System Sizing Basics

The key to optimizing any filtration system is to get the right balance between economy and performance. This balance is determined by a number of factors such as particle characteristics that include the nature of the particle and the volume of particles; fluid characteristics such as viscosity and temperature; and cartridge characteristics such as filter pore rating, efficiency and dirt holding capacity or throughput. Thus the choice of the correct type of filter, either a membrane filter, a pleated surface filter or a non-pleated depth filter, must be balanced against the filtration objective. To complicate things, often the filtration goal cannot be achieved in a single step and the use of multiple filters types through the process is required, or in other words, a prefilter. Once the goals have been defined, there are several approaches that should be considered for determining the appropriate system size.

MINIMUM CORE REQUIREMENTS

Flow through the core can be used as a baseline value to determine the minimum number of filters required to meet the flow demand. This is the quickest response to the question (answers the "at least" question), but tends to oversimplify the process since it does not consider the flow characteristics of the media nor the contaminant load. We use a flow rate of 15 GPM per core as the maximum flow value, as this is a practical flow limit for a 1" pipe (the typical core is essentially a 1" pipe), whether it is 10" or 40" long. As an example, in a system requiring a flow of 100 GPM, divide 100 GPM by 15, 100/15 = 6.6 or 7 cores at a minimum.

FLOW PER TEN INCH EQUIVALENT

This is the idealized maximum flow rate per ten inch cartridge (TIE) based upon the type of filter being used in the application. As a general rule, calculate membrane using 3 GPM per TIE; pleated media using 5 GPM per TIE; and depth filters using 5 GPM per TIE. For example, again in our 100 GPM flow rate system, the recommendation for membrane, 100 GPM/3 GPM/TIE = 33 TIEs; pleated or depth, 100 GPM/5GPM/TIE = 20 TIEs. As with the minimum core requirement, this does not consider the specific flow rates of the media nor the contaminant load.

FILTER FLOW RATE

The media specific flow rate should be considered when the correct filter media (micron rating, membrane, pleated or depth) has been identified for the application. Using the actual published filter flow rate data in specification sheets provided by the manufacturer, calculate the Minimum Cartridge Quantity as follows:

$$\frac{\textit{System Flow Rate} \quad X \quad \textit{Viscosity}}{\textit{Published Filter Flow (GPM/PSID/TIE)} \times \textit{Clean Pressure Drop}}$$

For example, for our 100 GPM flow rate system:

$$\frac{100 \quad x \quad 1\ cps}{3\ GPM@1\ psid \ \ x\ 1\ psid} \quad = \quad 33\ TIEs$$

As you can see from this math, the influence of viscosity or desired clean pressure differential on the number of filters can be significant. If viscosity is 3 cps, then 99 TIES are needed (3 times as many) to have the same clean pressure differential of 1 PSID. Failure to consider viscosity could result in under-sizing the system, which results in much higher clean pressure differential (learned from actual experience!). If the clean ΔP is 2 PSID versus 1 PSID, then 17 TIES are required (1/2 the number), so you can manipulate the targeted starting pressure to see what effect it will have on vessel sizing.

ACTUAL TEST DATA

This yields the best values but is often the most difficult to achieve due to the challenges with getting samples, testing on site or potential hazards associated with the product itself. For best scalability, this is best done with a 10″ filter/housing, but it is also possible to use small flat disk (47 or 90 mm) of the media. For example, to process a 10,000 gallon batch at 100 GPM and using 0.2 micron ZTEC, test a 10″ cartridge sample at 3GPM flow, record the volume of the throughput until filter is 80% plugged. Note: 80% would be equal to 20% of the flow rate at constant pressure, or 5X the initial differential if held at constant flow. If the data shows 335 gallons of throughput per TIE, in order to process 10,000 gallons will require 10,000/335 = 30 TIEs.

FINAL CONSIDERATIONS

Final system sizing would incorporate the various methods to make an ideal choice using the larger of the recommendations for the final sizing. We also must consider the available housing configurations (commonly 3, 5, 7, 12, 21, 26, 36 round). From the above example, we have identified the need for at least 7 cores to meet minimum flow requirement and 33 TIEs based upon use of a membrane. A 7 round x 40″ only give 28 TIEs, so the next largest is 12 round, with a 12 x 30″ giving us 36 TIES, which meets our targeted minimums.