

Technical cleanliness of pointer measuring instruments of special versions

WIKA data sheet IN 00.58

Application area

This document describes manufacturing processes for special versions that require a very high technical cleanliness of the wetted parts.

This applies for mechanical and mechatronic pointer measuring instruments with stainless steel materials (e.g. 316L) and special materials (e.g. Monel, Hastelloy).

Instrument	Model
Bourdon tube pressure gauge	1, 2, 3
Diaphragm pressure gauge	4
Absolute pressure gauge	5
Capsule pressure gauge	6
Differential pressure gauge	7
Mechatronic pressure gauge	PGS, DPGS, PGT, DPGT, APGT
Bimetal thermometer	TG53, TG54, 55
Gas-actuated thermometer	73
Mechatronic thermometer	TGS55, TGS73, TGT73

Pointer measuring instruments with wetted parts from copper alloy (brass) and diaphragm seals are not considered in this technical information.



WIKA expertise

WIKA has decades of experience in the production of pressure gauges and thermometers guarantees a high level of cleanliness of the wetted parts. This is ensured, among other things, by the use of standardised processes and the support of the WIKA expert group for technical cleanliness.

For the pressure gauge version “Oil- and grease-free for oxygen”, WIKA confirms a hydrocarbon limit value of $< 550 \text{ mg/m}^2$ for scale ranges $\leq 30 \text{ bar}$ [$\leq 400 \text{ psi}$] and $< 220 \text{ mg/m}^2$ for scale ranges $> 30 \text{ bar}$ [$> 400 \text{ psi}$], based on periodically recurring tests (in line with ISO 15001:2012 and ASTM G93 level D/E).

Additional fundamental sampling tests (burn-out test when exposed to oxygen pressure surges) at external test centres confirm the basic suitability of the “Oil and grease-free for oxygen” version of pressure gauges for this medium.

These special versions, and the additional cleaning-related manufacturing processes carried out for them, are described below.

Version: “Silicone-free”

Silicone-free or silicone oil-free means that all components in contact with the atmosphere must be largely free of silicone. This requirement is often made for paint finishing systems (e.g. in the automotive industry). The smallest silicone residues can lead to painting defects (so-called silicone craters) and ruin the painting result.

However, for process and production reasons, it is not possible to provide general confirmation of the absence of paint wetting impairment substances (freedom from PWIS) by selecting this version.

Cleaning steps in the production process

- If necessary, thorough hand cleaning before starting production, without the use of skin care products (hand cream)
- Regular cleanliness checks and, if necessary, cleaning of equipment (test and adjustment benches)
- Avoidance of assembly aids with silicone-containing, paint wetting impairment substances, where possible
- No storage of silicone or lubricating materials in the vicinity of the production process, where possible
- Selected models (e.g. diaphragm pressure gauges) receive separate cleaning and drying of selected parts and assemblies before assembly (also for internal surfaces)
- 100% cleaning of the surrounding parts of the instrument before packaging
- Individual packaging in silicone-free, sealable or heat-sealed plastic bag

Marking “Silicone-free”



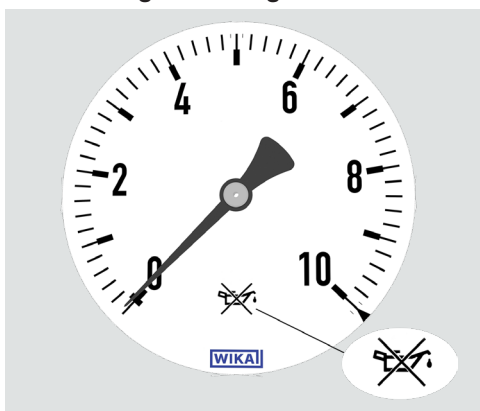
Version: “Oil- and grease-free”

The requirement for internal parts to be free of oil and grease is often made in the food and pharmaceutical industries. This requirement also exists in other sectors such as industrial gases, water and wastewater, machine building and automation.

Cleaning steps in the production process

- Regular cleanliness checks and, if necessary, cleaning of equipment (test and adjustment benches)
- The instruments are primarily adjusted using oil- and grease-free, dry compressed air or nitrogen. For higher pressure ranges, adjustment is only possible with water, followed by drying of all wetted parts in a vacuum oven.
- Particularly thorough visual inspection of the surfaces before shipping

Marking “Oil- and grease-free”



Version: “Oil and grease-free for oxygen”

The use of oxygen is very versatile and widespread. The demands are extremely high due to the easy flammability and high explosion risk of oxygen. Oil and grease are particularly dangerous in the presence of oxygen, as they can easily be an ignition source and burn with explosive ferocity. This ignition source is not always obvious in piping systems. A fire can be caused by friction, high flow rates, heating due to turbulence or adiabatic compression. For example, gas with a high flow rate can suddenly hit an obstacle, e.g. a closed valve. If pipe connections are contaminated with mineral oils or greases, oxidation reactions with the carbon components can easily occur. The resulting high temperatures can then lead to spontaneous combustion and trigger a chain reaction.

For oxygen applications, WIKA recommends the use of a restrictor in the process connection to reduce the rate of pressure increase in the measuring system.

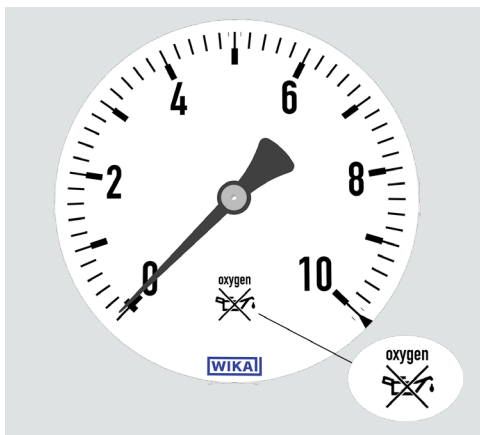
Applications of oxygen

- Breathing gas in medicine and aerospace
- Oxidising agents in combustion processes to achieve high temperatures
- Metallurgy, in pig iron and steel production and in copper refining
- Chemistry and biology
 - Olefin oxidation, partial oxidation of coal and heavy oil
 - Production of hydrogen and synthesis gas, sulphuric and nitric acid, acetylene
- Welding, cutting, separating, flame annealing
- Drinking water and wastewater treatment
- Semiconductor technology
- Fuel cells

Cleaning steps in the production process

- Regular cleanliness checks and, if necessary, cleaning of equipment (test and adjustment benches)
- The instruments are primarily adjusted using oil- and grease-free, dry compressed air or nitrogen. For higher pressure ranges, only adjustment with water is possible. In this case, the entire measuring system is then dried in a vacuum oven.
- Use of wetted materials, system fill fluids and casing fill fluids that are suitable or approved for use in conjunction with oxygen
- Before installation, the wetted parts are cleaned (e.g. in an ultrasonic bath) and then dried again. This also applies, in particular, to internal surfaces.
- After cleaning, internal transport is carried out in separately sealed and cleaned transport containers.
- The instruments are largely handled with gloves, so as not to contaminate internal parts
- Particularly thorough visual inspection of the surfaces
- The process connection is usually sealed with a protective cap for shipping
- Instruments are packed in sealed plastic bags (sometimes with desiccant)

Marking “Oil and grease-free for oxygen”



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The information provided in this document corresponds to the current state of the art and may vary slightly depending on the production site.

The information provided is for general information purposes only and is not legally binding. We reserve the right to make changes in individual cases or special versions.

In the event of a different interpretation of the translated and the English data sheet, the English wording shall prevail.



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Scale ranges of thermometers

Scale spacing and numbering per EN 13190

WIKA data sheet IN 00.56

General information

Scale range, nominal size (NS, case diameter) and accuracy class of a thermometer determine the design of the scale. The European EN 13190 standard contains the specifications about the layout of dials with concentric scales. In addition to the scales in accordance with EN 13190, all internationally common scale ranges, double and multiple scales, coloured scales etc. are, of course, also available.

Scale ranges of EN 13190

Degree Celsius, abbreviated by °C, is the preferred unit for temperature measurement.

Not all thermometer versions can be used for the temperature ranges indicated below or on the right.

Nominal sizes

For dial thermometers, the following nominal sizes (NS) are defined: NS 40, 50, 63, 80, 100 and 160

Accuracy classes

The following accuracy classes are specified: class 1 and class 2. Class 1 is intended for nominal sizes from 63 to 160, class 2 for nominal sizes 40 to 160.

The reference value of the ambient temperature is 23 °C. Other reference values deviating from 23 °C or a reference range are permissible and must be specified by the purchaser.

Scale range °C	Measuring range °C	Error limits ± °C	
		Class 1	Class 2
-20 ... +40	-10 ... +30	1	2
-20 ... +60	-10 ... +50	1	2
-20 ... +120	0 ... 100	2	4
-30 ... +30	-20 ... +20	1	2
-30 ... +50	-20 ... +40	1	2
-30 ... +70	-20 ... +60	1	2
-40 ... +40	-30 ... +30	1	2

Scale range °C	Measuring range °C	Error limits ± °C	
		Class 1	Class 2
-40 ... +60	-30 ... +50	1	2
-100 ... +60	-80 ... +40	2	4
0 ... 60	10 ... 50	1	2
0 ... 80	10 ... 70	1	2
0 ... 100	10 ... 90	1	2
0 ... 120	10 ... 110	2	4
0 ... 160	20 ... 140	2	4
0 ... 200	20 ... 180	2	4
0 ... 250	30 ... 220	2.5	5
0 ... 300	30 ... 270	5	10
0 ... 400	50 ... 350	5	10
0 ... 500	50 ... 450	5	10
0 ... 600	100 ... 500	10	15
0 ... 700	100 ... 600	10	15
50 ... 650	150 ... 550	10	15
100 ... 700	200 ... 600	10	15

Scale range in °F	Scale interval in °F
-100 ... +150	5
-80 ... +120	2
-80 ... +240	5
-40 ... +120	2
0 ... 140	2
0 ... 200	2
0 ... 250	5
30 ... 300	2
30 ... 400	5
50 ... 400	5
100 ... 800	10
150 ... 750	5
200 ... 1,000	10

The measuring range must be equal to at least 2/3 of the scale range.
Start and end of the measuring range must be marked through triangles on the edge of the scale. The marking is omitted if the measuring range is equal to the scale range. Further display or measuring ranges may be agreed.

Scale angle

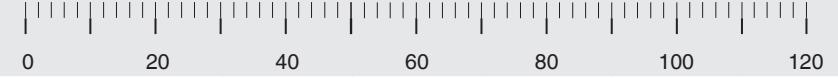
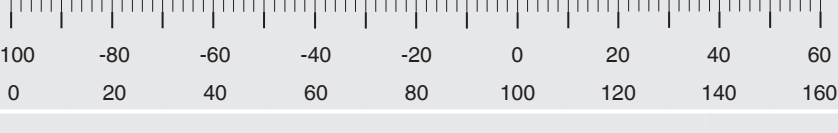
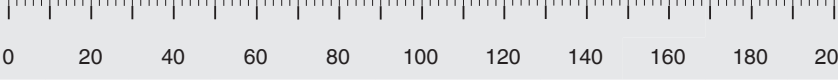
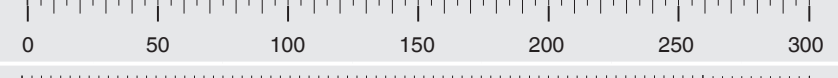
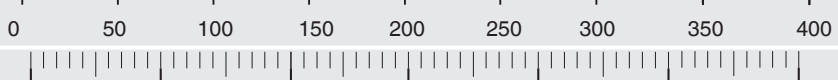
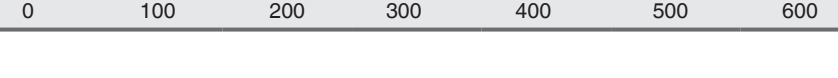
The scale angle is $270^{\circ} \pm 20^{\circ}$

Scale interval

The scale interval must be selected from the following values: 1 °C, 2 °C, 5 °C and 10 °C

Examples for scale spacing and numbering of scales

Examples for accuracy class 1 to 2

Scale range °C	Measuring range °C	Order of scale marks and numbering for dial thermometers	Scale interval	Number of scale mark intervals
-40 ... +60 0 ... 100	-30 ... +50 10 ... 90		1 1	100
-20 ... 120	0 ... 100		2	70
0 ... 120	10 ... 110		2	60
-100 ... 60 0 ... 160	-80 ... +40 20 ... 140		2 2	80
0 ... 200	20 ... 180		2	100
0 ... 300	30 ... 270		5	60
0 ... 400	50 ... 350		5	80
0 ... 600	100 ... 500		10	60

Scale range °F	Measuring range °F	Order of scale marks and numbering for dial thermometers	Scale interval	Number of scale mark intervals
0 ... +140	20 ... 120		2	70
0 ... 200	20 ... 180		2	100
-80 ... +120	-60 ... +100		2	
50 ... 400	100 ... 350		5	70
150 ... 750	250 ... 650		10	60
200 ... 1000	300 ... 900		10	80

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File formats for customer logos on dials

WIKA data sheet IN 00.51

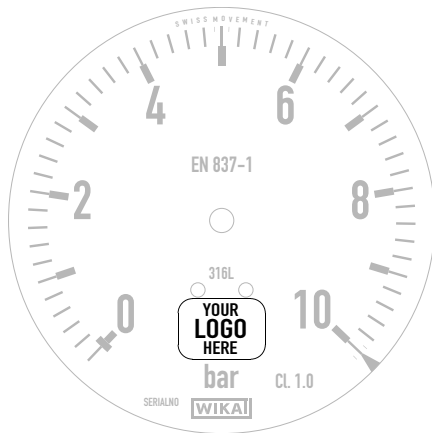
Technology

WIKA uses the latest technologies to custom print pressure gauge and thermometer dials. The high-quality printing features excellent UV resistance for long-lasting optimal readability of the measuring instruments.

The scale is defined using a specifically developed software tool and then drawn automatically using CAD software.

Trademark with customer logo

In pointer gauges, the dial is the component that permits the greatest variance for individual customer specifications. Since the dial is the focus of any measurement, WIKA is happy to fulfil the wish of many customers to have their own brand logo printed onto it.



Example of dial with customer logo

Requirements for the logo file

File format

For optimal representation of logos, they should be supplied in a vector format, as this allows scaling without losses.

Vector formats (preferred)

File type	Description
EPS / PS	Encapsulated Postscript / Postscript
AI	Adobe Illustrator
CDR	Corel Draw
DWG	Autodesk AutoCAD
DXF	Drawing Interchange File Format

Bitmap formats (if vector format not available)

File type	Description
TIFF / TIF	Tagged Image File Format
PNG	Portable Network Graphics
JPG / JPEG	Joint Photographic Experts Group

Size for bitmap formats

At least 1,200 pixels, width or height

Colour specifications

- Full-tone colours (RAL or Pantone)
- Colour space (CMYK or sRGB)

In the event that there is no colour specification, the correctness of custom colours cannot be guaranteed. Files in bitmap format are vectorised for further processing.

Data administration

For the correct processing of the logo file, it must be stated whether it replaces an existing logo. Ideally, the customer logo should be transmitted to the sales team contact via the [questionnaire](#) in the download area of the WIKA website.

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WIKAI standard documentation

WIKAI data sheet IN 00.24

Requirements

Extensive processes require detailed documentation. For complex operations, data sheets and operating instructions are not sufficient anymore as documents accompanying the products.

Additional documents such as certificates, analyses or quality management procedures provide exact proof that the instruments are ideally suited for the particular application. In this way a detailed documentation conforming to the law contributes to plant safety.

WIKAI standard documentation

The WIKAI standard documentation complies with the legal conditions of acceptance (in paper format and/or as a navigable CD-ROM).

Our individual documents are constantly updated. They are subject to the "product lifecycle" (further development of the existing product). A unique attribution of the documents to the production order at the time of manufacture is ensured. WIKAI provides these documents in many languages and in the desired quantity.

Customer-specific designs

Of course we can also provide the documentation according to your requirements:

- Customer logo
- Cover sheet layout
- Ring binders
- Sequence
- Further documents



WIKAI standard documentation

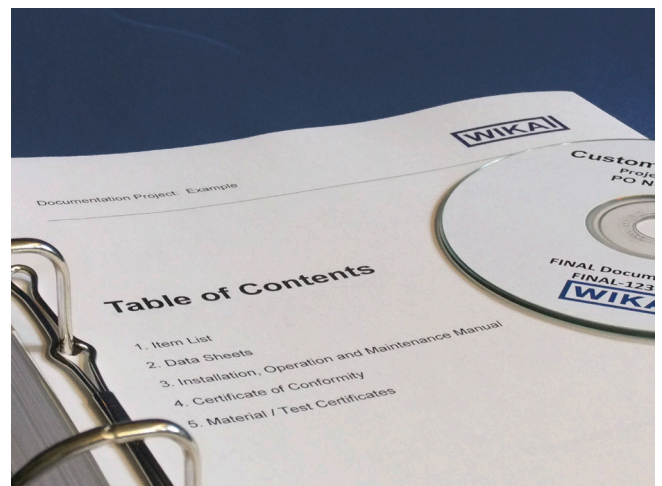


Table of Contents

WIKA standard documentation

This contains following documents:

Abbreviation	Description
TAG	Item list (Tag no. list)
CATL	Data sheets (catalogues)
IOM	Operating instructions (installation, operation and maintenance)
DOC	Declaration of conformity (EC, ATEX, EMC, PED)
ZGN	Certificates/Test reports
WFC	Wake frequency calculation (optional)
FLC	Flow calculation (optional)

These documents can be provided additionally:

Abbreviation	Description
DRWG	Drawings
QM	Quality management procedures
QT	Quality test procedures
CSP	Commissioning spare parts list
2SP	2 years spare parts list
NDE	Non-destructive examinations
SIP/RPP	Transport, packaging and storage instructions
MCOC	Manufacturer's certificates of compliance
PASS	Passport (import permit for instruments destined for Russia)

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Wake frequency calculation

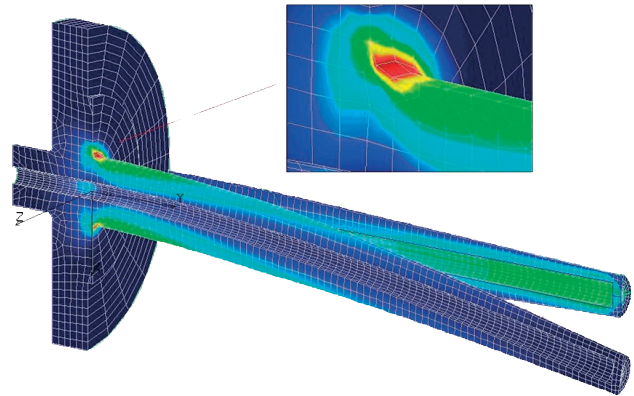
WIK A data sheet IN 00.15

Applications

- Minimisation of the risk of dynamic damage through vortex shedding of a Kármán vortex street (Vortex Induced Vibration; VIV)
- Calculation of the static loads due to inflow and process pressure
- Can be used in pipelines and process vessels

Special features

- Calculation of thermowells per ASME PTC 19.3 TW-2016
- Calculation of thermowells and protection tubes in accordance with Dittrich/Klotter
- If the permissible calculated load limits are exceeded, WIK A can, as an engineering service (subject to a charge), provide suggestions for modification of the thermowell design.



FEM representation of a thermowell within a flow with stress representation at the tip and in the root

Description

The wake frequency calculation in accordance with ASME PTC 19.3 TW-2016 is applicable for thermowells in tapered, straight or stepped design.

Protection tubes in accordance with DIN 43772 or comparable designs are calculated in accordance with Dittrich/Klotter.

All calculations are valid for non-corrosive or non-abrasive media, unless otherwise specified. The end users are responsible for the conformity of the process data with the calculation bases.

As a result of the pipeline design, a vibration excitation is also possible, which is not the subject of the wake frequency calculation.

A warranty by WIK A cannot be given.

Required process data for the wake frequency calculation

Process data	SI unit	Imperial	Others
Flow rate	m/s	ft/s	-
Medium density	kg/m ³	lb/ft ³	-
Temperature	°C	°F	-
Pressure	bar	psi	-
Dynamic viscosity ¹⁾	mm ² /s	ft/1000s	cP

1) ASME PTC 19.3 TW-2016 selectable, not required for Dittrich/Klotter

In accordance with ASME PTC 19.3 TW-2016, chapter 9-1, the designer of the system in which the thermowell is installed is responsible for specifying the process data used for the calculation (temperature, velocity, density, pressure).

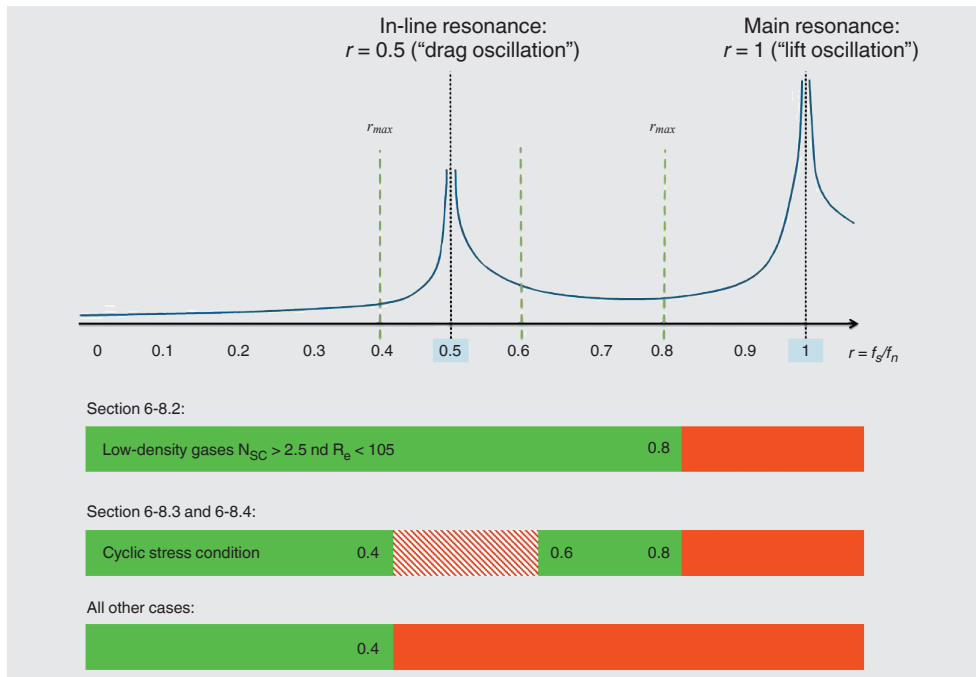
If several process data are provided to WIKA (e.g. min. / process / max. / design), in accordance with 6-3.3 of the standard, the highest value is always used for the calculation.

This procedure is applied to each wake frequency calculation, regardless of the standard.

ASME PTC 19.3 TW-2016

ASME PTC 19.3 TW-2016 is divided into dynamic and static calculation results and is exclusively applicable to thermowells installed in pipes or process vessels. Applications in process or industrial furnaces are thus outside the scope of the calculation.

For low-density gases, the frequency limit is typically $r_{\max} = 0.8$. With other gaseous media, constant operation in the range between $r = 0.4 \dots 0.6$ around the in-line resonance is not permissible. For liquid media, in many applications, the limit frequency $r_{\max} = 0.4$ for the in-line resonance is typically used.



The evaluation of the dynamic results is made using the damping factor N_{SC} (N_{SC} , the Scruton number, is directly related to the permissible frequency ratio $r_{\max}$ of the excitation frequency f_s to the natural frequency f_n). In simplified terms, for gaseous media, a characteristic value is $N_{SC} > 2.5$; liquids typically have an $N_{SC} < 2.5$.

The values mentioned must not be considered as absolute in any calculation and are calculated individually by the program.

The Scruton number N_{SC} depends on the intrinsic damping factor, the density of the thermowell material, the process medium and the tip and bore diameter of the thermowell.

Whether the frequency ratio $r < 0.8$ can also be used as an evaluation limit for liquid process media is decided by considering the permissible stresses in the thermowell material compared to the actual stresses in the event of resonance. In addition, the strength of the thermowell material is evaluated with respect to the fatigue stress in the area of installation of the thermowell. The static results of ASME PTC 19.3 TW-2016 are based on the maximum permissible process pressure (depending on the process temperature and the geometry data of the thermowell) and the bending stress in the area of the thermowell root. The bending stress caused by the incident flow on the thermowell is, among other things, dependent on the shielded length resulting from the flange nozzle.

In addition to the VIV, vibration excitation of thermowells in all designs can be caused, for example, by the following factors:

- pulsating or turbulent flows
- Vibrations of the pipeline system (e.g. caused by pumps)
- Excitation through acoustic/flow-induced vibrations (AIV/FIV)
- The pipeline geometry itself (e.g. after T-pieces, dead legs or pipe elbows)
- Thermowell mounting with too little distance to interrupters or other thermowells (e.g. “2oo3 installation”), whereby other causes are also conceivable.

These vibration excitations cannot be calculated by the calculation methods in accordance with ASME, Dittrich/Klotter or using CFD (Computational Fluid Dynamics), but must also be evaluated by the end user in the design of the measuring location. The calculation results of the aforementioned methods are not directly comparable with each other.

Dittrich/Klotter

The static calculation of thermowells for thermometers is based on the formulae published by P. Dittrich in 1954 in the technical journal “Allgemeine Wärmetechnik” (“General Heating Technology”). These formulae were considered in DIN 43763, a predecessor standard of the current DIN 43772 from 2000.

Around 1990, WIKA supplemented the static calculation in accordance with Dittrich with the dynamic calculation in accordance with Klotter, which originates from the textbook “Das Ingenieurwesen - Hütte” (“Engineering - Metallurgy”) in the chapter “Kinetik der Schwinger” (“Kinetics of oscillators”). This combination enables the calculation of protection tubes and the estimation of the loads in the operating case, caused by the vortex shedding of the Kármán vortex street. The in-line resonance introduced in 2010 by ASME PTC 19.3-TW is not considered in the calculation in accordance with Dittrich/Klotter.

The static evaluation is made via the “comparative stress”. The pressure loading at the thinnest wall thickness near the tip of the thermowell is combined with the combined bending load at the root of the flow and axial pressure loading, whereby a representative stress value, $S_{\text{comp}} = \max + \min/3$, is formed. In addition, a safety number S is calculated via the quotient of S_{comp} with the permissible stress $0.7 \times R_{p(T)}$.

For the dynamic consideration, the excitation frequency is calculated with the Strouhal number $St = 0.21$ and compared with the natural frequency in accordance with Klotter. The frequency ratio in accordance with ASME PTC 19.3-1974 should not exceed the limit value $r_{\text{max}} = 0.8$.

Solutions when the permissible frequency ratio $r_{\max}$ is exceeded due to design changes

If the maximum permissible limit frequency $r_{\max}$ for the in-line or main resonance is exceeded, the following design changes can be made:

a) Shortening of the insertion length

This is the most effective, and the design change recommended by all calculation methods, to improve the frequency ratio r .

b) Increasing the root diameter

By increasing the root diameter, the natural frequency f_n is reduced and thus the frequency ratio r is optimised.

c) Increasing the tip diameter

By increasing the tip diameter, the vortex shedding frequency f_s is reduced and thus the frequency ratio r is optimised

d) Support collar

Support Collars or other support devices are not included within the scope of ASME PTC 19.3 TW-2016 and are only offered on explicit customer request. The basics of the calculation in accordance with Dittrich/Klotter do not make any statements with regard to the support collar.

Supporting the thermowell with a support collar is not recommended, as a fixed support can only be achieved through an interference fit between the support collar and the flange nozzle (see ASME PTC 19.3 TW-2016, points 6-7-(e)).

The design of the thermowell below the support collar corresponds to the design and calculation criteria of ASME PTC 19.3 TW-2016 or Dittrich/Klotter.

Since each flange nozzle has individual dimensions, the support collar is delivered with an oversize. The operator is responsible for the interference fit of the collar in the nozzle, which makes it necessary to subsequently adapt the collar to the nozzle.

It should be noted that some nozzle designs are not suitable for use with support collars. A warranty for support collars is not provided.

→ Further information is described in the technical information IN 00.26.

e) ScrutonWell® design

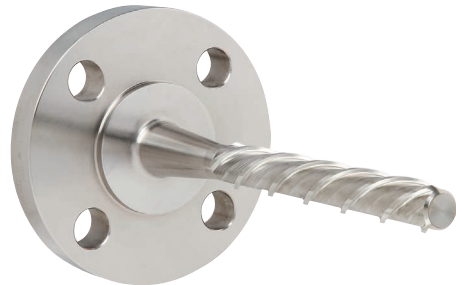
The ScrutonWell® design can be used for thermowells with flange connection, Vanstone design and also for welded or screwed process connections. This design enables the easy and quick mounting of the thermowell without the need for expensive and time-consuming adjustment on-site, as required for support collar.

The ScrutonWell® design reduces the vibration amplitude by more than 90 % with a vortex-induced excitation, which has been tested and proven by the independent laboratories TÜV SÜD NEL (Glasgow) and the Institute of Mechanics and Fluid Dynamics (Technische Universität Freiberg).

→ For further information, see data sheet SP 05.16

Strength calculation of the ScrutonWell® design using ASME PTC 19.3 TW-2016

- Maximum permissible pressure load with original stem dimensions
- Maximum permissible bending load with modified stem dimensions
- Due to the damping of the vibration amplitude by more than 90 %, no dynamic calculation is carried out



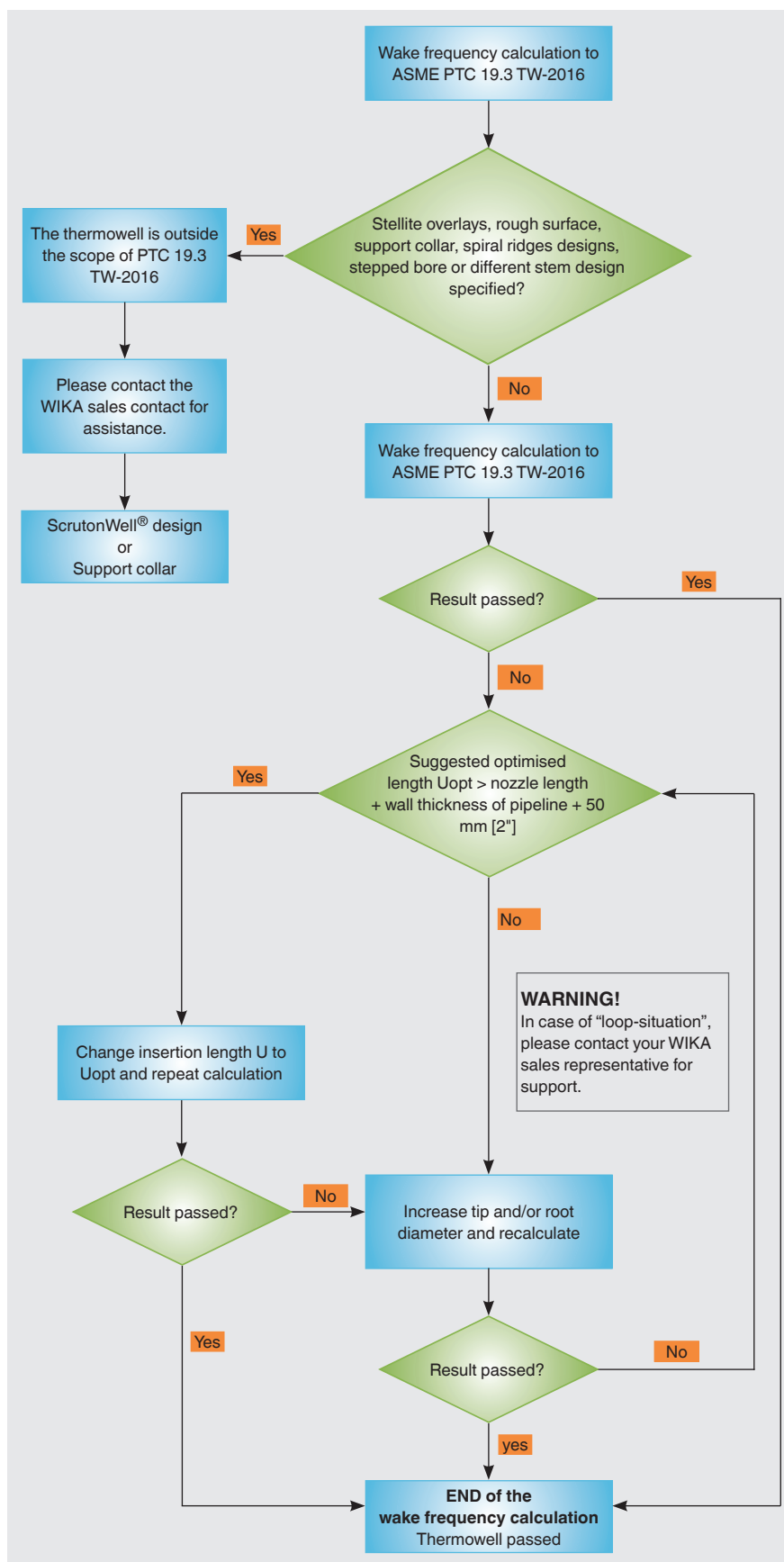
Thermowell model TW10 in ScrutonWell® design

Performing a standard wake frequency calculation in accordance with ASME PTC 19.3 TW-2016

This simplified flow diagram shows the procedure of performing a standard wake frequency calculation in accordance to ASME PTC 19.3 TW-2016 step-by-step. The diagram addresses a failed frequency ratio only.

Because of variation in thermowell designs in combination with various process parameters not all wake frequency calculations can follow this standard procedure.

If the procedure shown does not provide a satisfactory result, contact the manufacturer to get support. A specific technical solution might be needed.



Design details

ScrutonWell®: Calculation of Scruton length SL

The length of the helixes, the so-called Scruton length SL, must be designed so that they reach 25 mm [1 in] into the shielded length of the nozzle.

→ For further information, see data sheet SP 05.16

Support collar

■ Determine 1st support collar location

The position of the thermowell support collar is calculated as follows: Nozzle length - 25.4 mm [1 in]

■ Example:

Nozzle length 356 mm [14 in]. The 1st support collar is located 330 mm [13 in] from the flange sealing face.

The nozzle length is defined as the length from the outer diameter of the pipe / pipeline / vessel wall to the height of the nozzle (flange sealing face, etc.).

■ Determine the number and position of the support collars

If the 1st support collar is less than 127 mm [5 in] from the flange sealing face, then only one support collar is required.

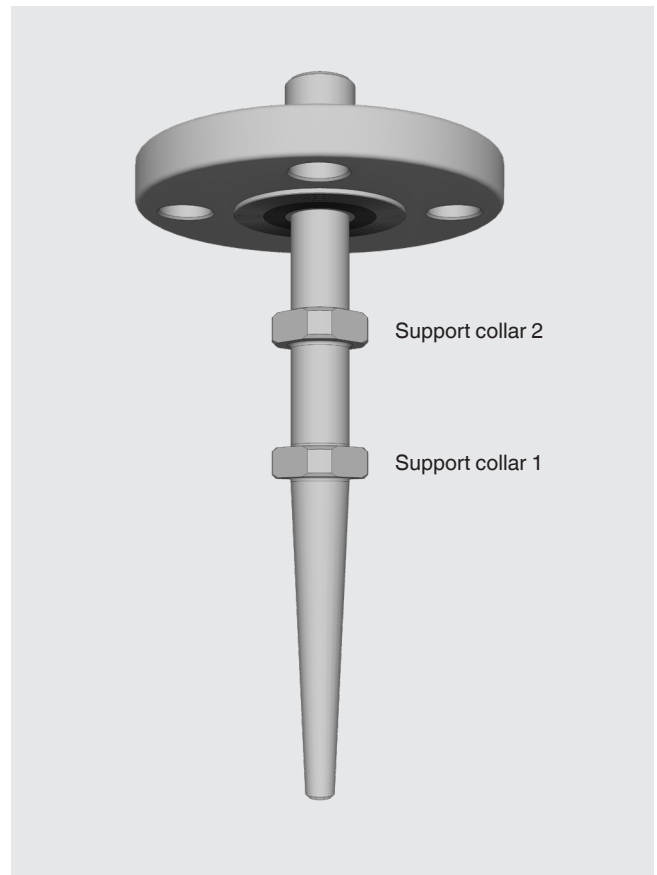
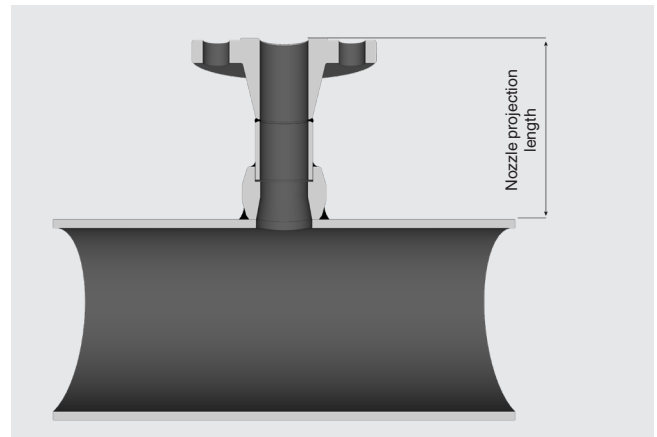
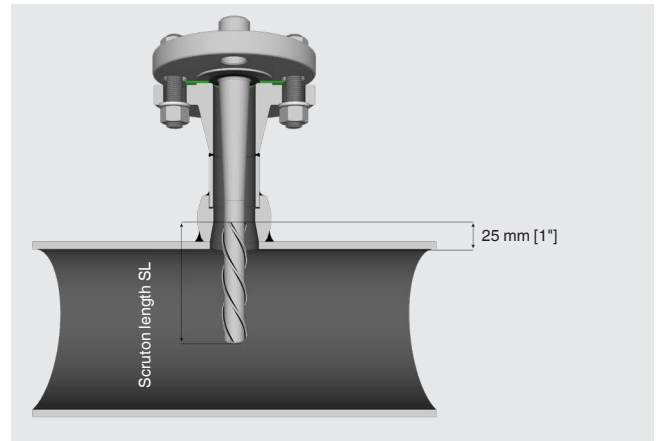
If the position of the 1st support collar is 127 mm [5 in] or more, then a 2nd support collar is required, at the point which is half the distance to the 1st support collar. For a nozzle projection length of more than 762 mm [30 in], please contact your WIKA sales representative.

■ Example no. 1 – Two support collars

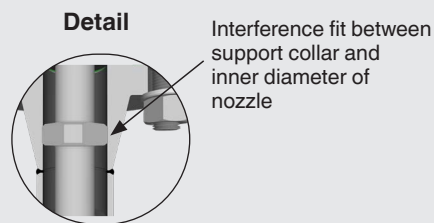
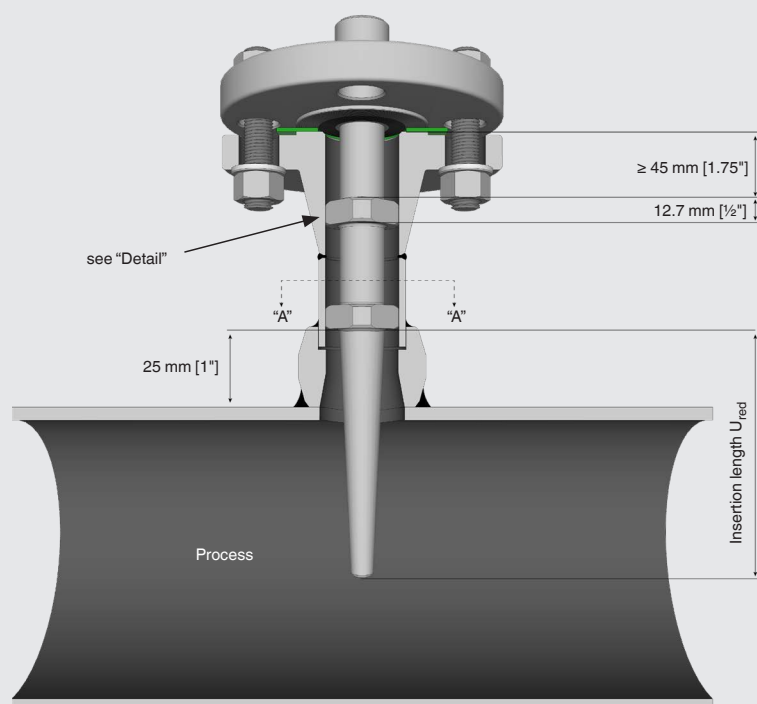
The nozzle length is 356 mm [14 in]. Support collar 1 is 356 mm [14 in] – 25.4 mm [1 in] = 330 mm [13 in]. Since this number is greater than 127 mm [5 in], two support collars are required. Thus, 330 mm [13 in] / 2 = 165 mm [6.5 in]. Support collar 2 is at 165 mm [6.5 in].

■ Example no. 2 – One support collar

The nozzle length is 114 mm [4.5 in]. Support collar 1 is at 114 mm [4.5 in] – 25.4 mm [1 in] = 89 mm [3.5 in]. Since this number is smaller than 127 mm [5 in], a support collar is required.



Typical installation through a nozzle



4-point support collar



Section "A"- "A"

Determine the support collar outer diameter from the pipe size and schedule

NPS	UOM	Outer diameter of the support collar						
		SCH.10	SCH.40	SCH.STD	SCH.80	SCH.XS	SCH.160	SCH.XXS
1"	in	1.107	1.059	1.059	0.967	0.967	0.825	0.609
	mm	28.1	26.9	26.9	24.6	24.6	21.0	15.5
1 1/2"	in	1.692	1.620	1.620	1.510	1.510	1.348	1.110
	mm	43.0	41.1	41.1	38.4	38.4	34.2	28.2
2"	in	2.167	2.077	2.077	1.949	1.949	1.697	1.513
	mm	55.0	52.8	52.8	49.5	49.5	43.1	38.4

Determine the suggested maximum root diameter based on nozzle size and schedule

NPS	UOM	Suggested root diameter at the support collar						
		SCH.10	SCH.40	SCH.STD	SCH.80	SCH.XS	SCH.160	SCH.XXS
1"	in	0.938	0.875	0.875	0.813	0.813	0.688	0.500
	mm	23.8	22.2	22.2	20.6	20.6	17.5	12.7
1 1/2"	in	1.500	1.375	1.375	1.250	1.250	1.125	1.000
	mm	38.1	34.9	34.9	31.8	31.8	28.6	25.4
2"	in	1.875	1.750	1.750	1.625	1.625	1.500	1.250
	mm	47.6	44.5	44.5	41.3	41.3	38.1	31.8

Design specifications in accordance with ASME PTC 19.3 TW-2016, Table 4-1-1, 4-2-1

Description	Tapered and straight designs		Stepped design	
	Minimum	Maximum	Minimum	Maximum
Insertion length L	63.5 mm [2.5 in]	609.6 mm [24 in] ¹⁾	127 mm [5 in]	609.6 mm [24 in]
Bore diameter d	3.175 mm [0.125 in]	20.9 mm [0.825 in]	6.1 mm [0.24 in]	6.7 mm [0.265 in]
Tip diameter B	9.2 mm [0.36 in]	46.5 mm [1.83 in]	-	-
Taper ratio B/A	0.58	1	-	-
Step ratio B/A for B = 12.7 mm	-	-	0.5	0.8
Step ratio B/A for B = 22.2 mm	-	-	0.583	0.875
Bore ratio d/B	0.16	0.71	-	-
Aspect ratio L/B	2	-	2	-
Length ratio Ls/L	-	-	0	0.6
Min. wall thickness (B-d)/2	3 mm [0.12 in]	-	3 mm [0.12 in]	-

1) Insertion lengths > 609.6 mm (24 in) are permissible, as long as a one-piece design of the thermowell without weld seams is used.

Marking	per ASME PTC 19.3 TW-2016	in WIKA data sheets
Insertion length	L	U
Bore diameter	d	B
Tip diameter	B	V
Root diameter	A	Q

If the thermowell dimensions, based on customer requirements or for specific applications, lie outside the requirements of ASME PTC 19.3 TW-2016, the calculation results can only be used for informative purposes. For this reason, no warranty can be given by the manufacturer.

Provision of calculation data

The table shows how process and geometry data should be provided electronically as an Excel spreadsheet for a chargeable thermowell calculation by WIKA engineering services.

Example for 6 measuring points in metric units:

Legend

Tag no.	Tag number	Ø Q	Root diameter
T	Temperature	Ø V	Tip diameter
P	Pressure	T _t	Tip thickness
v	Flow rate	N _{ID}	Inner diameter of nozzle
rho	Density of the process medium	N _L	Nozzle projection length
U	Insertion length	Model	WIKA thermowell model
Ø d	Bore size		

Tag no.	T	P	v	rho	Dyn. viscosity in cP	Model	Dimensions in mm [in]							Material
	in °C [°F]	in bar [psi]	in m/s	in kg/m ³			U	Ø d	Ø Q	Ø V	T _t	N _{ID}	N _L	
TW-0301	220 [428]	1.5 [21.76]	23.6	2.4	0.013	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4435
TW-0303	220 [428]	1.5 [21.76]	25.7	2.0	0.017	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4435
TW-0305	235 [455]	10 [145.04]	19.6	6.1	0.015	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4435
TW-0307	220 [428]	10 [145.04]	13	8.9	0.014	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4571
TW-0309	235 [455]	30 [435.12]	8.9	28.3	0.013	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4571
TW-0311	400 [752]	31.5 [456.88]	31.9	10.1	0.017	TW10	250 [10.04]	8.5 [0.34]	25 [0.98]	19 [0.75]	6.4 [0.25]	38.3 [1.51]	220 [8.66]	1.4571

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Mechanical temperature measuring instruments

WIKA data sheet IN 00.07

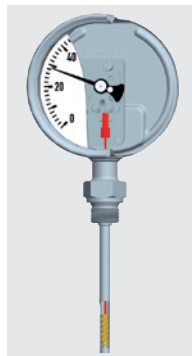
Temperature is an indicator of the thermal condition of a homogenous material or body. It expresses the energy of motion that is contained in the molecules of the material. Transmission of temperature from one body to another, e.g. process medium and thermometric sensor, requires close physical contact between both bodies to achieve thermal equilibrium. Conventional temperature measurement is based on the property of certain materials to alter their physical shape or volume proportional to the temperature applied. The most commonly used principles in the WIKA production are highlighted below.

Bimetal thermometers

Operating principle

The temperature is measured by means of a bimetal system inside the temperature sensor. The bimetal is made from two metal strips, permanently joined together, each metal having a different thermal expansion coefficient. This causes the strip to deflect in proportion to the temperature variation. The actual bimetal system consists of a bimetal strip that is either

- helically or
- spirally



wound, depending on the size of the sensor and the temperature range to be measured. Any temperature variation causes the bimetal to rotate an attached spindle. This rotation is indicated by a pointer on a dial scale. WIKA bimetal thermometers are available for temperature ranges from -70 to +600 °C with accuracies complying with Class 1 and 2 of EN 13190.

Expansion thermometers

Operating principle

The temperature is measured by a liquid-filled measuring system consisting of a temperature probe, a capillary and a bourdon tube. These three components form a sealed system. Any temperature variation causes a change in the internal pressure of this system. As a result of this pressure

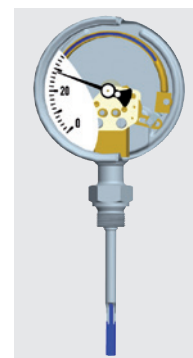
change the shaft and pointer connected to the tube rotate and the temperature value is indicated on the scale. With capillary lengths available between 500 and 10,000 mm, it is also possible to measure temperatures at remote measuring points.

WIKA expansion thermometers are available for temperature ranges from -40 to +400 °C with accuracies complying with Class 1 and 2 of EN 13190.

Gas actuated thermometer with or without capillary

Operating principle

Gas actuated thermometers consist of a stem, a capillary and a case containing the bourdon tube element. These components are connected to form a single system. The complete measuring system is filled with an inert gas under pressure. Any temperature variation causes a change in the internal pressure of the stem, leading to a deflection of the bourdon tube. A mechanical linkage (movement) transmits this deflection to the pointer.



Variations in the ambient temperature acting on the case are compensated for by a bimetal element mounted between the movement and the bourdon tube.

WIKA gas actuated thermometers are available for temperature ranges from -200 to +700 °C with an accuracy complying with Class 1 of EN 13190.

Conversion reference

How to calculate	From				
	K	°C	°F	°R	°Ré
K	x	$K = °C + 273.15$	$K = 5/9 (°F + 459.67)$	$K = 5/9 °R$	$K = 5/4 °Ré + 273.15$
°C	$°C = K - 273.15$	x	$°C = 5/9 (°F - 32)$	$°C = 5/9 °R - 273.15$	$°C = 5/4 °Ré$
°F	$°F = 9/5 K - 459.67$	$°F = 9/5 °C + 32$	x	$°F = °R - 459.67$	$°F = 9/4 °Ré + 32$
°R	$°R = 9/5 K$	$°R = 9/5 °C + 491.68$	$°R = °F + 459.67$	x	$°R = 9/4 °Ré + 491.68$
°Ré	$°Ré = 4/5 K - 218.52$	$°Ré = 4/5 °C$	$°Ré = 4/9 (°F - 32)$	$°Ré = 4/9 °R - 218.52$	x

Limit of error in °C per DIN EN 13190

Applicable for expansion and bimetal dial thermometers

Scale range in °C	Measuring range in °C	Limit of error in ± °C	
		Class 1	Class 2
-20 ... +40	-10 ... +30	1	2
-20 ... +60	-10 ... +50	1	2
-20 ... +120	-10 ... +110	2	4
-30 ... +30	-20 ... +20	1	2
-30 ... +50	-20 ... +40	1	2
-30 ... +70	-20 ... +60	1	2
-40 ... +40	-30 ... +30	1	2
-40 ... +60	-30 ... +50	1	2
-100 ... +60	-80 ... +40	2	4
0 ... 60	10 ... 50	1	2
0 ... 80	10 ... 70	1	2
0 ... 100	10 ... 90	1	2
0 ... 120	10 ... 110	2	4
0 ... 160	20 ... 140	2	4
0 ... 200	20 ... 180	2	4
0 ... 250	30 ... 220	2.5	5
0 ... 300	30 ... 270	5	10
0 ... 400	50 ... 350	5	10
0 ... 500	50 ... 450	5	10
0 ... 600	100 ... 500	10	15
0 ... 700	100 ... 600	10	15
50 ... 650	150 ... 550	10	15
100 ... 700	200 ... 600	10	15

Basic points of thermo-dynamic temperature scales

Unit	Symbol	Reference value	
		absolute zero	triple point of water
Kelvin	K	0	273.16
Grad Celcius	°C	-273.15	0.01
Grad Fahrenheit	°F	-459.67	32.01
Grad Rankine	°R	0	491.68
Grad Réaumur	°Ré	-218.52	0

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