HEAD AND DISCHARGE RELATIONSHIPS FOR THE POLYLOK PL-122 EFFLUENT FILTER AND CARTRIDGE IN SINGLE, DOUBLE, AND TRIPLE FILTER CONFIGURATIONS

Completion Report Prepared for

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by

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TABLE OF CONTENTS

OBJECTIVE

The objective of this work was to define relationships between head (height of water above the outlet invert of a simulated septic tank) and discharge through the PolyLok PL-122 Effluent Filter and Cartridge in the single, double, and triple filter cartridge configurations.

PROCEDURE

Three filter configurations were pre-assembled and delivered for testing. The single filter assembly consists a body, filter element, and buoyant sphere. The body has a rounded square cross section and measures approximately 22.5 inches in length by 4.25 inches to a side. Flow enters the frame enroute to the filter element via four rectangular slots situated near the bottom of the body measuring approximately 2.6 by 3.8 inches, with one slot to a side. A buoyant sphere, measuring approximately 4.5 inches in diameter, is present inside the bottom portion of the body and functions to prevent entry of water inside the filter body in the absence of the filter element (removal of the element will cause the sphere to move upward under force of buoyancy and seal the body). The filter element is approximately 19.5 inches in length (not counting the handle) with an irregular cross section. The filter element is inside the body during operation and can be inserted/removed from the top of the body. The filter element has slots measuring approximately $1/16^{th}$ inch in width. Manufacturer's information states that the element contains over 122 lineal feet of filtration slot in the element.

A knock-out panel (approximately 4.7 by 2.8 inches) is located approximately 1.25 inches beneath the top of the body on the rear side of the body (opposite the discharge side). This panel can be removed and another filter assembly attached to achieve a multiple filter configuration.

The general procedure used to test the filter configurations was to attach each filter configuration to the outlet of a simulated septic tank, introduce a range of measured clean water flows to the tank, and measure the corresponding heads of water relative to the outlet invert. This process was repeated for the septic outlet alone (no filter attached) to assess the flow resistance effects of the filter configurations relative to the presence of no filter. Non-linear regression analysis was applied to the results to derive equations that can readily be used to estimate flow rate corresponding to any head within the range of measurements used in this test. The results provide sets of curves and equations that can be used for each filter configuration to define relationships between head and discharge.

The simulated septic tank consisted of a wooden container measuring 3 ft wide (perpendicular to flow direction), 6 ft long and 5.5 ft tall. Water entered the simulated septic tank through a 4-inch PVC sanitary tee. The outlet was a 4-inch female slip fitting (i.e., sized to accept 4-inch inside diameter PVC). The inlet and outlet inverts were located approximately 4.5 ft above the floor of the tank. The interior of the tank was painted with white latex paint and treated with caulk to prevent leakage. The tank had a manometer, constructed of ½-inch inside diameter rubber tubing, installed to measure head. Head was defined as the height of water relative to the outlet invert and measured to the nearest 0.05 inch. Flow into the simulated tank was generated from a Zoeller 137 series effluent pump operated with constant reservoir head.

Each filter was tested by first attaching the filter, from the inside of the simulated septic tank, to the outlet. Since the filter uses a female slip connection, a short (6-inch) length of 4-inch PVC was used to join the filter to the septic tank outlet. All joints were sealed using silicon. Clean (no solids) water was then introduced into the tank through the inlet. The pump back pressure was adjusted using a gate valve to approximately achieve the desired flow rates. Actual

flow rates were measured by capturing the outflow from the septic tank outlet in a 5-gallon container, measuring the elapsed time with a stop watch ($1/100^{th}$ second precision), and measuring the weight of water captured in the container ($1/10^{th}$ lb precision). The weight of water was then converted to volume and divided by the time required to collect the sample. Corresponding values of head were read from the manometer described earlier. Each combination of flow/head measurements was replicated three times to ensure repeatability.

Flow rates were varied from 0 to approximately 20,000 gallons/day. The upper limit of investigated flows is considerably in excess of the rates capacities of the filter configurations (800, 1600 and 2400 gallons/day for the single, double and triple configurations, respectively) to ensure that performance during "surge" conditions would be accurately assessed.

RESULTS AND DISCUSSION

Head-discharge measurements for the single, double, and triple PL-122 effluent filter cartridges as well as for the outlet itself (no filter attached) are given below in Table 1.

Table 1. Average* Measured Head vs. Discharge Relationships

Filter Configuration							
Single PL-122		Double PL-122		Triple PL-122		Tank Outlet Only	
Head (in)	Discharge (gal/day)	Head (in)	Discharge (gal/day)	Head (in)	Discharge (gal/day)	Head (in)	Discharge (gal/day)
0.00	0	0.00	0	0.00	0	0.00	0
0.85	2,264	0.95	6,074	0.87	5,402	0.84	5,842
1.30	10,448	1.32	10,665	1.32	11,154	1.16	10,908
1.75	19,119	1.85	21,284	1.77	20,269	1.58	20,320

* Each reported value is the average of three measurements.

The relationships shown in Table 1 are also given in Figures 1-4 for discharge units in gallons/minute and Figures 5-8 for discharge units in gallons/day. Each single data point shown in the figures is the mean of three observations. The solid lines are the curves obtained from fitting the data to an equation of the form

$$Q = a H^{b} \qquad (1)$$

The values of the coefficients a and b were determined using the regression function included in the SigmaPlot 4.0 plotting software package and are reported in the figure legends. As can be inferred from the figures, Equation (1) did a very good job of describing the observed data. In each case, the coefficient of determination (the proportion of variance in the data that is explained by the regression equation) is equal to 0.999. The equations reported in Figures 1-8 can be used to directly estimate the discharge corresponding to a given head condition. For example, if one desires to estimate the discharge (in gallons/minute) from a single PL-122 for a head of 0.8 inches, one can calculate it from the equation given in Figure 1 as $Q = (4.60)(0.8)^{1.87} = 3$ gallons/minute. Similarly, one can estimate discharge (gallons/day) at 1.3 inches head for the triple PL-122 as $(6710)(1.3)^{1.93} = 11{,}100$ gallons/day.

Three observations regarding the figures are apparent. The first is that, each of the filter configurations investigated is capable of transmitting flows that are considerably in excess of rated capacity at relatively modest heads. For example, measured flow at a head of 1.75 inches for the single PL-122 was slightly greater than 19,000 gallons/day, which is more than 20 times the rated capacity of 800 gallons/day. In the absence of obstruction, then, each of the filter combinations has a significant excess of clean water flow transmission capability.

The second observation regarding the figures is that there are no significant differences in flow transmission capability among the single, double and triple filter configurations, an

observation that can be confirmed by noting the similarities in the regression relationships in the figure legends. For this reason, all the data are combined into a single figure, given as Figures 9 (discharge in gallons/minute) and 10 (discharge in gallons/day). As shown in these figures, the linking of up to two additional filters to a single PL-122 has no significant effect on flow transmission over the range of flows investigated. All the data can thus be described conveniently and accurately using a single curve, given in the figure legends as $Q = 4.56\ H^{1.92}$ (Q in gallons/minute) or $Q = 6566\ H^{1.92}$ (Q in gallons/day).

The final observation is that for heads of approximately 0.85" and less, none of the filter configurations offers any significant resistance to flow. This is apparent in Figures 11 (discharge in gallons/minute) and 12 (discharge in gallons/day), where the data and regression curves for the filters and for the tank outlet alone are statistically indistinguishable for heads of 0.85 inches and less. At heads of greater than 0.85", differences in discharge between the filters and the tank outlet alone become increasingly pronounced.

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine head vs. discharge relationships for the PolyLok PL-122 filter in the single, double and triple filter configurations. The findings of the study can be summarized as follows:

1. Clear water flow rates at heads of approximately 1.8 inches are significantly in excess of rated capacity, amounting to roughly 25, 13 and 8 times the rated capacities of the PL-122 in the single, double and triple configurations, respectively.
2. There are no significant differences in clean water discharge-head relationships among the three filter configurations investigated for the range of flow rates used in

the study. In other words, for heads of up to approximately 1.8 inches, the clean water hydraulic characteristics of the PL-122 in the single configuration are equivalent to those for the PL-122 in the triple configuration. Thus, a single curve and equation can be used to characterize performance of all three filter configurations.

3. The presence of the filters; whether in single, double or triple configuration; has no significant effect on clean water discharge from the tank for heads of up to approximately 0.85 inches.

In view of the relationships between rated filter capacities and the measured head-discharge relationships, it is reasonable to revisit the issue of how the rated capacities were developed in the first place and to consider revising them, if appropriate. If this desirable, then the obvious question would involve the basis for adjusting rated capacities. While the investigator has no direct, personal experience in this issue, his assessment is that the approach might best be based on the desired filter servicing interval and a data set that relates rate of obstruction (or maturity) to the filter application (e.g., effluent source and loading rate).

As an example, the manufacturer might judge (on the basis of head vs. discharge relationships for varying degrees of maturity) that the filter(s) should be serviced upon reaching 80% maturity (i.e., 80% of the total filtration area obstructed by filtered solids). The manufacturer might also judge that annual (or other frequency) servicing of the filter(s) is reasonable. The required information at this point would be data from a variety of configurations (e.g., single, double, and triple), effluent sources, and effluent loading rates (possibly obtainable through field trials). One could analyze this sort of data and determine, for example, that an average effluent load of 800 gallons/day from a residence requires 5 years to reach 80% filter maturity for a single-filter configuration. In such a case, the rating of 800 gallons per day could

be considered quite conservative, in view of the annual service interval specified. On the other hand, if 80% maturity were reached in six months, then there would be good grounds for revising the rated capacity downward for a single-filter configuration. Thus, while information such as that contained in this report is useful and necessary to characterize the filter configurations' hydraulic performance over a range of effluent load conditions, the investigator's judgement is that further information will be required to revisit any issues regarding the appropriate rated capacities.