Operating Instruction for the Thermowell Calculation Program according to ASME PTC 19.3 TW-2010

Version 2.5.2

Table of Content

Disclaimer

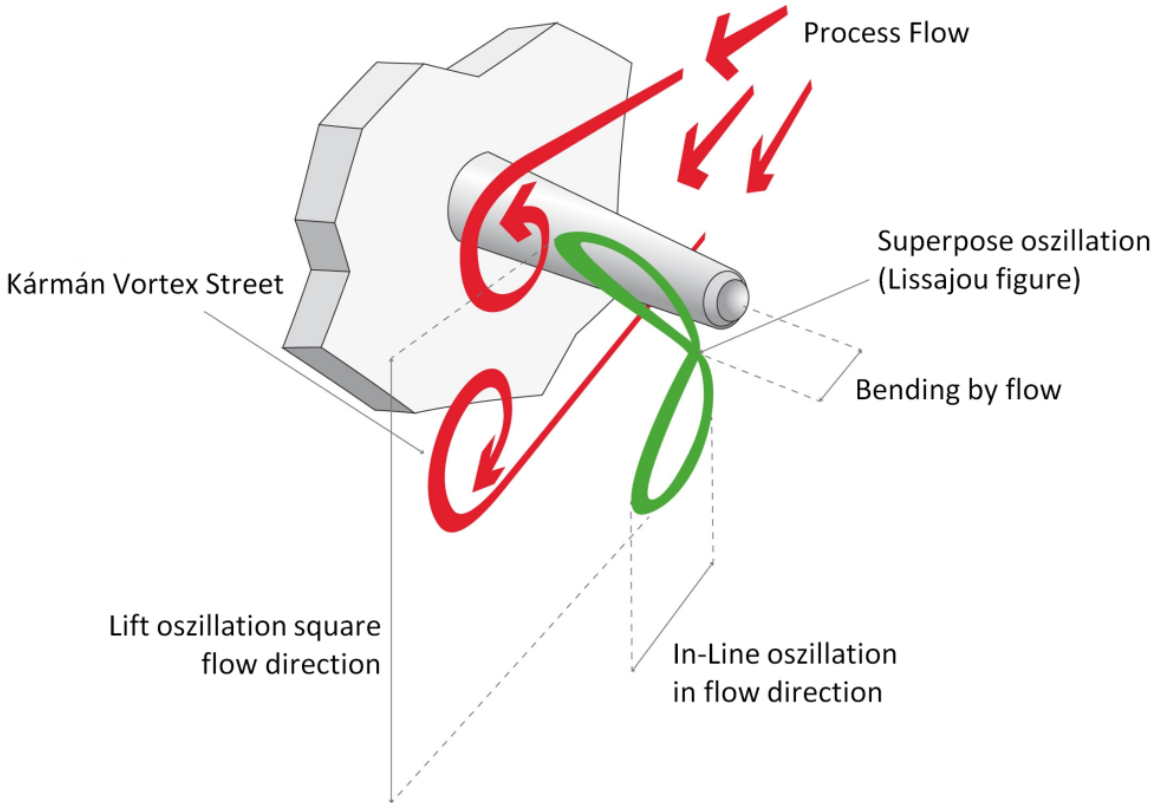
WIKA has made every reasonable attempt to validate the calculation procedure contained in this spread sheet, however, responsibility for validation rests solely with the end user.
This WIKA ASME PTC 19.3 TW-2010 spread sheet copyright© 2010 (compatible with Excel 2007/2010) is intended to assist the experienced designer of thermowells and should not be considered as a replacement for professional engineering.
The end user is responsible to assure that the calculation method is compatible to the process conditions. For further information see this Operation Instruction

Introduction

The wake frequency calculation for thermowells ASME PTC from 1974 (re-affirmed 1986) was widely used and well accepted. Many thousands of thermowells were designed using this method.

But after a catastrophic incident at the Japanese nuclear power station Monju in 1995, where a thermowell failed which previously had passed the ASME PTC calculation, the standard required a review.

It was discovered that there are specific conditions, which create a second so called ‘inline resonance’ of the thermowell. This critical oscillation has half of the frequency ratio of the known transverse resonance perpendicular to the flow. These results challenged the old standard.



During a long process, many global experts created a new thermowell calculation method ASME PTC 19.3 TW-2010, which is the base for the calculation program presented by WIKA Instruments.

Like in Monju it is possible, that a thermowell which has been designed using the ASME PTC 19.3 1974 standard fails using the new method. For that reason we strictly recommend the re-engineering of critical thermowell applications, especially if the process is filled with liquids of high density.

How does the ASME PTC 19.3TW-2010 works?

The most important innovation compared to the previous thermowell calculations is the superposed oscillation of the thermowell perpendicular to the flow direction of the medium in the pipeline (lift oscillation) and in the flow direction (drag oscillation) (fig. 1).

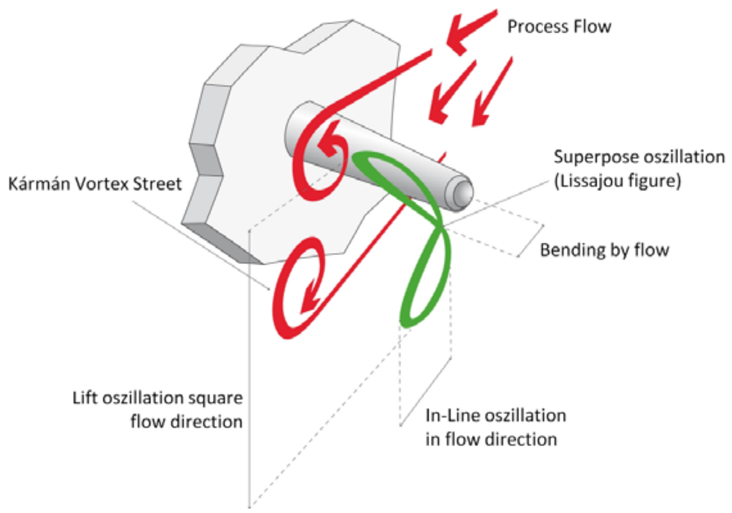


Fig. 1:
Representation of the oscillation directions

The two oscillations are superposed at an approximate amplitude ratio of 10:1, in which the ratio of the resonance frequencies of the two oscillations is approx. 1 : 0.5 (fig. 2)

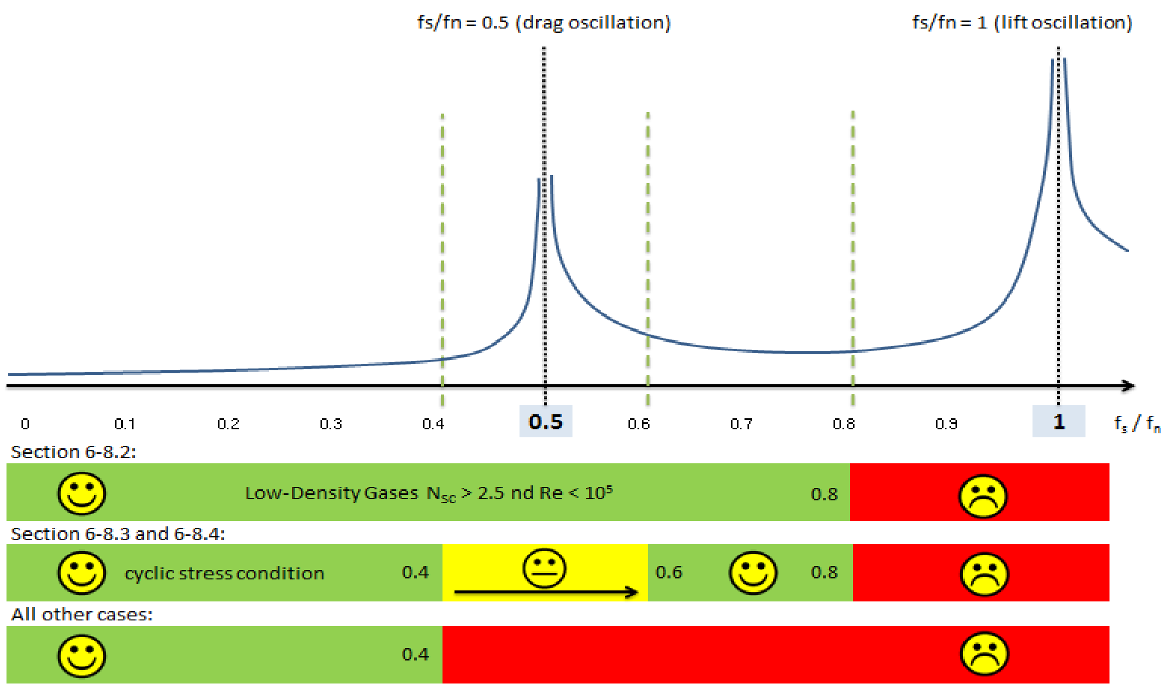


Fig. 2:
Representation of the in-line and main resonances

Further additions in the ASME PTC 19.3 TW-2010 include the shielding of the flange nozzle of the thermowell and the effect of the viscosity of the process medium on the calculation.

The ASME PTC 19.3 TW-2010 is divided into dynamic and static calculation results. The evaluation of the dynamic results is made using the damping factor N_{SC} (Scruton Number). For gaseous media, a characteristic value is $N_{SC} > 2.5$; fluids typically have an $N_{SC} < 2.5$. The Scruton Number N_{SC} has a direct relationship to the permissible frequency ratio "r_{max}" of the wake frequency f_s to the natural frequency f_n. Whereas for low density gases the previous limit frequency of $r_{max} = 0.8$ is still valid, for all other media the frequency limit of $r_{max} = 0.4$ for in-line resonance now applies. In accordance to section 6-8.3 and 6-8.4, the operation of the thermowell within frequency ratio 0.4 – 0.6 is not allowed.

Whether the frequency ratio, $r < 0.8$, can be used as an evaluation limit with liquid process media, is determined through a consideration of the permissible stresses in the thermowell material with respect to the actual stresses at resonance. In addition, an evaluation of the strength of the thermowell material with respect to the flexural fatigue stress in the area of the thermowell rigid support is carried out.
The static results of ASME PTC 19.3 TW-2010 are the maximum permissible process pressure, depending on the process temperature and the geometry of the thermowell, and the bending stress in the area of the thermowell root, caused by the incident flow on the thermowell, depending on the shielded length of the flange nozzle.

Getting started

The program was designed with Microsoft® Office Excel® 2007/2010, which is not included in the WIKA delivery. [1]

All calculations are performed by a macro operation process.
The usage of external macros is normally disabled, when you start to work with Microsoft® Office Excel® 2007/2010, so please change the security settings, if you want to work with the WIKA Thermowell calculation program.

Installation

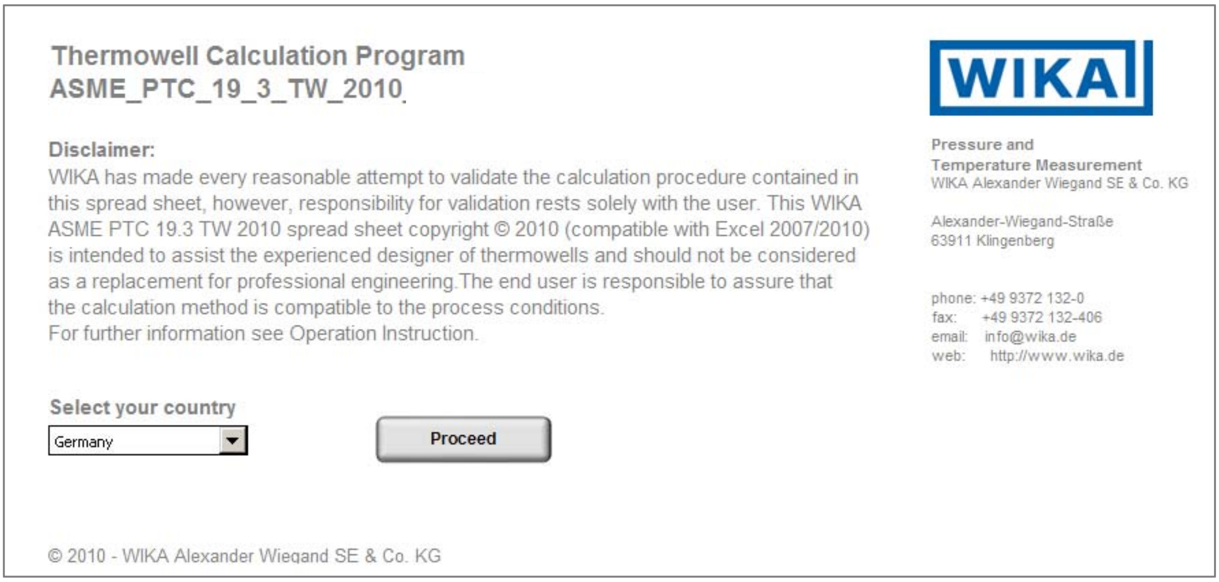
Please copy the Excel® file to a directory on your hard-disk.

Do not rename the file, otherwise some macros are locked and the program will not run anymore.

Starting

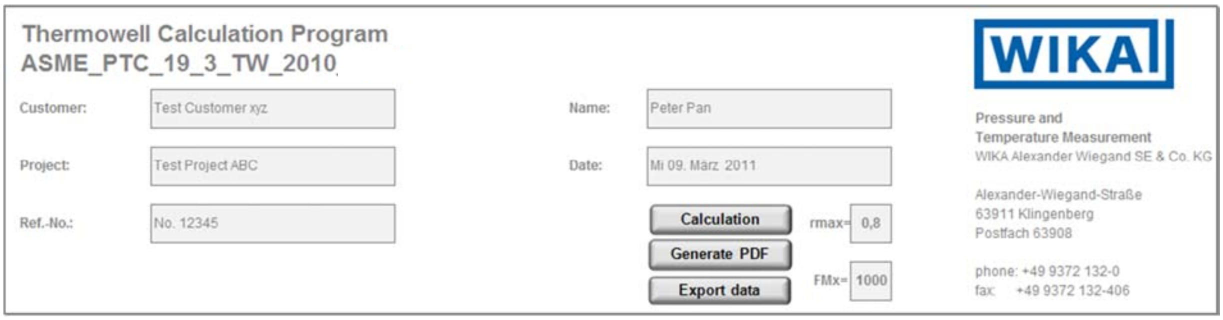
Start the Excel® file by double-clicking the name or symbol. Usually the program starts at the point, where you have left it at the last storage. Select your country and press **PROCEED** to continue.

- [1] Microsoft and Office Excel are registered trademarks of Microsoft Corporation in the United States and other countries.



Enter your data

Enter your name and the actual project data to make it possible to identify who has created the calculation. The use of special character (e.g. slash for date 2011/07/03) should be avoided.

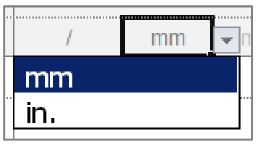


Default calculation settings

The default values for r_{max} = 0.8 and F_{Mx} = 1000 are recommended by the ASME standard. These values should not be changed. They are reserved for experienced users, who want to compare the results with other thermowell calculation programs.

Enter available data:

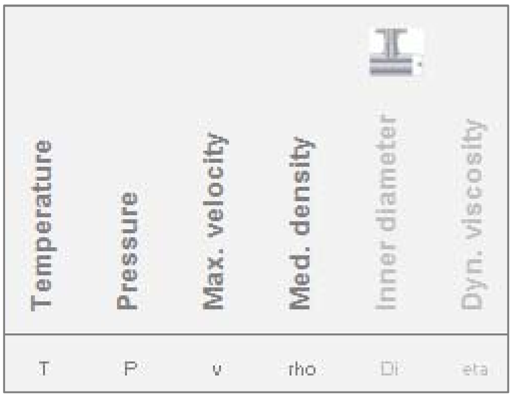
Choose unit



The thermowell calculation can be performed with imperial or metric units.
In the pull-down menu in the headlines you will get a list of acceptable units.

The selection of the unit is valid for all lines of this column. It is not possible to have different units in one column.

Process data



All necessary process data has to be entered.

Temperature
Enter here the temperature for stress calculation.

Pressure
Enter here the pressure for stress calculation.

Velocity
Enter here the velocity for stress calculation. By choosing the unit kg/h or lb/h, enter here the mass flow rate.

Density
Please enter the density at the operating point. Especially in applications for gas and vapour the density is highly affected by temperature and pressure. Liquids are nearly incompressible, so their density is mainly influenced by the operating temperature.

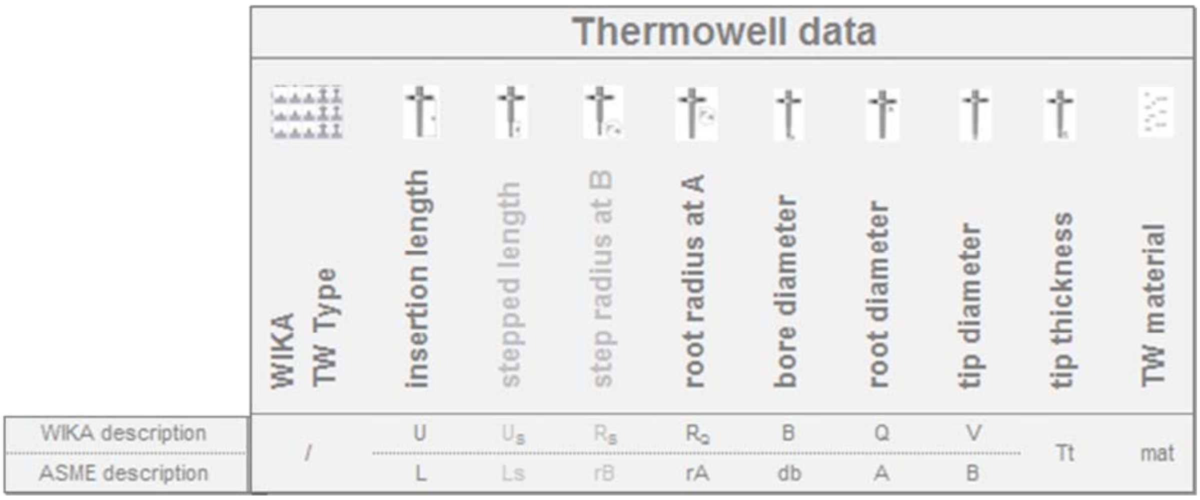
Inner diameter
If mass flow rate is chosen, then enter here the inner diameter of the process piping.

Viscosity
If the viscosity is unknown, please enter 0. The program will automatically work with a constant Strouhal number of 0.22.

Thermowell data

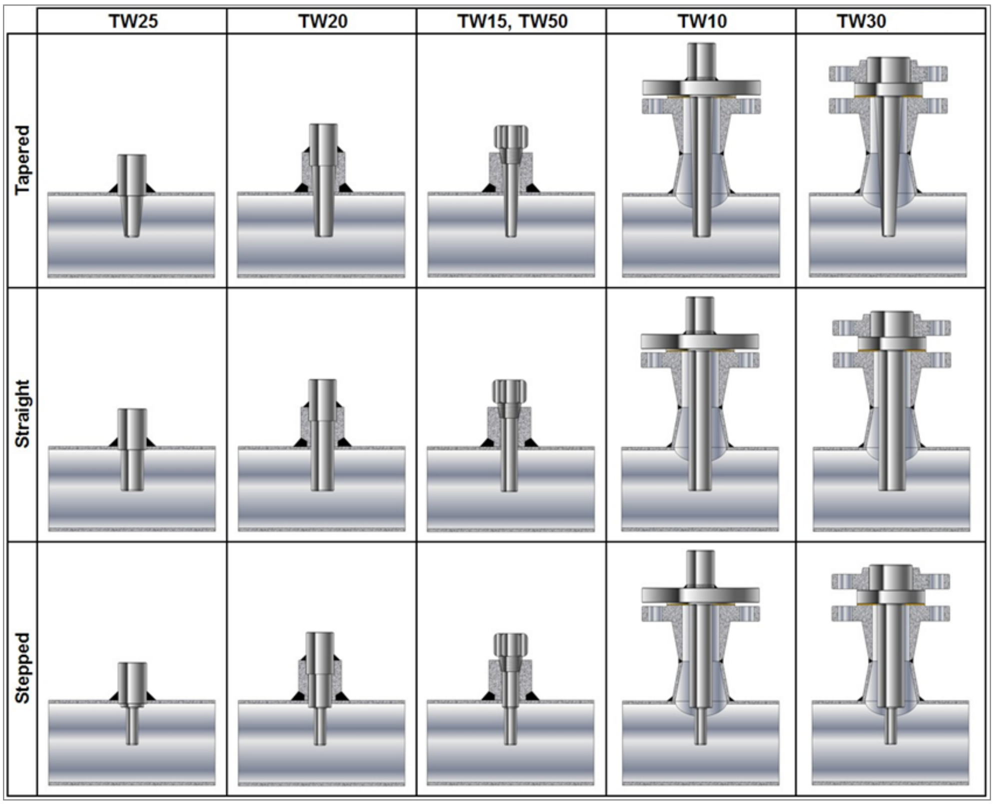
Enter here all design and material data for the thermowell. For description see the WIKA and the ASME PTC 19.3 TW-2010 abbreviation. The input should be done in decimal numbers; the use of fractions is possible after re-formatting cells from “standard” to “number”. For this please press ESC to come to the main Excel menu or press your right mouse button for formatting the cells.

Example: WIKA is using for the tip diameter of the thermowell the abbreviation “V”; the ASME PTC 19.3 TW-2010 is using the abbreviation “B”.



WIKA TW Type

Enter here the WIKA thermowell model you want to calculate. For an overview about the available WIKA models click the picture to enlarge. For detail information please see the thermowell datasheets available at www.wika.com



The table compares the WIKA thermowell models with the thermowell designs of the ASME PTC 19.3 TW-2010

ASME PTC 19.3 TW-2010 design	WIKA model	Straight	stepped	tapered	fatigue stress classification
Screwed	TW15, TW50				aw
Socket weld	TW20				aw
Flanged TW	TW10	Defined by dimension of the shank			wm
Van stone TW	TW30, TW31				nw
Direct weld	TW25				aw

Fatigue stress classification

By choosing the WIKA thermowell model the fatigue stress classification is automatically defined depending on welding influence and materials class.

The allowable fatigue stress amplitude limit of the thermowell depends whether the position of the maximum stress inside the thermowell is affected by a weld or a thread. There are three possible classifications.

nw = not welded

- Van Stone thermowells are produced from one solid piece and are not welded.

wm = welded and machined

- For flanged thermowells the bar stock and the flange are welded together (full penetration weld) and then machined on a lathe on the process side.

aw = as welded

- For a weld-in thermowell the position of the weld is equal to the position of maximum stress and the welding cannot be machined later on.
- Threaded thermowells are declared to be as welded by ASME PTC 19.3 TW-2010
- For a socket thermowell, the position of the welding is not equal to the position of the maximum stress.

Scope of the standard

The WIKA thermowell program applies to straight, tapered and stepped thermowells machined from bar stock or forging within the dimensional limits of ASME PTC19.3 TW-2010 Chapter 4 (see tables below taken from PTC Code Case #12-02)

Table 4-1-1 Dimensional Limits for Straight and Tapered Thermowells within the Scope of This Standard

Description	Symbol	Minimum	Maximum
Unsupported length	L	6.35 cm (2.5 in.) [Note (1)]	60.96 cm (24 in.) [Note (2)]
Bore diameter	d	0.3175 cm (0.125 in.)	2.0955 cm (0.825 in.)
Tip diameter	B	0.92 cm (0.36 in.)	4.65 cm (1.83 in.)
Taper ratio	B/A	0.58	1
Bore ratio	d/B	0.16	0.71
Aspect ratio	L/B	2	–
Wall thickness	$(B-d)/2$	0.30 cm (0.12 in.)	–
Tip thickness	t	0.30 cm (0.12 in.)	–

GENERAL NOTE: Limits in this table apply to the nominal dimensions of the thermowell.
NOTES:
(1) Thermowells of length less than the minimum specified require design methods outside the scope of this standard.
(2) The equation in this standard are valid for themowells longer than the maximum indicated; however, only single piece, drilled bar-stock shanks are covered in this standard.

Table 4-2-1 Dimensional Limits for Step-Shank Thermowells within the Scope of this Standard

Description	Symbol	Minimum	Maximum
Unsupported length	L	12.7 cm (5 in.)	60.96 cm (24 in.)
Bore diameter	d	0.61 cm (0.24 in.)	0.67 cm (0.265 in.)
Step diameter ratio, for B = 1.270 cm (0.5 in.)	B/A	0.5	0.8
Step diameter ratio, for B = 2.223 cm (0.875 in.)	B/A	0.583	0.875
Length ratio	L_S/L	0	0.6
Wall thickness	$(B-d)/2$	0.30 cm (0.12 in.)	0.6
Tip thickness	t	0.30 cm (0.12 in.)	
		Allowable Dimensions	
Tip diameter	B	1.270 cm (0.5 in.) and 2.223 cm (0.875 in.)	

GENERAL NOTE: Limits in this table apply to the nominal dimensions of the thermowell.

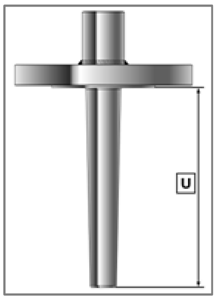
If the requested calculation exceeds these limits, the data is marked in red text and the result of the calculation cannot be guaranteed. In this case the result is only for information. The user of the program is responsible to prove the used thermowell dimensions.

Thermowells manufactured from pipe, a designed surface structure of the shank (flame sprayed or weld overlays or stepped bore design) or thermowells with support collars or other means of support are outside of the scope of the standard.

Due to the complexity of two phase flow ASME PTC 19.3 TW-2010 does not address this condition, but with some engineering judgment useful conclusions can be made. It is suggested, as a rule of thumb, to “be conservative” and perform a calculation of both the liquid and gas state using mass flow rate. This type of calculation should be validated with professional engineering.

Nomenclature of design dimensions

To enlarge the picture please click on the picture in the main spreadsheet. To reduce the size, click on the large picture again. The pictures show the WIKA abbreviations.



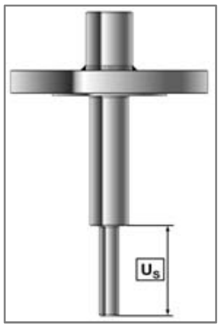
Insertion length
(WIKA abbreviation “U” / PTC 19.3 abbreviation “L”)

Unsupported length of thermowell, measured from the tip to the support plane

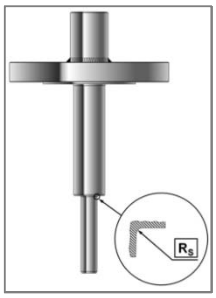
Stepped length
(WIKA abbreviation “U_s” / PTC 19.3 abbreviation “L_s”)

The length of the reduced-diameter shank for a step-shank thermowell is pre-defined by WIKA to U_s = 2 ½” (63.5 mm). The ASME PTC 19.3 TW-2010 doesn’t limit the U_s to this length.
The stepped length is limited by table 4-2-1 to: $0 < U_s/U < 0.6$.

Sample:



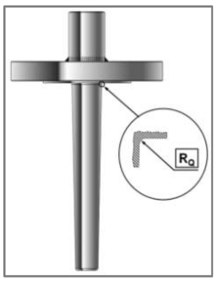
Insertion length U	Stepped length U_s (maximum)
min. 5” (127 mm)	3” (76 mm)
8” (203 mm)	4.8” (122 mm)
12” (305 mm)	7.2” (183 mm)
16” (406 mm)	9.6” (244 mm)
20” (508 mm)	12” (305 mm)
max. 24” (610 mm)	14.4” (366 mm)



Stepped radius at diameter B
(WIKA abbreviation “R_s” / PTC 19.3 abbreviation “r_B”)

Fillet radius at the base of the reduced-diameter length of a step-shank thermowell.

r_B maximum = ½ (Q-V), r_B minimum = 0 mm (not recommended),
r_B default = 1.5 mm (if cell is empty), with Q = root diameter, V=tip diameter



Root radius at diameter A
(WIKA abbreviation “R_Q” / PTC 19.3 abbreviation “r_A”)

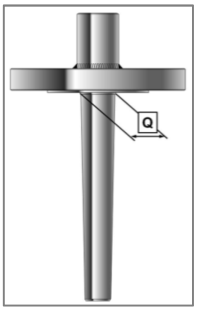
Fillet radius at the base of the reduced-diameter length of a step-shank thermowell
r_A maximum = ½ (nozzle ID-Q), r_A minimum = 0 mm (not recommended),
TW10: r_A default = 2 mm (if cell is empty), with Nozzle ID = inner diameter of the flange nozzle, Q=root diameter. All other TW models: r_A default = 0 mm

Bore diameter
(WIKA abbreviation “B” / PTC 19.3 abbreviation “db”)

Bore diameter of thermowell.

Root diameter
(WIKA abbreviation “Q” / PTC 19.3 abbreviation “A”)

Outside diameter of thermowell at support plane or root, based on which point is closest to thermowell tip.



Tip diameter
(WIKA abbreviation “V” / PTC 19.3 abbreviation “B”)

Outside diameter at tip of thermowell

Tip thickness
(WIKA and PTC 19.3 abbreviation “Tt”)

Minimum tip thickness of the thermowell

Recommended thermowell design limitations

The design of the thermowell, especially the root diameter dimension, can be limited by several factors:

1. Pipe nozzle inner diameter
2. Construction details and thread size

1) Maximum recommended root diameter for various pipe nozzles

NPS	UOM	SCH.10	SCH.40	SCH.STD	SCH.80	SCH.XS	SCH.160	SCH.XXS
1”	inch	0.938	0.875	0.875	0.813	0.813	0.688	0.500
1”	mm	23.8	22.2	22.2	20.6	20.6	17.5	12.7
1 ½”	inch	1.500	1.375	1.375	1.250	1.250	1.125	1.000
1 ½”	mm	38.1	34.9	34.9	31.8	31.8	28.6	25.4
2”	inch	1.875	1.750	1.750	1.625	1.625	1.500	1.250
2”	mm	47.6	44.5	44.5	41.3	41.3	38.1	31.8

2) Construction details and thread sizes

The table below shows the maximum root diameter for the flanged thermowell TW10-B in screwed and welded construction the threaded thermowells TW15 and TW50. (The model TW50 is limited by the DIN 43772 to straight shank design)

Model:	Maximum root dia. Q	Minimum tip dia. V
TW10-S or TW10-B with 1 NPT thread:	1.063" (27 mm)	0.617" (15,7 mm)
TW10-S or TW10-B with 1 1/4 NPT thread (special):	1.417" (36 mm)	0.822" (20,9 mm)
TW10-S or TW10-B with 1 1/2 NPT thread (special):	1.654" (42 mm)	0.959" (24,4 mm)
TW15 with 1/2 NPT thread:	0.669" (17 mm)	0.388" (9,9 mm)
TW15 with 3/4 NPT thread:	0.866" (22 mm)	0.502" (12,8 mm)
TW15 with 1 NPT thread:	1.063" (27 mm)	0.617" (15,7 mm)
TW15 with 1 1/4 NPT thread (special):	1.417" (36 mm)	0.822" (20,9 mm)
TW15 with 1 1/2 NPT thread (special):	1.654" (42 mm)	0.959" (24,4 mm)
TW50 with G 1/2 B thread:	0.669" (17 mm)	Straight design
TW50 with G 3/4 B thread:	0.906" (23 mm)	Straight design
TW50 with G 1 B thread:	1.102" (28 mm)	Straight design
TW50 with M20x1,5 thread:	0.630" (16 mm)	Straight design
TW50 with M27x2 thread:	0.866" (22 mm)	Straight design
TW50 with M33x2 thread:	1.102" (28 mm)	Straight design

The minimum tip diameter V is limited by ASME PTC 19.3 TW-2010 table 4-1-1 dimensional limits for taper ratio. Consult WIKA for non-standard maximum root diameter Q.

Thermowell material

Thermowell Calculation Program
ASME_PTC_19_3_TW_2010

Back | free

Valid names for the material base

3	4	5	6	8
Mat sign	others /equals	DIN/EN comp.	usual name	UNS No
LF2		1.0508		K03011
A105		1.0460	C22.8	K03504
F12		1.7335	A182 F12	K11562
F11		1.7337	A182 F11	K11597

The material data of the thermowell has a critical influence on the safety of the application. There are two methods to enter the necessary values.

Material list (recommended)

The program includes a list of the more commonly used materials for thermowells out of the ASME PBVC Section II Part D. To choose one of these materials, enter the name listed in one of the five columns.

Example:

Valid names for the material base

3	4	5	6	8
Mat sign	others /equals	DIN/EN comp.	usual name	UNS No
F51	329LN	1.4462	329LN	S31803

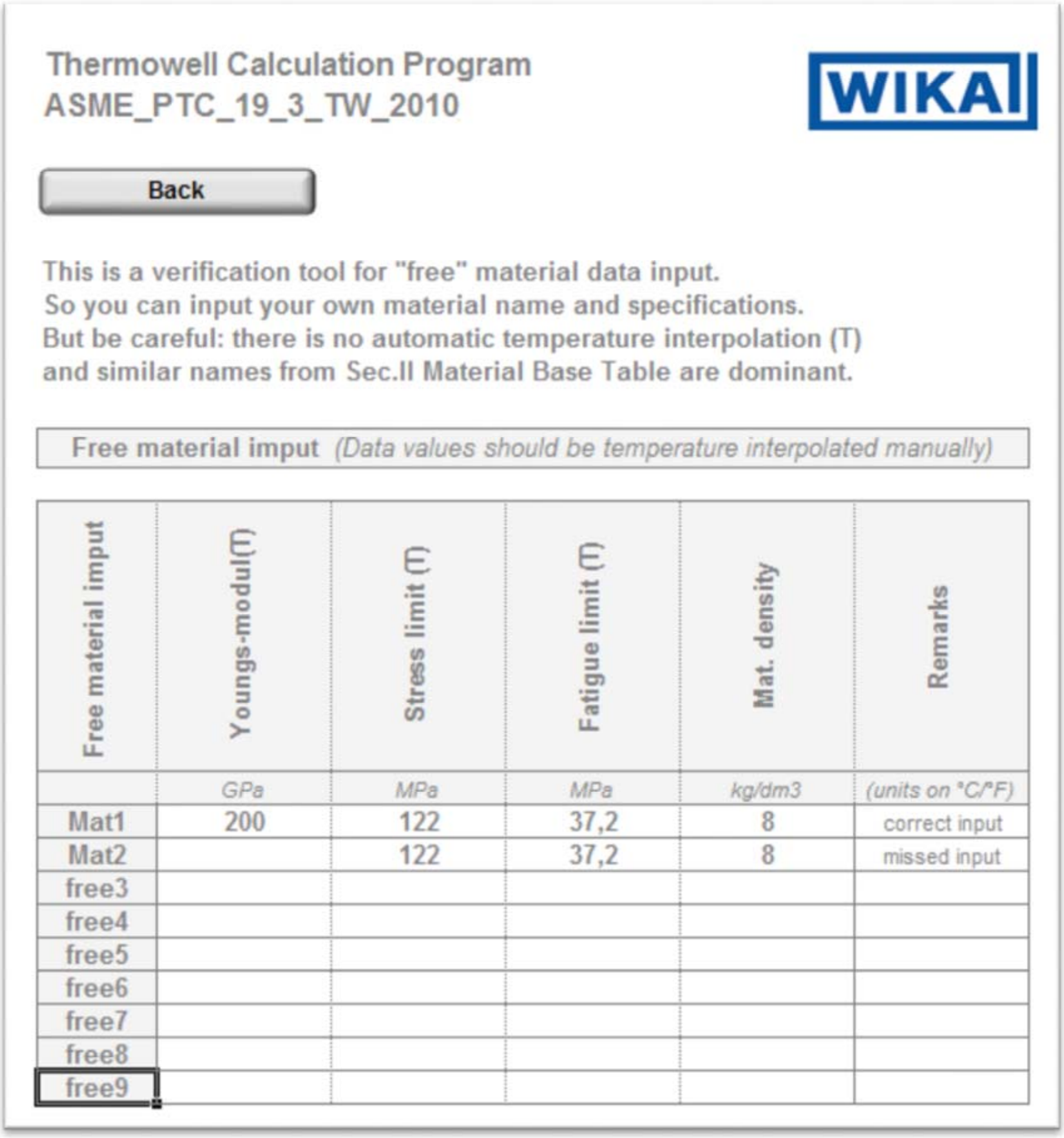
For Duplex F51, you can choose to use the material designation

- F51 …. or
- 329LN …. or
- 1.4462 …. or
- S31803

All of these designations will select the same material.

FREE material data input

If your required material is not listed, press **FREE** to continue. You can save 9 different materials. To choose the materials inside the calculation sheet use the material designation “free1” to “free9” or choose a specific name (e.g. Mat1 or Mat2).



Thermowell Calculation Program
ASME_PTC_19_3_TW_2010

Back

This is a verification tool for "free" material data input.
So you can input your own material name and specifications.
But be careful: there is no automatic temperature interpolation (T)
and similar names from Sec.II Material Base Table are dominant.

Free material imput *(Data values should be temperature interpolated manually)*

Free material imput	Youngs-modul(T)	Stress limit (T)	Fatigue limit (T)	Mat. density	Remarks
	GPa	MPa	MPa	kg/dm3	(units on °C/°F)
Mat1	200	122	37,2	8	correct input
Mat2		122	37,2	8	missed input
free3					
free4					
free5					
free6					
free7					
free8					
free9					

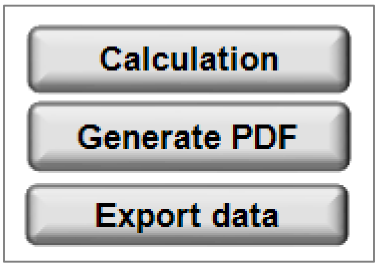
You have to enter here:

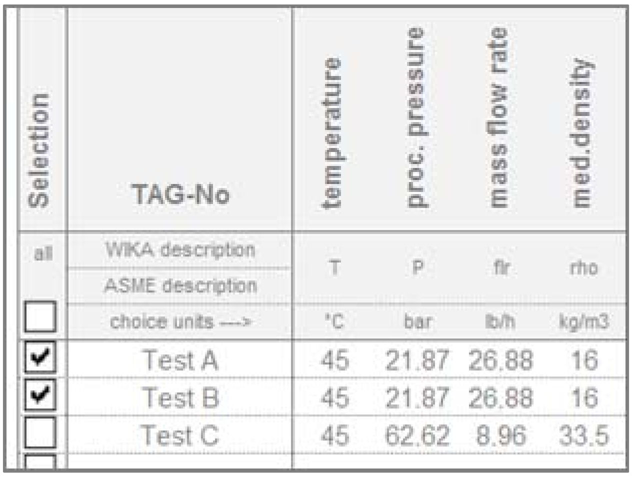
- Youngs-modul (E-modul)
- stress limit (Endurance limit R_p/1,5)
- fatigue limit
- material density
- additionally you can write some remarks (optional)

The unit of measure for the material data will be set automatically, depending from the temperature unit in the main page.

Please note: there is no temperature interpolation for the material data, so the material data at the operation temperature is needed! For that reason we recommend the usage of the available material lists according to ASMC PBVC Section II Part D which is temperature-interpolated.

Calculation





Selection	TAG-No	temperature	proc. pressure	mass flow rate	med.density
all	WIKA description ASME description	T	P	flr	rho
☐	choice units --->	°C	bar	lb/h	kg/m3
☑	Test A	45	21.87	26.88	16
☑	Test B	45	21.87	26.88	16
☐	Test C	45	62.62	8.96	33.5

To run the calculation press **CALCULATION** in the main spreadsheet. Now all selected Tag-No. will be calculated.

Example: Test A + Test B will be calculated; Test C is not selected and will be not calculated!

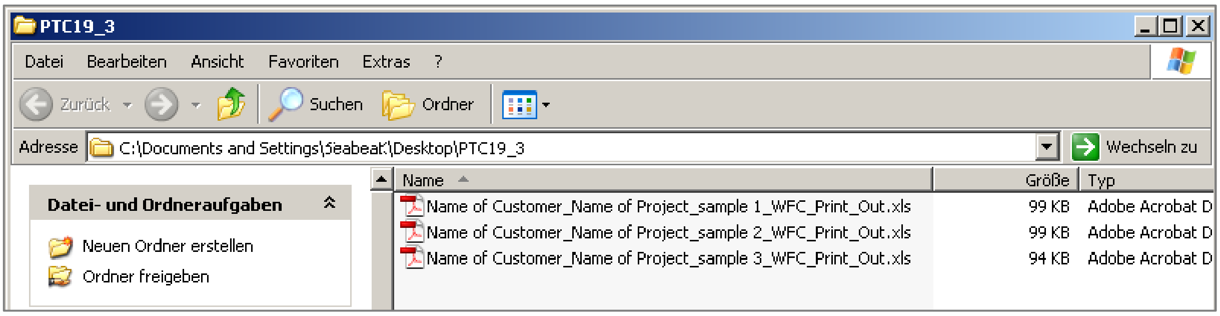
If you want to select (or deselect) all Tag-No, use the checkmark in the **SELECT ALL** box.

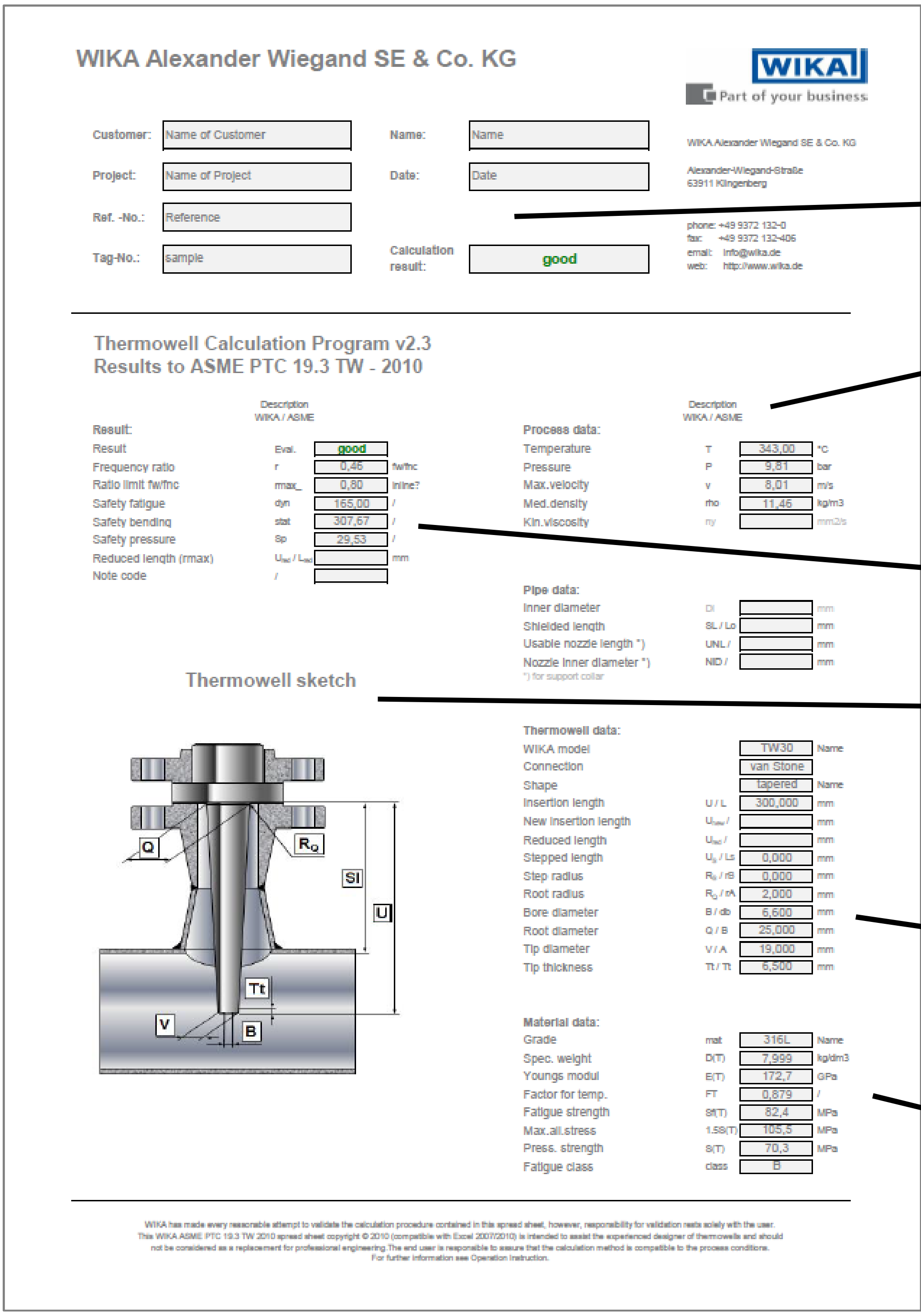
If there is an error in the entered data you will see a Microsoft® Visual Basic error message (e.g. division by zero, type mismatch) in your computer system language. If you encounter this error please verify the entered data to determine where the error may be.

Generate PDF

To print or save the selected Tag-No. press **GENERATE PDF** in the main spread sheet. This will create a new folder on your desktop named “PTC19_3”. Inside the folder you will find one separate PDF file for each selected Tag-No. The PDF is named with “Customer + Project + Tag-No” taken out of the data of the spreadsheet (Tag-No´s should be different or with indices).

Example for a Tag-No. PDF file:





Information about:
- Customer
- Project
- User
- Main result

Information about the process data

Detail information about the results

Sketch of the selected thermowell model and explanation about the abbreviations

Information about the thermowell design

Information about the thermowell material in detail at the working temperature

Export Data

To export all data in a new spreadsheet press **EXPORT DATA** in the main spreadsheet. The new spreadsheet is saved in the folder “PTC19_3” on your desktop with the name “customer + project + date” and includes no macros or functions and can be saved with a user-defined name.

To work with the data again, please copy all data and paste them to the calculation program.

Calculation result: good = ✓

If the application is fulfilling all requests of the ASMT PTC 19.3 TW-2010, you will see as the sign in column “results” a green check mark ✓

That means the thermowell meet the 5 criteria:

- Operating temperature
- Wake frequency calculation (resonance limits)
- Fatigue stress
- Bending strengths
- Operating pressure (max. B31.3)

The target is to get every line ✓

Calculation results:

Calculation result							
Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
x	x	x	/	/	/	mm	/
635,1	763,3	23,17	0,80	0,21	✓		s!
2,636	17,49	28,39	0,40	0,34	✓		
0,344	0,948	80,00	0,40	0,43	✗	75	RFB

In the columns you can see the numeric calculation results sorted in safety factors

- Safety fatigue (dyn)
- Safety bending (Stat)
- Safety pressure (Sp)
- Ratio limit f_w/f_{nc} (rmax_)
- Frequency ratio (r)

Safety factors

The safety fatigue value shows the security ratio for the combined drag and lift stress to the allowed fatigue stress limit.

The safety bending value shows the security ratio for the combined static stress at the root of the thermowell, caused by flow and pressure.

The safety pressure value shows the security ratio for the maximum allowed pressure in this design divided by the real operation pressure.

A safety factor of 1.0 would mean that the calculated stress or pressure is equal to the limit.
A value < 1.0 means that this limit was failed. In this case the value is highlighted in red.

The ratio limit f_w/f_{nc} indicates the acceptable frequency limit.

- a frequency ratio of 0.4 is accepted, if inline resonance could be possible
- a frequency ratio of 0.8 can be accepted if inline resonance can be excluded

The frequency ratio shows the frequency ratio which is calculated for the application in this line. (1.0 is equal to the natural wake frequency)

Calculation: failed = ×

If at least one safety factors is below 1.0 or the frequency ratio is higher than the acceptable limit, the thermowell fails the calculation.

You will receive a message in column "note code" of the actual line which gives you some hints about the reason.

Please note, that all design changes of the thermowell will affect every one of the tested values. It might happen that you will receive another error message after you have successfully corrected the first error.

Error codes:

Capital letters indicate a critical value at the root of the thermowell root.
Stepped thermowells are calculated at the root and at the position of the step diameter. Error codes in small letters indicate that a critical value was reached at the position of the step diameter.

Message T: Temperature

- The requested temperature of the application exceeds the allowed temperature range of the selected material.
- Counteraction: Select a material suitable for higher temperatures

Message R: frequency ratio

- A dangerous vibration of the thermowell that cannot be excluded.
- Counteraction: The resonance frequency of the thermowell can be affected by every design element of a thermowell. The most effective way to reduce the frequency ratio is to increase the natural frequency of the thermowell by reducing the insertion length. In the case of failing the frequency limit, the program will suggest a reduced length. Because this calculation system consists of a number of non-linear equations, this new reduced length must be entered in the field for the insertion length of the application data. In a new calculation this value must be reviewed. Caused by the non-linearity of the system, it might happen that this reduced length is denied by the second calculation step. Please repeat this procedure until you have found a new value, which passes all criteria.

Message F: fatigue strength
- The dynamic stress at design conditions caused by the vibration could reach a dangerous level.
- *Counteraction*: Increase the shank dimensions for root and tip to the direction of a stronger thermowell

Message B: static stress
- The static stress at the root of the thermowell, caused by bending and pressure, could reach a dangerous level.
- *Counteraction*: Increase the shank dimensions for root and tip to the direction of a stronger thermowell.

Message P: pressure limit
- The operation pressure is higher than the pressure limit of the requested design.
- *Counteraction*: Increase the tip diameter and thickness of the thermowell.

Message X: tip and wall thickness
- The tip thickness or the wall thickness is smaller than 3.0 mm
- For step style thermowells the wall thickness is outside the range of 3.0 to 6.0 mm
- *Counteraction*: Correct the design data into the given ranges

Message D: In-line (drag) resonance
- For frequency ratio f_w/f_{nc} = 0.4<x<0.6 if Nsc < 2.5 or Re > 10^5
- *Counteraction: Increase the thermowell insertion length U up to* f_w/f_{nc} = 0.6 …0.8
- *Or shorten the thermowell insertion length U up to* f_w/f_{nc} < 0.4

Message N: pipe nozzle length (shielded length)
- The insertion length U is smaller than the pipe nozzle length (=shielded length). This means, the thermowell shank is not immersed into the process.
- *Counteraction*: Increase the insertion length U or reduce the length of the pipe nozzle

Message M: Free material input
- There is a mistake in the free material input (e.g. missed material values for youngs modul in mat2)
- *Counteraction:* Check the free material input table

Free material imput	Youngs-modul(T)	Stress limit (T)	Fatigue limit (T)	Mat. density	Remarks
	GPa	MPa	MPa	kg/dm3	(units on °C/°F)
Mat1	200	122	37,2	8	correct input
Mat2		122	37,2	8	missed input

Messages r, f, u and/or b: Only stepped thermowells
- The lower case types indicate that the thermowell may fail at the stepped tip of the thermowell. The Messages are same than the upper case signs for thermowell root. They are indicating problems with frequency ratio, fatigue or static stress near the stepped tip.
- *Counteraction*: Reduce the stepped length OR increase the tip diameter and thickness

Message u: Stepped length

- The stepped length Us is larger or equal than the insertion length U.
- *Counteraction*: Reduce the stepped length Us. The length ratio in Us/U is between 0…0.6.

Message s!: Only stepped thermowells

- It is only for information. The thermowell has not failed, but stresses at tip are higher than them near the root. To obtain explicit values for the stepped location of the thermowell, a separate calculation may be done.

Calculation example:

The process data of a hypothetic example:

	Process data								Thermowell data									
Selection	Display detail TAG-No	Temperature	Pressure	Max. velocity	Med. density	Inner diameter	Kin. viscosity	Shielded length	WIKA TW Type	Insertion length	Stepped length	Step radius at B	Root radius at A	Bore diameter	Root diameter	Tip diameter	Tip thickness	TW material
All	WIKA description	T	P	v	rho	Di	ny	Sl	/	U	U_s	R_s	R_s	B	Q	V	Tt	mat
	ASME description							Ls		L	Ls	rB	rA	db	A	B		
☑	Choose units --->	°C	bar	m/s	kg/m3	mm	[illegible]	mm	/	mm	mm	mm	mm	mm	mm	mm	mm	name
☑	Sample	800	9,807	11	899				TW10	235				6,6	25	19	2	316L

The line calculation gives the result:

Calculation result							
Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
x	x	x	/	/	/	mm	/
0,26	2,471	20,01	0,40	0,49	✖	200	TRFX

You will also see that the operation temperature is marked in red.

The evaluation result is: **failed** with the code **TRFX**

Message T: Temperature

The operation temperature of 800°C exceeds the limits of the requested material 316L for Section II.
If you change the thermowell material to 316 you solve this temperature problem.

After a new calculation you will see:

TW material	Calculation result							
	Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
mat	dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
name	x	x	x	/	/	/	mm	/
316L	0,26	2,471	20,01	0,40	0,49	✖	200	TRFX
316	0,26	0,545	4,41	0,40	0,49	✖	200	RFBX

The evaluation result is: **failed** with the code **RFBX**

Message R: frequency ratio

The best way to eliminate this error code is to shorten the insertion length U of 235 mm to the recommended length U opt. of 200 mm

Thermowell data									Calculation result							
Insertion length	Stepped length	Step radius at B	Root radius at A	Bore diameter	Root diameter	Tip diameter	Tip thickness	TW material	Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
U L	U_s Ls	R_s rB	R_a rA	B db	Q A	V B	Tt	mat	dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
mm	mm	mm	mm	mm	mm	mm	mm	name	x	x	x	/	/	/	mm	/
235				6,6	25	19	2	316L	0,26	2,471	20,01	0,40	0,49	✖	200	TRFX
235				6,6	25	19	2	316	0,26	0,545	4,41	0,40	0,49	✖	200	RFBX
200				6,6	25	19	2	316	0,793	0,752	4,41	0,40	0,36	✖		FBX

Message F: Fatigue stress and Message B: bending stress

This problems can be solved by a stronger thermowell design. Change the shank dimensions A to 30 mm and B to 26 mm.

Thermowell data										Calculation result							
WIKA TW Type	Insertion length	Stepped length	Step radius at B	Root radius at A	Bore diameter	Root diameter	Tip diameter	Tip thickness	TW material	Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
/	U L	Us Ls	Rs rB	RR rA	B db	Q A	V B	Tt	mat	dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
/	mm	mm	mm	mm	mm	mm	mm	mm	name	x	x	x	/	/	/	mm	/
TW10	235				6,6	25	19	2	316L	0,26	2,47	20,01	0,40	0,49	✗	200	TRFX
TW10	235				6,6	25	19	2	316	0,26	0,54	4,41	0,40	0,49	✗	200	RFBX
TW10	200				6,6	25	19	2	316	0,79	0,75	4,41	0,40	0,36	✗		FBX
TW10	200				6,6	30	26	2	316	1,09	1	5,13	0,40	0,24	✗		X

The evaluation result is: **failed** with the code **X**

Message X: tip thickness

The PTC 19.3-TW2010 requires a tip thickness bigger than 3 mm. To solve the last error code X increase the tip thickness to WIKA standard 6.4 mm.

Thermowell data										Calculation result							
WIKA TW Type	Insertion length	Stepped length	Step radius at B	Root radius at A	Bore diameter	Root diameter	Tip diameter	Tip thickness	TW material	Safety fatigue	Safety bending	Safety pressure	Ratio limit fw/fnc	Frequency ratio	Result	Optimized length (--> 0,7/0,35 ... < rmax_)	Note code
/	U L	Us Ls	Rs rB	RR rA	B db	Q A	V B	Tt	mat	dyn	stat	Sp	rmax_	r	Eval.	Uopt Lopt	/
/	mm	mm	mm	mm	mm	mm	mm	mm	name	x	x	x	/	/	/	mm	/
TW10	235				6,6	25	19	2	316L	0,26	2,47	20,01	0,40	0,49	✗	200	TRFX
TW10	235				6,6	25	19	2	316	0,26	0,54	4,41	0,40	0,49	✗	200	RFBX
TW10	200				6,6	25	19	2	316	0,79	0,75	4,41	0,40	0,36	✗		FBX
TW10	200				6,6	30	26	2	316	1,09	1	5,13	0,40	0,24	✗		X
TW10	200				6,6	30	26	6,4	316	1,09	1	5,13	0,40	0,24	✓		

The evaluation result is: ✓ **= good**

Revision list:

Version 2.0 2011-05-02

- New design and new illustration for the worksheets
- Upgrading to Office 2007 for generating PDF files
- Export functionality for reduced files for storing results
- Checkboxes for choosing lines for calculation and documentation
- Dual Certified material SS316/316L is set equal to SS316
- All materials not in fatigue class B are set to lower class A

Version 2.1 2011-16-15

- Bug fixing on PDF Output (PrintOut)
- Corrected Celsius temperature (PDF)
- Added factor 1000 to medium density (PDF)
- Empty cell on not set inner shielded length SL/Lo
- Bug fixing on density unit choice (lb/in3, conversion factor corrected)
- Bug fixing on viscosity unit choice list (ft2/1000s), cSt added

Version 2.2 2011-06-28

- Bug fixing on converting flow rate Di imperial "in." to "mm”
- Problems with copy-and-paste formats not recognized as values without reentering numbers
- PrintOut new formatted for generating imperial PDF´s with 3 decimals on most result cells

Version 2.3 2012-11-12

- Unit error on Ured (°F with mm) merged
- V2_1 on "macro security" merged
- Down rounding of Ured in steps of metric 10mm and imperial 0.5 inch
- Kinematic viscosity in printout
- Dimensional check as tip thickness, step diameter
- Picture ´Root Diameter´ with nozzle table for max. value
- Free choice of the material name for free material input

Version 2.4 2013-11-07

- Correction for WIKA models in fatigue stress classification
- Modification of result evaluation
- Error code D for in in-line resonance
- Error code u for stepped length Us > U
- Change from U red to U opt
- Rounding of U opt for insertion length 2,5” (64 mm) < U < 4” (100mm) in a step of ¼” (5mm)
- Rounding U opt to frequency ratio r=0.7 or 0.35

Version 2.5 2014-05-07

- Tip / wall thickness dimensional limits in accordance to PTC Code case #12-02
- Evaluation low density gases
- Address list updated
- PDF printout: L_{red} changed to L_{opt}

Version 2.5.1 2014-05-12

- Address list updated (Wika Houston)

Version 2.5.2 2015-11-02

- Address list updated (Wika Houston + Korea)

WIKA Alexander Wiegand SE & Co. KG
Alexander-Wiegand-Straße 30
63911 Klingenberg/Germany
Tel. (+49) 9372/132-0
Fax (+49) 9372/132-406
E-mail info@wika.de
www.wika.de