KELLER
infrared temperature solutions ITS

Pyrometer
CellaTemp® PZ Profibus

for non-contact temperature measurement
from 0 °C to + 3000 °C

No 1 in terms of ACCURACY RELIABILITY INNOVATION

5 years warranty

QUALITY made in Germany

Range of models

Compact pyrometer

Single-colour pyrometer		
Model	Temperature range	Application
PZ 10	0 - 1000 °C	nonmetals
PZ 15	300 - 1300 °C	glass surfaces
	1000 - 2500 °C	
PZ 20	250 - 2000 °C	metals, ceramics, molten glass
	350 - 2500 °C	
PZ 27	150 (100) - 800 °C	metals at low temperatures, laser applications
	180 - 1200 °C	
	250 - 2000 °C	
PZ 30	500 - 2500 °C	precise measurement of metals, semiconductors
	800 - 3000 °C	
PZ 35	600 - 2500 °C	metals and silicon wafers

Two-colour pyrometer		
Model	Temperature range	Application
PZ 40	500 - 1400 °C	metal melts, cement, welding, crystal pulling, sintering, rolling
	700 - 1600 °C	
	900 - 2400 °C	
	1000 - 3000 °C	
PZ 50	500 - 1400 °C	metals, sintering
PZ 60	300 - 800 °C	galvanizing, heat treatment

Pyrometer with fibre optics and optical sensor head

Single-colour pyrometer		
Model	Temperature range	Application
PZ 21	350 - 2000 °C	metals, ceramics, molten glass
PZ 31	700 - 2500 °C	metals, ceramics at high temperatures

Two-colour pyrometer		
Model	Temperature range	Application
PA 41	900 - 2400 °C	exact measurement of metals, semiconductors

Pyrometer CellaTemp® PZ Profibus

Special Features

- Wide measuring ranges: 0 - 3000 °C / 32 - 5432 °F
- Focusable interchangeable optics
- Broadband, antireflection coated lenses
- 2 target sighting options: through-the-lens or laser spot light
- Field bus interface Profibus DP with a transmitting speed up to 12 MBit/s
- Single-colour or two-colour pyrometer
- Compact version or with fibre optics and optical sensor head

CellaTemp® PZ Profibus Series

The CellaTemp® PZ Pyrometer Series is based on a modular concept consisting of the following components: optics, sensor and signal processing, data output and target sighting.

The **optical system (1)** comprises one of five available objective lenses. Select the one most suitable, depending on the required target size and measuring distance. The pyrometer is infinitely adjustable to ensure superior precision across a wide focusing range.

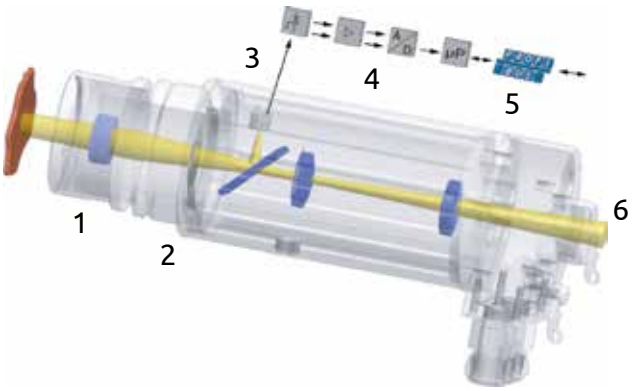
The **aperture (2)** determines the size of the measurement area.

A **sensor (3)** detects the IR radiation emitted by an object's surface. It is based on the latest DC technology and does not involve any moving parts. Depending on the specific model, CellaTemp® pyrometers are available either in a single-colour version (single wavelength detector) or in a two-colour version (dual wavelength detector).

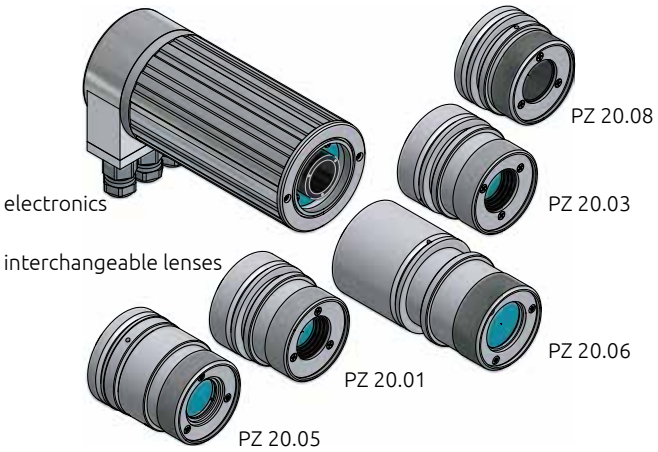
Special **signal processing (4)** combined with high-resolution analogue-to-digital conversion enables a wide measuring span. The temperature resolution remains uniformly high across the entire measuring range.

For measurement **data output (5)**, CellaTemp® PZ features a network compatible RS-485 Profibus-interface.

Two **target sighting (6)** systems are available to facilitate focusing, alignment and indication of spot size: through-the-lens sighting or a laser spot light.



Block diagram



Single-colour or two-colour pyrometer

The pyrometers of the CellaTemp® PZ Series are available both as single-colour and as two-colour pyrometers.

Whereas single-colour pyrometers detect thermal radiation at one single wavelength, two-colour or ratio pyrometers pick up the infrared radiation at two different wavelength channels. The ratio of these two intensities is a function of target temperature. When the radiation detected is equally reduced at both wavelengths e.g. due to vapour or dust in the field of view, a fogged or dirty lens, or changing surface characteristics of the target, the ratio signal will remain unchanged and the two-colour instrument will continue to provide a stable measurement.

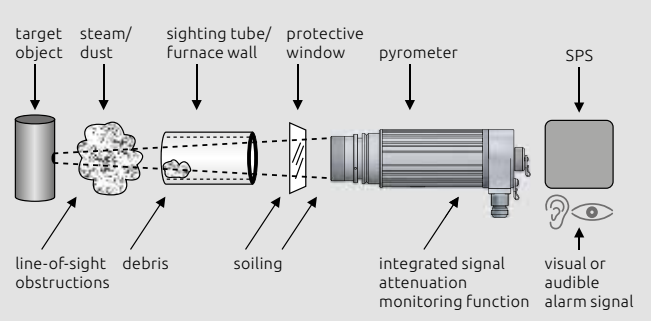
The two-colour CellaTemp® PZ also features an integrated contamination detection function. The pyrometer detects when the lenses of the optical system become too dirty or the sighting tube is impaired. If signal attenuation exceeds a user-defined threshold, an alarm will trigger.

Profibus interface

Profibus is a multivendor compatible field bus standard for a broad range of applications within the fields of measurement engineering and automation. Due to EN 50170 standardisation, Profibus enables flawless data communication between a wide variety of networked devices, regardless of manufacture. The CellaTemp® PZ Series pyrometers support the Profibus DP and have been approved by the Profibus User Organisation.

With RS 485 connection, data is transmitted at speeds of up to 12 MBit/s. Up to 32 PROFIBUS DP stations can be interconnected within a network segment. The use of RS 485 repeaters enables the connection of up to 127 stations, including masters.

A connection box with screw terminals, mounted to the back side of the CellaTemp® PZ, serves to connect the power supply line and the fieldbus cable. The termination resistor is provided in the connection box, therefore, removing a pyrometer from the bus system during running operations will not interrupt the bus line.

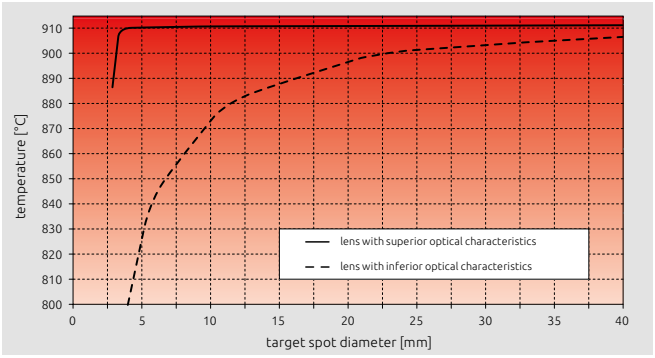


Indication of field-of-view obstruction

Optics

A pyrometer is an optical means of measuring temperature. The quality of the optics greatly influences the the accuracy of the measurement.

The „size of source effect" is a factor which affects the uncertainty of the measurement. Light scattered into the optical path will result in false temperature data. When the target size or the distance to the target change, as shown in the chart, the temperature reading will change as well, depending on the quality of the optical system.



Influence of the size of the measured object on the temperature display with good and bad error correction of the optics of the pyrometer

CellaTemp® PZ pyrometers feature an optical system which is optimized for the visible and infrared range. The superior glass lens features an antireflective coating. Due to its superior imaging properties, the high-precision lens provides consistently high optical resolution across the entire focusing range.

In addition, the patented optics and apertures are mechanically designed to minimize sensitivity to light scattered into the sight path.

Dirty window monitor

Two-colour pyrometers feature SCM (Smart Contamination Monitoring), a function which indicates when the pyrometer lens or the protective quartz window are dirty.

The pyrometer identifies when the emitted IR energy does not completely reach the sensor due to obstructions in the line of sight or dirt buildup in the furnace port hole. The user can adjust the sensitivity of this function to a tolerated amount of signal attenuation.

Supplementary lenses

The CellaTemp® PZ can capture target spots as small as Ø 0.3 mm when an additional lens is mounted.

The pyrometer models can be combined with supplementary lenses in a variety of ways, enabling additional optical resolutions for maximum versatility.

Electronics / Sensors

- High resolution and accuracy by a combined analog and digital signal processing
- Very fast response time
- Wide temperature ranges
- Based on light sensor technology; instrument contains no mechanical moving parts
- Non-wearing; requires no maintenance
- Immune to electromagnetic interference

Adjustable parameters

- Emissivity / Emissivity slope
  10 to 100% increments of 1 % (0.1% for PZ 10, PZ 15)
  74.4 to 125.5 increments of 0.1
- Smoothing filter
- Data storage
  Peak/valley hold, double peak hold with adjustable hold time
- Device address
- Temperature unit °C / °F

Sighting options for compact models

Through-the-lens

The CellaTemp® PA compact models can be supplied with through-the-lens, parallax-free sighting. The wide field of view makes it easy to focus on the target object. The ocular features a widened inter-pupillary distance, making it suitable for users who wear glasses or a helmet. The circle in the viewfinder indicates the exact position and size of the measured target spot.

If the target is especially bright, the polarizing filter PA 20/P can be mounted on the lens to protect the user's eye. Pyrometers with through-the-lens sighting can be retrofitted with the PA 20/Q laser adapter. This external auxiliary laser provides the user with an additional means of aiming at the target.

Laser spot light

The third sighting option available for CellaTemp® PA is an integrated laser spot light. The laser dot marks the center of the target spot and is well visible even from a distance of up to 10 m. The laser is activated either directly by push-button or remote by means of an external switch or via interface.

Technical data

Fieldbus interface
- Profibus DP (according to EN 50170) up to 12 MBit/sec.

Linearization
- Digital by high-resolution microcontroller

Temperature coefficient
- deviation to 23 °C:
  0.25 K/K (for T < +500 °C)
  (0.1 K/K for PZ 10, PZ 15)
  0.05 %/K (for T ≥ +500 °C)

Operating voltage
- 22 bis 27 VDC

Ambient temperature
- Electronics: 0 to +60 °C
- Sensor head of the fibre optic models: -20 to +250 °C
- Kevlar: -20 to +250 °C

Current consumption
- < 60 mA
- < 150 mA with laser sighting

Storage temperature
- -20 to +70 °C

Permissible humidity
- 95 % r.H. max. (non-condensing)

Housing material
- Aluminium

Protection
- IP 65 according to DIN 40050

Weight
- approx. 0.8 kg

Connection
- Screws

Fibre optics cable for CellaTemp® PZ

Type	Length	Weight
LWL-2HT	2 m	0.08 kg
LWL-5HT	5 m	0.19 kg
LWL-10HT	10 m	0.38 kg

Other lengths up to 50 m on request

- Ambient temperature: -40 - +250 °C
- Material: Nickel-plated brass

EMV standard

- EN 50081-1
- EN 50081-2
- EN 50082-2

Shipment includes

- Pyrometer CellaTemp® PZ
- Fibre optic version incl. measuring head
- Instruction manual
- GSD data on CD

The fiber optic cable must be ordered separately in desired length.

Compact single-colour pyrometer

Model		Technical data							
Target sighting		Temp. range	Wave-length	Lens system	Focus range	Distance ratio	Uncertainty	Re-peat-ability	Response time t_{98}
Through-the-lens	Laser spot light								
PZ 10 ...									
AF 401	AF 401/L	0 - 1000 °C 32 - 1832 °F	8 - 14 µm	PZ 10.01	0.30 m - ∞	40 : 1	1 % of temp. reading, at least 2 K	1 K	t_{90} ≤ 100 ms
AF 402	AF 402/L			PZ 10.05	0.15 m - 0.30 m	38 : 1			
PZ 15 ...									
AF 401	AF 401/L	1000 - 2500 °C 1832 - 4532 °F	4.46 - 4.82 µm	PZ 15.03	0.60 m - ∞	55 : 1	1 % of temp. reading, at least 2 K	3 K	t_{90} ≤ 100 ms
AF 402	AF 402/L	300 - 1300 °C 572 - 2372 °F		PZ 15.03	0.30 m - ∞	40 : 1			
PZ 20 ...									
AF 401	AF 401/L	250 - 2000 °C 482 - 3632 °F	1.1 - 1.7 µm	PZ 20.01	0.40 m - ∞	150 : 1	0.75 % of temp. reading	1 K	≤ 40 ms at T ≥ 750 °C
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	200 : 1			
AF 404	AF 404/L			PZ 20.05	0.20 m - ∞	32 : 1			
AF 409	AF 409/L			PZ 20.08	0.30 m - ∞	80 : 1			
AF 405	AF 405/L	350 - 2500 °C 662 - 4532 °F		PZ 20.01	0.40 m - ∞	150 : 1			
AF 406	AF 406/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 407	AF 407/L			PZ 20.06	1.20 m - ∞	200 : 1			
AF 408	AF 408/L			PZ 20.05	0.20 m - ∞	32 : 1			
PA 30 ...									
AF 401	AF 401/L	500 - 2500 °C 932 - 4532 °F	0.8 - 1.1 µm	PZ 20.01	0.40 m - ∞	175 : 1	0.75 % of temp. reading	1 K	≤ 40 ms at T ≥ 750 °C
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	240 : 1			
AF 404	AF 404/L			PZ 20.05	0.20 m - ∞	35 : 1			
AF 405	AF 405/L	800 - 3000 °C 1472 - 5432 °F		PZ 20.01	0.40 m - ∞	175 : 1			
AF 406	AF 406/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 407	AF 407/L			PZ 20.06	1.20 m - ∞	240 : 1			
AF 408	AF 408/L			PZ 20.05	0.20 m - ∞	35 : 1			
PA 35 ...									
AF 401	AF 401/L	600 - 2500 °C 1112 - 4532 °F	0.85 - 0.91 µm	PZ 20.01	0.40 m - ∞	175 : 1	0.5 % of temp. reading	1 K	≤ 40 ms at T ≥ 700 °C
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	240 : 1			
AF 404	AF 404/L			PZ 20.05	0.20 m - ∞	35 : 1			

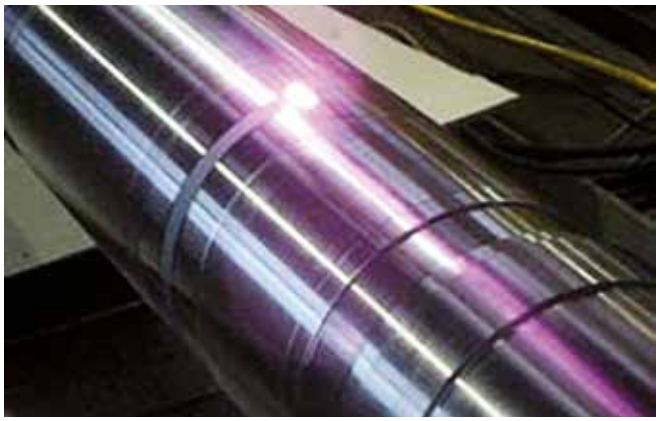
Pyrometer for aluminium, reflecticve metal surfaces or for laser applications

CellaTemp® PZ 27 was designed with a special band-stop filter and sensor which ignore interfering IR radiation from sources such as daylight or laser beams. CellaTemp® PZ 27 features a response spectrum which is far less sensitive to incidental light reflections from nearby hot objects than most commonly available pyrometers which are responsive at short wavelengths.

The individual components and subassemblies can be combined in different ways, yielding 24 instrument variants. In combination the with supplementary lenses the CellaTemp® PZ 27 can capture target spots as small as Ø 0.3 mm.

Due to the wide temperature ranges and the variety of available optics, the CellaTemp® PZ 27 provides maximum versatility.

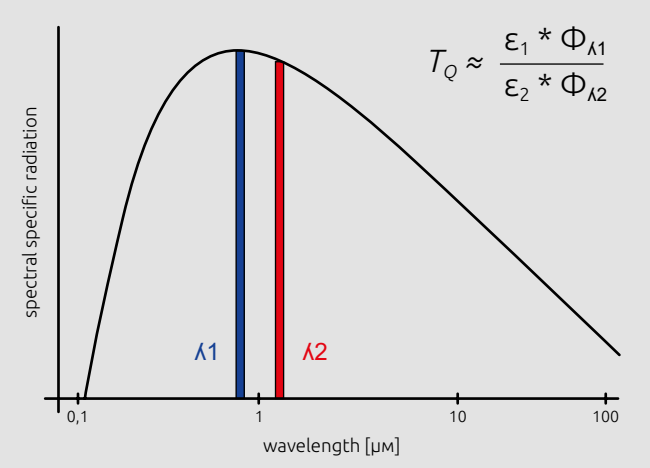
It is suitable for various applications in the metalworking industry, and is ideal for measuring reflective metals and aluminium at low temperatures.



Model		Technical data							
Target sighting		Temp. range	Wave-length	Lens system	Focus range	Distance ratio	Uncertainty	Re-peat-ability	Response time t_{98}
Through-the-lens	Laser spot light								
PZ 27 ...									
AF 410	AF 410/L	150 (100) - 800 °C 302 (212) - 1472 °F	1.8 - 2.2 µm	PZ 20.08	0.30 m - ∞	40 : 1	5 K or 0.75 % of temp. reading	2 K	≤ 40 ms at T ≥ 150 °C
AF 421	AF 421/L	180 - 2000 °C 356 - 2192 °F		PZ 20.01	0.40 m - ∞	60 : 1	2 K or 0.75 % of temp. reading	1 K	
AF 422	AF 422/L			PZ 20.03	0.20 m - 0.40 m	56 : 1			
AF 423	AF 423/L			PZ 20.06	1.20 m - ∞	96 : 1			
AF 401	AF 401/L	250 - 2000 °C 482 - 3632 °F		PZ 20.01	0.40 m - ∞	150 : 1	0.75 % of temp. reading		
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	200 : 1			
AF 404	AF 404/L			PZ 20.05	0.20 m - ∞	32 : 1			

Compact two-colour pyrometer

A two-colour pyrometer detects the infrared radiation emitted from an object's surface at two separate wavelengths. The dual sandwich detector uses a two-element photo-diode to capture both radiation intensities simultaneously from the exact same spot.



The pyrometer produces temperature data based on the ratio of these two intensities.

The advantage of the two-colour or dual wavelength technique is that the pyrometer will still produce highly accurate temperature data, even at signal attentuation of up to 90%.

A two-colour or ratio pyrometer is far less sensitive to contaminants in the line of sight such as steam, dust or smoke than a standard single-colour pyrometer. The same holds true for other sources of visibility impairment such as dirt on the pyrometer lens or sediment and debris buildup within the sight tube.

When the signal is equally attenuated at both wavelengths, this will have no impact on the accuracy of the temperature reading.

The two-colour method enables the pyrometer to correct for measurement errors which would otherwise occur when a material's emissivity varies as a function of temperature or surface properties, or when the pyrometer is used at a production line which produces a variety of products having different emissivities.

Model		Technical data							
Target sighting		Temp. range	Wave-length	Lens system	Focus range	Distance ratio	Uncertainty	Re-peat-ability	Response time t_{98}
Through-the-lens	Laser spot light								
PZ 40 ...									
AF 420	AF 420/L	500 - 1400 °C 932 - 2552 °F	0.8/ 1.1 µm	PZ 20.08	0.30 m - ∞	55 : 1	1 % of temp. reading	2 K	≤ 100 ms at T ≥ 750 °C
AF 401	AF 401/L	700 - 1600 °C 1292 - 2912 °F		PZ 20.01	0.40 m - ∞	80 : 1			
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	75 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	120 : 1			
AF 410	AF 410/L			PZ 20.05	0.20 m - ∞	17 : 1			
AF 404	AF 404/L	900 - 2400 °C 1652 - 4352 °F		PZ 20.01	0.40 m - ∞	150 : 1			
AF 405	AF 405/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 406	AF 406/L			PZ 20.06	1.20 m - ∞	240 : 1			
AF 411	AF 411/L			PZ 20.05	0.20 m - ∞	35 : 1			
AF 407	AF 407/L	1000 - 3000 °C 1832 - 5432 °F		PZ 20.01	0.40 m - ∞	150 : 1			
AF 408	AF 408/L			PZ 20.03	0.20 m - 0.40 m	140 : 1			
AF 409	AF 409/L			PZ 20.06	1.20 m - ∞	240 : 1			
AF 412	AF 412/L			PZ 20.05	0.20 m - ∞	35 : 1			
PZ 50 ...									
AF 401	AF 401/L	500 - 1400 °C 932 - 2552 °F	0.95/ 1.55 µm	PZ 20.01	0.40 m - ∞	80 : 1	1 % of temp. reading	2 K	≤ 100 ms
AF 402	AF 402/L			PZ 20.03	0.20 m - 0.40 m	75 : 1			
AF 403	AF 403/L			PZ 20.06	1.20 m - ∞	120 : 1			
AF 404	AF 404/L			PZ 20.05	0.20 m - ∞	15 : 1			
PZ 60 ...									
AF 401	AF 401/L	300 - 800 °C 572 - 1472 °F	1.15/ 2.2 µm	PZ 20.08	0.30 m - ∞	45 : 1	1 % of temp. reading	2 K	≤ 100 ms at T ≥ 350 °C

Single-colour / two-colour fibre optics pyrometer

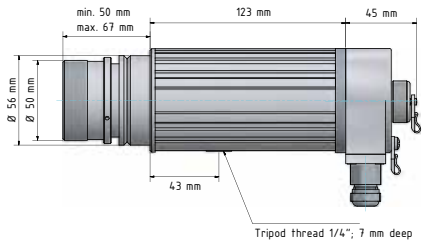
A pyrometer with fibre optics has the sensor head housed separately from the electronics assembly. A fibre optic cable transmits the detected infrared energy to the electronics. The optical sensor head can withstand ambient temperatures up to 250 °C without cooling. With a diameter of 30 mm, the measuring head can be installed in cramped conditions. Even at high electromagnetic fields, the fiber-optic pyrometers is used. The measuring heads are focusable.

To check the target sighting, the size of the measuring spot and focusing, the pyrometer features a built-in laser spot light. The optical fibre can be supplied at a length of up to 30 m, ensuring that the electronics can be installed at a safe distance. The fibre optic cable is equipped with a screw connector at each end to ease installation and detachment. Metallic armouring provides the optical fibre with a high degree of mechanical protection.

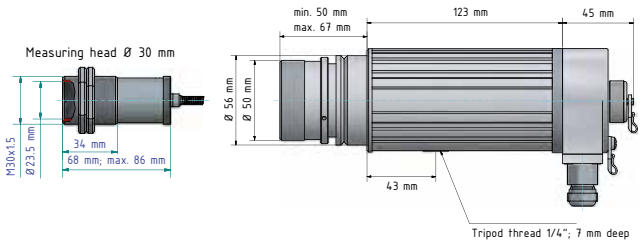
Model	Technical data								
Type	Temperature range	Wave-length	Lens system	Focus range	Distance ratio	Method	Uncertainty	Re-peat-ability	Response time t_{98}
PZ 21 ...									
AF 401	350 - 2000 °C 572 - 3632 °F	1.1 - 1.7 µm	PZ 41.31	0.15 m - ∞	80 : 1	single-colour	1 % of temp. reading	2 K	≤ 40 ms at T ≥ 1000 °C
PZ 31 ...									
AF 401	700 - 2500 °C 1292 - 4532 °F	0.8 - 1.1 µm	PZ 41.31	0.15 m - ∞	80 : 1	single-colour	1 % of temp. reading	2 K	≤ 40 ms at T ≥ 1200 °C
PZ 41 ...									
AF 401	900 - 2400 °C 1652 - 4352 °F	0.8 / 1.1 µm	PZ 41.31	0.15 m - ∞	80 : 1	two-colour	1.5 % of temp. reading	3 K	≤ 100 ms
AF 498			PZ 41.05	0.3 m - ∞	175 : 1				

Dimensions

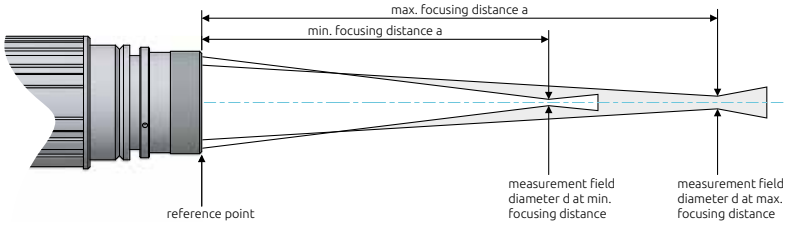
Compact pyrometer



Fibre optics pyrometer



Determination of the measurement field diameter



The measurement field diameter at the focus distance results from the formula:

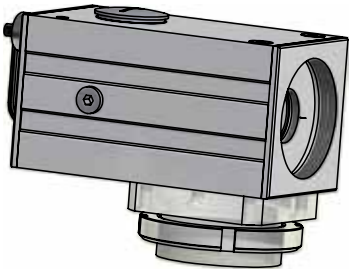
$$d = \frac{a}{D}$$

d: measurement field diameter at the focus distance
a: set focus distance
D: distance ratio

Special Accessories

Oscillating mirror PZ 20/X

An oscillating mirror can be mounted to the pyrometer. The measurement field is deflected to capture the target object.



With the PZ/20 X you can:

- Detect „hot spots“ at belt conveyors
- Capture swaying wires
- Generate temperature profiles of sheet metals and steel slabs
- Measure the temperature of objects at a roller table whose size and position are not constant

Illumination ring PZ 10/P

In dark furnaces, it is often impos-sible to see the target. Installing an auxiliary light source in a second porthole can be quite difficult and costly. Thus, in actual practice, pyrometers are often focused at the target only at the time of installation. Verification of correct focusing during running operations will not be possible.

The PZ 10/P illuminates the target spot in a closed furnace, utilizing the same furnace opening in which the pyrometer is installed. This built-in accessory is part of the pyrometer‘s mounting assembly.

The illumination ring helps you align and focus the pyrometer to the measurement field at the time of initial setup. What‘s more, this accessory lets you view the target area anytime later, such as during routine spot checks, and make adjustments if necessary.

Display unit DA 230

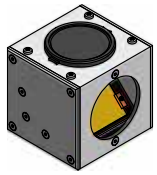
- Input: 0(4)–20 mA / 0(2)–10 V
  Thermocouples type K, S, J, T
  PT 100
- Analogue output: 0(4)–20 mA
- User-configurable ranges
- Panel mounting: 48 x 96 mm
- Supply voltage:
  115–230 V/50–60 Hz
- Source voltage: 24 V DC
- RS-485 interface
- Data communication in ASCII format

Controller URE 422

The URE 422 is an all-purpose PID controller for use with actuators and control elements.

- Input: 0(4)–20 mA /
  0(2)–10 V PT 100.
  Thermocouples K;S;J;T
- User-configurable ranges
- Output: 0(4)–20 mA
- 2 relay outputs
- Panel mounting: 96 x 96 mm
- Supply voltage:
  115–230 V/50–60 Hz
- Source voltage: 24 V DC (optional)
- RS-485 interface

Accessories

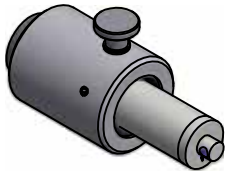


Mirror attachment
PA 20/E

Dust stop
PZ 20/T: Ø i = 20 mm
PZ 10/T: Ø i = 35 mm

Clamping collar
PZ 20/L: Ø 70 mm
PZ 20/N: Ø 65 mm

Pedestal mount
PB 08/K



Laser adapter
PZ 20/Q AF2

Air purge
PZ 20/A

Illumination ring
PZ 10/P

Adapter ring
PZ 20/E

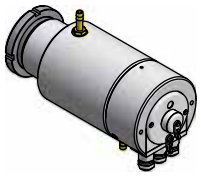
Polarising filter
PA 20/P

Ball flange
PB 08/I

Intermediate tube with
socket PZ 40/C

Intermediate tube
PZ 20/J

Intermediate tube
PZ 20/C

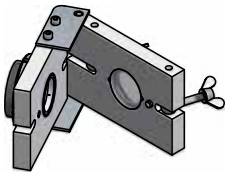


Cooling jacket
PZ 20/B AF8

Mounting flange
PZ 20/F

Window
ZnS: PA 10/I
Sapphire: PA 15/I
Quartz: PA 20/I

Quick connector with glass
ZnS: PA 10/C
Sapphire: PA 15/C
Quartz: PA 20/C



Quartz window with hinge
ZnS: PZ 10/I
CaF2: PZ 15/I
Quartz: PZ 20/I

Protective window
ZnS: PZ 10/I AF 1
Quartz: 70146

Supplementary lens
PZ 20/O-x

Typical assemblies

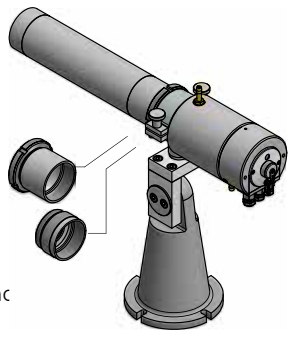
Mounting assembly PZ 20-097

consisting of:

- Pedestal mount PB 08/K AF2
- Hose nozzle G1/8“
- Cooling jacket PZ 20/B AF5
- Clamping collar PZ 20/L AF2
- Intermediate tube PZ 20/C
- Dust stop PZ 20/T
- Air purge PZ 20/A

optional

- Intermediate tube PZ 20/J at telephc
- Quartz window PA 20/I



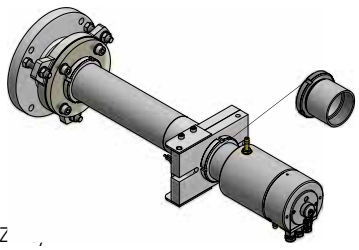
Mounting assembly PZ 20-096

consisting of:

- Cooling jacket PZ 20/B AF 5
- Air purge PZ 20/A
- Intermediate tube PZ 20/C
- Ball flange PB 08/I
- Dust stop PZ 20/S
- Mounting flange PZ 20/F
- Quartz window with hinge PZ

optional

- Intermediate tube PZ 20/J at telephoto optics



KELLER
infrared temperature solutions ITS

No 1 in terms of ACCURACY RELIABILITY INNOVATION

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