Evaluation of the Radial Flow Fluidized Filter (RFFF)and the Radial Flow Reverse Fluidized Filter (RFRF)

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Overview

The research and assessment program for the R3F Technology was undertaken over an 18 month time frame where the focus was the use of the technology in a filtration mode. This testing was subsequent to a 1997 computer modelling study undertaken by Dr. Guzman at University of Texas and the initial preliminary field tests undertaken by Dr. Chris Baxter at the University of Alberta and reported on in the paper entitled "New Product – A Preliminary Evaluation of the Radial Flow Fluidized Filter for Drinking Water Filtration", Baxter et al, April, 2002, American Filtration Society, Galveston TX. This paper is provided on the web site for the R3F Technology at www.r3finc.com under the *Filtration tab, Technical papers*.

All of the third party assessments of the R3F Technology, to date, have been undertaken by the University of Alberta. The reason the University of Alberta was selected was because of its very high credentials in this area of research.
Firstly, the University of Alberta is now rated has having the 3rd best Civil Engineering department of any University in North America. One of the key departments in Civil Engineering is the Environmental Engineering and Science Department. The head of this Department is Dr. Daniel Smith.
Professor Smith earned his doctorate in environmental health engineering from the University of Kansas and joined the University of Alberta in 1978, after eight years of service for various agencies including the U.S. Public Health Service, the University of Alaska, Environment Canada and R&M Consultants.
Secondly, the University is recognized for its work in the area of disinfection particularly with ozone but it has also gained a significant amount of recognition with the development of separation and disinfection methods for the removal of the cryptosporidium and giardia in water supplies. Therefore testing the R3F filter for particle removal, particularly, pathogen removal was important for the assessment of the technology.
Finally the University has had a significant amount of research and development experience in the membrane filtration area. In fact it is one of the leaders in the development of integrity monitoring for membrane systems. One of the major companies in the membrane field will be using the integrity monitoring system that was developed at the University of Alberta. Understanding particle removal and the having the infrastructure to test particle removal was important for the assessment of the R3F Filter.

The overall study was under the supervision of Dr. Daniel Smith but was undertaken by Mr. Kevin Liu as a Masters of Science candidate at the University of Alberta. Mr Liu is now carrying on his studies at the University of Alberta as a PhD candidate.

Although the reader is encouraged to read the entire document, the size of the file makes it difficult for the immediate use on the site however if one requires the full document please use the contact interface on the web site to request a CD of the full assessment report. There are a number of key items that should be noted as follows.

1. Filtration:

The study was on the use of the R3F Technology in the filtration mode only. However the study looked at the use of an up flow unit where the media was in the top half of the column during filtration and then when backwash occurred, the influent at the bottom of the column would stop, the beads would fall and the backwash water would come in from the top. The media would be held in the upper part of the column with the flow coming in from the bottom and the velocity vectors holding the media in place in the upper half of the column. This up flow arrangement was defined as the RFFF (up-flow) regime. If the flows were reversed where the influent came in from the top and the unit was backwashed with water from the bottom, then this flow arrangement was known as the RFRF (down-flow) regime.

2. Glass Beads:

The Study used one media; glass beads which as indicated in one of the SEM photographs are perfectly spherical in nature- see pg 29. In addition on page 29 the different sizes of the glass beads are outlined.

3. Pathogen Removal:

a. Page 21 explains the reason for the using of the Bacillus subtilis spores as a surrogate for pathogen removal.
b. Page 46 has a SEM photograph of the Bacillus subtilis spores.
c. Page 73 explains the high loss in spores through the equipment. This is an important measurement in that the loss was about 1 log which if not accounted for would have indicated spore removals of almost 2.6 log instead of the reported 1.6 log.
d. Page 73 explains the spore removal was accomplished without coagulant which in sand filters would result in little to no spore removal if no coagulant was added. It was speculated that removal levels would have been higher with coagulant addition. It was also noted that the spore removals were only tested on the RFFF (up flow) unit and not the RFRF (down flow)unit
e. Page 73 suggests the literature indicates that Bacillus spores are smaller than Cryptosporidium or Giardia cysts and that a 1.7 log removal of Bacillus spores is close to a 2 log removal of Cryptosporidium.
f. Page 73 also indicates the data did not support any correlation between particle removal and spore removal.

4. Particle Counts versus Turbidity versus Pathogen Levels:

a. Page 25 explains the differences in the measurement of these three parameters.

b. Page 98 explains the high particle counts that occurred during the Spring Runoff conditions at the EL Smith water treatment plant. In particular there were times the particle counts on the effluents from the clarifiers were over 15,000 counts per ml.

c. Page 99 discusses the correlation between the removal levels of the ISO Fine Dust and the removal levels of the particles in the pilot operation at the EL Smith water treatment plant. The correlation was generally not very good but became closer the lower the particle counts were in the raw water.

5. Backwash Operation:

a. Page 33 explains the backwash operation

b. Pages 79, 95 indicate that backwash volume for low particle count (200 to 500 particles/ ml) produces very low backwash volume ratio to through put (i.e.0.3%) and for high particle count influent waters (i.e. 10000 to 20000/ ml) the backwash ration is 3%

6. Equipment Layout at the E.L Smith Water Treatment Plant:

a. Figure 14 shows the overall layout of the pilot plant at the E.L Smith Water Treatment Plant

b. Page 82 indicates the flow rate per column was 16 gpm and the operation was declining rate filtration

7. ISO Fine Dust:

a. Page 46 has a SEM photo of the fine dust particles.

b. Page 95 indicated that 95% of the particles in the ISO fine dust were in the 2-8 micron

8. Screens:

a. Page 58 explains the issues with the use of PVDF and Teflon screens and the fact the use of heavy polyester screens resolved the issues

b. Page 65 has some SEM photographs of the screens

9. Performance:

a. Page 69 explains the overall filter performance for the removal of ISO Fine dust which was 91.1% $\pm$ 2.58% , 98.3% $\pm$ 0.61%, 96.9% $\pm$ 2.26% for the RFFF MS #10,12 and 13 respectively. For the RFRF the removal level was 98.3% $\pm$ 0.27%. For all other media, the RFRF had similar removal levels but less deviation (more consistent) than the RFFF.

b. Page 71 indicates that “increased particle loading with the ISO fine dust had no effect on filter particle removal percentages but did affect ripening time.

c. Page 79 indicates that for the on-site water treatment plant tests the RFRF performed better.

d. Page 79 indicates that no spikes occurred in the RFRF (down flow) unit. This is important because according to the AWWA's *National Assessment of Particle Removal by Filtration, McTigue et al,1998* , spiking is very characteristic of sand and duo media filters and it is during these spikes that cysts are released.
e. Page 82 indicates that for the RFRF (down flow) unit there was very little ripening time for the on site water treatment plant tests.
f. Page 83 indicated that Sequential Filtration performed well and was able to achieve 99% (2 log) removal of particles for both clarified and raw water at the E.L. Smith Water Treatment Plant. Again it was noted that this was accomplished with out chemical addition.
g. Page 85 indicated that better removals were achieved with less uniform media.
h. Page 88 indicated that when using the coarsest bead tested (i.e.MS#8) and when testing the raw water source for the E.L Smith water treatment plant during spring run off the use of a polymer improved performance from 5.75% removal to 46.5% removal. In addition, page 89 indicated that using MS #8 on the clarified water at the E.L Smith water treatment plant produced some very good removal levels. It was assumed that the use of chemical destabilizing chemistry in the clarifier allowed the MS 8 to remove larger particles and/ or oppositely charged or neutral particles to the media and/or screens.
i. Page 89 indicates that particle counts were significantly higher in the influent to the pilot's filtration units from the clarifiers at the EL Smith water treatment plant than shown in the EL Smith's water treatment plant data for particle counts in the clarifier. It is speculated that the centrifugal pump sheared the floc coming out of the clarifier prior to entry into the filter units there by increasing the particle count.
j. Page 95 notes that in all tests after the redesign on the filter, breakthrough was never observed.
k. Page 98 indicates that the redesigned filter achieved better filter performance than the results in the first validation experiments undertaken by Baxter