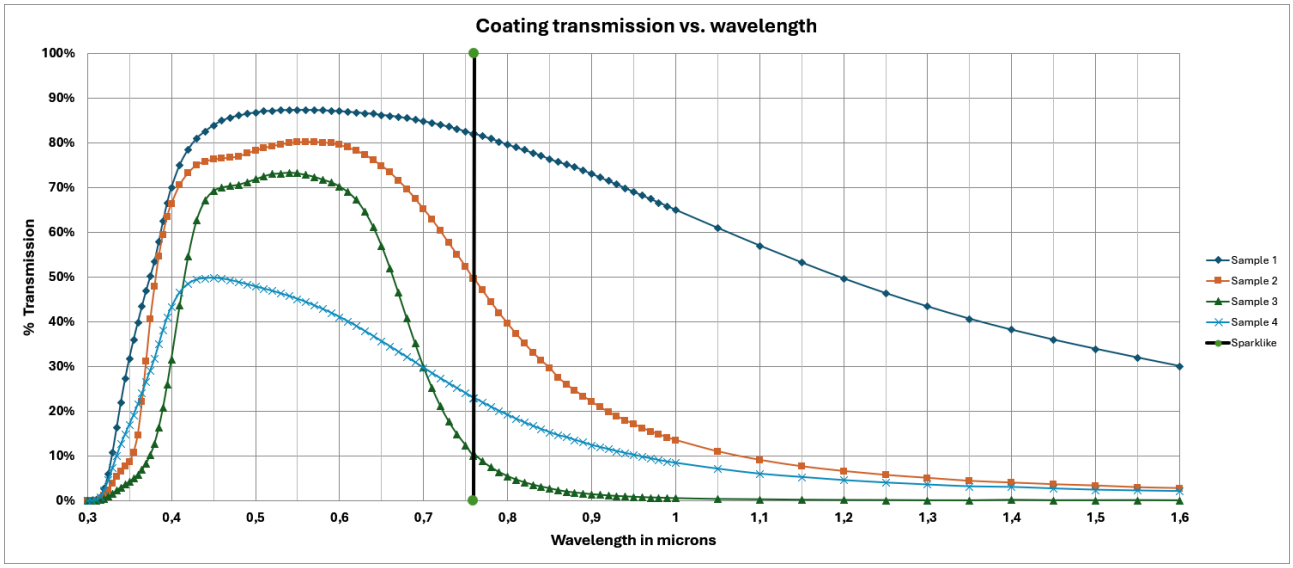
Guide for Sparklike Laser Users – How to measure?

1. Introduction

The Sparklike Laser (SL) is capable to measure insulating gas concentration of the most commercial Insulating Glass Units (IGUs). It can measure double and triple IGUs and through laminations and majority of the coatings. If the IGU have a coating with low transmission on one side, for the SL this obstacle can usually be worked around by measuring the IGU from other side. This guide has been created to help users to understand the basics of the SL measurement technology, it's benefits and limitations, and also to give some useful tips to get more accurate and reliable results.

Sparklike Lasers utilizes a tunable and narrow-line width (monochromatic) diode laser. Adjusting the diode laser operation current laser frequency can be tuned over an oxygen absorption line of interest and measure the variations in transmitted intensity. A sinusoidal component is added to the diode laser operation current resulting in a sinusoidal wavelength and amplitude modulation of the laser output. Interaction with a wavelength dependent and non-linear transmission (absorption lineshape) results in a periodic, but non-sinusoidal transmission signal that consists of the modulation frequency itself as well as its harmonic overtones. The amplitude of the harmonic component is proportional to the absorbance, i.e. amount of oxygen.

SL operates at a wavelength of 760 nm (near-infrared light), which is oxygen-specific and distinct from the wavelengths used in insulating glass unit transmission percentage (IGU) specifications. The typical range for IGUs transmission specification is 400-700 nm, which is visible to the human eye. Discussing the properties and transmission characteristics of insulating glass in terms of the visible spectrum is crucial because it directly impacts vision, comfort, and energy efficiency in buildings. Meanwhile, near-infrared light is used in specialized applications that benefit from its deeper penetration and unique interaction properties. Below, we show transmission of some LoE products' s at different wavelengths. However, the only wavelength that matters when measuring with Sparklike Laser devices is 760 nm (indicated by the black line).



The Sparklike Laser device measures the residual oxygen content, and the measurement result is then converted to represent the insulating gas content (typically argon). Therefore, it is more accurate to describe the Sparklike Laser as a non-invasive oxygen meter.

2. Quality perspective

Using the Sparklike Laser (SL) enhances the reliability and accuracy of measurements while preserving the integrity of the sample. This capability allows for multiple, non-invasive measurements, ensuring that the data obtained is both precise and dependable. The principle of “measure twice, cut once” is particularly applicable here, as it emphasizes the value of verification and careful measurement to avoid errors and ensure the best possible outcomes.

When measuring with spectrometry, various sources of error can affect the accuracy and precision of the results. Here are some of the main error sources:

- **Dirty Surfaces:** Dirty or scratched measuring-head window can scatter light or cause additional absorption, distorting the measurement results.
- **Improper Attachment:** Not securing the measuring head properly against the glass can lead to external oxygen influence and/or improper alignment, resulting in inaccurate readings.
- **Human Error:** Mistakes in operating the device, such as improper flushing of the measuring head, improper glass placement (such as back glass against other unit, or errors in preset values, can lead to significant inaccuracies.
- **Insufficient laser light to detector:** It is not recommended to measure through low transmission glass panes (transmission at 760 nm < 35 %).

To minimize these above-mentioned errors, consider the following best practices:

1. **Regular Calibration:** Ensure that the laser device is annually calibrated.
2. **Be Aware of Measuring Through Coatings:** Coatings can reflect the laser beam and potentially cause signal loss when the signal passes through coated glass to the detector. Understanding what type of glass you are measuring and the location of coatings is essential for accurate results."
3. **Proper Sample Handling:** Prepare and handle samples consistently and avoid contamination. If measured glasses are laminated or toughened, try using “preset mode” if proper measurements are not attained using “normal mode”
4. **Clean Equipment:** Ensure that measuring head window is free of dirt and scratches.
5. **Secure Setup:** Attach the measuring head securely to the sample to avoid light or air leakage and misalignment. Make sure foam seal is intact and permitting the establishment of vacuum.
6. **Training:** Ensure that all operators are well-trained in the use of the laser device and understand the importance of each step in the measurement process.
7. **Quality Control:** Implement a robust quality control system to detect and correct errors in data processing and interpretation.
8. **Environmental Control:** Conduct measurements in a controlled environment where temperature and humidity are according to the given operational area of Sparklike Laser.

"Measure twice, cut once" is a classic adage emphasizing the need for accuracy in quality assurance measurements. Ensure results are correct before taking any costly actions.

3. What should users know before measurements?

When measuring insulating glass, selecting the preferred side is crucial for obtaining the most accurate and repeatable results. Consider the following key points when choosing the correct side:

Identify coating types: Before measurement, identify the presence and type of any coatings on the glass. Use the manufacturer's specifications, coating detectors, or visual inspection techniques to ascertain which side is coated.

Avoid measuring through coatings if possible: Always measure from the side of the glass that is uncoated. Some coatings can be too reflective on the laser operating wavelength and affect the measurement results.

4. Measurement procedure

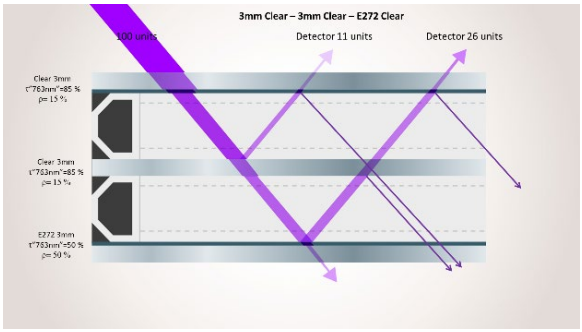
For triple glass units, the Sparklike Laser (SL) first measures the overall value of both cavities, then the 1st cavity. Based on these results, it calculates the gas content of the 2nd cavity. Results from the 2nd cavity are more indicative, as deviations in the second cavity measurements are therefore higher than the average. To minimize errors, users should consider the following:

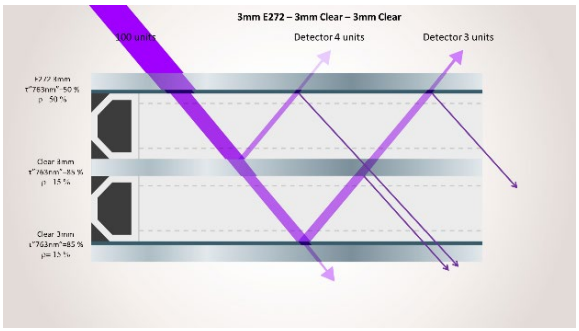
1. **Type of IGU Being Measured:** Identify whether you are measuring a double or triple unit.
2. **Coating Identification:** Detect any coatings on the glass, with particular attention to aggressive solar coatings, which often are hard to measure through but can be beneficial when measuring against them.
3. **Glass and Spacer Thickness:** Have at least a rough idea of the thickness of the glasses and spacers being used.
4. **Laminations and Toughened Glass:** Both laminations and toughened glass can affect measurements, primarily related to thickness. When measuring IGUs with laminated glasses, it is advisable to use preset values. If unsure what presets to use, refer to the manual. Errors in thickness measurements will cause faulty gas concentration results.

Best practices

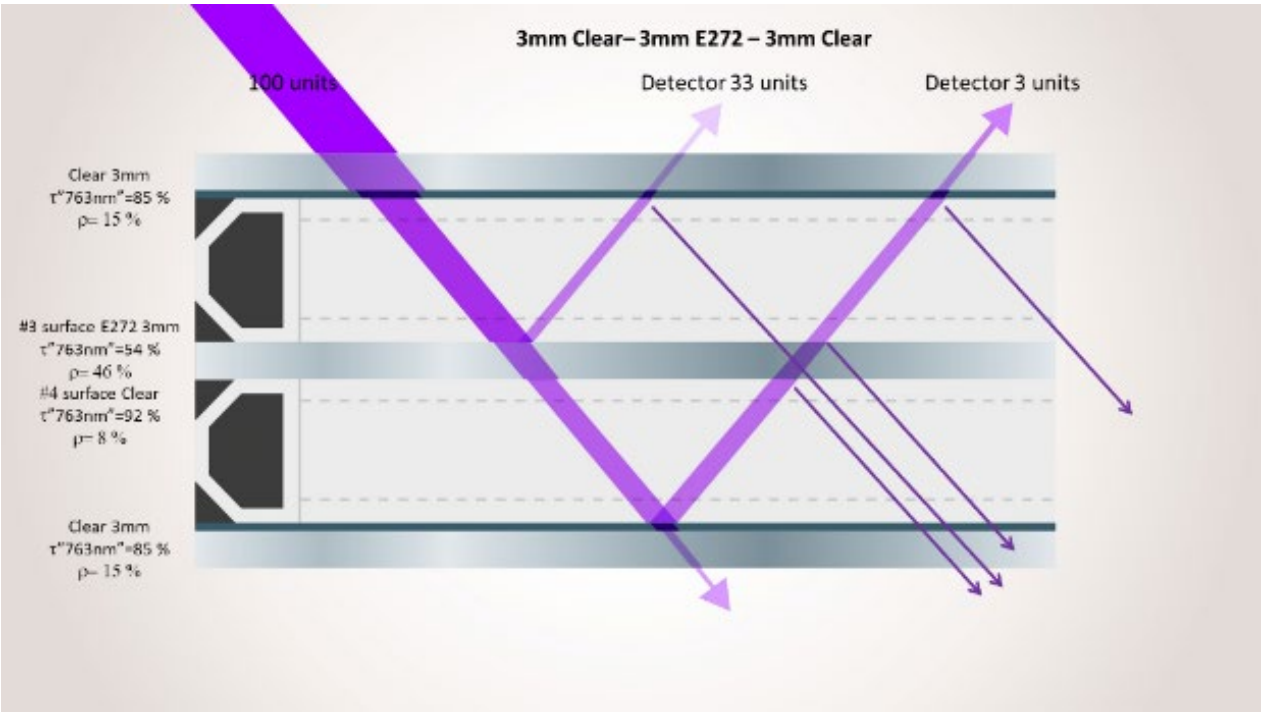
Minimize Measuring Through Coatings: Coatings might act as a highly reflective surfaces to the laser beam, causing high signal loss if the laser is obstructed due to the type of coating.

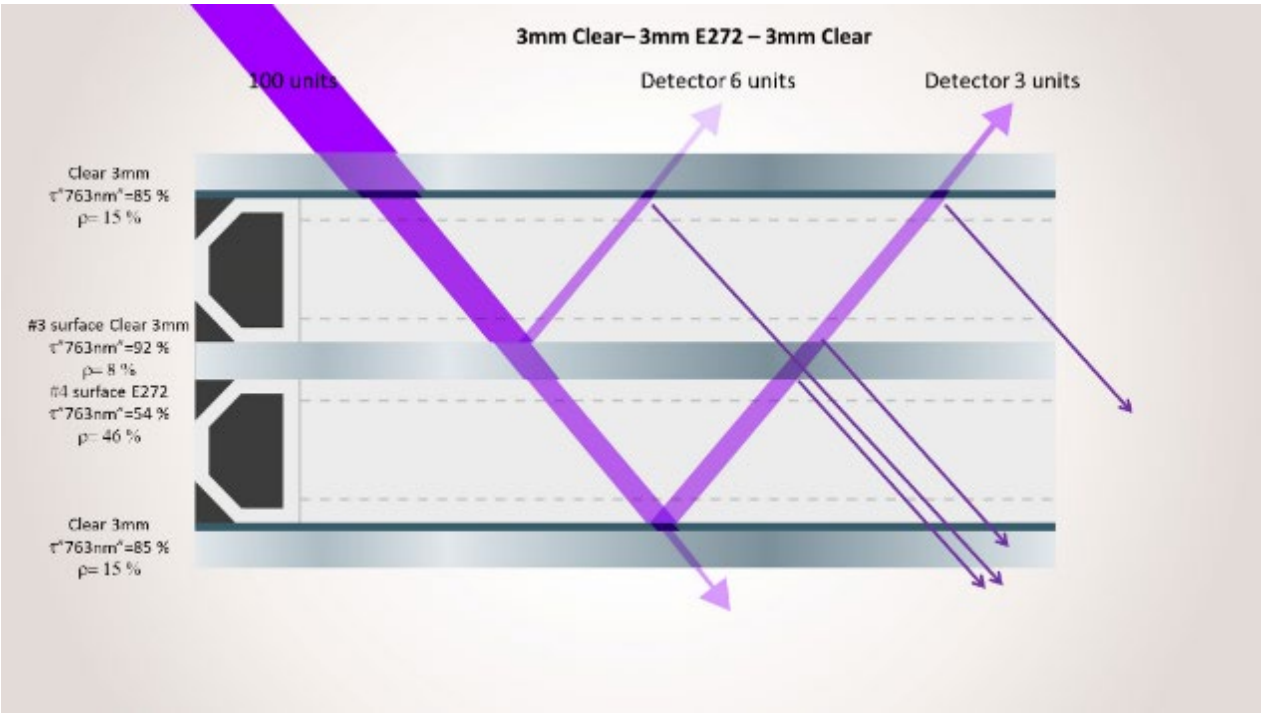
Preferred Measuring Sides: The left illustration shows the preferred side for measurement for this specific IG unit configuration, while the right side shows the non-recommended side. The number of units detected from the initial 100 units will help determine the preferred side. For more information on measurable glass types, refer to the GED Glass Transmission Values Spreadsheet.



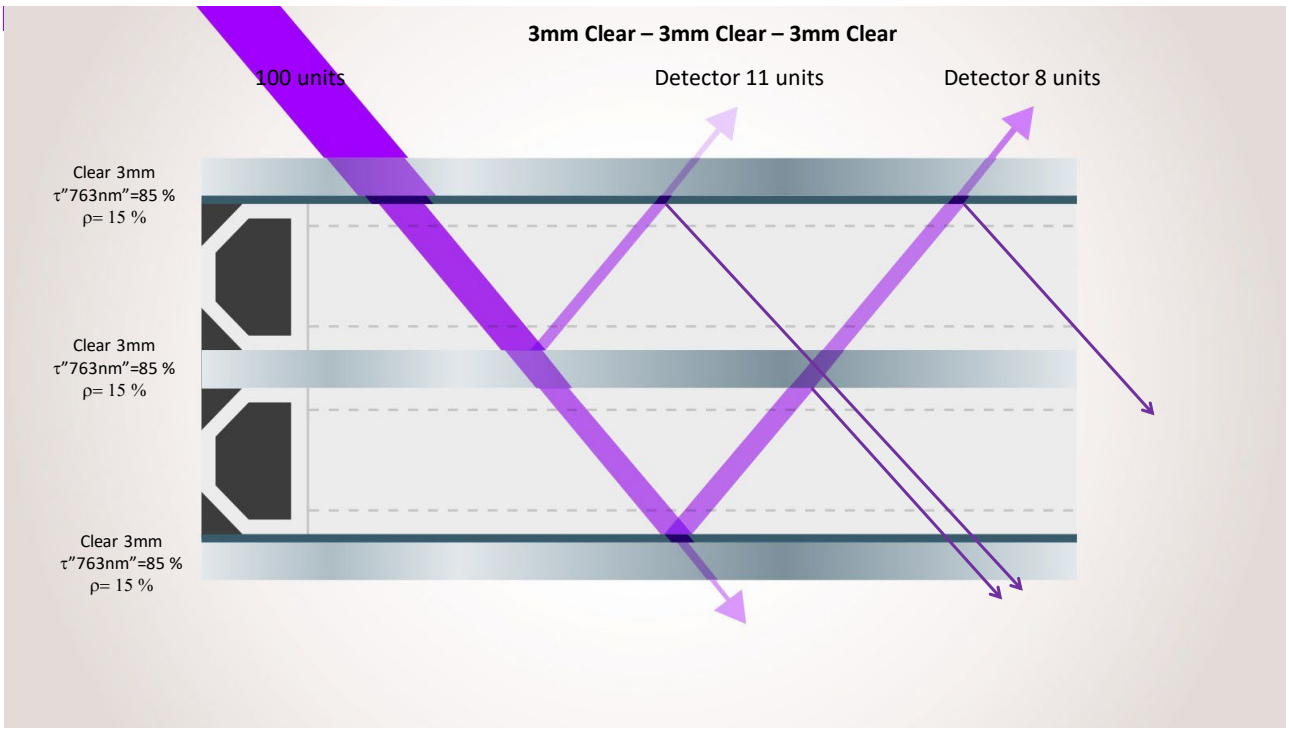


Coatings on Middle Glass: Know the surface where the coating is located. If it's on the #3 surface (left picture), measuring the 1st cavity gas concentration is easier from this side compared to the #4 surface (right picture). When measuring the average of the triple units, measurement side doesn't matter.





It is important to recognize that if all glass panes are clear, this is also not ideal. In such cases, there is minimal reflection, resulting in the loss of most of the initial signal (see picture below). However, it is important to note that despite the challenging setup, the glass measurements can still be conducted reliably, particularly when considering the average values.



5. Results

Repeated measurements are fundamental in achieving high-quality, reliable, and accurate results in any technical measurement instrument. They help identify and reduce errors, enhance precision, ensure reproducibility, and provide confidence in the data, ultimately supporting robust and valid conclusions.

When measuring 100 % of production on-line following trend of the results is often enough. When taking measurement sampling it is highly recommended to take at least 2 measurements from each measured IGU.

In industrial and manufacturing processes, repeated measurements are essential for quality control. Multiple measurements help monitor and ensure that processes remain within specified tolerances and standards.

At the end of the day, the extra measurements ensure that the gas press works as it should and the company fulfils the customer's promises.

6. Validation process

Accurate recording of measurement results in the spreadsheet template is a critical final step in the measurement process using the Sparklike Laser. This section of the guide details how to effectively document the data to ensure its reliability and usability in a production setting.

Validation process overview:

1. **Data Collection**: Each IGU should be measured from both sides, taking 30 readings per side. This approach helps in identifying which side yields more consistent and reliable results.
2. **Data Analysis**: After collecting the readings, calculate the average gas content value from the measurements and standard deviation. This helps determine whether the IGU is within the specified tolerance levels.
3. **Decision Making**: Based on the calculated results, decide the most appropriate side for ongoing production measurements. This decision is crucial as it impacts the ease and reliability of future measurements.

Importance of proper documentation:

1. **Consistency and Accuracy**: Keeping a detailed record in a spreadsheet ensures that all measurements are documented systematically, which aids in tracking and analyzing trends over time.
2. **Quality Control**: Spreadsheet records help in maintaining quality control by providing a historical data trail that can be reviewed to ensure the production process remains within specified tolerances.
3. **Decision Support**: Documented data supports decision-making processes by providing clear evidence of trends and averages, which are essential for making informed choices about production adjustments.

Supplemental documents to this guide:

1. **Glass Spectral Transmission values spreadsheet:** This is where the transmission values of various glass types are shown, making it an important document to visit when trying to establish measurability of a specific glass type from a theoretical standpoint.
2. **Data Collection Template:** Is where the 30 per side of IG measurements should be recorded. This will help in establishing the statistical framework for the preferred measurement side decision, if both sides are not measurable.

In summary, thorough documentation in a validated spreadsheet is not just about record-keeping; it is a fundamental part of the quality assurance process in the production of high-quality insulating glass units. This systematic approach ensures that each unit meets both regulatory standards and customer expectations, thereby safeguarding the manufacturer's reputation and reducing the risk of costly recalls or reworks.