Basics - Calculation

The calculation of the values, given in the catalogue, are based on the following assumptions and simplifications:

Transmissible torque

A shrink disc connection is capable of transmitting torque, bending moment and axial force. Alternatively, the transmissible torque M_{max} is specified in the product data. If such loads occur simultaneously then they must be added vectorially to the resultant moment M_{res}. The formula below applies to the resulting moment:

$$M_{res} \leq M_{max}$$

At different load cases, these are individually checked against M_{max}!

M_{res} is determined for combined loads as follows:

$$M_{res} = \sqrt{M_T{}^2 + M_B{}^2 + (F_{AX} \tfrac{dW}{2})^2}$$

with $M_B \leq 0{,}3\, M_T$ as the limit* for the the bending moment

*In principle, the maximum bending moment corresponds to the maximum transmittable torque. The limitation to 0,3 M_T is due to the change of the surface pressure at the edges of the connection. (see also „Bending moment")

This results in the following relationships:

Torque only:
The maximum torque is equivalent to M_{max} .

Bending moment only:
The maximum bending moment corresponds to 0,3 M_T .

Axial force only:
The maximum axial force is $M_{max} \frac{2}{d_W}$.

A different equation applies for very small shrink discs (3073):

$$M_B \leq 0{,}2\, M_T$$

Depending on the application, additional safety factors need to be considered for the individual loads!

Calculation of transmissible torques and forces

The catalogue data relates to specific shaft diameters which we recommend using. If the shaft diameter is between two sizes, the larger shrink disc should be selected. A deviation is possible within certain limits but the predetermined tolerances and surface roughness should be considered.

The shaft diameter and transmissible torque behave approximately proportional to each other. The transmissible torque increases with greater shaft diameter and vice versa. In contrast, the transmissible axial force changes only slightly. This is not due to the shaft diameter but because of the change in stiffness of the hub when the inner diameter changes.

Within certain limits, the changes can be linearly approximated. Information about the range of the respective shaft diameter can be found in the product data.
The determination of the deviating values is explained below. Please contact us if the shaft diameter must be outside the indicated range.
The formula below calculates the torque for specific shaft diameters:

$$M = M_{max\,(Catalog)} \frac{d_{W\,(target)}}{d_{W\,(Catalog)}}$$

The corresponding axial force which is transmitted instead of the torque, results as follows:

$$F_{ax} = M \frac{2}{d_{W\,(table)}}$$

Radial force

Radial forces cause a change in pressure at the contact surface. In the force direction, the pressure increases on the one side and is reduced accordingly on the other side. This depends on the amount of radial force and the rigidity of the parts.
The following equation can be used to approximate the pressure change:

$$\Delta p_W = 0{,}75 \frac{F_{AX}}{d_W\, l_K}$$

The modified pressures $p_{Wmin,\,max}$ results from the following equation:

$$p_{W_{min,\,max}} = p_W \pm \Delta p_W$$

The minimum pressure $p_{W_{min}}$ should be at least 50 N/mm² to avoid gap corrosion. In addition, the material must be designed for a maximum pressure $p_{W_{max}}$.

Basics - Calculation

Bending moment

Here the situation is similar to the radial forces. However the pressure is greatest at the ends of the connection in this case. Again, the amount and stiffness are important. This leads to the following approximation:

$$\Delta p_W = 4{,}5\,\frac{M_B}{d_W\, l_K^2}$$

As before, the modified pressures results from:

$$p_{W_{min,\,max}} = p_W \pm \Delta p_W$$

The conditions for minimum and maximum pressure are the same as before. It should be noted that there could be a change in pressure due to radial force!

Shaft and hub calculation

The catalogue contains information on the generated surface pressure for each shrink disc. The hub will be deformed due to the applied radial force. In addition to the clearance between shaft and hub, shaft stiffness and surface finish should be concidered. For solid shafts the flexibility can be ignored, but with hollow shafts (see „Bore in the shaft (hollow shaft)“) there is greater deformation and thus greater stresses in the components. This must be considered in addition to other loads.

The stresses in the hub can be determined by various hypotheses, such as GEH. We will not make a presentation and analyse results at this point because we would only be able to cover a very limited range of static applications. Various calculation methods for different cases can be found in engineering literature or using specialiced software. However, for complex geometry often only a calculation by FEM gives reliable results.

The information on the minimum yield strength of shafts and hubs are suggested recommendations, based on typical values for such applications. They are provided as guidelines and are not a replacement for a proper calculation for a given application!

Notch effect

Generally there is a notch effect on the components, caused by the radial pressure of the shrink disc. This depends mainly on the applied pressure. The notch effect is generally higher on the hub than on the shaft, because here the inner ring of the shrink disc is directly pressed onto the hub, while the stresses are distributed through the hub before reaching the shaft. The notch factors range from 2,5 to 3,5 for the hub and it is between 1,5 and 2 for the shaft. This can be mitigated by suitable design features, such as relief notches.

Some standards provide the possibility of a notch factor to be determined by a fit pairing for a shrink-connection. A similar method also can be used for a shrink disc connection. To this end an oversize can be calculated from the applied surface pressures. As a result, a matching fit pair can be determine and thus a resultant notch factor found.

Bore in the shaft (hollow shaft)

A large bore d_B in the shaft or the use of a hollow shaft, reduces the stiffness of this component against radial pressure. This leads to a decrease in pressure p_W, a reduced transmissible torque M, a contraction Δd_B within the shaft and an increase of stresses in these components. Basically, a bore should not be greater than 0,3 d_W.