MONITORING BASIC PARAMETERS CAN OPTIMIZE PACKAGE PLANT OPERATION

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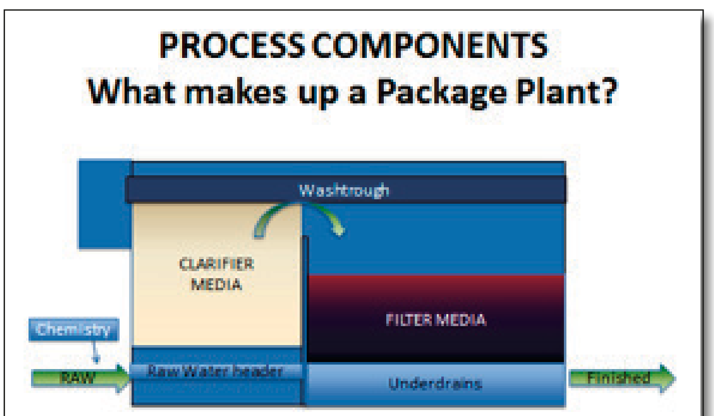
Today there are a large percentage of package water treatment plants that operate using obsolete or inefficient backwash methods. These methods can be improved upon by monitoring basic parameters to initiate a clarifier flush and a filter backwash based upon a set time intervals, head-loss across the media, and effluent turbidity. To save time and money, the water treatment plant must rely upon instrumentation that accurately monitors these parameters while producing high quality effluent, minimizing waste and optimizing net production.

A common package plant configuration is a clarification step followed by a filtration step. Chemicals such as a coagulant and one or more polymers are used to make contaminants insoluble so that they can be captured in the clarifier or filter. Basic instrumentation includes devices such as: influent and effluent turbidimeters, differential pressure transducers, or switches and gauges.



Many plants, initiate clarifier flush and filter backwash based upon a set-time. Typically this set-time is measured in minutes or hours by the PLC program. This method works well when water quality stays consistent or if it is fairly stable, such as ground water or ground water under the influence or when the flush, backwash, and downtime; occur while the demand is low.

However, surface water can be variable and influenced by seasonal changes, run off, or rain events which affect raw water turbidity. Increases in raw water turbidity increases solids loading and can shorten clarifier and filter run times. Initiating clarifier flush and filter backwash based on a set-time can be costly. If too often, more flushes and backwashes create more waste and fill the waste storage basins or lagoons too frequently. Time spent cleaning them is lost time and may even prevent the plant from producing usable water.

If the clarifier flushes too infrequently, excessive solids collect in the clarifier and spill over onto the filter. The filter then develops an increase in headloss. This is called breakthrough and causes the process to operate inefficiently. Breakthrough occurs when the solids holding capacity of the clarifier media or filter media is exceeded and solids pass through the media. In some cases, excessive headloss developed in clarifiers can damage the equipment and creating unnecessary downtime and expense for repairs. And with the filter there is the risk that effluent water quality could be impaired.

There are a number of parameters that can be monitored to show how well the process is working and will help to optimizing the overall package plant. The Influent turbidity is one parameter measured and typically higher than raw water turbidity as it contains the turbidity of the raw water, chemistry additions, and any coagulated particles, and can also be referred to as coagulated turbidity. Another is called settled water turbidity or inter-stage turbidity, which is the turbidity out of the clarifier or onto the filter. It is not necessary to continuously record the inter-stage turbidity. Of course filtered effluent water turbidity is needed, as well as a headloss across the clarifier and filter. For the clarifier, the pressure under the clarifier media is monitored over time which correlated to the solids load captured. Since this parameter is a gauge pressure, psig, then it is recorded as the clarifier differential pressure. Filter headloss is another common parameter monitored, also a gauge pressure in psig. Depending on how the plant monitoring devices are configured, filter headloss reading may be shown as negative or a vacuum pressure.

Most all of the parameters cited are commonly >>>

Optimizing clarifier and filter performance

	Clarifier				Filter		
TIME (hr)	Coagulated Turbidity	Clarifier Headloss	Percent Solids Removed	Inter-stage Turbidity	Effluent Turbidity	Filter Headloss	Percent Solids Removed
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							

recorded either on a log sheet or continuously monitored through a plant SCADA system. Inter-stage turbidity can be obtained as a grab sample when necessary. Even without a SCADA monitoring system, manual logs can be just effective.

A table like shown can be used to collect the data.

The parameters for the clarifier and filter are shown as column headings. The time at which time the data is taken is shown on the left. The time interval can be more frequent, such as each half hour, to provide better resolution. The intent is to compile and plot the data in enough detail that trending can be seen. Data collection that is too coarse may not show the same picture of headloss and turbidity spiking as a data set that has more points collected. This especially evident near the time which the clarifier flushes or filter backwashes. Frequent sampling would be more reflective of the actual events occurring prior to the backwash or clarifier flush.

One manufacturer suggests:

For the best characterization of the performance of the clarifier, make turbidity readings on the influent and effluent at least once per hour throughout a run. It is important to do this frequently since, under certain conditions, the removal across the clarifier can change significantly throughout a run.

The filter effluent turbidity (if not recorded continuously) should be checked frequently; as often as once every half-hour for an in-depth characterization.

COMPUTING SOLIDS REMOVAL:

With the data collected, other items can be computed to thoroughly understand the processes. For instance, knowing the inter-stage turbidity is helpful to determine the percent solids removed. By subtracting the inter-stage turbidity from the coagulated turbidity and dividing the difference by the coagulated turbidity, the percent solids captured or removed in the clarifier is determined. For the filter, take the difference of the inter-stage turbidity and effluent turbidity and divide this by the inter-stage turbidity, the percent solids captured is determined. In many cases, if the chemistry is properly dosed, percent of solids removed can be fairly high. Many regulators require turbidity of 1.0 NTU or less on top of the filter.

For example for the Clarifier at hour 3:

(7.2- - 0.7) / 7.2 = 0.903 or 90.3%

And for the filter

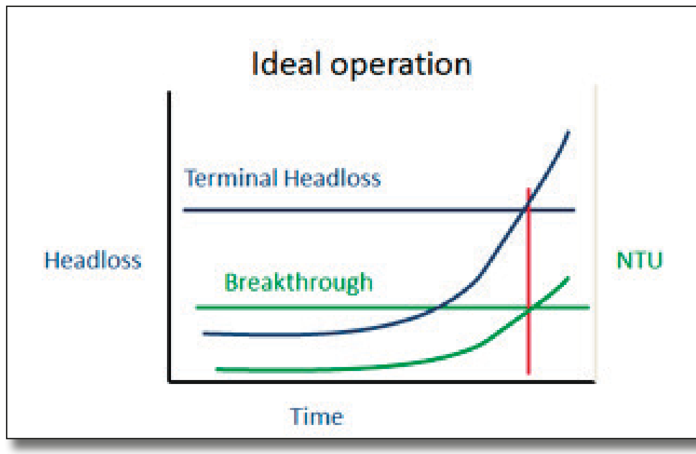
(0.7 – 0.06) / 0.7 = 0.914 or 91.4%

1	Optimizing clarifier and filter performance							
2		Clarifier				Filter		
3	TIME (hr)	Coagulated Turbidity	Clarifier Headloss	Percent Solids Removed	Inter-stage Turbidity	Effluent Turbidity	Filter Headloss	Percent Solids Removed
4	1	7.1	1.6	89%	0.75	0.05	0.2	93%
5	2	7.2	0.4	89%	0.8	0.05	0.5	94%
6	3	7.2	0.9	90%	0.7	0.06	0.8	91%
7	4	7.3	1.4	89%	0.8	0.06	1.1	93%
8	5	7.4	0.2	89%	0.8	0.059	1.4	93%

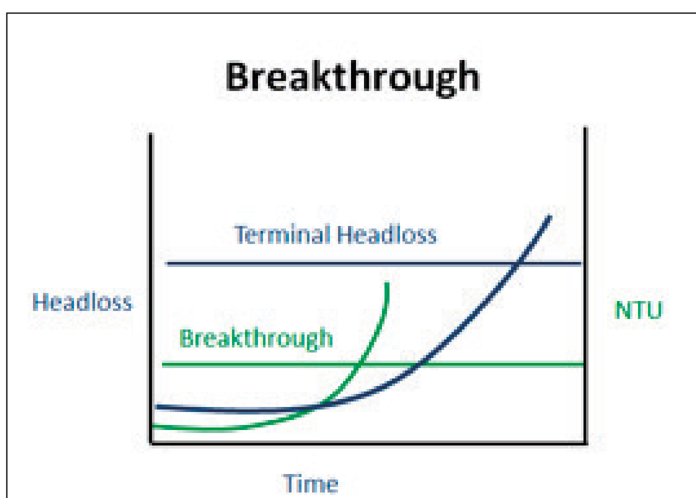
By reviewing the current operation of an existing water treatment plant using the parameters as noted, the best time to flush the clarifier or backwash the filter can be determined based on minimizing breakthrough.

OPTIMAL OPERATION

The graph shows the ideal operation of a filter, which can also apply to a package plant clarifier. The blue line uses the headloss axis on the left as a function of time on the lower axis. As time goes forward, headloss across a clarifier or filer can be steady for a period of time then increase until it reaches a terminal headloss. At which time a clarifier flush or filter backwash is initiated. The green line represents the turbidity out of the clarifier or out of the filter and as show if fairly steady over time until it cannot hold any more solids. It is at the point when both terminal headloss and breakthrough occur that the system is running at maximum efficiency, shown by the red vertical line. The goal is to get as close to the breakthrough point as possible without exceeding it.

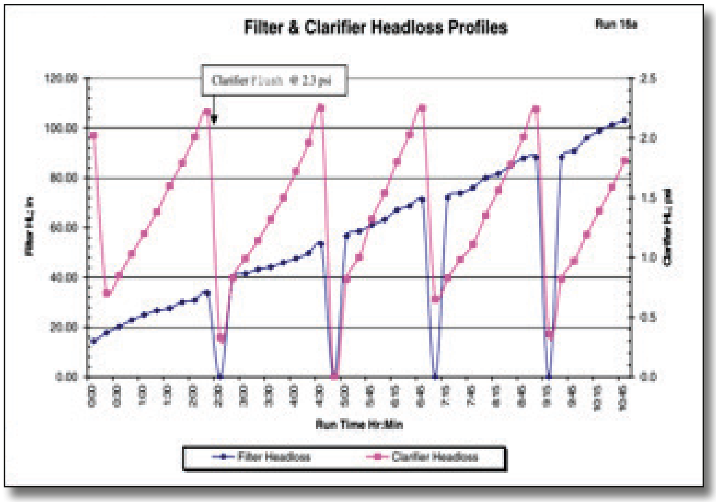


Breakthrough occurs when the rate of turbidity change increases. Headloss in blue on the left vertical axis, turbidity on the right in green and time along the horizontal axis. While the terminal headloss had not changed, breakthrough occurred much sooner than termanl headloss was achieved and is seen as a sudden spike or "hockey stick profile" in the curve.



HEADLOSS MONITORING AND REVIEW

When reviewing an operating packaged water treatment plant, monitoring headloss across a clarifier or a filter, is very useful as seen on the graph (below) that was done using a data logger and SCADA system. The same graph could have been generated using the table previously mentioned.



The graph shows both clarifier headloss and filter headloss versus time. Headloss is reported as inches of water column. The clarifier is flushing about every 2- 3 hours. Since influent turbidity is not shown here, changes in raw water turbidity between these events can reflect some variability. For the clarifier, the headloss after each event returns fairly close to the initial setting, indicating that it is being adequately cleaned. The filter shows corresponding changes in headloss, because flow to the filter stops during the clarifier flush. The spike at 10 hours would indicate the headloss has increased and likely to trigger a backwash soon. Collecting filter headloss data for more than 10 hours would provide a better profile.

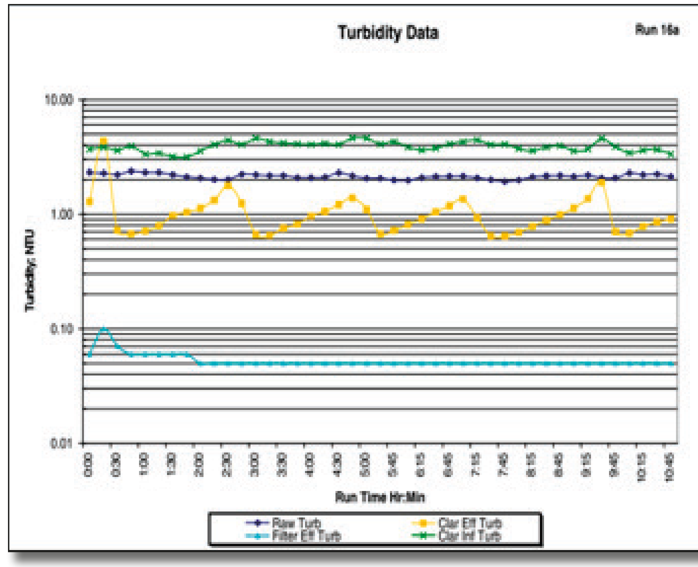
TURBIDITY MONITORING AND REVIEW

The graph shows run time in hours and minutes on the horizontal axis and turbidity on the vertical axis and is a good example of the difference between raw water turbidity (dark blue) and coagulated turbidity (green). The coagulated turbidity is often higher than the raw water turbidity due to the added chemistry used coalesce solids or treat color. . The yellow line shows the inter-stage turbidity and the light blue, the effluent turbidity. None of these curves reflect any turbidity breakthrough.

In the normal operation of any plant there comes a point, noted by turbidity breakthrough, when the media can no longer hold any more solids. These values should be kept on file and used when treating similar waters and chemical treatment.

OPTIMIZING:

Once the data has been collected and plotted, there are a



number of things that can be done to improve the operation

- Consider adjusting the time between clarifier flushes and filter backwashes. This can be done in most of the PLC programs.
- In conjunction with the time adjustments, adjust the headloss switches used to initiate the clarifier flush and filter backwash. This can be done by adjusting the switch settings.
- Reviewing the percent solids removed in both the clarifier and filter can uncover which process has more room for adjustment. Note that the goal is to optimize the overall plant which may or may not result in both clarifier and filter being optimized.
- Consider modifying the dosage or type of coagulant or polymer being used. Consult with your chemical supplier who can conduct on site jar testing of various options.
- Consider cleaning or replacing the media. Media analysis can be conducted by the manufacture or media supplier to determine if the media is worn or contaminated.
- Keep various turbidity and headloss profiles based on seasonal operations to check the impact of changing coagulant or polymer dosages.

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Waste Volume Calculation				
	based upon 1 MGD plant			
	Waste Volume	Frequency (hrs)	numbe of flushes per day	Total Waste Produced
Clarifier Flush	3500	5	4.8	16800
Filter Backwash	7000	8	3	21000
		Total		37800
Alternate				
	Waste Volume	Frequency (hrs)	numbe of flushes per day	Total Waste Produced
Clarifier Flush	3500	4	6	21000
Filter Backwash	7000	8	3	21000
		Total		42000

In all cases, before making any major change to your full scale operations, contact your local regulators or rural water association. Optimizing operations will save days of potential backwash time and money on an annual basis.

One example regarding improvement of operation in waste volume, could be if a clarifier run time was extended an additional hour. A one MGD package plant that flushes the clarifier every 4 hours and backwashes the filter every 8 hours, could reduce the waste volume produced by 10%, if the clarifier ran 5 hours between flushes. The increase of just one hour between flushes reduced the number of flushes per day from 6 to 4.8. Furthermore, assuming a flush duration that takes 15 mins, the plant will extend the run time such that an additional 10,500 gallons can be produced.

This simple method of monitoring the performance of the steps within the overall treatment process will produce the least amount of waste, optimize use of chemistry, and maximize utilization or net production.

CONCLUSIONS:

1) Operators must be focused on calibrating the instrumentation, properly operating the equipment, and periodically checking performance to ensure optimized operation. These duties are performance by qualified instrumentation technicians and enhanced by a good preventative maintenance program.

2) Changing water quality or chemistry can upset the process and system may need to run a performance test.

3) The breakthrough point can be directly associated with clarifier and filter headloss. The goal is to get as close to the breakthrough point as possible without exceeding it.

4) Maximizing solids holding capacity is paramount to understanding the optimal performance of the package plant.

5) Optimizing the process to operate with less frequent clarifier flushing and filter backwashing can reduce waste water production

6) Keeping, and reviewing, results of multiple tests are useful to optimizing the system's performance on a long term basis.

7) This test is independent of clarifier types, filter media types, underdrains system, or backwashing techniques.

8) Consult with the manufacturer for additional thoughts and suggestions on how to further optimize the process.

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