

Electrical temperature  
measurement

# Tubeskin temperature measurements



# About us



Alexander Wiegand,  
Chairman and CEO, WIKA

Over the past 60 years, WIKA Alexander Wiegand SE & Co. KG has been a renowned partner and competent specialist for any task in the field of pressure, temperature and level measurement. On the basis of a steadily growing efficiency, innovative technologies are applied when developing new products and system solutions. The readiness to face all challenges of the market have been the key factors for WIKA to achieve a leading position in the global market.

Within the WIKA group 7,300 employees are dedicated to maintaining and improving technology. Within our sales organisation you will find more than 500 skilled and experienced employees to talk to.

More than 250 engineers and technicians are continually searching to provide solutions for innovative products, improved materials and more economical production methods. In close cooperation with recognised universities, institutes and industrial companies solutions for specific applications are developed.

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## WIKA - GAYESCO

### Your engineered product solution for tubeskin temperature measurements

WIKA/Gayesco have been among the world leaders in the refinery and petrochemical industry for more than 50 years. The WIKA Group has further expanded by acquiring Gayesco International Inc. This strengthens the market position of the group in the field of electrical temperature measurement and on-site services.

Together there are well over **120,000** tubeskin sensors globally supplied by WIKA and Gayesco.

Thus we are more than simply a reliable supplier of high-quality measuring instruments: As a competent partner we develop products and solutions with you that are specifically tailored to your requirements. WIKA's high level of performance is characterised by a comprehensive and competent service and a reliable global presence. We are pleased to be committed to your success: yesterday, tomorrow and in the future.

# Tubeskin temperature measurement applications

## Furnace sections

### Direct radiation section

The direct radiation section is typically where the radiation from the flame heats the tubes. The tubes can be vertical or horizontal, arranged along the refractory wall, in the middle or arranged in cells. The tubes are typically 300 - 450 mm (12 - 18") apart inside the furnace. In the illustration on the right, the process tubes are arranged horizontally and the burners are located in the middle of the furnace.

### Convection heat section

The convection heat section is located above the direct radiation section. In this area the heat is not as intense and the tubes are typically not subjected to direct flame. Here the tubes are typically 150 - 230 mm (6 - 9") apart inside the furnace, which sometimes makes it difficult to attach tubeskin thermocouples. Typically tubeskin thermocouples are only installed on the bottom row (shock tubes).



Direct radiation section

## Furnace types

### Crude oil

Crude furnaces heat crude oil for processing in a crude distillation unit. The crude oil composition can vary widely with type. Crude furnaces are operated under steady state conditions.

### Vacuum

Vacuum furnaces heat crude oil bottoms for further processing in the vacuum distillation unit. Crude furnaces are operated under steady state conditions, but coke formation can be an issue with this furnace type.

### Coker

The coker furnace heats heavy oil cuts high in petroleum residues and asphaltenes for processing in the coke drum. Premature coke formation in the tubes can be a problem as well as frequent movement of the furnace during temperature variations and decoking.

### Catalytic reforming

The catalytic reformer furnace heats naphtha range oil for processing in the reforming reactors. These multi-cell furnaces are hot and often have three-dimensional process tube movement that can be problematic.

### Steam reformers/Primary reformers

The SMR furnace is a reaction furnace (catalyst filled tubes) that creates syngas for hydrogen, ammonia, or methanol production. These primary reformers are very hot furnaces that are generally steady state but have large tube movement parameters.

### Hydroprocessing

Hydroprocessing furnaces heat feedstock so that it can be treated (hydrotreaters) or cracked and treated (hydrocrackers). Hydroprocessing furnaces are generally steady state with coking potential depending on the type of material it is processing. Typical hydroprocessing units may handle just about all oil cuts.

### Fluid catalytic cracking

FCC furnaces heat up gas oil for processing in the FCC riser, and are generally steady state furnaces.

### Petroleum residues/Heavy oil processing

Heavy oil furnaces heat up heavy oil for processing in asphalt, ROSE, and other heavy oil processing units.

## Purpose of tubeskin temperature measurements

The purpose of tubeskin temperature measurements is to determine tube life and trending, and to provide safeguards within a system.

By relying on accurate tubeskin thermocouples clients can safeguard heater operations at their facilities. This can increase tube life in furnaces and increase production.

### Accuracy

- Provide accurate data to determine tube life assessment

### Durability

- Withstand harsh firebox environment for prolonged periods and should last the minimum of one turnaround cycle

### Ease of installation

- Secure weld attachment to the tube wall to fit any tube size
- Fast installation to meet tight maintenance schedule during a shutdown
- Quick replacement during a shutdown

### Sensitivity

- Detect overheating early on from coke formations
- Allow for accurate adjustment of furnace firing

### Safety device

- Monitor temperatures and alert in cases where high temperature is reducing the remnant life of the tube
- Monitor the maximum allowable temperature limits of the tube



Coke formation

# Tubeskin temperature measurement applications

## Design

WIKA uses trained specialists to customise the temperature measuring points to the application. These specialists utilise best practices derived from scientific properties to optimise the life and accuracy of the thermocouple. They make suggestions to optimise the system for temperature, movement, and burner firing.

Some design considerations that can help determine measuring points for the specific application in order to choose the best suitable product:

- Material compatibility with furnace tube
- Heat transfer (radiation, convection, conduction)
- Junction (grounded, ungrounded)
- Thickness of the mineral-insulated cable (flexibility vs. durability)
- Expansion loops (location and design)
- Flame impingement
- Furnace exit design options
- Burner fuel (flue gas composition)
- Welding procedure (TIG, stick, temperature monitoring)
- Mounting (location, orientation)
- Operating vs. design temperatures
- Bending radius
- Path to furnace wall
- Weld clips (location and routing)
- Connection head (material, location, approvals)
- Furnace design (burner locations)



Proper routing with clips



Expansion coils exiting the furnace

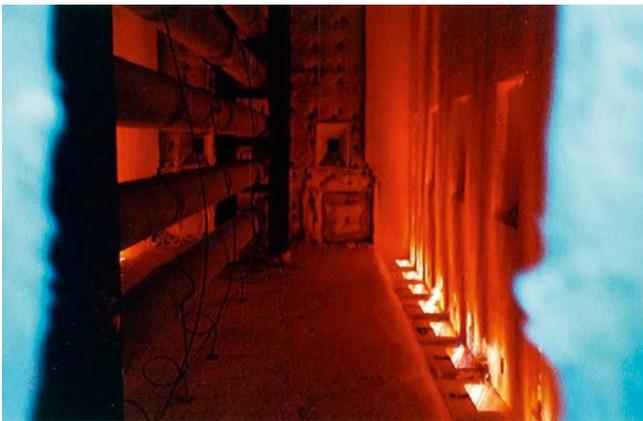
## Proper installation

A correct installation is essential to an efficient tubeskin thermocouple system. WIKA/Gayesco services have created installation animations to help those clients who want to install the product themselves. WIKA/Gayesco services also provide installation support up to and including full turnkey installations for those clients who want to be sure that the systems are installed properly.

Today, many major refiners, process licensors and furnace manufacturers rely on WIKA/Gayesco services to provide tubeskin thermocouple systems for them. Can we design a system for you?



Trained specialist installing sensor



Internal view of furnace

# Product solutions

## V-Pad™

The **V-Pad™** design includes a machined v-shaped block that is welded to the mineral-insulated cable.

Features of the **V-Pad™** include:

- Material compatibility for various service conditions
- Compaction of the mineral insulation inside of the **V-Pad™** protects the measuring point from radiant temperature influences.
- No special machining of the v-shaped block is required to match any tube profile.
- The thermocouple is welded into the base of the **V-Pad™** for maximum accuracy and fast response.
- The engineered v-shaped block allows a full penetration weld between the junction and tube surface, eliminating potential air gaps and substantial measurement inaccuracies.

## Application criteria

- Designed for critical mid-wall temperature measurements
- Designed for use with crude oil, vacuum & coker style furnace applications
- Early coke detection to optimise operations and increase production
- Ease of installation to minimise downtime during turnaround
- Suitable for any tube size due to v-shape, reducing spare parts inventory
- Grounded junction
- Longitudinal mounting onto tube



“**V-Pad™** is the most accurate thermocouple by far for all process heaters; it also can detect the onset (beginning) of coking events because of its small footprint. This has been proven in field tests, as well as from plant experience.”

Frank Liu, former Shell Global Solutions monitoring technology leader

## Refracto-Pad™

The **Refracto-Pad™** design utilises a Weld-Pad thermocouple and heat shield.

Features of the **Refracto-Pad™** include:

- Strong welded connection to the process tube
- Patented heat shield with a special insulating moulded part
- Shield and sensor profile designed to match tube curvature.
- Shield protects the sensor cable and allows for quick routing out of the radiant heat, increasing sensor life.

### Application criteria

- Designed for high heat flux or difficult applications, including flame impingement
- In harsh environments these sensors ensure reliable readings due to their patented shielded design.
- Grounded or ungrounded junction
- Radial or longitudinal mounting onto tube

“... Chevron regards type “A” (**Refracto-Pad™**) as the best answer to furnace tubeskin measurement ...”

“ Page 3; “Tubeskin Thermocouples”  
James G Seebold, Staff Engineer, Chevron Corporation,  
in Chemical Engineering Progress, 1985



# Product solutions

## Xtracto-Pad™

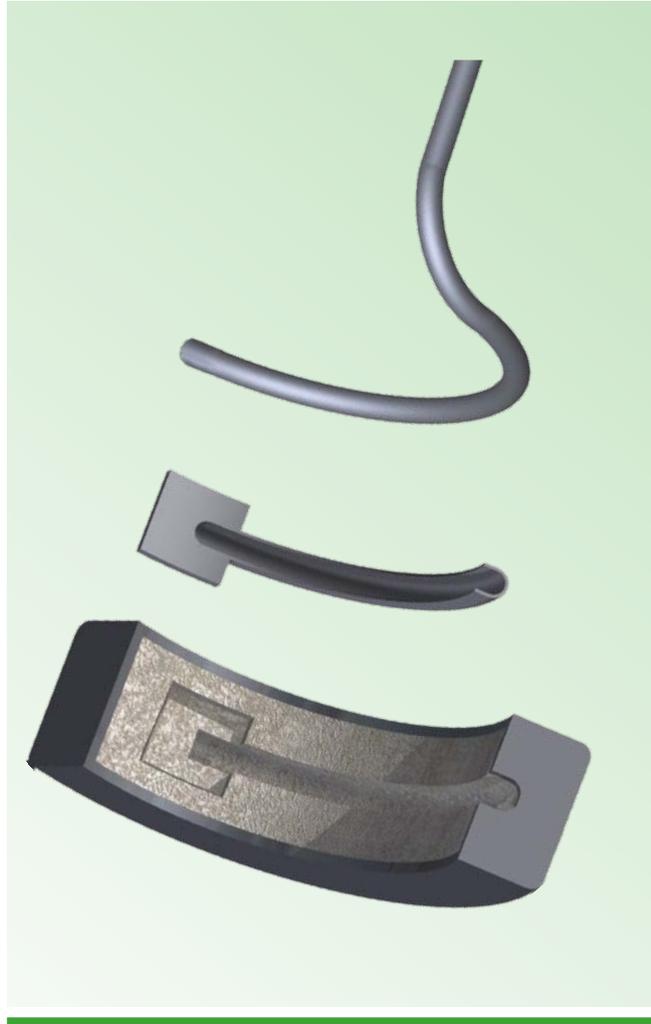
The **Xtracto-Pad™** design utilises a Weld-Pad attached to a guide channel and heat shield.

Features of the **Xtracto-Pad™** include all of the **Refracto-Pad™** plus:

- Removable thermocouple design allows the thermocouple to be replaced without any additional grinding or welding. It also allows for the weldable parts to be attached without the presence of the sensor. The Weld-Pad/guide channel, heat shield and clips can be put on by the manufacturer of the heater/boiler or even by the tube manufacturer in the case of special furnace tubes.
- Special features to improve the reliability of the reading accuracy

### Application criteria

- Designed for high heat flux or difficult applications, up to and including flame impingement
- Weldable parts can be sent to the furnace/tube manufacturer for initial installation. This is particularly helpful for special tubes, including spun cast tubes of unique alloy
- The **Xtracto-Pad™** ensures reliable readings due to its patented shielded design.
- Designed for use with catalytic reformers, steam methane/naphtha reformers and reaction furnaces
- Grounded or ungrounded junction
- Radial or longitudinal mounting onto tube



“This design (**Xtracto-Pad™**) has been adopted, ... as a standard for all high chrome furnaces tubes which require elaborate pre and post-weld heat treating ...”

“High Performance Skin Point Thermocouples - A Chronic Problem Solved”, Larry M. Braun, Senior Control Systems Engineer, Saudi Aramco 1996 Control System Technical Exchange Conference, Dhahran, Saudi Arabia, 1996

## Weld-Pad

The **Weld-Pad** design utilises a weld-on sheet that is welded to the furnace tube.

Features of the **Weld-Pad** include:

- Designed for low-temperature applications where accuracy is not crucial
- Used for tracking trending temperatures
- Low-cost alternative

### Application criteria

- Grounded or ungrounded junction
- Used when flame impingement is not a concern
- Ease of installation
- Small size



# Product selection guide

Selecting a suitable tubeskin thermocouple can be a daunting task. There are numerous variables that can determine one sensor style over another.

WIKA's application specialists can review your application and provide custom-designed solutions to fit your needs.

Below is a reference chart for sensor styles for specific applications.

For an in-depth product review and consultation please contact a WIKA representative for more information.

	V-Pad™	Refracto-Pad™	Xtracto-Pad™	Weld-Pad
<b>Accuracy - Mid wall</b>	+++++	++++	+++	+
<b>Accuracy - Surface</b>	++++	+++++	+++++	+
<b>Ease of installation</b>	+++++	++++	++++	+++++
<b>Durability (sensor life)</b>	+++	++++	+++++	+
<b>Replaceability</b>	--	--	+++++	--
<b>Low-temperature applications (below 900°F)</b>	+++++	++++	+++	++
<b>High-temperature applications</b>	+++	+++	+++++	+
<b>Early coke detection</b>	+++++	+++	++	+
<b>Applications with direct flame impingement</b>	+++	+++++	+++++	+
<b>Small size</b>	+++++	++	++	+++++

Legend:	
+	Suitable
++	Fair
+++	Good
++++	Very good
+++++	Excellent
--	Not suitable

# WIKA/Gayesco services for tube-skin temperature measurements

With WIKI/Gayesco services you can be sure that you have start-to-finish support. From initial on-site consultation to installation we have a custom-designed solution for you.



On-site installation crew

## Installation

WIKI/Gayesco services can provide all manpower, training and tools required for successful installation of our temperature measurement products. All crew members are familiar with the handling of these products and have completed extensive training programmes in working refining and petro-chemical plant environments.

## Installation supervision

On-site supervision is available to ensure the proper handling and installation of temperature measurement systems. Many clients have asked for WIKI/Gayesco services involvement from the initial shut down planning stage to the final loop check.

## Welding services

All site welders employed by WIKI/Gayesco services are qualified to ASME Section IX. Installation of our furnace tubeskin thermocouple assemblies is one of WIKI/Gayesco's field service specialties. Since the service life of these assemblies is dependent upon proper installation, many clients have turned to us for assistance in this area.

## Field repair

WIKI/Gayesco services can assist in repairing or modifying temperature measuring instruments in the field. Typical field work includes soldering, welding, splicing and bending.



Further information at [www.wika.com](http://www.wika.com)

# Application questionnaire

The data provided enables WIKA application specialists to assist you in specifying your thermocouple system. This data is entered in a corporate global application database for tubeskin temperature measurements, enabling the selection of suitable instruments and their continuous improvement.

Tubeskin thermocouple application questionnaire					
Company:	Name:		Contact:		
Customer details:	Phone:	Fax:	E-mail:		
Address:					
Type of application:	Furnace <input type="checkbox"/>	Boiler <input type="checkbox"/>	Tube surface <input type="checkbox"/>		
Unit type and location:					
Fuel source:					
Tube size:					
Tube material:	Vertical <input type="checkbox"/>		Horizontal <input type="checkbox"/>		
Location of tubes:	Radiation <input type="checkbox"/>		Convection <input type="checkbox"/>		
Condition of tubes:	Used in service <input type="checkbox"/>		New installation <input type="checkbox"/>		
Temperatures:	Ambient:		Process:		
	Inside vessel:		Inside tubes:		
Type of sensor:	V-Pad™ <input type="checkbox"/>		Xtracto-Pad™ <input type="checkbox"/>		
	Refracto-Pad™ <input type="checkbox"/>		Weld-Pad <input type="checkbox"/>		
Tag numbers:					
Location on tubes:					
Sensor pad material:					
Material of MI cable:			MI cable diameter:		
MI cable length (including expansion loops):					
Thermocouple calibration:					
Style of attachment to wall:	N.U.N. <input type="checkbox"/>	Gas seal <input type="checkbox"/>	Compression fitting <input type="checkbox"/>	Spring loaded <input type="checkbox"/>	Piston <input type="checkbox"/>
Style of attachment to tube:	Welded <input type="checkbox"/>		Strapped <input type="checkbox"/>		
Strap material:					
FEA calculations required:	<b>Consult engineering</b>				
Additional notes:					

# WIKA product lines

The WIKA programme covers the following product lines for various fields of application.

## Electronic pressure measurement

WIKA offers a complete range of electronic pressure measuring instruments: pressure sensors, pressure switches, pressure transmitters and process transmitters for the measurement of gauge, absolute and differential pressure. Our pressure measuring instruments are available in the measuring ranges 0 ... 0.6 mbar to 0 ... 15,000 bar. These instruments come supplied with standardised current or voltage output signals also intrinsically safe per ATEX or with flameproof enclosure, interfaces and protocols for various field buses. Whether ceramic thick film, metal thin film or piezo-resistive, WIKA is the leading manufacturer worldwide that develops and produces the full range of today's leading sensor technologies.

## Mechatronic pressure measurement

As a result of the almost unlimited options for different combinations of mechanical and electrical connections, an extraordinary range of instrument variants is possible. Various digital and analogue output signals are also available for these measuring instruments. For our measuring instruments we use latest sensors, tested in automotive applications millions of times over. They work without any kind of mechanical contact, consequently they are wear-resistant, and there's absolutely no influence on the mechanics.

## Mechanical pressure measurement

Indicating instruments for gauge, absolute and differential pressure with Bourdon tube, diaphragm or capsule pressure element have been tested millions of times over. These instruments cover scale ranges from 0 ... 0.5 mbar to 0 ... 7,000 bar and accuracies of up to 0.1 %.

## Diaphragm seals

WIKA diaphragm seals, fitted with pressure gauges, pressure transducers, pressure transmitters etc., are recognised and valued internationally for the most difficult of measuring tasks. The measuring instruments can thus be used at extreme temperatures -90 ... +400 °C and aggressive, corrosive, heterogeneous, abrasive, highly viscous or toxic media. The optimal diaphragm seal designs, materials and filling media are available for each application.

## Electrical temperature measurement

Our range of products includes thermocouples, resistance thermometers also with on-site display, temperature switches as well as analogue and digital temperature transmitters for all industrial applications, covering measuring ranges from -200 ... +1,600 °C.

## Mechatronic temperature measurement

As a result of the integration of switch contacts and output signals into our mechanical temperature measuring instruments, we can offer a wide variety of combined instruments. With switch contacts the pointer position triggers a change-over. Electrical output signals are realised via an additional, independent sensor circuit resistance thermometer or thermocouple.

## Mechanical temperature measurement

The mechanical temperature measuring instruments work on the bimetal, expansion or gas actuation principle and cover scale ranges from -200 ... +700 °C. All thermometers are suited for operation in a thermowell as required.

## Level measurement

WIKA has a comprehensive range of level measuring instruments available for temperatures up to 450 °C, specific gravity from 400 kg/m<sup>3</sup> and pressure ranges up to 420 bar. This includes standard instruments and customised products.

## Primary flow measurement

Orifice plates, meter runs, flow nozzles, Venturi tubes and pitot tubes are part of our portfolio of primary flow elements and restriction orifices. The wide range of our products is able to cover the majority of industrial applications. Customised solutions can be developed to meet your special needs.

## Calibration technology

WIKA offers a broad product spectrum of calibration instruments for the physical measured values of pressure and temperature, and for electrical measured values. A multitude of specific patents ensure unmatched performance characteristics with many of our calibration instruments. The range of services comprises the calibration of pressure and temperature measuring instruments in our accredited DKD/DAkkS calibration laboratories and a mobile service to calibrate your instruments on site.

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