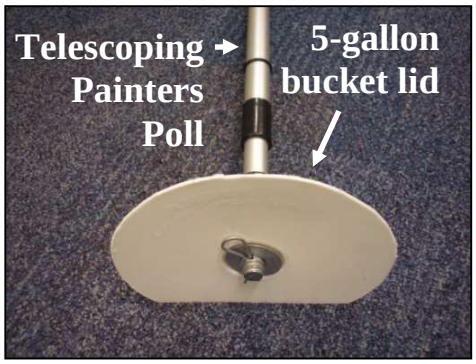
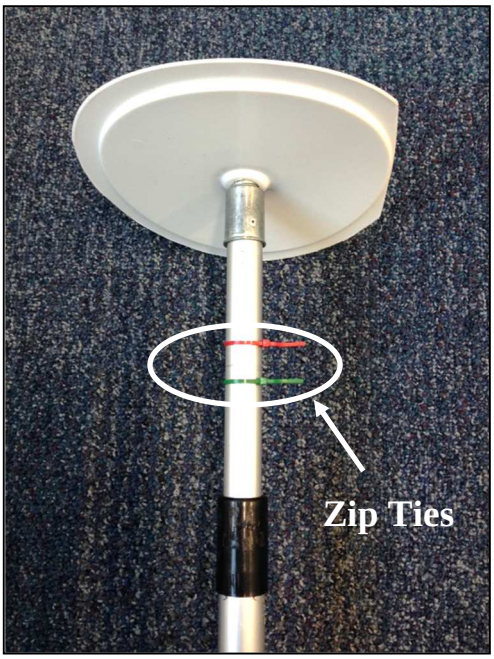
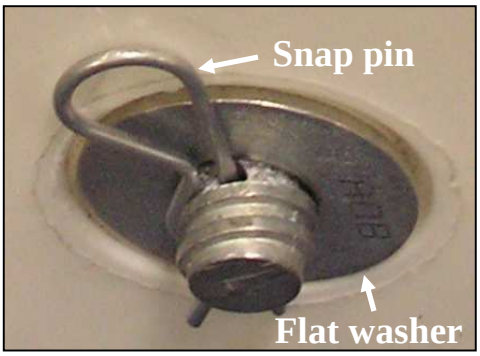
Filter Media Expansion Study

The goal of an effective backwash is to expand the media sufficiently (≥ 20%) in order to flush particulates out of the filter bed so that head loss can be restored to as near to "clean bed" specifications as possible.







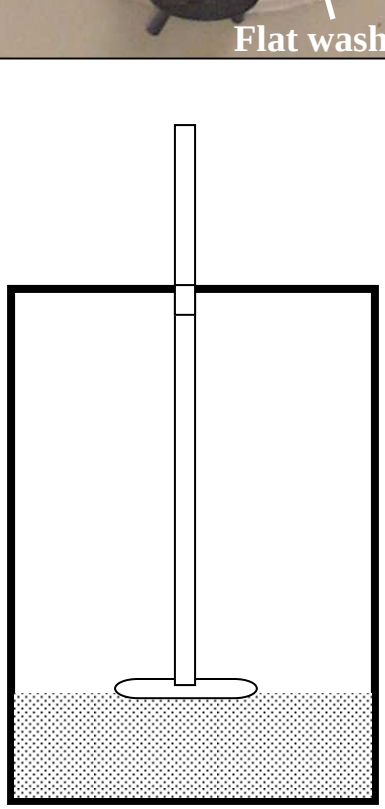
You can make a tool that assists in measuring how well the media is expanded during a backwash using the following materials:

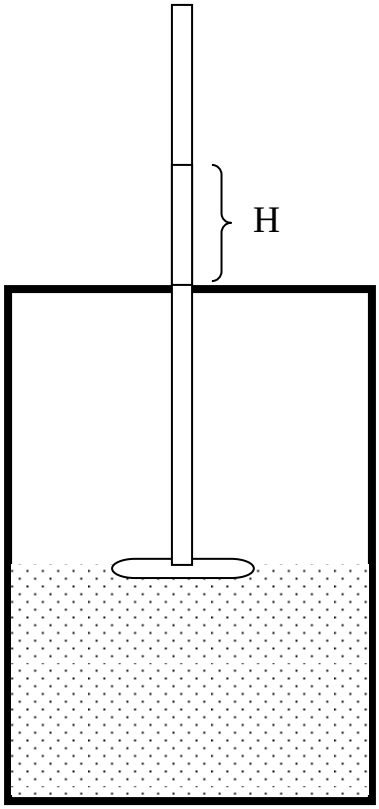
- 1 telescoping painter's pole
- 1 snap pin
- 1 flat washer
- 2 zip ties
- 1 5-gallon bucket lid

You will need to drill a hole through the threaded end of the painter's pole for the cotter key and cut the rim of the 5-gallon bucket off as shown in the pictures to the right. A flat edge allows the tool to be held close to the filter wall away from the surface wash arm.

Conduct the study as follows:

1. Turn the filter to be evaluated off.
2. Place the bed expansion tool into the filter so that the disk rests directly on top of the media.
3. Adjust the top zip tie in place so that it is even with the top of the filter wall (or other reference point) and remove the tool from the filter.
4. Begin the backwash sequence
5. Towards the end of the high rate backwash, lower the bed expansion tool into the water to the point where the disk is just above the churning media (you should only be able to see a slight amount of media occasionally floating over the bucket lid).
6. Adjust the bottom zip tie so that it is level with the top of the filter wall.
7. Measure the vertical distance (H) between the zip ties as shown in the diagram to the right.
8. Determine the expandable media (no gravel) depth using design records or field measurements.
9. Calculate the bed expansion using Table 1 on pg 3 or as shown (right).
10. Conduct this test in multiple parts of the filter to identify "dead zones".





Dual media bed

Layer	Typical sizes	Depth
Silica gravel	(1½" x 3/4")	9"
Silica gravel	(3/4" x 3/8")	3"
Silica gravel	(3/8" x 3/16")	3"
Garnet sand	1.0 - 3.0	3"
Garnet sand	0.25 - .35 mm E.S. u.c. 1.8	9"
Silica sand	0.45 - .55 mm E.S. u.c. 1.5	18"
Anthracite coal	1.0 - 1.2 mm u.c. 1.7	

Total 48"

H = 7-inches (measured)
D = 30-inches (sand & anthracite depth)
% Expansion = 100% * (H / D)
% Expansion = 100% * (7/30) = 23%
Expansion should be 20% or more

Creating the bed expansion tool:

1. Consider the durability of the materials you use (e.g., consider purchasing a stainless steel washer and snap pin).
2. The telescoping paint pole should capable of extending enough to allow you to safely lower the pole to the top of the resting media and adjust the zip ties as needed.
3. Marking the pole at various locations (every 6 inches) using a permanent marker will help when performing the study.
4. Using a white bucket lid or disk helps you view the disk better (similar to a secchi disk).
5. White 5-gallon bucket lids (without the buckets) and zip ties can be purchased at most home improvement stores.
6. Zip ties hold up better than O-rings, which tend to crack and can split over time. Depending upon the depth of the filter, you may need two sets of zip ties with one set located on the lower extension and the other located on the upper extension.

Before you begin the test:

1. Inspect the pole, bucket lid, snap ring, washer and zip ties before you begin. Make certain that nothing will fall off during the test.
2. Use of a high power cordless spotlight can help you see the white disk while measuring the expanded bed.
3. Use a straight edge extended horizontally 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.
4. Expandable media depth includes depth of GAC, anthracite, sand, and/or high density sand such as garnet. It does not include gravel. A 0.25-0.5-inch diameter metal or fiberglass rod can be used to probe the filter bed to the gravel layer while the filter is drained to measure the media depth (works well for filters with gravel support layer), however, you should not probe filters using that contain fragile structures below the filter media such as plastic filter cones or subsurface air headers. According to Sanks (1978), the optimum backwash occurs at a bed expansion of approximately 40% for sand media and 25% for anthracite. A good target for bed expansion would be 20% for sand and 25% for anthracite, or above 20% for the entire mixed media bed (due to the inability to measure the expansion of the individual media layers) – see Table 1 on page 3.

During the test:

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 (when the water has cleared up a bit).
3. Do not collapse your bed expansion pole between the resting and expanded bed measurements. This can significantly affect your measurements.

After the test:

1. If bed expansion is less than the target, first examine the condition, type, and depths of the media. The media materials and depths may also have changed from the original specifications. Gently excavate about 6-inches of the top layer or core down to the support gravel in a drained filter and look for the presence of mud balls (see page 4 for more information).
2. If results identify that the backwash rate may need to be adjusted upward, use caution when adjusting backwash rates. Gradual ramping is recommended. Be sure the bed is not expanded too much such that media is lost through the backwash troughs.
3. Bed expansion will change with temperature changes. Therefore, you should collect bed expansion measurements at least seasonally. Backwash flow rates may need to be seasonally adjusted depending upon the viscosity of the water.
4. 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. It can also aid in the identification of dead zones in the filters, which can indicate problems with the backwash or underdrain systems.
5. Keep track of quarterly bed expansion measurements at various locations for each filter in a spreadsheet for graphing and look for trends (e.g. seasonal fluctuations). Trending raw, settled, and filter effluent turbidity can also reveal the onset of problems and identify areas for improvement. Sudden changes or gradually declining expansion rates or increasing

Date	Filter 1 - Water Temp (deg C)	Filter 1 - Backwash Rate (gpm/sq ft)	Filter 1 - North Wall Expansion	Filter 1 - South Wall Expansion	Filter 1 - East Wall Expansion	Filter 1 - West Wall Expansion	Filter 1 - Side Wall Average Expansion	Filter 1 - NE Corner Expansion	Filter 1 - NW Corner Expansion	Filter 1 - SE Corner Expansion	Filter 1 - SW Corner Expansion	Filter 1 - Corner Average Expansion
1/1/2010	8.0	22.0	22%	12%	20%	11%	16%	20%	18%	19%	3%	
4/1/2010	10.0	22.0	23%	13%	22%	12%	18%	21%	19%	20%	4%	
7/1/2010	15.0	22.0	24%	14%	23%	13%	19%	22%	20%	21%	5%	
10/1/2010	10.0	22.0	23%	13%	21%	12%	17%	21%	19%	19%	4%	

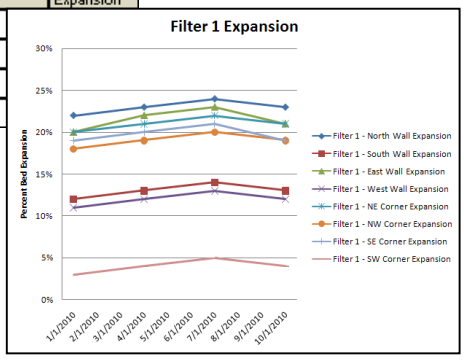


Table 1 can be used to identify the bed expansion in inches that would be anticipated given a target bed percent bed expansion. To use the table, find the depth of expandable media (e.g. sand and anthracite – no gravel) in the far left hand column. Then follow the row across until you get to your target expansion. Follow the column up to see the number of inches you should observe when conducting the study. For example, if you have 30 inches of expandable media and are targeting 30% expansion, you would expect the media to expand about 9 inches (H = 9 inches). The chart can also be used to determine the percent expansion given the depth of expandable media and the measured bed expansion in inches (e.g. given 30 inches of sand and anthracite and measured expansion of H = 6 inches, the percent expansion is 20%).

Table 1. Percent Bed Expansion Table.

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%
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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%

Addressing mud balls:

Mud ball formation can lead to more serious problems if not addressed. The most typical causes of mud ball formation are inadequate backwash rates, uneven backwash flow distribution, ineffective surface wash and/or improper chemical dosages, which can lead to floc carry-over and fouling of the filter media. Mud ball formation is heightened by the use of polymers such as coagulants or filter aids. Mud balls can usually be detected as they grow to the size of a pea, although they can grow to as large as 1-2 inches, or bigger. Large mud balls can sink into the filter bed causing the filter to have areas that do not filter ("dead zones"). This causes the remaining areas of the filter to filter more water than the designed rate, which increases the filter's potential for turbidity breakthrough. As the available filter area is increasingly blocked by mud balls, the filter run time will decrease. Continual deposition of mud balls may lead to areas in the filter that have solidified completely. A few simple activities that can be done to address mud balls are listed below.

Low-rate backwash straining: While the backwash rate is very low (just enough to fluidize the bed and without the use of sweep arms), use a strainer basket to sieve mud balls out of the reachable media.

Garden rake: Using a common stiff-tined garden rake during filter backwash (after the sweep arms have stopped rotating) can help break up mud balls.

Pressure washing: with the water level in the filter reduced to one or two inches above the surface of the media, pressure washers (80 – 90 psi) may be used to agitate the media and break up mud balls.

The final backwash should be monitored for turbidity to ensure that the filters are sufficiently cleaned prior to being put back into service. It may be necessary to conduct multiple "normal" backwashes or extend the duration of backwash before putting the filter back into service.