Statement of Verification

EU Environmental Technology
Verification pilot programme

ETA DANMARK

DANETV

Technology:	Mosbaek CEV flow regulator
Registration number:	VN20150002
Date of issue:	7. May 2015

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This EU-ETV verification statement summarizes the results from verification of the Vertical centrifugal flow regulator, CEV (CEntrifugal Vertical), produced by Mosbaek A/S in Køge, Denmark.

The EU Environmental Technology Verification (ETV) pilot programme is a voluntary programme. It aims to establish a framework for independent, qualified, third-party assessment of the performance of eco-innovative technologies to facilitate their entry into the market. The programme has been active since 2011.

A Danish ETV programme was established in 2008 as a partnership between five Danish technological service centres, providing experts and test facilities for the verification procedure. The partners are DHI, Danish Technological Institute, FORCE Technology, AgroTech and DELTA.

ETA-Danmark A/S is a subsidiary of Danish Standard and is the Danish verification body for Environmental Technology Verification. ETA-Danmark is accredited by the Danish Accreditation body, DANAK, according to EN 17020 for carrying out environmental technology verifications. The verifications are carried out in cooperation with the DANETV partners.

The statement of verification is available on the ETV Registry at the following webpage http://iet.jrc.ec.europa.eu/etv/verified-technologies

1. Technology description

The technology verified is the vertical centrifugal flow regulator, CEV (CEntrifugal Vertical) from Mosbaek. The flow regulator technology for extreme rainfall events is based on a quick rise to the maximum discharge flow, where it creates a vortex making it stay at or below this discharge flow while the remaining water is stored in the well.

Mosbaek has selected four models to represent their CEV-series;

- CEV 1.4l/s @ 1.00m – 100%
- CEV 4.9l/s @ 1.50 m – 100%
- CEV 10.5l/s @ 2.00m – 78%
- CEV 10.5l/s @ 2.00m – 100%

The name of the models indicates the designed maximum flow (for example 1.4 l/s) and the correlating maximum pressure height (for example 1.00 m). The percentage indicates the percentage of the design flow at the point/bump where the vortex is formed.

A schematic view of the CEV with inflow in the bottom is shown in Figure 1A .

Figure 1B shows the flow through a CEV. With a 100% model, the maximum outlet (Q_{design}) is met twice; first where the vortex is formed (the bump on the graph) and then at the specified H_{design}, where H_{design} is calculated from the invert of the discharge pipe to the maximum water level in the well. A 78% model is also shown; here the bump occurs at a flow of 78% of Q_{design}.

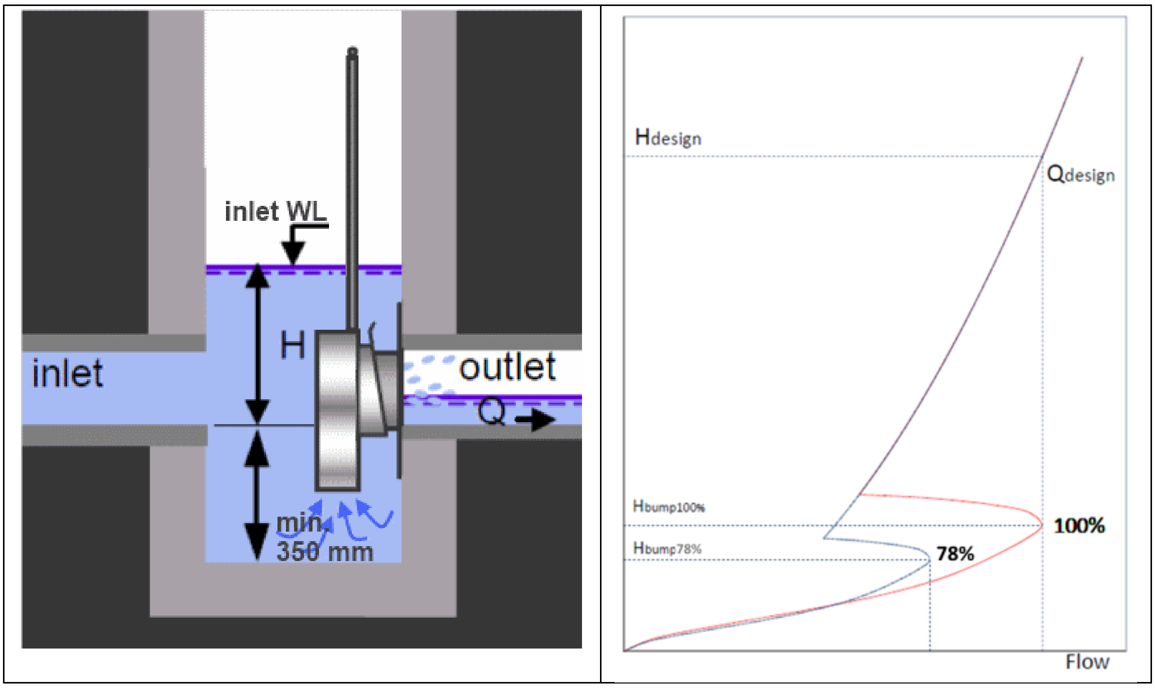

Figure 1 A) Sketch of CEV flow regulator installed in a well.
B) Graphic showing the general vortex brake effect on water outflow, with CEVs operating at 78% and 100% efficiency and water inflow to the well larger than outflow through CEV (well is filling up). Both figures were provided by Mosbaek.

2. Application

2.1. Matrix

The CEV is installed before the combined sewer system for storm water and wastewater and is restricting storm water inflow to the combined system. The verification covers only storm water.

2.2. Purpose

The purpose of a flow regulator is to protect the low-lying parts of a sewerage system (downstream) against overloading and flooding. One of the specific features of the flow regulator is that it allows liquid to pass further down in the sewerage system at a predetermined maximum amount per time unit, regardless of the variation in feed flow and water level immediately before the regulator. Flow regulators can be applied inline in combined systems or before wells and basins, depending on the piping network, in order to restrict the amount of storm water before it enters the system

2.3. Conditions of operation and use

Regular maintenance of the CEV is required. A visual inspection must be made and objects that may create blockages must be removed. This is quite simple as the system contains no moving parts.

2.4. Verification parameters definition summary

Two types of parameters have been verified:

1. Outflow (l/s) at H_{bump} and H_{design}
2. Flow reduction at H_{design}

3. Test and analysis design

The test was designed for this verification.

3.1. Existing and new data

No existing data have been included.

3.2. Laboratory or field conditions

The test was performed at a test set-up at Mosbaek's premises in Køge, Denmark, see Figure 2.

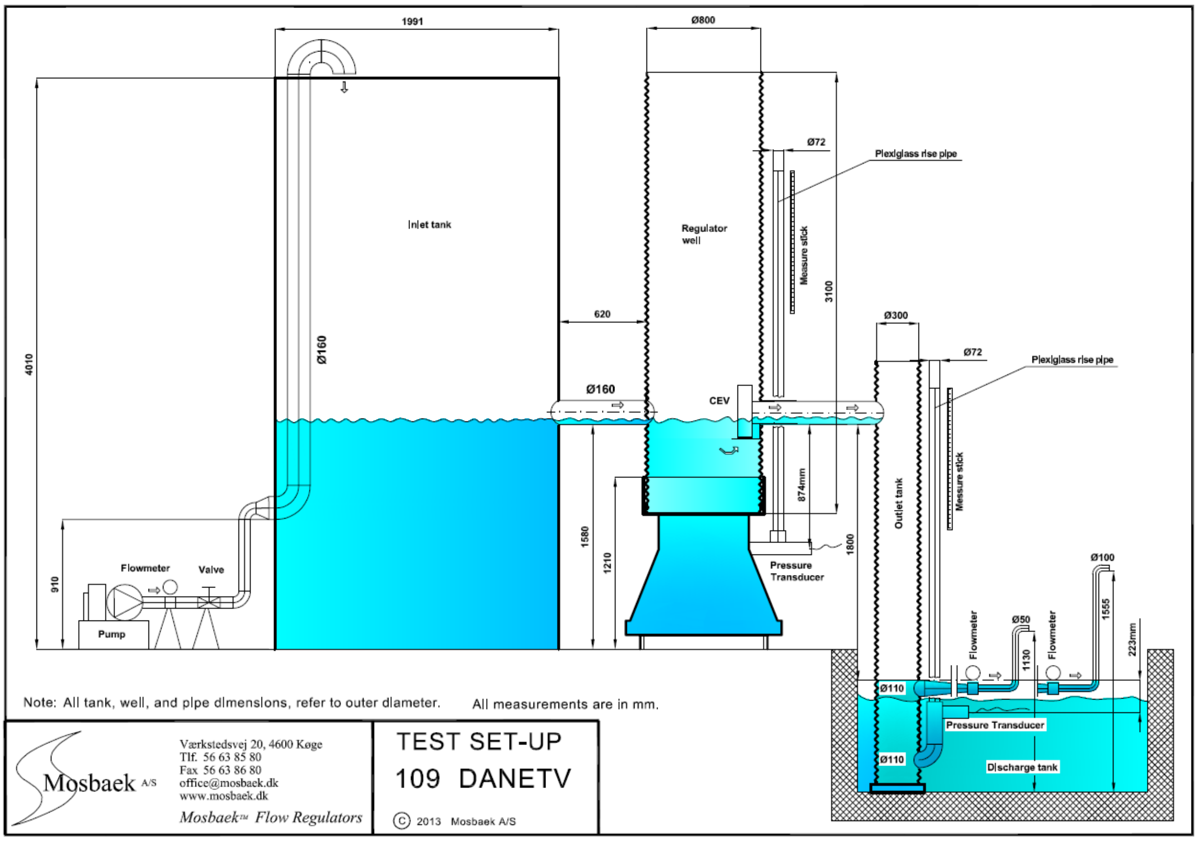

Figure 2 Sketch of test set-up.

The set-up consists of a well (regulator well) placed on a base; the CEV regulator is mounted in this well. Through a pipe, the regulator well is in direct connection with a large diameter tank (inlet tank) positioned just opposite the CEV outlet. The water levels in the regulator well and the inlet tank are identical. This set-up is established in order to secure that the increase of the water level in the regulator well can be controlled and limited still with a reasonably high flow rate to the well. The outlet connection goes through the CEV in the regulator well to the outlet tank. A pressure transducer is mounted in the base of the regulator well. A plexiglas riser is mounted on the base in order to follow the water level in the well during testing.

The flow to the inlet tank is fed at the top of the tank through a pipe placed internally in the tank by means of a pump, which is pumping water from a feeding tank. The flow from the feeding tank to the inlet tank is measured by means of the flowmeter. The water level in the feeding tank is kept constant by pumping water from a central reservoir into the feeding tank, where an overflow weir ensures that the water level in this tank is kept almost constant. In this way, it is possible to keep an almost constant pressure head at the pump and thus an almost constant flow.

From the regulator well, the water flows through the CEV to the outlet tank. The outlet tank is equipped with a pressure transducer, monitoring the water level in this tank. The outlet flow from the outlet tank is measured by a flowmeter.

3.3. Matrix compositions

The water used for the test came from an outdoor reservoir and had storm water characteristics.

3.4. Test and analysis parameters

The following test runs were performed. The table below shows the inflow conditions for the tests performed.

Table 1 Inflow conditions for the tests performed

CEV model	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 4	Inflow 4
	l/s	l/s	l/s	l/s	l/s	l/s
CEV 1.4l/s @ 1.00m – 100%	1.79	3.12	4.80	6.31	6.18	6.25
CEV 4.9l/s @ 1.50 m – 100%	5.89	6.52	8.20	9.99		
CEV 10.5l/s @ 2.00m – 78%	8.60	9.77	11.40	12.97		
CEV 10.5l/s @ 2.00m – 100%	11.32	12.07	13.75	15.24		
Orifice	13.72					

Tests of the performance at H_{bump} and H_{design} are marked in orange. The tests were carried out to determine the variation in H_{bump} and H_{design} for different inflow conditions. Test of the flow reduction at H_{design} was done by comparing the results from the hatched test runs.

The repetition tests of CEV 1.4l/s @ 1.00m – 100% (blue marking) were done to see if there was more than 10 % variation. The Specific Verification Protocol states that if the variation between runs with the same flow is larger than 10%, repetition tests should be performed with all CEVs. The tests showed that there was a very small variation with a relative standard deviation of about 1%; therefore the repetition tests were not done for the other CEVs.

3.5. Tests and analysis methods summary

The inflow and outflow from the CEV were measured by the use of flowmeters and pressure transducers. A detailed description is found in the test plan.

3.6. Parameters measured

- Inflow (l/s)
- Water level/pressure in the regulator well (mH_2O/Pa)
- Water level/pressure in the outlet tank (mH_2O/Pa)
- Outlet from the outlet tank (l/s), with and without the CEV for the 1.4 l/s model.

Inflow into the CEV is calculated by using the following equation:

$$Q_{outflow} = Q_{overflow} + \frac{\Delta Hout \times Aout \times 1000}{\Delta t}$$

$Q_{outflow}$: Flow out of CEV (l/s)
$Q_{overflow}$: Overflow from the outlet tank (l/s)
A_{out}: Surface area in the outlet tank+riser (m^2)
H_{out} : Pressure head in the outlet tank (mH_2O)
Δt: Time for changing H_{out} with ΔH_{out} (s)

4. Verification results

4.1. Performance parameters

The results of the verification with regards to flow at H_{bump} (Q_{bump}) and H_{design} (Q_{design}) are listed in the table below. Based on the results from a test with 1.4l/s@1.00m - 100 % and a corresponding orifice, it can be stated that Mosbaek CEVs are verified to reduce the flow by a factor of 4.45 at Q_{design}.

Table 2 Verified performance on Q_{bump} and on Q_{design}.

CEV model	Q_{bump}		Q_{design}	
	Mean^{+} and range (l/s)	Deviation from model charac-teristics (%)	Mean and range (l/s)	Deviation from model characteris-tics (%)
CEV 1.4l/s @ 1.00m – 100%	1.34 (1.22* – 1.45)	-4.3 (-13* – 3.6)	1.43 (1.42 – 1.45)	2.1 (1.4 – 3.6)
CEV 4.9l/s @ 1.50m – 100%	4.74 (4.50 – 5.04)	-3.3 (-8.2 – 2.9)	4.78 (4.76 – 4.80)	-2.4 (-2.9 – (-2.0))
CEV 10.5l/s @ 2.00m – 78%	8.17 (7.57 – 8.74)	-0.2 (-7.6 – 6.7)	10.11 (10.09 – 10.12)$^{\#}$	-3.7 (-3.9 – (-3.6))
CEV 10.5l/s @ 2.00m – 100%	10.18 (9.75 – 10.67)	-3.0 (-7.1 – 1.6)	10.56 (10.55 – 10.56)	0.6 (0.5 – 0.6)
Orifice	N/A	N/A	6.36	N/A

$^{+}$) Be aware that the results of Q_{bump} are uniquely influenced by Q_{inflow} *) For this flow, the water level rise was only 0.19 mm/s, while the operational requirement was >0.5 mm/s; this explains the deviation from the expected result. $^{\#}$) Based on two tests only.

4.2. Operational parameters

No additional operational parameters than the performance parameters were measured.

4.3 Environmental parameters

No additional environmental parameters than the performance parameters were measured.

4.4. Additional parameters

The user manual and other descriptions were considered complete.

Application of the CEV does not give rise to any special risk or contact to hazardous substances. However, installation in the well is subject to safety risk as all operations in wells, and standard safety precautions therefore have to be taken accordingly.

The CEVs are produced of stainless steel. Today 80% of the stainless steel on the marked is recycled. It is imported from Europe and certain places in Asia. The tested CEVs contain 6-25 kg stainless steel, and 4.1 kWh/kg steel is used in the production. The CEVs are reusable or 100% recyclable. They have an expected lifetime of 50 years.

5. Additional information

The CEV is designed to be effective within a flow range until a certain amount of water is stored in the connected well or basin. This means that if a storm water event exceeds the design criteria, the well or basin where the CEV is located will float over. This situation is not included in the verification.

The CEV is designed with the largest possible opening at the given hydraulic situation. The CEV is most often installed as a detachable unit and if required, obstacles can be removed in this way. At locations with many obstacles in the water, the CEV can be equipped with a grid. All tests are carried out with water without obstacles.

Industrial wastewater and backwater (backwards flow through the CEV) are not included, nor are rapid changes in head and flow. Such changes may occur in special situations (e.g. if pumps are started or stopped).

Characteristics obtained from the experiments are only 100 % valid for applications which have full geometric similarity with the set up defined in Figure 1. For applications with geometries that differ from this figure, the actual characteristic can deviate from the characteristic found from this verification experiment.

6. Quality assurance and deviations

A leakage test and a review of calibration certificates for pressure transducers and flowmeters were performed prior to testing. In addition, calibration tests of pressure transducers were performed on the inlet as well as the outlet side. During testing, internal and external test system audits were performed by DHI and ETA Danmark. Both companies have the relevant accreditations for this..