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User Manual

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Crank Monitor with Crank Elimination Function

Part of Mechanical Kiln Monitoring System (MKM2)

1 INTRODUCTION

Fig. 1.0.1 Crank Monitor Controller

The Crank Monitor is part of the new **MKM2** and is used to measure and warn about cranks in the kiln. It also can be used as controller for the patented **Crank Elimination System** which can neutralize cranks by selective shell cooling.

A crank is a deviation in the straightness of the kiln shell, which causes cyclic changes of the support load in the piers. Rotary kilns with more than two piers can be affected. Cranks can cause extreme overload and major damage. They are the main cause for cracks in tires, breakages of roller shafts and sinking foundation. Often, cranks are caused by uneven temperature around the circumference of the kiln shell. These thermal cranks occur temporarily, depending on coating formation and refractory thickness inside the kiln. Nevertheless, a crank can also remain. These permanent cranks can come for example from plastic deformations in the kiln shell due to overheating (Hot Spots) or from losing the rotation in hot condition for a certain period.
The Crank Monitor is designed to be installed permanently. It measures the variation in the deflection of a roller shaft at the middle pier and calculates the crank.

Fig. 1.0.2 Crank Up

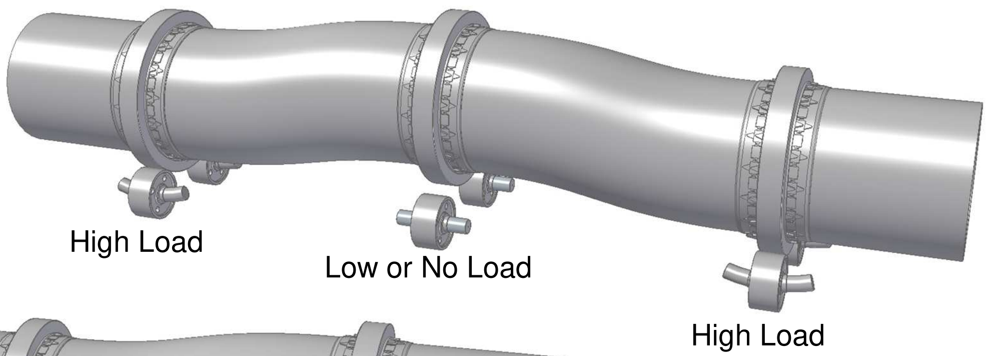
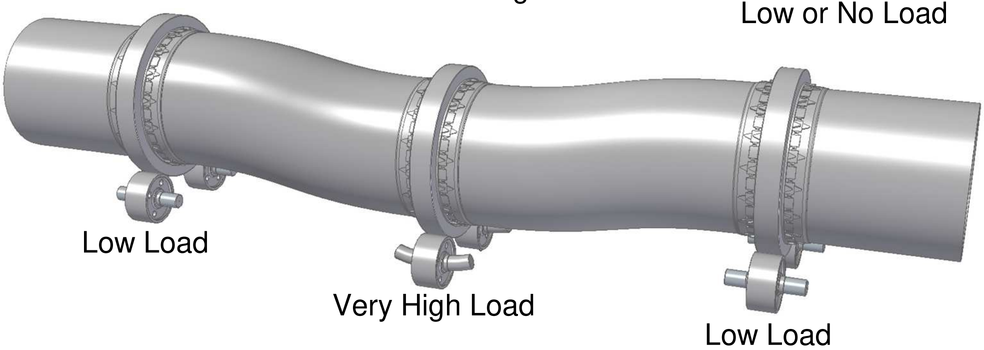


Fig. 1.0.3 Crank Down



2 SAFETY

Rotary kilns and dryers, where this system typically is used, are huge rotating equipment with many pinch points and hot surfaces which can cause serious injuries. Therefore, only specialized and trained personnel shall work close to these machines. For installation, follow strictly the local safety rules given by the respective plant / factory / local authorities and discuss the application with the safety engineer in charge.
The tools provided by TomTom-Tools GmbH have proven their functionality in various applications; nevertheless TomTom-Tools GmbH does not take any responsibility for the application on site regarding safety or machine damage. The plant is responsible for safety, according to the local law, in a way that nobody can be hurt or injured. The application and safety instructions below are guidelines and not exhausted which include the experience from previous installations. They might need to be adapted to the local circumstances and safety requirements.

Caution:

Pinch Points:
Do not put your hands nor any items close or into pinch points.
(e.g. girth gear / pinion, kiln tires / support rollers, …)
Keep safe distance to avoid getting caught by moving parts
(e.g. switch flags on kiln shell and tires)
Install the sensors only when the equipment is stopped. Place the Reference Sensor out of reach, out of normal access

Magnetic Fields:
The magnets attached to some of the components are strong.
Be aware of the strong magnetic fields.
Keep the tool away from people with pacemakers or any other sensitive item as credit cards or magnetic data carrier.

Hot Surfaces:
The kiln might be very hot, especially the shell of the kiln.
Do not touch it and keep a safe distance.

Fire:
Take care about the risk of fire during the installation of the sensors.
Special precautionary measures are required while performing hot work close to inflammable materials e.g. lubricants

Gloves:
Wear proper gloves to protect your hands from hot and rough surfaces and sharp edges.

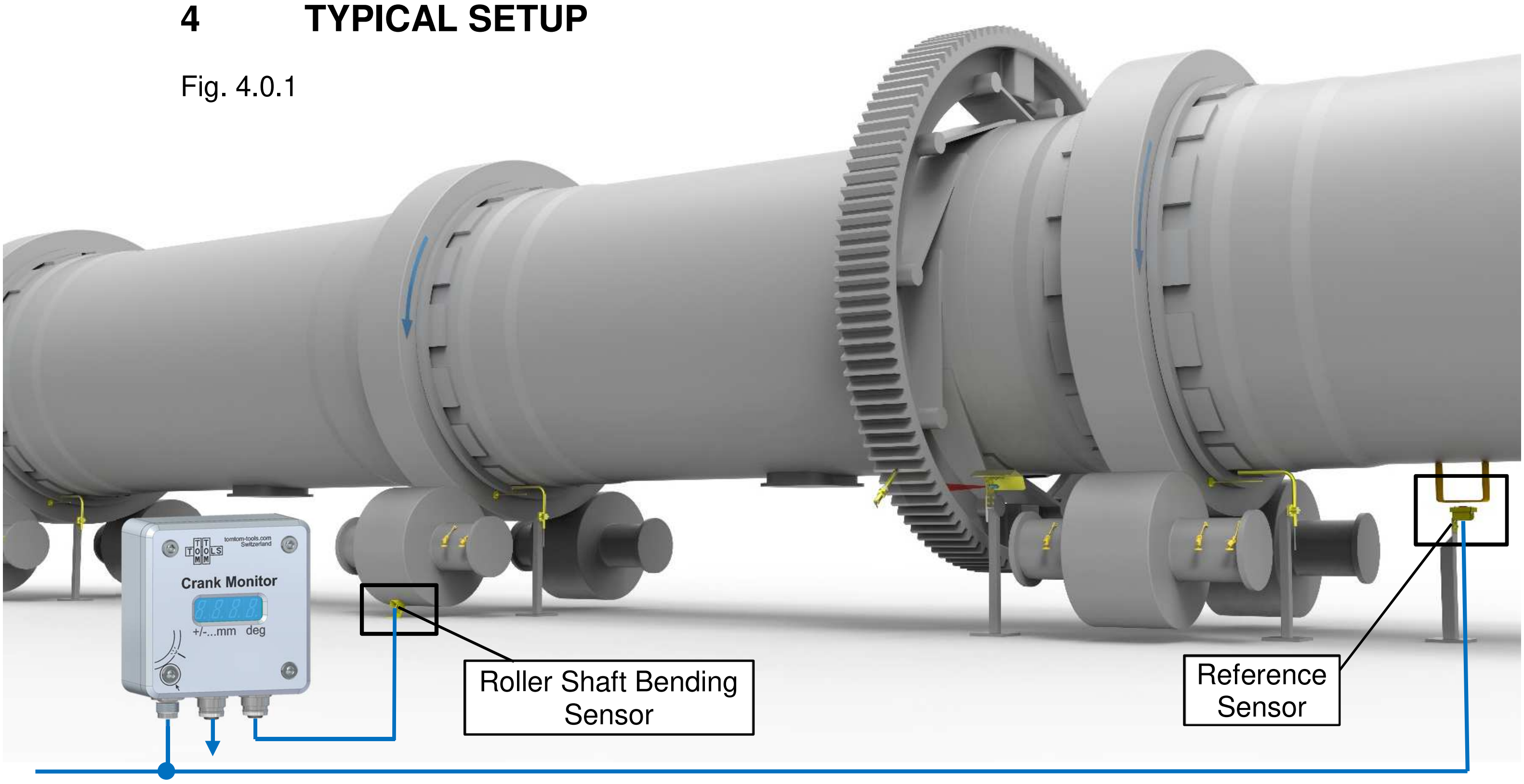
TABLE OF CONTENT

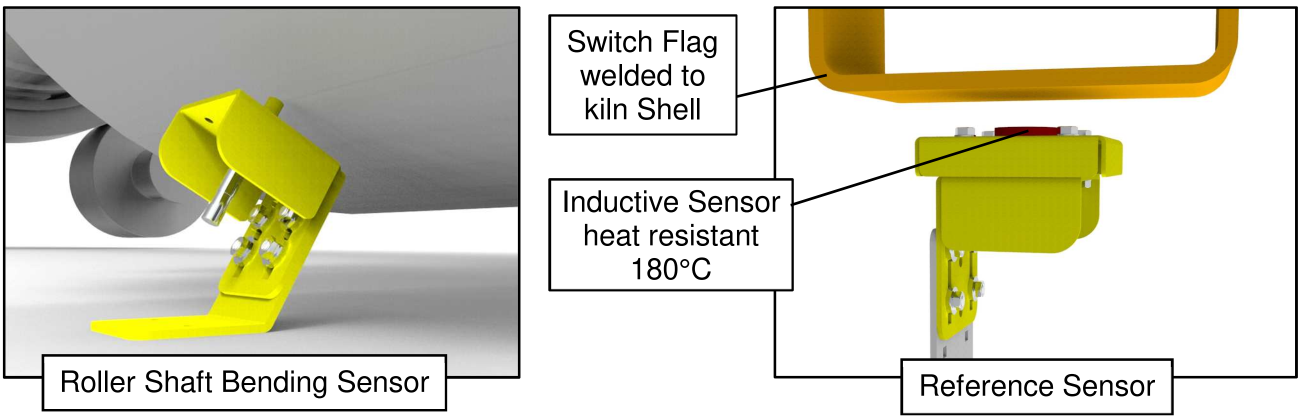
3 Features:

- Output 1: Amplitude value in mm, it indicates the severity of the crank
- Output 2: Phase angle, the location of the crank in circumferential direction
- Provides reliable results already with one continuous turn with the auxiliary drive
- Very stable results even on rollers with damaged surface
- Additional Crank Monitor Systems can be combined for kilns with 4 piers or more.
- Signal output to control the patented **Crank Elimination System**, which is using the effect of selectively cooling the kiln shell to neutralize cranks.

4 TYPICAL SETUP

Fig. 4.0.1





Roller Shaft Bending Signal:
On a kiln with 3 piers, one of the rollers of the middle pier must be equipped with a Roller Sensor. This inductive distance sensor is placed below the roller in the line of force, that means opposite the contact of the tire. On a kiln with 4 piers, two Crank Monitor Systems are needed for the two inner piers.
Note: kilns with more than 4 piers usually do not need more than 2 Crank Monitor Systems, because the typical area affected by cranks is within the 4 tires counted from the kiln outlet.

Reference Signal:
The kiln or dryer needs to be equipped with a sensor, which provides a pulse per turn, the “Shell Pace”. With this signal the controller knows the speed and the angular position of the shell. Only one Reference Sensor is needed per kiln. It can be used for additional Crank Monitor installations and for the Travel Monitor, which measures the axial position.

5 INSTALLATION

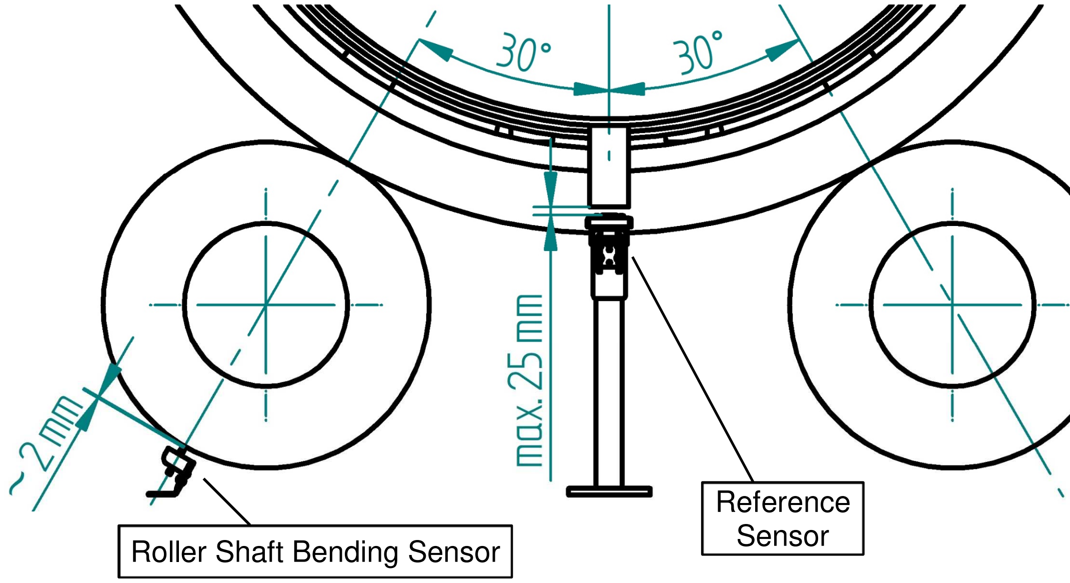
The installation and commissioning of the system is very easy and quick. All sensors come with readymade brackets and are connected via pre-assembled connection cables.
To be able to calculate the crank, two sensor signals are required. One provides the rotation signal from the kiln shell, the other measures the distance to the roller surface.

5.1 Roller Shaft Bending Sensor

This sensor is measuring by how much the support roller is pushed down cyclically during each kiln turn. The variations are small (<0.5mm), hence a small inductive sensor is used to measure. It provides an analog signal (0…20mA) depending on the distance to the roller surface.

a) If the kiln has 3 piers, install the Roller Shaft Bending Sensor at the middle pier. If the kiln has 4 piers or more, two Crank Monitor Systems and two Roller Sensors are required. They need to be placed on the 2nd and 3rd pier, counted from the kiln outlet.
b) The sensor must be placed under the roller in the line of force; that means opposite to the contact with the tire. Usually, it is at an angel of 30° (see sketch below)
c) Install the sensor in the middle of the roller width
d) Make sure, the sensor is stable and firm that it gets not moved accidently
e) Adjust the distance between sensor tip and roller surface to ~2mm, which is more or less in the middle of the sensor range of 0.5…4mm.

Fig. 5.1.1: Sensor Placing on Kiln



5.2 Switch Flag

Place the switch flag at the same angular position or even use the same switch flag as for the temperature scanner is used. (It should be the “A” if there is an “A, B, C” labeling on the kiln shell). By using the same reference, it will be easy to correlate the crank with the temperature profile and with other measurements (e.g. wobble of tires and girth gear, shell deformation and ovality readings) For safety reason, place the Reference Sensor where it cannot be reached accidently

5.3 Reference Sensor

The Reference Sensor is a heat resistant inductive sensor (up to 180°C). It is used to measure the speed and rotation position of the kiln. When the switch flag is passing in front of the sensor, it provides an electrical pulse to the Crank Monitor at each turn of the kiln (the shell pace).

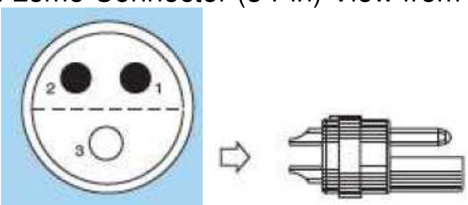
a) Look for a good location to place the sensor, before attaching the switch flag to the kiln shell. Make sure it is out of the way where regular access for maintenance is need.
b) Do not expose the Reference Sensor unnecessarily to high temperature. A good place for it might be between kiln inlet and the first tire.
c) Install a stable pole and attach the base plate by welding
d) Make sure the switch flag and the sensor are matching even when the kiln travels axially up or down and when the kiln changes its length due to thermal expansion.
e) Bolt the bracket to the base plate and install the sensor
f) Adjust the distance to the Switch Flag to be in the range of 10…25mm and make sure that the sensor will not touch the switch flag.
g) Connect the Reference Sensor with the heat resistant Teflon cable and the Lemo connector as shown in chapter 6.
Note: The cable can be extended with a standard M12 extension cord.

5.4 Pin Assignment

M12 Standard Pin	Standard Cables	Teflon Cable	Lemo Pin	Typical Usage
1	Brown	Brown	1	Power, +24VDC
2	White	White		Analog Signal
3	Blue	Green	3	GND
4	Black	Yellow	2	Signal
5 (optional)	Grey			various

Fig. 5.4.1: M12 Connector (A-Coded) View from Front Side

Fig. 5.4.2: Lemo Connector (3 Pin) View from cable side



5.5 Crank Monitor Controller

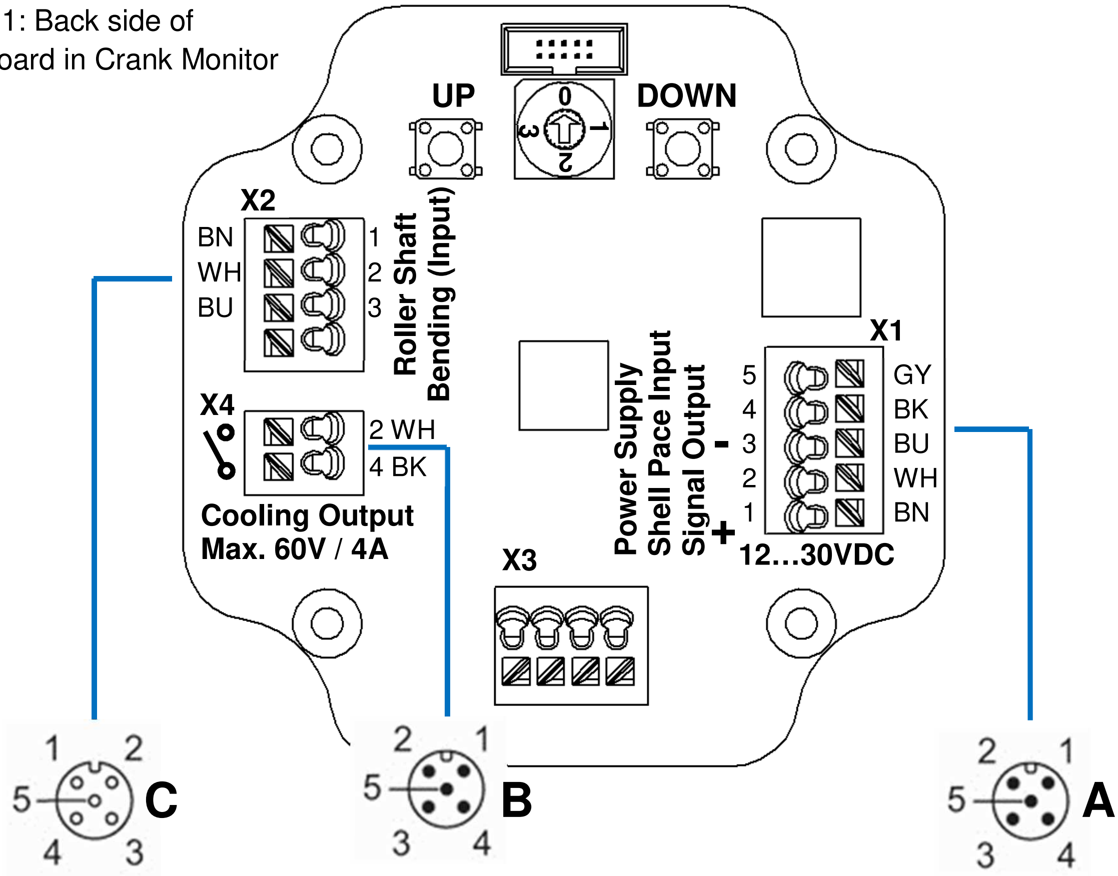
The controller is water and dust tight and made to be placed at the kiln piers. Nevertheless, make sure it is not exposed directly to the radiation from the kiln.
Install the heat shield if needed.
For quick installation the controller can be attached by strong magnets e.g. to one of the bearing housings, to the base frame or to a pole.
For bolting, use four M5 Allen bolts, going through the housing.
As an option, it is also possible to mount all the Crank, Creep and Travel Monitor controllers in one electrical cabinet together with the power source and the I/Os from the plant control system. The pier with the kiln drive might be a good place because there are often connections to the control system already available.

6 WIRING

The Crank Monitor is pre-wired from the terminal blocks on the circuit board to the M12 (A-coded) connectors on the housing.
The numbering and color coding is in Accordance with IEC 61076-2-101.

Pin No.	**1**	**2**	**3**	**4**	**5**
Color	Brown (BN)	White (WH)	Blue (BU)	Black (BK)	Grey (GY)
Connector A (X1)	Power Input 12…30VDC	Signal Output 4…20mA “Amplitude”	GND	Reference Signal Input “Shell Pace”	Signal Output 4…20mA “Phase Angle”
Connector B (X4)	n.c.	Shell Cooling Contact	n.c.	Shell Cooling Contact	n.c.
Connector C (X2)	Roller Sensor Power Supply	Roller Sensor Input 4…20mA	GND	n.c.	n.c.

Fig. 6.0.1: Back side of circuit board in Crank Monitor



6.1 Wiring with Junction Box

This type of wiring is used when more components of the MKM2 system are installed in combination with the Crank Monitor.
All the different parts of the MKM2 System (Crank Monitor, Creep Monitor and Travel Monitor) can be connected to the same junction box. Each controller is powered and supplied with the shell pace through an individual cable through which also the analog output signal is sent back to the junction box.

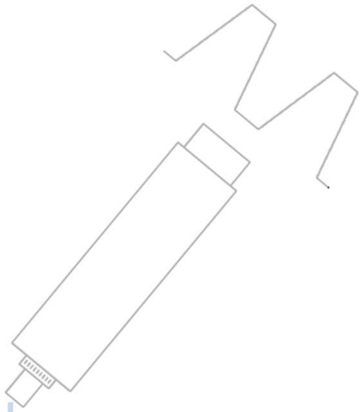


Fig. 6.1.1: Star Wiring (Option 1)

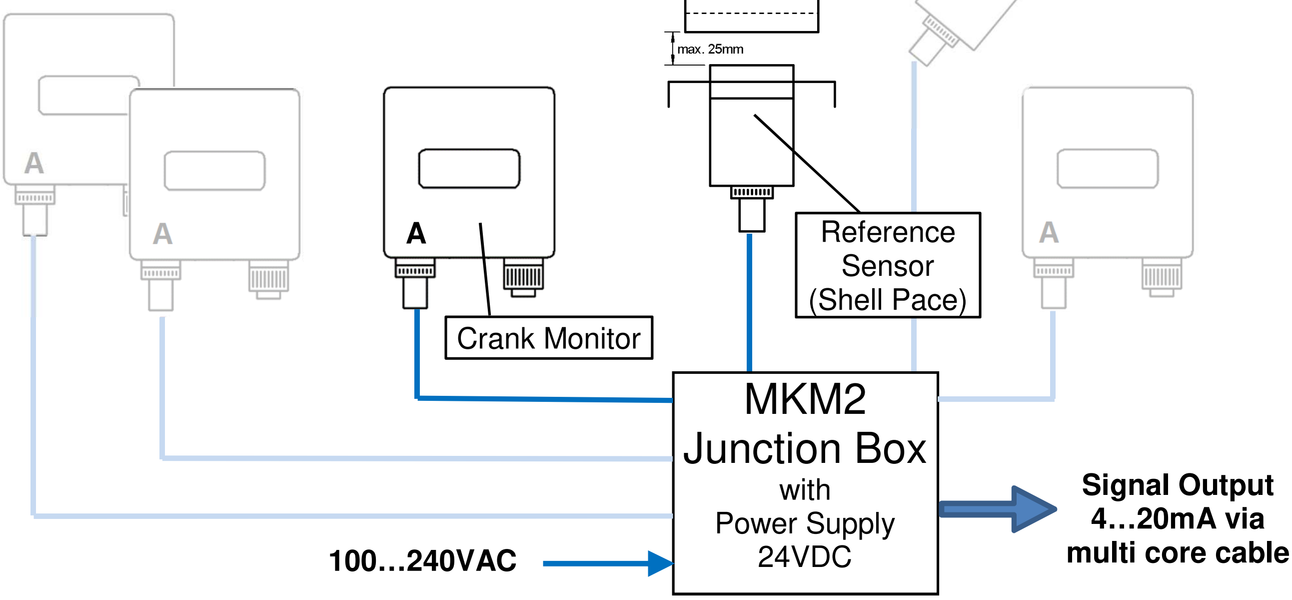
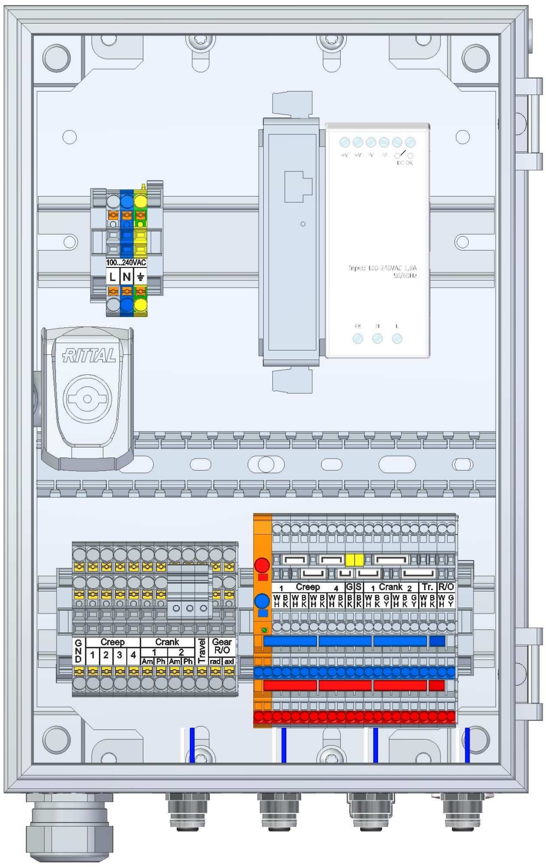


Fig. 6.1.2: MKM2 Junction Box (optional)
A pre-wired junction box with 24VDC power supply is available. It is compact, does not require much space and is equipped with M12 connectors, which make the installation very easy and quick.

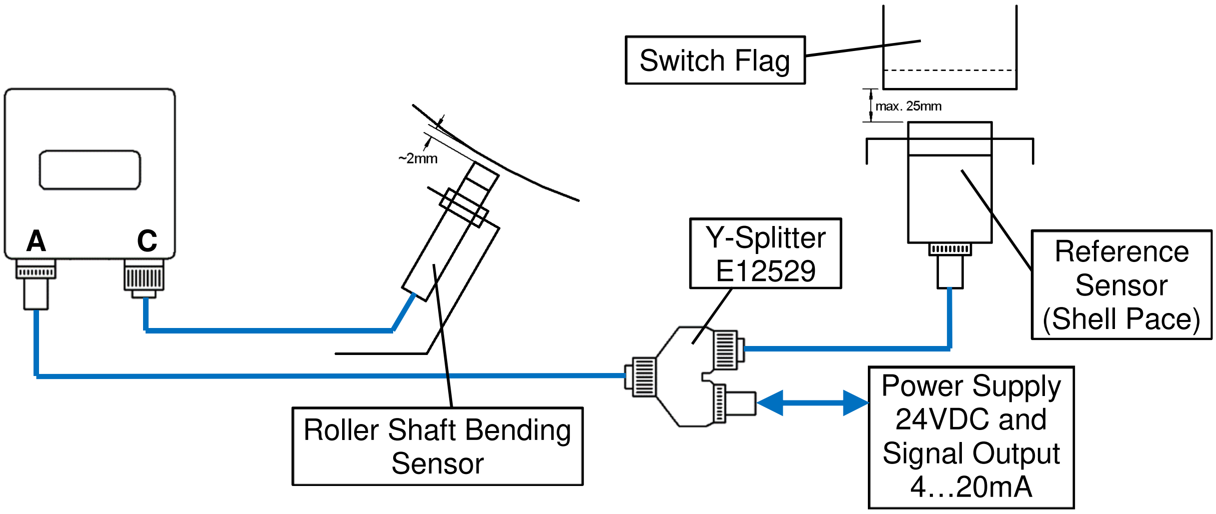
More details about the wiring can be found in Chapter 7.



6.2 Single Application

When only one Crank Monitor gets installed, it can be connected via simple wiring without the need of a junction box. A cable with 5 pins is sufficient to supply the power, the reference signal and to feed both output signals back to the control system of the plant.

Fig. 6.2.1: Power and Reference Signal Distribution



To feed the signal of the Reference Sensor to the controller, use the following Y-Splitter M12-A (with 5 pins): IFM E12529

Fig. 6.2.2: Y-Splitter

6.3 Power Supply

Only one single 24VDC (1A) power source is required for all Crank Monitor units on a kiln. By using the MKM2 Junction box, the 24V power supply converter is already included, hence 100…240VAC is required.
The power supply and also the connection to the control system of the plant is usually done at the pier with the kiln drive, because there are already connections to the plant control system available.

6.4 Reference Signal (Shell Pace)

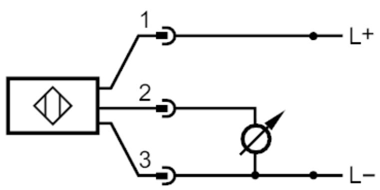
The rotation signal of the kiln, the Shell Pace, is provided by the Reference Sensor as shown in Fig. 6.1.1. or 6.2.1. The Shell Pace signal is fed to the different Crank or Travel controllers via pin 4 (black wire). They all are using the same reference signal, except the controllers from the Creep Monitor Systems, which use multiple pulses per kiln turn.

6.5 Roller Shaft Bending

The change of deflection in the roller shaft is measured by an inductive distance sensor. It provides an analog signal (4…20mA) on pin 2 (white wire) according to the distance to the roller surface. The Roller Sensor has to be connected to the controller via Connector C, as shown in Fig. 6.2.1.
The sensor IF6030 has a range of 0.4…4mm (4…20mA). Therefore, it should be installed with approximately 2mm distance from the roller surface to be in the middle of its range. If the sensor distance reaches the end of the range, the message “dist” will be displayed.

Note: The actual measured distance of the sensor is displayed when the rotary switch is in position 3 (see chapter 7.3)

Fig. 6.5.1: IF6030 Inductive analog sensor (M12x1) from IFM



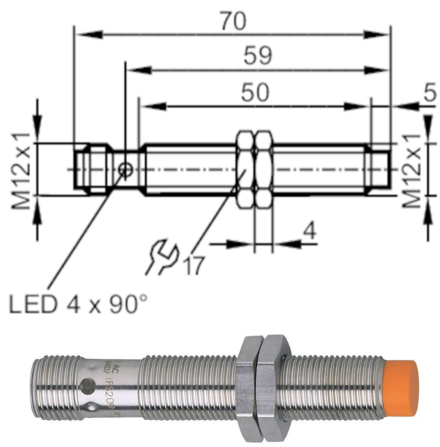
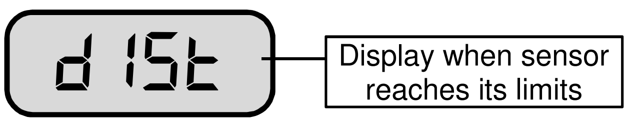


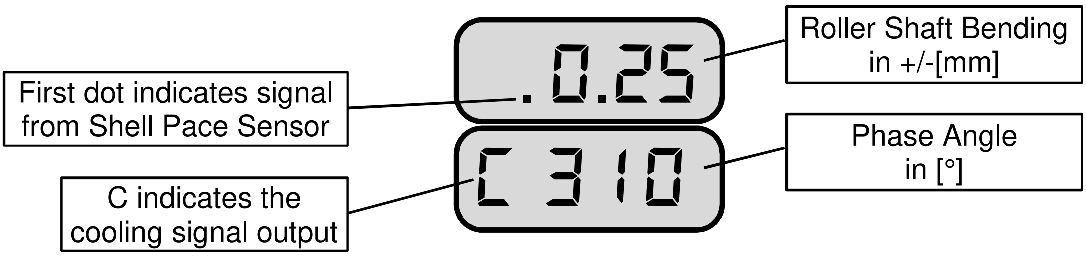
Fig. 6.5.2: Distance Warning



6.6 Signal Output

The controller is fitting a sine wave with the frequency of the kiln rotation into the signal of the Roller Sensor from where the amplitude and the phase angle is obtained. The two values are alternately displayed on the controller and provided as two separate 4…20mA signals.

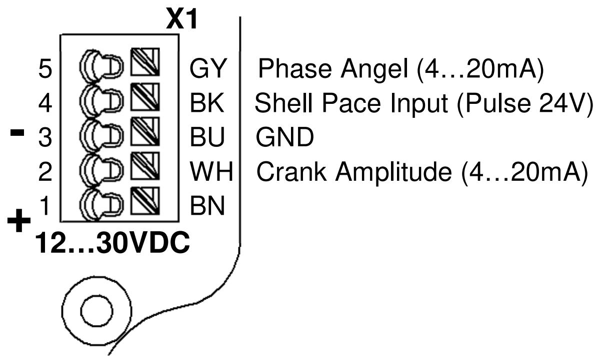
Fig. 6.6.1: Alternating Display



The output of the Crank Monitor is the roller shaft bending amplitude and the phase angle as two 4…20mA analog signals provided on the connector A coming from the terminal block X1.

Amplitude:	**Pin 2 (white):**	**4mA → +/-0.00mm**	**20mA → +/-0.48mm**
Phase Angle:	**Pin 5 (grey):**	**4mA → 0°**	**20mA → 360°**

Fig. 6.6.2: Terminal Block X1



The current loops are based on the common ground (GND) on Pin 3 (blue wire)

Note:
In case the crank cannot be calculated or if there is an issue with one of the sensors, the display will show - - - - and the analog output signals will be at the maximum of 20mA.

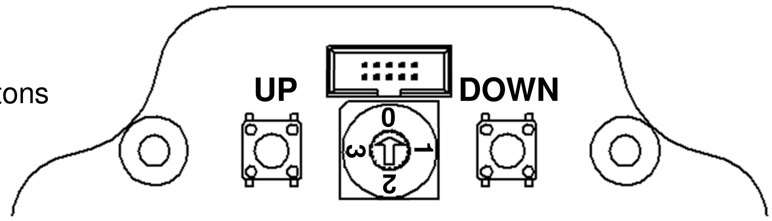
Usually applied limits for the amplitude value:

> ±0.2mm	**HH**	**Alarm**
> ±0.15mm…±0.2mm	**H**	**Warning**
0…±0.15mm		**Normal**

7 CONFIGURATION

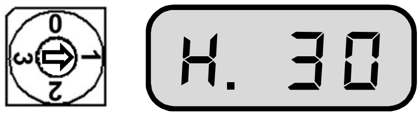
The Crank Monitor can easily be configured by using the rotary switch to select the parameter and the UP and DOWN button to change the values.

Fig. 7.0.1:
Configuration Switch and Buttons



Normal operation: rotary switch position "0"

7.1 Position of Roller Shaft Bending Sensor



Usually there is an angular offset between the Reference Sensor and the support roller that is equipped with the Shaft Bending Sensor. This offset (here 30°) has to be entered, that the Phase Angle is correctly calculated. To do so, turn the rotary switch to the position 1. The display will show the angle in [°]. To change the value, push the UP or DOWN button as required (possible range: 0 to 359°).

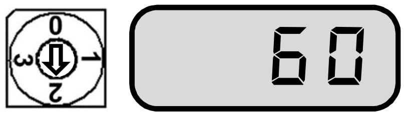
Examples:

If the switch flag is passing at the 6 o'clock position the Reference Sensor and reaches 30° later the support roller with the Shaft Bending Sensor, 30° have to be entered.
If the other roller is equipped with the sensor, the switch flag needs to move 330° until it reaches the roller, hence 330° have to be entered.

Note:

In this mode, the signal of the Reference Sensor is displayed as well. H: high, L: low

7.2 Position of Crank Elimination System (optional)



Enter the angular offset between the Reference Sensor and the water nozzles or fans of the Crank Elimination System (here 60°). It is done the same way as for the position of the Roller Sensor, described in chapter 7.1.

7.3 Cooling intensity (optional)

By default, the value is 0. But if the Crank Monitor is used to eliminate cranks, the cooling intensity can be selected. That defines at what amplitude how much of the area around the crank peak will be cooled to neutralize the crank.
Change the value by pushing the UP or DOWN button as required (possible range: 0 to 10).
If the intensity level is not 0, the cooling will start, when the amplitude reaches 0.15mm.
The cooling signal is provided by the terminal block X4 (Fig. 6.0.1). By default, it is wired to connector B as potential free contact, but it can be easily rewired to provide a 24V signal.

Note:

When the rotary switch is in position 3, the distance of the Roller Sensor is displayed as well (here 2.3mm).

8 CRANK ELIMINATION SYSTEM

8.1 The need for counteracting cranks

As already shown in the beginning, amplitudes of less than +/-0.15mm are typically not harmful and can be neglected. Cranks which cause variations in roller shaft bending of more than +/-0.2mm might damage the system in the long run, therefore countermeasures should be taken. The first approach should be to stabilize the clinker manufacturing process, to maintain a stable and uniform coating layer in the kiln. Typical reasons for changes in the coating, which cause cranks, are rapid changes in the fuel mix and in the raw material.
To understand how strongly the kiln is affected by cranks, the values from the Crank Monitor need to be trended for a few months or a year. If strong cranks are frequently present, despite all efforts on the process side, the Crank Elimination System will be needed. It will significantly prolong the lifetime of kiln tires and support roller shafts.

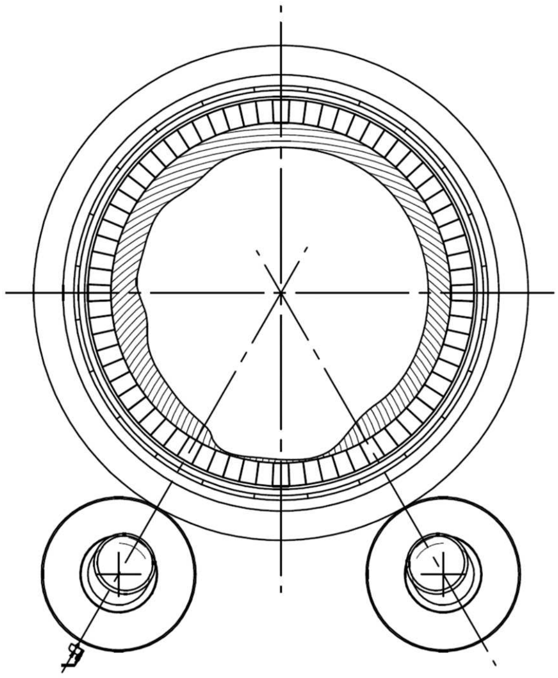


Fig.8.1.1 uneven coating inside the kiln

8.2 Working principle

The Crank Monitor also can be used to counteract cranks in a rotary kiln. This is achieved by controlled cooling of the kiln shell. The cooling is done typically by air but could also be done by water. In case of water, mist is sprayed with fine nozzles to the kiln shell. In case of using air, the cooling is done by fans / ventilators.
The patented feature of eliminating cranks is using the fact that the kiln shell temperature is elevated (typically between 200…400°C), when the kiln is in operation.
To counteract cranks, the kiln shell will be cooled in the crank peak, this is where the roller shaft bending is the highest. By cooling the crank area, this part of the kiln shell cools and contracts, which results in the reduction or even complete elimination of the crank. The intensity of cooling depends on the severity of the crank. It is managed by the controller of the Crank Monitor.
The shell is cooled over a larger or smaller portion of the circumference, whereas the center of the cooled area remains at the crank peak. For example: the cooling covers an area of the angle α of 20° before the crank peak and 20° after it. To increase the effect, the angle is automatically increased up to 90° before and after the crank peak, that would mean half of the kiln circumference will be cooled, if needed.
The highest impact is achieved by cooling the area near the middle tire. The cooling is done typically over a length L of about 1…1.5 times the kiln diameter on both sides of the middle tire.

8.3 Cooling Methods

As mentioned before, the kiln shell can be cooled by air fans or by water spray or by a combination of both.
Air cooling of kiln shells is typically done by ventilators, which blow ambient air towards the kiln shell. They are preferably installed below the kiln, somewhere in the area between the 4 o'clock and 8 o'clock position, in a row along the kiln axis.
Cooling the kiln shell with fans is less efficient than water but generates much less thermal stress in the shell. Therefore, cooling fans are the preferred option to eliminate cranks. The spray nozzles are also typically mounted below the kiln like the fans. But, as the spray system is not as much affected by the natural air draft of the heated air around the kiln, the nozzles can also be placed at any other area around the kiln, where it is convenient to install them.

Fig. 8.3.1: Cooling by Fans

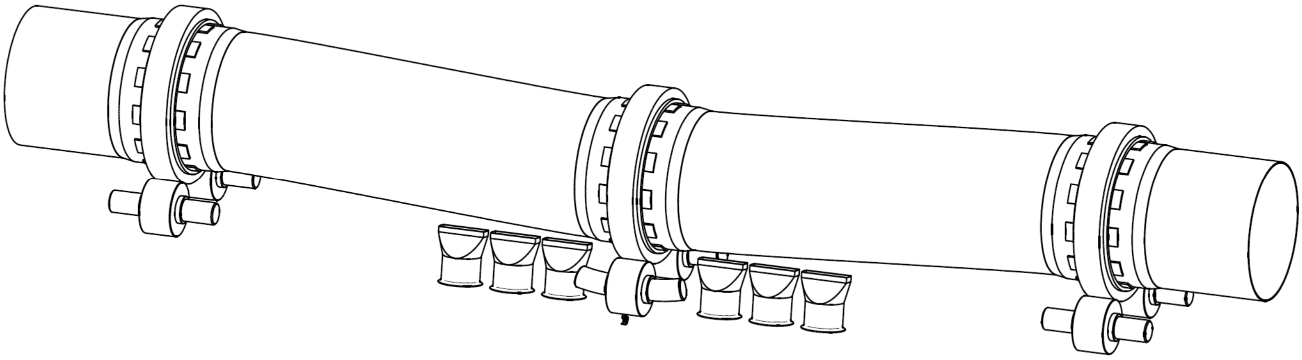
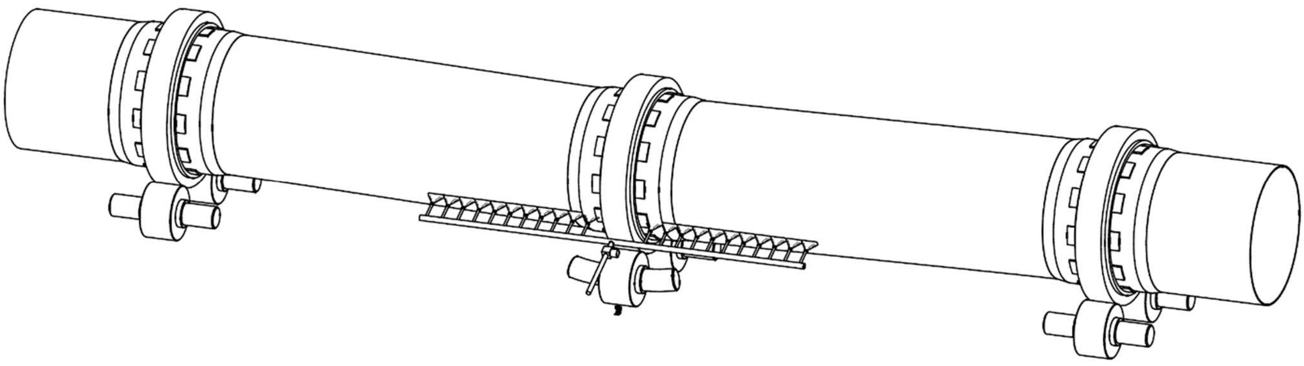


Fig. 8.3.1: Cooling by Water Spray



8.4 Cooling Control

To be able to counteract cranks, the air fans or water nozzles must be operated only during the time when the crank area is directed towards them. That means the fans or nozzles are switched on and off by the controller during each kiln revolution according to the roller shaft bending analysis described before.
In the preferred case, when all fans or nozzles are in one line along the kiln, the timing to switch them on and off is for all the same. In case the fans or nozzles are not installed in one line, the controller will activate them individually in a way that always the crank area is cooled.

Fig.8.4.1: Distance Sensor and Solenoid Valve connected to Controller / Crank peak and area to cool

[1]	Position of crank peak	[6]	Distance Sensor
[2]	Area to be cooled	[7]	Solenoid Water Valve
[3]	Cooling start line	[8]	Spray bar
[4]	Cooling stop line	[9]	Water feeding line
[5]	Controller		

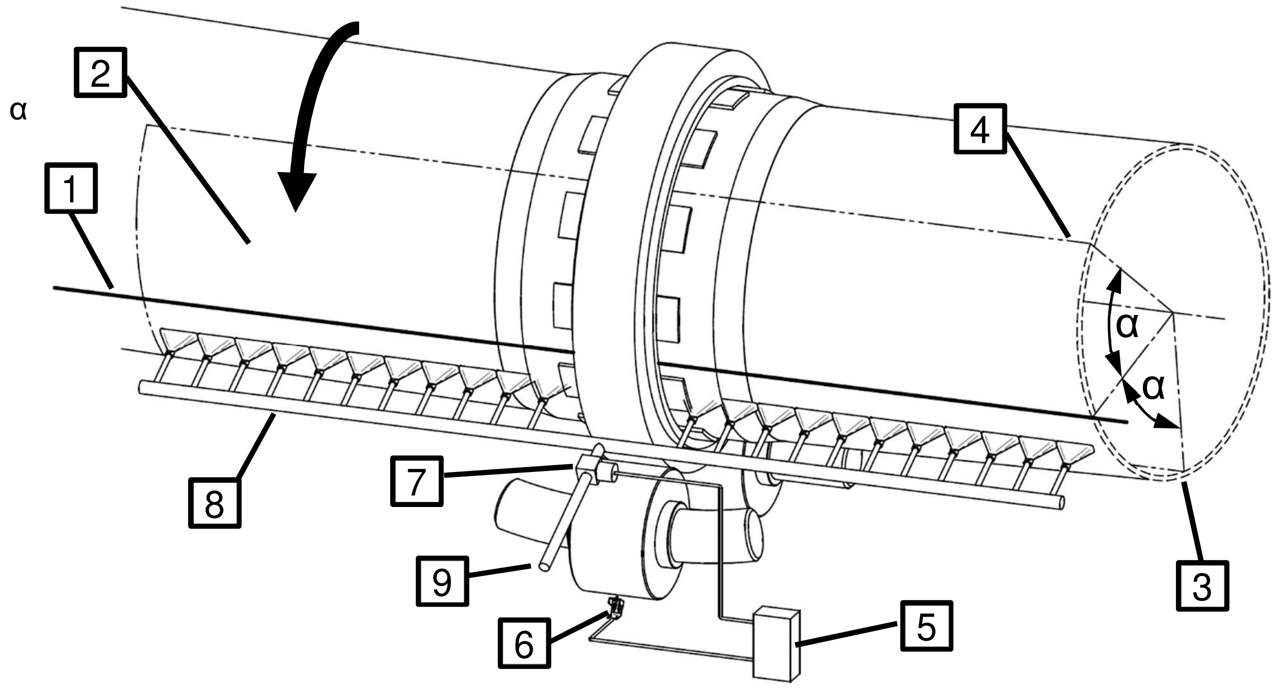
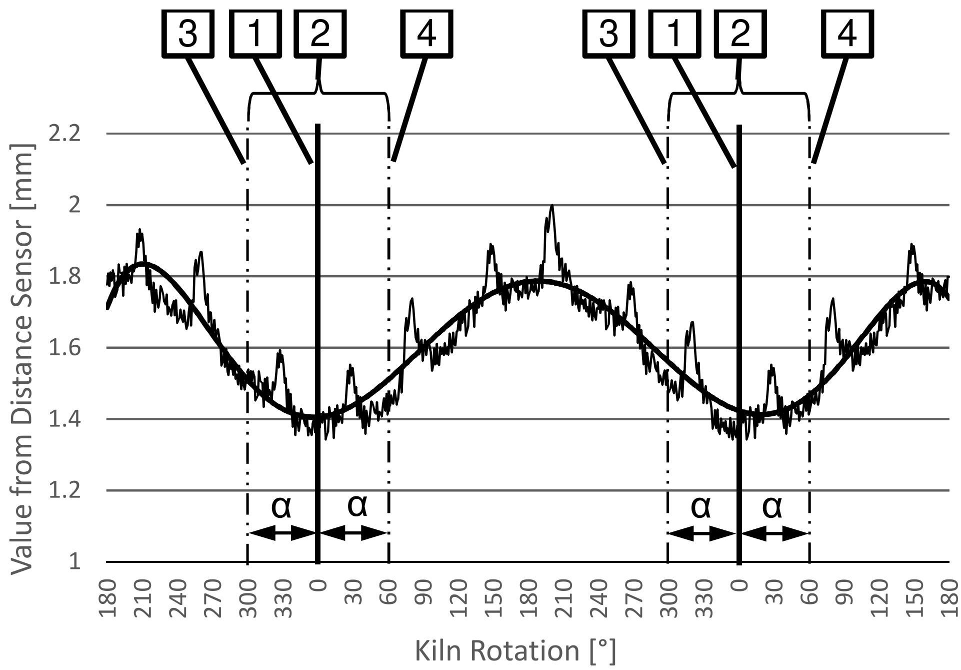


Fig.8.4.2: Analysis of the roller shaft bending values in the controller to locate the crank and to control the cooling



8.5 Kiln Shell Cooling Fans

The fans to counteract cranks must start and stop quickly, to provide air in the moment and the place where it is needed, especially on fast rotating kilns. Hence the fans must be at full speed within less than a second. Therefore, the motor power needs to be relatively high and the inertia of the rotor low. Axial fans in a round duct are used for this application with the following characteristics:

1. **Motor Power**
   The rated motor power must be 7.5kW or one size bigger even if the fan will not require that much power. A slightly oversized motor can better cope with the high number of starts and stops and the inertia of the rotor.

2. **Air Flow**
   An air flow of 25'000…30'000m3/h is expected from this size of fan. 3…4 fans are required at both sides of the middle tire, as shown in Fig. 8.3.1.

3. **Motor Speed**
   Use 3-phase asynchronous motors with 4 poles. They will run on ~1450rpm @50Hz, which keeps the noise within acceptable level. Fans with 2-pole motors and double speed would be too noisy.

4. **Silencer**
   To reduce the noise level, add silencer at the inlet and the outlet side of the fan.

5. **Diameter**
   The nominal diameter should be around 800mm. Larger diameters have the problem of too high rotor inertia; smaller diameter might not deliver sufficient air volume.

6. **Rotor Material**
   The rotor is preferably made of aluminum. It has the advantage of having low weight and low inertia, compared to steel rotors. Rotors made of plastic are possible too, but the heat resistance must be checked and be sufficient.

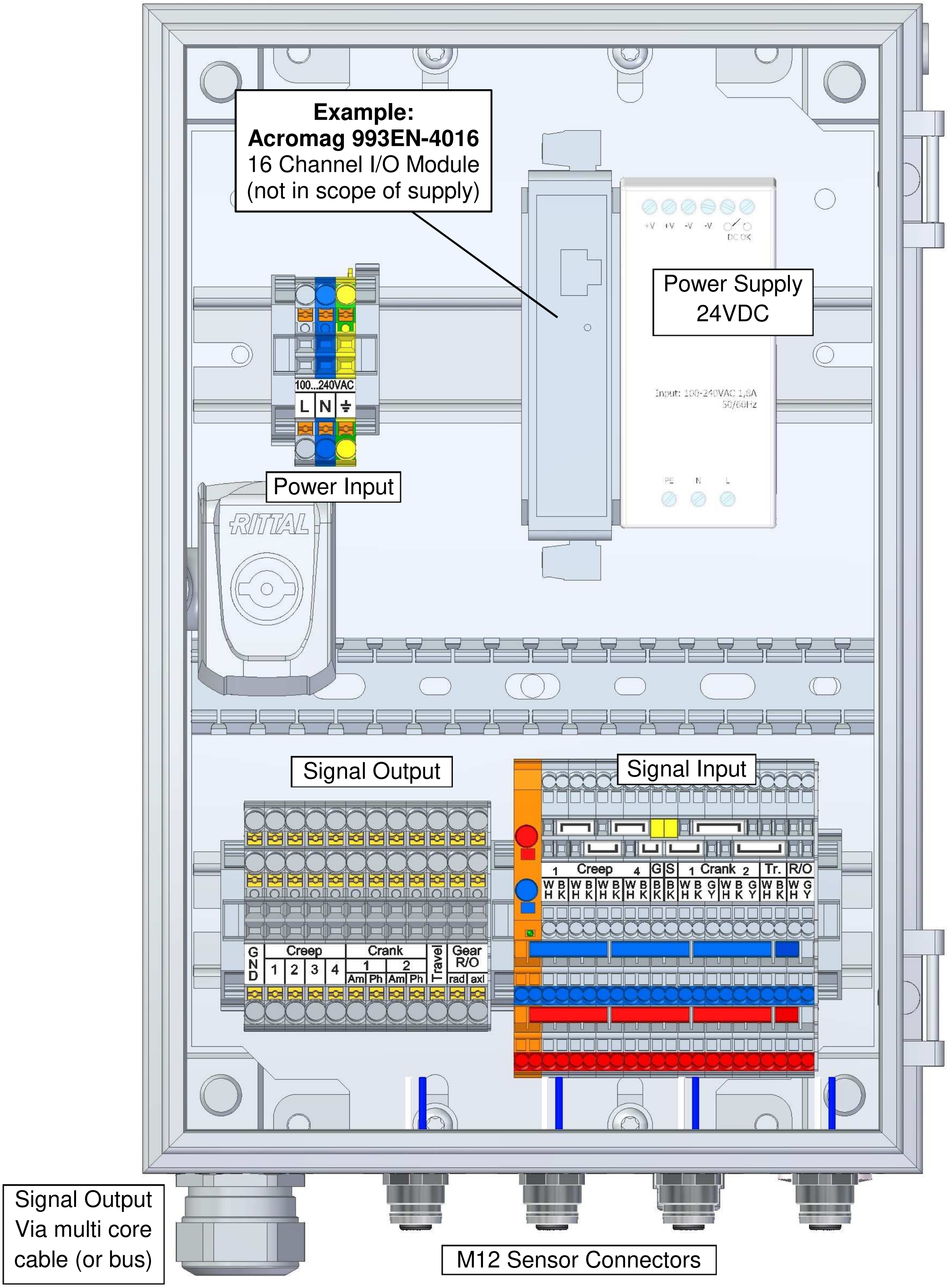
7. **Motor Switch**
   The fans must be switched on and off via Solid-State Relays. Mechanical relays are not suitable, because of the high number of switching. Each fan should be equipped with its own relay, which is controlled by the Crank Monitor (Terminal Block X4). To start fast, the motors are driven directly from the grid, without a Soft Starter and without a Wye-Delta starter. Therefore, the high start-up current needs to be considered when selecting the Solid-State Relay and designing the power supply and cables. The recommended rating of the 3-phase Solid-State Relay should be at least 100A per fan.

9 JUNCTION BOX

Dimensions:
200x300x155mm

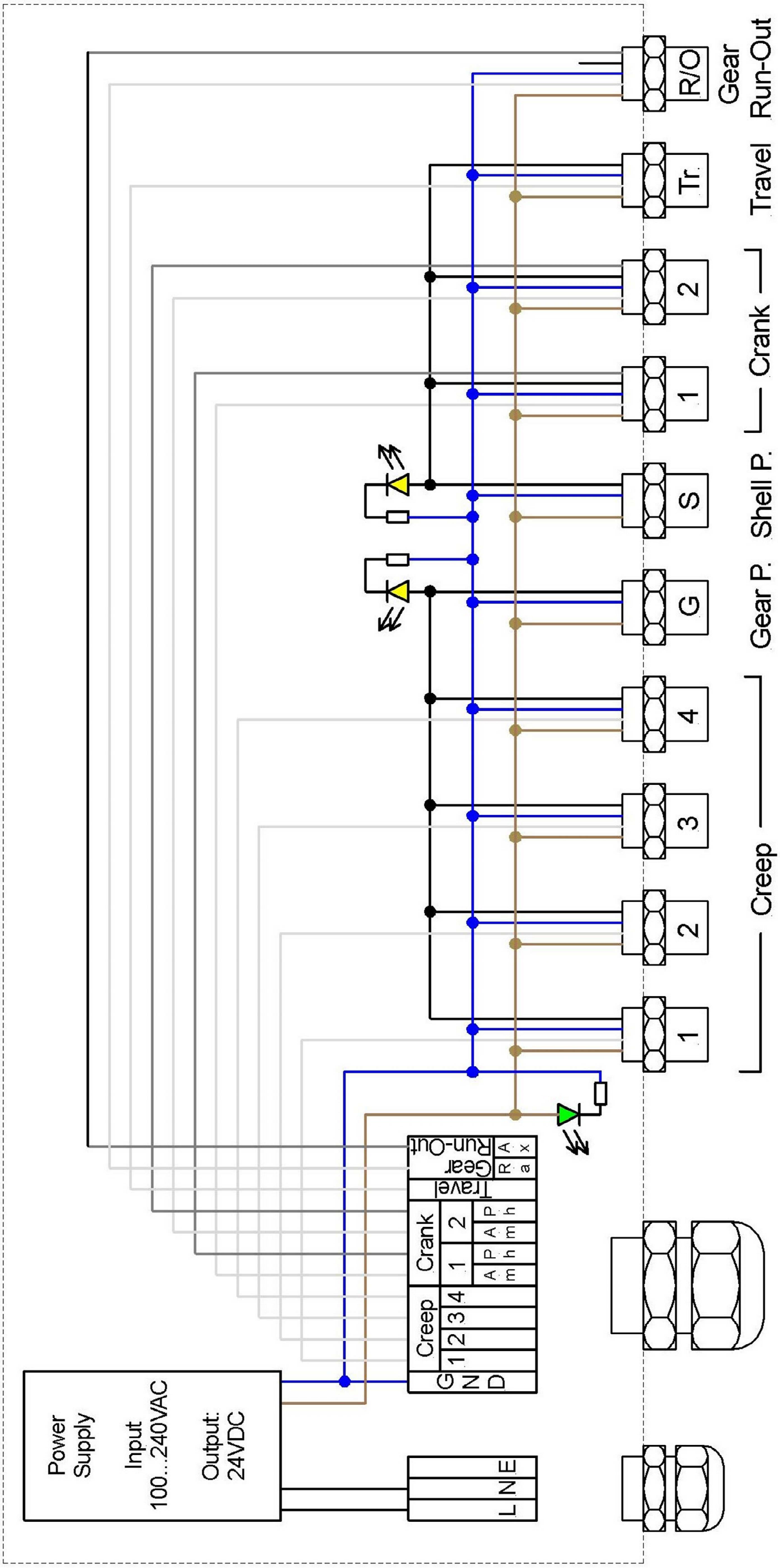
9.1 Layout

The following picture shows a fully equipped MKM2 Junction Box which is suitable to combine Crank Monitor, Creep Monitor, Travel Monitor and the Girth Gear Run-Out Monitor system. The box also offers space to add a serial protocol interface, e.g. Acromag 993EN-4016 or another I/O module.

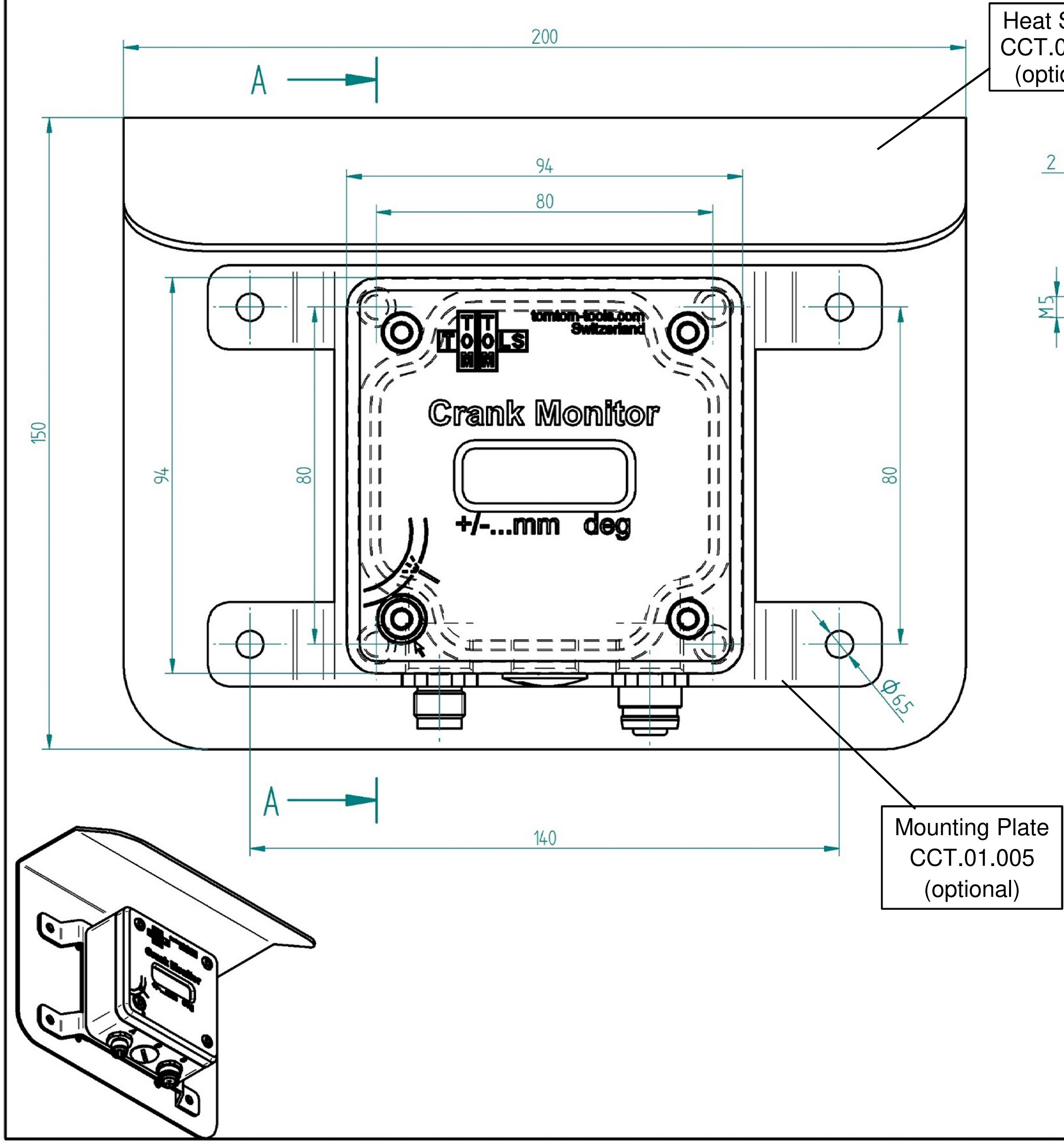


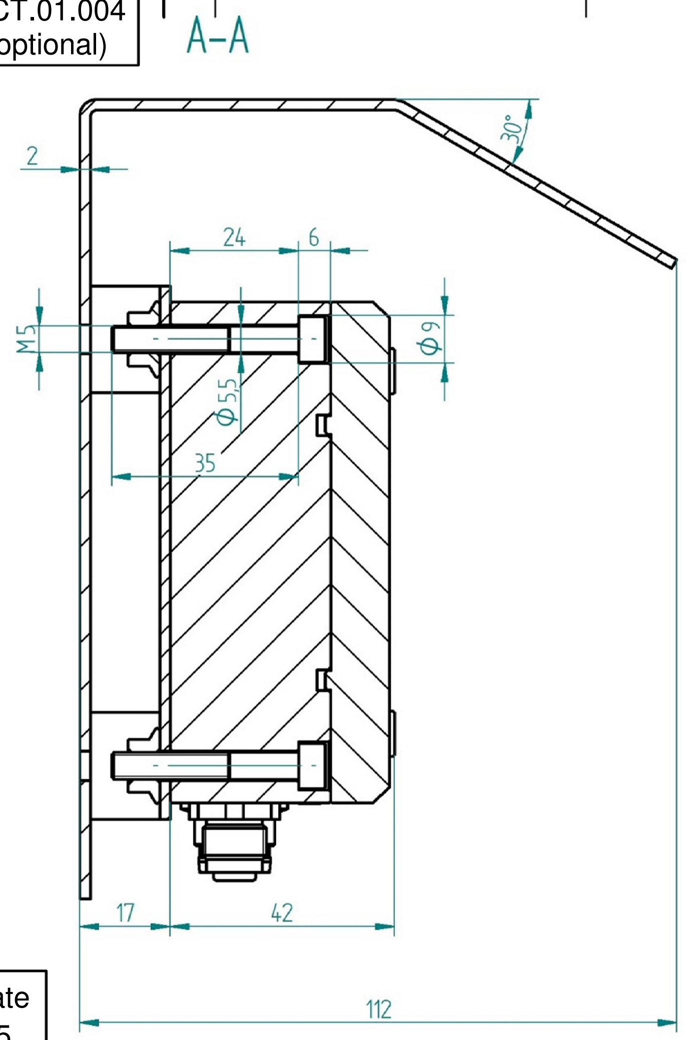
9.2 Schematic (typical configuration)

This configuration of the MKM2 Junction Box suits for Creep Monitor (4 Tires), Crank Monitor (2 Tires), Travel Monitor and Run-Out Monitor (Girth Gear).



REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED





	NAME	DATE
DRAWN	XYZ	05/22/20

TomTom-Tools GmbH
Zelgli 20
8905 Arni / Switzerland
www.tomtom-tools.com

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS ± 0.1 mm ANGLES ± 0.1°
TYPICAL EDGE CHAMFER 0.3x45°

Crank Monitor

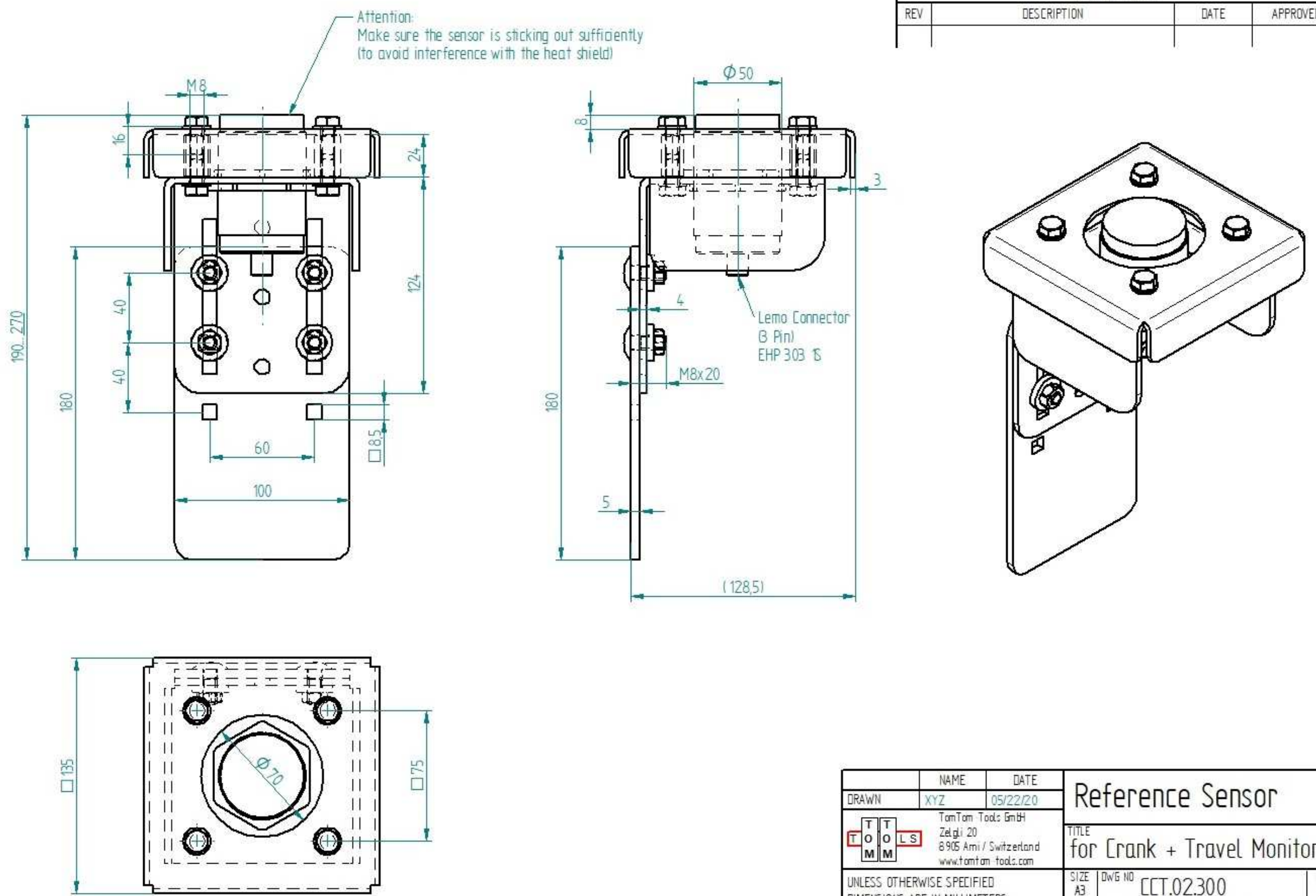
TITLE (Controller)

SIZE	DWG NO	REV
A3	CCT.02.000	

FILE NAME: CCT.02.000 Crank Monitor.dft

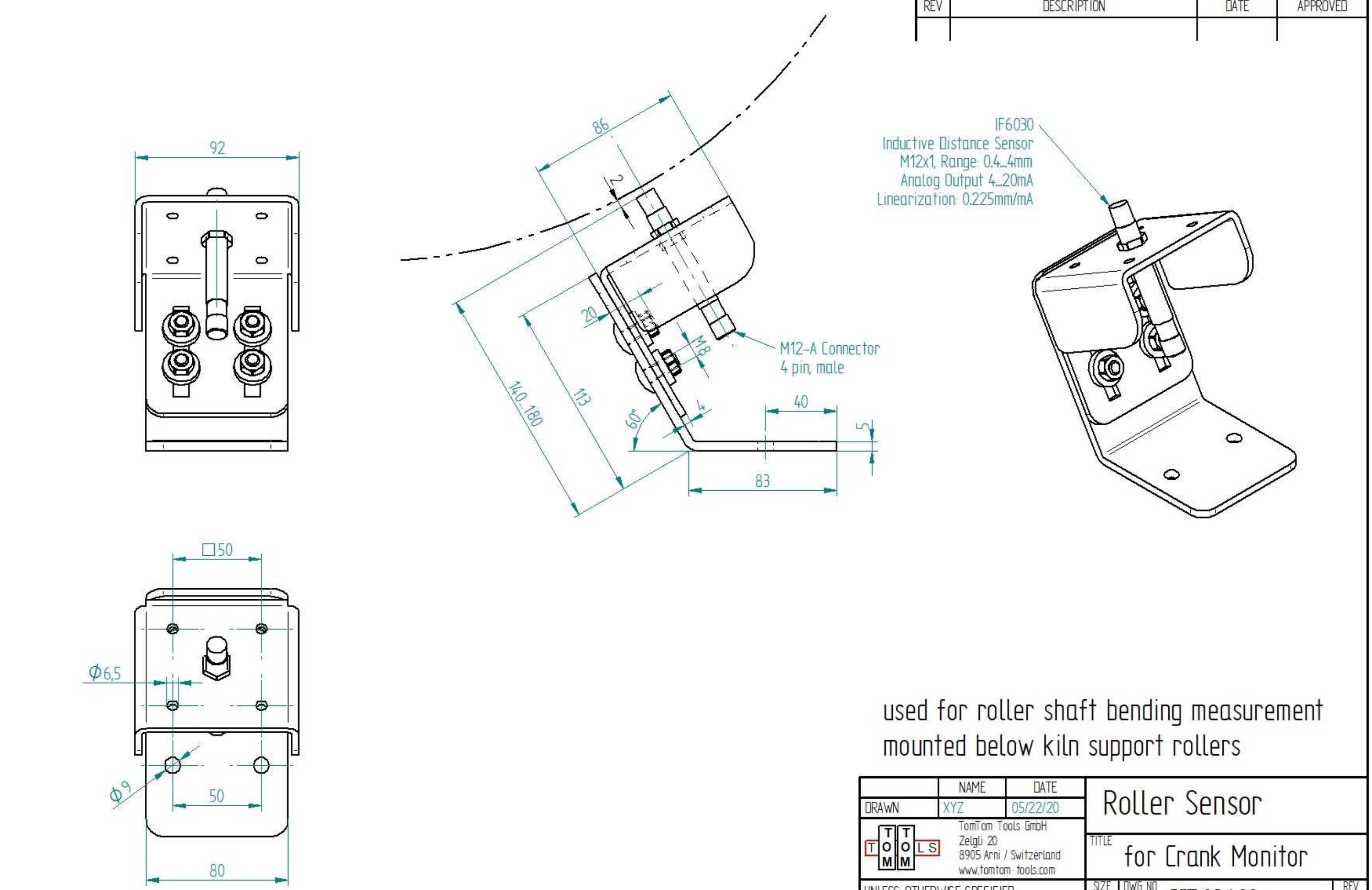
SCALE:	WEIGHT:	SHEET 1 OF 1

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



	NAME	DATE	
DRAWN	XYZ	05/22/20	Reference Sensor
TOOLS	TomTom Tools GmbH Zelgli 20 8905 Arni / Switzerland www.tomtom-tools.com		TITLE for Crank + Travel Monitor
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DIMENSIONS ± 0.1 mm ANGLES ± 0.1° TYPICAL EDGE CHAMFER 0.3x45°			SIZE A3 DWG NO CCT.02.300 REV
			FILE NAME: CCT.02.300 Reference Sensor.dft
			SCALE: WEIGHT: SHEET 1 OF 1

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



used for roller shaft bending measurement
mounted below kiln support rollers

	NAME	DATE	
DRAWN	XYZ	05/22/20	Roller Sensor
TOOLS	TomTom Tools GmbH Zelgli 20 8905 Arni / Switzerland www.tomtom-tools.com		TITLE for Crank Monitor
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS DIMENSIONS ± 0.1 mm ANGLES ± 0.1° TYPICAL EDGE CHAMFER 0.3x45°			SIZE A3 DWG NO CCT.02.400 REV A
			FILE NAME: CCT.02.400 Roller Sensor.dft
			SCALE: WEIGHT: SHEET 1 OF 1