BALLAST WATER FILTRATION

The Venturi Oxygen Stripping™ (VOS) ballast water treatment system is able to meet the International Maritime Organization (IMO) D-2 Ballast Water Performance Standard without the use of particulate filters. With the VOS system, the concentration of organisms greater than or equal to 50 micrometers (microns) is below the D-2 standards within 48 hours after entering the vessel. This is not the case with many competing ballast water treatment technologies.

The majority of ballast water treatment technologies in development require particulate filters to achieve the IMO D-2 standards. Ultra-violet light, electro-chlorination, ozone, and other chemical oxidizers all require filtration to be effective. There are two main reasons for this. First, the biocidal treatment component may be less effective at killing large organisms, and a filter is required to physically remove organisms above 50 microns to meet the standard. Second, the biocidal treatment technology may be rendered less effective by interference from, or chemical reaction with, particulate matter (i.e., mud) in the ballast water. An obvious solution to the first problem is a 50-micron filter. A 50 micron filter, however, will not always solve the second problem. To remove small diameter suspended particulate matter from incoming ballast water, a much finer filter is required.

The water in a commercial shipping port can have a concentration of total suspended solids (TSS) that is far above the TSS concentration in sea water. This is especially true of ports located within or near rivers. Navigable rivers such as the Yangtze, the Mississippi, the Elbe, and the Amazon are “muddy”, and exhibit TSS concentrations ranging as high as 1,000 milligrams per liter (mg/l). The Mississippi River TSS concentration varies seasonally between approximately 20 – 100 mg/l. After storm events it can be significantly higher.

Port of Rotterdam

Vessels taking on muddy ballast from high-TSS ports can experience sediment build-up in the bottom of ballast tanks. Eventually, this settled material has to be removed from the ships ballast tanks. Currently it is permissible to dispose of this material in port waters. [In the future, the IMO Ballast Water Convention (Regulation B-5) will require that sediment material removed from ballast tanks be discharged to a shore-side facility or at sea]. It is possible that filtration of
ballast water may be able to reduce the sediment build-up problem. At this time, however, despite the wide availability of compact, self-cleaning, cost-effective filters for ballast water, filtration is not commonly used to reduce sediment build-up in ballast tanks. The reason for this relates to the particle size distribution of suspended solids in natural waters.

The brown color of many rivers around the world is the result of the suspension of colloidal matter, clay, and silt. The size of particulate that can be carried by moving water relates to the velocity of the water. There are many factors involved, but small particles are suspended primarily because the turbulence of moving water counteracts the downward gravitational pull on each particle. Unlike larger, heavier particles, this material does not settle out of moving water. In general, a 1-knot river current is sufficient to suspend all colloidal, clay, and silt material.

The Wentworth Classification System is commonly used to categorize particulate matter by size. The very smallest particles are referred to as “colloids”, or colloidal. These are particles that are less than 1 micron in diameter. Clay particles are between 1 – 4 microns. Silt ranges from 4 to 62.5 microns, and very fine sand ranges from 62.5 to 125 micron.

Another factor involved is the percentage of each type of suspended particle that makes up TSS in a given location at a given time. This varies considerably, but when shown on a log-scale graph, river-bourne suspended solids typically exhibit a “bell-curve” distribution around a small-diameter particle size. The United Nation Environmental Program Global Environmental Water Monitoring Program, in describing TSS states, “In most rivers TSS is primarily composed of small mineral particles.” Please see Figure 3.2, below.

This Figure shows a log-scale of particle diameter from 100 micron on the left to 0 on the right. As shown, the mean particle size is approximately 4 microns. The red arrow indicates the 50-micron line. A vessel taking on ballast at a port near the mouth of the Amazon River would have total suspended solids with a mean size of 4 microns. In this location, all but a small percentage of suspended solids would pass through a 50 micron filter and into the ballast tanks.

A report of Mississippi River surface water found the distribution of TSS to average 36 percent clay, 63 percent silt, and 1 percent sand. This is similar to the Amazon. The majority of this
material is smaller than 50 microns. If the silt fraction is evenly distributed from 4 - 62.5 microns (a conservative assumption), then approximately 22 percent of the suspended solids in this water is greater than 50 microns. Since there is likely to be a silt particle size distribution similar to that shown in Figure 3.2, the fraction above 50 micron is likely to be closer to 5 percent.

The graph below shows the grain size distribution of sediments found in ballast tanks of 54 vessels sampled in 2001 and 2002 during “no ballast on board” (NOBOB) voyages in the Great Lakes (Johengen et al., 2005). The sediment wasn’t accumulated in the Great Lakes. This is an analysis of ballast tank sediments in vessels entering the Great Lakes from around the world. It is not known where the sediment was accumulated, but the shapes of the curves on this graph illustrate a critically important point – the distribution of sediment grain size in ballast tanks is remarkably similar.

In the “phi” scale 0 corresponds to 1.0 mm. Going up the phi scale each number represents half the size of the previous number. Therefore 1 = 0.5 mm, 2 = 0.25 mm, 3 = 0.125 mm, 4 = 0.063 mm, and so on. Thus 4 - 10 correspond to silt and clay. This graph shows that only one vessel had sediment with greater than 30 percent above 0.063 mm (63 microns), and the majority had less than 10 percent. This is consistent with the Amazon and Mississippi River sediment conditions. Therefore, if these 54 vessels had 50 micron ballast water filters they would only reduce the ballast tank sediment build-up by approximately 10 percent.

Although the concentration and distribution characteristics of shipping-port suspended solids vary geographically and seasonally, there are conclusions that can be drawn from analysis. A 50 micron filter can only remove a small fraction suspended particulate matter from water. Such a filter can be an effective component for treatment systems designed to achieve the IMO D-2 ballast water discharge standards. In order to significantly reduce sediment build-up in ballast tanks, however, a much finer filter is required.