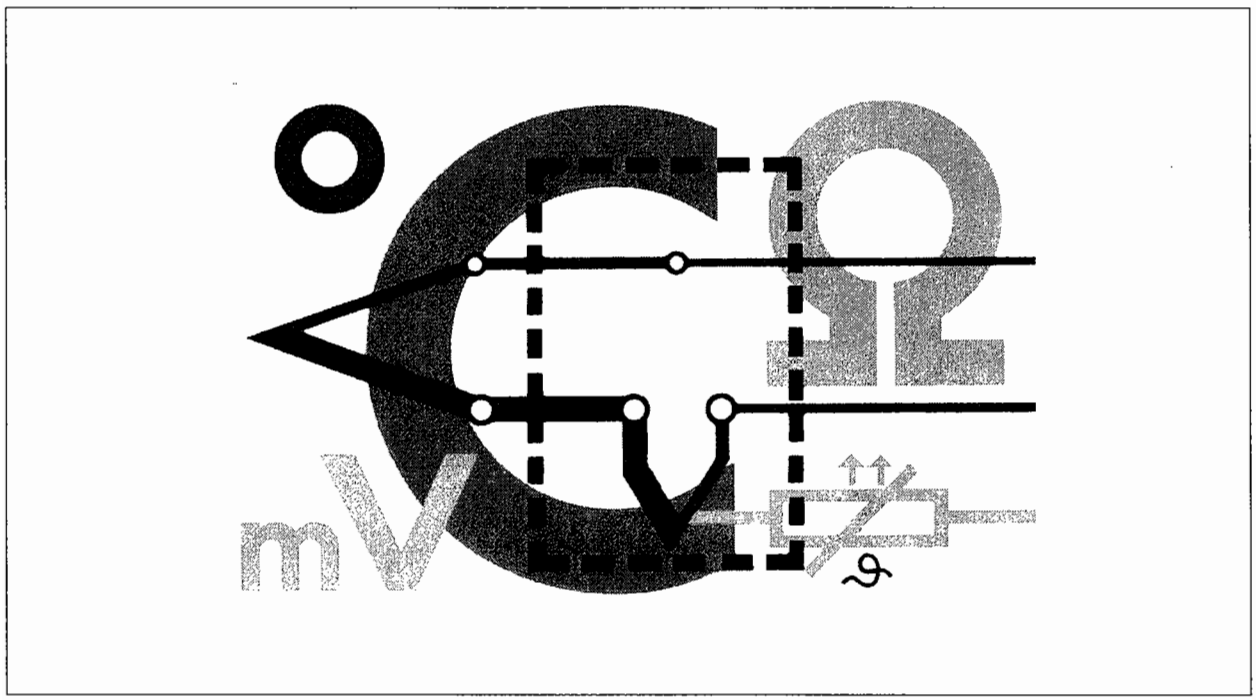
SensyTemp

Technical data for temperature sensors

10/10-3.03 EN



Temperature sensors with exchangeable measuring inset

- Components welded from pipe for low-stress applications; thermowells manufactured from barstock material for applications with a high level of stress caused by pressure, fluid flow or aggressive media
- For applications under pressure in vessels and pipelines with aggressive, explosive and gaseous media
- Measuring element can be exchanged without any interruption of the process
- Ex i and Ex d explosion protection

Measuring insets

- Standard design with extremely diverse electrical features
- Used as an exchangeable measuring element in thermowells

Sheathed thermocouples and resistance thermometers

- Can be produced in greater lengths and subsequently bent
- For applications that offer a low level of mechanical and aggressive stress

Straight thermocouples

- For temperatures up to 1200 °C thermowells are used which are made from heat-resistant steels
- For temperatures above 1200 °C ceramic thermowells are used
- Installed in hot gases, furnaces, incineration plants

Contents

New type liste

New name	Meaning	Data Sheet	Old name
SensyTemp WT R	**W**elded Protection **T**ube, **R**esistance Thermometer	10/10-3.22 EN	TW 311/312
SensyTemp TW R	**T**hermo**w**ell, **R**esistance Thermometer	10/10-3.23 EN	TW 321/322
SensyTemp ET R	**E**xtension **T**ube, **R**esistance Thermometer	10/10-3.24 EN	TW 331/332
SensyTemp WT T	**W**elded Protection **T**ube, **T**hermocouple	10/10-3.25 EN	TT 311/312
SensyTemp TW T	**T**hermo**w**ell, **T**hermocouple	10/10-3.26 EN	TT 321/322
SensyTemp ET T	**E**xtension **T**ube, **T**hermocouple	10/10-3.27 EN	TT 331/332
SensyTemp WT R-FP	**W**elded Protection **T**ube, **R**esistance-**F**lame **P**roof	10/10-3.32 EN	TW 411/412
SensyTemp IS R	**I**nse**t**, **R**esistance Thermometer	10/10-3.41 EN	WMF: TW 511/512
SensyTemp IS R-iZ	**I**nse**t**, **R**esistance-EEx i with PTB certificate of conformity	10/10-3.41 EN	WMF-iZ: TW 511/512
SensyTemp IS T	**I**nse**t**, **T**hermocouple	10/10-3.43 EN	TMF: TT 511/512
SensyTemp IS R-FP	**I**nse**t**, **R**esistance Thermometer-**F**lame **P**roof	10/10-3.45 EN	WMF-d: TW 511/512
SensyTemp WT D	**W**elded Protection **T**ube, **D**ial	10/10-3.47 EN	TB 311
SensyTemp MI R-0	**M**ineral **I**nsulated, **R**esistance Thermometer	10/10-3.56 EN	FW 0
SensyTemp MI R-1	**M**ineral **I**nsulated, **R**esistance Thermometer	10/10-3.56 EN	FW 1
SensyTemp MI R-2	**M**ineral **I**nsulated, **R**esistance Thermometer	10/10-3.56 EN	FW 2
SensyTemp MI R-31	**M**ineral **I**nsulated, **R**esistance Thermometer	10/10-3.56 EN	FW 31
SensyTemp MI R-51	**M**ineral **I**nsulated, **R**esistance Thermometer	10/10-3.56 EN	FW 51
SensyTemp MI T-0	**M**ineral **I**nsulated, **T**hermocouple	10/10-3.57 EN	FT 0
SensyTemp MI T-1	**M**ineral **I**nsulated, **T**hermocouple	10/10-3.57 EN	FT 1
SensyTemp MI T-2	**M**ineral **I**nsulated, **T**hermocouple	10/10-3.57 EN	FT 2
SensyTemp MI T-31	**M**ineral **I**nsulated, **T**hermocouple	10/10-3.57 EN	FT 31
SensyTemp MI T-51	**M**ineral **I**nsulated, **T**hermocouple	10/10-3.57 EN	FT 51
SensyTemp ST B-AM	**S**traight **T**hermocouple, **B**ase-metal, **M**etal Protection Tube	10/10-3.58 EN	TT 111, AM
SensyTemp ST B-AMK	**S**traight **T**hermocouple, **B**ase-metal, **M**etal Protection Tube, **C**eramic Inner Tube	10/10-3.58 EN	TT 112, AMK
SensyTemp ST P-AK	**S**traight **T**hermocouple, **P**recious-metal, **C**eramic Protection Tube	10/10-3.59 EN	TT 113, AK
SensyTemp ST P-AKK	**S**traight **T**hermocouple, **P**recious-metal, **C**eramic Protection Tube, **C**eramic Inner Tube	10/10-3.59 EN	TT 114, AKK
SensyTemp BA R-R	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTR
SensyTemp BA R-RF	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTRF
SensyTemp BA R-A	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTA
SensyTemp BA R-L	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTL
SensyTemp BA R-Lm	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTLm
SensyTemp BA R-Ro/1	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTRo/1
SensyTemp BA R-Ro/2	**B**uilding **A**utomation, **R**esistance Thermometer	10/10-3.61 EN	WTRo/2
SensyTemp HY R-1E	**Hy**gienic, **R**esistance Thermometer	10/10-3.64 EN	WTN 1E
SensyTemp HY R-2E	**Hy**gienic, **R**esistance Thermometer	10/10-3.64 EN	WTN 2E
SensyTemp HY R-5E	**Hy**gienic, **R**esistance Thermometer	10/10-3.64 EN	WTN 5E
SensyTemp HY R-4E	**Hy**gienic, **R**esistance Thermometer	10/10-3.65 EN	WTN 4E

Temperature sensors with welded thermowell and exchangeable measuring inset

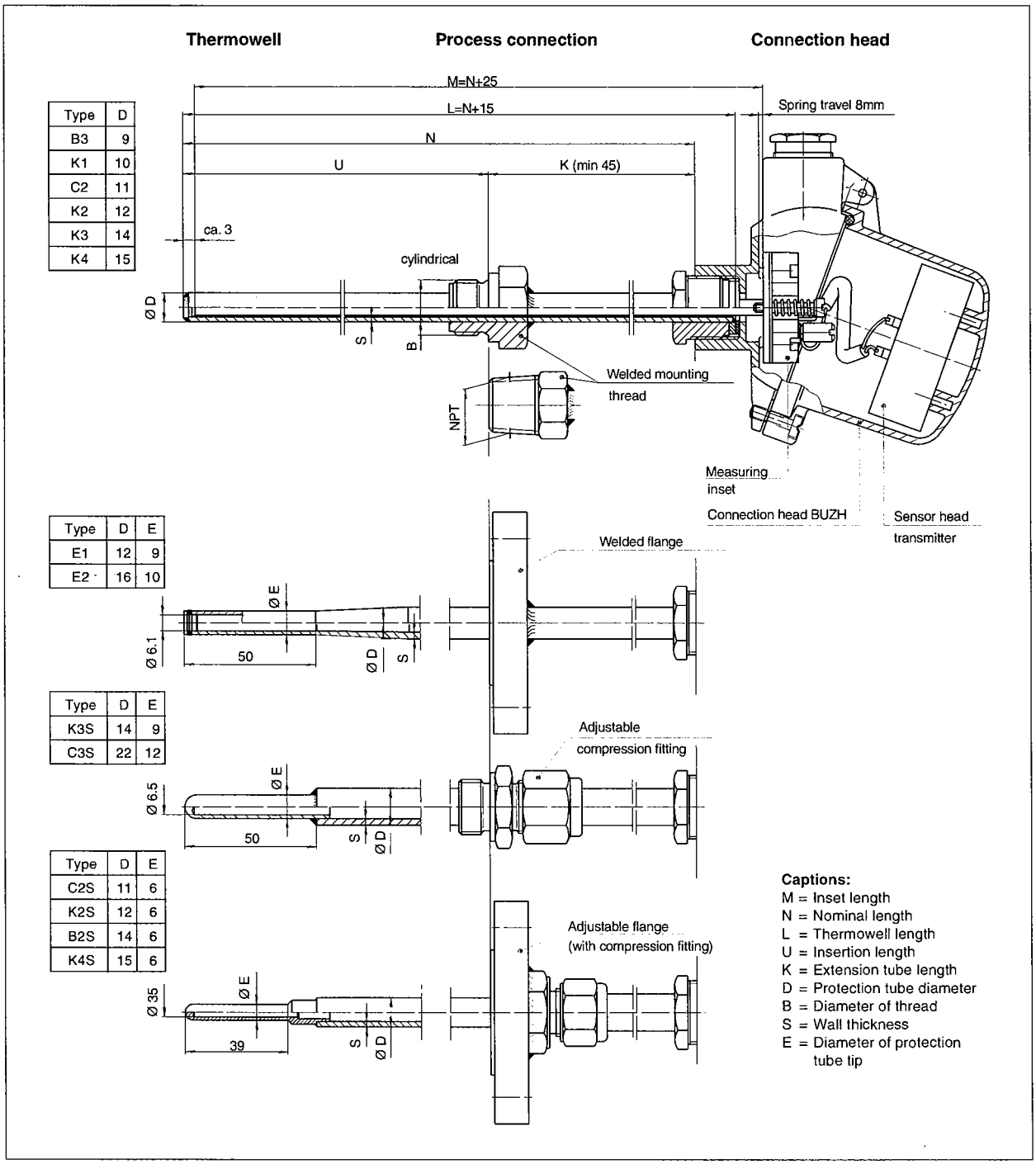
Designs SensyTemp WT R/WT T

The design
- of thermocouples and resistance thermometers
- for normal and Ex-i measuring circuits

is outwardly identical; the difference between them lies in the measuring inset installed.

Using measuring insets with a diameter of 6 mm or above, all the common combinations of sensors can be implemented in appropriate thermowells.

Using a measuring inset with a diameter of 3 mm it is possible to achieve thinner thermowell tips (C2S, K2S and B2S) with a shorter response time.



Type	D
B3	9
K1	10
C2	11
K2	12
K3	14
K4	15

Type	D	E
E1	12	9
E2	16	10

Type	D	E
K3S	14	9
C3S	22	12

Type	D	E
C2S	11	6
K2S	12	6
B2S	14	6
K4S	15	6

Temperature sensors with welded thermowell and exchangeable measuring inset

Thermowells

All thermowells for the temperature sensors are made of a drawn tube with a welded bottom plate. Depending on the mechanical and chemical stress imposed and the response time required, thermowell types can be selected with:
- diverse external diameters / wall thicknesses
- reduced measurement tip.

Special designs and special materials or coatings can also be supplied.

The directive 97/23/EG (Pressure Equipment Directive) are fulfilled. As the article 1, pragraph 2.1.4 does not apply, an Attest of Conformity and the CE-marking can not be done.

Operating data

The permissible stress depends on several factors:

Medium-related data	Installation-related data
– Medium – Viscosity – Flow velocity – Pressure – Temperature	– Material – Protection tube type – Insertion length – Sealing pressure of the process connection – Vibration

General application specifications cannot be given in view of manifold range of versions. The following table gives approximate values. If conditions differ greatly a stress analysis acc. to Dittrich or Murdock is recommended.

Response times

Apart from protection tube mass at the measuring point, factors governing the heat transport are the chief determinants for the response time:
- Medium, heat capacity
- Pressure, density, moisture
- Flow velocity.

The following table features approximate values, refering to water or air. Greater flow velocities and heat capacities considerably reduce the time intervals.

The values $T_{0.5}$ and $T_{0.9}$ give information on the time period after which 50 % or 90 % of a sudden temperature change is displayed.

Type	Ø at tip	In water 0.4 m/s		In air 3 m/s	
	(mm)	$T_{0.5}$	$T_{0.9}$	$T_{0.5}$	$T_{0.9}$
Resistance thermometers					
B2S/K2S	6	7	18	52	170
K3S/B3/E1	9	12	30	88	280
C2	11	14	38	106	320
Thermocouples					
B2S/K2S	6	7	14	39	128
K3S/B3/E1	9	10	24	66	210
C2	11	12	28	80	240

Type	Dimensions Material	Process connection	Max. flow velocity (m/s)		Max pressure (bar) for temperature (°C)					
			Air	Water	f. insertion length (mm)	0	100	200	300	400
B3	9 x 1 mm 1.4571 (AISI 316-TI)	Mounting thread G½"	25	3	160 250 400	50 40 18	48 40 18	44 40 18	40 40 18	36 36 18
C2, C2S	11 x 2 mm 1.4571 (AISI 316-TI)	Mounting thread G1"	40	5	160 250	100 50	95 50	92 50	88 50	80 50
K2 K2S E1	12 x 2,5 mm 1.4571 (AISI 316-TI)	Mounting thread G1"	40	5	160 220 280	100 100 100	100 100 100	100 100 100	100 78 55	100 78 55

Process connection

The insertion length U is primarily dictated by the installation site. Since the process connection assembly can be affixed to any point of the thermowell, it is recommended that the extension tube length K should always be selected such that U+K produces the standard nominal length N.

This results in shorter delivery times and a lower price and, to a large extent, relives the customer of the need to stock spare parts, since stock material can be used if needed.

We supply:
- as standard cylindrical threads with thread groove and seal collar acc. to DIN 3852 type A, as specified in the thermowell specification DIN 43772
- welded flanges conforming to standards
- adjustable compression fittings and flanges, which are adjusted once via a clamp ring when fitting (only for thermowells E... and K...)
- process connections based on specific industrial and company versions.

As a standard procedure, the welded process connection is welded only at the extension end, since this enhances the flow end vibration withstand capabilities.

Temperature sensors with welded thermowell and exchangeable measuring inset

Explosion protection type EEx i

Temperature sensors

- based on EN 50014 / EN 50020 pursuant to CENELEC are approved by PTB Certificate of Conformity no. Ex-94.C.4009, with a degree of protection EEx ia IIC T6 with a design approved thermowell in zone 0 and with a connection head in zone 1. This means that thermowells must conform to building regulations in respect of resistance to corrosion, mechanical stress, wall thickness and pressure tests. If the system supplied does not include a thermowell, then responsibility for using a suitable thermowell lies with the user. The temperature sensors in this Data Sheet can not be placed in zone 0 unless a thermowell is fitted. Installed transmitters are covered by a separate certificate of conformity.
- with a measuring inset conforming to NAMUR NE 24 are certified by a manufacturer's declaration, outlining the corresponding testing of the measuring inset.
- differing from PTB-approved design can be certified for EEx i installation by means of a manufacturer's declaration if they fulfil the requirements of EN 50020, Pkt. 5.4, to EN 60079-14 (VDE 0165 part 1). Sensors thus certified may only be installed in zones 1 and 2.

For Ex i installation, the following electrical values apply to the temperature sensor:

Max. measured voltage	12 V
Capacity of measuring inset	280 pF/m
Inductance of measuring inset	15 µH/m

Max. surface temperature:

Performance	Measuring inset type			
	IS T-iZ Ø 6 mm	IS T-iZ Ø 3 mm	IS R-iZ Ø 6 mm	IS R-iZ Ø 3 mm
0 W	40 °C	40 °C	40 °C	40 °C
0.5 W	48 °C	52 °C	57 °C	67 °C
1.0 W	52 °C	60 °C	72 °C	94 °C
1.5 W	56 °C	66 °C	87 °C	120 °C

For operation with transmitters the corresponding specifications should also be taken into account. Long thermowells must be supported at intervals of 750 mm in the vessel if necessary to withstand the fluid flow.

Measuring insets

All the measuring insets installed are made of a Mineral Insulated Cable (MIC) thus featuring a high degree of vibration resistance and flexibility. The standard measuring inserts installed are:

Thermometer design	Measuring inset type
Standard	IS R / IS T
EEx i with PTB certificate	IS R-iZ / IS T-iZ
EEx i with manufacturer's declaration	IS R-i / IS T-i
EEx i to NE 24	IS R-iN / IS T-iN
These measuring insets along with technical information on tolerances can be found in Data Sheets 10 3.41 EN and 10-3.43 EN.	

Factors relating to measurement and design feasibility must be taken into consideration for resistance thermometers when selecting the appropriate combination of measuring inset type, circuit type and tolerance.

The lead resistance produces an additional measurement error in the 2-wire circuit due to the conductors of the measuring inset and of the connecting cables. The following values must be borne in mind for the measuring inset lead wires:

- WMF- 3 mm Ø: 0.28 Ω /m (Cu lead wires) = 0.7 K (measuring error)
- WMF- 6 mm Ø: 0.1 Ω /m (Cu lead wires) = 0.25 K (measuring error)
- WMF- 6 mm Ø: 2.8 Ω /m (NiCr lead wires) = 7 K (measuring error)

With class B (0.3 °C at 0 °C) the additional error caused by the line resistance should not exceed 0.3 °C, i.e. for WMF

- 3 mm Ø max. 315 mm measuring inset length in a 2-wire circuit
- 6 mm Ø max. 1025 mm meas. inset length in a 2-wire circuit.

Temperature sensors with greater lengths than these, of type WMF-H and all those with restricted measuring resistance tolerances, should only be connected in a 3-wire or 4-wire circuit.

The diameter of the MIC limits the possibilities for the wire circuit. While 1 x Pt 100 can be implemented in all circuit types, with 2 x Pt 100 the following options are valid:

- 3 mm Ø only in 2-wire circuit
- 6 mm Ø bin a 4-wire circuit, only with NiCr lead wires and a special terminal block.

Further technical details see page 17.

Temperature sensors with welded thermowell and exchangeable measuring inset

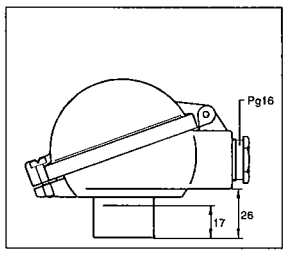
Connection heads

There are several connection heads available, differing with respect to material and lid-closure technique:

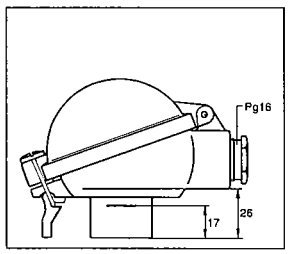
Connection head types	Material	Cable entry	Degree of protection	Lid closure	Surface
BUZ, BUS, BUZH, BUSH	Aluminium	PG 16	IP 66 / 67[1)]	Hinged lid	Painted
BUKH	Polyamide	PG 13.5	IP 66 / 67[1)]	Hinged lid	Black
B(H)	Aluminium	PG 16	IP 66 / 67[1)]	With 2 screws	Painted
BBK, BBKH	Reinforced plastic	PG 16	IP 54	Screwed lid	Black

[1)] With cable connectors authorised for use with degree of protection IP 67

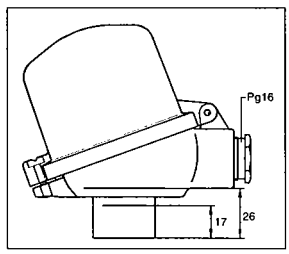
Type **BUZ** aluminium



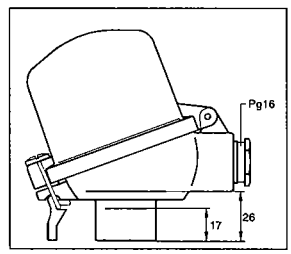
Type **BUS** aluminium



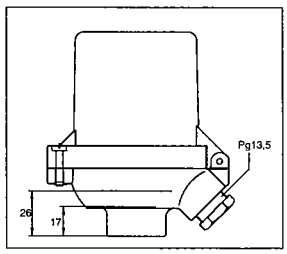
Type **BUZH** aluminium
for installation of transmitter



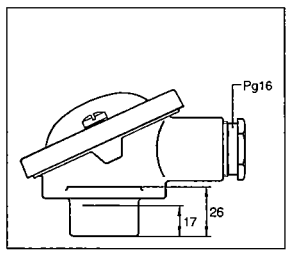
Type **BUSH** aluminium
for installation of transmitter



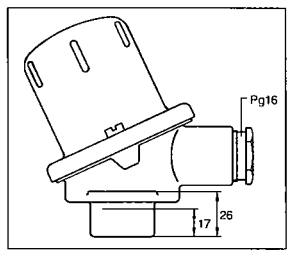
Type **BUKH** polyamide
for installation of transmitter



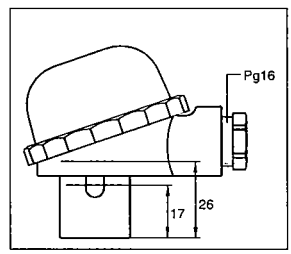
Type **B** aluminium



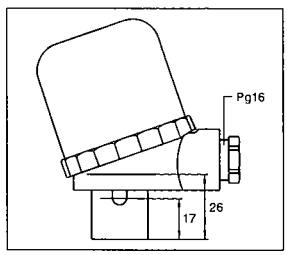
Type **BH** aluminium
for installation of transmitter



Type **BBK** reinforced plastic



Type **BBKH** reinforced plastic
for installation of transmitter



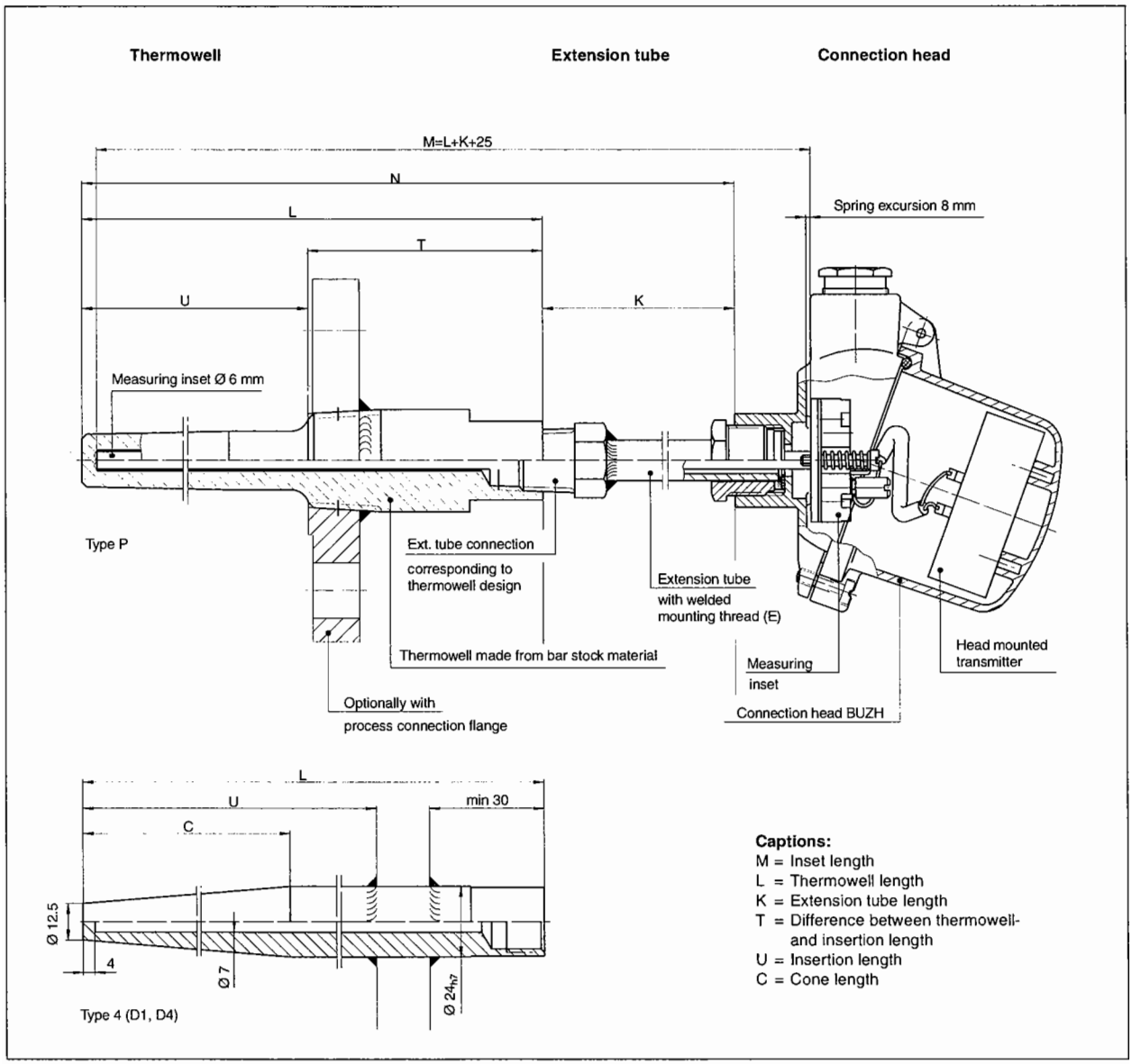
Temperature sensors with drilled thermowell and exchangeable measuring inset

Designs SensyTemp TW R / TW T

The design
– of thermocouples and resistance thermometers
– for normal and Ex-i measuring circuits
is outwardly identical; the difference between them lies in the measuring inset installed.

Using measuring insets with a diameter of 6 mm or above, all the common combinations of sensors can be implemented in appropriate thermowells.

Using a measuring inset with a diameter of 3 mm it is possible to achieve reduced thermowell tips with a shorter response time.



Temperature sensors with drilled thermowell and exchangeable measuring inset

Thermowells

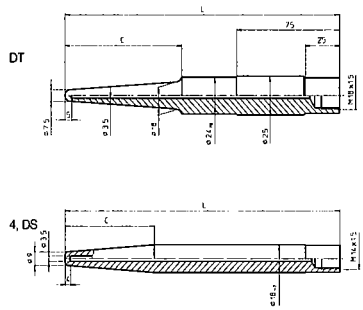
All thermowells in this Data Sheet for the temperature sensors are drilled from bar stock material and their outside shape machined.

The following thermowell designs are obtainable, and they represent models conforming to DIN as well as other company standards. Thermowells of similar design can also be supplied to any specification.

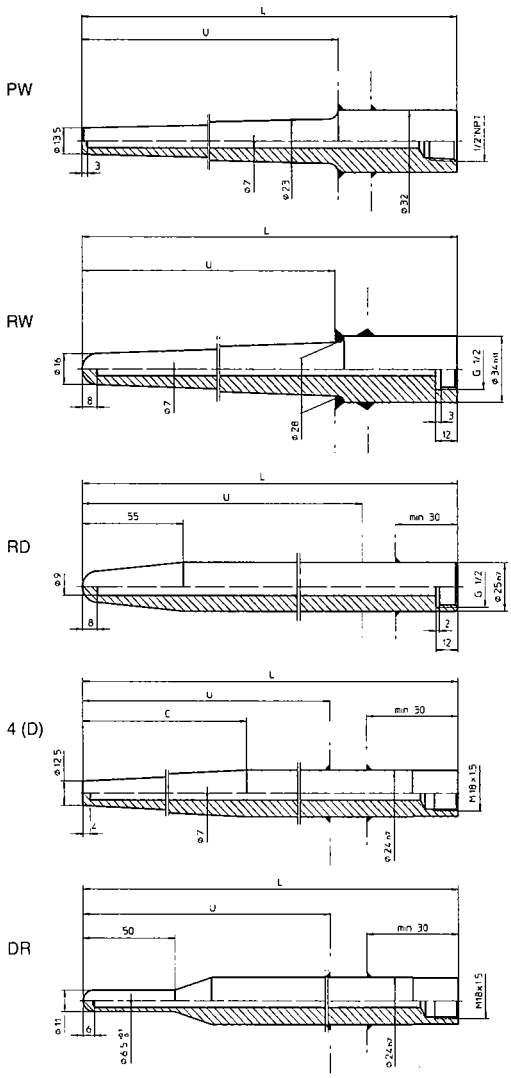
The directive 97/23/EG (Pressure Equipment Directive) are fulfilled. As the article 1, pragraph 2.1.4 does not apply, an Attest of Conformity and the CE-marking can not be done.

Captions:
L = Thermowell length
C = Cone length
U = Insertion length

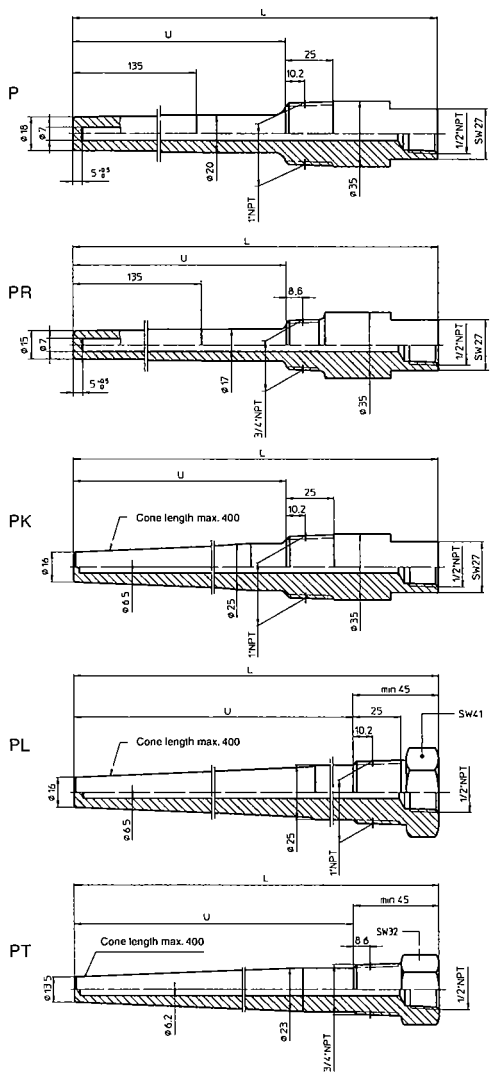
Thermowell designs
to weld in for measuring inset Ø 3 mm



Thermowell designs
to weld in, for measuring inset with Ø 6 mm



Thermowell designs
to screwed in, for measuring inset with Ø 6 mm



Temperature sensors with drilled thermowell and exchangeable measuring inset

Operational data

The permissible stress depends on several factors:

Medium-related data	Installation-related data
– Medium – Viscosity – Flow velocity – Pressure – Temperature	– Material – Thermowell type – Insertion length – Sealing pressure of the process connection – Vibration

General application specifications cannot be given in view of manifold range of versions. Approximate values are given in the following diagrammes. If conditions differ greatly a stress analysis acc. to Dittrich or Murdock is recommended.

Response times

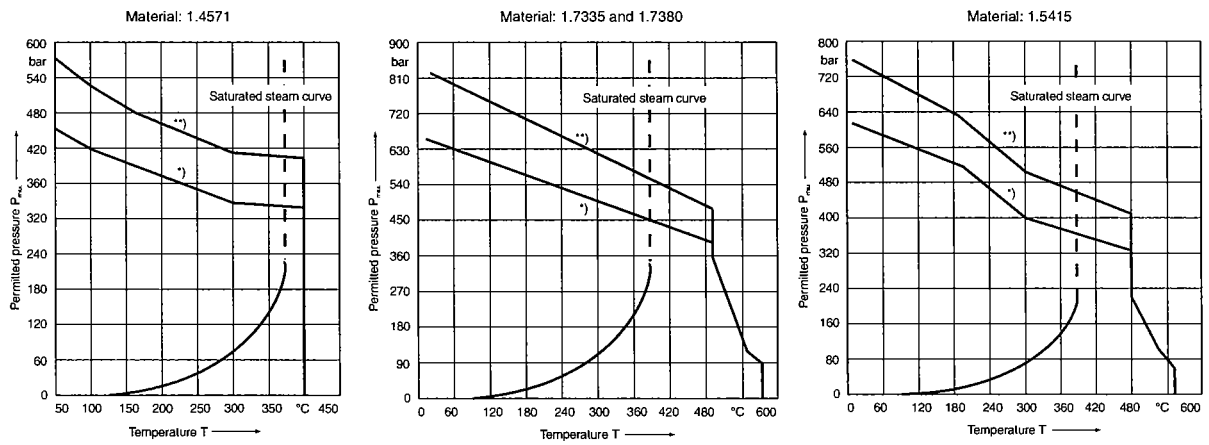
Apart from the thermowell mass at the measuring point, the factors governing the heat transport are the chief determinants for the response time:
– Medium, heat capacity
– Pressure, density, moisture
– Flow velocity.

The following table features approximate values, refering to water or air. Greater flow velocities and heat capacities considerably reduce the time intervals.

The values $T_{0.5}$ and $T_{0.9}$ give information on the time period after which 50 % or 90 % of a sudden temperature change is displayed.

Type	Conus length mm	In water 0.4 m/s		In air 3 m/s	
		$T_{0,5}$	$T_{0,9}$	$T_{0,5}$	$T_{0,9}$
Resistance thermometers					
4 (D1/D4)	65	20	63	300	900
4 (D2/D5)	125	14	44	235	706
Thermocouples					
4 (D1/D4)	65	16	50	235	705
4 (D2/D5)	125	10	40	150	500

Stress capacity of the thermowells type 4 conforming to DIN 43772 (replacement for type D conforming to DIN 43763)



*) Type 4 (D2, D5)
Thermowells c = 125 mm:
Bend, stream length = 125 mm
Thermowell diameter = 24 mm
Thermowell inside diameter = 7 mm

**) Type 4 (DS)
Thermowells c = 65 mm:
Bend, stream length = 65 mm
Thermowell diameter = 18 mm
Thermowell inside diameter = 3.5 mm

Flow velocity
Water = 5 m/s
Steam = 60 m/s
Air = 60 m/s

Temperature sensors with drilled thermowell and exchangeable measuring inset

Extension tube joint

All thermowells are extended by means of an extension tube with a threaded connection on both sides. We recommend the selection of a tube whose extension length K is such that the thermowell length L + K produces the standard nominal length N. This results in shorter delivery times and a lower price and, to a large extent, relives the customer of the need to stock spare parts, since stock material can be used if needed.

The extension tube and connection head are joined together by means of a coupling screw. This enables the head to be turned after assembly.

For this reason it is usual to have welded mounting threads at the end of the extension tube.

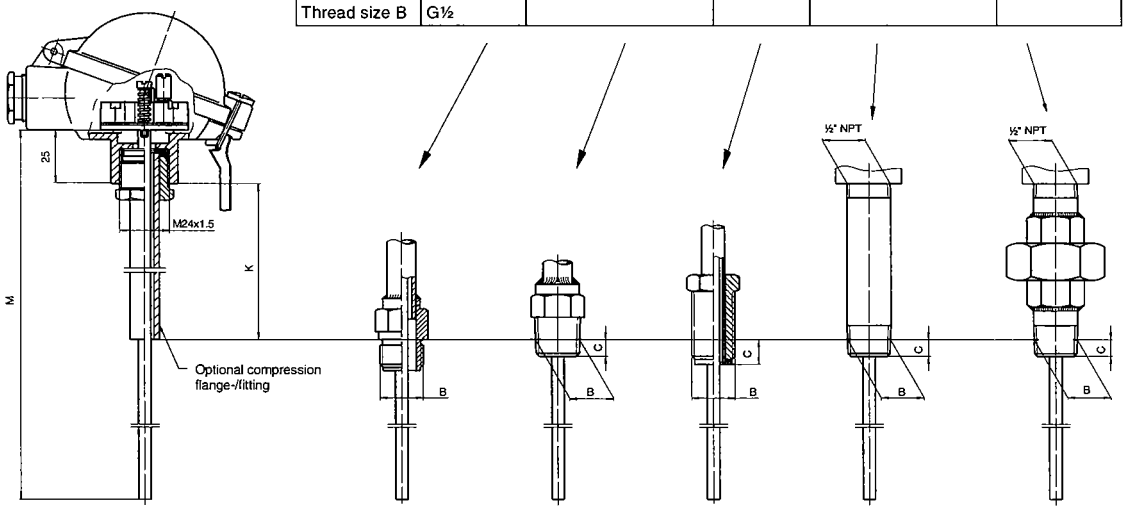
The measuring inset is spring loaded in such a way that it can be pressed down to the base of the thermowell. This should be taken into account for the measuring inset length (spring excursion = 0 to 8 mm).

Other forms of fastening can also be provided for company-standard designs of thermowell.

We deliver as standard cylindrical threads with thread groove and seal collar acc. to DIN 3852 type A, as specified in the thermowell specification DIN 43772.

Extension tubes

	Welded mounting thread		Coupling screw	Nipple	Nipple and union
Thermowell Thread size B	D, DR, DT M18x1.5	P, PR, PT, PW, PK, PL ½" NPT	RD, RW G½ C=12	P, PR, PT, PW, PK, PL ½" NPT C=8	P, PR, PT, PW ½" NPT C=8
Thermowell Thread size B	DS M14x1.5		– G½ C=20	RT G½ C=12	RD, RW G½ C=12
Thermowell Thread size B	– G½				



Captions:
M = Inset length
K = Extension tube length
B = Diameter of thread
C = Screwable thread length

Process connection

Drilled thermowells can be produced in versions for various different process connections:

- For welding in
  For this purpose a section of the thermowell with a fitting system is provided. With type 4 (D)-thermowells conforming to DIN 43 772 each cylindrical part is pushed into a welding socket and welded at its end.

- For screwing in
  The appropriate thread is already turned on the thermowell so that it can be screwed into a threaded connection.

- For flange connection
  weld-in and screw-in thermowells can be provided with a flange, which is welded up. A thermowell that is screwed into a flange and then welded is capable of withstanding a greater level of stress.

Explosion protection type EEx i
see page 5

Measuring insets
see page 5

Connection heads
see page 6

Temperature sensors for installation in a thermowell, exchangeable measuring inset

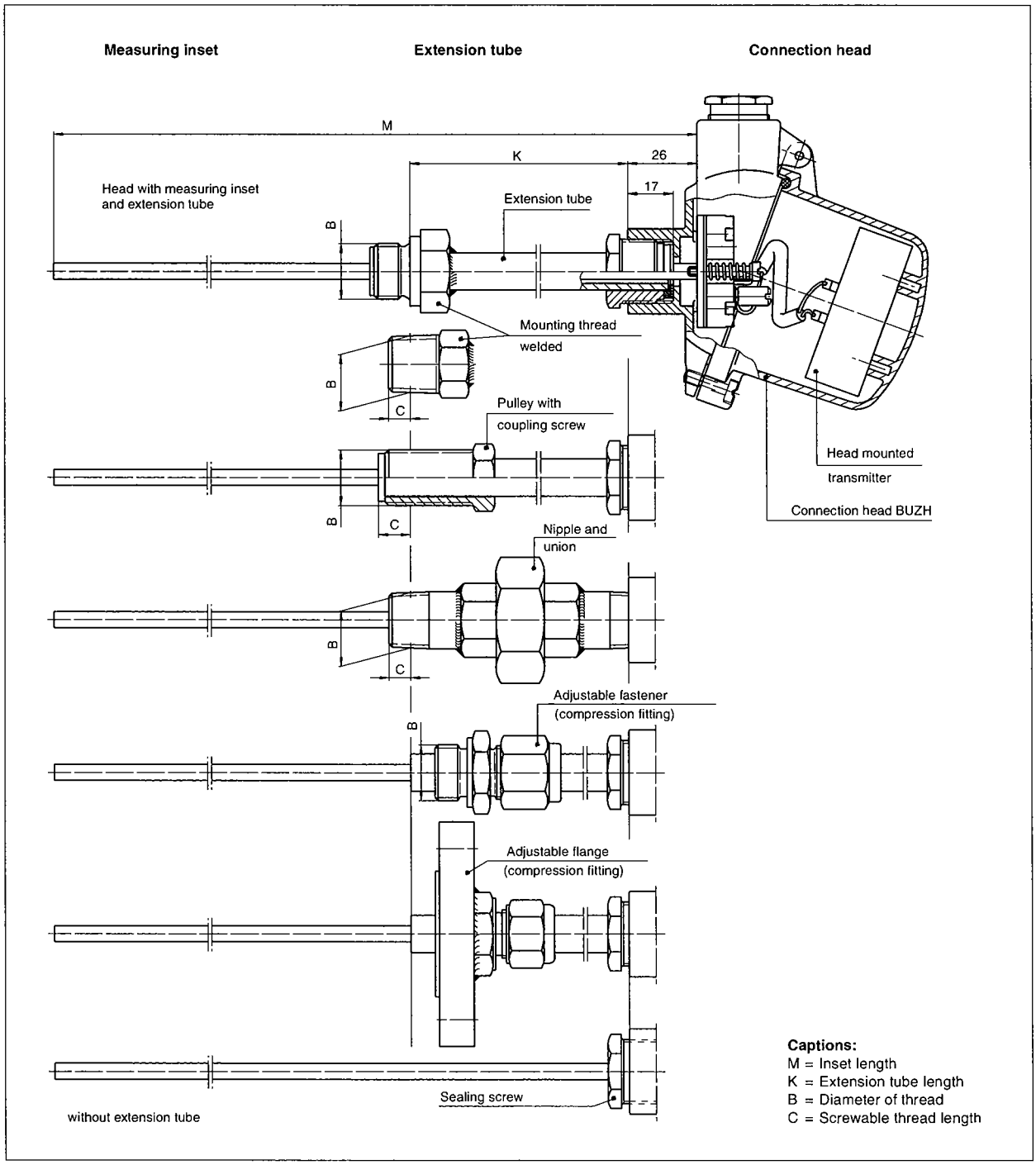
Designs SensyTemp ET R / ET T

The design
- of thermocouples and resistance thermometers
- for normal and Ex-i measuring circuits

is outwardly identical; the difference between them lies in the measuring inset installed.

Using measuring insets with a Ø of 6 mm or above, all the common combinations of sensors can be implemented in appropriate thermowells.

Using a measuring inset with a Ø of 3 mm, it is possible to achieve reduced thermowell tips with a shorter response time.



Temperature sensors for installation in a thermowell, exchangeable measuring inset

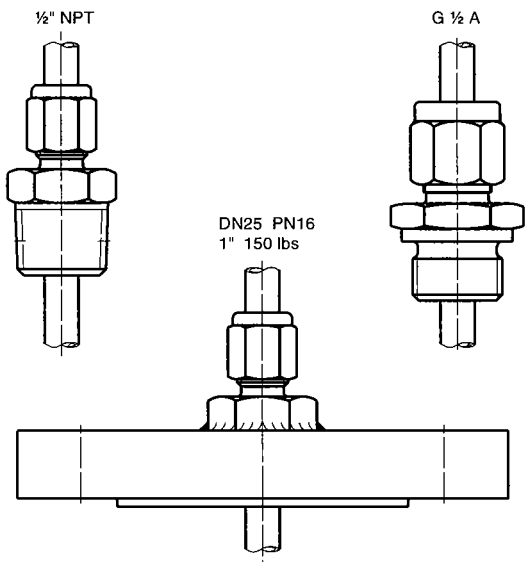
With the temperature sensors for installation in thermowells, the following thermometer types can be implemented:

- Without extension tube
  - by combination with thermowell designs from tube, temperature sensors as specified in Data Sheets10-3.22 EN and 10-3.25 EN
  - with screw fitting on to the measuring inset: fast responding temperature sensor for gases and liquids (head fixture may be required)
- With extension tube
  - by combination with thermowells made from bar stock material, temperature sensors as specified in Data Sheets 10-3.23 EN and 10-3.26 EN
  - without additional thermowell, with welded measuring inset: fast responding temperature sensor for gases and liquids
  - Without additional thermowell, as a variant, with measuring insets as specified in Data Sheets 10-3.41 EN and 10-3.43 EN.

Extension tube joint
see page 10

Process connection

Adjustable process connection



Explosion protection type EEx i
see page 5

Measuring insets
see page 5

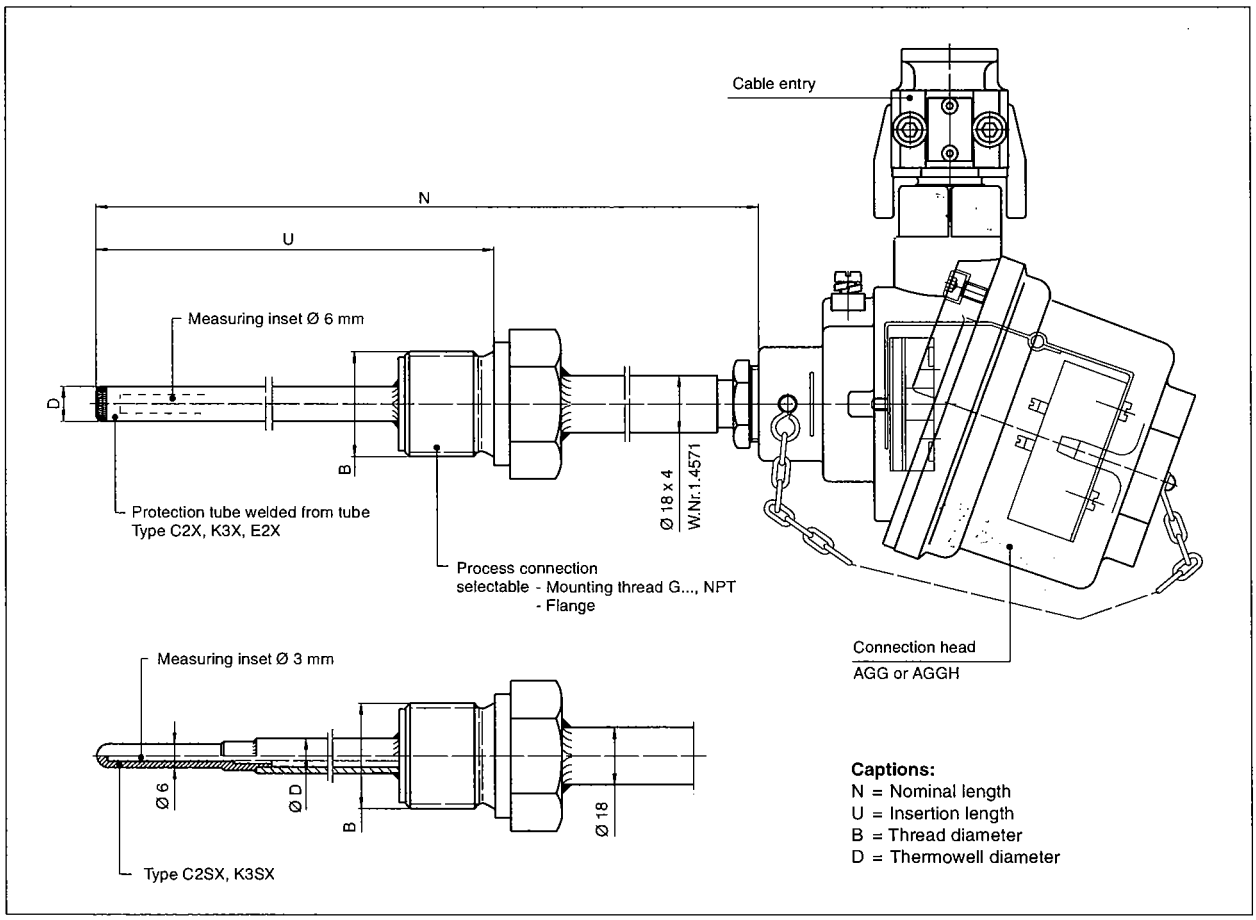
Connection heads
see page 6

Ex d thermometers

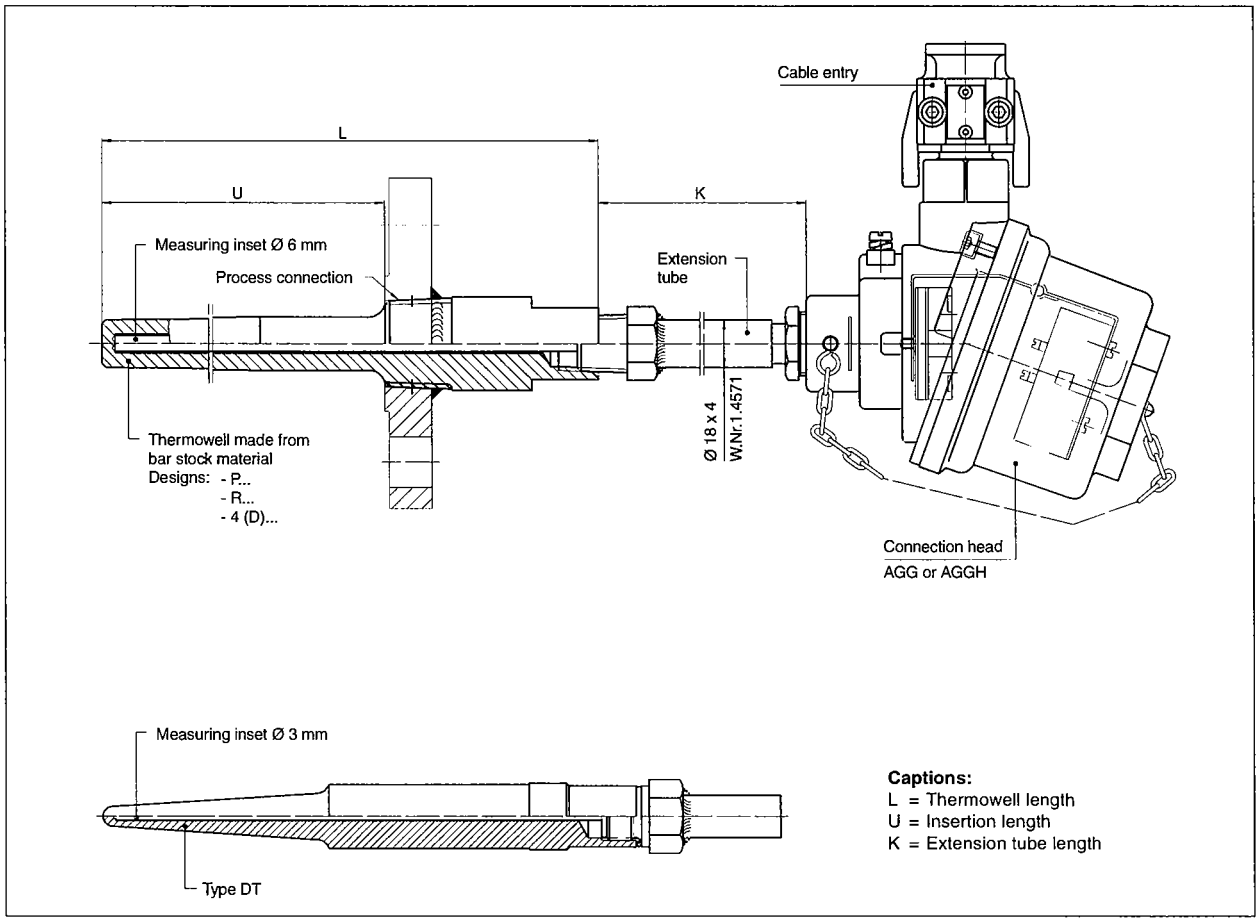
Designs

The designs are determined by the type of thermowell and of the measuring inset (see table below):

Thermowell			Measuring inset	Zone
Type	Construction	Standard versions	Diameter in mm	
WT R-FP/WT T-FP	welded from tube	C2X, K3X, E2X	6 (8; 9.5)	0
TW R-FP/TW T-FP	drilled from bar stock material	P, PR, PK, PL, PT, PW, RD, D, DR	6 (8; 9.5)	0
ET R-FP/ET T-FP	without thermowell	with various different extension tubes	6 (8; 9.5)	1, 2
WT R-FP/WT T-FP	welded from tube	C2SX, K3SX	3	0
TW R-FP/TW T-FP	drilled from bar stock material	DT	3	0
ET R-FP/ET T-FP	without thermowell	with various different extension tubes	3	1, 2



Ex-d thermometers



Thermowells, extension tubes and process connection

Ex-d thermometers are equipped with welded or drilled thermowells.

- The process connection can be used with:
  - Welded thermowells (protection tubes)
  - Welded mounting thread
  - Welded flange

  Drilled thermowells (thermowells):
  - Shaft for welding
  - Screw-on thread
  - Press-fit or screw-fit flange, welded.

In order to increase stability, all these constructional types are equipped with reinforced extension tubes.

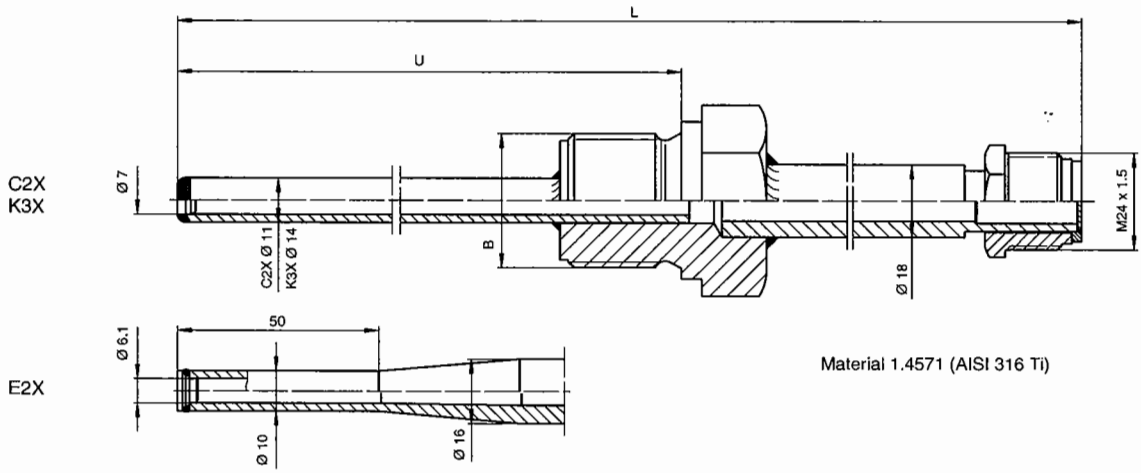
The permissible operating load is dependent on many factors and, if required, can be determined by a Murdock or Dittrich calculation. Before the thermowell leaves the factory it is tested with static pressure test depending on the design of the thermowell and/or the process connection. If the operational pressure is not specified by the customer, then the values shown in the following table are adopted:

Process connection	Design pressure
Thread: ½" Thread: ¾" Flange: to DIN or ANSI	40 bar 80 bar Flange nominal pressure
Thread: ¾", 1" Flange: to DIN or ANSI Weld	80 bar Flange nominal pressure Material-dependent pressure for thermowells conforming to DIN 43763

We deliver as standard cylindrical threads with thread groove and seal collar acc. to DIN 3852 type A, as specified in the thermowell specification DIN 43772.

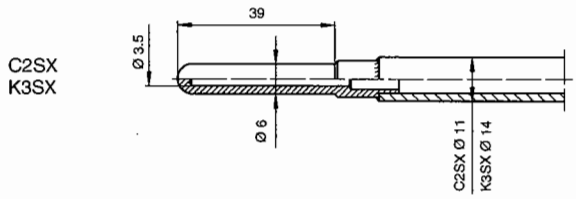
Ex d thermometers

Protection tube for measuring inset Ø 6 mm



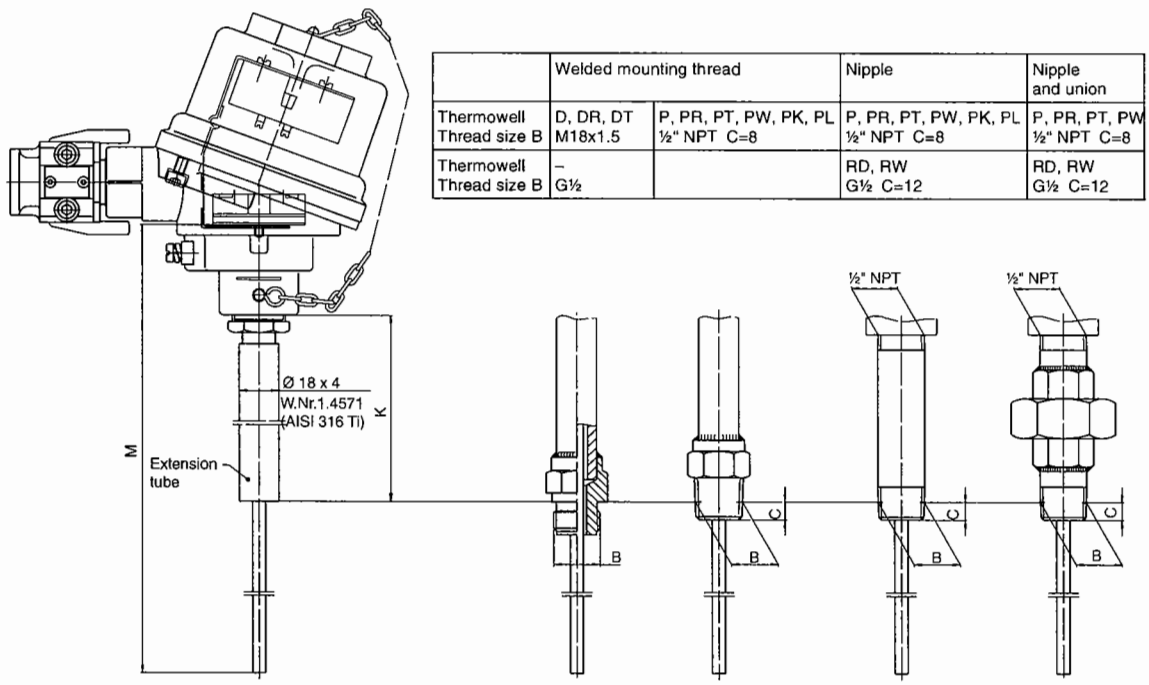
Material 1.4571 (AISI 316 Ti)

Protection tube for measuring inset Ø 3 mm



Captions:
L = Thermowell length
U = Insertion length
B = Diameter of thread
M = Inset length
K = Extension tube length
C = Screwable thread length

Extension tubes



	Welded mounting thread		Nipple	Nipple and union
Thermowell Thread size B	D, DR, DT M18x1.5	P, PR, PT, PW, PK, PL ½" NPT C=8	P, PR, PT, PW, PK, PL ½" NPT C=8	P, PR, PT, PW ½" NPT C=8
Thermowell Thread size B	– G½		RD, RW G½ C=12	RD, RW G½ C=12

Ex-d thermometers

Explosion protection

The thermometers covered by this data sheet are certified by PTB approval no. EEx 86.B.1073X for degree of protection EEx d IIC T6 with

- Thermowell in zone 0
- Connection head in zone 1
  (with special check also in zone 0)

Complete protection against explosion extending into the process medium can only be assured as long as the thermowell remains undamaged. It must meet the requirements for stability, corrosion resistance and max. dead volume.

This should be clearly established under operational stress, and checked at intervals:

- The resistance to chemical attack, pressure, fluid flow and vibration should be checked by calculation.
- When installed in a vessel, supports should be provided where required due to the stresses.
- The thermowell must be included in the recurrent pressure tests performed on the vessel.

All the above measures combine to ensure that any explosion occurring in the terminal enclosure cannot spread either into the thermowell or surrounding area.

Without a thermowell operation in zone 1 is permitted as long as it can be established that the protruding measuring inset cannot be damaged mechanically. This design can thus also be used for monitoring machine bearings and heat exchangers.

Measuring inset and connection head

The measuring inset and connection head form one unit corresponding to PTB approval.

For Ex d types, only the AGG Ex d and AGGH Ex d models of connection head should be used.

- Material: grey cast iron
- Screwed lid with IP 65 rubber seal, locking chain,
- Locking screw, which can only be undone with a tool
- Cable entry to the connection as stipulated by EN 50 018
- With thread for attaching a tube
- With screw fitting for cable
- Fitted bore hole for associated measuring insets
- Grounding screw inside and outside
- Weight approx. 2.5 kg

A screw fitting for cable certified to EN 50018 (type Gothe, cable Ø 12 mm) is incorporated, while other cable screw fittings or threads for tubes can be ordered as optional extras.

Operating data

The permissible sress depends on several factors:

Medium-related data	Insertion-related data
– Medium – Viscosity – Flow velocity – Pressure – Temperature	– Material – Protection tube design – Insertion length – Sealing pressure of the process connection – Vibration

General application specifications cannot be given in view of manifold range of versions. The following table gives approximate values. If conditions differ greatly a stress analysis acc. to Dittrich or Murdock is recommended.

Response times

Apart from protection tube mass at the measuring point, factors governing the heat transport are the chief determinants for the response time:

- Medium, heat capacity
- Pressure, density, moisture
- Flow velocity.

The following table features approximate values, refering to water or air. Greater flow velocities and heat capacities considerably reduce the response time.

The values $T_{0.5}$ and $T_{0.9}$ provide information on the times after which 50 % and 90 % of a sudden temperature change are displayed.

Type	Ø at tip (mm)	in water 0.4 m/s		in air 3 m/s	
		$T_{0.5}$	$T_{0.9}$	$T_{0.5}$	$T_{0.9}$
Resistance thermometers					
C2SX	6	10	18	52	170
C2X	11	14	38	106	320

Type	Material dimensions	Process connection	Max. flow velocity (m/s)		Max. pressure (bar) for temperature (°C)					
			Air	Water	For insertion length (mm)	0	100	200	300	400
C2X, C2SX	11 x 2 mm 1.4571 (AISI 316-TI)	welded mounting thread G¾"	40	5	160 250	100 50	95 50	92 50	88 50	80 50

Measuring insets for resistance thermometers and thermocouples

Measuring inset lengths

Since a measuring inset can be used universally in many different designs of thermometer, measuring insets form the basis for the standardisation of thermometer lengths.

Standard lengths of measuring inset are: 275, 375, 405, 435, 525, 555, 655, 735, 1025 mm. Custom lengths can also be produced.

Additional equipement

- Where the drill holes in the thermowell are of above average diameter, a sleeve can be pressed in the range of the resistance element to reduce the air gap. A tack-welded sleeve can be removed again so that a measuring inset can be used for drill holes > 6 mm and > 8 mm.
- If a particularly good contact needs to be achieved for measurements on surfaces, the tip can be adjusted for the hole-bottom face.
- With long, thin measuring insets a reinforcing tube can be fitted in order to prevent bending, kinking or vibration.
- Measuring points without an additional thermowell should be sealed off to the connection head in order to safeguard the IP degree of protection.
- Where there is heavy vibration, reinforced springs and screw-on caps can be fitted to the socket.

Identification

Measuring insets are identified unambiguously on the type label on the underside of the base plate.

- Type designation and additional designation
  This defines the measuring inset type (along with, in some cases, details of the official approval no.) e.g.

IS T	IS R-iZ Ex-94.C.4009	IS R-B	IS R-iN NE 24

- Measurement element, tolerance, circuit type
  Details are provided here in abbreviated form of the internal configuration, e.g.

1 x K Cl. 1 V	2 x Pt 100 B/2	1 x Pt 100 1/2 B; 0/3	1 x Pt 100 A/0-400/4

Explanation:
For thermocouples:
V Hot junction isolated
V Hot junction grounded

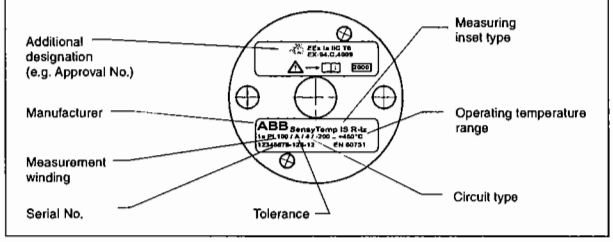
For resistance thermometers
R_L= Resistance of the lead wire in a 2-wire circuit, if > 0.1 Ω

B/2	Tolerance class B in 2-wire circuit
1/2 B, 0/3	Tolerance 1/2 Class B in 3-wire circuit
A/0-400/4	Tolerance Class A in the range 0-400 °C in 4-wire circuit
0.5; 280/4	Special tolerance 0.5 °C at 280 °C in 4-wire circuit

- Temperature range, serial no.
  This specifies the measuring range that is technically possible and an identification in relation to the order, e.g. .

-40...1000 °C	-200...450 °C	-50...150 °C	-200...450 °C
Serial no. ...	Serial no. ...	Serial no. ...	Serial no. ...

Measuring inset identification



EEx i measuring circuits

Max. internal inductance: L_i = 15 mH/m
Max. internal capacitance: Ci = 280 pF/m

When used in thermowells, the surface temperature on the thermowell is correspondingly lower. When the measuring inset in a thermometer is changed, the end user takes on responsibility for its correct installation in a thermometer of the associated approval no. Customer must provide us with the serial number marked on the old component in order that we can check that the model ordered is compatible with the component supplied originally and with the applicable certification.

Ex d Explosion protection
see page 16

Vibration resistance

The use of MIC and special resistance elements results in all measuring insets having a very high vibration resistance. The values (3 g) currently defined in EN 60751 (IEC 60751) for increased requirements are exceeded by all types. TMF/WMF measuring insets can withstand continuous loads of 10 g (frequency range tested 10-500 Hz). Short-term load can be much higher.

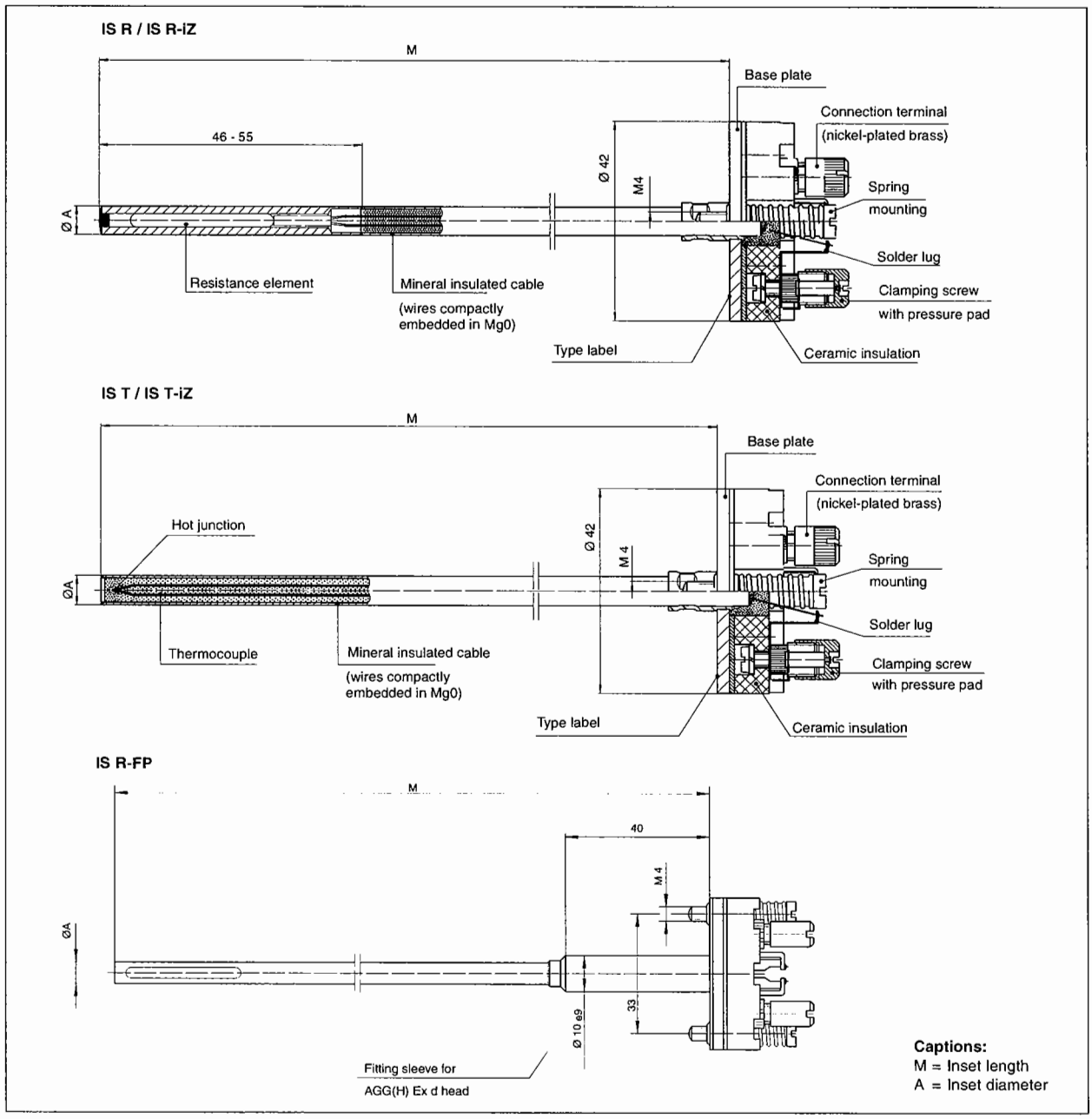
Measuring insets for resistance thermometers and thermocouples

Designs

The measuring insets shown here are designed for installation in fully-equipped temperature sensors.

- Temperature sensors with welded thermowell
  Data Sheets 10-3.22 EN and 10-3.25 EN
- Temperature sensors with drilled thermowell
  Data Sheets 10-3.23 EN and 10-3.26 EN
- Temperature sensors for installation in a thermowell
  Data Sheets10-3.24 EN and 10-3.27 EN
- Temperature sensors in an Ex d explosion protection
  Data Sheet 10-3.32 EN

In all the fully-equipped thermometers listed, the following measuring insets are installed as standard: IS T (thermocouple measuring insets), IS R (resistance thermometer measuring insets) and IS R-FP (Ex d resistance thermometer measuring insets).



Measuring insets for resistance thermometers

Measuring insets for resistance thermometers

The measuring inset is specified by its
- Reference table
- Standard
- Tolerance
- Number of lead wires
- Number of measuring circuits
- Outer sheath diameter

Nominal resistance/Standard/Tolerance

Resistance elements with platinum measurement winding are used. In accordance with EN 60751 the nominal resistance is defined as follows:
- 100 Ω at 0 °C
- Temperature coefficient
  3.85×10^{-3} (K^{-1}) – averaged between 0 °C and 100 °C.

As the temperature increases, the sensitivity reduces, resulting in a non-linear increase in resistance.

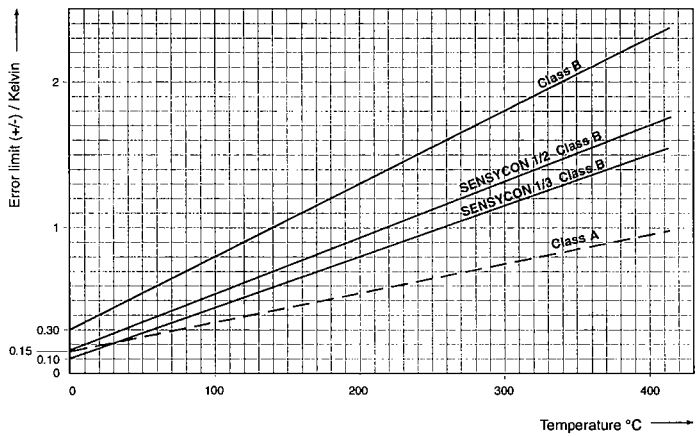
For the reference table permissible tolerances are defined for:
- a shift of the nominal value at 0 °C,
- a variation of the temperature coefficient.

The Class B tolerance conforms to the DIN 43760 value, which was valid until 1985. The tolerance Class B corresponds to the DIN 43760 value which was valid in 1985. For the additionally created Class A of EN 60751 (IEC 60751), the tolerance at 0° has been halved and the variance of the temperature coefficients limited by 60 %, when compared to Class B.

Further tolerance classes originating from this time have since been in use. However, these are no DIN classifications, but definitions created by Sensycon (1/2 and 1/3 Class B). According to these, the tolerance at 0° is divided into halves or thirds respectively, whilst in addition, the variance of the temperature coefficients are limited by about 20 % and 30 % resp., when compared to Class B.

Higher temperatures can cause slight alterations of characteristics in long-term operation. We recommend a maximum long-term temperature of max. 400 °C for reduced tolerances.

Measuring resistance tolerances acc. to EN 60751 (IEC 60751)



Basic values, deviations from platinum resistance element									
Temperature			0 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C
Basic value (Ω)			100.00	138.51	175.86	212.05	247.09	280.98	313.71
Tolerance (K)		Error limit							
EN 60751 (IEC 60751)	Class B	0.30 + 0.0050 * [t]	0.30	0.80	1.30	1.80	2.30	2.80	3.30
SENSYCON	1/2 Class B	0.15 + 0.0040 * [t]	0.15	0.55	0.95	1.35	1.75	2.15	–
SENSYCON	1/3 Class B	0.10 + 0.0035 * [t]	0.10	0.45	0.80	1.15	1.50	1.85	–
EN 60751 (IEC 60751)	Class A	0.15 + 0.0020 * [t]	0.15	0.35	0.55	0.75	0.95	1.15	–

[t] = Temperature in °C

Operational temperature

The temperature range is from -200...+600 °C (or may be limited by the explosion group).

The types of Ex measuring insets can be subdivided according to their classification grade:
IS R-iZ / IS T-iZ with PTB approval for Ex i (No. Ex 94.C.4009)
IS R-FP / IS T-FP with PTB approval for Ex d (No. Ex 86.B.1073 X)
IS R-iN conforming to NAMUR NE 24 for Ex i

Sheath material

The standard material used for all resistance thermometer measuring insets is 1.4571.

Measuring insets for resistance thermometers

Number of lead wires/measuring circuits/sheath diameters

Measuring insets can be supplied with:
- 1 or 2 measurement windings and
- in 2, 3 and 4-wire circuits.

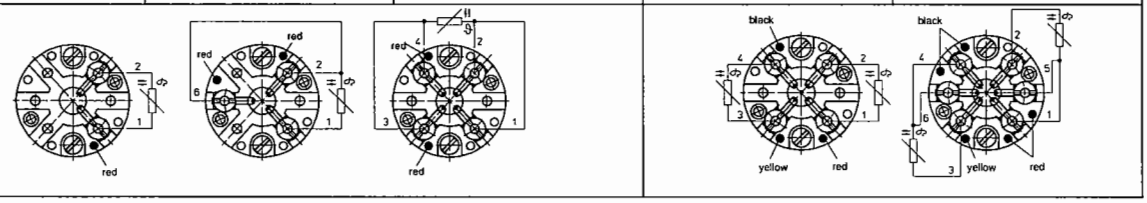
However, the combination in any particular case is restricted by the following conditions:

Design
- Measuring insets with a 3 mm Ø can have no more than 4 lead wires. This restricts 2 x Pt 100 to a 2-wire circuit.
- With Ex i-versions, 2 x Pt 100 can only be supplied with 6 mm Ø Mineral Insulated Cable (MIC) and only in a 2-wire circuit.

Circuit type, measuring inset length, tolerance
- The copper lead wire of the MIC contributes to the measured value in a 2-wire circuit, and must be taken into account. It depends on the diameter and length of the MIC. If it is not possible to correct the error in the measurements, then the following should be used as guide values:
  3 mm Ø (0.281 Ω/m →+0.7 °C/m):
  Class B, use max. 315 mm in 2-wire circuit
  6 mm Ø (0,1 Ω/m → +0.25 °C/m):
  Class B, use max. 1025 mm in 2-wire circuit
- All reduced tolerances should always be implemented in a 3-wire or 4-wire circuit.
- Special attention should be paid to the measuring inset WMF-H (-50 °C to +850 °C), since NiCr lead wires are used; (2.8 W/m → +7 °C)
- With 2 x Pt 100 in a 4-wire circuit, NiCr wires are also used. In this case a moulded plastic connection socket with 8 clamp screws is used.

Wiring diagrams and colour coding in accordance with EN 60751 (IEC 60751)

1 x Pt 100			2 x Pt 100	
2-wire circuit	3-wire circuit	4-wire circuit	2-wire circuit	3-wire circuit



Measuring insets for thermocouples

Thermocouple measuring insets

The measuring inset is specified by the
- Type of the thermocouple
- Standard
- Tolerance
- Grounding of hot junction
- Number of measuring circuits
- Outer sheath diameter

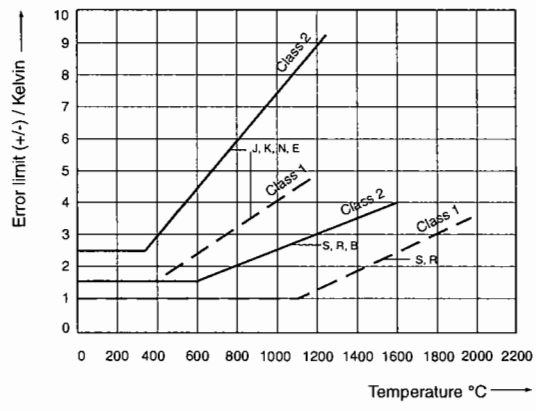
All types can be supplied with one or two thermocouples.

Tolerances
For thermocouples conforming to EN 60584 various different classes are defined for the permissible deviation from the e.m.f. reference table.

The measured thermoelectric e.m.f. corresponds to the temperature difference between hot junction and reference junctiont. The reference table conforming to EN 60584 relates to a reference temperature at 0 °C.

Because of the fact that, as the temperature rises, the effects of oxidation can have significant adverse effects on the characteristics and service life of a measuring inset, the specified operating temperatures (dependent on thermocouple type, tolerance class and sheath diameter) should never be exceeded for more than a short time.

Thermocouple tolerances acc. to EN 60584 (IEC 60584)



Measuring insets for thermocouples

Basic values, deviations acc. to EN 60584 (IEC 60584)

Temperature		200 °C	350 °C	500 °C	700 °C	900 °C	1100 °C
Thermoelectric voltage (mV)	Type J	10.78	19.09	27.39	39.13	51.88	63.79
	Type K	8.14	14.29	20.64	29.13	37.33	45,12
	Type N	5.91	11,14	16.75	24.53	32.37	40.09
Tolerance (K)	Class 2	2.5	2.6	3.8	5.3	6.8	8.3
	Class 1	1.5	1.5	2.0	2.8	3.6	–

Standard and special combinations

Type of thermocouple		Standard		Tolerance	
Standard types	Special	Standard type	Special type	Standard type	Special type
Type J (Fe-CuNi)	Type E (NiCr-CuNi)	EN 60584		Class 2	Class 1
Type K (NiCr-Ni)	Type T (Cu-CuNi)		ANSI MC96.1	Standard	Special
Type N (NiCrSi-NiSi)	Type R (Pt13Rh-Pt)		national standards	acc. to standard	acc. to standard
Type S (Pt10Rh-Pt) Type B (Pt30Rh-Pt6Rh)	Type L (Fe-CuNi) Type U (Cu-CuNi)	DIN 43710		DIN	½ DIN

Operating temperature, lead resistance, sheath material

Type of thermocouple	Measuring inset 3 mm Ø			Measuring inset 6 mm Ø			Sheath material
	Long-term temperature for tolerance class		Conductor resistance	Long-term temperature for tolerance class		Lead resistance	DIN 17 007
	1	2	Ω/m with R_t	1	2	Ω/m with R_t	
T	–	400 °C	3.2	–	500 °C	0.7	1.4541
E	–	600 °C	7.6	–	800 °C	1.8	1.4571
J	500 °C	600 °C	3.7	600 °C	700 °C	0.9	1.4571
K	700 °C	800 °C	6.2	800 °C	1000 °C	1.5	2.4816
N	700 °C	800 °C	6.2	800 °C	1000 °C	1.5	2.4816
L	500 °C	600 °C	3.7	600 °C	700 °C	0.9	1.4541
U	–	400 °C	3.2	–	400 °C	0.7	1.4541

Hot junction, sheath diameter

	Standard	Special
Hot junction	Insulated	Grounded
Meas. circuits	1 or 2	–
Sheath Ø	3 or 6 mm	1.5; 4.5; 8 mm

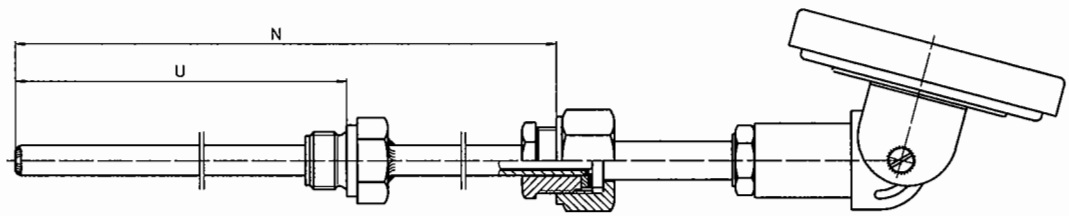
Wiring diagrams

Dial thermometers

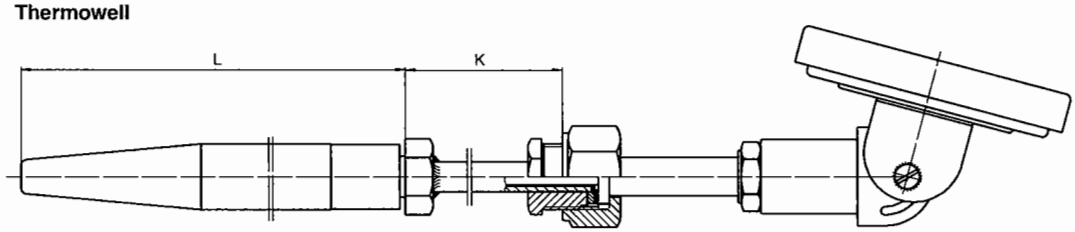
Designs

WT D Dial thermometer with protection tube (welded)
TW D Dial thermometer with thermowell (from bar stock) material)
ET D Dial thermometer for installation in a thermowell

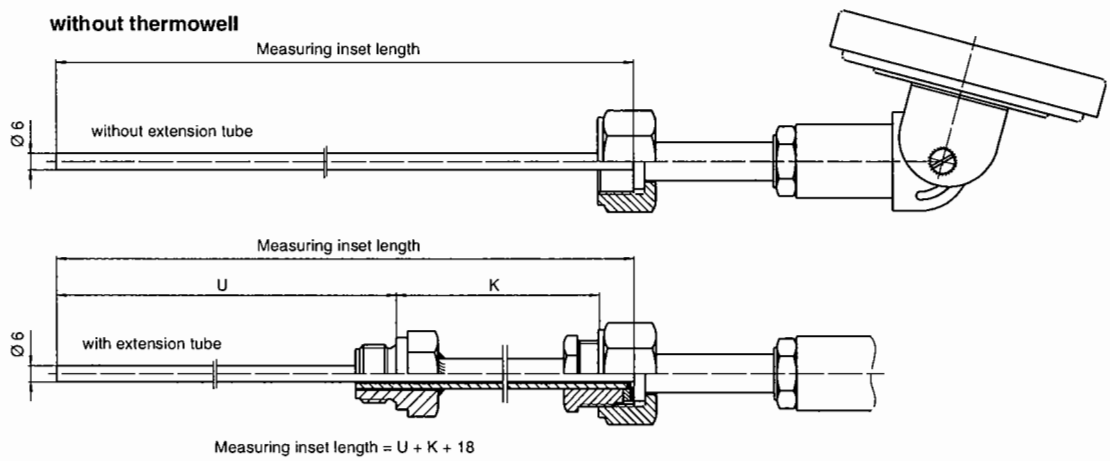
Protection tube



Thermowell



without thermowell



Measuring inset length = U + K + 18

Captions:
N = Nominal length
U = Insertion length
L = Thermowell length
K = Extension tube length

Dial thermometers

Measuring element

As with the measuring insets in electrical thermometers, the measuring element is installed in a 6 mm sensor tube. It consists of a bimetallic spiral, whose temperature-dependent change in length is transmitted to the measuring device.

Encased in the sensor tip of wall-mounting thermometers is a liquid whose temperature-dependent increase in pressure is transferred to the measuring device through a capillary tube.

The temperature-sensitive section is around 60 mm in length (span < 100 °C: approx. 80 mm).

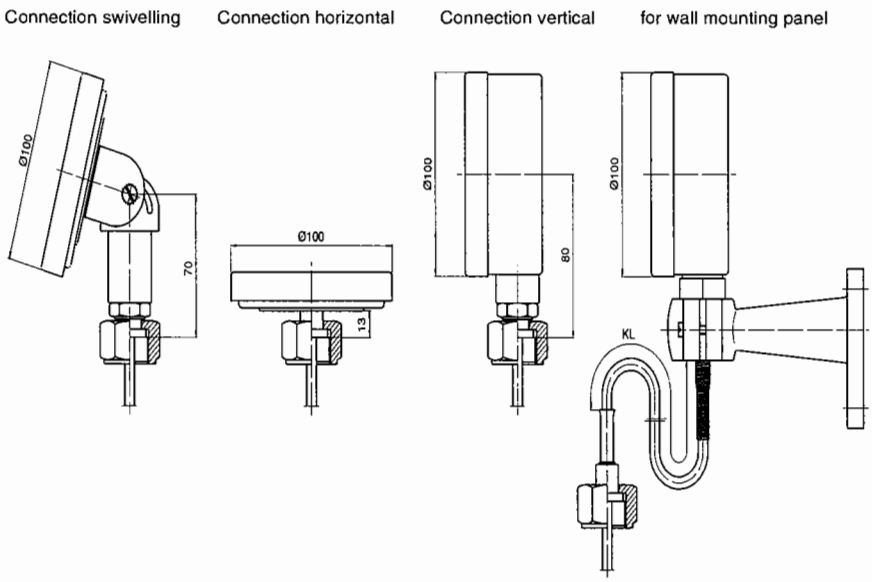
The measurement uncertainty comprises 1% of the full-scale value (1.5% where span > 160 °C).

The measuring insets are not spring loaded, and it is therefore important to ensure a good contact to the wall of the thermowell. For a swivelling scale head, a spring loaded measuring element can also be obtained as an optional extra, and this is push-fitted to the base of the thermowell, resulting in enhanced response time and vibration resistance.

Scale head forms

The circular scale indicator (approx. 270°) is installed in a stainless-steel housing with a macrolon glass face. For situations where there is a high level of vibration, the housing can optionally be liquid-filled for damping the measuring device. As the position in which the instrument will be installed and read is not generally known, scale heads with an indication position that can be swivelled in all directions are commonly used. Rigid vertical or horizontal scales can, of course, also be supplied. The wall-mounting scale head has an additional wall bracket.

Scale head forms



Dial thermometers

Thermowells, extension tubes and process connection

For dial thermometers all the analog types of thermowells, extension tubes and process connections for thermocouples and resistance thermometers can be supplied.

The directive 97/23/EG (Pressure Equipment Directive) are fulfilled. As the article 1, pragraph 2.1.4 does not apply, an Attest of Conformity and the CE-marking can not be done.

Process connections for protection tubes (welded)

- Welded mounting threads:
  G 1/2", G 3/4", G1", 1/2" NPT,3/4" NPT, 1" NPT
- Welded flange:
  DN 25 DIN 2527, 1" ANSI B16.5
- Adjustable compression fittings:
  G 1/2", 1/2" NPT

We deliver as standard cylindrical threads with thread groove and seal collar acc. to DIN 3852 type A, as specified in the thermowell specification DIN 43772.

Process connections for thermowells (from bar stock material)

- Weld sockets corresponding to type of thermowell
- Male threads corresponding to type of thermowell
- Screw-fit or push-fit flange, welded,
  DN 25, DN 50 DIN 2527,
  1", 11/2" ANSI B16.5

Extension tube connections for thermometers without thermowell

- Welded mounting thread:
  G1/2", 1/2" NPT, M 18 x 1.5
- Coupling screw:
  G1/2"

Operating data
The permissible stress depends on several factors:

Medium-related data	Installation-related data
– Medium – Viscosity – Flow velocity – Pressure – Temperature	– Material – Thermowell design – Insertion length – sealable pressure of the process connection – Vibration

General application specifications cannot be given in view of manifold range of versions. The following table gives approximate values, deduced from DIN 43763. If conditions differ, a stress analysis according to Dittrich or Murdock is recommended.

Type	Material dimensions	Process connection	Max. flow velocity (m/s)		Max. pressure (bar) for temperature (°C)					
			Air	Water	For insertion length (mm)	0	100	200	300	400
B3	9 x 1 mm 1.4571 (AISI 316-TI)	welded mounting thread G½"	25	3	160 250 400	50 40 18	48 40 18	44 40 18	40 40 18	36 36 18
C2 C2S	11 x 2 mm 1.4571 (AISI 316-TI)	welded mounting thread G1"	40	5	160 250	100 50	95 50	92 50	88 50	80 50
K2 K2S E1	12 x 2,5 mm 1.4571 (AISI 316-TI)	welded mounting thread G1"	40	5	160 220 280	100 100 100	100 100 100	100 100 100	100 78 55	100 78 55

Sheathed temperature sensor

Mineral Insulated Cables (MIC)

MIC have an outer sheath of metal with 2 to 8 lead wires. The insulation material is made from a highly compressed metal-oxide powder.

As well as the standard material (96%-pure MgO), MgO can also be supplied in a 99.4%-pure form as well as Al2O3.

MIC for thermocouples have lead wires of thermocouple base material. MIC for resistance thermometers have lead wires of copper.

The following steels and alloys are available as sheath materials:

- 1.4541 complies with AISI 321
- 1.4571 complies with AISI 316 TI
- 1.4749 complies with AISI 446
- 1.4841 complies with AISI 314
- 1.4845 complies with AISI 310 S
- 1.4876 complies with INCOLLOY 800
- 2.4816 complies with INCONEL 600
- Platinum 10% Rhodium

For other technical information on mineral insulated cables see Catalog 04/10.7 EN.

Standard materials

Max. oper. temperature	Sheath material	Material properties
800 °C	1.4571 AISI 316 TI	Increased resistance against corrosion from certain acids due to the addition of molybdenum. Resistant against pitting, salt water and aggressive industrial influences. Can be used continuously up to approximately 800 °C.
1100 °C	2.4816 Inconel 600 (Trademark of Inco Alloys)	Good general resistance to corrosion, resistant to tension crack corrosion. Excellent resistance to oxidation. Not recommended with gases containing CO_2 and sulphur above 550 °C. In air, resistant up to 1100 °C. Excellent ductility even after long-term use.

Guide values for insulation resistance by length and temperature (min. requirem. in terms of meas. technique appr. 500 KΩ)

Temperature °C	100 mm	300 mm	1000 mm	3000 mm	10000 mm	30000 mm
200	10000 MΩ	3000 MΩ	1000 MΩ	300 MΩ	100 MΩ	30 MΩ
300	1000 MΩ	300 MΩ	100 MΩ	30 MΩ	10 MΩ	3 MΩ
400	100 MΩ	30 MΩ	10 MΩ	3 MΩ	1 MΩ	300 kΩ
500	30 MΩ	10 MΩ	3 MΩ	1 MΩ	300 kΩ	100 kΩ
600	10 MΩ	3 MΩ	1 MΩ	300 kΩ	100 kΩ	30 kΩ
700	3 MΩ	1 MΩ	300 kΩ	100 kΩ	30 kΩ	10 kΩ
800	1 MΩ	300 kΩ	100 kΩ	30 kΩ	10 kΩ	3 kΩ
900	300 kΩ	100 kΩ	30 kΩ	10 kΩ	3 kΩ	1 kΩ
1000	100 kΩ	30 kΩ	10 kΩ	3 kΩ	1 kΩ	300 Ω

The hot junction is normally isolated from the sheath.

Bending radius of the MIC

Ø 1.0 > 3 mm	Ø 3.0 > 9 mm
Ø 1.5 > 5 mm	Ø 4.5 > 14 mm
Ø 2.0 > 6 mm	Ø 6.0 > 18 mm

Plug connections

For plug contacts we can offer coupling systems from various different manufacturers which can be assembled both directly on the MIC and on the free end of the cable:

- LEMO
  FFA or PCA cable coupling, size 1, gold-plated brass contacts, Nickel-plated brass housing, PEEK insulator, max. 200 °C, max. 6 contacts, snap locking device, IP 54
- THERMOCOUPLE
  Plug coupling, thermo-contacts, standard or miniature size Housing synthetic, max. 200 °C, max. 2 contacts, no locking

Explosion protection

Sheathed temperature sensors are fully encased. They therefore satisfy degr. of prot. IP 54 as a requirem. for suitability conforming to EN 50020 Pkt. 5.4, to EN 60079-14 (VDE 0165 part 1) for measuring circuits in zone 2. Suitability for zone 1 requires a voltage dielectric strength of 500 V AC, which is only achieved by:

Sheath Ø 3 mm
1 × thermocouple, 1 × Pt 100, 2-, 3-, 4-wire

Sheath Ø 6 mm
1/2 × thermocouple, 1 × Pt 100, 2-, 3-, 4-wire,
2 × Pt 100, 2-wire

Once we receive an order we declare the suitability for intrinsically-safe measuring circuits in zone 1 with a manufacturer's declaration. Deployment in zone 0 is not permitted.

Fastenings

Fastening and sealing is usually effected by means of compression fittings. To improve the stability, the sensor can be fitted with a support tube on the medium side. If the sheathed temperature sensor is used for measuring not in gaseous or liquid media but in solid materials, then the hot junction may need to be set up in such a way that a good heat contact is achieved, while at the same time a suitable means of securing the thermometer is found, e.g.:

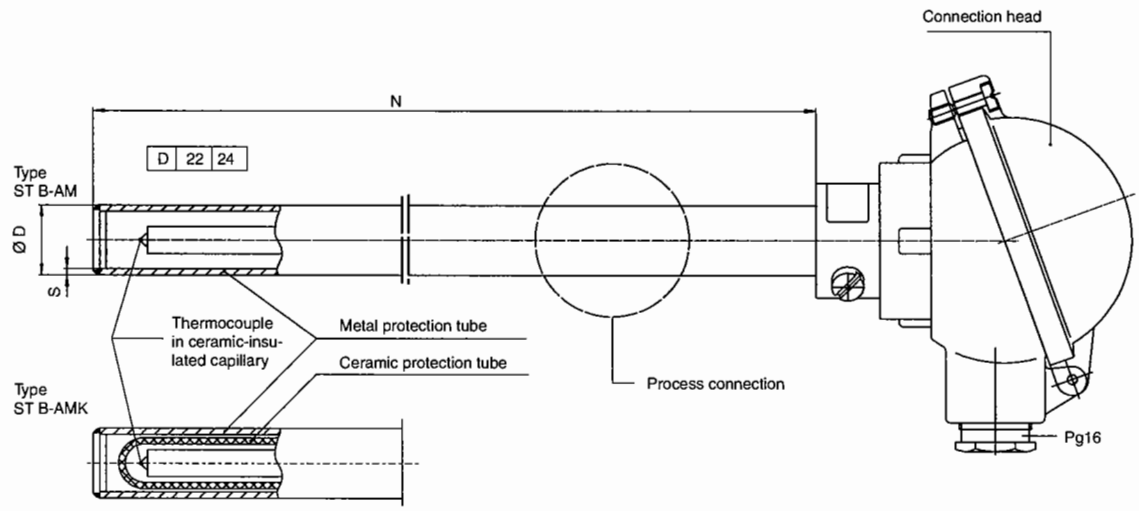
- Metal plate for screwing or welding to metal surfaces
- Metal block for securing to smooth or curved surfaces by means of a clamp.

Straight thermocouples

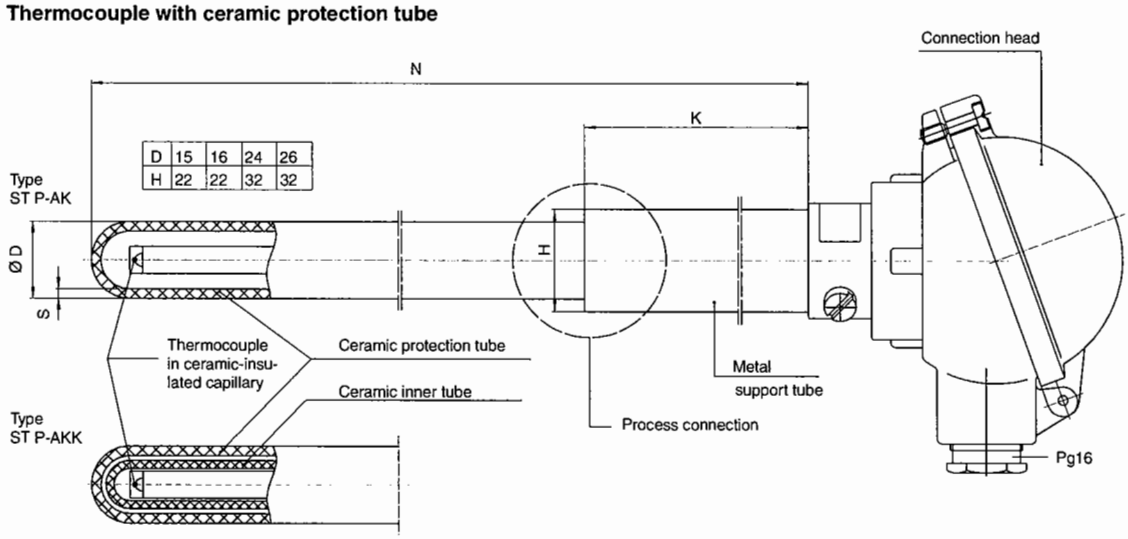
Designs

ST B-AM with metal protection tube
ST B-AMK with metal protection tube and ceramic inner tube
ST P-AK with ceramic protection tube
ST P-AKK with ceramic protection tube and ceramic inner tube

Thermocouple with metal protection tube



Thermocouple with ceramic protection tube



Captions:
N = Nominal length
D = Thermowell diameter
S = Wall thickness
H = Support tube diameter
K = Support tube length

Straight thermocouples

Thermocouple types and tolerances									
Type	Material	Standard	Standard tolerance Class	Deviation	Reduced tolerance Class	Deviation	Max. temperature	Wire Ø mm
Base-metal thermocouple combinations									
K	NiCr-Ni	EN 60751	2	2.5 °C or 0.0075 t	1	1.5 °C or 0.004 t	1200 °C	2.5
N	NiCrSi-NiSi	EN 60751	2	2.5 °C or 0.0075 t	1	1.5 °C or 0.004 t	1200 °C	2.5
J	Fe-CuNi	EN 60751	2	2.5 °C or 0.0075 t	1	1.5 °C or 0.004 t	800 °C	2.5
L	Fe-CuNi	DIN 43710	DIN:	3 °C or 0.0075 t			800 °C	2.5
Precious-metal thermocouple combinations									
S	Pt10Rh-Pt	EN 60751	2	1.5 °C or 0.0025 t	1	1 °C or 1 + 0.003 (t-1100 °C)	1600 °C	0.35 0.5
R	Pt13Rh-Pt	EN 60751	2	1.5 °C or 0.0025 t	1	1 °C or 1 + 0.003 (t-1100 °C)	1600 °C	0.35 0.5
B	Pt30Rh-Pt6Rh	EN 60751	3	4 °C or 0.005 t	2	1.5 °C or 0.0025 t	1800 °C	0.35 0.5

The currently valid standard EN 60584 specifies basic values and tolerances of the thermocouple combinations to be used. These are identical to the preceding standard DIN 43710 with the exception of Fe-CuNi. In order to safeguard the requirement for spare parts for old systems, type L can be supplied for these situations.

With precious-metal thermocouple combinations a choice is offered between thermocouple wire of 0.35 mm and 0.5 mm diameter. Since the long-term stability is far superior with thicker thermocouple wire, we recommend a diameter of 0.5 mm.

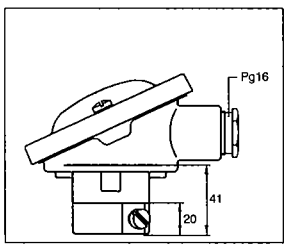
The greater value of the precious metal can be recouped after use through recycling. With type K there is a danger temperature range between 850...950 °C of green rot. If the operational temperature is constantly fluctuating within this range, we recommend the use of a sheathed thermocouple.

Connection heads

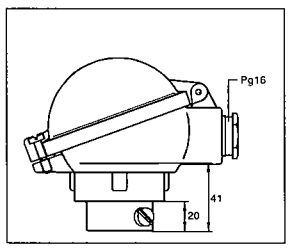
Several types of connection head are obtainable, and they vary both in material and lid closure technique.

Type	Material	Cable entry	Degr. of protection	Lid closure	Surface
A	Aluminium	PG 16	IP 54	Loose lid	Painted
AUZ, AUZH, AUS, AUSH	Aluminium	PG 16	IP 54	Hinged lid	Painted
AUG	Grey cast iron	PG 16	IP 54	Hinged lid	Painted
AGG, AGGH	Grey cast iron	PG 16	IP 54	Screwed lid	Painted

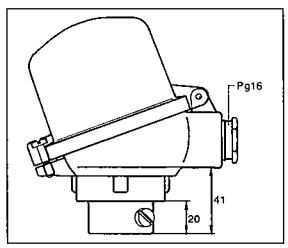
Type **A** aluminium



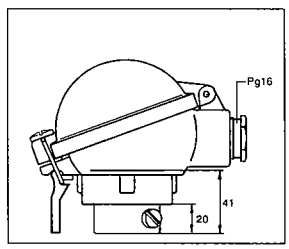
Type **AUZ** aluminium



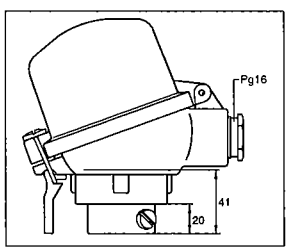
Type **AUZH** aluminium for installation of transmitter



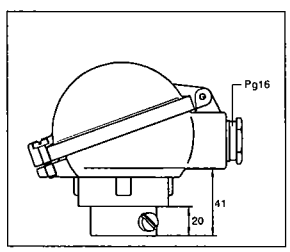
Type **AUS** aluminium



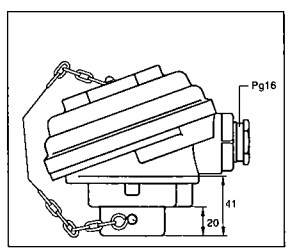
Type **AUSH** aluminium for installation of transmitter



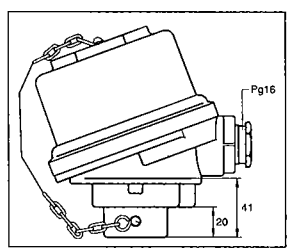
Type **AUG** grey cast iron



Type **AGG** grey cast iron



Type **AGGH** grey cast iron for installation of transmitter



Sheathed temperature sensor

Connecting cables

There can be many different requirements for cables:
- Number, size and material of lead wires
- Thermal stability, insulation material
- Electrical shielding, mechanical protective braiding
- Degree to which insulation is impervious to moisture
- Flexibility, diameter of cable
- Colour coding in accordance with standards

As a result of the necessary closure system for the open end of the MIC, the temperature at the transition point to the cable must be already reduced (max. 200 °C and/or appropriate cable insulation). The MIC must therefore be routed away from the process for a corresponding sufficient distance. Since in most cases the temperature drops as the distance from the process increases, insulation materials capable of withstanding temperatures above 200 °C are unnecessary from a technical point of view.

Compensating cables for Mineral Insulated Cables

Insulation designation	Number/size of lead wires	Outside Ø	Temperature min./max. °C	Composition of insulation	Suitability
JJ	2 × 0.22 4 × 0.2	3.6 4.1	-10 /+105	Core: PVC heat-resistant Sheath: PVC, heat-resistant	Weak alkaline solutions and acids, mineral oil, self-extinguishing
SLSLGL	2 × 0.22	5.0	-60 /+200	Core: Silicone Intermediate layer: Silicone Sheath: Fibre-glass braid	Weak alkaline solutions and acids, mobile installation, inflammable
TT	2 × 0.75 2 × 0.75	4.2 5.1	-200 /+200	Core: Teflon FEP Sheath: Teflon FEP	Oil, gasoline, benzene, alkaline solutions and acids, inflammable
TGLV	2 × 0.22 4 × 0.22	3.3 3.8	-200 /+200	Core: Teflon FEP Intermediate layer: Fibre-glass braid Sheath: Stainless steel wire braid	Oil, gasoline, benzene, alkaline solutions and acids, mechanical stress, inflammable

For other technical information on connecting cables see Catalog 04/10.7 EN

Response times

Apart from thermowell mass at the measuring point, factors governing the heat transport are the main determinants for the response time:
- Medium, heat capacity
- Pressure, density, moisture
- Flow velocity.

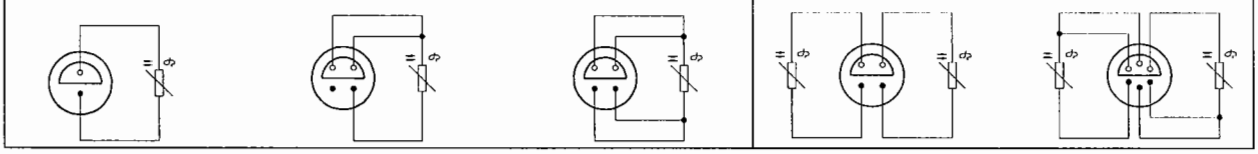
The following table features approximate values, refering to water or air. Greater flow velocities and heat capacities considerably reduce the response time.

The values $T_{0,5}$ and $T_{0,9}$ give information on the time period after which 50% and 90% of a sudden temperature change is displayed.

	Sheath Ø (mm)	in water 0.4 m/s $T_{0.5}$	in water 0.4 m/s $T_{0.9}$	in air 3 m/s $T_{0.5}$	in air 3 m/s $T_{0.9}$
Resistance thermometer					
	6	4	10	40	105
	3	1.5	4.5	15	50
Thermocouples					
	6	3	7.5	38	98
	3	0.8	2.1	14	44

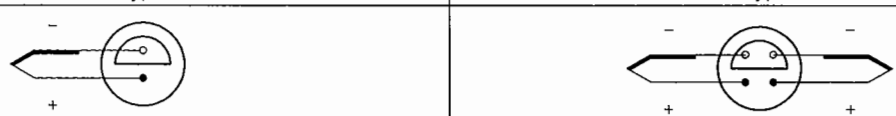
Wiring diagrams, Lemo socket/plug-connectors

1 x Pt 100			2 x Pt 100	
2-wire circuit	3-wire circuit	4-wire circuit	2-wire circuit	3-wire circuit



Wiring diagrams, Lemo socket/plug connectors

1 x type K	2 x type K



Straight thermocouples

Sensor operating conditions ST P-AK / ST P-AKK

At high temperatures, ceramic protection tube materials may become porous thus making the penetration of aggressive gases from the environment possible.

These pollution gases change the characteristic of the thermocouple. In order to prevent this, a gas-tight ceramic inner tube can be inserted in the protection tube to screen the thermocouple.

Precious metal thermocouples (types R/S/B) may also absorb impurities from the insulation ceramic at high temperatures. Above approximately 1400 °C, they should only be used in gas-tight thermowells or inner tubes of high-purity aluminium oxide C799.

Gas-tight ceramic materials are sensitive to thermal shock and impact load. The stress features can be optimized by appropriate choices of materials for the protection tube and inner tube.

Protection tube		Inner tube	
C530	Very resistant to temperature changes	C610	Relatively pure, gas-tight
C610	Gas-tight and resistant to temperature changes, but only relatively pure	C799	High purity, gas-tight
C799	Gas-tight, but only medium resistance to temperature changes	C799	High purity, gas-tight

Sensor operating conditions ST B-AM / ST B-AMK

At high temperatures, metal protection tube materials may become porous thus making the penetration of aggressive gases from the environment possible.

These pollution gases change the characteristic of the thermocouple. In order to prevent this, a gas-tight ceramic inner tube can be inserted in to the protection tube to screen the thermocouple.

The stress features can be optimized by appropriate choices of materials for the protection tube and inner tube, for example:

Protection tube	Inner tube
Heat-resistant steel Impact-resistant and resistant to temperature changes	C 610 Relatively pure, gas-tight

Operating conditions for thermowell materials

Material	Max. temperature	Advantages	Disadvantages
Metal thermowells			
1.0308 (ASTM 105)	550 °C	For air, medium resistance to gases containing nitrogen	Low level of resistance to gases containing sulphur
1.0308 enamelled (ASTM 105 enamelled)	550 °C	Corrosive applications in the dewpoint range of flue gases	Susceptible to impact and bending
1.4762 (AISI 446)	1200 °C	High level of resistance to gases containing sulphurs	Low level of resistance to gases containing nitrogen
1.4749 (AISI 446)	1100 °C	Very high level of resistance to gases containing sulphur	Low level of resistance to gases containing nitrogen
1.4841 (AISI 314)	1150 °C	High level of resistance to gases containing nitrogen and with a low oxygen content	Low level of resistance to gases containing sulphur
Ceramic thermowells			
C530 (Al_2O_3 > 80 %)	1400 °C	Resistant to temperature changes	Finely porous, not gas-tight, susceptible to impact
C610 (Al_2O_3 > 60 %)	1500 °C	Gas-tight, high level of fire resistance, medium resistance to temperature changes	Poor degree of Al_2O_3 purity, susceptible to impact
C799 (Al_2O_3 > 99 %)	1800 °C	Very gas-tight, extremely fire-resistant	Low level of resistance to temperature changes, susceptible to impact

Straight thermocouples

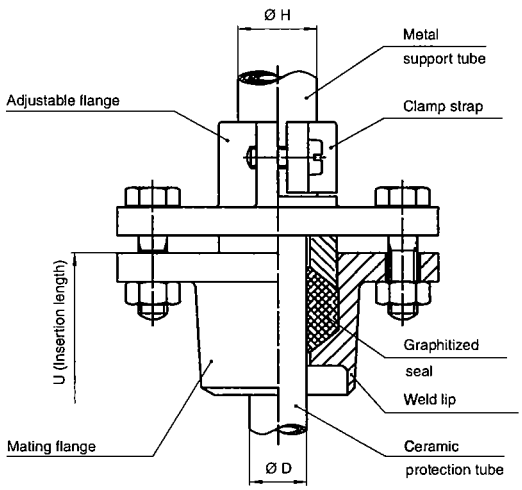
Process connection

Fastening is effected predominantly with detachable components which are sealed by means of a stuffing box:
- Adjustable flange and mating flange for welding on,
- Adjustable flange and mating flange for screwing on,
- Threaded bushing for screwing on.

Welded standard flanges can also be supplied.

With metal thermowells the fastening component can be moved to any position, while in the case of ceramic protection tubes it is always located at the transition to the support tube. In ceramic thermowells with adjustable flange and mating flange the fastening device is located at the end of the extension tube with the seal on the thermowell. The position of the threaded bushing or welded flange can be chosen as any point on the support tube.

Thermowell fastening



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