A strong group. For your success.
Our production locations: Germany (HQ), Brazil, China, India, Canada, Poland, Switzerland, South Africa, USA (f.l.t.r.)

All around the world - close to the customers

Global presence in over 43 countries

Our local services

- Sales/stock
- Consultancy, service, customised solutions
- Calibration for pressure and temperature measurement
- Diaphragm seal assembly
- Temperature sensor assembly
- Production
Range of products

Unique breadth and depth of product range

- Electronic pressure measurement
- Mechatronic pressure measurement
- Mechanical pressure measurement
- Diaphragm seals
- Electrical temperature measurement
- Mechatronic temperature measurement
- Mechanical temperature measurement
- Thermowells
- Level measurement
- Flow measurement
- Calibration technology
- Accessories
Competence
Able to meet any challenge

- Power engineering
- Chemical
- Petrochemical
- Oil & gas
- Water, waste water
- SF₆ gas excellence

- Machine building
- Heating, ventilation, air-conditioning
- Air handling
- Refrigeration
- Technical gases
- Semiconductor

- Food
- Pharmaceutical
- Beverage
- Biotechnology
- Cosmetics
Basic Training

Electrical Temperature Measurement

Content:
- Thermometer
- Thermowells
- Transmitter
Samples for industrial temperature measurement

**Power engineering**
- As higher the process temperature, as better the efficiency of the plant

**Chemical and petrochemical**
- The temperature is responsible for the produced product

**Food & Beverage**
- Sterilization and cleaning of the process

**Machine building**
- Measuring of bearing temperature

**Safety engineering**
- Protection against fire and explosions
Measuring Principles

**Temperature measurement is separated in:**
- Contact measuring (e.g. inserting)
- Non contact measuring (e.g. optical IR thermometer)
- Special (acoustic, crystals)

**The contact electrical temperature measuring at WIKA will be done in two ways:**
- Resistance sensors (e.g. Pt100)
- Thermocouples (e.g. Typ K)
The PT100 is a electrical device, which changes resistance with temperature.

- The Pt100 is a „PTC“, a resistant with a „positive temperature coefficient“ (temperature is rising → resistance is also rising)
- There are also Pt1000, Pt500 etc. existing
- Another common name for PT100 is also RTD = Resistance Temperature Detector

What means Pt100?
- Pt menas platinium, the main material of this sensors
- 100 means 100 Ohm at 0° C to DIN EN 60751 (IEC 751)
Mathematical Interrelation

Diagram Pt100 to DIN EN 60751

Resistance value [Ohm]

Temperature [°C]
Construction of a industrial RTD

- PT100 sensor
- Ceramic isolator
- Thermowell
- Minerals-isolated cable (MI-cable)
- Alumina oxide / Magnesia oxide
- Wires
2 principles and 3 versions

Ceramic sensor
- Platinum wire
- Platinum wire spiral in ceramic powders

Glass sensor
- Platinum wire spiral
- Platinum thin film

Thin Film (chip) sensor
- Glass
Thinfilm (chip) sensor

- High Vibration resistance
- Good price/benefit ratio
- Small size

- Temperature range: -50... +500 °C (class B)
- Not fully accepted by chemical industry
Ceramic sensor (platinum wire)

- Full temperature range -200 … +600 °C (class B)
- Fully accepted by all customers

- Limited vibration resistance
- High price
Glass sensor (wire)

- High vibration resistance
- Fully accepted by all customers

- Temperature range: -200 ... +400 °C (class B)
- High price
**2-wire-circuit**

![2-wire-circuit diagram]

**Easy and cheap**
- For short distance
- Measuring error because of wire resistance

**Sample:**
- Length of wire: 100m
- Cross section: 0.5mm² (40 Ohm/m/1000 m)

\[
2 \times R_{\text{line}} = 2 \times 100 \text{ m} \times \frac{40 \text{ Ohm}}{1000 \text{ m}} = 8 \text{ Ohm}
\]

This leads to an error of approx. 20 °C (!)
3-wire-circuit

Good cost/benefit ratio

- No measuring error if the resistance of all wires are identical
- Recommended wire length up to 30 meter
- Standard in electrical measurement
- Suitable for standard transmitter configuration
No influence of wire resistance
- Wire resistance is fully compensated
- Recommended for wire length over 100 meter

Applications
- Calibration and high accuracy measurement
- For accuracy class A or AA
- For SIL - applications
Pro & Cons of Resistance Thermometer’s

- Linear signal output
- No compensation circuit required
- In low temperature applications better accuracy than a thermocouple

- Limited up to 600 °C
- In comparison to TC’s longer response time
- Possible error by self-heating
- More expensive than a TC
- Mechanical strength not as high as a TC
Thermocouples
How a thermocouple works?

**The thermo-electric effect (Seebeck effect)**

A thermocouple never measures the absolute temperature, but always the difference between:

- **T1**: the measuring point (hot junction) and
- **T2**: the basis point (cold junction)
Each thermocouple has a different characteristic
- The characteristic is not linear
- The voltage of the seebeck effect is really small, approx. 0.04 Volt

(The voltage of a normal batterie is 40 times stronger)
The standard EN 60584-2 separate thermocouples into different classes
- class 1
- Class 2

ASME 230
Northamerican standard
- Standard
- Spezial
The most popular cable are codeable and listed in the WIKA equipment catalog.

- **Thermocable**: Are made of **identical** material as the thermo couple:
  - + accuracy
  - - cost

- **Compensation cable**: Are made of **similar** material as the thermo couple:
  - + cost
  - - accuracy

- **Leitungsmantel und Ausführung**
  - **Material**: PVC, silicon, teflon, fibreglas
  - **Armour**: yes / no
Why to use thermowells?

- Protection of the temperature sensor
- Protection of the workers and the environment
- Replaceability of the sensor during running process
Thermowell Lunch and Learn

WIKI Thermowell’s
Construction of Thermowells

Shank design of solid drilled thermowells
- Tapered: strong root and fast response time
- Straight: for highest pressure loads
- Stepped: fast response time

Shank design of fabricated thermowells
- Straight tube (standard)
- Tapered tube 12x2,5 mm to 9 mm for fast response time
Thermowell Lunch and Learn

Process Connections
Thermowell Lunch and Learn

Construction of Thermowells

**Full Penetration Welding**
- global acceptance
- use of blind flanges

**Partial Penetration Welding**
- use in Europe / Germany
- use of blind flange

**Screwed & Welded construction**
- roots in asian market
- threaded flange with hub
TW40: Special construction for exotic materials

TANTALUM:
- removable cover
- 12 x 0.4 mm with tube 11 x 2 mm
- 16 x 0.4 mm with tube 15 x 3 mm

EXOTIC MATERIAL
- Washer disc construction (also TW10)
- Wetted parts made of exotic material
- Flange body made of stainless steel
Focus on Oil & Gas
TW31 - The manufacturing of solid forged Thermowell’s

Flanged & single piece Thermowells machined from forged blanks…full adherence to ANSI B16.5 & essence of ASTM A182….
Forged Grain Structure

1. ONE PIECE FORGED
   - OK

2. FORGED BAR
   - NOT PERMITTED
   - ACCORDING TO ASTM A182

3. STEM DRILLED FROM BARSTOCK
   WELDED FORGED FLANGE
   - OK

4. STEM DRILLED FROM BARSTOCK
   WELDED FLANGE FROM BAR
   - NOT PERMITTED
   - ACCORDING TO ASME B1.5
Hydrostatic pressure test:
- outside pressure for flanged thermowells
- inside pressure for screwed and weld-in thermowells

Dye penetration test / Liquide penetration test:
- surface defects of welding connections

Positive material identification (PMI):
- verification of alloy content
- spectral analysis (OES) oder X-ray Fluorescence (XRF)

Ultrasonic testing and X-ray:
- defect inside welding connections
- check of bore concentricity

Helium leak test:
- leak test of thermowells
Thermowell Lunch and Learn

Outside pressure testing

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<th>Pressure rating</th>
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Thermowell Lunch and Learn

inside pressure testing

- Standard test for threaded and weld-in thermowells
- Special for flanged thermowells
- Testing time: 3 min
- Testing pressure: 400 bar
Dye Penetration Test (DPI)  
Liquide Penetration Test (LPI)

Surface defect on welding connections

- Methode red/white („Mat‘l Check“)
- Methode with ultraviolet light
X-ray Fluorescence (RFA)

- X-Ray = high energy radiation
- Energy of X-ray stimulate atomes
- Atome radiate a specific radiation
- Specific radiation = Indicator about alloy element in probe
Thermowell Lunch and Learn

X-Ray examination

- Internal defect of welding connections
- Full Penetration Welding
- Welds of end caps of fabricated thermowells
- Concentricity of bore
What this pictures have in common?

Kármán Vortex Street
WIKI Thermowell Wake Frequency Calculations

Principle of VORTEX shedding
Oszillation square to flow

Oszillation to ASME PTC 19.3-1974
What happen 1995 in the fast breeder reactor in Monju, Japan?
WIKI Thermowell Wake Frequency Calculations

Osislation to ASME PTC 19.3-TW2010

Drag – Oszillation 5%
in flow direction

Lift – Oszillation square to flow direction

\[ \text{fw/fn} < 0.8 \ (\text{ASME PTC 19.3 -1974}) \]

\[ \text{fw/fn} = 0.5 \]
### WIKI Thermowell Wake Frequency Calculations

**Wake Frequency Calculation program**  
**PTC 19.3- TW2016**

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</table>
WIKA Thermowell Wake Frequency Calculations

Results to PTC 19.3- TW2016
Error Codes for PTC 19.3- TW2016

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. Note 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

**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 gauge 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 $fw/fnc = 0.4 < x < 0.6$ if $Nsc < 2.5$ or $Re > 105$
- **Counteraction:** Increase the thermowell insertion length $U$ up to $fw/fnc = 0.6$ ...
- Shorten the thermowell insertion length $U$ up to $fw/fnc < 0.4$

**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
Wika Thermowell Wake Frequency Calculations

Options...Velocity Collars (interference fit)

Typical installation through a nozzle

- ≥ 45 mm (1.75"")
- 12.7 mm (½")

see "Detail"
WIKA ScrutonWell®
Thermowell ScrutonWell® design

WIKA - Part of your business
WIKI ScrutonWell®

Thermowell ScrutonWell® design
Sample for helical design in other technical applications:

The helical design is state of the art in different technical applications:

- Industrial chimneys
- Offshore platform
- Car antenna
How does the ScrutonWell® work?

- Kármán vortex street behind the thermowell stem
- This initiates the vibration of the stem in resonance
- The ScrutonWell® design avoids the formation of a Kármán vortex
- The vortex behind the thermowell stem gets diffuse
- The amplitude of the vortex can be reduced by more than 90%
- → NO RESONANCE – NO VIBRATION
Advantages of the ScrutonWell® design for the customer

ScrutonWell installation
Installing a thermowell with ScrutonWell® design is identical to installing a comparable standard thermowell. No time-consuming and expensive rework at the nozzle or thermowell adjustment is required for assuring an interference fit, as is the case with the installation of a thermowell with support collar.

Even flange nozzles with an axial or angular displacement have no influence on the installation of a thermowell with ScrutonWell® design.
Reduced response time

- Reduced response time in comparison to a standard thermowell stem design
- The increased surface by the helical strake structure reduces the response time of the thermometer

<table>
<thead>
<tr>
<th>Response time [s]</th>
<th>t50</th>
<th>t90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard thermowell</td>
<td>40.98 s</td>
<td>101.65 s</td>
</tr>
<tr>
<td>ScrutonWell®</td>
<td>39.35 s</td>
<td>97.34 s</td>
</tr>
</tbody>
</table>
Advantages of the ScrutonWell® design for the customer

- Damping of the oscillation can be reduced by more than 90% in comparison to a standard thermowell stem design.
- Easy, fast and trouble-free installation of the thermowell without rework
- Implementation of a globally established technical solution for thermowells
- Optimized response time of the thermometer compared to the conventional thermowell design through enlarged surface
- Eliminating the use of support collars and their disadvantages such as additional costs or rework
- Easy dismounting comparable to maintaining a standard thermowell
- The effectiveness of the ScrutonWell® design for thermowells has been verified by independent laboratory testing of TU Freiberg
- Dimensioning and calculation of the thermowells based on the static results of ASME PTC 19.3 TW-2016
WIKA ScrutonWell®

Technical data

- **Versions**
  - Solid-machined version with 3 strakes
  - Solid-machined version with 3 filler rods, welded

- **Materials**
  - Stainless steel 304/304L, 316/316L
  - Carbon steel A105
  - Special alloys - Monel 400 or Inconel 600
  - Other materials available on request

- **Process connection**
  - Flanges to all standards (e.g. ASME, API, EN, DIN, JIS, GOST)
  - Vanstone design for 1", 1 ½" and 2" nozzle
  - Threaded connections with 1" NPT, 1 ¼" NPT, 1 ½" NPT or 2" NPT on request
  - Weld-in connection for socket or direct welded thermowells on request
WIKI ScrutonWell®

Technical data

ScrutonWell® (solid-machined) for flanged and Vanstone thermowells

<table>
<thead>
<tr>
<th>Dimensions in mm (inch)</th>
<th>Outer diameter OD</th>
<th>Tip diameter V</th>
<th>Strake height Sh</th>
<th>Strake depth Sw</th>
<th>Scruton length (max) SL</th>
<th>Insertion length (max) U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; nozzle schedule 5 ... 80</td>
<td>22 (0.866&quot;)</td>
<td>17 (0.669&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>305 mm (12&quot;)</td>
<td>610 mm (24&quot;)</td>
</tr>
<tr>
<td>1 ½&quot; nozzle schedule 5 ... 160</td>
<td>25 (0.984&quot;)</td>
<td>20 (0.787&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>305 mm (12&quot;)</td>
<td>610 mm (24&quot;)</td>
</tr>
<tr>
<td>2&quot; nozzle schedule 5 ... 160</td>
<td>25 (0.984&quot;)</td>
<td>20 (0.787&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>2.5 (0.098&quot;)</td>
<td>305 mm (12&quot;)</td>
<td>610 mm (24&quot;)</td>
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</tbody>
</table>

ScrutonWell® (welded design) for flanged and Vanstone thermowells

<table>
<thead>
<tr>
<th>Dimensions in mm (inch)</th>
<th>Outer diameter (approx.) OD</th>
<th>Tip diameter V</th>
<th>Rod diameter R</th>
<th>Scruton length (max) SL</th>
<th>Insertion length (max) U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; nozzle schedule 5 ... 80</td>
<td>22 (0.866&quot;)</td>
<td>17 (0.669&quot;)</td>
<td>2.4 (0.094&quot;)</td>
<td>800 mm (31.5&quot;)</td>
<td>1,000 mm (39&quot;)</td>
</tr>
<tr>
<td>1 ½&quot; nozzle schedule 5 ... 160</td>
<td>25 (0.984&quot;)</td>
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<td>800 mm (31.5&quot;)</td>
<td>1,000 mm (39&quot;)</td>
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</table>

pitch angle $\alpha = 58^\circ$
How to define the Scrutonwell length?

**Insertion Length (U-dim)**
- Where possible use customer original specifications
- When not specified use a general rule of 1/3 to 1/2 of the pipe ID + nozzle projection

**Strake Length (SL)**
- Minimum length = U-dim - nozzle projection
Stress calculation

Calculation of ScrutonWell® design based on ASME PTC 19.3 TW-2016

- Maximum permissible pressure load with original stem dimensions
- Maximum permissible bending load with modified stem dimensions
- The dynamic part of the thermowell calculation is not calculated, as it does not fall within ASME PTC 19.3 TW-2010 scope. Based on an ASME article the damping of the oscillation is reduced by more than 90% when helical strakes are used. “Helical strakes in suppressing vortex-induced vibrations” (ASME report 11/2011 Vol. 113).
WIKA ScrutonWell®

Type testing summary

Report on the
High-speed visualization of flow structure
resonance of thermocouple wells

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Mario Köhler
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Benjamin Potsch

Freiburg, July 2014