



Development Work Notice

This document has been prepared as a notification of work in progress within the ESDU committees that will result in future product updates. It will be updated and re-issued throughout the development process.

ESDU Topic:

Dynamic characteristics of cylindrical helical springs.
Part 4: examples and computer program.

Scope:

The dynamic behaviour of cylindrical helical springs, comprising both tension/compression and torsion springs, is extremely difficult to calculate since its geometrical shape is a curve in three-dimensional space. To make the calculations manageable, simple but representative mathematical models are required. The simplest of such models is the straight elastic rod, the so called 'equivalent rod' which clearly must have the same elastic properties as the helical spring it represents.

This Data Item will provide examples that illustrate the use of the Parts 1, 2 and 3 of the series of Items on the dynamic characteristics of springs. A computer program will also enable dynamic spring characteristics to be evaluated.

Part 1 of the springs Item, ESDU 06024, defined the assumptions and limitations that apply to the calculation procedure for estimating the dynamic characteristics of springs, together with the prescribed loading conditions assumed to apply to the spring. The Item also provided derivation of the deformation, stresses and transverse loading on the spring and the form design of the spring ends which will affect the loading characteristics. The elastic stability of compression and torsion springs was discussed and formulae given for ensuring stability.

The second Data Item, ESDU 08015, extended the scope of the earlier Item, presenting the vibration characteristics of cylindrical helical springs. The Item discussed the axial vibration of compression/tension helical springs on the basis of the 'equivalent rod' approximation, dealing with both free and forced axial vibration. For free vibration, cases when both ends of the rod are free, one end of the rod is clamped and the other end is free and both ends of the rod are clamped, are considered. For forced vibration, the case when one end of the spring is forced to follow a cyclic motion and the stresses induced by the cyclic motion was also discussed. Further consideration was given to free and forced vibrations of a spring-mass system, dealing with the two cases when the system mass is large compared to the mass of the spring and when it is of comparable size. The influence of various kinds of damping, Coulomb and viscous friction, material hysteresis, etc. was also discussed. In

conjunction with forced vibration, the resonance phenomenon was dealt with in a number of sections.

Part 3 of the series on the dynamic characteristics of springs extended the scope of the earlier Items to impact loading. The classical theory of impact regards the bodies involved as rigid and the impact as being instantaneous and so it is suitable only for determining the kinetic consequences of the impact. When the impact process itself is to be investigated, *i.e.* its duration and the deformations, forces and stresses involved, much more advanced theories must be used. However, when the dynamic behaviour of only a spring-mass system after impact is the subject of the investigation, and not that of the spring itself, the classical theory of impact proves to be very useful. As far as the impact process is concerned, there are two extreme idealised cases, the perfectly non-elastic impact and the perfectly elastic impact. The reality lies somewhere in between these two extremes. Accordingly, in practical calculations a so-called "impact coefficient", designated κ , is introduced which has the values in the range $0 \leq \kappa \leq 1$. In the case of a perfectly non-elastic impact its value is zero, *i.e.* $\kappa = 0$, and in the case of a perfectly elastic impact, $\kappa = 1$. In the first part of that Item, the impact on spring-mass systems is investigated using the classical theory of impact. In the latter part of the Item the problem of an impact on an elastic rod is considered. This latter problem has a special practical significance, since an elastic rod can be used as an "equivalent rod" representing a helical spring.

Keywords: axial, coil, compression, cyclic, cylindrical, deformation, elastic, energy, equivalent, forced, free, frequency, friction, function, helical, helix, impact, kinetic, load, loading, mass, modulus, motion, oscillate, oscillation, period, potential, resonance, rod, shear, spring, spring, stability, step, stiffness, stress, tension, torque, torsion, transition, velocity, vibration, wire, Young's.

ESDU Series: Mechanisms.

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