PLUMESPECTOR USER MANUAL

USER MANUAL, EDITION 2
APRIL, 2017

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1. NOTICES

The material contained in this document is provided "as is" and is subject to change without notice in future editions.

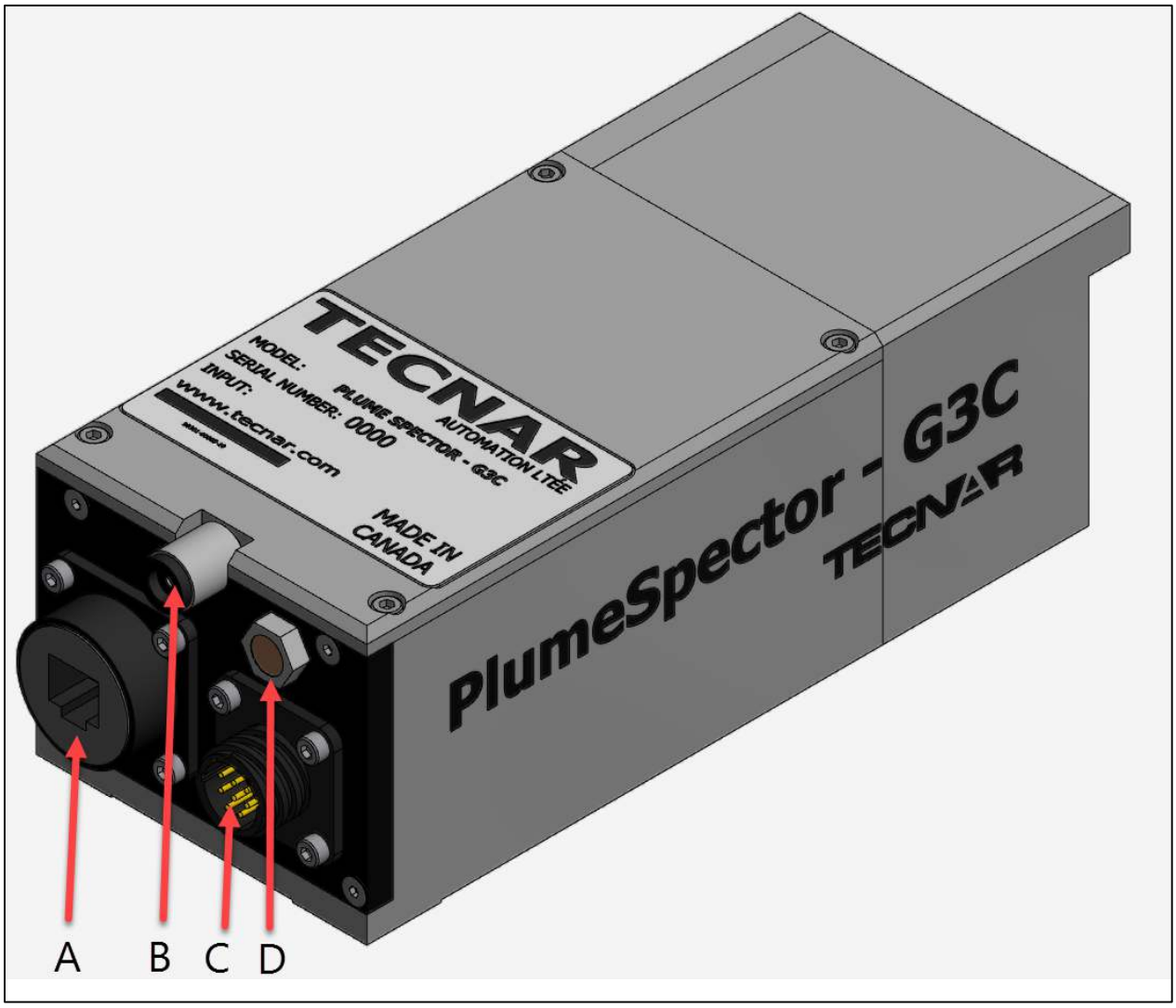
1.1 MANUAL EDITIONS

- Edition 1, April 2017

2. INSTALLATION & HARDWARE SETUP

2.1 MAIN COMPONENTS

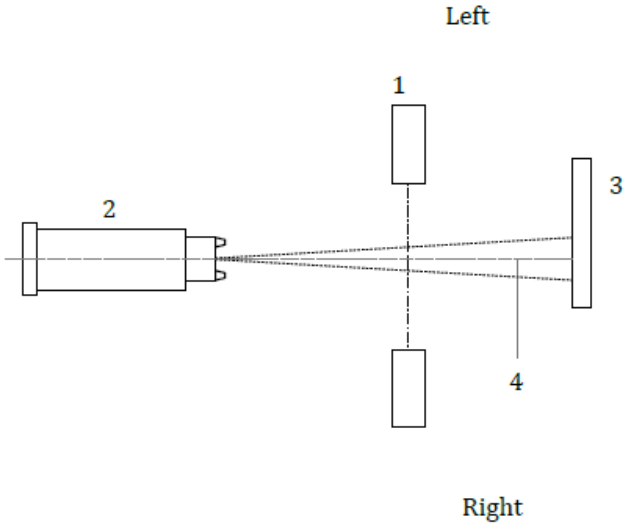
- The Plumespector camera
- The Plumespector laptop computer
- The mounting plate
- 12 Volts DC power supply
- 50 feet interconnect cable
- 15 feet air hose with a pressure regulator
- Two 35mm spare windows



A. Ethernet connector
B. Air hose connector
C. Camera power connector
D. Air breather

2.2 SETTING UP THE MACHINE FOR FIRST USE

1. Place the Plumespector camera (1) on the mounting plate (see appendix for mechanical drawing and bolt pattern). The camera can be placed on either side of the spray plume between the spray gun (2) and the work piece (3).



2. The Plumespector camera must be placed at a distance of 200mm away from the plume axis (4). This distance is measured from the front of the window. (this distance is critical to ensure reproducible measurements)

Note that the standoff distance (or coating distance) is not critical at this point since it will be tuned using the software interface later. Position the camera roughly at the standoff distance intrinsic to the powder, perpendicularly to the plume axis.

3. Connect the interconnect cable from the plume camera to the computer and the power supply.

4. Connect the air hose from your facility's air supply to the camera. Note that the regular doesn't have a digital nor analog display.

Dry and clean air must always be fed to the air camera at 2.0-2.7 bar (30-40 PSI).

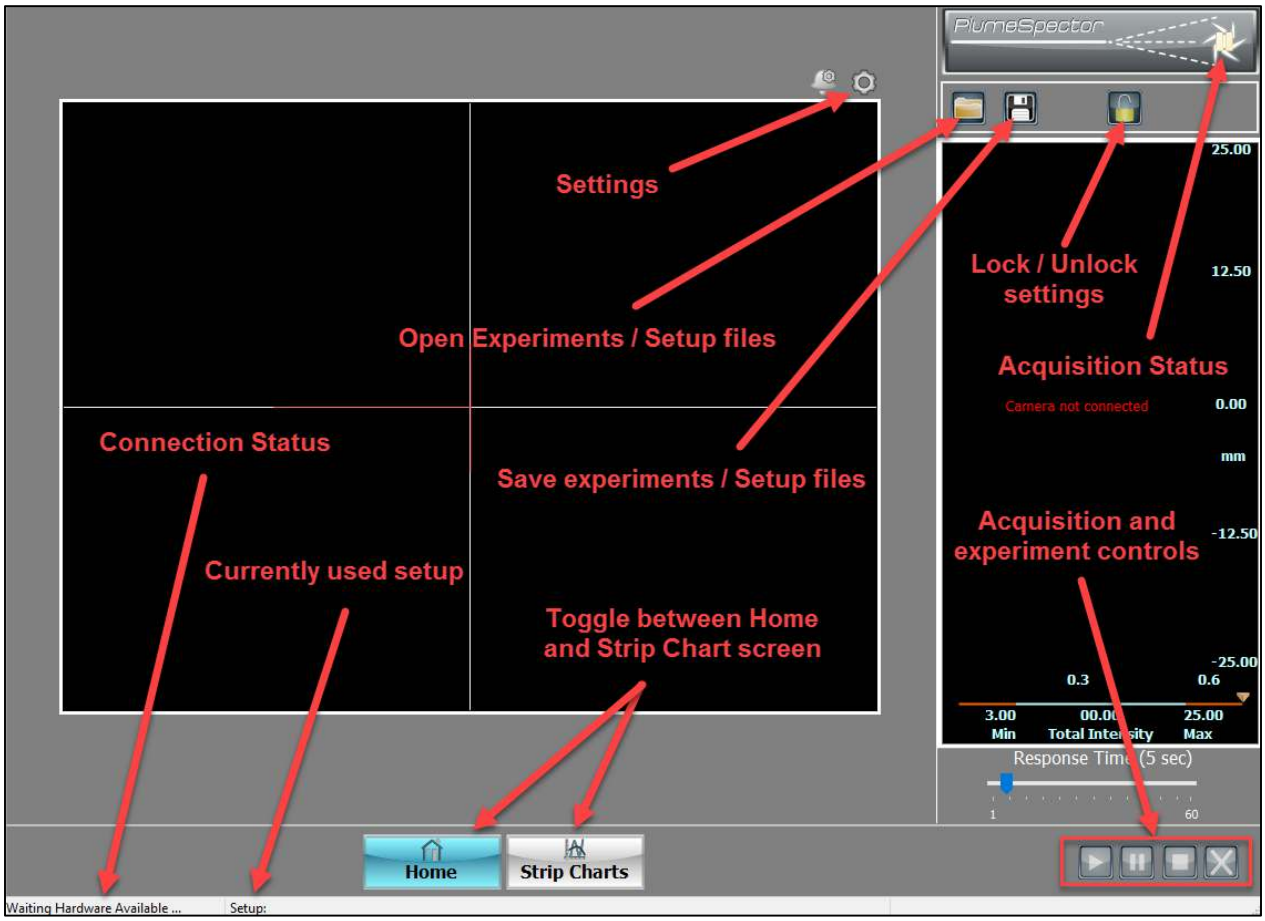
5. Run the Plumespector software.

3. SOFTWARE SETUP

3.1 OVERVIEW

In order to use the software efficiently, we strongly recommend you to use one (1) setup per powder type. Everything that you adjust: response time, shutter speed, min/max settings, etc., will be part of your setup file. Setup files (.STP) are saved in the "setup" subfolder.

Features of the main screen are detailed in the picture below. *Note that the alarm button next to the settings button is not used in this version of the software.*



All the settings can be changed through the settings panel except for the "response time" which is located on the home screen above the acquisition and experiment control buttons.

3.2 MAKING A SETUP FILE

1. Start by unlocking the software to access the settings panel by clicking on the padlock at the top right of the screen.

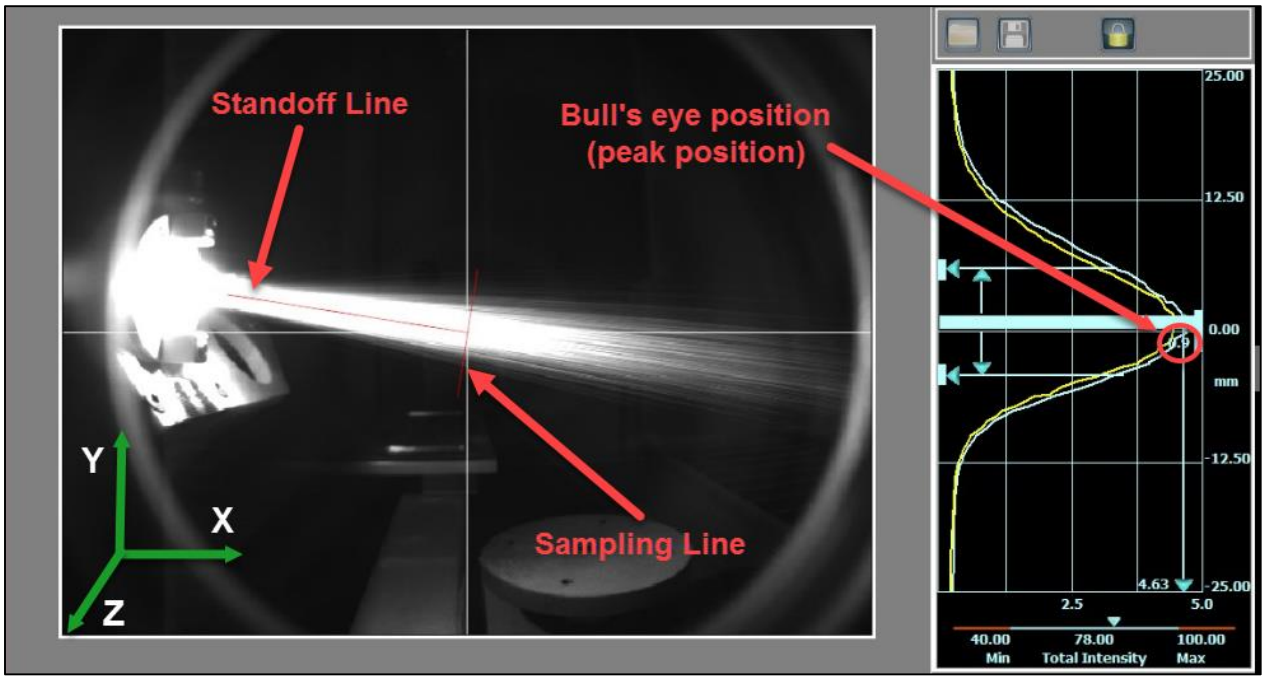
2. Enter the password : tecnar

The password prevents the user from modifying the settings during the production. Simply click on the padlock to lock/unlock the software.

3. Adjust the **"spray direction"** from left to right or right to left.

4. Adjust the **"standoff distance"** in the settings according to your process (set the real value in mm), Go back to the main screen. If the image is too bright, reduce the shutter speed in order to see clearly (as shown in the picture below).

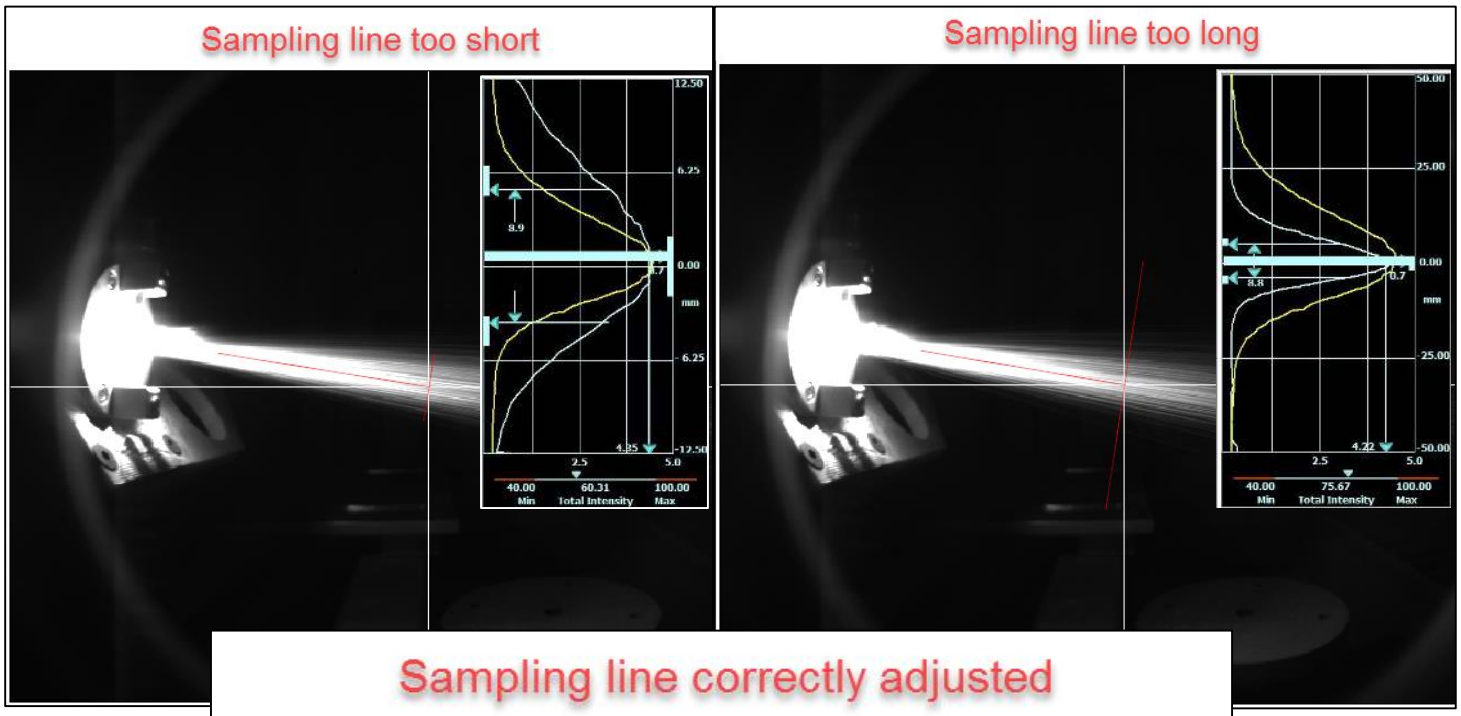
5. Let "X" be the standoff distance, "Z" the working distance of the camera (200mm). Adjust the X-axis so that the end of the standoff line reaches the nozzle (electrical arc). Then, adjust the Y-axis until the **"peak position"** is perfectly centered (0.0 ± 0.2mm, precision depends on the stability of the process). Typically, it will be much easier to adjust an HVOF process than a plasma process. The "response time" also affects the stability of the readings. More details on the response time are explained in section 3.2.9.

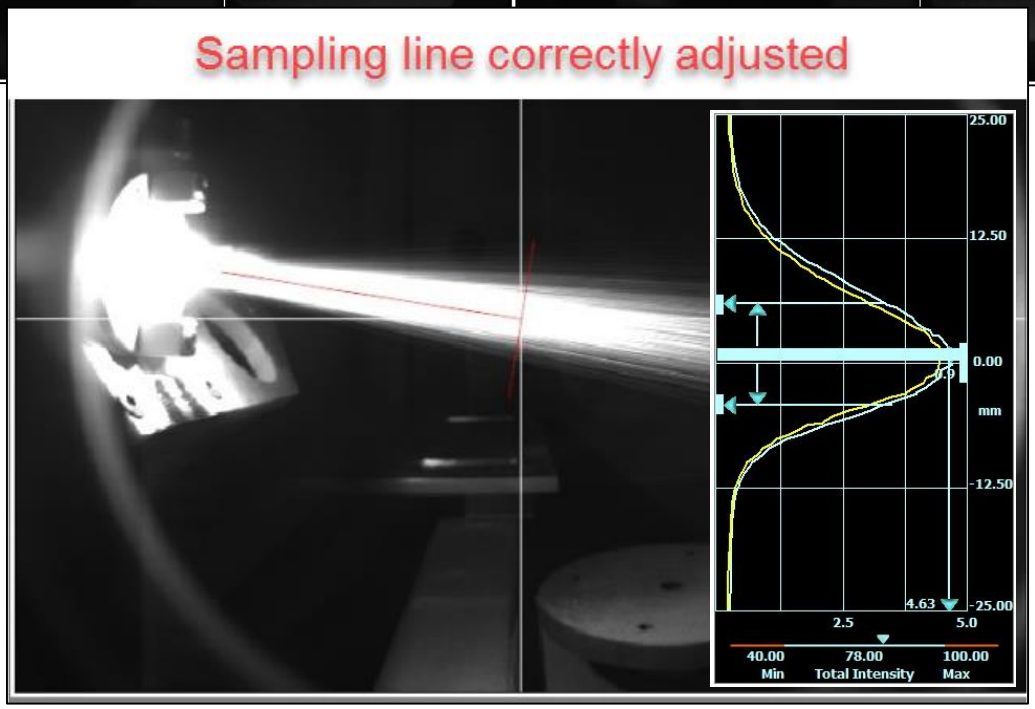


6. Adjust the **"Plume Angle"** so that the standoff line is perfectly centered on top of the plume. The standoff line should be parallel with the plume axis.

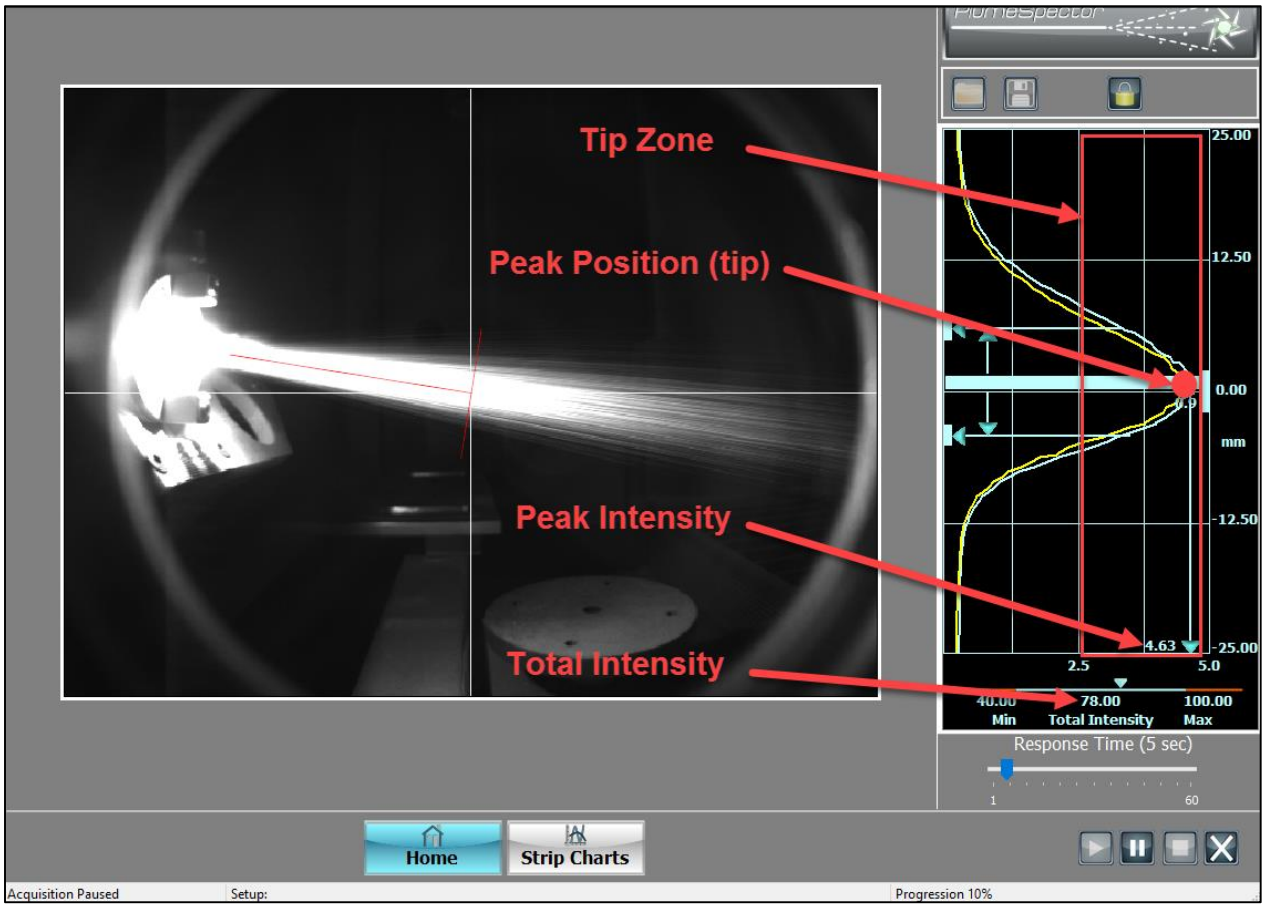
   The standoff line itself does not affect the measurements directly. However, the sampling line is ALWAYS perpendicular to the standoff line. That being said, the "Plume Angle" will affect the measurements since the intensity is sampled on the sampling line. Hence the importance to adjust the plume angle.

7. Adjust the "Sampling line length". In order to do that, you want to cover the full width of the plume + an additional ~20% excess on the edges. A long sampling line will reduce the resolution of the plot on the right side of the screen. A short sampling line will not get the global picture of the plume. Note that the line length will be the total range of the Y-axis in mm.





8. Adjust the "shutter speed" based on the brightness of the image. The goal is to have the tip of the plume located in the 3rd or 4th section on the right side of the screen.



The camera measures intensity (arbitrary units). Those units are based on the shutter speed (exposure time) and the pixels saturation percentage. For example, if the shutter speed is 1 / 500s, the maximum intensity for 1 pixel is 5 A.U. We arbitrarily divided the denominator of the shutter speed by 100.

$$Maximum\ Intensity\ for\ \ 1\ pixel\ at\ \frac{1}{500s} = \frac{500}{100}\ = 5\ A.U.$$

$$Intensity\ for\ \ 1\ pixel\ at \frac{1}{500s} = \frac{500}{100} * (pixel\ registry\ saturation\ \%)$$

The monochrome camera is comprised of a pixel matrix where every pixel can store up to 8 bits of data. In the example above, the peak intensity is 4.63 and the shutter speed is 1 / 500s. Therefore, the saturation is nearly reached. If the intensity was slightly higher, then we would need to reduce the shutter speed to 1 / 1000s where the maximum sample would be 10 instead of 5 in order to avoid the saturation.

Consequently, as long as there is no saturation, it is possible to compare the intensity from one shutter speed to another.

9. Adjust the **"response time"** based on the process stability. We found out that usually the response time is set between 3 and 8 seconds. If the process is stable, you can decrease it to 3-4 seconds. If the process is unstable, you can increase it to 7-8 seconds to get stable readings. The response time is a roll off-average.

   Do not set the response time too high since it will hide the process fluctuations and give biased readings.

   The response time can be changed at the bottom right of the main screen.

10. The sampling line offset will slide the sampling line across the standoff line. Adjust **"the sampling line offset"** if you want to measure at a different distance than the standoff distance. Say your standoff is 100mm and you want to measure at 110mm, put an offset of 10mm. Note that the field can take negative values as well.

Once those adjustments are made, you can now save the setup file using the floppy icon. Note that rejections criterias are also part of the setup file. We will address rejection criterias in the next section. Nevertheless, it is good to save the setup at this point to avoid data loss.

3.3 ADJUSTING THE REJECTION CRITERIAS

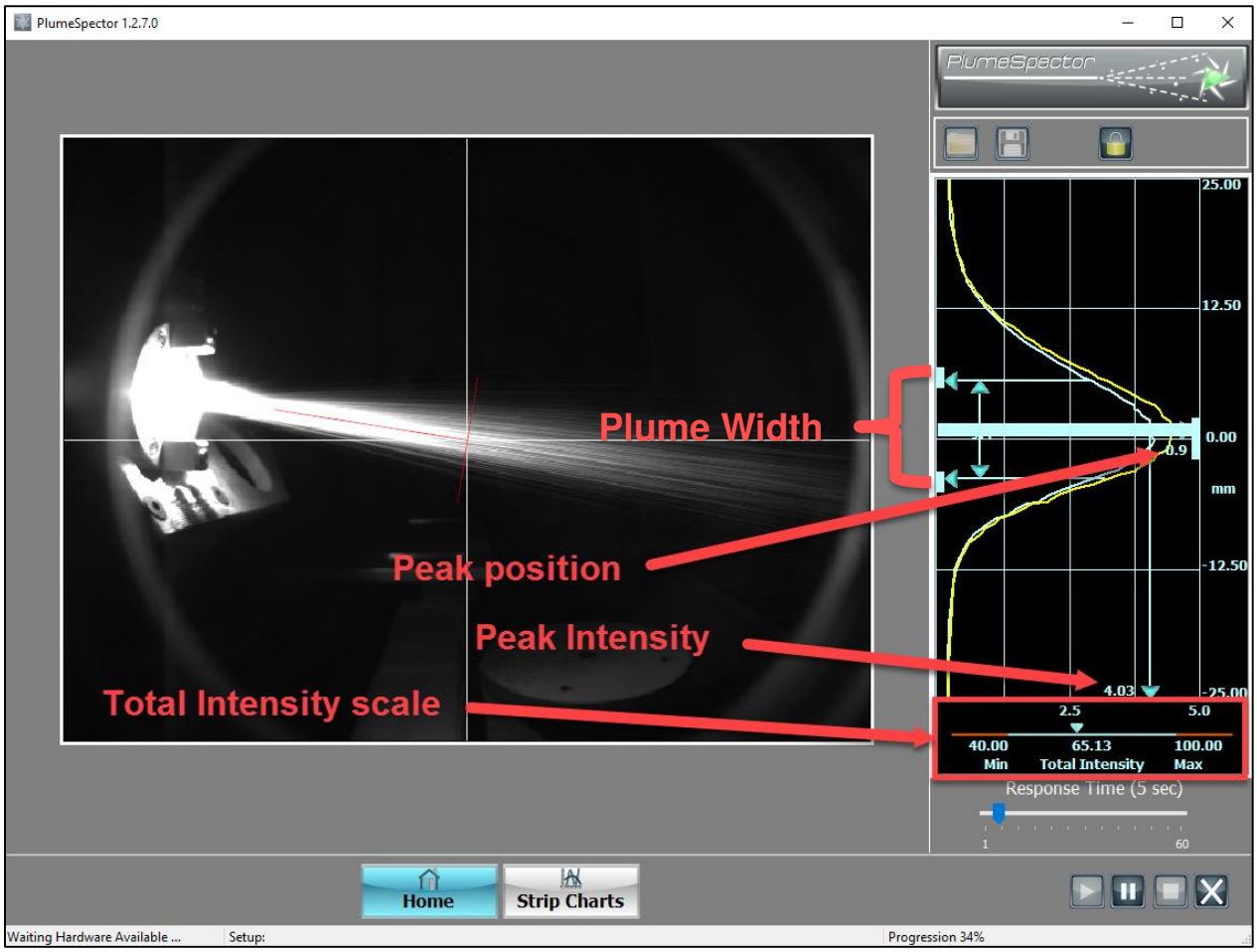
Using the settings panel, and according to the process, adjust the minimum and maximum values for the **"Total Intensity"**, **"Peak Intensity"**, **"Peak Width"** and **"Peak Position"**.

Plume Width: The plume width (in mm) is the zone where 70% of the total intensity is located.

Peak Position: The distance (in mm) of the alignment offset from the brightest spot in the plume.

Peak Intensity: The brightness (in A.U) at the tip of the plume.

Total Intensity: The total brightness of the plume. The total intensity is defined by the sum of all the pixels on the sampling line.



Once everything is adjusted properly, you can now create your own reference by clicking on **"new reference"**. It will generate a static, yellow profile of the plume at that moment. Whenever the values are out of range for a certain criteria, the section of the plot that concerns that specific criteria will turn orange and the "Light threshold" output in the PLC will be deactivated.

Note that adjusting the minimum and maximum values for the rejection criterias depend on the process itself. There is no 'absolute' range for a certain type of powder since too many external factors influence the characterization of the particles. Tecnar does not provide any database for such acceptable range.

That being said, the best way to find out what works best for you is to make a bunch of samples/coupons and correlate the best lab results with spray parameters and particles characterization with the Plumespector.

3.4 SAVING THE DATA

There are two ways to record the data:

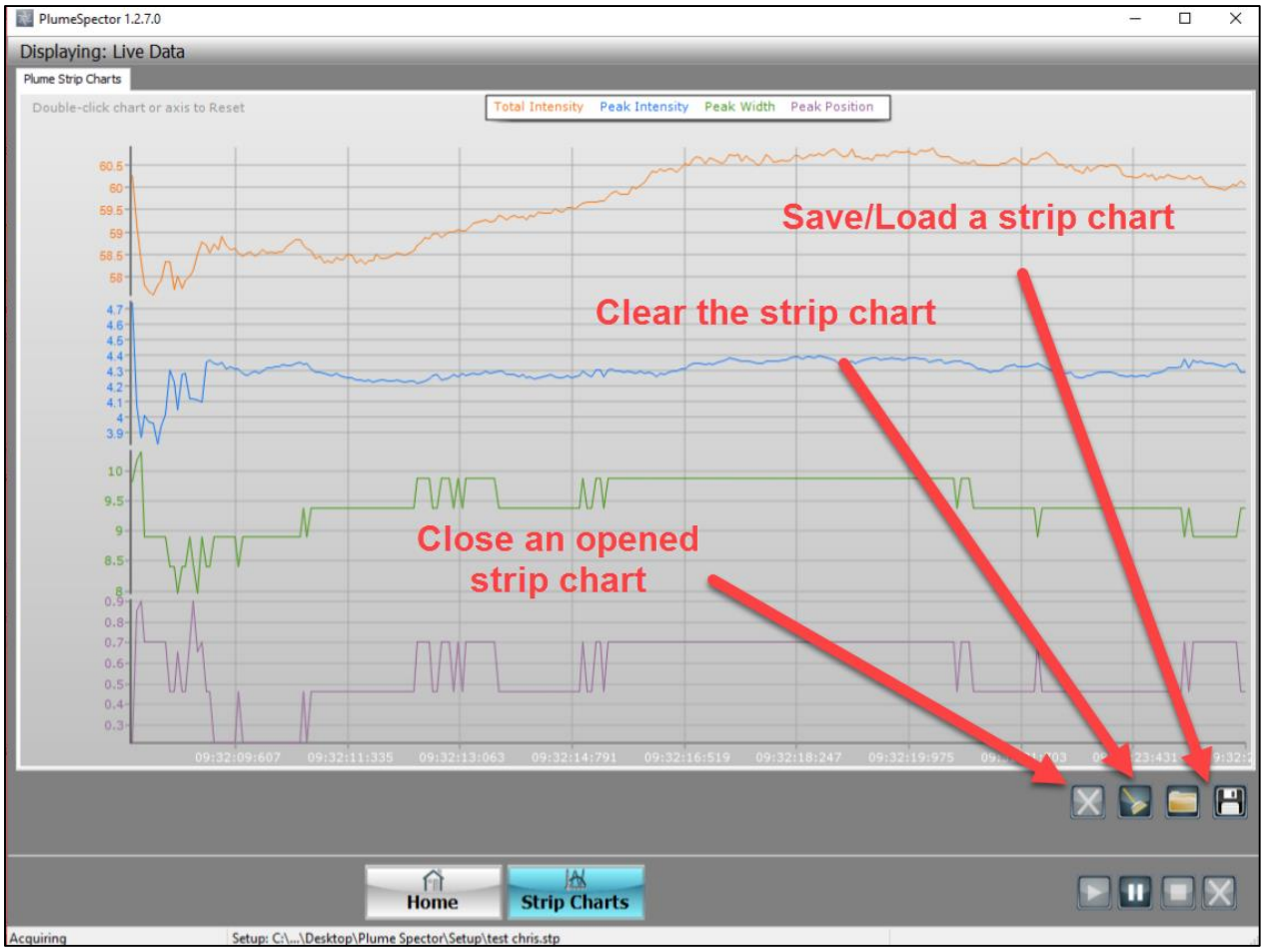
- By saving an experiment
- By saving a strip chart (.CSV file)

To save an experiment, simply click on the floppy icon, then click on save experiment. The software will start recording from that point. In general, experiments last less than 1 minute since it is sufficient to characterize the process. When you are satisfied with the length of your experiment, click on the "stop" button at the bottom right. The "REC" label at the top right indicates that an experiment is currently running. Experiments are saved in the "Experience" subfolder.

Note that the experiment will not be saved until you click the stop button.

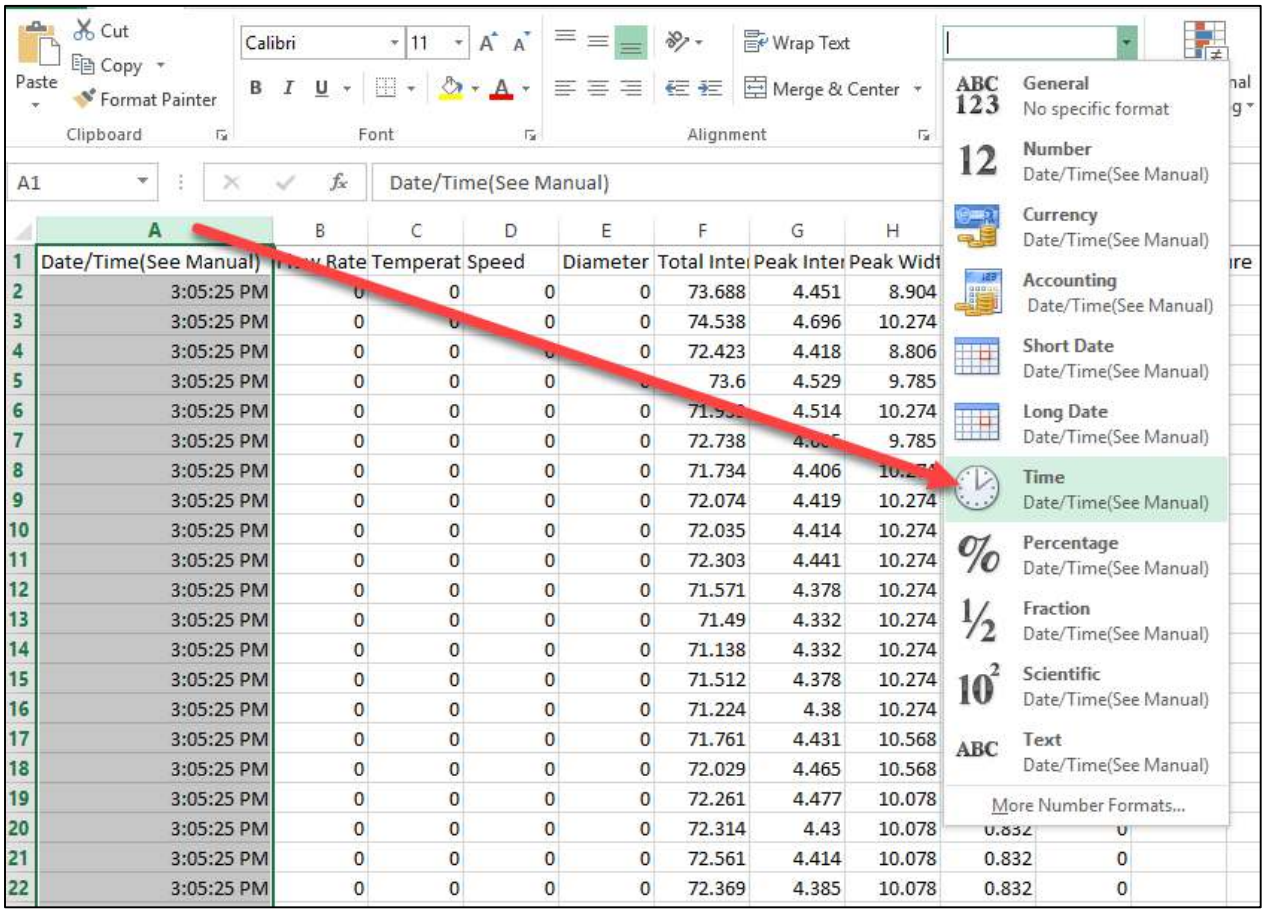
The strip chart saves all the data in a .CSV file. When you are ready to record a strip chart, first clear the screen by clicking on the broom icon. You should wait until the process is stable before doing so. Once you've accumulated enough data, click on the floppy icon to save the data.

In opposition to the experiment, the strip chart is 'always' recording and will only compile the file when you click the save button.



You can use the drag and drop feature of the strip chart to review data over time. Double-click on the chart or axis to reset it to default.

The strip chart retrieves the "Total Intensity", "Peak Intensity", "Peak Width" and "Peak Position" every second. By default, the strip chart will use the "Windows time format" for column A. To display the column as a real time table, change the column type to "Time" as shown in the picture below.



	A	B	C	D	E	F	G	H
1	Date/Time(See Manual)	Rate	Temperat	Speed	Diameter	Total Inte	Peak Inter	Peak Widt
2	3:05:25 PM	0	0	0	0	73.688	4.451	8.904
3	3:05:25 PM	0	0	0	0	74.538	4.696	10.274
4	3:05:25 PM	0	0	0	0	72.423	4.418	8.806
5	3:05:25 PM	0	0	0	0	73.6	4.529	9.785
6	3:05:25 PM	0	0	0	0	71.9	4.514	10.274
7	3:05:25 PM	0	0	0	0	72.738	4.6	9.785
8	3:05:25 PM	0	0	0	0	71.734	4.406	10.2
9	3:05:25 PM	0	0	0	0	72.074	4.419	10.274
10	3:05:25 PM	0	0	0	0	72.035	4.414	10.274
11	3:05:25 PM	0	0	0	0	72.303	4.441	10.274
12	3:05:25 PM	0	0	0	0	71.571	4.378	10.274
13	3:05:25 PM	0	0	0	0	71.49	4.332	10.274
14	3:05:25 PM	0	0	0	0	71.138	4.332	10.274
15	3:05:25 PM	0	0	0	0	71.512	4.378	10.274
16	3:05:25 PM	0	0	0	0	71.224	4.38	10.274
17	3:05:25 PM	0	0	0	0	71.761	4.431	10.568
18	3:05:25 PM	0	0	0	0	72.029	4.465	10.568
19	3:05:25 PM	0	0	0	0	72.261	4.477	10.078
20	3:05:25 PM	0	0	0	0	72.314	4.43	10.078
21	3:05:25 PM	0	0	0	0	72.561	4.414	10.078
22	3:05:25 PM	0	0	0	0	72.369	4.385	10.078

In the event that the strip chart is not displayed correctly, you might have to change your Windows language settings.

- Open the windows language settings
- Under the formats tab, click "Additional settings..."

A new tab will open, make sure that the "List separator" field is set to "," (comma). Please note that additional settings might have to be changed depending on your language/system configuration.

4. MAINTENANCE

The Plumespector doesn't require any maintenance except for cleaning the front window. Make sure that the window is clean before taking any measurements. Use isopropyl and water to clean it if required.

The camera should not be opened at any time since it will void the warranty and calibration. Annual calibration is NOT mandatory for the Plumespector camera since the calibration doesn't drift over time.

REPLACING THE WINDOW

1. Loosen the four screws holding the window with a 2.5mm Allen key.
2. Using gloves in order not to put grease or dirty on the glass, install a new window on the front façade and gently tighten the four screws.

SPARE PARTS LIST

- 20103-00018-00 12V DC power supply
- 20103-00330-00 Interconnect cable
- 30201-00820-00 Window assembly (minimum order of 5)

5. SERVICE AND SUPPORT

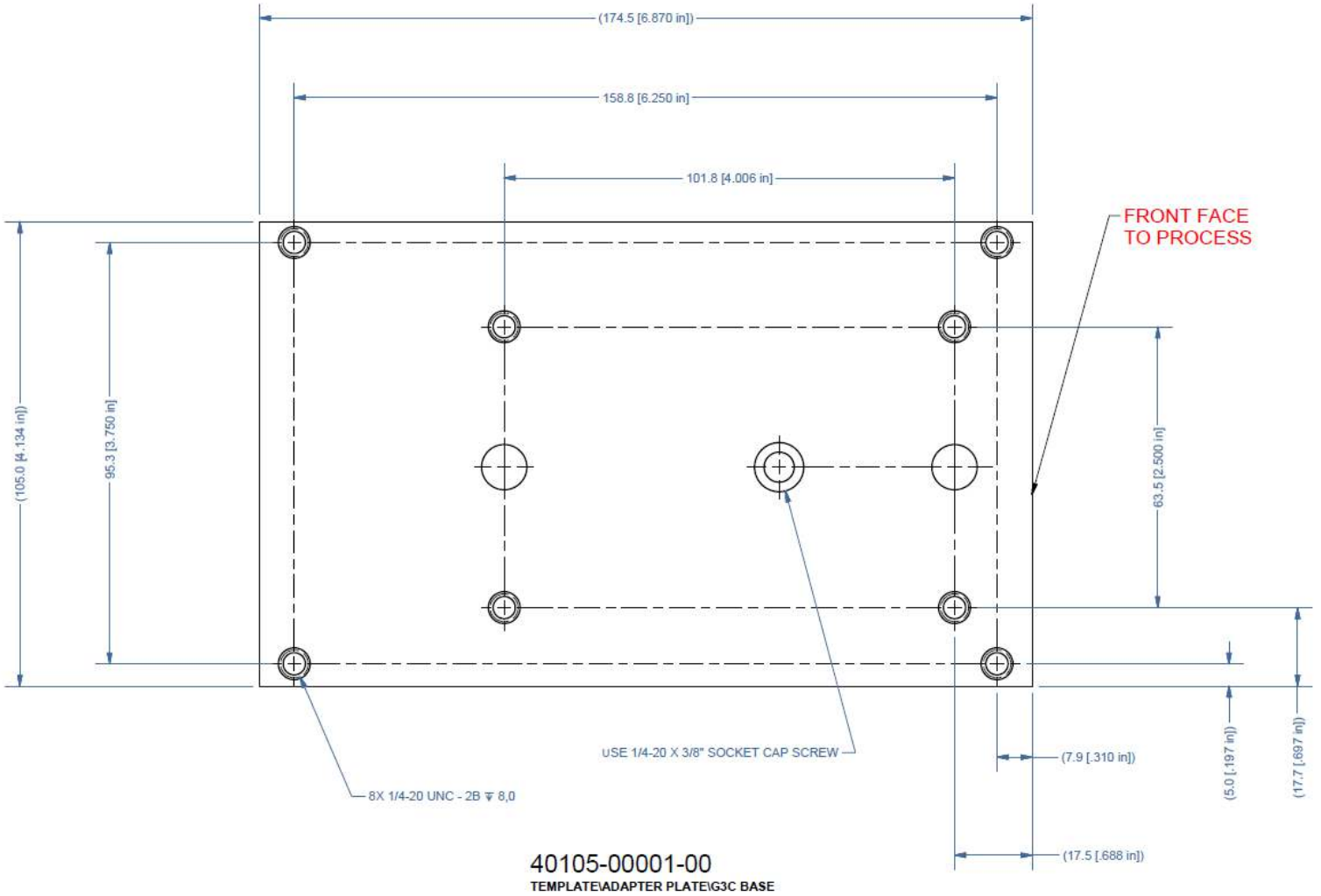
Please contact our service team at the address below for any inquiries, spare parts or any technical issues.

TECNAR Automation Ltd.
1321, Hocquart Street,
St-Bruno, Qc, Canada, J3V 6B5
Phone: 450-461-1221
Fax: 450-461-0808

Tecnar's Service Team :
service@tecnar.com

APPENDIX

BASE PLATE DRAWING



40105-00001-00

TEMPLATE\ADAPTER PLATE\G3C BASE