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# Using Turbidimeters to Monitor Backwash

*Backwashing is a potentially destructive process if not properly managed. If the process is initiated too quickly and/or at too high a flow rate, and/or terminated too quickly, severe damage can result to the bed. Inadequate backwashing can also create just as many problems. Leaving too many solids in the bed can lead to short filter runs, and even worse, to more severe problems like mudballs, or cementing entire areas of the bed.*

### *Background*

Rapid filters, rapid sand, dual media and multimedia beds require periodic cleaning to remove accumulated solids. In most configurations, water filters through the bed by gravitational force. The rate of filtration varies from about 2 gals/ft$^2$/min for a rapid sand bed to 7-10 for multimedia beds. During the cleaning cycle, or *backwash*, the flow is reversed and a flow rate of 13-20 gals/ft$^2$/min is forced back through the bed to remove accumulated solids. During this process, the bed expands and becomes fluid to allow release of accumulated solids. The rate of backwash depends on a number of factors including the design of the bed and water temperature. Typically, the backwash rate will be in the range of 15-17 gals/ft$^2$/min.

Backwashing is an expensive process. In a well-operated utility, backwashing may consume 1-3% of the filter's production, typically around 2%. Assuming the filter has a capacity of 2 MGD and operates for 48 hours between backwashes, the amount used to backwash would be approximately 2% of 4 MG or 80,000 gallons. If the water is sold by the utility for $2.00/thousand gallons (a very reasonable number), each filter wash costs at least $160 in otherwise saleable product.

Some operators and utility managers will argue that the water is not lost – "it is all recycled and therefore does not cost us much at all." In fact, those 80,000 gallons take up approximately an hour of production – 4% of the daily capacity of the filter. This is not a trivial amount in water-short regions, during periods of high demand or in drought condition.

**In fact, those 80,000 gallons are approximately an hour of production – 4% of the daily capacity of the filter. This is not a trivial amount in water-short regions, during periods of high demand or in drought condition.**

There are costs of backwashing:

1. Water used for washing (if recycled) must be treated again. If the water is not recycled, back washing results in increased need for raw water resources.

2. The water used for washing must be pumped. If the wash water is recovered, it typically goes through one or more stages of pumping and settling before it is returned.

3. Water used for washing is not available for sale. An amount equal to the wash water volume must be treated or retreated.

Water operators typically monitor backwashing either visually or on the basis of a pre-set time. If monitored at a specific time, at least it is consistent (though it could be consistently too much water or too little). Neither is good. If it is controlled visually, every operator will have a different idea of what constitutes clean and thus every wash will be different. Each operator making an independent judgment results in inconsistent operation at best.

Using a turbidimeter to monitor backwash has the benefits of consistency and a thorough wash based on measurement rather than on the subjective opinion of an individual.

The Solitax T-Line and TS-Line sensor can be applied for monitoring backwash.

*Figure 1: Actual Backwash Curve*

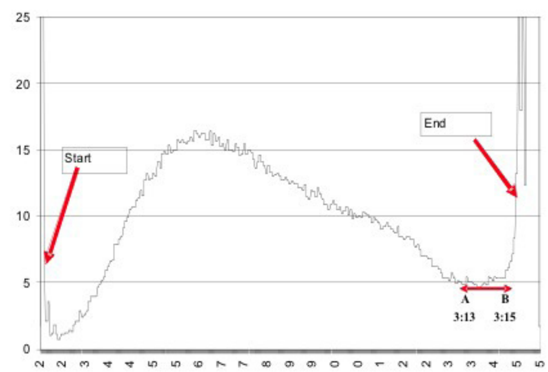


Figure 1 illustrates data from a backwash sample using the Solitax for backwash monitoring. The operations

# Cost Savings

staff started backwash as usual based on a preset time beginning at about 3:00 and then terminated the backwash based on their existing practices at about 3:15 (point B). But, as the data illustrates, the backwash turbidity leveled off at 3:13 (point A)! Continuing an additional two minutes was unnecessary. The normal backwash rate for this large filter was approximately 17,000 gallons per minute. Thus, terminating the backwash 2 minutes early could have saved approximately 34,000 gallons – a significant amount of water. If the water has a saleable value (water rate) of $2.00 per thousand gallons, 34,000 gallons amounts to $68 in lost product.

### *Monitoring Considerations*

In some cases, less than a minute of time will be saved. Yet, even these small amounts can add up to significant savings over time. Rapid response time is critical to achieving full benefit. A submersible design, like the Solitax is necessary to achieve nearly instantaneous measurement.

Measurement must be within the filter, preferably in the backwash trough to achieve optimal saving and ease of access. Mounting the probe in a pipe downstream of the filter and/or manifolding a number of filters to the same sensor may create too much delay in measurement. This delay will eliminate any possible benefit that could otherwise be gained. In-pipe or manifold mounting should be used only as a last resort.

### *Time Will Not Always Be Saved - Initially*

Visual or time-based judgment of the backwash period can also lead to under washing. As indicated earlier, serious problems can result from inadequate cleaning of the filter bed. Using a Solitax to monitor the backwashing process will help to restore the bed to peak condition and maintain it in peak condition. Invariably, this will lead to cost savings.

### *Calculations of Savings Possible by Using Turbidimeters to Monitor Backwash*

Properly applied, using a turbidimeter (Solitax) will save a significant amount

1. Calculate the direct and indirect dollar savings which can be achieved by using less wash water:

$$\frac{\text{\$ Cost of Operation}}{\text{1000 Gallons}} \times \frac{\text{1000 Gallons Saved}}{\text{Backwash cycle}} = \frac{\text{\$ Saved}}{\text{Backwash cycle}}$$

Where Cost of Operation per 1000 gallons is:

$$\frac{\text{Total Annual Budget}}{\text{1000 Gallons Produced Annually}} = \frac{\text{Cost of Operation}}{\text{1000 Gallons}}$$

The total annual budget is the expenditure for treatment plant operations – the bottom-line - including: salaries, benefits, utilities, chemicals, consulting fees, debt service, maintenance, depreciation and capital expenses.

And, 1000 Gallons saved per Backwash cycle is:

$$\frac{\text{1000 Gallons}}{\text{Minute}} \text{ (at maximum wash rate)} \times \frac{\text{Minutes Saved}}{\text{Backwash cycle}} = \frac{\text{1000 Gallons}}{\text{Backwash Cycle}}$$

And, dollars saved per backwash is:

| | | |
|---|---|---|
| 1000 gallons saved / Backwash | X cost of operation / 1000 gallons | = $ saved per backwash |

### *Example*

Assume a treatment plant has and annual budget of $500,000 and annual production of 2 billion gallons (2,000,000 thousand gallons). The cost per 1000 gallons of water produced is:

| | | |
|---|---|---|
| $500,000 / 2,000,000 thousand gallons | = | $0.25 / 1000 gallons |

Assume a wash water rate of 4,000 gallons/minute (4K gallons). If 1.5 minutes can be saved every backwash, saving per backwash just in cost of water will be:

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 K gallons / Minute | X | 1.5 minutes / Wash | X | $0.25 / K gallons | = | $1.50 / Wash |

The treatment plant has 4 filters with an average of 60 hours per filter run (time between backwashes). (8760 hours in a year). So, at 60 hours per filter run, each filter must be washed 146 times.

Annual savings in wash water is:

a.

| | | | | | | |
|---|---|---|---|---|---|---|
| $1.50 / Wash | X | 146 washes / Filter | X | 4 Filters | = | $876.00 |

Water used in washing must be treated again or more water brought in and treated. The cost to treat or retreat this quantity of water is numerically the same as above:

b.

| | | | | | | |
|---|---|---|---|---|---|---|
| $1.50 / Wash | X | 146 washes / Filter | X | 4 Filters | = | $876.00 |

a. Value of wash water saved $876.00

b. Value of re-treatment savings $876.00

$1,752.00

This is a very conservative estimate of savings because it indicates only the direct savings in treatment costs. Actual water saved amounts to 6,000 gallons per wash per filter (1.5 min. X 4,000 gallons/min) or 876,000 gallons per year per filter or at total of 3,504,000 gallons per year. Assuming a water rate of $2.00 per thousand gallons (again very conservative, many regions of the US have rates well in excess of $2.00 per thousand), that water has a saleable value of $7,008.00.

Summary of indirect annual savings:

c. Water saved from treatment or re-treatment per year = 3, 504,000

d. Revenue value of water = $7,008.00

2. Calculation of dollar savings of electrical power. The power consumption of every pump used in the backwashing process must be calculated. Be sure to include the main backwash pump, surface wash pump, wastewater return pump and any other pumps used in the process. Treatment plants using air scour and/or air wash also will need to calculate savings in blower operation. Since the surface wash pump generally is used only at the beginning of a backwash cycle, shortened backwash cycles may have no effect on operation of the surface wash pump. However, some water plants will use the surface wash throughout the backwash and its power use must then be accounted for.

Calculate the power for each pump and blower used as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| KW Used | X | Hours of Pumping / Backwash | X | Dollars / KWH | = | Dollars / Backwash |

Where KW = Kilowatts – the apparent power used by the pump or blower, sometimes indicated as KVA on the motor name plate can be calculated by multiplying the rated voltage by the running amps.

And, KWH = Kilowatt-hours. This is the basis most power companies charge for power (one kilowatt of demand for one hour). A telephone call to the power company will be sufficient to determine the cost per KWH. $0.04 to $0.10 would be typical around the US depending on whether the power is from gas, coal, wind or hydroelectric operations.

Continuing the example, saving 1.5 minutes per backwash, the 60 hp backwash pump rated at 24 KW (KVA, motor draws 50 amps at rated voltage of 480 Vac) is the only pump used. The water utility pays $0.07 per KWH.

Calculate the power savings:

$$24 \text{ KW used} \times \frac{0.025 \text{ hours of pumping}}{\text{Backwash}} \times \frac{\$0.07}{\text{KWH}} = \frac{\$0.042 \text{ Dollars}}{\text{Backwash}}$$

Note: The 1.5 minutes saved must be expressed as hours:

1.5/60 = 0.025 hours

$$\text{Hours} = \text{minutes} \times \frac{1 \text{ hour}}{60 \text{ minutes}}$$

With 146 backwashes per year on each of 4 filters, the total savings for operation of the backwash pump is:

$$\frac{146 \text{ washes per year}}{\text{filter}} \times \frac{\$0.042}{\text{wash}} \times 4 \text{ filters} = \$24.52 \text{ per year}$$

There are many other factors that contribute to cost savings as well. Cutting the backwash saves a total of 24.3 hours of pump operation per year, which will translate to longer pump life and decreased pump maintenance costs. When a treatment plant has a regular maintenance schedule based on hours of operation, these costs can be quantified and should be included.

3. Calculate the dollar savings based on reduced labor. This is often the toughest concept to sell. Many municipal utilities assume labor is free, "The operator is here for eight hours anyway, I can't possibly save any labor cutting 1.5 minutes from backwash."

4. Labor is not free. The time saved can be utilized doing something else. Continuing with the example, assuming the operator is paid a rate of $15/hour (a good average nationwide for a middle level operator).

$$\frac{0.025 \text{ hours}}{\text{Backwash}} \times \frac{146 \text{ backwashes}}{\text{filter}} \times 4 \text{ filters} = 14.6 \text{ hours}$$

Labor savings: $$14.6 \text{ hours} \times \frac{\$15}{\text{hours}} = \$219$$

# Calculation of Backwash Savings

Summary of direct savings:

| | | | |
|---|---|---|---|
| 1. | Savings from using less water: | | |
| a. | Value of water saved | $876 | |
| b. | Saving of re-treatment cost | $876 | |
| | | | Total $1,752 |
| 2. | Savings in power costs | | |
| a. | Backwash pump | $24.52 | |
| b. | Surface wash pump | $ | |
| c. | Waste return pump | $ | |
| d. | Other pump | $ | |
| e. | Blower | $ | |
| | | | Total $24.52 |
| 3. | Savings in labor | $219 | |
| | | | Total $219 |

Total Direct Annual Savings $1,995.52

Indirect Annual Savings

Revenue Generated from water saved $7,008.00

Water saved per year from treatment or re-treatment 3,504,000 gallons

# Calculation of Backwash savings Worksheet

Summary of direct savings:

1 Savings from using less water:

f. Value of water saved $__________

g. Saving of re-treatment cost $__________

Total $__________

2 Savings in power costs

a. Backwash pump $__________

b. Surface wash pump $__________

c. Waste return pump $__________

d. Other pump $__________

e. Blower $__________

Total $__________

3. Savings in labor $__________

Total $__________

Total Direct Annual Savings $_________

Indirect Annual Savings

Revenue Generated from water saved $_________

Water saved per year from treatment or re-treatment __________ gallons

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