# Total Dissolved Residue (Total Dissolved Solids, TDS) in Aqueous Matrices

**Environmental Express**

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## 1. Scope and Application

1.1. This method is based upon Standard Methods 2540 for the determination of Total Dissolved Residue in aqueous sample matrices.

1.2. This method is for use in the Environmental Protection Agency's (EPA's) data gathering and monitoring programs under the Clean Water Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation and Liability Act, and the Safe Drinking Water Act.

1.3. This method is used to determine Total Dissolved Residue (Total Dissolved Solids, TDS).

1.4. This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes

1.5. The concentration range for this method is determined by the minimum and maximum residue mass allowed (2.5 – 750 mg) and the volume of sample needed to achieve the desired residue mass. Samples for TDS have no upper volume limit specified but are limited by the size of the evaporation vessel and the practicality of repeated additions of sample volume.

1.6. Each laboratory that uses the method must demonstrate the ability to generate acceptable results using the procedure.

## 2. Summary of Method

2.1. For TDS the entire aliquot of sample is evaporated in a pre-weighed vessel and dried to constant weight at 180 ± 2°C. The mass of the residue is determined by difference in mass of the vessel.

## 3. Definitions

3.1. Laboratory Fortified Blank (LFB) - An aliquot of reagent water or other blank matrix to which known quantities of the method analytes and all the preservation compounds are added. The LFB is processed and analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements.

3.2. Laboratory Matrix/Duplicate (LM/LMD) also called Matrix / Duplicate (M/D): An aliquot of an environmental sample and a duplicate which are analyzed and its purpose is to determine whether the sample matrix contributes bias to the analytical results.

3.3. Laboratory Reagent Blank (LRB) - A volume of reagent water or other blank matrix that is processed exactly as a sample including exposure to all glassware and equipment, that

are used in the analysis batches. The LRB is used to determine if the method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

3.4. Minimum Reporting Level (MRL) - The minimum concentration that can be reported by a laboratory as a quantitated value for a method analyte in a sample following analysis. This concentration must not be any lower than the concentration of the lowest calibration standard for that instrument.

3.5. Total Dissolved Residue or Total Dissolved Solids is defined as all material that is not volatile at 180°C.

3.6. Water Sample: For the purpose of this method, a sample taken from one of the following sources: drinking water, surface water, storm runoff, industrial or domestic wastewater.

## 4. Interferences

4.1. Samples with multiple phases or those that settle into multiple layers present a problem with homogeneity. Ensure that such samples are well mixed during use. Vigorous shaking through inversion will provide a sufficient mixing for most samples. Samples that settle rapidly or resist mixing may require constant stirring with a magnetic stirrer. Use a wide bore pipette in such instances. Draw sample from the midpoint between the wall and the vortex. Avoid using propeller style mixers as these may shear particles resulting in underreported values.

4.2. Some samples may form a crust during drying. This crust can prevent some evaporation of water during the drying process. If a water trapping crust continues to be problematic reduce the amount of sample used to minimize the crust being formed or take other steps to allow water to evaporate. Document additional steps being used as well as the precautions that are taken to avoid loss of residue from the dried sample.

4.3. Organic compounds such as oil and grease may present problems in obtaining a stable final weight. Such compounds are often visible to the naked eye and well present as a constantly decreasing mass after each drying event. Develop a Quality Plan to positively identify these types of samples. Obtain a value for HEM for such samples, if possible and consult with the final data user how to use that value in conjunction with the data obtained from the analysis.

## 5. Safety

5.1. When working with and around ovens or other evaporation equipment the materials in use will become hot. Use appropriate heat resistant gloves and other necessary PPE to protect the analysts from exposure to heat. Different temperatures may require different PPE to be effective.

5.2. Use all standard PPE (gloves, safety glasses, lab coats, etc.) as required by your Laboratory Safety and Chemical Hygiene Plan. Pay particular attention to samples of unusual appearance or odor and request additional information from the sample source as necessary to identify unknown or unexpected hazards.

5.3. This method does not address all safety issues associated with its use. The laboratory is responsible for maintaining a safe work environment and 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's) must be available to all personnel involved in these analyses.

## 6. Equipment and Supplies

*Note: Brand names, suppliers and part numbers are cited for illustrative purposes only. No endorsement is implied. Equivalent performance may be achieved using equipment and materials other than those specified here, but demonstration of equivalent performance that meets the requirements of this method is the responsibility of the laboratory.*

6.1. Evaporation Vessel – StableWeigh™ TDS Vessel from Environmental Express, or equivalent. This vessel is not suitable for use in volatile solids determination. In such instances use ceramic, high silica glass, or platinum evaporating dishes of appropriate dimensions. When using the StableWeigh™ product, other accessories are recommended or required for ease of use.

6.2. StableWeigh™ modular rack – recommended. Used to transport and hold StableWeigh™ Vessels to, from, and in ovens and desiccators.

6.3. StableWeigh™ weighing bracket – recommended. Used to support vessels on the balance.

6.4. Static electricity dissipation device. Best results have been achieved using the Mettler Toledo balance deionizer or similar device. Mounted anti-static ionizing cartridges or brushes can be effective if care is taken to ensure the entire vessel is appropriately treated.

6.5. Drying oven for use at 103-105°C and 178-182°C.

6.6. Dessicator with dessicant– must include some indicator to determine when replacement of the desiccant is necessary. This can be indicating desiccant or other appropriate means.

6.7. Analytical balance capable of accurate and precise weighing to 0.1 mg.

6.8. Class A measuring devices of appropriate volume to measure necessary amounts of sample.

6.9. Glass Fiber Filter Discs – without organic binder, and 1.5 □m nominal pore size. Unprepared filters are available or use Washed & Dried filters from Environmental Express, or equivalent, to skip the filter preparation steps in the procedure.

6.10. Filtration apparatus, StableWeigh™ Filling Station – Use a filter funnel of the appropriate size to hold the volume of sample and diameter of filter being used. The StableWeigh™ Filling Station (single place or six place) will allow the analyst to filter samples directly into the vessel.

## 7. Reagents and Standards

7.1. The various forms of residue are determined based solely on physical characteristics. No specific chemicals or reagents are required for this analysis.

7.2. No specific standard is required. The TDS Standard from Environmental Express or equivalent may be used. Each purchased standard may have slightly different target values. Consult the certificate of analysis for the assigned true value of each standard. Alternatively, follow the directions in 9.6.1.2

## 8. Sample Collection Preservation and Storage

8.1. Always refer to the latest guidelines in 40 CFR part 136 for sampling guidelines, preservation guidelines, and holding time. Those instructions supersede any guidance given in this document.

8.2. Collect sample in a plastic or glass bottle. A recommended volume is a minimum of 250 mL.

8.3. Store samples at ≤ 6°C when not in use.

8.4. Store samples for no more than 7 days from collection.

## 9. Quality Control

9.1. Each laboratory that uses this method is required to develop and implement a formal Quality Manual. The minimum requirements of this program are outlined in 40 CFR part 136.7.

| Table 1: 40 CFR part 136.7 Quality Control Requirements | |
|---|---|
| **40 CFR 136.7 QC Requirement** | **Required (Yes/No) and Notes** |
| Demonstration of Capability (DOC), | Initial and Ongoing Demonstration of Capability Required |
| Method Detection Limit (MDL), | MDL $_{Spike}$ and MDL $_{Blank}$ not required for methods defined test. |
| Laboratory reagent blank (LRB), | Required daily or with each batch of 20 or fewer samples. |
| Laboratory fortified blank (LFB), also referred to as a spiked blank, or laboratory control sample (LCS), | LFB is required daily or with each batch of 20 or fewer samples. |
| Matrix spike (MS), matrix spike duplicate (MSD), or laboratory fortified blank duplicate (LFBD) for suspected difficult matrices, | Duplicates daily or with each batch of 20 or fewer samples. |
| Internal standard/s, surrogate standard/s (for organic analysis) or tracer (for radiochemistry), | Not required. |
| Calibration (initial and continuing), | Calibrate balance as per manufacturer and regulatory requirements. |
| Control charts (or other trend analyses of quality control results), | Required. |
| Corrective action (root cause analyses), | Required. |
| Specific frequency of QC checks, | Required. |
| QC acceptance criteria, and | Required. |
| Definitions of a batch (preparation and analytical) | Required. |

Note: Daily: Each day samples are analyzed in the laboratory.

9.2. Initial Demonstration of Capability (IDC)

9.3. Before new analysts run any samples, verify their capability with the method. Run a LFB at least four times. Calculate the standard deviation of the four samples. All 4 LFB values must fall within the LFB recovery limits for the analyst to pass the IDC

$$\text{LFB's initial recovery limits} = \text{Mean} \pm (5.84 \times \text{Standard Deviation})$$

Where:

5.84 = the two-sided Student's t factor for three degrees of freedom.

**Figure 1: Initial Demonstration of Capability Calculation**

9.4. Laboratory Reagent Blank (LRB):

9.5. High quality laboratory water that is analyzed as a sample. Analyzed at a frequency of no less than once per sample batch. Develop control chart limits to determine acceptable recovery. Perform Root Cause Analysis as per the laboratory Quality Manual in recovery is unacceptable

$$\textit{Experimental Value} = \text{LRB}$$

$\textit{Experimental Value}$ = LRB Concentration determined experimentally

**Figure 2: LRB Calculation**

9.6. Laboratory Fortified Blank (LFB):

9.6.1. LFB can :

9.6.1.1. Be purchased from a 3rd party supplier such as Environmental Express. Follow supplier's directions or:

9.6.1.2. Prepare in a 1000 ml volumetric flask put 0.2500 g (± 0.0001 g) of Celite and 20.0000 g (± 0.0001 g) of Sodium Chloride. Dilute to volume with DI water and mix well. Transfer 10 ml of the LFB to a StableWeigh vessel and dry. Recovery will be 20.0000 g/L.

9.6.2. A maximum recovery range of 80% to 120% is expected. Develop control chart limits to determine acceptable recovery. Perform Root Cause Analysis as per the laboratory Quality Manual in recovery is unacceptable.

$$\left(\frac{\text{Experimental Value}}{\text{Expected Value}}\right) * 100 = \text{Percent Recovery LFB}$$

Experimental Value = LFB Concentration determined experimentally

Expected Value = Known LFB concentration

**Figure 3: LFB Calculation**

9.7. Laboratory Matrix/ Laboratory Matrix Duplicate (LM/LMDD):

9.8. A duplicate set of TS samples are analyzed. LM/LMD are analyzed at a frequency of no less than once per sample batch. A Relative Percent Difference (RPD) will be calculated for each LM/LMD set. Develop control chart limits for RPD to determine acceptable recovery. Perform Root Cause Analysis as per the laboratory Quality Manual in recovery is unacceptable.

$$\text{Absolute Value}\left(\frac{(\text{LM-LMD})}{\left(\frac{\text{LM+LMD}}{2}\right)}\right)*100 = \text{RPD}$$

LM = Concentration determined for LM
LMD = Concentration determined for LM duplicate

**Figure 4: RPD Calculation**

9.9. Ongoing Demonstration of Capability

9.10. Samples consisting of the LRB, LFB, and LM/LMD will be run each batch of samples. These results will be charted on control charts to determine ODC for the laboratory. Develop control chart limits to determine acceptable recovery. Perform Root Cause Analysis as per the laboratory Quality Manual in recovery is unacceptable.

9.11. Balance Check. An appropriate check weight should be evaluated at the beginning and end of each weighing sequence. The checks will demonstrate lack of drift in the balance. Reasonable choices would be within the same order of magnitude as the expected mass of the residue plus StableWeigh vessel used for the samples. Develop control chart limits to determine acceptable check weight. Perform Root Cause Analysis as per the laboratory Quality Manual in check weight is unacceptable.

9.12. Sample Batch

9.12.1. A group of samples which behave similarly with respect to the sampling or the testing procedures being employed and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch. A batch cannot span between laboratory work days (24 hrs.). New batches must be started each laboratory work day.

9.12.2. Sample Batch: Typical sample analysis sequence.

9.12.2.1. Balance Check

9.12.2.2. LRB

9.12.2.3. LFB

9.12.2.4. LM

9.12.2.5. LMD

9.12.2.6. Samples

9.12.2.7. Balance Check

9.12.2.8. Other Equipment Checks

9.13. Other equipment used in this analysis, such as ovens, balances, and thermometers, must be maintained and checked as required by the laboratory Quality Manual.

9.14. Control charts and trend analysis will be performed on all areas identified in the Quality Control section in this method and in the laboratories Quality Manual.

## 10. Procedure

*Note: This method is entirely empirical. Acceptable results can be obtained only by strict adherence to all details.*

10.1. Select an appropriate number of StableWeigh TDS vessels for the required number of samples and QC. Assign each vessel to a sample and note the vessel tare weight in the appropriate analysis data log. StableWeigh vessels must not be used if the sample aliquot is to be analyzed for volatile solids.

10.2. If ProWeigh Washed and Dried filters are used, skip the following preparation steps and proceed to 10.7

10.3. Insert a filter into the filtration apparatus and apply vacuum.

10.4. Wash the filter with three successive 20 mL portions of reagent water. Continue to apply vacuum to remove all traces of wash water from the filter.

10.5. Discard wash water.

10.6. Choose a sample size expected to yield between 2.5 and 700 mg of residue. Mix the sample well through appropriate means (repeated inversion, stirring with magnetic stirrer or other) and measure out the appropriate sample volume. If the vessel is not of sufficient size to hold the volume required, successive portions of sample may be added after evaporation.

10.7. Place the filter and StableWeigh TDS Vessel in the StableWeigh filling station. Apply vacuum and add the sample to the filter holder. No more than 10 minutes should be required for sample filtration. Larger filter sizes or smaller sample volumes may be necessary to fulfill this time requirement. After filtration is complete wash the filter with three successive 10 mL portions of reagent water to ensure complete transfer of dissolved constituents into the filtrate. Continue suction until all visible water has been removed from the filter.

10.8. Remove the StableWeigh TDS vessel from the filling station and transfer it to the oven rack.

10.9. Evaporate the sample to dryness using a block digester, oven, steam bath, or other appropriate method. Set the evaporation temperature low enough that the samples do not boil and splatter.

10.10. Dry the evaporated sample and vessel in a drying oven at 180 ± 2°C for at least one hour.

10.11. Remove the vessels from the oven and place in a dessicator until they have reached balance temperature. Cooling time for StableWeigh vessels can be reduced by transferring the vessels to a cool rack prior to placing in the dessicator.

10.12. Weigh each vessel on the balance and record the weight to 0.1 mg.

10.13. Repeat steps 11.2.8 - 11.2.10 at least one more time and as many times as necessary to obtain consecutive weights that differ by less than 0.5 mg. QC samples must go through the drying/cooling/weighing cycle as long as other samples require them. Other samples may be removed from the cycle once they have shown weight stability. When using crucibles, keeping the dessicator time constant with each cycle will help to reduce the number of cycles needed to achieve constant weight.

## 11. Data Analysis and Calculations

11.1. Calculations for Total Dissolved Solids

$$\frac{(A\text{-}B)\,x1000}{C} = \text{Total Dissolved Solids (mg/L)}$$

A = Weight of dried sample + StableWeigh (mg)

B = Weight of StableWeigh (mg)

C = volume of sample (mL)

**Figure 5: Total Solids Calculation**

## 12. Method Performance

12.1. See Standard Methods 2540 for performance data on the original analysis method.

12.2. Comparison data validating the use of the StableWeigh vessel in comparison to the crucibles required for TDS are found in Tables/Appendices.

## 13. Pollution Prevention

13.1. The main source of pollution from this method is from unknown samples. Follow your laboratory Waste Management Program for the identification and disposal of potentially hazardous samples.

## 14. Waste Management

14.1. It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

14.2. Use the least amount of sample possible to generate valid results, particularly for TS. This will minimize the amount of waste generated by the analysis.

14.3. For further information on waste management, consult "The Waste Management Manual for Laboratory Personnel," and "Less is Better: Laboratory Chemical Management for Waste Reduction," both available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street N.W., Washington DC, 20036.

## 15. References

15.1. Eaton, A. D., Clesceri, L. S., Baird, R. B., Rice, E. W., American Public Health Association., American Water Works Association., & Water Environment Federation. (2012). *Standard Methods for the Examination of Water and Wastewater, 22nd edition*. Washington, DC: American Public Health Association

## 16. Tables, Diagrams, Flowcharts, and Validation Data

| Table A1: Environmental Express TDS Stable-Weigh Tests Blank | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | |
| **Date** | **4/14/2016** | | | | | | | | |
| **Blank** | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Percent Change** |
| **1** | **144** | 100 | 3.7783 | 3.7785 | 3.7782 | | -0.3 | 3.7782 | 0.00265% |
| **2** | **145** | 100 | 3.7329 | 3.7330 | 3.7329 | | -0.1 | 3.7329 | 0.00000% |
| **3** | **147** | 100 | 3.8709 | 3.8709 | 3.8708 | | -0.1 | 3.8708 | 0.00258% |
| **4** | **148** | 100 | 3.7953 | 3.7958 | 3.7955 | | -0.3 | 3.7955 | -0.00527% |
| **5** | **150** | 100 | 3.8747 | 3.8748 | 3.8745 | | -0.3 | 3.8745 | 0.00516% |
| **6** | **75** | 100 | 3.7540 | 3.7543 | 3.7540 | | -0.3 | 3.7540 | 0.00000% |
| **7** | **58** | 100 | 3.7246 | 3.7249 | 3.7245 | | -0.4 | 3.7245 | 0.00268% |
| **8** | **81** | 100 | 3.7105 | 3.7107 | 3.7105 | | -0.2 | 3.7105 | 0.00000% |
| **9** | **82** | 100 | 3.7503 | 3.7503 | 3.7503 | | 0.0 | 3.7503 | 0.00000% |
| **10** | **83** | 100 | 3.7500 | 3.7495 | 3.7497 | | 0.2 | 3.7497 | 0.00800% |
| **11** | **94** | 100 | 3.7312 | 3.7313 | 3.7316 | | 0.3 | 3.7316 | -0.01072% |
| **12** | **86** | 100 | 3.7855 | 3.7854 | 3.7855 | | 0.1 | 3.7855 | 0.00000% |
| **13** | **77** | 100 | 3.9155 | 3.9153 | 3.9154 | | 0.1 | 3.9154 | 0.00255% |
| **14** | **85** | 100 | 3.7716 | 3.7716 | 3.7716 | | 0.0 | 3.7716 | 0.00000% |
| **15** | **79** | 100 | 3.8572 | 3.8574 | 3.8572 | | -0.2 | 3.8572 | 0.00000% |
| **16** | **111** | 100 | 3.6931 | 3.6929 | 3.6931 | | 0.2 | 3.6931 | 0.00000% |
| **17** | **53** | 100 | 3.8009 | 3.8009 | 3.8009 | | 0.0 | 3.8009 | 0.00000% |
| **18** | **74** | 100 | 3.8078 | 3.8079 | 3.8079 | | 0.0 | 3.8079 | -0.00263% |
| **19** | **52** | 100 | 3.7902 | 3.7896 | 3.7900 | | 0.4 | 3.7900 | 0.00528% |

| Table A1: Environmental Express TDS Stable-Weigh Tests Blank | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | |
| **Date** | **4/14/2016** | | | | | | | | |
| **Blank** | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Percent Change** |
| **20** | **80** | 100 | 3.7825 | 3.7826 | 3.7825 | | -0.1 | 3.7825 | 0.00000% |
| **21** | **143** | 100 | 3.7904 | 3.7907 | 3.7904 | | -0.3 | 3.7904 | 0.00000% |
| **22** | **42** | 100 | 3.7561 | 3.7566 | 3.7566 | | 0.0 | 3.7566 | -0.01331% |
| **23** | **141** | 100 | 3.8124 | 3.8124 | 3.8125 | | 0.1 | 3.8125 | -0.00262% |
| **24** | **140** | 100 | 3.7322 | 3.7327 | 3.7324 | | -0.3 | 3.7324 | -0.00536% |
| **25** | **139** | 100 | 3.7765 | 3.7763 | 3.7761 | | -0.2 | 3.7761 | 0.01059% |
| | | | | | | | | **Average** | -0.00002% |
| | | | | | | | | **Standard Deviation** | 0.00508% |

| Table A2: Environmental Express TDS Stable-Weigh Tests 200 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/18/2016** | | | | | | | | | |
| **200.03 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **1** | **188** | 50 | 3.7495 | 3.9508 | 3.9505 | | -0.3 | 3.9505 | 201.0 | 100.50% |
| **2** | **187** | 50 | 3.7712 | 3.9721 | 3.9718 | | -0.3 | 3.9718 | 200.6 | 100.30% |
| **3** | **186** | 50 | 3.8070 | 4.0078 | 4.0076 | | -0.2 | 4.0076 | 200.6 | 100.30% |
| **4** | **185** | 50 | 3.7333 | 3.9339 | 3.9338 | | -0.1 | 3.9338 | 200.5 | 100.25% |
| **5** | **184** | 50 | 3.8077 | 4.0074 | 4.0073 | | -0.1 | 4.0073 | 199.6 | 99.80% |
| **6** | **182** | 50 | 3.7256 | 3.9263 | 3.9260 | | -0.3 | 3.9260 | 200.4 | 100.20% |
| **7** | **183** | 50 | 3.7304 | 3.9318 | 3.9314 | | -0.4 | 3.9314 | 201.0 | 100.50% |
| **8** | **181** | 50 | 3.6925 | 3.8962 | 3.8926 | | -3.6 | 3.8926 | 200.1 | 100.05% |
| **9** | **180** | 50 | 3.7520 | 3.9522 | 3.9519 | | -0.3 | 3.9519 | 199.9 | 99.95% |
| **10** | **179** | 50 | 3.7577 | 3.9580 | 3.9585 | | 0.5 | 3.9585 | 200.8 | 100.40% |
| **11** | **178** | 50 | 3.7507 | 3.9509 | 3.9506 | | -0.3 | 3.9506 | 199.9 | 99.95% |
| **12** | **177** | 50 | 3.7350 | 3.9356 | 3.9360 | | 0.4 | 3.9360 | 201.0 | 100.50% |
| **13** | **153** | 50 | 3.7772 | 3.9776 | 3.9775 | | -0.1 | 3.9775 | 200.3 | 100.15% |
| **14** | **165** | 50 | 3.8030 | 4.0027 | 4.0026 | | -0.1 | 4.0026 | 199.6 | 99.80% |
| **15** | **176** | 50 | 3.7986 | 3.9986 | 3.9985 | | -0.1 | 3.9985 | 199.9 | 99.95% |
| **16** | **167** | 50 | 3.7678 | 3.9679 | 3.9679 | | 0.0 | 3.9679 | 200.1 | 100.05% |
| **17** | **168** | 50 | 3.8320 | 4.0326 | 4.0324 | | -0.2 | 4.0324 | 200.4 | 100.20% |
| **18** | **166** | 50 | 3.7805 | 3.9820 | 3.9816 | | -0.4 | 3.9816 | 201.1 | 100.55% |
| **19** | **169** | 50 | 3.7557 | 3.9559 | 3.9557 | | -0.2 | 3.9557 | 200.0 | 100.00% |

| Table A2: Environmental Express TDS Stable-Weigh Tests 200 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/18/2016** | | | | | | | | | |
| **200.03 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **20** | **171** | 50 | 3.7430 | 3.9435 | 3.9439 | | 0.4 | 3.9439 | 200.9 | 100.45% |
| **21** | **170** | 50 | 3.8467 | 4.0469 | 4.0467 | | -0.2 | 4.0467 | 200.0 | 100.00% |
| **22** | **172** | 50 | 3.7228 | 3.9229 | 3.9228 | | -0.1 | 3.9228 | 200.0 | 100.00% |
| **23** | **174** | 50 | 3.7589 | 3.9589 | 3.9585 | | -0.4 | 3.9585 | 199.6 | 99.80% |
| **24** | **138** | 50 | 3.8743 | 4.0761 | 4.0757 | | -0.4 | 4.0757 | 201.4 | 100.70% |
| **25** | **163** | 50 | 3.7442 | 3.9456 | 3.9458 | | 0.2 | 3.9458 | 201.6 | 100.80% |
| | | | | | | | | **Average** | 200.4 | 100.21% |
| | | | | | | | | **Standard Deviation** | 0.6 | 0.29% |

| Table A3: Environmental Express TDS Stable-Weigh Tests 100 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/20/2016** | | | | | | | | | |
| **100.0 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **1** | **160** | 50 | 3.8295 | 3.9296 | 3.9299 | | 0.3 | 3.9299 | 100.4 | 100.40% |
| **2** | **159** | 50 | 3.8089 | 3.9089 | 3.9090 | | 0.1 | 3.9090 | 100.1 | 100.10% |
| **3** | **157** | 50 | 3.8275 | 3.9276 | 3.9274 | | -0.2 | 3.9274 | 99.9 | 99.90% |
| **4** | **155** | 50 | 3.7905 | 3.8908 | 3.8912 | | 0.4 | 3.8912 | 100.7 | 100.70% |
| **5** | **132** | 50 | 3.6963 | 3.7967 | 3.7964 | | -0.3 | 3.7964 | 100.1 | 100.10% |
| **6** | **126** | 50 | 3.7543 | 3.8542 | 3.8541 | | -0.1 | 3.8541 | 99.8 | 99.80% |
| **7** | **121** | 50 | 3.8094 | 3.9093 | 3.9092 | | -0.1 | 3.9092 | 99.8 | 99.80% |
| **8** | **154** | 50 | 3.7894 | 3.8895 | 3.8898 | | 0.3 | 3.8898 | 100.4 | 100.40% |
| **9** | **135** | 50 | 3.7178 | 3.8179 | 3.8177 | | -0.2 | 3.8177 | 99.9 | 99.90% |
| **10** | **137** | 50 | 3.7489 | 3.8488 | 3.8485 | | -0.3 | 3.8485 | 99.6 | 99.60% |
| **11** | **136** | 50 | 3.7907 | 3.8907 | 3.8904 | | -0.3 | 3.8904 | 99.7 | 99.70% |
| **12** | **61** | 50 | 3.8120 | 3.9121 | 3.9120 | | -0.1 | 3.9120 | 100.0 | 100.00% |
| **13** | **56** | 50 | 3.7894 | 3.8890 | 3.8889 | | -0.1 | 3.8889 | 99.5 | 99.50% |
| **14** | **NA** | 50 | 3.7348 | 3.8346 | 3.8344 | | -0.2 | 3.8344 | 99.6 | 99.60% |
| **15** | **69** | 50 | 3.7634 | 3.8644 | 3.8648 | | 0.4 | 3.8648 | 101.4 | 101.40% |
| **16** | **92** | 50 | 3.8360 | 3.9362 | 3.9362 | | 0.0 | 3.9362 | 100.2 | 100.20% |
| **17** | **96** | 50 | 3.7731 | 3.8732 | 3.8732 | | 0.0 | 3.8732 | 100.1 | 100.10% |
| **18** | **60** | 50 | 3.7506 | 3.8504 | 3.8505 | | 0.1 | 3.8505 | 99.9 | 99.90% |
| **19** | **93** | 50 | 3.7791 | 3.8791 | 3.8790 | | -0.1 | 3.8790 | 99.9 | 99.90% |

| Table A3: Environmental Express TDS Stable-Weigh Tests 100 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/20/2016** | | | | | | | | | |
| **100.0 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **20** | **103** | 50 | 3.7646 | 3.8638 | 3.8635 | | -0.3 | 3.8635 | 98.9 | 98.90% |
| **21** | **84** | 50 | 3.7944 | 3.8945 | 3.8940 | | -0.5 | 3.8940 | 99.6 | 99.60% |
| **22** | **78** | 50 | 3.8620 | 3.9630 | 3.9629 | | -0.1 | 3.9629 | 100.9 | 100.90% |
| **23** | **86** | 50 | 3.7344 | 3.8343 | 3.8341 | | -0.2 | 3.8341 | 99.7 | 99.70% |
| **24** | **87** | 50 | 3.7374 | 3.8379 | 3.8382 | | 0.3 | 3.8382 | 100.8 | 100.80% |
| **25** | **161** | 50 | 3.7346 | 3.8346 | 3.8344 | | -0.2 | 3.8344 | 99.8 | 99.80% |
| | | | | | | | | **Average** | 100.0 | 100.03% |
| | | | | | | | | **Standard Deviation** | 0.5 | 0.52% |

| Table A4: Environmental Express TDS Stable-Weigh Tests 20 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/24/2016** | | | | | | | | | |
| **20.1 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **1** | **195** | 50 | 3.8442 | 3.8635 | 3.8632 | | -0.3 | 3.8632 | 19.0 | 94.53% |
| **2** | **194** | 50 | 4.1223 | 4.1430 | 4.1431 | | 0.1 | 4.1431 | 20.8 | 103.48% |
| **3** | **193** | 50 | 3.9300 | 3.9498 | 3.9498 | | 0.0 | 3.9498 | 19.8 | 98.51% |
| **4** | **191** | 50 | 3.8884 | 3.9087 | 3.9087 | | 0.0 | 3.9087 | 20.3 | 101.00% |
| **5** | **189** | 50 | 3.9631 | 3.9836 | 3.9835 | | -0.1 | 3.9835 | 20.4 | 101.49% |
| **6** | **190** | 50 | 3.7477 | 3.7681 | 3.7680 | | -0.1 | 3.7680 | 20.3 | 101.00% |
| **7** | **184** | 50 | 3.8975 | 3.9170 | 3.9174 | | 0.4 | 3.9174 | 19.9 | 99.00% |
| **8** | **188** | 50 | 3.9284 | 3.9479 | 3.9482 | | 0.3 | 3.9482 | 19.8 | 98.51% |
| **9** | **187** | 50 | 3.8906 | 3.9112 | 3.9109 | | -0.3 | 3.9109 | 20.3 | 101.00% |
| **10** | **186** | 50 | 3.9480 | 3.9680 | 3.9685 | | 0.5 | 3.9685 | 20.5 | 101.99% |
| **11** | **209** | 50 | 3.8724 | 3.8925 | 3.8929 | | 0.4 | 3.8929 | 20.5 | 101.99% |
| **12** | **185** | 50 | 3.9345 | 3.9543 | 3.9545 | | 0.2 | 3.9545 | 20.0 | 99.50% |
| **13** | **210** | 50 | 3.9015 | 3.9221 | 3.9217 | | -0.4 | 3.9217 | 20.2 | 100.50% |
| **14** | **219** | 50 | 3.7434 | 3.7632 | 3.7635 | | 0.3 | 3.7635 | 20.1 | 100.00% |
| **15** | **213** | 50 | 3.7270 | 3.7472 | 3.7473 | | 0.1 | 3.7473 | 20.3 | 101.00% |
| **16** | **212** | 50 | 3.9431 | 3.9632 | 3.9633 | | 0.1 | 3.9633 | 20.2 | 100.50% |
| **17** | **218** | 50 | 3.7349 | 3.7549 | 3.7551 | | 0.2 | 3.7551 | 20.2 | 100.50% |
| **18** | **217** | 50 | 3.8864 | 3.9062 | 3.9064 | | 0.2 | 3.9064 | 20.0 | 99.50% |
| **19** | **216** | 50 | 3.9130 | 3.9329 | 3.9331 | | 0.2 | 3.9331 | 20.1 | 100.00% |

| Table A4: Environmental Express TDS Stable-Weigh Tests 20 mg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/24/2016** | | | | | | | | | |
| **20.1 mg per 50 mL** | | | | | | | | | | |
| **Sample #** | **Bag #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **20** | **215** | 50 | 3.7322 | 3.7522 | 3.7524 | | 0.2 | 3.7524 | 20.2 | 100.50% |
| **21** | **214** | 50 | 3.7237 | 3.7437 | 3.7437 | | 0.0 | 3.7437 | 20.0 | 99.50% |
| **22** | **211** | 50 | 3.7281 | 3.7486 | 3.7482 | | -0.4 | 3.7482 | 20.1 | 100.00% |
| **23** | **220** | 50 | 3.7186 | 3.7394 | 3.7393 | | -0.1 | 3.7393 | 20.7 | 102.99% |
| **24** | **221** | 50 | 3.7429 | 3.7629 | 3.7629 | | 0.0 | 3.7629 | 20.0 | 99.50% |
| **25** | **196** | 50 | 3.6729 | 3.6929 | 3.6931 | | 0.2 | 3.6931 | 20.2 | 100.50% |
| | | | | | | | | **Average** | 20.2 | 100.28% |
| | | | | | | | | **Standard Deviation** | 0.3 | 1.72% |

| Table A5: Environmental Express TDS Stable-Weigh Tests 20 mg-Evaporation Dish | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/22/2016** | | | | | | | | | |
| **20.2 mg per 50 mL (Evaporation Dish)** | | | | | | | | | | |
| **Sample #** | **Evaporation Dish #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **1** | **1** | 50 | 80.0804 | 80.1007 | 80.1004 | | -0.3 | 80.1004 | 20.0 | 99.01% |
| **2** | **2** | 50 | 88.0705 | 88.0913 | 88.0916 | | 0.3 | 88.0916 | 21.1 | 104.46% |
| **3** | **3** | 50 | 80.7484 | 80.7695 | 80.7698 | | 0.3 | 80.7698 | 21.4 | 105.94% |
| **4** | **4** | 50 | 80.6551 | 80.6759 | 80.6758 | | -0.1 | 80.6758 | 20.7 | 102.48% |
| **5** | **5** | 50 | 80.1832 | 80.2041 | 80.2045 | | 0.4 | 80.2045 | 21.3 | 105.45% |
| **6** | **6** | 50 | 71.8200 | 71.8405 | 71.8410 | | 0.5 | 71.8410 | 21.0 | 103.96% |
| **7** | **7** | 50 | 77.3487 | 77.3690 | 77.3694 | | 0.4 | 77.3694 | 20.7 | 102.48% |
| **8** | **8** | 50 | 71.2989 | 71.3192 | 71.3190 | | -0.2 | 71.3190 | 20.1 | 99.50% |
| **9** | **9** | 50 | 71.0469 | 71.0674 | 71.0670 | | -0.4 | 71.0670 | 20.1 | 99.50% |
| **10** | **10** | 50 | 70.3869 | 70.4077 | 70.4072 | | -0.5 | 70.4072 | 20.3 | 100.50% |
| **11** | **11** | 50 | 71.0414 | 71.0622 | 71.0618 | | -0.4 | 71.0618 | 20.4 | 100.99% |
| **12** | **12** | 50 | 71.3383 | 71.3591 | 71.3589 | | -0.2 | 71.3589 | 20.6 | 101.98% |
| **13** | **13** | 50 | 71.7408 | 71.7612 | 71.7612 | | 0.0 | 71.7612 | 20.4 | 100.99% |
| **14** | **14** | 50 | 70.1571 | 70.1774 | 70.1776 | | 0.2 | 70.1776 | 20.5 | 101.49% |
| **15** | **15** | 50 | 82.6046 | 82.6254 | 82.6256 | | 0.2 | 82.6256 | 21.0 | 103.96% |
| **16** | **16** | 50 | 70.3772 | 70.3975 | 70.3976 | | 0.1 | 70.3976 | 20.4 | 100.99% |
| **17** | **17** | 50 | 71.1090 | 71.1291 | 71.1294 | | 0.3 | 71.1294 | 20.4 | 100.99% |
| **18** | **18** | 50 | 69.7257 | 69.7460 | 69.7464 | | 0.4 | 69.7464 | 20.7 | 102.48% |
| **19** | **19** | 50 | 88.4661 | 88.4867 | 88.4872 | | 0.5 | 88.4872 | 21.1 | 104.46% |

| Table A5: Environmental Express TDS Stable-Weigh Tests 20 mg-Evaporation Dish | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Analyst** | **Edward F. Askew** | | | | | | | | | |
| **Date** | **4/22/2016** | | | | | | | | | |
| **20.2 mg per 50 mL (Evaporation Dish)** | | | | | | | | | | |
| **Sample #** | **Evaporation Dish #** | **Volume (ml)** | **Initial weight (g)** | **Final weight 1 (g)** | **Final weight 2 (g)** | **Final weight 3 (g)** | **Two Consecutive Weights Difference (mg)** | **Final weight used (mg)** | **Final Solids Recovered Weight (mg)** | **Percent Recovery** |
| **20** | **20** | 50 | 91.8973 | 91.9196 | 91.9191 | | -0.5 | 91.9191 | 21.8 | 107.92% |
| **21** | **21** | 50 | 92.1109 | 92.1311 | 92.1312 | | 0.1 | 92.1312 | 20.3 | 100.50% |
| **22** | **22** | 50 | 93.7274 | 93.7480 | 93.7478 | | -0.2 | 93.7478 | 20.4 | 100.99% |
| **23** | **23** | 50 | 92.0551 | 92.0755 | 92.0750 | | -0.5 | 92.0750 | 19.9 | 98.51% |
| **24** | **24** | 50 | 94.5897 | 94.6106 | 94.6105 | | -0.1 | 94.6105 | 20.8 | 102.97% |
| **25** | **A** | 50 | 83.3947 | 83.4134 | 83.4134 | | 0.0 | 83.4134 | 18.7 | 92.57% |
| | | | | | | | | **Average** | 20.6 | 101.80% |
| | | | | | | | | **Standard Deviation** | 0.6 | 2.99% |

| Table A6: StableWeigh and Porcelain Evaporation Dish Precision | | | | | |
|---|---|---|---|---|---|
| **TDS Mass** | **Vessel** | **Average** | **Standard Deviation** | **% RSD** | **Duplicate Relative Percent Difference** |
| 200 mg | StableWeigh | 200.4 | 0.57 | 0.29% | 1.00% |
| 100 mg | StableWeigh | 100.0 | 0.52 | 0.52% | 2.50% |
| 20 mg | StableWeigh | 20.2 | 0.35 | 1.71% | 9.05% |
| 20 mg | Porcelain Evaporation Dish | 20.6 | 0.60 | 2.94% | 15.31% |

| Table A7: StableWeigh Method Blank | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample #** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** |
| **Blank Weight Difference (mg)** | -0.1 | 0 | -0.1 | 0.2 | -0.2 | 0 | -0.1 | 0 | 0 | -0.3 | 0.4 | 0 | -0.1 | 0 | 0 | 0 | 0 | 0.1 | -0.2 | 0 | 0 | 0.5 | 0.1 | 0.2 | -0.4 |

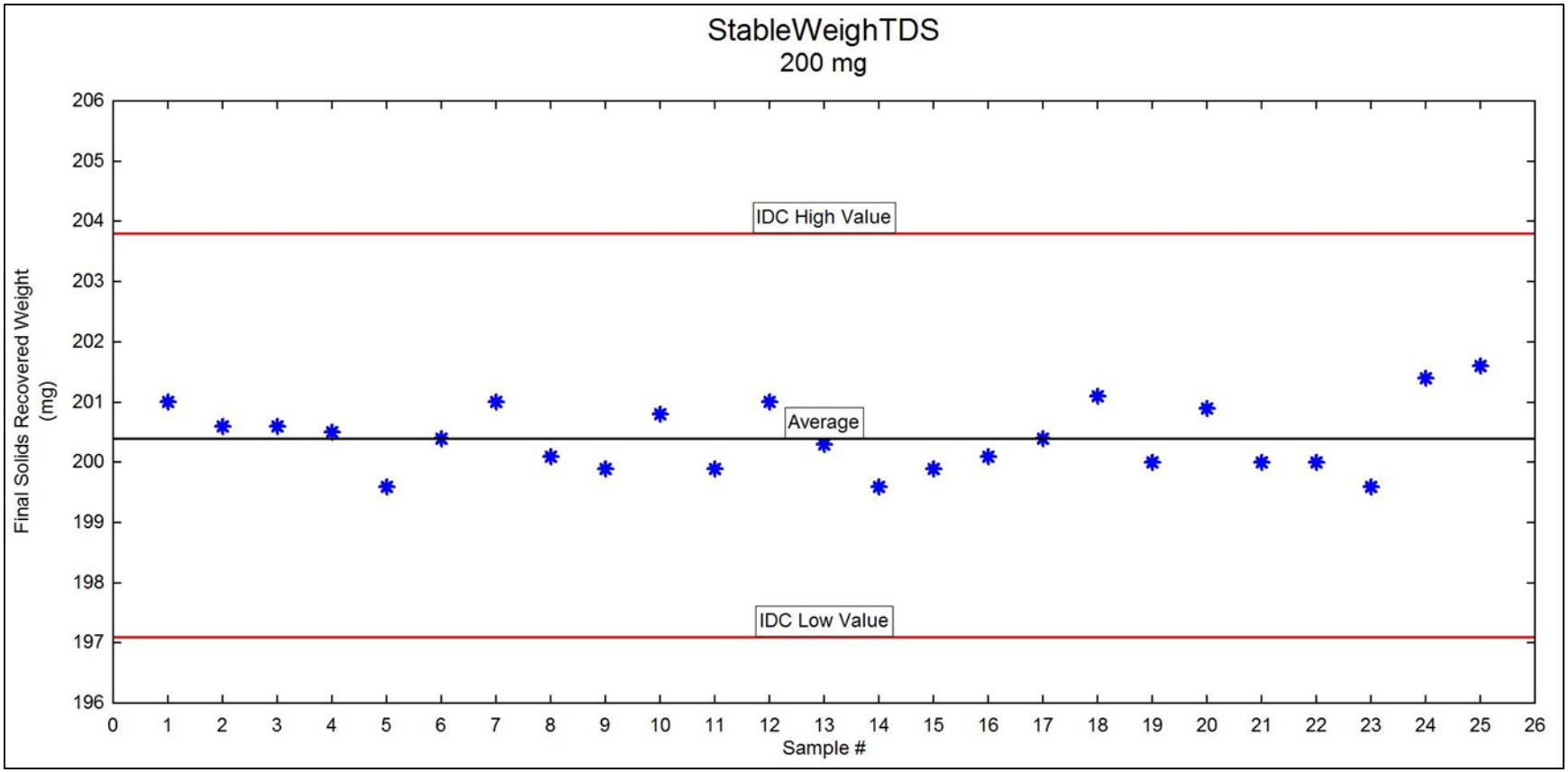


**Figure 6: StableWeigh 200 mg Initial Demonstration of Capability**

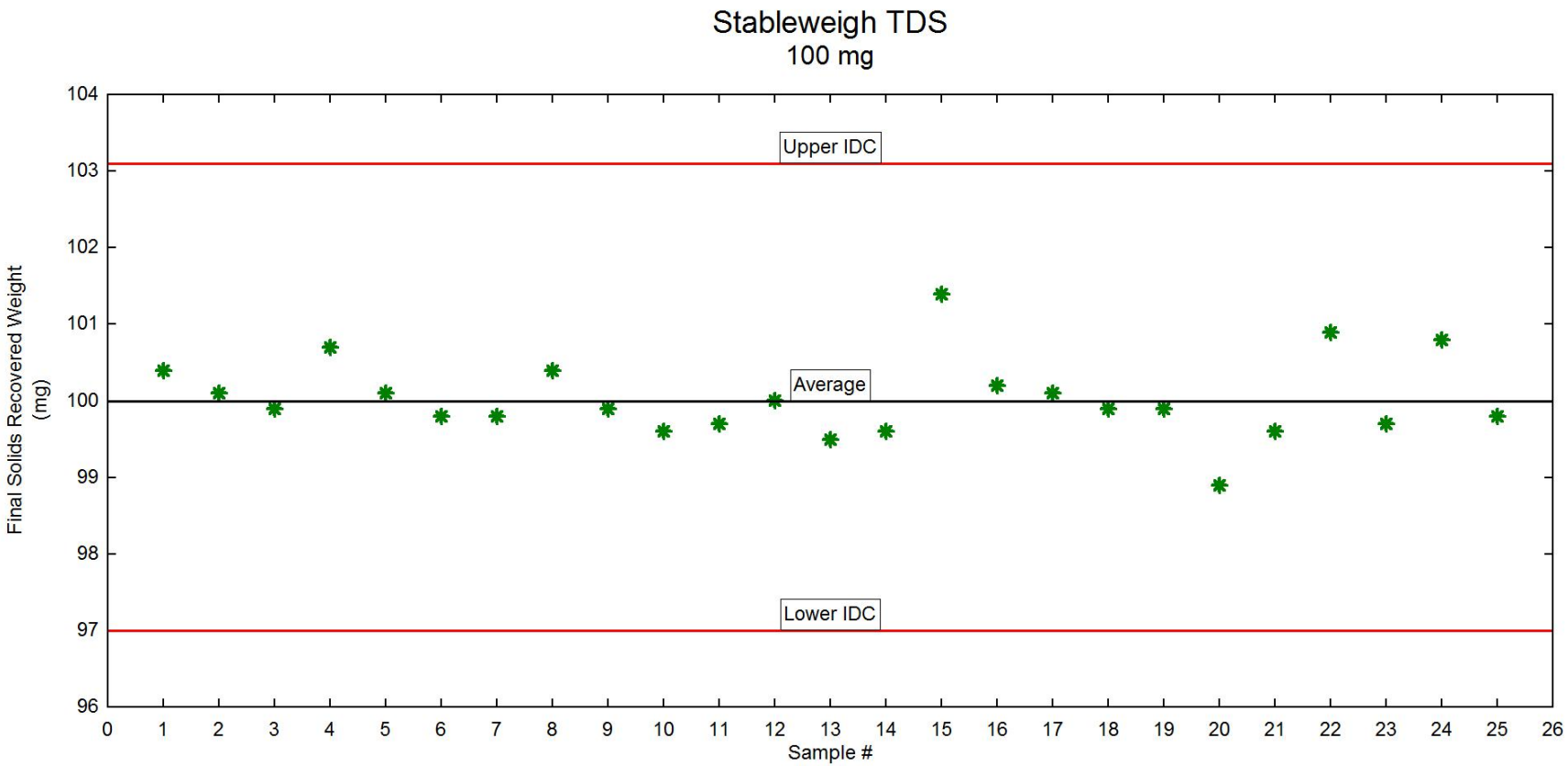


**Figure 7: StableWeigh 100 mg Initial Demonstration of Capability**

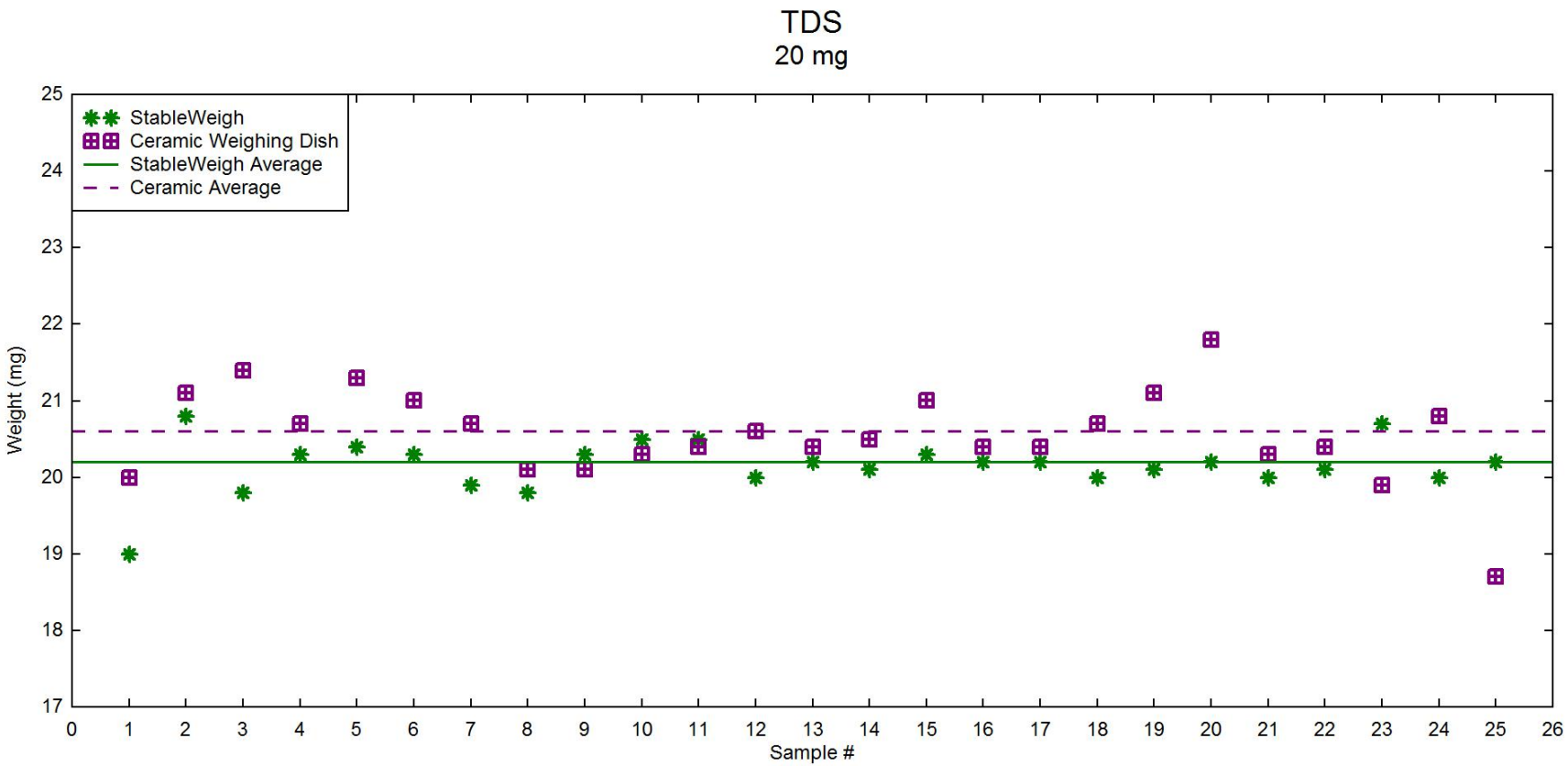


**Figure 8: StableWeigh vs. Porcelain Evaporation Dish Averages**