

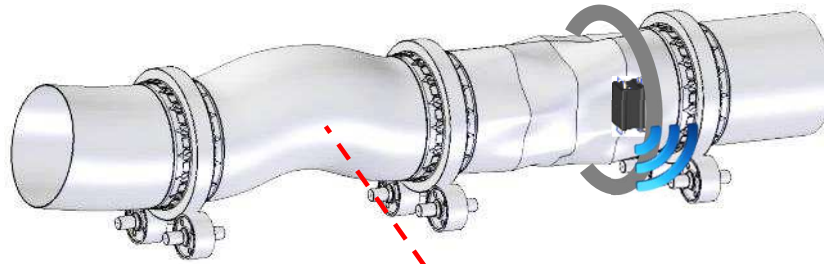
TomTom-Tools Ltd.

**Zelgli 20
8905 Arni
Switzerland**

Phone: +41 79 774 06 44

Info@tomtom-tools.com

www.tomtom-tools.com



User Manual:

Kiln Shell Laser

With Rotation Trigger



1. INTRODUCTION:

The Kiln Shell Laser is a measurement tool, which measures the deformations in rotary kilns, dryers or other slow rotating cylinders during operation.

The tool can be used to measure just one cross section, a specific area containing a few cross sections of interest or the whole kiln to get the full picture.

The steel shell of rotary kilns is exposed to high temperature. In case of excessive heat the shell might deform. In areas with deformations the refractory installation becomes typically difficult, which has a negative impact on its lifetime.

To measure the shape (roundness and eccentricity) of the shell, the Kiln Shell Laser is placed along the rotating kiln and measures continuously the distance to the shell surface. Deformations result in changes of the distance and will be recorded by the laptop PC, which is connected via Bluetooth with the laser. From each measured position a graph with the cross-section of the kiln is generated. Several measurements along the kiln can be combined in the software to a full 3d graph.

The 3d graph shows the severity of the deformations in different colors. It is a great help to identify the areas where special attention to the refractory is required. In case of reduced refractory life time, due to shell deformation, the software helps to decide, which shell sections need to be replaced.

1.1 Safety:

Rotary kilns and dryers, where this tool 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. To use the tool, 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 Ltd. have proven their functionality in various applications; nevertheless TomTom-Tools Ltd. does not take any responsibility for the application on site regarding safety. The plant is responsible for the 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 measurement campaigns and might need to be adapted to the local safety requirements.

Caution:



Laser Beam:

Visible laser radiation, do not stare into beam

Class 2 laser product



Magnet Fields:

Be aware of the strong magnet field of the magnet

Keep the tool away from people with pace makers or any other sensitive item as credit cards or magnetic data carrier.



Gloves:

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



Hot Surface:

The kiln shell might be very hot. Do not touch it and keep sufficient distance.



Radio Waves:

Be aware of the radio waves (Bluetooth) which are emitted from the tool as well from the Bluetooth adapter on the computer.

Do not keep the tool unnecessary in operation; switch it off, after usage.



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.

TABLE OF CONTENT

1.	Introduction:	1
1.1	Safety:	1
1.2	Measuring Principle:	4
1.3	Tool Kit includes:	5
2.	Main Components	6
3.	Software:	6
3.1	Software Installation:	6
3.2	Bluetooth Adapter	7
4.	Connect The Device with the Laptop	8
5.	Measurements	9
5.1	Set Up the Measurement Window	9
5.2	Bring the tool in position	10
5.3	Take Measurements	10
5.4	Display Results	12
5.5	Denseness of Cross Sections	13
6.	Data Review	14
6.1	Change Window Range	14
6.2	Removal of Outliers (wrong points)	14
7.	Kiln Assessment in 3d View	15
7.1	Topography View	15
7.2	Review the Kiln in the 3D Model	16
7.3	The different ways to display	16
7.4	Add Tires and Girth Gear	16
7.5	Limits	20
8.	Report	21
8.1	Export to Excel	21
8.2	Create a report	21
9.	Rotation Trigger (Optional)	22
9.1	Connect the Rotation Trigger with the PC	22
9.2	Attach Rotation Trigger to Kiln	22
9.3	Combined Measurement with Kiln Shell Laser and Rotation Trigger	22
10.	Dimensions Rotation Trigger	23
11.	Dimensions Kiln Shell Laser	24

1.2 Measuring Principle:

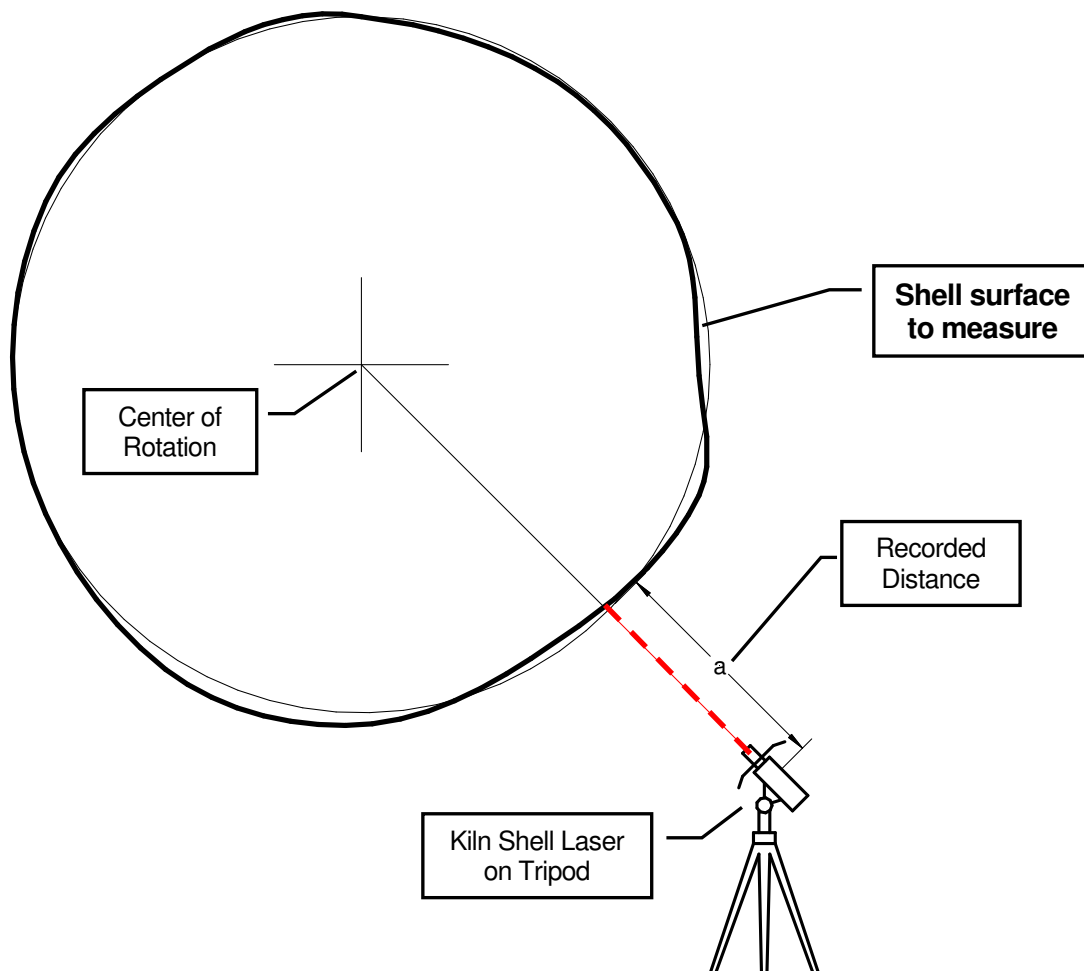
The Kiln Shell Laser kit consists mainly of a battery powered distance laser sensor with a high range Bluetooth connection and a heat shield.

The measuring principle of the distance laser sensor is based on optical phase comparison measurement. The laser which hits the kiln surface gets partially reflected. A very sensitive optical sensor located in the same housing as the laser is measuring the returned light reflected by the kiln shell. The laser light is modulated and the phase shift between outgoing and incoming light gives the distance.

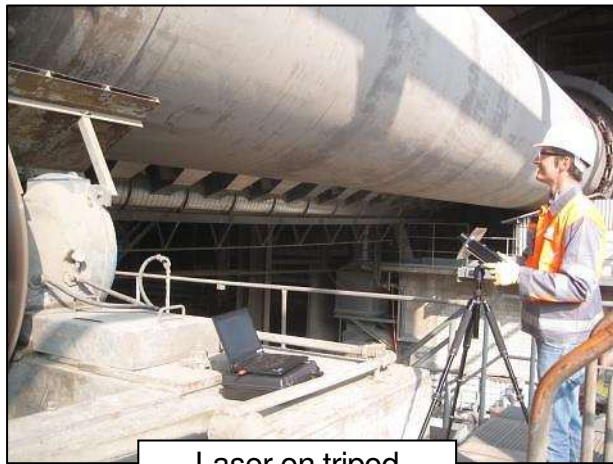
To measure the shape (roundness and eccentricity) of the shell, the Kiln Shell Laser is placed along the rotating kiln and measures continuously the distance “a” to the shell surface. Deformations result in changes of the distance and will be recorded by the laptop PC, which is connected via Bluetooth to the laser. From each measured position a graph with the cross-section of the kiln is generated. Several measurements along the kiln can be combined in the software to a full 3d graph.

The Kiln Shell Laser takes in the standard setting 10 readings per second (10Hz). To reach a sufficient resolution in the graph; the shell is typically measured during two kiln revolutions. For special application, in case the reflection on the surface is sufficient, it is possible to increase the sampling rate to 50Hz.

a) Schematic with Laser on a tripod



b) Examples: Run-Out Measurement of Kiln Shell



Laser on tripod

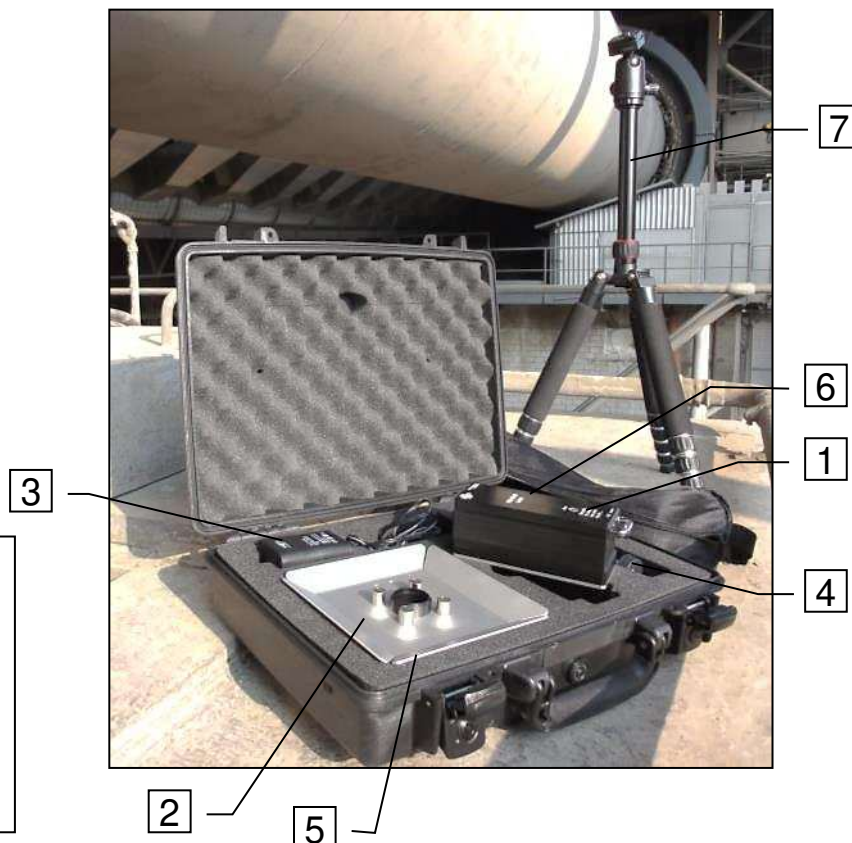


Laser fixed with G-clamp

1.3 Tool Kit includes:

The Kiln Shell Laser is coming as a tool kit in a strong and tight transport case, which includes the following items:

1. **Kiln Shell Laser** with Bluetooth interface
2. **Heat Shield** with magnets
3. **Battery Charger** with different plug adapters (100...240VAC)
4. **G-Clamp** to hold the laser, in case no tripod is available
5. **USB Bluetooth Adapter** (below heat shield)
6. **USB Memory Stick** with manual and software "Measurement Studio"
7. **Tripod** (optional)

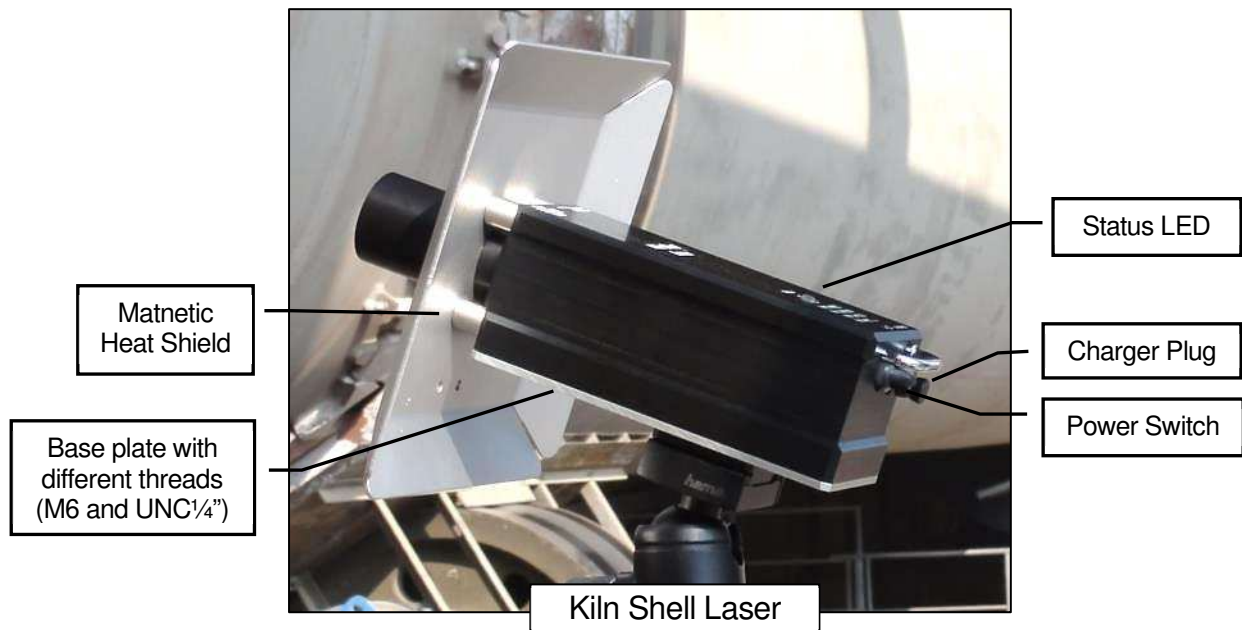


Transport Case
Type: Peli 1470
42.9x33.6x11.4cm

Tripod in separate bag:
40x12x12cm

Weight total: 7.5kg

2. MAIN COMPONENTS



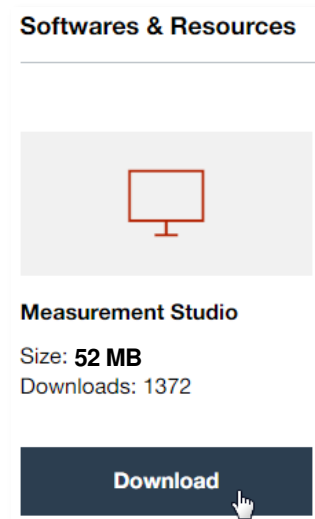
3. SOFTWARE:

3.1 Software Installation:

The software (**TomTom-Tools Measurement Studio**), which is used for the Kiln Shell Laser and for all others of our tools, comes along with the tool kit on a USB Memory Stick. Nevertheless it is recommended to **install the software from www.tomtom-tools.com** , where always the latest version is available.

During any start of the Measurement Studio, it is checking for updates if the computer is connected to the internet. In case of available upgrades the user gets asked if they should be downloaded and installed.

Please keep your PC up to date.



3.2 Bluetooth Adapter (optional)

To connect to the Kiln Shell Laser, the inbuilt Bluetooth of a normal Laptop PC is usually strong enough to establish a reliable connection, because only short distances are required.

By using the Panasonic Tablet PC (FZ-G2) with the integrated Long-Range Bluetooth, large distances (>100m) can be reached easily.

It is also possible to reach large distances (>100m) with a regular PC, by using the Long-Range Bluetooth adapter (Sena UD100 or new ZEXMTE), which comes along with the tool kit.

Note:

- To force the PC to connect via the Long-Range Bluetooth Adapter, the integrated Bluetooth needs to be disabled in the Device Manager as shown below.
The Bluetooth Adapter communicates **only with the generic Windows Bluetooth Stack**. If there is another Bluetooth software installed (e.g. Intel, Toshiba, Widcomm, ThinkPad,...), **deactivate it**.

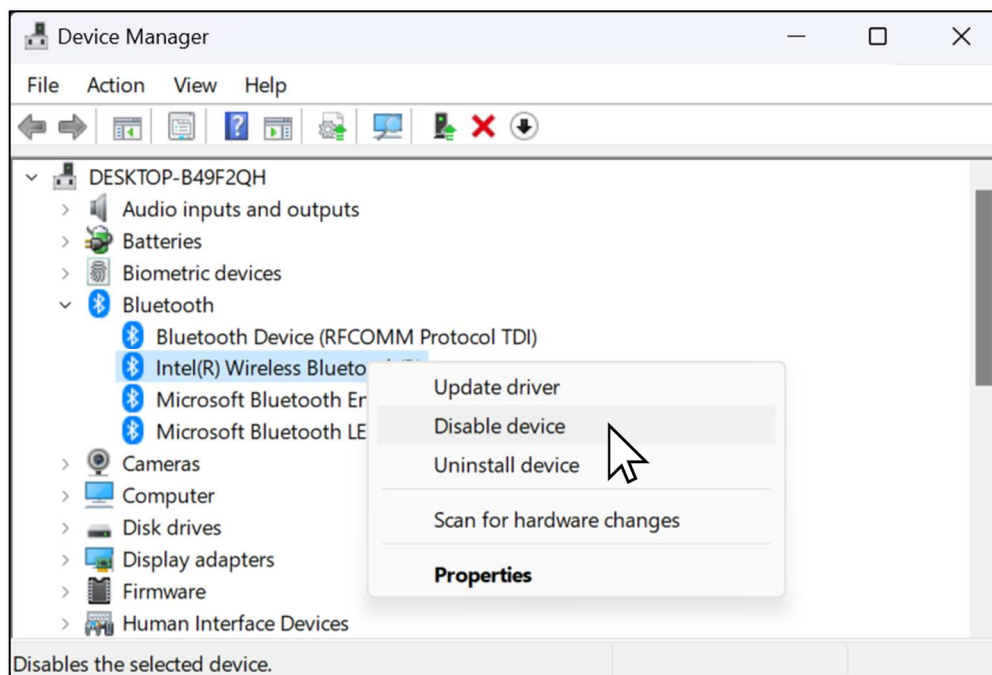


Fig.3.2.1
Device Manager

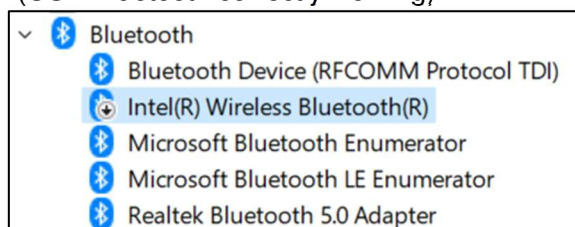
- Then plug the Bluetooth adapter ZEXMTE
Windows will recognize the new hardware
and automatically install the suitable Windows drivers
- The Device Manager will show the following:
 - Generic Bluetooth Radio
 - Microsoft Bluetooth Enumerator
 - the not required Bluetooth is down
(indicated by the small arrow at the Bluetooth icon)



Fig.3.2.2

Fig.3.2.3 Device Manager

(USB Bluetooth correctly working)



ZEXMTE Bluetooth Adapter Specifications:

- Bluetooth 5.1 and EDR Class 1 (dual mode)
- USB-A 3.0
- Frequency Range: 2.402 ~ 2.480GHz
- Antenna: RP-SMA

4. CONNECT THE DEVICE WITH THE LAPTOP

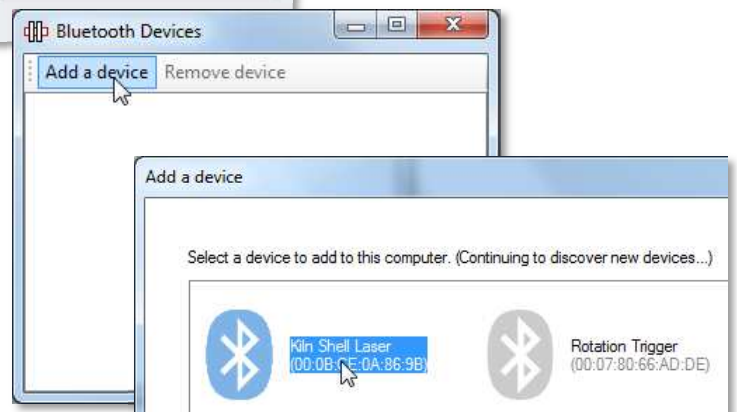
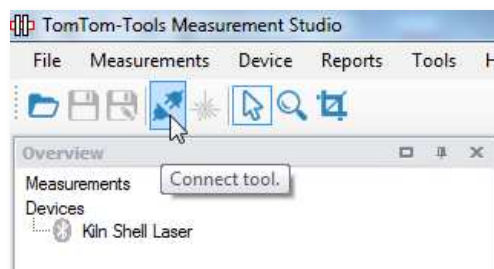
When the software installation is completed, it starts automatically.
To connect a tool for the first time it has to be paired with the computer.
To do so, follow this sequence:

- Switch on the Kiln Shell Laser (green LED).
- Click on “Tools / Bluetooth Devices / Add a device”
- Wait until the tool got found
Note: Depending on the search speed of the computer, it might take up to one minute.
- Select the device, which has to be connected; (here the Kiln Shell Laser) and click “OK”

Fig. 4.1
(Add Device)

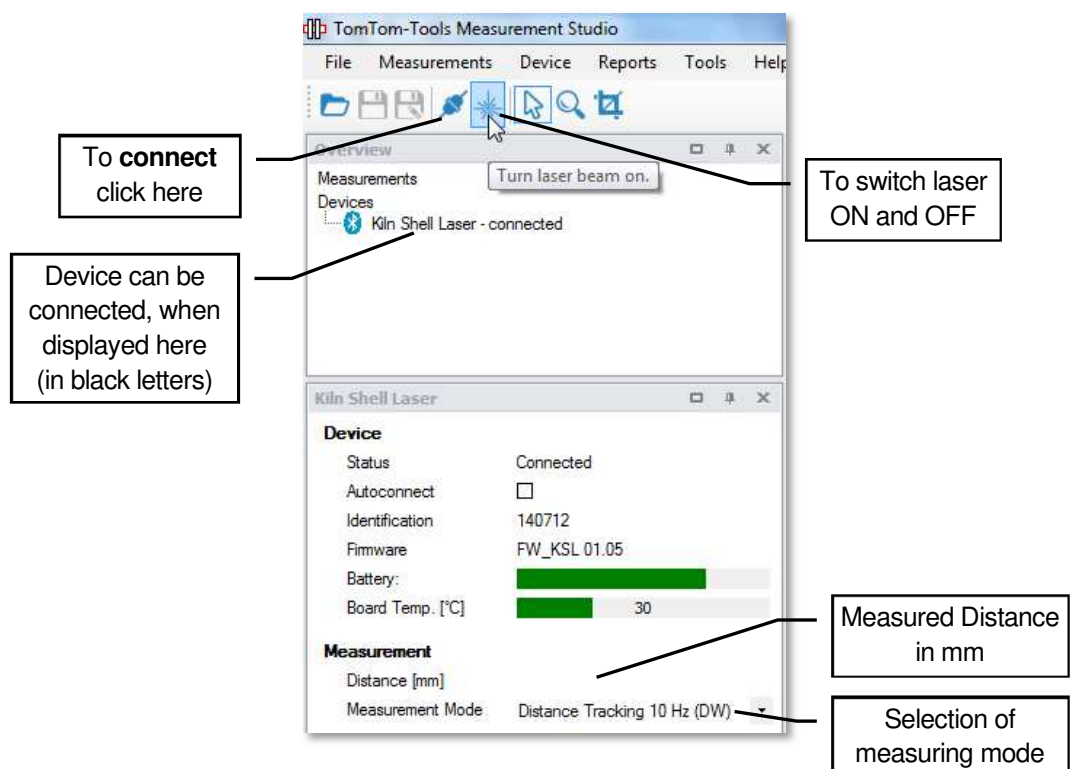


Fig. 4.2
(Connect Device)



- The Kiln Shell Laser gets added to the Device List
- To connect the Kiln Shell Laser, click on the “Connect” Button

Fig. 4.3
(Device Window)



5. MEASUREMENTS

5.1 Set Up the Measurement Window

- To start a new measurement, click on “Add Shell Runout” as shown in Fig. 5.1.1
- The first position will be displayed as per default
- More position can be added by clicking “Add @....m” as shown in Fig. 5.1.4
- Specify the kiln in the Project Settings. The Settings can be reached via menu bar or by mouse right click, as shown in Fig. 5.1.2

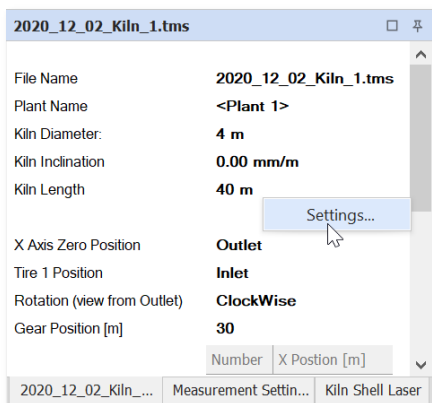


Fig. 5.1.2 Kiln Data

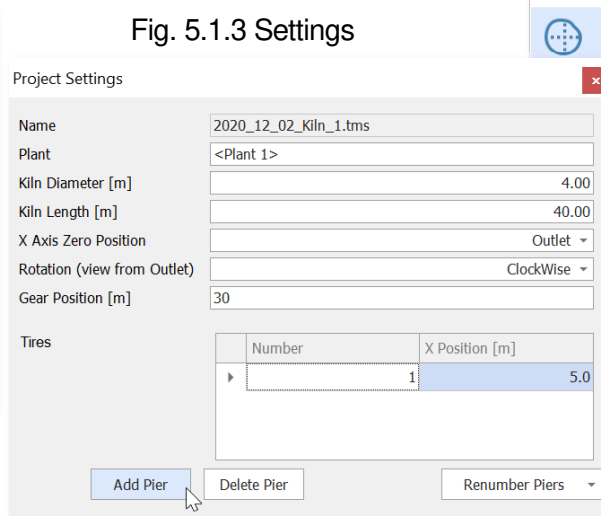


Fig. 5.1.3 Settings

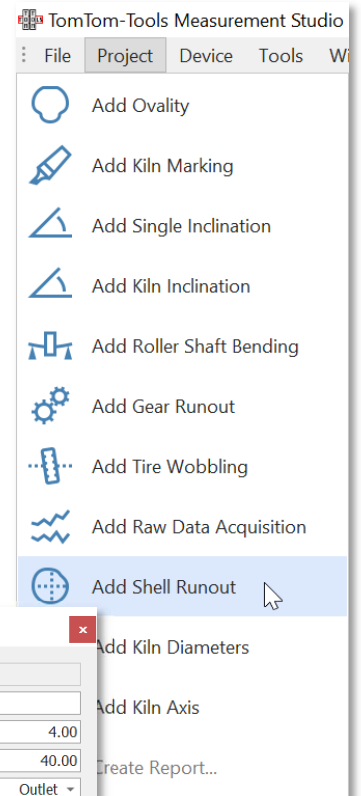
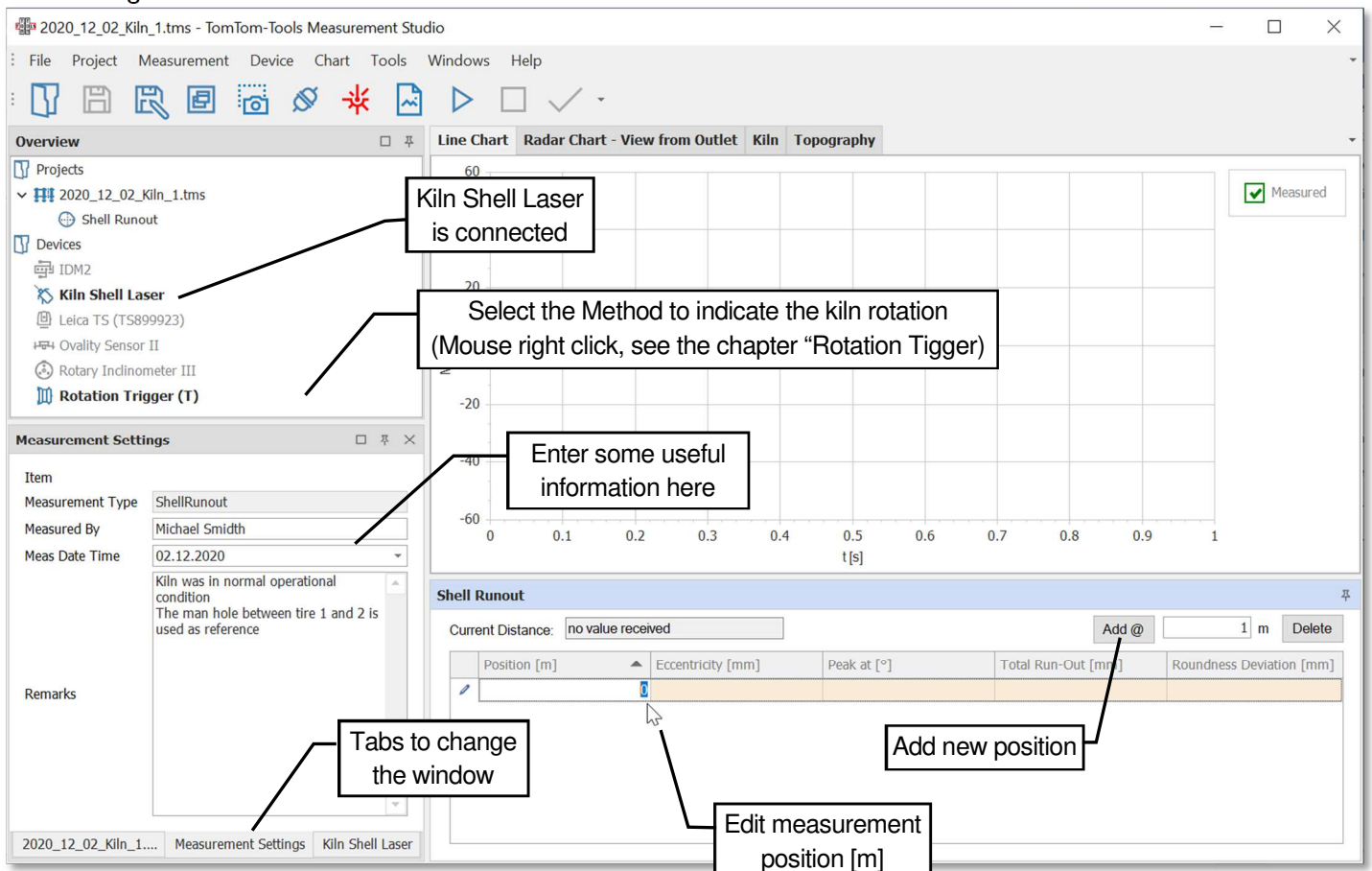


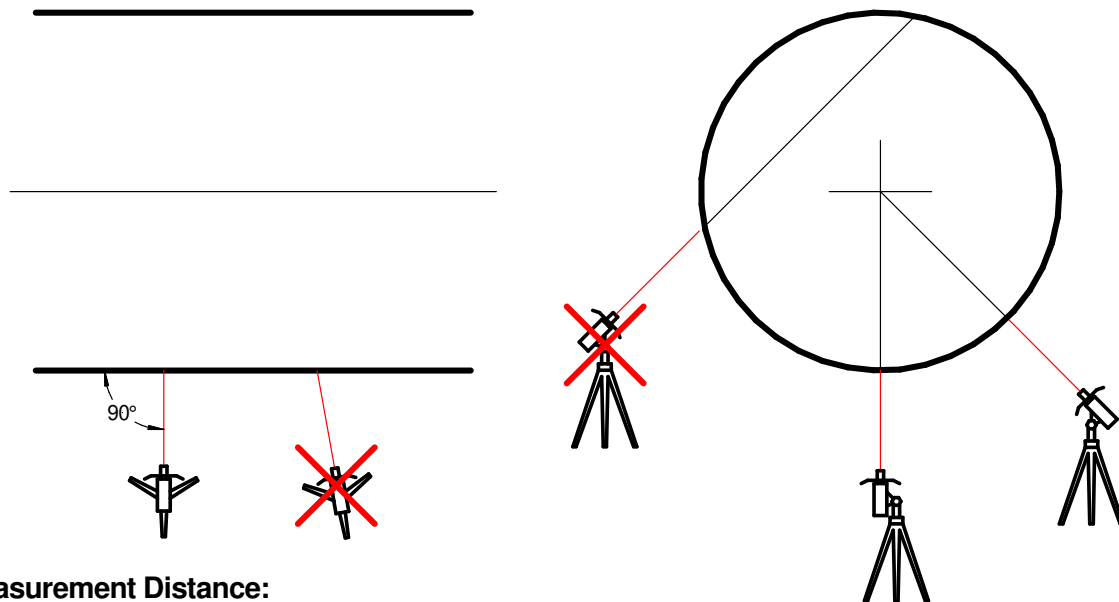
Fig. 5.1.4 Main Screen



5.2 Bring the tool in position

The Kiln Shell Laser has to be placed below or beside the kiln at the location, which has to be measured. The laser beam has to be perpendicular to the shell surface and pointing towards the center (according Fig. 5.2.1).

Fig. 5.2.1



Measurement Distance:

The maximum distance for the Kiln Shell Laser depends on the influence of disturbance.

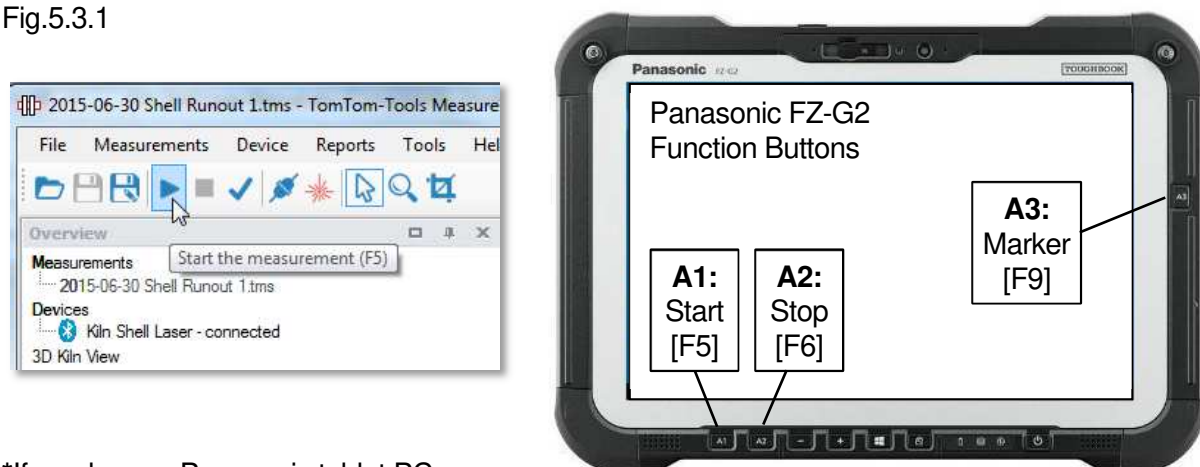
Typically, the tool is used within the distance of **4...20m**. In case of strong sunlight, measure at the shady side, not where the sun is directly shining onto the kiln.

In case the kiln surface is reflecting the laser light well (not too much corrosion), and the measurement is done at night, where no sunlight disturbs the laser receiver, distances up to 50m are possible.

5.3 Take Measurements

To start the measurement, enter the position [m] on the computer screen and push the **Start** button or **[F5]** or **[A1]*** on the Panasonic Tablet PC.

Fig.5.3.1



*If you have a Panasonic tablet PC use the function buttons as shown here

After that, the values will appear on the computer screen (green points)

Note:

To be able to place the measured points correctly into the graph and to calculate the position of the eccentricity, the software needs a reference signal. This reference signal has to be given, in the moment when the reference point is in line with the laser point.

Typically the manhole in the kiln shell is used as reference point.

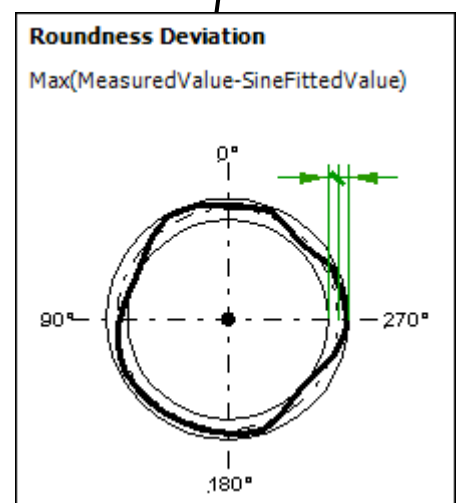
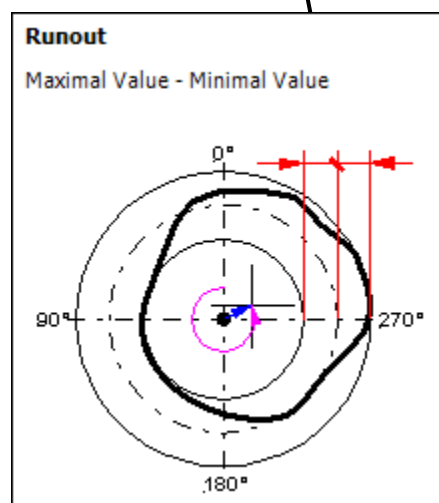
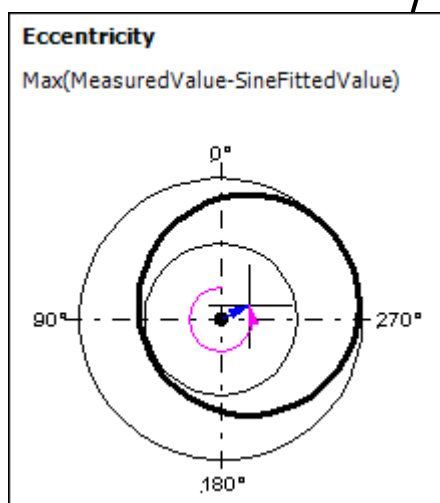
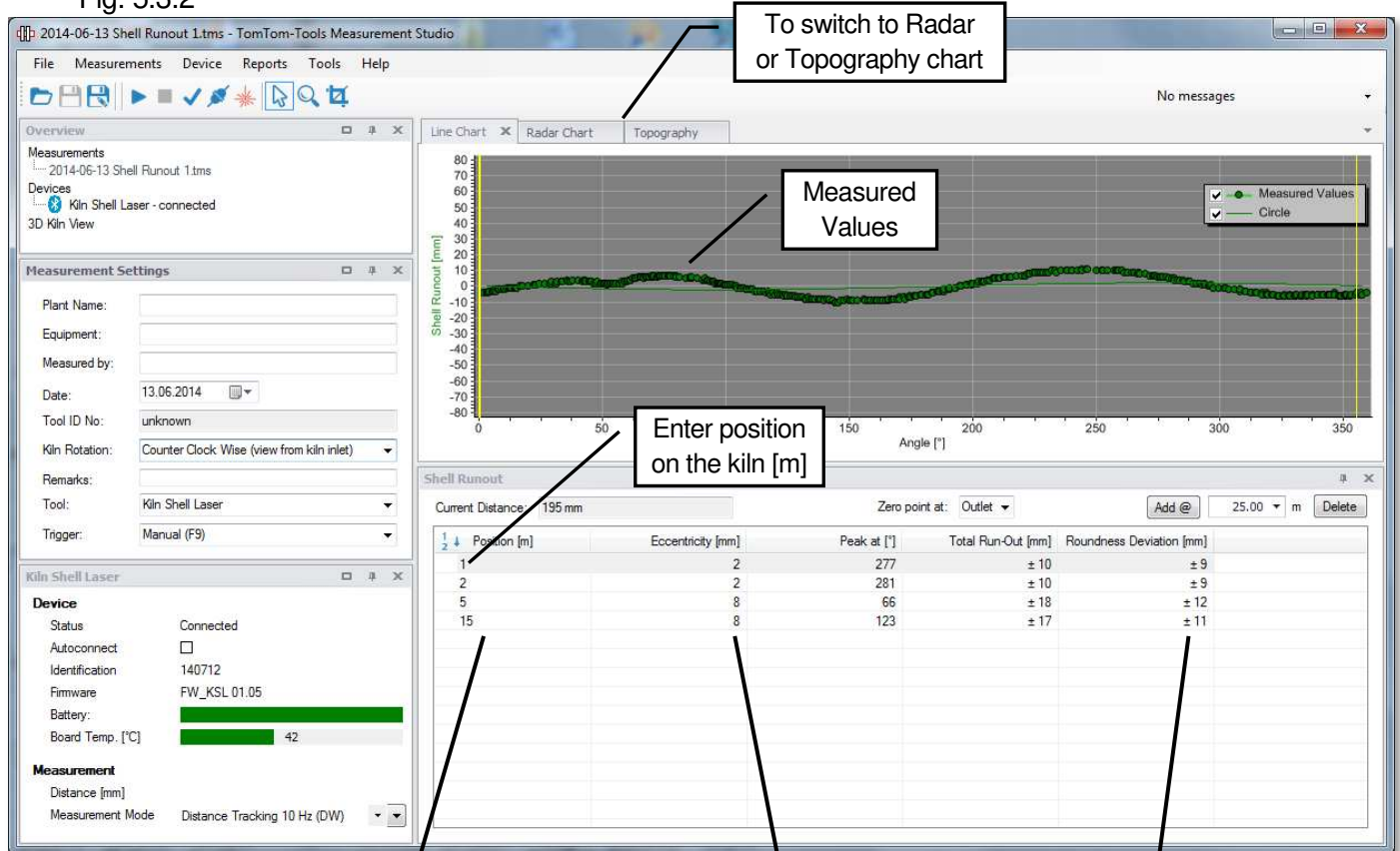
It is utmost important to use the same reference point for all measurements.

Each time when this reference point is passing the position of the laser, click on  or push the **button [F9] or [A3]*** to indicate the kiln rotation. A yellow line in the graph will show the position of the reference point.

Optionally a **Rotation Trigger** is available, which makes the rotation indication easier (see chapter 9 "Rotation Trigger")

After 2...3 complete kiln revolutions, sufficient data are collected and the measurement can be stopped. **To stop** the measurements, push the **Stop** button or **[F6] or [A2]***

Fig. 5.3.2



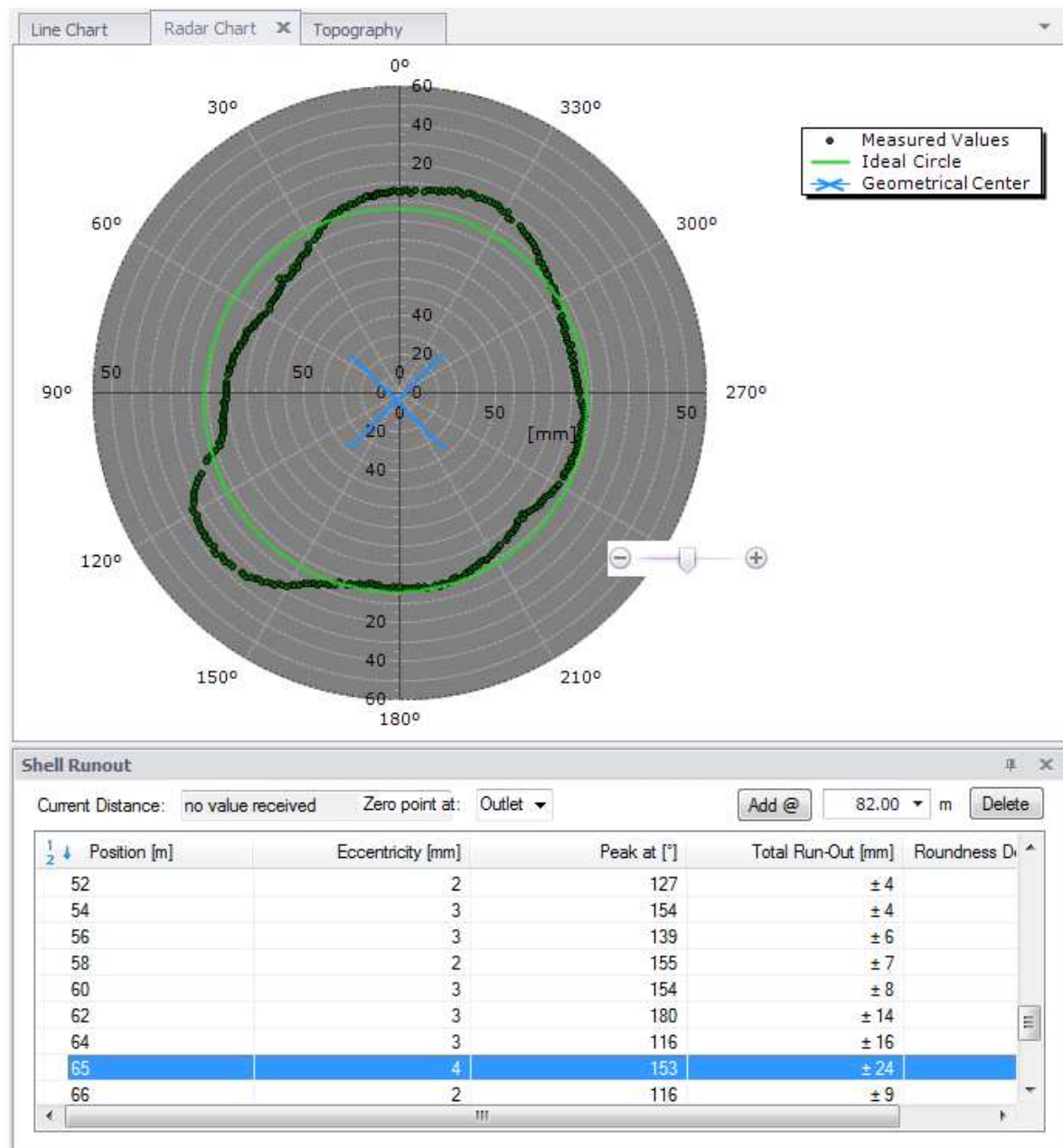
- **Eccentricity:** shows how much the girth gear is out of the center of rotation, it is the distance between the center of rotation and the center of the girth gear (blue arrow)
- **“Peak at”:** indicates the angle (purple arrow) where the peak of the eccentricity is located. It is counted in degrees after F9 was pressed. The position of F9 appears in the radar chart on top at 0°.
- **Roundness Deviation:** shows the maximal deviation from the ideal circle. It is a +/- value (green arrows)
- **Total Run-Out:** is the combination of eccentricity with roundness deviation. It corresponds directly to the measured values. The Total Run-Out is a +/- value (red arrows)

5.4 Display Results

The values can also be displayed in a Radar Chart, which appears as the measured cross section.

Each measurement is shown in a row of the table below the graph window. More measurements can be added by clicking the “Add” button. The rows get automatically sorted by the position [m] value.

Fig.5.4.1



5.5 Denseness of Cross Sections

The more cross sections are measured, the more detailed becomes the picture of the kiln. But in most cases, only some areas are from interest. Here some examples:

- **In areas of refractory failures:**
to check if a roundness deviation in the shell is the root cause
- **Kiln Inlet and outlet:**
to know the impact on the seals
- **In areas of kiln tires:**
to see the impact of the shell deformations on the tire wobbling, to understand their correlation and to identify the location of possible correction cuts.
- **In areas, where shell sections need to be replaced**
to find good locations with low run-out where new shell pieces easily can be connected
- **Shell in the area of the girth gear:**
in case of a replacement of the gear, if the shell needs to be replaced as well

In most cases, for a general overview, the kiln is measured every 1...2m. In case of localized refractory failure, it might make sense to measure the affected area every 0.5m or even less. It will provide a clearer picture of the “steepness” of the deformation in longitudinal direction.



Note:

To ease the orientation along the kiln, it is recommended to mark the meter positions. That can be fix marks either on the catwalk beside the kiln or even better, directly on the kiln shell.

6. DATA REVIEW

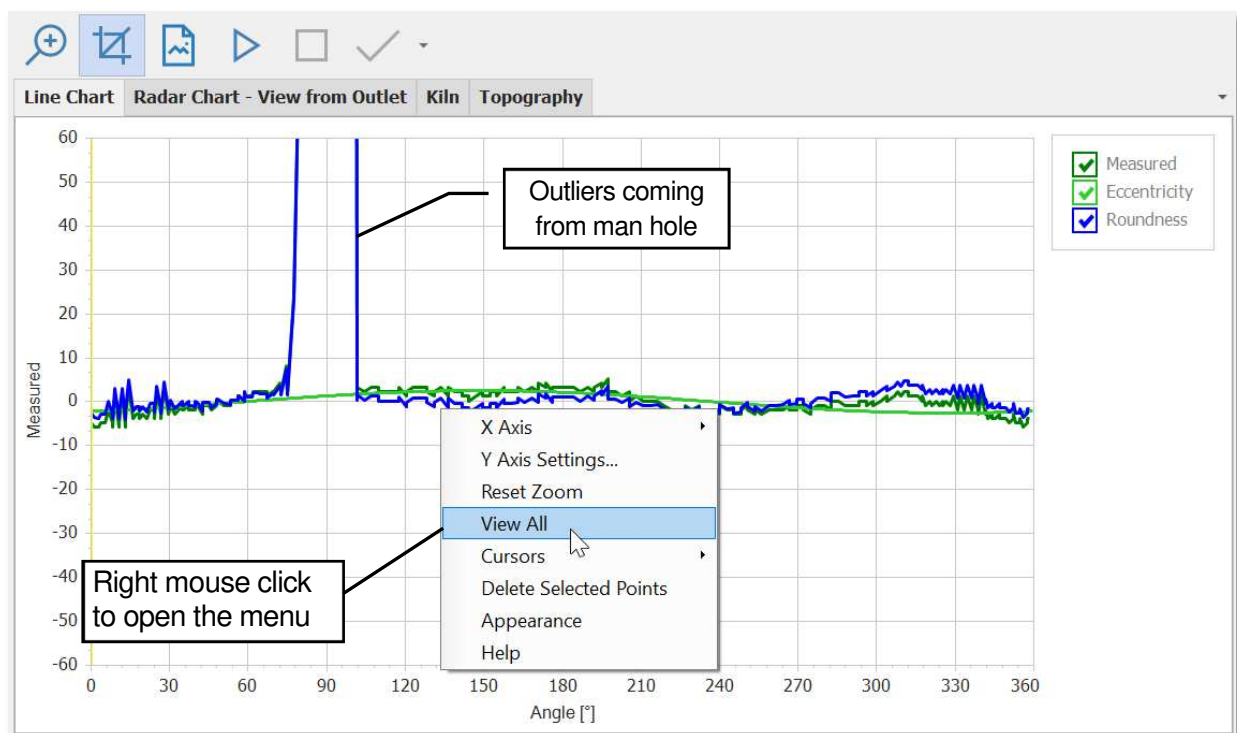
The Data can be reviewed in all the 3 different charts (Line Chart, Radar Chart and Topography). Nevertheless, the easiest way is to browse through the data first in the Line Chart, to see if the readings are good or if they have to be repeated.

6.1 Change Window Range

Some of the measured points might be out of the displayed range. These are typically wrong readings or outliers coming from pieces welded to the kiln shell.

To get also these points displayed, the range can be changed by right mouse click onto the vertical axis and increasing the “Range Max” value.

Fig.5.6.1 (change display range)



6.2 Removal of Outliers (wrong points)

The shell run out measurement might be disturbed in some areas; for example, by pieces welded to the kiln shell, by the man hole or by components from the tire fixation hardware. Hence the graphs might include wrong points.

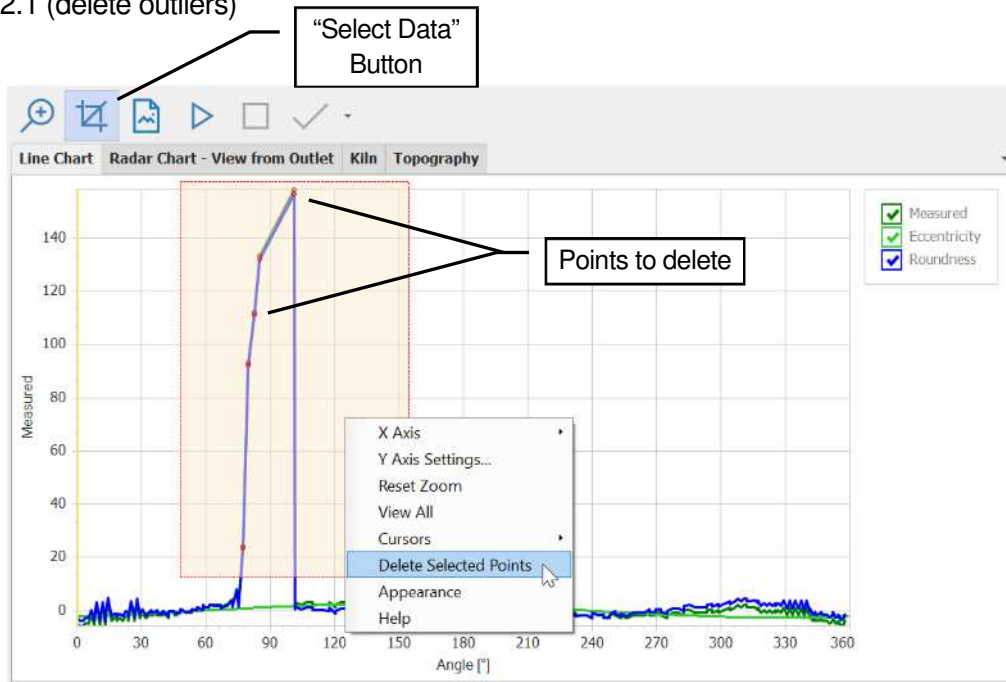
These outliers can easily be detected and removed in the linear graph.

- Click on the “Select Data” button
- Select the outliers with the cursor (drag from top left to right down)
- Delete the selected points by pushing the “Delete” button or by right mouse click

Note:

It is recommended to **make a backup copy** of the file before deleting any points.

Fig. 6.2.1 (delete outliers)



7. KILN ASSESSMENT IN 3D VIEW

To get a clear picture about the deformation in the kiln shell there are ways to display the data in 3d.

The simple way is the "Topography View" which is good for static analysis and printouts.

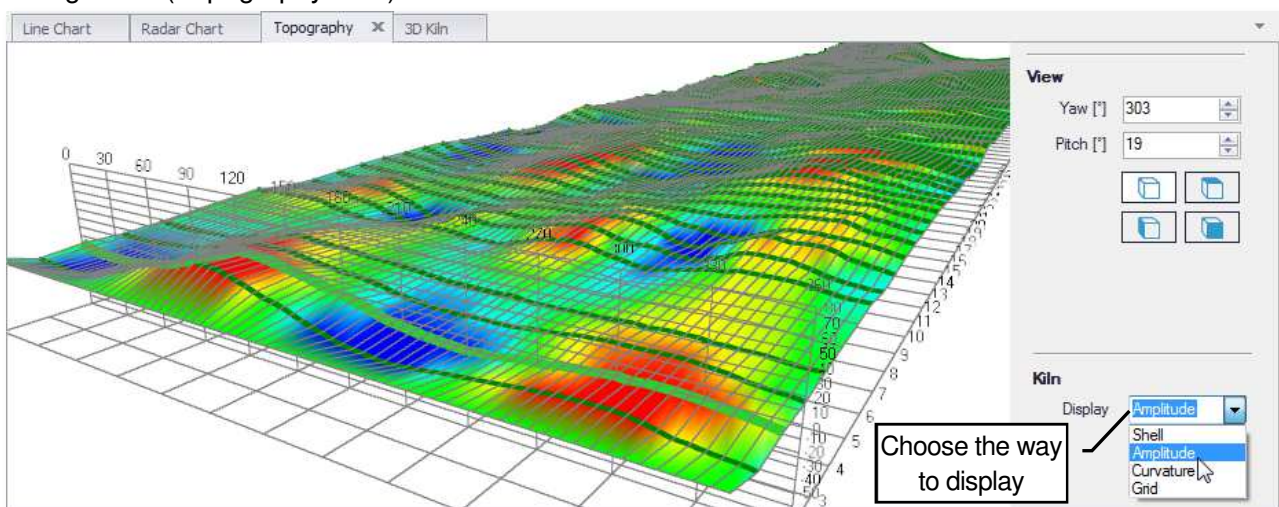
The much more powerful tool is the 3d modelling of kiln. It is animated and shows the center line with its eccentricity .and can combine the shell deformation readings with other measurement results.

7.1 Topography View

The Topography View is displayed as shown in the following window.

To colorize the deformations, select the "Amplitude" or "Curvature" view.
(see also 7.3)

Fig. 7.1.1 (Topography view)



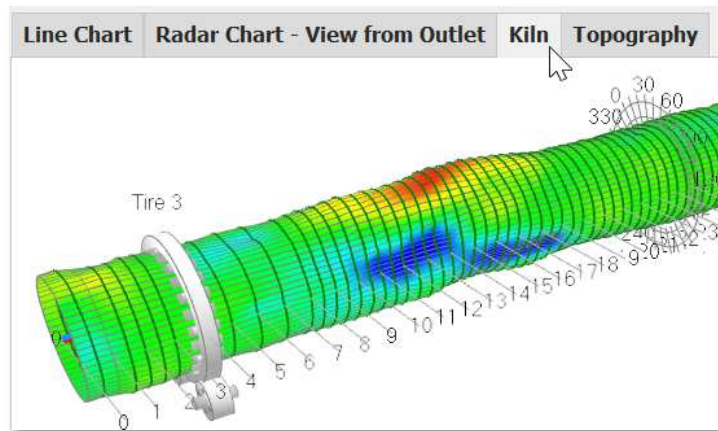
To zoom, rotate and move; use the mouse or the arrow buttons in combination with "Shift" and "Ctrl"

7.2 Review the Kiln in the 3D Model

The full functionality will be given, when the measurement file is displayed in the 3d Model.

Click on the “Kiln” Tab

Fig. 7.2.1



7.3 The different ways to display

The deformations are exaggerated to make them visible on the computer screen. There are different possibilities to visualize the deformations.

- **Shell View:** shows just the kiln shell as it is, without color coding
- **Amplitude:** shows the height of the deformations in different colors
- **Grid:** displays the grid lines but hides the shell surface. It allows the view inside the kiln to the blue center line (Shell Axis)
- **Curvature:** shows the steepness of the deformations in the kiln shell. This is the most important indicator for the refractory installation. Sharp / abrupt changes in the kiln shell have a negative impact on the refractory life time (see also chapter “Limits”)
- **Replacement*:** gives indications, which sections are out of limits, where a close look on the refractory life time is recommended and which section might need to be replaced.

(* under construction)

7.4 Add Tires and Girth Gear

To get a more realistic view and for better understanding, the kiln piers and the girth gear should be added. To do so, go to the Kiln Settings (see next picture)

It is recommended to measure also the run-out of the tires and girth gear with the help of the Inductive Distance Measurement (IDM) Tool Kit.

The results of these run-out measurements can also be added and displayed in the 3D model.

To add run-out measurements:

- Open the file with the tire or girth gear readings
- In the tree view, drag and drop them into the project you are working on
- Then save the project file

Fig.7.4.1: Amplitude View

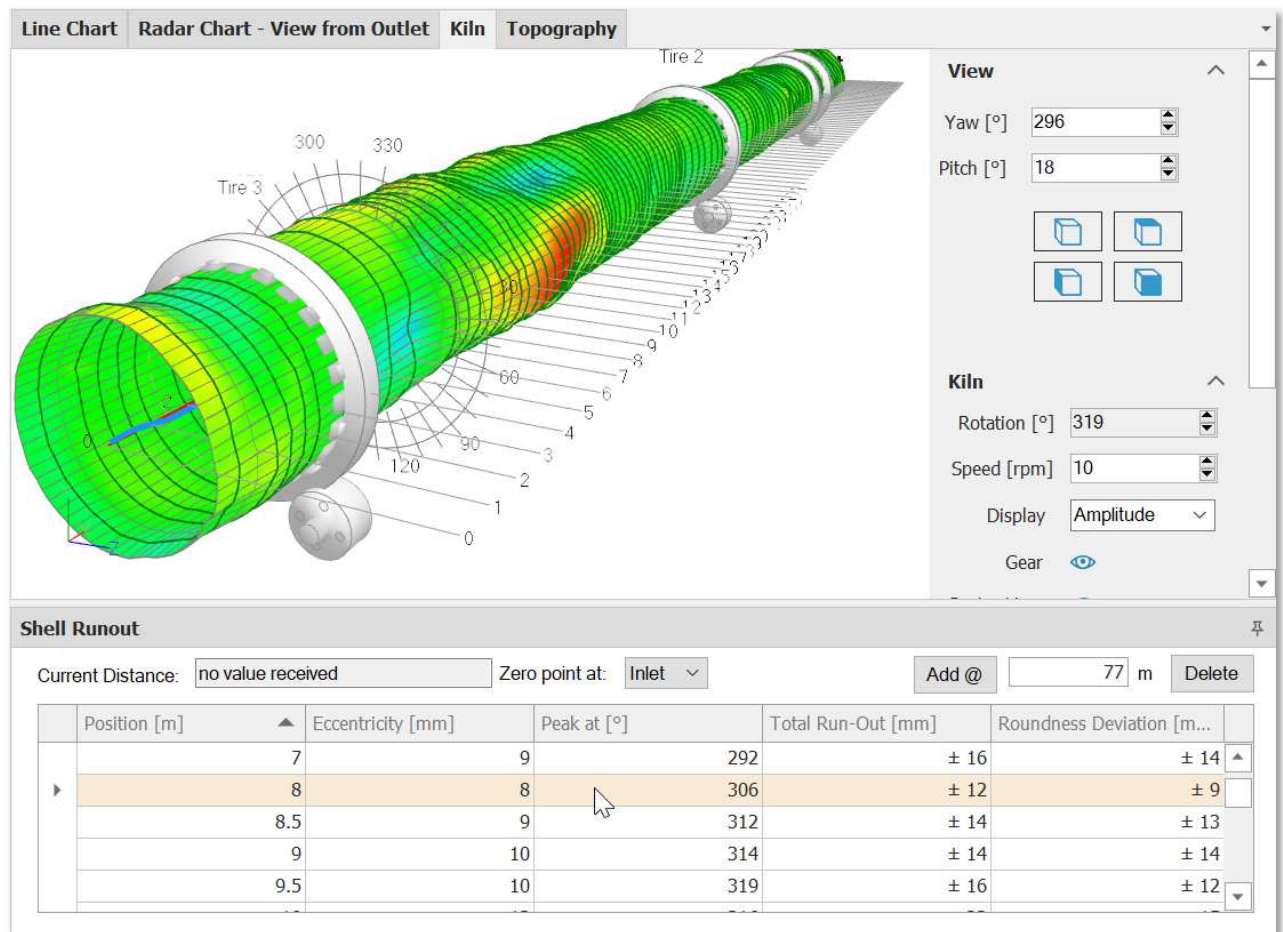


Fig.7.4.2: Grid View (including girth gear measurement results)

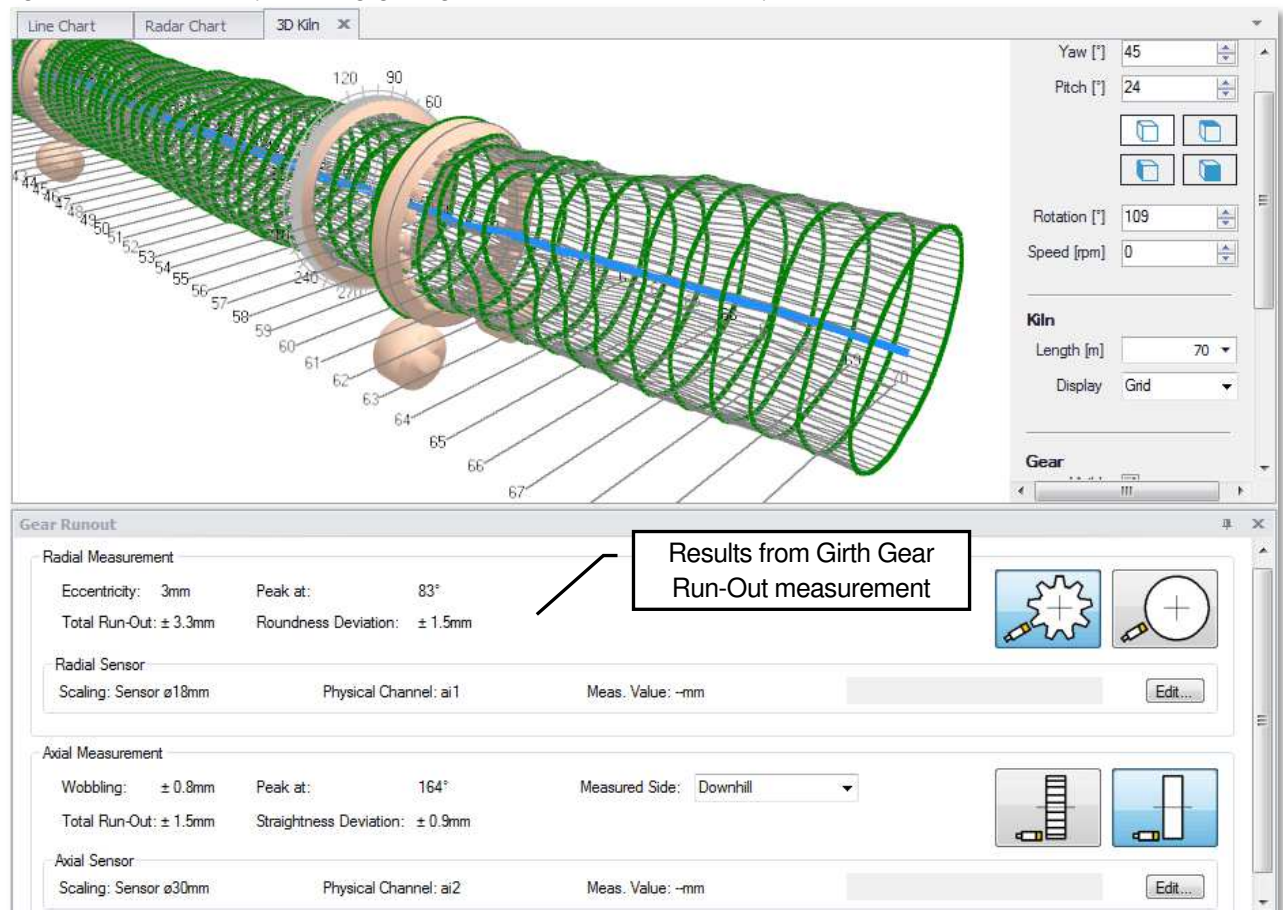


Fig.7.4.3: Curvature View

By selecting “Curvature View” the changes in the curvature are displayed. In other words, it shows how much the straightness and the roundness are changing within a specific area, or how abrupt the deformations are.

Abrupt or sudden changes in the shape have a negative impact on the lifetime of the refractory bricks. (See more in the chapter “Limits”)

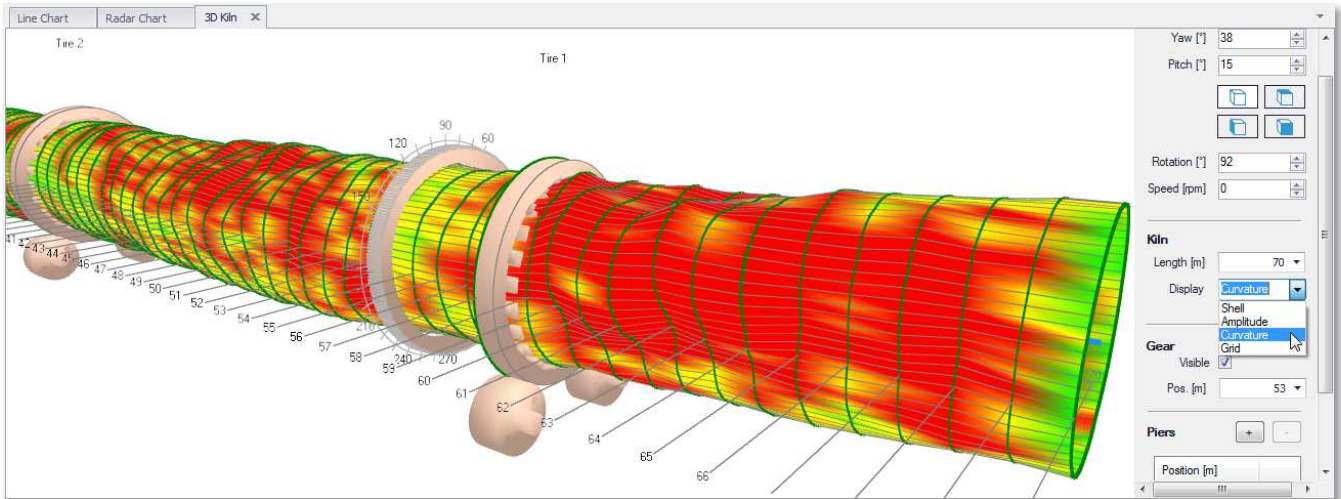


Fig.7.4.4: Orthogonal View

By bringing the kiln into orthogonal position, in this example can be seen easily that...

- The kiln is not straight, high eccentricity at kiln inlet (see blue center line)
- The tire #1 is wobbling heavily
- The girth gear runs well

Click here for
Orthogonal Orientation

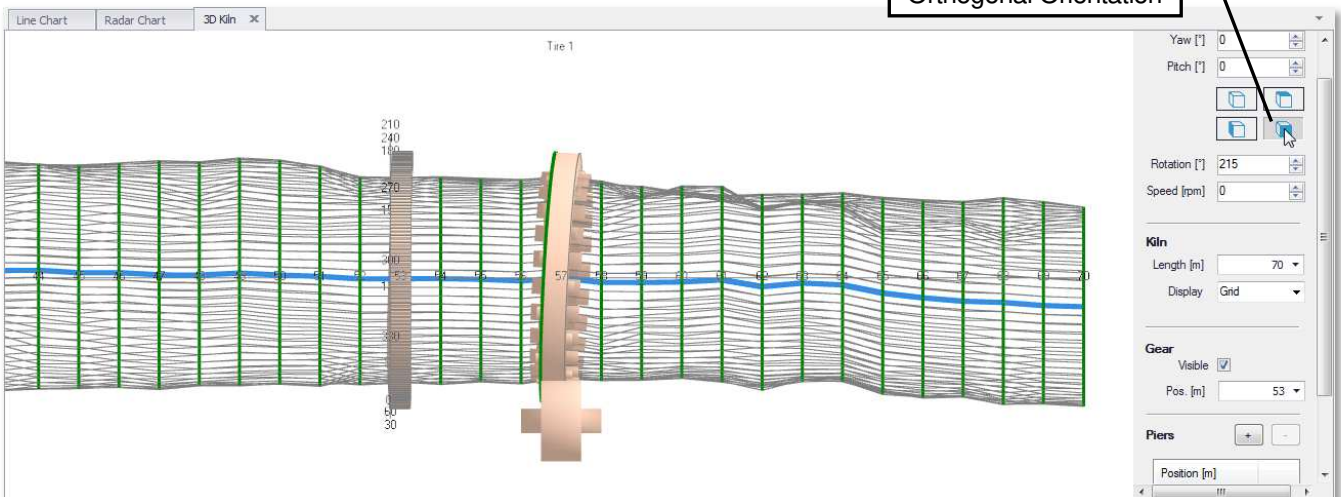
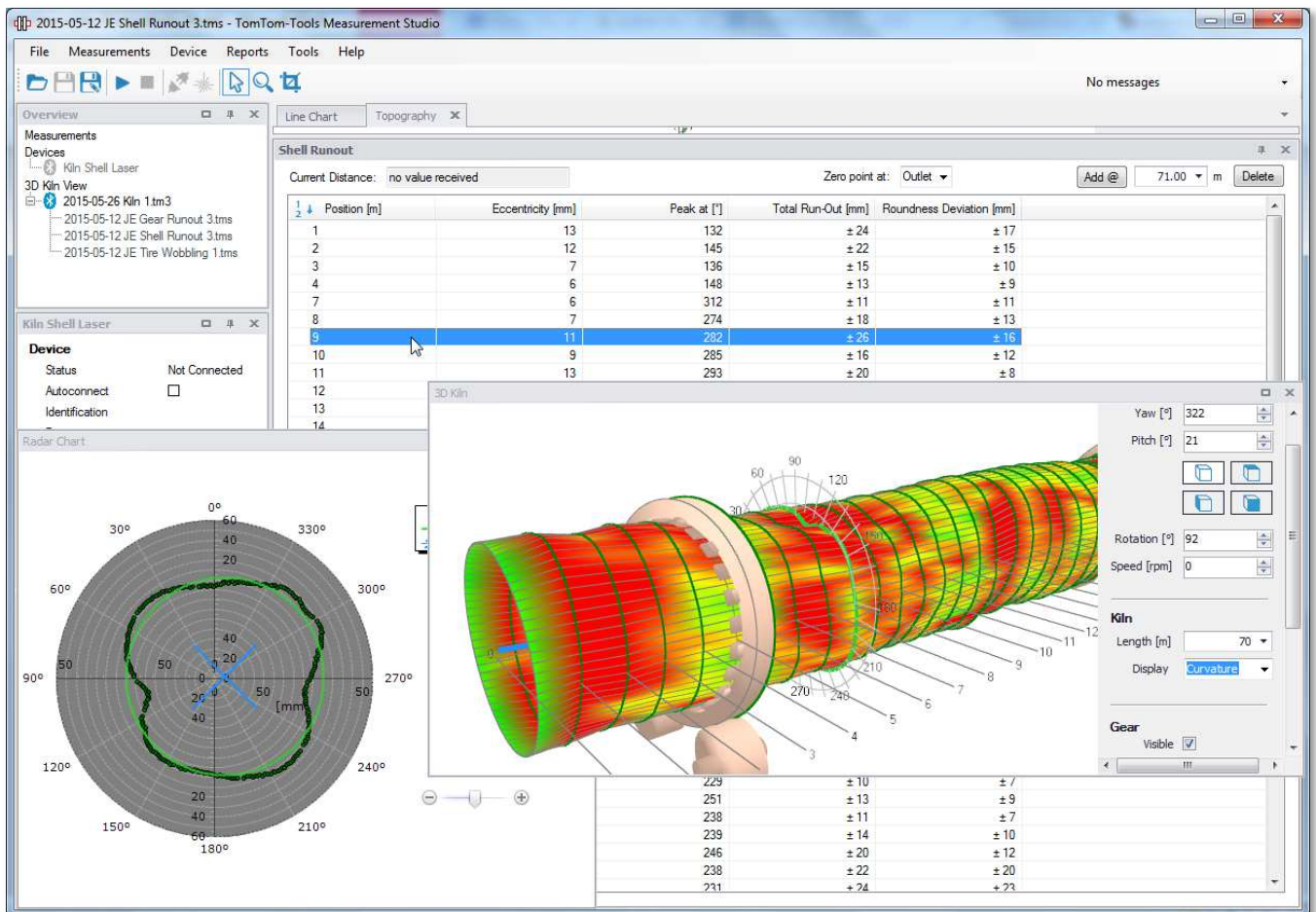


Fig.7.4.5: Combined View, Radar and 3D window open

By dragging out the windows, several graphs can be displayed simultaneously. This makes it easy to understand, how the cross section looks like at each position of the kiln.

While scrolling through the list of the measurement points, the 3d view is showing the position and the radar chart the shape of the cross section at the same time.

This applies as well for the run-out measurement of the girth gear and the tires.



To restore the default window view, click on "Tools / Reset Window Layout"

Fig. 7.4.6



Note:

There is also a video available under www.tomtom-tools.com, which shows how to use the Kiln Shell Laser and the Measurement Studio.

7.5 Limits

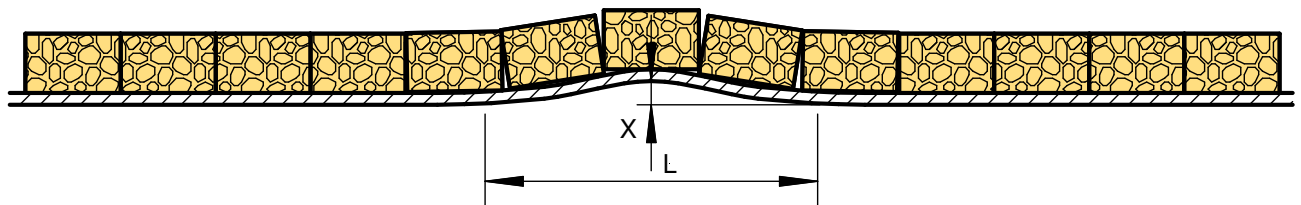
The experience on refractory life has shown clearly, that a good roundness of the kiln shell is the key, whereas the impact of eccentricity can be neglected. Just the pure amplitude of deformations in a kiln shell does also not give sufficient information about the situation. The “smoothness / sharpness” of deformations has to be considered. A smooth deformation, even with high amplitude, might still allow the proper installation of refractory, whereas an abrupt change of curvature typically reduces the refractory lifetime drastically.

TomTom-Tools Ltd. does not provide guide lines about deformation values or limits.

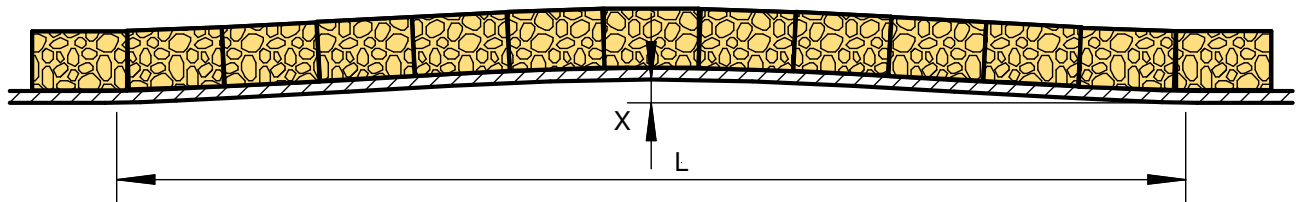
It has to be discussed with the refractory suppliers, how much deformation can be allowed.

Out of experience the following table can be taken as an example but **might need to be adjusted to the specific case**:

a) Sharp or Abrupt Shell Deformation



b) Smooth Shell Deformation



The „Sharpness “of a shell deformation has a much higher impact on the refractory than its amplitude

No problem

$$X \leq \frac{L}{300}$$

To be monitored

$$\frac{L}{300} < X < \frac{L}{100}$$

Might need replacement

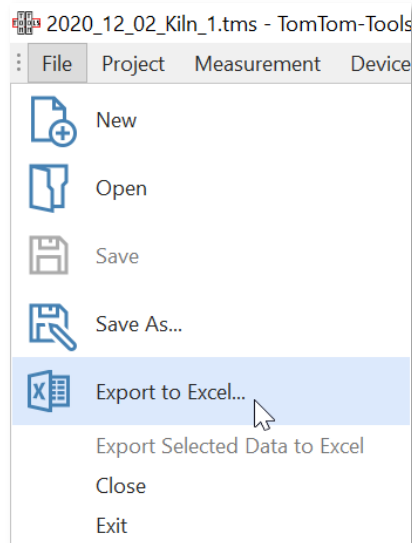
$$X \geq \frac{L}{100}$$

Note:

The decision to replace a piece of kiln shell should be based also on the refractory lifetime history and not only on deformation measurement results

8. **REPORT**

8.1 **Export to Excel**



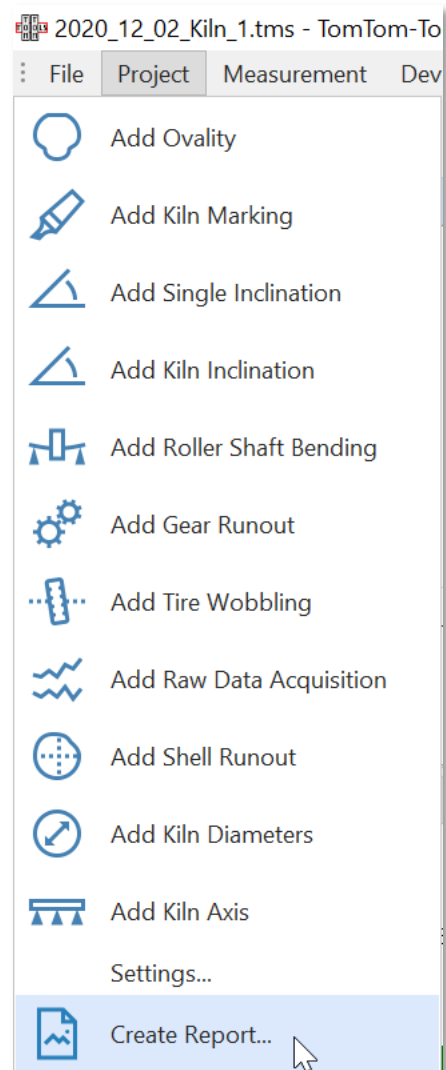
All data can easily be exported to excel.

Fig.8.1.1

8.2 **Create a report**

The measurements can be extracted into a report.
All additional information from the “Settings Window”
is included in the report as well.

Fig. 8.2.1

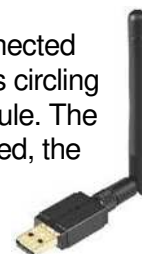


9. ROTATION TRIGGER (OPTIONAL)

The Rotation Trigger is a small unit, which provides via Bluetooth the rotation position of the kiln during the measurement campaign. It minimizes the need for the manual rotation indication (pushing “F9” button, see in chapter 5.3 “Take Measurement”)

9.1 Connect the Rotation Trigger with the PC

The Rotation Trigger is equipped with a long-range Bluetooth transmitter and gets connected to the PC in the same way as the Kiln Shell Laser. But for the Rotation Trigger, which is circling around the kiln, it is essential that also the PC is equipped with a strong Bluetooth module. The Bluetooth of the Panasonic Tablet PC FZ-G2, is strong enough, but if another PC is used, the long-range Bluetooth adapter, might be required. (see chapters 3 and 4).



9.2 Attach Rotation Trigger to Kiln

Typically, the rotation trigger remains at the same place on the kiln during the whole measurement campaign; hence it has to be attached where the temperature is low. In most cases, the side face of the girth gear is the best location.

Note:

It is important to attach it to one or the other side face (see picture below)

It has not to be aligned in a special way.

Do not attach it on a tire unless the temperature is below 70°C.

Fig.9.2.1

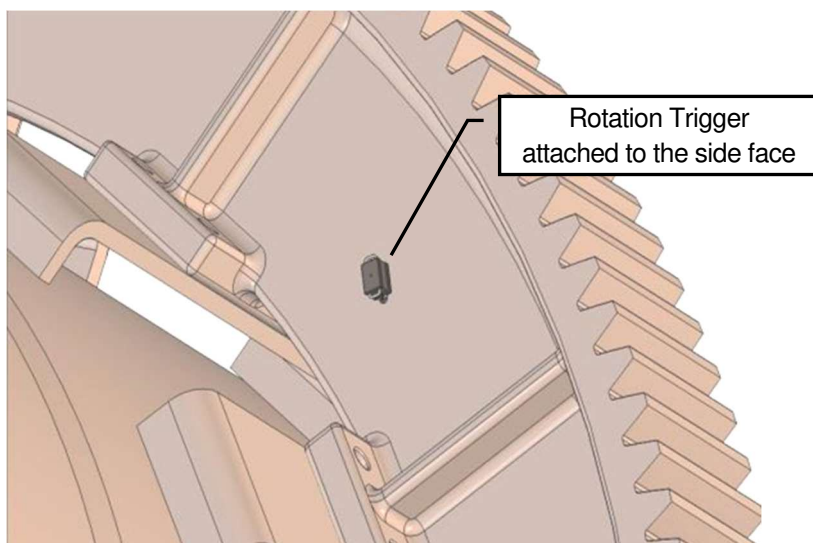
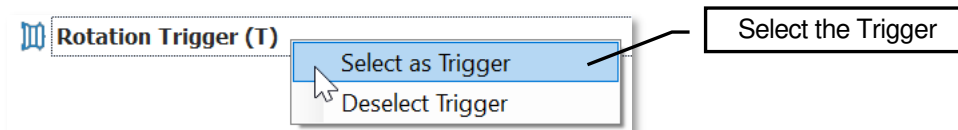


Fig.9.2.2 Rotation Trigger

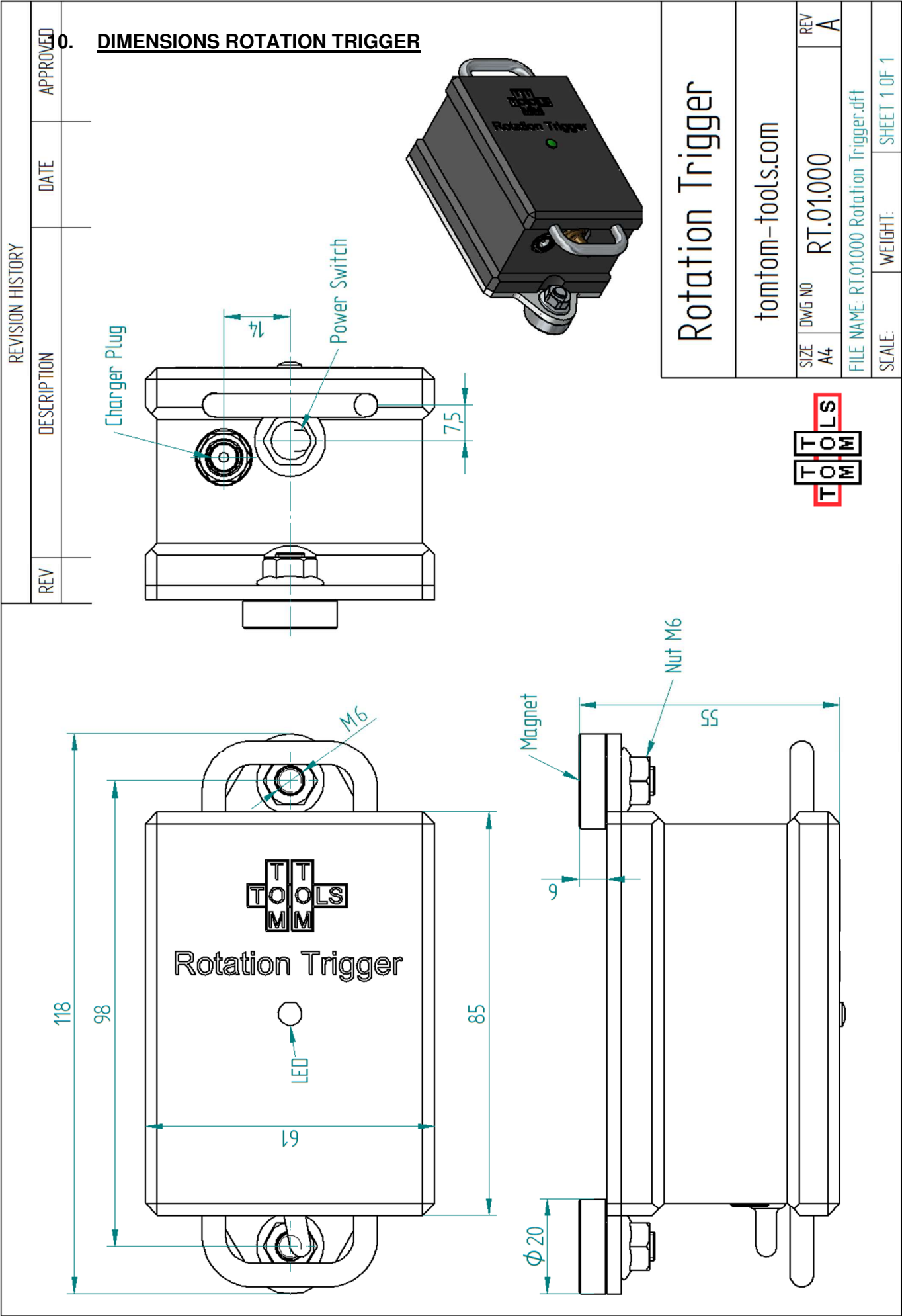


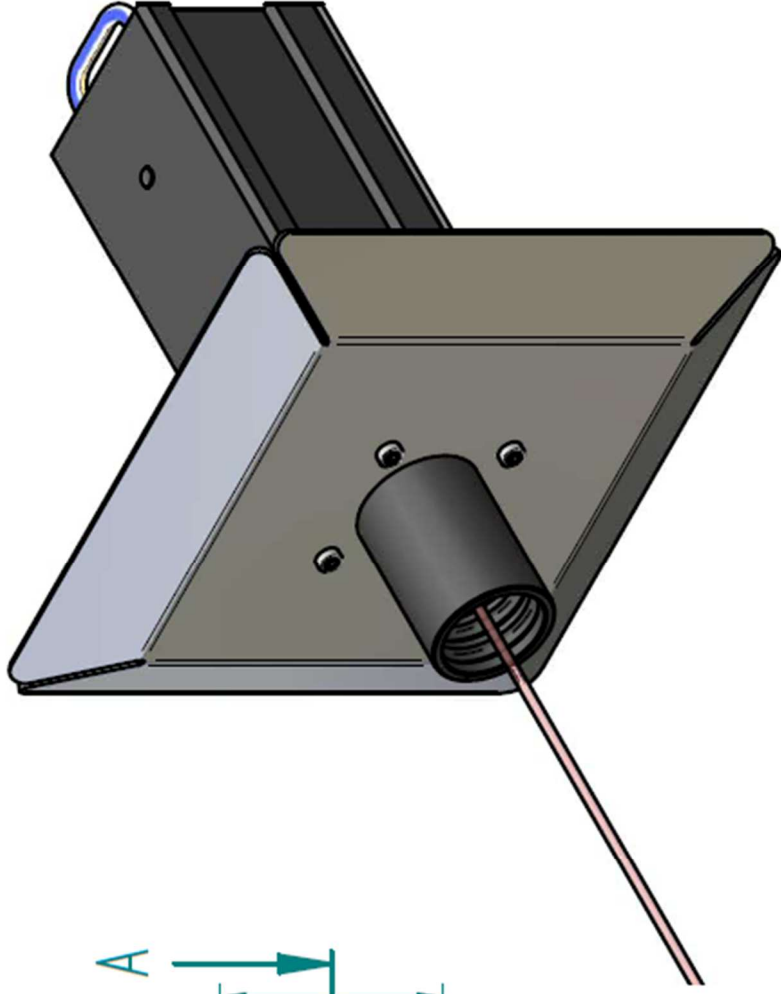
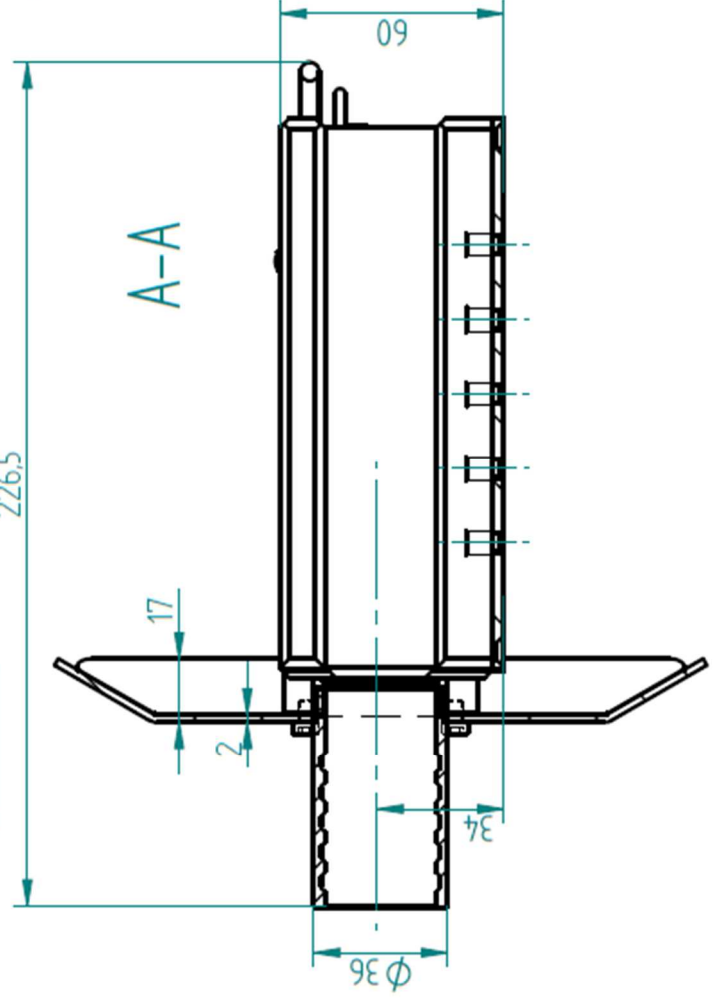
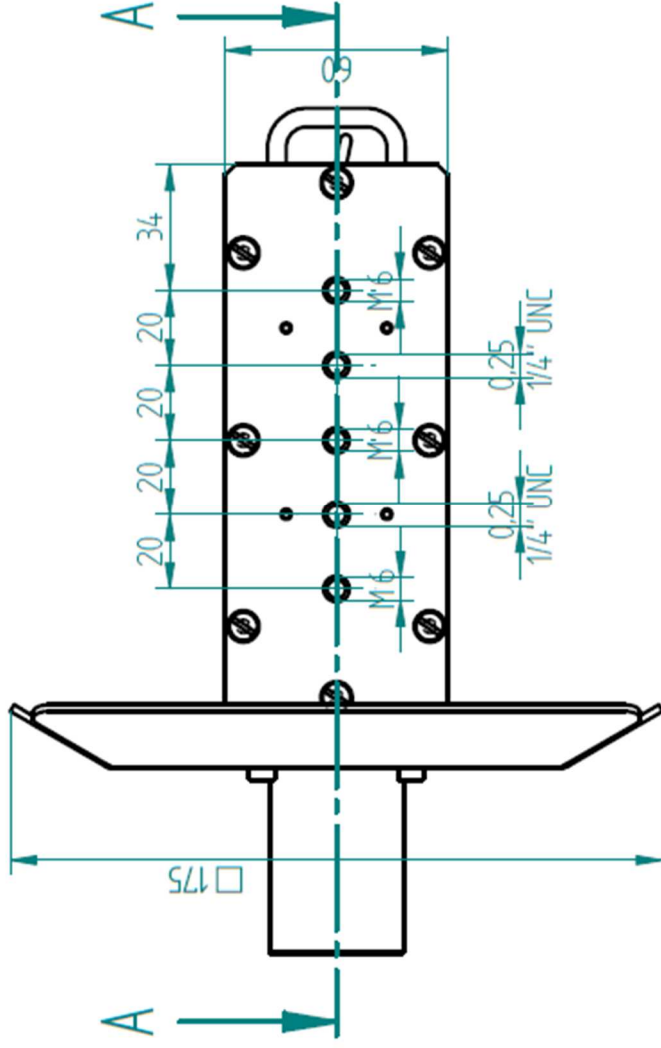
9.3 Combined Measurement with Kiln Shell Laser and Rotation Trigger

To use the signal coming from the Rotation Trigger, it has to be selected in the “Settings Window” by right mouse click. (See picture)



Note: In the moment when the reference point (typically the man hole) is in line with the laser point, “F9” has to be pushed. With the Rotation Trigger this still applies for the first time of each measurement point; in the consecutive revolutions it will be done automatically.





Kiln Shell Laser

TomTom-Tools Ltd.

SIZE	DWG NO	REV
A4	KSL01.000	
FILE NAME: Kiln Shell Laser.dft		
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1