SECTION X

NOVIBRA MOUNTS

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How to select Novibra mountings

Hardness
To avoid too many sizes, a selection of 2 rubber hardnesses is available for most of the models. These are expressed as hardness A (40°IRH) or hardness B (60°IRH) clearly marked on either the mounting's rubber body or the bottom metal plate.

Key questions
- ▶ Type of machinery.
- ▶ Total weight of machinery.
- ▶ Number of mountings.
- ▶ Interfering frequency.
- ▶ Installation environment.

Selection of mounting – some basics
- ▶ Type RA, RAEM or M for most machinery subject to vibration. Selection depends on desired degree of isolation, type of machinery, rpm, site, etc.
- ▶ Type GK or SAW isolate vibration on heavy machinery.
- ▶ Shock-absorption should preferably be isolated by means of a "soft" mounting, e.g. type M.
- ▶ Machine mounting type TF (Trell Foot) can be recommended for most workshop machines, but should be avoided for compressors, generators or similar machinery on suspended floors.

Degree of isolation
Generally discussed as percentage (%) of isolation or degrees of isolation. The higher the figure the more effective the mounting is in the installation. For a specific machinery installation the objective is to decide upon the degree of isolation. In the first place this is determined by the environment where the machinery is to be situated. The type and brand of machine is only seen as a secondary consideration.

Selection of degree of isolation – Some basics
- ▶ In a sensitive environment, the highest possible degree of isolation should be attained.
- ▶ The higher the speed range the more a machine is subject to out of balance forces and vibration. In such cases a high degree of isolation can be achieved with type RA or RAEM.
- ▶ For low interference frequencies, a "soft" mounting should be selected.
- ▶ "Soft" mountings provide higher degrees of isolation.
- ▶ A high degree of isolation assures a quiet environment.

Novibra AV-mountings

An effective and natural way to protect people and machinery from unnecessary strain caused by damaging vibrations and shocks.

In most cases a small investment will limit unpleasant noise and very often lead to a prolonged life of valuable machinery.

Some good reasons to select **Novibra**
- covering up to 99% of all applications
- expert technical advice
- ex stock supplies
- easy to install
- low installation profile
- no maintenance
- wide selection range
- load rating options 1–60.000 kg
- isolation degree up to 98%

Novibra antivibration mountings

Novibra is the name for Trelleborg's rubber and metal composite antivibration mounts which eliminates harmful vibrations and greatly reduces noise. Their long-lasting resilience is achieved by the rubber's molecular structure. The Novibra design is being used increasingly, and is based on rubber's isolation properties and on the special technique of fastening rubber to metal so securely that the joint is stronger than the bulk of the rubber.

The design and configuration of the antivibration mounts vary according to the application. In most cases standard stock parts can be used. In addition to the existing range, a large number of special isolators are produced; details can be supplied on request.

Suitable Novibra mounts can be calculated from the tables and diagrams in this catalogue. Please contact us over more difficult isolation problems.

Conversion tables

Force

N (Newton)	kp (kilopond)	lbs (pound-force)
1	0,101972	0,224809
9,80665	1	2,20462
4,44822	0,453592	1

Pressure

Pa (=N/m²) (Pascal)	kp/cm²	lbs/in²(=psi)
1	$10{,}1972 \times 10^{-6}$	$0{,}145038 \times 10^{-3}$
98066,5	1	14,2233
6894,76	$70{,}307 \times 10^{-3}$	1

Frequency

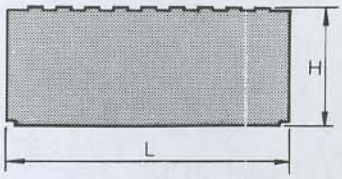
1 Hz(hertz)=60 r/min.

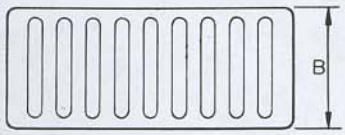
Energy and torque

Nm (Newtonmeter)	kpm	lbf×ft
1	0,101972	0,737562
9,80665	1	7,23301
1,35582	0,138255	1

NOVIBRA MOUNTS - GK

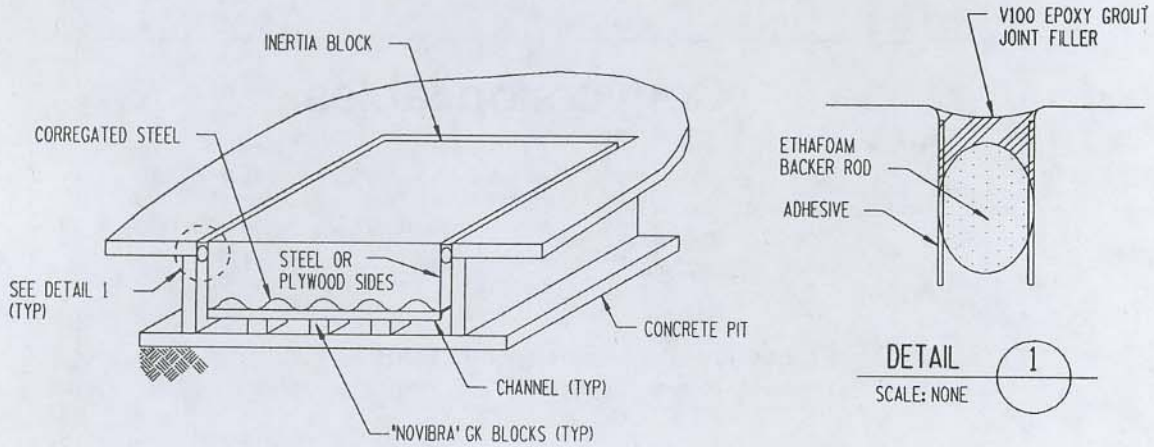
Novibra
GK





GK is a heavy duty mounting. It has been designed to support heavy machines, such as refiners, defibrators, industrial fans, mixers, roll-mills, etc. It is very soft, both vertically and laterally, thus providing a high degree of isolation. Its design also ensures excellent protection during an emergency stop of the machine.

Type	Art.no Hardness A	Art.no Hardness B	Dimensions in inches L	B	H	Weight Lbs.	Max load Lbs. Hardness A	Hardness B
GK 0	1534080	1861630	7.68	6.89	5.91	13.23	4,408	8,377
GK 1	67959	67967	15.75	6.89	5.91	27.12	8,818	17,637



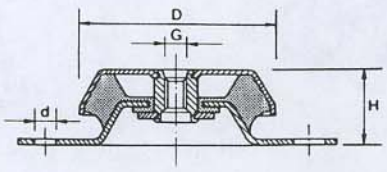
The above illustration shows the Novibra Type GK Block being used to support a concrete foundation. This is a very widely used application for this product. Used in this way, the GK Blocks can be very effectively used to isolate extremely sensitive machinery such as precision grinders and coordinate measuring machines, thus protecting them from ambient plant vibrations. The GK Block can obtain deflections up to 1.18 inches, and can isolate down to a natural frequency of 4 Hz.

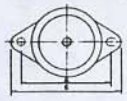
Other applications for use of the GK Block are:

Rolling Mills	Paper Mills
Mixers	Converters
Gear Wheels	Sound Enclosures
Industrial Fans	Floating Structures

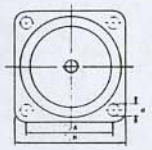
NOVIBRA MOUNTS - RA, RAEM, RAB, M

Novibra RA





RA 100–RA 800

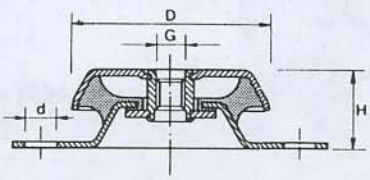


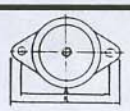
RA 1200–RA 1800

For most machines that vibrate because of their rotating parts, such as gen-sets, compressors, combustion engines, fans, generators, mills, paper machines, pumps and printing machinery. Also for presses, punches and workshop machines.
RA is a vertically soft, laterally stable mounting with a low profile, making installation easy. Securing to the floor is not always necessary. As standard, it is fitted with a shock-proof device (up to 5 g) with resilient stop, making RA ideal for use on mobile or marine applications.

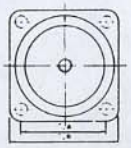
Type	Art.no Hardness A	Art.no Hardness B	D	A	H	K	d	Thread G	Weight Lbs.	Max load Lbs. Hardness A	Max load Lbs. Hardness B	Qty/carton
RA 100	1861700	1861710	3.11	4.33	1.18	5.12	.35	M 10	.73	209	419	4
RA 200	1861740	1861750	3.70	4.88	1.38	5.91	.39	M 10	1.04	397	595	4
RA 350	1861760	1861770	3.98	5.67	1.50	6.89	.55	M 16	1.62	551	992	4
RA 500	1861800	1861810	4.84	6.22	1.65	7.56	.55	M 16	2.25	882	1,323	4
RA 800	1861820	1861830	5.67	7.17	1.89	8.50	.55	M 16	3.50	1,653	2,866	4
RA 1200	2255360	2255370	6.34	5.51	2.28	6.69	.55	M 20	4.82	1,984	3,527	–
RA 1800	2255380	2255390	7.13	6.30	2.62	7.48	.55	M 20	5.13	2,866	4,630	–

Novibra RAEM





RA 40 EM–RA 800 EM

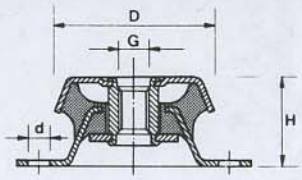


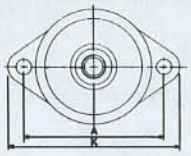
RA 1500 EM–RA 2500 EM
RA 1500 EM Duplex

Same applications as RA. RAEM is a further developed RA. EM stands for "extra soft". It is softer than RA and can therefore provide a higher degree of isolation.
RAEM is the real all-round anti-vibration mounting, and also fitted as standard with a shock-proof device with resilient stop.

Type	Art.no Hardness A	Art.no Hardness B	D	A	H	K	d	Thread G	Weight Lbs.	Max load Lbs. Hardness A	Max load Lbs. Hardness B	Qty/carton
RA 40 EM	1861860	1861870	2.52	3.47	1.40	4.33	.35	M 10	.50	55	99	4
RA 125 EM	1861720	1861730	3.31	4.33	1.40	5.32	.43	M 10	.82	154	331	4
RA 350 EM	1861780	1861790	4.33	5.67	1.65	6.89	.55	M 16	1.76	441	882	4
RA 800 EM	1861840	1861850	6.10	7.17	2.13	8.50	.55	M 16	3.93	1,102	1,764	4
RA 1500 EM	2255400	2255410	7.17	5.75	3.37	7.09	.55	M 20	6.61	1,984	3,748	–
RA 2500 EM	2255420	2255430	8.82	7.09	4.15	8.66	.69	M 24	10.19	3,748	7,496	–
RA 1500 EM Duplex	101105		9.76	5.75	4.53	7.09	.57	M 20	14.21	1,984	–	–

Novibra RAB

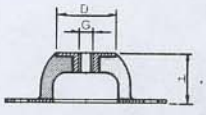


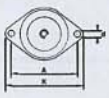


Similar in design to the RA/RAEM range, type RAB uses rubber in shear and compression for optimum stiffnes characteristics and horizontal stability. Especially effective on small 1, 2 and 3 cylinder diesel engines where the special compound employed provides effective isolation of vibration whilst eliminating much of the excessive movement normally associated with 1–3 cylinder engines.

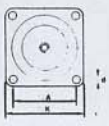
Type	Art.no (55° IRH)	D	A	H	K	d	Thread G	Weight Lbs.	Max load Lbs.
RAB-0	740258	2.48	2.99	1.38	3.68	.37	M 12	.49	287
RAB-2	1661270	2.48	2.99	1.38	3.68	.37	M 12	.49	231
RAB-3	1661020	2.48	2.99	1.38	3.68	.37	M 12	.49	154

Novibra M





M 7–M 200



M 400–M 1500

M is extremely soft, both vertically and laterally, for the isolation of low-frequency disturbances in all directions. Designed to provide a high degree of isolation for machines which vibrate because of their rotating parts, such as compressors, refrigerating machines, electric motors, fans, etc. M is also suitable as a shock isolator for applications ranging from small electronic equipment to big and heavy constructions to protect these from incoming g-forces and vibrations.

Type	Art.no Hardness A	Art.no Hardness B	D	A	H	K	d	Thread G	Weight Lbs.	Max load Lbs. Hardness A	Max load Lbs. Hardness B	Qty/carton
M 7	2255110	2255120	.59	1.97	.79	2.56	.28	M 6	.04	8	20	20
M 25	1861220	1861230	1.18	2.60	.98	3.35	.32	M 8	.15	44	88	12
M 50	1861240	1861250	1.65	3.62	1.38	4.49	.39	M 10	.34	88	143	4
M 100	1861620	1861610	1.97	4.33	1.58	5.35	.45	M 10	.57	154	287	4
M 200	1861660	1861670	2.17	4.88	1.77	5.95	.45	M 10	.92	287	485	4
M 400	1861680	1861690	2.95	4.72	2.48	5.91	.57	M 12	2.35	617	1,102	4
M 600	1533710	1533720	3.94	6.30	3.35	7.87	.57	M 16	5.18	838	1,653	–
M 1500	1533730	1533740	7.32	9.84	6.30	12.21	.71	M 24	20.79	3,086	5,511	–

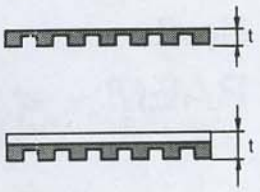
NOVIBRA MOUNTS - BA, VIBRATION PLATE, TF, U

Novibra BA

Especially suited for the isolation of low speed machines, such as light fans, instruments and gauging equipment. BA guarantees soft elasticity under shearing strain. It is easy to install. BA 20/2 is basically the same as half a BA 20 but for lower loads.

Type	Art.no Hardness A	Art.no Hardness B	Dimensions in inches B	A	L	H	d	t	Weight lbs.	Max load lbs. Hardness A	Hardness B
BA 20/2	2255170	2255180	.79	2.44	3.54	2.28	.35	.16	.21	26	60
BA 20	2255230	2255240	.79	-	3.54	1.97	.39	.16	.35	44	77
BA 50	2255250	2255260	1.97	-	3.54	1.97	.47	.16	.93	132	243
BA 100	2255270	2255280	3.94	-	3.54	1.97	.59	.16	1.83	276	485

Novibra VIBRATION-PLATE

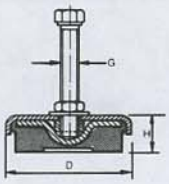


For vibration-isolation of limited requirements, for example high-frequency vibrations or high and unsteady machines which have to be secured to the floor, such as pillar drills and transformers. The rubber is oil resistant.

Type	Art.no	Dim. inches	Thickness inches	Weight lbs.	Max load psi
Single	70136	23.62 x 19.69	.18	2.68	71.12
Double	70151	23.62 x 19.69	.32	4.00	71.12

Novibra TF

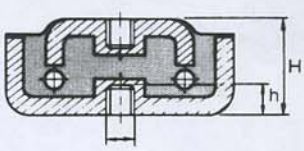
(with levelling bolt)

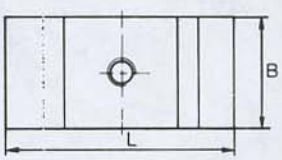


Machine supports TF with level adjuster suited for a great variety of workshop machinery, such as milling machines, lathes, grinding machines, presses, punches, etc. The rubber is oil resistant.

Type	Art.no	Dimensions in inches D	H	Thread G	Weight lbs.	Max load lbs.
TF 250	1860740	2.72	.91	M 12	.78	551
TF 600	1860780	3.19	.98	M 12	1.07	1,323
TF 1200	1860790	4.25	1.14	M 16	2.18	2,646
TF 3000	1860800	5.95	1.38	M 20	4.90	6,614
TF 4000	1860810	6.69	1.54	M 20	6.45	8,818
TF 6000	1860820	8.07	1.73	M 24	10.61	13,228

Novibra U

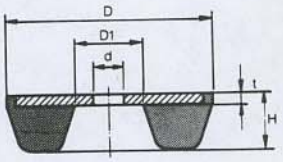




U is a sturdy vibration mounting for presses, punches, weaving machines, transformers, woodworking machines, printing machines and heavy high-speed machines. It ensures a very rigid installation.

Type	Art.no Hardness A	Art.no Hardness B	L	B	Dimensions in Inches H	h	Thread G	Weight lbs.	Max load lbs. Hardness A	Hardness B
U 100	67363	67371	3.94	1.97	1.65	.47	M 12	1.43	441	882
U 130	67421	67439	5.12	2.76	2.13	.47	M 12	2.91	882	1,764
U 170	67488	67496	6.69	3.94	2.76	.71	M 16	7.77	1,433	2,646
U 200	67546	67553	7.87	3.94	2.76	.79	M 20	9.08	2,205	4,409

Novibra SE

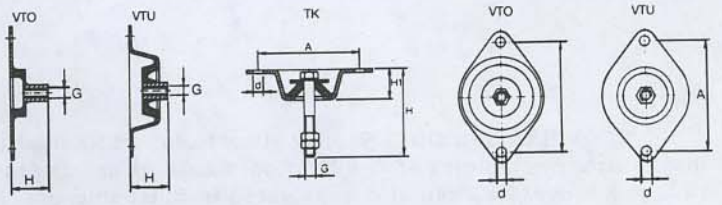


For office machines, sewing machines, electric motors, etc. SE is a simple vibration mounting which needs not to be secured to the surface.

Type	Art.no Hardness R	Dimensions in inches D	D1	d	H	t	Weight lbs.	Max load lbs. Hardness R
SE 75	1661010	2.17	.71	.32	.59	.12	.15	331
SE 250	1861110	2.95	.98	.39	.67	.16	.38	882
SE 750	1861120	4.53	1.58	.55	.95	.16	1.01	2,425

Note: Only available as 1 hardness, i.e. R = 50° IRH.

Novibra VT TK



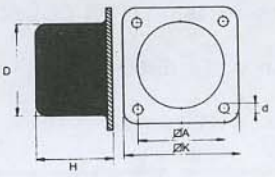
VT has been designed to protect instruments and apparatus fitted on walls and ceilings. TK is suited for instruments and apparatus fitted on ceilings as well as light fittings, for example on board ships.

Type	Art.no Hardness A	Art.no Hardness B	Dimensions in inches A	H	d	Thread G	Weight lbs.	Max load lbs. Hardness A	Hardness B
VT over	69526	69534	3.78	1.30	.35	M 8	.33	66	154
VT under	69567	69575	3.78	1.30	.35	M 8	.23	66	154

Type	Art.no Hardness R	Dimensions in inches A	H	H'	d	Thread G	Weight lbs.	Max load lbs. Hardness R
TK	1861410	1.81	1.56	.51	.28	M 5	.08	11.02

Note: Only available as 1 hardness, i.e. R = 50° IRH.

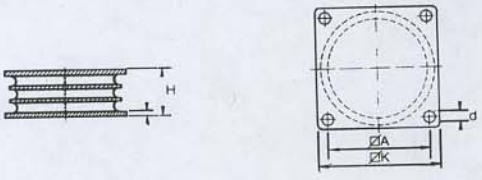
Novibra ANB



ANB is a shock absorbing mounting which isolates shocks on mobile machines or moving machine parts that have to be slowed down, such as waggons, cranes and overhead cranes.

Type	Art.no	Dimensions in inches K	A	D	d	H	Weight lbs.
ANB 50	2255290	2.76	1.97	1.97	.28	1.69	.42
ANB 75	2255300	3.94	2.95	2.95	.35	2.48	1.12
ANB 100	2255310	5.12	3.94	3.94	.43	3.31	2.61
ANB 150	68569	7.28	5.91	5.91	.53	4.96	8.59
ANB 200	68577	9.45	7.87	7.87	.53	6.61	20.06

Novibra SAW



SAW has been developed for crushers, mills, grinders and similar large, heavy machines. It is laterally very flexible in order to isolate horizontal forces. It can be mounted at angles from 0° to 90° to reach optimum efficiency. Its low height makes installation easy.

Type	Art.no Hardness A	Art.no Hardness B	Dimensions in inches K	H	A	d	t	Weight lbs.	Max load lbs. Hardness A	Hardness B
SAW 125	2255130	2255140	5.83	2.05	4.65	.53	.20	5.69	4,960	9,921
SAW 150	2255150	2255160	6.54	2.48	5.35	.53	.24	9.14	8,267	16,534
SAW 200	814467	814475	8.66	3.23	7.24	.67	.32	20.34	13,228	26,455
SAW 300	814483	814491	12.21	4.72	10.63	.87	.39	59.52	33,069	66,138

NOVIBRA MOUNTS - TECHNICAL INFORMATION

NOVIBRA PRODUCTS now allow isolation foundations to be capable of providing extremely low natural frequencies of 3-4 hz. Coordinate measuring machines and other equipment , sensitive to low frequencies , can also be isolated from troublesome sources at a fraction of the cost of air or steel springs.

NOVIBRA MOUNTS make use of rubber components and have the rubber's efficiency for absorbing impact , noise and vibration , as well as the ability to withstand exposure to moisture and acids.

NOVIBRA MOUNTS are offered with two classes of rubber hardness :

Hardness A - Soft Rubber with a Hardness of 40 deg IRH

Hardness B - Rubber with a Medium Hardness of 60 deg IRH

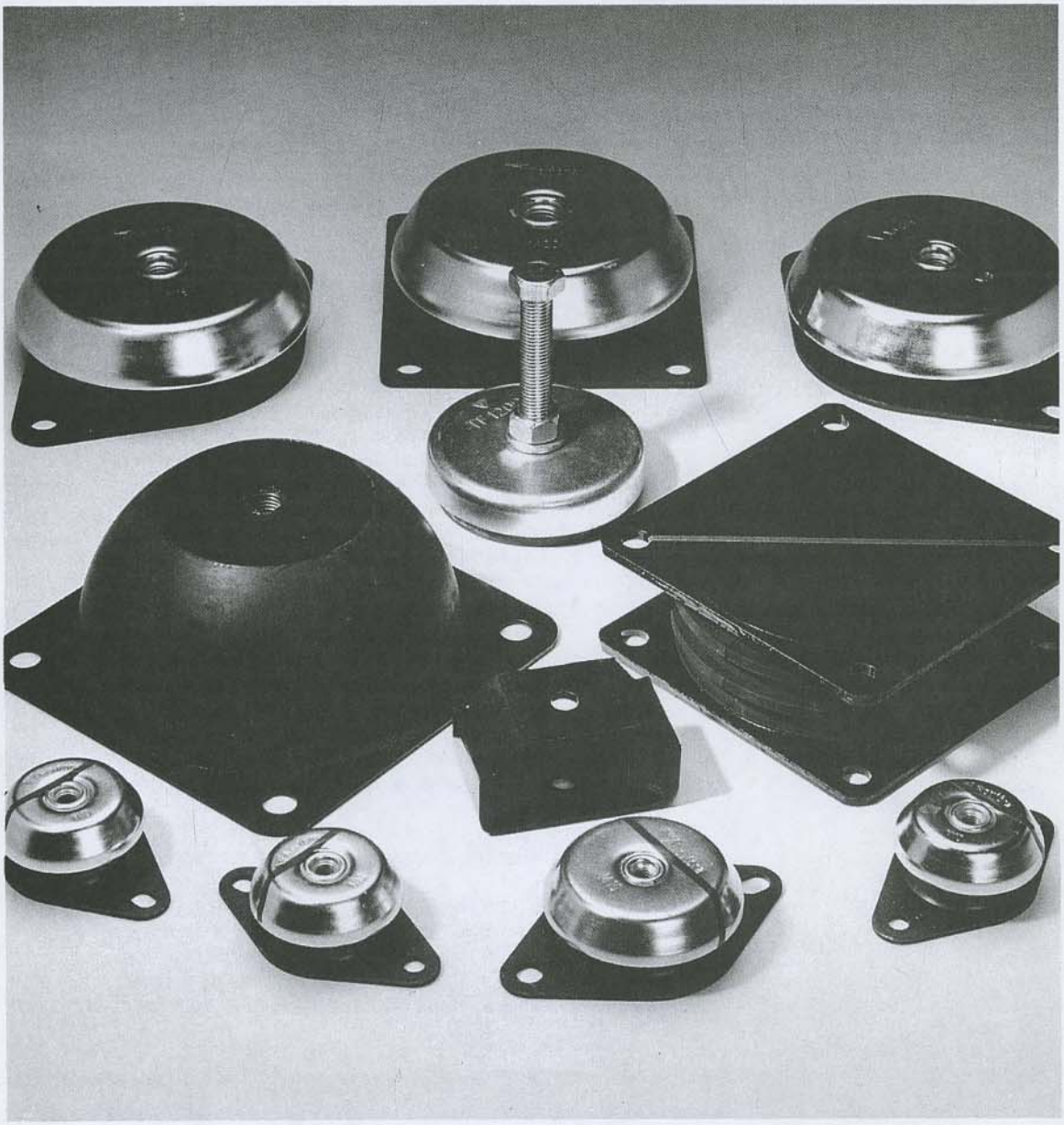
Rubber hardness is COLOR CODED on all products with:

Green = Hardness A

Black = Hardness B

A special bonding process developed by *NOVIBRA* makes the bond stronger than the rubber.

Supported by ENGINEERING computer programs , *NOVIBRA* , through the - TOLL FREE - services of ACORN INDUSTRIAL PRODUCTS CO. can provide the - TECHNICAL ASSISTANCE - to determine the optimum solution and correct choice of mounts.



The Novibra range comprises a wide selection of different mountings covering up to 99% of all applications.

General

Vibrations are produced by any machine with rotating or reciprocating parts which are out-of-balance. If it is rigidly connected to its foundations, these also are forced to participate in the vibrations and transmit them to surrounding structures. These vibrations often create irritating noise in the building housing, the machine, and in places at a distance from it. This is usually described as body noise.
Apart from noise, vibrations can seriously interfere with adjacent sensitive machinery and instruments which must be vibrationless in operation.
The human body can also be adversely affected – the effects being reduced work capacity, tiredness and headaches (especially where there is noise from high-frequency machines). These and similar harmful effects can be eliminated by:

1. minimizing out-of-balance and natural vibration of the machine by greater manufacturing precision, suitable design of cutting tools, etc.;
2. isolating the machine against vibration so that none is transmitted to its surroundings;
3. isolating the machine against vibration from incoming disturbances;
4. soundproofing the machine with appropriate material, together with sound-deadening material to combat atmospheric noise.*

Production costs involved in precision machine balancing are high. These rise particularly sharply with increasingly fine adjustment of machine parts. These additional costs can be avoided by allowing machinery to be slightly out-of-balance and eliminating harmful effects with vibration insulation.

Cushioning material

The cushioning material previously in common use was cork; its cushioning properties were based on compression and expansion of the enclosed air. However, over a period of time the air is gradually pressed out with the result that the isolation effect ceases. Cork is hygroscopic and provides only slight cushioning; it is therefore no longer widely used for particularly demanding requirements. The same applies to felt—which has comparable properties.

The cushioning materials now coming to the fore are steel and rubber. Steel springs are usually the spiral and leaf types. These have the advantage of permitting relatively high loads while providing extremely limited damping – thus it is very difficult to operate them within the resonance range, special measures frequently having to be adopted to limit deflection.

In comparison with steel, rubber possesses high internal damping. It absorbs sound and has good elastic formability and chemical resistance – properties which make rubber particularly suitable as a cushioning material.

Stress-strain diagrams show clearly the difference in the elongation properties of various materials. Fig. 1 shows, in diagram form, a tensile test on steel; Fig. 2 shows the corresponding test on rubber. For steel the load increases linearly up to the limit of proportionality. Below this, Hooke's law (which states that the stress o is equal to the strain multiplied by the modulus of elasticity E) applies. Just below the limit of proportionality is the elastic limit, up to which steel is elastic and regains its original form. At the yield point lying just above the limit of proportionality, the material is elongated without the need to increase the tensile force. Maximum tensile force is reached at the yield point. Failure occurs after further strain but at a lower tensile force, because the area decreases.

Rubber's tensile behavior is quite different: elongation of rubber is considerable even at very low tensile stresses. The load increase is also non-linear; in other words, elongation of the rubber is not proportional to the load. It follows from this that the modulus of elasticity is not constant and Hooke's law does not apply. There is no yield point; instead, the load is increased until failure suddenly occurs.

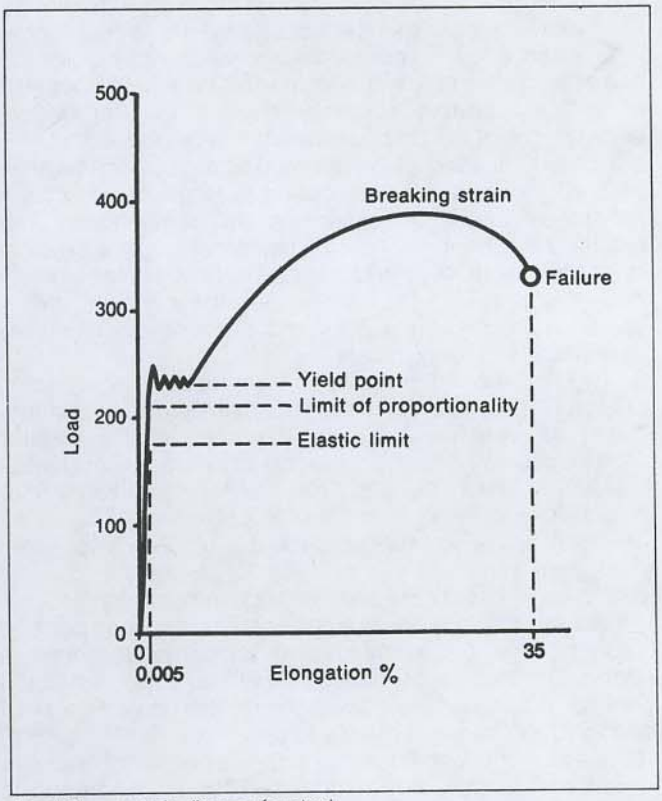


Fig. 1 Stress-strain diagram for steel

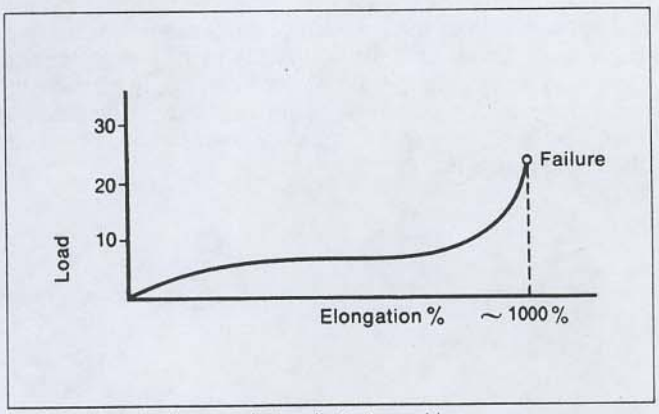


Fig. 2 Schematic diagram of a tensile test on rubber

Rubber as structural material

Rubber behaves very differently from other structural materials. Elongation can, in some cases, amount to more than 1000 % and by far the biggest part of this elongation is elastic. Metals, on the other hand, show very little elongation below the elastic limit. Rubber's tensile strength, however, is quite low compared with metals; with rubber, it is possible to attain at most approx. 4000 lbs/in². Yet because of its considerable elasticity, rubber has tremendous energy absorption compared with the best steel.

If a body is loaded below the elastic limit, deformation is proportional to the load according to Hooke's law. This is not true of rubber under tension and compression. This means that rubber has no constant tensile or compressive modulus of elasticity. Metals are usually softer towards the end of a tensile test; with rubber, the opposite mostly applies. It has no yield point and the modulus increases until failure suddenly occurs.

A. High elastic deformability is thus rubber's outstanding property. The ease with which rubber is deformed is immediately apparent from the fact that its compressive modulus of elasticity within the normal hardness range of 30–80° IRH lies between 300 and 1700 lbs/in², while the modulus of elasticity for steel is approx. $3.05 \cdot 10^7$.

This means that soft rubber is roughly 100,000 times softer than steel.

B. Damping capacity is another of the more important properties of rubber. It has special significance when passing through the resonance range with a machine resting on a spring. The resonance deflection with a rubber isolator is only 1/5 to 1/50 compared with the deflection when a steel spring of the same hardness is used.

With a rubber spring working under compressive load, the direct energy loss is in general 15 % to 25 %, and up to 35 % to 40 % for occasional impact. Damping is thus sufficient for rubber springs to be employed as dampers in many cases. However, care must be exercised when damping with a rubber part. If the load is high, a great deal of energy is converted to heat – which can easily damage the rubber part. Rubber with high damping very often also has high compression set, i.e. residual deformation, which can be a disadvantage.

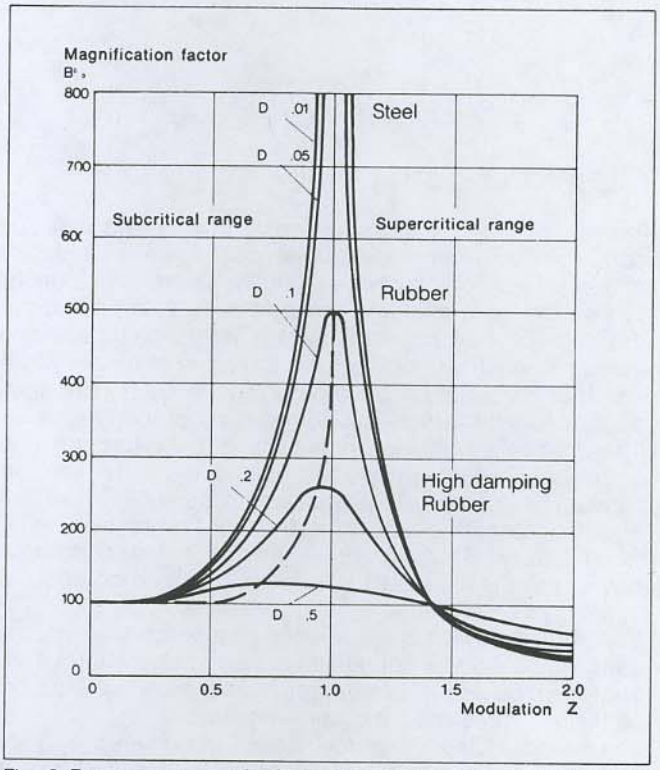


Fig. 3 Resonance curve for isolators materials with different internal damping

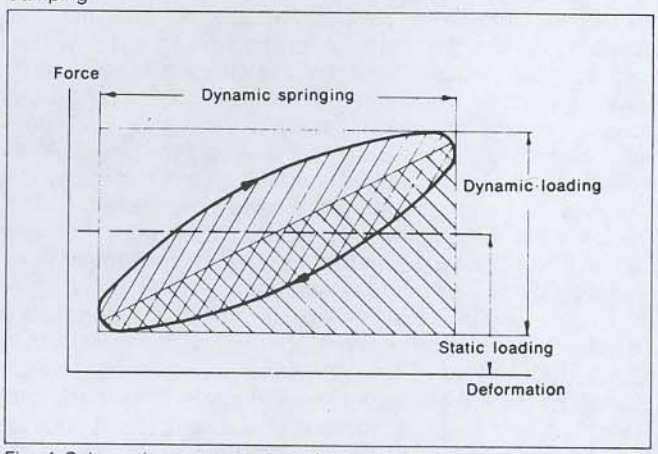


Fig. 4 Schematic representation of the internal damping of rubber. The ellipse surface indicates energy loss

On occasional impact, oscillation proceeds as in Fig. 5. The left-hand diagram represents a steel spring, the diagram on the right a rubber spring. The curves show clearly how quickly the oscillations fade away in rubber whereas they only diminish slowly in steel springs.

C. Rubber is an outstanding sound isolating material. The sound isolating effect increases with thickness of the rubber. It absorbs impact noise from foundations, floors, buildings, etc. extremely well.

D. Another of rubber's valuable properties is its high chemical resistance when used as a cushioning material. Steel springs, on the other hand, corrode from exposure to moist air and acids. They also give rise to fatigue problems. Rubber is fully resistant to moist air and most acids it is likely to encounter and now shows no aging symptoms at normal temperatures. The highest temperature to which natural rubber should be subjected continuously is approximately (+167°F) +75°C. At very low temperatures, (−22° to −40°F) −30° to −40°C, rubber stiffens and becomes rigid, and at even lower temperatures it becomes inelastic.

When mountings are subject to continuous exposure to oils, oil resistant synthetic compounds must be used. Synthetic compounds, however, have reduced elastic properties when compared with natural rubber. It is also possible to obviate oil's harmful effects by fitting mechanical protection or coating the insulator with elastic, oil-resistant varnish.

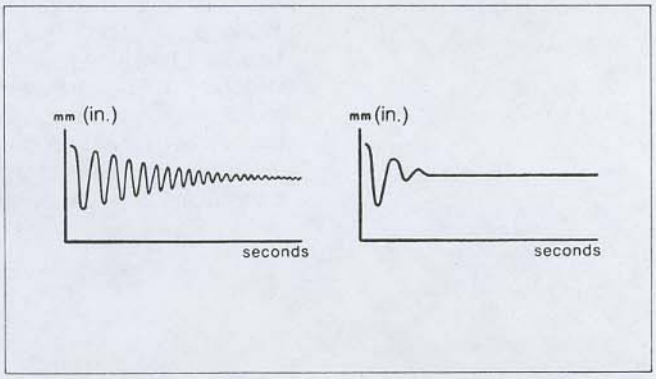


Fig. 5 Oscillation path from a single blow for a steel spring (left) and a rubber spring (right)

Bonding of rubber to metal

Now that rubber can be strongly bonded to metal, it is possible to design parts for mounting machinery at a few points using a simple construction. The bonding between rubber and metal can be made so strong that it will withstand tensile stresses of up to, and even above, 1000 lbs/in². High values of this order are attained on small parts on a laboratory scale. Under high tension, the rubber is more likely to fail than become detached from the metal. The diagrams below (Fig. 6) show a rubber part before, during and after a tensile test, in which failure occurred characteristically in the main part of the rubber.

A breaking load of 220 lbs/in² is usually applied for large scale production. This lower value is followed primarily because tensile stresses in large parts are very unevenly distributed. The stresses at the edges are therefore very much higher than in the middle; this is why any failure usually begins at one of the edges and is then propagated inwards in the rubber. The shape of the isolator is a significant factor as regards strength.

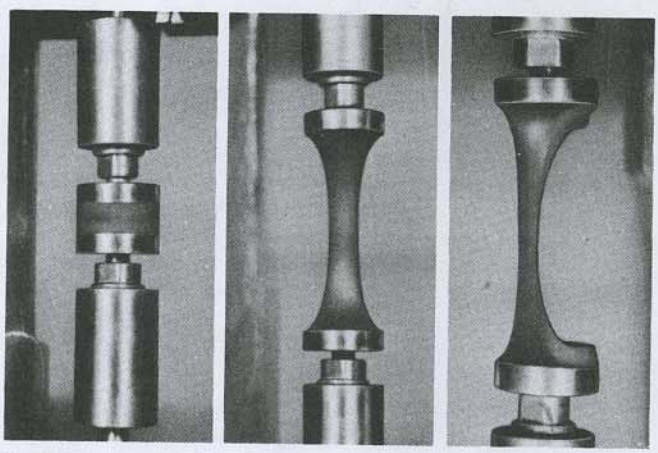


Fig. 6

A. Rubber component mounted for tensile testing.

B. Rubber component being subjected to high tension during testing.

C. Failure has finally occurred characteristically in the main part of the rubber. The bonding between rubber and metal is still intact.

Design aspects

It has already been mentioned that, when calculating rubber's compressive deformation, resilience is not directly proportional to load, and the modulus of elasticity of compression increases with the stress. On the other hand, the shear modulus is constant for normal stresses.

If the rubber is enclosed so that it cannot move freely, even greater deviations are produced in the modulus of elasticity and consequently in a calculation. Rubber in itself is practically incompressible. Its volume is reduced by only some 5% for a stress of 29000 lbs/in². The spring action is therefore only possible when the rubber under load can deform in a different direction. Fig. 7 shows on the left an incorrectly mounted rubber part which cannot give and on the right how the part should be mounted.

It can therefore be seen that the ratio of loaded to free surface, the "form factor" (denoted below by S) in a rubber spring, greatly affects the modulus of elasticity. A particularly high modulus of elasticity can be obtained with very thin rubber.

The rigidity of a rubber spring is otherwise determined by the rubber's dimensions and hardness. The hardness indicates the resistance offered by the material to deformation under pressure. Usually the Shore durometer is employed for testing the hardness of rubber; this is a pocket instrument with a blunt spring-loaded tip. Indentation depth is measured and read off on a scale, graduated from 0° to 100°. 0° indicates infinitely soft and 100° infinitely hard. The numbers in IRH degrees are not used directly in calculations but are converted to values which indicate the modulus of compression or of shear. Fig. 8 illustrates the relation between the hardness of the rubber and the modulus of shear and Fig. 9 shows how the modulus of compression is dependent on the shape factor. The latter curves are for 10% deformation.

The graphs show that, with shape factor 0.25, rubber is approximately six to eight times softer in shear than in compression, with the hardness of the rubber the same.

Since only three to four times higher stress in compression than in shear can be expected, rubber is best used for springs in shear. Moreover, since the modulus of shear is not changed appreciably by load and configuration, this type of load is now generally used for rubber springs when high resilience is required. The modulus values given apply to a static compression test in which the end surfaces cannot slide. When the rubber is subjected to rapid vibrations, it behaves as though more rigid than in a static test. Allowance has to be made for this in accurate calculations.

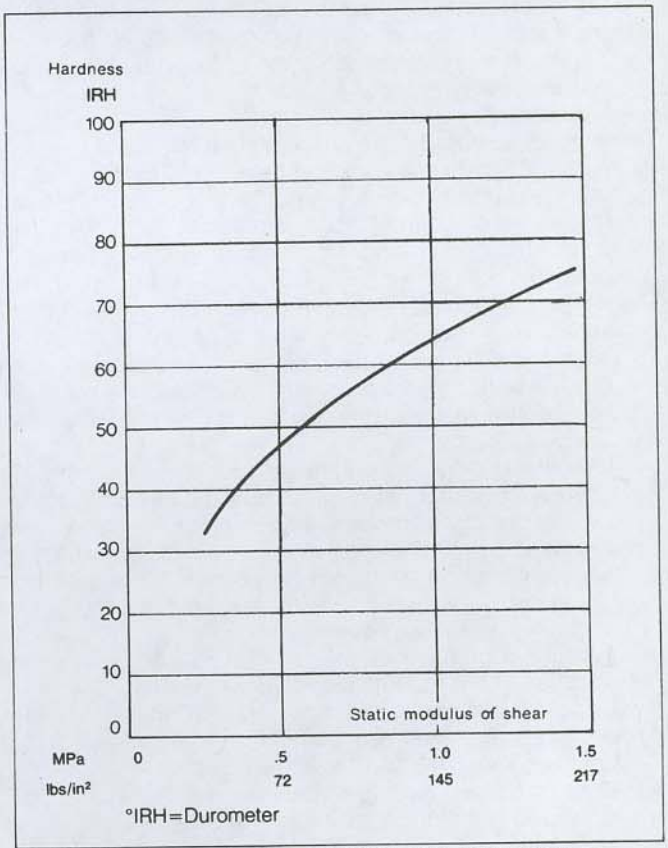


Fig. 8 Relation between hardness of rubber and modulus of shear

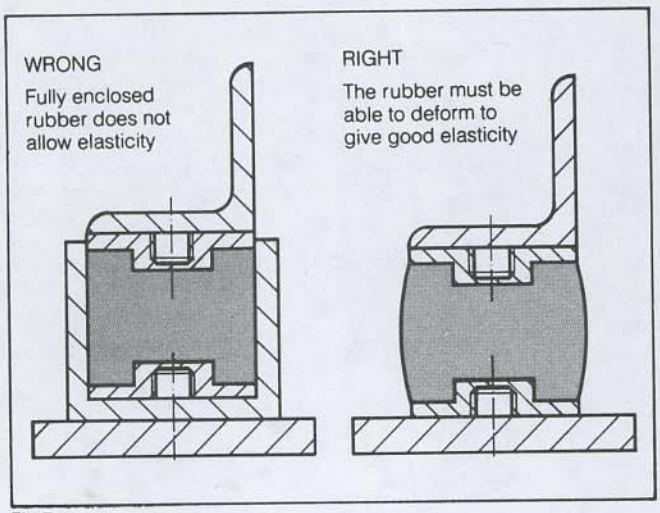


Fig 7

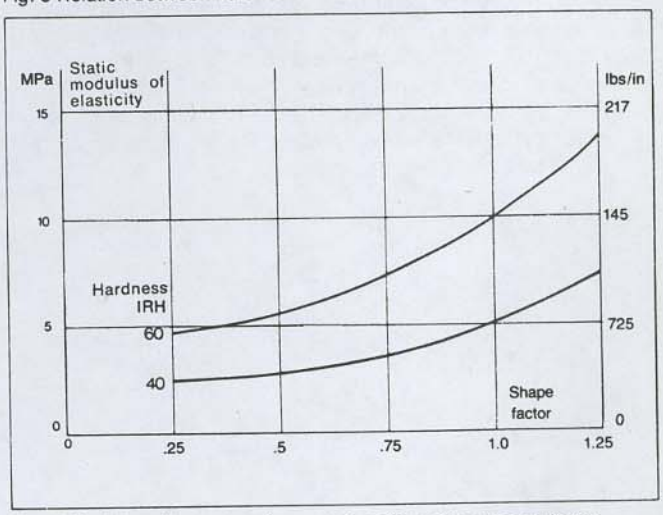


Fig. 9 Modulus of compression as a function of the shape factor

NOVIBRA MOUNTS - TECHNICAL INFORMATION

The ratio between dynamic and static rigidity of Trelleborg antivibration mountings is approximately 1.3, which means that the static elastic deflection constants have to be multiplied by this factor to obtain the dynamic elastic deflection constants.

So that the properties of rubber of varying hardness can be satisfactorily utilized. Novibra antivibration mountings are available as standard in two hardnesses.

These are:

the soft material A of hardness 40° IRH, and

the medium hard material B of hardness 60° IRH.

The hardness of the rubber is indicated by color marking:

hardness A is green,

hardness B is black.

Novibra standard parts are produced in natural rubber.

A rubber part of known hardness requires a certain minimum thickness to give the desired resilience. Thin rubber mats and of course those in cork or felt are hard and unsatisfactory for isolating vibrations at low operating frequencies.

If the rubber material is thin because a low machine construction is desired, a through air channel can increase cushioning. Sharp metal edges should not come into direct contact with the rubber, otherwise it would be subjected to severe stresses with the risk that the rubber might be cut. See Fig. 11.

In comparison with steel, rubber has a considerably higher coefficient of thermal expansion. On cooling after vulcanization, therefore, rubber shrinks more than steel. Allowance must be made for this – particularly in the design of parts with rubber between two concentric steel rings, in which the rubber profile has to be such that adverse tensile and compressive stresses are reduced. Fig. 12 shows how the rubber profile is shaped to eliminate adverse shrinking stresses at the outer case edges.

Under all circumstances, antivibration mountings must be designed and fitted so that there is no metallic contact between machine and base (Fig. 13).

Care must be taken to fasten the isolator with a bolt designed to prevent contact with the base and transmission of vibrations.

Mobile machinery should not be driven from outside via overhead transmission, for instance. The best method is to mount the motor on the joint stand and fit the power transmission direct or with rubber V-belt.

Pipe connexions for compressed air, steam or water, for instance must also be flexible. They can be of rubber hose or metal piping, laid in a coil.

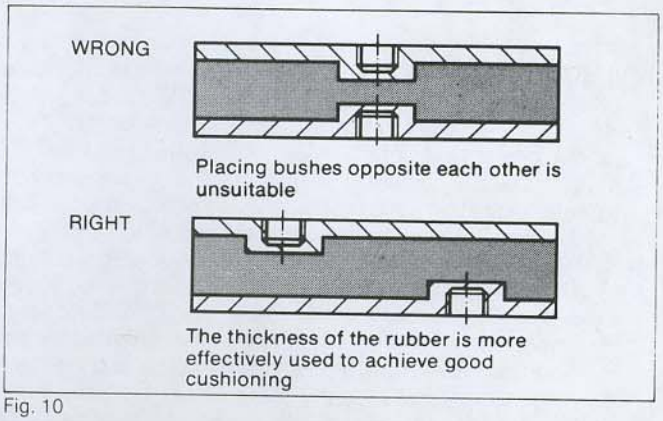


Fig. 10

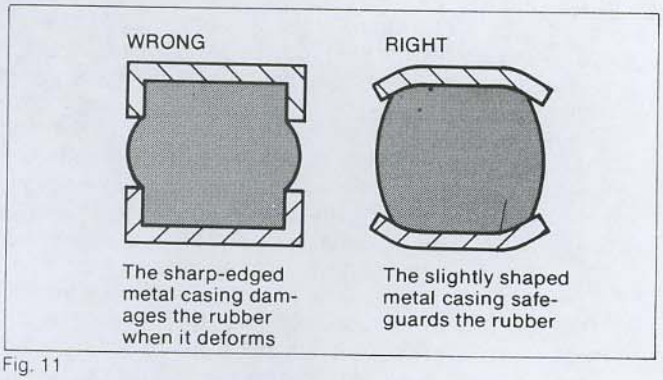


Fig. 11

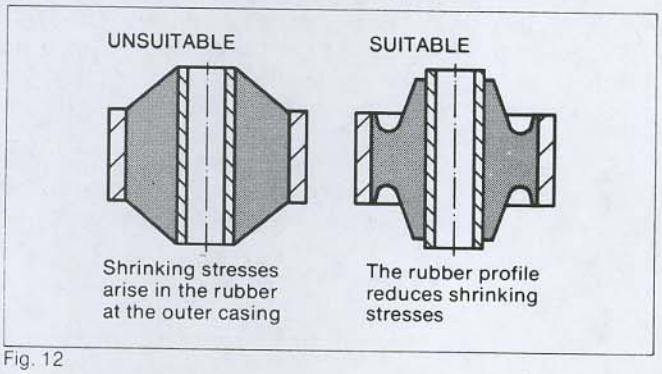


Fig. 12

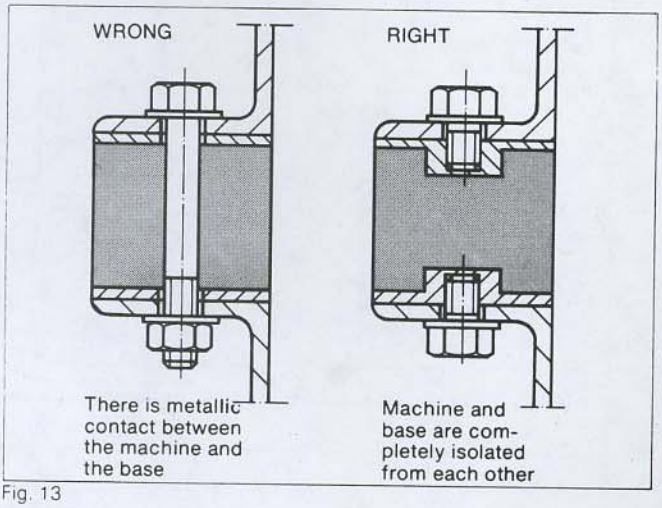


Fig. 13

Permissible stresses

One very important question is the degree of continuous stress to which rubber can be subjected. In the case of shear, 50 lbs/in² is usually regarded as the normal stress but, in some cases, it is possible to go as high as 75 lbs/in² without trouble. Higher shear stresses are unsuitable since shear then changes to tensile stress. Experience has shown that stress of this magnitude adversely affects rubber-to-metal-bonded mounts. If the mounts are subject to higher shear stresses, the rubber should be slightly pre-stressed.

When subjected to compressive stress, 145 lbs/in² is usually considered for rubber parts bonded to metal, with the reservation that deformation should not exceed 20% to 25%. The stress can be slightly increased for harder rubber. Since the load-bearing surface is very large in relation to the free surface, as in rubber plates and washers, deformation is very slight. It is then possible to accept even higher stress. Since the shear strength is approximately 1000 lbs/in² and the compression strength is very much higher than the tensile strength, i.e. above 2900 lbs/in², it may be assumed that these stress figures include an excessively high safety factor. This allowance must be made because rubber becomes permanently deformed if subjected to too high a load. This is called "compression set". The most important factor in reducing compression set is the use of good quality vulcanized rubber. It is also important to avoid exposing rubber mounts to excessively high temperatures.

Vibration concepts

Amplitude indicates the extent of displacement of the vibration from the center position. The total vibration is thus double the amplitude.
Frequency indicates the number of vibrations per unit of time. The unit is cycles per second and is abbreviated to cps or Hz.
The interfering frequency is denoted by *f* and is mostly equal to the machine speed (rev/min).
The natural frequency is denoted by *fo* and is the number of vibrations completed by a freely vibrating system per unit of time. It can be indicated in the equation:

$$fo = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

fo = natural frequency in Hz = cps
F = load in N or lbs
m = mass in kg or lbs
δ = elastic deflection in m or in
$k = \frac{F}{\delta}$ = elastic deflection constant in N/m or lbs/in

The elastic deflection constant *k* thus indicates the force required to compress the isolator one meter or one inch.
Modulation is denoted by Z and is the relation between the interfering frequency *f* and the natural frequency *fo*.

It follows from this that the modulation $Z = \frac{f}{fo}$

The interfering force is denoted by *Fs*. It is the force transmitted to the base in a spring-mounted machine.
The impulse force is denoted by *Fi* and is the full force transmitted to the base in a rigidly mounted machine.
The magnification factor is denoted by *B* and is the efficiency for the transmitted vibrational force. It thus indicates the relation between interfering force *Fs* and impulse force *Fi*.

It is written $B = \frac{Fs}{Fi}$

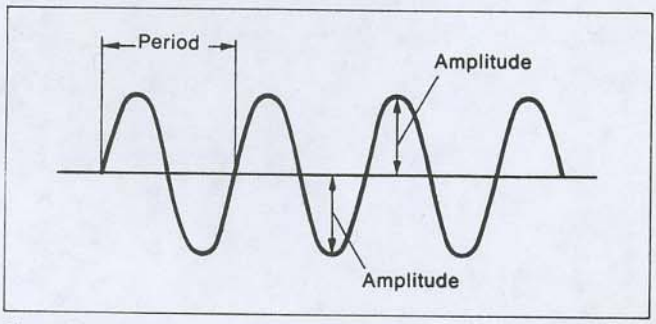


Fig. 14 Diagram showing period and amplitude

Calculation of vibration isolators

When isolating vibration, the principle is to place the isolators between the machine and its base. For effective isolation, the mountings have to be calculated very carefully, otherwise they can aggravate matters. In favorable cases, the dynamic force can be reduced to 2–3%. Vibration is practically eliminated in such cases.
The relative degree of dynamic force transmitted depends entirely on the modulation ratio Z. If Z is high, the percentage of force transmitted is low.
The formula for the magnification factor *B*, i.e. the change of amplitude in the base for an isolator mounted machine compared with a rigidly mounted machine, is:

$$B=\frac{1}{\sqrt{(1-Z^2)^2+4D^2\cdot Z^2}}$$

The factor *D* is dependent on the internal damping in the isolator material. For rubber the value of *D* is 0.04–0.1, depending on the rubber compound. The term $4\,D^2\cdot Z^2$ can generally be completely disregarded except in the resonance range, i.e. when $Z=1$. If $Z=1$, i.e. machine speed = the natural frequency of the system, resonance is said to prevail; the vibrations become infinitely large if there is no damping. In this instance a rubber mount thus has a big advantage over a steel spring, which has very little internal damping and in which the amplitude theoretically increases to a very high value at the resonance point (see Fig. 3, page 4). As can be seen from Fig. 15, at $Z=\sqrt{2}$ *B* has dropped to 100% and, with a further increase in *Z*, *B* drops rapidly. There is therefore no point in vibration damping unless the operating frequency is considerably greater than the natural frequency. For practical purposes *Z* should lie between 3–5, which means that 88% and 96% respectively of the interference forces are eliminated.
The operating speed (interfering frequency) of a machine is usually given. If the natural frequency of the system can be altered in some way and thereby influence *Z*, it is possible to change the force transmitted. Vibration isolation with rubber mounts in fact accomplishes this. The low moduli of elasticity and shear of rubber are utilized to obtain soft mountings, so that the natural frequency of the system is also low.
The static elastic deflection δ of a part for a certain load *F* can easily be calculated from the modulus *Es*, if the load surface is *A* and the height *h* in accordance with the formula

$$\delta=\frac{F\cdot h}{A\cdot Es}\,(m)\ or\ in$$

Since the constant $k=\frac{F}{\delta}$, the formula can also be written

$$k=\frac{Es\cdot A}{h}\,(N/m)\ or\ lbs/in$$

For shear the formula is the same, but with the shear modulus *Gs* replacing the compression modulus *Es*.

To summarize, vibrations can be transmitted in three ways:
1. Rigidly mounted machines transmit vibrations to the base, which then moves with the machine. (*B* factor equals approximately 100%.)
2. If an isolator system is inaccurately engineered, the *B* factor will be increased several hundred per cent.
3. The percentage of vibrations transmitted drops considerably if correctly calculated and designed isolators are fitted between machine and base. The forces transmitted can be reduced in favorable cases to as little as 2%.
   All machines have more than one resonance point, since they can vibrate in many different ways owing to a number of combined movements. The resonance points can be determined but the calculation methods are mostly very tedious. Experience shows that it is not necessary to determine every resonance speed which can arise; it is usually sufficient to calculate the most significant. The resonance speeds which might give rise to difficulties can nevertheless be calculated and established relatively easily.
   The degree of isolation desired and the interfering frequency determine where the resonance frequency shall lie. The level of static resilience which the isolators must provide to achieve the desired result can be read off from the diagram.

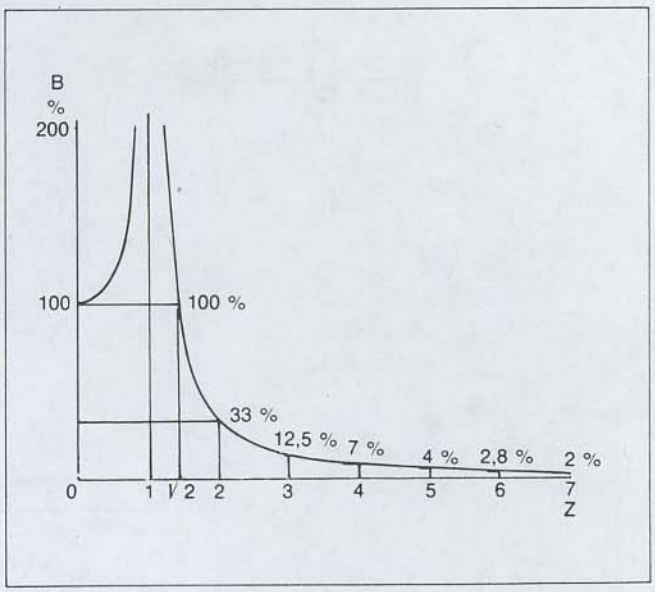
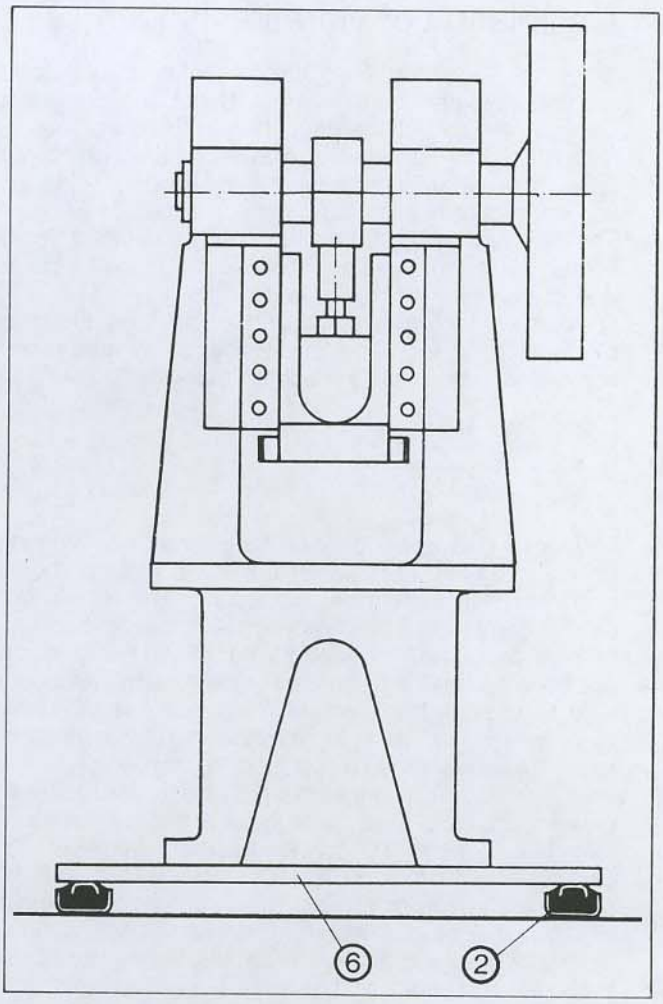
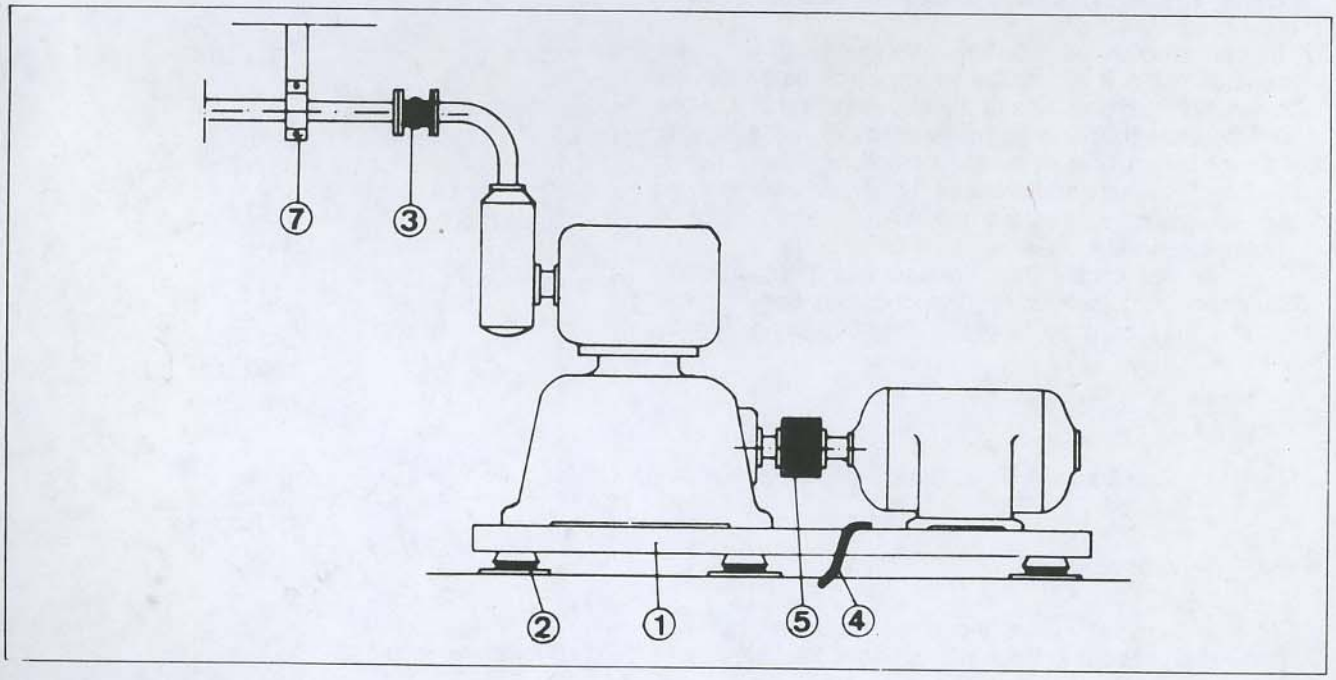


Fig. 15 Resonance curve

Installation principles

1. The various parts of the unit are brought together on a common rigid base.
2. The entire unit is isolated with suitable Novibra antivibration mounting.
3. Elastic connections to the unit are required in order to achieve effective isolation.
4. Motors should be grounded.
5. Novibra coupling for elastic force transmission.
6. Tall, unstable machines must be fitted with an enlarged baseplate with a thick, rigid plate or a girder frame. This gives more of a stable mounting and a better isolation.
7. Novibra resilient pipe supports eliminate vibration and shock load transmission.





Calculation examples

Example 1

A fan weighs 440 lbs, including the motor, and has a direct drive with a speed of 1450 rev/min. Its base frame weighs 220 lbs. Four vibration isolators are to be fitted between the base frame and the floor. Mounting must give at least 90% isolation.

The diagram shows that, for the interfering frequency $\frac{1450}{60} = 24.2$ Hz, static elastic deflection of approximately ~.24 in. is required to give 90% isolation. The load per isolator is 165 lbs. A suitable isolator is Novibra type M size M200, hardness A, which gives by approximately ~.24 in. under a load of 165 lbs. and which has a permissible compression load of 285 lbs. An alternative is Novibra type A 50/48 hardness A, which gives by approximately ~.24 in. under a load of 165 lbs. The permissible load in this case is 165 lbs.

Example 2

A motor converter weighing 6600 lbs. runs at 2900 rev/min and is mounted on a concrete base weighing 8800 lbs. The complete assembly is then to be isolated with six vibration isolators.

Vibration isolation is to be such that the resonance speed is up to 600 rev/min (10 Hz). The diagram shows that the static elastic deflexion required is ~.13 in. and isolation is approximately 95%.

With six isolators and a total weight of 15400 lbs., the load is 2567 lbs/mounting. If Novibra type RA 1800, hardness B, is chosen, static deflection of ~.15 in. is obtained; this means that the resonance speed is approximately 550 rev/min and isolation approximately 96%.

The permissible load for this mounting is 4630 lbs.

Example 3

A compressor, for marine installation, weighs 1940 lbs. including the motor and girder frame and has a speed of 1450 rev/min (driven directly by the motor). It has two cylinders in V-form. Four mountings are to be fitted to dampen vibrations.

In multi-cylinder machines, it is usually the number of working impulses per revolution which constitutes the interfering frequency. In this case it should therefore be 48.4 Hz.

The degree of isolation required is 95%. It is found from the diagram that static compression should be approximately .118 in.

Suitable isolators for this and similar purposes are Novibra types HK and RA with stops for cases when restriction is required both at the sides and in the direction of pull. With a load of 485 lbs. per mounting, HK 115, hardness B can be chosen. The elastic deflection is ~.13 in. and the permissible load is 835 lbs.

RA350 with stops, hardness A, can also be chosen. Elastic deflection is then ~.15 in. and the permissible load 550 lbs.

Calculation examples

In this catalogue you will find two different types of product information pages. The first group includes the types RA, RAEM, RAB, M and GK and the other the types BA, U, SE, SAW, VT, TK, Novibra plate and BL. The two groups have a quite different outlook and the first one uses metric units only.

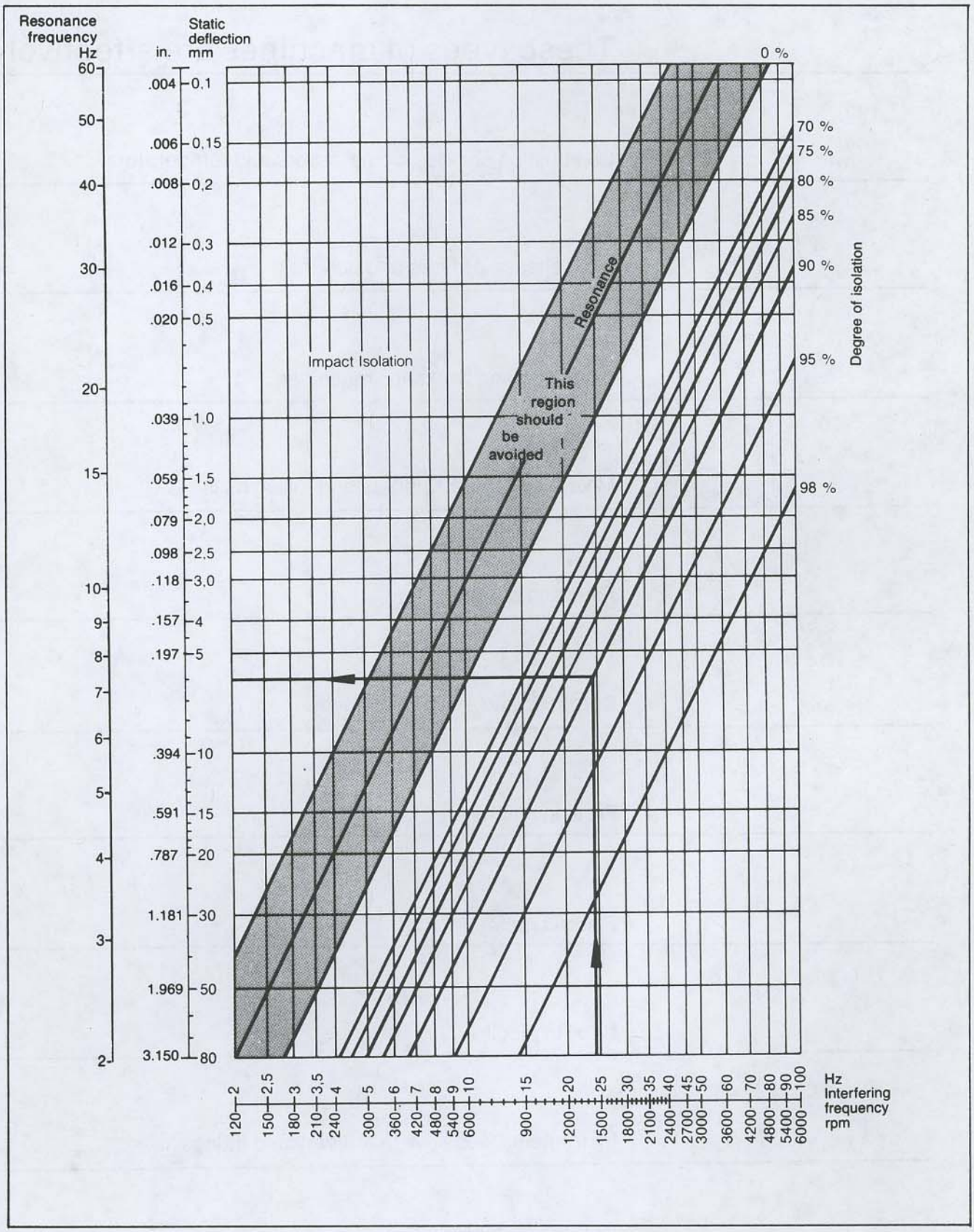
RA, RAEM, RAB, M and GK
Product information pages for these types are designed to make it possible to find the right size for a certain load on the mounting and also given the disturbing frequency. The curves representing each size in Diagramme 1 of each individual product information page gives the true natural frequency for a specific load, based on tested dynamic properties. In Diagramme 2 you can easily find out the degree of isolation for a certain given disturbing frequency. If you are not satisfied with the isolation degree you go to another product type with lower natural frequencies for the same load, i.e. a softer mounting.

BA, U, SE, SAW, VT, TK, Novibra plate and BL
For these products you have to find out a desired static deflection from your disturbing frequency and desired degree of isolation in the nomogram you see on a reduced scale on this page and in full size on the fold out page connected to the back cover. When you know the static deflection needed you have to scan the load-deflection diagrams for these products to find the suitable one.

Example 1
A fan weighs 800 lbs including the motor and has a direct drive with a speed of 1450 rpm. Its base frame weighs 300 lbs. Four antivibration mountings are to be fitted between the base frame and the floor. The mountings have to give at least 90 % isolation.
The nomogram shows that, for the interfering frequency 1450/60 = 24.2 Hz, static elastic deflection of approximately 0.24 in. is required to give 90 % isolation. Load per isolator is 275 lbs. A suitable mounting is Novibra type BA size BA 100, hardness A, which deflects ~0.24 in. under a load of 275 lbs. The maximum permissible load for this mounting is 275 lbs.

Example 2
A big heavy machine with an interfering frequency of 1800 rpm or 1800/60 = 30 Hz needs an Novibra antivibration mounting with a static deflection of 4 mm to reach a 90 % degree of isolation. The weight of the machine is 108000 lbs and it can be placed on 6 points wich means 18000 lbs per mounting. A suitable choice is Novibra type SAW, size SAW 200 in hardness B.

NOVIBRA MOUNTS - TECHNICAL INFORMATION



These types of machines are effectively

Combustion engines, compressors and refrigerators

Plate shears, presses and punches

Carpentry and workshop machines

Mixers, crushers, grinders and rolling mills

Fans and pumps

Domestic and office machines

Printing machines

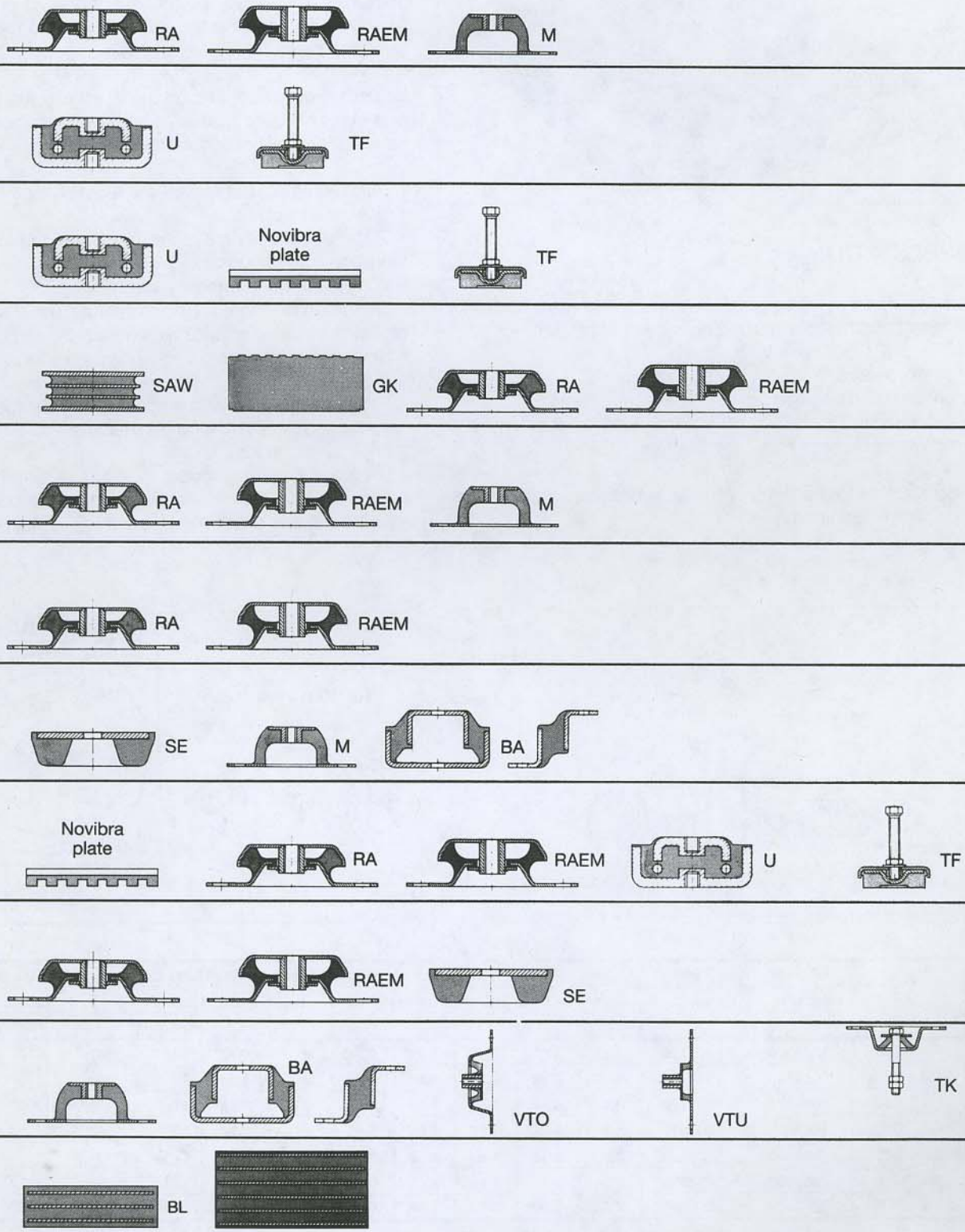
Electric motors

Cabs in mobile units

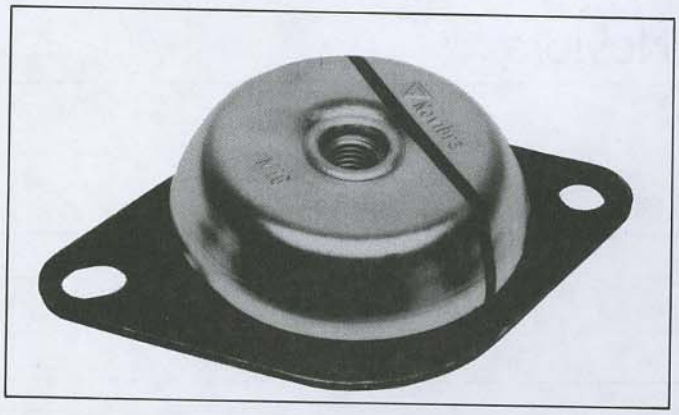
Instruments, sensitive machinery and fittings

Bridges and buildings

isolated against vibration by Novibra



FEATURES & SPECIFICATIONS - TYPE RA



APPLICATION

For the effective isolation of vibration and noise on different machines with rotating movements, like:

- compressors
- combustion engines
- generators
- converters
- pumps
- industrial and marine gen sets
- fans

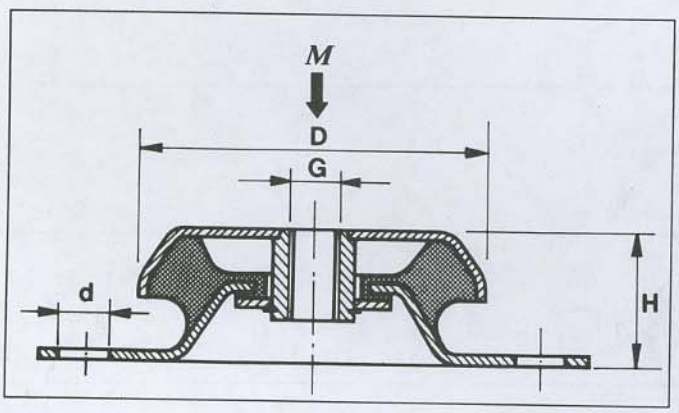
Also suitable for use with presses, punches and other workshop machines.

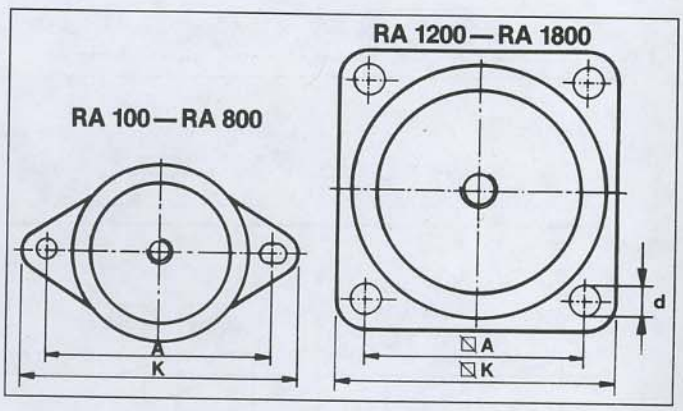
FEATURES

RA uses the rubber profile in shear and compression obtaining good vertical flexibility with the advantage of horizontal stability. For normal speeds of approx. 1500 rpm the RA type provides a degree of isolation of 75–85%. For even better isolation, the alternative RAEM or M can be chosen.

Its unique construction and the latest production methods make Novibra type RA a high performance mounting having a number of advantages:

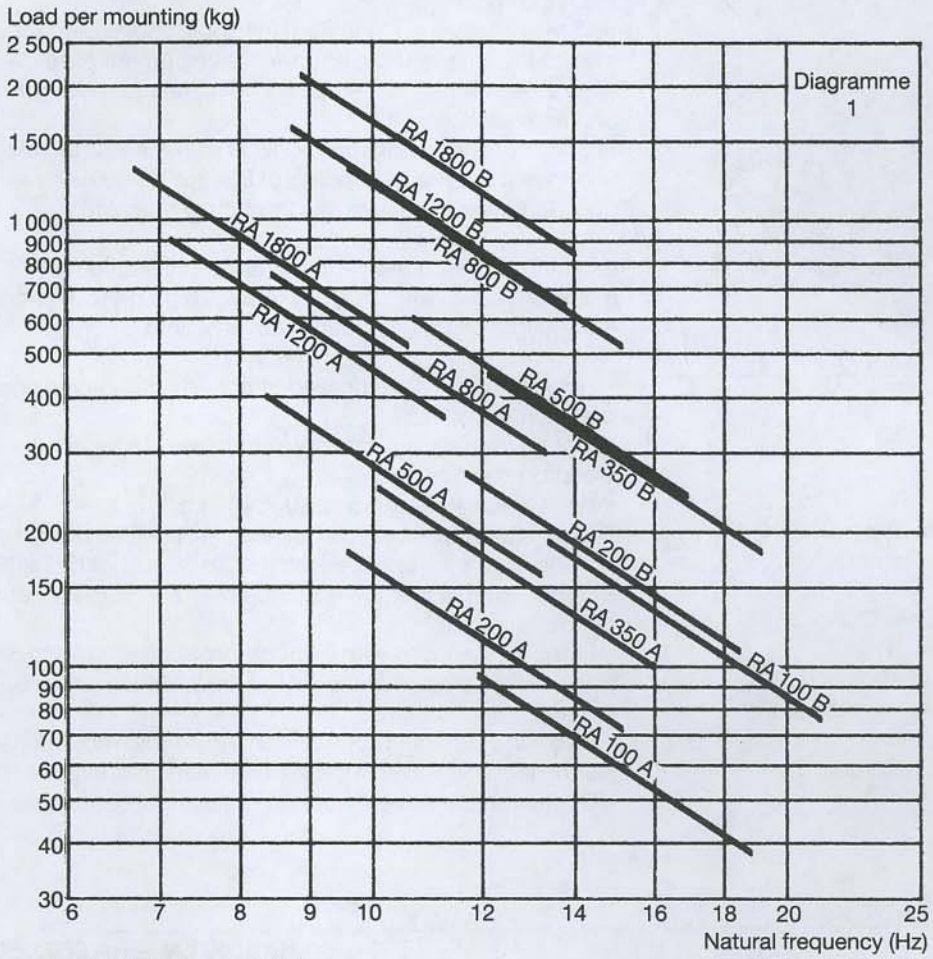
- Rubber features are utilized effectively combining compression and shear.
- Tight tolerances on dynamic stiffness rate for accurate vibration calculations.
- Wide load rating options, 40–2100 kg.
- Corrosion protected to cope with arduous environments on land or marine applications (Fe/Zn 8C as per ISO 2081).
- Stronger base metal withstands high shock loads without deformation.
- Fitted as standard with a shock-proof device (up to 5 g) with resilient stop, making RA ideal for use on mobile or marine applications.
- Clear and durable product marking so that mountings can be identified even after several years in operation.
- Domed shape cover to protect against oil contamination.

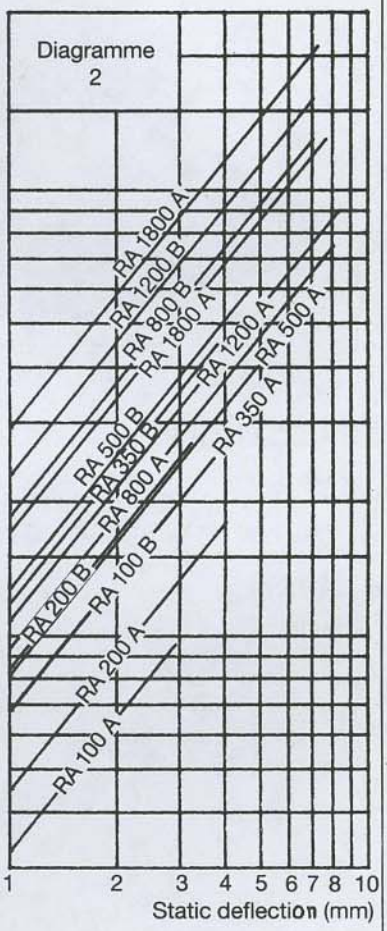


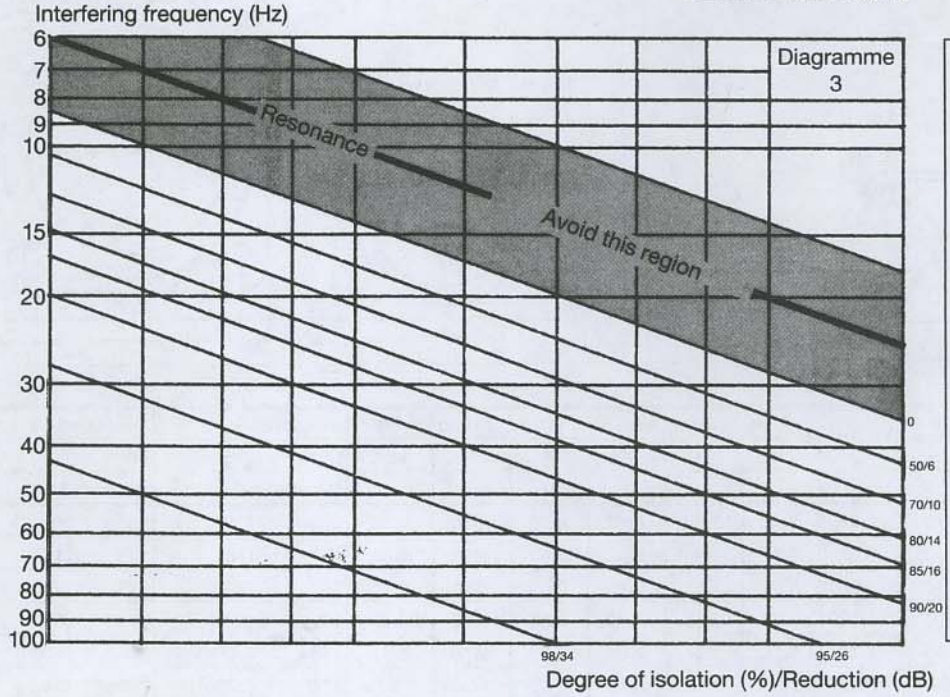


Type	Part #	Part #	Dimensions (ins.)					Thread	Wt	Max Load	Max Load
	Hardness A	Hardness B	D	A	H	K	d	G	Lbs	Lbs (kg) Hardness A	Lbs (kg) Hardness B
RA 100	1861700	1861710	3.11	4.33	1.18	5.12	0.35	M10	0.73	209 (95)	419 (190)
RA 200	1861740	1861750	3.70	4.88	1.38	5.91	0.39	M10	1.04	397 (180)	595 (270)
RA 350	1861760	1861770	3.98	5.67	1.50	6.89	0.55	M16	1.62	551 (250)	992 (450)
RA 500	1861800	1861810	4.84	6.22	1.65	7.56	0.55	M16	2.25	882 (400)	1323 (600)
RA 800	1861820	1861830	5.67	7.17	1.89	8.50	0.55	M16	3.50	1653 (750)	2866 (1300)
RA 1200	2255360	2255370	6.34	5.51	2.28	6.69	0.55	M20	4.82	1984 (900)	3527 (1600)
RA 1800	2255380	2255390	7.13	6.30	2.62	7.48	0.55	M20	5.13	2866 (1300)	4630 (2100)

Note: The natural frequencies and degrees of isolation are based on the dynamic characteristics of the mountings.

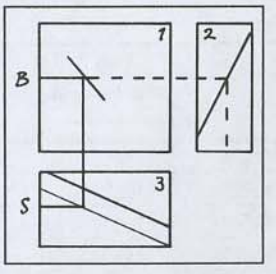




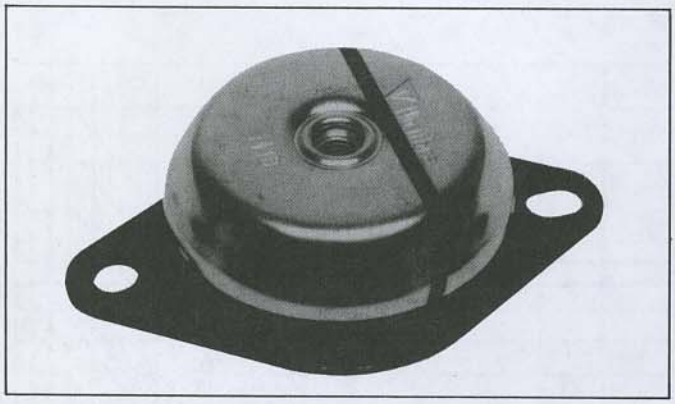


To choose a mounting with required degree of isolation, please use diagramme 1 and 3. Two basic values must be considered: Load per mounting and interfering frequency [Interfering frequency in Hz (1/s) $= \frac{\text{rpm}}{60}$]

To determine static deflection, please check diagramme 2.



FEATURES & SPECIFICATIONS - TYPE RAEM



FEATURES

RAEM is a universal mounting for applications demanding maximum isolation. It is a further development of RA, where EM stands for "extra soft". Suitable for both light and heavy machines.
For normal speeds of approx. 1500 rpm the RAEM type provides a degree of isolation of 85–95%, and gives a good isolation even with low frequency machines.

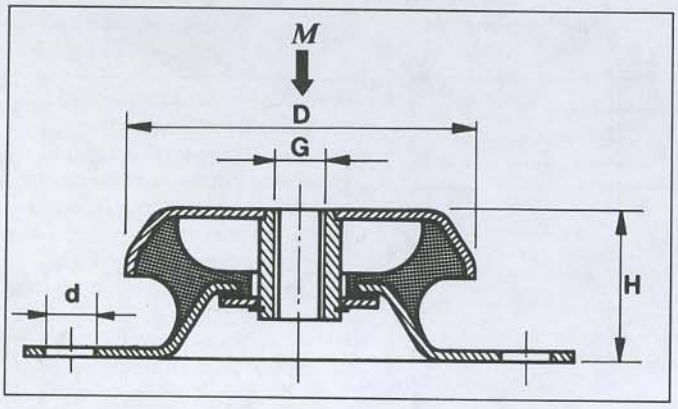
Its unique construction and the latest production methods make Novibra type RAEM a high performance mounting having a number of advantages:

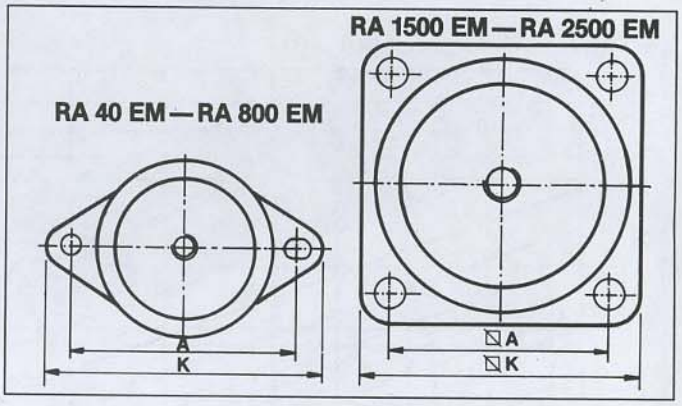
- Rubber features are utilized effectively combining compression and shear.
- Tight tolerances on dynamic stiffness rate for accurate vibration calculations.
- Wide load rating options, 10–3400 kg.
- Corrosion protected to cope with arduous environments on land or marine applications (Fe/Zn 8C as per ISO 2081).
- Stronger base metal withstands high shock loads without deformation.
- Fitted as standard with a shock-proof device (up to 5 g) with resilient stop, making RAEM ideal for use on mobile or marine applications.
- Clear and durable product marking so that mountings can be identified even after several years in operation.
- Domed shape cover to protect against oil contamination.

APPLICATION

For the effective isolation of vibration and noise on different machines with rotating movements, like:

- compressors
- AC units
- industrial fans
- generators
- combusting engines
- emergency power sets
- large milling machinery
- industrial and marine gen sets
- refiners
- defibrators

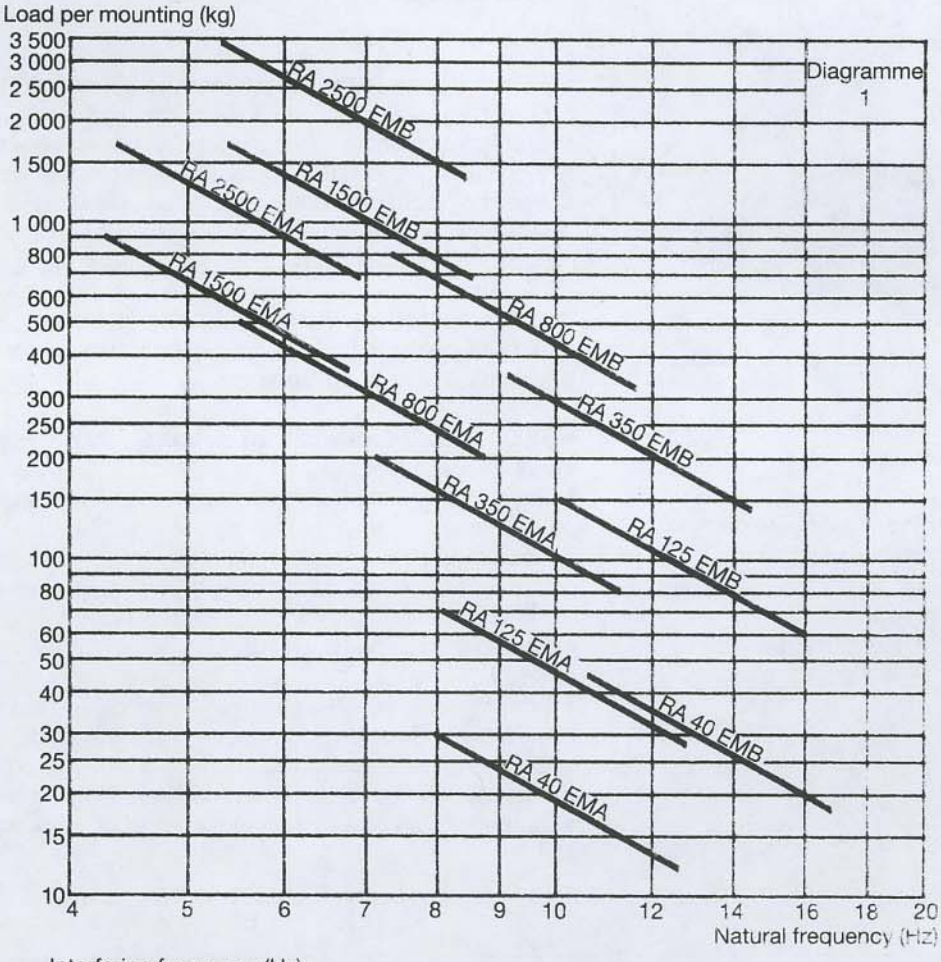


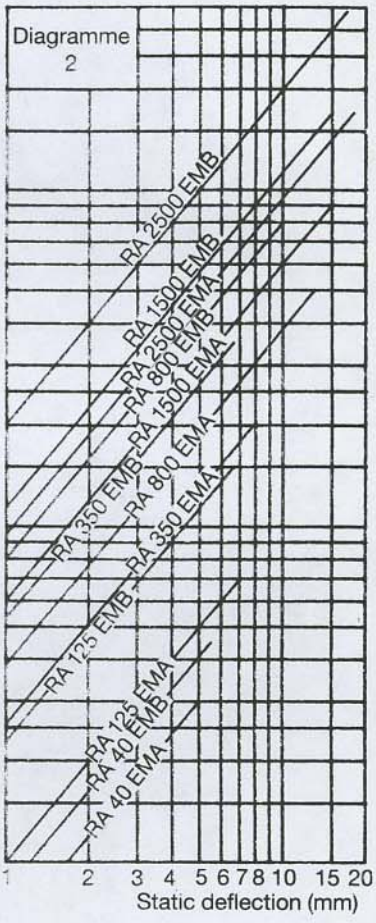


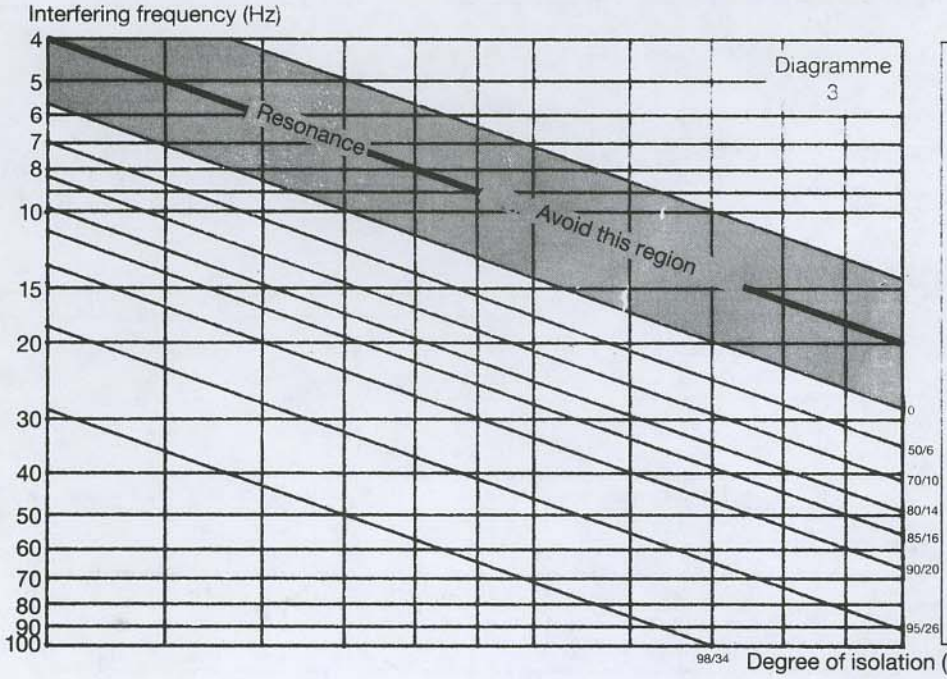
Type	Part #	Part #	Dimensions (ins.)					Thread	Wt	Max Load		Max Load	
	Hardness A	Hardness B	D	A	H	K	d	G	Lbs	Lbs	(kg)	Lbs	(kg)
										Hardness A		Hardness B	
RA 40EM	1861860	1861870	2.52	3.47	1.40	4.33	0.35	M10	0.50	55	(25)	99	(45)
RA 125EM	1861720	1861730	3.31	4.33	1.40	5.32	0.43	M10	0.82	154	(70)	331	(150)
RA 350EM	1861780	1861790	4.33	5.67	1.65	6.89	0.55	M16	1.76	441	(200)	882	(400)
RA 800EM	1861840	1861850	6.10	7.17	2.13	8.50	0.55	M16	3.93	1102	(500)	1764	(800)
RA 1500EM	2255400	2255410	7.17	5.75	3.37	7.09	0.55	M16	6.61	1984	(900)	3784	(1700)
RA 2500EM	2255420	2255430	8.82	7.09	4.15	8.66	0.69	M24	10.19	3748	(1700)	7496	(3400)
RA 1500EM DP	101105	-	9.76	5.75	4.53	7.09	0.57	M20	14.21	1984	(900)		-

FEATURES & SPECIFICATIONS - TYPE RAEM

Note: The natural frequencies and degrees of isolation are based on the dynamic characteristics of the mountings.

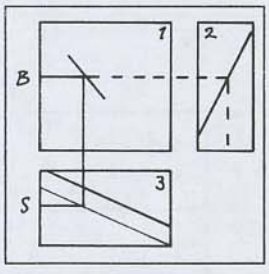




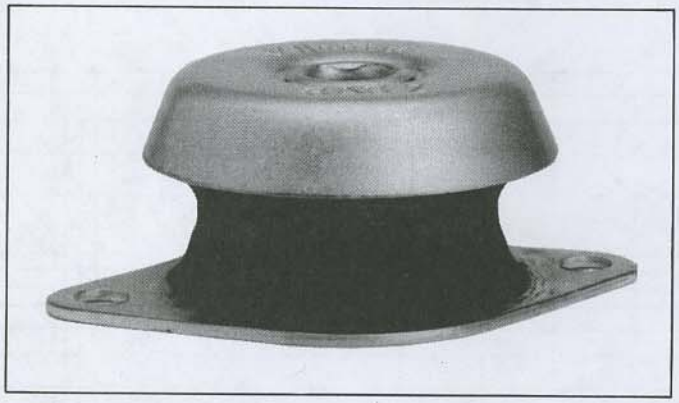


To choose a mounting with required degree of isolation, please use diagramme 1 and 3. Two basic values must be considered: Load per mounting and interfering frequency [Interfering frequency in Hz (1/s) $= \frac{\text{rpm}}{60}$]

To determine static deflection, please check diagramme 2.



FEATURES & SPECIFICATIONS - TYPE RAB



APPLICATION

For the effective isolation of vibration and noise on different machines with rotating movements, like:

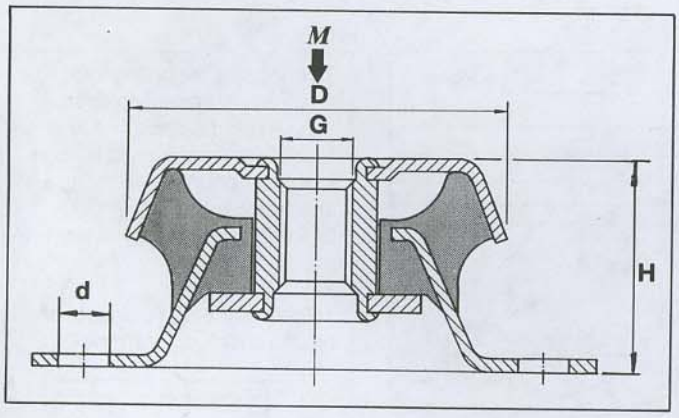
- diesel engines
- combustion engines
- emergency power packs
- pumps
- industrial generators
- marine generators

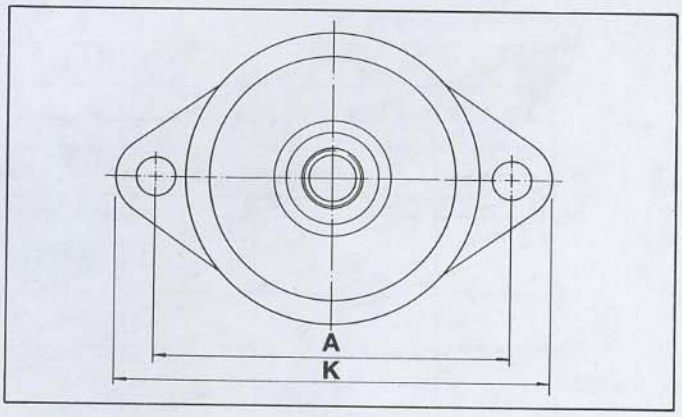
FEATURES

Similar in design to the RA/RAEM range, type RAB uses rubber in shear and compression for optimum stiffness characteristics and horizontal stability. Especially effective on small 1, 2 and 3 cylinder diesel engines where the special compound employed provides effective isolation of vibration whilst eliminating much of the excessive movement normally associated with 1–3 cylinder engines.

Its unique construction and the latest production methods make Novibra type RAB a high performance mounting having a number of advantages:

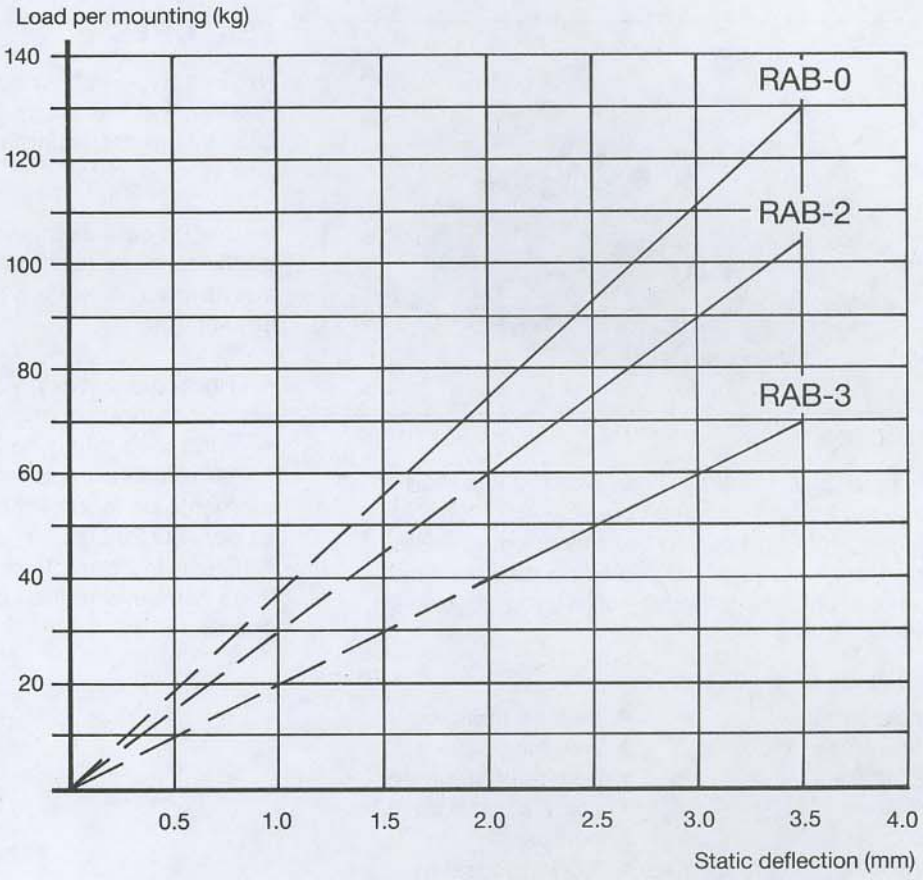
- Rubber features are utilized effectively combining compression and shear.
- Tight tolerances on stiffness rate for accurate vibration calculations.
- Load rating options, 10–130 kg.
- Corrosion protected to cope with arduous environments on land or marine applications (Fe/Zn 8C as per ISO 2081).
- Stronger base metal withstands high shock loads without deformation.
- Fitted as standard with a shock-proof device (up to 5g) with resilient stop, ideal for mobile or marine use.
- Clear and durable product marking so that mountings can be identified even after several years in operation.
- Domed shape cover to protect against oil contamination.



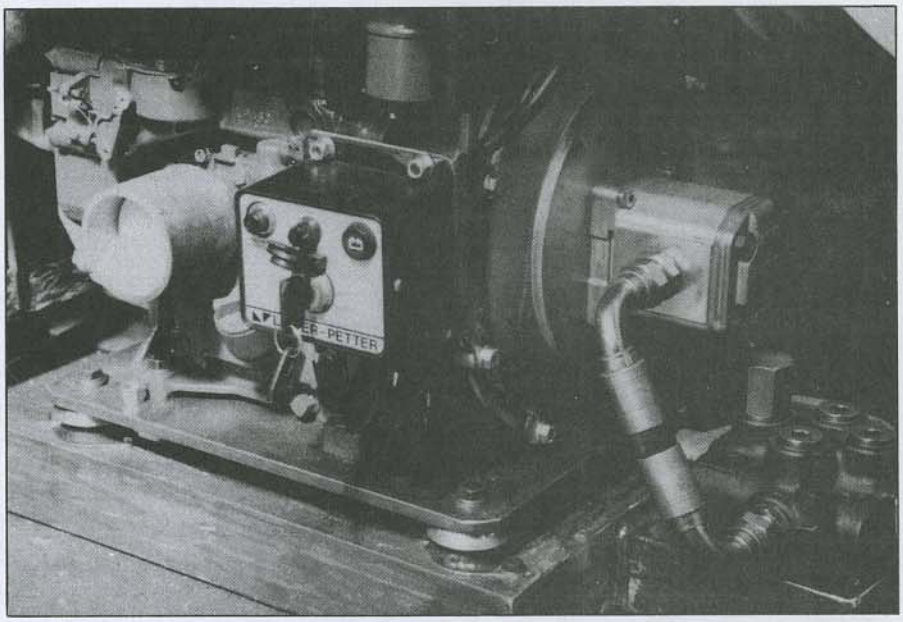


Type	Part #		Dimensions (Ins.)					Thread	Wt	Max Load	
	Hardness A		D	A	H	K	d	G	Lbs	Lbs	(kg)
	55 deg IRH										
RAB-0	740258		2.48	2.99	1.38	3.68	0.33	M12	0.49	287	(130)
RAB-2	1661270		2.48	2.99	1.38	3.68	0.33	M12	0.49	231	(105)
RAB-3	1661020		2.48	2.99	1.38	3.68	0.33	M12	0.49	154	(70)

FEATURES & SPECIFICATIONS - TYPE RAB



Fully approved by Nato and Europes leading manufacturers of 1- 2- and 3-cylinder versions of compact diesel engines.



Example of RAB-installation on a 3-cylinder diesel engine power pack for powering an hydraulic lifting crane.

FEATURES & SPECIFICATIONS - TYPE M

APPLICATION

Type M is ideal for applications involving isolation of low frequency vibrations in all planes. Also suitable for shock attenuation due to the designed ability to give large deflections whilst providing passive vibration on electronic instruments, measuring equipment, test cells.

Specific fields of application are:

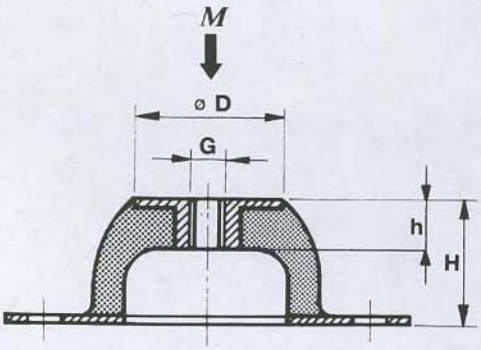
- compressors
- refrigerators
- AC-units
- ventilators
- fans
- powder handling machinery
- vibratory screens
- packaging applications
- electric motors
- weighing scales
- test cell equipment
- noice control units
- pumps
- food processing equipment

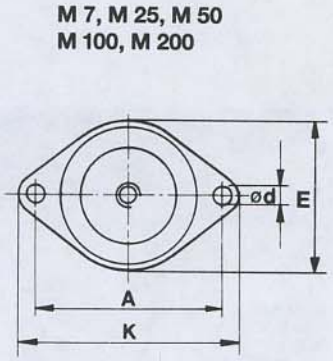
FEATURES

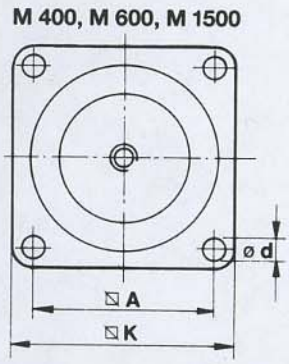
Novibra type M is specifically designed to give high resilience at low loads. Although the mount design allows high deflection, they are compact in weight and easy to install.

Its unique construction and the latest production methods make Novibra type M a high performance antivibration mounting having a number of advantages:

- Tight tolerances on dynamic stiffness rate for accurate vibration calculations.
- Wide load rating options, 3,5-2500 kg.
- Corrosion protected to cope with arduous environments on land or marine applications (Fe/Zn $8C_3$ as per ISO 2081).
- Clear and durable product marking so that mountings can be identified even after several years in operation.



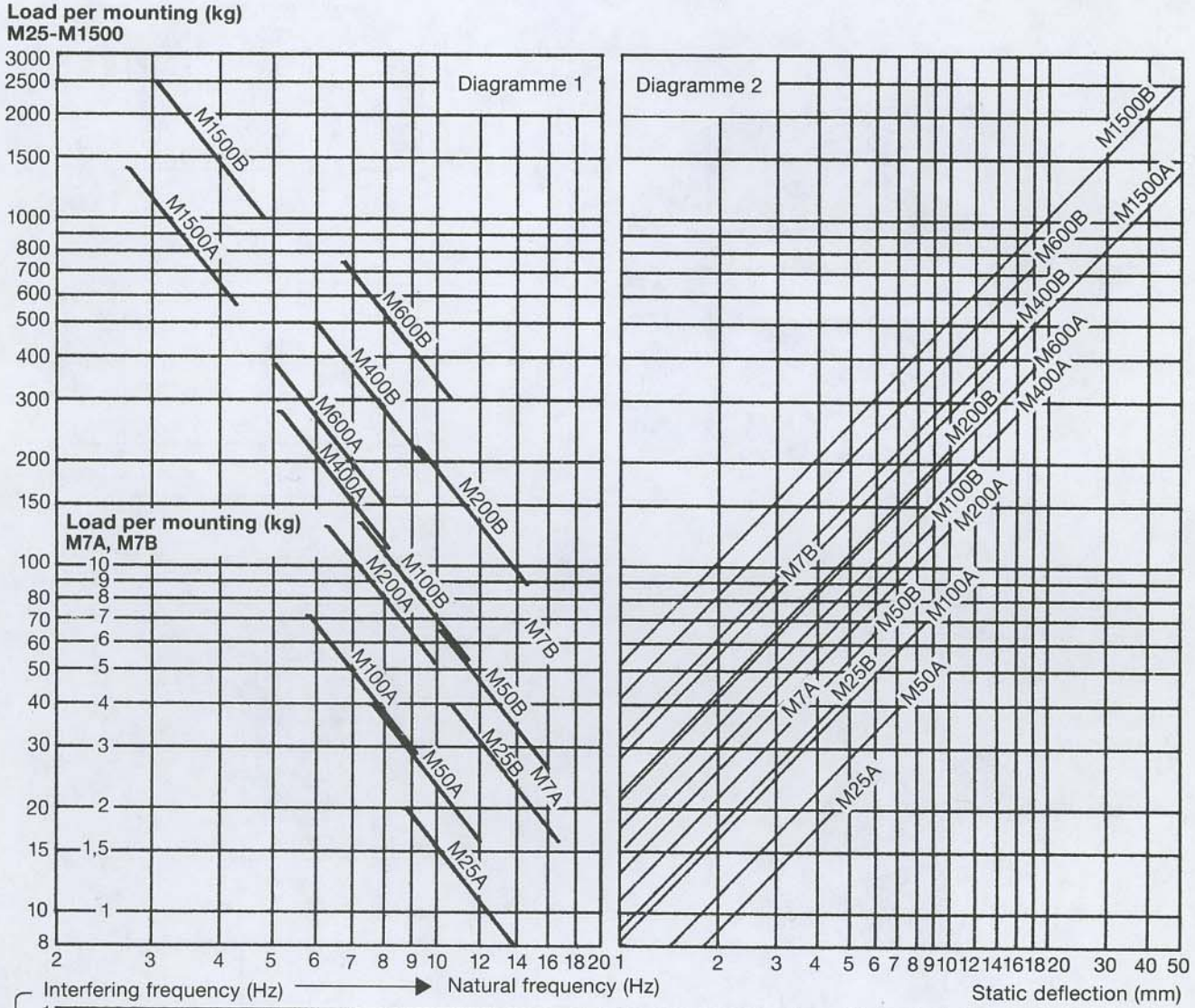


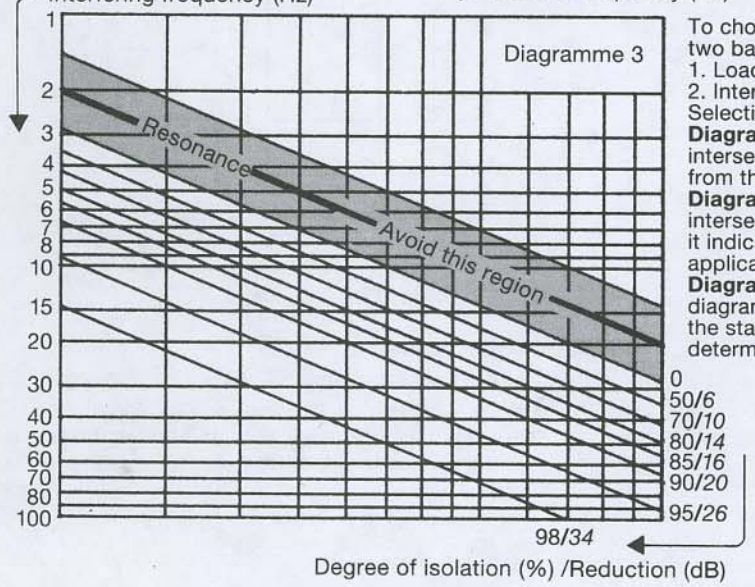


Type	Part #	Part #		Dimensions (ins.)					Thread	Wt	Max Load		Max Load	
	Hardness A	Hardness B	E	D	A	H	K	d	G	Lbs	Lbs	(kg)	Lbs	(kg)
											Hardness A		Hardness B	
M 7	2255110	2255120	1.69	0.59	1.97	0.79	2.56	0.28	M 6	0.04	8	(3.5)	20	(9)
M 25	1861220	1861230	2.20	1.18	2.60	0.98	3.35	0.32	M 8	0.15	44	(20)	88	(40)
M 50	1861240	1861250	2.98	1.65	3.62	1.38	4.49	0.39	M 10	0.34	88	(40)	143	(65)
M 100	1861620	1861610	3.76	1.97	4.33	1.58	5.35	0.45	M 10	0.57	154	(70)	287	(130)
M 200	1861660	1861670	3.96	2.17	4.88	1.77	5.95	0.45	M 10	0.92	287	(130)	485	(220)
M 400	1861680	1861690		2.95	4.72	2.48	5.91	0.57	M 12	2.35	617	(280)	1102	(500)
M 600	1533710	1533720		3.94	6.30	3.35	7.87	0.57	M 16	5.18	838	(380)	1653	(750)
M 1500	1533730	1533740		7.32	9.84	6.30	12.21	0.71	M 24	20.79	3086	(1400)	5511	(2500)

FEATURES & SPECIFICATIONS - TYPE M

Note: The natural frequencies and degrees of isolation are based on the dynamic characteristics of the mountings.



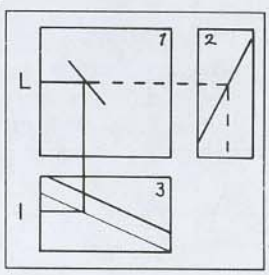


To choose a mounting with required degree of isolation. two basic values must be considered:
1. Load per mounting (kg)
2. Interfering frequency in question (Hz) [Hz = rpm/60]
Selection– Decide upon degree of isolation required.

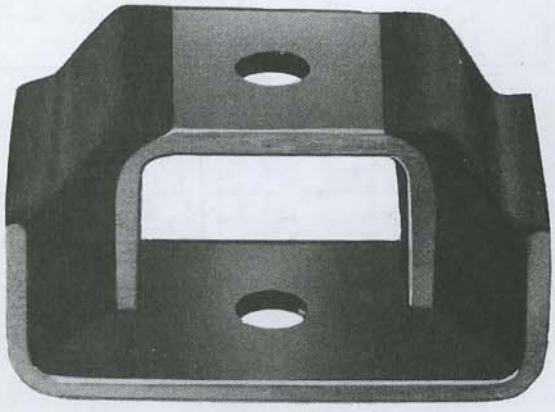
Diagramme 3: Follow selected diagonal line upwards until intersection with disturbing frequency. Continue a vertical line from this point to diagramme 1.

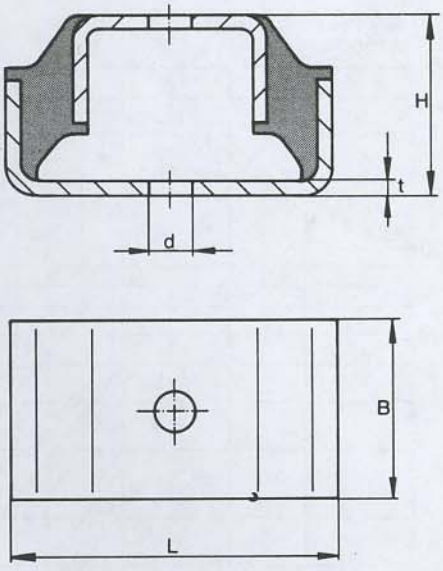
Diagramme 1: Where the vertical line from diagramme 3 intersects the diagonal line at the relevant load per mounting, it indicates the type and hardness of mounting for the application.

Diagramme 2: By following the horizontal line from diagramme 1 at the selected point, the static deflection can be determined.

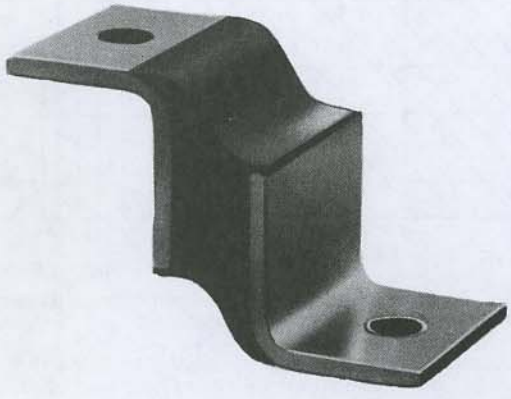


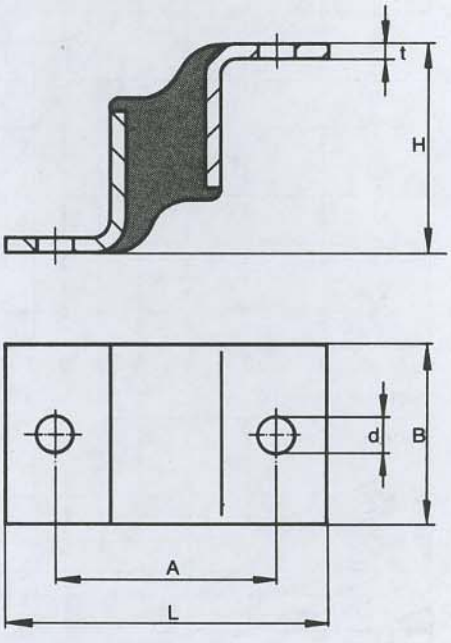
FEATURES & SPECIFICATIONS - TYPE BA





BA 20/2





Construction

This antivibration mounting is constructed of two steel profiles of different size with blocks of rubber securely bonded between them. It provides resilience when the rubber is subjected to shear stress.

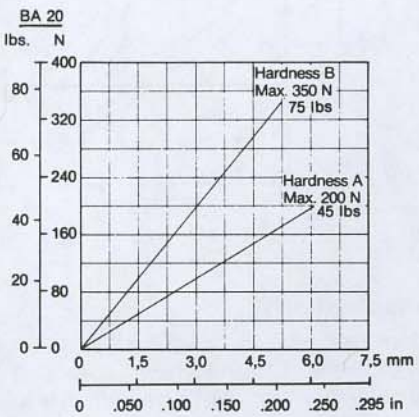
Application

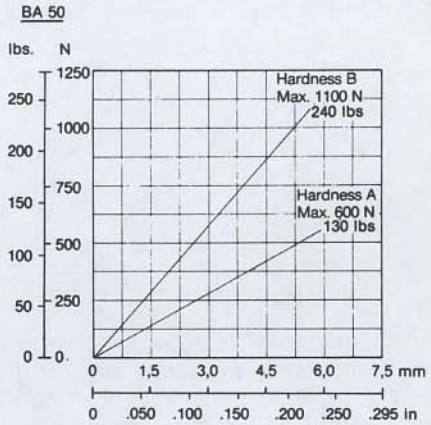
This isolator is used when soft, resilient mounting is required for low loads. Type BA is suitable for isolating low-speed machines and light fans, as well as for suspension mounting of measurement apparatus, instruments, etc.

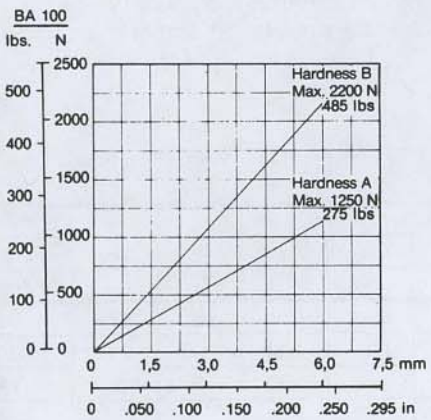
FEATURES & SPECIFICATIONS - TYPE BA

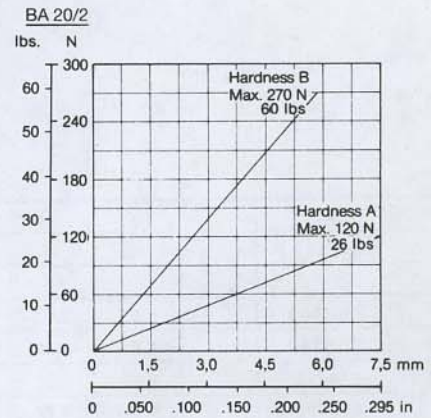
Type	Part #	Part #			Dimensions (ins.)					Wt	Max Load	Max Load
	Hardness A	Hardness B	B	A	L	H	t	d		Lbs	Lbs	Lbs
											Hardness A	Hardness B
BA 20 / 2	2255170	2255180	0.79	2.44	3.54	2.28	0.16	0.35		0.21	26	60
BA 20	2255230	2255240	0.79	*	3.54	1.97	0.16	0.39		0.35	44	77
BA 50	2255250	2255260	1.97	*	3.54	1.97	0.16	0.47		0.93	132	243
BA100	2255270	2255280	3.94	*	3.54	1.97	0.16	0.59		1.83	276	485

Static spring rate curves

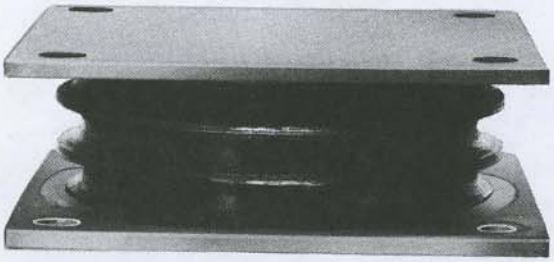


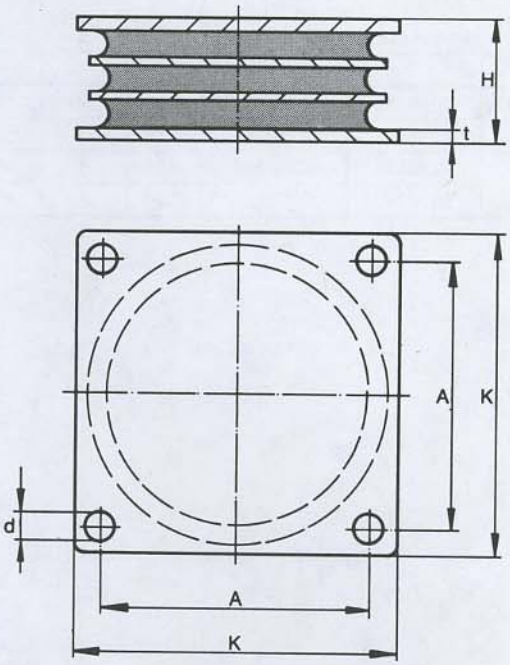






FEATURES & SPECIFICATIONS - TYPE SAW





Construction

Novibra antivibration mounting type SAW consists of a cylindrical rubber component, with steel mounting and intermediate plates securely bonded to it. The part can absorb large vertical forces with little deformation. Mounting is simple since the mounting plates have clearance holes at the corners. Its installation height is low, giving good stability.

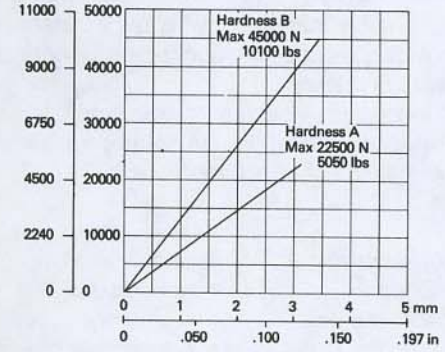
Application

Novibra type SAW provides isolation against horizontal vibrations. This has high deflection capacity in the horizontal direction, while deflection is low in the vertical direction. With these deflection properties, low interference frequencies can be horizontally isolated while achieving subcritical mounting in the vertical direction with a safe distance to the resonance point. Greater vertical resilience can be obtained by connecting two mounts in series; large angular movements can then also be absorbed. This mount is particularly suitable for heavy machines such as crushers, vibrating screens and others.

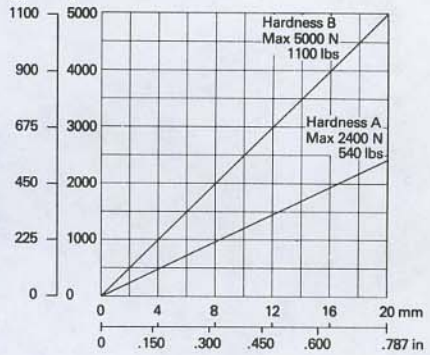
Type	Part #	Part #		Dimensions (ins.)						Wt	Max Load	Max Load
	Hardness A	Hardness B		K	H	A	d	t		Lbs	Lbs	Lbs
											Hardness A	Hardness B
SAW125	2255130	2255140		5.83	2.05	4.65	0.53	0.20		5.69	4960	9921
SAW150	2255150	2255160		6.54	2.48	5.35	0.53	0.24		9.14	8267	16534
SAW200	814467	814475		8.66	3.23	7.24	0.67	0.32		20.34	13228	26455
SAW300	814483	814491		12.21	4.72	10.63	0.87	0.39		59.52	33069	66138

Static spring rate curves

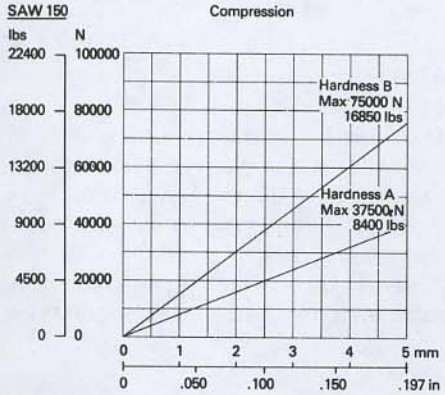
SAW 125 Compression



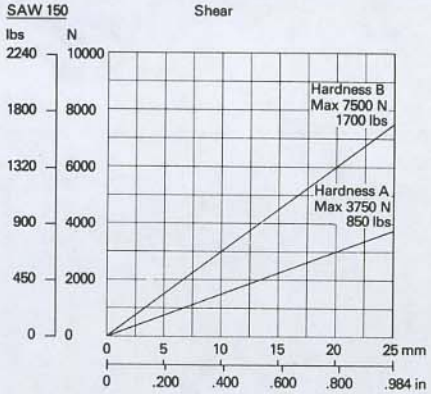
SAW 125 Shear



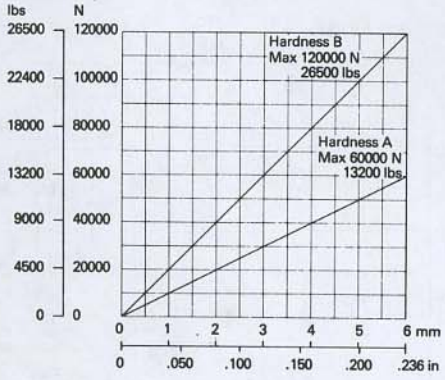
SAW 150 Compression



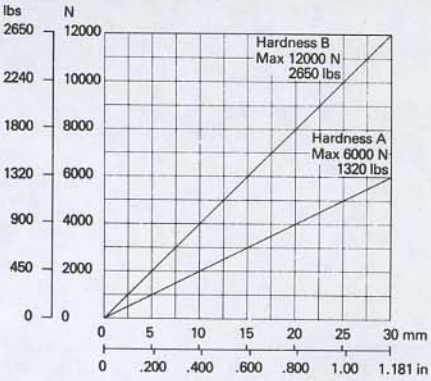
SAW 150 Shear



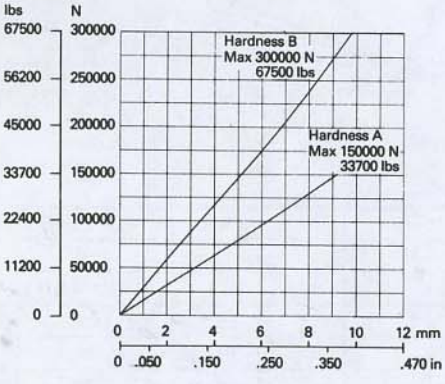
SAW 200 Compression



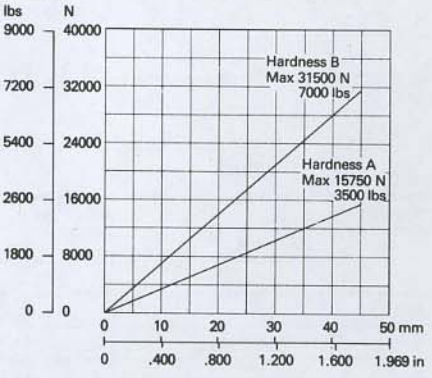
SAW 200 Shear



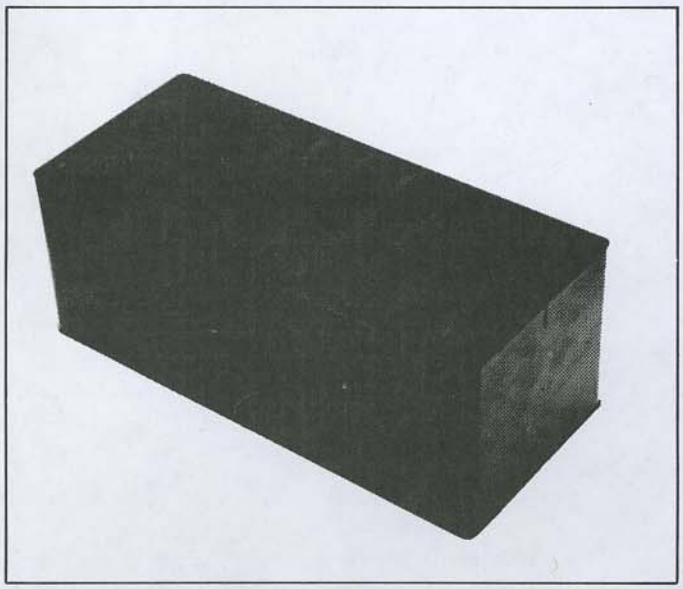
SAW 300 Compression



SAW 300 Shear



FEATURES & SPECIFICATIONS - TYPE GK



Also See Pages 210-211.

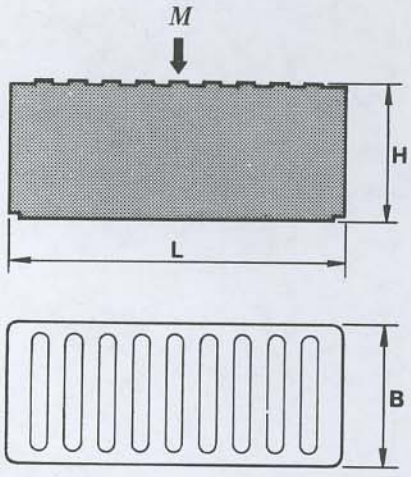
APPLICATION

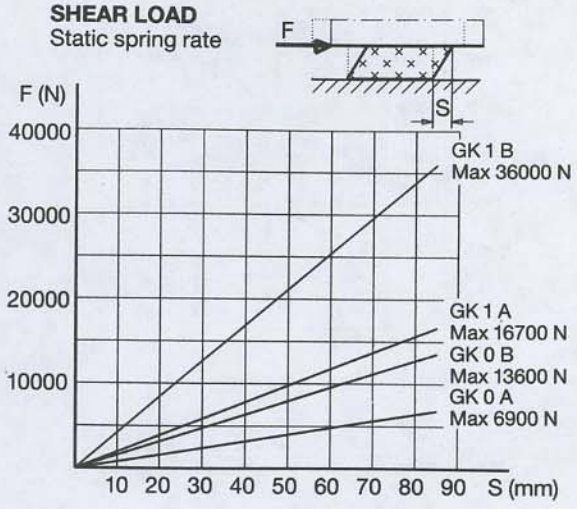
Novibra mounting type GK is specifically meant for isolation of heavy machinery with low interfering frequencies. It is widely used under concrete foundations supporting heavy machinery.
The long narrow section makes type GK also suitable for composite installations on common structural framework.
Typical fields of application are:

- rolling mills
- mixers
- gear wheels
- industrial fans
- paper mills
- converters
- sound enclosures
- floating structures

FEATURES

Type GK is a heavy duty mounting with excellent flexible characteristics in both vertical and lateral planes.
Deflections up to 30 mm can be obtained which makes Novibra type GK suitable for installations with low disturbing frequencies.
Installation is simple with no need for traditional means of attachment to machinery or support structure.

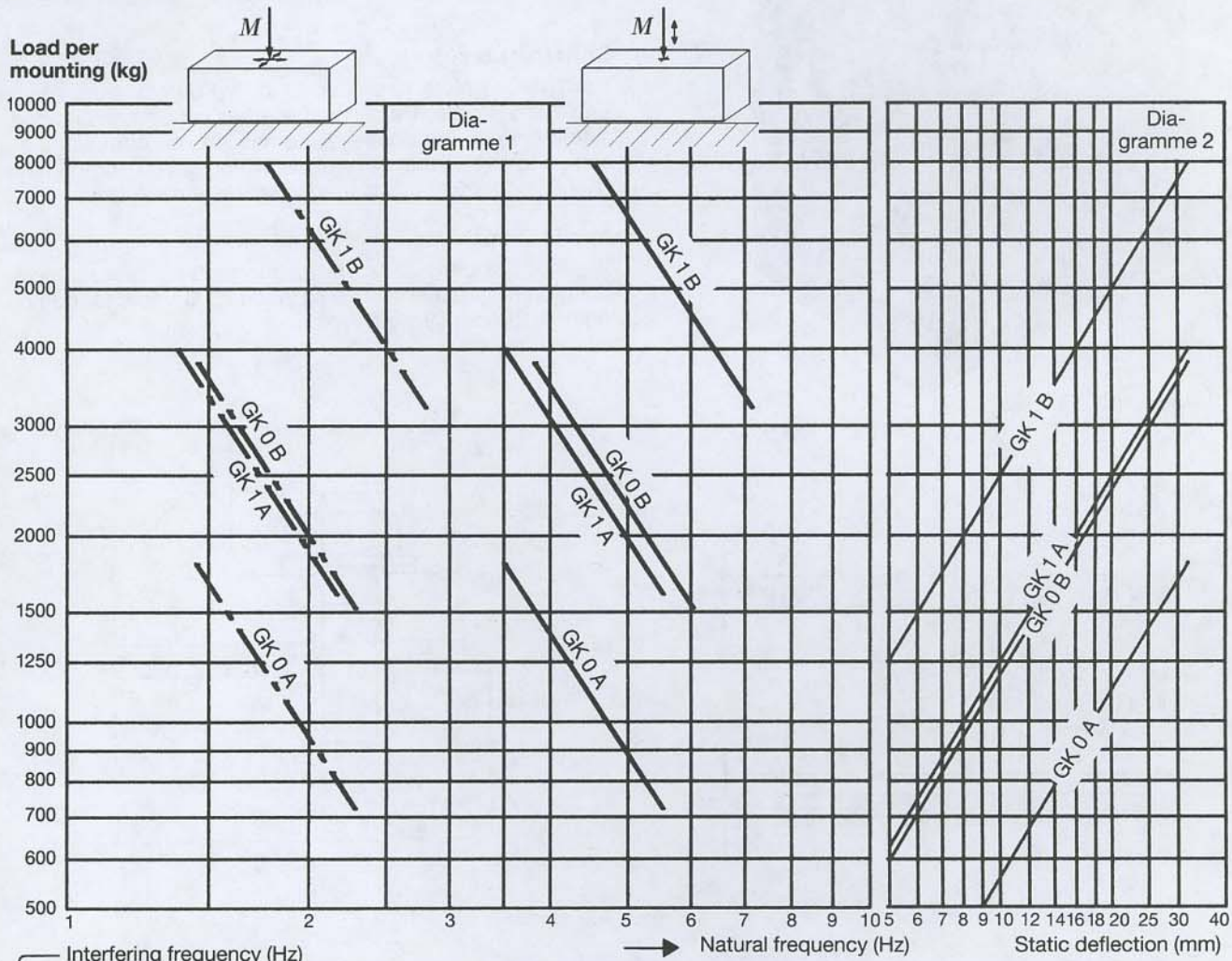


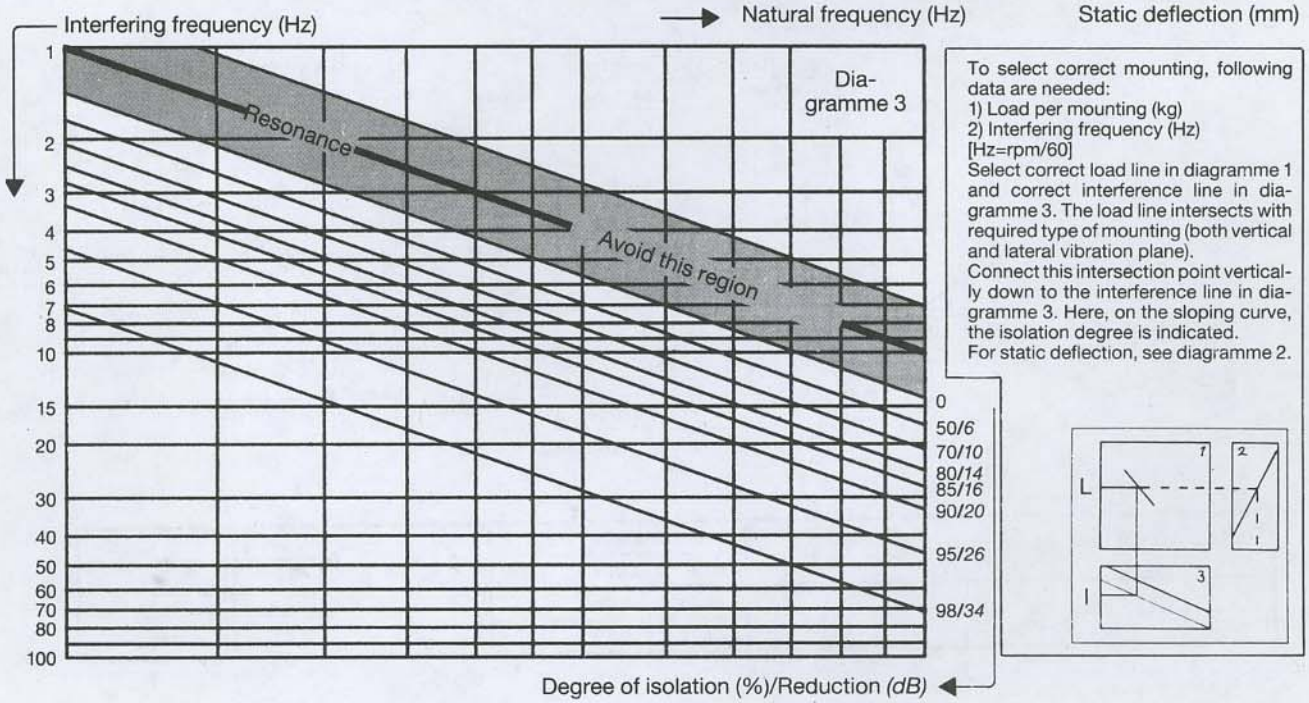


Type	Part #	Part #		Dimensions (Ins.)					Wt	Max Load	Max Load
	Hardness A	Hardness B		L	B	H			Lbs	Lbs	Lbs
										Hardness A	Hardness B
GK 0 A	1534080	*		7.68	6.89	5.91			13.23	4408	*
GK 0 B	*	1861630		7.68	6.89	5.91			13.23	*	8377
GK 1 A	67959	*		15.75	6.89	5.91			27.12	8818	*
GK 1 B	*	67967		15.75	6.89	5.91			27.12	*	17637

FEATURES & SPECIFICATIONS - TYPE GK

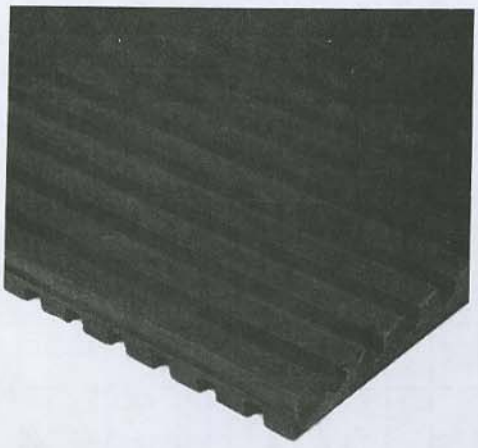
Note: The natural frequencies, degrees of isolation and dB-reductions are based on the dynamic characteristics of the mountings.





To select correct mounting, following data are needed:
1) Load per mounting (kg)
2) Interfering frequency (Hz) [Hz=rpm/60]
Select correct load line in diagramme 1 and correct interference line in diagramme 3. The load line intersects with required type of mounting (both vertical and lateral vibration plane).
Connect this intersection point vertically down to the interference line in diagramme 3. Here, on the sloping curve, the isolation degree is indicated.
For static deflection, see diagramme 2.

FEATURES & SPECIFICATIONS - VIBRATION PLATE



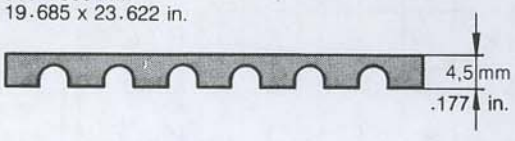
Construction

The Novibra plate is produced in two different versions: single and double. The single plate has uniform ribs on one side, whereas the double plate has ribs on both sides at angles to each other. The plate, which is 500 × 600 mm (19·685 × 23·622 in.), is made in oilresistant rubber.

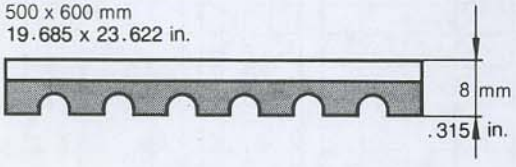
Application

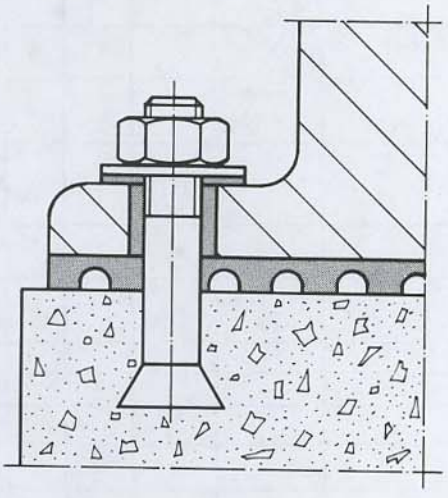
The Novibra plate is primarily intended for more simple isolation requirements. It is particularly suitable for damping high frequency vibrations.

Novibra plate, single
Size 500 x 600 mm
Size 19.685 x 23.622 in.



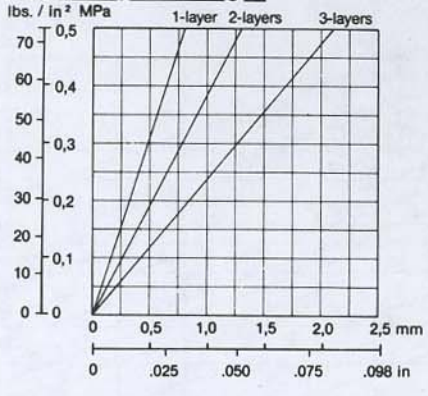
Novibra plate, double
Size 500 x 600 mm
Size 19.685 x 23.622 in.



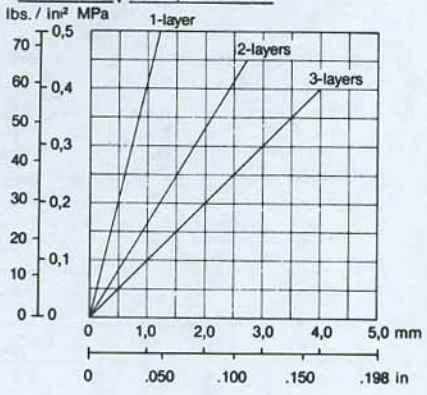


Static spring rate curves

Novibra plate, single

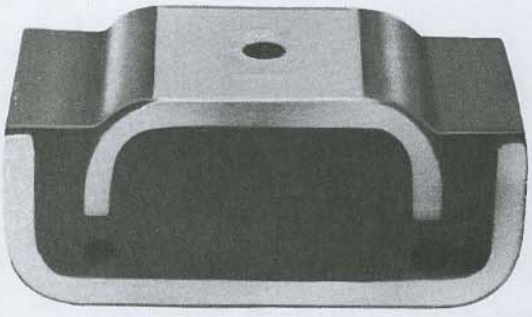


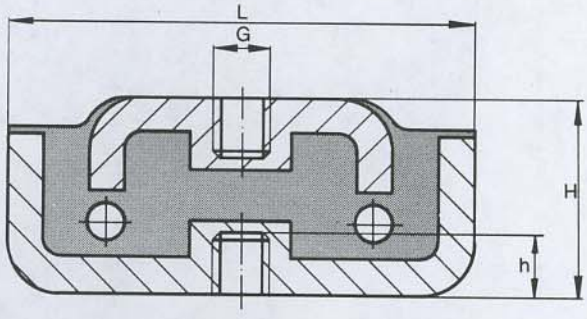
Novibra plate, double

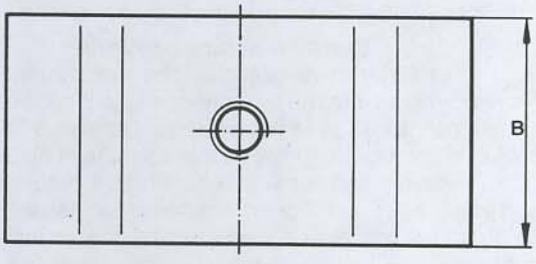


Type	Part #		Dimensions (ins.)				Wt	Max Load
			Wdth	Lgth	Thick		Lbs	psi
Single	70136		23.62	19.69	0.18		2.68	71.12
Double	70151		23.62	19.69	0.32		4.00	71.12

FEATURES & SPECIFICATIONS - TYPE U







Construction

Novibra antivibration mounting type U is a strong component consisting of two solid U-shaped steel parts with rubber securely bonded between them. To improve resilience there are two through holes under the inner shanks. The top steel plate is fastened to the machine foot or baseplate with a bolt and the bottom steel plate is secured to the floor—with an expansion bolt, for instance. In some cases a dowel pin may be adequate.

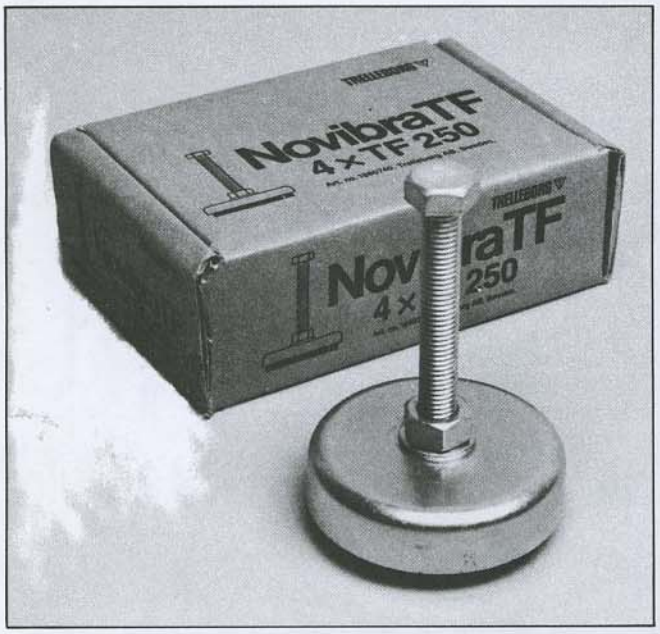
Application

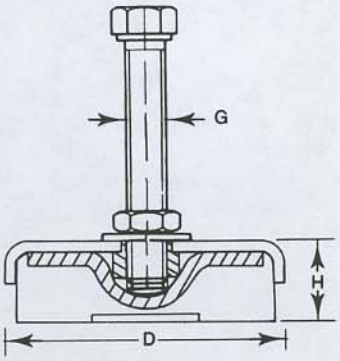
Novibra type U provides stable machine mounting and is therefore particularly suitable for heavier and high-speed machinery. It is suitable for isolating presses, punches, weaving machines, carpentry machines, transformers, etc.

Standard range

Type	Part #	Part #	Dimensions (ins.)					Thread	Wt	Max Load	Max Load
	Hardness A	Hardness B	L	B	H	h		G	Lbs	Lbs	Lbs
										Hardness A	Hardness B
U 100	67363	67371	3.94	1.97	1.65	0.47		M 12	1.43	441	882
U 130	67421	67439	5.12	2.76	2.13	0.47		M 12	2.91	882	1764
U 170	67488	67496	6.69	3.94	2.76	0.71		M 16	7.77	1433	2646
U 200	67546	67553	7.87	3.94	2.76	0.79		M 20	9.08	2205	4409

FEATURES & SPECIFICATIONS - TYPE TF



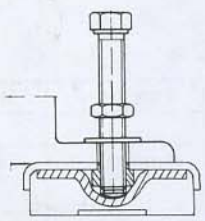


Stable machine mounting
Easy to re-position the machines.

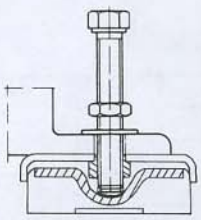
Trelleborg antivibration mountings make it unnecessary to bolt machines to the floor. The rubber sole of the antivibration mounting keeps the machine in place. Fitted with Trelleborg antivibration mountings, all your machines can easily be re-positioned whenever necessary. The height of the machine is increased by only an insignificant amount – Trelleborg antivibration mountings have a low overall height.

Application Chart for General Workshop Machines *

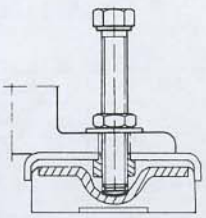
Type *	Part #		Dimensions (ins.)			Thread G	OAL Screw	Wt Lbs	Min-Max Load (lbs.)
			D	H (Min)					
TF 250	1860740	* Rubber is oil resistant	2.72	0.91		M12	3.94"	0.78	up to 551#
TF 600	1860780	* Rubber is oil resistant	3.19	0.98		M12	3.94"	1.07	552 - 1323#
TF1200	1860790	* Rubber is oil resistant	4.25	1.14		M16	3.94"	2.18	1324 - 2646#
TF3000	1860800	* Rubber is oil resistant	5.95	1.38		M20	4.72"	4.90	2647- 6614#
TF4000	1860810	* Rubber is oil resistant	6.69	1.54		M20	4.72"	6.45	6615 - 8818#
TF6000	1860820	* Rubber is oil resistant	8.07	1.73		M24	5.91"	10.61	8819 - 13228#



1 Fit the Trelleborg antivibration mounting to the machine.

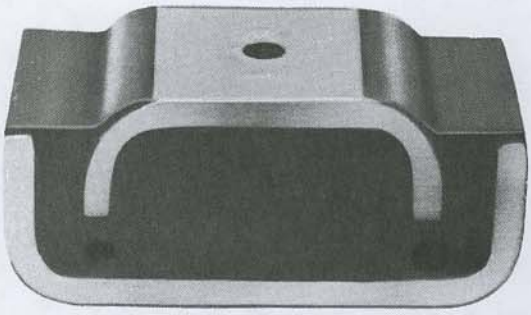


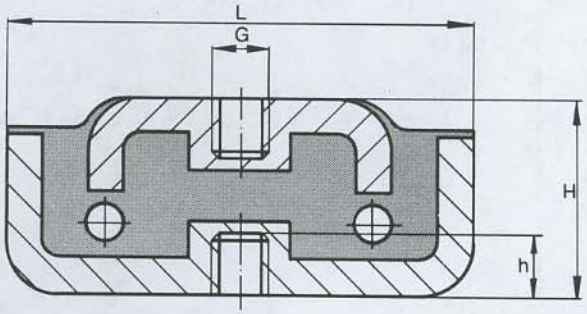
2 Align the machine horizontally by means of the levelling screw. Adjustment can be carried out along the whole length of the screw.

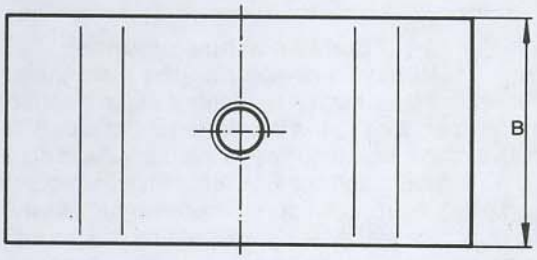


3 Secure the levelling screw by means of the locknut.

FEATURES & SPECIFICATIONS - TYPE U







Construction

Novibra antivibration mounting type U is a strong component consisting of two solid U-shaped steel parts with rubber securely bonded between them. To improve resilience there are two through holes under the inner shanks. The top steel plate is fastened to the machine foot or baseplate with a bolt and the bottom steel plate is secured to the floor—with an expansion bolt, for instance. In some cases a dowel pin may be adequate.

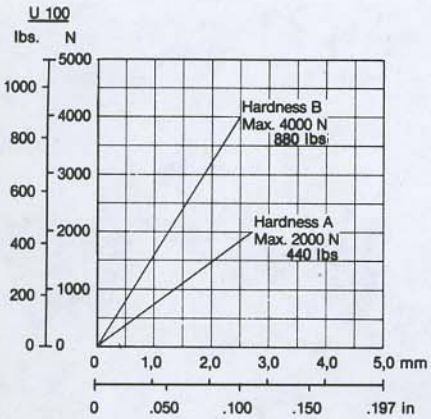
Application

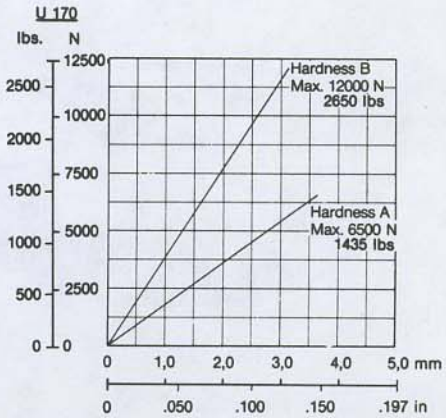
Novibra type U provides stable machine mounting and is therefore particularly suitable for heavier and high-speed machinery. It is suitable for isolating presses, punches, weaving machines, carpentry machines, transformers, etc.

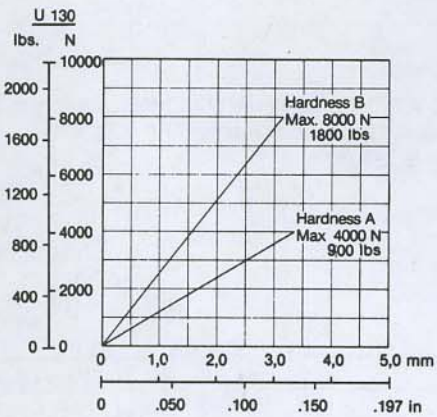
Standard range

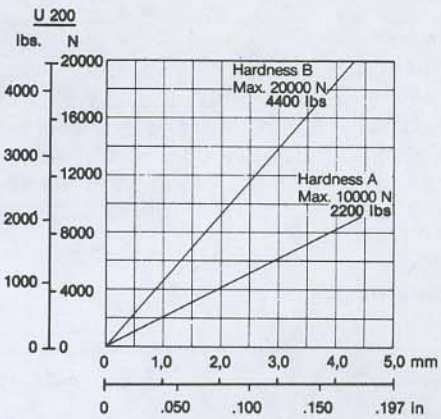
Type	Part #	Part #	Dimensions (ins.)					Thread	Wt	Max Load	Max Load
	Hardness A	Hardness B	L	B	H	h		G	Lbs	Lbs	Lbs
										Hardness A	Hardness B
U 100	67363	67371	3.94	1.97	1.65	0.47		M 12	1.43	441	882
U 130	67421	67439	5.12	2.76	2.13	0.47		M 12	2.91	882	1764
U 170	67488	67496	6.69	3.94	2.76	0.71		M 16	7.77	1433	2646
U 200	67546	67553	7.87	3.94	2.76	0.79		M 20	9.08	2205	4409

Static spring rate curves

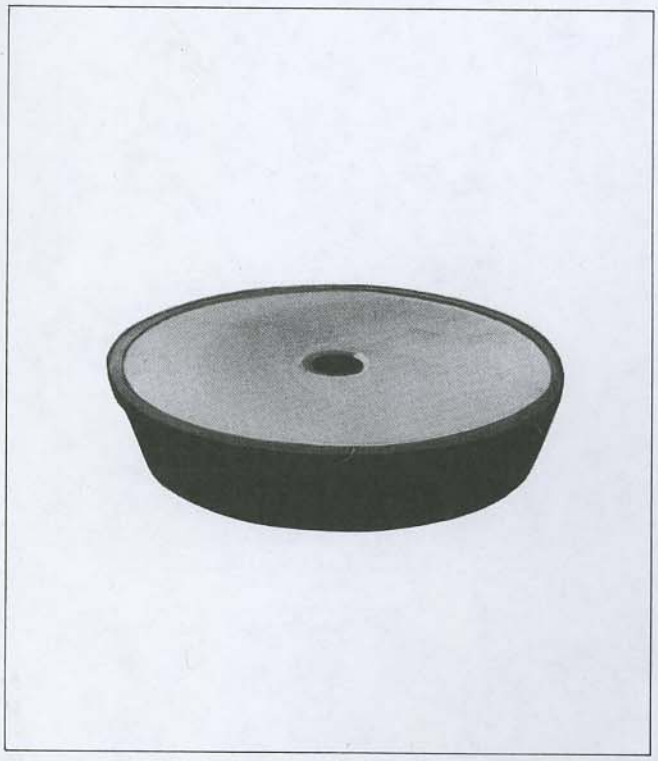


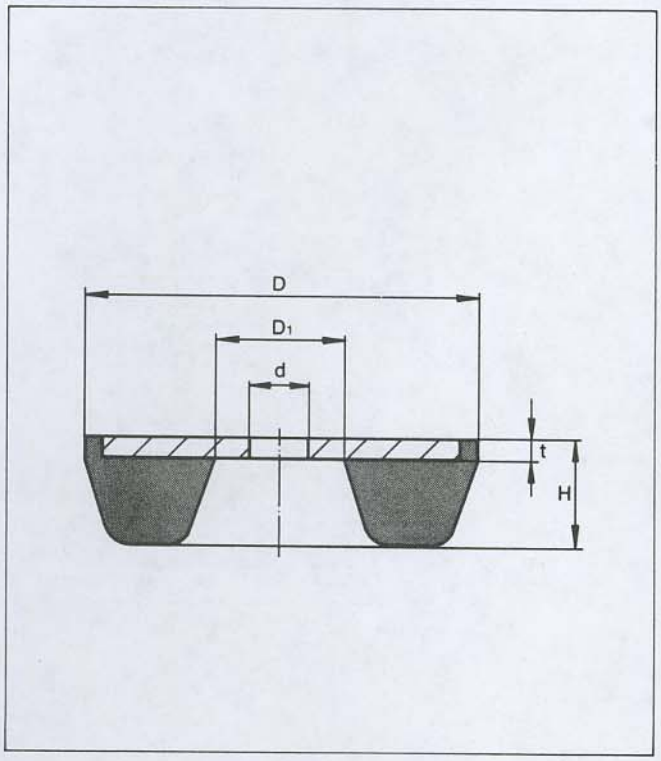






FEATURES & SPECIFICATIONS - TYPE SE





Construction

Novibra type SE consists of an annular rubber part, one end of which is securely bonded to a steel baseplate. The steel plate has a clearance hole for mounting. Since the rubber component comes into direct contact with the base, friction is often sufficient to prevent the machine from "travelling".

Application

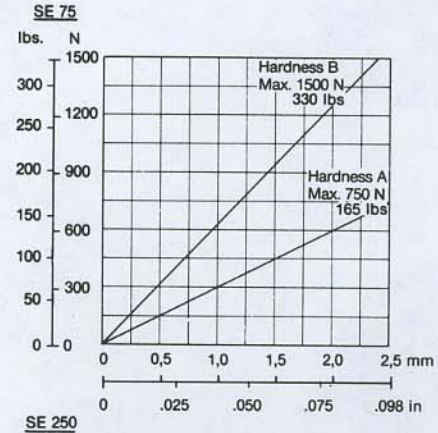
Novibra type SE is used to isolate various machines, such as sewing machines, office machinery, domestic machines, electric motors, etc.

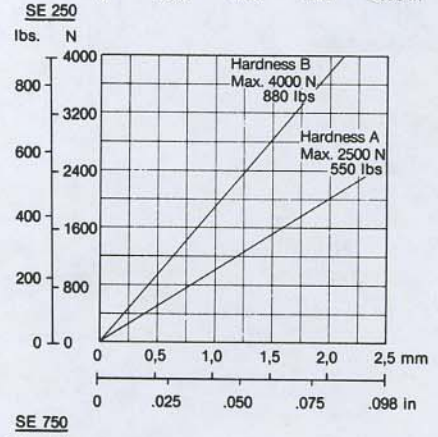
Standard range

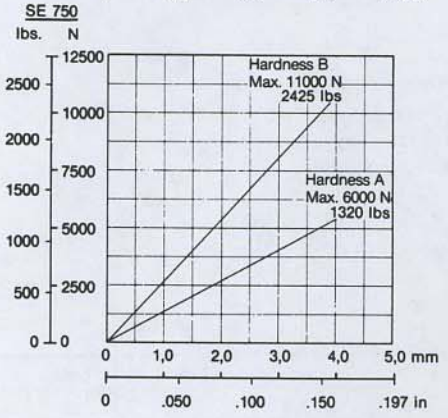
Type*	Part #		Dimensions (ins.)						Wt	Max Load
	Hardness R		D	D1	d	H	t		Lbs	Lbs
										Hardness R
SE 75	1661010		2.17	0.71	0.32	0.59	0.12		0.15	331
SE 250	1861110		2.95	0.98	0.39	0.67	0.16		0.38	882
SE 750	1861120		4.53	1.58	0.55	0.95	0.16		1.01	2425

*= Note: Only available in Hardness 50 deg IRH

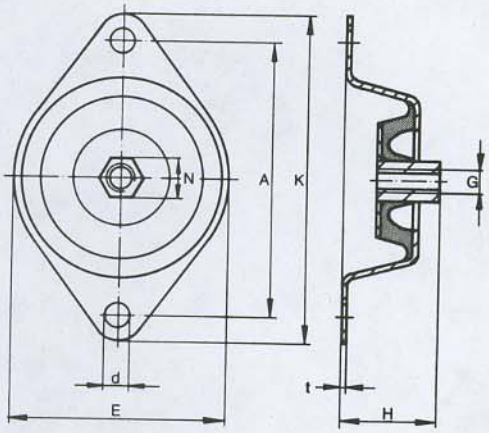
Static spring rate curves

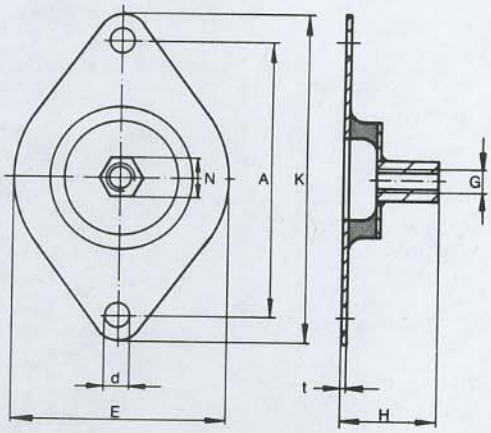






FEATURES & SPECIFICATIONS - TYPE VT & TK





Construction

Novibra type VT is constructed so that the rubber is subjected to shear load when the isolator is mounted. In this way high resilience is obtained even at low loads. Two versions of the antivibration mounting are manufactured: the top and bottom part. The top is protected against tension, which means that the isolated unit cannot fall down through overloading. This part can therefore also be used for roof suspension mounting.

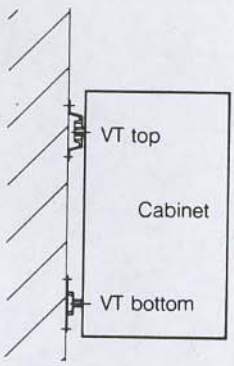
Novibra type TK is of similar construction to the top VT

Application

Novibra type VT protects sensitive instruments, equipment cabinets, electrical control boxes, etc., from vibrations and disturbances generated by nearby motors, working machinery and the like. It is also suitable for isolating small wall-mounted machines, fans, refrigerators, etc.

The over VT is used for roof suspension mounting of, for instance, fittings, fans etc., for which type TK is similarly designed.

Mounting instructions



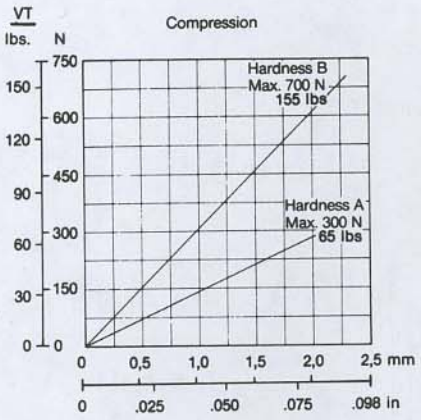
Type	Part #	Part #	Dimensions (ins.)					Thread		Wt	Max Load	Max Load
	Hardness A	Hardness B	K	E	A	H	d	G	N	Lbs	Lbs	Lbs
											Hardness A	Hardness B
VT over	69526	69534	4.48	2.95	3.78	1.30	0.35	M8		0.33	66	154
VT under	69567	69575	4.48	2.95	3.78	1.30	0.35	M8	0.59	0.23	66	154

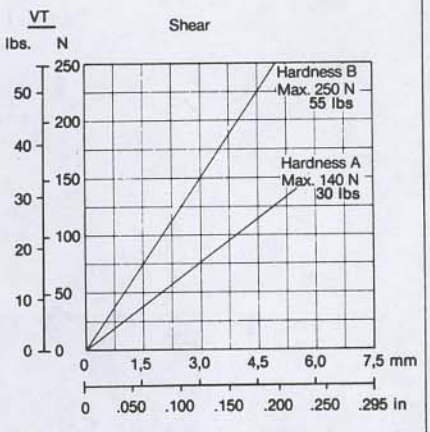
Type	Part #		Dimensions (ins.)					Thread		Wt	Max Load(lbs)
	Hardness R		E	d	A	H	H1	G	N	Lbs	Hardness R
TK*	1861410		2.28	0.28	1.81	1.56	0.51	M5	0.59	0.08	11.02

*= Note: Only available in Hardness 50 deg IRH

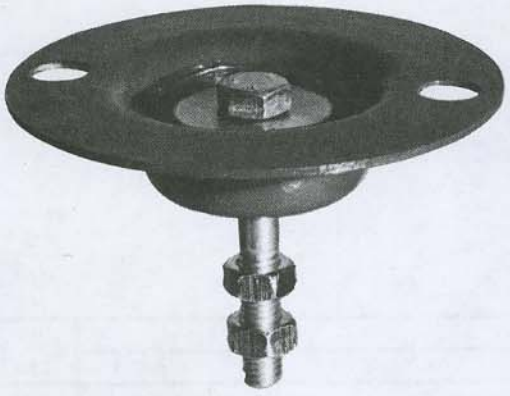
FEATURES & SPECIFICATIONS - TYPE VT & TK

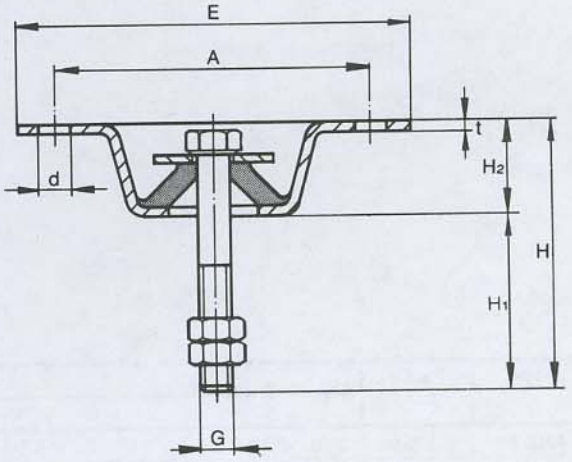
Static spring rate curves



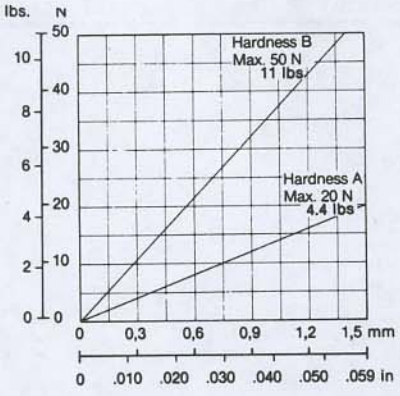


Novibra type TK

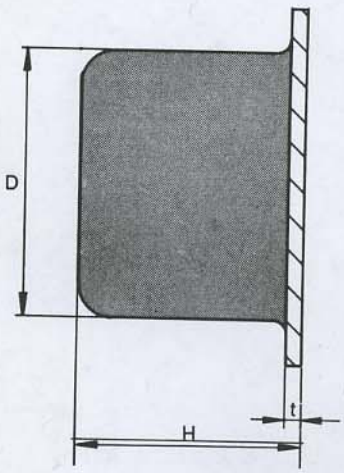


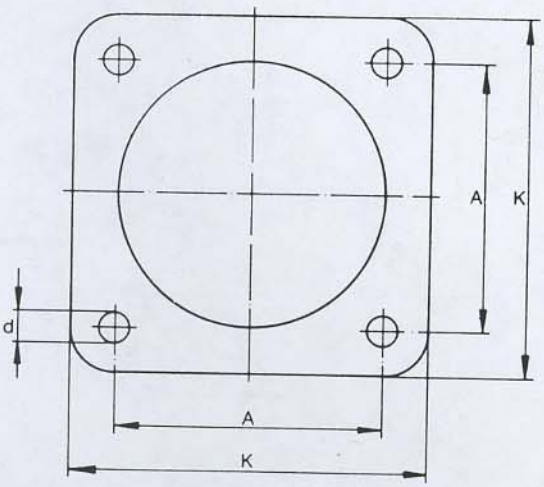


Static spring rate curves



FEATURES & SPECIFICATIONS - TYPE ANB





Type	Part #	Dimensions ins. (mm)						Wt
		K	A	D	d	H	t	Lbs
ANB 50	2255290	2.76" (70 mm)	1.97" (50 mm)	1.97" (50 mm)	0.28" (7 mm)	1.69" (43 mm)	3 mm	0.42
ANB 75	2255300	3.94" (100 mm)	2.95" (75 mm)	2.95" (75 mm)	0.35" (9 mm)	2.48" (63 mm)	3mm	1.12
ANB100	2255310	5.12" (130 mm)	3.94" (100 mm)	3.94" (100 mm)	0.43" (11 mm)	3.31" (84 mm)	4mm	2.61
ANB150	68569	7.28" (185 mm)	5.91" (150 mm)	5.91" (150 mm)	0.53" (13.5 mm)	4.96" (100 mm)	6mm	8.59
ANB200	68577	9.45" (240 mm)	7.87" (240 mm)	7.87" (240 mm)	0.53" (13.5 mm)	6.61" (168 mm)	8mm	20.06

Static spring and energy curves

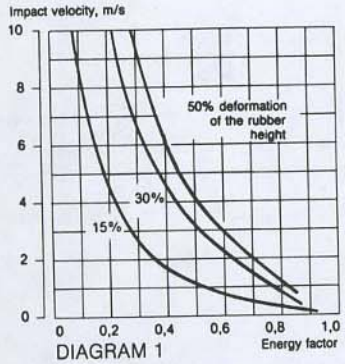


DIAGRAM 1

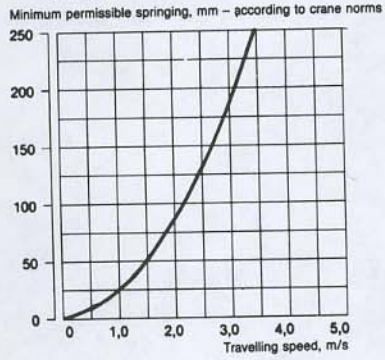


DIAGRAM 2

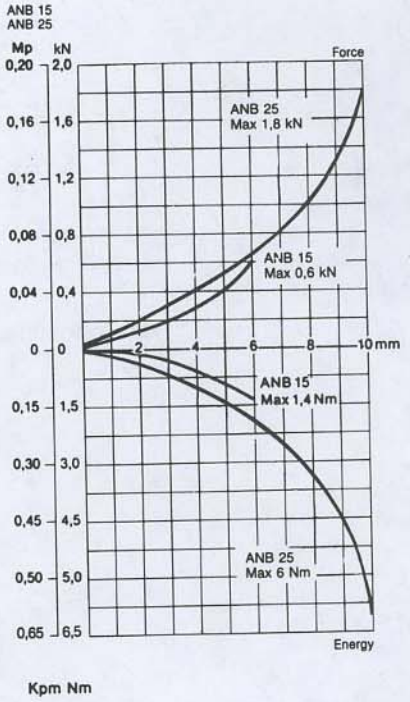


DIAGRAM 3

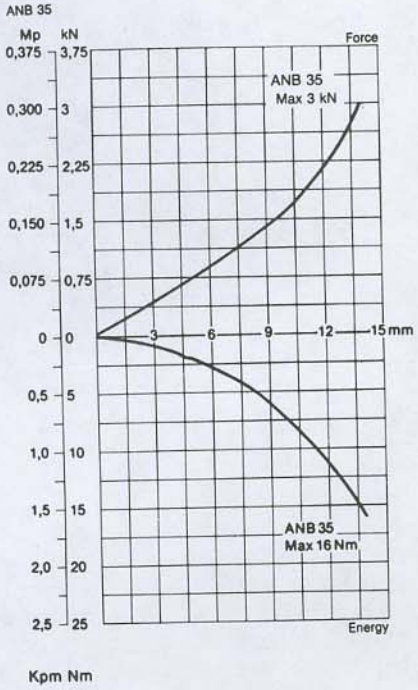


DIAGRAM 4

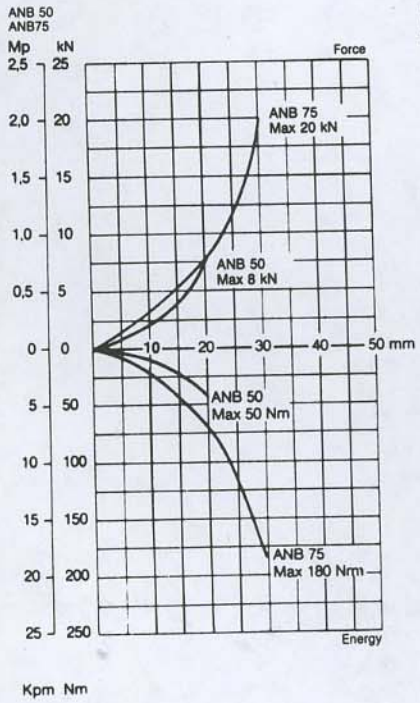


DIAGRAM 5

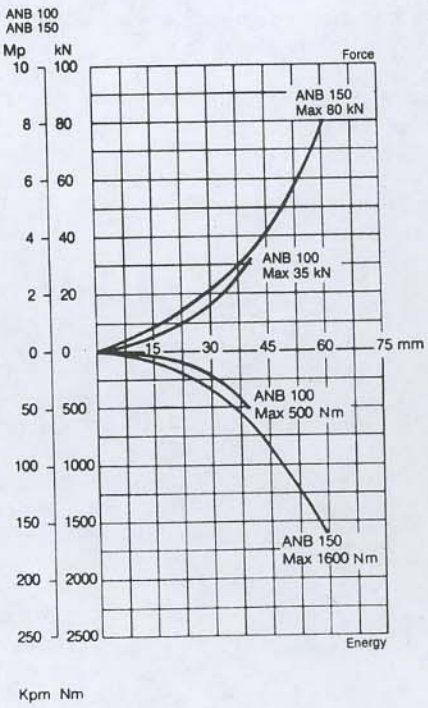


DIAGRAM 6

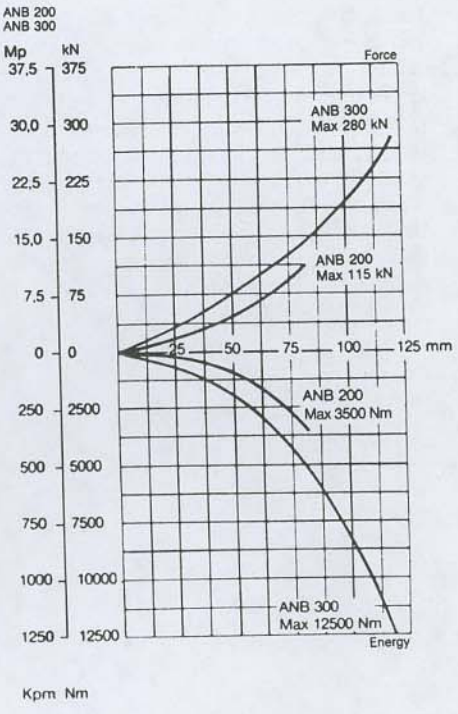


DIAGRAM 7

FEATURES & SPECIFICATIONS - TYPE ANB

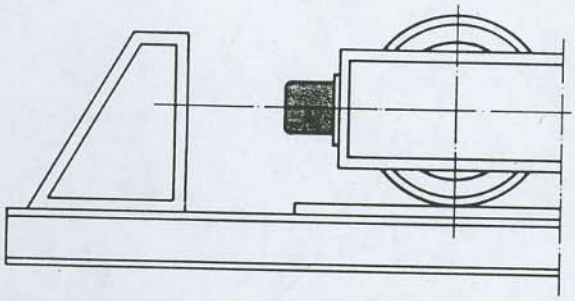


Fig. 1. Gantry crane trolley with buffer.

Design

Novibra type ANB buffers consist of a cylindrical rubber body bonded to a square baseplate of steel. Mounting holes are provided in each corner of the plate. Special high-hysteresis rubber is used to absorb as much energy as possible. The volume of rubber is thus used at optimum efficiency. This permits the use of simpler designs since the buffers can be dimensioned for lower forces.

Application

Novibra types ANB buffers are used for effectively damping the movement of machines or machine components which have to be slowed down or stopped. Typical applications are wagons, various types of cranes, falling goods, etc. Through the outstanding resilience of rubber a high degree of energy absorption is possible. The rubber is harder for rapid dynaic processes than for slow static processes. With the same deformation this means that more energy is absorbed in fast processes than in slow ones. For that reason an energy factor has been inserted in Diagram 1.

The following equations can be used for calculation

$$E = \frac{m \cdot v^2}{2} \quad (1)$$

$$E = F \cdot S \quad (2)$$

$$F = m \cdot a \quad (3)$$

$$S = \frac{a \cdot t^2}{2} \quad (4)$$ Applicable if initial velocity = 0

$$v = a \cdot t \quad (5)$$ Applicable if initial velocity = 0

$$v = \sqrt{2 \cdot a \cdot S} \quad (6)$$ Applicable if initial velocity = 0

$$v = \sqrt{2 \cdot g \cdot h} \quad (7)$$ Applicable in free fall

$$v_r = 0.7 \cdot v \quad (8)$$ Inserted in (1) for calculation according to the crane norms

$$\delta_{serie\ s} = \sqrt{\frac{E_{stat} \cdot 2}{k_{stat}}} \quad (9)$$

$$k_{stat} = \frac{F}{\delta} \quad (10)$$

E = energy in Nm
m = mass in kg
v = velocity in m/s
F = force in N
S = distance in m
a = acceleration in m/s^2
t = time in s
G = acceleration due to gravity 9.81 m/s^2
h = height in m
v_r = reduced velocity in m/s according to crane norms
δ = spring travel in m
k = spring constant in N/m

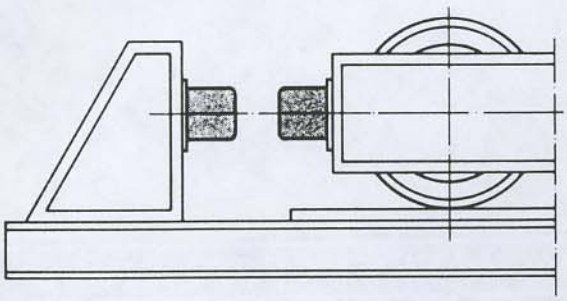


Fig. 1. Gantry crane trolley with two buffers in series.

Calculation examples
The figures in parenthesis refer to the equations.

1.
An object weighing 1 500 kg is to be dropped from a height of 1.83 m. How many and what size ANB buffers should be used? How great will be the force transmitted to the underlying surface?

The energy to be absorbed is calculated as $E = F \cdot S$ (2). This will give 26 928 N. The velocity of the falling object on impact will be $v = \sqrt{2 \cdot g \cdot h}$ (7); $v = \sqrt{2 \cdot 9.81 \cdot 1.83}$; $v = 6$ m/s.

The higher the velocity, the more energy can be absorbed by rubber. According to Diagram 1 the energy factor at 6 m/s and 50% deformation will be 0.4. The static energy curve is shown in the energy diagrams for the various ANB sizes. 26 928 Nm is therefore multiplied by 0.4. This will give 10 771 Nm which then corresponds to the static energy indicated by the curves. According to the static energy curve an ANB 200 buffer can absorb a maximum of 3 500 Nm. Four ANB 200 buffers are chosen. Each ANB buffer then deflects 73 mm, which corresponds to 46% deformation. (The energy factor is consequently in actual fact slightly less than 0.4 but that can be ignored here.)

The actual force against the underlying surface is obtained if the force for an ANB 200 buffer at 73 mm deflection according to the static deflection curve is divided by the energy factor. i.e.

$$\frac{96}{0.4} = 240 \text{ kN.}$$

The force against the underlying surface will accordingly be 240 kN under each ANB buffer. The total force against the underlying surface will then be 960 kN.

2.
A gantry grane trolley weighs 2 100 kg. Travelling speed is 1.6 m/s. Choose a suitable ANB buffer and calculate the final force.

$$E = \frac{m \cdot (0.7 \cdot v)^2}{2} \text{ (1) and (8)}$$

which gives 1 317 Nm dynamic energy. According to Diagram 1 the energy factor is 0.75 at 50% deformation and 1.6 m/s. Static energy will then be $1\,317 \cdot 0.75 = 988$ Nm. An ANB 150 buffer springs 49 mm at 988 Nm. But 49 mm corresponds to 41% deformation. The energy factor is then changed to 0.72. $1\,317 \cdot 0.72 = 948$ Nm, which then corresponds to 48 mm compression and 45 kN static force.

$$\frac{45}{0.72} = 63 \text{ kN dynamic load.}$$

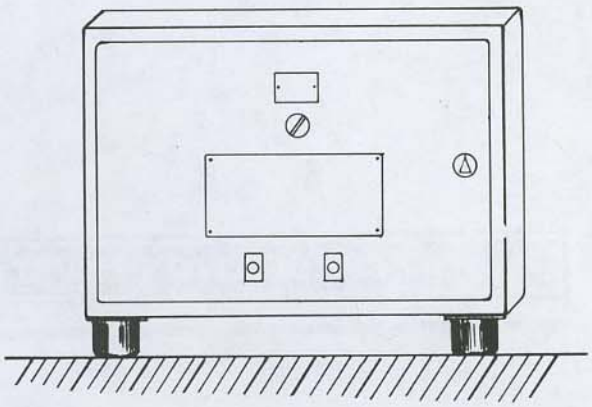


Fig. 2. Type ANB buffers can also be mounted under cabinets, for example.

An ANB 150 buffer gives a final force of 63 kN but its spring travel is only 48 mm.

According to Diagram 2 (crane norms), spring travel must be at least 60 mm.

Two ANB 150 buffers are therefore connected in series.

According to (9) is $\delta = \sqrt{\frac{E_{stat} \cdot 2}{k_{stat}}}$; $k_{stat} = \frac{F}{\delta}$ (10) for one ANB buffer. Two ANB buffers connected in series will be softer, whereby

$$k_{stat} = \frac{F}{\delta \cdot 2}; \; k_{stat} = \frac{45\,000}{0.048 \cdot 2} \text{N/m}; \; \delta = \sqrt{\frac{948 \cdot 2 \cdot 0.048 \cdot 2}{45\,000}};$$

$\delta = 0.064$ m, which is approved.

The force transmitted to the underlying surface will be less than 63 kN (for one ANB 150). The force is obtained from (10)

$$k_{stat} = \frac{F}{\delta}; \; F = \frac{45\,000}{0.048 \cdot 2} \cdot 0.064; \; F = 30 \text{ kN.}$$ Each of the ANB 150 buffers connected in series springs

$\frac{0.064}{2} = 0.032$ mm. This gives $\frac{32 \cdot 100}{120} = 27\%$ compression and an energy factor of 0.63 ·

$\frac{30}{0.63} = 48$ kN which is then the load acting on the underlying surface.

Two ANB 150 buffers connected in series have a spring travel of 64 mm and a final force of 48 kN.

3.
An electrical cubicle weighing 90 kg is to be mounted on four ANB buffers. The cabinet can resist 3 g. Calculate a suitable ANB buffer size.

Try with a deflection of 6 mm. According to equation (6) $v = \sqrt{2 \cdot a \cdot S}$ $v = \sqrt{2 \cdot 3 \cdot 9.81 \cdot 0.006} = 0.6$ m/s is obtained.

According to equation (3) $F = m \cdot a$, $F = \frac{90 \cdot 3 \cdot 9.81}{4}$ is obtained.

$F = 622$ N per ANB buffer.

At 0.6 m/s the energy factor = 0.9 according to Diagram 1. $0.9 \cdot 622 = 596$ N per ANB buffer. An ANB 15 buffer springs 6 mm at 600 N and this size is therefore chosen.