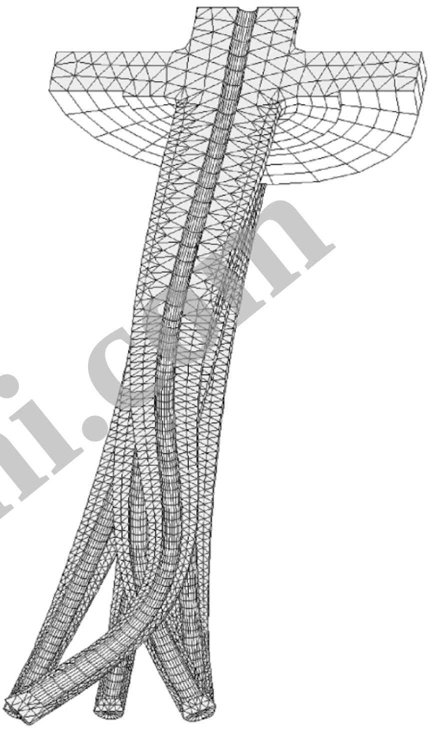
Strength Calculation for Thermowells

Applications

- The wake frequency calculation of thermowells serves as mathematical proof of the strength with respect to static and dynamic stress in consideration of the operating temperature

Special Features

- Calculation acc. to ASME PTC 19.3 or Dittrich/Klotter as engineering service
- Suggestions for a constructive change of the thermowell if the permissible stress limits are exceeded



FEM description of a thermowell's oscillation when the first three natural frequencies are superimposed

Description

The calculation acc. to ASME PTC 19.3 is used for taperd solid machined thermowells such as, for example, type SI400F, SI410F, SI440F, etc.

A calculation acc. to Dittrich/Klotter is recommended for all thermowells of WIKA's range of products, but especially for fabricated thermowells.

The process data required to perform a calculation in accordance with both of the a.m. methods is as follows:

- Flow velocity (m/s)
- Medium density (kg/m³)
- Temperature (°C)
- Pressure (bar)

Moreover, the following information will be required for suggestions concerning constructive changes if the admisible stress limits are exceeded:

- Inner diameter of nozzle
- Height of nozzle
- Inner diameter and wall thickness of pipeline / container

The results in both methods are considered separately in a static and dynamic part.

ASME PTC 19.3

The frequency ratio of the wake frequency to the natural frequency *fw / fn* is the result of the dynamic calculation of the thermowell and should be less than 0.8.
The frequencies are calculated as follows:

$$\frac{fw}{fn} < 0.8 \qquad fw = 2.64 \times \frac{v}{ØF_3} \qquad fn = \frac{Kf}{U_1{}^2} \times \sqrt{\frac{E\,\mathrm{mod}}{\rho}}$$

The wake frequency *fw* is calculated from the flow velocity v of the process medium and the tip diameter F_3 of the thermowell. The factor 2.64 is based on the Strouhal figure and is assumed to be constant for subcritically turbulent flows.

The insertion length U_1, the modulus of elasticity as well as the specific gravity of the thermowell material are required in order to calculate the natural frequency *fn*.
The factor *Kf* results from the empirically ascertained tables of value of the ASME PTC 19.3

Neither the insertion length of the thermowell shielded by the nozzle nor the viscosity of the medium will affect the original calculation according to ASME PTC 19.3.

In addition to the above, the maximum pressure and the maximum insertion length U_1 will be calculated for the static consideration.

Dittrich / Klotter

The dynamic consideration is carried out analoguous to ASME PTC 19.3. It may, however, deviate to a minor degree from the results of tapered thermowells.
The calculation results of straight thermowells deviate significantly when compared to ASME PTC 19.3, as the fundamentals of this calculation rest on tapered thermowells.

The statical consideration is based on the calculation of the strain, which acts upon the thermowell in case of stress. This strain is compared with the permissible strain of the thermowell material and indicated via safety factors.

Suggestions for constructive changes if the permissible stress limits are exceeded

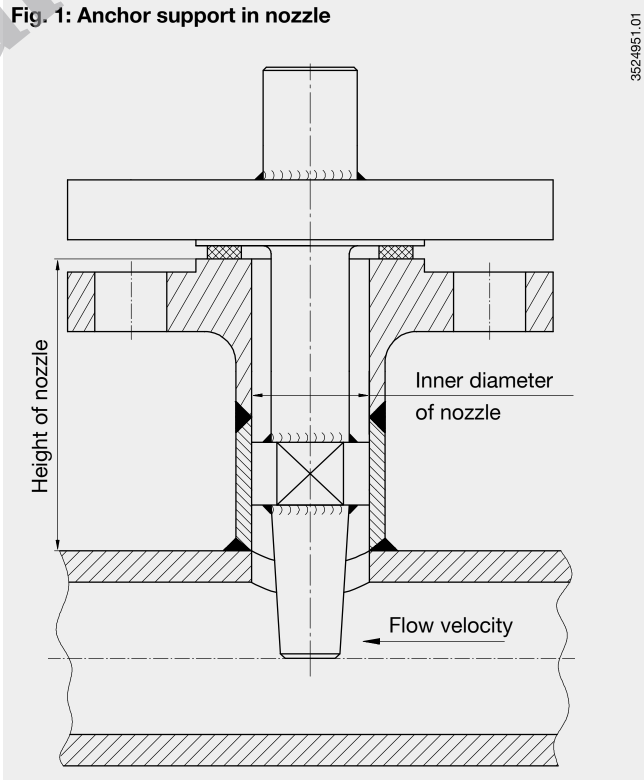
If the ratio of the wake frequency to the natural frequency *fw / fn* is gigger then 0.8 it is possible to perform the following constructive changes:

a) Shortening of the insertion length U_1
This is the most effective way to improve the frequency ratio *fw / fn* < 0.8.
It may happen, however, that the max. calculated insertion U_1 is smaller than the length of the nozzle, which would result in a complete shielding of the thermowell through the nozzle. This requires alternative designs.

b) Support via anchor
For the anchor support principle, please refer to fig. 1.
By supporting the thermowell in the nozzle, the insertion length U_1 is reduced to the freely oscillating insertion length $U_{red.}$; the latter complies with the requirements of the dynamic consideration *fw / fn* < 0.8.

A weld-on 3-point anchor is used which allows the pressure medium to progress as far as to the flange sealing face. This enables an excellent temperature transfer of the medium to the thermowell, excluding drawbacks with respect to the response time at the same time.
The anchor will be produced to the effect that it provides an air gap on both sides < 0.15 mm to the inside of the nozzle.

Fig. 1: Anchor support in nozzle

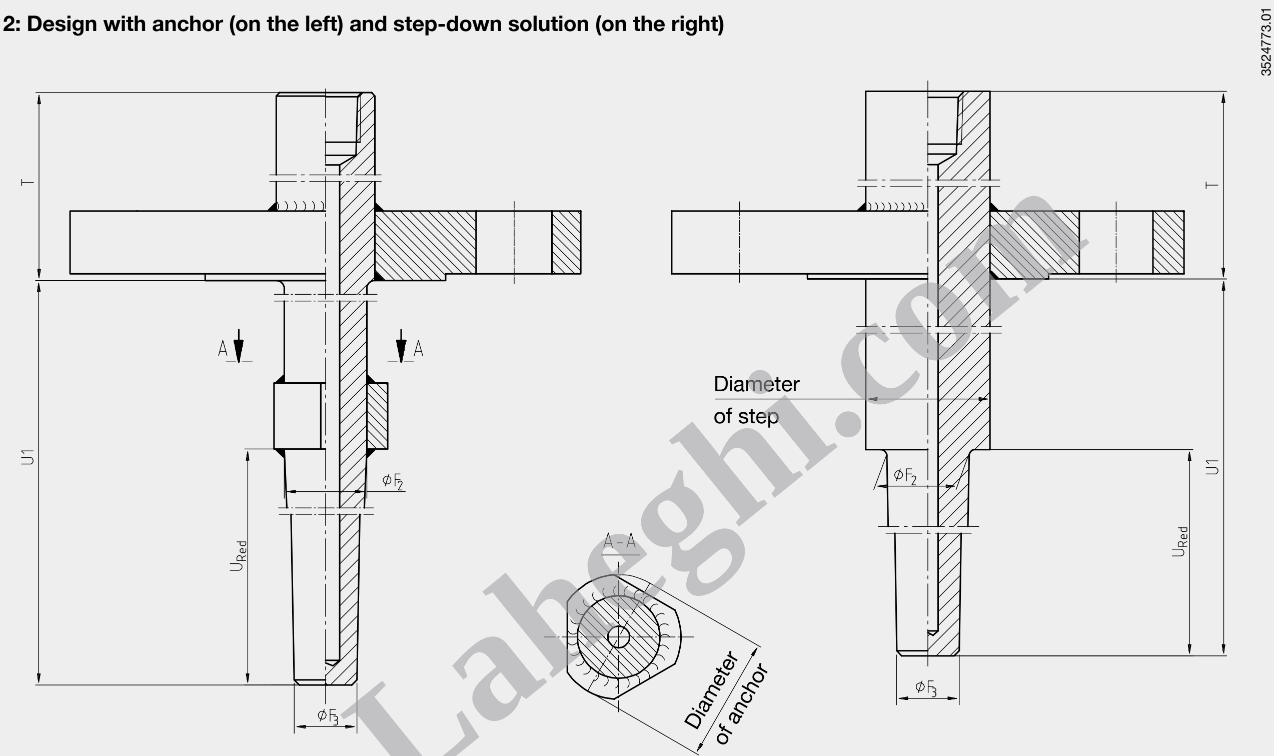


c) Step-down solution

The principle of the step-down solution (see fig. 2) is identical to that of the support by means of the 3-point-anchor.

The benefit of the 3-point-anchor is based on the profitablity provided by lower material usage and the simplifed installation in the nozzle.
The step-down design is used for nozzles with small inner diameters, as the anchor support cannot be used for them.

Fig. 2: Design with anchor (on the left) and step-down solution (on the right)



Provision of calculation data

The example in the following spreadsheet shows how the process and geometry data should be provided for further electronical processing by WIKA .

Sample spreadsheet including calculation data for 6 measuring points

Tag No.	T	P	v	rho	U_1	d_1	F_2	F_3	s_1	Material	IDS	HS
	in °C	in bar	in m/s	in kg/m^3	in mm	in mm	in mm	in mm	in mm	EN	in mm	in mm
TW-0301	220	1.5	23.6	2.4	250	8.5	25	19	7.5	1.4435	38.3	220
TW-0303	220	1.5	25.7	2.0	250	8.5	25	19	7.5	1.4435	38.3	220
TW-0305	235	10	19.6	6.1	250	8.5	25	19	7.5	1.4435	38.3	220
TW-0307	220	10	13	8.9	355	8.5	25	19	7.5	1.4571	38.3	220
TW-0309	235	30	8.9	28.3	355	8.5	25	19	7.5	1.4571	38.3	220
TW-0311	400	31.5	31.9	10.1	355	8.5	25	19	7.5	1.4571	38.3	220

Legend:

T	Temperature
P	Pressure
v	Flow velocity
rho	Density of process medium
U_1	Insertion length
Ø d_1	Bore size
Ø F_2	Root diameter
Ø F_3	Tip diamter
S_1	Tip thickness
IDS	Inner diameter of nozzle
HS	Height of nozzle

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