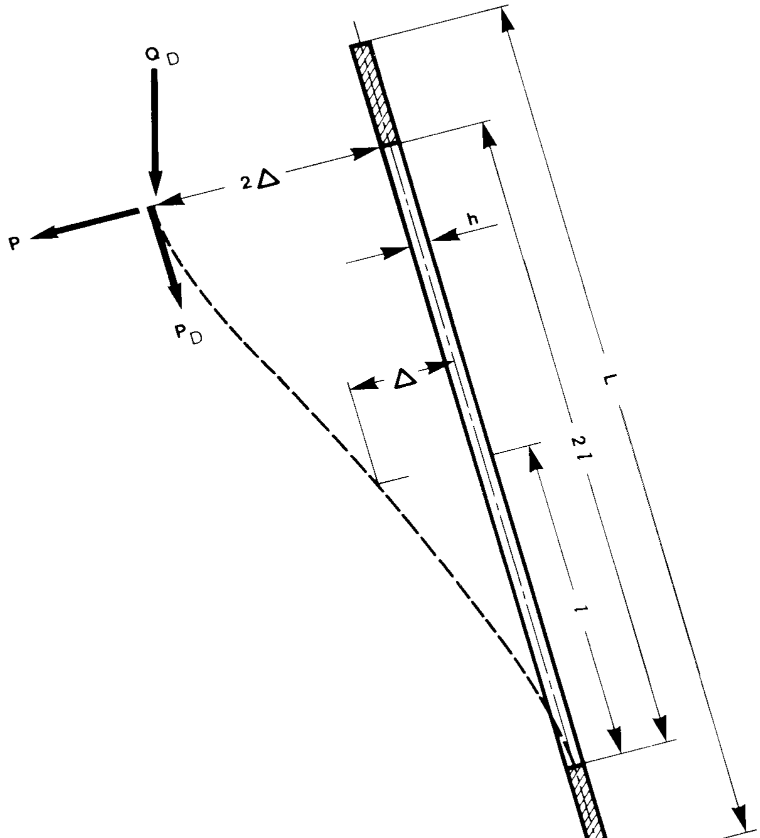
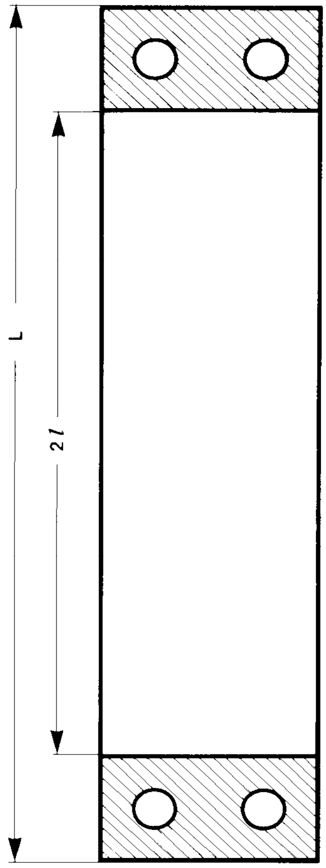
Product-Information

S-Ply®

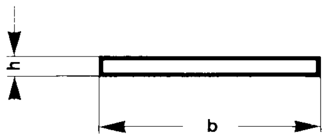
Calculation principles for leaf springs at resonant frequency (part I of III)





Influencing variables:

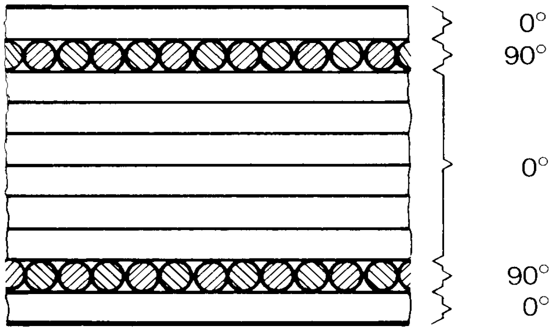
Q_D (kg) = Weight on spring
P_D (N) = Columnload on spring due to Q_D
P (N) = Force at support to deflect spring
2Δ (mm) = Deflection
L (mm) = Total spring length
2*l* (mm) = Unsupported length
h (mm) = Thickness of spring
b (mm) = Width of spring
f (sec^{-1}) = Working frequency
F_N (sec^{-1}) = Resonance frequency of the vibrating system
E (N/mm^2) = Flexural modulus of the spring material



* for vibroconveyors with positive drive in resonance frequency

Calculation principles for leaf springs at resonant frequency (part II of III)

Spring configuration



Thickness h of a leaf spring is made up of:

n layers 0° times 0,25 mm per layer
plus 2 layers 90° (for leaf spring thicknesses $\leq$ 10 mm)
plus 4 layers 90° (for leaf spring thicknesses 10 – 19 mm)
plus 6 layers 90° (for leaf spring thicknesses $\geq$ 20 mm)

Mechanical properties (at room temperature):

Young´s modulus	**E**	**= 28 · 10³ N/mm²**
Flexural strength	**σ_b**	**= 138 N/mm²**
Friction coefficient	**S-Ply - steel**	**= 0,17 µ**
	S-Ply - aluminium	**= 0,18 µ**

Remarks and calculations:

Q_D calculated from the weight of the trough (Q_1) plus 20% of the weight of the transported material (Q_2), distributed on n supporting leaf-springs.

(1)
$$Q_D = \frac{Q_1 + 0{,}2 \cdot Q_2}{n}$$

The calculation principle for the determination of the leaf-spring thickness applies to oscillating conveyors with an operating frequency approaching the systems resonant frequency. The following applies:

(2)
$$f_N = \frac{1}{2\pi} \cdot \sqrt{\frac{K}{M}}$$

for f $\cong f_N$ [Hz]
M = Q_D [kg]
K in [N/m]

Thus the spring constant K in **N/mm** is derived:

(3)
$$K = \left(\frac{f_N}{5{,}03}\right)^2 \cdot M \quad \text{[N/mm]}$$

To calculate force ***P*** for the maximum amplitude of a leaf-spring:

(4)
$$P = K \cdot 2 \cdot \Delta = \frac{E \cdot b \cdot h^3 \cdot \Delta}{4 \cdot l^3}$$

Thus the leaf-spring thickness ***h*** is derived:

(5)
$$h = \sqrt[3]{\frac{4 \cdot P \cdot l^3}{E \cdot b \cdot \Delta}} \quad \text{[mm]}$$

To calculate the maximum bending stress σ_b, the following applies:

(6)
$$\sigma_b = \frac{6 \cdot P \cdot l}{b \cdot h^2} + \frac{12 \cdot P_D \cdot \Delta}{b \cdot h^2} \quad \text{[N/mm}^2\text{]}$$

Thus for $P_D \ll P$:

(7)
$$\sigma_b = \frac{3 \cdot E \cdot h \cdot \Delta}{2 \cdot l^2} \quad \text{[N/mm}^2\text{]}$$

Stress analysis and result discussion:

The leaf-spring is suitable, for oscillating conveyors of the specified design, if the value for σ_b does not exceed the maximum allowed value of $\sigma_{b\ (allowed)}$.
However, if the **value is exceeded**, a damage (delamination or breaking) can occur as a result of overstraining.

The following design changes can be helpful:

a) Extension of the free spring-length *2 l*
b) Increasing the number of supporting points
c) Installation of multiple leaf-springs per supporting point

Calculation principles for leaf springs at resonant frequency (part III of III)

Replacement of single leaf-springs:

For the replacement of a leaf-spring with the thickness h_1, the following applies:

$$\boxed{n = \frac{h_1^3}{h_2^3}}$$

at a constant rigidity of the total system

Derivative:

$$\boxed{h_2 = \sqrt[3]{\frac{h_1^3}{n}}}$$

Replacement of steel-leaf-springs by S-Ply-leaf-springs:

For the equivalent rigidity of S-Ply-leaf-springs to steel-leaf-springs
at the same spring displacement, the following applies:

$$\boxed{h = h_{Stahl} \cdot \sqrt[3]{\frac{n \cdot E_{Stahl}}{E_{S\text{-}Ply}}}}$$

In which n represents the quantity of steel-leaf-springs, h_{stahl} the thickness of the steel-leaf-spring and E_{stahl} represents the Young´s modulus of the steel-leaf-spring.