



## The 2004 Solids Control API RP 13C

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### Abstract

The API Sub-Committee 13 organized a Task Group to rewrite the API RP13C (the recommended practice for drilling fluid processing systems evaluation) and 13E (the recommended practice for shale shaker screen cloth designation) before they were submitted to the International Standards Organization (ISO) to become an international standard. The Task Group completed its work during the past year and new procedures are now in place to describe solids control equipment. The major change is in the way shale shaker screens are described.

### Introduction/Background

A brief review of the history of shale shaker screens may help to understand how difficult it was to arrive at the changes that eventually were agreed upon.

Initially screens were easy to describe. They were square mesh made with market grade wire. The mesh size was the number of openings per inch in two directions.

Louis Brandt designed a triple-deck, circular motion shaker for a mud company that was not marketed very successfully and subsequently was not used by many people. He left that organization and formed his own company where he began manufacturing a double deck, circular motion shaker. To improve volume throughput, he also introduced a "B" series of screens which had rectangular openings. The B-60 had about 44 openings in one direction and about 12 openings in the other direction (Fig.1). He correctly diagnosed that rig hands were only measuring the volume flow rate through the screens [rig pump rate] and had little way to measure relative quantities of solids removed from a drilling fluid.

Other wire sizes (many of which were smaller in diameter) were introduced which gave the same number of openings per inch, but ended up having larger openings due to the smaller diameter wire. This was in contrast to what a standard ASTM screen would have had. The new type of screens could legitimately report the mesh count and also have superior capacity, or

throughput. It was argued by some that the superior throughput was being obtained by allowing more drill solids to be returned to the pits.

The size of solids moving through a screen depends on mesh **AND** on the diameter of the wire. The openings (and the solids that pass through it) are larger if the wire has a small diameter (Fig.2).

The wire mesh on the left will have a greater flow capacity but will also return more solids to the drilling fluid. Specifying "mesh" does not necessarily identify the ability of a shaker screen to remove solids.

The next problem with describing shaker screens was the problem with multilayers of screens. If screens with two different mesh counts are placed on top of each other, a large assortment of openings is created. Service companies have found that these screens do a good job of removing solids but, almost surprisingly, have a much higher fluid capacity than expected. These screens have become common on drilling rigs.

To solve the description problem, the recently supplanted RP 13E document tried to determine a particle separation potential by looking at 1500 openings in a screen with a microscope. The length, width, and height of these 1500 openings were measured. An ellipsoidal volume was calculated for each opening. Each ellipsoidal volume was then translated into a spherical volume and a diameter of the sphere was calculated for each opening. These diameters were then plotted as a cumulative percent. The diameter representing 16%, 50%, and 84% of the distribution were to be reported as the d16, d50, and d84. The lower case letter 'd' was used to separate it from a real separation curve.

A D50 separation means the diameter where one-half the solids are captured on the screen and one-half of the solids pass through the screen. The 16 and 84 numbers were selected because these are one standard deviation away from the mean in a Gaussian distribution.

This became an accepted Recommended Practice when API RP 13E was approved and issued in May, 1993. Few vendors labeled their screens with this information. The apparatus to make the measurements was originally located in the Amoco Research Laboratory in Tulsa before it closed. Availability of the equipment for routine labeling was non-existent.

New screens with a variety of opening sizes and shapes make it a challenge to describe the openings in a meaningful manner. A new Task Group was formed to reconsider both RP 13C and RP 13E. They explored many different options and techniques. Many hours of laboratory time were devoted to the project by many different solids control vendors and screen manufacturers.

### The New API RP13C

- **Section 1** Scope

This International Standard covers the standard procedure for assessing and modifying the performance of solids control equipment system in the field. It is not intended as a procedure for the comparison of similar types of individual pieces of equipment.

- **Section 2** References.

- **Section 3.1** Definitions – 130 words defined

API sand is still defined as any particle too large to pass through a square opening screen which will now be labeled: API 200 (74microns). Particles can be shale, barite, wood, gold, or diamonds. Pixels and other words associated with the optical method of determining separation potential of a screen have been eliminated.

- **Section 3.2** Symbols and abbreviations

- **Section 4** Requirements

This describes what is in this document.

- **Section 5** Drilled Solids Removal – System Performance

This procedure gives a method to determine drilled solids removal efficiency from the system.. It assumes that the volume of clean drilling fluid added to the system dilutes the remaining drilled solids to the targeted value. This procedure was developed by Jason Bradley and Brad Smolen for the last API RP 13C.

A long drilling interval is required for accuracy. The dilution factor is calculated by monitoring the amount of base fluid (oil or water) added to the system and/or the volume of clean drilling fluid added to the system to dilute the remaining drilled solids after processing the drilling fluid through the solids control equipment. Barite can also be used as a “tracer” to determine the volume of clean drilling fluid.

This section describes how to determine drilled solids equipment removal efficiency. It remains unchanged from the original document, although the committee

spent many hours ‘discussing’ improvements and expansion of the calculations.

- **Section 6** Rig site evaluation of drilled solids management equipment

This is a new section which presents “capture equations” to determine the effectiveness of individual pieces of equipment. Capture is defined as the fraction of incoming suspended solids that report to the rejected stream.

- **Section 7** Practical operating guidelines

This section is a guideline for design and operation of removal equipment. It presents most of the same information provided in the preceding 13C but is now organized in sections to separate design from operations. Following these guidelines will result in a very good functional drilling fluid system.

The remainder of the new API RP 13C was modified from API RP 13E. One goal was to describe shale shaker screens without involving their performance. These sections will be introduced here and then discussed later in greater detail.

- **Section 8** Shale shaker screens conductance

Conductance is a measure of the ability of a Newtonian fluid to pass through the screen. It has the units of permeability per unit thickness of the screen.

Darcy’s Law is used to determine conductance.

- **Section 9** Shale shaker screen designation

Screens will be compared with ASTM standard square mesh screens using a RoTap and aluminum oxide grit.

- **Section 10** Non-blanked area of shale shaker screen panel

The procedure described in API RP 13E needed no change

- **Section 11** Shale shaker screen labeling

- The label will have the following information:
  - API Screen Designation [for example, API 200 will represent a screen that separates particles like an ASTM 74 micron or alternate designation of 200.]
  - Equivalent Aperture
  - Conductance
  - Non-blanked area
  - Manufacturer’s designation/Part number
  - Optional but recommended information:
    - Manufacturer’s name
    - Country of manufacture or assembly.

The principal changes to the new Recommended Practice have been related to determining the conductance of a screen and a description of the openings in a screen. The Task Group also wanted to create a method of measurements which will allow a screen to be removed from a rig and tested to determine if it is labeled properly.

## Conductance

API 13E conductance was measured by pumping a 35cp glycerin/water solution through a small sample of the screen and measuring the permeability. The pressure drop was very small and the viscosity of the fluid difficult to control. An experienced technician was required to acquire reproducible data. The new Task Group designed a test where the measurements were easier to make.

Procedures were changed so that the screen used to measure conductance can also be used to determine screen description. Screens must be stretched – in the same manner they are mounted on shakers in order to make meaningful measurements. A screen without tension will appear to be a much coarser screen.

Motor oil was selected as the Newtonian fluid to flow through the screen because the viscosity was much larger than the viscosity of glycerin/water solution. This allows a larger head to be applied with a reasonable flow rate.

Test screens are mounted between two short pieces of 6" diameter Schedule 80 PVC pipe. The screens are stretched before mounting to allow the shape of the openings to resemble the shape the openings will have when mounted on a shale shaker. A 6" diameter plastic pipe was selected instead of mounting the screen in an eight inch diameter metal ring (like the standard ASTM screens) because the flow volume through the screen would be more manageable. The screens can also be stretched and epoxied onto the rings to create a sample that could be used for both conductance and screen designation.

A large container (around 50 gallons) of motor oil is located above the test screen. Motor oil flow rate is adjusted so that it flows through the screen at a constant rate. A chart of oil viscosity and density as a function of temperature is developed before the test. Oil overflowing from the screen is directed away from the fluid flowing through the screen. The flow through the screen is captured in a container on a scale connected to a recorder. When the weight increase is constant, the flow rate through the screen is determined from the density of the oil.

Oil overflows the top section of PVC pipe. The height of the fluid above the screen determines the pressure causing flow through the screen.

Since conductance is derived from Darcy's Law, obviously smaller openings in a screen will result in a lower value for conductance. The capacity of shaker screens decrease as the opening size decreases. Much

more fluid can flow through an API 40 than an API 200 screen. The quantity of solids removed from the drilling fluid increases as the opening size decreases.

Motor oil was selected because it will oil-wet the screen and has a high Newtonian viscosity. The flow velocity through the screen is maintained less than 2 in/sec to make certain that the flow is laminar. The equations apply to only laminar flow and not turbulent flow. [Fluid flowing at 400gpm through a 4' X 5' screen with 35% open area would have an average velocity of 1.5 in./sec.]

The goal of the mounting procedure was to develop a technique that would also allow screens to be shipped in from a drilling rig for confirmation testing. The same screen could be used for both the conductance and the screen description. Conductance testing will normally be completed after the screen designation is completed or the screens can be washed and dried to remove the oil from the conductance testing (Fig. 3, 4 & 5).

## Screen Description

Most of the controversy and discord on the Task Group came from trying to complete this section.

The Task Group started by trying to identify the real problem with providing a meaningful screen description. As described earlier, the word "mesh" no longer provided much information because the openings in screens varied so much. Different wire diameters, different rectangular weaves mounted in different orientations, and different size openings prevented a simple designation to be applicable to all screens. In addition to this problem, the openings would now be described in metric (SI) units when the Recommended Practice became an International Standard.

Currently, triple layer screens are used, which seem to improve flow capacity while removing a large quantity of solids. Even a two layer screen is difficult to describe with the term "mesh" (Fig. 6 & 7).

The word "mesh" was also used to categorize screens with greatly different appearances. The images of the four screens shown above were taken through a microscope with the same magnification [Note the scale marking on each image.]. The screens were taken from four different rigs. The manufacturer's stock numbers have been removed for anonymity. The largest number appearing on the screen box is shown on each image. It may be argued that most people on a drilling rig would assume that these were mesh numbers. One of the above did have the word "mesh" printed after the

number. Clearly, each of these screens differs from the others in many ways. It can be postulated that all can not have the same equivalent opening sizes.

Many different methods to describe screens were tested and/or discussed by the API Task Group during the past five years. Methods included developing a dedicated test shaker, wet sieving, different grits, mathematical models, and optical methods. The new procedure finally developed is a physical test which compares a test screen with standard ASTM screens.

The Task Group decided a physical test would be the fairest way to take measurements to describe current screens and also any future unusual designs. The ASTM standard set of screens specifies the openings widths, tolerances, and wire diameters for screens coarser and finer than those used in the oil field.

Solids can be sieved and sorted through a stack of standard ASTM screens. These solids, when presented to a test screen, will be sorted by the test screens into sizes equivalent to some ASTM designation. This will describe the effective screen openings and is not intended to describe performance of the screen on any particular shaker (Fig.8).

A complete list of ASTM screens is presented in the new API RP 13C. A short list is presented in Figure 9 of sizes most commonly used on drilling rigs.

### **D100 Separation**

Shaker screens are considered go-no-go separators. Initially, with square screens, some particle size would be the maximum size that could go through the screen. This is the D100 separation point. The Task Group decided to return to this concept with the new screen designation. Presumably, the largest particle that could possibly enter the drilling fluid system will be the opening size determined by the new test. Smaller particles may be rejected. As the liquid film that surrounds the screens increases in thickness, the effective opening size is smaller than indicated by the D100 separation point. For example, when a screen becomes water-wet, NAF (Non-Aqueous Fluid) will not pass through an API 200 screen. The NAF, even without solids, finds the openings too small to permit passage of another liquid phase.

### **Wet or Dry??**

Evaluations by members of the committee indicated that wet-sieving is difficult and does not contribute to screen description. Although while in use; drilling fluids will wet the screen, the goal is to describe the screen openings NOT the performance. The ring of wetting fluid effectively decreases the opening size in a screen. The

thickness of the wetting fluid ring depends upon the wetting fluid properties. A "standard" wetting fluid was discussed but no consensus could be reached. The Task Group decided to use dry sieving.

### **Grit?**

Choices seem to be sand, glass beads, or aluminum oxide. Sand was the first choice because it is prevalent and can be acquired so easily. Sand grains have different shapes, roundness, and can even be associated with specific geographic locations, which complicates specifications of the grit material. More importantly, Task Group members reported great difficulty with getting reproducible results.

Glass Beads offered the next opportunity. Two round-robin blind comparison testing of four different screens by four different companies resulted in failure to reproduce results. All screens appeared much finer than screens compared with aluminum oxide grit.

Aluminum Oxide gave reproducible results in the two round-robin comparison testing. This material has been used extensively in sieving tests. Surprisingly, the grit actually resembles shale cuttings that arrive at the surface when a well has good carrying capacity (Fig. 10).

Glass beads resemble the shale which arrives at the surface on drilling rigs with poor drilling practices. With poor carrying capacity, shale cuttings are tumbled in the annulus and arrive at the surface with no sharp edges.

Subsequent testing indicated that if the glass beads and aluminum oxide were washed thoroughly before testing, the glass bead data matched the aluminum oxide data. Aluminum Oxide was chosen as the proper grit to use.

The new designation for screens may cause some types of screens to be labeled as much coarser as they are presently labeled. The four screens shown in Fig. 11 reveal a significant change. The number 180 seems to actually refer to the micron opening size rather than the mesh size. The number 175 also seems to refer to the equivalent opening micron size instead of the mesh size. The API numbers also appear to match a visual approximate guess about the size of openings in the screen. The smallest openings appear to be in the screen with the highest API number.

The new API RP 13C was one of the first documents written by an SC13 Task Group for immediate submission to the ISO. As such, all units must become SI. The concept of "mesh" is, therefore, not sustainable. Openings per centimeter or openings per meter would not be easily translated into the understanding of a

derrick man and related to openings per inch. Rig hands are accustomed to inventorying and handling screens by mesh size. To help the conversion from “mesh”, the Task Group decided to give the screens a designation which highlighted the ASTM Alternative Designation. As such, the Task Group decided to use the ‘alternate’ designation of the ASTM standard as an “API NUMBER”. The openings will then be designated by the API number and an equivalent micron size opening.

ASTM screens are created with a specific wire diameter and opening sizes. The “alternative designation” will be called the ‘API number’. For example, API 170 would have a 90 micron equivalent opening. The specifications on opening sizes provide a large latitude to meet specifications. An ASTM 200 standard screen could have openings from 85 to 95 microns. An API 200 screen could have an opening between 69 microns to 82.5 microns.

### Procedure to Measure API Number

To measure the API number of a screen, different grit sizes are placed on a test screen and shaken in a RoTap for 10 minutes. The weight of the grit sizes remaining on the screen can be used to determine the size of grit that could not go through the screen. This would be the D100 or the separation potential of the screen to remove 100% of the particles larger than the openings. This technique is called the “finder” method and is used initially by laboratory technicians to determine roughly what size grits should be placed in a RoTap stack to efficiently measure the test screen’s equivalent opening size. This was not included in the procedure but the technique allows a technician to select grit sizes correctly the first time.

### Equivalent aperture opening size

Known weights of aluminum oxide grit previously sized on a stack of ASTM screens are placed on the top screen and vibrated for 10 minutes. The grit weight on the test screen is used to compare with the apertures of known ASTM square mesh screens.

In the case illustrated in Fig. 12 & 13, 10.72gms cumulative were captured on the test screen and the API 80 screen below it. In this case, the opening size would be equivalent to 173 microns and designated as an API 80 screen.

The screen designation would be API 80 (173 microns). The fact that the micron size number is different from the ASTM 180 micron [Alternative Designation 80] indicates that the screen description was determined from the API RP 13C test.

### Conductance

The measurements of conductance for the screens shown in Fig.11 are presented in the table below. Three different heights of motor oil were used to make three determinations of the conductance of the screens. Care was taken to make certain that the flow was laminar by limiting the velocity through the screens to less than 1 inch per second.

### Summary

Shaker screens will be labeled in a manner that should find good acceptance on drilling rigs. The largest number on the screen box or label will be the API number. The screen equivalent opening size, in microns, will be displayed below the API number. A standard API 170 screen would have square openings that are 90 microns by 90 microns. The screen designation below indicates this screen has been measured with the API procedure and has an equivalent opening size of 93 microns.

SAMPLE SCREEN LABEL:  
**ISO 13501/ API 13C**  
**Screen Designation**  
**API 170**  
**(93 Microns)**  
**Catalogue # XX-13**

In addition to the information about the Screen Designation, the non-blanked area and the conductance will be on the label. This may not be as important to a derrickman as the opening sizes, but this information can be used to select other screens to improve performance on a drilling rig.

**Non-Blanked Area**  
**7,23 square feet**  
**Conductance**  
**1.22 KD/mm**

In addition to the above information, the manufacturer will include stock numbers, identification numbers, their addresses, phone numbers, e-mail contacts, or other information necessary to reorder the screens.

We-R-Shakers  
311 Fantasy Lane  
Utopia, Texas, 77777

## APPENDIX

Additional data has been acquired to verify the procedure and to identify another shaker screen. This data was not reported in the API Task Group 5 report to API SC 13.

A panel screen was mounted in a short section of 6' diameter PVC pipe. Preliminary 'Finder Tests' indicated the test screen was in the range between an API 120 and an API 140. Eight grams of aluminum oxide in the size range of an API 100, API 120, API 140 and API 170 were blended together to form a 32.0 gram test sample.

The test screen was placed in the middle of a RoTap stack of tarred ASTM screens. The aluminum oxide test sample was placed on the top screen and the stack vibrated for 10 minutes. A weight of aluminum oxide on each screen was determined. The cumulative weight was plotted as a function of the micron opening size of the standard screens. The opening size of the test screen could be determined from the cumulative weight on aluminum oxide grit captured on the test screen. The procedure was repeated three times.

The opening sizes are 114, 114.9, 114.4 microns with an average of 114.4microns. The screen designation would be:

**API 140**  
(114 microns).

Please see Figures 15,16,17 & 18.

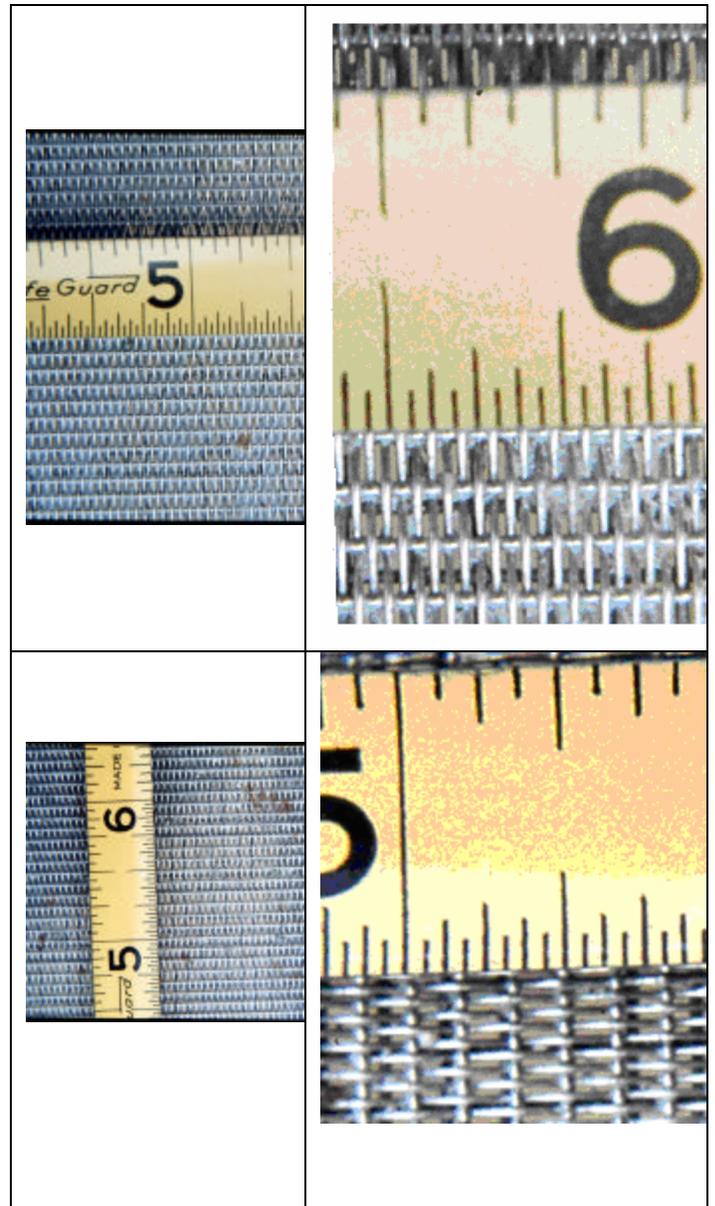


Figure 1

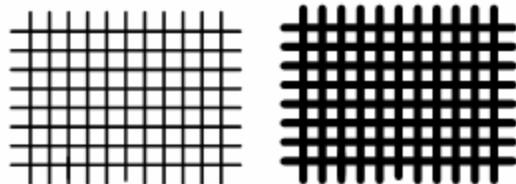


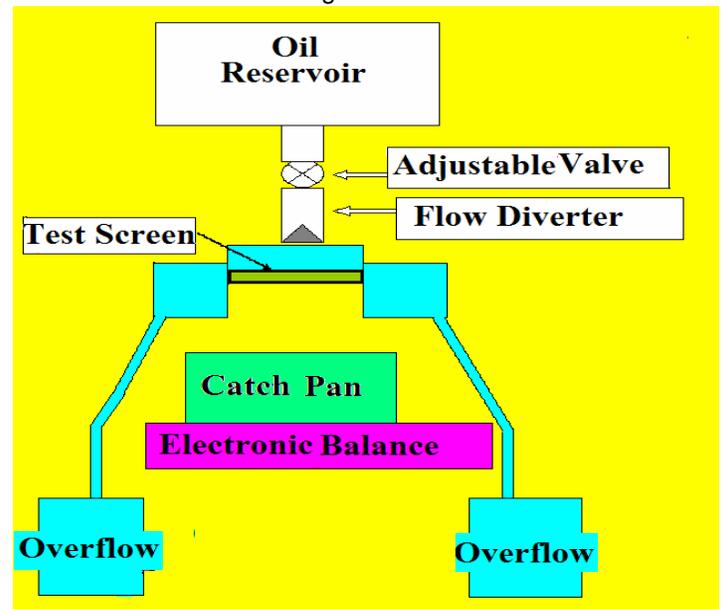
Figure 2



Figure 3



Figure 4



Darcy's Law:

$$Q = \frac{K \Delta P A}{m L}$$

Solve for conductance:

$$\frac{K}{L} = \frac{m Q}{\Delta P A}$$

Measure flow rate  $Q$ , area  $A$ , viscosity  $m$ , and pressure  $P$ .

[The thickness  $L$  does not have to be measured.]

Figure 5

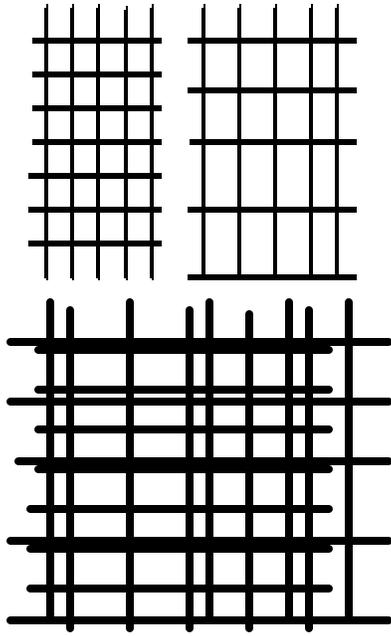


Figure 6

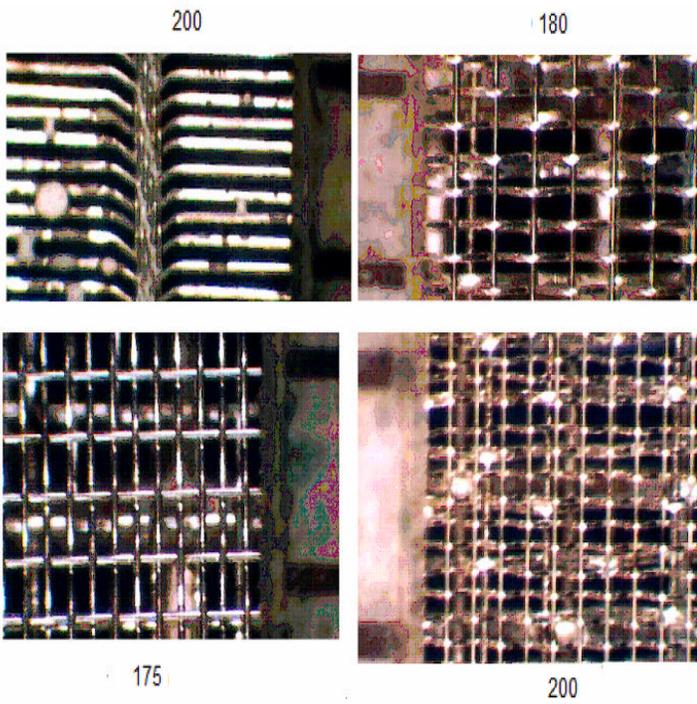


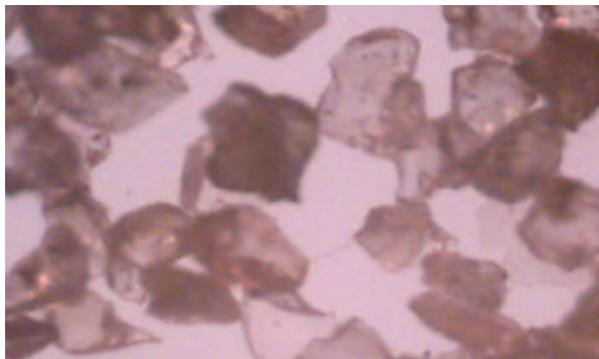
Figure 7



Figure 8

| Standard<br>microns | Alternative<br>Designation | Permissible<br>Variation<br>+/-<br>microns | Max.<br>Openings<br>for 5%<br>microns | Maximum<br>Individual<br>Openings<br>microns |
|---------------------|----------------------------|--|---------------------------------------|--|
| 300                 | 50                         | 14   | 337                                   | 363  |
| 250                 | 60                         | 12   | 283                                   | 306  |
| 212                 | 70                         | 10   | 242                                   | 263  |
| 180                 | 80                         | 9  | 207                                   | 227  |
| 150                 | 100                        | 8  | 174                                   | 163  |
| 125                 | 120                        | 7  | 147                                   | 192  |
| 106                 | 140                        | 6  | 126                                   | 141  |
| 90                  | 170                        | 5  | 108                                   | 122  |
| 75                  | 200                        | 5  | 91                                    | 103  |
| 63                  | 230                        | 4  | 66                                    | 89   |
| 53                  | 270                        | 4  | 57                                    | 76   |
| 45                  | 325                        | 3  | 48                                    | 66   |

Figure 9



Aluminum Oxide



Shale  
Figure 10

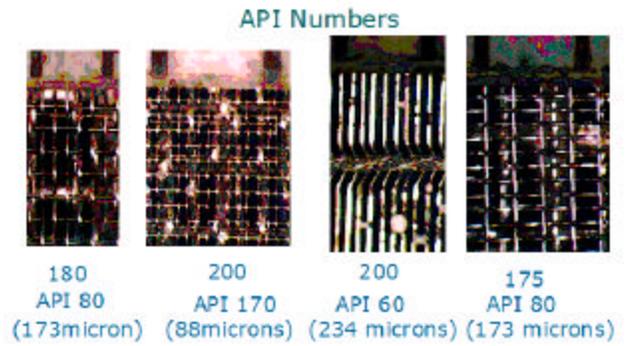


Figure 11

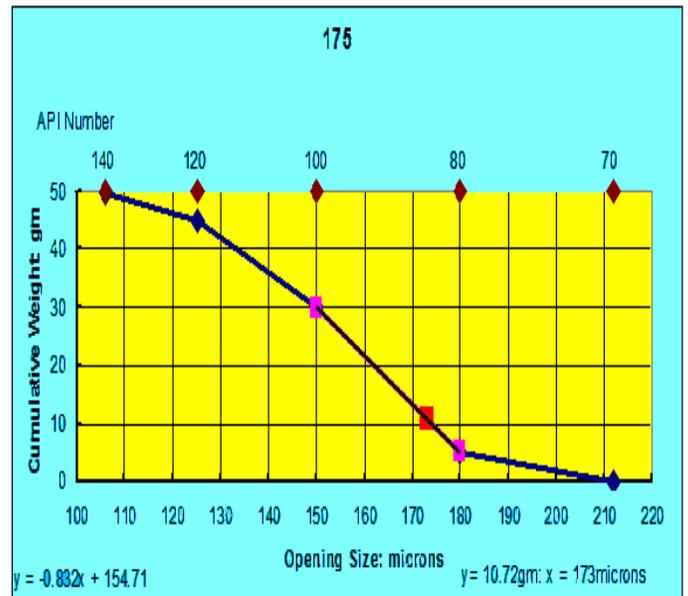


Figure 12

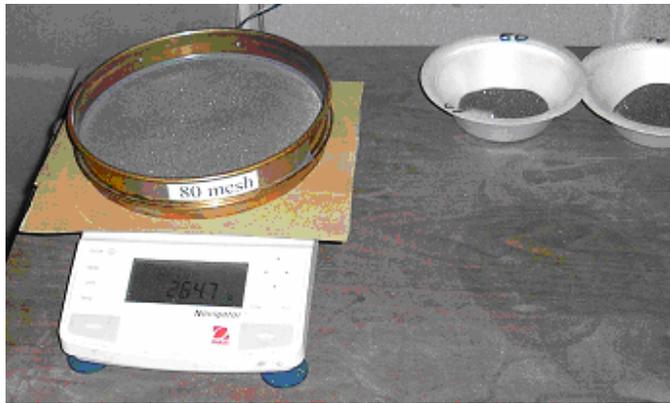
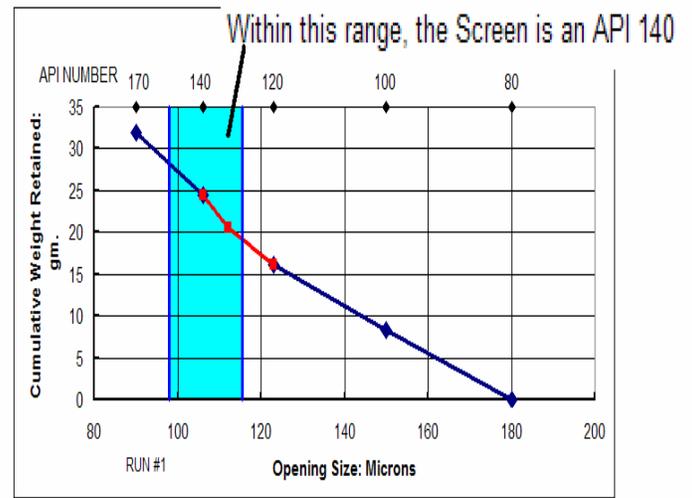


Figure 13

Figure 16-18



CONDUCTANCE

|                           | 200 Flow Velocity in./sec. | 180 Flow Velocity (in./sec.) | 200 Flow Velocity (in./sec.) | 175 Flow Velocity (in./sec.) |
|---------------------------|----------------------------|------------------------------|------------------------------|------------------------------|
| 1 in. Head                | 0.07                       | 0.11                         | 0.10                         | 0.11                         |
| 2 in. Head                | 0.13                       | 0.17                         | 0.18                         | 0.21                         |
| 3 in. Head                | 0.18                       | 0.24                         | 0.29                         | 0.30                         |
| Average Conductance KD/mm | 0.79                       | 1.05                         | 1.13                         | 1.27                         |

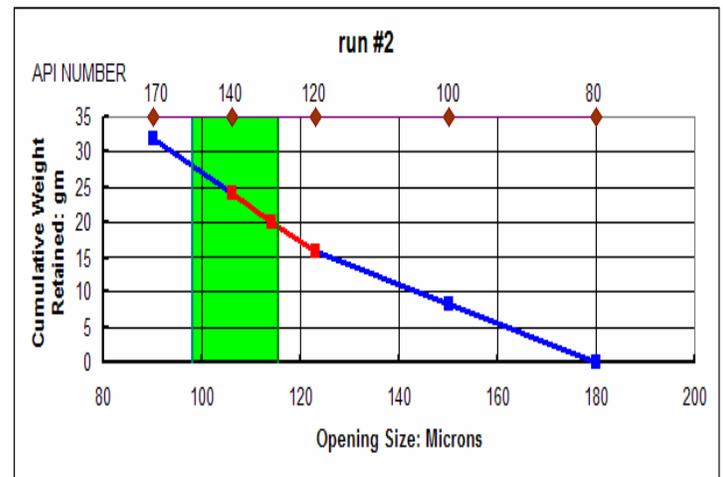


Figure 14

| ASTM API Number | ASTM Opening Size microns | Test Samp Start Wt grams | Run # 1 Cumm. Weight Retained grams | Run # 2 Cumulative Weight Retained grams | Run # 3 Cumulative Weight Retained grams |
|-----------------|---------------------------|--------------------------|-------------------------------------|--|--|
| 80              | 180                       | 0                        | 0                                   | 0  | 0  |
| 100             | 150                       | 8.00                     | 8.4                                 | 8.30                                     | 8.40                                     |
| 120             | 123                       | 8.00                     | 16.1                                | 15.90                                    | 16.1                                     |
| Test Screen     |                           |                          | 20.6                                | 20.2                                     | 20.4                                     |
| 140             | 106                       | 8.00                     | 24.4                                | 32.00                                    | 24.6                                     |
| 170             | 90                        | 8.00                     | 32.00                               | 32.00                                    | 31.8                                     |
| Pan             |                           |                          |                                     |  | 0.20                                     |
| Cumulative      |                           | 32.00                    | 32.00                               | 32.00                                    | 32.00                                    |

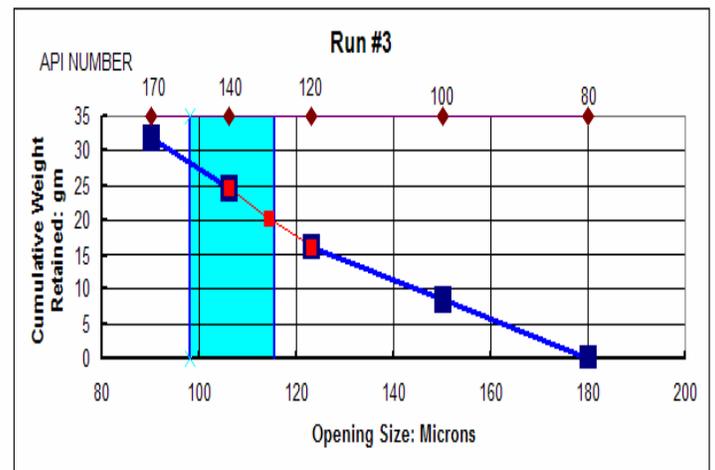


Figure 15

