VPE Hardware – Understanding the Zero Pathlength Position

Abstract: This document has been prepared to explain the Zero Pathlength Position to users of the SoloVPE variable pathlength system; what it is, why it is important, how it should be maintained, and its role in variable pathlength measurements.

Applicability: This article applies to the Zero Pathlength Position in the SoloVPE hardware and applications which are a part of C Technologies' SoloVPE Software.

Introduction: The Zero Pathlength Position and corresponding measures will be explained as it pertains to servicing of the instrument as well as daily customer use. Additional information can be found in the SoloVPE V3 User Manual DOC0126

Detailed Info: The ***Zero Pathlength Position*** is the position to which the system moves in order to prepare the SoloVPE and the Fibrette for data acquisition. This location establishes the benchmark "*Zero Pathlength*" position in preparation for variable pathlength measurements. When in this position, the Fibrette tip will be in contact with the bottom of the sample vessel. All pathlength positions and motions are referenced from this position. In the same way that reaching the temperature of Absolute Zero (Degrees Kelvin) is not possible, achieving an absolute zero pathlength is not a mechanical possibility, however, the "*Zero Pathlength Position*" serves as the benchmark datum from which all other pathlength positions are defined. Because Slope Spectroscopy® methods rely on pathlength changes, absolute pathlengths are not critical. The ability of the SoloVPE (and FlowVPE) systems to move in increments as small as 0.005 mm (5 microns) is the enabling technology of the system which dynamically adjust to measure a wide range of samples and concentrations. Understanding the role of the Zero Pathlength Position (ZPP) and the scale of the pathlength steps possible will help Method Designers and Users achieve success with their variable pathlength solution. So exactly how big (or small) is a micron? *Figure1* graphically provides a sense of scale relative to the diameter of a human hair which is comparable to the thickness of a standard sheet of paper.

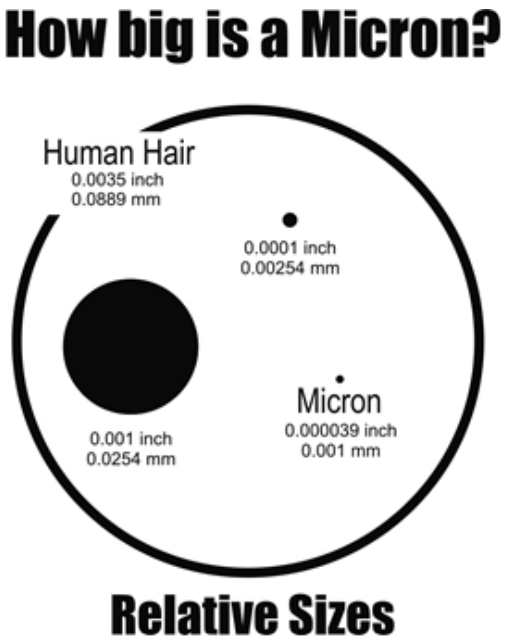

Figure 1

One of the most attractive & powerful features of the SoloVPE system and the Slope Spectroscopy® technique is the fact that system relies on data that is compliant with the Beer-Lambert Law. This attribute of the technique should provide users with confidence in their measurements even in cases when the software excludes data points from being used in the analytical result. The SoloVPE system simply characterizes the sample and acts as a linear range finder by identifying the linear region of the Section data. The optimization of the regression (e.g. omission of non-linear data points) is not an indication of error, it is the system simply identifying the optimal subset of data within the Section curve that quantifiable demonstrates the greatest compliance with the Beer-Lambert Law.

It is important for users of variable pathlength technologies, such as the SoloVPE, to fully understand what the Zero Pathlength Position is, why it is important, how it should be maintained, and its role in variable pathlength measurements. The following *Frequently Asked Questions* have been prepared based upon years of customer interactions such as IQOQ services, PM services, training engagements and help desk calls. They provide a detailed explanation of the ZPP. The examples that follow provide a useful reference for understanding system behavior and the interpretation of the data and results. The Solo Service Group is also always available for more information and support.

Frequently Asked Questions

- **Why is it important?**

  The Zero Pathlength Position defines the benchmark datum from which all other pathlengths are referenced during data acquisition. It is a unique parameter for each SoloVPE device and plays an important role in the Fibrette preparation sequence for each measurement. The action of setting the Fibrette for measurement is similar to the taring of a scale.

- **How is the Zero Pathlength Position configured?**

  The Zero Pathlength Position is configured by trained SoloVPE service technicians using specialized tools and procedures. The Zero Pathlength Position will be unique for every SoloVPE system and is configured and stored in the *SoloVPE Administration* application as an integer value.

- **Why is setting the Fibrette™ for measurement so important?**

  The process of setting the Fibrette for measurement involves the user loading a Fibrette into the SoloVPE and then preparing it for measurement by properly positioning it for zeroing. Proper execution of the Fibrette setting process is critical because it ensures that the Fibrette will definitely contact the bottom of the Sample Vessel thus guaranteeing a good ZPP benchmark datum and that the relative positions of the Delivery Fiber and the Fibrette are controlled for optimal optical coupling*. The exact process will differ depending on whether you have the current standard *Quick Set Fibrette Coupler* or the older *Legacy Fibrette Coupler*.

  - **Quick Set Coupler** – The Quick Set Coupler was developed to make the Fibrette Setting process very fast and consistent by controlling the Fibrette positioning with mechanically constrained movements.
  - **Legacy Coupler** – The original Legacy Coupler relies on the user manually pulling the Fibrette down a "short distance" after inserting Fibrette and pushing it upward until it stops. The necessary "short distance" does not require extreme precision, it just needs to be pulled enough to ensure the Fibrette will make contact with the bottom of the Sample Vessel. Though customer have been very successful using the Legacy Coupler, most have chosen to upgrade to the easy to use Quick Set Coupler, if you have a Legacy (Blue) Fibrette Coupler and are interested in upgrading please contact Solo Service.

* It is worth noting, that changes in the optical coupling due to the normal variations in Fibrettes and Sample Vessels will cause commonly seen absorbance shifts between Section data sets. This is completely normal and to be expected.

- **Would changing the Quick Set Coupler Insert or the Delivery Fiber alter the Zero Pathlength Position?**

  No. While there are factors that could cause a change in the Zero Pathlength Position (*See next question*), changing a Delivery Fiber, the Quick Set Coupler Insert or a Legacy Coupler will not impact the Zero Pathlength Position. Therefore, these actions do not require verification of the Zero Pathlength Position by a trained technician.

- **How does the Zero Pathlength Position affect (or relate to) the Quick Slope search algorithm?**

  The Zero Pathlength Position itself has not direct affect or relationship to the Quick Slope search algorithm that is performed when collecting data using the Quick Slope feature in the software. The Quick Slope search algorithm is an initial interrogation or characterization of the sample that is made in order to determine the range of pathlength at which data will be collected for the given sample. The ZPP does not influence that process in any way. However, as will be made clear in the examples to follow, improper setting of the Fibrette or a failure to follow the best practices could influence the results of the Quick Slope search and therefore the final Quick Slope results.

- **Why would the Zero Pathlength Position change on a SoloVPE system?**

  The SoloVPE is a mechanical device that will exhibit minor changes over time, however, the system has been designed to tolerate these normal variations. This tolerance, combined with the fact that the Slope Spectroscopy technique relies on characterizing how absorbance changes with pathlength rather than absolute absorbance, creates the robustness and flexibility of variable pathlength systems. C Technologies, still recommends taking advantage of the routine periodic Preventative Maintenance services it offers to ensure the health of the SoloVPE System and detect any potentially problematic changes.

  Zero Pathlength Position change could be caused by a failure to follow the best practices for routine cleaning which could result in a Fibrette Crash Event. In those rare but possible circumstances debris may get caught in the Fibrette Coupler or between the Delivery Fiber and Fibrette.

- **How and when should the Zero Pathlength Position be set and/or verified?**

  The Zero Pathlength Position is initially determined at the Factory and is subsequently verified and set during IQOQ services and all PM services. It is normal for there to be a difference between the Factory Default setting and ZPP when the unit is installed into its environment at the customer site.

Examples and Interpreting Data

- **Properly Set Zero Pathlength Position**: When the Zero Pathlength Position is within the acceptable range for a specific SoloVPE, a properly set Fibrette will always touch the bottom of the Sample Vessel during the zeroing event and have room to move upward without contacting the Delivery Fiber. This action simultaneously locks the "Zero Pathlength Position" reference datum as well as the optical coupling between the Delivery Fiber and the Fibrette thus ensuring optimal throughput for the given measurement conditions. The result will be Section Data that accurately characterizes the sample for slope analysis and quantification of the concentration. (*See Figure 2*)

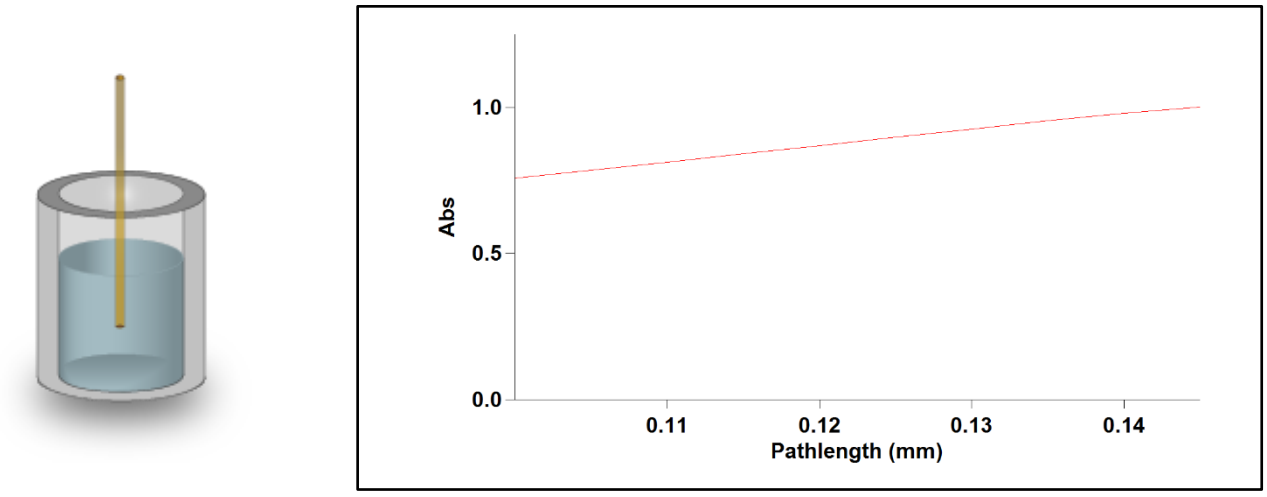

Figure 2

- **Improperly Set Zero Pathlength Position – Too Loose:** If the Zero Pathlength Position is set unacceptably loose for a specific SoloVPE or the user fails to properly set the Fibrette (e.g. forgets to pull down the Fibrette or actuate the Quick Set Coupler) the Fibrette may not touch the bottom of the Sample Vessel during the zeroing event and would not be pushed upward to improve the optical coupling. In this situation all pathlength positions are underreported because there will be a gap between the bottom of the Fibrette and the Sample Vessel. The improper pathlength reference datum will result in higher absorbance values and the results of the Quick Slope Threshold Pathlength search will potentially include non-linearities or significant shifts in the pathlengths chosen for data acquisition. Depending on the magnitude of the offset, Quick Slope may still produce acceptable results based upon the slope optimization algorithm though some data points, particularly in the longer pathlength range, may be excluded. (*See Figure 3*)

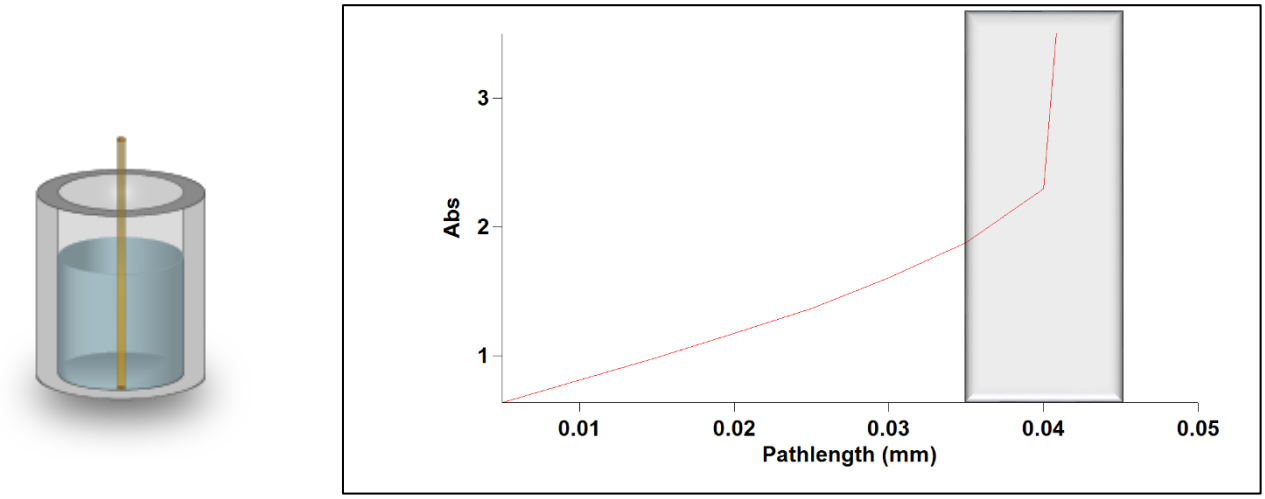

Figure 3

- **Improperly Set Zero Pathlength Position – Too Tight:** If the Zero Pathlength Position is set unacceptably tight for a specific SoloVPE, the Fibrette will make contact with the bottom of the Sample Vessel during the zeroing event but may end up getting compressed between the bottom of the Sample Vessel and the Delivery Fiber at the upper end. Depending on the magnitude of the compression, the Fibrette may bend or potentially break and pathlength changes may not actually cause the Fibrette to separate from the bottom of the Sample Vessel until the increase in pathlength fully relieves the compression and the Fibrette "lifts off" the bottom of the Sample Vessel to create a gap. The improper pathlength reference datum will result in non-linearities that will typically appear as a flattening out of the Section Data at the shortest pathlengths where Fibrette is in Contact with the bottom of the Sample Vessel with a "bend" or "kink" in the plot that shows the region where Fibrette lift off occurred. (*See Figure 4*) The resultant slope and concentration may be dramatically different from the expected value depending on the results of the slope optimization algorithm. If the Quick Slope optimization identifies multiple data points where the slope is very flat, extremely low concentrations could be reported. If the Quick Slope optimization identifies a region that is in the nominal zone, the results could be consistent with the expected value. If the Quick Slope optimization identifies a region that includes only some of the flattened Section data the concentration results could be understated slightly. It is always important to look at the plots and results when data points have been excluded. While an improperly set Zero Pathlength Position could cause this type of behaviors, the more commonly observed cause is debris inside the Fibrette Coupler, possibly due to a rare break of a Fibrette. Should a Fibrette Break occur it is always best practice to discard the existing Fibrette Coupler and replace it. This is an action that can be performed by users. It is also important to clean the existing Delivery Fiber and perform a Quick Check and normal system suitability tests. Depending on the results, replacement of the Delivery Fiber may be required.

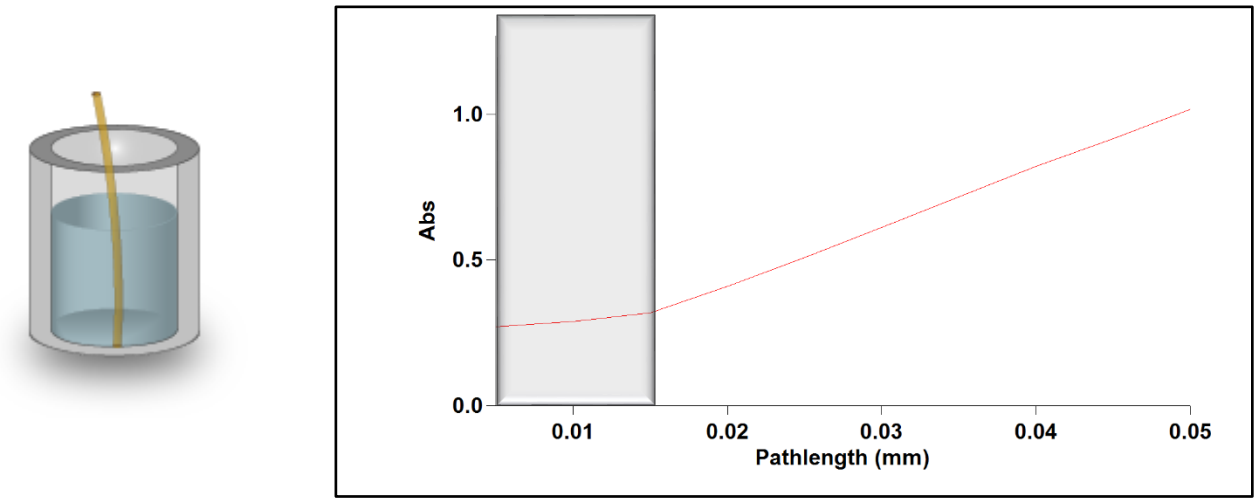

Figure 4

Document Info:

Revision History					
Rev	**Rev Date**	**Revision Changes**	**Revision By**	**QA Approval By**	**Approve Date**
00	2018-03-19	Initial Release	JF	MCS	

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