

accuraspray CS

User manual

In-line
cold spray
sensor

tec**nar**

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NOTICES

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MANUAL PART

40101-00075-00 Revision B

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Laser Safety

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

General Precautions

To protect your Accuraspray CS from damage, you must:

- Connect it to an unloaded, properly grounded power line (50–60 Hz., 100- 240VAC, 1.5 A).
- We also recommend using an additional power line filter to filter out any power surges or bursts.
- Use it at an ambient temperature between 4 and 45 °C.
- ALWAYS supply 30 LPM (2CFM) of cooling/cleaning air at 1.7–2.7 bar (25–40 psi) to the sensor head while the unit is powered on.
- Use only original spare parts.

All Accuraspray CS users should read this user manual, take the web-based introduction and training sessions, and contact Tecnar at service@spraysensors.tecnar.com with any further questions. We also recommend that a copy of the user manual should always be kept near the equipment.

Authorized Use

The Accuraspray CS is intended for use solely for cold spray process monitoring and control. Any other use is regarded as unauthorized.

The Accuraspray CS has been designed and manufactured according to state-of-the-art technology and recognized safety regulations. However, unauthorized use can result in danger to the operator or third parties’ body or even life and/or in damage to the product itself or other machinery.

Class 4 Laser Safety

The Accuraspray CS emits Class 4 laser radiation during operation.

Class 4 laser radiation hazards are defined as follows:

“Laser products for which intrabeam viewing and skin exposure is hazardous and for which the viewing of diffuse reflections may be hazardous. These lasers also often represent a fire hazard.”

The Accuraspray CS contains two class 4 laser diodes with the emission overlapping at the point of measurement.

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Total laser emission:

Laser wavelength:	940 nm
Duration:	Continuous wave
Nominal power:	20 W
Maximum power (fault condition):	40 W
Nominal laser density:	15.7 W/cm ²
Beam divergence (each laser source):	3.3° Horizontal / 0.88° Vertical
Maximum permissible exposure:	31 W/m ²
Nominal ocular hazard distance:	44 m (10 Second exposure time)

Radiation Pattern:

Both laser sources start near circular and become more elliptical the further away from the source they are.

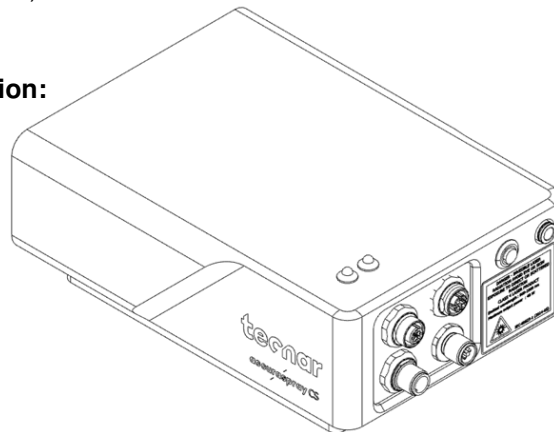
Beam dimensions at window: 7.3mm horizontal by 6.8mm vertical.

Beam dimensions 200mm from the output: 18mm horizontal by 9mm vertical.

Eye protection:

Optical density:	OD \geq 4.62
Wavelength range:	900-1000nm
Radiation exposure (fault condition):	40 W

Legible reproductions & position:



Description of Controls and Safety Functions

1. Key Control:

The HMI Remote has a key switch which controls laser emission. When the key is removed laser emission is disabled. The key must be inserted and turned to the ON position to be able to arm the lasers.

Note turning the key to the ON position does not automatically restart laser emissions, a manual start is required.

2. Remote Interlock Connector:

The controller has a two-channel remote interlock circuit. When the contacts are open-circuited, laser emission is disabled. Both channels must be closed to be able to arm the lasers.

Note closing the contacts does not automatically restart laser emissions, a manual start is required.

It is recommended to use the interlock to control access to the laser environment. For example, an interlock on the access door to the laser hazard area.

3. Sensor Head Beam Stop:

On the sensor head, a safety switch is provided. When the switch is turned to the vertical OFF position laser emission is disabled. The switch must be turned to the vertical ON position to be able to arm the lasers.

Note turning the switch to the ON position does not automatically restart laser emissions, a manual start is required.

4. Manual Start and Stop Controls

The HMI Remote has two buttons to start and stop laser emission. If all the safety devices are clear to allow laser emission, pressing the green button will start laser emission, and pressing the red button will stop laser emission.

The green button must be pressed to restart laser emission after any safety device has stopped emission or after mains power to the controller has been lost.

5. Laser emission warning

The sensor head and the HMI Remote are both equipped with redundant indicator lights to indicate that the laser is armed, and emission is possible. The lights remain on as long as the power to the laser is not completely discharged, even if laser emission has stopped.

System Description

Introduction

The present document gives a complete description and principle of operation of the Accuraspray CS sensor as well as a description of its components.

Overview

The main purpose of the Accuraspray CS is to ensure consistent, high-quality coatings by monitoring the in-flight particles and plume properties before each spray run. This ensures that the spray properties are within predetermined acceptance ranges for ideal coating and performance.

To help detect potential issues such as partial clogging of the nozzle or in the powder injection system, and instability of the powder feeder before the coating process, the Accuraspray CS monitors:

- Inflight particle velocity
- Relative powder feed rate
- Process Stability
- Standard deviation of all measurements
- Substrate temperature (optional)

The Accuraspray CS can also be used to:

- Develop and optimize spray parameters
- Transfer parameters from one booth to another (anywhere in the world)
- Transfer parameters from one spray gun to another
- Extend the useful lifespan of hardware
- Significantly reduce the number of test coupons
- Troubleshoot day-to-day issues

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Components Description

The Accuraspray CS system includes the following elements:

1. Controller
2. HMI unit
3. Sensor head
4. Air filter and hoses
5. Substrate pyrometer and its support bracket (optional)
6. Communication cable, laser power cable and safety switch cable

Each element is described in detail on the following pages.

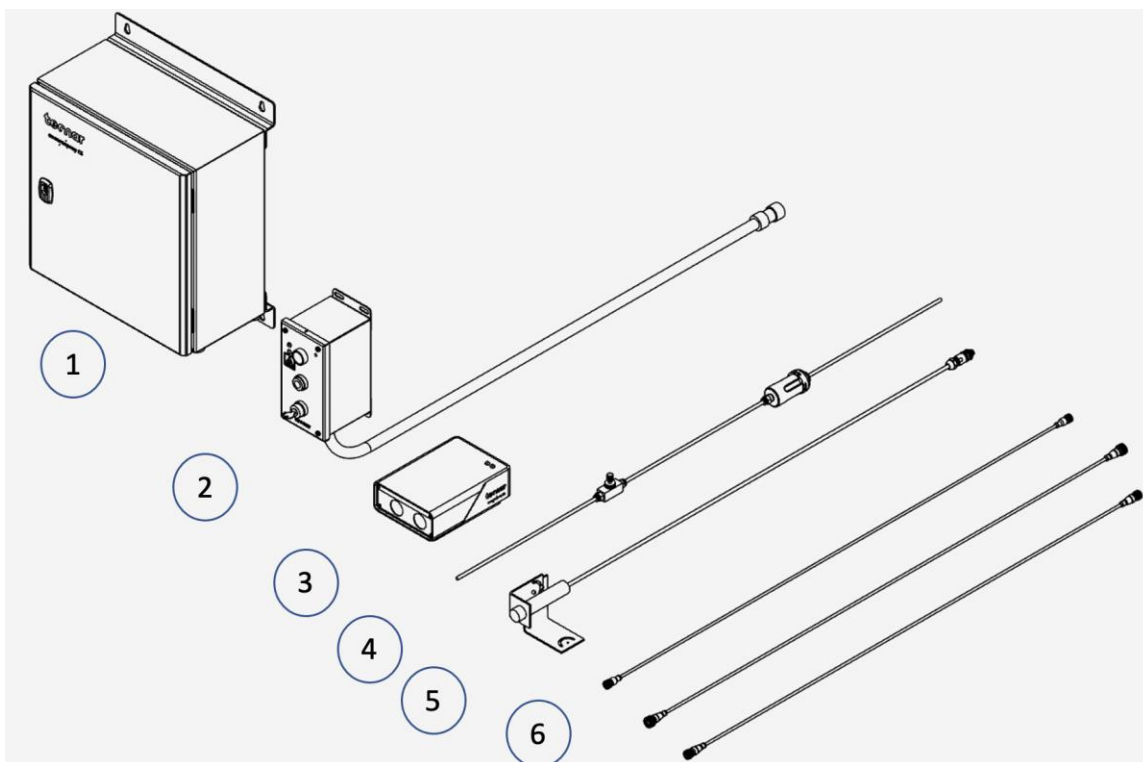


FIGURE 1: SCHEMATICAL DESCRIPTION OF THE SYSTEM

Controller

The controller must be kept in a ventilated area to reduce the risk of overheating.

The controller receives readings from the sensor head. It processes the data and broadcasts the results to the user interface(s).

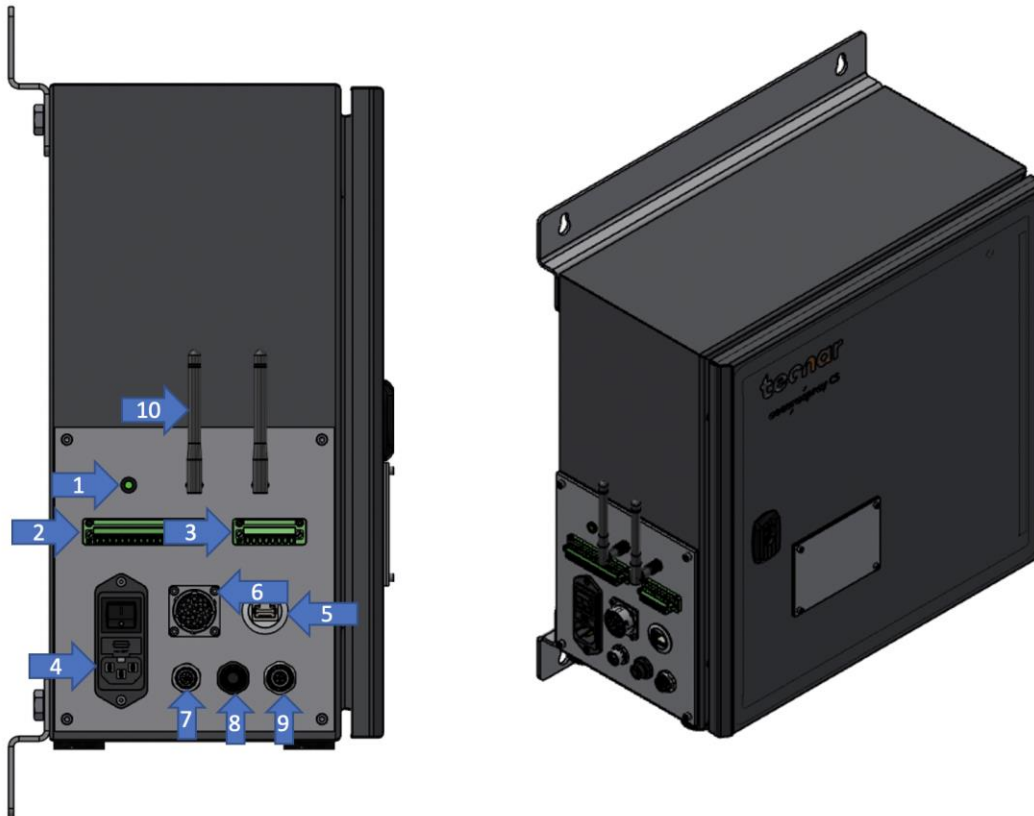


FIGURE 2: CONTROLLER (SIDE AND ISOMETRIC)

Component	Description
1. LED	LED Off: Power supply is OFF Green: The system is ON
2. I/O interface	Used to interface the Accuraspray CS to the user's spray controller via digital I/O ports.
3. Safety interlock	Used to setup safety interlocks with the booth access points
4. Power switch and inlet	Used to activate the unit. <i>Connect it to an unloaded, properly grounded power line (100-240VAC, 50-60Hz, 1.5 A).</i>
5. Ethernet port	Used to access the Accuraspray CS user interface through a wired network connection (either static or DHCP).
6. HMI cable port	Used to connect the HMI unit with the controller.
7. Laser power port	Used to power the lasers in the sensor head
8. Safety switch port	Used to display the status of the laser beam stop on the UI.
9. Communication cable port	Used to communicate with the sensor head.
10. Wi-Fi antennas	Used to access the Accuraspray CS user interface through a wireless network connection. The Wi-Fi connection acts as a hotspot. It can be disabled but not reconfigured.

Sensor head

The sensor head measures the following particles and spray plume properties:

- Particle's velocity
- Relative feed rate
- Process Stability

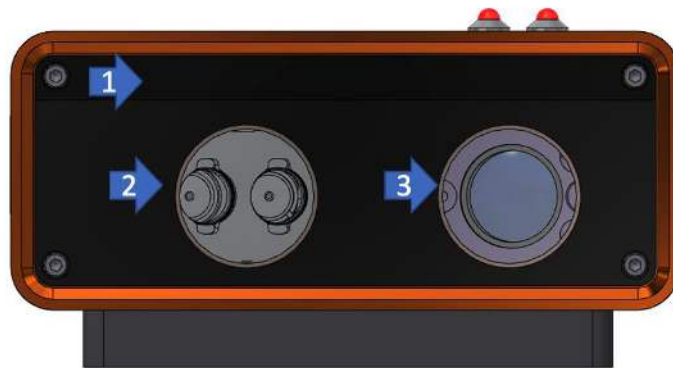


FIGURE 3: SENSOR HEAD (FRONT)



FIGURE 4: SENSOR HEAD (BACK)

Component	Description
1. Air knife	The air knife is used to keep the sensor head windows cleaned and free of dust.
2. Laser Illumination	Laser illumination chamber for the illumination of the plume.
3. Detector viewport	Viewport of the detectors used to characterize the velocity and feed rate.
4. Safety switch connector	Used to relay information about the mechanical shutter in the sensor head to the controller.
5. Substrate pyrometer connector	Used to power and communicate with the optional substrate pyrometer sensor.
6. Communication port connector	Used to power the sensor head and communicate with the controller.
7. Laser power port connector	Used to connect the laser diodes with power.
8. Alignment beam switch	Activation switch for the alignment beam.
9. Compressed air port connector	Compressed air is used both as active cooling for the head's internal components, and as it is exhausted from the head, to generate an air knife that keeps the viewport windows clean.

Cables, hoses and antennas

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

Cables/Hoses/Antennas	Description
1. IEC power cable	Used to connect the Accuraspray to a power outlet.
2. Communication cable	Communication between the controller and the sensor head.
3. Antennas	Used for Wi-Fi communication to the controller.
4. Safety switch cable	Used to communicate the status of the beam stop in the sensor head
5. Laser power cable	Used to power the lasers in the sensor head through the controller
6. Compressed air hoses	Provide compressed air to the sensor head for cooling and purging purposes. <ul style="list-style-type: none"> • 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 sensor head

Software Operation

User interface overview

The Accuraspray CS user interface is accessible through a web browser, but it is not actually hosted on the internet. It is streamed from the Accuraspray CS controller. 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: ACCURASPRAY CS USER INTERFACE

Accessing the user interface

To connect to the UI through the Wi-Fi use the following steps:

1. Open the Wi-Fi menu on your computer or tablet
2. Look for “Accura CS – serial number”.
3. The password to access the Wi-Fi is “accura.wifi”.
4. Follow the procedure in the section “Modifying Windows “hosts” file” of the “40107-00047” document.

To connect to the UI through static IP use the following steps:

1. Connect the Accuraspray controller directly to your PC with an Ethernet cable.
2. Click on the Windows icon, type “View Network Connections”.
3. In the connection window, identify the connection connected to the Accuraspray.
4. Right-click on the connection and click “properties”.
5. Double-click on “Internet Protocol Version 4 (TCP/IPv4).
6. Click on “Use the following IP address”.
7. Enter the following:
 - IP address: 192.168.101.254
 - Subnet mask: 255.255.255.0
 - Default gateway: (leave blank)
7. Follow the procedure in the section “Modifying Windows “hosts” file” of the “40107-00047” document.
8. You are now ready to connect to the software, please refer to the section “Connecting to the software”.

Connecting to the software

To connect to the software, use the following steps:

1. Open your browser
2. Enter the URL: `http://accuracs-00000000/` to connect to the Accuraspray CS user interface. 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 or under the controller.

Logging in

The Accuraspray CS user interface 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 Accuraspray CS interface, users that 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.




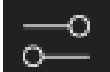


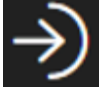
To make changes to the setup and record sequences it is necessary to log in by clicking the designated icon. Users can log in either as operator or administrator.

- 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: **accura.operator**
- Administrators (**username: admin**) have the same rights as the operators and can also create, modify, and delete setups. The default password for administrator is: **accura.admin**

Users’ passwords can be changed in the settings tab.

Navigation tabs

The navigation icons are displayed on the he left of the Accuraspray CS user interface to access the different tabs. The following table describes those icons.

Icons	Description
	Access the main measurement screen (live).
	Access the production files screen.
	Access the setup screen (spray parameters).
	Access the IO settings.
	Access the substrate pyrometer screen.
	Access system settings.
	Take control and access the setup settings.

Live screen

The live screen displays in real time all measurements taken by the Accuraspray CS.

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 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, and a measurement outside the acceptance range is shown in red. 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, you will find two graphs, each displaying one type of measurement. It is possible to select which measurement to display from the table located to the right of the graphs.



FIGURE 6: ACCURASPRAY 4.0 LIVE SCREEN

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


Parameters	Description
1. Velocity	Average particles speed that are passing through the sensor's measurement volume (bullseye).
2. Feed Rate	Measure of the intensity reflected light by the spray plume. This is a derived estimate of powder feed rate. As the number of particles in the plume increases, the light reflection intensity increases.
3. Process stability	The stability of the process. This value will vary based on the selected stability mode.
4. Part temperature	Temperature of the substrate on which the coating is applied. This value is visible in the part temperature window.

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 the strip charts tab. However, the data for these measurements will still appear in the .pdf and .csv when you save a production report.



FIGURE 7: ACTIVE GAUGES

Clicking on the gauge button  will spawn the “Active Gauges” menu. This button is also duplicated in the settings tab along with the other spray parameters.

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 0.5 minute (30 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.

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.

Part temperature screen

The part temperature, also known as the substrate temperature, has been moved from the live screen to its own separate tab. The reason for this is mainly because the part temperature cannot be measured at the same time as the process itself. The process must be qualified when not spraying the part.

When you change the min/max settings in this tab, make sure to go back to the settings tab and save your changes.

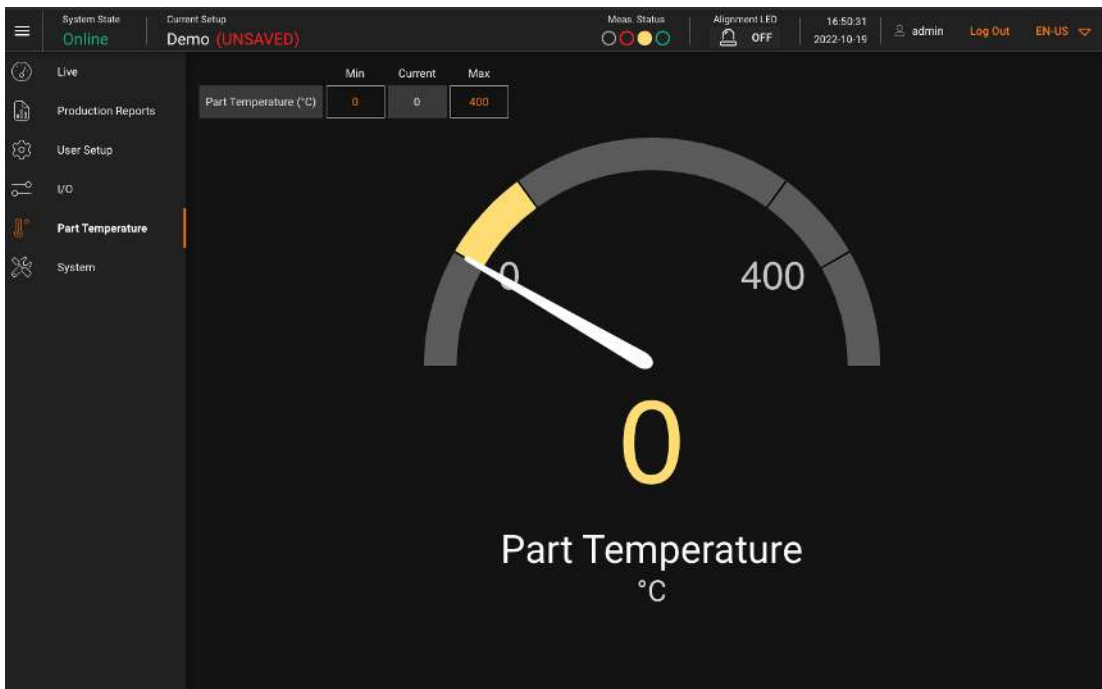


FIGURE 8: PART TEMPERATURE SCREEN

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. Thorough analysis of the spray parameters can be found in the production report (.pdf).



FIGURE 9: STRIPCHART BUTTONS BAR

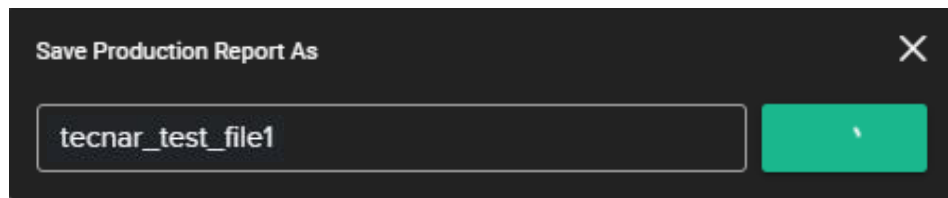


FIGURE 10: SAVING PRODUCTION FILE

The production reports are stored on the Accuraspray CS 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). 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 files screen:

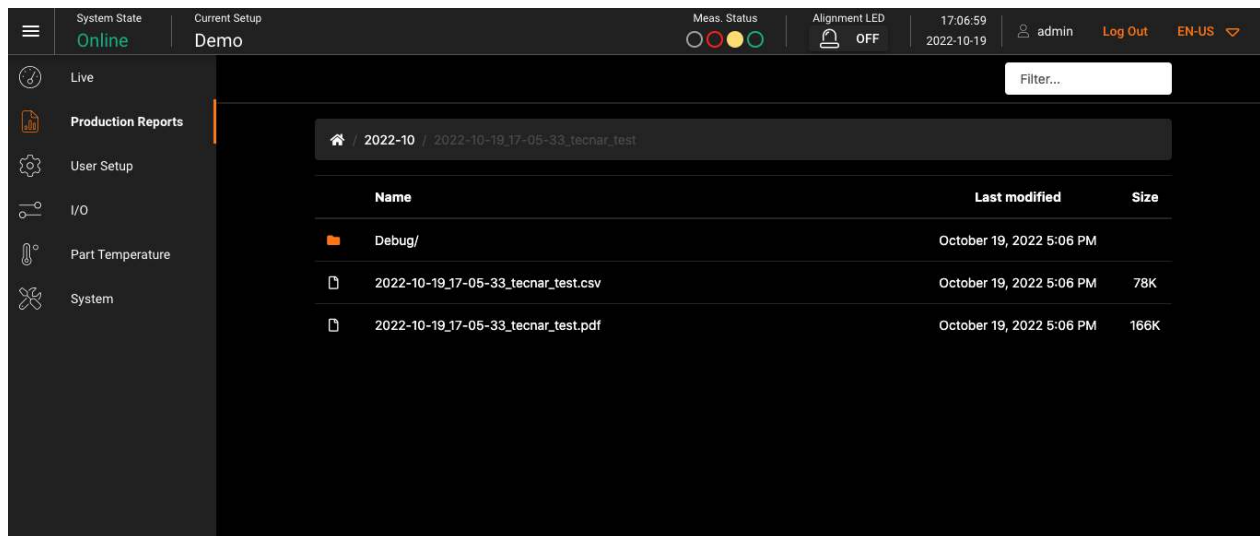


FIGURE 11: PRODUCTION FILES SCREEN

Setup screen (operator and administrator only)



The setup screen is where the sensor's parameters are managed. Click the gear icon to access the setup screen.

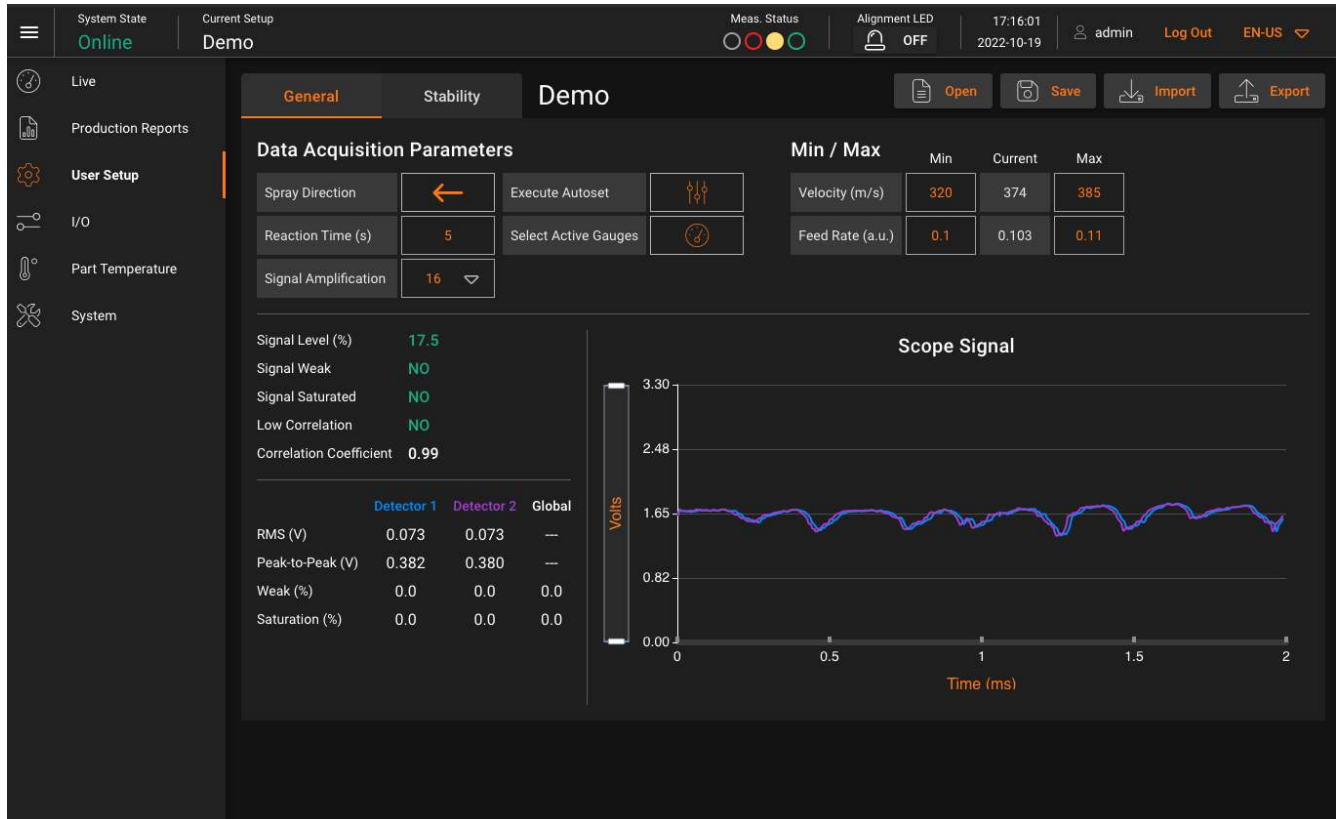


FIGURE 12: SETUP SCREEN

Min/max adjustments

The left side of the setup screen shows the data acquisition parameters for the current process. Under “Current Setup”, the setup control bar allows users to open/delete, save, import, and export setups.

The left side of the configuration screen shows the acceptance ranges, when the “general” menu is selected. 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 40% of the total span, starting from the lower and upper thresholds, as shown in the picture below:

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.

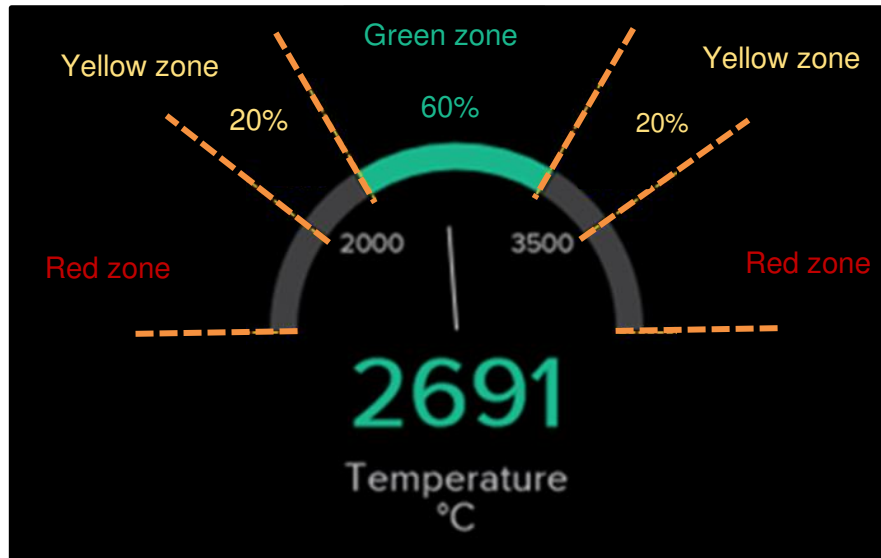


FIGURE 13: GAUGES PROCESS CONTROL ZONES

Opening/Deleting setups

In the setup screen, click . 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.

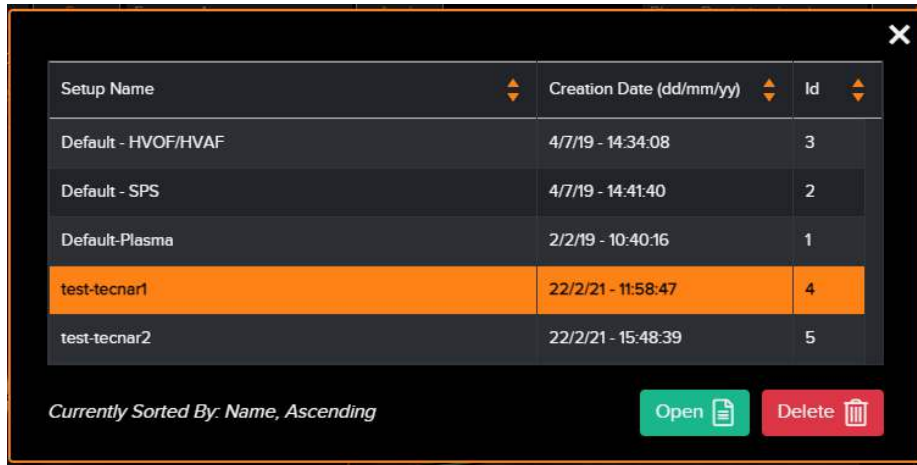


FIGURE 14: OPENING/DELETING SETUPS

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 either in the top right corner or above the setup name, depending on the current tab.

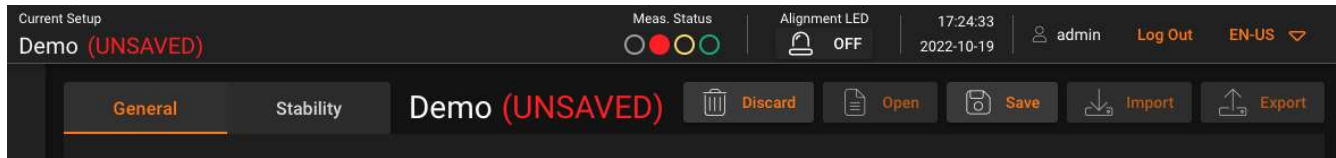



FIGURE 15: UNSAVED SETUP MESSAGE



In the setup screen, click . This displays the following window.

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”.

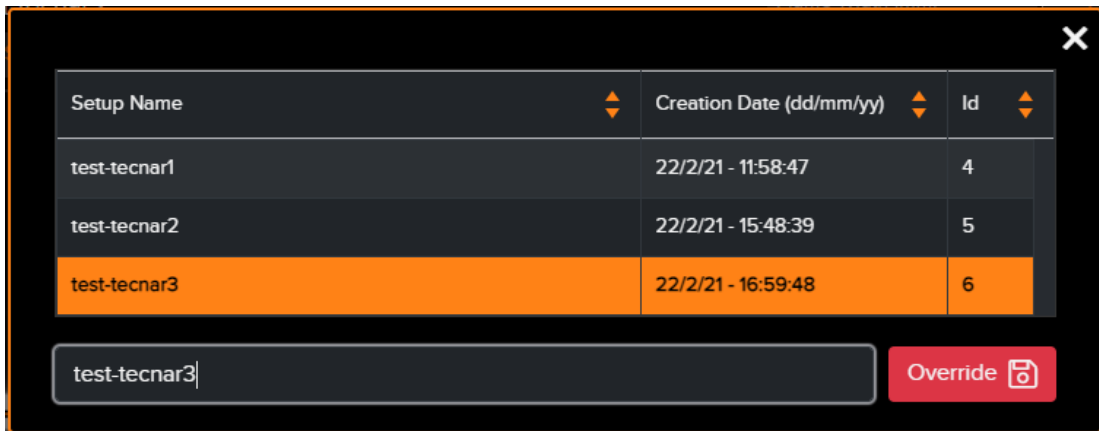


FIGURE 16: SAVING SETUPS

Importing and exporting setups

Setups can be exported from one Accuraspray CS unit and imported into another. When clicking on the “Export” button a setup file with the “setup” extension will be downloaded on 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 have two different Accuraspray CS units.



FIGURE 17: IMPORT/EXPORT SETUPS

Setup parameters

The table below explains the data acquisition parameters that are used to configure the Accuraspray CS according to the spray process you will be monitoring. See Figure 12 for additional information.

Parameters	Description
Spray direction	Particle’s travel direction (left to right or right to left) relative to the Accuraspray CS field of view.
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. Typical reaction time for cold spray and HVAF is between 1 to 5 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.
Execute Autoset	This feature automatically adjusts the “signal amplification” for the measurements. These settings can also be modified manually using the drop-down selectors. However, before an auto-set can be performed, the spray plume must be centered on the bullseye and the spray direction parameters must be set properly: <ul style="list-style-type: none"> • Spray direction
Select Active Gauges	When clicking this button, a pop-up menu will appear, allowing the user to activate or deactivate specific gauges. This button is the same as the “gauge” button in the live screen.
Min/Max Thresholds	The lower and upper limits for each measurement type.

Stability
Thresholds

Just like the min/max thresholds, the stability thresholds are applied to every measurement type (except for the part temperature). Each measurement type is comprised of 3 thresholds:

- Standard Deviation Reference
- Standard Deviation Yellow Threshold
- Standard Deviation Red Threshold

Changing ANY of these parameters will affect the current setup. Please make sure that you save your changes by clicking the “Save” button.

System settings

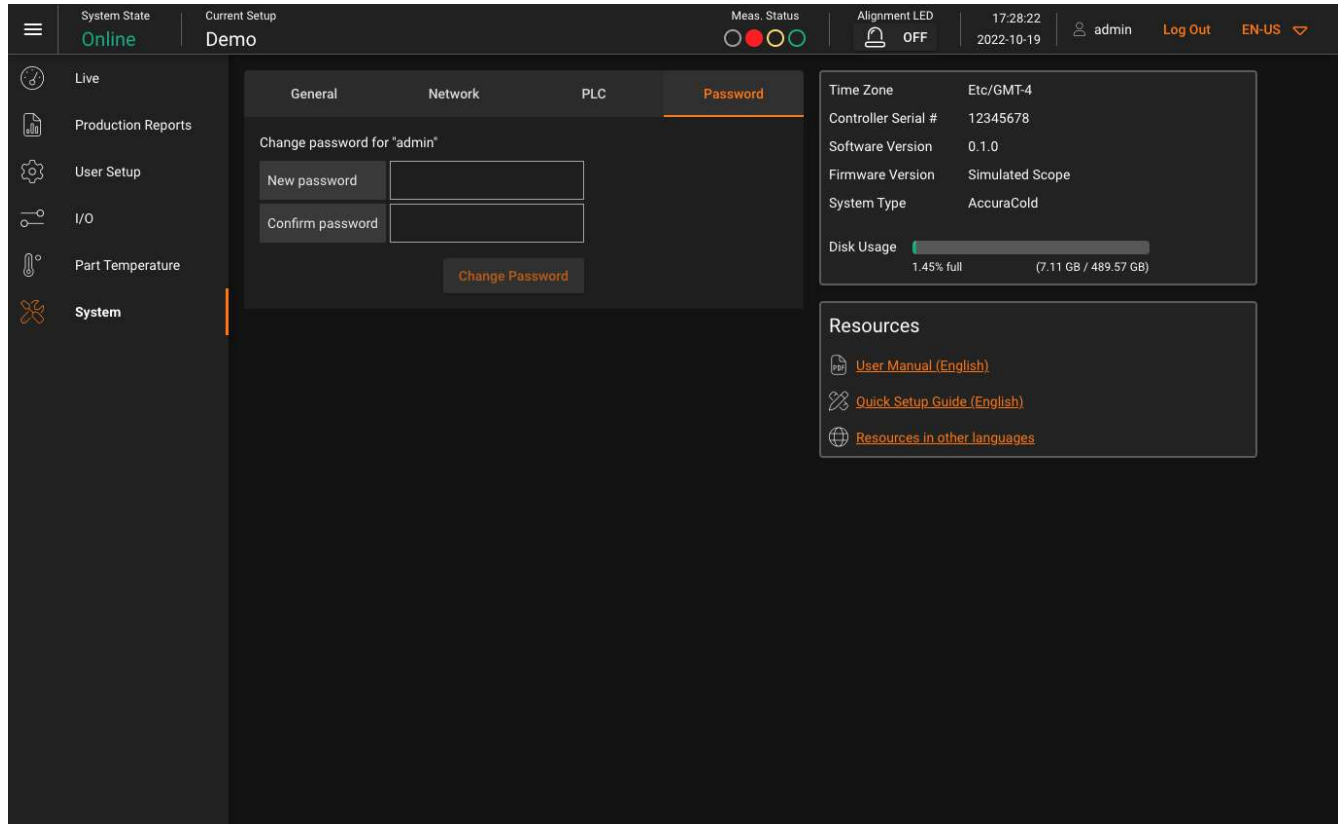


FIGURE 18: SYSTEM SETTINGS

Changing the user password

Enter a new password and click 'Change Password' to modify it.

Note that you will have to login either as Operator or Administrator to access the settings screen.

Enabling/Disabling Wi-Fi

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.

Changing the static IP of the controller

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 "40107-00047 – Network Connections" for in-dept details.

DHCP IP

The Accuraspray 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 Accuraspray CS to your facility's network is the easiest way to set-up. An address will be obtained from your DHCP server, and you can connect to the Accuraspray CS directly (<http://accuracs-12345678>). 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 as mentioned previously. Refer to the document "40107-00047" for in-dept details.

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.

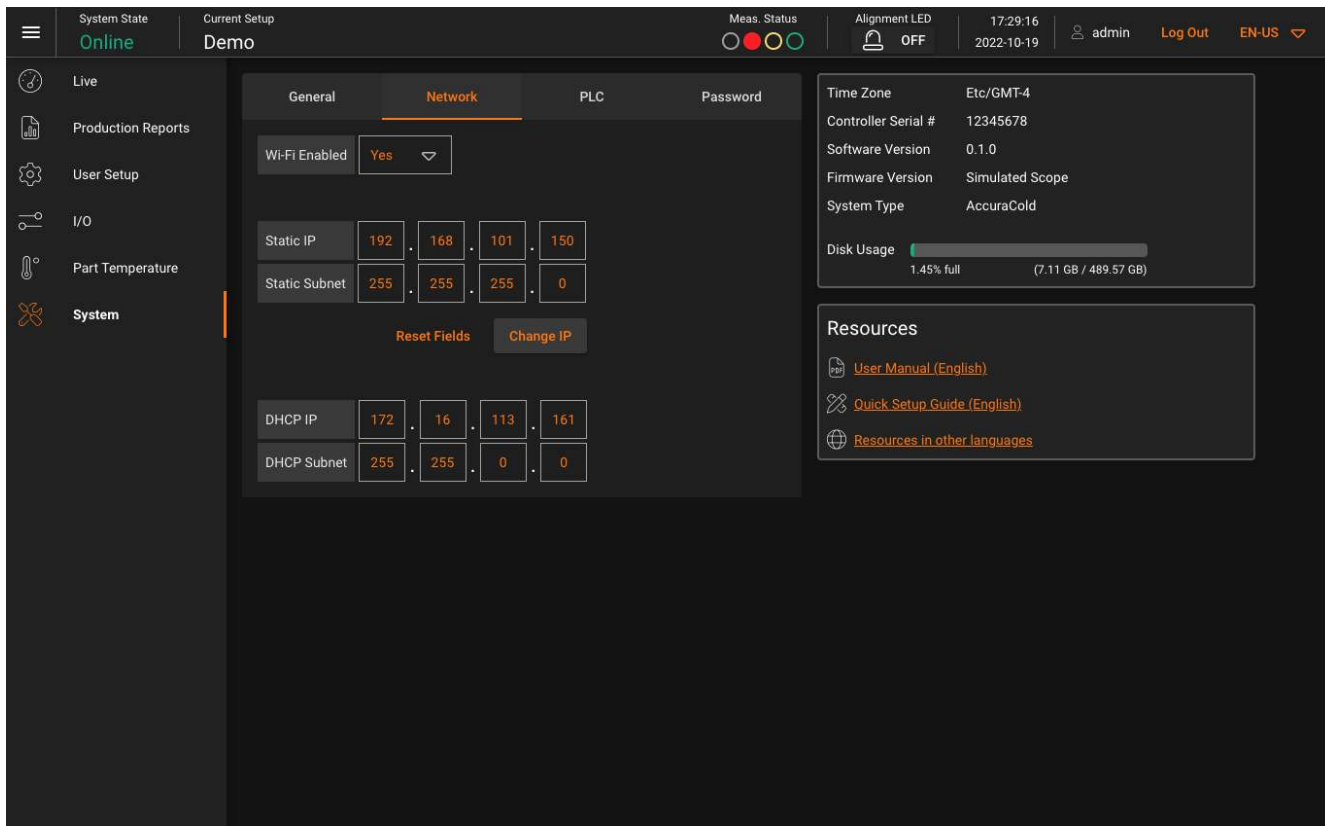


FIGURE 19: SYSTEM SETTINGS FOR WIFI.

Report Generation Mode

Using the IO tab, the user can explore the possibility of generating production reports through IO controls. The IO ports can also be used for various other tasks such as indicating on an alarm when a measurement is in the red zone. The inputs and outputs possible are illustrated in the image below.

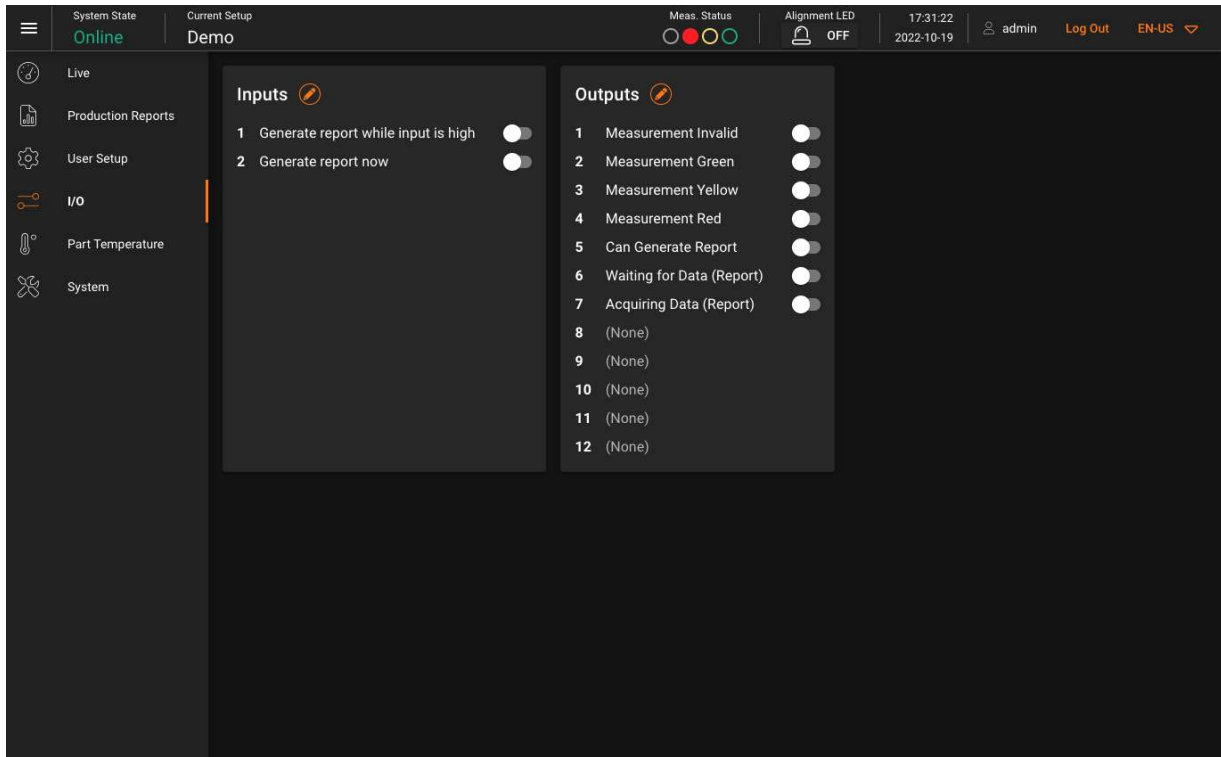


FIGURE 20: IO CONTROL TAB.

Changing the time zone

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 “what’s my time zone”. The figure 21 is an example using UTC-4. 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.

Updating your system

Download the latest update archive (.7z) from Tecnar’s website and update your system gracefully 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.

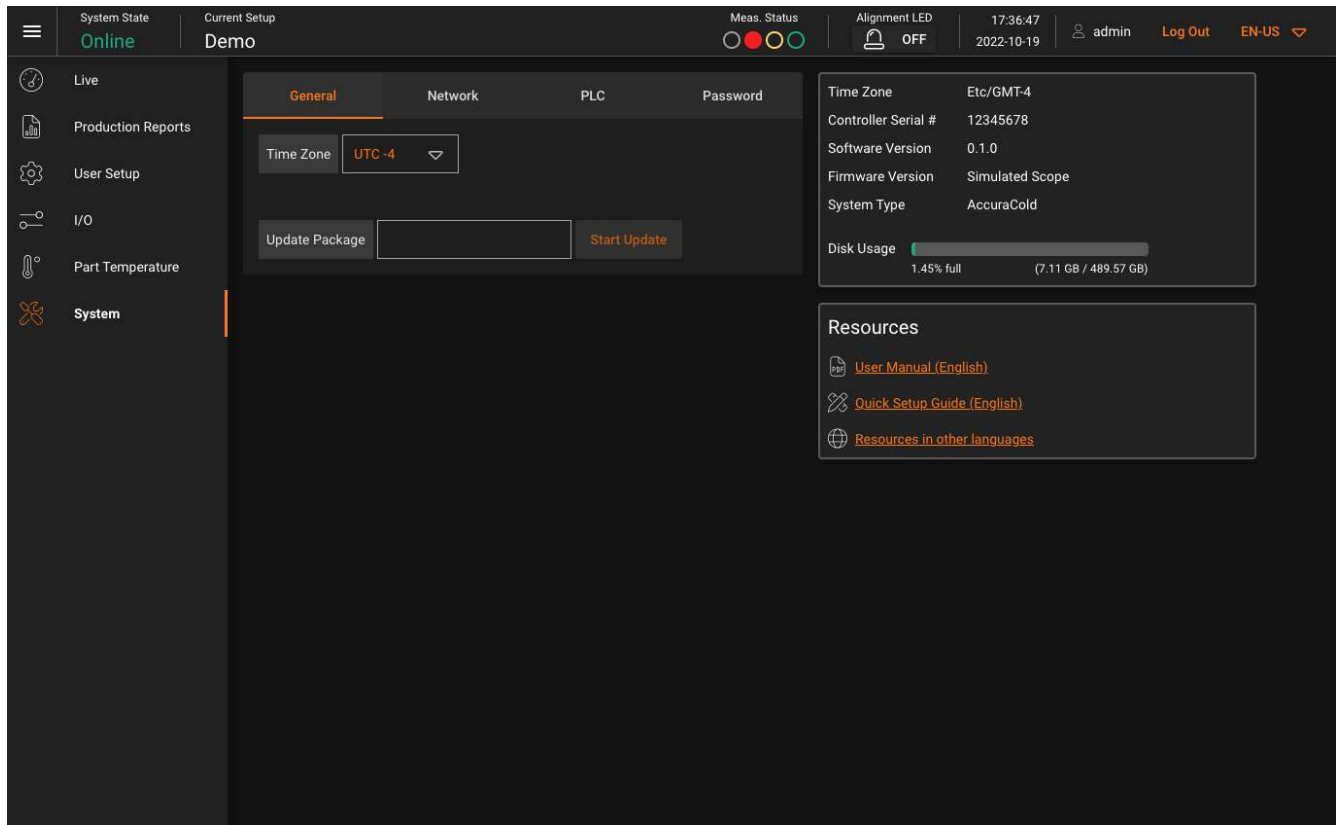


FIGURE 21: SOFTWARE UPDATE EXAMPLE

Process stability

Philosophy and measurement principle

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 on the stability of the process, the stability gauge comes into play. Though 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 in 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 25 Hz and 20 Hz respectively. Hence, using a 5 second moving average, we would have a total of 125 entries for scope measurements (temperature, velocity), and 100 entries for camera measurements (all the other 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. 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 are 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.

Overview of the stability panel

The top half of the screen lets you adjust the parameters 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 Red Threshold”, 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. Finally, at the right edge of the screen, a status circle displays the current stability status for that measurement.

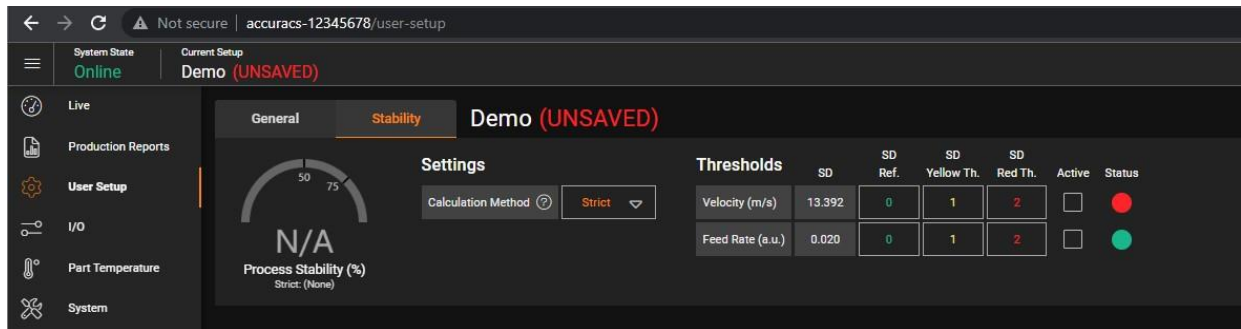


FIGURE 22: STABILITY FEATURE TAB

The distribution chart

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 rejections criteria are applied on 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” in our current context. When the data is normally distributed, the probability density function is a bell-shaped curve, as show 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 $\mu + 2\sigma$ is:

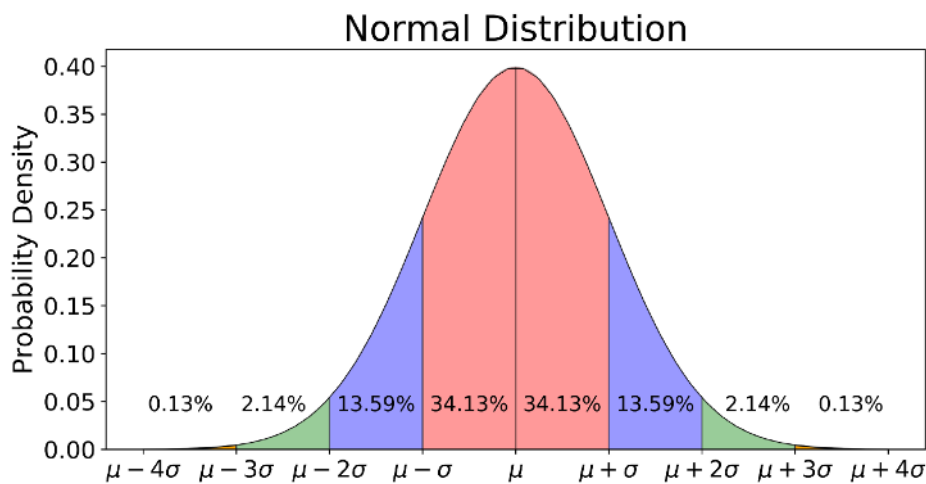


FIGURE 23: NORMAL DISTRIBUTION

From “Explaining the 68-95-99.7 rule for a Normal Distribution, by Michael Galarnyk, 2018.
<https://towardsdatascience.com/understanding-the-68-95-99-7-rule-for-a-normal-distribution-b7b7cbf760c2>

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

Tecnar has chosen to use 2σ 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 $\mu + 6\sigma$. 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.

The calculation methods

As mentioned previously, there are 2 calculations 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 a 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.

Adjusting thresholds based on previous runs

The stability analysis can also be performed on any csv file previously generated by the Accuraspray CS. Simply click the “Load CSV” button and the statistics will be automatically generated. You can also load runs from different controllers if necessary. Therefore, you can use the results to update the thresholds for the currently loaded setup.

Adjusting thresholds manually based on multiple runs

The stability analysis is limited to one csv file, meaning that you cannot “aggregate” files from different runs, booths, guns, etc. Depending on your use case and the level of integration, you may want to build the reference setup based on runs executed in different booths, using different torches, etc. This is a valid approach. However, you will have to process the data externally using Excel, MATLAB, or other external tools to find the proper limits for the aggregated runs.

You could also bypass this limitation by “aggregating” the content of the different csv files into a single file. The Accuraspray CS will then process the results as if it was one set of data. This will have the same effect as processing the files externally to find your limits. The only thing to keep in mind is that the time domain chart will appear as one cluster of data, and you won’t be able to differentiate the runs by doing so. However, the calculated thresholds will be the same.

Technical Specifications

Sensor head

Parameters	Description
Width	149 mm (5.8 in.)
Height	62 mm (2.4 in.)
Length	205 mm (8.1 in.)
Working distance from spray gun axis	200 mm (7.87 in.) at 90°
Particle velocity measurement range	5 – 1200 m/s at 2% accuracy
Particle's measurement volume	3 mm DIA x 10 mm DOF = 71 mm ³
Substrate temperature	From -18 to 538°C

Controller

Parameters	Description
Width (a)	21 cm (8.27 in.)
Height (b)	40 cm (15.7 in.)
Length (c)	42 cm (16.5 in.)
Power requirement	100–240 VAC, 50–60 Hz, 1.5 A, auto-switch

Installation

Installing the sensor head

Unpacking the parts

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

1. Controller
2. HMI unit
3. Sensor head
4. Air filter and hoses
5. Substrate pyrometer and its support bracket (optional)
6. Communication cable, laser power cable and safety switch cable

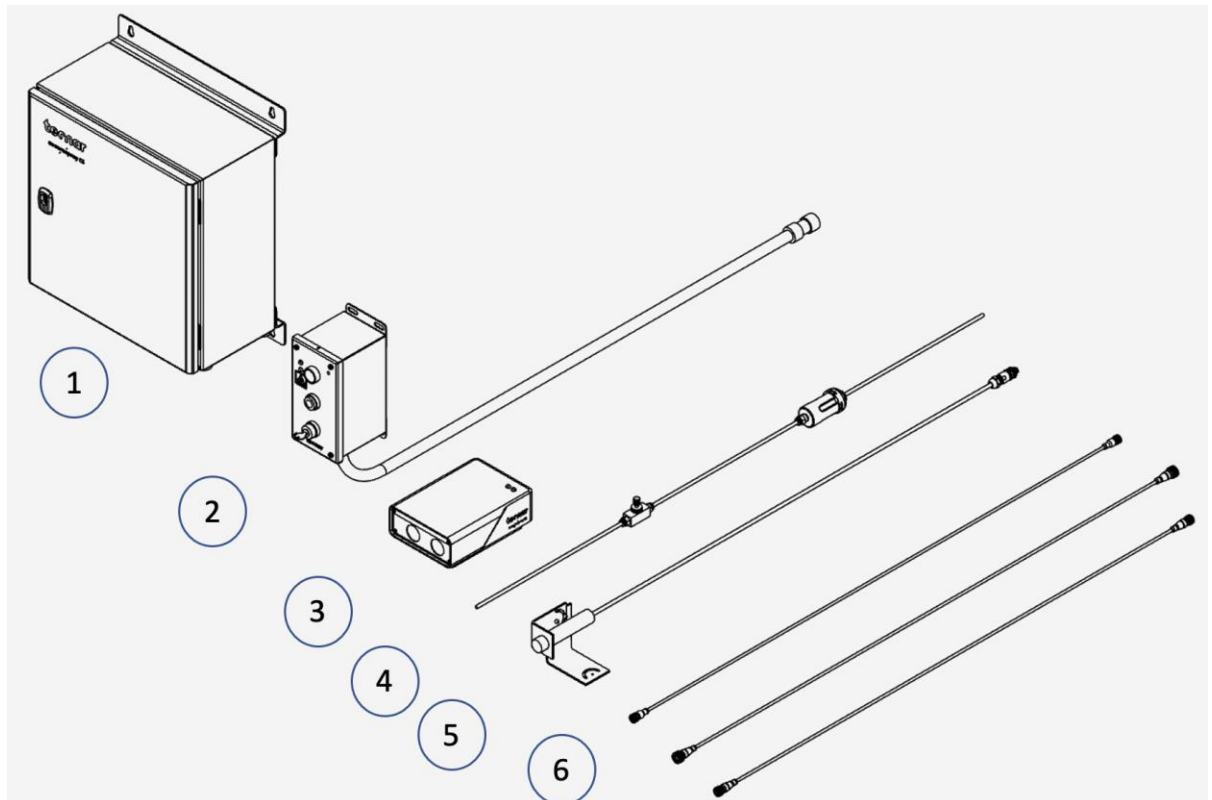


FIGURE 24: UNPACKING THE PARTS

Installation procedure

In order to nstall the sensor head in the spray booth at a location easily reachable by the robot (spray gun). Also, ensure that the sensor head does not interfere with normal spraying operations.

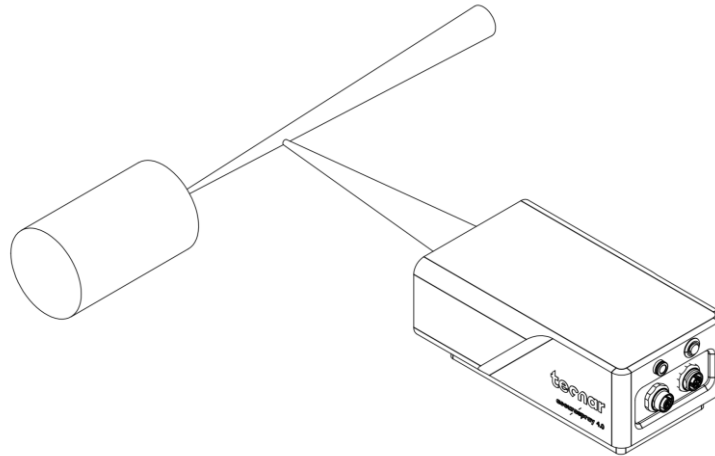


FIGURE 25: POSITION OF THE SENSOR HEAD

Install the sensor head on a sturdy mounting that does not vibrate or move during spraying. Refer to the following schematics of the Accuraspray CS mounting plate.

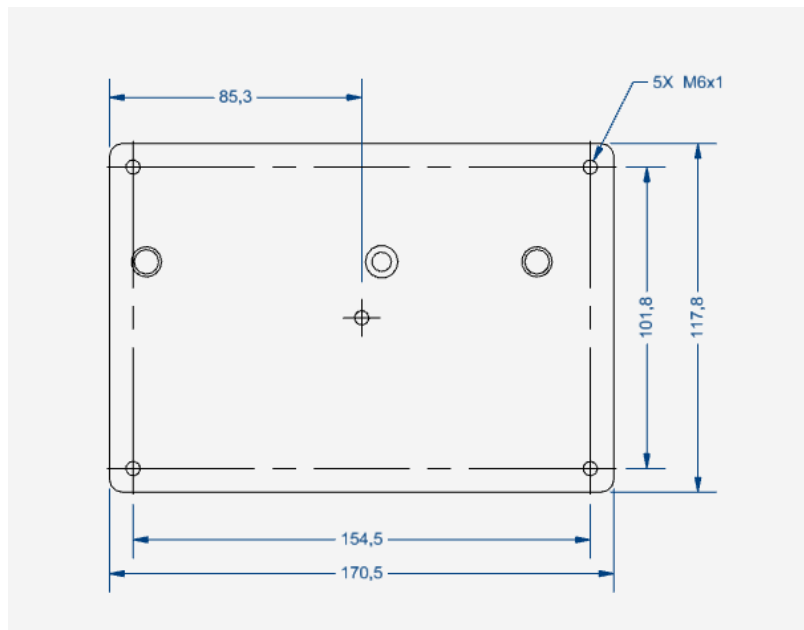


FIGURE 26: SENSOR HEAD MOUNTING PLATE DIMENSIONS.

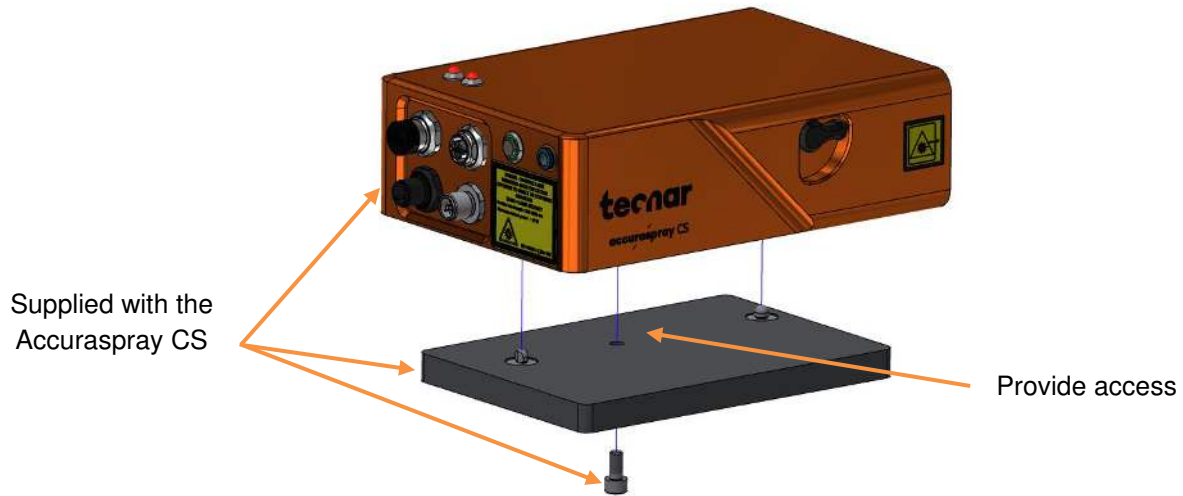


FIGURE 27: MOUNTING THE SENSOR HEAD.

Connect the compressed air hoses to the sensor head. Connect the communication cable, the laser power cable, and the safety switch cable to the sensor head. Pull the other end of the cables out of the spray booth. Connect the air hoses to the booth air supply. Connect the other ends of the cables to the controller as indicated on the Figure 28.

Installing the HMI module

Connect the HMI module to the controller using the cable CBL 1004, as indicated in the diagram. Install the HMI module on the door of your booth. Ensure that the laser is disarmed before entering the spray booth without appropriate PPE.

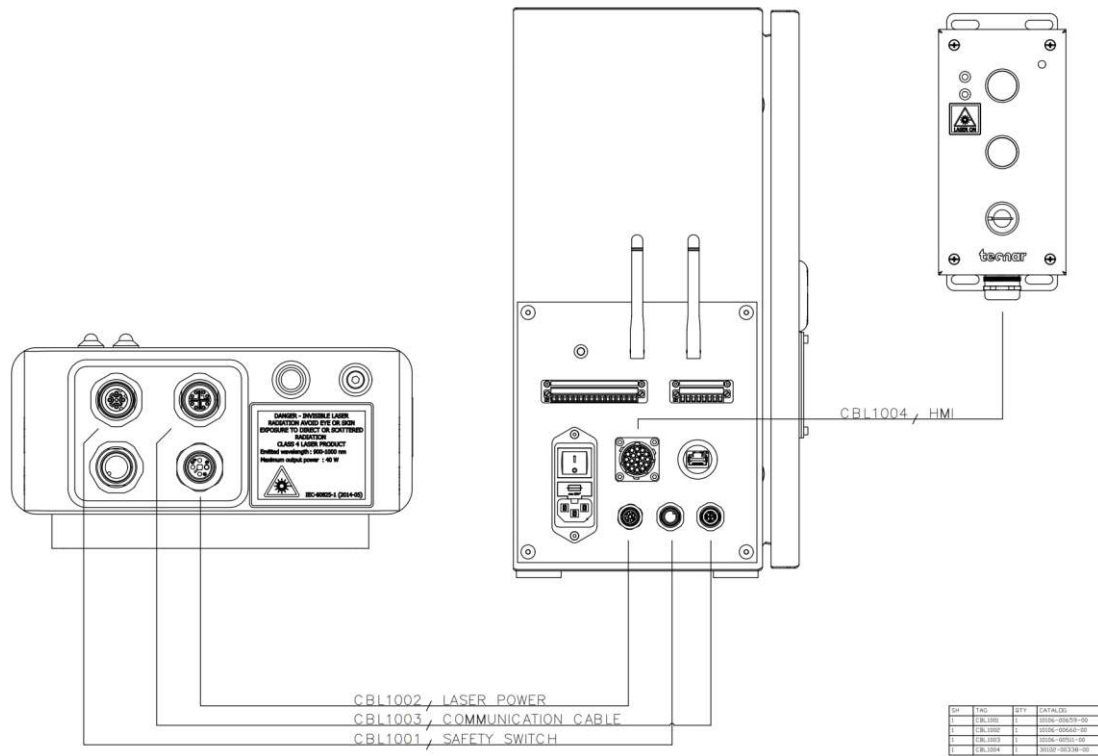


FIGURE 28: CABLE CONNECTIONS BETWEEN THE SENSOR HEAD AND THE CONTROLLER.

Installing the controller

Install the controller outside the spray booth, ideally, close to the booth control equipment.

Connect the power cable to the controller and into a power socket.

Flip the power switch on the controller to position ON.

Adjusting the spray gun position

Activate the alignment beam using the push button located at the back of the sensor head. Bring the spray gun near the sensor head as shown on the schematic below.



FIGURE 29: SENSOR HEAD ALIGNMENT BUTTON.

The sensor measurement point is normally set to your standard process spray distance.

The distance between the front of the sensor head and the spray torch axis should be adjusted to 200mm.

Use the green LED to align your measurement point vertically. Fine tuning to ensure that the measurement point is in the center of the plume can be done by starting the spray process and moving the robot to scan the plume velocity profile vertically to find the location with the fastest particles which would typically be the center of the plume. Save this position as the sensor home position on the spray gun.

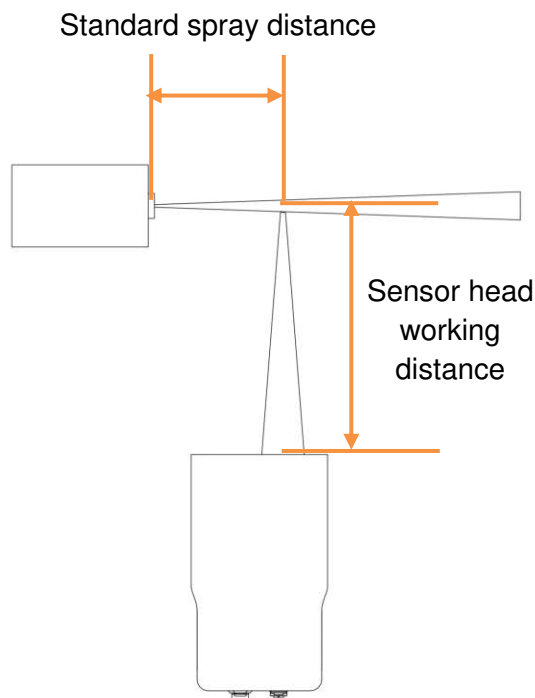


FIGURE 30: SENSOR HEAD WORKING DISTANCE.

Setting up the Accuraspray on a network (optional)

To connect the Accuraspray CS to your local network you must connect the controller to the network with an Ethernet cable. Refer to the document “40107-00047 [Accuraspray 4.0 Network Connections](#)” for in-depth details.

Connecting the I/Os (optional)

You may remotely control the Accuraspray CS using the I/O connections. To use the I/O connections, please refer to the following schematic and descriptions

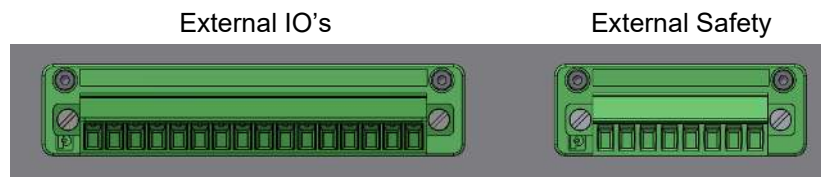


FIGURE 31: IO PORTS ON THE CONTROLLER.

Using the input to generate reports

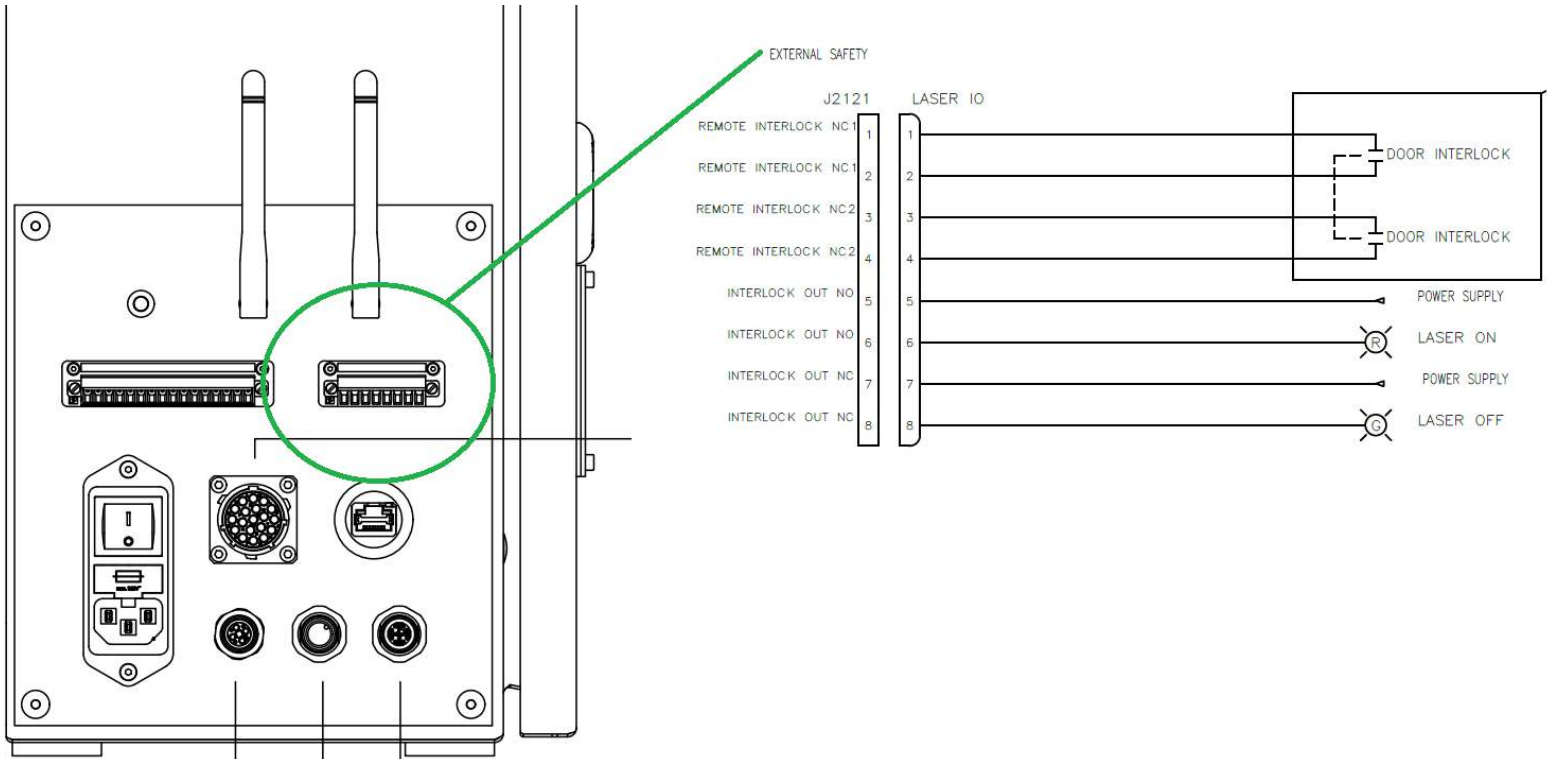
The Input can be used to automatically generate reports and .csv files. It must be held ‘high’ for at least 1 second to be detected by the controller. The input status is fetched every 500ms. If you set the input ‘high’ for more than 1 second but less than the reaction time, the auto-generated report length will be set to 1 second. Therefore, the system will record 1 second of data after the reaction time. This is a safety measure, not a feature. The csv will most likely contain a single line, and the graphs cannot be plotted.

The typical usage is to set the input “high” for more than the reaction time. The auto-generated report length will be set to (“input high time” – “reaction time”). For example, if you set the reaction time to 5 seconds and leave the input “high” for 10 seconds, the auto-generated report will contain 5 seconds of data, starting after the 5 seconds reaction time. While recording using the input, you cannot save reports or videos through the User Interface, and vice-versa.

External IO's Connections

Pin	Name	Description	Logic
1	IN 24 VDC	Input/Output reference Voltage + Supplied by user	
2	IN 0 VDC	Input/Output reference Voltage – Supplied by user	
3	IN 1	Start measurement sequence (the data acquired by the Accuraspray will be saved) when logic is 1 and stop when logic is 0	Logic <u>1</u> : 11-24V above 0VDC IN Logic <u>0</u> : 0-5V above 0VDC IN
4	OUT 1	Wait for data acquisition. This output indicates that the sensor is acquiring its initial data buffer. Once the buffer is filled, this output will fall.	Logic rising edge: Acquiring initial buffer Logic falling edge: Initial buffer acquired
5	OUT 2	Measurement valid. Following the acquisition of the first buffer this output 1 will be raised when measurements are valid. If the measurements are invalid, error messages will be displayed in the user interface and measurements results should be ignored.	Logic <u>1</u> : 24 VDC IN Logic <u>0</u> : 0 VDC IN
6	OUT 3	All measurements are within the green zone .	Logic <u>1</u> : 24 VDC IN Logic <u>0</u> : 0 VDC IN
7	OUT 4	At least one measurement is within the yellow zone .	Logic <u>1</u> : 24 VDC IN Logic <u>0</u> : 0 VDC IN
8	OUT 5	At least one measurement is within the red zone .	Logic <u>1</u> : 24 VDC IN Logic <u>0</u> : 0 VDC IN

External Safety Connections



Maintenance

Maintenance schedule

Components	Actions	Frequency
Sensor head	Cleaning the sensor head windows	Daily
	Replacing the sensor head windows assembly	When damaged
	Sensor head calibration	Annually
Compressed air filter cartridge	Replacing the filter cartridge	Periodically (see visual indicator on the cartridge assembly)

Maintenance procedures

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.

Tools and materials required:

- Lens optical cloth
- Isopropanol (rubbing alcohol)

Instructions

- Clean the windows with an optical cloth. Wipe the paper across the window in a single motion instead of rubbing back and forth.
- If any marks remain, clean the windows with lens paper and a small amount of isopropanol. Wipe the paper across the window in a single motion instead of rubbing back and forth.
- If any marks remain, replace the sensor head window assembly (see next section).

Replacing the sensor head window assembly

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:

- Latex or nitrile gloves
- 2.5 mm Allen key
- Sensor head window plate

Instructions

- Remove the four M3 screws and carefully remove the window assembly.
- Put the new assembly on the sensor with the air knife at the top (facing downward). Insert the four M3 screws to secure the plate.

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 maintain the repeatability of the measurements.

You must send the sensor heads to Tecnar Automation Ltd every year for calibration, contact service@tecnar.com. There is no need to send the cables and controller.

Recommended spare parts

Components	Part number
Compressed air filter cartridge	10201-00599-00
Sensor head windows assembly	20303-01349-02
O-ring	10603-00470-00
Shutter cable	10106-00659-00
Communication cable	10106-00511-00
Laser power cable	10106-00660-00
AS CS HMI	30201-02360-00
Fuses kit – AS CS	30100-00191-00

Troubleshooting

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 becomes 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.

LED error codes

As mentioned previously, in the case of hardware failure, the back-plate LED 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.

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

Error reporting in the user interface

Error code	Corrective measures
Invalid velocity measurement (Low correlation)	<ul style="list-style-type: none"> • The sensor head is aimed perpendicular to the spray plume. • The sensor head is 200mm away from the center of the spray plume. • The SPRAY DIRECTION is set correctly. • The spray plume angle is no more than $\pm 15^\circ$.
Invalid velocity measurements (Signal level too low)	<ul style="list-style-type: none"> • The sensor head is aimed at the spray plume. • The proper setup has been selected. • Powder is injected into the spray plume. • The sensor head windows are clean. • The SIGNAL AMPLIFICATION is set adequately for your process.
Invalid velocity measurements (Saturated signal)	<ul style="list-style-type: none"> • The proper setup has been selected. • The SIGNAL AMPLIFICATION is set adequately for your process.
Invalid measurements (Saturated signal)	<ul style="list-style-type: none"> • The proper setup has been selected. • EXPOSURE TIME is set adequately for your process.

Service & support

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

TECNAR Automation

1321, Hocquart Street

St-Bruno, Qc, Canada, J3V 6B5

Phone: 450-461-1221

Fax: 450-461-0808

Email: service@tecnar.com