tecnar

shotmeter 4.0

User manual

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Rev. A

Revision History

Rev	Description	Written by	Date
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NOTICES

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1. Introduction

1.1. Purpose

The present document gives a complete description and principles of operation of the Shotmeter 4.0 sensor as well as a description of its components.

1.2. Scope

This user manual is intended for engineers, technicians, and operators with a technical background in the shot peening industry who are responsible for the installation, operation, and maintenance of the shot peening sensor. It provides detailed guidance on safe handling, proper setup, integration with peening systems, and interpretation of measurement data. The document assumes a working knowledge of shot peening processes and equipment. It is designed to support users in achieving seamless integration of the sensor within existing shot peening setups while maintaining compliance with industry safety and quality standards.

2. Definitions and Abbreviations

A: Ampere (amperage)

A.U.: Arbitrary units

A/R: As required

CFM: Cubic Feet per Minute

CMOS: Complementary Metal-Oxide-Semiconductor

DHCP: Dynamic Host Configuration Protocol

FIFO: First in, first out

Hz: Hertz (frequency)

in.: Inch

kg: Kilogram

lb: Pound (mass)

LED: Light Emitting Diode

LPM: Liters Per Minute

Max: Maximum

Min: Minimum

m/s: Meters per second

mm: Millimeters

NTP: Network Time Protocol

PLC: Programmable Logic Controller

PSI: Pound per square inch

UTC: Universal Time Control

SD: Standard Deviation

Shotmeter 4.0: Product name of shot peening sensor.

Standoff distance (SOD): distance between the axis of peening nozzle and the position of measurement.

UI: User Interface

V: Volt (voltage)

VAC: Volt Alternating Current

Working distance: Distance between the nozzle axis and the window of the sensor (perpendicular to the axis of the nozzle)

3. Safety Considerations

The Shotmeter 4.0 has been designed with user safety in mind; however, improper use may result in injury, damage to the product, or hazardous situations. To ensure safe operation, please read and follow all instructions and warnings in this manual before use.

3.1. General safety

WARNING

DISCONNECT POWER BEFORE INSTALLING, SERVICING, OR REMOVING THE SENSOR. ENSURE ALL WIRING IS PROPERLY GROUNDED AN MEET LOCAL ELECTRICAL SAFETY STANDARDS. FAILURE TO SO MAY CAUSE DAMAGE TO EQUIPMENT AND FATAL INJURIES.

CAUTION

MAKE SURE TO CONNECT THE SHOTMETER 4.0 TO AN UNLOADED, PROPERLY GROUNDED POWER LINE (115VAC 4A / 230VAC 2A, 50-60Hz). FAILURE TO DO SO MAY CAUSE DAMAGE TO PROPERTY AND TO SHOTMETER 4.0. IT IS HIGHLY RECOMMENDED TO USE AN ADDITIONAL POWER LINE FILTER TO PREVENT ANY POWER SURGES OR BURSTS.

CAUTION

ONLY OPERATE THE SHOTMETER 4.0 WITHIN ITS SPECIFIED TEMPERATURE AND ENVIRONMENTAL LIMITS. EXCESSIVE HEAT, VIBRATION, OR CONTAMINATION MAY CAUSE DAMAGE OR FAILURE OF THE EQUIPMENT.

CAUTION

USE ONLY ORIGINAL SPARE PARTS PROVIDED BY TECNAR. THE USE OF NON-ORIGINAL OR UNAUTHORIZED COMPONENTS MAY COMPROMISE SYSTEM PERFORMANCE, CAUSE DAMAGE TO EQUIPMENT, AND VOID WARRANTY.

NOTE
IMPROPER CALIBRATION OR ALIGNMENT OF THE SENSOR MAY RESULT IN INACCURATE MEASUREMENTS OR REDUCED SYSTEM PERFORMANCE. FOLLOW ALL INSTALLATION AND SETUP INSTRUCTIONS CAREFULLY.

Failure to follow these safety considerations may result in product malfunction, injury, or legal liability. Always operate the Shotmeter 4.0 in accordance with local safety regulations and industry best practices.

3.2. Lamp safety

The following precautions should be observed at all times while operating the Shotmeter 4.0. Tecnar Automation Ltée assumes no liability whatsoever for a user's failure to comply with these precautions or the warnings throughout this manual.

CAUTION
THE SHOTMETER EMITS A MAXIMUM OF 35W OF INFRARED, VISIBLE, AND ULTRAVIOLET LIGHT FROM AN INCANDESCENT LIGHT BULB. YOU SHOULD NEVER LOOK DIRECTLY AT THE SHOTMETER FROM THE FRONT WHILE THE LAMP IS OPEN, SINCE THIS CAN CAUSE DAMAGE TO THE EYE (RETINA AND/OR CORNEA).

The Shotmeter 4.0 uses a 35 W halogen lamp equipped with an optical lens to concentrate light onto the measurement volume. This illumination enables the system to capture and analyze the light reflected by the media passing by its measurement volume. It radiates light in the infrared, visible, and UV range.

According to the international standard IEC 62471, this lamp is classified as Risk Group 2 (moderate risk). The natural human reaction times allow you to blink/close your eyes in time to prevent permanent eye damage. However, direct or prolonged viewing of the lamp should be avoided to minimize the risk of eye injury.

The following table outlines the applicable safety warnings for a Risk Group 2 lamp, categorized by the type of emitted radiation.

TABLE 1 – RISK GROUP 2 LAMP SAFETY WARNING

Hazard	Group 2 Safety Warning
Actinic UV	CAUTION. UV emitted from this product. Eye or skin irritation may result from exposure. Use appropriate shielding.
UVA	CAUTION. UV emitted from this product. Eye or skin irritation may result from exposure. Use appropriate shielding.
Blue Light Radiance	CAUTION. Possibly hazardous optical radiation emitted from this product. Do not stare at the operating lamp. Maybe harmful to the eye.
Retinal Thermal Hazard	CAUTION. Possibly hazardous optical radiation emitted from this product. Do not stare at the operating lamp. Maybe harmful to the eye.
IR Radiation Eyes	CAUTION. IR emitted from this product. Do not stare at the operating lamp.
Retinal Thermal Hazard Weak Visual	CAUTION. IR emitted from this product. Do not stare at the operating lamp.

4. Product Overview

The Shotmeter 4.0 is an optical diagnostic system designed for real-time monitoring of shot peening processes. By analyzing in-flight media characteristics and jet properties, it provides continuous feedback on key in-flight characteristics. This allows operators to monitor process stability, verify compliance with predefined acceptance ranges, and maintain consistent surface treatment quality throughout production.

The system integrates seamlessly into shot peening setups and offers automated data acquisition, visualization, and storage through its dedicated user interface.

4.1. Product Description

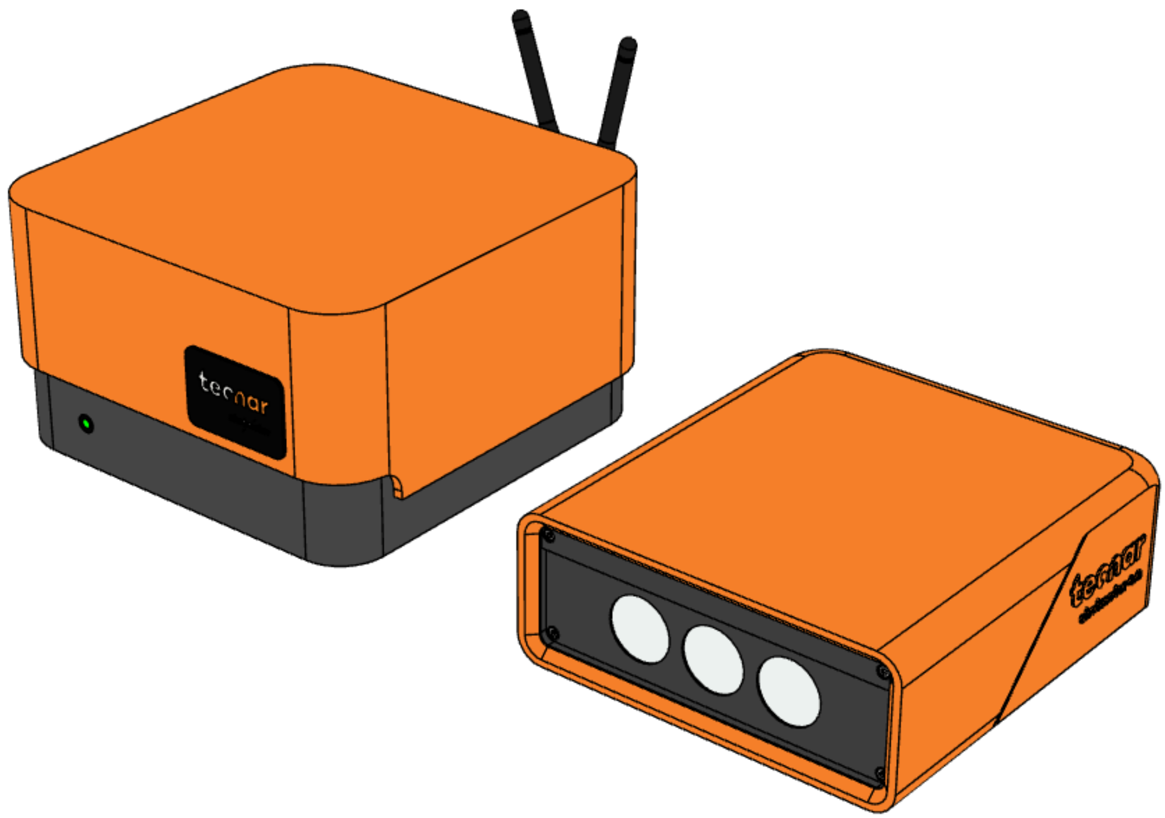


FIGURE 1 - SHOTMETER 4.0 MAIN COMPONENTS

The main purpose of the Shotmeter 4.0 is to ensure consistent, high-quality surface treatment by monitoring the shot peening stream properties before each run. This ensures that they are within predetermined acceptance ranges for ideal surface properties.

To help detect potential equipment problems such as air pressure variation, nozzle and/or hoses degradation, inconsistent particle velocity, and instability of the media feed before the shot peening process, the Shotmeter monitors:

- Media velocity.
- Shot stream profile.

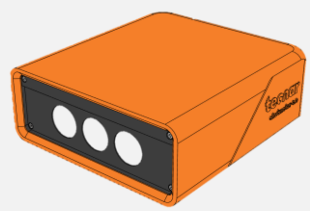
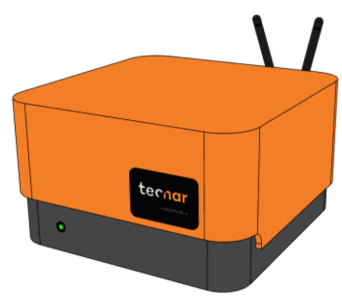
The Shotmeter 4.0 can also be used to:

- Develop and optimize shot peening parameters.
- Transfer parameters from one peening cell to another (anywhere in the world).
- Reproduce the same velocity from one nozzle to another.
- Extend the useful lifespan of hardware.
- Reduce the number of Almen strips used for validation.
- Troubleshoot day-to-day issues.

4.2. Product Specifications

Specifications for the primary components of the Shotmeter 4.0 are detailed in the following table:

TABLE 2 - PRODUCT SPECIFICATIONS

Components	Specifications		Visual
Sensor Head	**Dimensions**	Width: 200 mm Length: 210 mm Height: 75 mm	
	Weight	3.3 kg (7 lbs)	
Controller	**Dimensions**	Width: 230 mm Height: 230 mm Length: 132 mm	
	Weight	6.6 kg (15 lbs)	
	Power Requirements	115VAC 4A / 230VAC 2A, 50-60Hz	

4.3. Technical Specifications

The following table presents the technical specifications of the Shotmeter 4.0.

TABLE 3 - TECHNICAL SPECIFICATIONS

Measurements	
Particle Velocity	10-1200 m/s (30-4000 ft/s) at 2% precision
Process Brightness	5% accuracy
Process stability	Automatic instability detection
Measurement Area Information	
Velocity Measurement Area with Cylindrical Lens (default)	2.2 mm x 16 mm = 35mm² (0.09 in. x 0.63 in. = 0.055 in.²)
Working Distance	125 mm (4.9 in.)
Velocity Measurement Area without Cylindrical Lens	Ø2.2 mm = 3.8 mm² (Ø 0.087 in = 0.006 in.²)
CMOS Camera Field View	290 mm (17.7 in.)
Plant Supplies	
Electrical requirements	115VAC 4A / 230VAC 2A, 50-60Hz
Air Supply	1.7 to 2.7 bar (25-40 psi) of clean and dry air

4.4. Components Description

The Shotmeter 4.0 system includes the following elements:

1. A sensor head
2. A controller
3. Air hoses and filter
4. Controller power cable and adapter
5. Sensor head communication and illumination lamp power cables

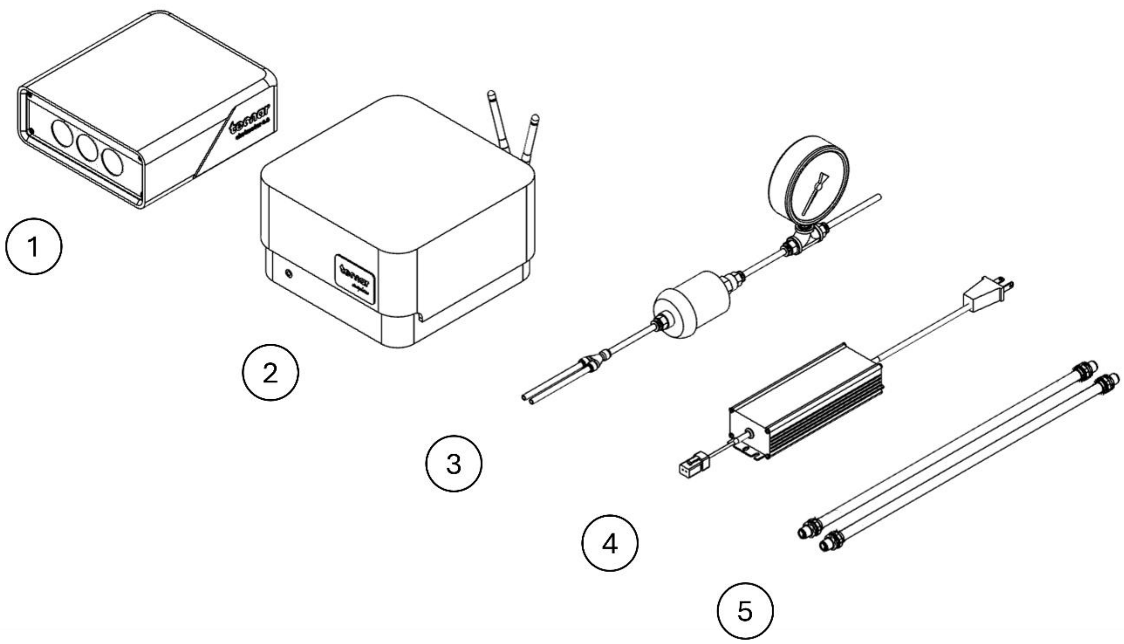


FIGURE 2 - SHOTMETER 4.0 COMPONENTS DESCRIPTION

Each element is described in detail on the following pages.

4.4.1. Sensor Head

The sensor head measures the following media properties:

- Media's velocity
- Peening stream brightness

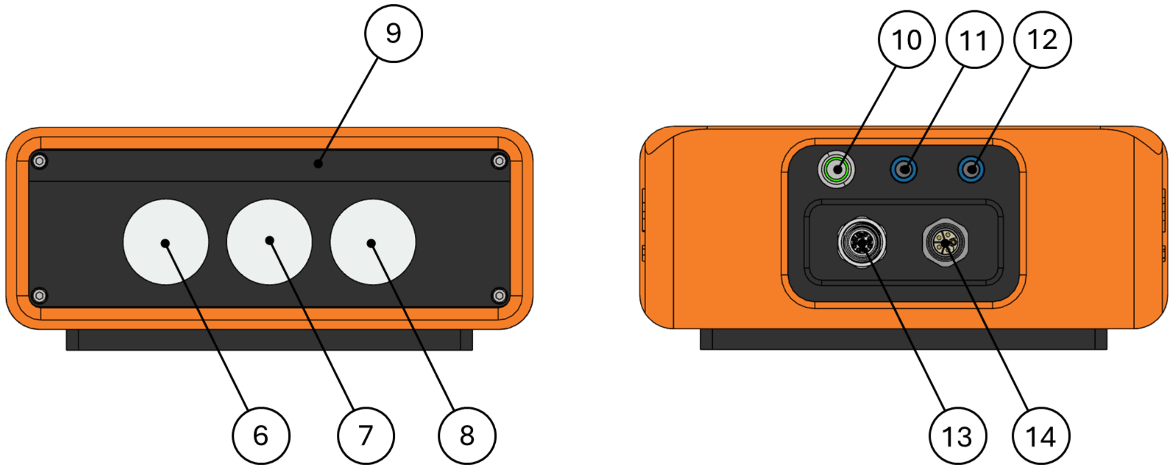


FIGURE 3 - SENSOR HEAD (FRONT AND REAR VIEW)

The following table details all the features on the Shotmeter 4.0 sensor head.

TABLE 4 - SENSOR HEAD DESCRIPTION

Components	Description
6. Camera viewport	Viewport of the camera used to characterize the peening jet geometry.
7. Lamp viewport	Viewport of the lamp that illuminates the particles.
8. Optical system viewport	Viewport of the velocity measurement sensor.
9. Air knife	Cleans and keeps Shotmeter windows free of dust.
10. Alignment beam switch	Activation switch for the alignment beam.
11. Compressed air inlet #1	Compressed air inlet used to actively cool the head's internal components.
12. Compressed air inlet #2	Compressed air inlet used to generate an air knife to keep windows clean.
13. Communication cable	Used to power the sensor head and communicate with the controller.
14. Illumination lamp power cable	Used to power and communicate with the illumination lamp.

4.4.2. Controller

The controller receives readings from the sensor head. It processes the data and broadcasts the results to the user interface. The controller must be kept in a ventilated area to reduce the risk of overheating. The Shotmeter 4.0. Unit should only be used at an ambient temperature between 4 and 45°C.

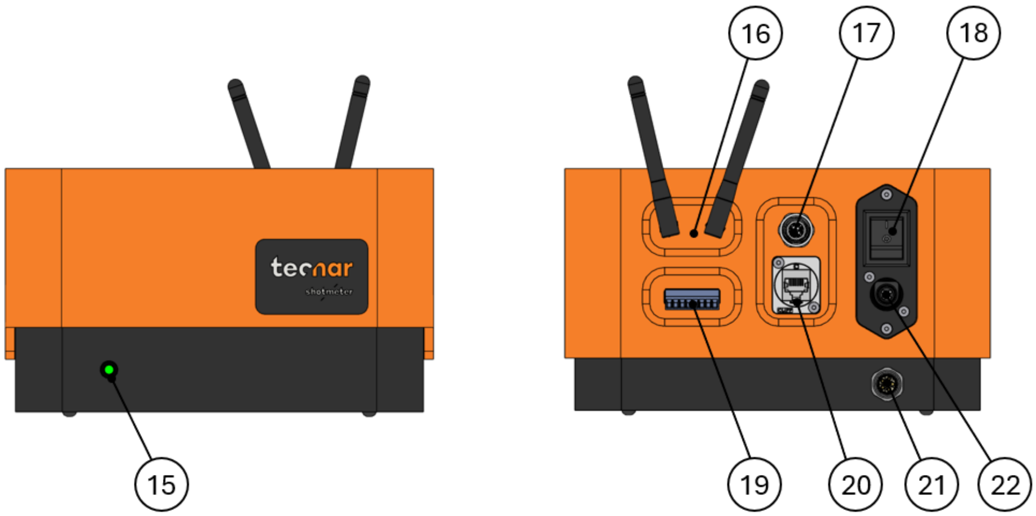


FIGURE 4 - CONTROLLER (FRONT & BACK)

The following table details all the features on the Shotmeter 4.0 controller.

TABLE 5 - CONTROLLER DESCRIPTION

Components	Description
15. LED	**OFF**: Power supply is OFF. **Green**: The system is working properly. **Yellow**: Sensor head is not connected. **Red**: Unit powered up but is in error state.
16. Wi-Fi antennas	Used to access the Shotmeter user interface through a wireless network connection. The Wi-Fi connection acts as a hotspot. It can be disabled but not reconfigured.
17. Sensor head communication cable	Used to power and communicate with the sensor head.
18. Power switch	Used to activate the unit.
19. I/O interface	Used to interface the Shotmeter to the user's controller via digital I/O ports.
20. Ethernet	Used to access the Shotmeter user interface through a wired network connection (either static or DHCP).
21. Illumination lamp power cable	Provide power to the illumination lamp.
22. Power inlet	Provides power to the Shotmeter.

4.4.3. Cables, Hoses, and Antennas

The Shotmeter 4.0 is delivered with several cables, hoses, and antennas, which are described in the following table.

TABLE 6 - CABLES, HOSES, AND ANTENNAS DESCRIPTION

Components	Description
IEC power cable	Used to connect the Shotmeter to a power outlet.
Illumination lamp power cable	Used to connect the illumination lamp between the head and controller.
Communication cable	Communication between the controller and the measurement head.
Antennas	Used for Wi-Fi communication.
Compressed air hoses	Provide compressed air to the measurement head for cooling and purging purposes. • One hose connects the compressed air supply to the air filter • One hose connects the air filter to the pressure regulator • One hose connects the regulator to the measurement head

4.5. Software Overview

4.5.1. User Interface Overview

The user interface can be accessed with most internet browsers. Tecnar recommends using Google Chrome or Microsoft Edge (Chromium-based) browsers. Any modern computer with at least 4GB of RAM should be sufficient to run the user interface smoothly. Connect the PC to the controller via an Ethernet cable or through the built-in Wi-Fi.

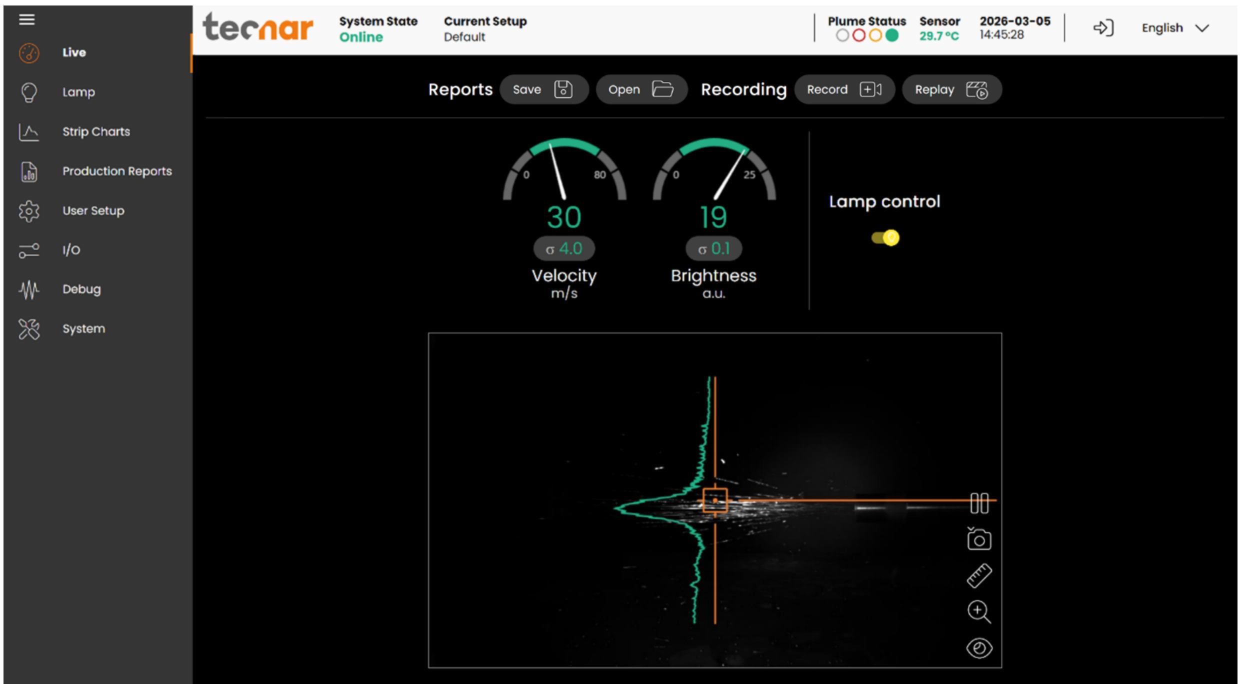
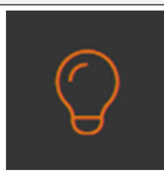
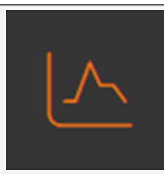
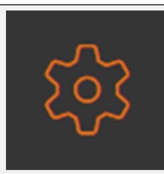
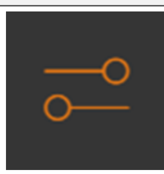
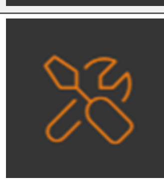


FIGURE 5 - SHOTMETER 4.0 USER INTERFACE

4.5.2. Navigation Tabs

The navigation icons are displayed at the top of the Shotmeter user interface to access the different tabs. The following table describes those icons.

TABLE 7 - USER INTERFACE ICON DESCRIPTION

Icons	Description
	**Live** Access the main measurement screen (in real time).
	**Lamp** Access the lamp dashboard.
	**Strip Charts** Access the strip charts screen.
	**Production Reports** Access the production files screen.
	**User Setup** Access the setup screen (sensor parameters).
	**I/O** Access the I/O dashboard.
	**Debug** Access the debug page to help with troubleshooting
	**System** Access the system settings.

4.5.3. Live Screen

The **Live** screen displays in real time all measurements taken by the Shotmeter.

The measurements are displayed at the top of the screen.

Color codes indicate whether the measurements are within the acceptance range as defined in the User Setup by the process engineer.

A measurement fully within the acceptance range is shown in green.

A measurement just barely within the acceptance range is shown in yellow.

A measurement outside the acceptance range is shown in red. When properly configured, corrective actions should be taken to ensure that all measurements are within the acceptance range and displayed in green.

In the middle of the screen, in the camera view, an orange bullseye represents the position where the media velocity is measured. The distance between the bullseye and the tip of the peening nozzle, called the standoff distance (SOD), is represented by the dotted horizontal orange line. The green curve shows the media stream brightness profile as measured by the sensor along the orange vertical line, called the sampling line.

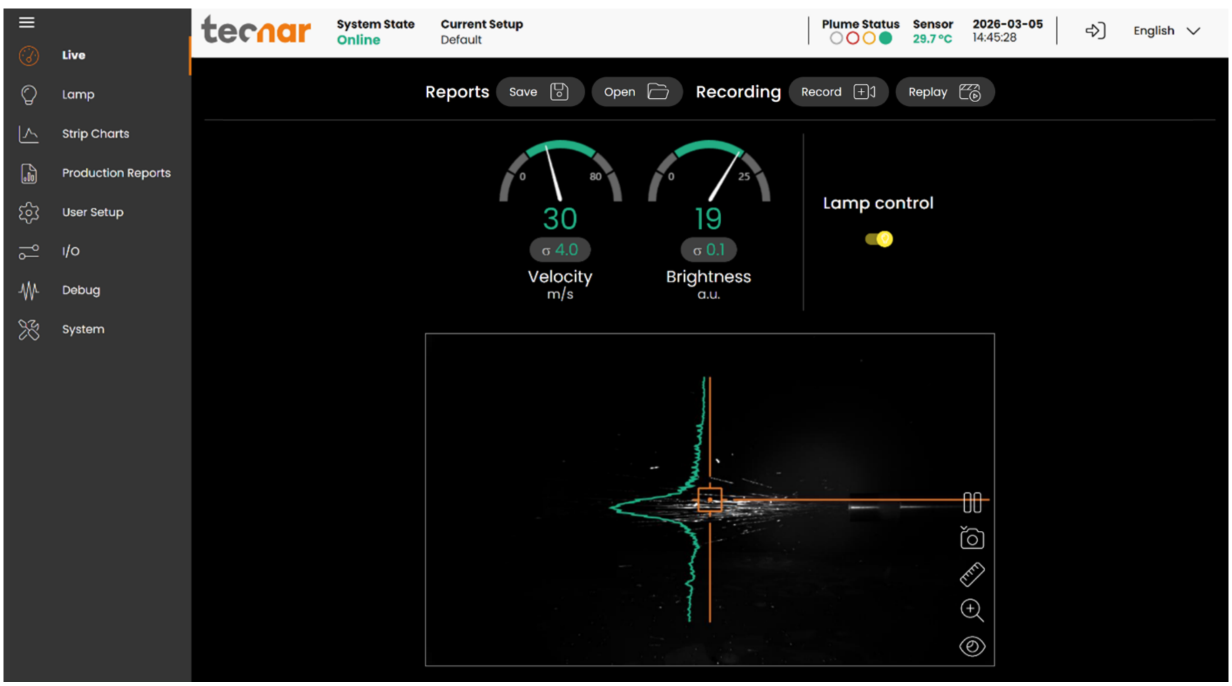


FIGURE 6 - SHOTMETER 4.0 LIVE SCREEN

The different measurements provided by the Shotmeter are described in detail in the table below.

TABLE 8 – DESCRIPTION OF PARAMETER PROVIDED IN THE USER INTERFACE

Parameters	Description
Velocity	Average media speed passing through the sensor's measurement volume (represented by the bullseye).
Brightness	Camera brightness of the media jet. This measurement is very sensitive to minute changes in the peening conditions. The parameters that have the strongest effect on the brightness are: • Average media size and size distribution • Media type (reflectivity) • Protective windows cleanliness • Media velocity • Feed rate • Background[1] • Sampling line length[2]
Process stability	The stability of the process. This value will vary based on the selected stability mode.
Measurements standard deviation	Each measurement given by the Shotmeter comes with a standard deviation, which is an indication of the spread of the data around the average value. This value is always positive. For example, a process where every velocity reading is exactly 50 m/s will have a standard deviation of 0, but a process having velocities varying from 40 to 60 m/s could have the same average value but a higher standard deviation. See the **APPENDIX A** for more details.

[1] Use the following guidelines for the background configuration:

- Keep the background surface as far as possible from the sensor head.
- The background surface should be as non-reflective as possible, especially in situations where the surface is close to the stream.
- It should be kept constant between experiments.
- If you have any doubts about the measurement field of view, contact Tecnar Service Team at service@spraysensors.tecnar.com

[2] When possible, the sampling line should be long enough to cover the entire jet, with both ends located in a quiet zone or a region of consistently low signal. Its length should be kept constant across experiments to ensure valid comparisons.

4.6. Software Functionalities

4.6.1. Zoom in / Zoom out

It is possible to zoom in on the image.

To do so, click on the magnifying glass icon or use the scroll wheel. To return to the full screen click on the magnifying glass again.

The zoom will not affect the readings.

4.6.2. Recording a Video Sequence

Sequences can be recorded and replayed using the icons at the top right of the **Live** page. The camera icon or **Record** is used to start recording. A minimum of 5 seconds must be recorded before clicking the **Stop Recording** button.

Once the Shotmeter is recording, the camera icon will appear in the header and start blinking red. The video length will also be displayed.

To stop recording, click on the square icon next to the camera. This will automatically download the sequence to your computer in your web browser's default download directory. Simultaneously, you will have access to a dialog box to name and give a description to the video sequence. The controller will also save and generate a report (.pdf + .csv) that will be stored in the controller. The loading overlay will appear during that time, indicating "Saving Report in the Controller".

Recorded video sequences (video files) are not stored on the Shotmeter Controller. Lastly, it is not possible to start recording a sequence when the setup is unsaved. This is intended to avoid confusion and discrepancies with the active setup.

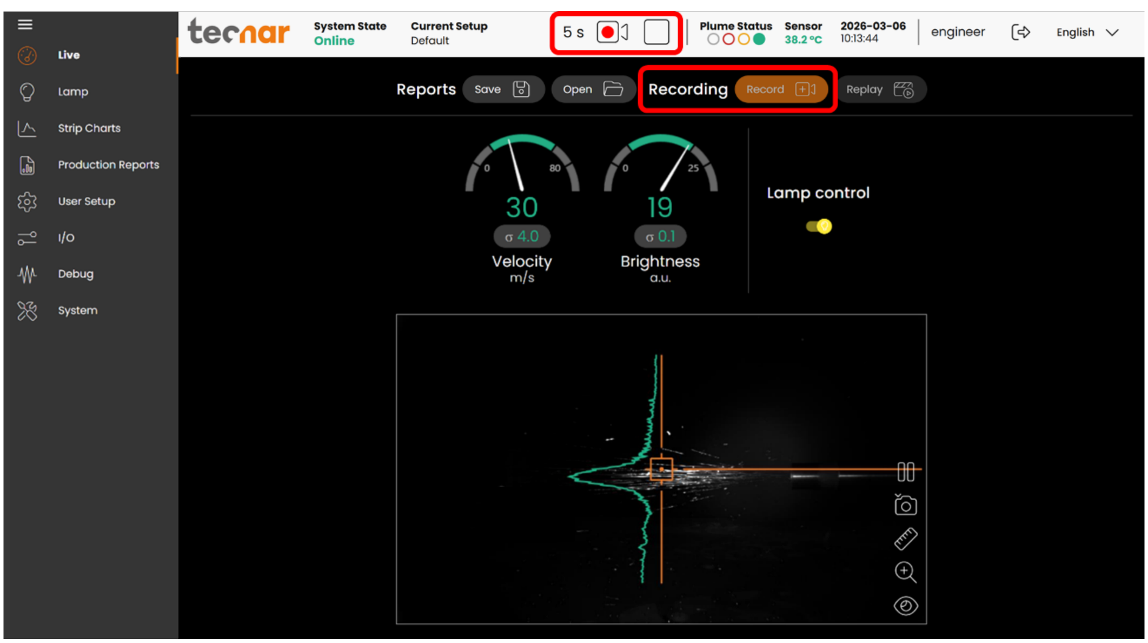


FIGURE 7 - VIDEO RECORDING SEQUENCE

4.6.3. Replaying a Video Sequence

To open and start replaying a saved sequence, click on the **Replay** button next to the **Record** button, and select the sequence that you want to replay.

The video sequences are not stored on the Shotmeter controller. You will find them on your computer in your default download directory or wherever you have stored them.

When replaying a sequence, the **Stop Replaying** icon will appear. Use it to exit replaying mode and go back to live mode.

It is possible to pause a sequence using the **Pause** icon and resume playback using the **Play** icon. You can also switch from the **Live** screen to the **Strip Chart** screen to view the plots in real-time.

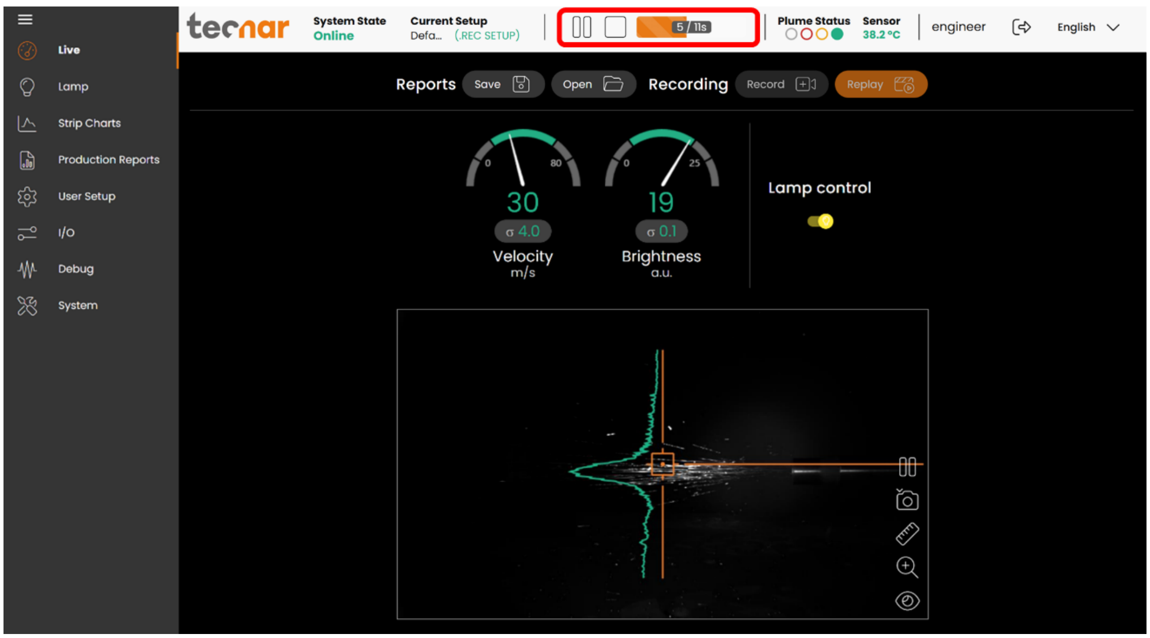


FIGURE 8 - VIDEO PLAYBACK

In video mode, the setup parameters will reflect the ones that were active at the time of the recording.

4.6.4. Selecting Active Gauges

It is possible to select active gauges for the measurement status. Inactive gauges will NOT be considered for the measurement status (output state). In some cases, you may want to focus on certain measurements, since other measurements may be less relevant to you based on your process and application. In that case, "uncheck" the gauges that you wish to deactivate. Inactive gauges will not show up in the **Live** screen, nor in the **Strip Charts** tab. However, the data for these measurements will still appear in the **Strip Charts** when you save a production report.

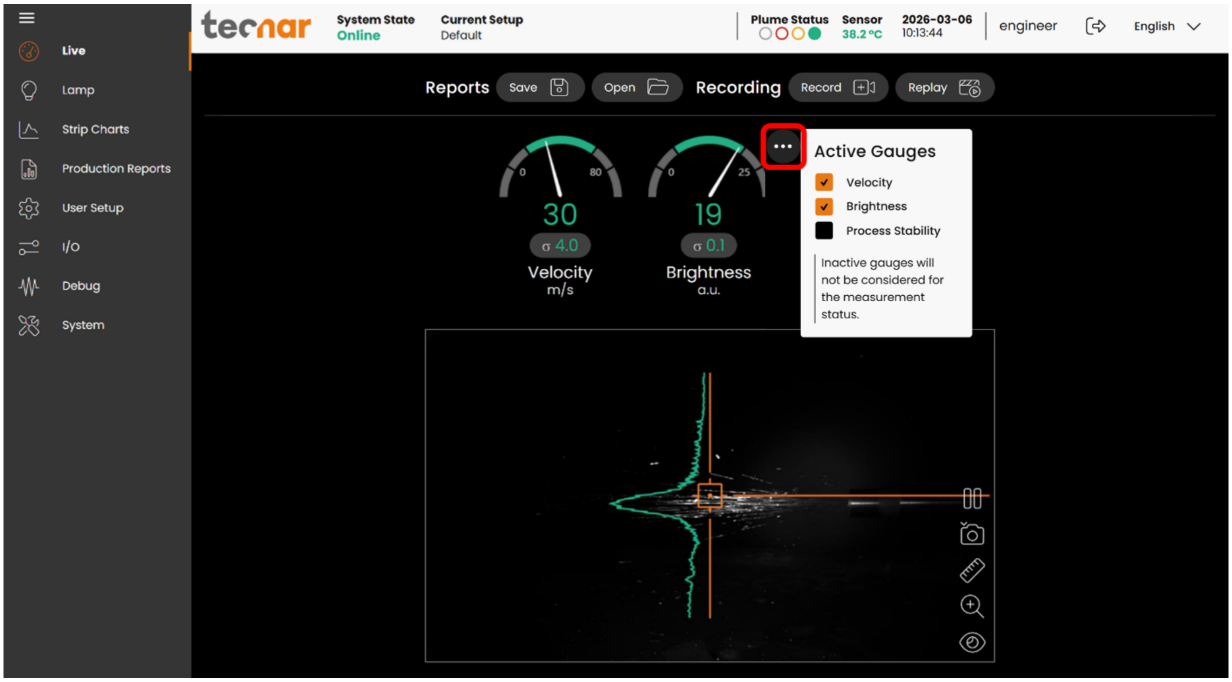


FIGURE 9 - ACTIVE GAUGES

Clicking on the triple dots button will open the **ACTIVE GAUGES** menu. This button is also duplicated in the **User Setup** tab. It is located under **Gauge Parameters**.

4.6.5. Strip Chart Screen

The **Strip Charts** screen displays the evolution over time of measurements available on the **Live** screen. In the middle of the screen, you will find two graphs, each displaying one type of measurement.

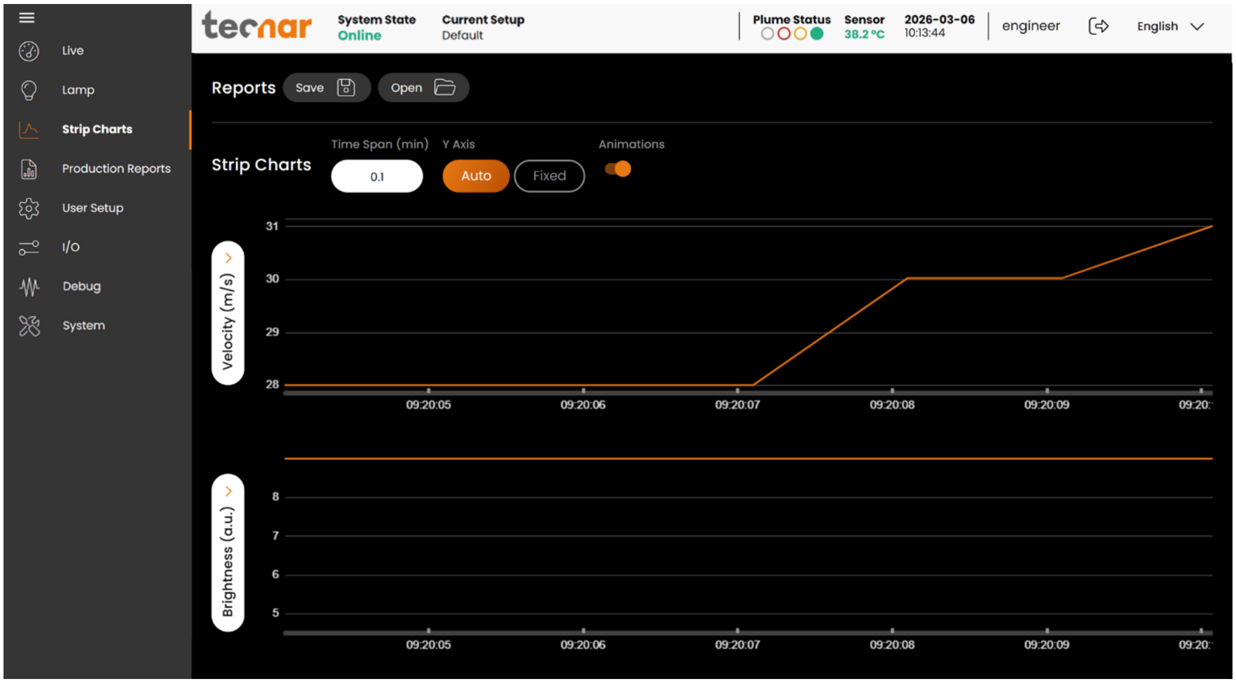


FIGURE 10 - STRIPCHART SCREEN

4.6.6. Adjusting the Time Span

The time duration displayed on the strip charts can be adjusted using the number input at the top left of the page. The charts can display up to 24 hours of measurements. The default value is 5 minutes. The minimum time span is 0.083 minute (5 seconds), and the maximum is 24 hours (1440 minutes).

The last 24 hours are stored in the database and can be recalled at any time.

4.6.7. Adjusting the Y-Axis Display

The range of the strip charts Y-axis can be adjusted in two ways:

- **Fixed**: sets the Y-axis limits (min and max values) according to the acceptance ranges as defined in the setup.
- **Auto**: sets the Y-axis limits (min and max values) according to the full scale of the values captured by the sensor in the current **Time Span** selected.

4.6.8. Production Reports

Production reports can be generated from the **Strip Charts** screen, the **Live** screen, and through the IO module. When clicking the **SAVE** button, the data contained in the strip charts and a screenshot of the camera screen will be copied into a .pdf and .csv file. Setting a time span of 1 minute will generate a report that contains the last minute of data with one data point per second. Thorough analysis of the spray parameters can be found in the production report (.pdf). Recording a video file will also trigger a report generation. The name of the report will match the name of the video file.

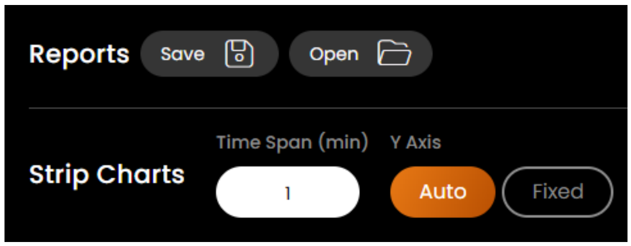


FIGURE 11 - STRIPCHART BUTTONS BAR

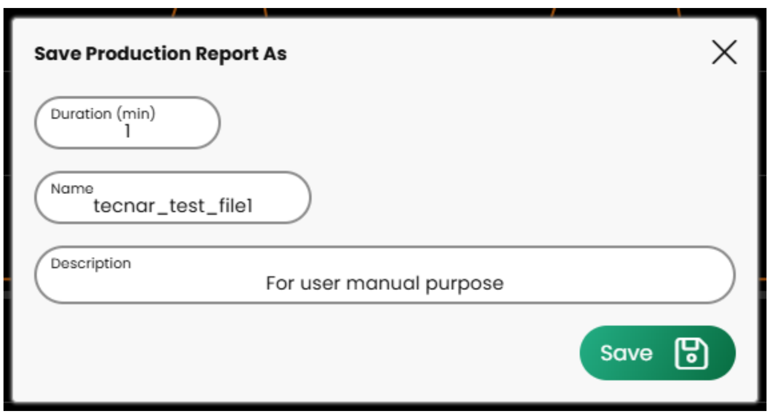


FIGURE 12 - SAVING PRODUCTION FILE

The production reports are stored on the Shotmeter controller's hard drive. The directory where the files are stored is accessible by clicking on the **Open** button. It also contains all the strip charts (.csv files) and the debug files. The duration of the strip charts in the production report is the same as the value in the user interface when the production report was generated. Clicking the **Open** button will redirect the user to the production files screen, directly in the folder of the last generated file. If desired, you can also use the raw .csv data and generate your own plots. Here is an example of the production report screen:

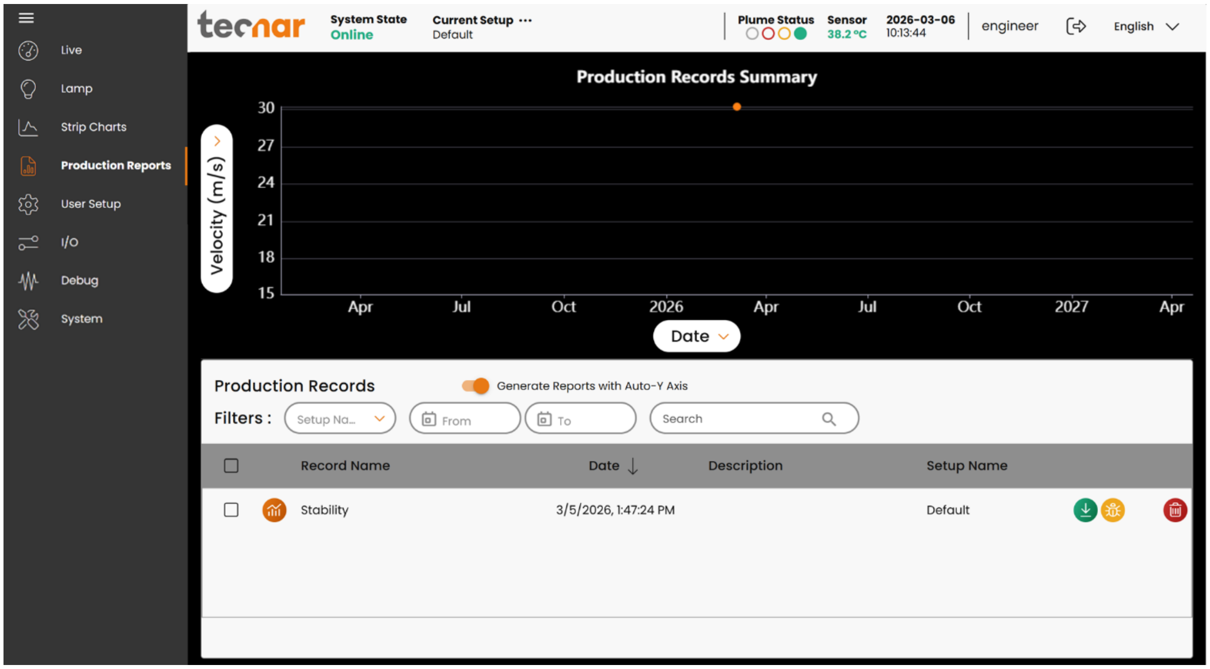
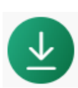


FIGURE 13 - PRODUCTION REPORT SCREEN

In this page, you can access all files that are saved on the Shotmeter's controller. In the top section of the screen, you can see a graph of the average measurement chosen (velocity in this example) of all production files that were recorded. Filters include the setup name and the date range. Those filters will change the data displayed on the top graph, only using data that respects the selected filters.

At the bottom of the screen, you will see all files recorded that respect the selected filters. The buttons are explained here:

 to view detailed information about a specific production file (see Figure 14).

 to download the PDF version of your production file.

 to download the CSV version of the production report and the debug files

 to delete the production files.

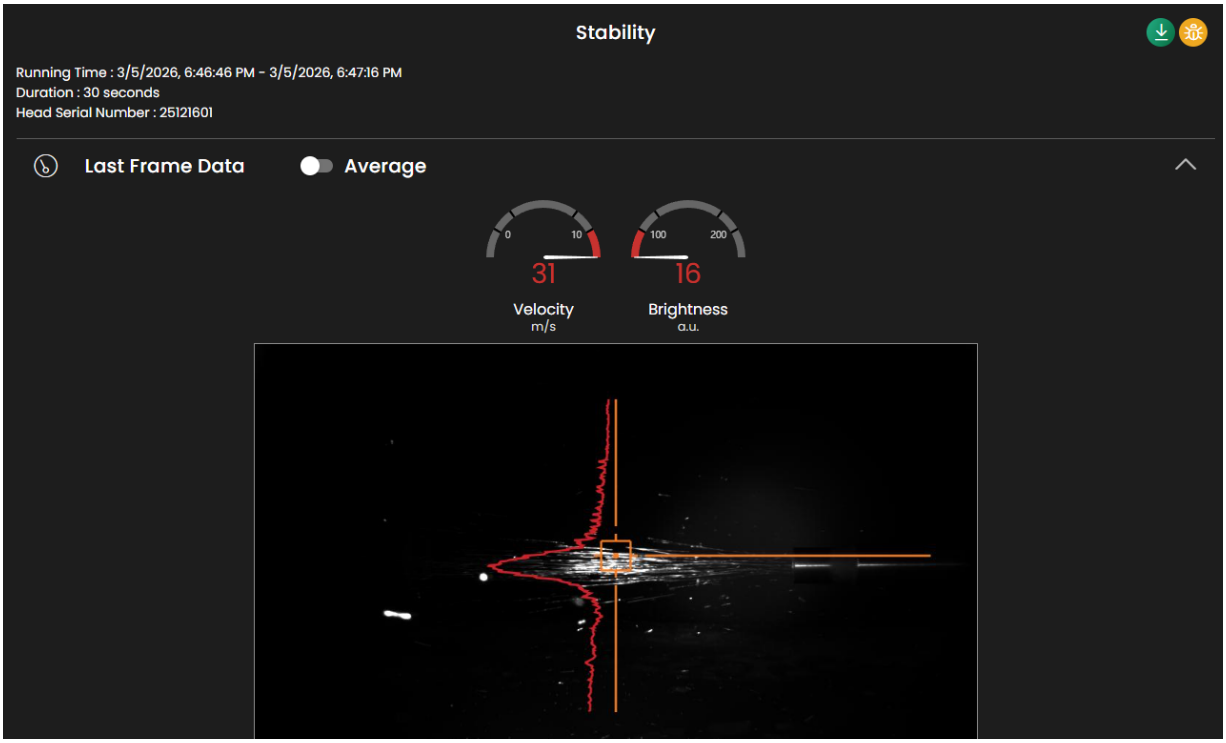


FIGURE 14 – SUMMARY OF THE PRODUCTION FILE

By default, this will show you the last frame measurements, but you can also toggle the **Average** button to see the average measurements of that production file. By scrolling down to the **Plume Characteristics** section, you will be able to see a detailed view of your production file for each measurement. You can change the axis to any measurement to review it.

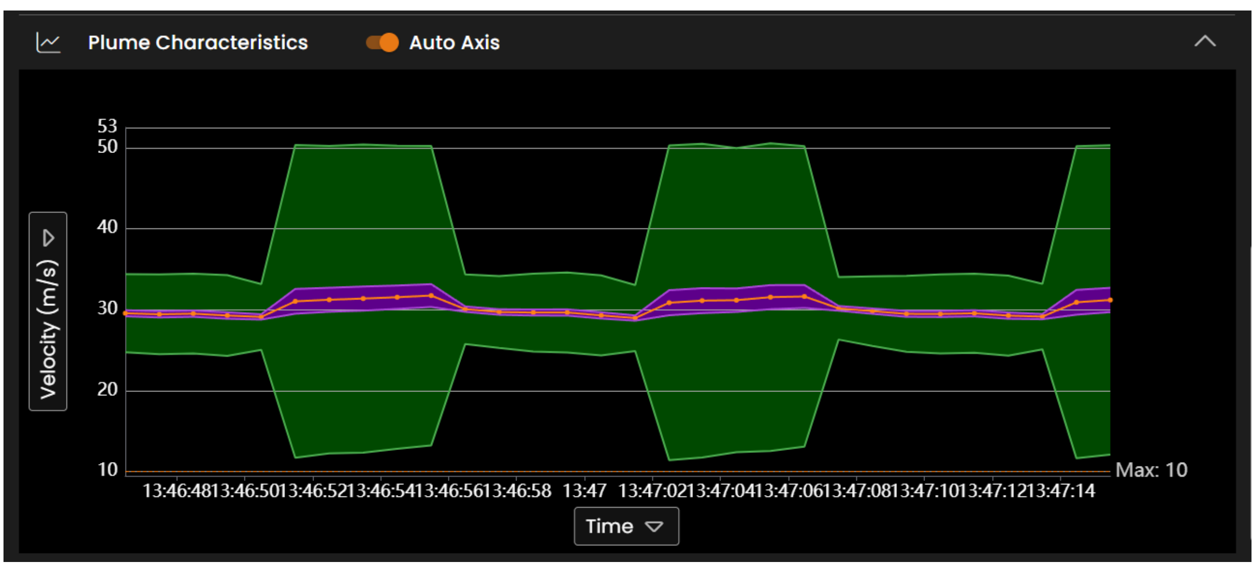


FIGURE 15 – PLUME CHARACTERISTICS OF THE PRODUCTION REPORT

When scrolling again, you will be able to see the **User Setup** details used while recording this production file.

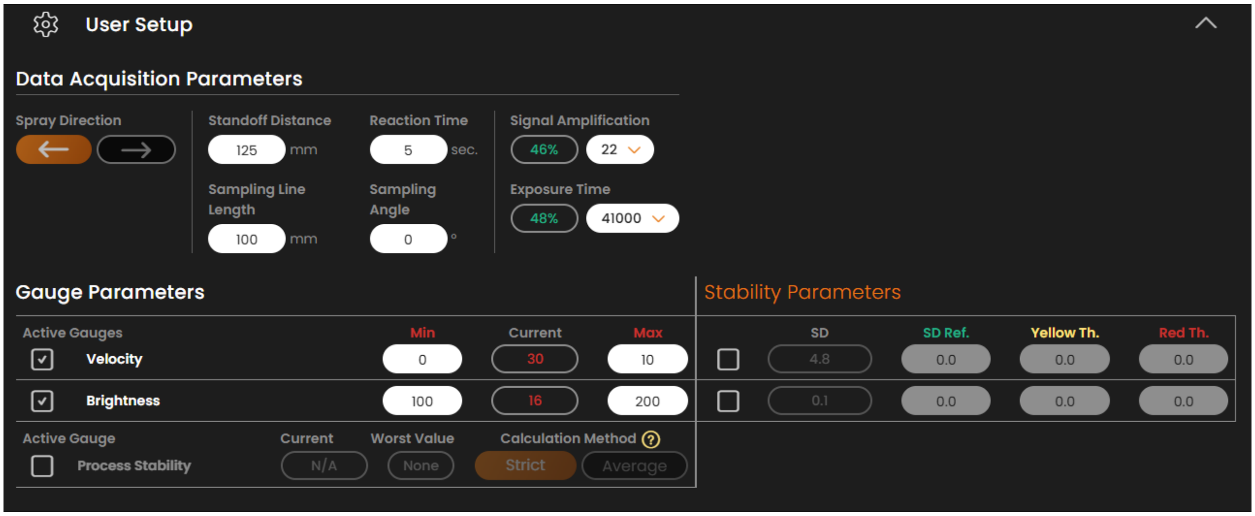


FIGURE 16 – USER SETUP OF THE PRODUCTION REPORT

4.6.9. Logging In Functionalities

The Shotmeter's interface allows multiple, simultaneous users (up to 5). For instance:

- One user or the "operator" can be using the system for measurement (will need to **Take Control** as covered in subsequent sections).
- Another user can be "watching" the "operator" from the engineering office via the network or wireless.
- Another user can be viewing saved files from previous runs in the QC department.

When accessing the Shotmeter interface, users who are not logged in are in viewer mode and can only visualize the sensor's readings from the live screen or the strip charts screen.

To make changes to the setup and record sequences, it is necessary to log in by clicking the designated icon. Users can log in either as an operator, an administrator, or an engineer.

- Operators (**username: operator**) can change (load) the setup used by the sensor and record measurement sequences. Operators cannot modify setups. The default password for operators is: **sm.operator**
- Administrators (**username: admin**) have the same rights as the operators and can also create, modify, and delete setups. The default password for administrators is: **sm.admin**
- Engineers **(username: engineer)** have the same rights as the administrators and can also access the **Debug** page. The default password for engineers is: **sm.engineer**

To log in, click on the “Log in” icon to display the login window and enter your credentials as shown below:

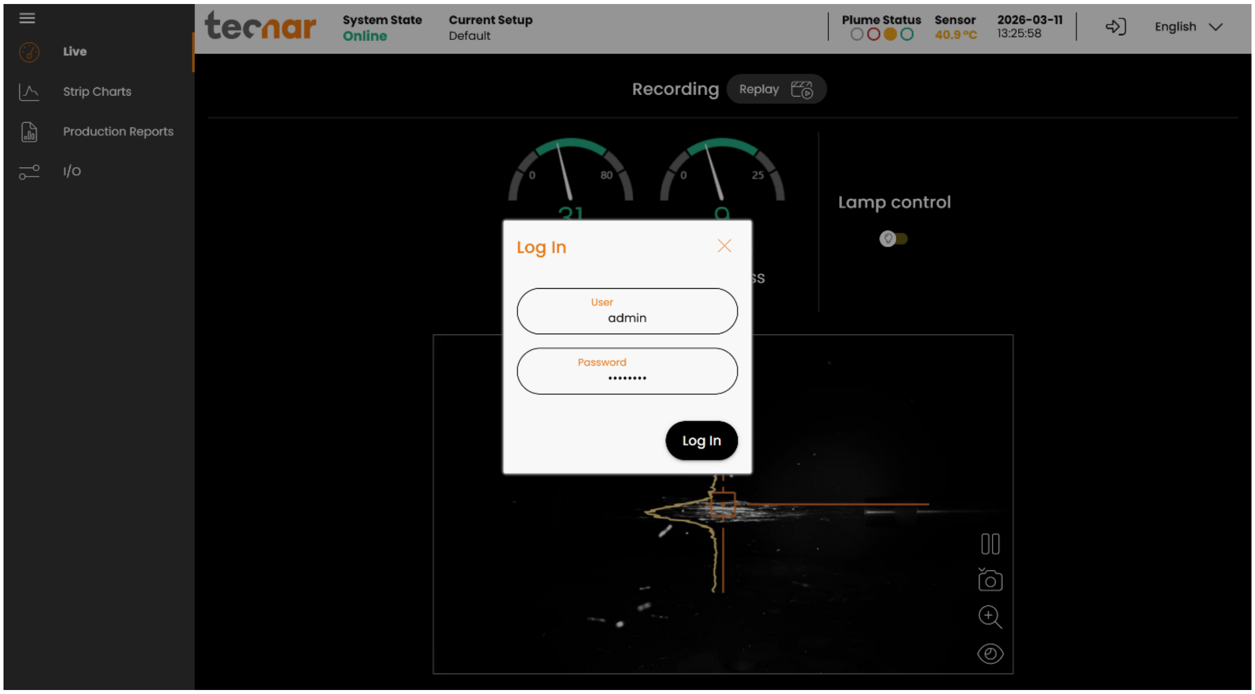


FIGURE 17 - LOGIN WINDOW

4.6.10. Setup Screen

The setup screen is where the sensor’s parameters are managed. Click the “Gear” icon to access the setup screen.

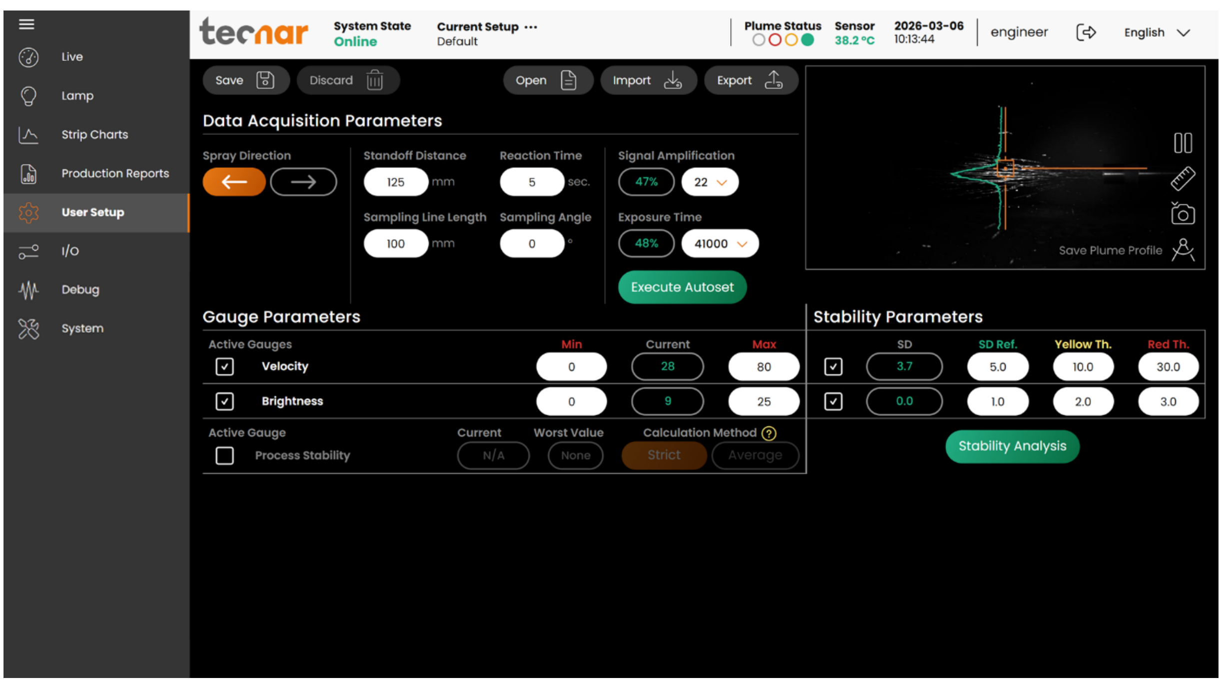


FIGURE 18 - SETUP SCREEN

4.6.11. Min/Max Adjustments

The top of the **User Setup** screen shows the **Data Acquisition Parameters** for the current process. Above the parameters, the icons allow users to save or discard changes, open/delete, import, and export setups.

The bottom side of the configuration screen shows the **Gauge Parameters.** These min and max values represent the values past which the process is considered off (red zone). The range between those values contains the green and yellow zones. The green value represents 60% of the full range between the min and max, while the yellow regions warn the operators that the measurement is leaning towards the red zone. The yellow zones represent 20% of the total span, starting from the lower and upper thresholds, as shown in the image below.

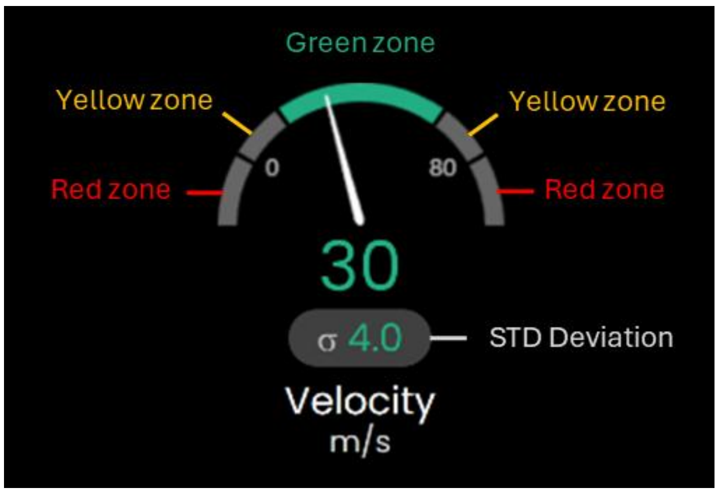


FIGURE 19 - GAUGES PROCESS CONTROL ZONES

The red zones cover all other values. In other words, the values below the minimum threshold and above the maximum threshold will be considered red.

Under each measurement, the standard deviation can be shown (to enable or disable the standard deviation, access the **User Setup** page). If you need help setting up your min/max, see **APPENDIX A** or contact our service team using service@spraysensors.tecnar.com

4.6.12. Opening/Deleting Setups

In the setup screen, click the **OPEN** button. This will open the list of setups.

To load a setup, select the setup and click **OPEN**. The new setup is automatically applied. To delete a setup, click the "Delete" button. A confirmation message will appear. You will notice that the default setups cannot be deleted.

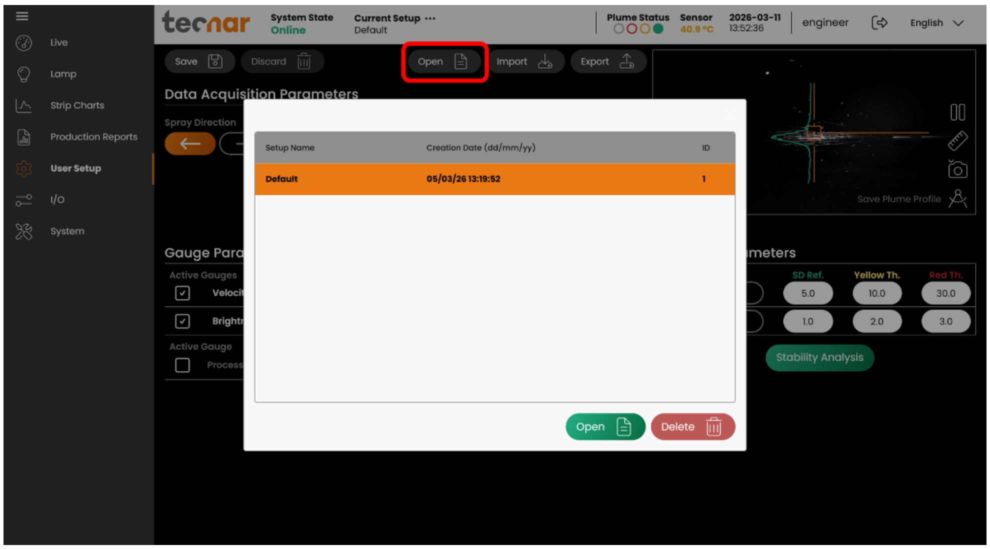


FIGURE 20 - OPENING/DELETING SETUPS

4.6.13. Saving Setups

Upon modifying any parameter in the setup screen, you can save the modifications as a new setup or overwrite the existing setup. Whenever you have pending changes in the current setup, the "UNSAVED" message will appear. It will appear in the top header of the software page. You can either save the new setup by clicking the save button at the top of the **User Setup** tab, or in the white header of the software. You can also click the delete icon to delete all unsaved changes.

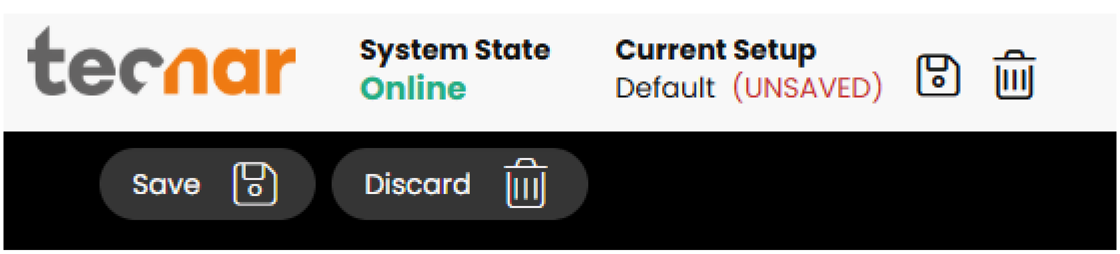


FIGURE 21 - UNSAVED SETUP MESSAGE

In the setup screen, click the **SAVE** button. This displays the following window.

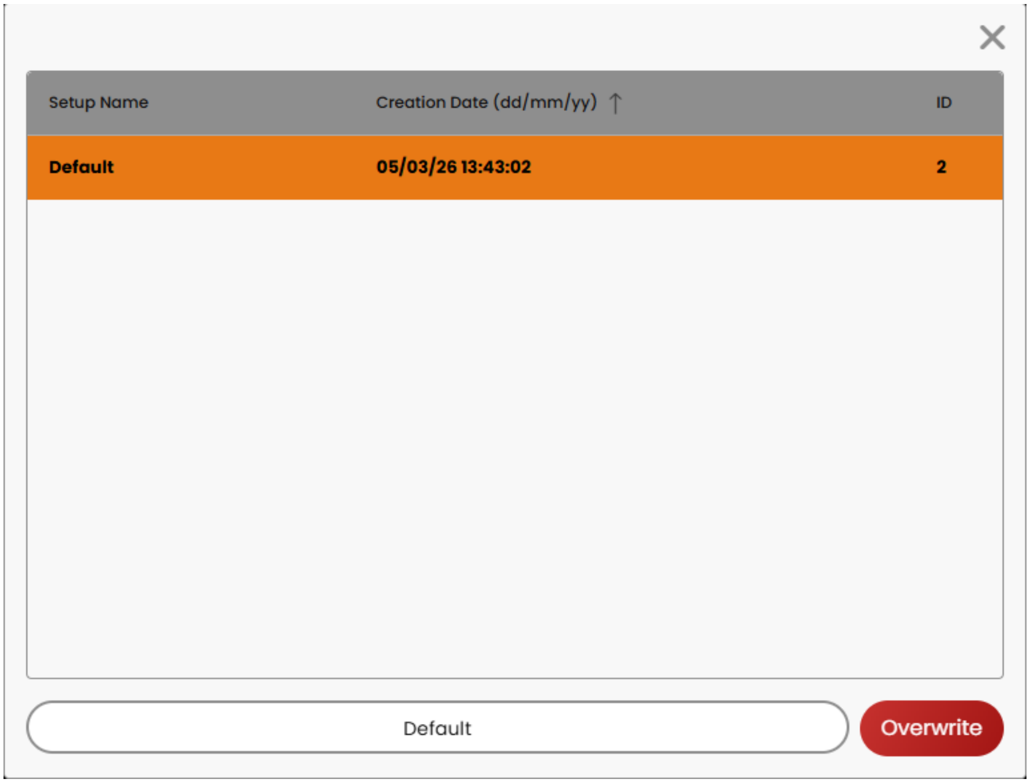


FIGURE 22 - SAVING SETUPS

To overwrite a setup, select a setup and click **OVERRIDE**. The new parameters are automatically saved.

To add a new setup, enter a new setup name and click **SAVE**.

4.6.14. Importing and Exporting

Setups can be exported from one Shotmeter unit and imported into another. When clicking on the **EXPORT** button, a setup file with the ".setup" extension will be downloaded to your computer.

To import a setup, simply click on the **IMPORT** button and select the setup file that you wish to import from your computer.

This functionality ensures that multiple sensors are using the same settings in a production environment. This is especially useful when comparing two booths using the same hardware and having two different Shotmeter units.

FIGURE 23 - IMPORT/EXPORT SETUP

4.6.15. Setup Parameters

The following table explains the data acquisition parameters that are used to configure the Shotmeter according to the spray process you will be monitoring.

NOTE	
ⓘ	**Modifying any of these parameters will impact the current configuration. Ensure your changes are saved by clicking the SAVE button.**

TABLE 9 – DATA ACQUISITION PARAMETERS

Parameters	Description
Spray direction	Media projection direction (left to right or right to left) relative to the Shotmeter field of view.
Standoff distance	Distance between the Shotmeter measurement point (bullseye) and the peening nozzle output. Typically, it is the process peening distance from the nozzle to the part.
Sampling line length	This value determines the length, in the plane of the jet, of the path along which the brightness profile is measured. It is normally set to about four times the regular jet width.
Sampling angle	This value tilts the sampling line so that it lies perpendicular to the general direction of the media flow.

Parameters	Description
Reaction Time	Length of the moving average used by the sensor to display measurements. This parameter is used to smooth out natural variations in the process that would make the sensor's reading unstable and unusable for process control. The sensor takes 50 readings per second. Default = 5 seconds; Minimum = 1 seconds; Maximum = 60 seconds
Signal amplification	This value needs to be increased until the signal level reaches roughly 35% (the percentage value next to the amplification level is the signal level). This is the scope signal level. In general, the auto-set feature will take care of this adjustment for you.
Exposure time	This value needs to be increased until the signal level reaches roughly 50% (the percentage value next to the amplification level is the signal level). This is the camera signal level. Note that the "optimal" camera signal level differs from the scope signal level. In general, the auto-set feature will take care of this adjustment for you.
Execute Autoset	This feature automatically adjusts the "exposure time" for the camera measurements and the "signal amplification" for scope measurements. These settings can also be modified manually using their respective drop-down selectors. However, before an auto-set can be performed, the spray jet must be centered on the bullseye, and the following data acquisition parameters must be set properly: • Peening Direction • Standoff Distance • Sampling Line Length • Sampling Angle
Save Brightness Profile	By clicking this button, the user captures the current jet profile and sets it as the reference for future measurement.
Gauge Parameters	This section allows you to select the active gauges and determine their tolerances or "Process windows".
Stability Parameters	This section allows you to activate the standard deviation alarms along with determining their thresholds: • Standard Deviation Reference • Standard Deviation Yellow Threshold • Standard Deviation Red Threshold
Stability Analysis	This feature allows you to select specific data files saved using the same setup and perform a standard deviation analysis. It is useful to help you set the Standard Deviation Thresholds.

4.6.16. I/O Screen

This page shows the status of every I/O port. By clicking on the pen icon, you can also edit how the inputs and outputs are configured.

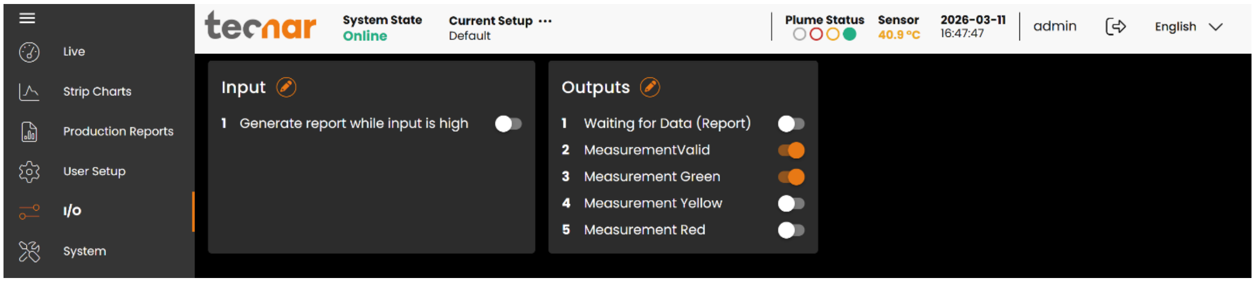


FIGURE 24 – I/O SCREEN

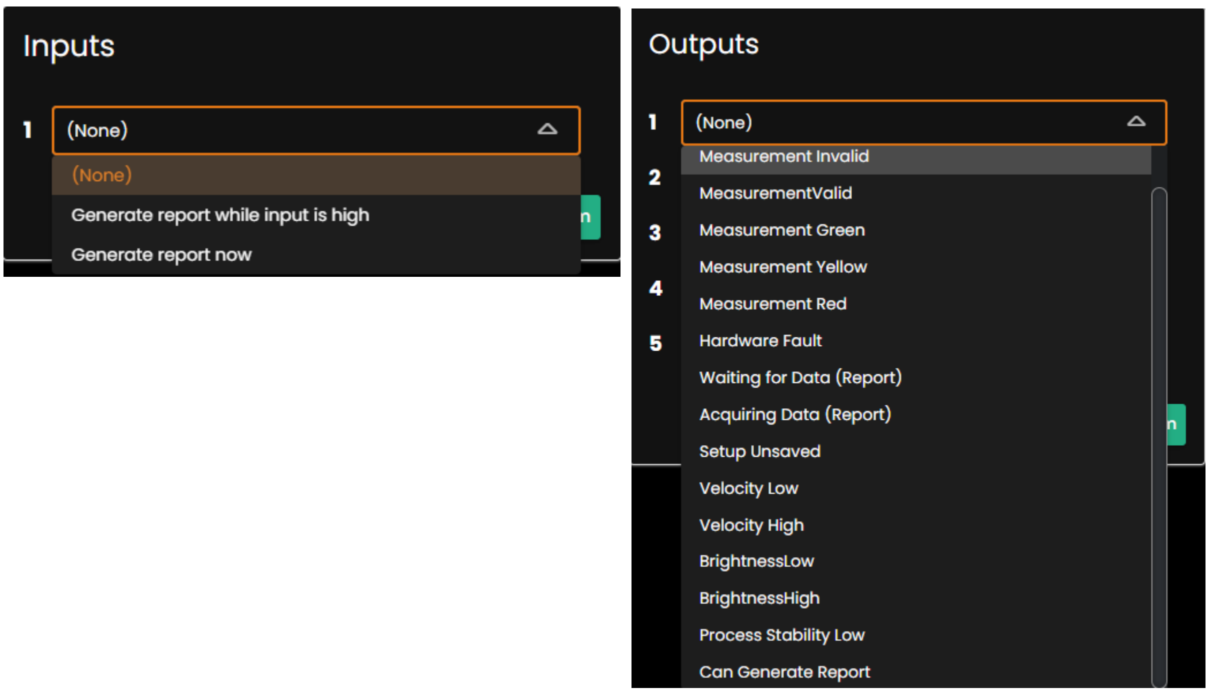


FIGURE 25 – LIST OF AVAILABLE INPUTS AND OUTPUTS

4.7. System Settings

The figure below illustrates the system settings interface

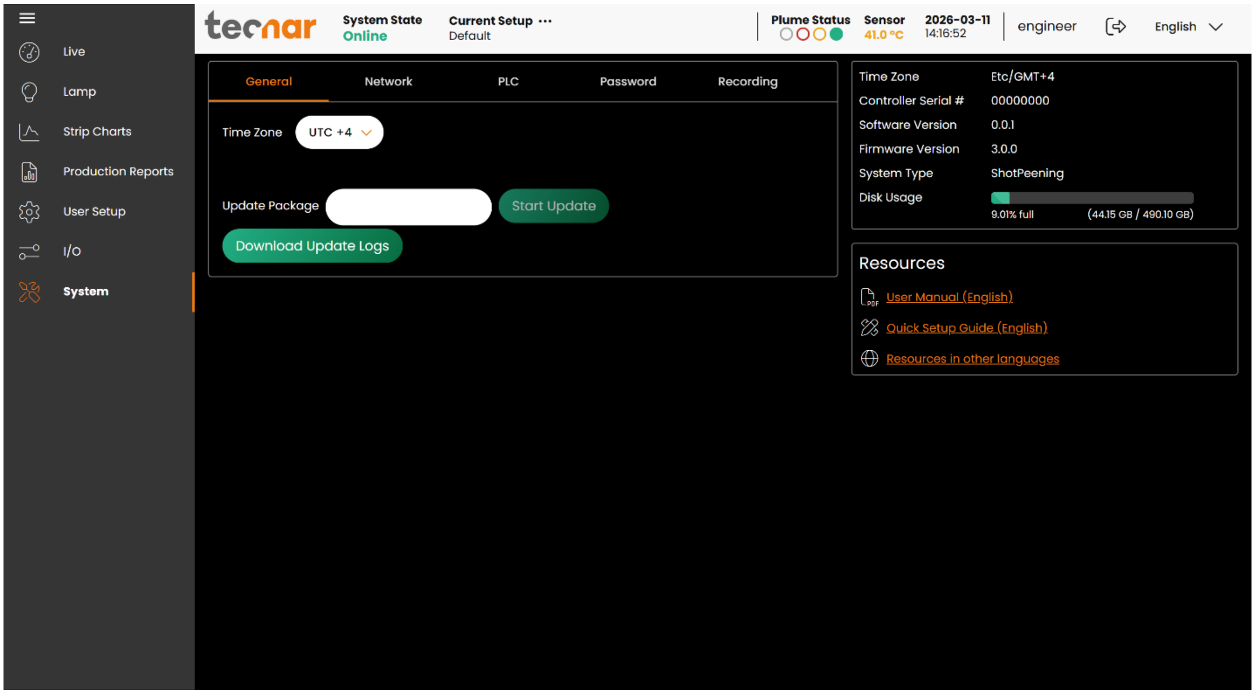


FIGURE 26 - SYSTEM SETTINGS INTERFACE

4.7.1. Changing the Time Zone

In the General section, change the time zone to match your local settings using the drop-down selector. This UTC/GMT format matches the default time zone used by Windows systems. If you are not sure which one to choose, refer to your local Windows settings or simply google search “What’s my time zone?”. The picture below is an example using UTC-05. Please note that the NTP server is not enabled on the controller, as it is not connected to the Internet. You may have to adjust the time zone manually to compensate for your local DST settings.

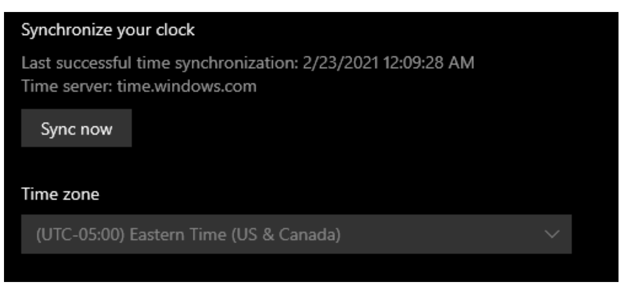


FIGURE 27 - WINDOWS TIME ZONE EXAMPLE

4.7.2. Updating the system

In the General section, download the latest update archive (.7z) from Tecnar's website and update your system easily with a single click. Upload the archive and click **START UPDATE**. Simply follow the on-screen instructions. The UI will automatically refresh once the update is finished. If not, refresh the page manually.

4.7.3. Enabling/Disabling Wi-Fi

In the Network section, Users may choose to enable or disable the built-in Wi-Fi for security purposes. A reboot is not necessary, but it will take a few seconds for the change to take effect.

4.7.4. Changing the Static IP of the Controller

In the Network section, it is possible to change the IP of the controller to match your desired static network. Simply click the "Change IP" button. Keep in mind that you will need to adjust your "/etc/host" interface file to be able to access the controller using its "hostname". This is important to make sure that all the features work correctly in the UI, such as the production file tab. A reboot is required for this operation. Refer to the document ***40107-00121-EN - Shotmeter 4.0 Network Connections*** for in-depth details.

4.7.5. DHCP IP

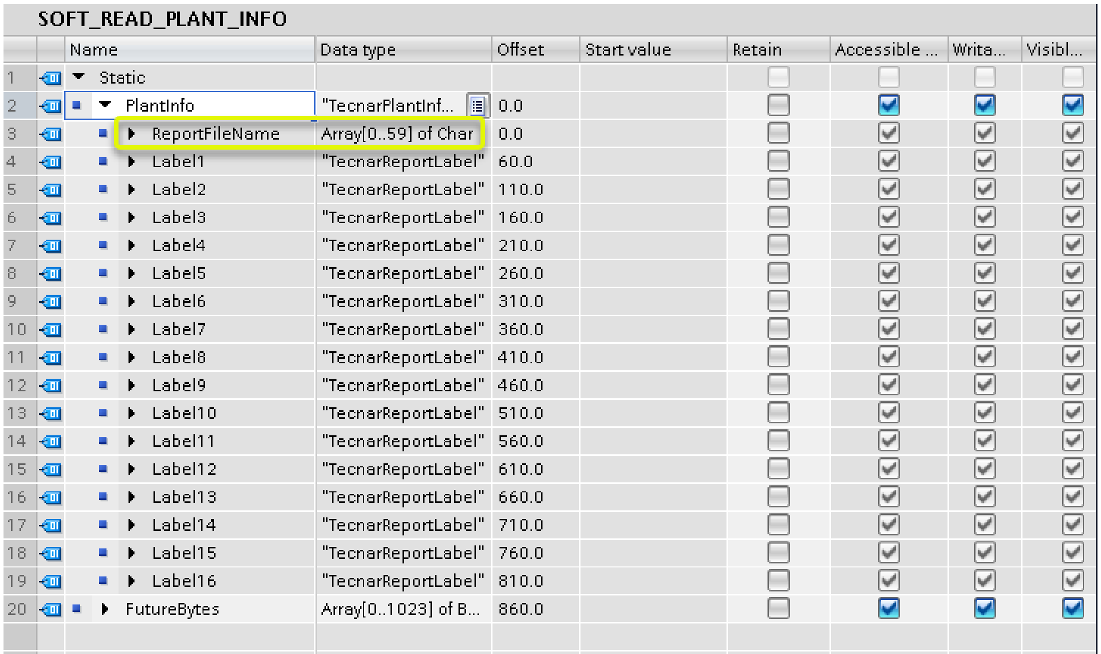
The Shotmeter has only one physical Ethernet interface, but multiple sub-interfaces. This allows us to use both the static and dynamic network configurations at the same time. Connecting the Shotmeter to your facility's network is the easiest way to set up the Shotmeter. An address will be obtained from your DHCP server, and you can connect to the Shotmeter directly (http://shotmeter-00000000). Change the numbers to match the serial number of your machine. The DHCP IP is displayed in the system tab for reference only. It cannot be changed since it is provided by your DHCP server. Refer to the document ***40107-00121-EN – Shotmeter 4.0 Network Connections*** for in-depth details.

4.7.6. Enabling/Disabling the PLC

The PLC is an optional feature that provides a deeper level of integration for customers who wish to make use of the Shotmeter's functionalities without necessarily having to go through the User Interface. The Shotmeter can stream data through a PLC Profinet interface. Contact Tecnar at service@spraysensors.tecnar.com if you wish to obtain more details regarding this bundle. Implementation details for this feature can be found in ***40107-00122-EN – Shotmeter 4.0 Profinet PLC Configuration.***

4.7.7. Timestamp Prefix in PLC Filename

This option lets users override the automatically generated timestamp with their own locally generated timestamp. This can sometimes avoid mismatches between your PLC and the Shotmeter timestamps. When activating this option, make sure that you include your own timestamp in the PLC's "ReportFileName" tag.



	Name	Data type	Offset	Start value	Retain	Accessible ...	Writa...	Visibl...
1	▼ Static				☐	☐	☐	☐
2	▼ PlantInfo	"TecnarPlantInf...	0.0		☐	☑	☑	☑
3	▶ ReportFileName	Array[0..59] of Char	0.0		☐	☑	☑	☑
4	▶ Label1	"TecnarReportLabel"	60.0		☐	☑	☑	☑
5	▶ Label2	"TecnarReportLabel"	110.0		☐	☑	☑	☑
6	▶ Label3	"TecnarReportLabel"	160.0		☐	☑	☑	☑
7	▶ Label4	"TecnarReportLabel"	210.0		☐	☑	☑	☑
8	▶ Label5	"TecnarReportLabel"	260.0		☐	☑	☑	☑
9	▶ Label6	"TecnarReportLabel"	310.0		☐	☑	☑	☑
10	▶ Label7	"TecnarReportLabel"	360.0		☐	☑	☑	☑
11	▶ Label8	"TecnarReportLabel"	410.0		☐	☑	☑	☑
12	▶ Label9	"TecnarReportLabel"	460.0		☐	☑	☑	☑
13	▶ Label10	"TecnarReportLabel"	510.0		☐	☑	☑	☑
14	▶ Label11	"TecnarReportLabel"	560.0		☐	☑	☑	☑
15	▶ Label12	"TecnarReportLabel"	610.0		☐	☑	☑	☑
16	▶ Label13	"TecnarReportLabel"	660.0		☐	☑	☑	☑
17	▶ Label14	"TecnarReportLabel"	710.0		☐	☑	☑	☑
18	▶ Label15	"TecnarReportLabel"	760.0		☐	☑	☑	☑
19	▶ Label16	"TecnarReportLabel"	810.0		☐	☑	☑	☑
20	▶ FutureBytes	Array[0..1023] of B...	860.0		☐	☑	☑	☑

FIGURE 27 - PLC PLANT INFORMATION

4.7.8. Changing the PLC IP

Changing the PLC IP will change the IP of Tecnar's PLC in the controller's database. You must also update the IP in the PLC itself, as this only tells the controller which IP to look for when establishing the connection. Make sure that the controller, Tecnar's PLC, and your own PLC are all on the same network/subnet.

4.7.9. Changing the User Password

NOTE

To change the password, make sure to be logged in to access the settings screen.

In the password section, enter a new password and click **CHANGE PASSWORD** to modify it.

5. Getting Started

This section is dedicated to the installation of the Shotmeter 4.0 components. The installation procedure is presented step by step.

5.1. Unpacking the Parts

Step 1. Carefully open the box, remove the content, and set it on a work surface. The box should contain the following items:

1. Sensor head
2. Controller (+ Wi-Fi antenna, separated from the controller)
3. Air filter and hoses
4. Power adapter and cable
5. Communication and illumination lamp power cable
6. Spare fuse box (not shown in the figure)

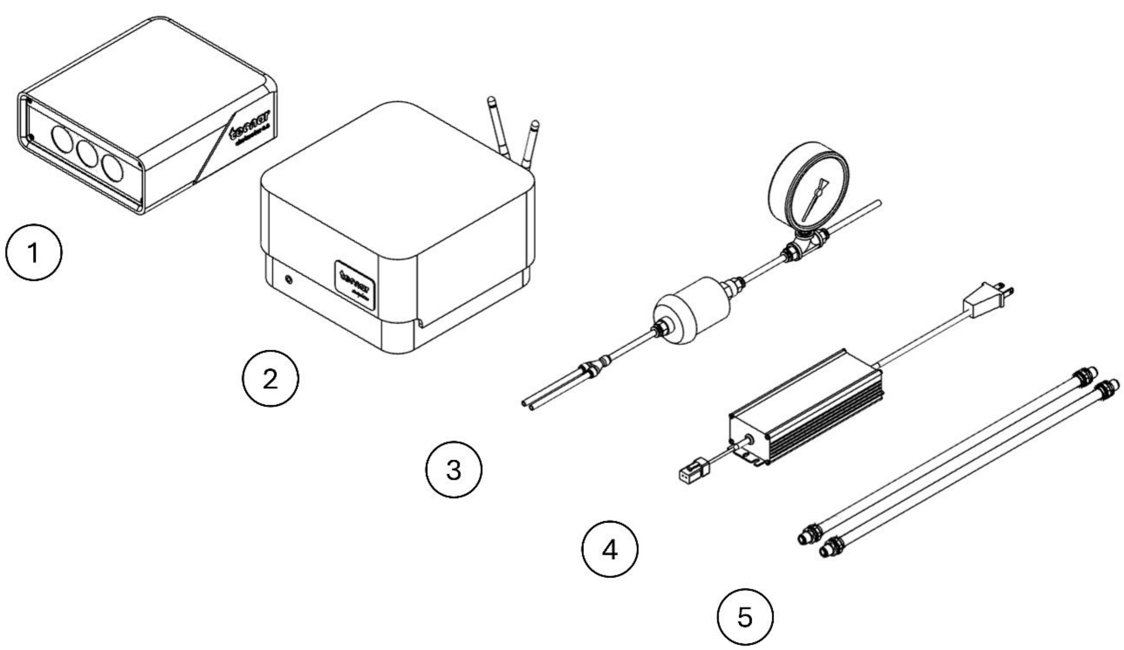


FIGURE 28 - UNPACKING THE PARTS

.

5.2. Installing the Sensor Head

5.3.1. Sensor Head Installation Requirements

Step 2. Install the sensor head in the peening cell at a location easily reachable by the robot (peening nozzle).

Step 3. Ensure that the sensor head does not interfere with normal peening operations. The sensor head should be at a 125 mm working distance between the front window of the sensor and the center of the spray jet. It is the focal distance of the optical system and the camera.

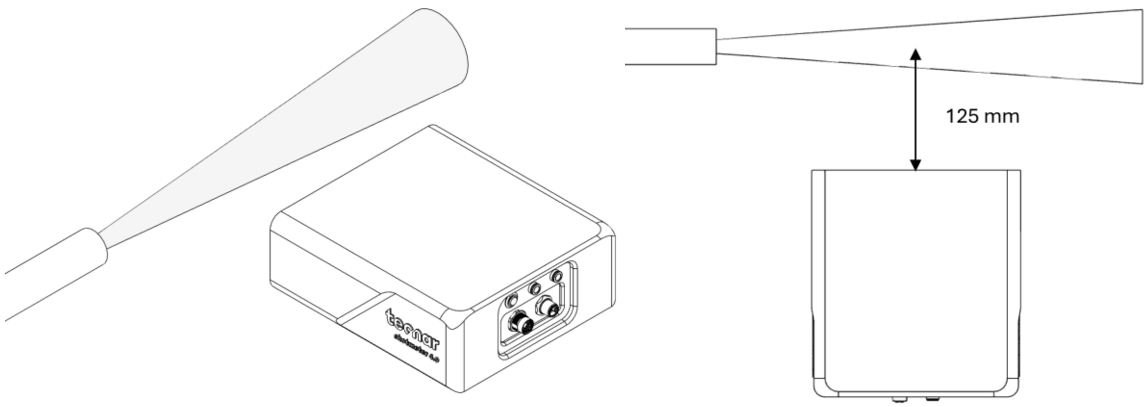


FIGURE 29 - POSITION OF THE SENSOR HEAD

Step 4. Install the sensor head on a sturdy mounting that does not vibrate or move during spraying. Refer to the following schematic of the Shotmeter mounting plate.

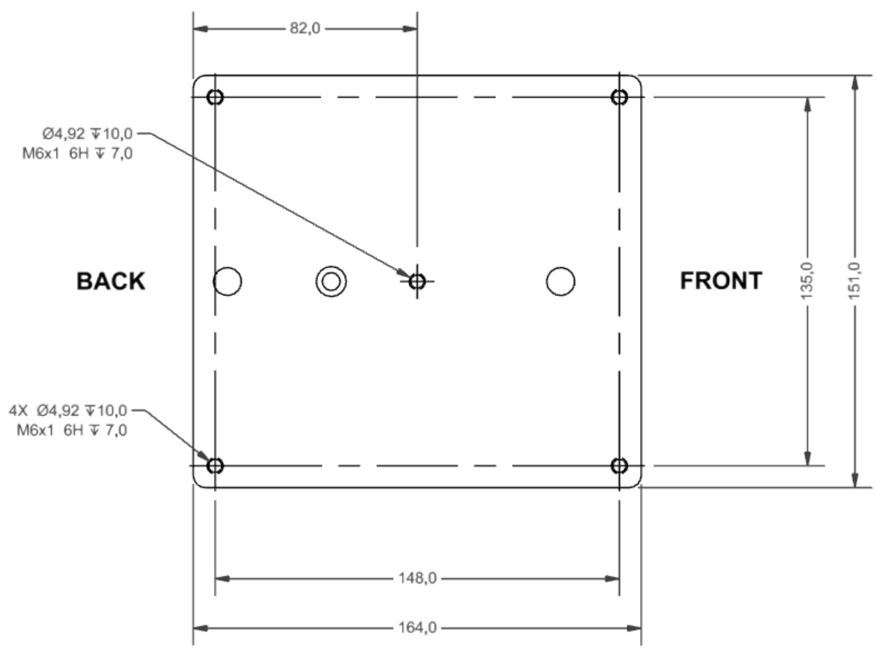


FIGURE 30 - SENSOR HEAD MOUNTING PLATE DIMENSIONS (mm)

5.3.2. Sensor Head Installation Procedure

Step 5. Attach the sensor head baseplate to your support bracket using the four mounting holes.

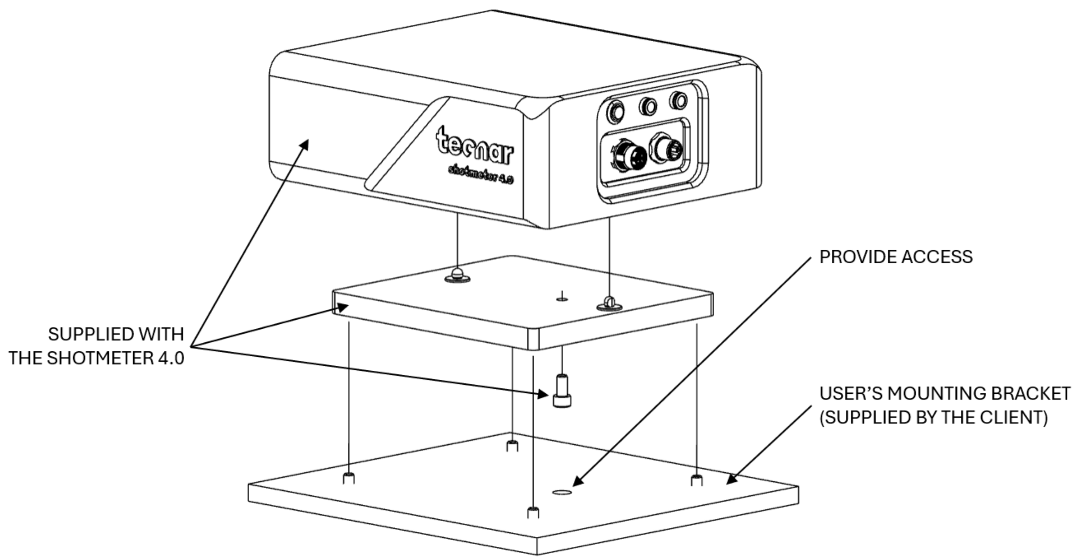


FIGURE 31 - MOUNTING THE SENSOR HEAD

Step 6. Connect the compressed air supply, communication, and illumination lamp power cable to the sensor head's air supply port (11 & 12), communication port (13), and lamp power port (14).

Step 7. Pull the other end of the communication cable out of the spray booth.

Step 8. Connect the air hoses to the booth air supply.

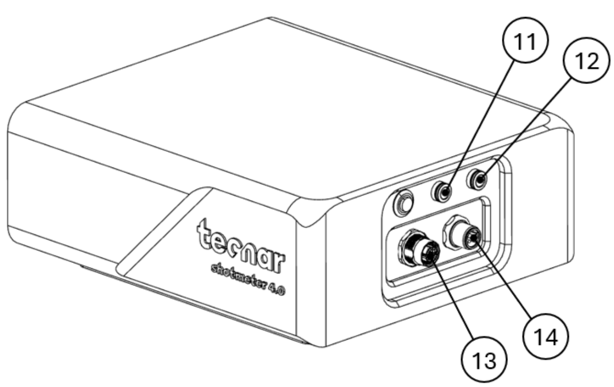


FIGURE 32 - SENSOR HEAD INTERFACE

5.3. Installing the Controller

5.4.1. Controller Installation Requirements

Step 9. Install the controller outside the peening cell, ideally close to the cell's control equipment or any other equipment you would like to integrate it with.

5.4.2. Controller Installation Procedure

Step 10. Connect the sensor head communication cable (17) and lamp power cable (21).

Step 11. Connect the power cable to the controller and into a power socket (22).

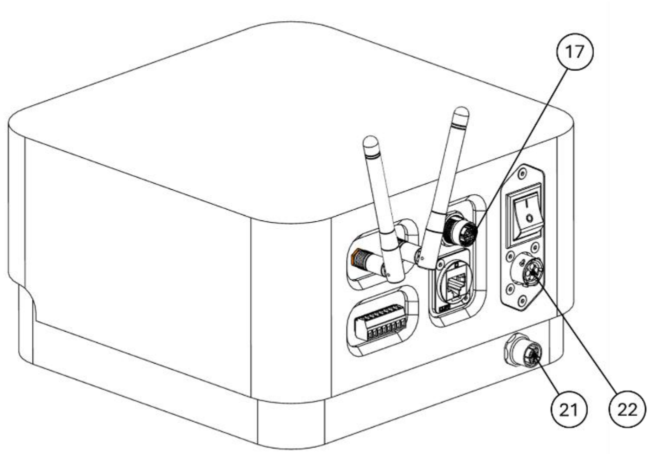


FIGURE 33 - CONTROLLER CONNECTION INTERFACE

Step 12. Flip the Shotmeter controller power switch to **ON**. Wait until the LED (15) turns Green.

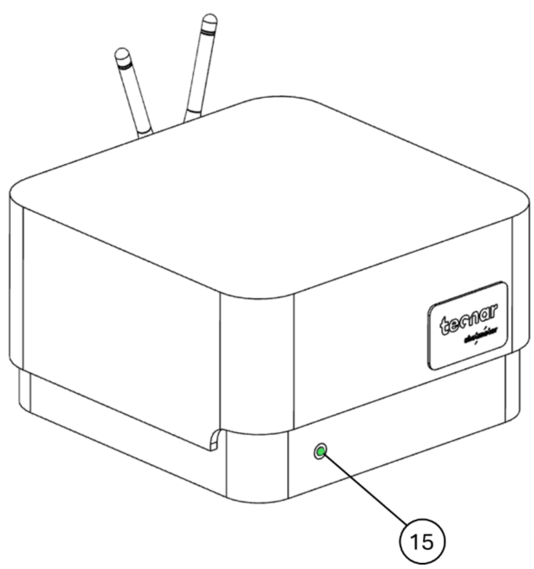


FIGURE 34 - CONTROLLER LED STATUS

5.4. Adjusting the Peening Nozzle Position

Step 13. On the sensor head, activate the alignment beam using the push button (10) located at the back of the sensor.

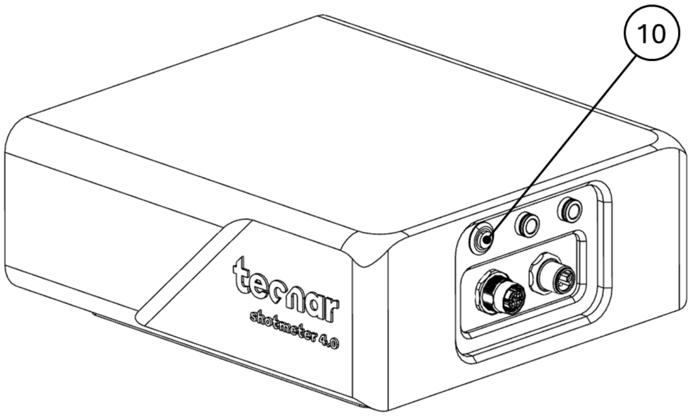


FIGURE 35 - SENSOR HEAD ALIGNMENT BUTTON

Step 14. Bring the peening gun near the sensor head as shown in **Figure 36**. The sensor measurement point is normally set to your standard process peening distance. The distance between the front of the sensor head and the nozzle axis should be adjusted to 125 mm (from the sensor's window to the center of the peening jet).

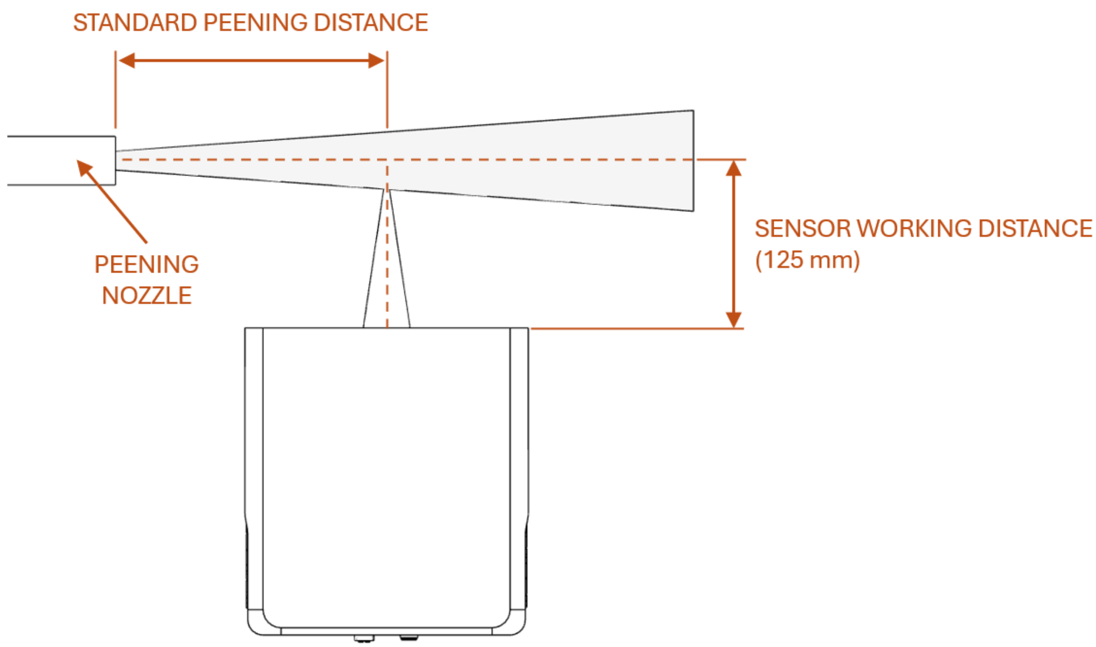


FIGURE 36 - SENSOR HEAD WORKING DISTANCE

Step 15. Save the new position as **SENSOR HOME** on the peening nozzle.

5.5. Accessing the User Interface

The Shotmeter 4.0 user interface is accessible through a web browser, but it is not actually hosted on the internet. It is streamed from the Shotmeter controller. We recommend using Google Chrome, Microsoft Edge, or any browser using the Chromium engine for optimal performance.

Step 16. Go to the Wi-Fi menu on your computer or tablet and look for “Shotmeter – serial number”. The password to access the Wi-Fi is: shotmeter.wifi

Step 17. Open your browser and enter the URL: “http://shotmeter-00000000/” (replacing the zeros with your serial number) to connect to the Shotmeter user interface.

Step 18. Replace the zeros with the serial number of the unit you are trying to reach. The serial number is composed of 8 digits, which can be found in the Wi-Fi network name and under the controller. Refer to the document ***40107-00121-EN – Shotmeter 4.0 Network Connections*** for in-depth details.

5.6. Setting Up the Shotmeter on a Network

You can decide to connect the Shotmeter to your local network. To do so, you must connect the controller to the network with an Ethernet cable. Refer to the document ***40107-00121-EN – Shotmeter 4.0 Network Connections*** for in-depth details.

5.7. Connecting the I/Os

The Shotmeter can be remotely controlled through the I/O connections. For the use of these connections, refer to the schematic and descriptions provided below.

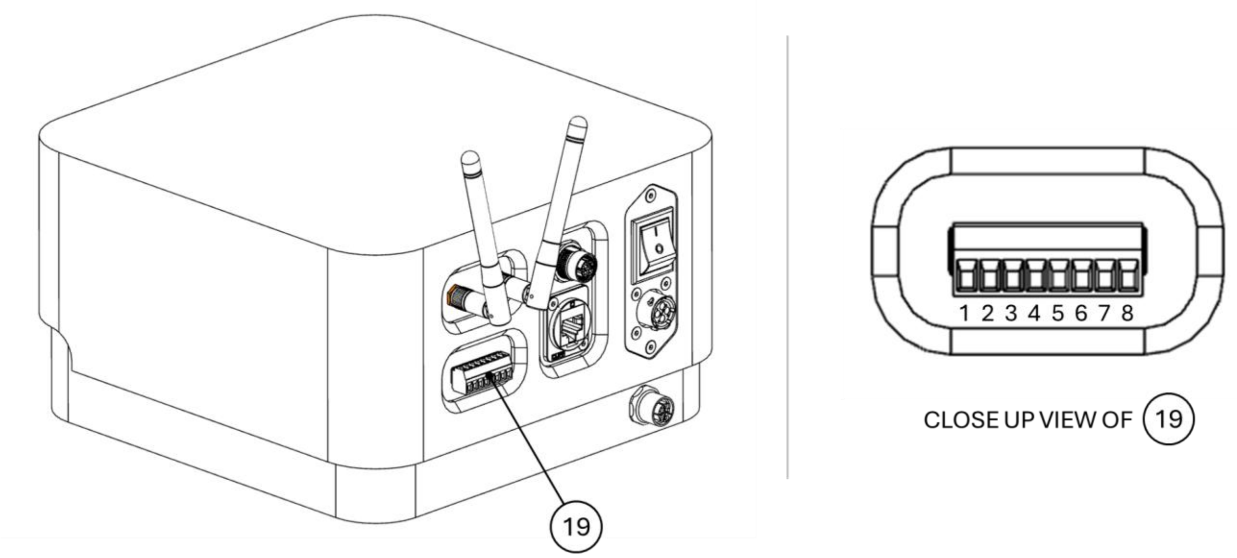


FIGURE 37 - I/O PORT

5.8. Using the Input to Generate Reports

The input can be used to automatically generate reports and .csv files using two different logic.

When using ‘’Generate report while input is high’’, it must remain "high" for at least 1 second to be detected by the controller. The input status is retrieved every 500 ms. If the input is held "high" for more than 1 second but less than the reaction time, the auto-generated report length is set to 1 second. Consequently, the system records 1 second of data after the reaction time. This behavior is a safety measure rather than a feature. In such cases, the .csv file typically contains a single line, and graphs cannot be plotted.

The typical usage consists of holding the input "high" for a duration longer than the reaction time. The auto-generated report length is then set to (“input high time” – “reaction time”). For example, if the reaction time is configured to 5 seconds and the input remains "high" for 10 seconds, the auto-generated report contains 5 seconds of data, starting after the 5-second reaction time. When recording via the input, saving reports or videos through the User Interface is not possible, and vice versa.

When using ‘’Generate report now’’, the software will generate a report as soon as the controller receives a ‘’Logic 1’’ using the ‘’Time Span’’ configured in the software.

TABLE 10 - I/O PORT PIN DESCRIPTION

Pin	Name	Description	Logic
1	**IN 24 VDC**	Input/Output reference Voltage + (Supplied by user)	N/A
2	**IN 0 VDC**	Input/Output reference Voltage – (Supplied by user)	N/A
3	**IN 1**	Select between the possible inputs described in Section 4.6.16.	Logic 1: 11-24V above 0VDC IN Logic 0: 0-5V above 0VDC IN
4 - 8	**OUT 1 - OUT 5**	Select between the possible outputs described in Section 4.6.16.	Logic 1: 24V IN Logic 0: 0V IN

5.9. Recommended Practices when using the Shotmeter

5.9.1. To ensure reliable reading

Measurements can be affected by some particles bouncing back in front of the Shotmeter's head and impacting the quality of the signal. This can be determined by looking at the camera feed when taking measurements; some particles will be travelling in the opposite direction to the jet. This behavior can arise when the shot peening nozzle is pointing towards a perpendicular wall or if it is close to another object.

To avoid this pollution of the signal, try to place the system at an angle such that the direct rebounds of the media won't pass in front of the camera. Also, a plate can be used to redirect the particles after they have left the measurement volume of the Shotmeter, or a rubber/polyurethane curtain to slow down the particles and minimize the bouncing back of the media as much as possible.

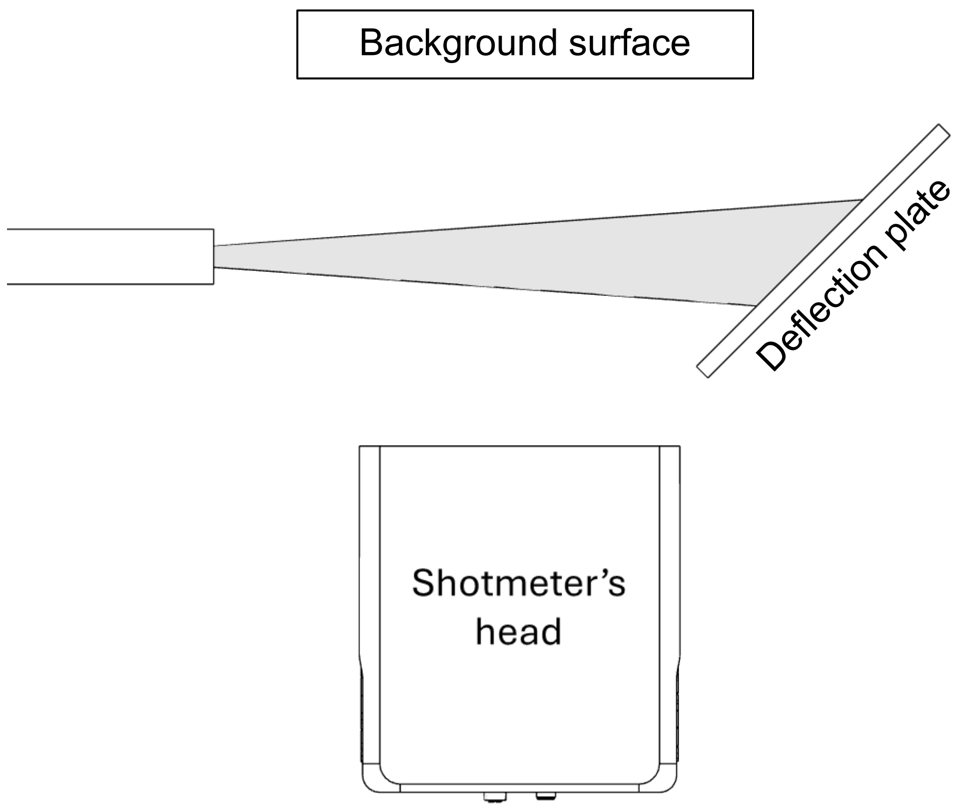


FIGURE 38 - DEFLECTION PLATE EXAMPLE

Also, ensure that the background surface is non-reflective and as far as possible from the Shotmeter's head. Reflective surfaces can impact brightness measurements and may interfere with the signal used for velocity measurement. Using a mat, dark rubber sheet is an effective solution for reducing surface reflectivity while also providing the durability needed to withstand long-term exposure to typical shot peening conditions.

6. Maintenance and Care

This section provides the necessary guidelines for maintaining the equipment in proper working conditions. It includes the recommended maintenance schedule and instructions for performing simple replacement procedures. Following these guidelines will help ensure reliable performance, extend the service life of the equipment, and maintain accuracy over time.

6.1. Maintenance Schedule

The following table outlines the maintenance schedule for the Shotmeter 4.0 components.

TABLE 11 – MAINTENANCE SCHEDULE

Components	Actions	Interval
Sensor Head	Cleaning the sensor head windows (Refer to section **CLEANING THE SENSOR HEAD WINDOWS**)	Daily
	Replacing the sensor head window assembly (Refer to section **REPLACING THE SENSOR HEAD WINDOW ASSEMBLY**)	When damaged
	Calibrating the sensor head (Refer to section **CALIBRATING THE SENSOR HEAD**)	Annually
Compressed air filter cartridge	Replacing the filter cartridge (Refer to section **REPLACING THE FILTER CARTRIDGE**)	Periodically (see visual indicator on the cartridge assembly)

6.2. Maintenance Procedures

This subsection provides the cleaning and replacement procedures listed in the maintenance schedule. Performing these tasks as prescribed helps maintain system performance and extend service life.

6.2.1. Cleaning the Sensor Head Windows

To ensure accurate measurements, the sensor head windows must be free of dust, oil, and scratches. The sensor head windows must be cleaned after each measurement procedure.

Recommended tools and materials required:

- 1x - Pair of latex or nitrile gloves
- 1x – Safety glasses
- A/R – Compressed air
- A/R – A cloth (preferably lint-free wipes, e.g. Kimwipes)
- A/R – Isopropanol (rubbing alcohol)

Procedure:

Step 1. Blow clean and dry compressed air on the windows

Step 2. If any marks remain, clean the windows with a cloth. If some dust still stands on the windows, blow clean and dry compressed air on the windows.

Step 3. If any marks remain, add some isopropanol to the windows and clean with a clean part of a cloth until the isopropanol is evaporated. Then blow clean and dry compressed air on the window to remove any remaining dust.

Step 4. If any marks remain, replace the sensor head window assembly (refer to section **6.2.2 - REPLACING THE SENSOR HEAD WINDOW ASSEMBLY.)**

6.2.2. Replacing the Sensor Head Window Assembly

NOTE
We recommend using latex or nitrile gloves when replacing the sensor head window plate. To avoid damaging the lens, do not use your fingers or sharp objects.

Tools and materials required:

- 1x – Pair of latex or nitrile gloves
- 1x – Safety glasses
- 1x – Allen key, 2.5 mm
- 1x – Sensor head window plate, 30201-03116

Procedure:

Step 1. Make sure that the controller is turned **OFF**.

Step 2. Make sure that the compressed air supply going to the sensor head is turned **OFF**.

Step 3. With compressed air, clean the front of the sensor head (1) of any dust or small debris.

Step 4. On the back of the sensor head, disconnect the air hose (11 & 12), communication (13), and illumination lamp power cable (14) from their respective port.

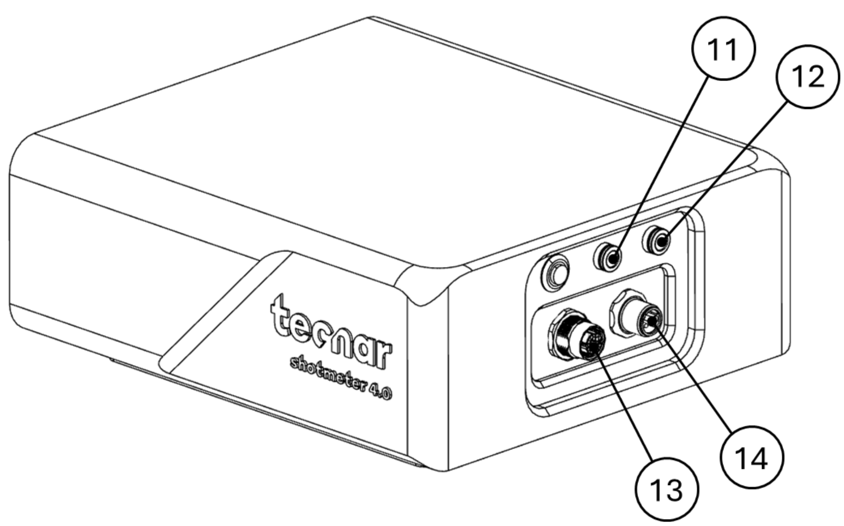


FIGURE 39 - HEAD SENSOR AIR SUPPLY PORT, COMMUNICATION & POWER PORT

Step 5. Remove the four M3 screws (23), then carefully remove the protective window assembly (24) and the air knife (9) from the sensor head.

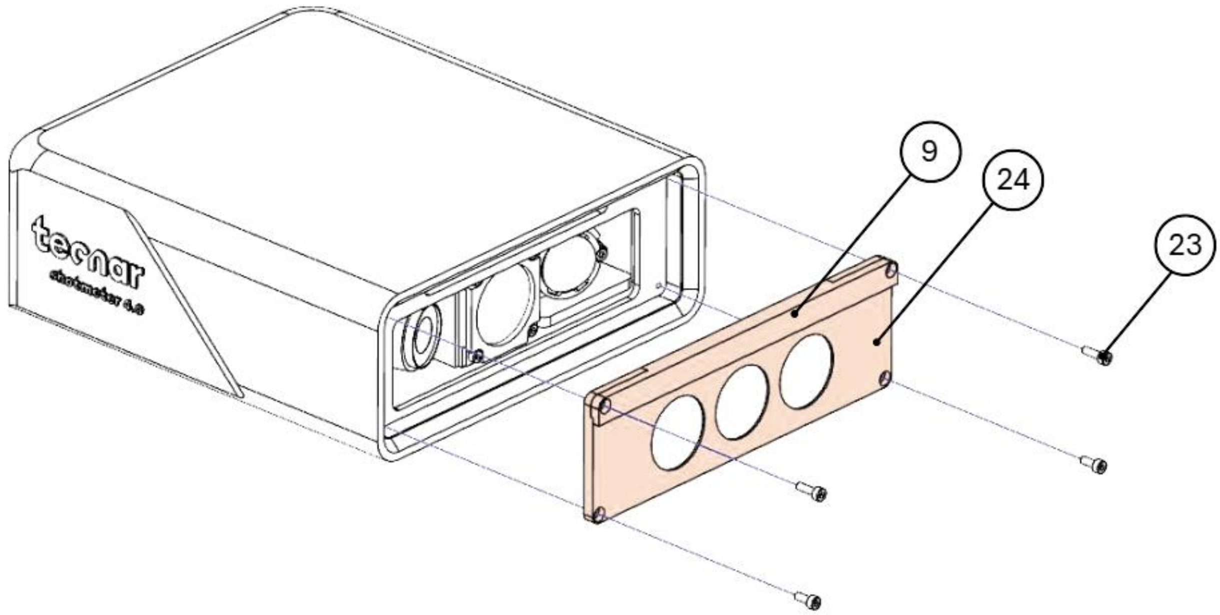


FIGURE 40 - SENSOR HEAD PROTECTIVE WINDOW ASSEMBLY

Step 6. Set the air knife (9) aside and discard the rest of the old window assembly (24).

Step 7. Install the new window assembly (24) with the air knife (9).

CAUTION

DO NOT OVERTIGHTEN SCREWS WHEN SECURING THE PLATE TO THE WINDOW ASSEMBLY. OVERTIGHTENING MAY CAUSE DAMAGE TO THE WINDOW.

Step 8. Screw back the four screws (24) at around 2 N·m (1.5 ft-lbs) to secure the plate.

6.2.3. Calibrating the Sensor Head

All sensor heads are calibrated at Tecnar before being shipped to the end-users. To ensure accurate measurements, sensor calibration should be verified every year to keep the calibration NIST-traceable.

It is recommended to send the sensor heads to Tecnar Automation Ltée every year for calibration. Contact service@spraysensors.tecnar.com for more information. There is no need to send the cables and controller unless a problem is suspected.

6.2.4. Replacing the Filter Cartridge

Tools and materials required:

- 1x – Needle-nose plier
- 1x – Teflon Tape
- 1x – Wrench, 15 mm
- 1x – Wrench, 16 mm
- 1x – 30201-03119, Air filter assembly

Procedure:

CAUTION
MAKE SURE TO SHUT DOWN THE AIR SUPPLY BEFORE DISCONNECTING THE AIR HOSE FROM THE AIR SUPPLY PORT ON THE HEAD SENSOR. FAILURE TO DO SO MAY CAUSE DAMAGE TO EQUIPMENT OR INJURIES.

Step 1. Make sure the lamp & the air supply are closed, then disconnect the air hose from its 2 ports (11 & 12).

Step 2. Disconnect the two air hoses (25) from the push-in fittings on the filter cartridge (26).

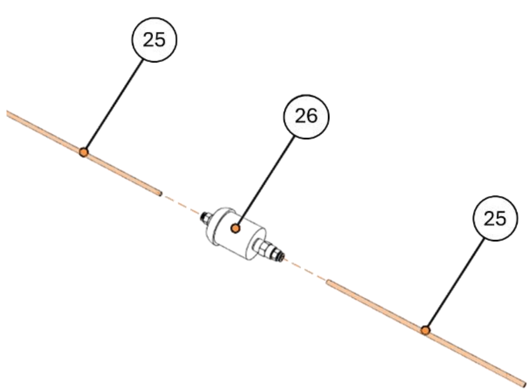


FIGURE 41 - AIR HOSE REMOVAL FROM FILTER CARTRIDGE

Step 3. Discard old filter cartridge (26).

Step 4. On the new filter cartridge (26), remove the plugs on both sides with needle-nose pliers.

Step 5. On the outlet of the new filter cartridge (26) and on the threads of the two push-in fittings (28), apply three to four rounds of Teflon tape.

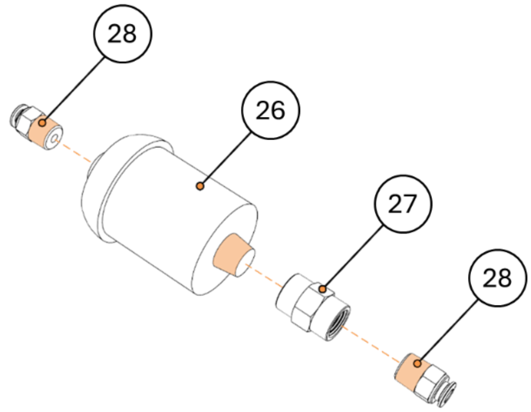


FIGURE 42 - TEFLON WRAP ON FILTER CARTRIDGE

Step 6. Screw on the push-in fitting (28) back into the brass coupling (27).

Step 7. Screw the brass fitting (27) back into the outlet side of the filter cartridge (26).

Step 8. Screw the second push-in fitting (28) into the inlet side of the filter cartridge (26).

Step 9. Reconnect the two air hoses (25) back into the push-in fittings on the filter cartridge (26).

Step 10. Reconnect the communication cable and air hose into the communication port (13) and the air supply ports (10).

6.3. Recommended Spare Parts

The table below lists the recommended spare parts to keep in stock.

NOTE

The part numbers listed below correspond to the latest version of the Shotmeter 4.0. Before placing an order, please contact the service department with your serial number to confirm the correct part number for your specific version.

TABLE 12 – RECOMMENDED SPARE PARTS LIST

Components	Part number
Compressed air filter cartridge	10201-00599
Sensor head windows assembly	30201-03116

7. Troubleshooting Guide

On power-up of the controller, once the sensor is initialized properly, the head's back-plate LED will start blinking quickly (3 quick blinks every 5 seconds). This initial blinking indicates that the electronics components inside the sensor are up and running, and that the sensor is waiting for the software to connect. Note that the back-plate LED button is not available during this initialization sequence. Once the software is connected to the sensor, the LED will stop blinking immediately, and the back-plate button will become available. Thus, it can now be used for alignment purposes. The start-up time of the controller is usually as fast as the initialization of the sensor head. Depending on the start-up time duration, the blinking might be hard to notice if the controller connects to the sensor as soon as it is initialized. This process usually takes less than 30 seconds.

If the initialization sequence is not successful, the LED will not stop blinking. Instead, it will start blinking more slowly, indicating that the sensor is now in error state (the LED will be held ON for approximately 1.5 seconds instead of 166 milliseconds, maintaining a 5-second interval in between the blinks). The back-plate button will remain disabled. Refer to the troubleshooting section for more information on the LED error codes.

7.1. LED Error Codes

In the case of hardware failure, the back-plate LED on the controller is used as a troubleshooting tool to provide more information on the system error state. Here is a list of all the possible codes, descriptions, and troubleshooting actions to be taken.

TABLE 13 - LED ERROR CODES

Error Code	Description	Actions
2 blinks	The controller did not connect to the sensor within 2 minutes after the initialization.	Reboot the controller
3 blinks	Internal micro-switch error.	Contact Tecnar service team
4 blinks	Microcontroller error.	Contact Tecnar service team

7.2. Error Reporting in the User Interface

The table below presents the error codes of the UI along with the corresponding corrective actions for each error.

TABLE 14 - USER INTERFACE ERROR CODES

Description (Error Code)	Actions
Invalid velocity measurements (Scope low correlation)	• The sensor head is aimed perpendicular to the peening nozzle axis. • The sensor head is 125 mm away from the center of the peening jet. • The **SPRAY DIRECTION** is set correctly. • The spray jet angle is no more than ± 15°.
Invalid velocity measurements (Scope signal level too low)	• The sensor head is 125 mm away from the center of the peening jet. • The proper setup has been selected, or the **SIGNAL AMPLIFICATION** is set adequately. • Media is injected into the peening jet. • The lamp is turned ON. • The sensor head windows are clean.
Invalid velocity measurements (Scope saturated signal)	• The proper setup has been selected, or the **SIGNAL AMPLIFICATION** is set adequately.
Invalid brightness measurements (Camera signal level too low)	• The sensor head is 125 mm away from the center of the peening jet. • The proper setup has been selected, or the **EXPOSURE TIME** is set adequately for your process. • Media is injected into the peening jet. • The lamp is turned ON. • The sensor head windows are clean.
Invalid brightness measurements (Camera saturated signal)	• The proper setup has been selected, or the **EXPOSURE TIME** is set adequately for your process.

7.3. Technical Support

Should you have any questions concerning our equipment, please contact us at:

TECNAR Automation Ltée

1021, Marie-Victorin Street,

St-Bruno, QC, Canada, J3V 0M7

Phone: 450-461-1221 ext. 232

Email: service@spraysensors.tecnar.com

8. Related Documents

To support the effective use, maintenance, and understanding of this product, the following related documents are available. These documents provide complementary information such as communication protocols, connection methods, PLC configurations, and other integration-related topics. We recommend reviewing them alongside this manual to ensure proper setup, optimal performance, and long-term reliability of the system.

- **40107-00121: "Shotmeter 4.0 Network Connections"**
  This document explains every possible connection method that can be used to connect one or multiple Shotmeter Controllers to your network.

- **40107-00122: "Shotmeter 4.0 Profinet PLC Configuration"**
  This document provides additional information on the PLC Profinet interface, integration, and database structure.

- **40107-00123: "Shotmeter 4.0 Http Communication"**
  This document describes the communication protocol used by the Shotmeter 4.0 to stream measurement data and load setups (system configurations) remotely.

APPENDIX A. Process Stability

I Philosophy and Measurement

Imagine a process that fluctuates within a short time frame. Depending on your min/max settings and the duration of this instability, the average measurement may still fall within the green zone. However, the standard deviation for this measurement may be outside the green zone, producing a sub-optimal coating. To have better control over the stability of the process, the stability gauge comes into play. This concept is statistics-based. However, this tool is extremely flexible, and you may choose your own thresholds experimentally that do not necessarily follow statistical principles.

The base metric for the stability measurements is the Standard Deviation (SD) of the population contained in the FIFO buffers at any given time. Each measurement has its own timed queue. These buffers are simply moving averages based on the reaction time of the current setup. The acquisition rates of the scope and the camera are set to 50 Hz and 30 Hz, respectively. Hence, using a 5-second moving average, we would have a total of 250 entries for scope measurements (velocity), and 150 entries for camera measurements at any given time. Every time a new value is inserted, the software computes the new average and the new standard deviation of that population.

Each gauge has its own stability measurement or SD. However, the software only uses one “global” stability indicator, called the “Process Stability”. How the process stability is calculated depends on the calculation method. There are two calculation methods: strict and average. More details regarding these methods will follow.

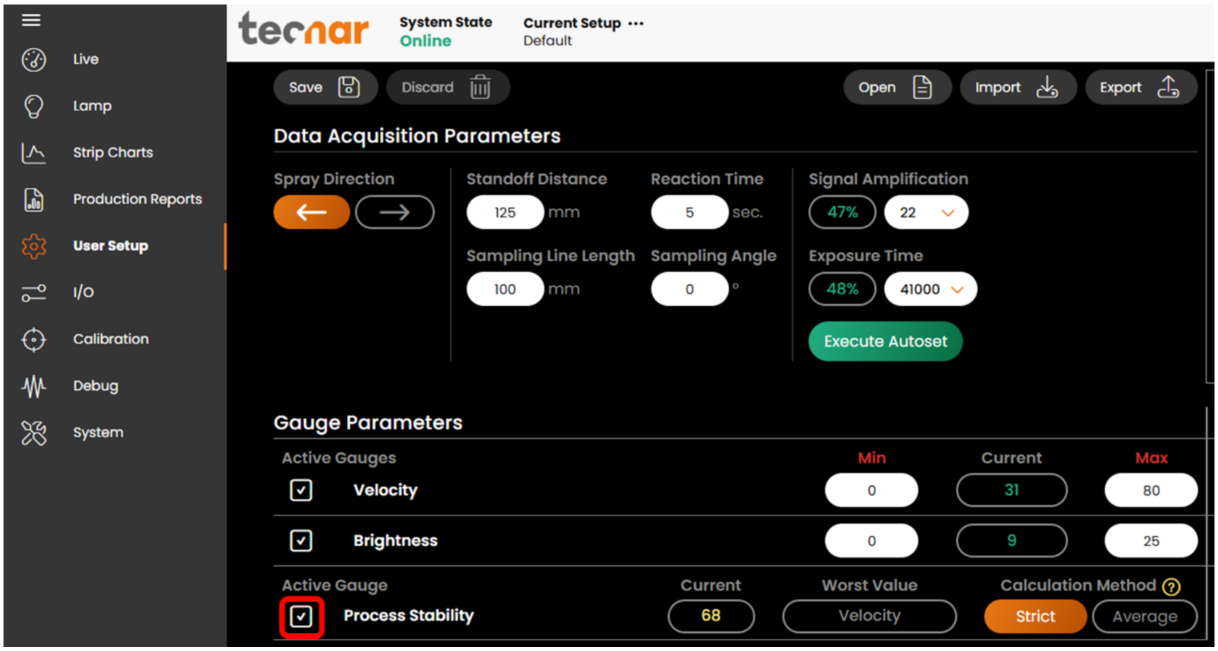
For the time being, let’s focus on a single stability indicator. A total of 3 thresholds is required to set the proper limits for the stability gauge.

- The standard deviation reference
- The standard deviation yellow threshold
- The standard deviation red threshold

The reference is the “typical” deviation for that kind of process under normal conditions. Therefore, when set properly, the probability of being stable is 100% for values below this threshold. As the SD increases, the probability of being stable will start to decrease and eventually reach the yellow threshold. For all values BELOW the yellow threshold, OUT3 will be set high (green signal). If the standard deviation is HIGHER than the yellow threshold, OUT4 will be set high (yellow signal). If it keeps decreasing, it will eventually reach the red threshold, and OUT5 will be set high instead (red signal). Remember that these 3 output states are mutually exclusive, red being the highest priority. Additional details about the thresholds and how to set them properly are provided in the following sections.

II Overview of the Stability

The bottom of the **Gauge Parameters** settings is related to the stability. On the right side, like the min-max settings, you will find the different thresholds for each measurement. In addition, the current standard deviation value is displayed in a separate box. Next to the "SD", a checkbox lets you activate or deactivate individual measurements. In other words, you have the freedom to select the stability gauges that are relevant to you.



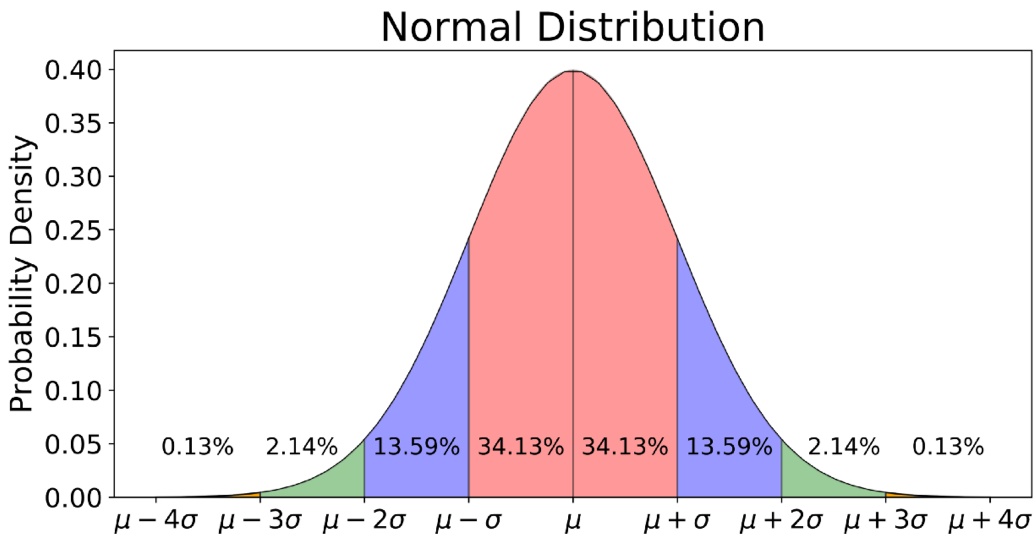
The ''Stability Analysis'' button lets you review the data for current or previous runs. When running a stability analysis, the controller reads the content of the CSV selected. They must have been saved using the same setup file.

I INTRODUCTION TO NORMAL DISTRIBUTION

In probability theory, the probability density function (PDF) represents a likelihood to fall within a certain range, and it is generally represented by the Gaussian equation:

$$f(x) = \frac{1}{\sigma * \sqrt{2 * \pi}} * e^{-\frac{1}{2} * \left(\frac{x-\mu}{\sigma}\right)^2}$$

In the current context, the parameter μ represents the SD (standard deviation) of the timed queue population. To clarify, the base metric being the standard deviation, the distribution generated is the distribution of the standard deviation. Since the rejection criteria are applied to the SD, the distribution is based on the SD as well. Consequently, the σ in the equation above represents the "standard deviation of the standard deviation". When the data is normally distributed, the probability density function is a bell-shaped curve, as shown in the picture below:



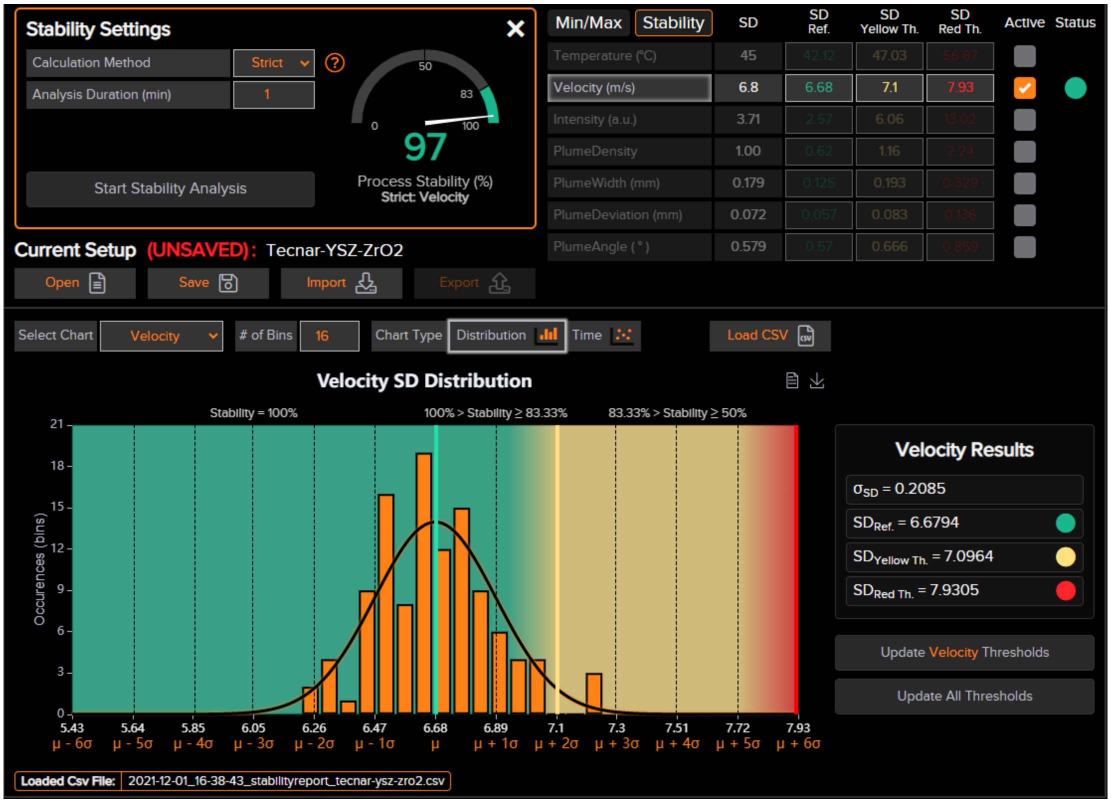
As shown in the figure, there is a 50% chance for the value to be below the average (μ) of the distribution. Furthermore, the chance to fall below μ + 2σ is:

$$50\% + 34.13\% + 13.59\% \cong 97.72\%$$

Tecnar has chosen to use 2 σ as the threshold starting point for the yellow thresholds, if you decide to generate the thresholds automatically in the UI. You can always update the thresholds manually if you wish to use a different approach. The red threshold is set at a level where manual intervention is required to adjust or stop production to avoid bad coatings. The automatically generated value is μ + 6σ. Once again, for a normally distributed dataset, we can declare that any value beyond that threshold is more than 99.99% likely to NOT be stable.

II Example Using Real Data (from Accuraspray 4.0 software)

In the example below, we are focusing on the velocity measurement to understand how the thresholds are calculated and applied. You will also notice that the only “active” stability measurement is the velocity.



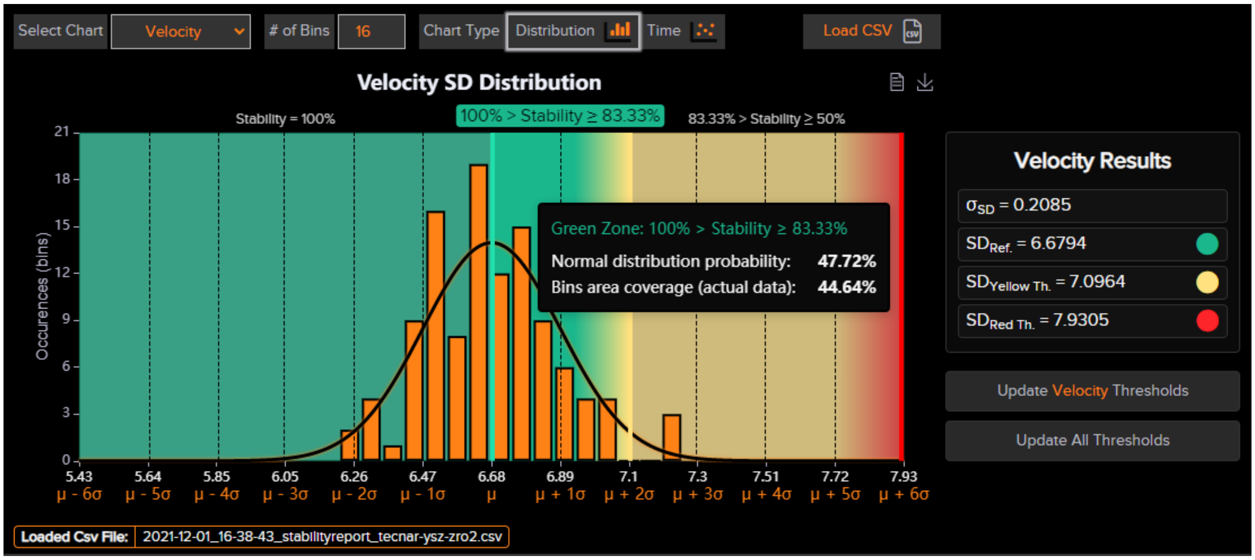
Here are the results:

- The velocity SD average is $6.6794\ m/s\ (\mu_{SD})$.
- The standard deviation of the standard deviation (σ_{SD}) is $0.2085\ m/s$.
- The yellow threshold is set to $\mu_{SD} + 2 * \sigma_{SD} = 7.0964\ m/s$.
- The red threshold is set to $\mu_{SD} + 6 * \sigma_{SD} = 7.9305\ m/s$.

We can easily tell from the graph that most of the data falls within the green zone. Only one bin is in the yellow zone. That bin represents 2.68% of the total area of the bins. As we have seen in the previous section, the theorical value for combination of the yellow and the red zone should be around 2.28%. That tells us that this dataset follows a normal distribution. In this case, setting the yellow limit to 7.0964 m/s would mean that 97.32% of the time, we’d fall within the green zone (100% - 2.68%). Using this we can say that the stability reading is unusually high, and it’s drifting towards instability.

Additionally, the chart embeds a lot of information in the tooltips. Scroll over the different thresholds, bins, or areas to view the tooltips. Here is an example when hovering over the area in-between the green and the yellow thresholds:

As illustrated, the coverage of the area in-between μ and μ + 2σ is 44.64%, which is close to the theoretical target of 47.72%. For SD values within this range, we expect a process stability between 100% and 83.33%.



III From the Distribution Chart to the Stability Gauge

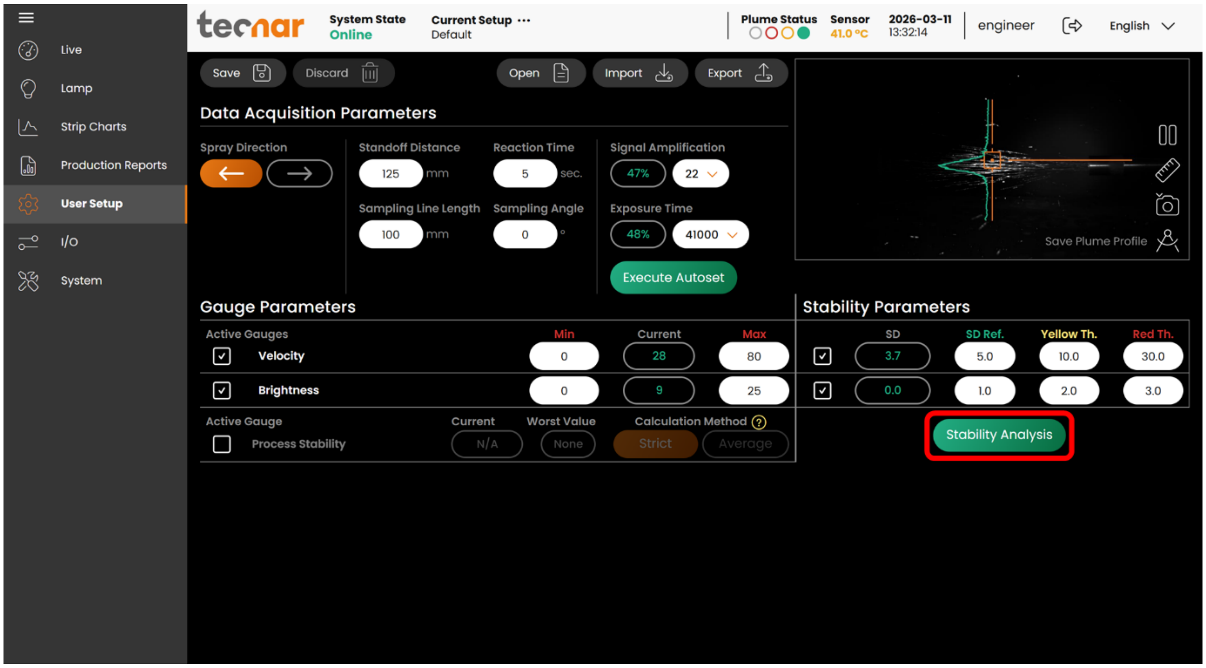
The "Process Stability" value can be anything between 0 and 100%. To establish the relationship between the distribution chart and the stability gauge, the SD value must be normalized based on the position of the thresholds. The green threshold always represents 100% stability. As for the red threshold, it represents 50%. This cannot be changed. However, the yellow threshold is dynamic. It can be interpreted as a percentage of the red threshold, relative to the green threshold. Thus, using the default thresholds, the yellow thresholds is one third of the red limit. Because the span between the green and the red threshold is 50%, this is equivalent to 16.66%. In addition, because the green threshold is set to 100% stability, the yellow threshold becomes 100% - 16.66% = 83.33%. Consequently, if you chose to set your yellow thresholds manually, the stability percentage that it represents may not always be 83.33%.

Hence, assuming the default thresholds, the ranges will be set as follows:

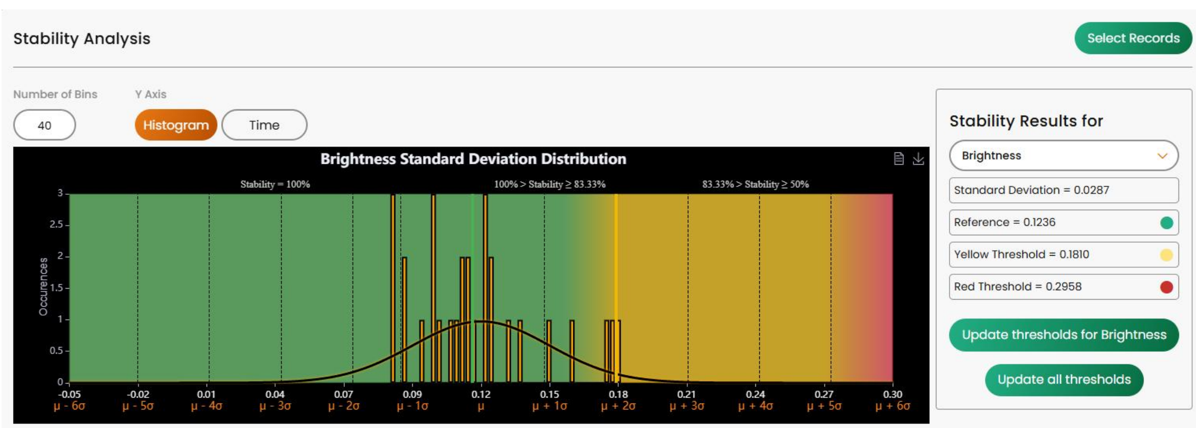
- For all SD values below the "Standard Deviation Reference" (μ_{SD}), the process stability will be set to 100%.
- For all SD values in-between the "Standard Deviation Reference" and the "Standard Deviation Yellow Threshold", the process stability will range from 100% to 83.33%.
- For all SD values in-between the "Standard Deviation Yellow Threshold" and the "Standard Deviation Red Threshold", the process stability will range from 83.33% to 50%.
- For all SD values above the "Standard Deviation Red Threshold" ($\mu_{SD} + 6 * \sigma_{SD}$), the process stability will range from 50% to 0%.

IV Performing a stability analysis in real-time

The usefulness of this tool is to allow users to perform stability analysis of multiple runs instead of processing the data externally in Excel. To do so, simply click on the “Stability Analysis” button at the bottom right. Select production files that represent a standard peening process for your current setup.



Once the process is finished, a menu will appear:



Then, you can click to update a selected measurement’s threshold or all measurements thresholds. This is useful to determine your green, yellow, and red regions if you are unsure of where to start, although it is purely based on statistics.

V The calculation methods

As mentioned previously, there are 2 calculation methods: “strict” and “average”.

- Strict (recommended): The “Process Stability” will display the parameter with the lowest stability among those that are active. The other parameters with higher stability will be ignored. Since the yellow threshold is dynamic, the lowest stability (%) of the worst color will be selected. Based on your yellow limits, this might not always be the lowest percentage.

- In average mode: All active stability measurements will have an equal weight to calculate the global “Process Stability”. In this mode, the yellow thresholds are ignored and forced to 50% of the red limit (relative to the green limit). This is equivalent to a process stability of 75%. This method is a good starting point until you fully qualify the process.