3M™ High Flow Cartridges
Dirt Loading & Filter System Sizing

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Introduction:
The dirt holding capacity of particle removal filters is dependent on the rate of fluid flow through the filter. This dirt-holding-to-flow-rate response in non-linear and is a critical consideration when sizing a filter system for industrial filtration applications. Understanding how a filter's dirt holding capacity is impacted as flow increases or decreases will help to project individual filter service life, and also determine how many filters are needed to meet filter change-out targets (as in number of days).

This technical application brief will show how to calculate the dirt load – or dirt removal work that a filter or set of filters will be required to do – as well as how to use the dirt loading information to size a filter system, depending on customer requirements, such as capital costs, system footprint, filter life, etc.

Calculating Dirt Load
The first step in estimating filter life is to determine the quantity and rate of incoming dirt being sent to the filter. For this one needs to know the total suspended solids (TSS) in milligrams per liter (mg/L - also sometimes given as parts per million, or ppm, which is an equivalent unit) and the flow rate (in gallons or liters per minute). Once you have this information, it is a simple mathematical calculation to determine the incoming dirt load to the filter - as measured in grams (or pounds) per minute. An example is given below.

Example: A sample of fluid is measured and found to have 10 mg/L of solids. The fluid is from a system that has a constant flow rate of 100 gpm and operates continuously, 24/7.

Inlet TSS = 10 mg/L
Inlet Flow rate = 100 gpm

Step 1:
Calculate the inlet solids (dirt) rate:
Convert gpm to lpm by multiplying by 3.786.

100 gal/min x 3.786 L/gal = 378.6 L/min

Multiply the volume of flow by the TSS in the fluid:
378.6 L/min x 10 mg/L = 3,786 mg/min.

Convert mg to grams by dividing by 1,000.

3,786 mg/min / 1,000 mg/g = 3.79 g/min.

Step 2:
Calculate the daily inlet solids (dirt) loading:
The above calculations show that for every minute of operation, 3.79 grams of solids (dirt) flows into the filter. **So in one hour the dirt load will be:**

3.79 g/min x 60 min/hr =227.2 grams.

This is roughly one half of a pound as shown by dividing by 454 g/lb.

227.2 g / 454 g/lb = 0.50 lb.)

In one full day the dirt load will be:

227.2 g/hr x 24 hr/day =5,453 g/day.

In pounds the dirt load per day is:

5,453 g/day / 454 g/lb =12 lb

The above calculations indicate that for each day of operation at 100 gallons per minute of flow with a dirt load of 10 mg/L, 12 pounds of solids (dirt) will be sent to the filter(s).

Calculating Filter Life
The next part of the analysis is to calculate how long the filter(s) will last with an inlet solids (dirt) loading of 12 pounds per day. For this analysis we will assume that the filter removes 100% of the incoming dirt.

The amount of dirt that a particular filter will hold requires knowledge of the average dirt holding capacity of the filter at a given flow rate. Fortunately, this information is readily available for 3M™ High Flow cartridges. The Appendix contains dirt holding graphs for the 10", 40", and 60" length 3M™ High Flow cartridges (test data is for silica dust in water to a terminal differential pressure of 20 psi.). Note that dirt loading is slightly different for the different grades of media.

For the preceding example, we will assume the use of the 10 micron 3M 40" length High Flow filter cartridge is desired. From Figure 3B , we see that the dirt loading at a 100 gpm flow rate is 12 pounds. Therefore for this example, we would estimate ~24 hours (or one full day) of run time before the filter would require changing (note that actual performance will vary in each customer's application depending on type of fluid and the nature of the contaminants being removed.)

Sizing a 3M™ High Flow Filter System
Typically, there are two primary considerations when sizing a filter system:

1. Filter hardware cost & system footprint (capital costs)
2. Desired filter life and filter change-out frequency (operating costs)

As described previously, flow rate and dirt loading (filter life expectancy) are closely linked and move counter to one another (i.e. higher flow rates per filter lead to more frequent increased filter consumption and vice versa).

The example below, demonstrates the impact of filter hardware sizing on filter consumption. For this example, we will use an inlet flow rate of 500 gpm and an inlet TSS level of 5 ppm and the use of 10 micron 60" length 3M High Flow cartridges.

Using the steps shown in the **Calculating Dirt Load** section, a dirt removal rate of 1.25 lbs/hr is calculated. Below is a summary of the impact on filter change-out filter frequency based on various filter hardware choices.

Figure 1: High Flow vs. Dirt Capacity

Scenario 1: Use One Round 3M™ High Flow Housing (8.625" Diameter):

- # of Cartridges: 1
- Flow Rate per Cartridge: 500 gpm/ 1 =500 gpm
- Dirt Holding Capacity per cartridge (from Figure 2): 8.5 lbs
- Total Dirt Holding Capacity: 8 lbs x 1 = 8.5 lbs
- Filter Run Time: 8.5 lbs/1.25 lbs/hr = 6.8 hours

Scenario 2: Use Three Round 3M™ High Flow Housing (16" Diameter):

- # of Cartridges: 3
- Flow Rate per Cartridge: 500 gpm/3 = 167 gpm
- Dirt Holding Capacity per cartridge (from Figure 2): 15 lbs
- Total Dirt Holding Capacity: 15 lbs x 3 = 45 lbs
- Filter Run Time: 45 lbs/1.25 lbs/hr = 36 hours

Scenario 3: Use Five Round 3M™ High Flow Housing (20" Diameter):

- # of Cartridges: 5
- Flow Rate per Cartridge: 500 gpm/5 = 100 gpm
- Dirt Holding Capacity per cartridge (from Figure 2): 23 lbs
- Total Dirt Holding Capacity: 23 lbs x 5 = 115 lbs
- Filter Run Time: 115 lbs/1.25 lbs/hr = 92 hours

The above calculations (depicted in Figure 2 on the next page) demonstrate how filter change-out time can be increased by over 14 times (92 vs. 6.4 hours) by installing a five-around 3M High Flow filter housing.

While the larger 3M High Flow filter housing will be a higher capital cost and require a larger system footprint, the reduced filter change-out frequency may be of greater benefit. In any extent, the above is a useful exercise to undertake when sizing a new filter system.

Figure 2: Effect of Filter Hardware Sizing on Required Filter Change-out Frequency:
Flow Rate: 500 gpm
Inlet TSS level: 5 ppm
Cartridge Type: 10um, 60" Length 3M High Flow Cartridge

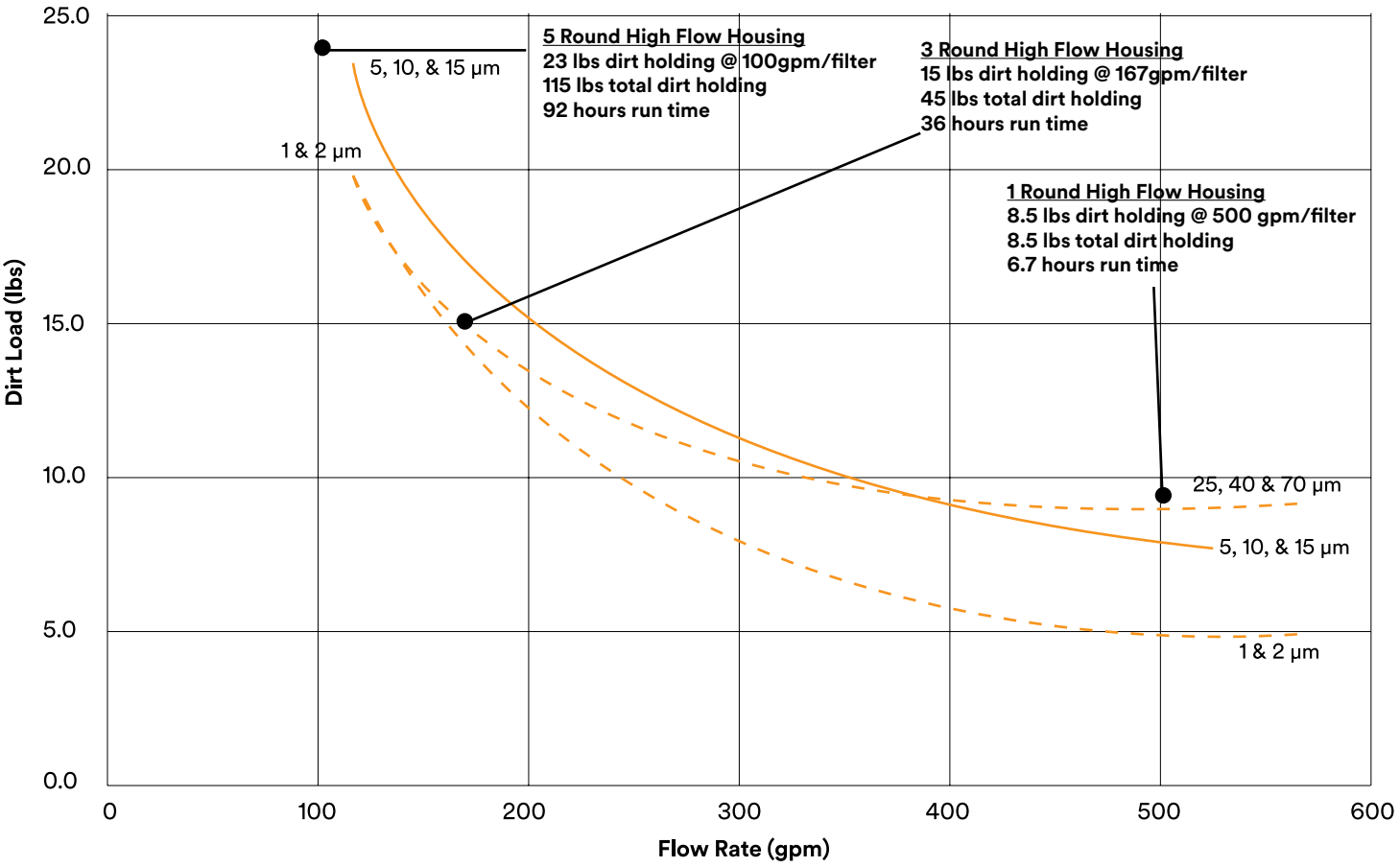


Figure 3A: Flow vs. Dirt Capacity (10”L Cartridge)

Dirt Holding Test Protocol:

- Contaminant: ISO A4 Coarse dust
- Contaminant Challenge Rate: 0.286 grams/gallon (76 ppm). Dust injection rate and tank dust concentration adjusted to keep the challenge rate constant across all flow rates
- Terminal Pressure Drop: 20 psid
- Each cartridge weighed before and after the test once completely dried to calculate the amount of dust retained

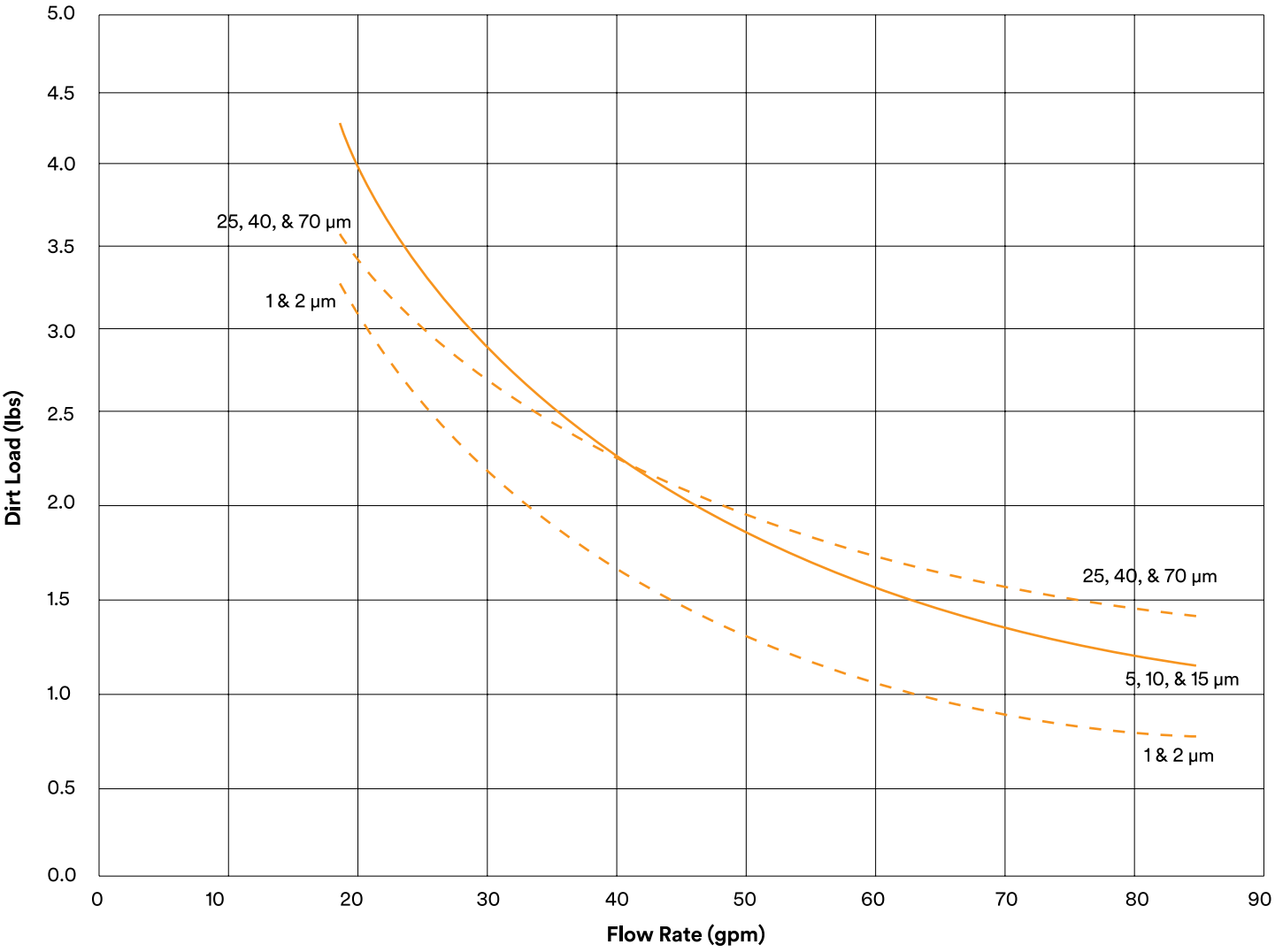


Figure 3B: Flow vs. Dirt Capacity (40”L Cartridge)

Dirt Holding Test Protocol:

- Contaminant: ISO A4 Coarse dust
- Contaminant Challenge Rate: 0.286 grams/gallon (76 ppm). Dust injection rate and tank dust concentration adjusted to keep the challenge rate constant across all flow rates
- Terminal Pressure Drop: 20 psid
- Each cartridge weighed before and after the test once completely dried to calculate the amount of dust retained

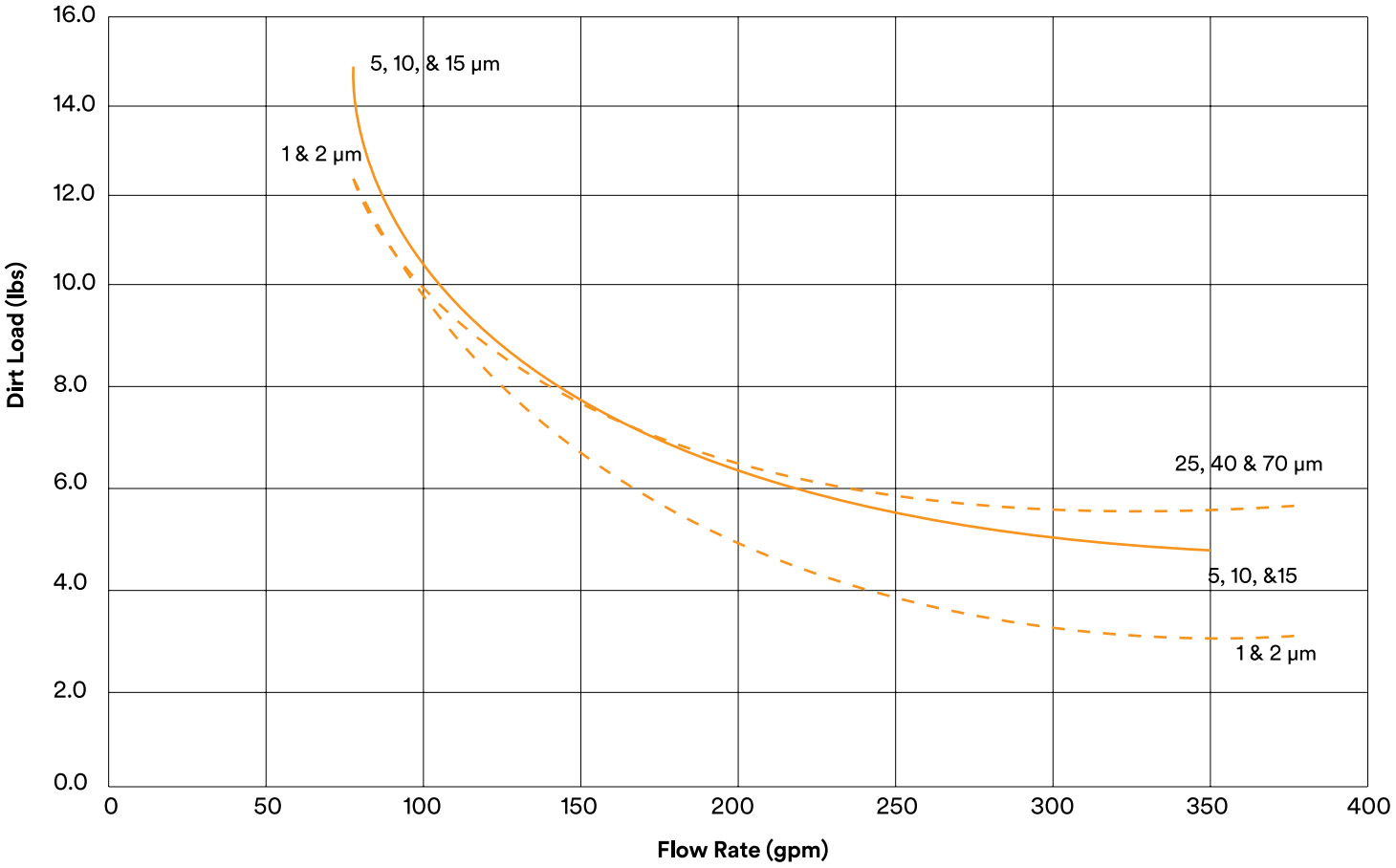
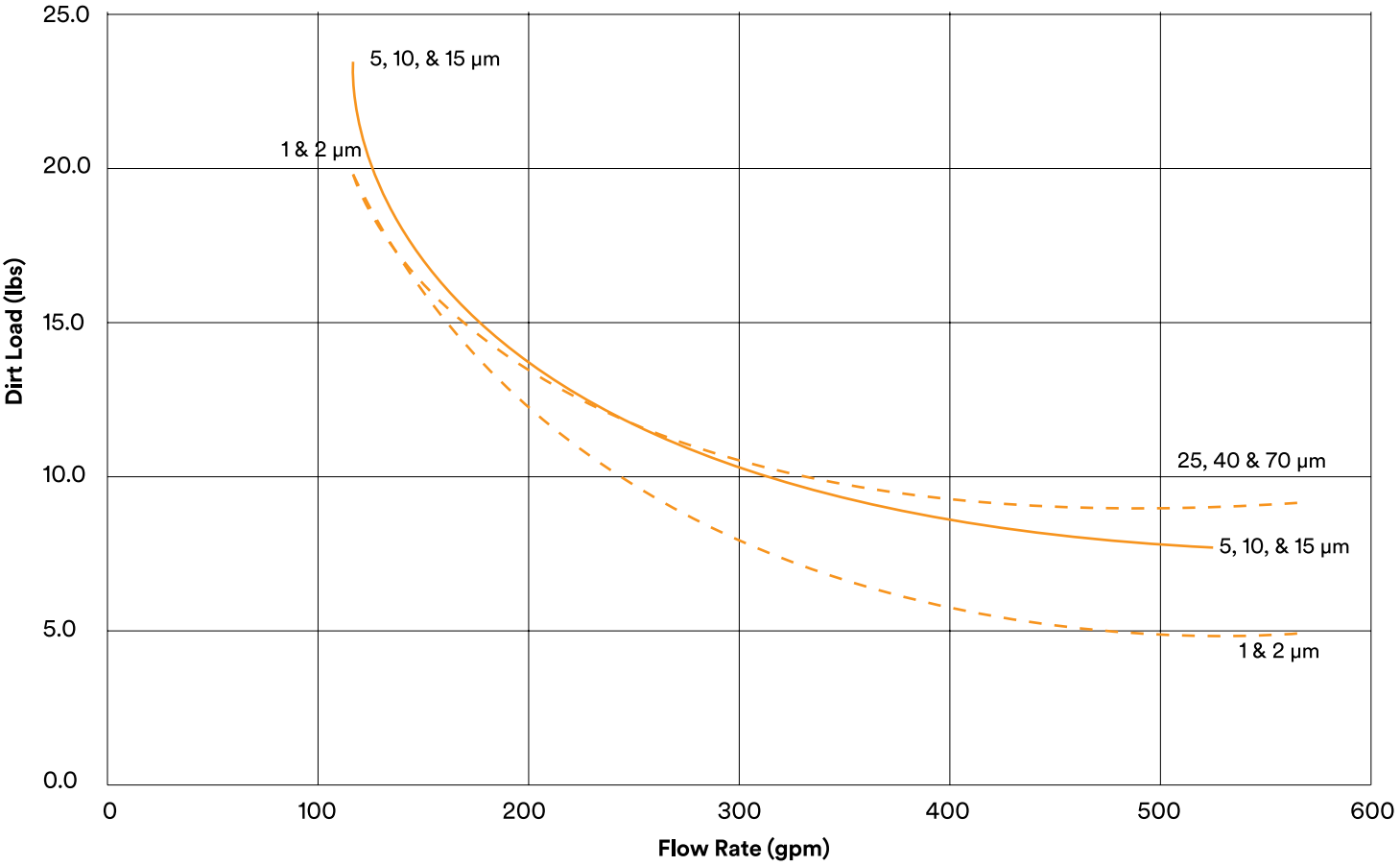


Figure 3C: Flow vs. Dirt Capacity (60”L Cartridge)

Dirt Holding Test Protocol:

- Contaminant: ISO A4 Coarse dust
- Contaminant Challenge Rate: 0.286 grams/gallon (76 ppm). Dust injection rate and tank dust concentration adjusted to keep the challenge rate constant across all flow rates
- Terminal Pressure Drop: 20 psid
- Each cartridge weighed before and after the test once completely dried to calculate the amount of dust retained



For more information about the 3M™ High Flow Series System please contact your local Industrial territory Sales Manager, call 1-800-243-6894, Option 4 or visit our website at 3M.com/highflow.

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