**Turbidity Spike Q & A**

**AWOP National Meeting**

**July 19 – 21, 2021**

1. **Bethany – Can DO bubbles be picked up in the new smaller sample cell instruments? Any suggestions on how to eliminate supersaturated DO before a turbidimeter if bubble traps don’t work?**
* A turbidimeter cannot determine that a bubble is comprised of oxygen, so the best approach is to react to DO bubbles like any other bubble. Just use the approaches we mentioned to minimize bubbles and all types should be minimized.
1. **Mike Bolf – My understanding is that EPA approves turbidity measuring methods, not instruments. There was discussion about algorithms, signal averaging, bubble traps, etc., and all these things will impact the measurement. As a regulator, it seems uncertain to me (e.g., issues with large bubble traps). Do we accept what the manufacturer says or is there other guidance?**
* EPA does look at individual instrumentation and how it is designed so that it doesn’t cause any problems. EPA does not restrict manufacturers to certain algorithms or signal averag­ing, but manufacturers try to maximize these effects because they understand how important they are. There is usually a statement telling the user to set the instrument up according to manufacturer specifications. When data is collected for approval of an EPA method, typi­cally that data is collected under manufacturer-recommended conditions.
1. **Evan Hofeld – What signal averaging do you recommend?**
* In most cases, I recommend longer times. Ideally, 90- second averaging coupled with bub­ble reject being turned on works very well with most instruments. This will definitely give a stable baseline, and any bubble caused spikes will be eliminated.
1. **Roy Robertson – Great presentation. I would love to be able to have a link to it on *YouTube* that I could share with engineers, operators, and my staff. Do you happen to have a favorite reference that you used when preparing the presentation that you could provide a link to?**
* This presentation was not recorded, but Mike will be presenting this material (in a slightly different format) in a Lovibond webinar on October 13, 2021, at 11 AM ET. Those inter­ested may register for the event here, and, even if they can’t join live, they would get a link to the recording afterwards. <https://us02web.zoom.us/webinar/register/1916154111588/WN_ZxRkVYo6TRKjq0QbAKhmEg>
1. **Robert Reaves – Does Lovibond have a default *“signal hold value”* setting? If so, what would that default be?**
* I am not exactly sure what you mean by this value. We do allow measurements to go all the way down to zero, but this should never happen, as even pure water will generate a minimal amount of light scatter. We have an alarm that will be triggered if the value is repeated. This frozen measurement alarm was requested by operators because some of the old GLI instruments would freeze at a low value around 0.012 NTU. What we do is calculate the turbidity out to several decimal points (0.0000001) NTU. If we get readings that duplicate more than twice at this level, this alarm is triggered. The only way this should ever happen is if there was a dead signal from the detector.
1. **Larry DeMers – What is the lower boundary for quantification of turbidity for filtered water? How does the limit of detection, accuracy (other factors?) determine this lower boundary? What would this lower boundary be for an older instrument like a Hach 1720E? I have considered 0.02 NTU to be about this boundary based on the instrument accuracy of ± 0.02 NTU and the reported lower range of 0.001 NTU. What is it for the newer instruments like Lovibond’s PTV series?**
* On measurement quantification, I have attached a white paper on the LOD that we deter­mined for our PTV series of instruments (Attachment 4A). We reference the LOD to a standard from ISO (International Standardization Organization) Method 15839. Here it defines the limit of detection (LOD) as three times the standard deviation of a spike that is 5% of full scale. For most turbidimeters, this 5% level is much too high, as even an instru­ment that just measures to 100 NTU would be tested at 5 NTU. Thus, we modify this method to test with a spike of 0.050 NTU, which is 5% of a reading scaled to 1 NTU. This covers the regulatory range of interest. We take the standard deviation of several spikes (minimum of seven) and average them. We then multiply this value by three, and that is the detection limit. This limit is really the lowest turbidity change that an instrument can detect that is due to turbidity. Any level below this value could be due to instrument noise or a blend of instrument noise and turbidity that cannot be separated out. The limit of quantifica­tion (LOQ) is generated from the same test, and it is ten times the standard deviation. Thus, if we determine the LOD to be 0.001 NTU, then the LOQ would be 0.01 NTU. Putting LOD and LOQ into practice, the LOD tells us that a change in turbidity from a predefined baseline must at least be greater than the LOD value for it to be due to a turbidity change. If the turbidity change exceeds the LOQ, then the value is quantifiable.

The LOD and LOQ tell us the minimum threshold of a given change that is needed to con­firm it is due to turbidity for a given make and model of an instrument. However, it does not tell us what the lowest turbidity measurement a given make and model of a turbidimeter will be capable of making. The lowest turbidity level is normally defined by the stray light of an instrument. As you mentioned, with tungsten light sources this is around 0.020 NTU. For instruments that use LEDs with a narrow bandwidth, the values are somewhat lower. For Lovibond PTV instruments they range between 0.007 and 0.012 NTU (IR or Red 660 nm LED) sources. For a laser it is in the range of 0.007 to 0.010 NTU, depending on the instru­ment. Basically, a user should never see values below these turbidities. If they do, there is something wrong with the instrument, or they have incorrectly used the measurement offset feature. (Some instruments allow the user to subtract an offset value (basically a blank value) from all their readings. This is very hard value to estimate, and we do not recom­mend doing it, but some insist anyway).

The lowest turbidity reading is normally captured in the accuracy specification for a given instrument. As we all know, the percent of reading accuracy specification gets larger as the measurement gets lower to the point where it is not really a valid statement anymore. Nor­mally this is below about 1 NTU, where a 2% of reading specification is equivalent to ±0.02 NTU. This is why most accuracy specs will have the percent specification ± a *“numerical”* value. This numerical value typically ranges between 0.005 and 0.020 NTU, which accounts for the stray light and normally covers for the lowest reading on an instru­ment. Thus, if the spec is 2% of reading ±0.02 NTU, that tells the user that any measure­ment below 0.020 NTU can only be rounded to 0.02 NTU for all measurements below 1.00 NTU. From a practical perspective, the lowest possible baseline that such an instru­ment (that is measuring really clean water such as from a membrane application) will proba­bly read no lower than 0.02 NTU on a White light turbidimeter. If an instrument with a nar­row band LED or laser was used, the baseline would be lower because its stray light is lower.

There are a lot of statistics here, but, in summary, the accuracy specification will tell you the lowest baseline a turbidimeter will be capable of measuring on the cleanest water. The LOD will tell the user the minimum turbidity change above this baseline that is needed to be due to turbidity, and the LOQ will tell the user the minimum change in turbidity that would be quantifiable. For regulatory purposes the LOQ would be the lowest turbidity change that a regulator could theoretically impose that could be verified with quantifiable methodologies.