# INCORPORATING FILTER BED EXPANSION MEASUREMENTS INTO YOUR BACKWASHING ROUTINE

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**Abstract**

Adequate filter bed expansion is critical to achieving an effective filter backwash. While this is a simple and well-known concept, many filter plant operators have not been able to effectively incorporate bed expansion measurements into a filter backwash routine. Accomplishing this task can be cumbersome, unless proper equipment, techniques, and guidance are provided. During Pennsylvania's 14-year history of conducting over 1,000 detailed Filter Plant Performance Evaluations at 340 filter plants, Pennsylvania Department of Environmental Protection (DEP) staff have had the opportunity to perform countless filter bed expansion measurements. Over the years, DEP staff have observed common performance trends and have refined expansion measurement techniques to gather information that can be readily applied to operators across the country. These experiences have enabled DEP staff to devise an inexpensive and easy-to-construct device to measure bed expansion. The authors will share the innovative construction and measurement techniques in their research paper, with the goal of enabling filter plant operators to routinely conduct efficient bed expansion measurements.

**Introduction**

According to the AWWA Research Foundation Filter Maintenance and Operations Guidance Manual, bed expansion can be defined as the effect produced during backwashing when the filter media becomes separated and rises [1]. It is usually expressed as a percentage increase of bed depth. While this is a simple concept, effectively incorporating this measurement into your filter backwash routine requires some preparation.

During Pennsylvania's 14-year history of conducting detailed Filter Plant Performance Evaluations (FPPE's) at 340 filter plants, the authors have had the opportunity to perform countless filter bed expansion measurements. Over the years, the authors have seen some common performance trends and refined their expansion measurement techniques to allow for efficient gathering of useable information. The authors would like to share these experiences with water treatment plant operators and others in the water industry.

DEP staff have recorded filter bed expansion results that were collected from plants throughout Pennsylvania. In this paper, the authors place each plant into one of four criteria based on their filter bed expansion. The total number of plants in each criteria provides information on the percentage of filter plants that achieved various levels of filter bed expansion. Filter bed expansion results are also looked at region by region to determine if plants in different parts of the state are achieving different levels of filter bed expansion. In addition, acid-solubility results of filter media samples were collected at plants throughout Pennsylvania. The authors will show that plants, which develop acid-soluble coatings (e.g. calcium carbonate, manganese dioxide, etc), on filter media may be at a higher risk of having low filter bed expansion.

Throughout this paper, the authors use their findings to demonstrate the importance of measuring and recording filter bed expansion, establishing filter bed expansion goals, and adjusting backwash flow rates to achieve those goals. The authors believe this is critical in order to optimize the backwashing of rapid rate filters throughout changing water conditions.

**Why measure filter bed expansion?**

One common trend has been evident among rapid rate filters. Inadequate filter bed expansion eventually contributes to poor filter performance and reduced finished water quality. In general, if the filter is not sufficiently expanded during the backwash, it will not become sufficiently cleaned. This can lead to numerous problems including poor post-backwash recovery, sensitivity to hydraulic surges during flow changes, shortened filter run times, and eventually mud ball formation. All of which can increase the likelihood of breakthrough of waterborne disease-causing organisms. Therefore, the authors' experiences have indicated that proper filter bed expansion is a very important operational parameter to consider.

Unfortunately, the importance of filter bed expansion is often overlooked. There can be many reasons why this occurs. One common pitfall is that operators rely upon visual observation of the clarity of the water over the filter towards the end of the wash as a means of determining the effectiveness of the backwash procedure. While this is definitely a good practice, the authors feel this information alone may provide an incomplete picture of what is occurring within your filter bed.

For example, if backwash rates are too low, the filter bed may not expand adequately. The backwash water could short circuit through parts of the filter and could bypass other parts leaving dirt trapped within. These areas of trapped dirt are known as dead spots. As a result, the operator could observe relatively low turbidity water over the filter towards the end of the wash even though dirt is still trapped in dead spots. This is because the lack of bed expansion prevents the media from fluidizing. Fluidizing the media allows the grains of media to move and bump against each other. This creates a scrubbing action that releases the dirt from the media. However, if the filter bed is not expanded and the media is not fluidized, the dirt stays in the filter and does not show up as dirty water over the filter. In this case, an operator would incorrectly think that the filter is clean. Verifying adequate filter bed expansion in addition to the visual observation should prevent this scenario from occurring. The combination of this information can give you a much better idea of the effectiveness of your filter backwash.

The only way to know if you have sufficient bed expansion is to perform your own measurements. The next several pages will provide you with information on how to easily incorporate filter bed expansion measurements into your operational routine. If you are already measuring bed expansion, you may find this information helpful in refining your existing techniques.

**Constructing an inexpensive bed expansion tool**

Before bed expansion can be measured, a measuring device is needed. Through field-testing at hundreds of filter plants, the authors developed a bed expansion tool that is relatively inexpensive and easy to make and use. This tool requires an investment of about $15.00, and one hour of effort to assemble.

Most necessary items can be purchased at a local hardware store or home improvement warehouse. Items include:

- Telescopic (extendable) paint pole (4' to 6' closed length)
- White plastic disk 10" in diameter; bottom of a 5 gallon bucket works well
- Metal Washer
- Snap Pin
- Two O-rings (optional, used to mark the location on the pole)

Figure 1. Bed expansion tool before assembly (left) and after assembly (right).

Once the necessary items have been obtained, the next step is assembly. Please reference Figure 1 for a visual. Preparation of the white disk requires the most effort. White PVC sheeting (similar to plywood) can be purchased at specialty stores and cut to shape with the proper saw. This can be expensive. To reduce cost, it is suggested that the bottom of a white 5-gallon plastic bucket be used for the disk.

Carefully cut out the bottom of the bucket. This can be kept circular or cut in half. Cutting the disc in half creates a straight edge, this allows for ease of contact with filter walls, backwash troughs, etc. Once the disk has been cut, it is necessary to drill or cut a hole in the center of the disk that is the same diameter (or slightly larger) than the threaded end of the telescopic paint pole. Next, slide the disk onto the threaded end of the pole. Make a mark on the threaded plastic of the pole, just below the disk. Remove the disk and drill a small hole (perpendicular to the pole and just big enough to allow insertion of the snap pin) through the threaded plastic of the pole. Slide the disc back on the pole, next add the washer, then insert the cotter snap pin through the hole below the washer. If the disk does not fit snugly on the pole, you may want to add an additional washer.

The next step is to mark the closed pole handle with measurements. It is suggested that you mark about 36 inches on the pole. Transferring the measurements from a yardstick to the pole using a permanent marker can suffice. Or, as in Figure 1, you may want to add a self-adhesive strip with pre-marked measurements. This is much easier. For best results, use waterproof/laminated sticker material. An optional item that saves time is to slip two O-rings onto the closed pole handle. See Figure 2. These should fit snugly, and can be rolled to help mark measurements.

**Measuring bed expansion**

To use the bed expansion tool, follow these steps:

Warning! Always be sure to follow safety precautions when working around a filter.

1) Extend the telescopic pole until it is of sufficient length to easily reach the top of the filter media and still be safely grasped from a standing or kneeling position above.
2) To record the resting bed measurement, measure the top of the filter bed at rest (normal operation, before backwashing). Lower the expansion tool into the filter until the bottom of the disk touches the media surface. From a fixed location, record the reading, or slide an O-ring to mark the measurement. It's best to use a straight edge to find your measurement as demonstrated in Figure 2.
3) To record the expanded bed measurement, measure the top of the filter during the high rate wash from the same fixed location. Lower the expansion tool into the filter until you can just start to see filter media coming over the white disk. Hold the expansion tool steady and record the reading, or slide an O-ring to mark the measurement.
4) Inches of bed expansion can be determined by calculating the difference of the two numbers recorded in steps 2 and 3 above. If the O-rings were used to mark your measurements, you can simply measure the distance between the O-rings. You will need this number to calculate percent bed expansion.
5) Measure total inches of expandable media depth. This would include granular activated carbon (GAC), anthracite, sand, and/or high density sand such as garnet. Do not include gravel. You will need this number to calculate percent bed expansion. The authors use a six-foot long, 0.5-inch diameter metal rod to probe to the gravel layer while the filter is drained to measure media depth. This works well for most filters that have a gravel support layer. However, you should not probe filters that contain fragile structure below the filter media such as plastic filter cones or subsurface air headers. The metal rod can easily damage them.

Helpful Hints:

1) If a filter is equipped with surface wash, do not try to measure bed expansion while the surface wash arms are moving.
2) You should always measure bed expansion during the high-rate wash. It's usually easiest to see the disk during the last few minutes of the high-rate wash.
3) Bed expansion will change as temperatures change. Therefore, you should collect bed expansion measurements at least seasonally.
4) Use of a high power cordless spotlight can help you see the white disk while measuring the expanded bed.
5) Use a straight edge from a fixed location to the expansion pole to take your measurements. Use the same fixed location for both the resting and expanded bed measurements.
6) Do not collapse your bed expansion pole between the resting and expanded bed measurements. This can significantly affect your measurements.
7) Measure bed expansion in a few different locations within the filter. Measuring various locations can provide you with a better understanding of the distribution and effectiveness of the backwash.
8) Expandable media depth includes depth of GAC, anthracite, sand, and/or high density sand such as garnet. It does not include gravel.
9) Use caution when adjusting backwash rates. Gradual ramping is recommended.

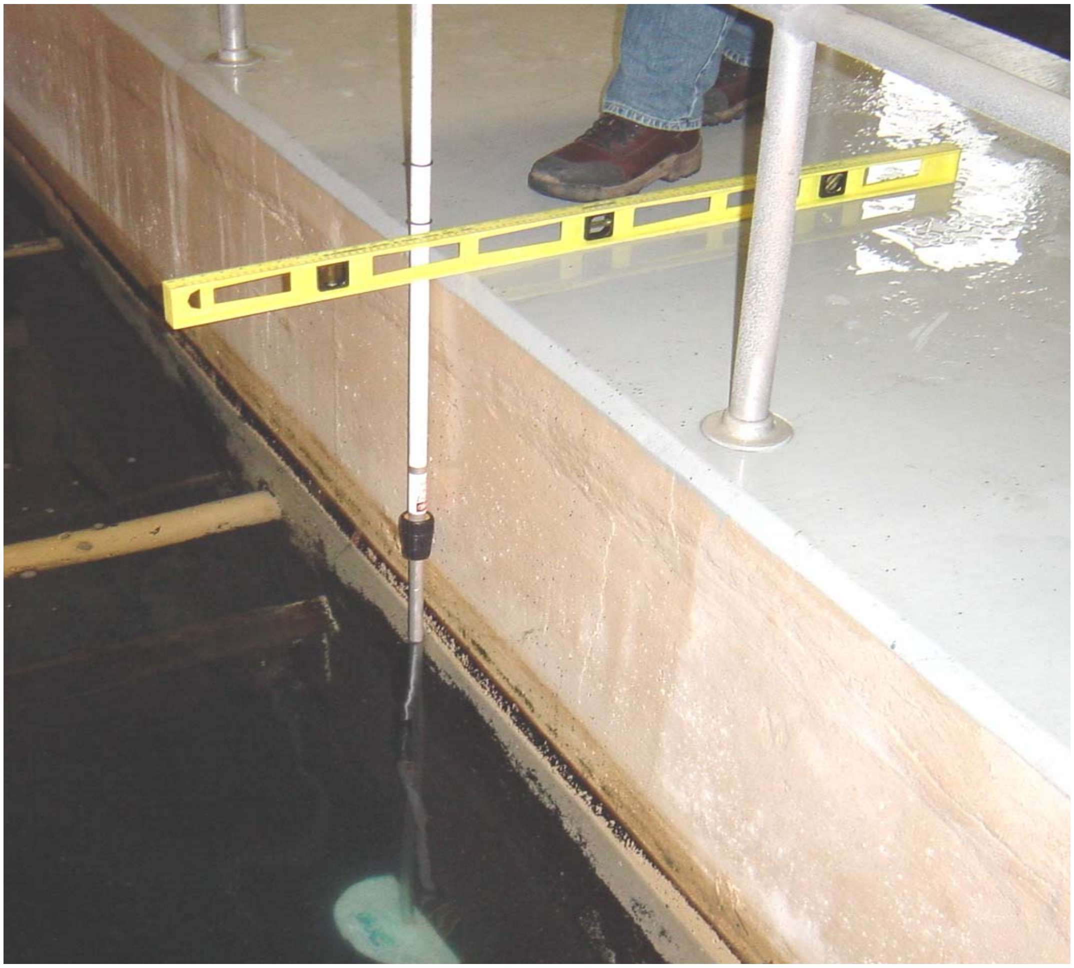

Figure 2. Using a straight edge and a fixed location to record bed expansion measurements. This photo also illustrates the use of the o-rings to record each measurement.

**Advantages Over Other Devices**

Many types of expansion measuring devices exist, most of which are fixed to a particular area of the filter. One major advantage of the authors' measuring device is its portability. Plant personnel can easily move the device from filter to filter and with practice, take several measurements within a particular filter. Use of the telescopic pole increases ease of use and portability. Operators can also check for filter media loss by watching for the filter media to pass over the white disk as the backwash water enters the backwash trough. This is demonstrated in Figure 3.

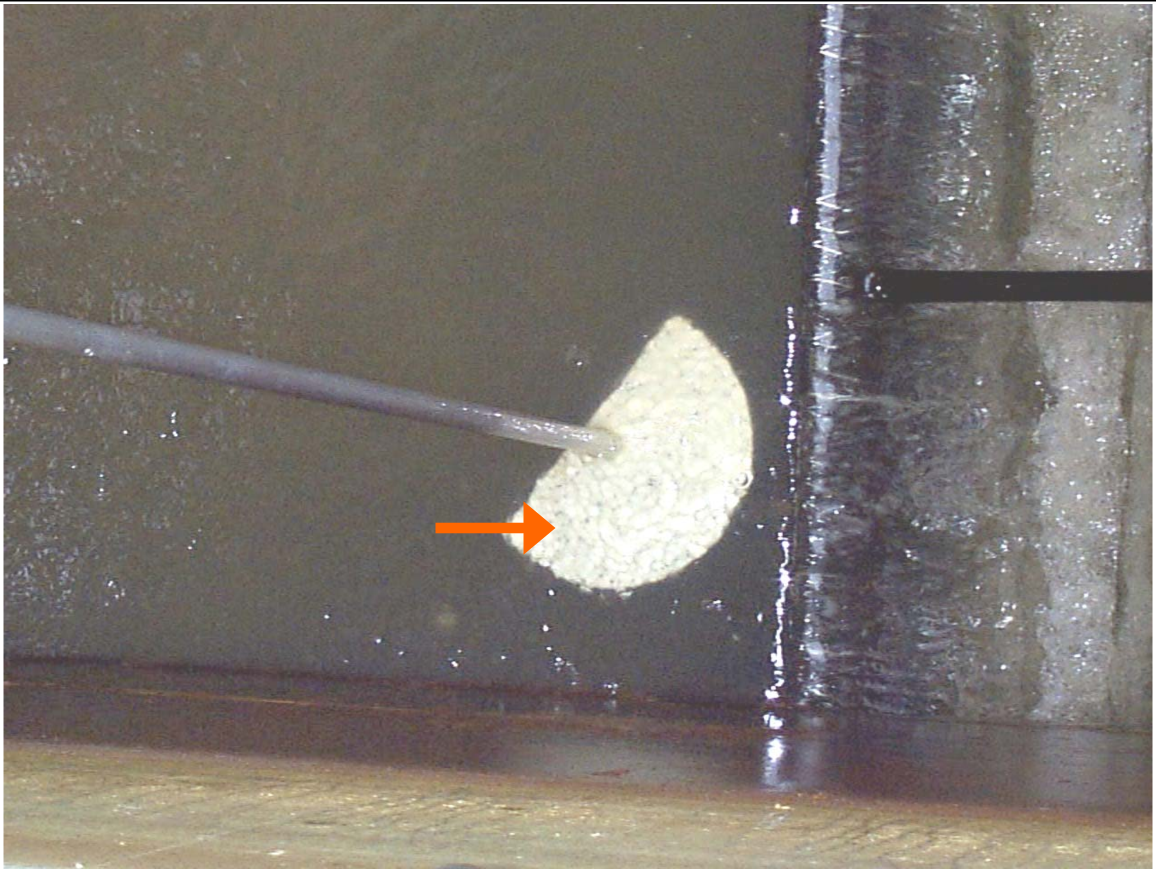

Figure 3. Checking for media loss. The red arrow points to anthracite media grains entering the waste trough during the high rate wash.

**How to calculate percent bed expansion?**

The most widely used comparison of filter bed expansion is "percent filter bed expansion". Therefore, for the most meaningful interpretation, you should standardize your measurement into a percentage. Use the following equation to calculate percent bed expansion:

$$\frac{\text{Inches of Bed Expansion}}{\text{Inches of Expandable Media}} \times 100 = \text{Percent Bed Expansion}$$

To facilitate this process, the authors prepared a bed expansion table. Please see Table 1, "Percent Bed Expansion Table." This table can be conveniently used while at the filter plant; no calculator is needed. To use this table, find inches of bed expansion at the top of the table and inches of total media depth at the left side of the table. Then follow the column down and the row across. You will find the percent bed expansion in the box where the column and row meet.

Compare your results with your filter bed expansion goal. If necessary, adjust the backwash rate in order to meet your goal. It is important to record the temperature of the water and the backwash rate that is used to accomplish your bed expansion goal.

This information will be needed to create a bed expansion chart, which will be discussed on page 11.

**PERCENT BED EXPANSION TABLE**

| | BED EXPANSION IN INCHES | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXPANDABLE MEDIA DEPTH IN INCHES | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 12 | 17% | 25% | 33% | 42% | 50% | 58% | 67% | 75% | 83% | 92% | 100% | 108% | 117% | 125% | 133% | 142% |
| 13 | 15% | 23% | 31% | 38% | 46% | 54% | 62% | 69% | 77% | 85% | 92% | 100% | 108% | 115% | 123% | 131% |
| 14 | 14% | 21% | 29% | 36% | 43% | 50% | 57% | 64% | 71% | 79% | 86% | 93% | 100% | 107% | 114% | 121% |
| 15 | 13% | 20% | 27% | 33% | 40% | 47% | 53% | 60% | 67% | 73% | 80% | 87% | 93% | 100% | 107% | 113% |
| 16 | 13% | 19% | 25% | 31% | 38% | 44% | 50% | 56% | 63% | 69% | 75% | 81% | 88% | 94% | 100% | 106% |
| 17 | 12% | 18% | 24% | 29% | 35% | 41% | 47% | 53% | 59% | 65% | 71% | 76% | 82% | 88% | 94% | 100% |
| 18 | 11% | 17% | 22% | 28% | 33% | 39% | 44% | 50% | 56% | 61% | 67% | 72% | 78% | 83% | 89% | 94% |
| 19 | 11% | 16% | 21% | 26% | 32% | 37% | 42% | 47% | 53% | 58% | 63% | 68% | 74% | 79% | 84% | 89% |
| 20 | 10% | 15% | 20% | 25% | 30% | 35% | 40% | 45% | 50% | 55% | 60% | 65% | 70% | 75% | 80% | 85% |
| 21 | 10% | 14% | 19% | 24% | 29% | 33% | 38% | 43% | 48% | 52% | 57% | 62% | 67% | 71% | 76% | 81% |
| 22 | 9% | 14% | 18% | 23% | 27% | 32% | 36% | 41% | 45% | 50% | 55% | 59% | 64% | 68% | 73% | 77% |
| 23 | 9% | 13% | 17% | 22% | 26% | 30% | 35% | 39% | 43% | 48% | 52% | 57% | 61% | 65% | 70% | 74% |
| 24 | 8% | 13% | 17% | 21% | 25% | 29% | 33% | 38% | 42% | 46% | 50% | 54% | 58% | 63% | 67% | 71% |
| 25 | 8% | 12% | 16% | 20% | 24% | 28% | 32% | 36% | 40% | 44% | 48% | 52% | 56% | 60% | 64% | 68% |
| 26 | 8% | 12% | 15% | 19% | 23% | 27% | 31% | 35% | 38% | 42% | 46% | 50% | 54% | 58% | 62% | 65% |
| 27 | 7% | 11% | 15% | 19% | 22% | 26% | 30% | 33% | 37% | 41% | 44% | 48% | 52% | 56% | 59% | 63% |
| 28 | 7% | 11% | 14% | 18% | 21% | 25% | 29% | 32% | 36% | 39% | 43% | 46% | 50% | 54% | 57% | 61% |
| 29 | 7% | 10% | 14% | 17% | 21% | 24% | 28% | 31% | 34% | 38% | 41% | 45% | 48% | 52% | 55% | 59% |
| 30 | 7% | 10% | 13% | 17% | 20% | 23% | 27% | 30% | 33% | 37% | 40% | 43% | 47% | 50% | 53% | 57% |
| 31 | 6% | 10% | 13% | 16% | 19% | 23% | 26% | 29% | 32% | 35% | 39% | 42% | 45% | 48% | 52% | 55% |
| 32 | 6% | 9% | 13% | 16% | 19% | 22% | 25% | 28% | 31% | 34% | 38% | 41% | 44% | 47% | 50% | 53% |
| 33 | 6% | 9% | 12% | 15% | 18% | 21% | 24% | 27% | 30% | 33% | 36% | 39% | 42% | 45% | 48% | 52% |
| 34 | 6% | 9% | 12% | 15% | 18% | 21% | 24% | 26% | 29% | 32% | 35% | 38% | 41% | 44% | 47% | 50% |
| 35 | 6% | 9% | 11% | 14% | 17% | 20% | 23% | 26% | 29% | 31% | 34% | 37% | 40% | 43% | 46% | 49% |
| 36 | 6% | 8% | 11% | 14% | 17% | 19% | 22% | 25% | 28% | 31% | 33% | 36% | 39% | 42% | 44% | 47% |
| 37 | 5% | 8% | 11% | 14% | 16% | 19% | 22% | 24% | 27% | 30% | 32% | 35% | 38% | 41% | 43% | 46% |
| 38 | 5% | 8% | 11% | 13% | 16% | 18% | 21% | 24% | 26% | 29% | 32% | 34% | 37% | 39% | 42% | 45% |
| 39 | 5% | 8% | 10% | 13% | 15% | 18% | 21% | 23% | 26% | 28% | 31% | 33% | 36% | 38% | 41% | 44% |
| 40 | 5% | 8% | 10% | 13% | 15% | 18% | 20% | 23% | 25% | 28% | 30% | 33% | 35% | 38% | 40% | 43% |
| 41 | 5% | 7% | 10% | 12% | 15% | 17% | 20% | 22% | 24% | 27% | 29% | 32% | 34% | 37% | 39% | 41% |
| 42 | 5% | 7% | 10% | 12% | 14% | 17% | 19% | 21% | 24% | 26% | 29% | 31% | 33% | 36% | 38% | 40% |
| 43 | 5% | 7% | 9% | 12% | 14% | 16% | 19% | 21% | 23% | 26% | 28% | 30% | 33% | 35% | 37% | 40% |
| 44 | 5% | 7% | 9% | 11% | 14% | 16% | 18% | 20% | 23% | 25% | 27% | 30% | 32% | 34% | 36% | 39% |
| 45 | 4% | 7% | 9% | 11% | 13% | 16% | 18% | 20% | 22% | 24% | 27% | 29% | 31% | 33% | 36% | 38% |
| 46 | 4% | 7% | 9% | 11% | 13% | 15% | 17% | 20% | 22% | 24% | 26% | 28% | 30% | 33% | 35% | 37% |
| 47 | 4% | 6% | 9% | 11% | 13% | 15% | 17% | 19% | 21% | 23% | 26% | 28% | 30% | 32% | 34% | 36% |
| 48 | 4% | 6% | 8% | 10% | 13% | 15% | 17% | 19% | 21% | 23% | 25% | 27% | 29% | 31% | 33% | 35% |
| 49 | 4% | 6% | 8% | 10% | 12% | 14% | 16% | 18% | 20% | 22% | 24% | 27% | 29% | 31% | 33% | 35% |
| 50 | 4% | 6% | 8% | 10% | 12% | 14% | 16% | 18% | 20% | 22% | 24% | 26% | 28% | 30% | 32% | 34% |
| 51 | 4% | 6% | 8% | 10% | 12% | 14% | 16% | 18% | 20% | 22% | 24% | 25% | 27% | 29% | 31% | 33% |
| 52 | 4% | 6% | 8% | 10% | 12% | 13% | 15% | 17% | 19% | 21% | 23% | 25% | 27% | 29% | 31% | 33% |
| 53 | 4% | 6% | 8% | 9% | 11% | 13% | 15% | 17% | 19% | 21% | 23% | 25% | 26% | 28% | 30% | 32% |
| 54 | 4% | 6% | 7% | 9% | 11% | 13% | 15% | 17% | 19% | 20% | 22% | 24% | 26% | 28% | 30% | 31% |
| 55 | 4% | 5% | 7% | 9% | 11% | 13% | 15% | 16% | 18% | 20% | 22% | 24% | 25% | 27% | 29% | 31% |
| 56 | 4% | 5% | 7% | 9% | 11% | 13% | 14% | 16% | 18% | 20% | 21% | 23% | 25% | 27% | 29% | 30% |
| 57 | 4% | 5% | 7% | 9% | 11% | 12% | 14% | 16% | 18% | 19% | 21% | 23% | 25% | 26% | 28% | 30% |
| 58 | 3% | 5% | 7% | 9% | 10% | 12% | 14% | 16% | 17% | 19% | 21% | 22% | 24% | 26% | 28% | 29% |
| 59 | 3% | 5% | 7% | 8% | 10% | 12% | 14% | 15% | 17% | 19% | 20% | 22% | 24% | 25% | 27% | 29% |
| 60 | 3% | 5% | 7% | 8% | 10% | 12% | 13% | 15% | 17% | 18% | 20% | 22% | 23% | 25% | 27% | 28% |

Table 1. Percent Bed Expansion Table.

**How much bed expansion is enough?**

You've made a tool and you've gathered some data. How do you interpret your results? As with other operational parameters, it is best to establish a goal for filter bed expansion. While the exact goal can vary slightly due to filter design, overall we've found that 20% is a good goal for most plants. Plants that perform best seem to meet or exceed this goal. As bed expansion begins to drop below the 20% range, the effectiveness of the backwash seems to decline. Less than 15% bed expansion will likely cause inadequate cleaning of the filter. Signs of inadequate bed expansion usually begin with light mud ball formation on the surface of the filter bed. Light mud balls mostly consist of pretreatment chemicals; they feel "spongy" to the touch. Severe signs of inadequate cleaning may show presence of heavy or dense mud balls. These mud balls consist mostly of clay-sized particles and are more rigid to the touch. Very severe signs of inadequate cleaning may show cracking of the filter bed and/or separation between the wall and the filter bed. Cracking and separation usually occurs when the filter bed becomes caked with mud. This also indicates that the filter bed is not being backwashed at a rate high enough to fluidize the filter media. The authors have found the percent bed expansion specifications from page 58 of the *AWWARF Self Assessment Guide for Surface Water Treatment Plant Optimization* to mirror our experiences.

**Charting Bed Expansion Data**

Filter bed expansion should be measured frequently enough to capture changes in water temperature. Different backwash rates will be needed at different water temperatures. Cold water has a higher viscosity than warm water. Imagine dropping filter media in cold maple syrup versus warm maple syrup. Gravity tends to have less of an effect on the media in the cold syrup. The media stays suspended for a longer period of time. This effect is similar with filter backwashing. With the backwash rate staying the same you will get a higher percent bed expansion during cold water temperatures than during warm. As a result, backwash rates will need to be decreased as water temperatures decrease and increased as water temperatures increase. Plants that do not change their backwash rates seasonally may be at a higher risk of losing filter media during the winter and forming mud balls during the summer.

Operators can create a chart by plotting temperature (Y-axis) vs. backwash rate (X-axis). This data needs to be collected during various temperatures and backwash rates that meet your bed expansion goal. Please see Figure 4 for an example of how a bed expansion chart may look. A bed expansion chart could be used to predict the backwash rate needed to meet the operators' bed expansion goal based on temperature. For example, in Figure 4, if the temperature of the water were 8 degrees Celsius, you would find 8 degrees Celsius on the Y-axis. Then you would follow the gridline across until you get to the line plotted in red. From the red line you would follow the gridline down to the X-axis to read the estimated backwash rate that would be needed to achieve 20 percent bed expansion. In this example the backwash rate would be 17 gallons per minute (GPM)/square foot (sq. ft.). Operators at different plants would need to create their own bed expansion chart because of differences in filter design and filter media specifications. Separate charts may be needed for each filter within a plant if the filters are designed differently. Figure 4 is a general example and is not intended to be applied to other filters. Expansion charts must be created using data collected from the filter for which you intend to use the chart.

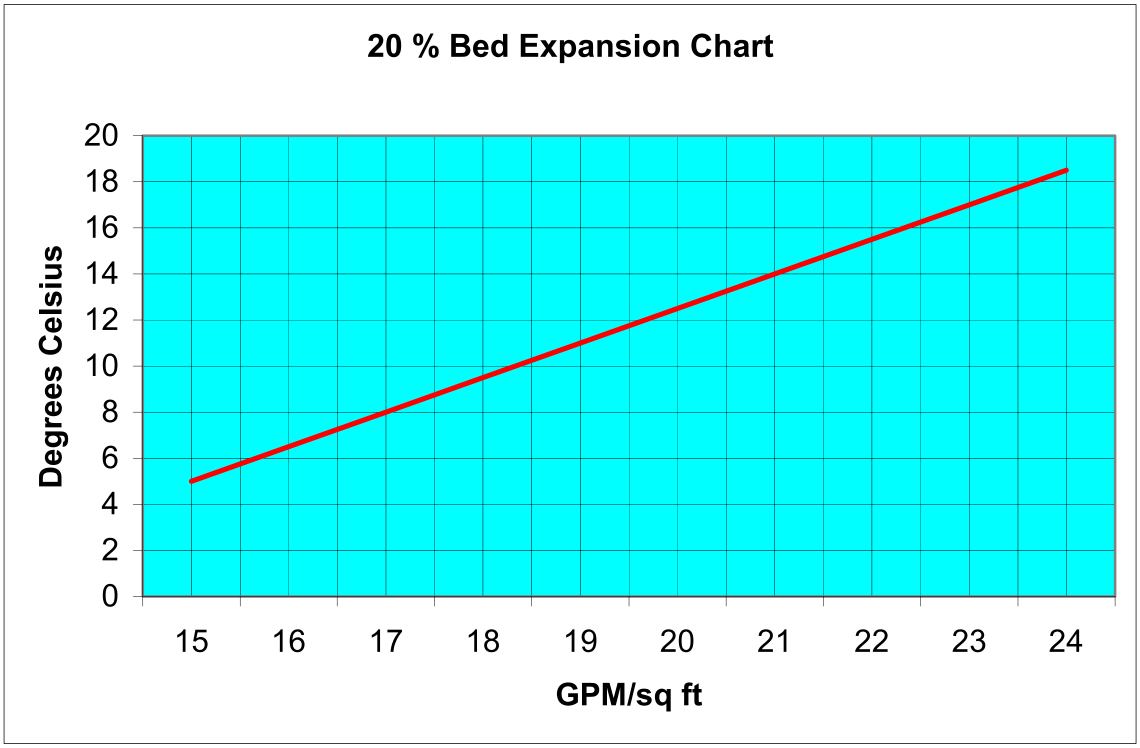


Figure 4. Example Bed Expansion Chart

**Bed Expansion Results from Plants in Pennsylvania**

During July 1, 1999 to June 30, 2003, the authors and regional FPPE staff collected filter bed expansion measurements at 147 filter plants in Pennsylvania. The percent filter bed expansion was recorded for each plant. Then each plant was placed in one of four categories based on their filter bed expansion. As seen in Figure 5 below, 52 plants had bed expansion measurements of >20%, 22 plants had bed expansion measurements of 15% to <20%, 32 plants had bed expansion measurements of 10% to <15%, and 41 plants had bed expansion measurements <10%.

Figure 5 shows that 52 of the 147 filter plants evaluated in Pennsylvania met the 20% filter bed expansion goal. This suggests that 35% of the plants evaluated are achieving optimal filter bed expansion. However, 65% of the plants do not appear to be achieving optimal bed expansion. This reinforces the need to monitor filter bed expansion routinely and make adjustments to backwash rates if needed.

Greater concern should be given for plants in the <10% filter bed expansion category. Typically severe mud balls, mounding, caking, cracking, and separation from the filter wall are filter conditions that are often seen when filter bed expansion is <10%. These conditions can significantly affect filter performance.

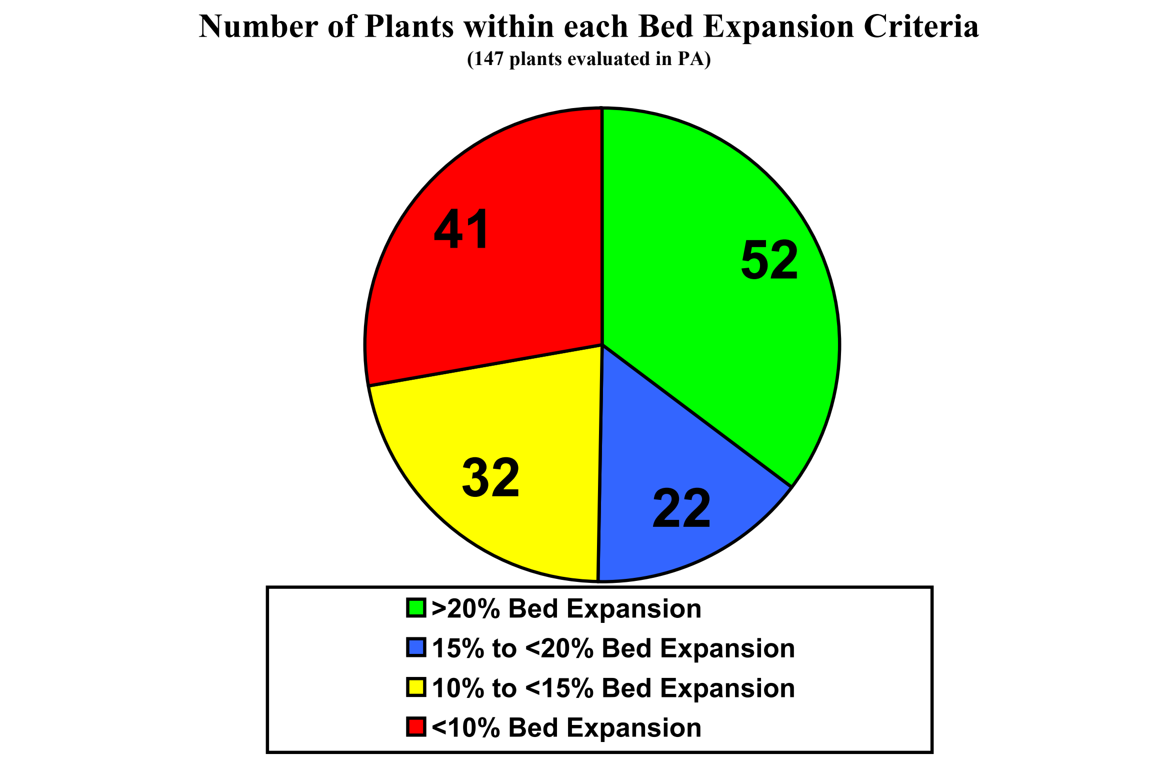


Figure 5. Number of Plants within each Bed Expansion Criteria

Figure 6 shows percentage of plants with <10% filter bed expansion for each region within Pennsylvania (Pennsylvania has six DEP regions: southwest (SW), northwest (NW), south central (SC), north central (NC), southeast (SE), and northeast (NE)). The NC region was not included in this graph, because the number of plants evaluated for filter bed expansion in the NC region was not sufficient to provide an accurate representation. This graph suggests that low bed expansion is fairly common at plants in Pennsylvania, since 27% of all plants evaluated had <10% bed expansion. In addition, the graph suggests that low bed expansion may be more common at plants in certain geographical locations within Pennsylvania. For example the SW and NW regions had a greater percentage of plants with <10% filter bed expansion than the state average.

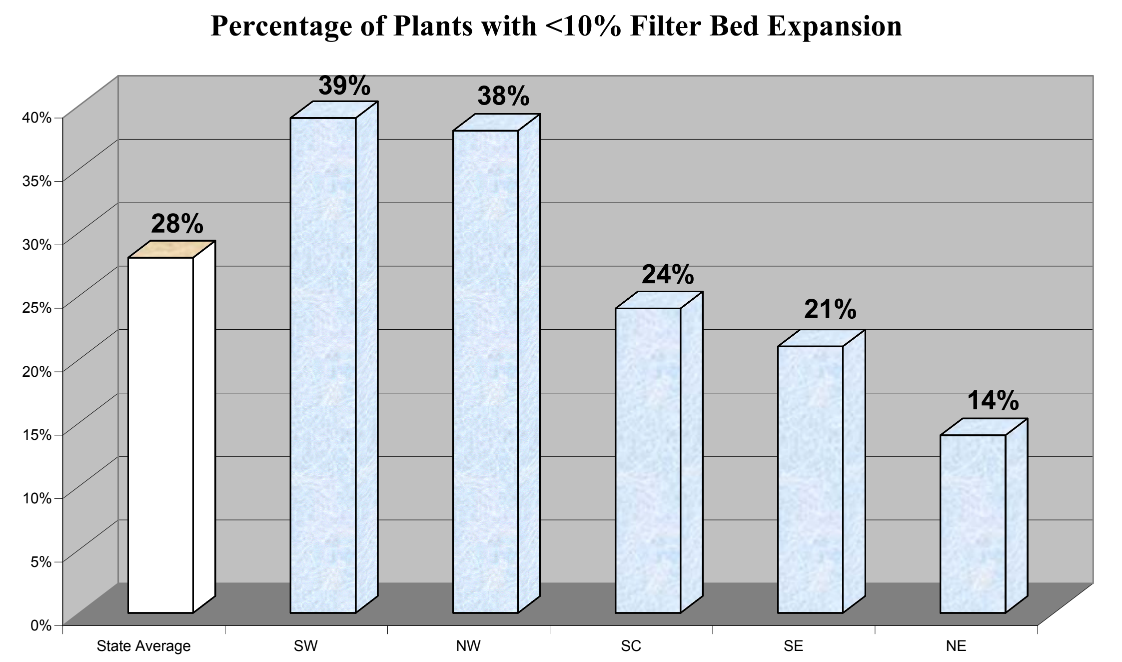


Figure 6. Percentage of Plants with <10% Filter Bed Expansion in Pennsylvania and in each region.

The authors believe that acid-soluble coatings on filter media may have an impact on filter bed expansion. Acid-soluble coatings, most notably calcium carbonate and manganese dioxide, can change the size and density of filter media making it more difficult to fluidize. In addition, acid-soluble coatings can accumulate on support gravel and under drains, which can restrict the flow of the backwash water. As a result, filter bed expansion can be reduced and filters may not be adequately cleaned.

From July 1, 1999 to June 30, 2003, 217 filter media samples were collected at filter plants in Pennsylvania and tested for acid-solubility. According to the AWWA B100-01 standard, the acid-solubility test provides a means of measuring acid-soluble minerals and other impurities [2]. AWWA B100-01 standard recommends that acid-solubility for sand and anthracite should be <5%. Figure 7 shows the percentage of media samples collected in each region with acid-solubility results >5%. Plants containing filter media with >5% acid-solubility were more common in the SW, NW, and NE regions. Note that the SW and NW regions showed a greater percentage of plants with <10% filter bed expansion (Figure 6). This data correlation supports the authors theory that acid-soluble coatings on filter media may reduce filter bed expansion.

The NE region had the highest percentage of plants with >5% acid-solubility, but the lowest percentage of plants with <10% filter bed expansion. The authors believe that the reason for this anomaly is due to the large number of new filter plants in the NE region. The newer plants seem to be designed to accommodate higher backwash rates and provide better distribution of the backwash water through the under drains. The improved designs at the newer facilities seem to counteract the impacts of the mineral coatings.

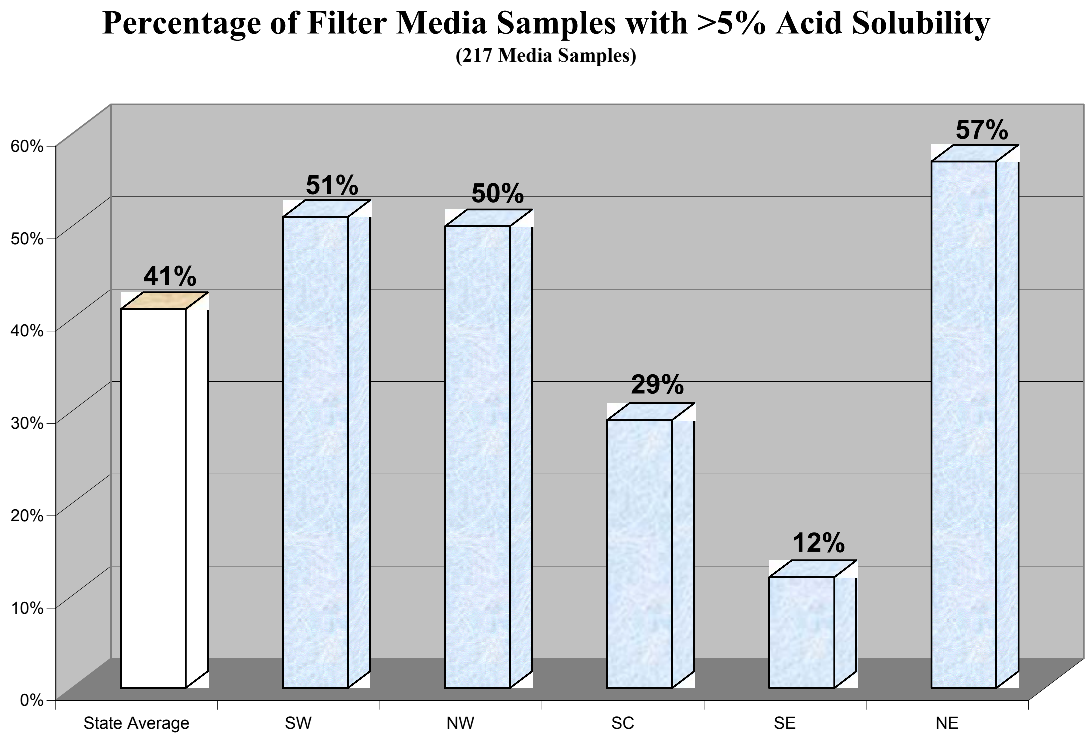


Figure 7. Percentage of Filter Media Samples with >5% Acid-Solubility within each Region

As a result of these findings, it is suggested that operators have their filter media tested for acid-solubility about once/year. If acid-solubility results are >5%, operators should be aware that mineral coatings on their filter media and under drains could reduce filter bed expansion and may affect the cleaning of their filters.

## Summary

Through analysis of filter bed expansion measurements collected at plants in Pennsylvania, readers should be aware that low filter bed expansion is a common occurrence. After reading the contents of this paper, operators should have all of the instructions needed to build a filter bed expansion tool. In addition, readers will be able to collect, record, and interpret filter bed expansion measurements at their filter plant. By trending their findings on a filter bed expansion chart, operators can determine what backwash rate produces adequate bed expansion during various water temperatures. Seasonal flow adjustments can then be made to maintain adequate filter bed expansion. As a result, filters can be adequately cleaned throughout the year. Operators that routinely measure filter bed expansion seem to be better equipped to adjust flow rates to ensure optimal backwashing, despite changing raw water temperatures. Also, filter media testing conducted in Pennsylvania, seem to indicate that acid-soluble coatings on filter media may negatively affect filter bed expansion. Therefore, operators should consider having filter media tested routinely for acid-solubility.

In conclusion, data collected by DEP staff at filter plants in Pennsylvania supports the importance of routinely measuring filter bed expansion and adjusting backwash rates.

References:

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