Application note

# Drinking water process optimisation using Turbidity sensors

## TO OPTIMIZE FILTER BACKWASHING IN DRINKING WATER PLANTS

This article deals with control of rapid gravity filtration (RGF). In order for this filtration process to be effective, the filter bed must be periodically backwashed to flush out contaminants and particulates which have built up within the filter over time reducing its performance.

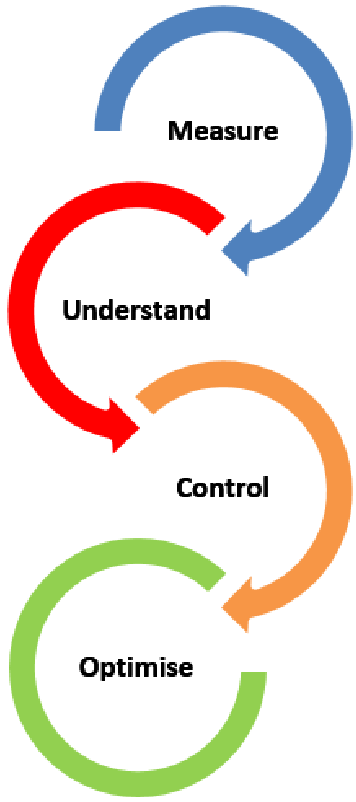


Figure 1

**Background**

Backwashing is a potentially destructive process if not managed correctly.

The backwash is triggered on a timed cycle and, most often, ended via a timer as well. Operating this process purely on a timed basis runs two risks: under washing and over washing.

Over washing can lead to a loss of filter media potentially damaging for transfer pumps, a waste of salable drinking water and wasted power.

Under washing leads to shorter filter runs, accumulation of solids in the filter, cementing portions of the filter bed and migration of filter media.

Each filter within a bed will have an adjustable backwash sequence where all parameters (run time, air scour time and backwash time) can be set to the operators requirements, the typical sequence for each filter wash  is (1) remove from service (2) air scour (3) reduced flow backwash (4) full flow back wash (5) return to service.

Example times and cleaning flowrates for each of the stages of the filter operation and cleaning process are given below:

1. Filter operation / runtime – 72 hours
2. Air scour (3 minutes at 1023m³/hr)
3. Reduced backwash (3 minutes at 145l/s)
4. Full flow backwash (10 minutes at 168l/s)

A single physical parameter can be applied to enable optimization of the backwash process: turbidity.

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There are a number of locations around the filter where this measurement could be made: (i) Over the bed itself, (ii) in the launder channel and (iii) in the combined backwash outlet channel serving the complete process stage. These are shown in figure 2.

The **first option** is generally the simplest in terms of installation but suffers from two major drawbacks:  turbulence and aeration during the backwash process and unrepresentative sampling. The first issue occurs because of the way online turbidity instruments measure via 90° reflected light. When this light beam intersects with the microbubbles caused by the backwash, the light is scattered thus preventing an accurate measurement. The second issue arises because it is most likely that instrumentation will consist of a single sensor per filter at most. This sensor will be in a fixed position and so will only measure what is happening at that location preventing an understanding of the progress of the backwash across the while filter bed.

The **second option**, placing the sensor at the discharge end of the launder channel enables measurement of the backwash water coming from the entire filter bed. This then enables assessment of the overall backwash performance. This installation is more difficult than the first option as it is dependent both on the location of the launder channels and their dimensions for sensor access, orientation and to minimize measurement impedance due to proximity of walls. As with the first option, turbulence and aeration need to be taken into consideration. These can be minimized by careful location of the sensor following investigation during the initial specification phase.

The **third option** is the most ideal in terms of ensuring minimal turbulence and aeration at the point of measurement.
However, the combined backwash discharge channel is often the most difficult to access. Additionally, a filter specific lag-time component will be required within the SCADA system to which the data is sent to ensure the data measured is a reflection of the process. As it is common practice to only backwash one filter within a bank at any given time, incorporation of these specific lag-times is of no great difficulty as the SCADA system will know which filter is undergoing backwash and apply the correction accordingly.

From the example site data, presented in the graphs below, it can be seen that the filter enters the backwash with a very low turbidity (1 FNU) which quickly rises during the air scour to approximately 80 FNU where it remains until the final 10 seconds of the air scour when it increases to 90 FNU until the air scour ceases. Backwash then commences and the turbidity drops and eventually settles to approximately 10FNU after 4 minutes, it then stays at this level for the remainder of the backwash. Following the backwash the filter returns to service and slowly drops from 10NTU to around 1.3FNU over the next hour.

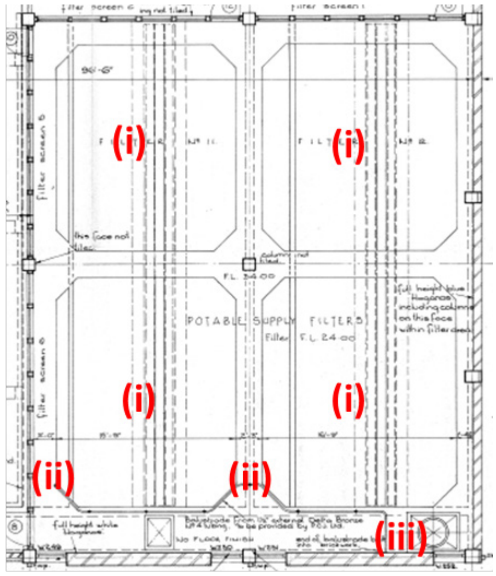


Figure 2: Schematic view of a set of filter beds showing measuring locations.

Figure 3: Photograph of a drained filter showing launder channel against back wall, bunding wall and filter bed in foreground

In this instance, there are 7 minutes of backwash operation during which no further improvements in turbidity are measured. The system is at this point being overwashed. This additional time equates to an excess water usage of 70560L for one cycle on one filter for the example operational parameters provided above. Viewed over a year of operation, this filter will be backwashed 122 times with a total excess water consumption of 8,608,320L.

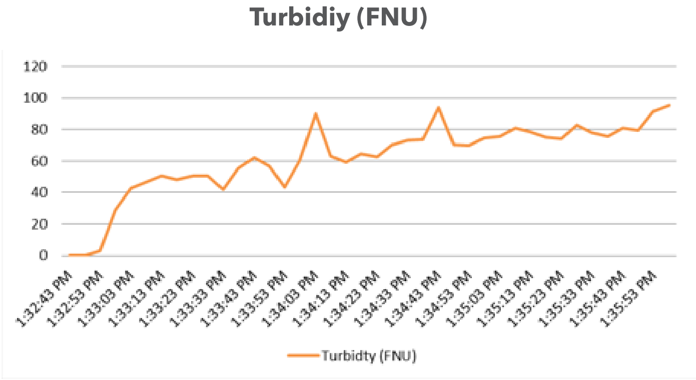


Figure 4: Example RGF Air Scour Turbidity

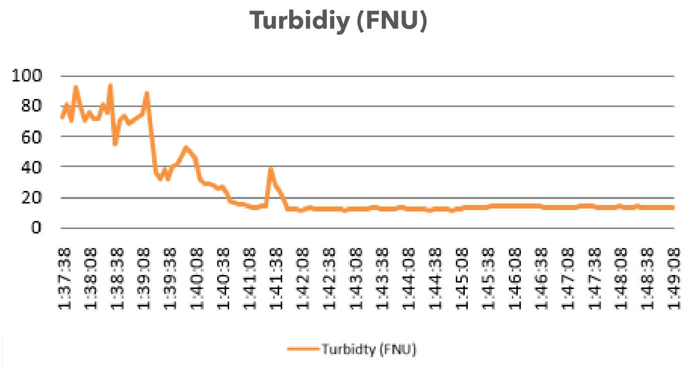


Figure 5: Turbidiy (FNU)

Turbidity, as mentioned above, is measured using light beams. Maintaining accuracy of this measurement is dependent on the cleanliness of the windows through which the beam must pass to exit and enter the instrument. Often, this function has been performed by wipers in various guises. Whether these are external wiper blades similar to those on a car or wipers held internally through which the sensor windows are drawn, these systems have three things in common: wiper degradation, motor degradation and points of potential water ingress.
Over the course of the sensor life, the wipers and, more infrequently, the motors will require replacement. Should these actions be delayed then sensor performance will be reduced and possibly even completely compromised if seal failure around motor shafts or sensor windows leads to water ingress. If these actions are completed improperly then the same will be true. Either will result in one outcome, sensor replacement.
In order to remove these issues and eliminate any components passing through the body and enabling water ingress, Xylem developed the VisoTurb® 700 IQ sensor which incorporates an ultrasonic cleaning function within the head of the sensor itself.

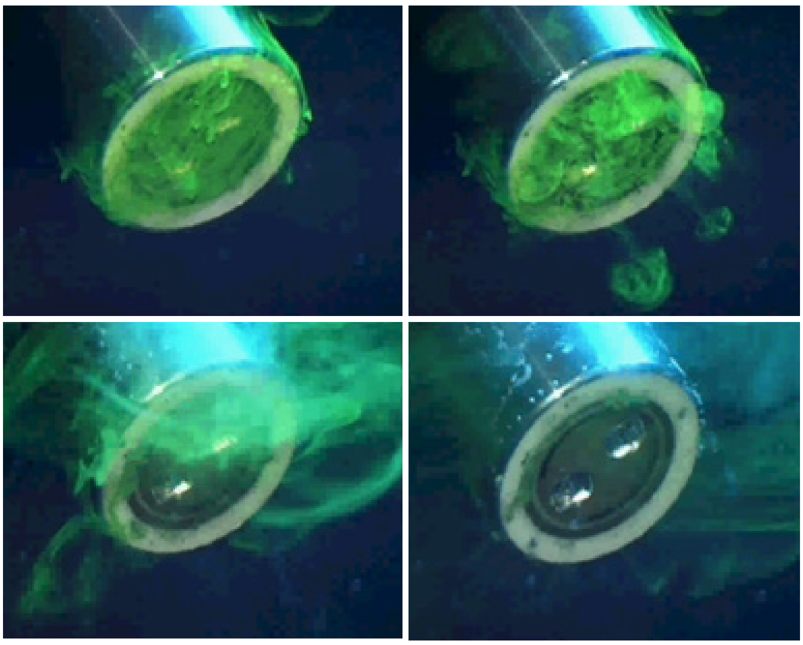

Figure 6: 1 minute Timelapse photos of ultrasonic cleaning removing deliberate heavy fouling. With the cleaning on continuously, this degree of fouling is not experienced during operation.

This has required considerable R&D investment to ensure that the windows, potting and indeed the sensor itself can withstand the vibrations induced by the ultrasonic operation.
The result is a sensor with no seals, wipers or motors which require replacement over the life of the instrument.

Do you have further questions?
Please contact our
Customer Care Center:


Xylem Analytics Germany Sales
GmbH & Co. KG, WTW
Am Achalaich 11
82362 Weilheim, Germany
Phone +49 881 1830
Fax +49 881 183-420
Info.WTW@xylem.com


xylemanalytics.com