Q&A

22Q5: Head loss of our rapid sand filters has increased in a short time and the filters have clogged soon. We have often lost filter media from the filters. Let me know the issues to be considered when we select filter media and its maintenance. （Mr. Z.O. Myanmar）

A1: Rapid sand filter has been used widely in most of waterworks all over the world, because it can produce a lot of amount of filtered water in small size of facility comparatively. It enhances the removal effect of turbid matters, chlorine tolerant protozoa and so on by combining with coagulation and sedimentation process.

Filter Clogging: Filters clog with various reasons.

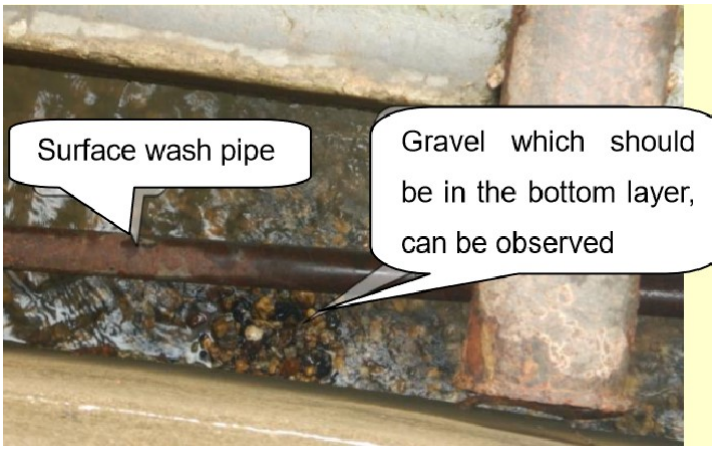
1) One of the reasons is that the inflow water to the filter may contain turbid mattes more than the original design. In this case, improvement of coagulation-sedimentation process which is the previous treatment process of the filter, is necessary.

2) When turbid matters which was trapped in the filter media, cannot be removed by backwashing of the filter due to the wrong wash condition, filter clogging may happen. In this case, it is required to set the appropriate condition of the filter wash newly.

3) In the case that the filter clogging is caused by the filter media, it is thought that particle size of media is smaller than designed one. The particle size of filter media is generally shown by two parameters; one is an effective size (d10)* and the other is a uniformity coefficient (d60/d10)*. When new filter media is used, it is essential to check the size of filter media by sieving test to confirm that the size is same as designed one. Even if the result of sieving test satisfies designed size, in the case that filter media contains very fine particles, e.g. less than 0.3 mm, it is said that filter clogs in a short time. The fine particles can be easily removed, because most of fine particles tend to gather on the surface after washing the filter.1） Dual media filter and multimedia filter are often used to get more large quantity of filtered water in the same filter size. As a dual layer filter, it is common to use anthracite in the top layer and sand in the second layer, because specific gravity of anthracite is lighter than sand although the particle size of anthracite is bigger than sand. Therefore, the filter clogging happens less than single sand filter. And filtration rate can be set at higher speed compared to single sand filter, and

running time also becomes longer. On the other hand, anthracite tends to flow out from the filter basin during filter washing. In the case that most of anthracite flow out and sand layer comes to top, it causes a filter clogging in a short time. It needs to pay a special

attention for the media in the top layer so as not to flow out from the dual or multimedia filter. Regular check of the filter is very important. It is no matter whether the type of the filter is single or dual media. By the regular check system, a depth of each layer and particle size should be measured. When the media flow out more than the volume which is predetermined, media should be filled in the filter basin immediately.



Picture shows a filter. Two filter media, anthracite and sand have almost flowed out and gravel under the sand layer can be observed. Even though there are almost no filter media, operation of the filter has been continued. The reason that the filter media flowed out is thought not only single reason, but some reasons mentioned above have been combined in this case. It's also thought that there are no periodical check and maintenance system in the waterworks. Using larger particle size of filter media would enable to make filter running time longer, so that larger amount of filtrate can be obtained. However, as imagined easily, using larger size media may reduce effectiveness of turbid mater's capturing and it is possible to compensate by increasing a filter media depth (L). This relation is explained as the ratio of depth of filter media to particle size of media (L/d). So far, several coefficients, which are thought to be enough for filter function, have been proposed. There are some different coefficients (L/d), because different parameters of particle size (d) have been adopted in the proposed equations. Detail information may be obtained from the references of 1)-6). It is said that as the filter media depth, at least 1000 times of the effective size of filter media would be necessary. (e.g. an effective diameter is 0.6 mm, more than 60 cm of filter media depth is necessary.)

Flow Out of Filter Media: When filter washing condition is not adequate and washing rate is too high, it causes the loss of filter media. Even if filter washing condition is adequately set as the designed condition, in the case that the media size is smaller than

the designed size, it also causes the loss of media. In this case, confirming a size of filter media by sieving test is important. “Japan Water Works Association Standard” (JWWA A 103: 2006-2 Filter media for water works) provides the standards of the physical properties of filter media, such as effective size, uniformity coefficient, etc. and their testing methods. Filter media (particle size, specific gravity) and wash condition, especially backwash condition, have subtle relationship extremely, and keeping the relationship in good is to keep adequate function of a filter. It is desirable for staff in charge of water treatment operation to understand these key issues.

*d10:effective size: the filter media particle diameter of passage weight percentage 10% in the sieving test. It is used widely as representative size of the media.

* d60/d10: uniformity coefficient: an index showing the degree of uniformity of a particle size distribution. (d60: the filter media particle diameter of passage

weight percentage 60% in the sieving test).

References

1) :The Design Criteria for Waterworks Facilities 2012, pp.215-217、 Japan Water Works Association, (2012)

2) Water Quality and Treatment, p.8,20, McGraw-Hill INC., (1999)

3) Integrated Design and Operation of Water Treatment Facilities, Wiley, (1991)

4) K. Fujita, Journal of JWWA, No.485, pp.2-14, (1975)

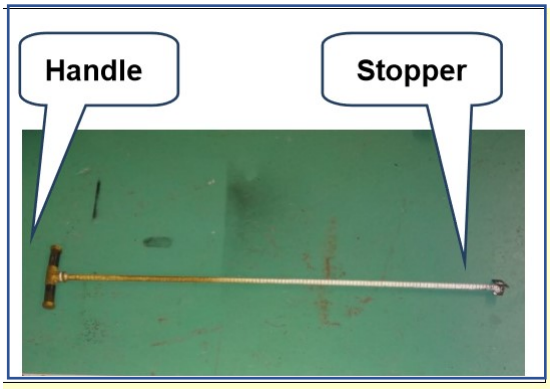
5) Filtration + Separation. Com; http://www.filtsep.com/view/29675/granular-filter-media-evaluating-filter-bed-depth-to-grain-size-ratio/

6) Filter Operations and Performance, Marvin Gnagy, Ohio Section AWWA SDWA Seminar, November 4, 2013, p.19;

(Answerer Mr. TERASHIMA Katsuhiko, Osaka City Waterworks Bureau, O.B, 2016)

A2: I would like to mention about the concrete maintenance of rapid sand filter from my experience. Ability of filter is determined by sand layer depth and sand diameter (effective size). In order to get sufficient ability, the depth of layer needs more than 1,000 times of effective size. Commonly the sand whose effective size is 1.0mm and whose uniformity

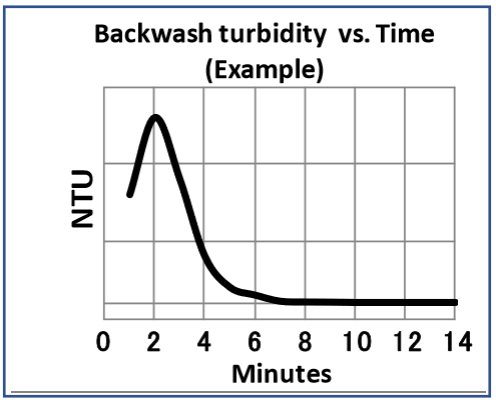
coefficient is 1.4 -1.6 is used as a filter media in Southeast Asia. When the diameter of sand is 1.0mm, required minimum depth is 1,000mm. During backwashing, a very little sand flow out from filter basin, so the depth of sand layer usually decreases a little bit gradually. But the decreasing rate is very small under appropriate backwashing. The depth of sand layer should be measured periodically at least once a year and when the depth is less than minimum standard (effective size multiply 1,000), sand should be refilled. Commonly, sand is refilled with around 15% excess of minimum standard. The specification report from the sand supplier should be checked before refilling. 1.5m iron bar with scale marked is used for measuring the depth of sand layer. Stopper plate and handle are welded. This tool is easily prepared at water treatment plant.



When the decrease is pretty large, check **the backwash water rate.** Too much backwash water makes much sand flow out, so it should be adjusted to appropriate rate according to designed specification. When air source is used together with backwash water, possibility of sand flow out becomes higher. When sand flow out is still much even after adjusting backwash water rate, separating air from backwash is one of the options to stop sand flowing out.

For reference, the backwash water rate is 0.6-0.9m^3/min/m_2 in Japanese standard. Another important parameter of backwash is **washing time**. Too long backwash time wastes clean water for backwash. Appropriate backwash time can be known by checking the graph of the backwash water turbidity versus the backwash time. Sample the backwash water at 1-minute Interval. Measure the turbidity and make the graph of the backwash turbidity versus the time. For example, in the next graph, appropriate backwash time is around 8 minutes.

Sampling of backwash water at 1minute interval



One more important maintenance work of filter is the checking of floc retention on the sand grain after backwashing. Most of adhered floc is washed away by backwashing but small amount of floc is retained. Floc retention is one of indicator to know the condition of sand layer (effectiveness of backwash). Sample should be taken from some points of depth of sand layer after backwash and draining. Digging sand layer and taking sample from each depth point is one sampling method. Using coring pipe is other easier method to take such samples. Electrical conduit of around 40mm in diameter and having scale marked is good for coring. Measuring method of **floc retention (turbidity of wash water)** in JWWA is as follows.

- Dry sampled sand naturally.
- Weigh 30mg of dried sand and put it into 500ml reagent bottle.
- Add 300ml of clean water and plug it.
- Shake it 150 times for 1 minute with 15cm stroke.
- Leave 3 minutes.
- Put 150ml of upper part into another bottle.
- Measure the turbidity of this wash water.
- Less than 30mg/l (Japanese turbidity unit) is standard, this number is around 50 in NTU.

When solid retention is more than 50NTU, increase the frequency of backwash.

When solid retention is very large such as more than 100NTU, reevaluate backwash procedure. The parameters which should be reevaluated are

1) backwash water rate,

2) time and

3) the mixing of air and backwash water. After reevaluating, periodical measurement of floc retention is desirable. Frequent refilling and a lot of backwashing during many years' filter operation may change the effective size and the uniformity coefficient of sand. So the analysis of sand is recommended in every 5~10 years. When the result is very

different from the original (designed specification),

rehabilitation should be considered. If you do not have the equipment for sand analysis, outsourcing to a sand supplier or a laboratory is one of the options.

Finally, I would like to mention my idea about clogging of filter to questioner. He said filter media flowing out so often. It means that small grain of filter media has been lost a lot already. Therefore, I think cause of filter clogging (head loss increased in short time) comes not from filter media, it comes from insufficient coagulation and flocculation. A lot of unsettled floc flows into the filter basin and makes clogging. Therefore, appropriate dosing rate of coagulant (alum) is very important and this can be confirmed by jar test and observation of flocculation in actual process. One more cause of filter clogging is propagation of some kind of algae (e.g. *synedra acus*) in raw water. It is very difficult to coagulate and settle *synedra acus*. When this happened, frequent backwash is required**.**

(Answerer: Mr. KAGATA Katsutoshi, Kitakyushu City Water and Sewer Bureau, O.B, 2016)