Report on the Test Results for KLT Filtration Ceramic Filter Model CF115W

1.   Introduction

The ceramic filter 'CF115W' is a product of KLT Filtration Ltd. The filter comprises a dome ended ceramic cylinder attached to a plastic end cap with a male thread which can be screwed into a filter housing. Style CF115W is a "ceramic only" filter containing no additional filtration media or active substances inside the ceramic.

The purpose of the experiment was to challenge the ceramic filter under controlled conditions using *E. coli* spiked RO water to a point in which breakthrough was achieved. This would allow KLT to assess the ability of its proprietary ceramic to reject typical bacteria.

The filters to be challenged were delivered to the testing site by a KLT representative (Andrew Dahl); along with the filters and rig used for the challenge testing.

Before any testing could commence all filters to be tested were visually inspected for any cracks or imperfections, the rig used for the analysis was sterilised using 5% V/V Hycolin detergent and thoroughly rinsed afterwards, after sterilisations the filter itself was aseptically attached, the drum holding tank filled and spiked with *E. coli* using a solution with a concentration $\sim 10^8$. This was equivalent to 2×10^6 cfu/100 ml For further details of the protocol see *Appendix* 1.

2.   Test results
2.1   Initial Testing

Initial testing was conducted in accordance with the original protocol in *Appendix 1.* However because there was no sign of any breakthrough it was decided to increase the quantity of bacteria added in Runs 5 to 10. The sample flow rate was 2 litres/min as agreed.

As per the agreed protocol (See *Appendix 1*), all Vitroid™ stock was batch tested using in house methods to ensure suitability.

Sample were also taken from a tap prior to the filter (in conjunction with the post filter samples) to ensure that there was no significant organism death from inside the rig. No significant "added organism" death was detected

Results of the initial testing are summarised in *Table 1* below: -

Table 1 Initial testing results

Run	Volume (Litres)	Cumulative total water volume filtered. (Litres)	Total No. of *E. coli* added per run (cfu)	Estimated cumulative total number of *E. coli* passed through the filter (cfu)	Breakthrough observed
1	50	50	1.0×10^7	1.0×10^7	None
2	50	100	1.0×10^7	2.0×10^7	None
3	50	150	1.0×10^7	3.0×10^7	None
4	50	200	1.0×10^7	4.0×10^7	None
5	50	250	2.0×10^7	6.0×10^7	None
6	50	300	2.0×10^7	8.0×10^7	None
7	50	350	2.0×10^7	1.0×10^8	None
8	50	400	2.0×10^7	1.2×10^8	None
9	50	450	2.0×10^7	1.4×10^8	None
10	50	500	6.0×10^7	2.0×10^8	None

2.2   Testing with Increased *E. coli* Concentration

Since no breakthrough was detected during the initial testing it was not possible to estimate the total amount of bacteria the filter could withstand before breakthrough.

There was a slight deviation from the original protocol in terms of spike levels; a higher spike concentration was used. It was therefore decided to re-run tests, using the same procedures but at materially higher *E. coli* concentrations.

Results for the re-run tests are summarised in *Table 2* below:

Table 2 Subsequent testing results with higher *E. coli* levels

Run	Volume (Litres)	Cumulative total water volume filtered (Litres)	Total No. of *E. coli* added per run (cfu)	Estimated cumulative total number of *E. coli* passed through the filter (cfu)	Breakthrough observed
1	50	50	1.0×10^8	1.0×10^8	None
2	50	100	1.0×10^8	2.0×10^8	None
3	50	150	1.0×10^8	3.0×10^8	None
4	50	200	1.0×10^8	4.0×10^8	None
5	50	250	1.0×10^8	5.0×10^8	None
6	50	300	1.0×10^8	6.0×10^8	None

After Run 6 the supply of Vitroids™ ordered for the testing was exhausted. No further testing was therefore possible despite the fact that no breakthrough had been detected.
NOTE: - 6.0×10^8 = 600,000,000 E. coli. With a regulatory E. coli limit of 1 per 100 ml of sample, this indicates good protection

3.   Conclusions

3.1   As can be seen from ***Table 2*** above, the ceramic filter CF115W was challenged with a total of ~6×10^8 *E. coli* bacteria in 300 litres of RO water. The ALcontrol test method for identifying *E coli* bacteria has a Lower Detectable Limit (LDL) of 1 CFU / 100 mL

- Using this LDL gives an *E. coli* Log rejection value (LRV) greater than 6.08. This figure is based upon the worst case scenario of just using 100 ml sample at the end each 50 litres for each run. Thus, the filtered water comprises one five hundredth of the total volume filtered. This is equivalent to a removal greater than 99.9999%

- Incidentally, if the LRV was based upon the total filtered volume (300 litres), then the LRV would be greater than 8 assuming no breakthrough occurred in the unsampled water.

3.2   It can be concluded from this data set that the filter CF115W is capable of rejecting greater than a 6 log removal of *E. coli* bacteria.

3.3   Due to the nature of the filters rejection mechanism it would be appropriate to suggest that this filter could be capable of blocking other organisms of a similar/larger size to a similar level although this would need to be verified by the laboratory. This would include significantly larger parasitic organisms such as *Cryptosporidium* and *Giardia*

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Appendix 1

Escherichia coli Challenge Testing of Ceramic Filters

- The challenge testing will be performed at the ALcontrol Rotherham water microbiology lab by a fully trained and competent microbiologist.

- The filters that are to be tested are being provided by KLT Filtration ceramics as is the rig used for the challenge testing.

- The test specifications are that 2 litres/minute of RO water spiked with *E. coli* are passed through the ceramic filter.

- The tank on the rig holds 50 litres of water, every 50 litres of RO water will be spiked with 10^6 cfu *E. coli* with the overall aim to achieve >99.99% reduction of 500 litres with an overall spike value of 10^7 cfu. Should there be no breakthrough at this point the filter will continue to be tested at 50 litres a time spiked with 10^6 cfu *E. coli*.

- The 50 litre tank will be spiked by using in house methods, specific Vitroids™ have been manufactured for this testing and the batch of Vitroids™ will be tested prior to the challenge testing.

- Before any testing against the filters takes place, the rig will be cleaned by ALcontrol staff using appropriate cleaning agents and rinsed thoroughly with samples taken to ensure sterility.

- During the testing samples will be taken at 5 and 50 litres, a sample will be taken from a tap prior to the filter to ensure there is no significant organism death from inside the rig. This sample will be quantified using in house analytical methods that are UKAS accredited.

- Samples will be taken from a separate tap; these samples will be post filter and are expected to be free from bacterial contamination.

- In the event of un-expected early breakthrough the test will be aborted and another filter tested, should the same occur then the results reported. Should the second filter perform as expected another filter will be tested as a comparison.

- The overall aim is for the filter to withstand an overall value of 10^7 *E. coli* organisms spread over 500 litre of RO water. Should 500 litres pass with no breakthrough the test will continue until there is less than 99.99% reduction.

- The time between sampling and membrane filtration will not exceed the stability time of 24 hours; all samples will be logged and tested on the same day of sampling.

- Samples will be processed by trained analysts only, to verify results any organism recovery will be confirmed using in house methods.

- A reported will be generated by ALcontrol after all testing is completed.