Designation: C1893 − 23

Standard Practice for Laboratory Performance Verification of Hydrodynamic Separators for the Treatment of Stormwater Runoff[1]

This standard is issued under the fixed designation C1893; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the criteria for the laboratory verification of Hydrodynamic Separators (HDS) as it relates to the removal of suspended solids in stormwater runoff.

1.2 HDS manufactured treatment devices are placed as offline or online treatment devices along storm drain pipe lines to remove suspended solids and associated pollutants from stormwater runoff. These devices may be used to target removal of other pollutants which are not covered in this standard. The criteria in this standard specifically relate to the removal of silica particles in controlled laboratory conditions, which is considered an appropriate surrogate for predicting the removal of stormwater solids from actual stormwater runoff.

1.3 This practice provides guidelines for independent regulatory entities, collectively referred to as Authority Having Jurisdictions (AHJs), to streamline data requirements for the certification of HDS devices within their jurisdiction. For any given AHJ, additional criteria may also apply.

1.4 *Units*—The values stated in inch-pound units are to be regarded as standard, except for methods to establish and report sediment concentration and particle size. It is convention to exclusively describe sediment concentration in mg/L and particle size in mm or µm, both of which are SI units. The SI units given in parentheses are mathematical conversions, which are provided for information purposes only and are not considered standard. Reporting of test results in units other than inch-pound units shall not be regarded as nonconformance with this test method.

1.5 Acceptance of test results attained according to this specification may be subject to specific requirements set by a Quality Assurance Project Plan (QAPP), a specific verification protocol, or AHJ. It is advised to review one or all of the above to ensure compliance.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—This practice is also intended to ensure that the data resulting from completion of testing in accordance with the ASTM test methods referenced herein can be utilized to satisfy the requirements of the New Jersey Department of Environmental Protection's manufactured treatment device (MTD) certification process.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1745/C1745M Test Method for Measurement of Hydraulic Characteristics of Hydrodynamic Stormwater Separators and Underground Settling Devices

C1746/C1746M Test Method for Measurement of Suspended Sediment Removal Efficiency of Hydrodynamic Stormwater Separators and Underground Settling Devices

D3977 Test Methods for Determining Sediment Concentration in Water Samples

D4959 Test Method for Determination of Water Content of Soil By Direct Heating

D6913/D6913M Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

D7928 Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

E3317 Specification for Silica-Based Sediments for the Evaluation of Stormwater Treatment Devices

E3318 Terminology for Standards Relating to Stormwater Control Measures

E3373 Test Method for Scour of Hydrodynamic Separators and Settling Devices

[1] This practice is under the jurisdiction of ASTM Committee E64 on Stormwater Control Measures and is the direct responsibility of Subcommittee E64.01 on Lab Evaluation.

Current edition approved April 15, 2023. Published May 2023. DOI: 10.1520/C1893-23.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 *Additional References:*

New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" January 1, 2021

NJDEP Laboratory Test Protocols and Verification Procedure: NJCAT Interpretations", NJDEP, August 4, 2021

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology E3318.

4. Significance and Use

4.1 This practice provides criteria for the verification of the silica sediment removal efficiency of hydrodynamic separators.

4.2 Verification can be used to support certification of the technology within different AHJs provided that:

4.2.1 HDS units are sized using the resulting performance data to treat the prescribed water quality flow rate or annual mass load requirement at the level of performance desired by the certifying entity.

4.2.2 Scaling of results to different MTD model sizes is in accordance with this standard.

4.2.3 The technology is designed consistently with the tested unit such that it operates within the specified limits determined by the verification as well as other restrictions placed by the certification entity.

5. Performance Evaluation Requirements

5.1 *Laboratory Qualifications*—The testing laboratory shall be capable of conducting all testing in strict accordance with the applicable laboratory test methods. Testing shall be conducted at either an independent test facility or at a manufacturer's laboratory under the direct supervision of a qualified third party observer. There shall be no conflict of interest between the independent test facility or third party observer and the manufacturer. A conflict of interest is defined as any person employed as a third party observer or at an independent test facility that is directly engaged in the testing or verification process with the potential to undermine the quality of results for the MTD due to personal, professional, or financial interest. Elements of the supervision shall be outlined in a test QAPP and approved by the verification entity prior to commencing with the verification testing.

5.2 *Third Party Observer Qualifications*—Unless otherwise specified by the applicable verification entity this section provides guidance on suggested qualifications and professional experience for those serving as a qualified third party observers.

5.2.1 *Minimum Educational Requirements*—B.E., B.S., or B.A. in an engineering-based or science-based curriculum.

5.2.2 *Essential Experience*—Experience with hydraulic testing, water quality monitoring, and analytical measurements. Demonstrated knowledge and practice of experimental design and setup, sampling methods, handling, sample security (that is, chain of custody), task documentation, and data management.

5.2.3 *Relevant Experiences*—Consulting or academic (reporting, general laboratory practices).

5.3 *Expectations for Third Party Observer*—The third party observer shall witness all active aspects of testing carried out at a manufacturers facility as described herein as well as any supplemental test runs, measurements, sampling and analysis:

5.3.1 Observe and document the preparation and collection of test sediment samples for PSD analysis, background suspended sediment concentration (SSC) samples, and effluent SSC scour test sediment samples.

5.3.2 Document test setup, including key dimensions, such as, pipe sizes including diameter, slopes, and condition, hopper location and height, false floor elevation, location of sediment injection point, and sediment scour preloading depth and time.

5.3.3 Observe/document influent sediment feed samples, initial and post run feed hopper sediment weights, and background sample collection and timing.

5.3.4 Record/verify times for sediment calibration samples, sediment feed start, feed stop and flow start/stop.

5.3.5 Observe and document the recovery and measurement of the mass of sediment captured in the sump and inlet pipe.

5.3.6 Document/observe hydraulic testing (flow path, water elevations, bypass, and head loss).

5.3.7 Check sample labeling, management, and security for transportation/shipping.

5.3.8 Ensure calibration of flow meters, scales, etc. per manufacturer's requirement.

5.3.9 Review and confirm calculations, and adherence to protocol as well as the QAPP.

5.3.10 Maintain logbook and documentation of notes, measurements, etc.

5.4 *Quality Assurance Project Plan*—Prior to testing the laboratory shall submit a QAPP for approval to the verification entity. The QAPP format will be designated by the verification entity. Recommended minimum content for QAPP inclusion:

5.4.1 Applicant information.

5.4.2 Test scope and objectives.

5.4.3 *Description of the technology including* purpose, operation, MTD name/model ID being tested, limitations, methods of bypassing flow, and a standard detail drawing.

5.4.4 *Description of test setup including* flow path explanation, sampling/measurement locations, schematic and photos, lab MTD unit to be tested, key dimensions disclosed, and equipment to be used.

5.4.5 *Description of testing procedure including* sample times/spacing, collection and handling procedures, analysis to be performed, and treatment of data (calculations, statistics, exclusions).

5.4.6 *Lab information including* in-house or independent test lab, third party observer qualifications and duties, and analytical laboratory qualifications.

5.5 *Laboratory Evaluation of Performance of Hydrodynamic Separators and Settling Devices:*

5.5.1 A comprehensive laboratory performance evaluation of hydrodynamic separators shall include assessments of system hydraulics, sediment removal efficiency, and susceptibility to scour, all over a range of flows as defined by the protocol.

5.5.2 Laboratory performance evaluations shall include at a minimum, testing at seven flow rates ranging from 10 % to 150 % of the claimed maximum treatment flow rate (MTFR) of the device being tested. Unless defined differently by a local jurisdiction, expected MTFR shall be estimated as the flow rate at which the device will achieve >50 % suspended solids removal using the five flow rates from 25 % to 125 % of MTFR and the weighting formula provided in Table X1.1 of Appendix X1. The manufacturer can choose to test at additional operating rates as desired and should use the resulting performance curve to determine the MTFR at which other rates of suspended sediment removal will be achieved.

NOTE 2—Regulatory agencies can select weighting factors appropriate for their specific local rainfall conditions and desired annualized removal efficiency. The removal efficiency curve can then be used with these weightings to determine an appropriate MTFR to meet local removal efficiency goals. Alternatively, regulatory agencies can select a specific loading rate from the removal efficiency curve that corresponds to a desired level of removal efficiency.

5.5.3 All testing shall be conducted on a fullscale, commercially available unit. Alternate housing materials such as aluminum, plastic, fiberglass, or wood may be used to ease the logistics of moving test units within the laboratory. Use of a scaled model of the HDS unit for laboratory testing is not permitted.

5.5.4 The test sediment shall be characterized in accordance with Specification E3317. The sediment particle size distributions for performance and scour testing shall be in accordance with Specification E3317, Table 1, Sediment A and Sediment C respectively.

5.5.5 All analytical methods used for TSS (measured as suspended sediment concentration, or SSC) samples collection and analyses required by the protocol (that is, Test Methods D4959, D3977, D6913/D6913M, D7928, and USGS I3765-85) must be conducted by a laboratory certified by a NELAP or ISO recognized accreditation body to conduct the specific test method. If a laboratory is not specifically certified for Test Methods D3977, they must demonstrate proficiency as described in 5.5.5.1. All analytical analysis must be performed by an independent accredited laboratory.

5.5.5.1 Prior to the start of testing, an analytical laboratory shall demonstrate proficiency in executing Test Methods D3977 as follows:

5.5.5.2 In order to ensure analytical laboratories, not certified for Test Methods D3977, are proficient in analyzing samples in accordance with Test Methods D3977, two spiked samples shall be prepared by the vendor and analyzed by the laboratory prior to the start of testing.

5.5.5.3 Spiked SSC samples shall be prepared using the same test sediment prepared for SSC testing. Spiked SSC samples shall be prepared at concentrations between 20 mg/L and 50 mg/L. These spiked samples should be separated by at least 15 mg/L in concentration.

5.5.5.4 SSC results for spiked samples shall be ±15 % of the known concentration to be in compliance.

5.5.6 *Alternate Unit Configurations*—At the discretion of the AHJ, documentation of equivalent performance to the tested unit configuration may be required for alternate unit configurations. To allow for a system configuration that differs from the tested inlet/outlet piping configuration, a manufacturer may wish to test different inlet/outlet angles to allow for greater flexibility during design and installation. In such instances, at least one alternate inlet/outlet pipe angle must be tested at 25 % and 75 % of the manufacturer's target MTFR, and the results must be within ±5 % of the original configuration test results. For example, in the original testing configuration the inlet/outlet pipes were set opposite of each other offset at 180 degrees. In an alternative test, with the inlet pipe and outlet pipe offset by 90 degrees, two data points are tested at 25 % and 75 % of the manufacturer's target MTFR. If the initial testing found 62 % and 56 % removal efficiency at 25 % and 75 % of the target MTFR, the alternate testing must be within + or –5 % of those numbers (that is, 57-67 % and 51-61 % respectfully). If those targets are met, the piping configuration for the NJCAT verification and NJDEP certification for the MTD would be extended to include installations with inlet/outlet pipes offset by up to 90 degrees. Any alternate configuration testing must follow the protocol requirements. Additionally, the use of multiple inlets or grate inlets would also require separate testing in accordance with this provision to demonstrate equivalence with the tested configuration.

6. Testing Requirements

6.1 An independent third party shall observe and verify all laboratory measurements. This requirement is satisfied if the testing is done by an independent third party laboratory.

6.2 The laboratory layout and test set up, which includes the test loop dimensions and configuration as well as applicable equipment shall be in full accordance with the referenced standards.

6.3 Hydraulic characterization of the HDS unit shall be in accordance with Test Method C1745/C1745M.

6.4 Suspended sediment removal characterization shall be done in accordance with Test Method C1746/C1746M.

6.4.1 The mass recovery (modified mass balance) test method will be the basis for determining suspended sediment removal performance. At a minimum, suspended sediment removal efficiency testing will be performed at constant flow at rates of 10 %, 25 %, 50 %, 75 %, 100 %, 125 % and 150 % of the expected MTFR for the device.

6.5 Scour testing shall be done in accordance with Test Method E3373.

NOTE 3—Details on sampling, mass recovery, effluent testing, and removal efficiency calculations are included in Test Methods C1746/C1746M and E3373.

7. Scaling

7.1 The suspended sediment removal rate determined for the tested full scale, commercially available MTD may be applied to similar MTDs with different maximum treatment flow rates (MTFR) when proper scaling is applied. Scaling the tested MTD to determine other model sizes and performance without completing additional testing is acceptable provided that:

7.1.1 The ratio of the MTFR to the Effective Sedimentation Treatment Area for the similar MTD is the same or less than the tested MTD.

7.1.2 MTDs must be scaled geometrically proportional to the tested unit. A MTD is considered geometrically proportional to a reference MTD when the ratios of the inside dimensions of length, width and depth is the same as the ratios of the inside dimensions of length, width and depth of the reference MTD. A deviation of 15 % is allowable in the depth of the unit below the inlet pipe invert to the false floor to allow for the practicality of nominal dimensions of available construction components. If the criteria in 7.1 are met, the suspended sediment removal efficiencies of the similar MTD will be equal to the tested MTD's removal efficiency determined in accordance with Section 5.

7.1.3 If requirements in 7.1 are not met because the MTD provider wishes to demonstrate an alternate scaling methodology is appropriate for their technology, then a second full scale, commercially available MTD with an MTFR difference of more than 250 % is required to be tested to validate the alternative scaling methodology. Testing of the similar model shall follow all applicable test methods. Testing must be executed at the same facility and on the same test loop without changes to any components or dimensions. The only allowable exceptions are changes to the pipe diameter and MTD model size. The alternate scaling methodology shall be deemed valid if the weighted sediment removal efficiency of the similar MTD is within five percentage points of the weighted sediment removal efficiency of the first tested MTD.

8. Reporting

8.1 A qualified independent third party that has been vetted and approved by the verification entity based on the minimum qualification documented in 5.2 shall verify the accuracy of all laboratory reporting. This requirement is satisfied if the reporting is done by the independent laboratory tasked with performing the testing.

8.2 Unfounded marketing statements are not allowed in final verification reports. Unfounded marketing statements are claims made regarding performance characteristic of the tested unit that cannot be verified using the reported results.

8.3 The following information shall be provided in reports. Omission of any pertinent information shall include justification for its exclusion.

8.3.1 Overview of the manufacturer including responsible parties and contact information.

8.3.2 A signed letter from the independent laboratory and/or independent observer to attest to the validity of the testing and resulting data.

8.3.3 A description of the technology and its functionality with unit process diagrams, including any pretreatment requirements.

8.3.4 A description of the laboratory test setup including all relevant equipment, drawings, and photographs of the test apparatus and unit tested.

8.3.5 A detailed description of the sampling and analytical methods used in conformance with applicable standards.

8.3.6 *Presentation of Data:*

8.3.6.1 Tabular summary of flow, water surface, and water quality data with removal calculation.

8.3.6.2 Plot headloss versus downstream velocity head.

8.3.6.3 Plot removal efficiency versus flow rate (hydraulic loading rate).

8.3.6.4 Statistical analysis and calculations as defined in the applicable standards.

8.3.6.5 Sediment removal efficiencies are to be plotted versus flowrate to generate a removal efficiency curve from which an annual weighted removal efficiency can be calculated. Removal efficiency can be interpolated from the resulting curve but results shall not be extrapolated beyond the minimum and maximum tested flow rates on the curve.

8.3.6.6 The curve fitting approach shall result in a minimum R^2 of 0.95. The curve fitting approach selected should yield the highest possible R^2. The maximum polynomial fit is third order. Curve fit should be monotonically decreasing and curves cannot be used to extrapolate performance outside of the range of tested loading rates.

8.3.6.7 If the data does not meet the R^2 requirements, additional test runs can be completed and added to the existing dataset to achieve compliance.

8.3.7 A performance claim statement for final verification.

8.3.8 A detailed description of the sizing methodology and a table of different commercially available units available with corresponding HLRs.

8.3.9 A detailed description of the Operation and Maintenance requirements including maintenance sediment storage depth and volume and an active link to the maintenance guidelines online.

8.3.10 A description of the unit's hydraulics, headloss, and internal bypassing capacity.

8.3.11 The verification entity may add additional reporting requirements.

9. Units of Measure

9.1 All dimensions shall be reported in the following Units:

9.1.1 *Area*—square feet (sf);

9.1.2 *Concentration*—milligrams/liter (mg/L);

9.1.3 *Flow Rate*—cubic feet per second (cfs) and gallons per minute (gpm);

9.1.4 *Hydraulic Loading Rate (HLR)*—gallons per minute per square foot (gpm/sf);

9.1.5 *Length/Distance*—inches (in.), feet (ft);

9.1.6 *Velocity*—feet per second (ft/s); and

9.1.7 *Volume*—cubic feet (ft^3), milliliters (mL), liters (L), gallons (gal).

10. Keywords

10.1 stormwater control measures; manufactured treatment devices