

Choosing a woven wire screen for top separation performance

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In any screening application, achieving top-quality product and peak efficiency requires careful screen selection. This article explains how to choose the right woven wire screen for your application. Sections cover screen basics, how to choose the right screen opening size, wire diameter, and attachment method, and how to operate and maintain your screener after the screen is installed.

A screener (also called a *separator* or *sifter*) mechanically separates dry free-flowing materials by particle size by moving the material in relation to a screen (or screens). Each screen is round or rectangular and is attached to a frame in an assembly called a *screen deck*. The screener can be used in a range of applications — including chemicals, pharmaceuticals, food products, plastics, minerals, and pigments — to scalp material, remove fines, or grade material. In any of these applications, choosing the right screen is the single most important factor in achieving top separation performance.

The ABCs of woven wire screen

Most screeners use a woven wire screen with square openings. Four parameters — mesh count, wire diameter, opening size (often just called *opening*), and open-area percentage — can be used to describe the woven wire screen. These parameters are mathematically interrelated, as shown in Figure 1. When choosing a screen, you need to specify at least two of the parameters, and which two you specify depends on whether you use US or metric units.

In the US, screens are specified by mesh count and wire diameter. The mesh count is the number of wires per linear inch or, depending on the user's preference, the number of openings per linear inch. The wire diameter is the wire's nominal diameter in inches. While this approach to specifying screens has been used for centuries, it's rather counterintuitive because the larger the mesh count, the smaller the opening. Specifying a wire screen in countries using the metric system is a bit more logical because the screen is specified by its opening size (in microns) and either its wire diameter (in microns) or the open-area percentage.

So why isn't specifying the opening size by itself enough to precisely specify a wire screen? Figure 2 shows two screens with approximately the same opening size but different wire diameters. Because of the difference in wire diameters, the screens will perform very differently during screening (discussed in the later section "Choosing the wire diameter").

About screen types. Woven wire screen cloth (also called *screen media*) is manufactured in high volumes using standard combinations of mesh count and wire diameter. For a dry bulk material application, you'll typically select one of three screen cloth types: market grade, mill grade, and tensile bolting cloth (TBC). Market-grade screen has the largest wire diameter for a given opening size, and TBC screen has the smallest.

A note about differences in process screener screens and lab test sieves: Confusion often results because of the apparent similarity between the mesh count for process screens and the sieve number for sieves used in lab test sieve shakers. (In a lab test sieve shaker, a stack of sieves is shaken so that a representative material sample falls from

the top sieve [with the largest opening size] down through the other sieves [with progressively smaller opening sizes]; then the material remaining on each sieve is weighed to reveal the sample's particle size distribution.) For instance, for a process screener, a 50-mesh TBC screen has a 368-micron opening size and a 50-mesh market-grade screen has a 279-micron opening size. But neither equates to the 300-micron opening size of a number 50 US Standard test sieve. For clarification, refer to a particle-size-to-screen-mesh conversion chart, which lists commonly available screen cloths for process screeners and aligns each with the US Standard test sieve with the most similar opening size.¹

About wire. Most woven wire screens are made of stainless steel. [Editor's note: For information on other screen materials, see the sidebar "Beyond woven wire."] Type 304 and Type 316 stainless steel wires are by far the most common for screening granules and powders. They not only resist corrosion, but are durable, readily available, and economical.

Some screens are available in Type 430 stainless steel, which is suited to applications with strict product quality requirements. This is because, unlike most stainless steels, Type 430 stainless steel is magnetic and can often be picked up by magnetic separators downstream of the screener. This improves the odds of capturing stray wires that might become detached from the screen and fall into the screened material. However, Type 430 stainless steel tends to be more brittle than other stainless steels, which can reduce the screen's service life.

Choosing the screen opening size

The opening size is the most important criteria to consider when selecting a screen because it has the greatest impact on your screening process's separation quality. But before you can choose the opening size, you need to know what specifications the final product must meet. This depends on whether you're using the screener for scalping, fines removal, or grading.

Scalping. In a scalping application, the screener has one screen and "cuts a little off the top" — that is, it removes a small quantity of oversize particles from a material that's already almost entirely within a particle size spec (or *on size*). In a typical scalping application, the material entering the screener contains more than 95 percent on-size particles.

To choose the right screen opening size, work backward from your final product spec. Let's say that your scalping spec is 0% +60 US. This means that when you analyze a representative sample of the screened final product with a lab test sieve shaker, no material should be retained on the number 60 US Standard test sieve. This sieve has a 250-micron opening size, so you should select a process screen with an opening no larger than 250 microns. In fact, due to variations in the wire-weaving process (called *weaving tolerances*), you'd want to choose a screen with an opening size several percentage points smaller than that of the specified test sieve. So, by referring to a particle-size-to-screen-mesh conversion chart, you'd see that a 60-mesh market-grade screen would probably be a good choice for

Figure 1

Four inter-related parameters for woven wire screen

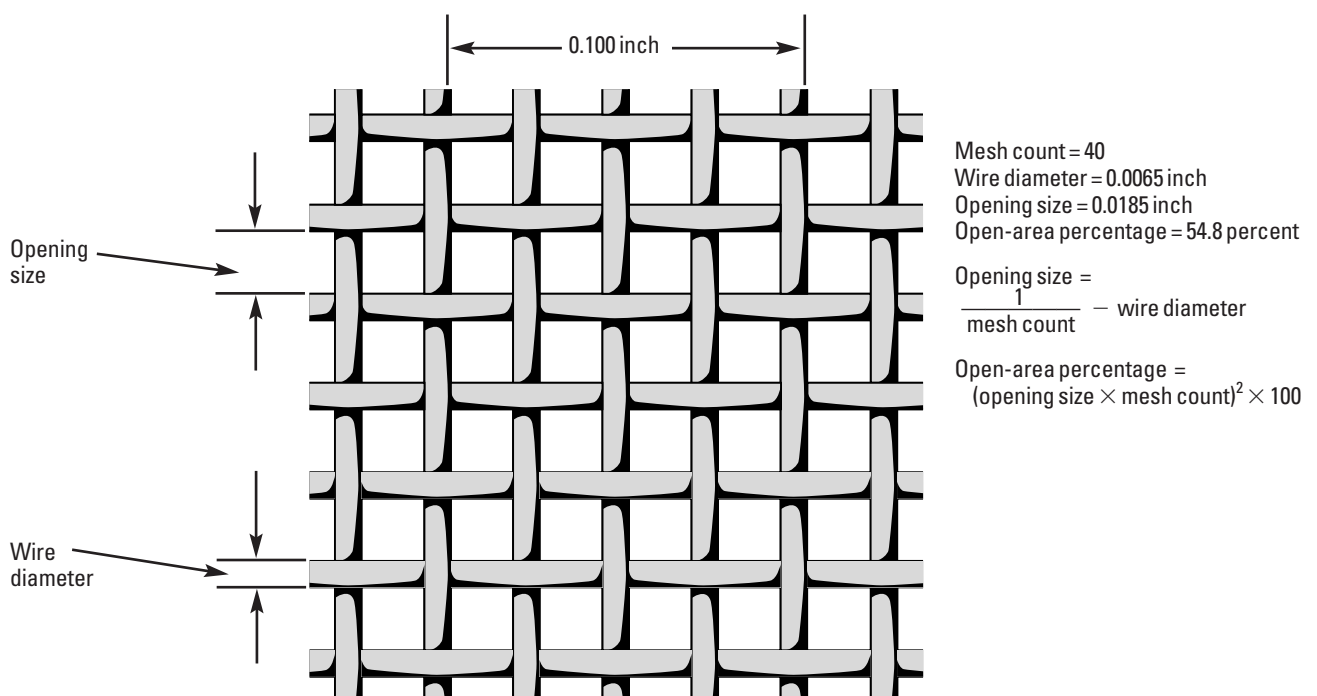
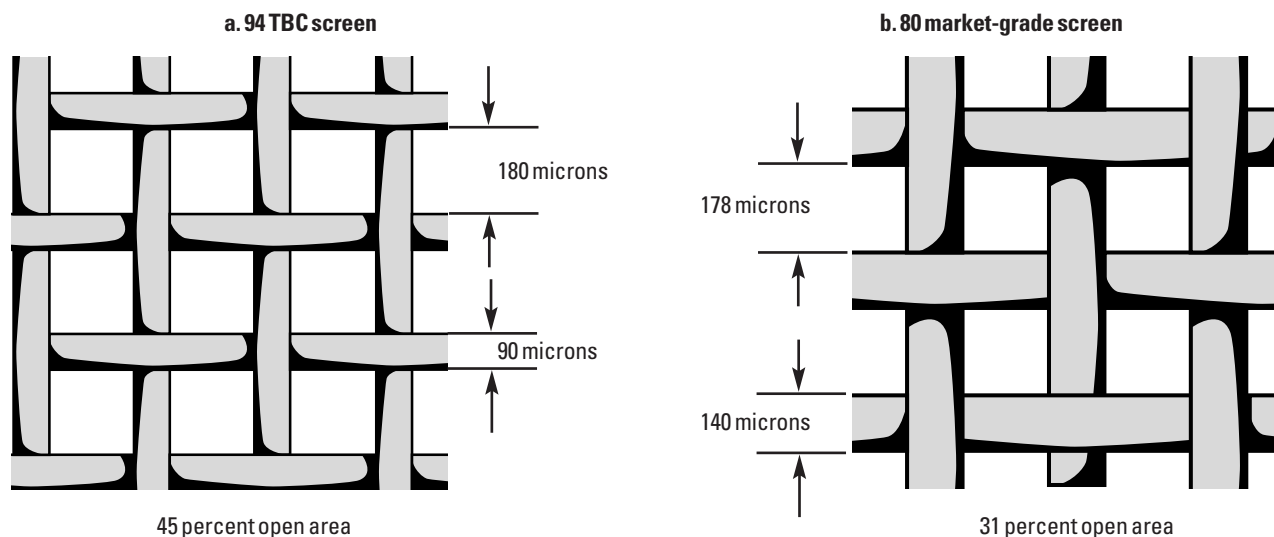


Figure 2

Screens with similar opening sizes but different wire diameters



this application. Its 234-micron opening is slightly smaller than that of the number 60 US Standard test sieve. In contrast, a 60-mesh TBC screen *wouldn't* be appropriate for this application. Its smaller wire diameter gives the TBC screen a 310-micron opening size, considerably larger than that of the number 60 US Standard test sieve. As a result, oversize particles from 250 to 310 microns will pass through the 60-mesh TBC screen and contaminate the on-size final product. When you analyze this final product in a test sieve shaker, some material will be retained on the number 60 US Standard test sieve, causing the sample to fail your 0% +60 US scalping spec.

Fines removal. Screen selection can get more complicated when your screener must remove fine particles, the opposite of scalping. This application also requires only one screen. Let's say that your screener must remove fine particles *smaller* than a number 60 US Standard test sieve's opening size. Because of inefficiencies inherent in all screeners, it's impossible to remove all fine particles, so any properly crafted product spec for a fines-removal application allows some tolerance. For instance, a reasonable spec for allowable fines in the final product would be 5% max -60 US. This means that when a representative sample of your final product is analyzed with a test sieve

Beyond woven wire

While stainless steel woven wire is the most common screen material for separating dry bulk solids, there are other options.

Screens can be made from woven synthetic filaments like polyester

and nylon. These filaments are very smooth and extremely flexible, making synthetic screens less prone to blinding than woven wire screens in some applications. Synthetics are also suited to screening materials that are too corrosive for stainless steel woven wire.

In other applications, the screen material isn't a screen at all, but a metal perforated plate. The plate, which has round perforations rather than square openings, is stronger and more durable than woven wire screen. The plate also presents a very smooth surface to

the material moving across it, which helps separate elongated particles from granules or more spherical, uniformly shaped particles. The round openings provide a more precise opening size than a woven wire or synthetic screen's square openings because the round holes don't have the square openings' larger diagonal dimension. However, the plate has a very low open-area percentage, which reduces capacity and makes the plate susceptible to blinding. A common application for perforated plate is removing streamers and strands from plastic pellets. —J. Dierig

shaker, no more than 5 percent of the sample should pass through the number 60 US Standard test sieve.

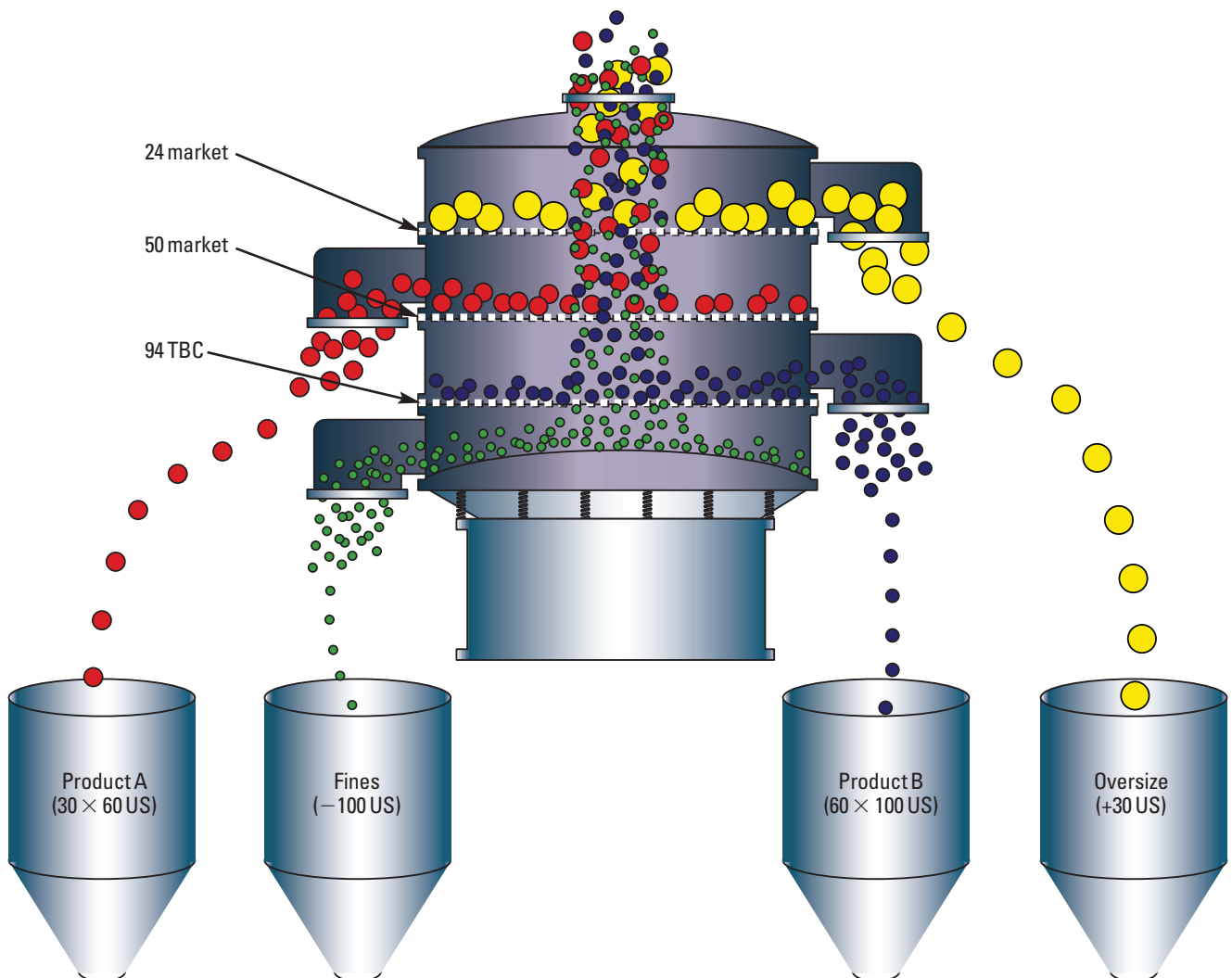
To achieve the $5\% \max -60 \text{ US}$ product spec, your first instinct might be to select a 60-mesh screen. However, if you choose a 60-mesh market-grade screen, it's highly unlikely that the final product would be within your allowable fines tolerance because this screen's 234-micron opening size is smaller than the 250-micron opening on the number 60 US Standard test sieve. A better choice would be a market-grade or TBC screen with an opening size somewhat larger than that of the 60-mesh market-grade screen. The larger opening size will encourage near-size fine particles to pass through the screen, making it more likely that the final product will meet your allowable fines tolerance. In fact, the larger the opening size, generally the better the fines removal. Be aware, however, that if the opening size is too large, at some point a large number of on-size particles will pass through the screen and discharge with the fines.

Grading. In grading (also called *sizing* or *classifying*) applications, the screener uses multiple stacked screen decks to separate material into distinct discharge streams. Each stream has its own particle size distribution, and typically one or more of the discharge streams constitutes the final product, which usually has a spec limiting the amount of oversize or fine particles allowable in it. For grading applications, choosing the right screen opening size for a replacement screen is especially critical because any change in the opening size can affect not just one, but multiple final products.

Figure 3 shows a typical three-deck screener for a grading application that yields two products, A and B. Product A's spec is $30 \times 60 \text{ US}$ (that is, the particles must be small enough to pass through a number 30 US Standard test sieve and too large to pass through a number 60 US Standard test sieve). Product B's spec is $60 \times 100 \text{ US}$ (that is, the particles must be small enough to pass through a number 60 US Standard test sieve and too large to pass through a number

Figure 3

Three-deck screener for grading two products



100 US Standard test sieve). The screener's top deck has a 24 market scalping screen (that is, a 24-mesh market-grade screen) that removes oversize particles (+30 US particles, which are too large to pass through a number 30 US Standard test sieve) from Product A. The bottom deck has a 94 TBC fines removal screen that removes fine particles (-100 US particles, which are small enough to pass through a number 100 US Standard test sieve) from Product B. But the middle 50 market deck performs two functions: controlling the amount of fine particles in Product A while limiting the amount of oversize particles in Product B.

Thus, replacing the middle deck's screen with one that has a different opening size will affect the particle size distributions of both products. For instance, using a screen with a larger opening size will change both products' size distributions, reducing the fines content of Product A and increasing the oversize in Product B. Changing the middle screen's opening size will also affect the product yield, or relative production rates. Because of these interdependent factors, it's best to choose the screen opening size for a grading application based on results of screening tests performed in your screener manufacturer's lab.

The screener's impact on opening size. Other factors in selecting screen opening size have more to do with how the screener operates. Why? Unlike material in a lab test sieve shaker, which spends several minutes in the shaker, material in a process screener spends only seconds in the machine. The screener's motion is different too. The test sieve shaker moves only in a horizontal plane, which is effective for passing a small batch of material through the sieve stack. But a process screener's motion has a vertical component. This is because the machine operates continuously, and as the feed material enters, screened material must be removed by conveying it across the screen to the discharge. The screener's vertical screen motion, together with the screen slope, conveys the screened material out of the machine. Because the particles in the process screener spend less time on the screen and move differently, they have less chance of passing through the screen than through a test sieve in a lab test shaker. This has the effect of making the screen's *apparent* opening size smaller than the actual measured opening size in that screen, as shown in Figure 4. (In the figure, the apparent opening size is represented by the small opening in the double images near the image's center.) Because the apparent opening size is smaller, the actual opening size for a screen in a process screener should be up to 10 percent larger than that in a corresponding test sieve.

Some screeners have an inclined screen (or screens), which also has an effect on the screen opening size. As shown in Figure 5, the material on an inclined screen is exposed to two different opening sizes: the actual measured opening size and the *effective* opening size that results from gravity's influence on each particle's impact on the inclined screen. (You can calculate the effective opening size by multiplying the actual opening size by the cosine of the

screen angle [$\cos \Theta$].) The result is typically less accurate separation, making a horizontal screener with a flat rather than inclined screen the best choice for applications with exacting particle size tolerances.

Choosing the wire diameter

To determine which wire diameter is best for your screen, consider the screener capacity, screen flexibility, and screen durability your application requires.

Screener capacity. Choosing the right wire diameter can have a major impact on your screener's capacity because wire diameter affects the screen's open-area percentage and, thus, how quickly material can be screened. Any woven wire screen can be described in terms of its open-area percentage (Figure 1). Generally, the larger the open-area percentage (rather than opening size), the higher the screen's capacity. For instance, consider two screens with the same overall dimensions and the same opening size: an 80-mesh market-grade screen (with a large wire diameter) with a 178-micron opening size, and a 94-mesh TBC screen (with a smaller wire diameter) with a 180-micron opening size. The market-grade screen has a 31.4 percent open area, while the TBC screen has a 45 percent open area. This means that the 94-mesh TBC screen with its smaller wire diameter has 43 percent more openings than the 80-mesh market-grade screen for the same screen dimensions. As a result, the TBC screen provides much higher screening capacity.

A screen with smaller-diameter wire tends to give a little, so that the screen's natural movement can dislodge the particle.

Screen flexibility. A screen with a smaller wire diameter has another advantage for screening: It tends to be more flexible, which helps the screen resist blinding. Blinding occurs when particles just slightly larger than the screen opening become lodged in it, which is most likely in sizing applications handling materials with a high percentage of near-size particles. Larger-diameter wire tends to tightly grip a particle stuck in the opening, which makes it hard to dislodge the particle. A screen with smaller-diameter wire tends to give a little, so that the screen's natural movement can dislodge the particle. Antiblinding devices mounted under the screen (such as vibrating sliders [plastic rings] or bouncing balls) also work better with a more flexible screen.

Screen durability. Before you decide that a screen with a smaller wire diameter and more flexibility is best for your application, be aware that there's a tradeoff for this flexibility: less durability. A screen with a smaller wire diameter is less

durable than one with a larger wire diameter and can have an unacceptably short service life in applications handling large, heavy material loads or abrasive materials. For these applications, it may be more practical to choose a screen with a larger wire diameter. But if you're concerned about blinding problems, you can choose a screen with a smaller wire diameter and simply replace this screen more often.

Choosing the screen attachment method

Different methods are available for attaching a screen to its frame and achieving the proper screen tension when you install or change out the screen. The methods include using mechanical fasteners and hook strips (which you can handle in your plant) and using pretensioned screens on rigid frames (which are most often provided by the

screener manufacturer). With any of these methods, consult the screener manufacturer to determine the right screen tension for your application.

Mechanical fasteners. Using mechanical fasteners such as tension bolts (for a round or rectangular screen) or spring clips (for a rectangular screen) is the oldest and simplest way to attach the screen to the frame. With this method, the screen periphery has a metal, cloth, or plastic edging with holes punched in it. The bolts or spring clips are placed through the holes to fasten the screen to the frame and are adjusted to achieve the right screen tension.

While a screen that's attached with mechanical fasteners is relatively inexpensive and, when equipped with flexible edging, can be rolled up for easy transportation and storage, it has several disadvantages. For one thing, it's difficult or impossible to achieve proper, consistent tensioning of the mechanically fastened screen because its flexible edging allows tensioning only at the bolt or spring clip locations. And because the screen is held tightly to the frame only at discrete points around the screen edging, coarse material can bypass the screen and simply flow under the edging between these points, contaminating the screened material. With a larger screener, dozens or even hundreds of bolts or spring clips can be required to attach the screen to the frame, making screen changes slow and labor-intensive. Screening vibration can also loosen the bolts or break or dislodge the spring clips, loosening the screen tension and, perhaps worse, contaminating the screened material with metal fragments. These disadvantages limit this attachment method to relatively coarse screens in noncritical applications, such as scalping minerals.

Hook strip. A more advanced method, which is used for rectangular screens, is attaching the screen to the frame with a hook strip. In this case, a rigid metal edging forms a lip (called a *hook strip*) around the screen's sides. Tension bolts mounted on the frame engage the edging's hook strip, and tightening the bolts to a specified torque value applies the proper tension to the screen. Unlike the flexible edging on a mechanically fastened screen, the rigid hook strip edging distributes tension more evenly along all screen sides. The hook strip screen is much faster to install than a screen with mechanical fasteners and can also be rolled up for easy transportation and storage. However, the screen isn't suitable for fine screening applications because it's difficult to maintain adequate tension on the screen, and poor sealing between the tension bolts around the frame can allow material to flow over the edging, bypassing the screen.

Pretensioned screens on rigid frames. A pretensioned screen applied to a rigid frame is the most advanced attachment type and is available for round or rectangular screens. The screen is manufactured by stretching the screen cloth on a special tensioning fixture that can be adjusted to pro-

Figure 4

Apparent and actual measured opening sizes

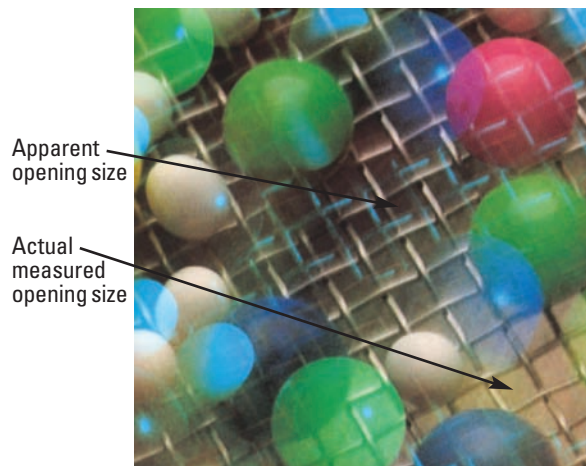
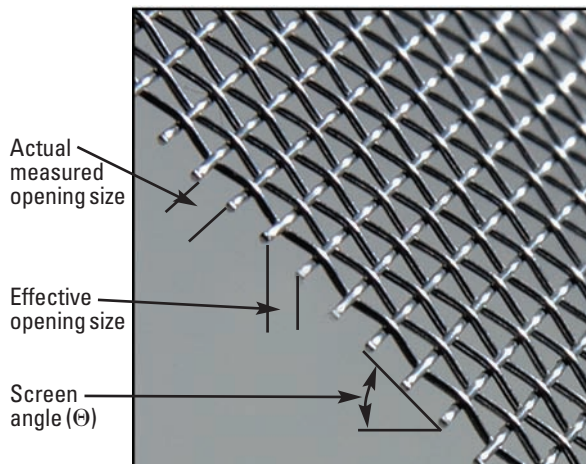


Figure 5

Effective and actual measured opening sizes on an inclined screen



vide the optimal tension for that screen. Then the tensioned screen's perimeter is permanently bonded with epoxy to a rigid screen frame that's typically made from square or rectangular stainless steel tubing. Once the epoxy sets, the screen-and-frame assembly (screen deck) is removed from the tensioning fixture and the excess screen cloth outside the frame is trimmed away. The pretensioned screen typically costs more than mechanically fastened or hook strip screens, but provides several advantages. The uniform tension throughout the screen's entire surface provides accurate and efficient separation performance, particularly in fine screening applications. And because it has no bolts, spring clips, or edging to wear or break off, the pretensioned screen is better suited than the other screens to sanitary applications with high product safety requirements, such as food and pharmaceutical applications.

If your screen is attached to its frame with mechanical fasteners or a hook strip, take extreme care when handling and installing the loose screen.

With a pretensioned screen, the frame must have enough structural rigidity to withstand the forces exerted by the highly tensioned screen. In some cases, the screen is mounted on flat sheet-metal plates instead of a stainless steel tubular frame. Because the flat plates tend to distort under load, this frame type is suited only to screens with very low tension. Other pretensioned screens are mounted on a composite frame made of polymer encasing a metal core. The polymer provides a bonding surface for the screen cloth. Instead of bonding the cloth to the frame with epoxy, the cloth is fused to the frame by heating the cloth and melting it into the polymer surface. Because the frame's metal core is completely encased in polymer, the screen provides excellent durability for screening very corrosive materials.

To increase the pretensioned screen's service life, a *backup screen* can be installed under the more delicate process screen in the same frame to provide mechanical support for it. The backup screen is coarser and more durable than the process screen and is simultaneously pretensioned and bonded to the frame with the process screen. The backup screen also protects the process screen from direct impact and abrasion by antiblinding devices.

Some advice for operating and maintaining your screener

Once you've selected a screen, it's important to keep it in good shape to ensure that it provides top separation performance over the long term. This means properly transporting, storing, installing, and maintaining your screen. Always transport the screen in its original reinforced, cor-

rugated carton, and leave the screen in this carton until you're ready to install it. Store the screen vertically not only to conserve floor space in your plant but to prevent damage caused by stacking other items on the screen. Follow the screener manufacturer's instructions when installing the screen in your screener.

If your screen is attached to its frame with mechanical fasteners or a hook strip, take extreme care when handling and installing the loose screen: Any dents or creases in the screen cloth will create stress concentration points that can lead to premature failure (tears or holes). Also take care when tensioning such a screen because under- or over-tensioning will impair the screen's separation performance and shorten its service life.

You can keep your screener running smoothly over the long term by periodically inspecting the screen (or screens) and providing regular preventive maintenance. This is even more important if your screener has a fine mesh screen. A screener that handles fine particles typically has multiple inspection openings on each screen deck so the operator can make a quick visual check of the screen without having to disassemble the screener.

Your routine maintenance should include checking screen tension, checking for material buildup or blinding on each screen, checking the condition of antiblinding devices, and — most important — inspecting each screen for tears or holes.

PBE

Reference

1. To receive a copy of a particle-size-to-screen-mesh conversion chart, contact the author at the address listed below or download the chart from the "Technical Library" on Sweco's Web site (www.sweco.com).

For further reading

Find more information on screens and screeners in articles listed under "Screening and classifying" in *Powder and Bulk Engineering's* comprehensive article index at www.powderbulk.com and elsewhere in this issue.

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