CARBON DIOXIDE INFRARED SENSOR
Exd CERTIFIED VERSION
TYPE MSH-CO2

PATENT NUMBER: GB 2372099B; US 6,753,967 B2

FEATURES

- ★ ATEX, IECEx and UL Exd Certified for hazardous area use.
- ★ High sensitivity to carbon dioxide, suitable for full scales up to 5% volume
- ★ Housing and internal optical paths constructed from stainless steel offering superior performance when compared to the earlier version CO2/TC sensor
- ★ Direct replacement for CO2/TC sensor
- ★ Optional, integral anti-condensation heater
- ★ Reduced baseline temperature dependency when compared to CO2/TC sensor
- ★ Excellent baseline repeatability after temperature cycling
- ★ Minimum device to device temperature dependency variation
- ★ Standard sensor size
- ★ Temperature compensated detector elements
- ★ Fast Response
- ★ Internal temperature sensor to allow accurate temperature compensation
- ★ Low power
- ★ Gas diffusion sampling

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DESCRIPTION

Dynament infrared sensors operate by using the NDIR principle to monitor the presence of target gas. The sensor contains a long life tungsten filament infrared light source, an optical cavity into which gas diffuses, a dual temperature compensated pyroelectric infrared detector and an integral thermistor to monitor the internal temperature. The infrared source should be driven externally with a constant voltage supply switched at a fixed frequency with a 50% duty cycle. The dual pyroelectric detector produces two output signals in response to pulsed incident radiation from the source:

- An active signal which decreases in the presence of target gas
- A reference signal which is used to monitor the intensity of the source

Both signals are composed of a DC offset voltage (typically 0.7V – 1.0V) with a small superimposed response signal alternating in sympathy with the source drive voltage. The alternating signal must be extracted and amplified to obtain a measure of the peak to peak value for both the active and reference. The ratio of active to reference peak to peak signals is essentially independent of variations in source intensity over time and this ratio reduces in the presence of target gas. It is the reduction in this ratio that is used to determine the target gas concentration. The reduction in ratio is non-linear and the gas concentration can be extracted using the expression:

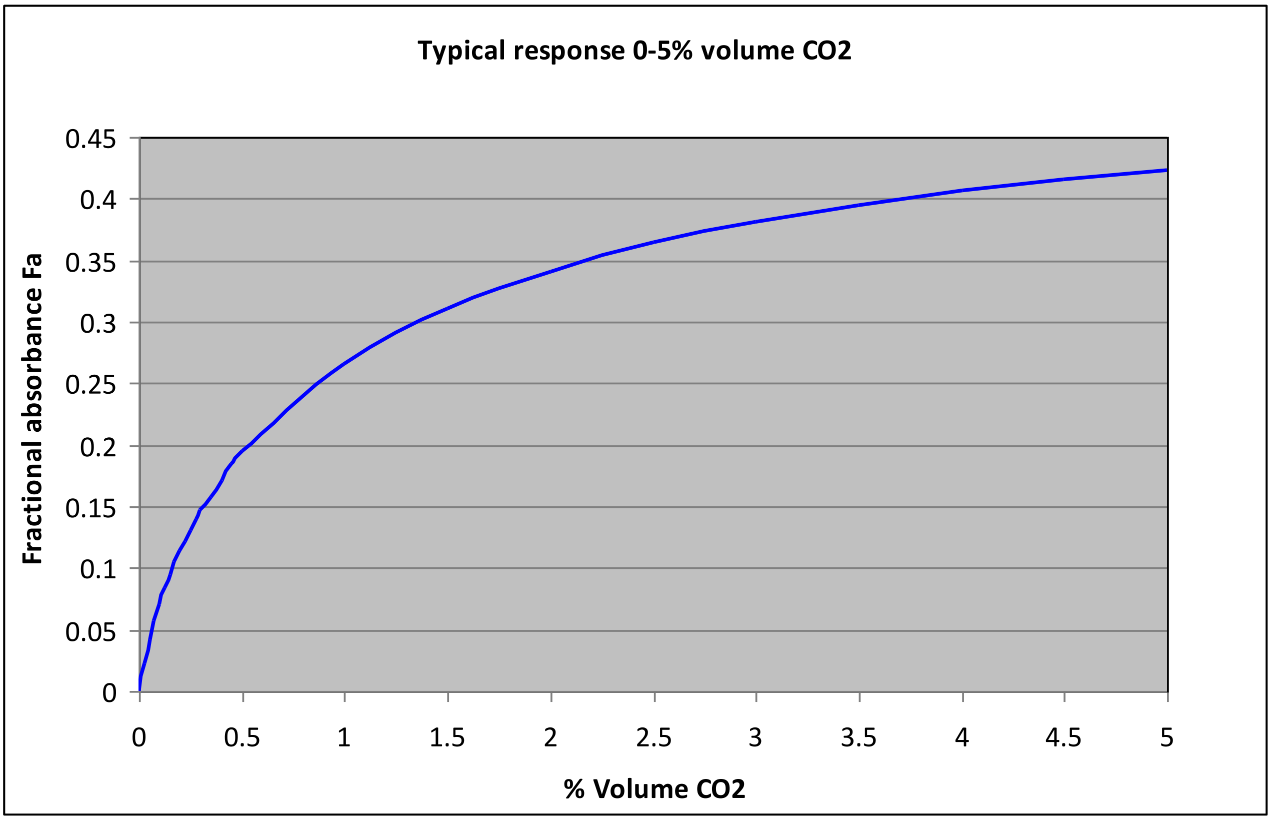
[concentration] = (-(ln (1 – (1 – Ratio/**zero**)/**span**)) / **a**) ^ (1/**b**)

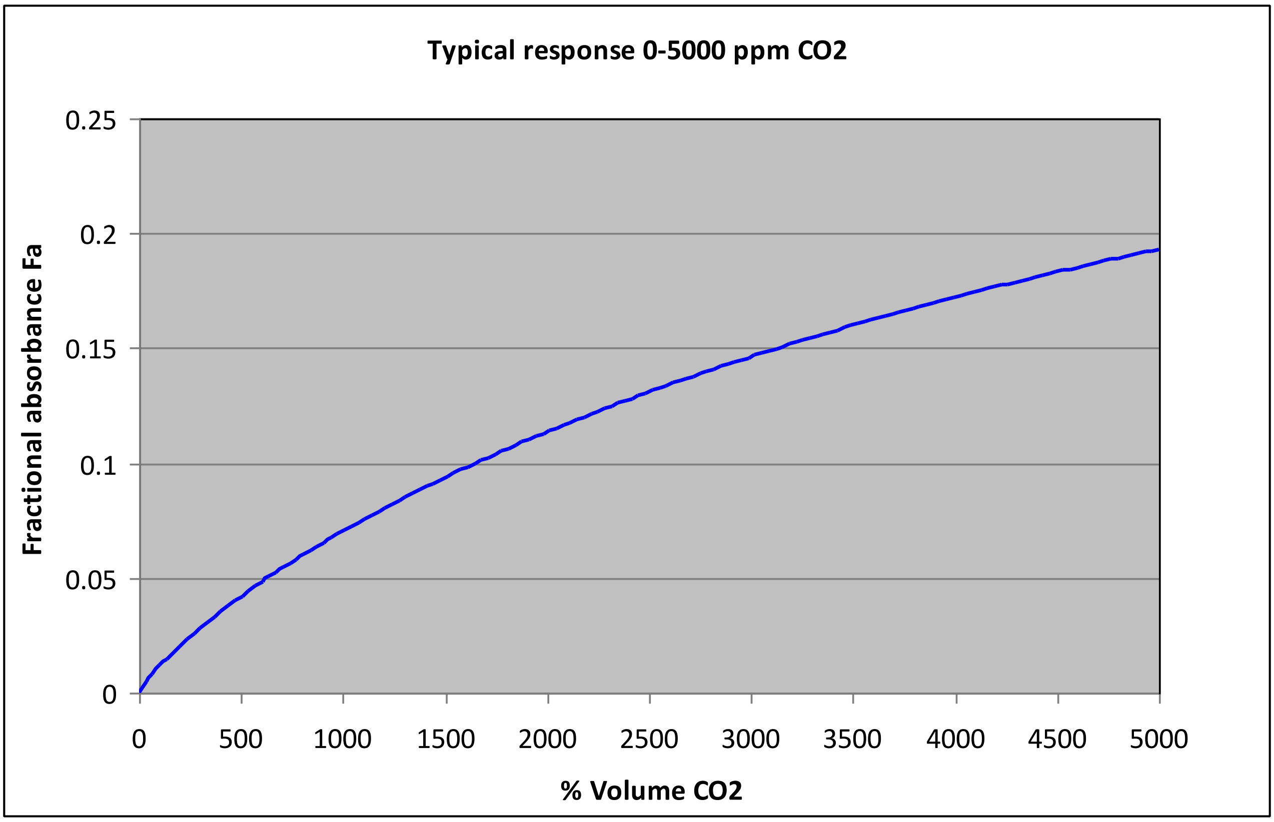
Where **zero** is the ratio in the absence of target gas, **span** is determined during calibration and

a = 0.000849, **b** = 0.826 and the typical **span** = 0.313 for a range of 0-5000ppm CO_2.
a = 0.911, **b** = 0.704 and the typical **span** = 0.446 for a range of 0-5% volume CO_2.

The internal temperature signal is used to measure the temperature inside the sensor. This temperature measurement is used to correct for the ideal gas law and also to correct for any optical filter effects on zero and span as a function of temperature. The internal temperature is typically 8°C higher than ambient at 20°C due to the heat generated from the infrared source. This internal heating beneficially reduces the probability of water condensing within the optical cavity.

Further details on the sensor, interfacing circuitry and signal extraction can be found in the Dynament application notes, on the Dynament website or by contacting Dynament directly.





Note: The response curves show typical responses, there will be a variation from sensor to sensor.

TEMPERATURE COMPENSATION

Pyroelectric devices exhibit a certain degree of temperature dependency; this is largely due to the band pass filter characteristics. For this reason, it is necessary to apply temperature compensation to the values used to calculate the gas readings.

Temperature compensation can be applied to the **Zero factor** and to the **Span factor,** depending upon the sensor type. Typically hydrocarbon sensors require only **Zero factor** temperature compensation whereas carbon dioxide sensors require **Span factor** temperature compensation.

The closely matched temperature dependency of the HC/NC/M sensors make it possible to apply a single value of temperature compensation to the “Zero factor” thereby improving accuracy, and eliminating the need to apply individually calculated values for each sensor.

The following temperature compensation technique is provided as a guide, end-users may employ other procedures that are more appropriate to their specific applications.

Zero factor temperature compensation.

The way in which the zero-factor temperature compensation is used to correct the reading is as follows:

Zero factor = Zero factor X (1.0 + (Temperature offset X Zero Temperature Compensation value))

Where Temperature offset = Current temperature – Zero temperature

Span factor temperature compensation.

The way in which the span factor temperature compensation is used to correct the reading is as follows:

Span factor = Span factor X (1.0 + (Temperature offset X Span Temperature Compensation value))

Where Temperature offset = Current temperature – Span temperature

The reading is now calculated using the formula provided in Application Note AN0003.

An approximation to the Ideal Gas law is then applied to the reading as follows:

Reading = Reading without correction X Temperature offset

Where Temperature offset = (Current temperature + 273.15) / (Span temperature + 273.15)

Summarising:

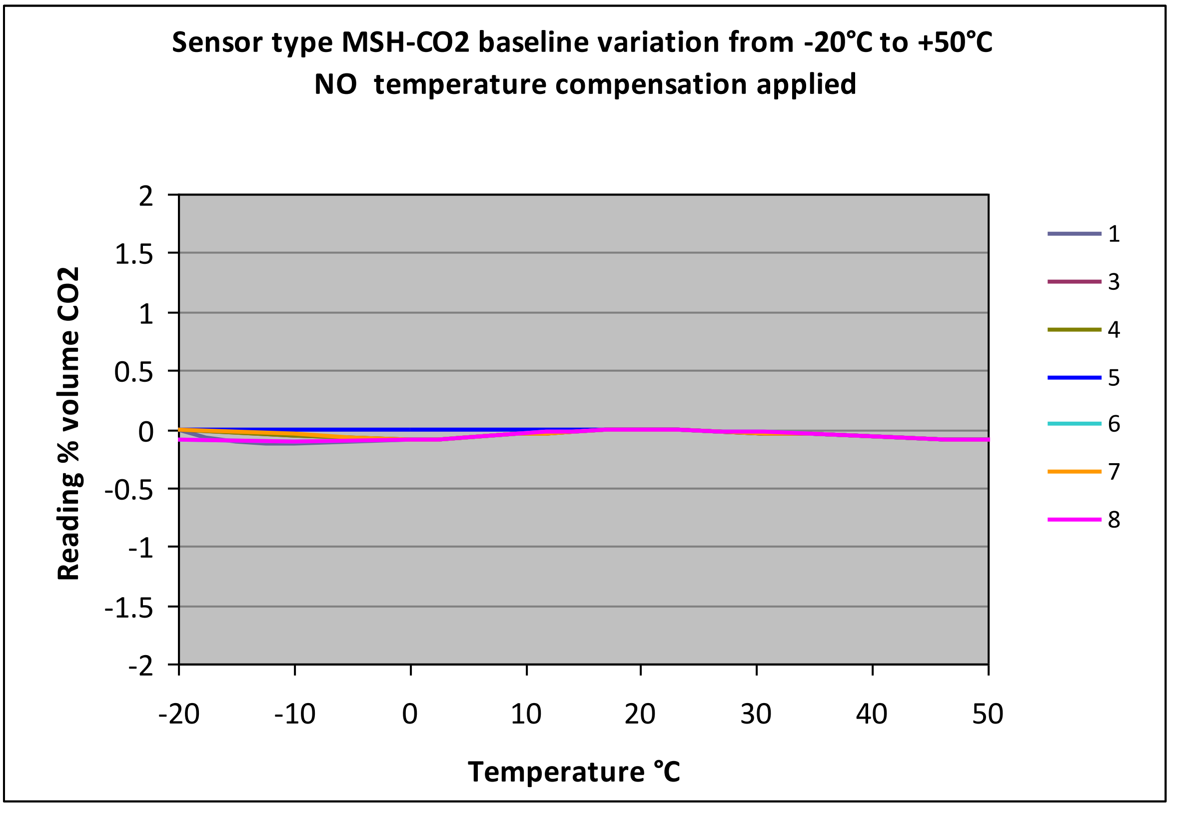
1) The **Zero factor** is corrected for temperature.

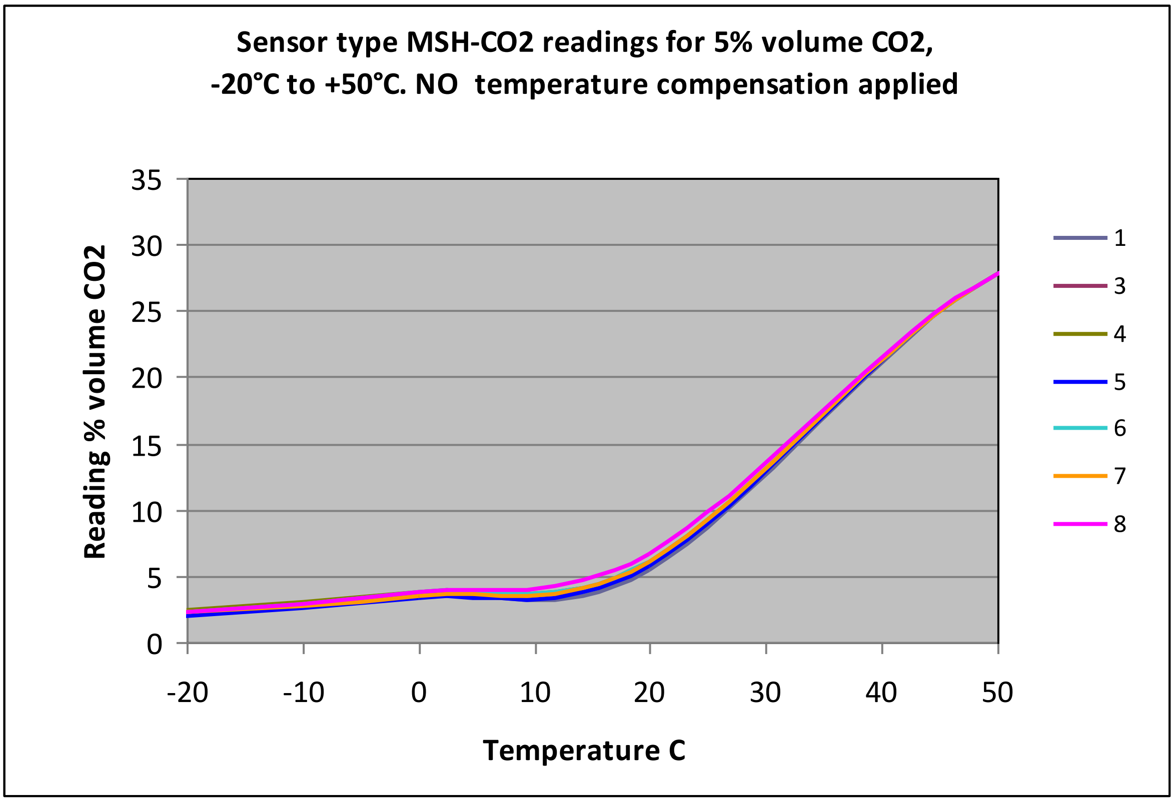
2) The **Span factor** is corrected for temperature.

3) The reading is calculated.

4) The reading is adjusted using the ideal gas law.

The following graphs show the outputs of eight sensors in nitrogen, and in 5% volume CO2 with no temperature compensation applied.





The non-linear nature of the span temperature dependency needs to be taken into account when applying temperature compensation. Whilst the variation from sensor to sensor is very small, multiple-point temperature compensations are required in order to achieve accurate results across the full operating temperature range.

It should be noted that the temperature performance displayed above represents the combined temperature behaviour of both the sensor and the associated electronic circuitry. It is recommended that manufacturers perform their own temperature tests to validate the performance of their equipment over the required operating temperature range.

OPTIONAL ANTI-CONDENSATION HEATER

Under certain operating conditions it is possible for condensation to take place on the optical paths of the sensor. This will cause temporary inaccuracies in the sensor outputs. Condensation can ocur when the gas sample is high in humidity, and at a higher temperature than the internal optical surfaces of the sensor. In order to prevent condensation the optical surfaces need to be a few degrees celsius above the temperature of the gas sample. The addition of a heating resistor embedded within the epoxy encapsulation of the sensor raises the sensor’s working temperature, in free air, by approximately 8ºC above ambient temperature. Without the heating resistor the sensor’s working temperature is 4ºC above ambient temperature.

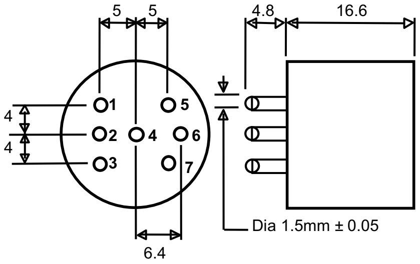
The heating resistor is fitted across the lamp supply and has a value of 120 ohms. With a 5V lamp supply voltage the resistor will dissipate 0.21W and draw an additional 42 mA from the supply.

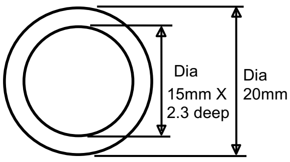
For applications where the additional lamp current cannot be delivered by the drive circuit, an alternative arrangement is available with the heating resistor fitted across the supply to the pyroelectric device. Refer to the “Example of Ordering Codes” for further information on how to specify the heating options.

SPECIFICATION

Maximum lamp Power Requirements:	5V d.c. 60mA max. (50% duty cycle source drive)
Minimum operating voltage:	3.0V d.c. (50% duty cycle source drive)
Source drive frequency:	2.0Hz minimum, 3.0 Hz typical, 4.0 Hz maximum
Active mV pk-pk output in N_2:	5.2mV typical @ 3Hz, 50% duty cycle
Reference mV pk-pk output in N_2:	4.0mV typical @ 3Hz, 50% duty cycle
Sensitivity (reduction in active signal) at 20°C, 3Hz, 50% duty cycle:	14% typical @ 5000ppm CO_2 30% typical @ 2.0% volume CO_2
Measuring range:	0 -1000ppm up to 0 - 5% volume CO_2
Resolution:	1% of measuring range
Warm up time:	To final zero ± 100ppm : <20s @20°C (68°F) ambient To specification: < 30 minutes @20°C (68°F) ambient
Response Time T_{90}:	<30s @20°C (68°F) ambient
Zero Repeatability:	± 50ppm @20°C (68°F) ambient
Span Repeatability:	± 50ppm @20°C (68°F) ambient
Long term zero drift:	± 50ppm per month @20°C (68°F) ambient
Operating temperature range:	-20°C to +50°C (-4°F to 122°F)
Storage temperature range:	-20°C to +50°C (-4°F to 122°F)
Humidity range:	0 to 95% RH non-condensing.
MTBF:	> 5 years
Temperature signal:	Integral thermistor for temperature monitoring
Weight:	17 grams

MECHANICAL DETAIL





NOTES

1. TOLERANCE +/- 0.15 UNLESS OTHERWISE STATED
2. RECOMMENDED PCB SOCKET: WEARNES CAMBION LTD CODE: 450-3326-01-06-00
3. WEIGHT: 15g
4. USE ANTI-STATIC PRECAUTIONS WHEN HANDLING
5. DO NOT CUT PINS
6. DO NOT SOLDER DIRECTLY TO PINS
7. THE LABELLING ADDS UP TO 0.2 TO THE OUTER DIAMETER AND UP TO 0.2 TO THE OVERALL HEIGHT

PIN OUT

1. LAMP RETURN
2. LAMP +5V
3. +5V PYRO SUPPLY
4. DETECTOR OUTPUT
5. REFERENCE OUTPUT
6. THERMISTOR OUTPUT
7. 0V PYRO SUPPLY AND CASE CONNECTION

EXAMPLE OF ORDER CODES

Available sensor options:

L XXX = Heater on lamp supply, plus value in ohms

P XXX= Heater on pyroelectric supply, plus value in ohms

P = Removable 45 micron plastic insert dust filter

F = Replaceable, self adhesive, microporous PTFE filter

I = Case isolated from 0V pin

MSH- CO2 / L XXX / F / I

OPTIONS

ISOLATION — BLANK = STANDARD; I = ISOLATED CASE

FILTER — BLANK = OMITTED; F = FITTED

L = Heater on lamp supply, value XXX ohms
P = Heater on pyroelectric supply, value XXX ohms

GAS TYPE : CO2 = Carbon dioxide

CERTIFICATION DETAILS	
European ATEX Certification	**Sensor type MSH *** **
Approval body	**SIRA**
Certificate Number	**SIRA 04ATEX1357U**
Test Standards	**EN60079-0:2012+A11:2013, EN60079-1:2014, EN60079-11:2012, EN60079-26:2015**
Certification Codes	**I M2 Ex db I Mb II 2 G Ex db IIC Gb**
Input parameters	**0.8W max, 30V max. (See footnote)**
Operating temperature	**-20°C to +60°C (See footnote)**
International IECEx Certification	**Sensor type MSH *** **
Approval body	**SIRA**
Certificate Number	**IECEx SIR 05.0053U**
Test Standards	**IEC 60079-0:2011 IEC60079-1:2014 IEC 60079-11:2011 EN 60079-26:2014**
Certification Codes	**Ex db I and/or Ex db IIC**
Input parameters	**0.8W max, 30V max.**
Operating temperature	**-20°C to +60°C (See footnote)**
North American Certification	**Sensor type MSH *** **
Approval body	**Underwriters Laboratory Inc.**
File Reference	**E336365**
Test Standards	**UL 60079 – 0, 4th Edition UL 60079 - 1, 6th Edition CAN/CSA-C22.2 No. 60079-0-1-7 CAN/CSA-C22.2 No. 60079-1 part 1, 1st Edition**
Hazardous Locations	**Class 1, Zone 1, AEx d IIC and Ex d IIC Hazardous Locations**
Input/Entity parameters	**0.8W max, 30V max.**

Input parameters are defined for certification purposes only, refer to the "Specification" table for the sensor operating voltage and temperature range.

Warranty information

All Dynament Standard sensors carry a two-year warranty against defects in materials and workmanship. The warranty is invalidated if the sensors are used under conditions other than those specified in this data sheet.

Attention should be paid to the following criteria:

- **Observe the correct supply polarity**
- **Do not exceed the maximum rated lamp supply voltage of 5V**
- **Do not solder directly to the sensor pins**
- **Do not expose the sensor to corrosive gases such as hydrogen sulphide**
- **Do not allow dust or liquids to enter the sensor**
- **Do not exceed the operating temperature range**