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shock & vibration solutions
product information

www.socitecuk.com

introduction

Socitec UK is the UK market leader in the provision of shock and vibration isolation and monitoring systems.

Our solutions, based on 30 years of experience, have covered multiple applications and have been tested and approved by the world's largest international contractors.

Proven products

The full list of products and services include:

- Unrivalled range of wire rope shock and vibration isolators
- Comprehensive range of standard vibration mounts and fixtures
- Bespoke, isolation component solutions manufactured to meet your individual requirements
- Standardised COTS equipment racking with suspension, for naval applications
- Data loggers for shock, temperature, relative humidity, inclination, air pressure amongst others

Shock and vibration design and consultancy

The specialised product range is supported by the following capabilities:

Comprehensive advice and design support for vibration and shock applications.

- Unsurpassed experience working in all types of shock and vibration applications allows us to provide a complete engineering service to help you and to advise you on: improving the quality and reliability of your products, determining critical design features before going to test, advice on optimising mass and rigidity of components.

- Advanced Non-linear Dynamic simulation techniques using SYMOS, our own *n* Degree of Freedom (D.o.F) simulation software allows us to predict the shock and vibration isolation performance in your application.

- Finite Element Analysis
  For a detailed picture of dynamic and structural loading. FEA analysis allows the fine tuning to meet the most demanding shock and vibration requirements.

- Dynamic simulation of mechanical structures and mechanisms
  Allows us to simulate motion loading directly from 3-D model assemblies enabling us to investigate, linkage layout, size springs/dampers, and determine how contacting parts behave, thus reducing prototyping costs and reducing product development time.

Test

Our specialised environmental test - capability includes:

- Shock and vibration testing
- Temperature cycling -100°C to +200°C
- Humidity

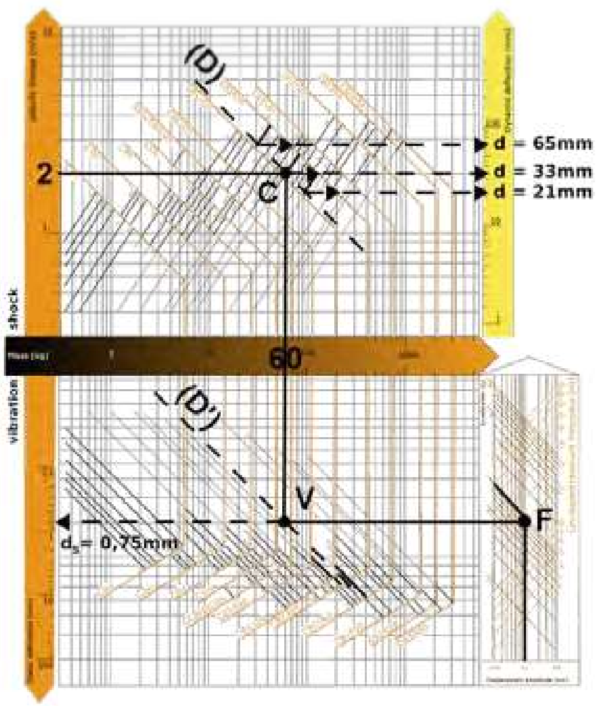
Our list of products, services and capabilities are intended to give you a clear understanding of the wide range of ways in which we can help you deliver mechanical solutions.

Call us to discuss your application

choosing the right cable mount for the job

The nomographs in each section will help you select a suspension system according to the mount orientation: either, compression, 45 degree compression / roll, shear or roll. They use a single-degree-of-freedom model to predict shock and/or vibration behaviour for any input along the 3 principal axes. A full 6-degree-of-freedom analysis is still indispensable in those cases where the system is strongly unbalanced (coupled). Please contact us for advice.

1. Refer to the graph corresponding to the mount attitude



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TG_BA_MA_0001_1a

2. Calculate the suspended weight per mount

If C of G is at geometric centre and mounts are identical m = M/n where M is suspended mass and n is number of mounts
Ex.: 240 kg mass on 4 mounts in compression, m = 60kg

3. Select for shock according to type (a) or (b)

(a) Velocity change :

It is assumed that the shock is an impulse or impact (after a free fall drop for example). We regard this as an instantaneous velocity change between the suspended mass and the support
Ex.: Shock 1/2 sine 50g 6ms or drop height 20 cm

- On the nomograph, place point C, intersection of *m = 60kg* (mass scale) and *Δv = 2 m/s* (velocity change scale)
- Select through position C the optimum mount series (each series is separated by 2 blue longitudinal lines):
  - lower series cannot meet the shock input
  - higher series would be underloaded.

Here in our example, C is within the area corresponding to the CB1400 series.

- Select the right model in the series. Mount selection depends on the protection required on the suspended mass. The diagonal line on the graph corresponds to a 10 g's protection for the model of the series being considered. If point C is below (respectively above) the mount characteristic diagonal line, the transmitted acceleration will be below (respectively above) 10 g's
  The anticipated deflection under shock is read on the dynamic deflections scale at the intersection of D (parallel at C to series separators) and the characteristic line of the model as previously illustrated.

Ex.: Within the CB1400 series, the
CB1400-12 would give d = 21 mm t > 10 g's (~ 16 g's)
CB1400-20 would give d =33 mm t = 10 g's
CB 1400-60 would give d = 65 mm t < 10 g's (~ 5 g's)
d: dynamic deflection, t: transmitted acceleration

(b) Displacement step

It is assumed that the shock is an instantaneous displacement of the foundation (after an underwater explosion for example), which generates an immediate corresponding deflection in the mounts.
Ex.: Displacement step 65 mm, as per typical naval shock response spectrum

- On the nomograph place point C, intersection of *m=60 kg* (mass scale) and *d=65 mm* (dynamic deflection scale)
- Select through C position the optimum mount series each series is separated by 2 orange diagonal lines.

Here in our example, C is within the area corresponding to the CB1400 series.

- Select the right model in the series. Mount selection depends on the protection required on the suspended mass. The diagonal lines (in black) on the graph correspond to a 10 g's protection for the model being considered. If point C is on the right (respectively on the left) of the mount characteristic diagonal line, the transmitted acceleration will be below (respectively above) 10 g's. The deflection of the mounts under shock will be 65 mm.

Ex: within the CB1400 series, the CB1400-40 would give gamma=10 g's and CB1400-50 and 60 would give gamma<10 g's, all with 65mm displacement.

4. Select for vibrations

- Put F on the frequencies scale, intersection of the requested resonant frequency and the vibration input (vertical lines for displacement input or lateral lines for acceleration input).

Ex.: Requested F ~ 15 Hz Vibration input +/- 1 mm or 1 g (whichever less)

- Place point V given by the horizontal line at point F intersecting with the vertical line from mass
- Draw D' parallel to the characteristic vibration lines of the mounts. The mounts which have a line is closest to D' meet the requirements.

Ex.: m = 60 kg The isolators CB1380-12/CB1400-30 on one side, or CB1400-20/CB1500-30 on the other side will meet the 15 Hz (under +/- 1 mm 1 g input) criteria.

- Read the corresponding static deflection on the left vertical scale, here d_s = *0.75 mm*

5. Select for both shock and vibration

In our example will lead to the choice of CB1400-30 or possibly CB1400-20 (slightly harder but smaller). Note: as a rule, shock determines the series and vibration the model within the series.

6. Data checking

Check with the series data sheet that the selected mounts are capable of the calculated deflection and loading in all planes.

product overview

Helical

- All metal multidirectional modular wire rope mounts, combined shock and vibration isolation from 5Hz upwards
- Interface : 2 or 4 fixture points to equipment and foundation
- Exceptional reliability and long life, temperature range -180 +380 deg C
- Static loading per mount 0.1 to 5000 kg approx., damping ratio 15-25% to viscous.

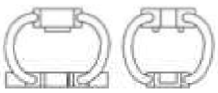
Typical applications in the Defence, Aerospace, Nuclear, Oil research, Railways and Medical industries for transport and handling of delicate equipment under very severe climatic and/ or mechanical environment.

Half Helical

- Compact multidirectional modular metal wire rope mounts, combined shock and vibration isolation from 5Hz upwards
- Interface : 2 fixture points to equipment and foundation
- Exceptional reliability and long life, temperature range -180 +380 deg C
- Static loading per mount 0.1 to 2000 kg approx., damping ratio 15-25% to viscous.

Typical applications in the Defence, Aerospace, Nuclear, Oil research and Medical industries for transport and handling of delicate equipment under very severe climatic and/ or mechanical environment.

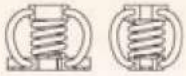
Polycal



- All metal multidirectional wire rope mounts, combined shock and vibration Isolation from 5Hz upwards
- Interface : 1 and 2 fixture points to equipment and foundation respectively
- Exceptional reliability and long life, temperature range -180 +380 deg C
- Static loading per mount 0.1 to 500 kg approx., damping ratio 15-25% to viscous.

Typical applications in the Defence, Aerospace, Nuclear, Oil research and Medical industries for transport and handling of delicate equipment under very severe climatic and/or mechanical environment.

Spring Polycal



- All metal combined coil spring/ wire rope isolators, vibration isolation from 4.5 Hz upwards
- Interface : 1 and 2 fixture points to equipment and foundation respectively
- Exceptional reliability and long life, temperature range -180 +380 deg C
- Static loading per mount 0.5 to 2000 kg approx., damping ratio 5-10% to viscous.

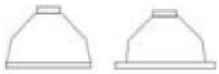
Typical industrial applications for direct isolation of rotating/ vibrating machinery or passive isolation of sensitive equipment .

Axycal

- All metal multidirectional wire rope mounts, combined shock and vibration isolation from 15Hz upwards
- Interface : 1 fixture point to equipment and foundation
- Static loading per mount 0.01 to 2 kg approx., damping ratio 5-10% to viscous.

Typical applications in the Defence, Aerospace, Medical and Electronic industries for direct isolation of lightweight delicate equipment under severe climatic and mechanical environment.

Elastomer BFB



- Multidirectional elastomer mounts, combined shock and vibration isolation from 15Hz upwards, displacement under shock up to 30mm, oil and grease resitant.
- Interface : 1 and 2 fixture points to equipment and foundation respectively temperature range -30 +100 deg C
- Static loading per mount 15 to 120 kg approx., damping ratio 8-10% to viscous.

Typical applications in the Defence, Aerospace, Medical and Machinery industries for direct isolation of delicate equipment.

Elastomer BFC

- Multi-directional elastomer mounts, vibration isolation from 10 Hz upwards, displacement under shock up to 38m, oil and grease resistant
- Interface: 1 and 4 fixture points to equipment and foundation respectively
- Temperature range -30 +100 deg C
- Static loading per mount 25 to 1500 kg approx., damping ratio 8-10% to viscous.

Typical applications in the Defence, Aerospace, Medical and Machinery industries for direct isolation of delicate equipment.

product overview

Elastomer BFJ

- Multidirectional elastomer mounts, combined shock and vibration isolation from 15Hz upwards, displacement under shock up to 50mm, oil and grease resistant
- Interface : 1 and 2 fixture points to equipment and foundation respectively
- Temperature range -30 +100 deg C
- Static loading per mount 10 to 130 kg approx., damping ratio 8-10% to viscous.

Typical applications in the Defence, Aerospace, Medical and Machinery industries for direct isolation of delicate equipment.

Elastomer BFL

- Multi-directional elastomer mounts, vibration isolation from 12 Hz upwards, displacement under shock up to 50 mm, oil and grease resistant.
- Interface: 1 and 4 fixture points to equipment and foundation respectively.
- Temperature range -30 +100 deg C
- Static loading per mount 4 to 12 kg approx., damping ratio 8-10% to viscous.

Typical applications in the Defence, Aerospace, Medical and Machinery industries for direct isolation of lightweight delicate equipment

Elastomer BF45

- Multidirectional elastomer mounts for Naval applications, combined shock and vibration isolation from 7Hz upwards, displacement under shock up to 55mm, oil and grease resistant
- Interface : 1 and 4 fixture points to equipment and foundation respectively
- Temperature range -30 +100 deg C
- Static loading per mount 30 to 1100 kg approx., damping ratio 5-8% to viscous.

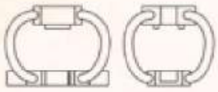
Typical applications on Naval vessels for protection of non-deck mounted shipboard equipment against underwater shock and ship vibration.

Elastomer BFN45

- Multidirectional elastomer mounts for Naval applications, combined shock and vibration isolation from 7Hz upwards, displacement under shock up to 55mm
- Interface : 1 and 4 fixture points to equipment and foundation respectively
- Temperature range -30 +70 deg C
- Static loading per mount 30 to 1100 kg approx., damping ratio 3-5% to viscous.
- low dynamic stiffening coefficient (<1.4)

Typical applications on Naval vessels and submarines for protection of non-deck mounted shipboard equipment against underwater shock and ship vibration.

Naval Polycal



- Multi-directional equivalents to Admiralty X and Y mounts, vibration isolation from 5 Hz upwards
- Interface : 1 and 2 fixture points to equipment and foundation
- Exceptional reliability and long life, transmitted acceleration limited to 7 g, temperature range -180 +300 deg C
- Static loading per mount 10 to 450 kg approx., damping ratio 8-25% to viscous.

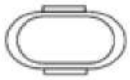
Typical applications on Naval vessels for protection of non-deck mounted shipboard equipment against underwater shock and ship.

Naval Half Helical

- Multi-directional equivalent to Admiralty X and Y mounts, vibration isolation from 5 Hz upwards
- Interface : 2 fixture points to equipment and foundation
- Exceptional reliability and long life, transmitted acceleration limited to 7 g, temperature range -180 +300 deg C
- Static loading per mount 10 to 450 kg approx., damping ratio 8-25% to viscous.

Typical applications on Naval vessels for protection of non-deck mounted shipboard equipment against underwater shock and ship vibration

Leaf Springs



- Multi-directional Admiralty X and Y mounts, vibration isolation from 5 Hz upwards
- Interface : 1 fixture point to equipment and foundation
- Transmitted acceleration limited to 15 g, temperature range -20 +40 deg C
- Static loading per mount 10 to 450 kg approx., damping ratio 8-25% to viscous.

Typical applications on Naval vessels for protection of non-deck mounted shipboard equipment against underwater shock and ship vibration.

Fundamental dynamics

Free vibration-single linear oscillator

Linear vibration analysis is based on the simple single degree of freedom harmonic oscillator depicted in figure 1, and is generally referred to as the mass-spring-damper model. The forces acting in the system and hence the motion behaviour are governed by the three components: 'm' represents mass inertial forces,: 'k' the stiffness component (depicted as a spring) which exerts a restorative force proportional to its deformation 'x' and finally a dashpot 'c' which supplies a force proportional to the relative velocity of motion in the link otherwise known as viscous damping. This simplified system, or a summation of these systems can be used to represent a range of linear, rigid body dynamic behaviours.

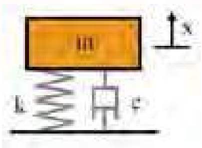


Figure 1 Mass spring damper model

From Newton's second law, the equations of motion for mass-spring-damper system is can be represented as an ordinary differential equation using mass, stiffness and damping coefficients.

$$\ddot{x} + 2\xi\omega_n\dot{x} + \omega_n^2 x = 0 \quad \text{Where:} \quad \omega_n = \sqrt{\frac{k}{m}} \quad \text{is}$$

The natural angular frequency of free vibration without damping, giving the natural frequency in cycles per second or Hertz,

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

The damping component ξ, is expressed as the ratio of damping in the system to the critical value C_c where oscillation in the system would cease.

$$\xi = \frac{C}{C_c} = \frac{C}{2\sqrt{km}}$$

The frequency of the oscillations in the damped system is related to the un-damped natural frequency.

$$\omega_d = 2\pi f_d = \omega_n\sqrt{1-\xi^2}$$

Forced vibration

To illustrate what happens when an external force acts to excite the mass-spring-damper system harmonically at frequency f we use the ratio of the harmonic force frequency to that of the undamped natural frequency of the model,

$$r = \frac{f}{f_d}$$

and calculate the resulting amplitude and phase gives the frequency response of the system (see figure 2) .

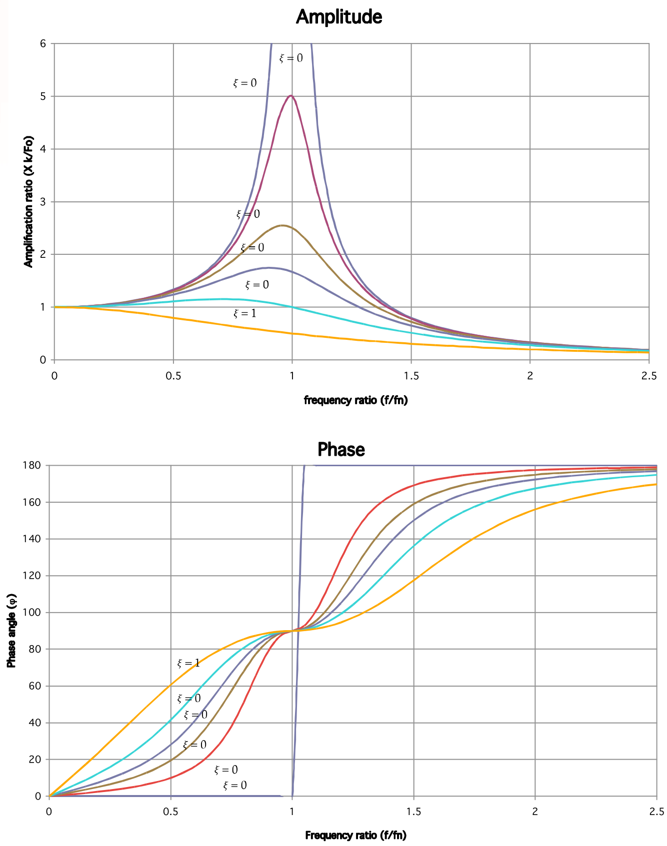


Figure 2 Frequency response

We see that the amplitude of the vibration can resonate in a lightly damped system when the forcing frequency nears the natural frequency ($r \approx 1$). Consequently the major reason for vibration analysis is to predict when resonance may occur and to take preventative steps.

Damping can significantly reduce the magnitude of the vibration and the magnitude of transmitted vibration can be reduced if the natural frequency can be shifted away from the forcing frequency by changing the stiffness or mass of the system. With little or no damping, the vibration is in phase with the forcing frequency when the frequency ratio r < 1 and 180 degrees out of phase when the frequency ratio r >1. When r<<1 the amplitude is just the deflection of the spring under the static force F_0. This deflection is called the static deflection. Hence, when r<<1 the effects of the damper and the mass are minimal. When r>>1 the amplitude of the vibration is actually less than the static deflection. Here the force generated by the mass dominates because the acceleration experienced by the mass increases with the frequency. Since the deflection seen in the spring is reduced in this region, the force transmitted by the spring to the base is reduced. Therefore the mass-spring-damper system is isolating the harmonic force from the mounting base—referred to as vibration isolation. Adding more damping actually reduces the effects of vibration isolation when r>>1 because the damping force is also transmitted to the base.

Shock

Unlike vibration, which is analysed as steady-state, shock is transient principally modelled as either a change in velocity or as displacement. An isolator's function is to store energy and then release it over a longer period of time. That energy is stored as deflection and can be analysed using the same mechanisms discussed in the sections above.
Shock input is often defined as a drop impact or by a pulse, for example: half-sine, triangular and rectangular waveforms. An acceleration single pulse corresponds to a velocity step, a double respectively to a displacement step. To calculate the shock response of a linear system, a convenient tool is the shock response spectrum as shown opposite in figure 3.

Nonlinearity

All of the above applies to linear systems, never met in the real world: the above differential equations are still valid, however no longer with constant coefficients, meaning that the solutions are not purely sinusoidal. Solutions can be found by direct integration and numerical methods. The equations are often linearised : in vibration, an initial stiffness is found from the load deflection curves of the elastic supports assuming a certain displacement, the corresponding resonance frequency and response displacement calculated , then re used to correct the initial value and so on by iterations.

Shock is a bit more risky to linearise as it involves larger displacements than vibration: then the input is usually considered as a short impulse diluted in the response, calculated by equating kinetic and potential energy. Sets of nomograms are supplied in the relevant catalogue sections, making it easier to take nonlinearities into consideration. Adequate programs have also been developed by Socitec.

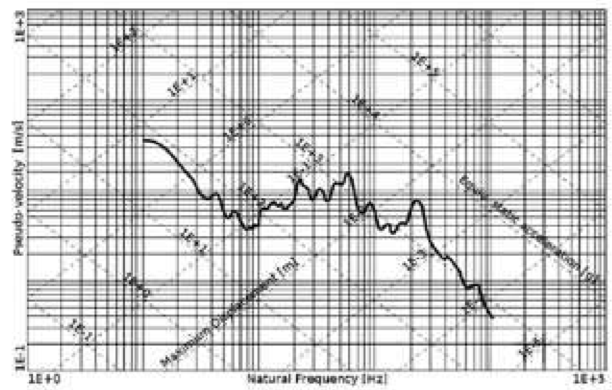


Figure 3 Shock response spectrum

Multiple degree-of-freedom systems

A further complication is introduced when the degree of analysis requires to take into accounts rotations and flexibility of the equipment and/or the supporting structures. Single oscillator equations apply in rotation by substitution of mass by moment of inertia and stiffness by rotational stiffness : there are many cases, however, where rotation and translations are coupled, thus a more sophisticated model is required to approach the global dynamic behaviour of the system. Again, the initial equations can be used, replacing variables and constants by matrixes: then we talk about mass/inertia matrix, stiffness and damping matrix.
The excitation is row matrix vector, as well as the response, and solving the differential system is called the eigenvalues, eigenvector problem, in the complex domain if damping is considered. It is not easy, nor even conceivable to carry out such calculations by hand above 3 degree-offreedom and it is then made good use of lump programs (up to 500 degree-of-freedom), such as Socitec SYMOS, or further to finite elements programs, where limitation is only computing power and ...collecting the proper data ! Multiple degree-of-freedom systems can be nonlinear as well in a more general approach, and again linearization can be used for vibration, whereas direct integration is needed for transients.

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