Physical Model Testing of Hydrodynamic Vortex Separator (HDVS) for Controlling Total Suspended Solids in Stormwater

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Introduction

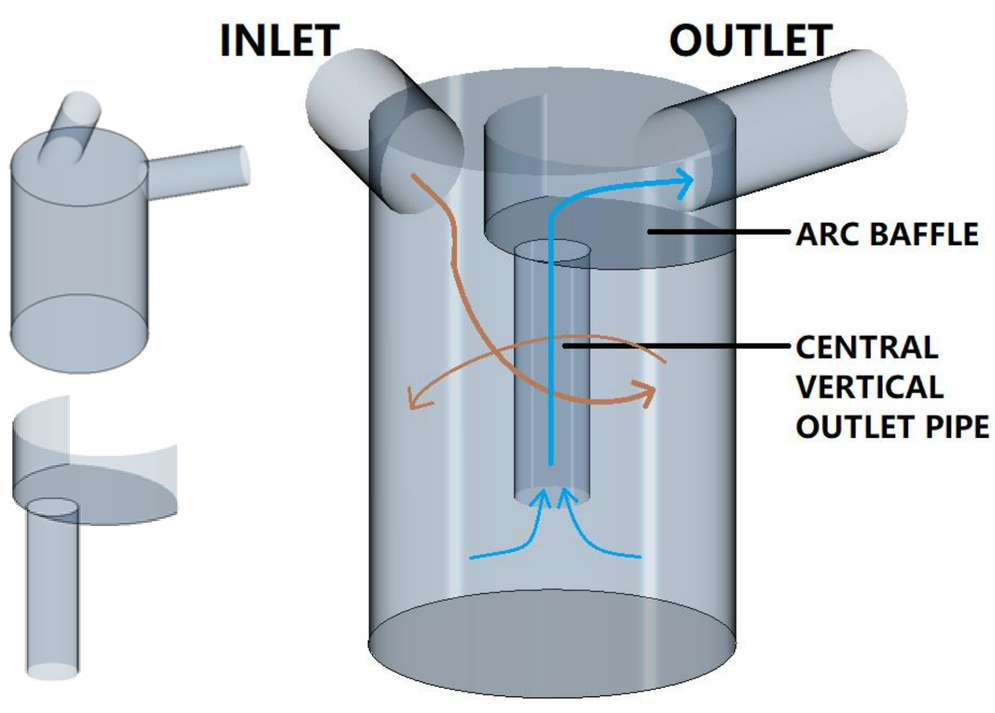
Removal or reduction of Total Suspended Solids (TSS) in stormwater is important in order to protect receiving water from sedimentation and reduce the water quality impacts of the associated pollutants. In highly urbanized area, the space is usually limited to apply most of water quality treatment technologies. Oil/Grit Separator (OGS) is preferred in these cases due to its compact size as well as the reasonable solids removal efficiency with a typical range of 40% to 60%, while some can be higher.

In the year of 2013, a regulatory guideline titled the "***Procedure for Laboratory Testing of Oil/ Grit Separators***" was developed by the Toronto and Regions Conservation Authority (TRCA) for the Canadian Environmental Technology Verification Program. ***Procedure*** (TRCA, 2014) specified the testing standards of the sediments and oil removal of manufactured treatment devices (MTDs) in Canada. The physical experiments of this research study, which focused on the TSS removal performance of a typical hydrodynamic vortex separator (HDVS), was proceed aligning with TRCA's ***Procedure*** (2014).

Key Requirements in the Procedure

Table 1. Requirements vs. Reality

No.	Key Requirements	Adopted Scheme
1	**Scale:** 1:1.	Real-size physical model (D: 1.2m; H: 1.8m).
2	**Flow Rates:** from 5 to 48 L/s (±10%; COV < 0.04).	Two flow rates (5 and 10 L/s) were tested, both satisfied the ±10% threshold with an average COV of 0.02.
3	**Constant Concentration:** 200 mg/L (±25 mg/L).	As required.
4	**Test Duration:** "Either 25 minutes or the time required for eight complete volume exchanges during primary sedimentation, whichever is larger." (TRCA, 2014)	25 minutes.
5	**PSD:** "The test sediment used for sediment removal tese shall be comprised of inorganic ground silica with a specific gravity of 2.65, uniformly mixed to meet the required PSD (Table 2), which stands for a broad range of particles from clay to coarse sand." (TRCA, 2014)	Six sizes were chosen (75 µm, 100 µm, 150 µm, 250 µm, 500µm, and 1000 µm), as shown in Table 3.



Sketches of the Component Parts of MTD (left) and the Simplified Process of the Solids Treatment (right)

Required & Adopted Particle Size Distribution

Table 2. Required PSD (TRCA, 2014)

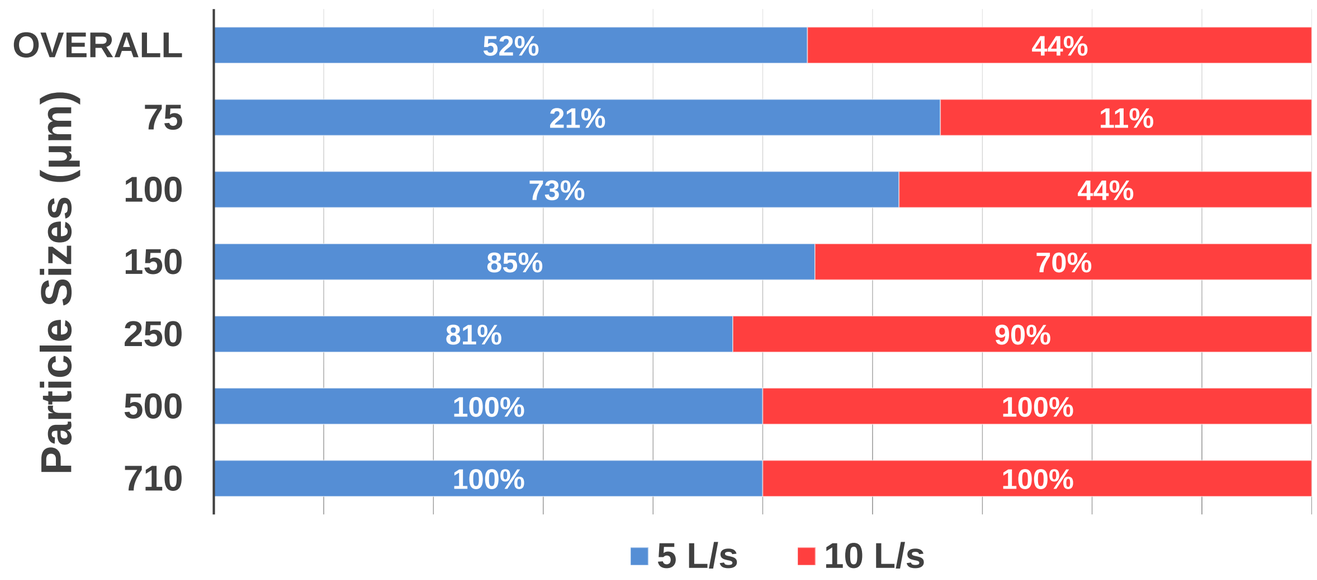
Paricle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Table 3. Adopted PSD

Paricle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	<75	50

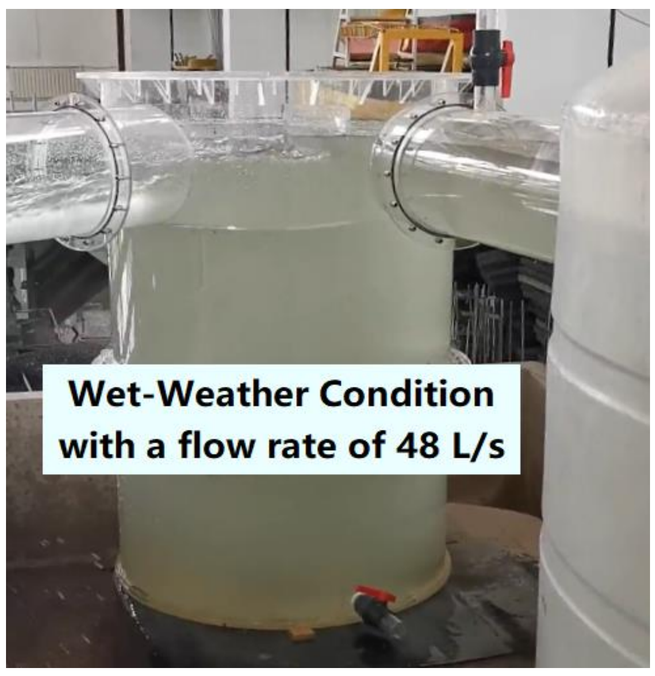
Before running the tests, the sediments must be uniformly mixed. 3 samples shall be taken and the average of which can vary from the 'Percent Less Than' value by 6% (e.g., for 100-micron particles' sample, the 'Percent Less Than' value should be 60% ± 6%). If the specified value exceed this allowance threshold, a report must be accomplished (TRCA, 2014).

Solids Treatment Efficiency Result Presenting



Photographs of Experiments On-Going

Flow patterns, scour and disturbance, as well as the local head loss can be visualized through the transparent plexiglass.



Conclusion

- ✓ An elaborated plan of the input mechanism of sediments/oil and the sampling of influent concentration should be adopted;
- ✓ Collecting removed (trapped) particles at the bottom of MTD by installing a sloping base with the 'sludge outlet pipe' located at the middle is more practical than collecting at the outlet;
- ✓ If flow-recirculation system is preferred, filter with a mesh size as fine as the minimum particle size shall be installed before the inlet of recirculation pump to avoid accumulative impact from the background sediments/oil concentration;
- ✓ As far as the performance of MTD, the treatment efficiency was observed to declined with the particle size; and as the flow rate doubled to 10 L/s, the overall performance was decreased to 44% from 52%; in the mean time, the removal efficiency of 100-µm particles dropped significantly (approximately 30%) while that of 250-µm particles increased slightly.

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