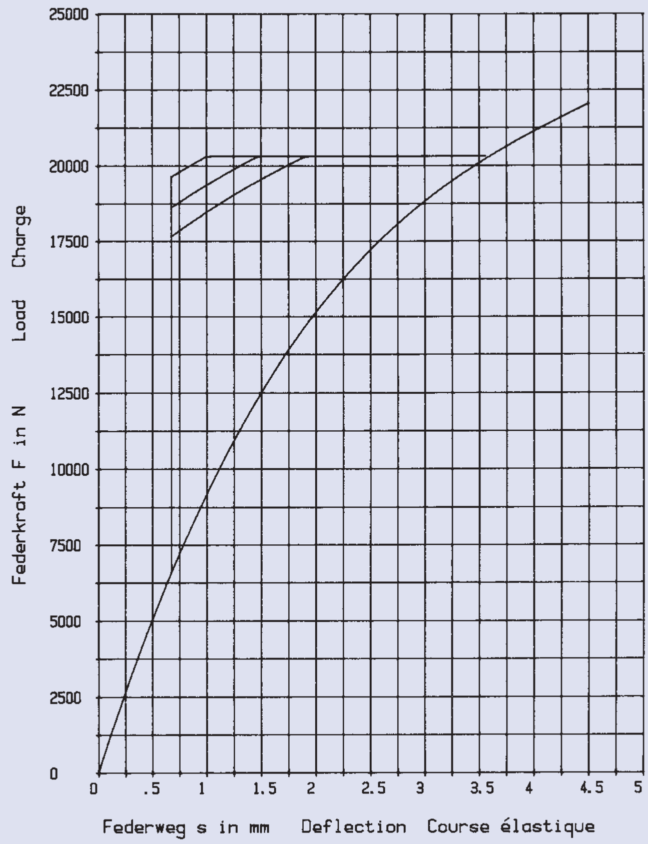


h_0 = 4,5mm　　D_e/D_i = 2,45

t = 4,0mm　　D_e/t = 31,25

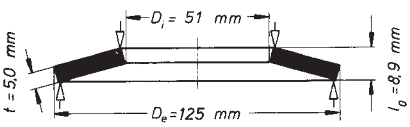
h_0/t = 1,125　　m = 321,18 g





125 x 51 x 5,0

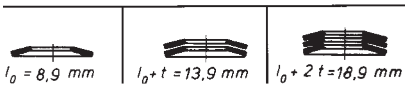
GR 2



h_0 = 3,9 mm　　D_e/D_i = 2,45

t = 5,0 mm　　D_e/t = 25

h_0/t = 0,78　　m = 401,478 g



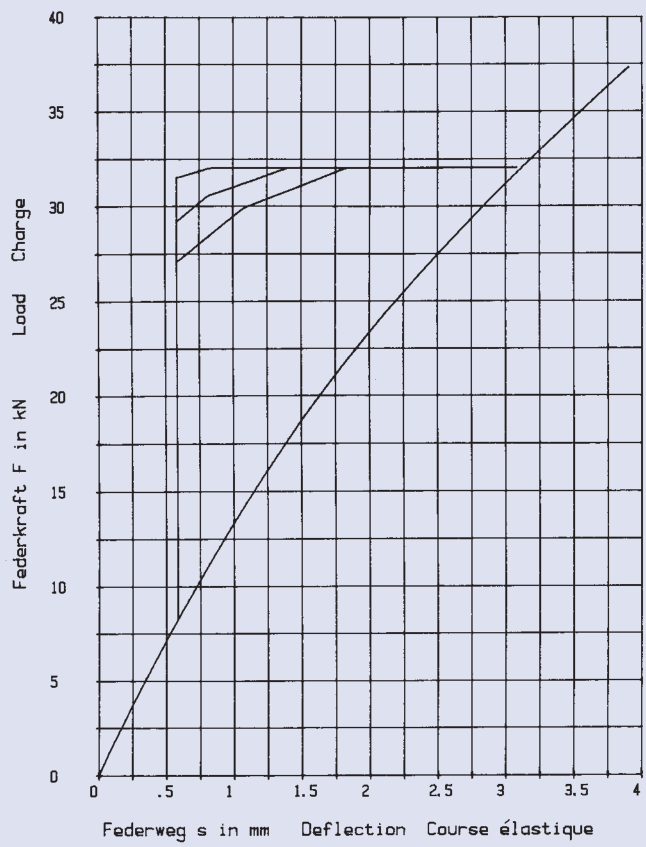
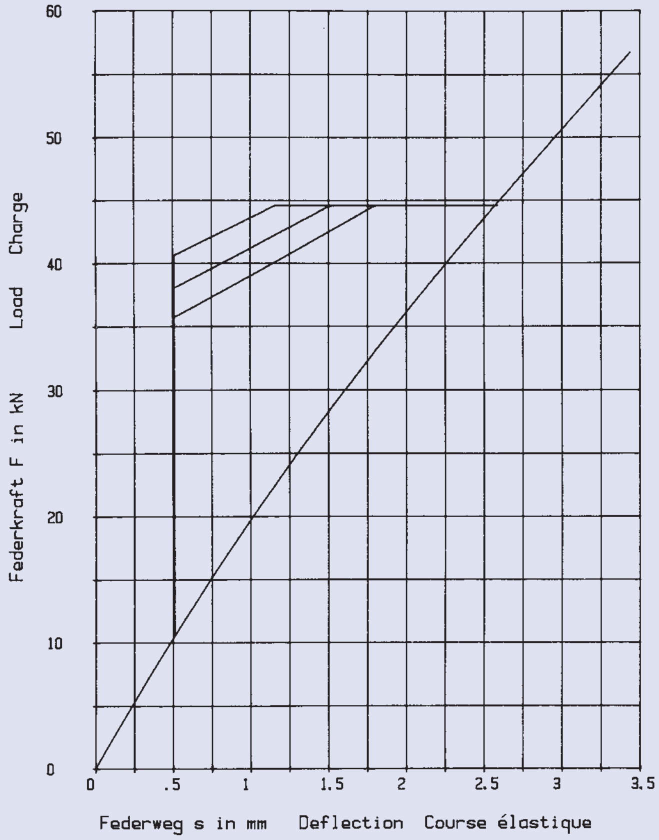
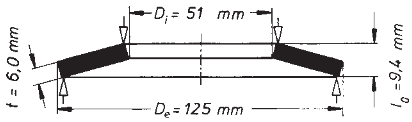


Diagramme | Diagrams | Diagrammes

125 x 51 x 6,0



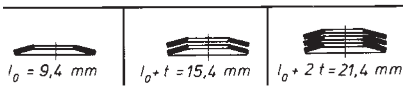
GR 2



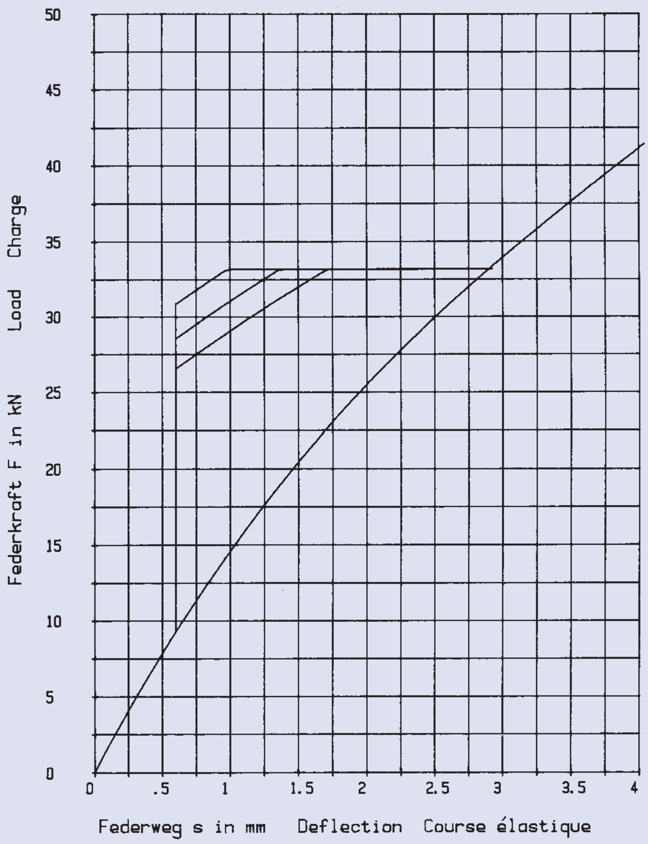
h_0 = 3,4 mm D_e/D_i = 2,45

t = 6,0 mm D_e/t = 20,833

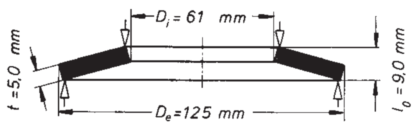
h_0/t = 0,566 m = 481,773 g



125 x 61 x 5,0



GR 2



h_0 = 4,0 mm D_e/D_i = 2,049

t = 5,0 mm D_e/t = 25

h_0/t = 0,8 m = 366,953 g

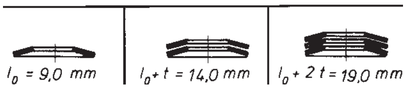
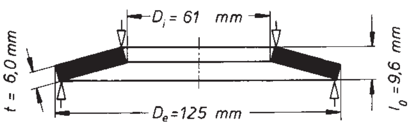


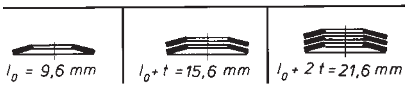
Diagramme | Diagrams | Diagrammes

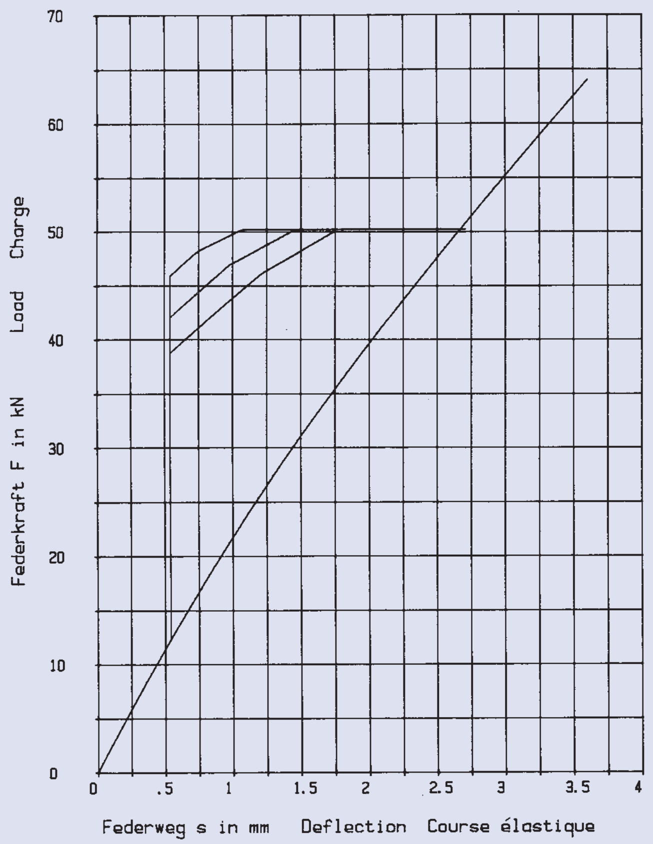
125 x 61 x 6,0

GR 2



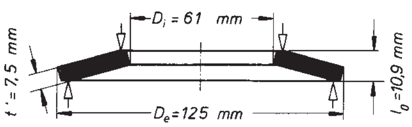
$h_0 = 3,6$ mm	$D_e / D_i = 2,049$
$t = 6,0$ mm	$D_e / t = 20,833$
$h_0 / t = 0,6$	$m = 440,343$ g



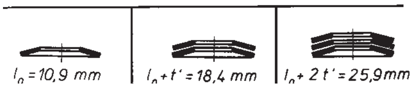


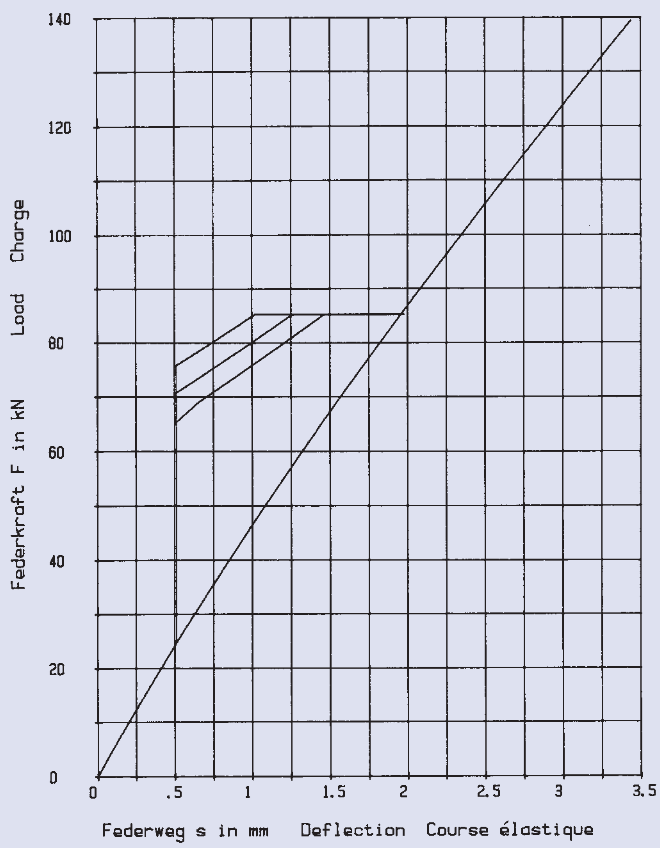
125 x 61 x 8,0

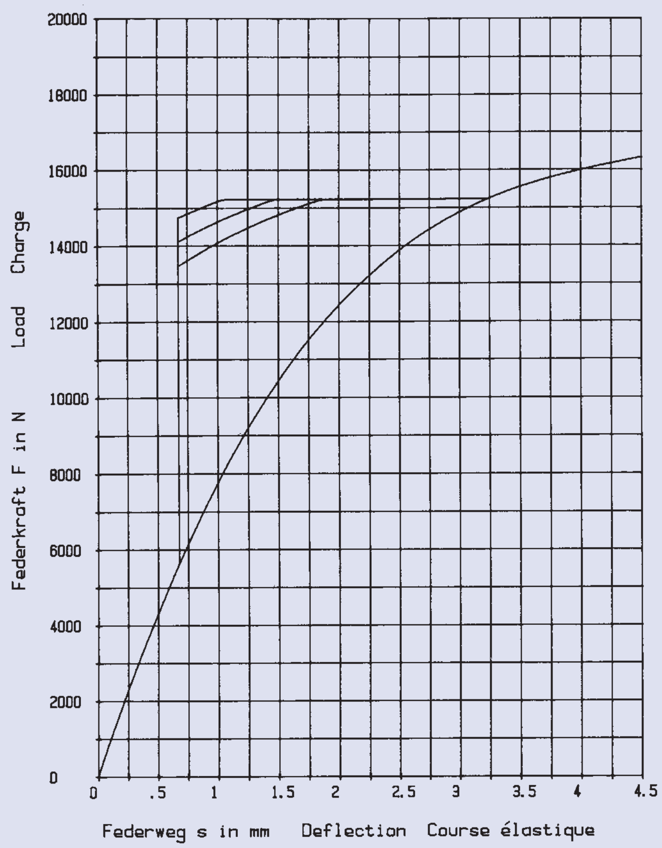
GR 3



$h_0 = 2,9$ mm	$D_e / D_i = 2,049$	$h_0' = 3,4$ mm
$t = 8,0$ mm	$D_e / t = 15,625$	$t' / t = 0,937$
$h_0 / t = 0,362$	$m = 550,43$ g	$h_0' / t' = 0,453$

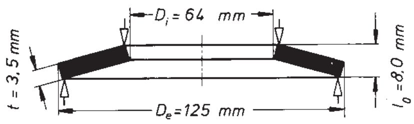




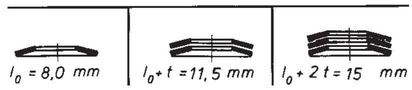


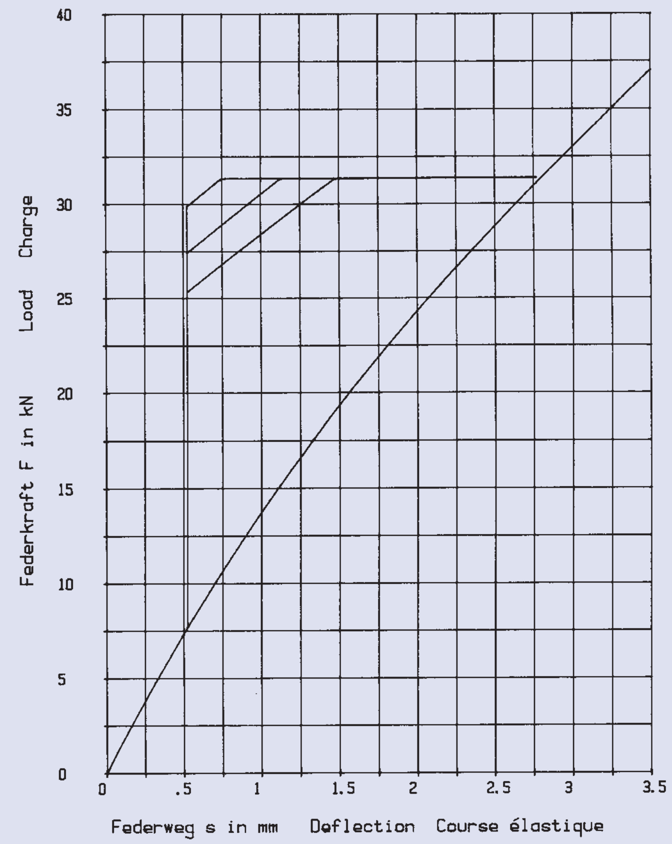
125 x 64 x 3,5

GR 2, DIN 2093 – C 125



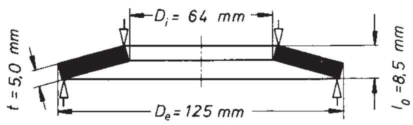
h_0 = 4,5 mm	D_e/D_i = 1,953
t = 3,5 mm	D_e/t = 35,714
h_0/t = 1,285	m = 248,775 g





125 x 64 x 5,0

GR 2, DIN 2093 – B 125



h_0 = 3,5 mm	D_e/D_i = 1,953
t = 5,0 mm	D_e/t = 25
h_0/t = 0,7	m = 355,393 g

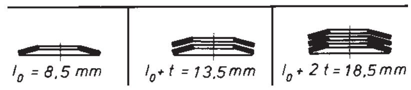
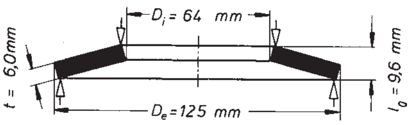


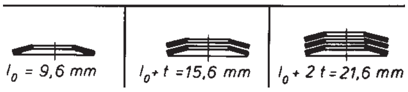
Diagramme | Diagrams | Diagrammes

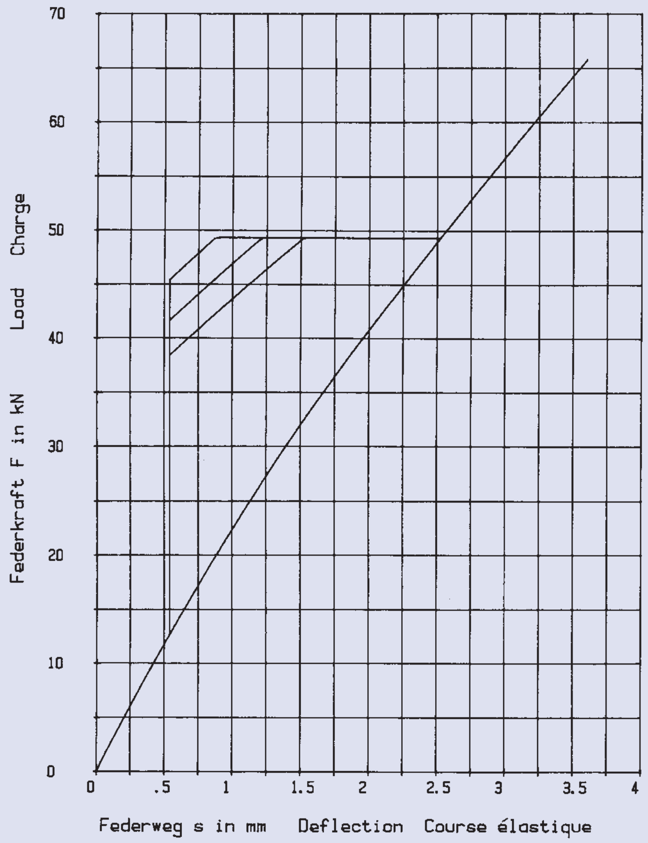
125 x 64 x 6,0

GR 2



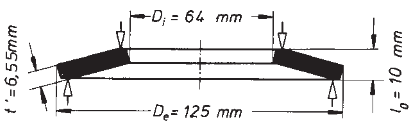
h_0 = 3,6 mm	D_e/D_i = 1,953
t = 6,0 mm	D_e/t = 20,833
h_0/t = 0,6	m = 426,471 g



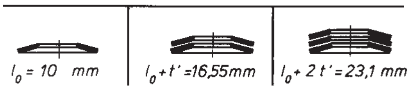


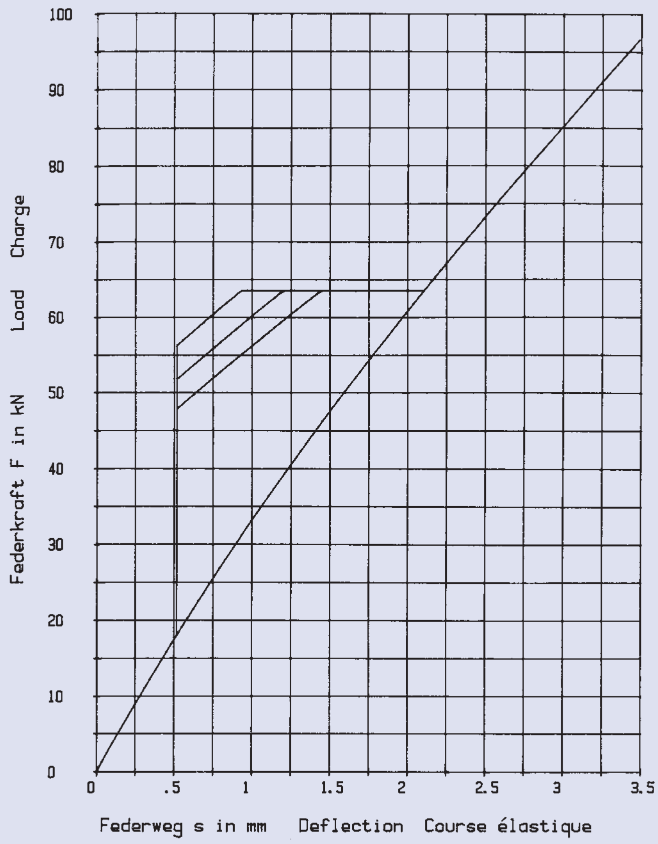
125 x 64 x 7,0

GR 3



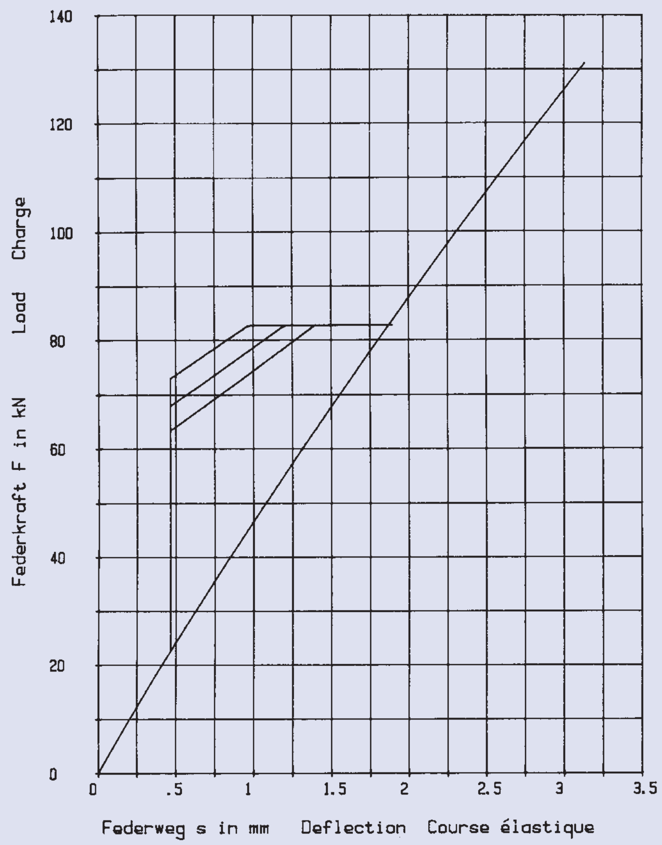
h_0 = 3,0 mm	D_e/D_i = 1,953	h_0' = 3,45 mm
t = 7,0 mm	D_e/t = 17,857	t'/t = 0,935
h_0/t = 0,428	m = 465,56 g	h_0'/t' = 0,527

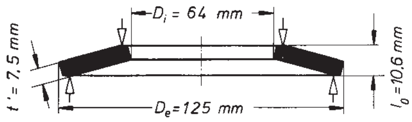




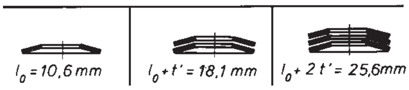
125 x 64 x 8,0

GR 3, DIN 2093 – A 125



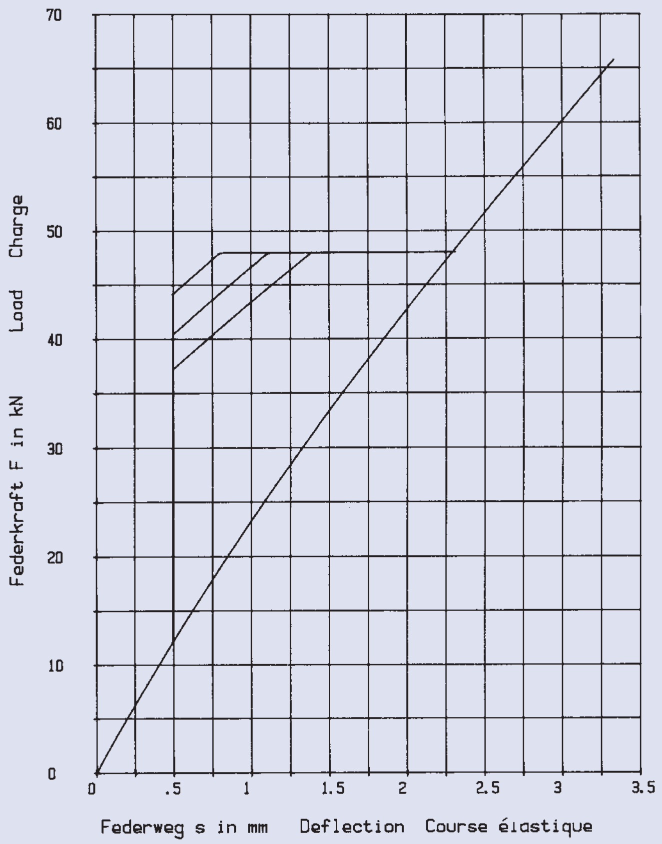


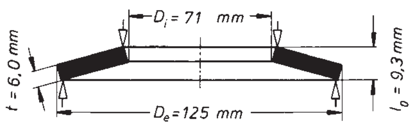
h_0 = 2,6 mm	D_e/D_i = 1,953	h'_0 = 3,1 mm
t = 8,0 mm	D_e/t = 15,625	t'/t = 0,937
h_0/t = 0,325	m = 533,089 g	h'_0/t' = 0,413



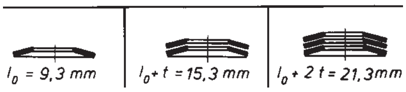
125 x 71 x 6,0

GR 2





h_0 = 3,3 mm	D_e/D_i = 1,76
t = 6,0 mm	D_e/t = 20,833
h_0/t = 0,55	m = 391,515 g



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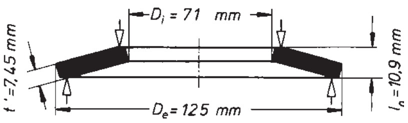
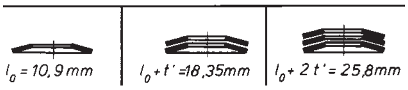
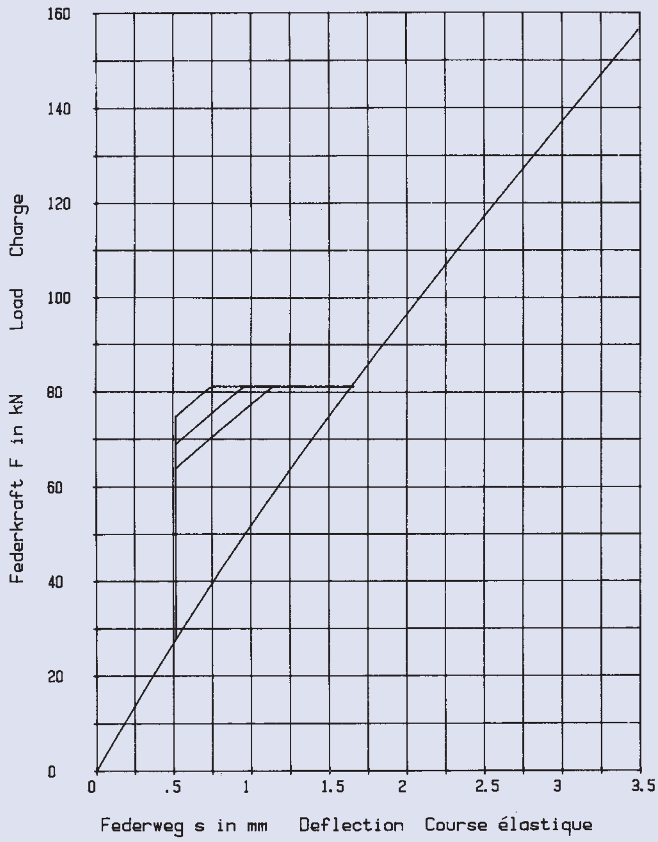
125 x 71 x 8,0

GR 3



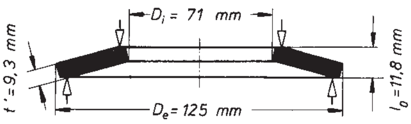
= 2,9 mm	D_e /D_i = 1,76	h_0' = 3,45mm
= 8,0 mm	D_e / t = 15,625	t' / t = 0,931
/t = 0,362	m= 486,13 g	h_0'/ t' = 0,463



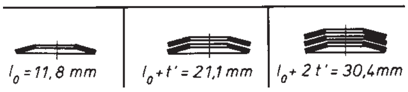


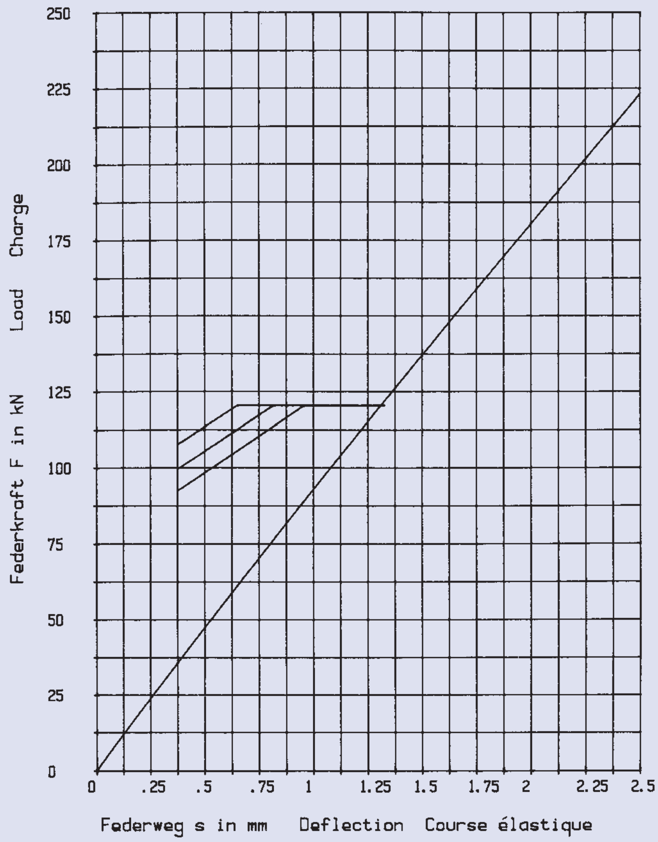
125 x 71 x 10

GR 3



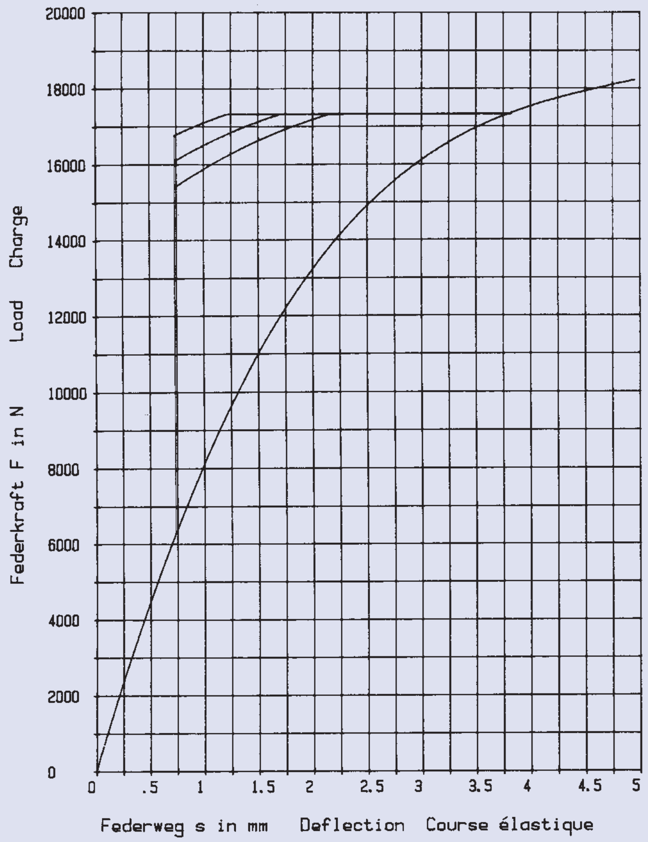
= 1,8 mm	D_e /D_i = 1,76	h_0' = 2,5 mm
= 10 mm	D_e / t = 12,5	t' / t = 0,93
/t = 0,18	m= 606,85 g	h_0'/ t' =0,269

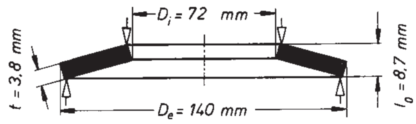




140 x 72 x 3,8

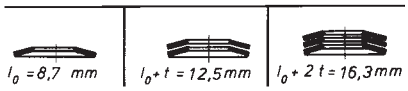
GR 2, DIN 2093 – C 140





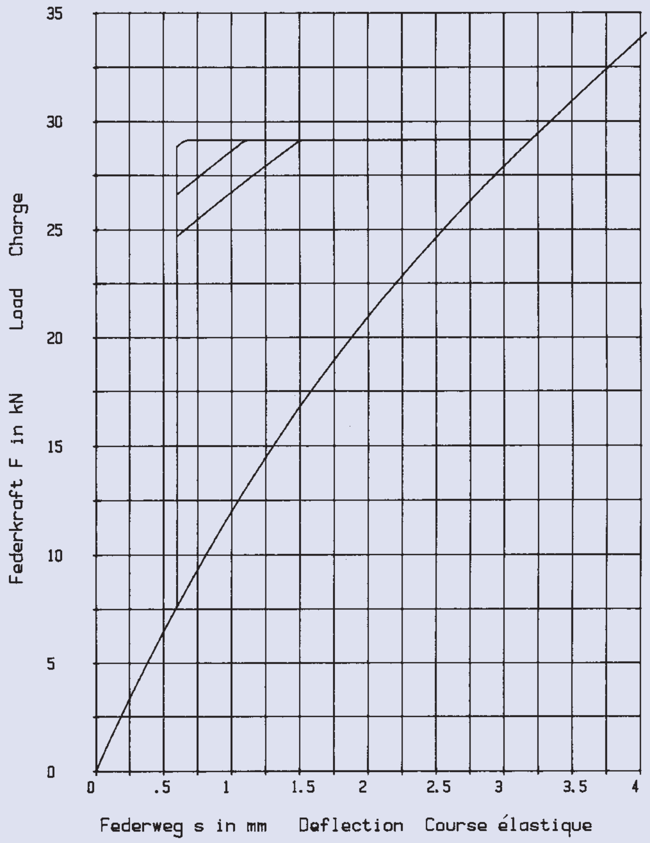
h_0 = 4,9 mm
t = 3,8 mm
h_0/t = 1,289

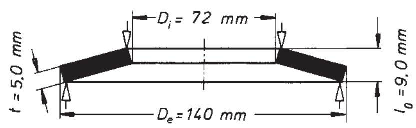
D_e/D_i = 1,944
D_e/t = 36,842
m = 337,734 g



140 x 72 x 5,0

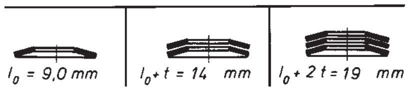
GR 2, DIN 2093 – B 140





h_0 = 4,0 mm
t = 5,0 mm
h_0/t = 0,8

D_e/D_i = 1,944
D_e/t = 28
m = 444,388 g



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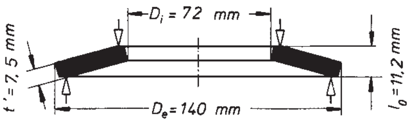
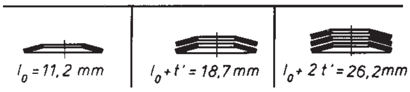
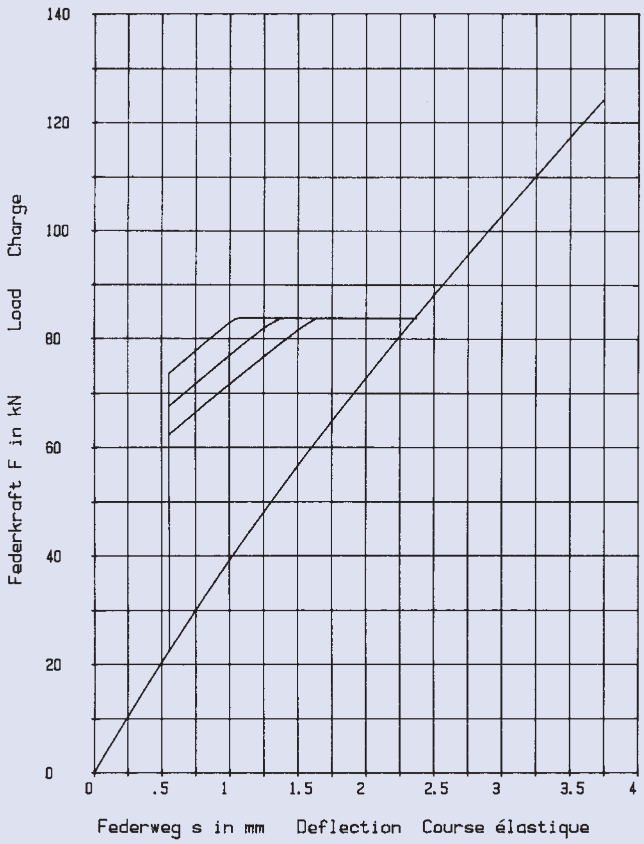
140 x 72 x 8,0

GR 3, DIN 2093 – A 140



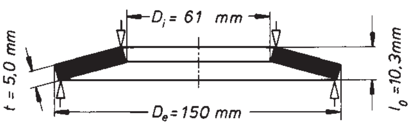
h_0 = 3,2 mm	D_e/D_i = 1,944	h_0' = 3,7 mm
t = 8,0 mm	D_e/t = 17,5	t'/t = 0,937
h_0/t = 0,4	m = 666,581 g	h_0'/t' = 0,493



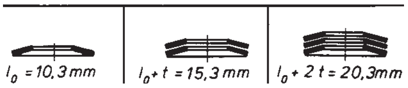


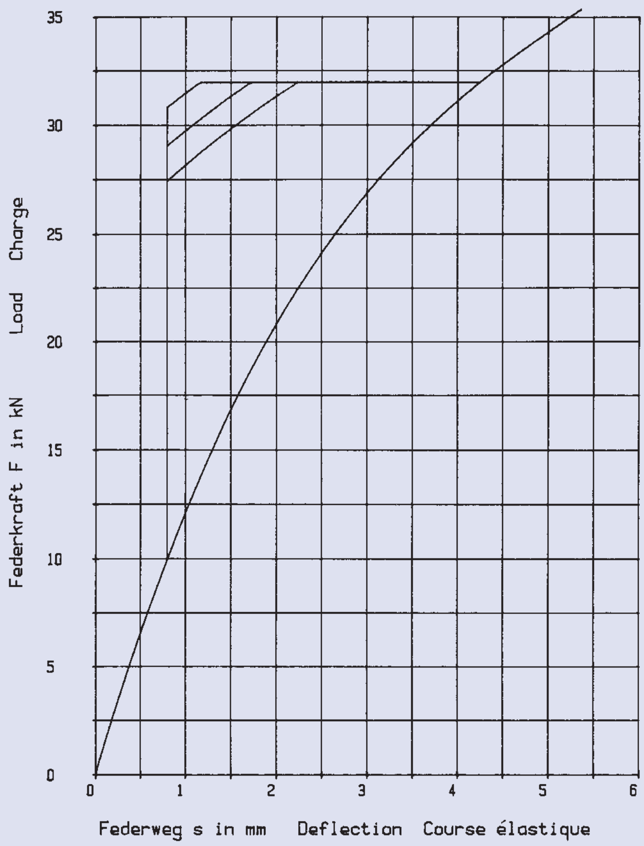
150 x 61 x 5,0

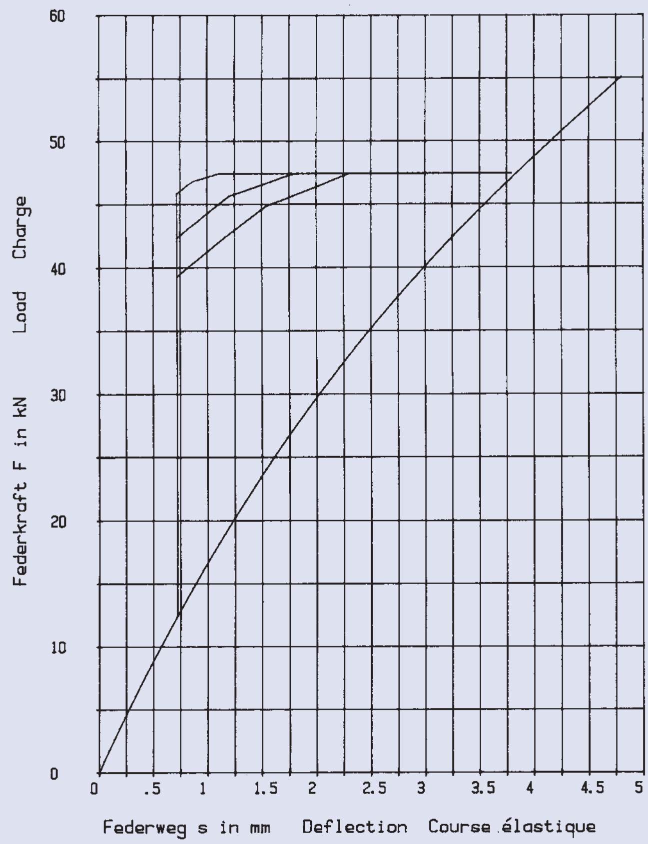
GR 2



h_0 = 5,3 mm	D_e/D_i = 2,459
t = 5,0 mm	D_e/t = 30
h_0/t = 1,06	m = 578,881 g

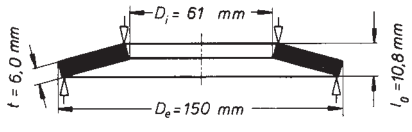






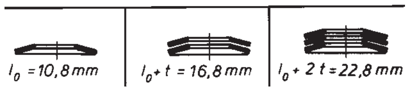
150 x 61 x 6,0

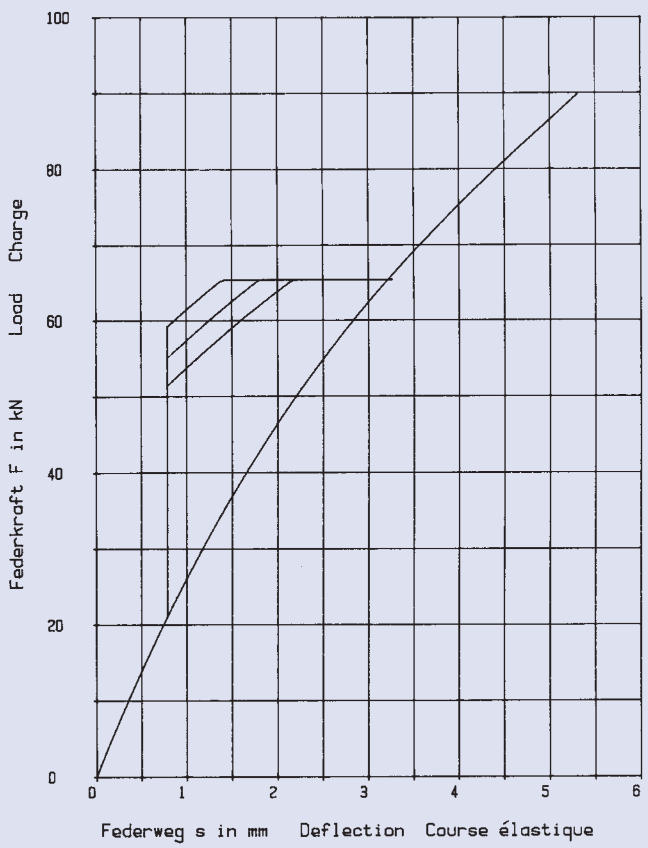
GR 2



h_0 = 4,8 mm
t = 6,0 mm
h_0/t = 0,8

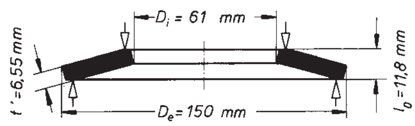
D_e/D_i = 2,459
D_e/t = 25
m = 694,658 g





150 x 61 x 7,0

GR 3



h_0 = 4,8 mm
t = 7,0 mm
h_0/t = 0,685

D_e/D_i = 2,459
D_e/t = 21,428
m = 758,34 g

h_0' = 5,25 mm
t'/t = 0,935
h_0'/t' = 0,802

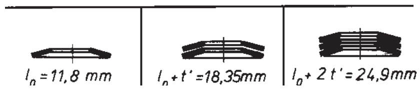
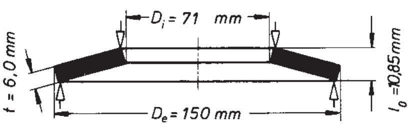


Diagramme | Diagrams | Diagrammes

150 x 71 x 6,0

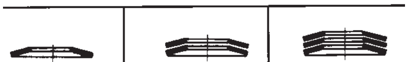
GR 2



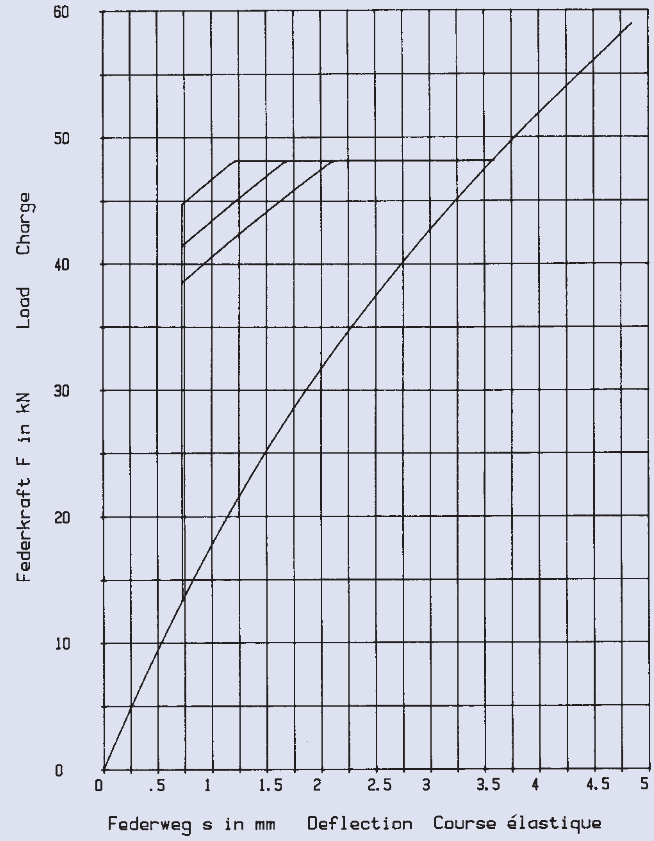
$h_0 = 4,85$ mm $D_e/D_i = 2,112$

$t = 6,0$ mm $D_e/t = 25$

$h_0/t = 0,808$ $m = 645,829$ g

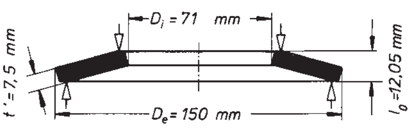


$l_0 = 10,85$ mm | $l_0 + t = 16,85$ mm | $l_0 + 2t = 22,85$ mm



150 x 71 x 8,0

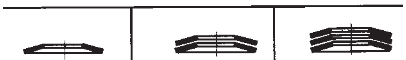
GR 3



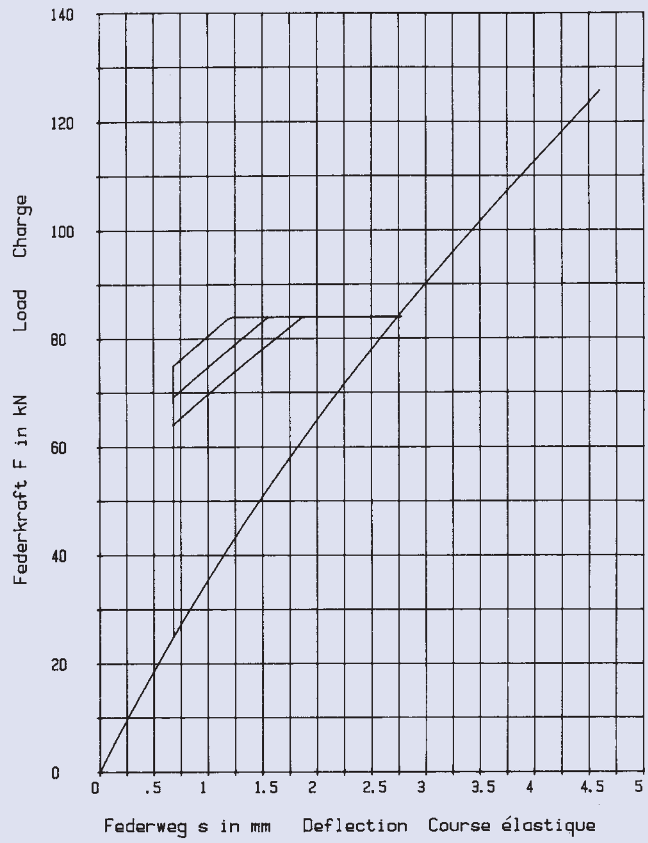
$h_0 = 4,05$ mm $D_e/D_i = 2,112$ $h_0' = 4,55$ mm

$t = 8,0$ mm $D_e/t = 18,75$ $t'/t = 0,937$

$h_0/t = 0,506$ $m = 807,29$ g $h_0'/t' = 0,607$

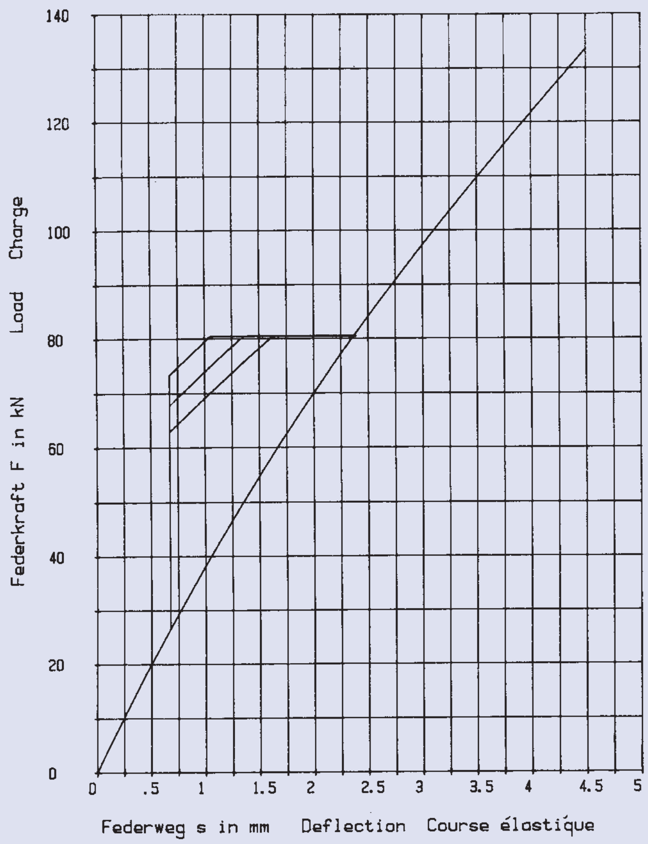


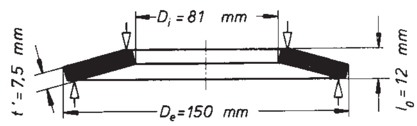
$l_0 = 12,05$ mm | $l_0 + t' = 19,55$ mm | $l_0 + 2t' = 27,05$ mm



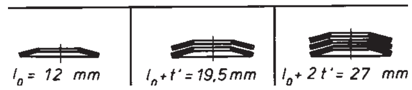
150 x 81 x 8,0

GR 3



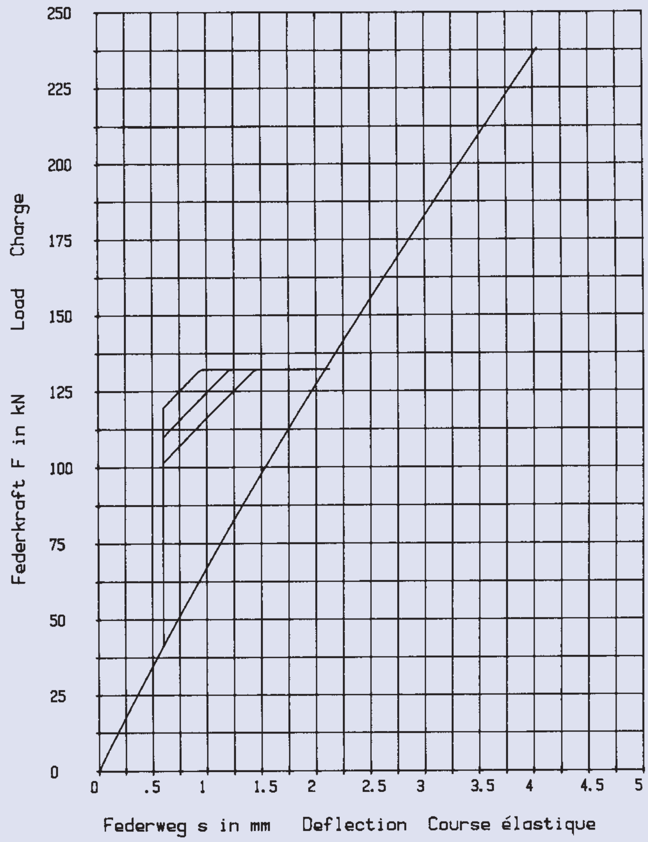


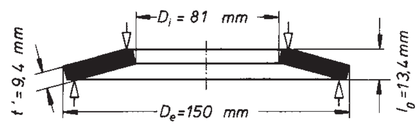
h_0 = 4,0 mm	D_e/D_i = 1,851	h_0' = 4,5 mm
t = 8,0 mm	D_e/t = 18,75	t'/t = 0,937
h_0/t = 0,5	m = 737 g	h_0'/t' = 0,6



150 x 81 x 10

GR 3





h_0 = 3,4 mm	D_e/D_i = 1,851	h_0' = 4,0 mm
t = 10 mm	D_e/t = 15	t'/t = 0,94
h_0/t = 0,34	m = 923,71 g	h_0'/t' = 0,426

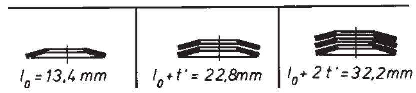
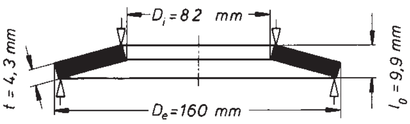


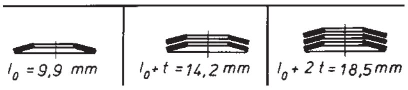
Diagramme | Diagrams | Diagrammes

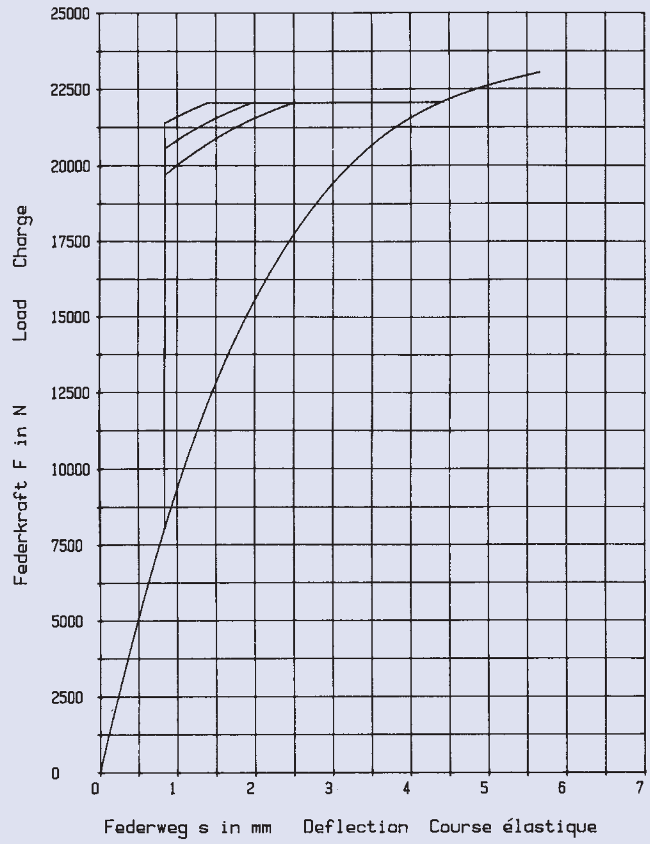
160 x 82 x 4,3

GR 2, DIN 2093 – C 160



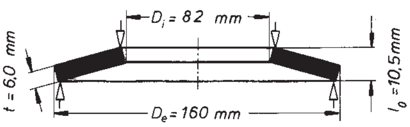
h_0 = 5,6 mm	D_e/D_i = 1,951
t = 4,3 mm	D_e/t = 37,209
h_0/t = 1,302	m = 500,409 g



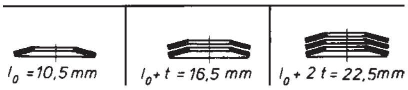


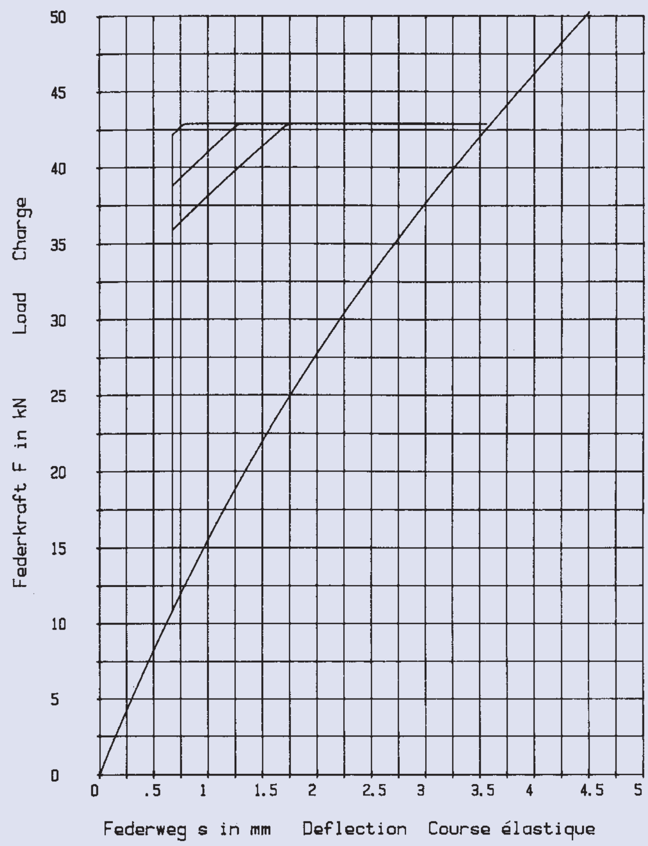
160 x 82 x 6,0

GR 2, DIN 2093 – B 160



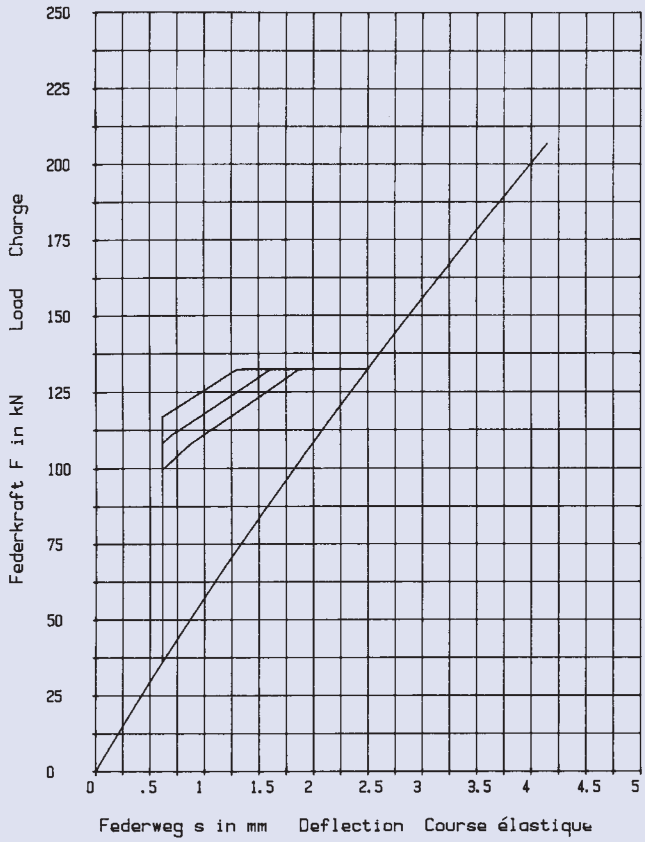
h_0 = 4,5 mm	D_e/D_i = 1,951
t = 6,0 mm	D_e/t = 26,666
h_0/t = 0,75	m = 698,246 g

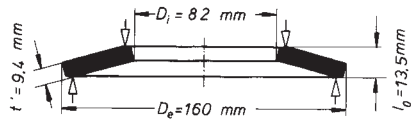




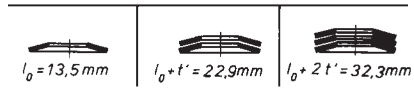
160 x 82 x 10

GR 3, DIN 2093 – A 160



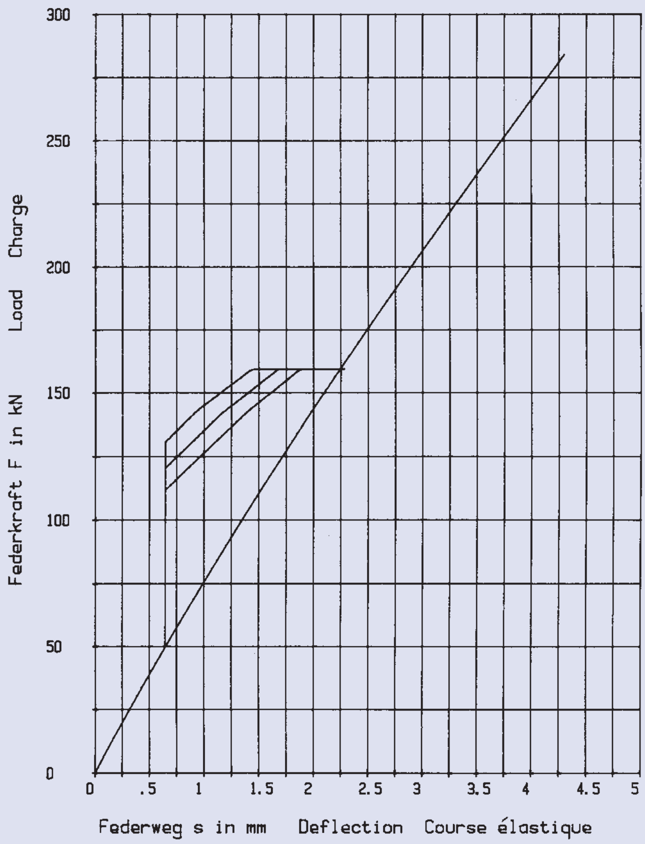


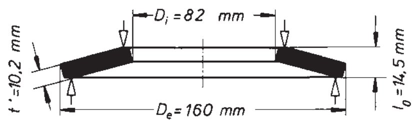
h_0 = 3,5 mm	D_e/D_i = 1,951	h_0' = 4,1 mm
t = 10 mm	D_e/t = 16	t'/t = 0,94
h_0/t = 0,35	m = 1,094 kg	h_0'/t' = 0,436



160 x 82 x 11

GR 3





h_0 = 3,5 mm	D_e/D_i = 1,951	h_0' = 4,3 mm
t = 11 mm	D_e/t = 14,545	t'/t = 0,927
h_0/t = 0,318	m = 1,187 kg	h_0'/t' = 0,422

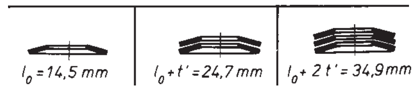
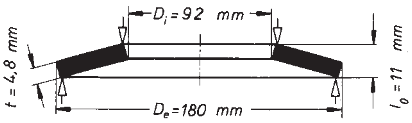


Diagramme | Diagrams | Diagrammes

180 x 92 x 4,8

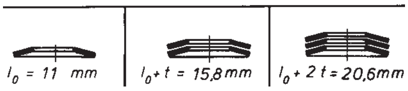
GR 2, DIN 2093 – C 180

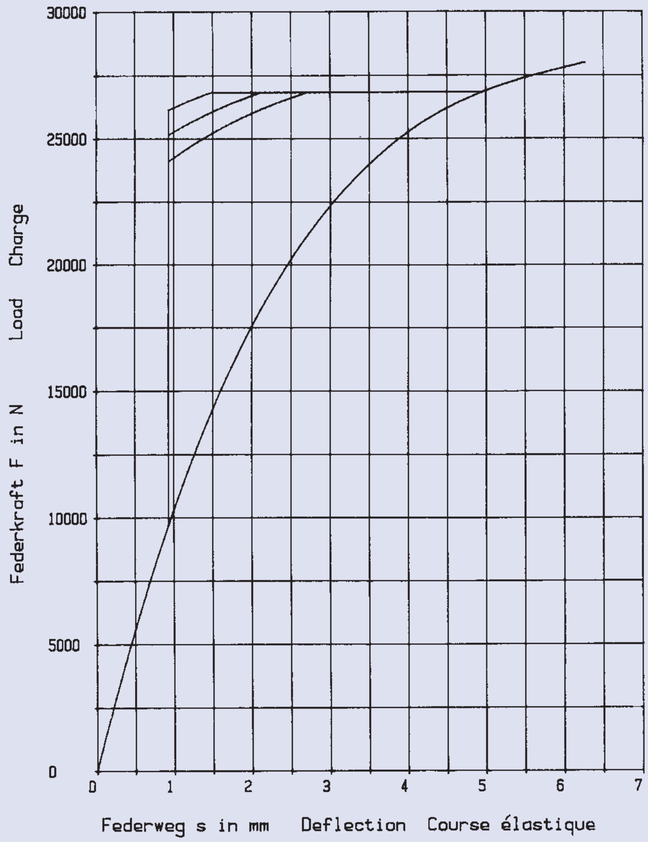


$h_0 = 6,2$ mm $D_e/D_i = 1,956$

$t = 4,8$ mm $D_e/t = 37,5$

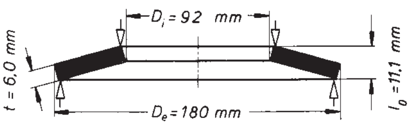
$h_0/t = 1,291$ $m = 708,337$ g





180 x 92 x 6,0

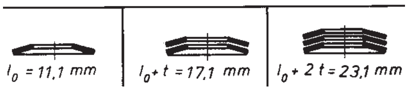
GR 2, DIN 2093 – B 180



$h_0 = 5,1$ mm $D_e/D_i = 1,956$

$t = 6,0$ mm $D_e/t = 30$

$h_0/t = 0,85$ $m = 885,421$ g



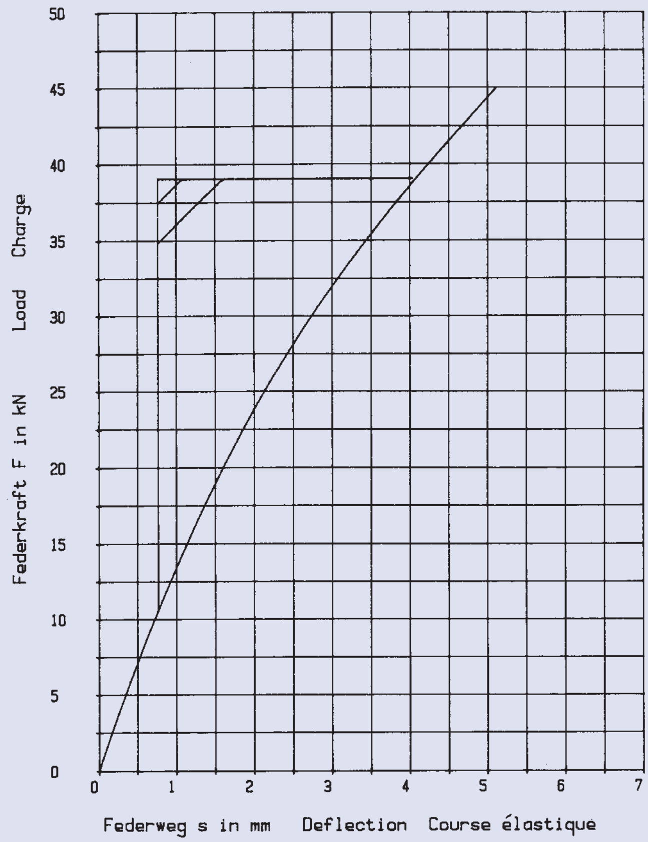
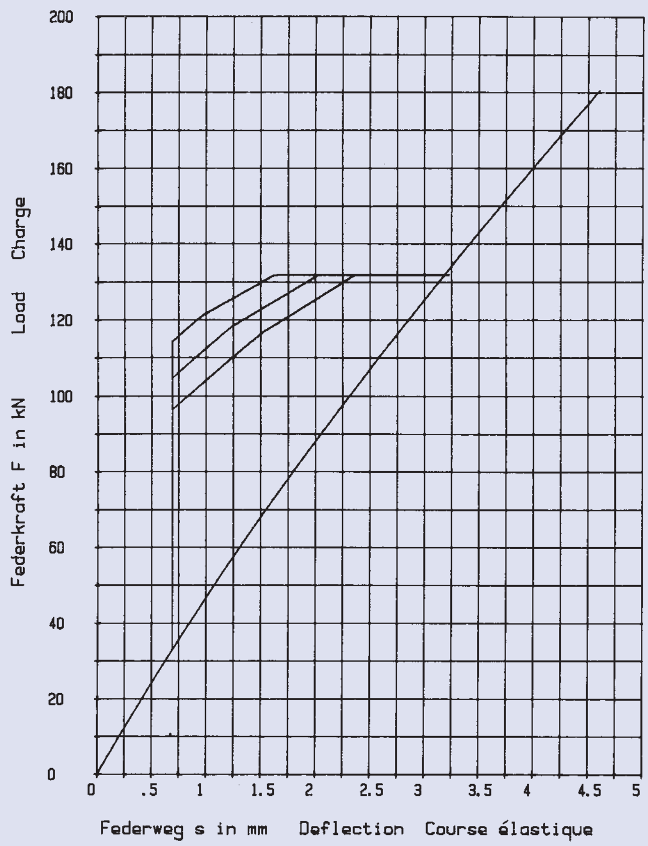
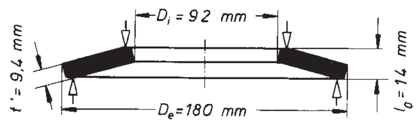


Diagramme | Diagrams | Diagrammes

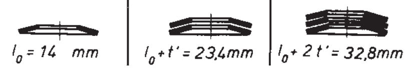
180 x 92 x 10



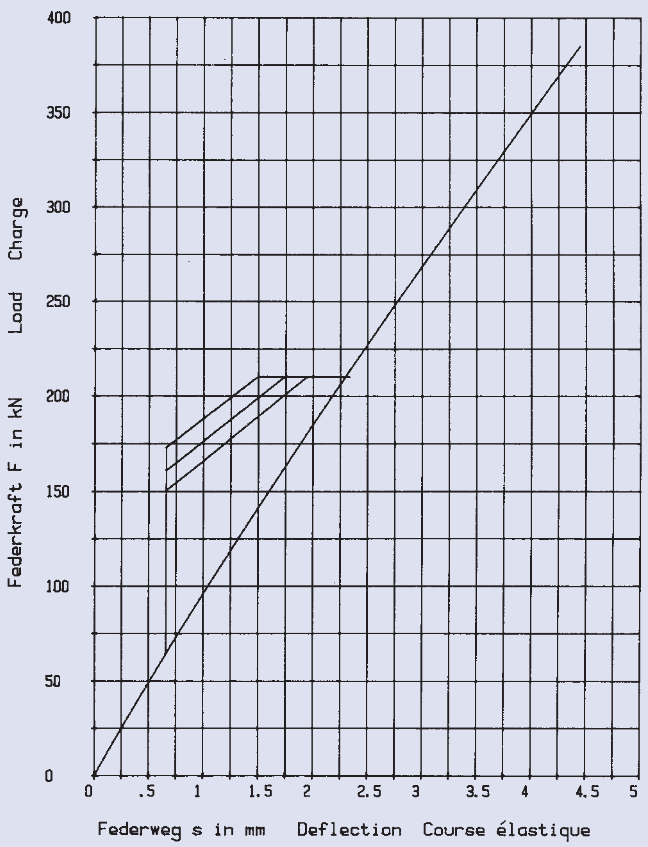
GR 3, DIN 2093 – A 180



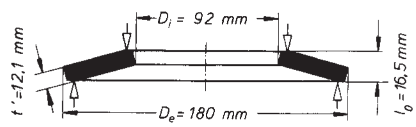
h_0 = 4,0 mm	D_e/D_i = 1,956	h_0' = 4,6 mm
t = 10 mm	D_e/t = 18	t'/t = 0,94
h_0/t = 0,4	m = 1,387 kg	h_0'/t' = 0,489



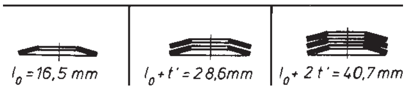
180 x 92 x 13



GR 3

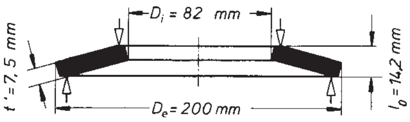


h_0 = 3,5 mm	D_e/D_i = 1,956	h_0' = 4,4 mm
t = 13 mm	D_e/t = 13,846	t'/t = 0,93
h_0/t = 0,269	m = 1,786 kg	h_0'/t' = 0,364

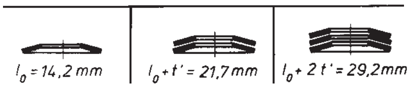


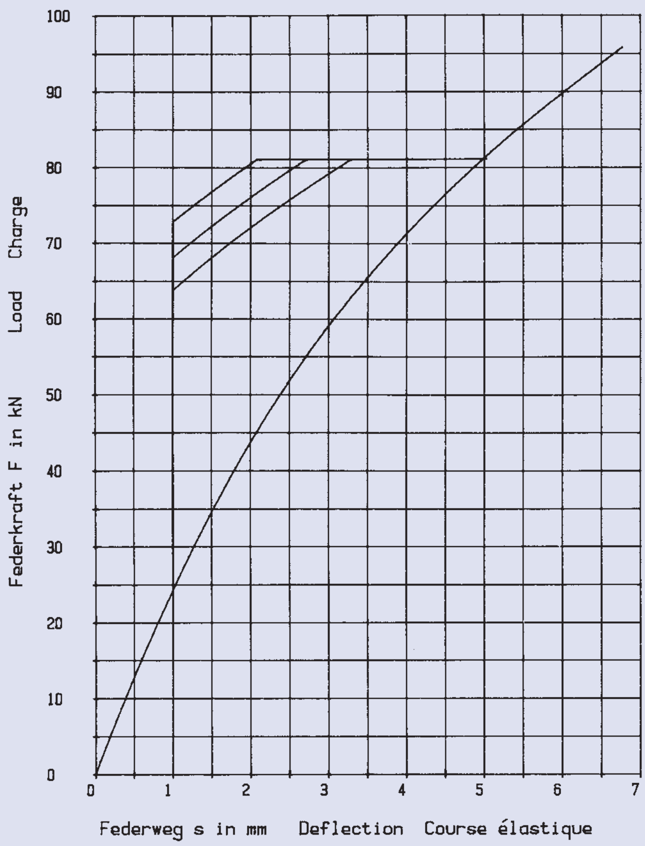
200 x 82 x 8,0

GR 3



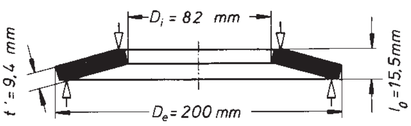
h_0 = 6,2 mm	D_e/D_i = 2,439	h_0' = 6,7 mm
t = 8,0 mm	D_e/t = 25	t'/t = 0,937
h_0/t = 0,775	m = 1,539 kg	h_0'/t' = 0,893



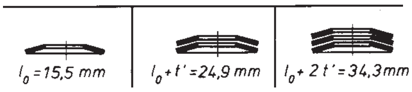


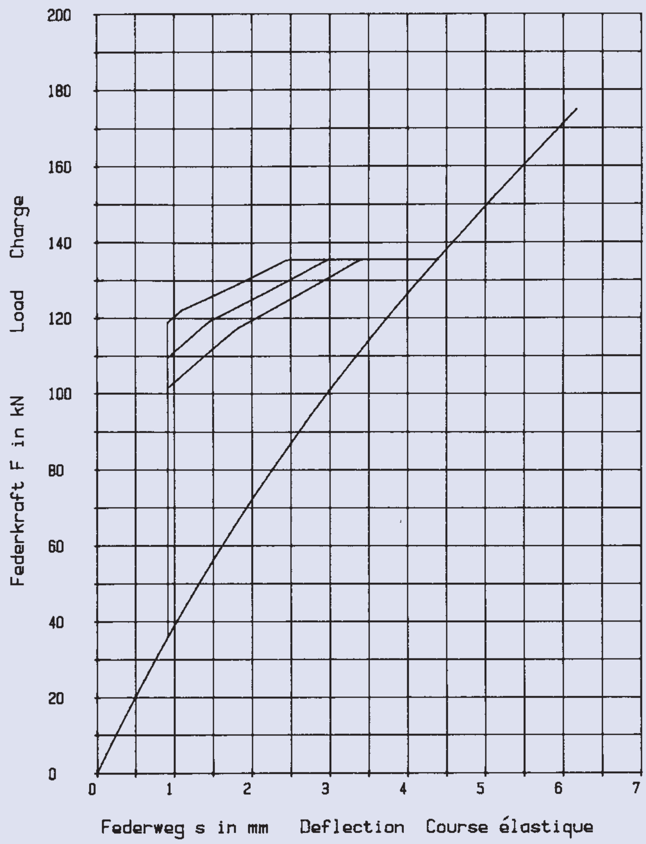
200 x 82 x 10

GR 3



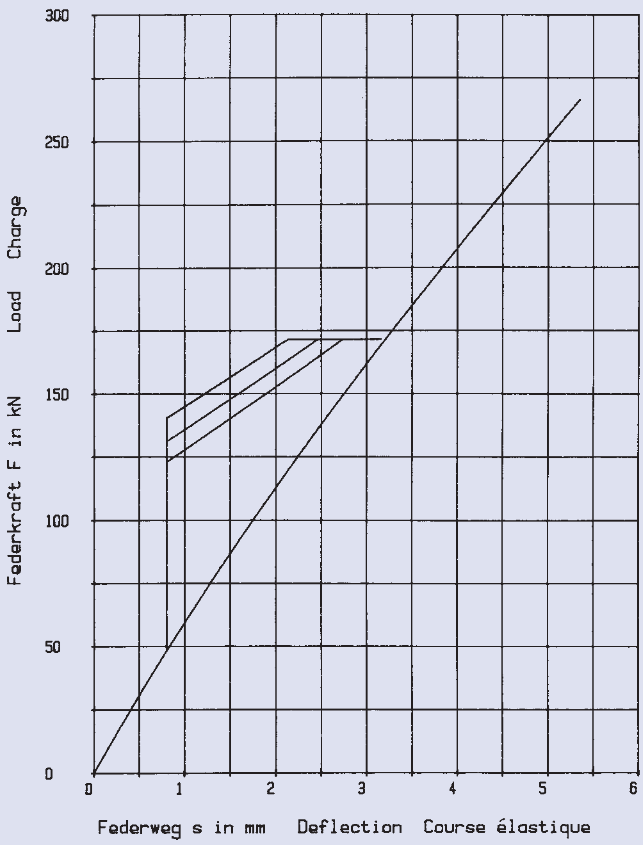
h_0 = 5,5 mm	D_e/D_i = 2,439	h_0' = 6,1 mm
t = 10 mm	D_e/t = 20	t'/t = 0,94
h_0/t = 0,55	m = 1,928 kg	h_0'/t' = 0,649

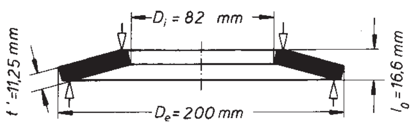




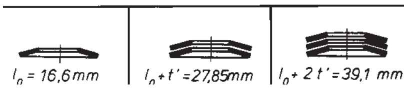
200 x 82 x 12

GR 3



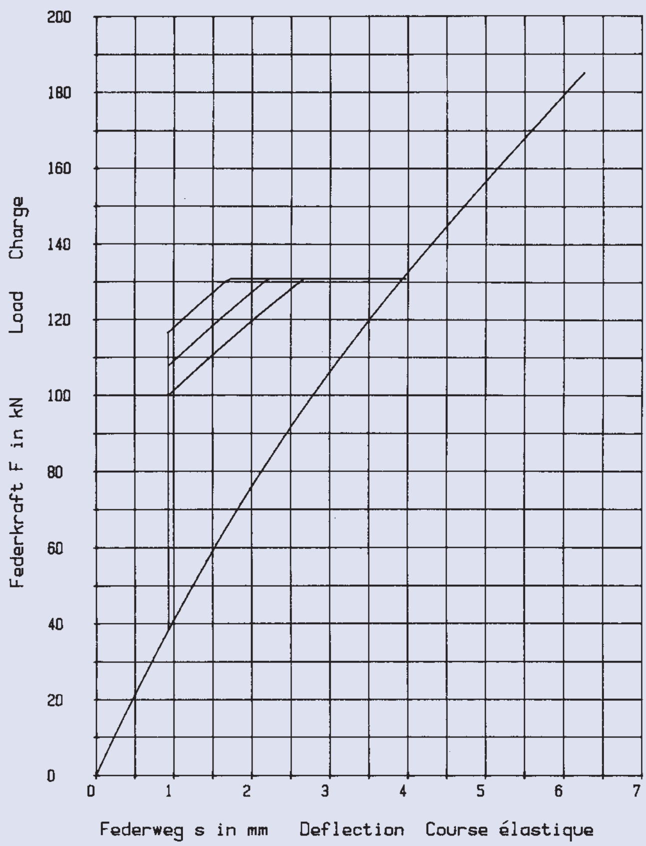


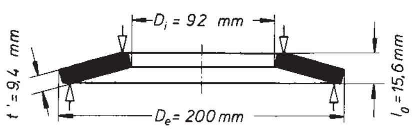
h_0 = 4,6 mm	D_e / D_i = 2,439	h_0' = 5,35mm
t = 12 mm	D_e / t = 16,667	t' / t = 0,937
h_0 /t = 0, 383	m= 2, 308 kg	h_0'/ t' = 0,476



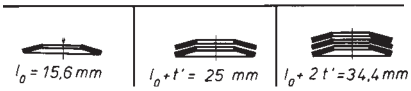
200 x 92 x 10

GR 3





h_0 = 5,6 mm	D_e / D_i = 2,173	h_0' = 6,2 mm
t = 10 mm	D_e / t = 20	t' / t = 0,94
h_0 /t = 0,56	m= 1, 828 kg	h_0'/ t' = 0,66



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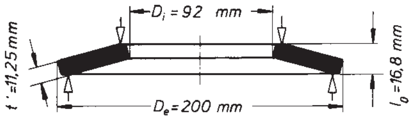
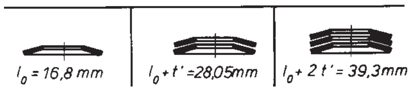
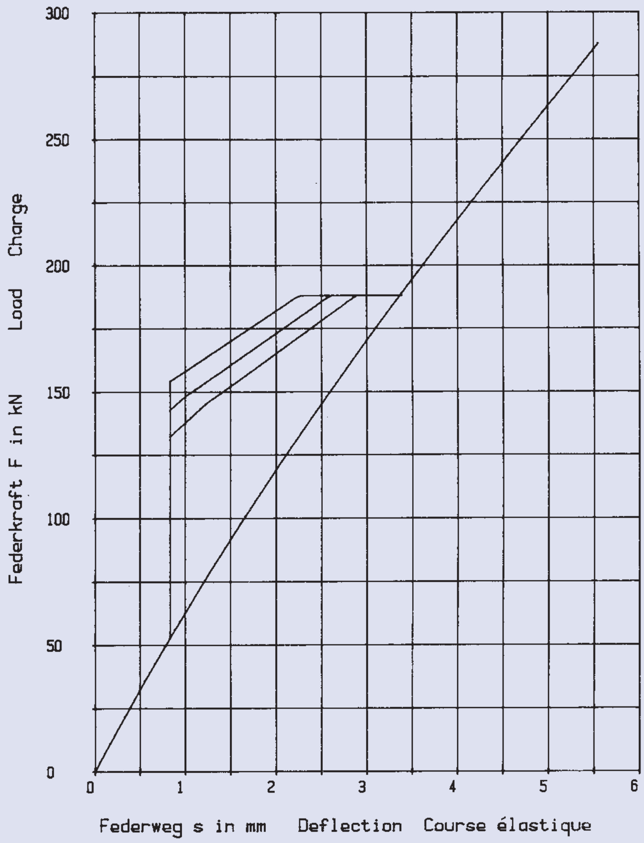
200 x 92 x 12

GR 3



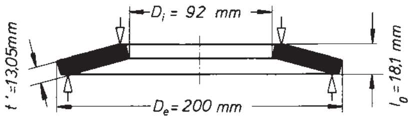
$h_0 = 4,8$ mm	$D_e / D_i = 2,173$	$h_0' = 5,55$ mm
$t = 12$ mm	$D_e / t = 16,667$	$t' / t = 0,937$
$h_0 / t = 0,4$	$m = 2,187$	$h_0' / t' = 0,493$



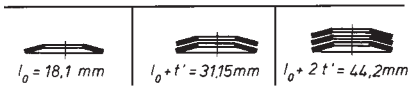


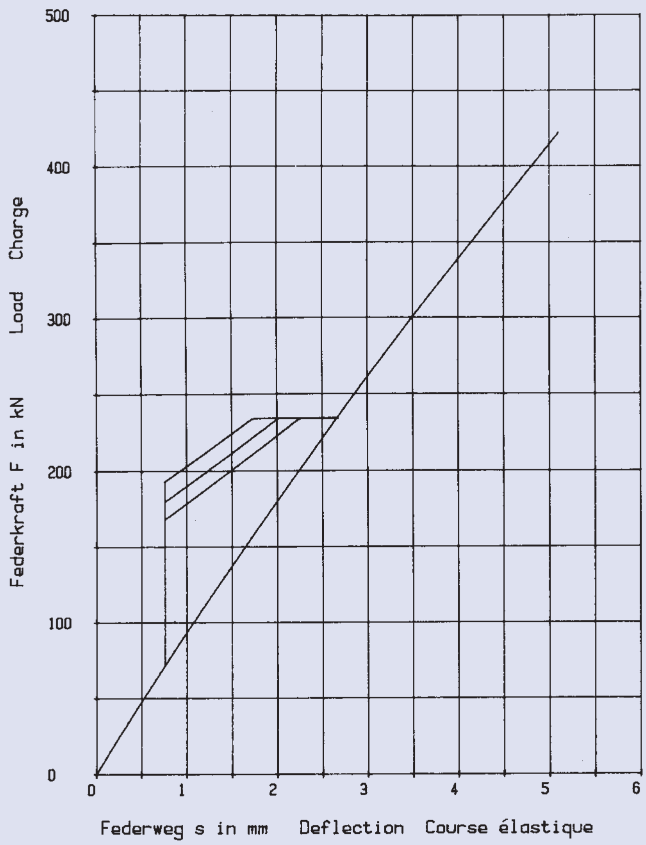
200 x 92 x 14

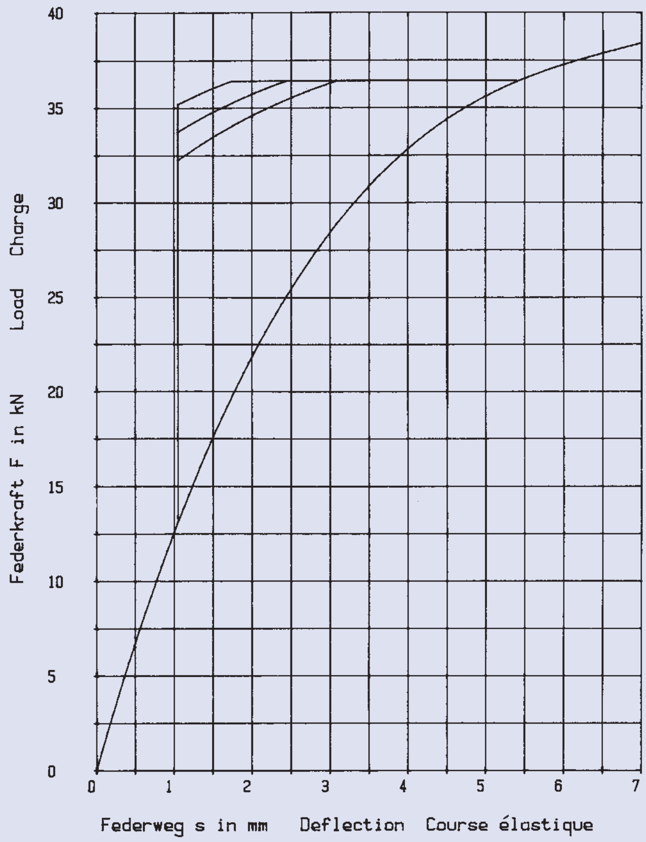
GR 3



$h_0 = 4,1$ mm	$D_e / D_i = 2,173$	$h_0' = 5,05$ mm
$t = 14$ mm	$D_e / t = 14,285$	$t' / t = 0,932$
$h_0 / t = 0,292$	$m = 2,537$ kg	$h_0' / t' = 0,387$

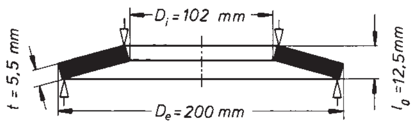




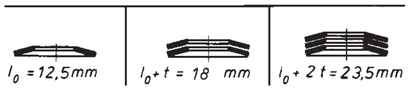


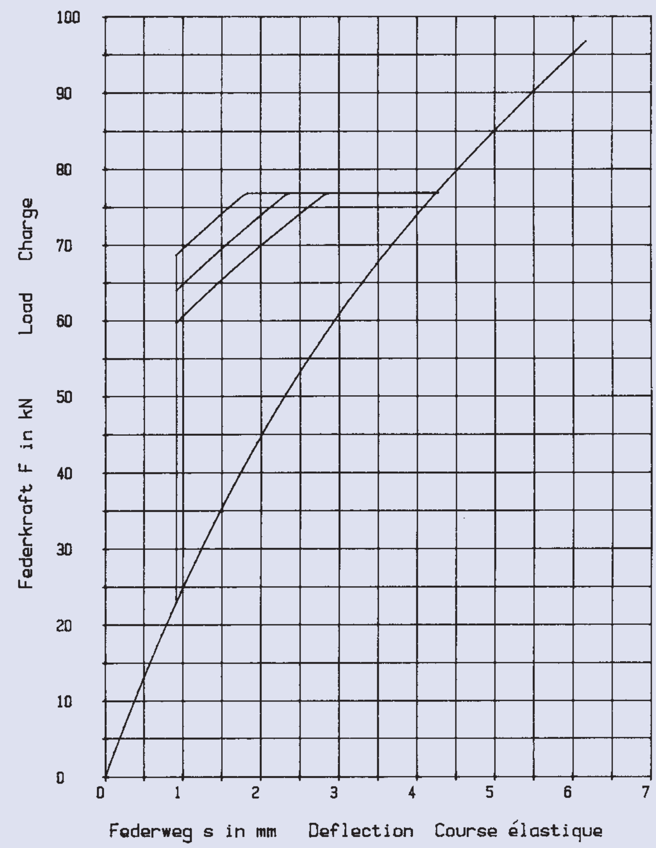
200 x 102 x 5,5

GR 2, DIN 2093 – C 200



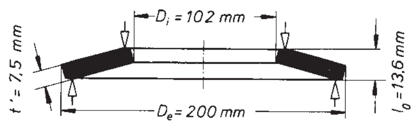
h_0 = 7,0 mm	D_e/D_i = 1,96
t = 5,5 mm	D_e/t = 36,363
h_0/t = 1,272	m = 1,004 kg





200 x 102 x 8,0

GR 3, DIN 2093 – B 200



h_0 = 5,6 mm	D_e/D_i = 1,96	h_0' = 6,1 mm
t = 8,0 mm	D_e/t = 25	t'/t = 0,937
h_0/t = 0,7	m = 1,368 kg	h_0'/t' = 0,813

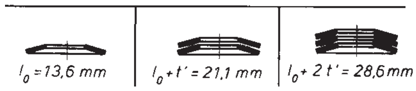
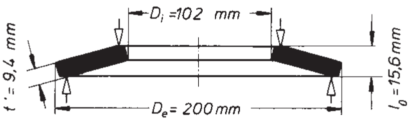


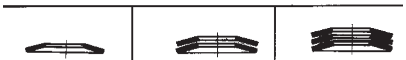
Diagramme | Diagrams | Diagrammes

200 x 102 x 10

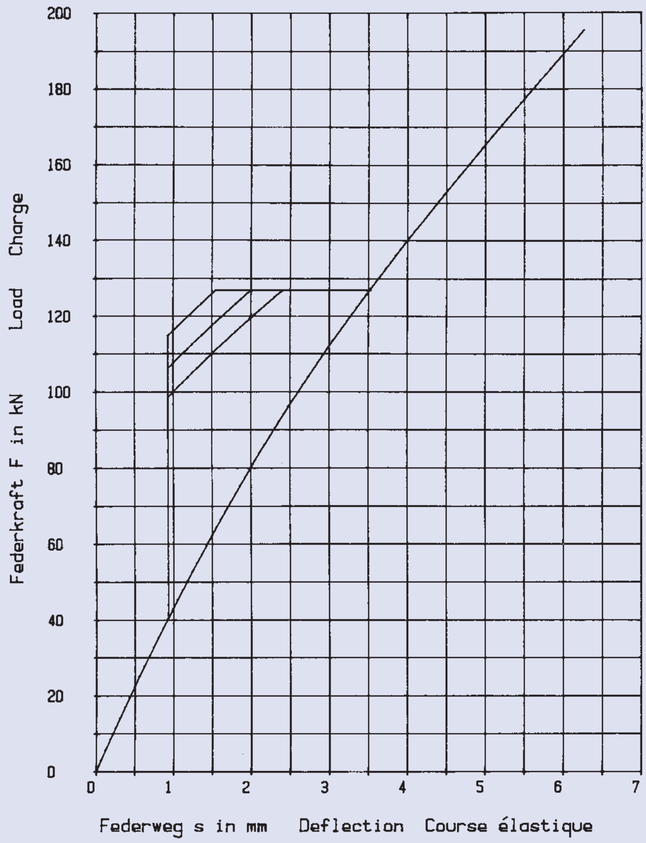
GR 3



h_0 = 5,6 mm	D_e/D_i = 1,96	h_0' = 6,2 mm
t = 10 mm	D_e/t = 20	t'/t = 0,94
h_0/t = 0,56	m = 1,716 kg	h_0'/t' = 0,66

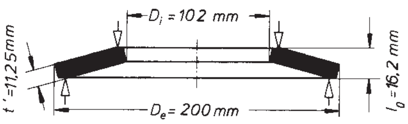


l_0 = 15,6 mm	l_0 + t' = 25 mm	l_0 + 2 t' = 34,4 mm



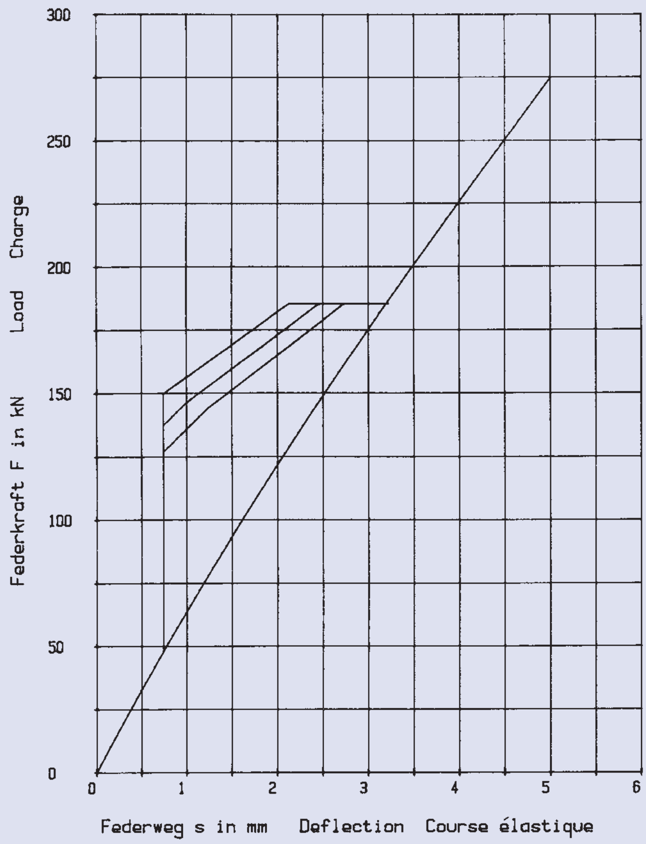
200 x 102 x 12

GR 3, DIN 2093 – A 200

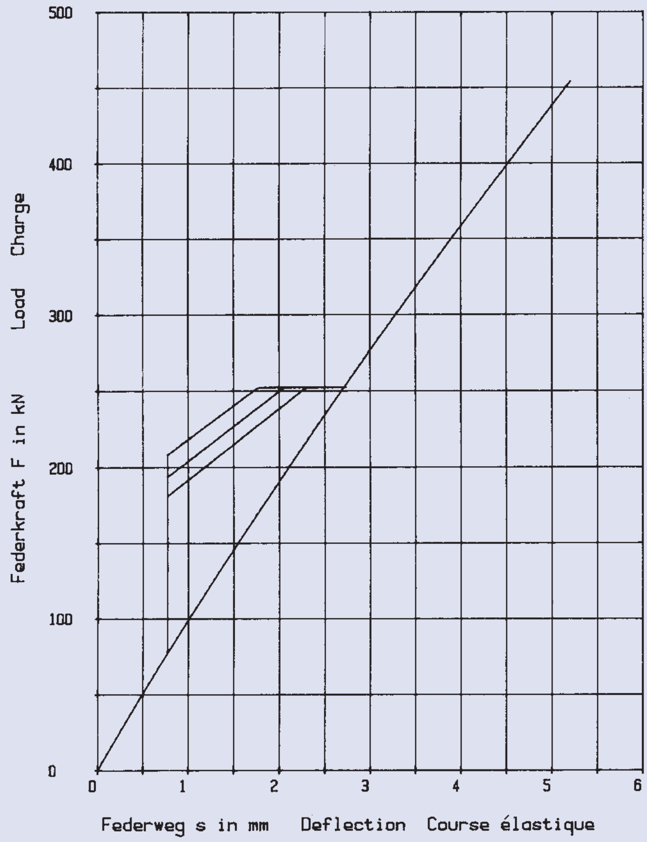


h_0 = 4,2 mm	D_e/D_i = 1,96	h_0' = 4,95 mm
t = 12 mm	D_e/t = 16,666	t'/t = 0,937
h_0/t = 0,35	m = 2,053 kg	h_0'/t' = 0,44

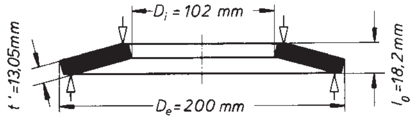
l_0 = 16,2 mm	l_0 + t' = 27,45 mm	l_0 + 2 t' = 38,7 mm



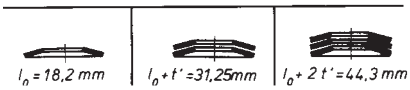
200 x 102 x 14



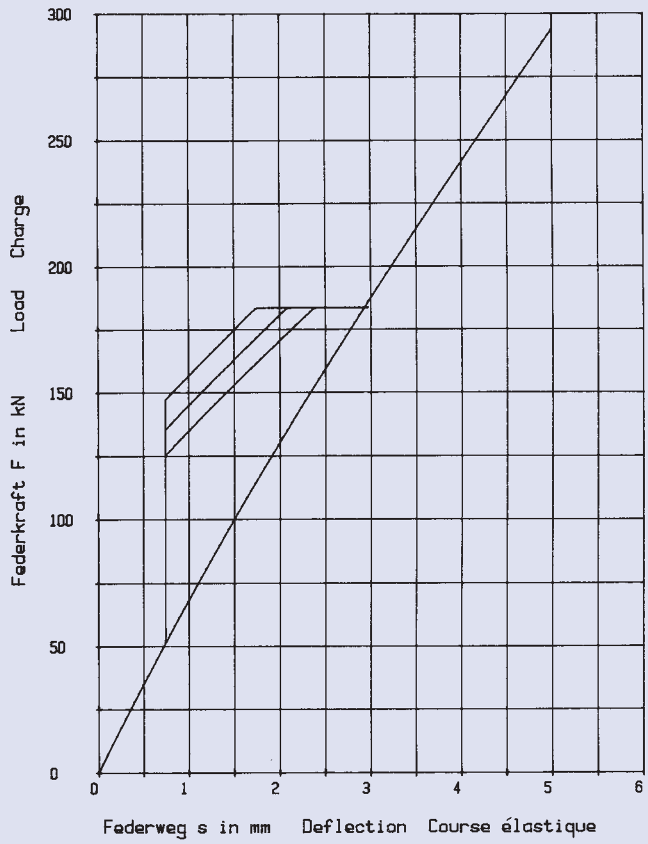
GR 3



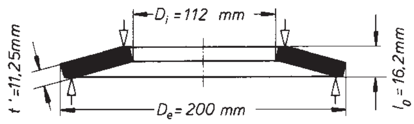
h_0 = 4,2 mm	D_e/D_i = 1,96	h_0' = 5,15 mm
t = 14 mm	D_e/t = 14,285	t'/t = 0,932
h_0/t = 0,3	m = 2,381 kg	h_0'/t' = 0,395



200 x 112 x 12



GR 3



h_0 = 4,2 mm	D_e/D_i = 1,785	h_0' = 4,95mm
t = 12 mm	D_e/t = 16,667	t'/t = 0,937
h_0/t = 0,35	m = 1,904 kg	h_0'/t' = 0,44

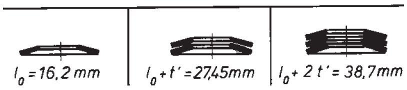
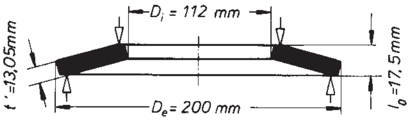


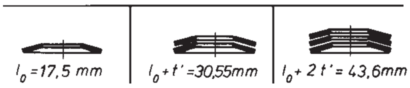
Diagramme | Diagrams | Diagrammes

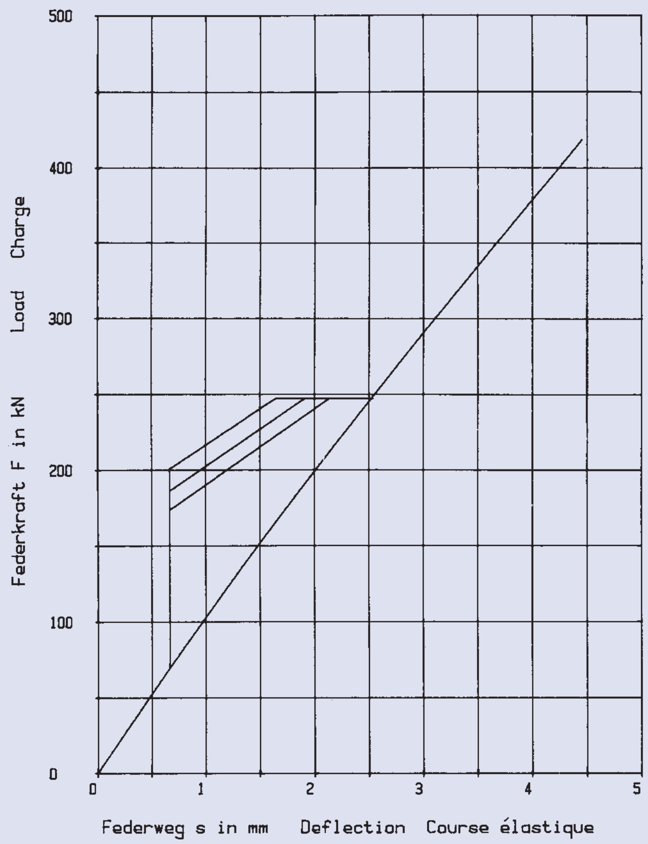
200 x 112 x 14

GR 3



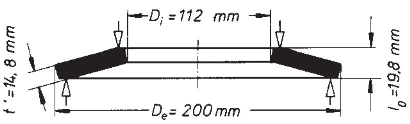
h_0 = 3,5 mm	D_e/D_i = 1,785	h_0' = 4,45mm
t = 14 mm	D_e/t = 14,285	t'/t = 0,932
h_0/t = 0,25	m = 2,209 kg	h_0'/t' = 0,341



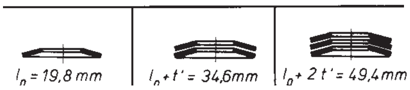


200 x 112 x 16

GR 3



h_0 = 3,8 mm	D_e/D_i = 1,785	h_0' = 5,0mm
t = 16 mm	D_e/t = 12,5	t'/t = 0,925
h_0/t = 0,237	m = 2,505 kg	h_0'/t' = 0,338



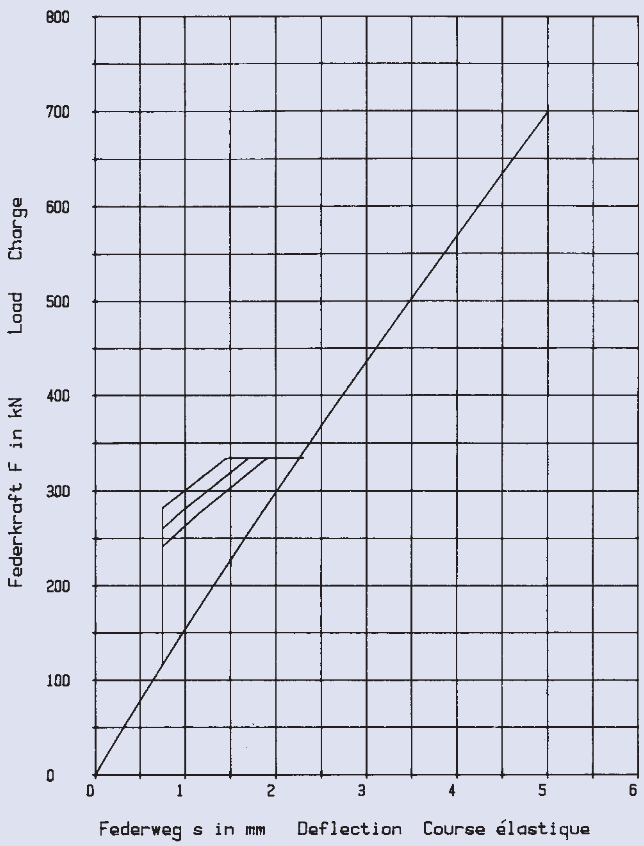
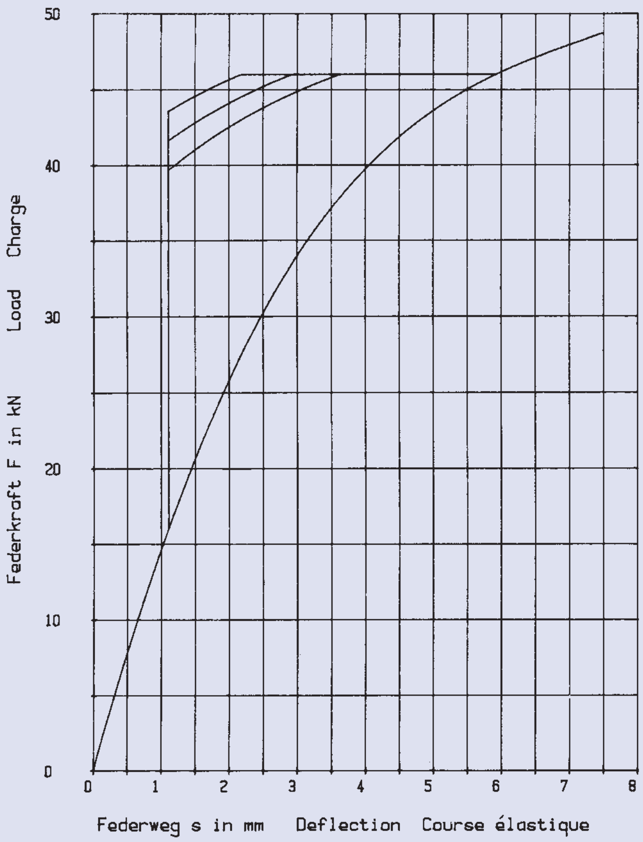
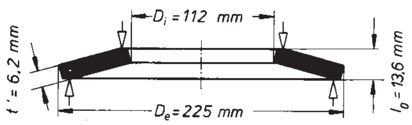


Diagramme | Diagrams | Diagrammes

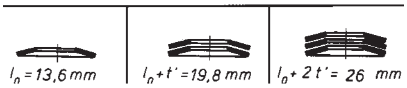
225 x 112 x 6,5

GR 3, DIN 2093 – C 225



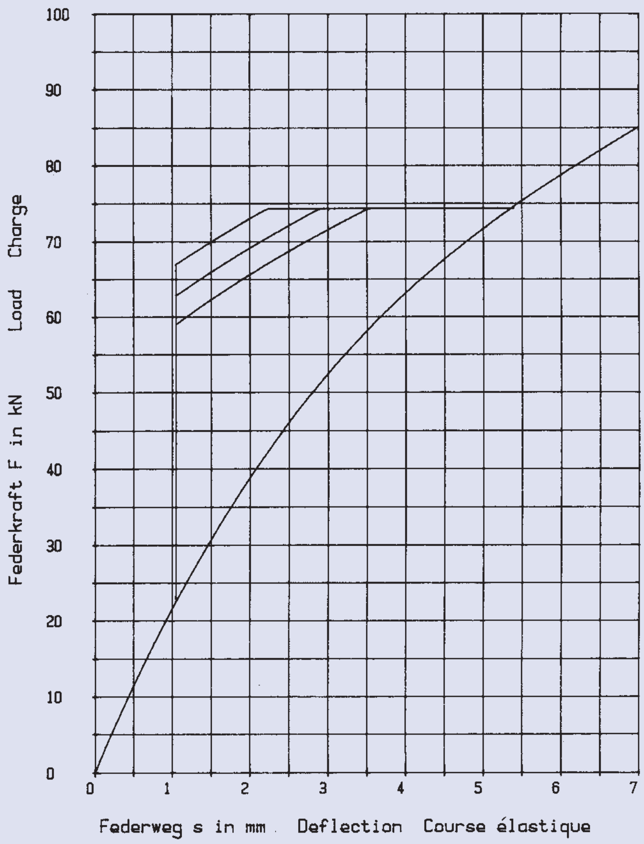


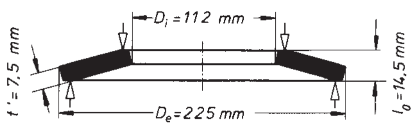
h_0 = 7,1 mm	D_e/D_i = 2,008	h_0' = 7,4 mm
t = 6,5 mm	D_e/t = 34,615	t'/t = 0,953
h_0/t = 1,092	m = 1,455 kg	h_0'/t' = 1,194



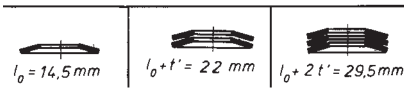
225 x 112 x 8,0

GR 3, DIN 2093 – B 225





h_0 = 6,5 mm	D_e/D_i = 2,008	h_0' = 7,0 mm
t = 8,0 mm	D_e/t = 28,125	t'/t = 0,937
h_0/t = 0,812	m = 1,761 kg	h_0'/t' = 0,933

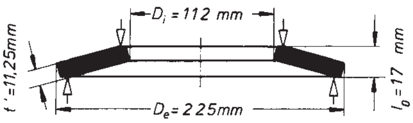


Kapitel | Chapter | Chapitre 6

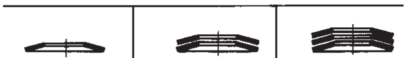
Diagramme | Diagrams | Diagrammes

225 x 112 x 12

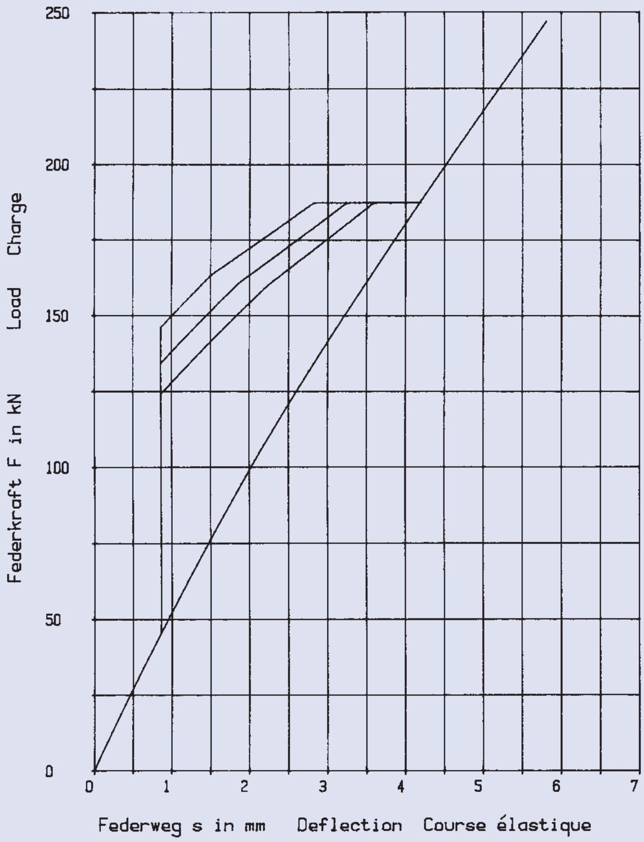
GR 3, DIN 2093 – A 225



h_0 = 5,0 mm	D_e/D_i = 2,008	h_0' = 5,75mm
t = 12 mm	D_e/t = 18,75	t'/t = 0,937
h_0/t = 0,416	m = 2,641 kg	h_0'/t' = 0,511

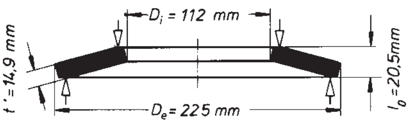


l_0 = 17 mm	l_0+t' = 28,25 mm	l_0+2t' = 39,5mm



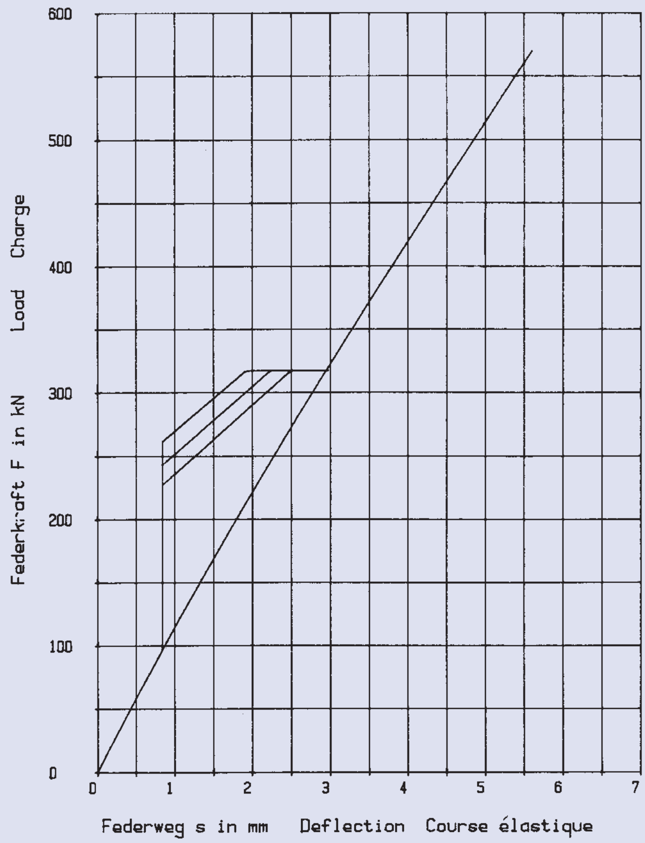
225 x 112 x 16

GR 3



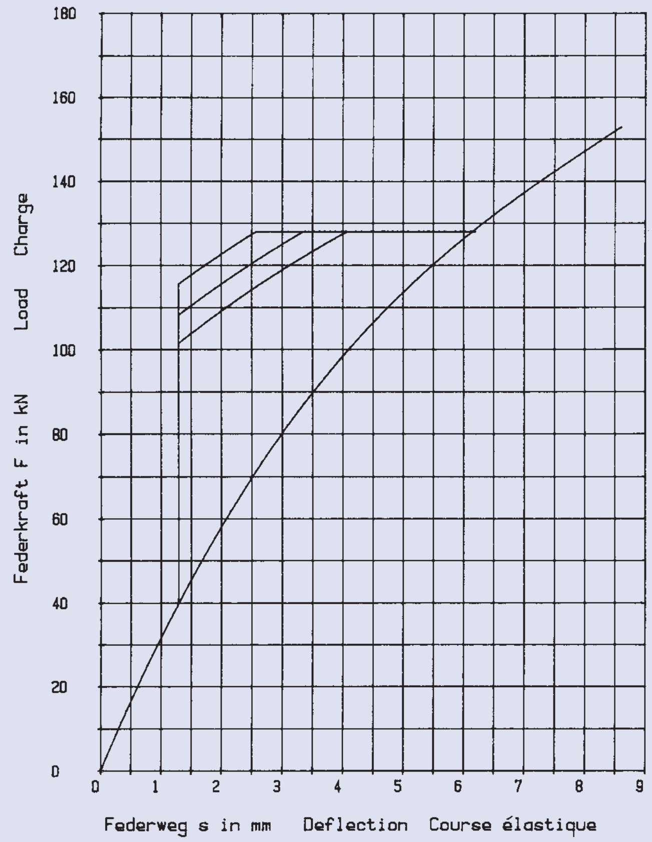
h_0 = 4,5 mm	D_e/D_i = 2,008	h_0' = 5,6 mm
t = 16 mm	D_e/t = 14,062	t'/t = 0,931
h_0/t = 0,281	m = 3,498 kg	h_0'/t' = 0,376

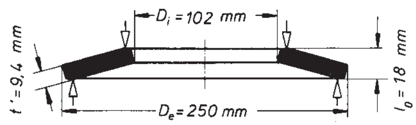
l_0 = 20,5 mm	l_0+t' = 35,4mm	l_0+2t' = 50,3mm



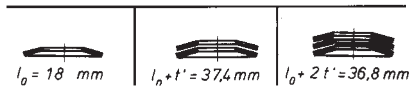
250 x 102 x 10

GR 3



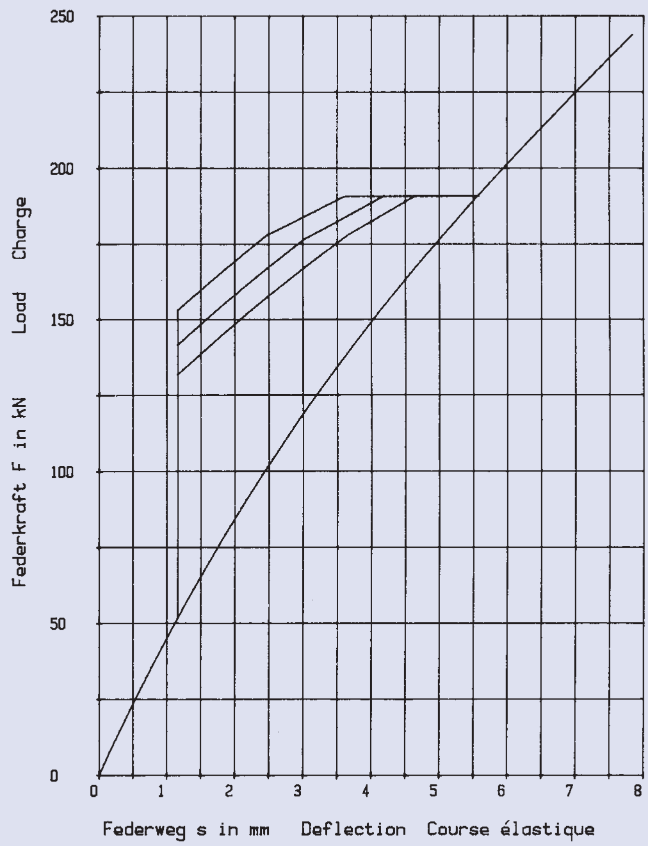


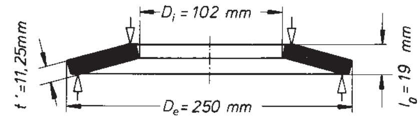
h_0 = 8,0 mm	D_e/D_i = 2,45	h_0' = 8,6 mm
t = 10 mm	D_e/t = 25	t'/t = 0,94
h_0/t = 0,8	m= 3,019 kg	h_0'/t' = 0,915



250 x 102 x 12

GR 3





h_0 = 7,0 mm	D_e/D_i = 2,45	h_0' = 7,75 mm
t = 12 mm	D_e/t = 20,833	t'/t = 0,937
h_0/t = 0,583	m= 3,613 kg	h_0'/t' = 0,689

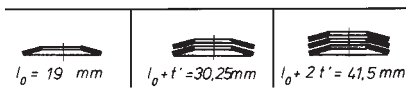
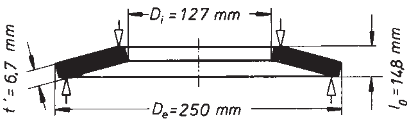


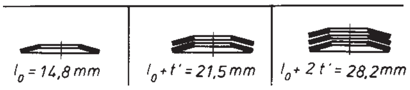
Diagramme | Diagrams | Diagrammes

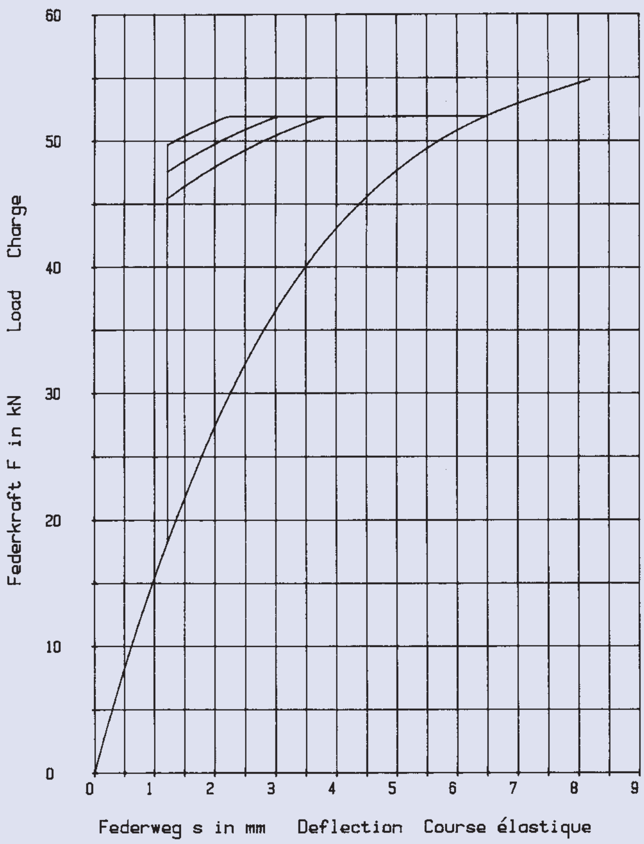
250 x 127 x 7,0

GR 3, DIN 2093 – C 250



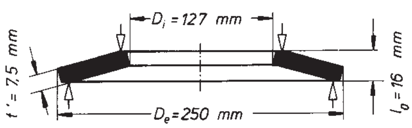
h_0 = 7,8 mm	D_e / D_i = 1,968	h_0' = 8,1 mm
t = 7,0 mm	D_e / t = 35,714	t' / t = 0,957
h_0 / t = 1,114	m = 1,915 kg	h_0' / t' = 1,209



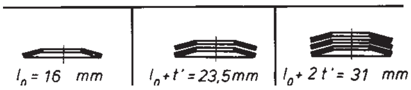


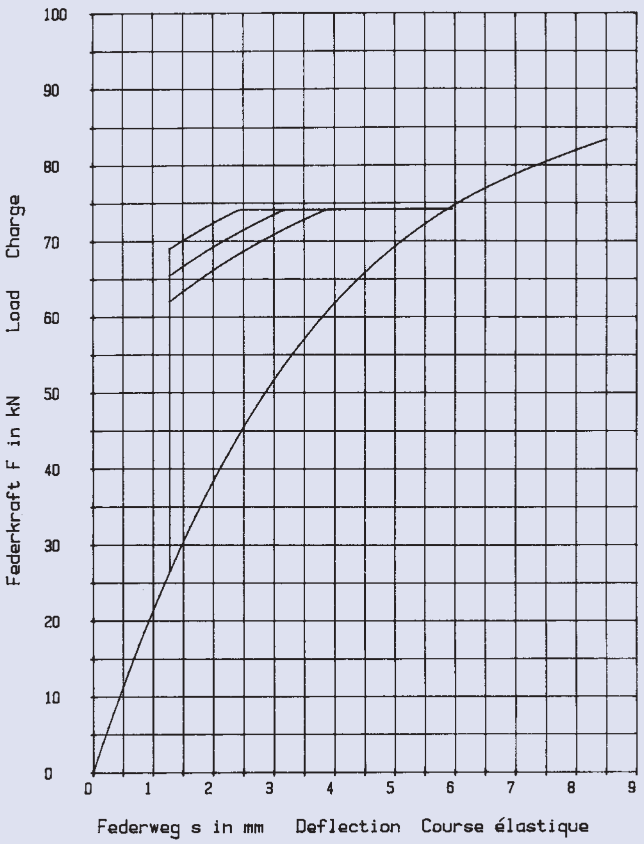
250 x 127 x 8,0

GR 3



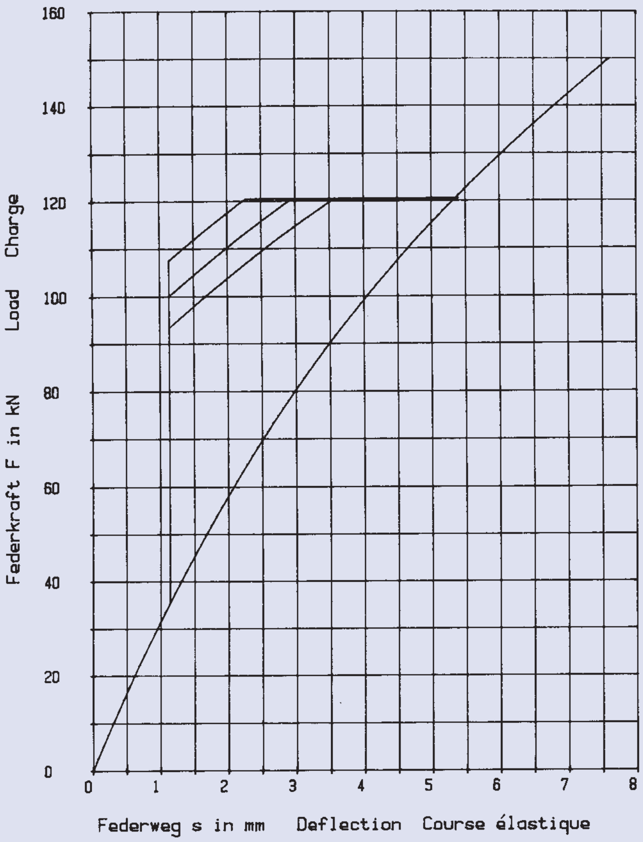
h_0 = 8,0 mm	D_e / D_i = 1,968	h_0' = 8,5 mm
t = 8,0 mm	D_e / t = 31,25	t' / t = 0,937
h_0 / t = 1,0	m = 2,144 kg	h_0' / t' = 1,133

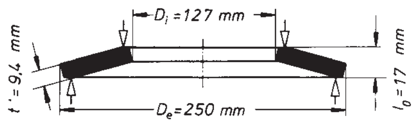




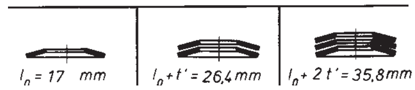
250 x 127 x 10

GR 3, DIN 2093 – B 250



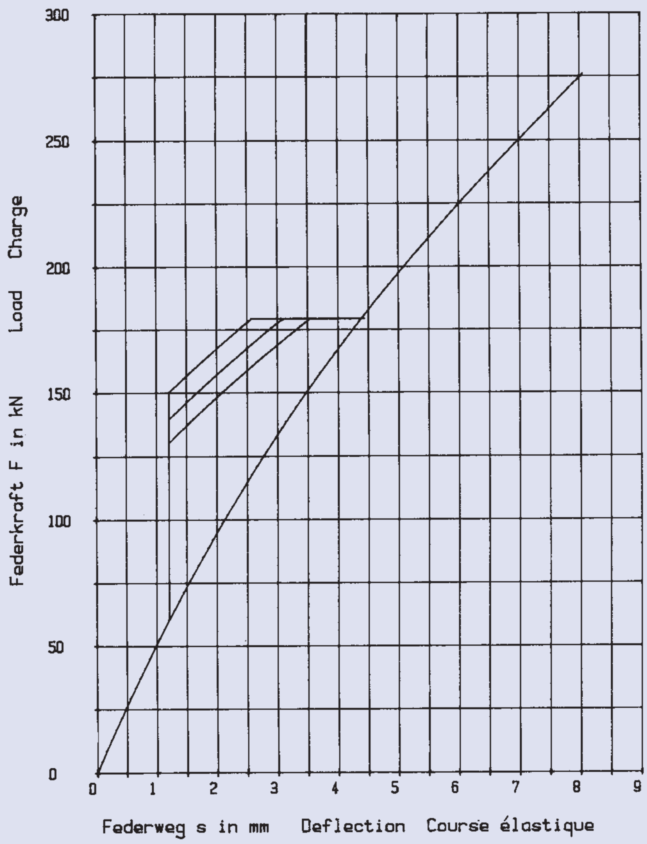


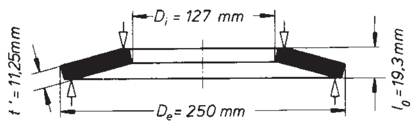
h_0 = 7,0 mm	D_e/D_i = 1,968	h'_0 = 7,6 mm
t = 10 mm	D_e/t = 25	t'/t = 0,94
h_0/t = 0,7	m = 2,687 kg	h'_0/t' = 0,809



250 x 127 x 12

GR 3





h_0 = 7,3 mm	D_e/D_i = 1,968	h'_0 =8,05 mm
t = 12 mm	D_e/t = 20,833	t'/t = 0,937
h_0/t = 0,608	m = 3,216 kg	h'_0/t' = 0,716

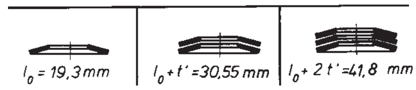
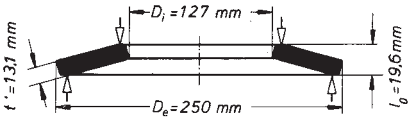


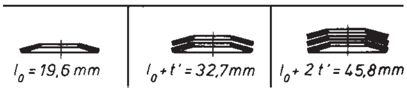
Diagramme | Diagrams | Diagrammes

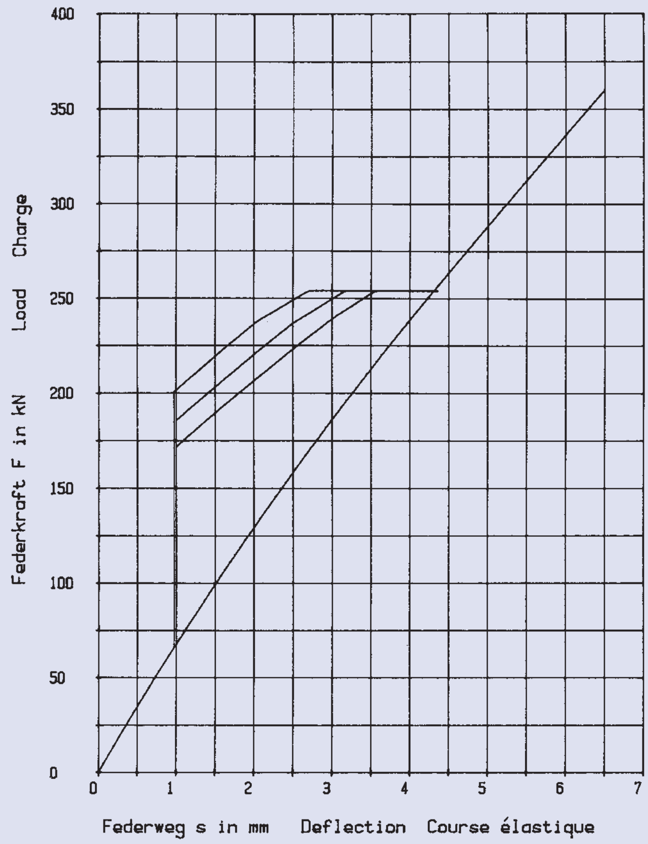
250 x 127 x 14

GR 3, DIN 2093 – A 250



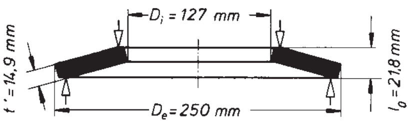
h_0 = 5,6 mm	D_e/D_i = 1,968	h_0' = 6,5 mm
t = 14 mm	D_e/t = 17,857	t'/t = 0,935
h_0/t = 0,4	m = 3,745 kg	h_0'/t' = 0,496





250 x 127 x 16

GR 3



h_0 = 5,8 mm	D_e/D_i = 1,968	h_0' = 6,9 mm
t = 16 mm	D_e/t = 15,625	t'/t = 0,931
h_0/t = 0,362	m = 4,260 kg	h_0'/t' = 0,463