Lovibond TB 3500

Measurement of Drinking Water Turbidity of a Captured Sample Using a Lovibond White Light LED Portable Turbidimeter

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1.0 SCOPE AND APPLICATION

1.1. This method is applicable to any colorless drinking water samples with a turbidity less than 10 Nephelometric Turbidity Units (NTU).

1.2. The applicable range is from 0 to 10 NTU for any aqueous sample.

1.3. It meets the requirements for compliance monitoring and reporting as demanded under the Safe Drinking Water Act (SDWA).

1.4. This method is applicable for use in measuring grab samples from process turbidimeters using a portable turbidimeter for the purpose of process turbidimeter verification.

2.0 SUMMARY OF METHOD

2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. Readings, in NTUs, are made in a nephelometer designed according to specifications given in section 6.2.

2.2 Formazin, prepared under closely defined conditions, is used as a primary standard suspension to calibrate the instrument. However, other approved primary standards may be used with this method.

2.3 Examples of standards that can be used to calibrate the instrument include dilutions from commercially available 4000 NTU formazin, stabilized versions of formazin with preassigned turbidity values such as T-Cal™, and Styrenedivinylbenzene polymer suspensions with preassigned values for the specific make and model of the instrument to be calibrated.

3.0 DEFFINITIONS

3.1 CALIBRATION BLANK (CB) – A volume of reagent water fortified with the same matrix as the calibration standards, but without the analytes, internal standards, or surrogate analytes.

3.2 INSTRUMENT PERFORMANCE CHECK SOLUTION (IPC) – A solution of one or more method analytes, surrogates, internal standards, or other test substances used to evaluate the performance of the instrument system with respect to a defined set of criteria.

3.3 LABORATORY REAGENT BLANK (LRB) – An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples. The LRB is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

3.4 LINEAR CALIBRATION RANGE (LCR) – The concentration range over which the instrument response is linear.

3.5 SAFETY DATA SHEET (SDS) – Written information provided by vendors concerning a chemical/s toxicity, health hazards, physical properties, fire, and reactivity data including storage, spill, and handling precautions.

3.6 PRIMARY CALIBRATION STANDARD (PCAL) –The PCAL suspensions are used to calibrate the instrument response with respect to analyte concentration.

3.7 QUALITY CONTROL SAMPLE (QCS) - A solution of the method analyte of known concentrations that is used to fortify an aliquot of LBR matrix. The QCS is obtained from a source external to the laboratory and used to check laboratory performance.

3.8 SECONDARY CALIBRATION STANDARDS (SCAL) – commercially prepared stabilized sealed liquid standards that have not been evaluated by EPA, gel turbidity standards, or other apparatus or mechanism calibrated against properly prepared and diluted Formazin or styrene divinylbenzene polymers.

3.9 STOCK STANDARD SUSPENSION (SSS) – A concentrated suspension containing the analytic solution prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source. Stock standard suspensions are used to prepare calibrant suspensions or other needed values of suspensions.

3.10 SAMPLE BLANK - A sample that has been filtered to remove its turbidity. The sample blank is then run using the same procedure that is used when running a sample. This includes the sampling point, preparation of the sample for measurement and performing the measurement. The sample blank subtraction can reduce measurement interferences (4.5) and improve data comparability.

4.0 INTERFERENCES

4.1 The presence of floating debris and coarse particulate matter within the sample may settle out of suspension resulting in low turbidity readings.

4.2 Finely divided air bubbles will cause random high spikes in readings.

4.3 The presence of dissolved, light absorbing substances or chemicals in the sample, i.e. the presence of color, can absorb portions of the incident light spectra, resulting in low turbidity readings, although this effect is generally not significant for drinking water.

4.4 Light-absorbing particles in suspension within the sample, such as activated carbon of significant concentration, can cause low readings.

4.5 Construction materials of the nephelometric device within the measurement chamber can result in elevated stray light due to spurious reflections of the incident beam can cause a false positive bias at the bottom end of the range.

5.0 SAFETY

5.1 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable.

5.2 Each laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of Safety Data Sheets (SDS) should be made available to all personnel involved in the chemical analysis. The preparation of a formal safety plan is also advisable.

5.3 Hydrazine sulfate (7.2.1) may reasonably be anticipated to be a carcinogen: Fourth Annual Report on Carcinogens (NTP85-002 1985), p115. Formazin can contain residual hydrazine sulfate. Proper protection should be employed.

6.0 EQUIPMENT

6.1 The installation shall be according to the manufacturer’s instructions.

6.2 The turbidimeter shall consist of a nephelometer with a light source for illuminating the sample, and one or more photo-detectors to measure the amount of scattered light at a right angle to the incident beam, a correlation means to relate the amount of scattered light to a known turbidity standard and a communication means to convey the turbidity value to the plant operator or other responsible water authority.

6.3 Differences in the physical design of the turbidimeter will cause differences in measured values for turbidity, even though the same suspension is used for calibration. To minimize such differences, the following design criteria shall be observed:

6.3.1 The light source shall be a Light Emitting Diode (LED) emitting white light in the visible spectrum between 380 and 780 nm. The LED, all optical elements and detectors shall have a spectral peak response between 400 nm and 600 nm.

6.3.2 The value of turbidity is determined by the ratio of the amount of light incident upon the sample to the amount of scattered light.

6.3.3 The rays comprising the incident beam shall be parallel with no divergence and not to exceed 1 degree of convergence within the measurement volume.

6.3.4 Non-scattered or non-attenuated light of the incident beam after passing through the sample shall pass into a light trap that encompasses the diameter of the incident beam.

6.3.5 Distance traversed by incident light and scattered light within the sample cuvette not to exceed 10 cm.

6.3.6 Detector/Light Receiver shall be centered at 90º ± 1 ½ degrees to the incident beam.

6.3.6.1 Scattered light shall be received by the detector/light receiver at a subtended angle between 20 and 30 degrees from the center-point of the measurement volume.

6.3.6.2 The detector/light receiver shall have a spectral response that encompasses the peak spectral output of the incident light source.

6.3.7 The amount of light received by the scattered light detector/light receiver not due to light from scatter by the sample, i.e. stray light, should not cause a significant error in the determination of the turbidity of the sample.

6.3.8 A linear-based algorithm shall be used to convert detector signal to NTU’s in correlation to a known calibration standard.

6.3.9 The turbidimeter shall be free from significant drift after a short warm-up period.

6.3.10 The sensitivity of the instrument shall detect differences in turbidity of 0.01 NTU or less in waters less than 1 NTU.

6.3.11 The instrument shall measure from 0 to 10 NTU turbidity units. Several ranges may be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.

6.3.12 The sample cuvettes to be used with the available instrument must be of clear, colorless glass or plastic. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. A light coating of silicon oil may be used to mask minor imperfections in glass cuvettes. They must not be handled where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be handled. Tubes should be checked, indexed and read at the orientation that produces the lowest background blank value.

6.3.13 A nephelometric device that meets these specifications is the Lovibond White Light LED Portable Turbidimeter.

6.3.13.1 If the portable turbidimeter is being used for verification of results from the process or bench instrumentation, then matching the light source may improve data comparability between the instruments.

7.0 REAGENTS AND STANDARDS

7.1 Reagent water, turbidity-free: Pass deionized distilled water through a 0.45 micron or smaller pore-size membrane filter if necessary. Water should have a turbidity ≤0.03 NTU. This value should be considered when preparing standards.

7.2 Stock standard suspension (Formazin) 4000 NTU

7.2.1 Dissolve 5.00g hydrazine sulfate (CASRN 10034-93-2) into approximately 400 ml of reagent water contained in a cleaned 1-L Class A volumetric flask.

7.2.2 Dissolve 50.00g hexamethylenetetramine (CASRN 100-97-0) in approximately 300 ml of reagent water contained in a 500-ml volumetric flask.

7.2.3 Quantitively transfer the hexamethylenetetramine solution (7.2.2) into the 1-L flask that contains the dissolved hydrazine sulfate solution (7.2.1).

7.2.4 Dilute the 1-L flask (7.2.3) to volume with reagent water.

7.2.5 Stopper and mix by inversion for 10 minutes.

7.2.6 Allow to stand 24 hours at 25 ± 2 degree C. During this time, the formazin polymer will develop. The Turbidity of this standard is 4000 NTU.

7.2.7 Store this solution in the dark and away from a source of heat. Bring the solution to room temperature and thoroughly mix before preparing dilutions (7.3).

7.3 Primary calibration standards: Using Class A glassware, first mix and then dilute 10.00 mL of stock standard suspension (7.2) to 1-L with reagent water. The turbidity of this suspension is defined as 40 NTU. For other turbidity values, mix and dilute portions of this suspension as required using clean Class A glassware.

7.3.1 A new stock standard suspension (7.2) should be prepared each quarter. Primary calibration standards (7.3) should be prepared daily by dilution of the stock standard suspension.

7.4 Formazin in commercially prepared, certified, primary concentrated stock standard suspension (SSS) may be diluted and used as required. Dilute turbidity standards should be prepared daily.

7.5 Stabilized formazin suspensions, T-CAL® sealed stabilized formazin suspensions, or styrene divinylbenzene (SDVB) polymers are commercially prepared, certified and ready to use primary standard dilutions. Manufacturer's instructions should be followed for choosing the appropriate standard values for the instrument. These standards must not be used beyond their respective expiration dates.

7.6 Secondary standards may be acceptable as a calibration check but must be monitored on a routine basis for deterioration and replaced as required.

8.0 SAMPLE COLLECTION AND INSTRUMENT SETUP

8.1 Set up the instrument according to the manufacturer's instructions.

8.2 Preferably, immediately analyze samples at the point of collection.

8.3 If collection is necessary, samples should be collected in clean plastic or glass containers that have been rinsed with turbidity free water. Volume collected should be enough to ensure representative sampling and allow for duplicate analysis. Samples may be stored at 4C for 48 hours. No chemical preservation is necessary[1].

8.4 The best practice is to place the portable instrument on a flat horizontal surface.

8.5 Perform a QCS verification when measuring in the field. If verification fails, re-calibration of the instrument should be performed.

9.0 QUALITY CONTROL

9.1 Each laboratory using this method is required to operate a formal quality control (QC) program. The minimum requirements of this program consist of an initial demonstration of the portable turbidimeter system's capability and analysis of laboratory reagent blanks and other solutions as a continuing check on performance. The laboratory is required to maintain performance records that define the quality of data generated.

9.2 Initial and ongoing demonstrations of performance

9.2.1 The initial demonstration of performance is used to characterize instrument performance (determination of LCRs and analysis of QCS).

9.2.2 Linear Calibration Range (LCR) – The LCR must be determined initially and verified every three months or whenever a significant change in instrument response is observed or expected. The initial demonstration of linearity must use sufficient standards to ensure that the resulting curve is linear. The verification of linearity must use a minimum of a blank and three standards. For example, standards could be 0.5, 2.0 and 8.0 NTU. If any verification data exceeds the initial values by ± 10% or exceeds the stated specifications of the turbidity standard, whichever is greater, linearity must be reestablished. If any portion of the range is shown to be nonlinear, sufficient standards must be used to clearly define the nonlinear portion.

9.2.3 Quality Control Sample (QCS) – When beginning the use of this method, on a quarterly basis or as required to meet data-quality needs, verify the calibration standards and acceptable instrument performance with the preparation and analysis of a QCS. If the determined concentrations are not within ± 10 % of the stated QCS values, performance of the determinative step of the method is unacceptable. The source of the problem must be identified and corrected before continuing with on-going analyses.

9.2.4 Laboratory Reagent Blank (LRB) -- The laboratory must analyze at least one LRB with each batch of samples. Data produced are used to assess contamination from the laboratory environment[1].

9.2.5 Sample Blank – The sample blank can be determined once the LRB has been performed. The sample blank can be subtracted from the measured turbidities of samples to generate a more accurate result.

9.2.5.1 The sample blank should be used for turbidities below about 1 NTU.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Turbidity calibration: the manufacturer's operating instructions should be followed for calibration. Perform any cleaning and maintenance to the instrument and cuvettes prior to calibration. Calibration should be performed under the same ambient conditions as sample measurement.

10.2 Measure standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales.

10.3 At least one standard should be run in the expected measurement range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities.

10.4 Solid standards, if used, must be protected from surface scratches which may cause potential calibration changes. These standards can only be used for verification purposes.

10.5 If a pre-calibrated scale is not supplied, calibration curves should be prepared for each range of the instrument.

11.0 PROCEDURE

11.1 Low Turbidity Samples

11.1.1 A clean sample cuvette is rinsed at least 3 times with a representative sample from the treatment process. It is then filled with sample and capped.

11.1.2 The outside of the sample cuvette is wiped dry with a clean cloth that does not scratch the cuvette surface. If needed, silicone oil is used to polish the outside of the cuvette according to the manufacturer's instructions.

11.1.3 The sample cuvette is gently inverted 2 to 3 times to ensure turbidity is suspended; and immediately placed into the instrument for measurement.

11.1.4 If needed, allow time for bubbles to vacate the sample (10-30 seconds is typically adequate).

11.1.5 Measure the turbidity of the sample and record the displayed turbidity value.

11.2 High Turbidity Samples (Exceeding 10 Units)

11.2.1 Mix the sample to thoroughly disperse the solids.

11.2.2 Dilute mixed sample with one or more volumes of turbidity-free water (7.1) until the turbidity falls below 10 units. Use the procedure (11.1) for low turbidity samples to perform the analysis.

11.2.2.1 Some turbidimeters are equipped with higher measurement ranges. Use these as a guide on how much to dilute the sample to within the range of this method.

11.2.3 The turbidity of the original sample is then computed from the measured turbidity result of the diluted sample multiplied by its dilution factor.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Report results as follows:

NTU	Record to Nearest
0.01 - 1.0	0.03
1 - 10	0.05

13.0 METHOD PERFORMANCE

13.1 Prior to testing, all instruments were calibrated according to manufacturer's instructions. This was followed by running a QCS sample to verify the determinative step for each turbidimeter was within the specified criteria of this method (Section 9.2.3).

13.2 Accuracy and precision testing with turbidity spikes – The Lovibond White LED Portable Method was conducted in a qualified laboratory. Since the reference instrument required continuous sample flow, a pump injection system was used to introduce different spikes of turbidity. Each turbidity spike was of a constant and stable turbidity that is generated by the addition of a defined formazin standard that is pumped into the sample stream at a constant flow rate.

13.3 The spiked sample stream passed through the reference turbidimeter where its turbidity value was measured and recorded. The sample then passed through the exit port where it was collected into 8 sample vials and measured on the test instrument. This mimicked the approach used by water treatment plants to verify turbidities through comparative measurement.

13.3.1 Changing the injection rate of the formazin standard that was spiked into the filtered sample or changing the actual value of the formazin standard that was spiked into the filtered sample yielded a different stable turbidity value that was continuously delivered to the reference instrument. This approach generated various turbidity levels within the range of this method.

13.2.2 The injection rate of the turbidity standard was calculated in grams/minute and the flow of the filtered sample was measured in grams per minute. This allowed for the theoretical calculation of each turbidity spike. The instrument response was calculated as a percent recovery of the theoretical spike(s). This data is presented in Table 1 (17.1) for comparison between the candidate and reference instruments and Table 2 for comparison between the candidate and Process turbidimeter that utilize the same light source.

13.2.3 The sequence of spikes started with a turbidity free baseline and progressed with increasing turbidity up to the highest turbidity level.

13.2.4 The pre-filtered water supply was a blend of hot and cold tap water that was supplied by the city of Fort Collins. The source water was from mountain snow runoff that was treated with conventional techniques and filtered using dual media filtration.

13.2.5 Results provided the initial demonstration of linearity for the measurement system.

13.3 Testing at public water utilities. The TB 350 Portable turbidimeter (represents the Lovibond White Light LED Portable Turbidity Method) was tested at two public water utilities. One utility was a surface water treatment plant that required an additional softening step. The second plant was a dual media water filtration plant that was in an expansion phase. Both utilities are members of the partnership for safe drinking water. The USEPA compliant Hach FT660sc reference turbidimeter, was used to measure the filter effluent. The PTV1000 process turbidimeter also measured the filter effluent. Samples were collected into 10 vials and measured on the test turbidimeter. The reference and PTV1000 turbidity values were recorded during each collection. A deviation between the TB350 (test) and the FT660sc (reference) was 0.0207 NTU and 0.0208 NTU respectively at the two different water facilities. A deviation between the TB350 (test) and the PTV1000 Process turbidimeter was 0.003 NTU and 0.002 NTU respectively at the two different water facilities.

13.4 The instruments were calibrated according to manufacturer's instructions. After calibration, a QCS was run on each instrument to verify the determinative step for each turbidimeter was within the specified criteria.

13.5 Accuracy of the Lovibond WL LED Portable Turbidity Method. Accuracy (bias) was presented as percent recoveries relative to the theoretical values for the turbidity spikes. Refer to Tables 1 and 2 in section 17 for a summary of all spike recovery and precision data.

13.5.1 Percent Recoveries versus theoretical for spikes in the 0 to 0.10 NTU range:

The average percent recoveries of turbidity for turbidity spikes across up to 0.10 NTU range were:

Lovibond TB 3500 Method: 101.6%
FT660sc reference: 104.5%
PTV1000: 110.3%.

13.5.2 Percent Recoveries for spikes in the 0.10 to 1.0 NTU range

The average percent recoveries of turbidity for the spikes in the 0.10 to 1.0 NTU range were:

Lovibond TB 3500 Method: 97.0%
FT660sc reference: 97.1%
PTV1000: 97.3%.

13.5.3 Percent Recoveries for spikes in the 1.0 to 10.0 NTU range

The average percent recoveries of turbidity for turbidity spikes from the 1.0 to 10 NTU range were:

Lovibond TB 3500 Method: 99.5%
FT660sc reference: 99.2%
PTV1000: 98.2%.

13.6 Precision of the Lovibond WL LED Portable Turbidity Method

13.6.1 Precision for spikes in the 0 to 0.10 NTU range

The standard deviation for the turbidity for turbidity spikes across up to 0.10 NTU range were:

Lovibond TB 3500 Method: 0.007 NTU
FT660sc reference: 0.0004 NTU
PTV1000: 0.0006 NTU.

13.6.2 Precision for spikes in the 0.10 to 1.0 NTU range

The standard deviation for the turbidity spikes in the 0.10 to 1.0 NTU range were:

Lovibond TB 3500 Method: 0.011 NTU
FT660sc reference: 0.002 NTU
PTV1000: 0.003 NTU.

13.6.3 Precision for spikes in the 1.0 to 10.0 NTU range

The standard deviation for the turbidity spikes from the 1.0 to 10 NTU range were:

Lovibond TB 3500 Method: 0.045 NTU
FT660sc reference: 0.012 NTU
PTV1000: 0.026 NTU.

13.7 Accuracy and precision should be checked on a routine basis to monitor the overall performance of the instrument. A series of reagent blanks and check standards should be run to validate the quality of sample data. These checks should occur at a frequency that is required for regulatory compliance.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste as the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution-prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 The quantity of chemicals purchased should be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

15.0 WASTE MANAGEMENT:

15.1 The U.S. Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect air, water, and land by minimizing and controlling all releases from hoods and bench operations; complying with the letter and spirit of any waste discharge permit and regulations; and by complying with all solid hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions.

16.0 REFERENCES

1 USEPA. “Method 180.1 Determination of Turbidity by Nephelometry,” Revision 2.0, (1993).

17.0 Tables and Validation Data

17.1 Summarized precision and bias (percent recovery) data in tabular form between the test and reference instrument (Table 1).

17.2 Summarized precision and bias (percent recovery) data in tabular form between the test and PTV1000 instrument (Table 2).

Table 1 - Results Table for the Percent Recovery to Turbidity Spikes for the Lovibond WL LED Portable Turbidity Method and the Reference FT660sc Turbidimeter

	Lovibond White Light LED Portable Turbidity Method (NTU)						**Reference Turbidimeter Reading FT660sc (NTU)**					
Spike #	Baseline (Blank) NTU	Theoretical Value NTU	Response Value (blank Corrected) NTU	Recovery %	Precision (SD) NTU	N	Baseline (Blank) NTU	Theoretical Value NTU	Response Value (blank Corrected) NTU	% Recovery %	Precision (SD) NTU	N
1	0.031	0.015	0.0142	92.1	0.0024	8	0.011	0.015	0.017	107.5	0.0003	20
2	0.031	0.030	0.0314	103.1	0.0027	8	0.011	0.030	0.032	106.7	0.0005	20
3	0.031	0.062	0.0726	117.4	0.0172	8	0.011	0.062	0.066	106.8	0.0005	20
4	0.031	0.099	0.0935	94.0	0.0036	8	0.011	0.099	0.096	96.9	0.0005	20
5	0.031	0.192	0.1885	98.1	0.0211	8	0.011	0.192	0.183	95.4	0.0008	20
6	0.031	0.372	0.3564	95.8	0.0047	8	0.011	0.372	0.359	96.5	0.0019	20
7	0.031	0.590	0.5877	99.7	0.0104	8	0.011	0.590	0.587	99.5	0.0018	20
8	0.031	1.135	1.1046	97.3	0.0164	8	0.011	1.135	1.105	97.3	0.0029	20
9	0.031	2.789	2.7544	98.7	0.0345	8	0.011	2.789	2.747	98.5	0.0080	20
10	0.031	6.024	6.1001	101.3	0.0470	8	0.011	6.024	6.110	101.4	0.0126	20
11	0.031	10.966	11.0414	100.7	0.0803	8	0.011	10.966	10.921	99.6	0.0242	20

Table 2 - Results Table for the Percent Recovery to Turbidity Spikes for the Lovibond White Light LED Portable Turbidity Method and the PTV Process Turbidimeter. Both use the same LED light source type.

	Lovibond White Light LED Portable Turbidity Method (NTU)						**Process Turbidimeter Reading Lovibond PTV 1000 (NTU)**					
Spike #	Baseline (Blank) NTU	Theoretical Value NTU	Response Value (blank Corrected) NTU	Recovery %	Precision (SD) NTU	N	Baseline (Blank) NTU	Theoretical Value NTU	Response Value (blank Corrected) NTU	% Recovery %	Precision (SD) NTU	N
1	0.031	0.015	0.0142	92.1	0.0024	8	0.028	0.015	0.018	115.3	0.0003	20
2	0.031	0.030	0.0314	103.1	0.0027	8	0.028	0.030	0.035	115.4	0.0008	20
3	0.031	0.062	0.0726	117.4	0.0172	8	0.028	0.062	0.070	112.4	0.0005	20
4	0.031	0.099	0.0935	94.0	0.0036	8	0.028	0.099	0.097	98.0	0.0007	20
5	0.031	0.192	0.1885	98.1	0.0211	8	0.028	0.192	0.186	96.9	0.0006	20
6	0.031	0.372	0.3564	95.8	0.0047	8	0.028	0.372	0.358	96.2	0.0120	20
7	0.031	0.590	0.5877	99.7	0.0104	8	0.028	0.590	0.585	99.2	0.0010	20
8	0.031	1.135	1.1046	97.3	0.0164	8	0.028	1.135	1.091	96.1	0.0022	20
9	0.031	2.789	2.7544	98.7	0.0345	8	0.028	2.789	2.711	97.2	0.0159	20
10	0.031	6.024	6.1001	101.3	0.0470	8	0.028	6.024	5.976	99.2	0.0587	20
11	0.031	10.966	11.0414	100.7	0.0803	8	0.028	10.966	10.982	100.1	0.0279	20