VSMA Vibrating Screen Handbook

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CONSTRUCTION INDUSTRY MANUFACTURERS ASSOCIATION
Producers of CONEXPO®
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Introduction

The Vibrating Screen Manufacturers' Association has developed this publication in the belief that an engineering handbook applying to mechanical vibrating screen equipment, and its selection and operation would benefit the manufacturers, the distributors, the users and operators, as well as engineering students. It represents the combined efforts of the following past and present members of VSMA:

> FMC Corporation; Hewitt-Robins; Nordberg, Inc; Simplicity Engineering Company; Svedala Industries; Symons Brothers Co; Tabor Machine Co.; Telsmith; W.S. Tyler, Inc.

The Vibrating Screen Manufacturers' Association was founded in June, 1959, by five charter members, and was originally known as the Mechanical Vibrating Screen Manufacturers' Association. In 1996, the members of VSMA voted to become a bureau of the Construction Industry Manufacturers Association (CIMA).

The purposes of the Association as set forth in its By-laws are:

a) To promote and sustain standardization of specifications for vibrating screens and feeders where it is in the best industry interests, and those of the customers and the general public.

b) To promote and further the interests of manufacturers of vibrating screens and feeders with new techniques in production, distribution (domestic and export), shipping, safety, environmental controls, engineering research, and other facets of the industry.

c) To collect cooperatively, on a strictly confidential basis as to individual company information, and disseminate to members, combined statistical data relative to the manufacture, bookings, and distribution of mechanical vibrating screens and feeders.

d) To promote the use of vibrating screens and feeders and improve the quality of the same.

e) To act on behalf of the industry as a unit, on any general questions that involve the industry as a whole, and to cooperate with the Federal and State governments and their agencies in the formulation of regulations affecting the industry, in a manner which will best serve the interests of government and the industry.

Additional copies of this handbook can be obtained from CIMA, 111 East Wisconsin Avenue, Suite 1000, Milwaukee, WI 53202-4879; 414/272-0943, FAX 414/272-1170.

Chapter 1
The History of Screening

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History Of Screening

The History of Screening predates recorded history and probably originated in man's effort to abstract clays and minerals from raw earth. The first recorded references date to 150 B.C. in descriptions of Greek and Roman Mining Methods where crude sieves of woven horse hair, reeds or planks and hides punched full of holes were first used for particle size separation. The first use of woven wire screens in the 15th century is attributed to the Germans.

The first mention we have been able to find of mechanically shaken screens is in "John Smeaton's Diary of his Journey to the Low Country", in 1775. (John Smeaton, as some readers may recall, was the English Civil Engineer who built the famous Eddystone Light House and was the first Englishman to discover the secret of hydraulic cements). At Rotterdam, The Netherlands, he found the Dutch pulverizing Terras or Trass, in stamp mills, with screens in closed circuit. He called them sieves. By a cord tied to the stamper, the head end of the screen was raised 5" or 6" when the stamper went up and dropped back on the sills with a jog when the stamper came down. The screen was hinged near the lower end and was inclined at an angle. The undersize material dropped into a hopper below the screen and the oversize was shoveled back into the stamp mill.

This bit of history is worth recording here because it shows that the fundamental idea of a vibrating screen as well as the advantages of closed circuit grinding were known in Europe 200 years ago. The first attempts at vibrating screens in this country were various devices for shaking or vibrating the screen deck by impact with hammers, tappets or cams. Some screens of this type were put into operation in the late 1890's and early 1900's.

From 1900 on many methods of screening were tried. Barrel or Rotary Drum Screens and slow speed shaker screens were among the popular units.

About 1910, the first truly modern vibrating screens (500 rpm and faster) started to make their appearance.

The first crude vibrating screens took several forms.

The first and simplest of the vibrating screens was vibrated merely by an off-center shaft or shaft with an off-center weight. When the shaft was revolved rapidly, it shivered or vibrated whatever was attached to it. Hence when rigidly attached to the sides of a screen frame, the weights vibrated the screen. The first and simplest one was a wooden box, one side open at the lower end with screen cloth fastened to the bottom. About half way down the screen box was a plank with a solid steel shaft off-center between bearings driven by a belt and pulley. The whole rig was mounted on wagon springs top and bottom. The next type of mechanical vibrating screen that was developed was the positive throw type. On this type of unit, the screen body itself takes the place of the off-center weights. It rides up and down or around the circle on eccentric bearings. The underlying principle is that the whole screen has an orbit or vibratory motion with an amplitude equal to the eccentricity of the shaft or rings that carry the bearings on which the screen body rides. Counterweights are employed either as part of the drive shaft or as unbalanced flyweights at the end of the shaft to absorb the vibration of the screen. The third type of vibrating screen experimented with in the early part of the 20th century was the electric vibrating screen. This unit depended on electric lmagnets and moving armatures for its vibration. The screen cloth was held at drum head tension and the reciprocating armature was attached to the screen surface not far from the center, flexing it in every cycle.

During the 1920's and 30's, improvements were made in the design of the three above-mentioned types of screens. Screen box design was improved, vibrator design was simplified and improved by the use of better lubricating methods and better bearings. By the early 1940's, inclined vibrating screens had become an extremely important part of most processing plants, replacing the older less efficient screening methods, such as, shaking screens, and tromell screens.

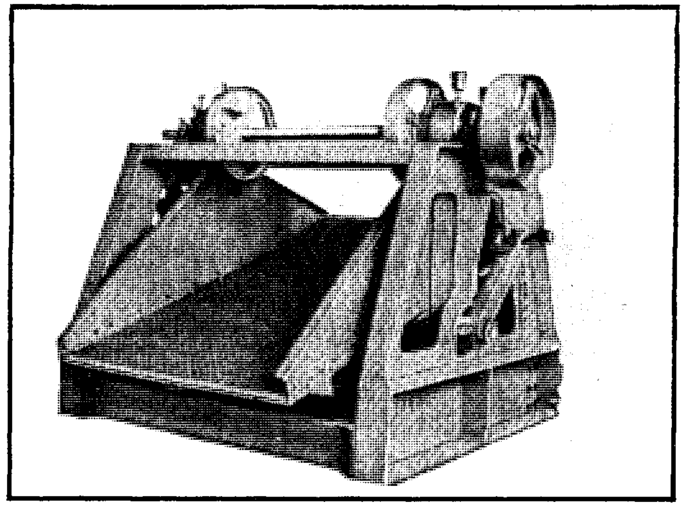
In the early 1930's, experimentation began with the development of a screen that would do a sizing or dewatering job but operate on the horizontal rather than relying on gravity for the conveyability of material.

These screens were originally pushed because of their great advantage in saving in head room. Development on this type of machine was worked on on a continuing basis to a point where in the early 1940's, the horizontal vibrating screen became an accepted piece of equipment for dewatering in coal preparation and other mining preparation plants. From the 1940's until the present time, the basic types of vibrating screens mentioned above have continued to be improved in design to a point where it is possible to build the mechanical vibrating screen in normal commercial sizes up to 8' x 24' with some special sizes being available at 10' x 30'.

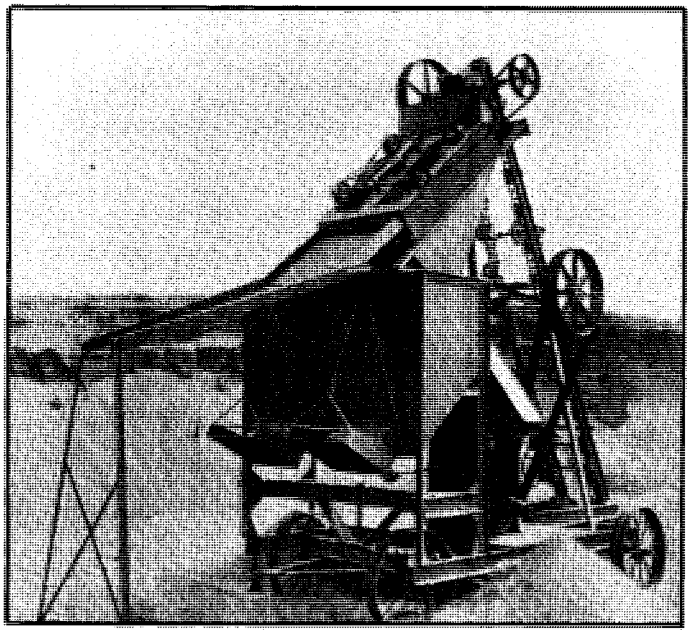
While there have been improvements in lubrication systems, bearing life steels, construction and manufacturing procedures, the basic design of the mechanical vibrating screen remains pretty much the way it was at its early concept.

In the late 1950's and early 1960's, the Free Resonance type of screen was introduced in Europe and quickly emerged in America. Its great appeal was that it required very little horsepower because it generated most of its action by the interaction of two elastically connected-actuated masses. Because of the high maintenance, high first cost, and precise adjustments required, this screen has, at least temporarily, lost its popularity. It may emerge again as electrical energy becomes a major operating cost.

The manufacturers of vibrating screens continue to search for ways to better separate the product through such methods as higher speed, longer stroke or combinations of amplitude and frequency.

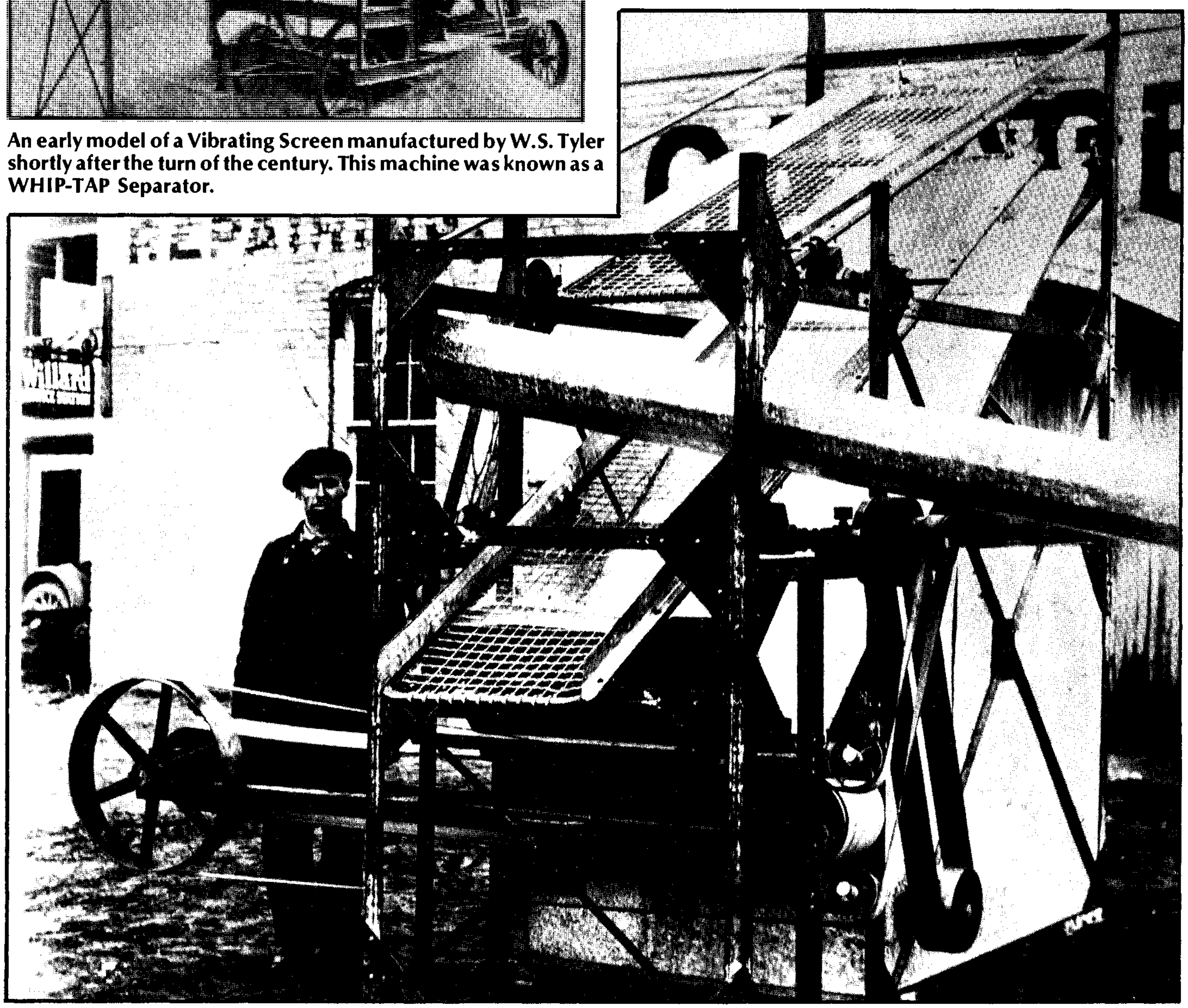


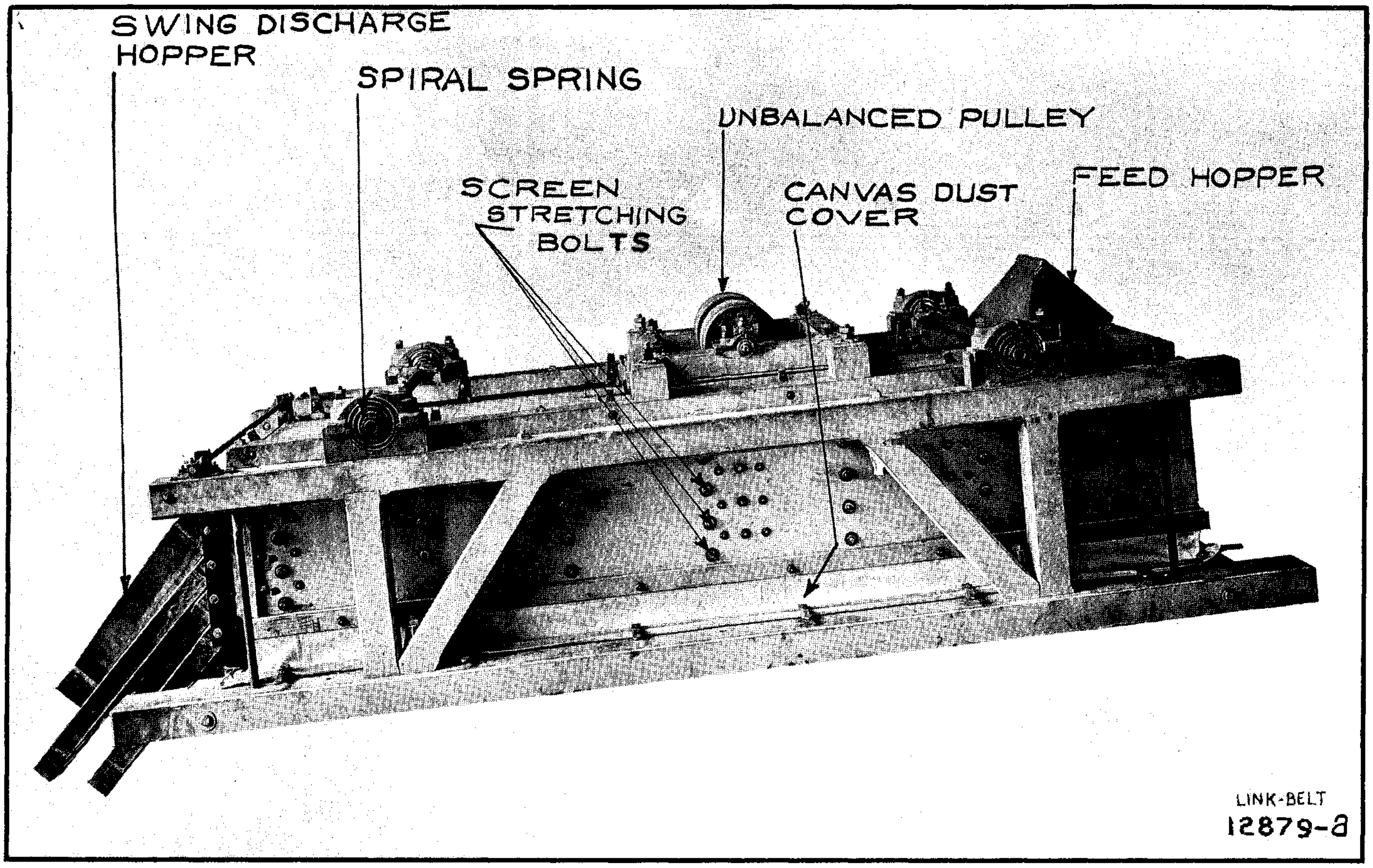
The ROCO—an early HewittRobins Single Deck 2′ x 8′ Screen built in 1912 for coke screening at a steel plant. The machine was suitable for sizing bulk materials at 1/4″ to 3″ separation.



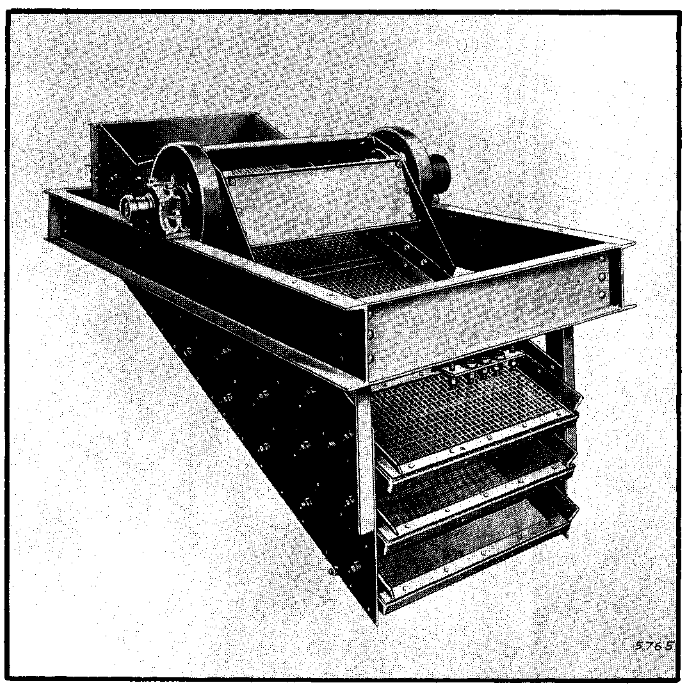
An early model of a Vibrating Screen manufactured by W.S. Tyler shortly after the turn of the century. This machine was known as a WHIP-TAP Separator.

A 4′ x 12′ Two Deck Four Bearing Screen built by Simplicity in 1922. The Vibrating Screen had a counterbalanced shaft on an offset eccentric shaft to produce a circular motion. This model had a capacity of 30 yards per hour.

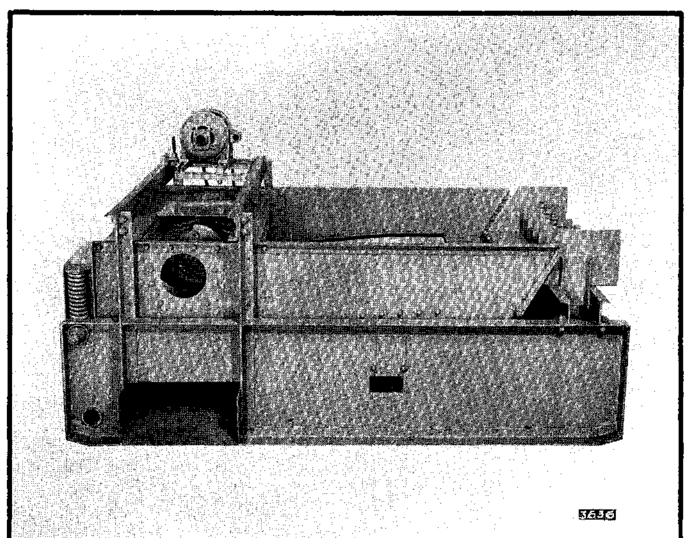




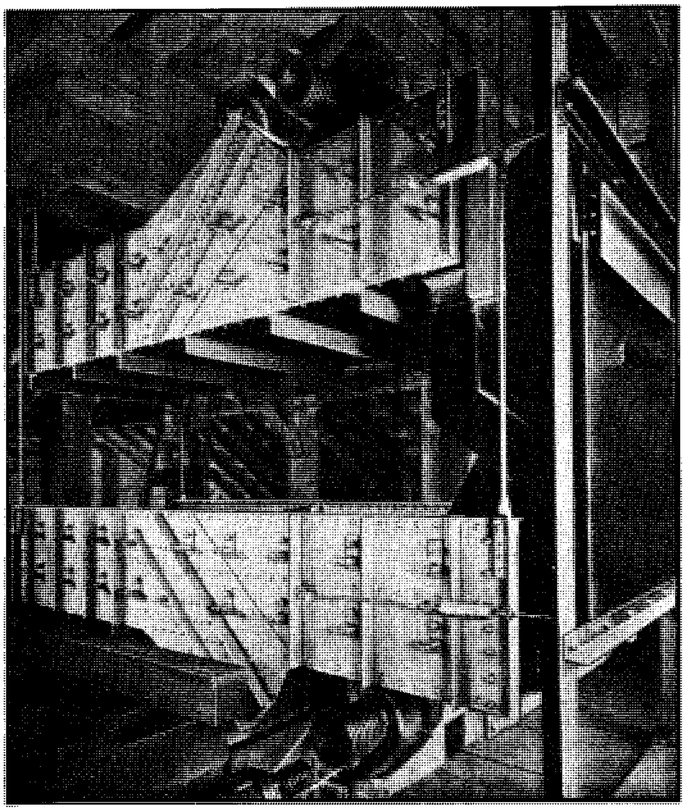
A Link-Belt Multi-Deck Vibrating Screen designed to take up to four screening trays or screen panels. The vibrator unit was an unbalanced pulley type, oil lubricated and driven by a flat belt. The original screen was a 3′ x 8′ built in 1923. Later versions of this unit were made 8′ wide x 6′ long to screen coke.



The Pulsator Screen designed by Smith Engineering Works (Telsmith DivisionBarber Greene) in the early 1930′s. The Pulsator Screen featured a fourbearing vibrator of the fixed throw, eccentric type, with the eccentricity built into the bearing races. The Vibrating Screen had removable trays on which wire cloth or perforated plate was bolted.

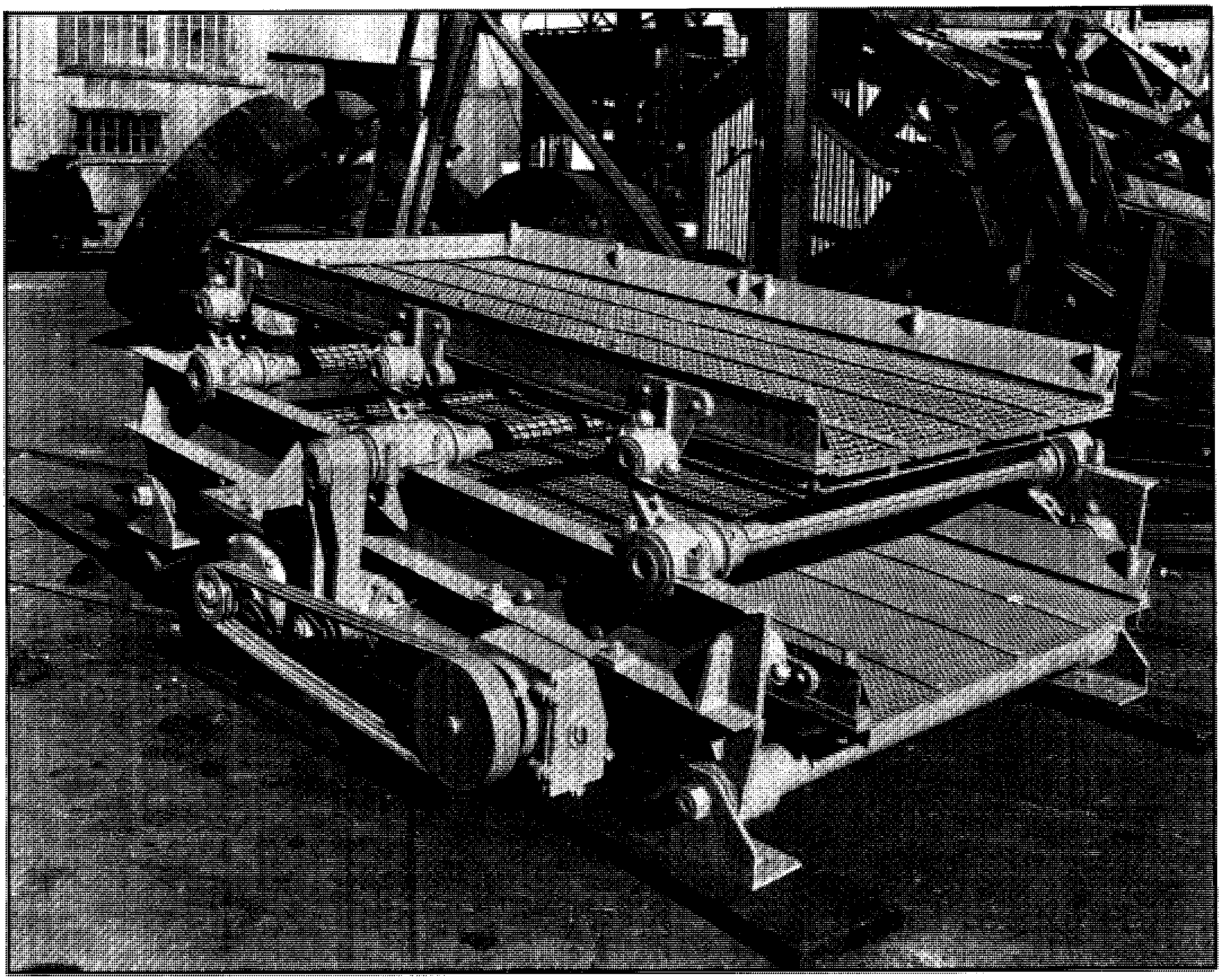


A 42″ x 72″ Symons Type JW Mud Screen developed primarily for the cleaning of drilling mud. This model was designed and built in the mid1930′s by the Nordberg Mfg. Co. The vibrator was a twobearing unbalance weight type, operating about 1200 rpm. The screen cloth was end tensioned.



Two Allis Chalmers Horizontal Vibrating Screens. These 5′ x 14′ were among the earlier screens built in the mid1930′s. The two screens are sizing coal in a Kentucky Colliery.

The Symons Rocker Screen was developed in early 1930, and the first units were put into operation in 1931 at various aggregate plants in the western United States. The Rocker Screen was the first positive throw unit built by Symons Brothers Co. and became the forerunner of the Symons F Screen.



Chapter 2

VIBRATING SCREENS

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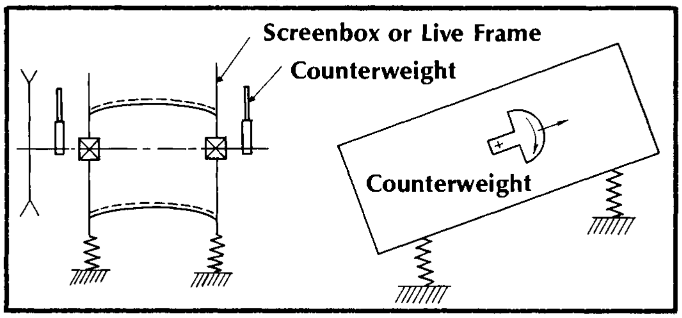
Types of Vibrating Screens

FOREWORD:

The basic reason for a viabrating screen is to accomplish a separation of a granular product into various sizes. In order to effect this separation, the various size particles must be given as many opportunities as possible to pass thru the screening medium. Particles that adhere to one another must be dislodged, and stratification or sifting of the fines down to and thru the screening media must be accelerated.

The best means of accomplishing this is by moving (vibrating) the screen under the product as often as possible to allow the product multiple chanches of being sized.

A. TWO BEARING CIRCLE THROW (UNBALANCED PULLEY) INCLINED SCREENS:



One of the earliest and simplest machines developed was the Two Bearing Circle Throw. These machines depend on gravity to effect a rate of travel of material over the screen surface, therefore, they are sloped between 15 degrees to 30 degrees from the horizontal for dry separations and somewhat flatter for wet sizing. The screening surface is generally drawn tightly over an open framework and anchored to vertical sideplates with tension members to keep it stretched tight. Fastened to the sideplates, normally thru the center (and near the center of gravity), is a shaft supported at the sideplates by two bearings. A pulley or sheave is attached to one end of the shaft and a driving mechanism - usually an electric motor thru a V-belt - is attached. The screen frame is supported by springs at each corner allowing it to move freely in a vertical circle. Therefore, it is often referred to as "Free Floating". The screen frame is vibrated by attaching equal weights eccentric to each end of the shaft (often called counterweights). As the shaft (with counterweights attached) is rotated it throws the frame in the opposite direction of the counterweights. Since the direction is constantly changing thru an arc of 360 degrees the effect on the live frame is a circular throw or stroke. The magnitude of the stroke can be varied by increasing or decreasing the amount of counterweight.

Counterweight is often built into the shaft eccentric to the centerline of the bearings or attached with plates to the shaft, or a combination of outboard and/or externally attached central counterweights are used.

The Two Bearing Screen is a versatile type of screen. Variations in (1) Stroke, (2) Speed, (3) Slope, and (4) Direction of Rotation all can be used to give the best combination for sizing a product.

It is characteristic of all Two Bearing Screens to bounce freely during that period in starting and stopping when the frequency of vibration equals the natural frequency of the springs.

TYPES OF UNBALANCED PULLEY SCREENS

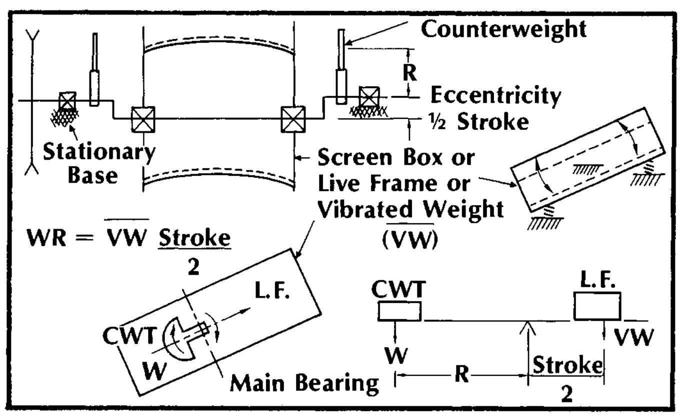
1. Screens with a center mounted vibrator as described above constitute the majority of unbalanced pulley type machines.

2. Off center vibrators give differing stroke patterns to the screen from one location to another on the deck which may benefit screening a particular product.

3. Two vibrators are used on some units. These synchronize and give a circle throw if located adjacent to one another and rotated in the same direction. If the vibrators have differing counterweights and are located at opposite ends of the screen frame, various strokes will be obtained at those locations and a variety of each in between.

4. Some manufacturers incorporate the motor and counterweights into one unit which is attached directly to the live frame. Multiple motor vibrators at each end of a screen will give varying stroke patterns, but their use is not widespread.

B. FOUR BEARING POSITIVE STROKE INCLINED CIRCLE THROW SCREENS:



The four bearing screen frame is similar to that used on Two Bearing Unbalanced Pulley Screens. The shaft, however, is eccentrically machined on the ends and supported by two additional outboard bearings located on a stationary base frame or on a resilient mount attached to a base frame. The driven sheave is installed on one end of the shaft next to the outboard bearings. Since the two bearings on the screen and the two on the stationary housing are in different planes, rotation of the shaft causes the screen to move in a circle about the center of the outboard bearings. You could equate this to a crank action.

In order to counteract vibration, a counterweight or counter balance is installed between the bearings on the centerline of the outboard shaft or these weights may be part of the shaft placed between the inboard bearings. This counterweight does not act as the one on a Two Bearing Screen, but is used to counteract the weight and centrifugal force of the live frame on the shaft at the inboard bearings, and reduce or eliminate vibration. This counterweight is 180 degrees to the direction of the stroke of the screen at all times.

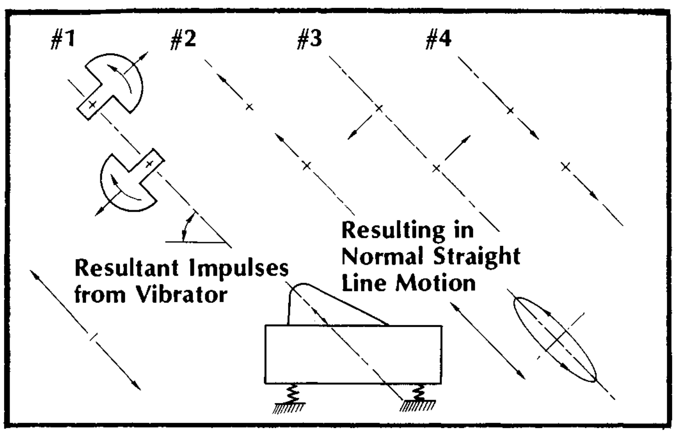
This positive stroke screen, often referred to as a four-bearing screen, starts and stops very smoothly.

The performance of a Positive Stroke Screen can be varied by changing (1) Speed, (2) Direction of Rotation, and (3) Inclination. The stroke can be changed by modifying the eccentric of the shaft since this is the source of the stroke.

Although resilient mounts are not absolutely necessary for Four Bearing Positive Stroke Screens some manufacturers provide them to (1) reduce impact of large lumps or (2) isolate vibration if the screen is not in perfect balance.

One manufacturer employs resilient mounts for both sets of bearings, thus the shaft is free to rotate about its own center of mass which lies between the centerline of the two sets of bearings.

C. TWO SHAFT HORIZONTAL SCREENS:



Although the reasons Horizontal Screens came into existance was in order to save headroom and because there was a need to better control fluids and dewater coal and other products, they have since become quite popular for these applications as well as for many sizing operations.

The primary difference in the horizontal screen is its ability to convey the product since gravity is no longer a force in moving the material over the screen surface.

Another feature of most Horizontal Screens is that they incorporate two shafts and produce an essentially straight line stroke at an angle to the horizontal in the direction of material flow. This throws the oversized material out of the apertures and conveys it along the screen. The action is necessary since horizontal screens don't have the benefit of being installed with a down-hill inclination.

Due to the larger size of the vibrators, they are seldom found in the center of the screen frame, but mounted above or below the frame. In either case, the line of action is usually set at around 45 degrees from the horizontal.

The vibrator consists of two shafts with eccentric counterweights attached, and supported at each end by roller bearings. The shafts are driven so that they operate in opposite directions. The counterweights forces are additive when in line and cancel out when opposed :See Diagram C). The vibrator is normally located so that the line of action is at approximately 45 degrees to the center of the mass of the screen frame. Since the reactions from the counterweights cancel out one another at all points except two during a cycle the result is a nominal straight line or elliptical motion.

TYPES OF HORIZONTAL SCREENS

Due to their conveying feature horizontal screens can operate slightly uphill, as much as 5 degrees. This is beneficial in some dewatering applications.

1. **GEAR DRIVEN HORIZONTAL SCREENS**

   Many screen manufacturers use gears to control the relationship of the shafts on their Horizontal Screens. Changes to the nominal 45 degree line of action can be made by retiming the gears to give either a flatter angle for faster rate of travel, or a steeper angle for longer retention of material on the surface and possible sharper sizing of the product (provided the bed is not too deep with this slower travel rate).

2. **CHAIN DRIVEN HORIZONTAL SCREENS**

   Instead of gearing together the eccentric shafts, a chain and sprocket arrangement can be used to accomplish the same end as the use of gears.

   There are some units produced which use three shafts which produce various stroke configurations which are basically oval rather than straight line or slightly elliptical.

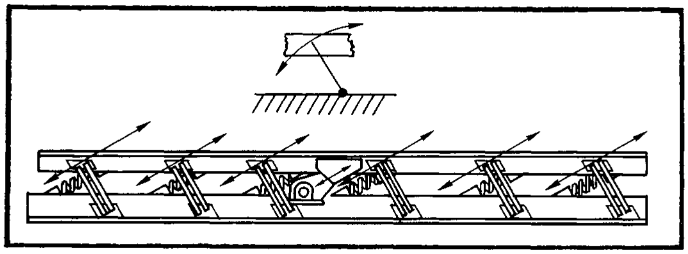
3. **MULTIPLE ECCENTRIC SHAFT HORIZONTAL SCREENS**

   Larger units requiring more driving force have been produced. This is accomplished by gearing together more than two shafts, or adding more vibrators.

4. **SYCHRONIZED SHAFT HORIZONTAL SCREENS**

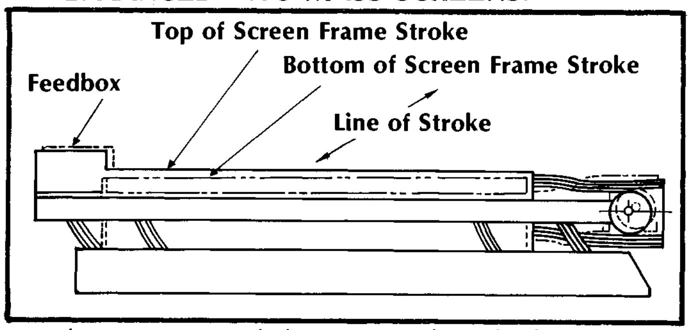
   Horizontal screens are produced where the shafts are neither geared together or linked by a chain drive. Instead each shaft is driven independently by a separate motor. They will synchronize and produce the same motion as those that are physically connected by gears or chain.

D. SINGLE ECCENTRIC SHAFT HORIZONTAL SCREENS



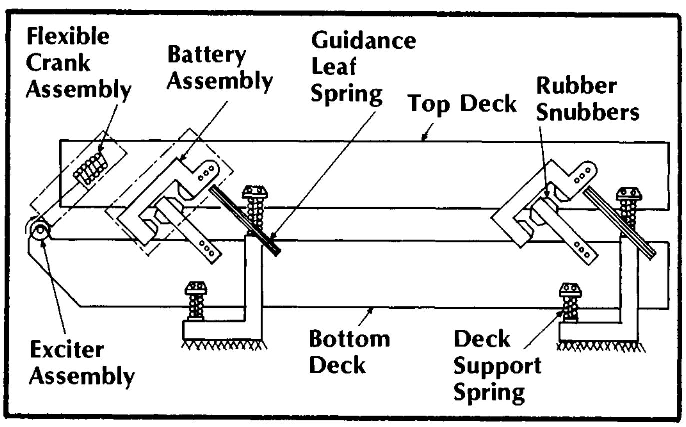
The principle of producing the vibration in this type of screen is similar to the Inclined Four Bearing except the screen deck is held in a horizontal position by the use of both coil and leaf springs. The thrust motion produced by the crank shaft pulls the deck forward and upward. It is guided in its movement by the leaf springs. The coil springs also add upward and forward thrust to the deck.

E. SINGLE SHAFT ECCENTRIC HORIZONTAL BALANCED TWO MASS SCREENS:



Another variation of the screen described in item D is a unit composed of two masses, one consisting of a screen frame mounted on leaf springs and attached to the crank or eccentric portion of the drive, and another counterweight frame attached to the concentric portion of the shaft. The screen frame movement is limited in direction by the angle of the leaf springs. The stroke is a major arc about the fixed spring mount.

F. FREE RESONANCE SCREENS



The operation of a Resonant Screen is dependent upon the interaction of two oscillating masses or live frames which are coupled together and restricted in movement in one direction by leaf springs. The power source is either a two bearing unbalanced pulley or a four bearing crank which is attached to one of the live frames.

As the one live frame is excited, it reacts thru rubber bumpers or batteries which both limit the stroke and store energy for the rebound stroke. Since the two masses are tuned to act and react in opposite directions, the amount of vibration is minimal and the power required is only that needed to convey the material and overcome losses in friction.

Resonant Screens have two features; (1) low horsepower requirements, and (2) minimal vibration transmitted to the supporting structure.

G. HIGH SPEED SCREENS:

Although previously described inclined screens, in small sizes, are sometimes operated at relatively high speeds, a group of screens are designed specifically for high speed and fine separation. These High Speed Screens commonly operate at or above 1800 RPM with small strokes (in the order of 1/8'' and smaller). In some cases the frame is not meant to vibrate, only the cloth. This is accomplished by attaching a vibrating mechanism to the center of a cloth panel which is held tight at the side or the ends. Here again, the speed on these units is high, the stroke usually is low. The cloth wires or panels ''whip'' generally with a uniform motion to keep the surface free from blinding or plugging.

Motorized vibrators are popular for high speed applications as well as electromagnetic vibrators. One unit of this type uses a mechanical cam/tappet which produces a differential stroke.

Electromagnetic screens are not considered mechanical, thus are not covered in this discussion. Sonic vibrators have been used to vibrate cloth. All these high speed units discussed normally operate at steep angles, generally between 27 and 40 degrees for dry separations. Flatter angles are often used for wet application.

G1. HORIZONTAL PLANE VIBRATING SCREENS:

These are relatively large stroke units (sometimes also referred to as Sifters) that are actuated by a vertical eccentric or crankshaft at the discharge end and pivot on springs at the feed end. In addition they use bouncing balls under the deck. The balls are thrown against deflectors which cause them to bounce upward and strike the cloth. Units are generally operated relatively flat (about 5 to 10 degrees downhill).

H. SIFTERS:

A large variety of screening devices are classified as Sifters. Generally these are round or square with multiple, nearly horizontal, decks. Motion is normally along the horizontal plane with a secondary vertical motion.

Vibration is accomplished by many means including unbalanced pulley, electromagnetic vibrators, air pulse, sonic, crank motion and combinations.

Most sifters are used for fine separations, wet or dry.

I. FLEXIBLE DECK SCREENS:

Rubber screen decks are tensioned between attachments across a deck which are alternately moved in opposite directions to flex the rubber screening media and accomplish the separation. The combinations of rubber deck and flexing action tends to combat blinding. The driver has a crank action which moves both masses to which the deck is attached in alternating directions.

J. CENTRIFUGAL VIBRATING SCREENS:

Some screens utilize centrifugal force to effect fine separations. Material is fed by a rotating plate at the top of a cylindrical screen surface which also rotates. A combination of rotation and gyrating action of the drum accomplish fine separation as the material flows down the cylindrical cone-shaped screening media.

K. PROBABILITY SCREEN:

This type of vibrating machine uses multiple decks set on progressively greater slopes with progressively smaller openings.

The theory of operation takes advantage of the fact that a coarse particle will pass a given mesh opening with more difficulty than a smaller particle. The use of multiple decks, at larger mesh than the desired separation, effects a rapid stratification, since the opening that the particle "sees" is diminished by the increase in slope.

SCREEN ACCESSORIES AND VARIATIONS:

Screens for specific purposes require certain accessories to perform that purpose. Other accessories are to reduce maintenance. Some modifications and variations of screens are used to accomplish particular or specific operations.

DECK ACCESSORIES:

Many types of Screening Media are available and are covered in Chapter III "Types of Screening Media".

Ball Tray Decks - A ceck, located under another deck, which retains rubber balls. The bouncing balls impart a secondary vibration to the screening deck above to reduce plugging and blinding.

Blank Plates Section - A deck with no openings used to convey product after it is sized on an upper deck.

Dams - Used to retard the product on a deck for a longer period, generally in order to dewater it better.

Electrically Heated Decks - Resistance heat applied to the wire cloth to reduce the tendency of material to stick to the wires.

Longitudinal Dividers or Partitions - Used to process two or more different products on the same screen surface.

Lump Breakers - External weight suspended over a screen surface to break lumps such as sand or agglomerated material. Many varieties of lump-breakers are used.

Spray Pipes - These are equipped with spray nozzles for water and are located along the deck to wash the product and aid in screening.

Spray Pipe Holes - Placed in the screen side plates to accommodate spray pipes. Holes are generally 5" in diameter or larger, however, if spray pipes are affixed the holes need only be large enough to insert the pipe.

Step Decks - A succession of steps in the deck to turn or flip the product for better removal of fines.

Troughs - A recessed section in a deck to aid in mixing or pulping a product. Usually used with sprays.

LIVE FRAME ACCESSORIES:

Backplates - Installed at the feed end of the screen. They eliminate spillage from the decks.

Discharge Lips - Extensions to the deck to discharge material in the proper chute or bin and allow for the chute to clear the live frame.

Feed Boxes - Installed ahead of a screen surface to take impact and spread the feed.

Hand Holes - Sometimes provided to allow the operator to change screen cloth from outside the live frame.

Liners - Installed wherever product can wear the live frame. These may be made from steel, rubber, plastics, ceramics or other materials. They protect vital parts which, if weakened, could lead to failure.

Lifting Eyes or Lugs - It is important to properly handle a screen prior to installation. Manufacturers often install lifting eyes or lugs in the proper locations to avoid damage in unloading and installation.

Tension Wedge Fasteners - Devices that replace tension bolts. They allow for rapid screen retensioning and speed cloth changes.

VIBRATOR ACCESSORIES:

Heat Shields - Attached to the vibrator or sideplates to shield the vibrator and lubricant from excessive heat.

Water Cooled Vibrator - A secondary jacket around the vibrator mechanism filled with recirculating water to remove excess heat.

Lubrication System - Some hot and/or dusty applications require lubricant filtration and cooling. Many systems are available.

EXTERNAL ACCESSORIES:

Carts or Carriages - Special carts are sometimes used to wheel away discharge chutes to gain access to the screen for cloth changes and maintenance. Some screens are installed on wheel mounted carriages to allow for rapid change-over of screens in critical service.

Drive Guards and Shields - Many types of shielding devices are necessary to protect personnel from accidental injury. The V-belts and sometimes the motors must be guarded. Large lumps must be contained on the screen surface. Clearance points between vibrating screens and stationary external structures should be avoided or guarded.

Enclosures - Often used to contain dust and noise. They are of two basic varieties. (1) Vibrated Enclosures attached to the screen frame which vibrate with it and (2) Stationary Enclosures that surround the live frame, but do not move with it.

Friction Checks - A motion dampener of the friction brake type which minimizes stroke build-up during start and stop, and may also stabilize a screen during operation.

Motors - The driving force required to operate screens. The majority of these are electric with a few gasoline or diesel engines. There are also hydraulic drive motors. Most of the electric motors are hi-torque, to overcome the inertia of the large eccentric counterweights. Totally enclosed Fan Cooled is also a very common motor requirement due to the dusty atmosphere in screen operation.

Pivoted or Spring Loaded Motor Bases - Take up the initial torque of a motor to reduce strain on the motor and keep tension on the belts.

Rubber - Many forms of solid rubber are used to absorb shock and store energy.

Snubbers - A flexible device that restricts motion.

Springs - Many types are used to isolate vibration transmittal from vibrating screens, and to direct the line of motion, absorb shock loads, transmit and limit stroke, maintain tension such as:

(a) **Coil Springs** are the most common type of spring used to support the load and absorb shock.

(b) **Leaf Springs** are used most extensively to direct the line of action.

(c) **Air Springs** are used in place of coil springs. These inflatable rubber springs are used to reduce vibrations and noise. They can be made hard or soft by regulating the air pressure.

(d) **Solid Rubber Springs** perform the same function as coil or air springs.

Chapter 3
Types of SCREENING MEDIA

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TYPES OF SCREENING MEDIA

1. Woven Wire Cloth
2. Plastics (Monofilament)
3. Piano Wire
4. Profile Deck
5. Rod Deck
6. Grizzly Bar
7. Louvered Deck
8. Perforated Plate
9. Cast Plate Deck
10. Rubber-Clad Perforated Plate
11. Perforated Rubber
12. Polyurethane

INTRODUCTION

This chapter describes various types of screening media currently available commercially for use on vibrating screens. While many of these media may be interchangeable without modification to an existing vibrating screen, some may require extensive alterations. In all cases, the vibrating screen manufacturer should be contacted prior to their installation so as to prevent adverse effect to the vibrating screen.

WOVEN WIRE CLOTH

Woven Wire Cloth is a widely accepted screening medium for the vibrating screen industry. It is used in all phases of the screening industry to screen most any product which is reduced to a fixed gradation by size. By application it is used in primary scalping, sizing, and dewatering for both wet and dry processes.

Woven Wire Cloth is designated by either space screen (clear opening) or square mesh (Fig. 1.1). Space screen is the actual measured opening between the wires. Square mesh is the number of openings in one lineal inch measured from centerline to centerline of the wires. Wire Cloth is woven using warp and shoot wires. As the Wire Cloth is woven, the warp wires run parallel to the length of the cloth and the shoot wires run across the width of the cloth or perpendicular to the length.

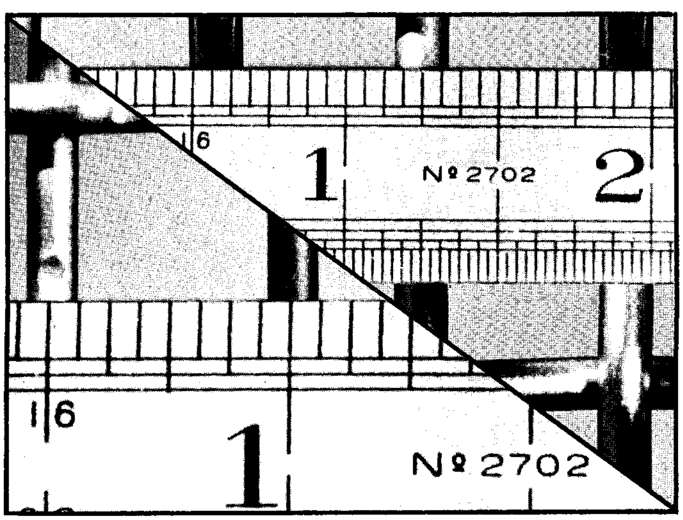


Fig. 1.1

There are two basic configurations common to Woven Wire Cloth. They are square and rectangular.

Square openings are obtained by weaving wires equally spaced in both directions of the weave (Fig. 1.2). Square openings are the most common of the two configurations and the most accurate. Oversize materials are less apt to pass through a square opening, thereby decreasing the chance of either contamination or loss of product.

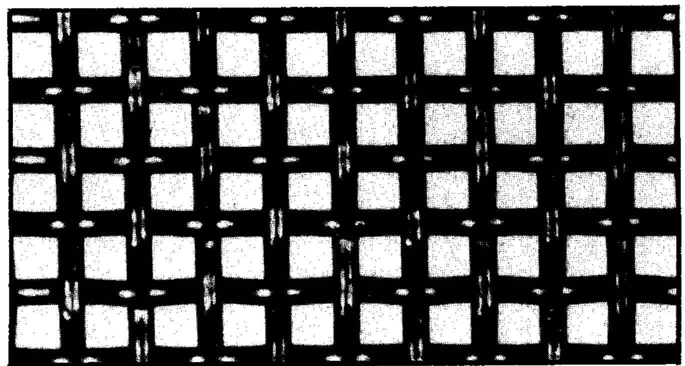


Fig. 1.2

There are two types of rectangular openings: short slot and long slot. The short shot classification is determined when the length of the slotted opening is about three to four times the width of the opening (Fig. 1.3). A larger amount of open area can be provided as compared to a square opening with an identical wire diameter. This advantage comes to light when it is necessary to use heavier diameter wire to increase service life, yet a sufficient open area can be maintained. Short slot openings can reduce clogging or blinding of material. A disadvantage of the short slot is its inability to scalp some flat shaped, elongated particles due to its rectangular configuration.

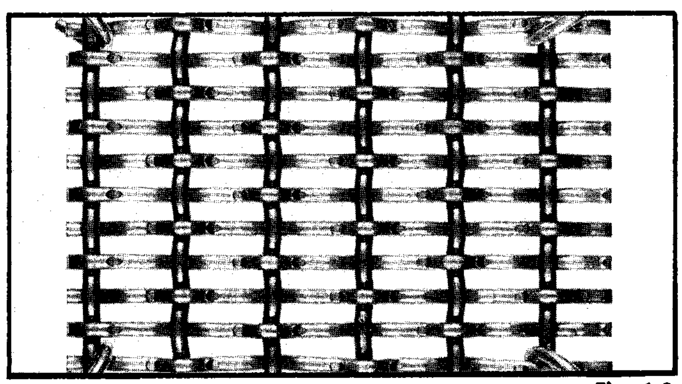


Fig. 1.3

The long slot weave has a slot length longer than four times the width and normally ranging from 1″ to 6″ long (Fig. 1.4). Normally, the slots are created by a cluster of three shoot wires, where the clusters are evenly spaced throughout the section. These clusters of shoot wires also insure a tightly woven screen section. Long slots are commonly used when screening materials tend to plug or blind the Wire Cloth either from a near mesh condition or from moisture in combination with fine materials. The long wires develop a secondary motion which relieves the near mesh particles from wedging and sheds the cake formed by the agglomerated product over the opening. Rectangular openings are normally installed with the length of the opening perpendicular to the material flow to minimize the passage of flat or elongated particles. They are installed parallel to flow when maximum throughput is of primary consideration.

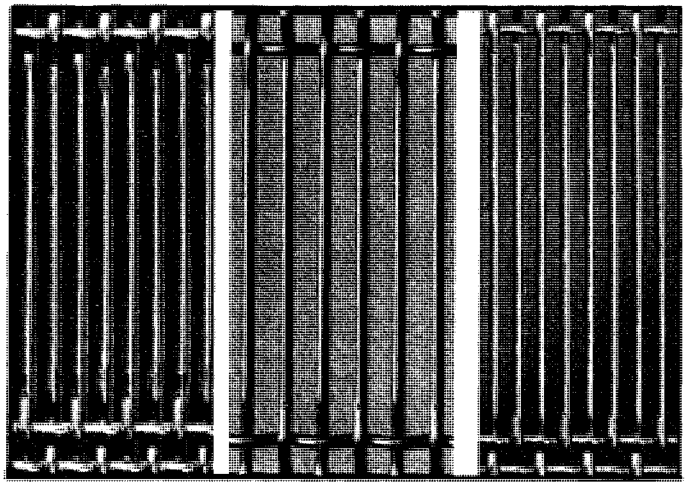


Fig. 1.4

The weaving of the various grade wires into cloth is accomplished on a variety of looms, depending upon the combination of aperture and wire diameter. There are four basic types of weaves (Fig. 1.5).

(1) **Plain Weave:** The wire is double crimp woven on a fly shuttle loom. This weave includes specifications 10 mesh and finer.

(2) **Semi-Crimp:** This is a combination of plain weave warp and pre-crimped shoot wires providing accurate apertures within the 10 to 20 mesh range.

(3) **Pre-Crimp:** Very exacting precision space openings of 1/8″ and larger, for a maximum wire diameter of .375″. The wires are pre-crimped by roll dies prior to weaving.

Within the Pre-Crimp category there are the following weaves:

(a) **Double Crimp:** Continuous crimping of both warp and shoot wires without special modification.

(b) **Press Lock Crimp:** Special crimping providing a very secure, tightly woven specification.

(c) **Intermediate Crimp:** The crimps are within the aperture. These crimps are not recommended for screen sections.

(d) **Flat Top Weave:** All the knuckles of the crimp are located on the underside of the screen section. The top surface of the cloth is flat.

(4) **Press Crimp:** Very exacting precision space openings where the wire diameters ranging from 7/16″ to 1″ are required. These large diameter wires are pre-crimped on a press prior to weaving.

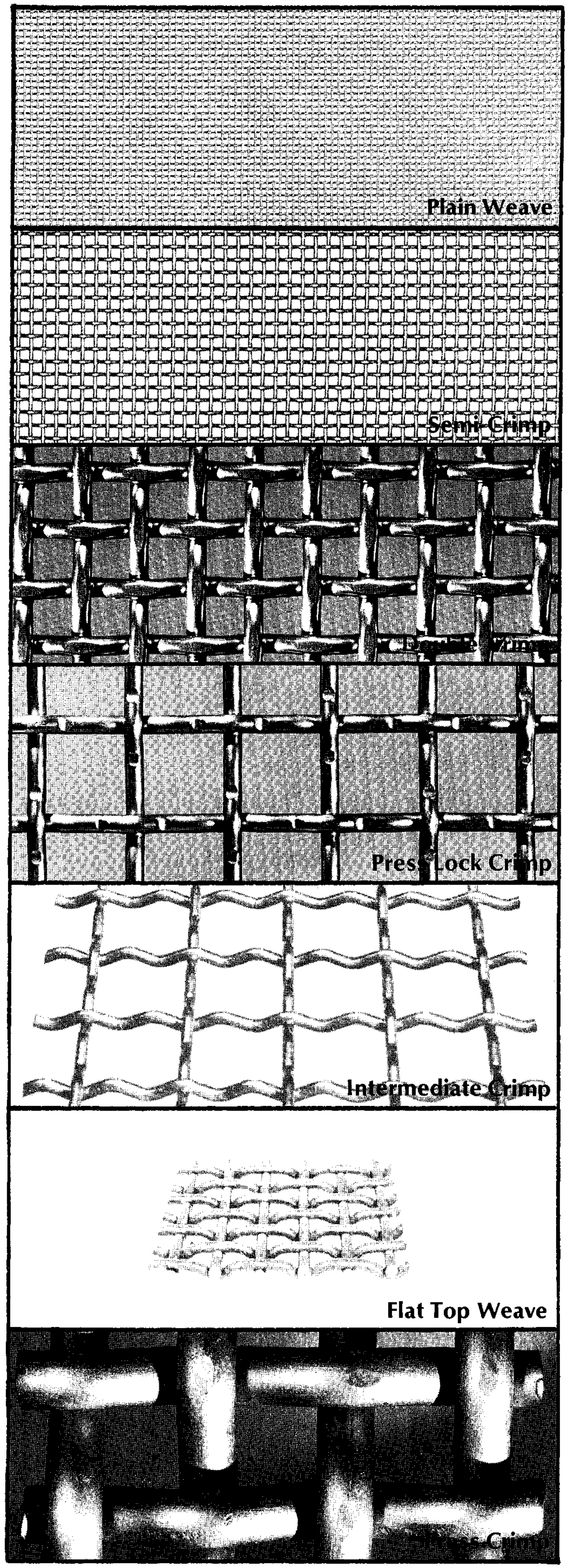


Fig. 1.5

The wire used for Woven Wire Cloth screen sections is available in a wide variety of grades to meet the demands of the screening industry.

(1) Steel alloys consist of high carbon and spring steel, hard drawn for abrasion resistance and oil or lead tempered steel for extra abrasion resistance.

(2) The copper alloys consist of brass, bronze, phosphor bronze, and are used primarily because of their corrosive resistance.

(3) Nickel alloys are noted for their resistance to corrosive materials. Monel is the most widely used. The nickel alloys are used in the food industry where sanitation is a determining factor.

(4) Stainless steels are used for severe corrosive and temperature conditions, as well as for heated screen sections and to reduce blinding. There are many variations for special conditions, but Type 304 (18% chrome, 8% nickel) is the most commonly used.

(5) Heat resisting alloys are composed of various combinations of nickel, chromium, and iron to resist extremely high temperatures.

Woven Wire Cloth can be installed in both flat or crowned screen decks. They are attached to the screen frames by means of reinforced hooked or flanged edges for wire diameters .375″ and below, or by means of a tension plate for wire diameters greater than .375″. There are various types of reinforced hook edges. The correct hook is determined by the diameter of the wire (Fig. 1.6). Hook strips allow the wire cloth section to be stretched to a drum-head tension essential for adequate screen life when vibrated. Aperture selection for a vibrating screen depends on the size of product required and the installation angle of the machine.

Woven Wire Cloth has proven itself by repeated sales to be the most frequently used screening medium. It is economical, provides high screening accuracy, and is readily adaptable to most screen applications.

PLASTICS (monofilament)

Plastics are woven similar to Wire Cloth. They have been effective as screening media in the chemical industry due to corrosion resistance (Fig. 2.1).

Plastic cloth is best suited to screening light material with low abrasion and light load capacity. Plastic Cloth is less expensive than Woven Wire Cloth, therefore, making it the least expensive screening media.

PIANO WIRE

Piano Wire screening surfaces or harp screens were developed to handle damp, fine materials on vibrat-

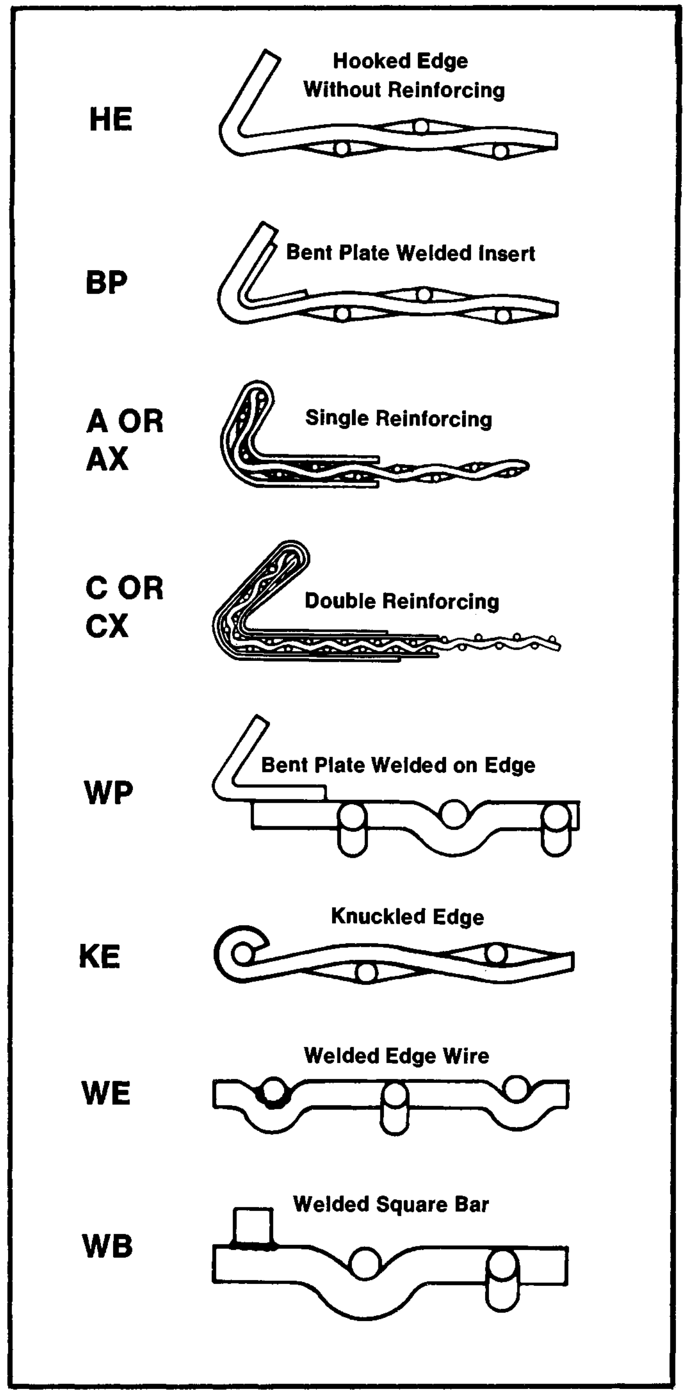


Fig. 1.6

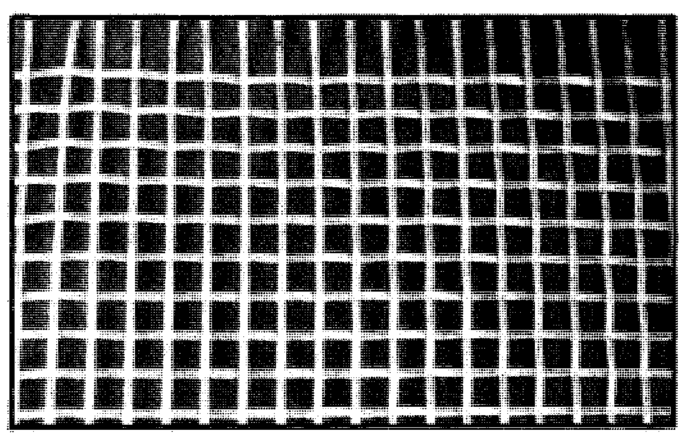


Fig. 2.1

ing screens. The most common apertures are between 1/16″ and 3/8″.

Piano Wire decks are constructed of high-tensile wires stretched over a frame (Fig. 3.1). The wires are individually tensioned. In principle it is similar to the strings on a harp. Support frames have recess guides spaced at prescribed intervals to maintain the proper opening.

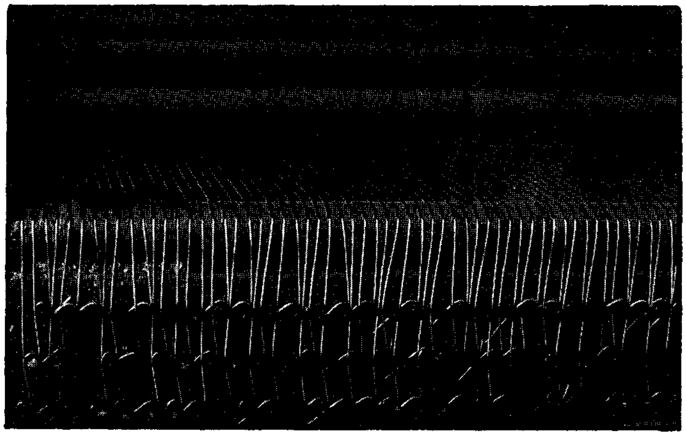


Fig. 3.1

Piano Wires have proven most successful at increasing the capacity of damp fine screening applications which are considered difficult. Its success is due to its construction, which provides increased open area and allows supplementary vibration of the individual wires, decreasing the incidence of plugging or blinding.

A scalping deck is normally required to reduce the impact and wear on the light gauge wires used in the construction of Piano Wire decks. The tensioning of the wires is a major concern. Over-tensioning of th wires can cause frame damage, and under-tensioning can cause wires to pop out of their respective recess guides.

PROFILE DECK

Profile Deck is a screening medium consisting of wires in various shapes, running substantially parallel to each other. Profile Deck is used primarily in dewatering applications and for small particle separation. Profile Deck is used by the coal industry almost exclusively for drain and rinse, desliming, and dewatering applications. Although Profile Deck is normally used on horizontal vibrating screens for coal applications, the iron ore, potash and phosphate industries are examples of incorporating Profile Deck in other applications.

Profile Deck is constructed by two basic methods (Fig. 4.1). The first method is welding of the wires to perpendicular supports. The supports are usually round rods, bars, or diamond-shaped rods, although others are available. The second method of construction consists of wire wrapped around the perpendicular supports.

There are a great variety of shapes available in Profile Deck (Fig. 4.2). The most common shape is the triangle, of which there are many variations. This V-shape has proven to be most effective because the opening gets steadily wider, decreasing the possibility of wedging. All the shapes are based on this non-plugging principle.

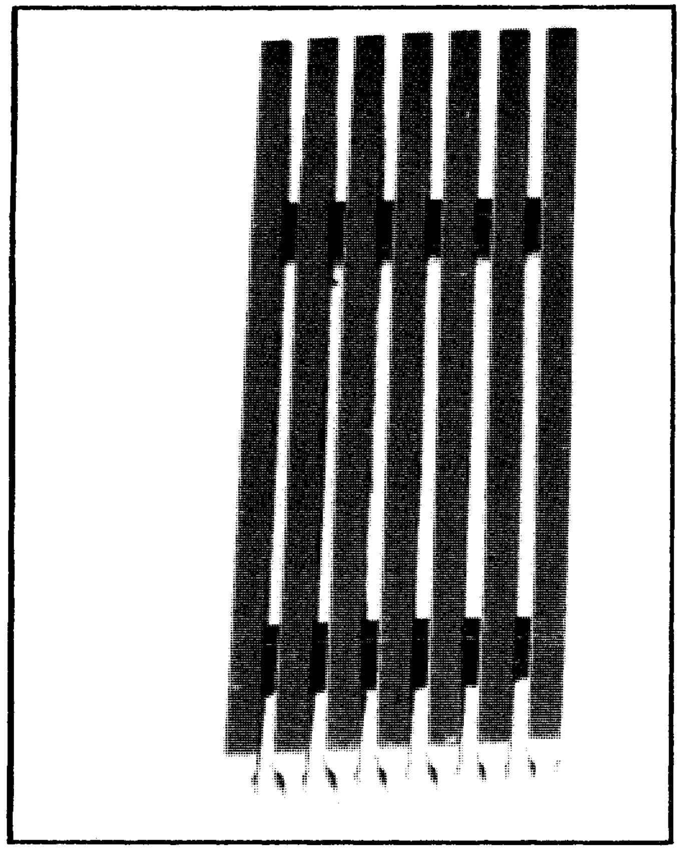


Fig. 4.1

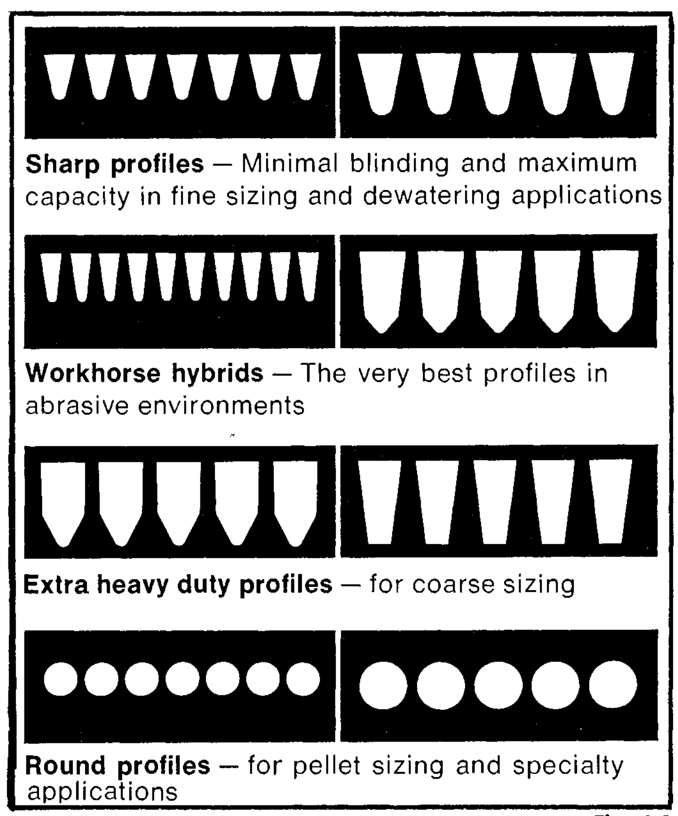


Fig. 4.2

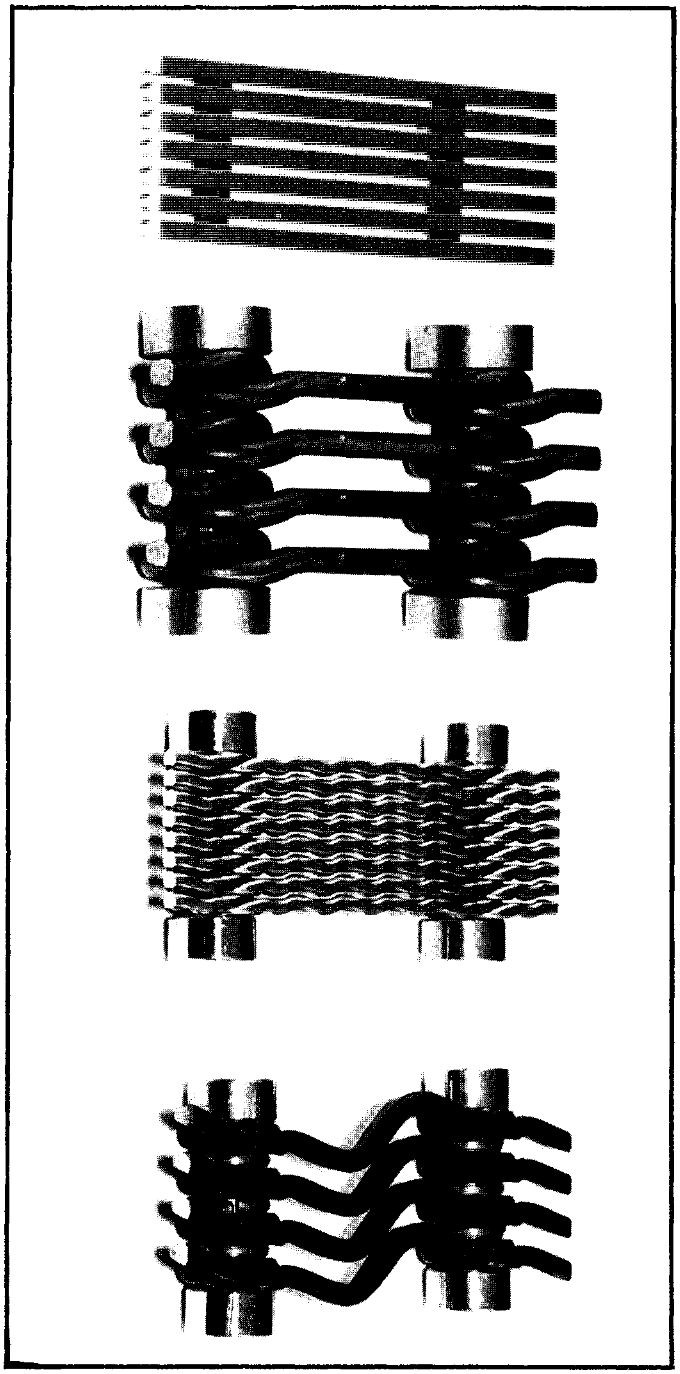


Fig. 4.3

Profile Deck is available in two basic configurations (Fig. 4.3). First is the straight-line configuration where all the wires are both straight and parallel. The second type has many variations, but it is basically wires that are still parallel, but run in a wavy pattern over the support rods. Profile Decks can be installed with openings parallel or perpendicular to the flow of material. The parallel arrangement is most common. Profile Deck can be installed on flat and crowned screen panels.

Most Profile Decking is of stainless steel construction to combat corrosion. Profile Deck is also constructed of other metals including carbon steel, brass, bronze, aluminum and high-nickel alloys. Its design gives Profile Deck longer service life. A major limitation is its low percentage of open area in the small opening range. The high initial cost could also be viewed as a disadvantage for some applications.

ROD DECK

Rod Deck is a screening medium constructed of round rods arranged parallel to each other. The Rod Deck was designed to handle high volume feed of wet or dry abrasive materials. Openings on the Rod Deck range from approximately 1/8″ to 2″. There are two types of Rod Deck available: The Rigid-Rod and the Loose Rod (Fig. 5.1).

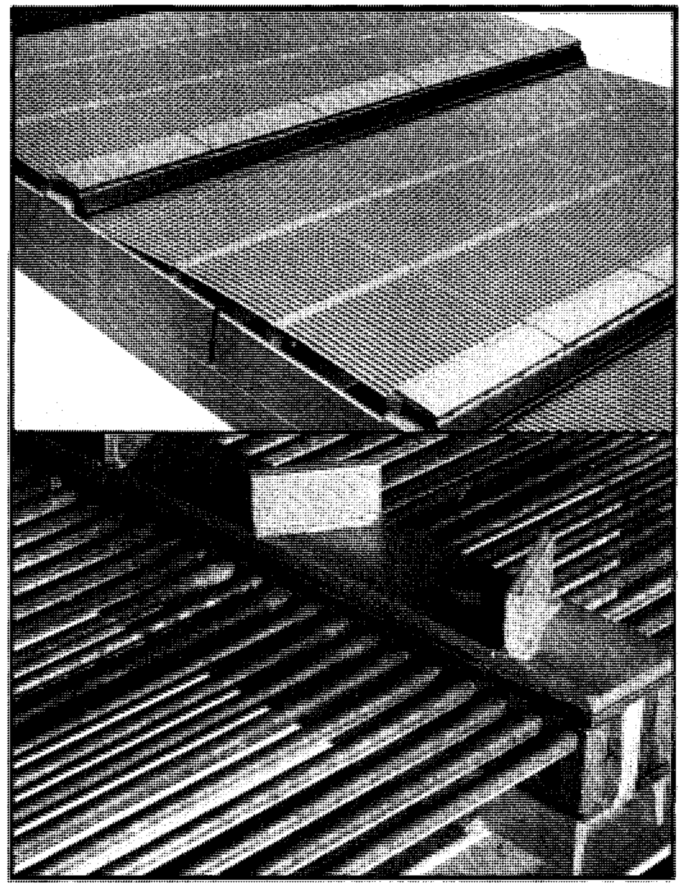


Fig. 5.1

The Rigid-Rod Deck has rods assembled in rubber or steel rod holders to form individual sections, and the rods are positioned by the holders and rod spacers so that the opening is constant. The Rigid-Rod Deck can be installed parallel or perpendicular to the flow of material. The parallel configuration is more common. The rods are normally constructed of abrasion resistant steel.

The Loose-Rod Deck has similar construction except the rods are loosely held in place. The rods can be installed perpendicular or parallel to the flow of material. The rods rotate opposite to the rotation of the vibrating mechanism on those decks installed perpendicular to the flow of material.

The Rod Deck has several advantages. There is less blinding, and greater capacity since the undersize material readily passes through the long openings between the rods. This design permits the use of heavy 3/16″ and larger diameter rods for longer service life. Generally, only worn rods need to be replaced, not entire screen sections.

The Loose-Rod Deck has some additional advantages. The independent vibration of the rod keeps damp, sticky materials from bridging the opening.

The application of Rod Decks is limited. Fine screening is generally not feasible. The large lumps inherent in some scalping operations could be destructive to Rod Decks.

GRIZZLY BAR

A Grizzly Bar is defined by the VSMA glossary as "a heavy duty screening surface consisting of spaced bar, rail, or pipe members running in the direction of material flow." Grizzly Bars are used primarily in heavy duty scalping operations where accuracy of separation is unimportant such as (1) producing rip-rap, (2) relieving load to a lower deck, (3) bedding a conveyor, (4) removing fines ahead of a crusher, and (5) minimizing production of fines. They are also used to screen very abrasive materials.

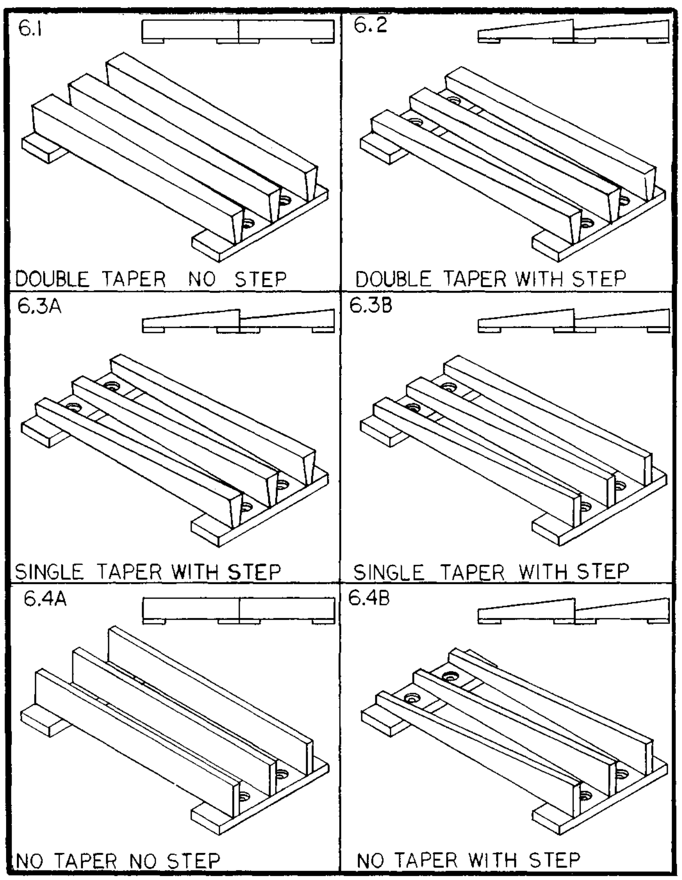


Fig. 6.1 - Fig. 6.4

There are two types of Grizzly Bars: cast and fabricated. Grizzly Bar sections are primarily used for sizing with openings greater than 1-1/2". They are available in a variety of configurations. A common configuration is the double-tapered Grizzly (Fig. 6.1). This bar produces nominal openings that increase from the feed end to the discharge end of the section to reduce plugging of material. The double-tapered Grizzly is also tapered in the side view so it is wider at the top than at the bottom again to reduce plugging. Another common configuration is the double-tapered, stepped Grizzly (Fig. 6.2). This bar is similar to the double-taper with the addition of a taper in the plan view so the bar increases in height from the feed end to the discharge end. This gradual increase in height creates a beneficial tumbling action as the material flows from the end of one Grizzly section to the beginning of the following Grizzly section. Other common configurations include two types of single taper bars which can also be stepped (Fig. 6.3), and a Grizzly Bar which has no tapers or is stepped with no tapers (Fig. 6.4).

Grizzlies can also be fabricated with rods. These rods can be stepped by sloping the rod and can have openings that increase from the feed end to the discharge end by properly adjusting the rods

Grizzly Bar decks have a long service life, but a very high initial cost due to the heavy duty construction and the expensive materials involved.

LOUVERED DECK

Louvered Decks are primarily used in foundry shake-out applications to separate sand from castings. Louvered Decks are available in two basic designs: cast and fabricated.

These louvers may either be bolted or welded to spaced supports (Fig. 7.1). The design is constructed with slots which run the width of the machine (Fig. 7.2). The louvers are installed on an angle and slightly overlap each other, similar to a slightly open Venetian blind. This configuration allows fine material to pass through, yet minimizes plugging or hang up of pieces due to the tumbling action created by the overlapping.

Louvered Decks can also be utilized in some scalping operations due to their ability to allow fine material to pass through. This screening media carries a high initial cost; however, it has a moderate to long wear life.

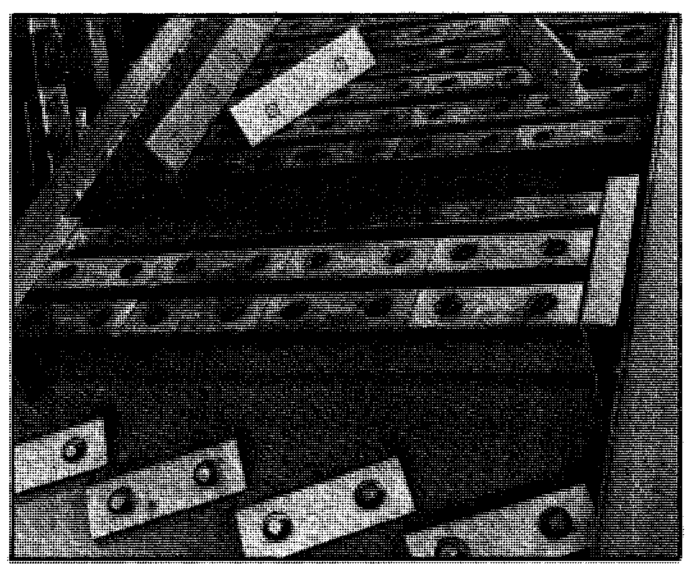


Fig. 7.1

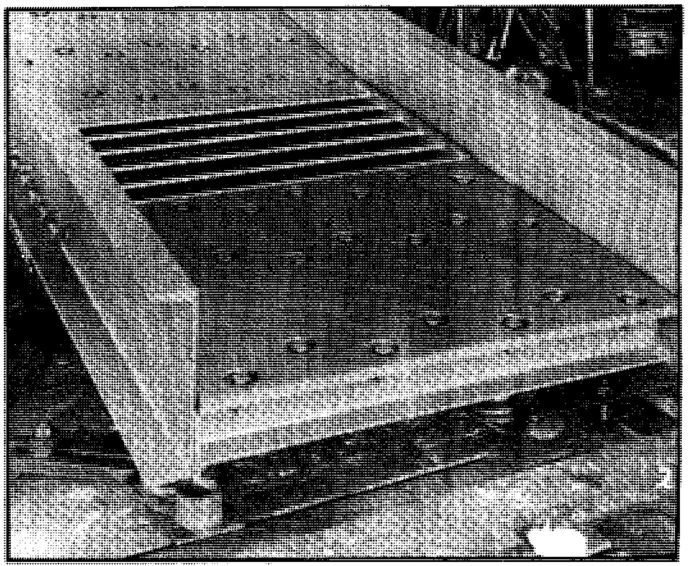


Fig. 7.2

PERFORATED PLATE

Perforated or Punched Plate is used in many industries. Perforated Plate is primarily chosen when the material being screened is in large lumps, the loads are heavy, or the material is highly abrasive.

Perforated Plate comes in a wide variety of openings, but the actual shape has a minimal effect on screening capacity provided the plates have an equivalent open area. Shapes that are available include square, round, hexagonal, rectangular, square-round, slotted, diamond, and flanged lip (Fig. 8.1). The flanged lip screen is different from the other shapes. It has tapered openings and is stepped or flanged.

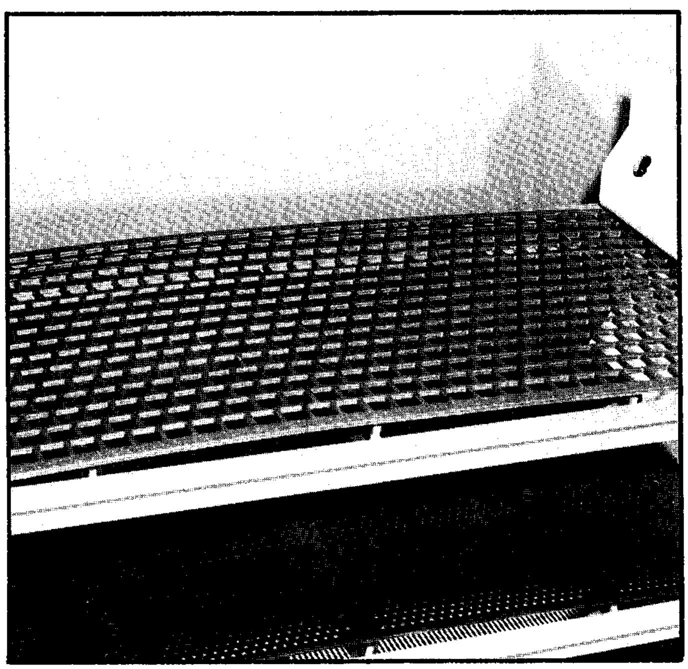


Fig. 8.1

Perforated Plate can be constructed from a wide variety of materials including carbon steel, stainless steel, bronze, brass, copper, nickel, tin, zinc, monel and aluminum.

The two considerations in manufacturing Perforated Plate are the plate thickness and bar, with the thickness of Perforated Plate limited by the size and shape of the holes required. The thickness is given in inches or by gauge number. The bar is the width of metal measured at the point where the perforations are closest. The bar must be properly chosen to insure adequate strength.

Perforated Plate screen sections can have hook flanges, be bolted down, or be clamped to the frame of the vibrating screen. The Plate can be manufactured to fit either flat or crowned screen decks. For crowned screen panels, the radius of the crown must be known to provide proper fit. Perforated Plate can be made available with skid bars running parallel to the flow of material to protect the Plate from large lumps (Fig. 8.2).

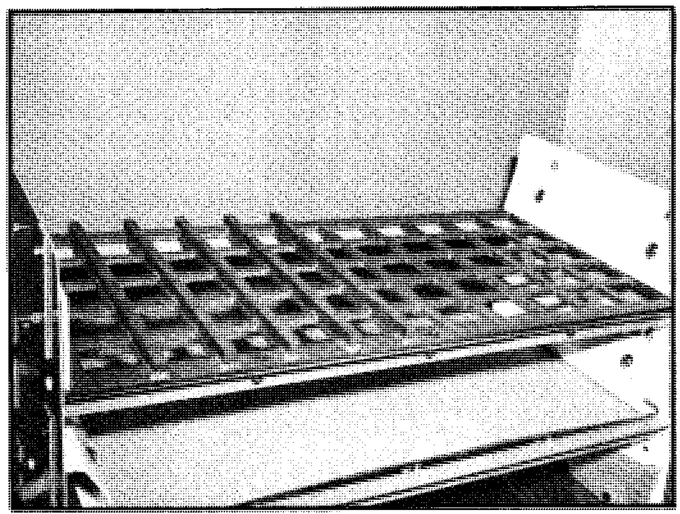


Fig. 8.2

The patterns of Perforated Plate can either be straight line or staggered. Staggered is more advantageous because the material is not permitted to ride on the bars very long before reaching an openig (Fig. 8.3).

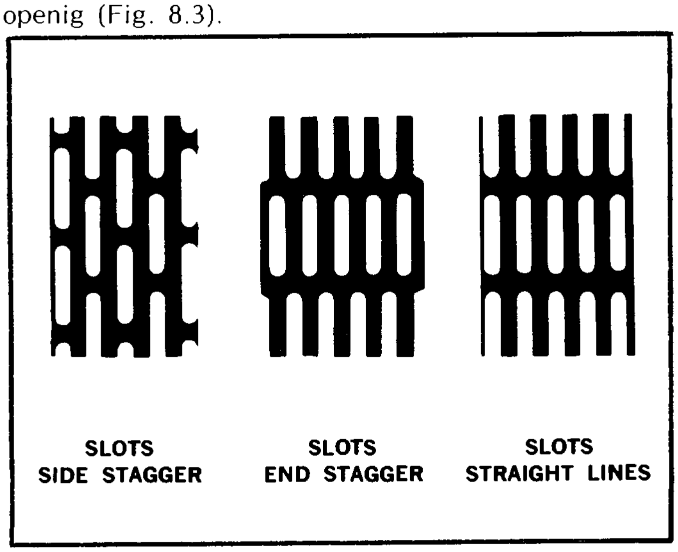


Fig. 8.3

Since Perforated Plate is of solid, one-piece construction, it will seldom require retensioning after initial installation. The service life of Perforated Plate has greater life expectancy than that of Woven Wire Cloth.

The limitations of Perforated Plate would include the following points. The greater weight of the Plate could produce problems for vibrating screens with light-duty vibrators or of light-weight construction. The open area decreases dramatically as the holes get smaller. The smallest hole available is approximately .020″ diameter.

CAST PLATE DECK

Cast Decks are similar to Perforated Plate except the Deck is cast rather than rolled and punched. Cast Decks are another alternative for screening extremely abrasive material (Fig. 9.1).

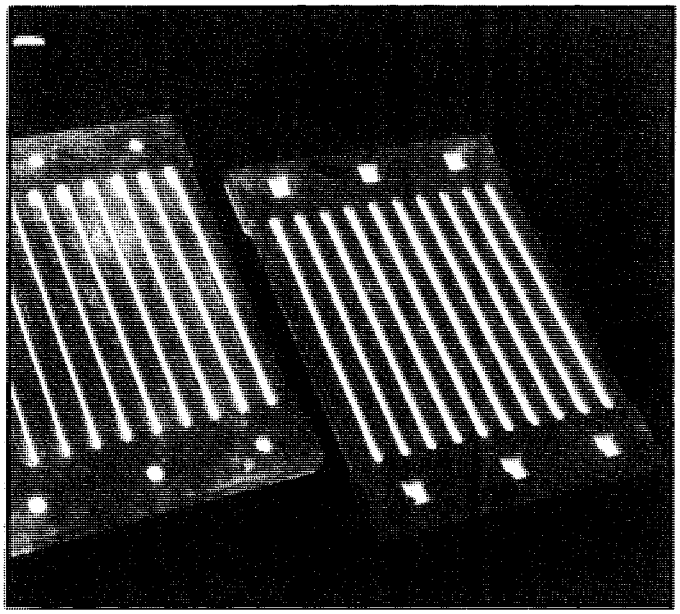


Fig. 9.1

This screening medium is usually cast with square or slotted openings and is generally used in scalping operations. These decks are primarily used in foundry, coke, sinter, and other abrasive applications. They have a high initial cost, but a long service life. The major limitation is its low percentage of open area.

RUBBER-CLAD PERFORATED PLATE

Rubber-Clad Perforated Plate is used for applications where extreme abrasive conditions exist. The plate and rubber are combined under pressure using special adhesives to insure proper bonding (Fig. 10.1). There are several types of rubber used in manufacturing Rubber-Clad Plate: natural, synthetics, and slow-cured latex. The thickness of the rubber is dependent on the application, while the steel plate is generally 1/4″ thick.

The holes in Rubber-Clad Plate are designed to minimize plugging and blinding. The hole in the rubber is determined by the product size required, while the steel plate has a larger hole for clearance. Rubber-Clad Plate is generally punched with round or square holes (Fig. 10.2). The holes range in size from 1/8″ to 4-3/4″.

The combination of steel plate and rubber gives rigidity and helps eliminate premature failure by not allowing the section to whip. These sections are manufactured with hook flanges enabling them to fit most vibrating screens. The service life of Rubber-Clad Plate is often an improvement over conventional Perforated Plate, but is higher in initial cost. In wet-screen applications, the water acts as a lubricant and promotes longer life. The rubber also reduces the operational noise level.

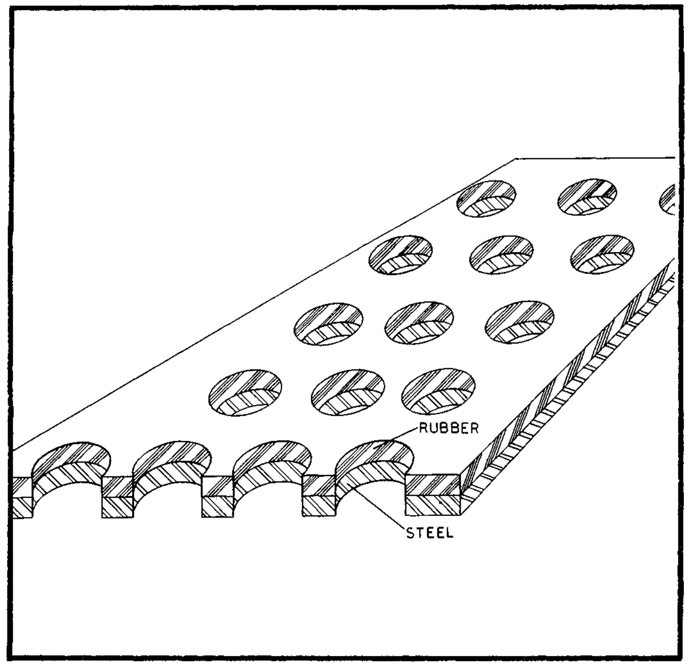


Fig. 10.1

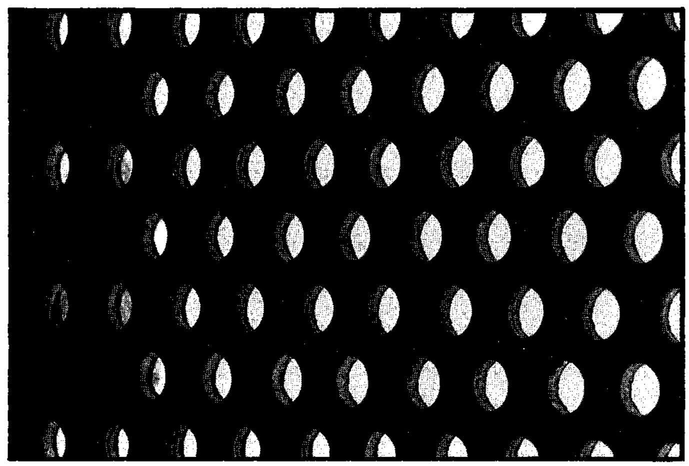


Fig. 10.2

PERFORATED RUBBER

Perforated Rubber screen decks are used for both wet and dry applications and are available in square, round, and slotted holes (Fig. 11.1). Generally, round holes are best suited for crushed materials; square holes are used for material in its natural state; and slotted holes are used for both crushed and raw materials. The perforations can be staggered or straight line as with Perforated Plate.

Perforated Rubber is normally constructed of two or three layers of rubber (Fig. 11.2). Top layers are made of wear resistant rubber and the bottom layers of high tensile strength rubber. For the three layer version, there is a middle layer made of soft

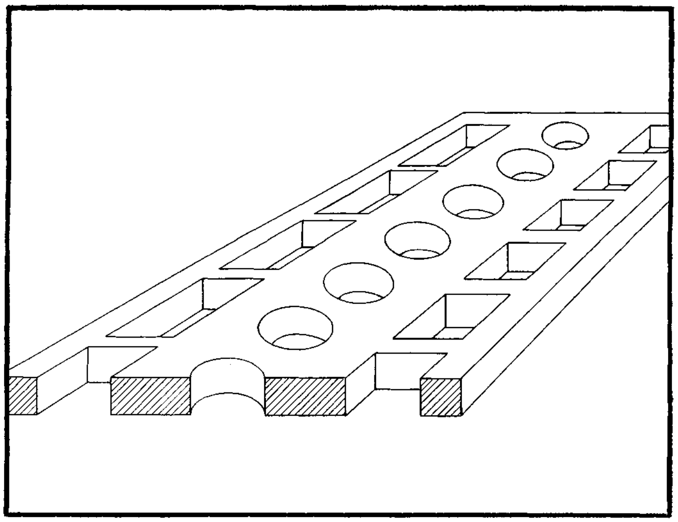


Fig. 11.1

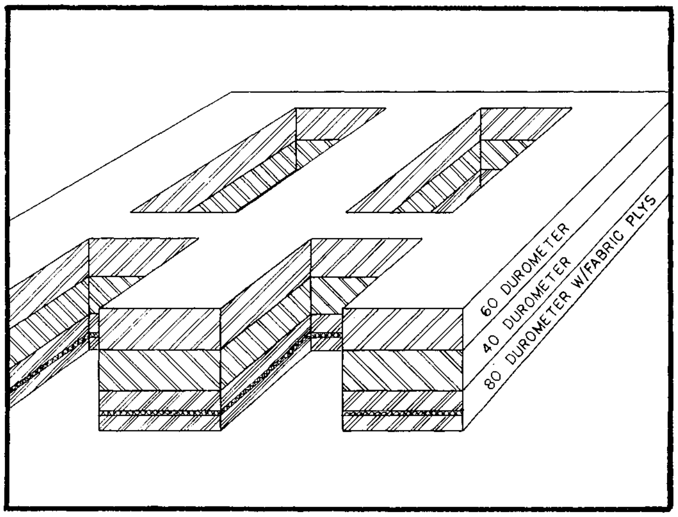


Fig. 11.2

rubber to produce a cushioning effect.

There are two types of reinforced rubber sections. The two-layer variety utilizes an embedded cord reinforcement in the bottom layer. The three-layer variety utilizes two layers of Polyester/Nylon which sandwiches the soft middle layer of rubber. These two types of reinforcement provide added tensile strength necessary for side tensioning on vibrating screens. The two-layer, embedded cord type was also developed for use in high-frequency screens, operating at more than 1000 RPM. The three-layer, Polyester/Nylon version, is less prone to cuts and cracking because the two reinforcing layers take the tension, leaving the rubber in a relaxed state.

Perforated Rubber sections offer several advantages. Rubber has a phenominal resistance to both impact and abrasion. Rubber can reduce plugging and blinding due to its flexibility. In wet screening applications, as with Rubber-Clad Plate, the water acts as a lubricant and promotes longer life. Degradation of friable material is kept to a minimum due to the resilient surface. An important factor is that the operational noise level is reduced. Caution should be exercised when installing Perforated Rubber decks on a vibrating screen to assure proper support and hold down.

POLYURETHANE

Polyurethane is a synthetic polymer derived from hydrocarbons. The material has gained popularity as a screening medium because of its excellent wear resistant properties. Screen sections have been shown to last appreciably longer than Woven Wiere Cloth in applications involving dry material. In wet screening operations, even longer service life can be expected.

Polyurethane is a very tough material. The material is also very resilient, an attribute which permits screen sections to absorb the impact of heavy loads. Material noise is significantly reduced.

Polyurethane can withstand temperatures ranging from -35°F to 176°F. Above 176°F the material begins to weaken and deform. In addition, if hot water or steam is present, a chemical reaction known as hydrolysis will cause chemical deterioration and lead to eventual failure.

Polyurethane is resistant to most common solvents; mineral oils, and grease. However, material containing chemical additives or alcohol should be avoided as they may cause swelling. Mild acids (pH range of 4-9) will not adversely affect Polyurethane; however, strong corrosive chemicals will cause deterioration and should be avoided.

Polyurethane screen decks may be fabricated by a casting process or by injection molding. Screen decks requiring larger openings are usually fabricated by a casting process (Fig. 12.1). Generally, molded decks are used in applications requiring small precise openings. Size limitations prohibit injection molding an entire screen panel.

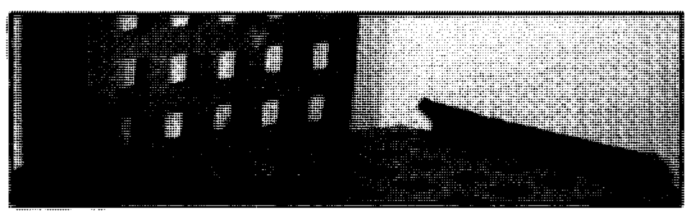


Fig. 12.1

Injection molded segments are available in a variety of apertures (Fig. 12.2). Both square and slotted openings are available to meet the needs of specific applications.

In both types, the apertures are molded to close tolerances and tapered to widen slightly at the bottom. The flared opening combined with the material's resilience will help eliminate blinding and plugging.

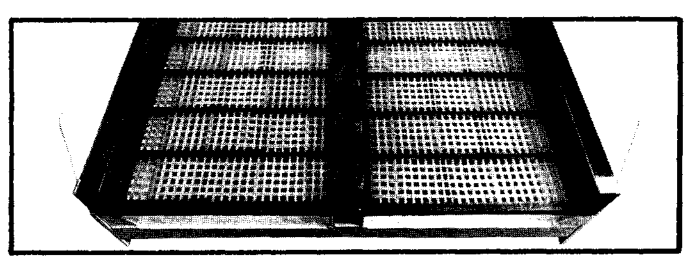


Fig. 12.2

Chapter 4

SAMPLING and SIEVE ANALYSES

VSMA

QUALITY / INTEGRITY

SAMPLING & SIEVE ANALYSES

A testing sieve is defined by the VSMA glossary as "a cylindrical or tray-like container with a screening surface bottom of standardized apertures." Testing sieves are an accepted means of classifying material, by particle size, during the various stages of preparation to a final product.

A nest or group of sieves are required to make a sieve analysis of the material (Fig. 1.1) The sieve analysis will then show the percentages retained or passing each sieve used in the test.

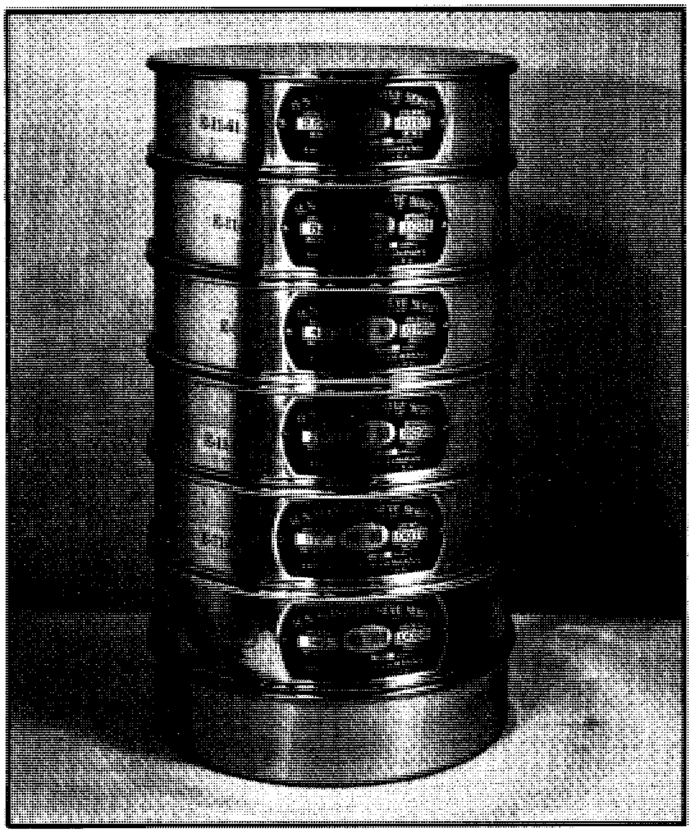


Fig.1.1

There are two widely used sieve series, the U.S.A. Sieve Series and the Tyler Standard Screen Scale Series. Tyler Screen Scale Sieves are identified by a mesh designation while the U.S.A. Sieves are identified by the opening in millimeters or microns and by arbitrary numbers which do not necessarily correspond to the mesh count. Both are based on openings which increase or decrease in the ratio of the square root of 2 or 1.414. For closer sizing, the sieve openings increase in the ratio of the fourth root of 2 or 1.189. The basic difference between the two series is their identification method, thus they are interchangeable (Fig. 1.2) When close accuracy is required, certified and matched sieves are available. Certified sieves can be supplied with the precision seal of the National Bureau of Standards certifying conformity to standard specifications. An extra charge is made for these certified sieves. A certified sieve is a guarantee that the sieve comes within the tolerances of the U.S.A. Sieve Series and this calibration is done by the National Bureau of Standards, Washington, D.C. Where extreme accuracy is desired in comparing the results of two or more plants, matched sieves are recommended.

U. S. A. SIEVE SERIES AND TYLER EQUIVALENTS
A.S.T.M.—E-11-70

Sieve Designation		Sieve Opening		Nominal Wire Diameter		Tyler Screen Scale Equivalent Designation
Standard (a)	Alternate	mm	in (approx. equivalents)	mm	in (approx. equivalents)	
125 mm	5 in	125	5	8	3150	
106 mm	4 24 in	106	4 24	6 40	2520	
100 mm	4 in (b)	100	4 00	6 30	2480	
90 mm	3½ in.	90	3 50	6 08	2394	
75 mm	3 in	75	3 00	5 80	2283	
63 mm	2½ in	63	2 50	5 50	2165	
53 mm	2 12 in	53	2 12	5 15	2028	
50 mm	2 in. (b)	50	2.00	5.05	.1988	
45 mm	1¾ in	45	1 75	4 85	1909	
37 5 mm	1½ in	37 5	1 50	4 59	1807	
31 5 mm	1¼ in	31 5	1 25	4 23	1665	
26 5 mm	1 06 in	26 5	1 06	3 90	1535	1 050 in.
25.0 mm	1 in. (b)	25.0	1.00	3.80	.1496	. . . . .
22 4 mm	7/8 in.	22 4	0 875	3 50	.1378	.883 in.
19 0 mm	3/4 in	19 0	0 750	3 30	1299	.742 in.
16 0 mm	5/8 in.	16 0	0 625	3 00	1181	.624 in
13 2 mm	530 in	13 2	0 530	2 75	1083	525 in
12.5 mm	1/2 in. (b)	12.5	0.500	2.67	.1051	. . . . .
11 2 mm	7/16 in	11 2	0 438	2 45	0965	441 in.
9 5 mm	3/8 in.	9 5	0 375	2 27	0894	371 in
8 0 mm	5/16 in	8 0	0 312	2 07	.0815	2½ mesh
6 7 mm	265 in.	6 7	0 265	1 87	0736	3 mesh
6.3 mm	1/4 in. (b)	6.3	0.250	1.82	.0717	. . . . .
5 6 mm	No 3½ (c)	5 6	0 223	1 68	0661	3½ mesh
4 75 mm	No 4	4 75	0 187	1 54	0606	4 mesh
4 00 mm	No 5	4.00	0 157	1 37	0539	5 mesh
3.35 mm	No. 6	3.35	0.132	1.23	.0484	6 mesh
2 80 mm	No 7	2 80	0 111	1 10	.0430	7 mesh
2 36 mm	No 8	2 36	0 0937	1 00	.0394	8 mesh
2 00 mm	No 10	2.00	0.0787	900	0354	9 mesh
1.70 mm	No. 12	1.70	0.0661	.810	.0319	10 mesh
1 40 mm	No 14	1 40	0 0555	.725	.0285	12 mesh
1 18 mm	No 16	1 18	0.0469	.650	0256	14 mesh
1 00 mm	No 18	1.00	0 0394	.580	0228	16 mesh
850 μm	No. 20	0.850	0.0331	.510	.0201	20 mesh
710 μm	No 25	0.710	0.0278	.450	0177	24 mesh
600 μm	No 30	0 600	0 0234	390	.0154	28 mesh
500 μm	No. 35	0.500	0.0197	340	.0134	32 mesh
425 μm	No. 40	0.425	0.0165	.290	.0114	35 mesh
355 μm	No 45	0 355	0.0139	247	0097	42 mesh
300 μm	No. 50	0 300	0.0117	.215	.0085	48 mesh
250 μm	No 60	0 250	0 0098	.180	.0071	60 mesh
212 μm	No. 70	0.212	0.0083	.152	.0060	65 mesh
180 μm	No. 80	0.180	0 0070	.131	.0052	80 mesh
150 μm	No 100	0 150	0 0059	.110	.0043	100 mesh
125 μm	No 120	0.125	0 0049	.091	0036	115 mesh
106 μm	No. 140	0.106	0.0041	.076	.0030	150 mesh
90 μm	No 170	0 090	0 0035	064	.0025	170 mesh
75 μm	No 200	0 075	0 0029	053	.0021	200 mesh
63 μm	No 230	0 063	0 0025	044	.0017	250 mesh
53 μm	No. 270	0.053	0.0021	.037	.0015	270 mesh
45 μm	No 325	0 045	0 0017	030	.0012	325 mesh
38 μm	No. 400	0.038	0.0015	.025	.0010	400 mesh

(a) These standard designations correspond to the values for test sieves apertures recommended by the International Standards Organization Geneva Switzerland

(b) These sieves are not in the fourth root of 2 Series but they have been included because they are in common usage

(c) These numbers (3½ to 400) are the approximate number of openings per linear inch but it is preferred that the sieve be identified by the standard designation in millimeters or μm
1000 μm = 1 mm

Fig.1.2

Matched sieves are selected by conducting actual sieve analyses tests first on a master set and then on the matched sieves being selected. Preferably the same material and procedure are used in these tests as are employed by the customer. When matched sieves are ordered, a sample of the typical material on which the sieves will be used as well as a description of the test procedure employed should be furnished the sieve manufacturer.

Accurate sampling is essential for reliable sieve analyses. There are two basic steps necessary for accurate sampling. First, the gross or primary sample must be representative and second, great care again must be taken to reduce the gross sample to the required size of test sample.

There are a variety of methods used in obtaining gross samples. Method of selection is dependent on the material's characteristics and the medium from which it must be extracted. The American Society for Testing and Materials (A.S.T.M.) has published standards on sampling procedures for a variety of materials.

There are two popular methods used to reduce the gross sample to a test sample. The first is coning and quartering which is (1) piling the gross sample into a cone, (2) spreading it into a circle of uniform thickness, (3) dividing the circle into quarter, (4) rejecting the two opposite quarters, and (5) forming a cone with the remaining material and repeating the process until the sample is reduced to the required size (Fig. 1.3)

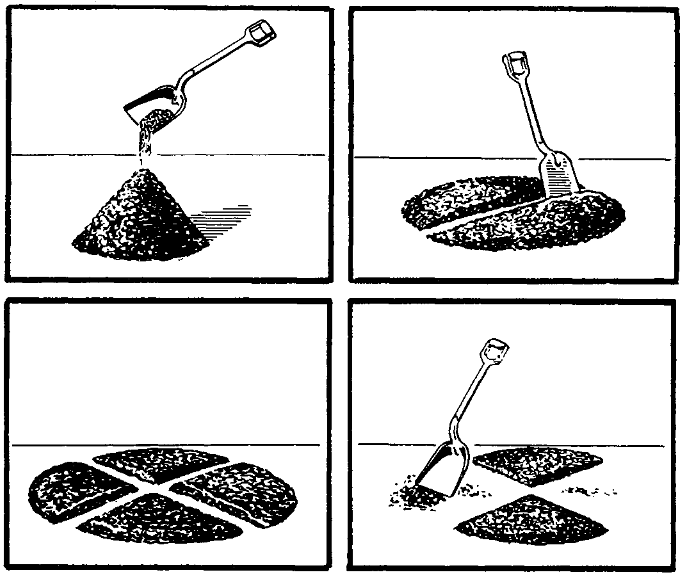


Fig.1.3

The second method, which is less time consuming, is using a sample splitter or reducer. They are capable of dividing a gross sample from halves to a representative sixteenth part while maintaining the original particle size distribution (Fig. 1.4)

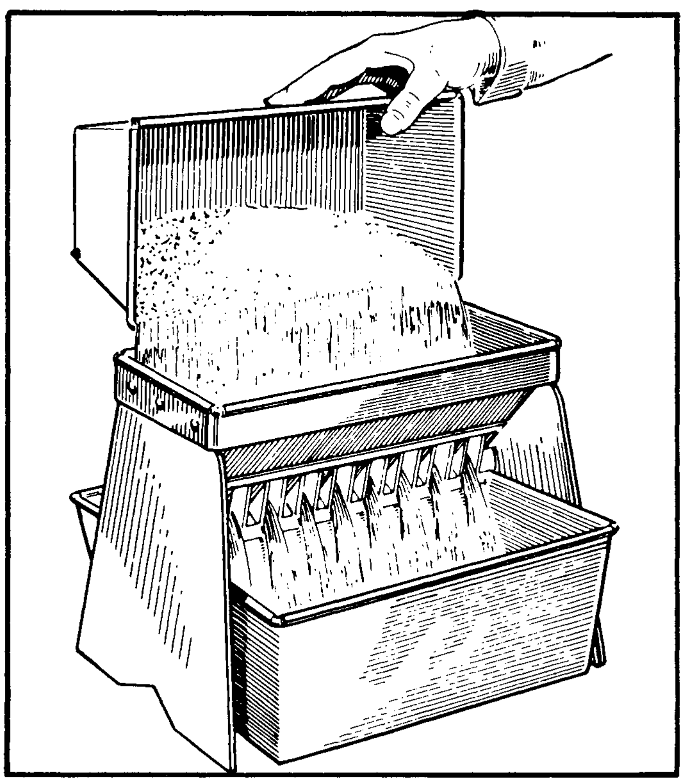


Fig. 1.4

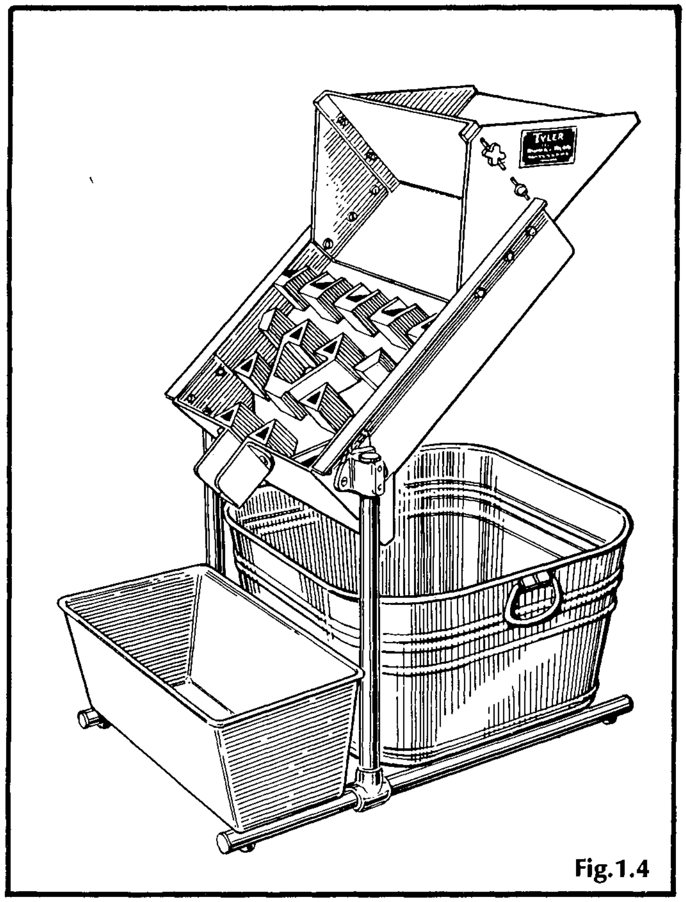


Fig.1.4

The size of the test sample is another important factor. It is also dependent on the characteristics of the material, especially the bulk density. The size of the sample should be limited to avoid overloading on any of the sieves in the series.

The general test sieving procedure consists of three fundamental steps. First, if the test sample isn't dry and free flowing due to moisture content, it must be dried to its constant weight. The second step is to weigh and record the weight of the test sample. The third step is the selection of sieves required to run the test.

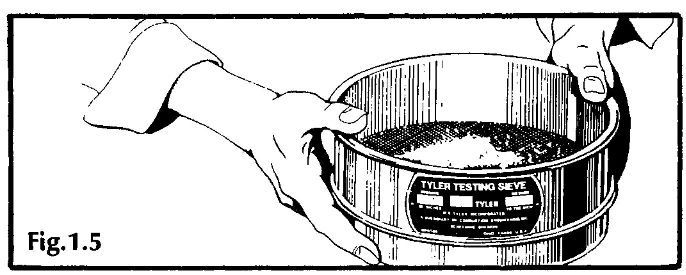


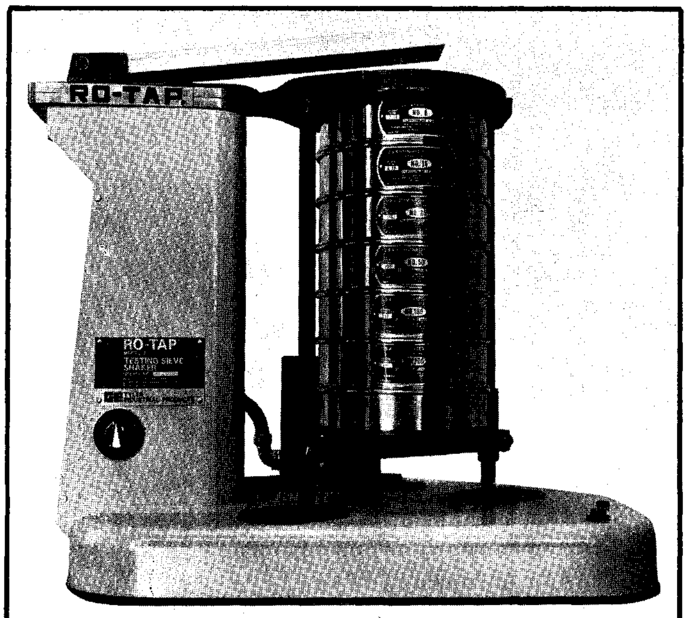
Fig.1.5

Hand sieving is the original method used to run a sieve analysis (Fig. 1.5) . The sieve is held in one hand at an angle or 20° from horizontal. The sieve is then moved up and down at a rate of 150 times per minute while the free hand strikes the sieve at the top of each stroke. The sieve should be rotated every 25 strokes at about one sixth of a revolution in the same direction. This procedure should be continued until further sieving fails to pass an amount sufficient to change the result or the end point.

When a number of sieves are required, they are stacked with the coarsest sieve on top. The nest of sieves can then be placed on a table and shaken in a circular motion with a simultaneous tapping motion for two to three minutes. After this preliminary shaking, each sieve is shaken as previously described for one sieve, starting with the coarsest and continually adding the through material to the next sieve. Each sieve is then shaken to the end point.

Consistency is very important in hand sieving. The same action must be reproduced to establish consistent results. In cases where certain results from mechanical sieve shakers are questionable, the results of a hand sieve test are used to check the disputed figures and these results are then final.

Mechanical sieve shakers are commonly used where frequent testing is required. They eliminate time consuming hand labor and if used properly produce consistent results. There are many general types of sieve shakers available. One type provides a circular motion with a tapper duplicating the hand sieving technique (Fig. 1.6) There are sieve shakers that produce vigorous agitation for large test samples (Fig. 1.7) Another type of shaker utilizes an electromagnetic motor with variable speed control to provide a high speed, short-stroke vibration (Fig. 1.8) The oscillating air column-type shaker classifies material by means of an oscillating column of air inside the nest of sieves (Fig. 1.9)



RO-TAP TESTING SIEVE SHAKER TYLER INDUSTRIAL COMBUSTION ENGINEERING, INC

Fig.1.6

It is important for consistent results when comparing analyses of the same sample by a producer and his customer that the same type of mechanical shaker be used in both tests.

When running a sieve test on a mechanical shaker, it is necessary to determine the length of time required for a given sample. Generally, three to five minutes is sufficient, but some materials may

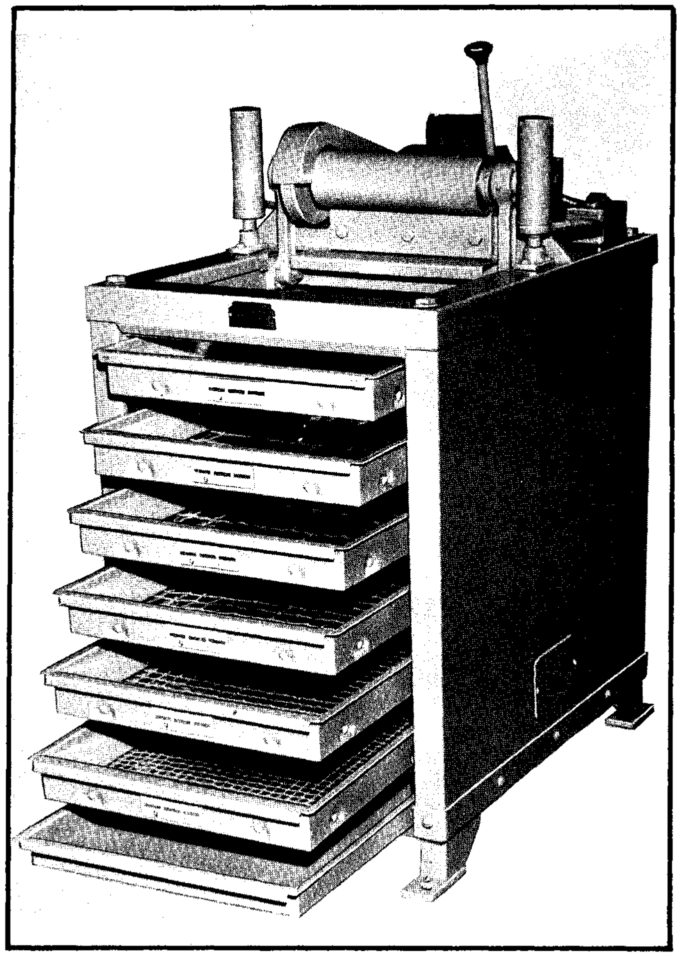


Fig. 1.7

necessitate up to 30 minutes of shaking, while some friable materials would require less than three minutes. For most tests the proper length of time has been reached when one additional minute of shaking does not produce a change in weight of more than 1.0 per cent on any sieve.

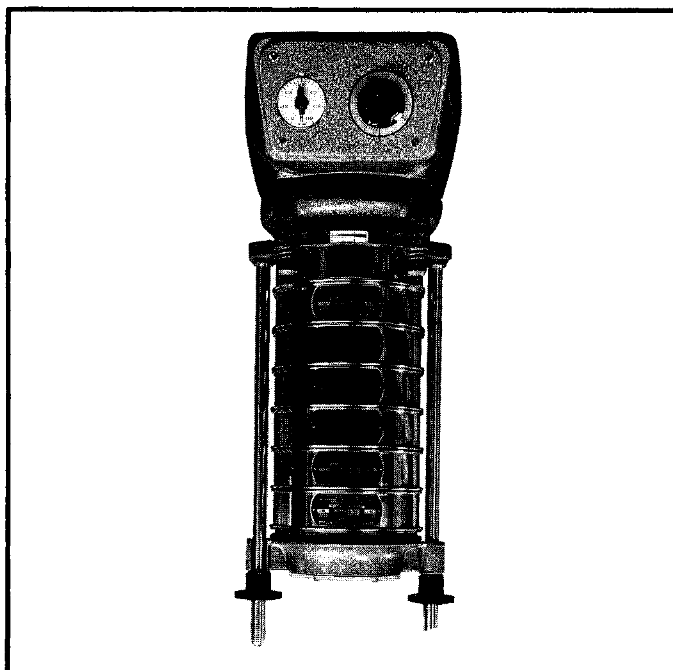


Fig.1.8

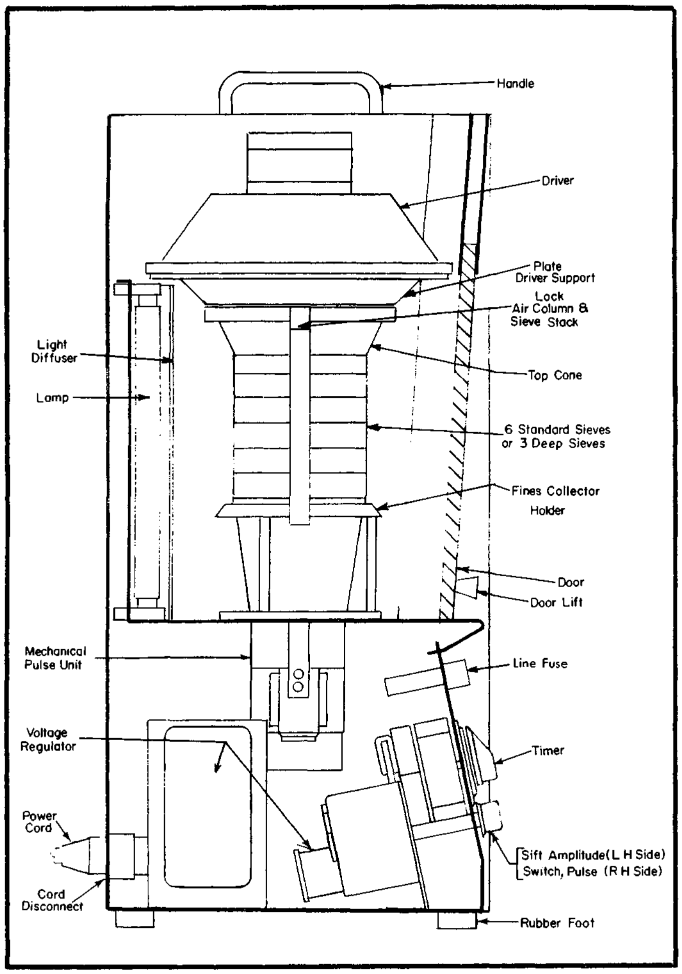


Fig. 1.9

For materials that are difficult to screen, accurate sieve testing can be done by the wet method (Fig. 1.10) When the material readily mixes with water, the test sample is placed on the finest sieve and gently washed until the water passing through the sieve is clear. The residue is then dried and weighed. This procedure is then repeated on the next coarser sieve. If the material doesn't mix well with water, the test sample is dried and weighed and then placed in a quart jar three quarters filled with water and is shaken vigorously. You are then able to follow the procedure used for material that mixes well with water.

Mechanical sieve shakers can also be modified to receive water through the top and drain through the bottom pan (Fig. 1.11). It is also possible to conbine wet and dry testing for material with fine particles that are difficult to sieve. The fine particles are removed by the wet method and the remaining particles are then tested on a dry basis.

After the sieve testing is completed, the material on each sieve in the nest must be weighed, including the material in the pan. These weights are then divided by the total weight of the sample to determine the percentage retained on each sieve. The cumulative percentage retained on each sieve is the percentage retained on that sieve plus the percentages retained on the coarser sieves. From these percentages it is also possible to determine

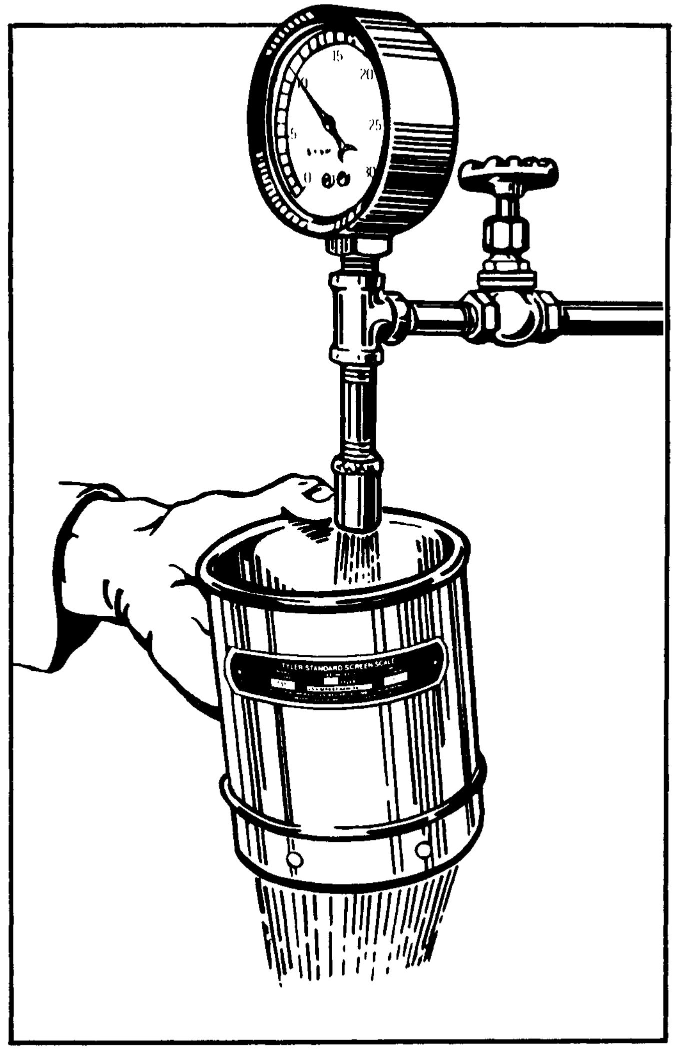


Fig.1.10

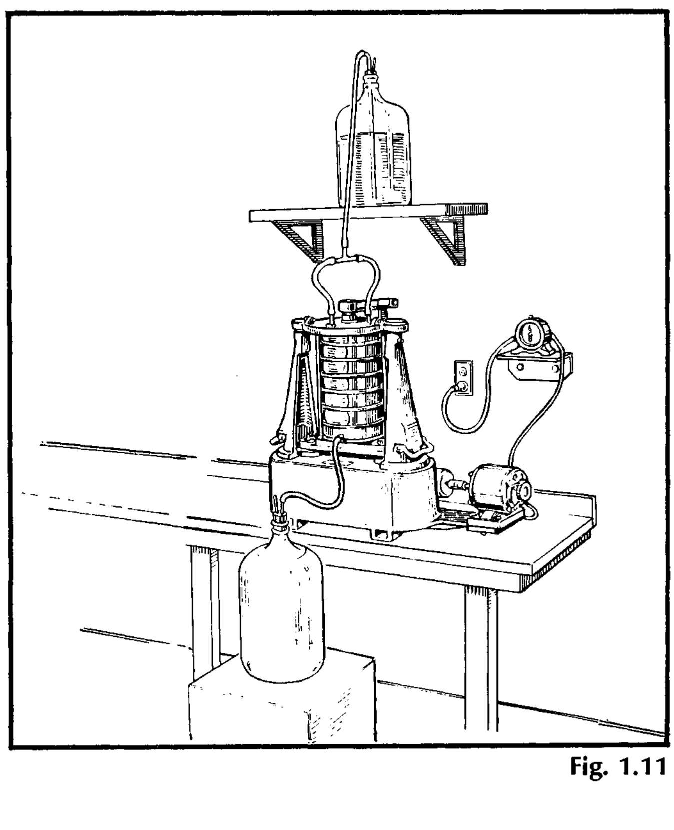


Fig. 1.11

the percentages through each sieve and the cumulative percentages through (Fig. 1.12)

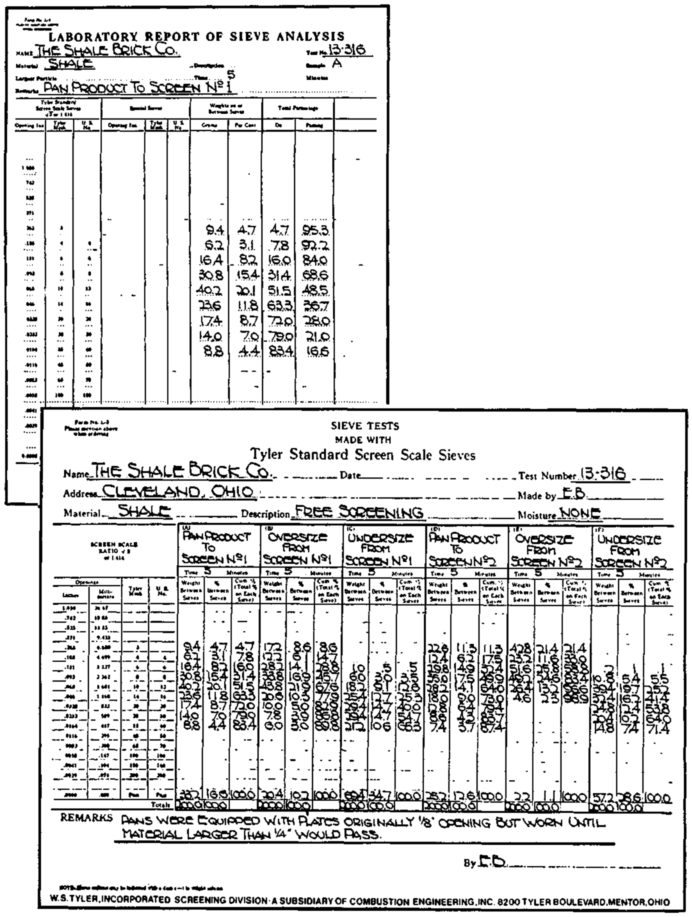


Fig.1.12

The sieve analysis can now be presented graphically. The graphic presentation simplifies comparing results and enables interpolation of percentages or sieves not used in the test. Normally, the sieve scales are represented on the abscissa and the percentages retained or passing on the ordinate. The scales can be arithmetic or logarithmic with the later advantageous in representing standard sieve sizes since they are related to each other by the fourth root of two. The lineal scale is normally used to plot the percentages (Fig. 1.13).

The results of a sieve analysis are used to calculate the performance and sizing of crushing, pulverizing, and screening equipment. Frequent sieve tests are recommended to maintain a uniformly sized product. Gradual inefficiency brought out in frequent testing could be the result of wearing parts, providing the operator the opportunity to make necessary repairs or change-outs, prior to severe contamination of the product.

Sieve analyses are very useful in determining the order of equipment in the plant flow. For instance, if the sieve test results show there is a large quantity of fine material being fed to a crusher, it may be more profitable to place a vibrating screen ahead of the crusher to reduce the fines which tend to decrease the efficienty of the crusher.

The sieve analysis plays an integral role in estimating the size of a vibrating screen. After installation the sieve analysis is used again to spot changes in the feed material which could adversely affect production. The quality of the finished product can now be determined and compared with previous production results.

Sieve analyses provide a permanent record of the performance of many types of material handling equipment. A new operator would benefit from this record when attempting to duplicate previously, satisfactory performance. For further information on sampling and sieve analyses, refer to the Manual on Test Sieving Methods, STP 447, published by the American Society for Testing and Materials.

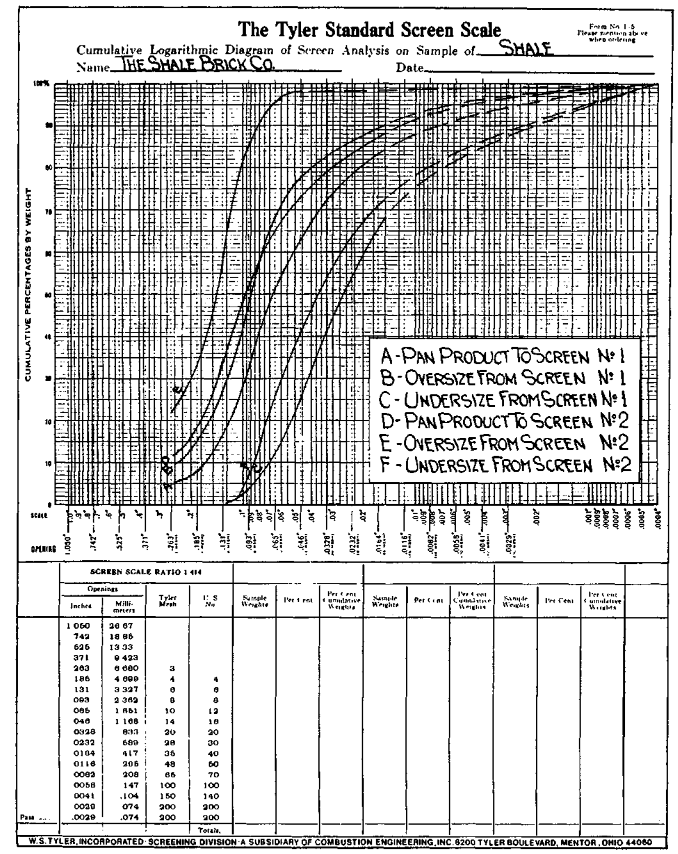


Fig. 1.13

Chapter 5
Selection of Screen Size & Type

VSMA

QUALITY / INTEGRITY

SELECTION OF SCREEN SIZE AND TYPE

Screening is defined as "a mechanical process which accomplishes a division of particles on the basis of size and their acceptance or rejection by a screening surface". Most often the process of screening is accomplished on a vibrating screen.

There are several types of vibrating screens. More details on this subject can be found in Chapter II of this manual.

In the mineral and ore processing plants of today there is need for various stages of screening. The primary or starting point, where material is first delivered to the plant, normally requires large separations. As the material continues on through various stages of reduction, finer separations are needed. There is a vibrating screen specifically designed to handle these various screening applications. The most common screening applications are given in Section 11 of this chapter.

Because of the need to produce material sized to a rigid specification, the vibrating screen has taken on more prominence than ever before in today's material processing plant. The proper type of screen and a sufficient quantity to economically produce the sizes and tonnages needed can mean the success or failure of an operation.

To intelligently select the proper size and type of screen, specific details of every application are necessary. The simplest way of acquiring or providing this information is to complete a screen questionnaire. A copy of the VSMA questionnaire is included in this chapter.

After this information is available, one can begin to review the application and determine the type and size of screen best suited for the duty.

Many materials look alike but will separate somewhat differently. The general characteristics of a material determine its rate of passage through a given hole. Some materials have characteristics that cause them to fracture at a critical size due to their grain structure. If the bulk of the material fractures at a critical size near the dimensions of the screen surface opening, it is difficult to separate. On the other hand, some materials are more friable and have a tendency to break up in quantity to a fine size which makes separation much easier. These are a few of the variables that one encounters in screening. Some others will be covered later.

Although screen size selection is often referred to as an art, a lot of experience has been compiled through research at test facilities and through field data; thus, some very reliable capacity criteria has been developed by the individual vibrating screen manufacturers.

Using the volume of factual data tabulated from the multitude of field test results, a set of statistics—a formula for calculating theoretical screen area—has been developed. While there is some variance among manufacturers, this information is used as the basis of the capacity chart .

The next few pages are devoted to the use of a formula for calculating screening area. The formula presented in this chapter is typical of that used in the industry. ALL CAPACITY FORMULAS ARE INTENDED TO BE USED ONLY AS A GUIDE. Always enlist the knowledge and experience of one of the VSMA members or a reliable screen manufacturer for final recommendations on the type and size of screen best suited for your application.

APPLYING SCREENING AREA FORMULA

A separate calculation is required for each deck of a multiple deck screen, but the same formula is used in each calculation:

$$\text{Screening Area} = \frac{U}{A \times B \times C \times D \times E \times F \times G \times H \times J} = \text{Square Feet}$$

The succession of unknowns that must be established before using the above formula is as follows:

Factor "U"– Undersize	Amount in STPH of material in feed to deck that is smaller than a specified aperture.
Factor "A"– Basic Capacity	Predetermined rate of material STPH through a square foot of a specified opening when feed to deck contains 25% oversize (Factor "B") and 40% halfsize (Factor "C").
Factor "B"– Oversize	Actual % of material in feed to deck that is larger than a specified aperture (Adjusts Factor "A" to suit conditions.)
Factor "C"— Halfsize	Actual % of material in feed to deck that is one-half the size of a specified aperture. (Adjusts Factor "A" to suit conditions).
Factor "D"— Deck Location	Applies for multiple deck screens. Total screening area is available for top deck separation. Time delay for material to pass top deck and 2nd or 3rd decks leaves less effective area available. This factor is expressed in a percent of the top deck effective area.
Factor "E"— Wet Screening	Applies when water is sprayed on the material as it moves down the screening deck. Generally, about 5 to 7 GPM of water are used per STPH of solids fed to the screen. The volume of water required should be supplied so that a portion is combined with the solids into a feed box to prepare a slurry feed to the screen. The balance

of water is added through a series of spray bars located over the screening deck.

Factor "F"— Material Weight: Applies for weights other than 100 lbs. per cu. ft. If bulk density of one cubic foot of material weighs ± 100 lbs. cu. ft., Factor "F" =

$$\frac{\text{lbs. per cu. ft.}}{100}$$

Factor "G"— Screen Surface Open Area: Applies when open area of screening surface is less than open area shown in Factor "A" capacity chart. Factor "G" =

$$\frac{\text{\% open area of screen surface being used}}{\text{\% open area indicated in capacity chart}}$$

Factor "H"— Shape of Opening: Applies when rectangular openings are used. Slotted or oblong openings will pass more material per square foot than square openings.

Factor "J"— Efficiency: Applies when objective screening efficiency is less than 95%

SCREEN EFFICIENCY

Screening efficiency is the percent of the undersize in the feed that actually passes the screen surface opening, or:

$$\text{Efficiency} = \frac{\text{\% of undersize in feed which actually passes}}{\text{\% of undersize in feed (should pass)}}$$

It would be most desirable for an operator if every screen attained 100% efficiency. However, it is understood and accepted in the industry that this is impossible. The capacity formula is based on 95% screening efficiency. Normally, 90 to 95% efficiency is an accepted rate in most screening operations. However, even 90% is not always attainable. Considering the many factors that affect material classification, it is a very difficult task to constantly control screening efficiency to an exact percentage. Furthermore, multiple deck screens present separate problems for each deck.

With the many factors that govern efficient screening, it is impractical to expect a numerical factor in the capacity formula will automatically control this. By the very fact that industry accepts that 100% efficiency is impossible, it also recognizes there are screening applications when 90% or even 80% may be impossible, regardless of the amount of available screening area.

The difficult-to-pass "nearsize undersize" is most often a controlling factor in determining the problems you can expect to encounter in attaining a high efficiency. Moisture and peculiar particle shapes will compound the problem.

Keep in mind that material remains on a vibrating screen for only a matter of seconds. Evaluation of the efficiency of the screen is checked by testing sieves for three to five minutes or longer. This seems to be an unfair method of checking a vibrating screen's efficiency but it is an accepted method.

The screen manufacturer will review the application and determine what percent of efficiency can be expected.

The VSMA form "Vibrating Screen Questionnaire" should be used as a guide to record the application data necessary to apply the above formula. When using the formula, a sieve analysis of the material being fed to the screen is the basis to determine the percent of oversize (Factor "B"), undersize (Factor "U") and halfsize (Factor "C") for each separation, A numerical factor corresponding to the actual percent is selected from the charts and placed in its proper location in the formula. After all factors are determined, proceed to calculate the required theoretical area.

Before establishing the size of screen from the screen area calculations only, check that the theoretical bed depth is in accordance with good operating practice.

$$DBD = \frac{O \times C}{5 \times T \times W} = \text{Inches of Bed Depth}$$

FACTORS

DBD = Discharge End Bed Depth
O = Oversize in STPH
C = Cubic Feet Per Ton of Material
5 = Constant
T = Rate of Travel (nominal 75 fpm for inclined screen at slope of 18° to 20° with flow rotation and nominal 45 fpm for horizontal screen)
W = Width of Screening Area in Feet

The feed to a vibrating screen consists of a mass of material in different sizes. The oversize will retard passage of the undersize; and this temporary restriction results in a build-up of material on the screen surface. The bed diminishes as the undersize passes the opening. However, the bed of material should never reach a depth where the undersize does not stratify before it discharges off the end of the screen. A rule of thumb is that the bed depth at the discharge end of the screen should not exceed four times the size of the surface opening when separating material weighing 100 lbs. per cu. ft. or three times for material weighing 50 lbs. per cu. ft. This rule should be followed and is practical in most applications. However, it is based on volume only and many times the dimensions of the topsize pieces in the feed to the deck will exceed the calculated bed depth. This is not cause for alarm but it deserves consideration before selecting the screen size.

To select the size of screen, first determine, from the bed depth calculations, the width that will maintain the proper bed depth for efficient screening and then choose the length that, together with the width, provides a minimum total screening area equivalent to that arrived at in the screen area calculations.

*FACTORS FOR CALCULATING SCREEN AREA

Formula: Screening Area= $\dfrac{U}{A \times B \times C \times D \times E \times F \times G \times H \times J}$

***Basic Operating Conditions**

Feed to screening deck contains 25% oversize and 40% halfsize
Feed is granular free-flowing material
Material weighs 100 lbs. per cu. ft.
Operating slope of screen is: Inclined Screen 18° – 20° with flow rotation
Horizontal Screen 0°
Objective Screening Efficiency – 95%

FACTOR "A"

Surface Square Opening	% Open Area	STPH Passing A Sq. Ft.
4″	75%	7.69
3½″	77%	7.03
3″	74%	6.17
2¾	74%	5.85
2½″	72%	5.52
2″	71%	4.90
1¾″	68%	4.51
1½″	69%	4.20
1¼″	66%	3.89
1″	64%	3.56
⅞″	63%	3.38
¾″	61%	3.08
⅝″	59%	2.82
½″	54%	2.47
⅜″	51%	2.08
¼″	46%	1.60
3/16″	45%	1.27
⅛″	40%	.95
3/32″	45%	.76
1/16″	37%	.58
1/32″	41%	.39

FACTOR "B"

(Percent of Oversize in Feed Deck)

% Oversize	5	10	15	20	25	30	35
Factor B	1.21	1.13	1.08	1.02	1.00	.96	.92

% Oversize	40	45	50	55	60	65	70
Factor B	.88	.84	.79	.75	.70	.66	.62

% Oversize	75	80	85	90	95
Factor B	.58	.53	.50	.46	.33

FACTOR "C"

(Percent of Halfsize in Feed to Deck)

% Halfsize	0	5	10	15	20	25	30
Factor C	.40	.45	.50	.55	.60	.70	.80

% Halfsize	35	40	45	50	55	60	65
Factor C	.90	1.00	1.10	1.20	1.30	1.40	1.55

% Halfsize	70	75	80	85	90
Factor C	1.70	1.85	2.00	2.20	2.40

FACTOR "D"

(Deck Location)

Deck	Top	Second	Third
Factor D	1.00	.90	.80

FACTOR "E"

(Wet Screening)

Opening	1/32″	1/16″	1/8″	3/16″	1/4″	3/8″	1/2″	3/4″	1″
Factor E	1.00	1.25	2.00	2.50	2.00	1.75	1.40	1.30	1.25

FACTOR "F"

(Material Weight)

Lbs./cu.ft.	150	125	100	90	80	75	70	60	50	30
Factor F	1.50	1.25	1.00	.90	.80	.75	.70	.60	.50	.30

FACTOR "G"

(Screen Surface Open Area)

Factor "G" = $\dfrac{\text{\% Open Area of Surface Being Used}}{\text{\% Open Area Indicated in Capacity}}$

FACTOR "H"

(Shape of Surface Opening)

Square 1.00
Short Slot (3 to 4 Times Width) 1.15
Long Slot (More than 4 Times Width) 1.20

FACTOR "J"

(Efficiency)

95% 1.00
90% 1.15
85% 1.35
80% 1.50
75% 1.70
70% 1.90

MEMBER

VSMA QUALITY / INTEGRITY

VIBRATING SCREEN MANUFACTURERS ASSOCIATION

Date: 6-1-78

Company: Hard Rock Inc.

Location: Quarry, California

VIBRATING SCREEN QUESTIONNAIRE

1. Kind of material: Crushed limestone

2. Duty required: (Refer other side)

____ Scalping X Sizing Dry ____ Dewatering

____ Sizing Wet ____ Washing ____ Rescreening

3. Characteristics of material:

a) Wt. Per Cu. Ft. 100 lbs.

b) Material conditions when fed to screen:

Dusty Dry X Damp ____ Clayey ____

Wet ____ Hot ____ Sticky ____

% Surface Moisture LESS than 2%

Temperature ____ °F ____ °C

c) Particle shape(s):

Cubical X Round ____

Slabby/Flake ____

Slivery ____ Other ____

4. Operating schedule:

Hours per day 8-10 Days per week 5

5. Feed rate (including circulating load if applicable):

Maximum 300 TPH

Average 300 TPH (Ton 2,000 lbs.)

If feed is slurry: ____ gpm

%Solids: ____ % by wt. ____ % by volume

6. Feed analysis:

Maximum size particle ____

Opening	Cumulative % Passing
2"	100%
1 1/4"	91%
1"	85%
3/4"	70%
1/2"	60%
3/8"	45%
1/4"	30%
5/16"	22%
1/8"	15%
#10	6%

Test Sieve Series: Square X Round ____

US X Tyler ____ Other ____

7. Product sizes required:

a) − 2" + 1"

b) − 1" + 1/2"

c) − 1/2" + 1/4"

d) − 1/4" +

e) − +

8. Preferred type of screen media:

		Specify Deck Location
a) Wire cloth	X	ALL
b) Perforated plate		
c) Profile wire		
d) Elastomer		
e) Combination		
f) Other		

9. If space is restricted for installation fill in limiting dimensions:

Height ____ Width ____ Length ____

10. Preferred type of screen:

Inclined X Horizontal ____ Other ____

Open ____ Enclosed ____

11. Type of Installation:

Stationary Plant X

Portable Plant ____

12. Type of Mounting Preferred:

Floor X

Suspension ____

Other ____

13. Desired Screen Efficiency:

Top Deck: X 95% ____ 90% ____ 85% ____ 80%

2nd Deck: X 95% ____ 90% ____ 85% ____ 80%

3rd Deck: ____ 95% X 90% ____ 85% ____ 80%

COMMON VIBRATING SCREEN APPLICATIONS

SCALPING SCREEN

A vibrating screen used to remove a small amount of oversize from a feed which is predominantly finer without regard for finished product sizes.

SIZING SCREEN (Dry or Wet)

A vibrating screen used to produce material sizes that meet specifications in a particular range of sizes. Usually expected to perform at a high and constant rate of efficiency.

WASHING SCREEN

A vibrating screen equipped so that water can be sprayed on the material. Normally water is used to clean material and/or assist in the sizing.

DEWATERING SCREEN

A vibrating screen used to remove liquid from material.

RESCREEN SCREEN (Dry or Wet)

A vibrating screen used dry or wet to remove fines or contaminants from previously screened material. Often called dedusting screen (dry) desliming screen (wet) or a polishing screen.

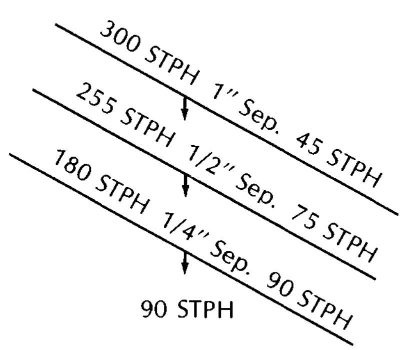
EXAMPLE
CALCULATING SCREEN AREA
Application Details from Screen Questionnaire

Material .... Crushed Limestone
Weight .... 100 lbs. ft.^{3}
Feed Rate .... 300 STPH
Separations Required .... 1", 1/2", 1/4"
Type of Screen .... Inclined Triple Deck

Sieve Analysis of Feed to Screen

Opening	Cumulative Passing	STPH Passing
2"	100%	300 STPH
1-1/4"	91%	273 STPH
1"	85%	255 STPH
3/4"	70%	210 STPH
1/2"	60%	180 STPH
3/8"	45%	135 STPH
1/4"	30%	90 STPH
3/16"	22%	66 STPH
1/8"	15%	45 STPH
#10	6%	18 STPH

Feed Distribution per Sieve Analysis



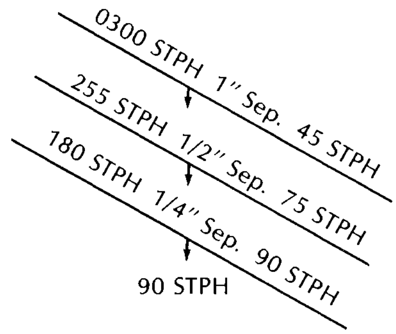
Formula:

$$\frac{U}{A \times B \times C \times D \times E \times F \times G \times H \times J}$$

EXAMPLE
CALCULATIONS FOR TOP DECK

Sieve Analysis of Feed to Top Deck

Opening	Cumulative % Passing	STPH Passing	Conditions for Top Deck
2″	100%	300 STPH	Feed to 1st Deck = 300 STPH
1-1/4″	91%	273 STPH	Factor "A" (for 1") = 3.56
1″	85%	255 STPH	Factor "B" (for +") = 1.08
3/4″	70%	210 STPH	Factor "C" (for -1/2") = 1.40
1/2″	60%	180 STPH	180 STPH = 60%
3/8″	45%	135 STPH	Factor "D" for Top Deck = 1.00
1/4″	30%	90 STPH	Factor "E" (Dry Screening) = 1.00
3/16″	22%	66 STPH	Factor "F" (100 lbs. cu. ft.) = 1.00
1/8″	15%	45 STPH	Factor "G" (64% Surface O.A.) = 1.00
#10	6%	18 STPH	Factor "H" (Square Opening) = 1.00



Area 1″ Separation =

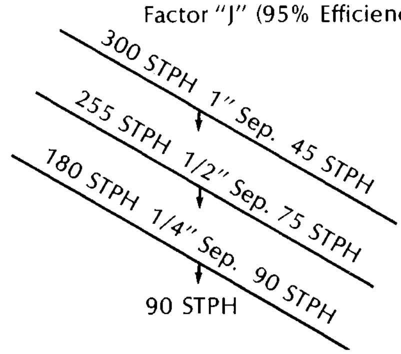
$$\frac{255}{\underset{\text{"A"}}{3.56} \times \underset{\text{"B"}}{1.08} \times \underset{\text{"C"}}{1.40} \times \underset{\text{"D"}}{1.00} \times \underset{\text{"E"}}{1.00} \times \underset{\text{"F"}}{1.00} \times \underset{\text{"G"}}{1.00} \times \underset{\text{"H"}}{1.00} \times \underset{\text{"J"}}{1.00}} = \frac{255}{5.38} = 48 \text{ Sq. Ft.}$$

EXAMPLE
CALCULATIONS FOR SECOND DECK

Theoretical Analysis of Feed to 2nd Deck

Opening	Cumulative % Passing	STPH Passing	Conditions for Second Deck
1″	100%	255 STPH	Feed to 2nd Deck = 255 STPH
3/4″	82%	210 STPH	Factor "A" (for 1/2") = 2.47
1/2″	71%	180 STPH	Factor "B" (for +1/2") = .968
			75 STPH = 29%
3/8″	53%	135 STPH	
			Factor "C" (for -1/4") = .90
1/4″	35%	90STPH	90 STPH = 35%
3/16″	26%	66 STPH	Factor "D" for 2nd Deck = .9
1/8″	18%	45 STPH	Factor "E" (Dry Screening) = 1.00
#10	7%	18 STPH	Factor "F" (100 lbs. cu. ft.) = 1.00
			Factor "G" (54% Surface O.A.) = 1.00
			Factor "H" (Square Opening) = 1.00
			Factor "J" (95% Efficiency) = 1.00

Feed Distribution per Sieve Analysis



Area 1/2″ Separation =

$$\frac{180}{\underset{\text{"A"}}{2.47} \times \underset{\text{"B"}}{.968} \times \underset{\text{"C"}}{.90} \times \underset{\text{"D"}}{.90} \times \underset{\text{"E"}}{1.00} \times \underset{\text{"F"}}{1.00} \times \underset{\text{"G"}}{1.00} \times \underset{\text{"H"}}{1.00} \times \underset{\text{"J"}}{1.00}} = \frac{180}{1.94} = 93 \text{ Sq. Ft.}$$

EXAMPLE

CALCULATIONS FOR THIRD DECK

Theoretical Sieve Analysis of Feed to 3rd Deck

Opening	Cumulative % Passing	STPH Passing
1/2"	**100%**	**180 STPH**
3/8"	75%	135 STPH
1/4"	50%	90 STPH
3/16"	37%	66 STPH
1/8"	25%	45 STPH
#10	10%	18 STPH

Conditions for Third Deck

Feed to 3rd Deck = 180 STPH

Factor "A" (for 1/4") = 1.60

Factor "B" (for + 1/4") = .79
90 STPH = 50%

Factor "C" (for − 1/8") = .70
45 STPH = 25%

Factor "D" for 3rd Deck .8

Factor "E" (Dry Screening) 1.00

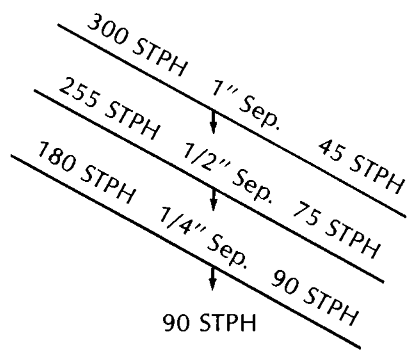
Factor "F" (100 lbs. cu. ft.) = 1.00

Factor "G" (46% Surface O.A.) = 1.00

Factor "H" (Square Opening) = 1.00

Factor "J" (90% Efficiency) =1.15

Feed Distribution per Sieve Analysis

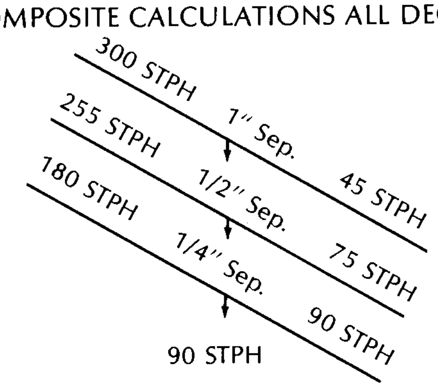


Area 1/4" Separation $= \dfrac{90}{1.6 \times .79 \times .70 \times .80 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.15} = \dfrac{90}{.81} =$ 111 Sq. Ft.

"A" ::B" "C" "D" "E" "F" "G" "H" "J"

EXAMPLE

COMPOSITE CALCULATIONS ALL DECKS



Area 1" Separation $= \dfrac{255}{3.56 \times 1.08 \times 1.40 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.00}$

"A" "B" "C" "D" "E" "F" "G" "H" "J"

$$\text{Area } 1/2'' \text{ Separation} = \frac{180}{\underset{\text{"A"}}{2.47} \times \underset{\text{"B"}}{.968} \times \underset{\text{"C"}}{.90} \times \underset{\text{"D"}}{.90} \times \underset{\text{"E"}}{1.00} \times \underset{\text{"F"}}{1.00} \times \underset{\text{"G"}}{1.00} \times \underset{\text{"H"}}{1.00} \times \underset{\text{"J"}}{1.00}} = \frac{180}{1.94} = 93 \text{ Sq. Ft.}$$

$$\text{Area } 1/4'' \text{ Separation} = \frac{90}{\underset{\text{"A"}}{1.6} \times \underset{\text{"B"}}{.79} \times \underset{\text{"C"}}{.70} \times \underset{\text{"D"}}{.80} \times \underset{\text{"E"}}{1.00} \times \underset{\text{"F"}}{1.00} \times \underset{\text{"G"}}{1.00} \times \underset{\text{"H"}}{1.00} \times \underset{\text{"J"}}{1.15}} = \frac{90}{.81} = 111 \text{ Sq. Ft.}$$

EXAMPLE

CALCULATING BED DEPTH DISCHARGE END

$$\text{DBD} = \frac{\text{O} \times \text{C}}{5 \times \text{T} \times \text{W}} = \text{Inches of Bed Depth}$$

$$\text{Top Deck} = \frac{45 \times 20}{5 \times 75 \times 6} = \frac{900}{2200} = 7/16'' \text{ Depth to } 1'' \text{ Separation}$$

$$\text{Second Deck} = \frac{75 \times 20}{5 \times 75 \times 6} = \frac{1500}{2200} = 11/16'' \text{ Depth to } 1/2'' \text{ Separation}$$

$$\text{Third Deck} = \frac{90 \times 20}{5 \times 75 \times 6} = \frac{1800}{2200} = 13/16'' \text{ Depth to } 1/4'' \text{ Separation}$$

A logical choice from the above calculations is to select a 6′ x 20′ triple-deck screen.

This completes the exercise of calculating theoretical screening area. The experienced screen application specialist will proceed from here and devote some time in reviewing some of the variables that govern screening performance but cannot be included in a formula. These variables can contribute to a more favorable or unfavorable screening condition. It is the presence of unfavorable conditions that requires attention after calculated screen area is established.

Moisture can affect a separation as it presents problems with blinding of the screen surface. The manufacturer may have an accessory available that will alleviate this condition.

Peculiar particle shapes, such as wedges, slivers and flats, are often difficult to separate. This can have an adverse effect on screen capacity and efficiency.

If the feed to the deck contains a large amount of nearsize, there is also the danger of plugging. The screen surface specifications become very important in making an efficient separation when this condition exists.

Obviously, the screen area calculations deal with a mathematical formula but there are several factors unaccounted for in this formula. It is impossible and impractical to assign a numerical value to all of the uncontrollable variables present in separating materials. Experience and common sense must be applied after completing capacity calculations. That is why it is important that the formula be considered as only a guide.

Chapter 6

Speed, Stroke and Slope

QUALITY / INTEGRITY

SPEED STROKE AND SLOPE

After selecting the proper size and type (inclined or horizontal) of screen, it is essential that it be operated to produce optimum results. This means that it must be operated at the best combination of speed, stroke and in the case of inclined screens, slope.

To prevent any misunderstanding, we define these operating variables as follows:

SPEED

The frequency at which a vibrating screen operates, usually expressed in revolutions per minute or cycles per minute.

STROKE

The distance between extremities of traverse: viz; the diameter of a circular motion.

SLOPE

The angle with the horizontal made by the first or top deck screen section.

Each of these variables has its own effect on the screen performance. For example; The speed at which the screen is operated should be enough to produce a bed depth that allows stratification to occur before the material is discharged. This gives the fines an opportunity to pass through the screening media. The speed, however, should not be so high that the bearing life is reduced to an uneconomical level. The stroke must be large enough to throw the near size particles out of the opening and keep the screen from plugging. The stroke however, cannot be so great that it interferes with stratification and tends to throw near size particles out of the aperture before they have a chance to adjust themselves and pass through. Too much stroke will tend to increase the distance a particle is thrown and, as a result, reduce the effective life of the screen. Too large a stroke also has a tendency to affect the life of the screening surfaces as well as the screen body parts and mechanism.

The slope of inclined screens must be sufficient to keep the material moving across the deck, and yet not so steep that it foreshortens the opening too much and interferes with the passage of the material through the deck. In most instances, the slope of the screen should be steeper for counter-flow rotation than for with-flow rotation.

In general, a lesser slope will increase the depth of the bed of material on a deck. This increase in load on a deck will increase screening media wear and also produce more plugging. In extreme cases the load can become so great the screen will bog down.

Conversely, a steeper slope will have the same affect as too large a stroke. It will increase the distance between impacts on a screen for a given particle and reduce the effective length of the screen. This will require a longer screen for a given efficiency.

All these variables are inter-related and dependent on each other. Each screen manufacturer has its own standards of combinations of speed, stroke and slope which should be used for given situations. While these combinations vary to some extent, they can be grouped into ranges as shown in Figures 1.1 and 1.2 for inclined and horizontal screen, respectively. As one can see from these tables, all screen manufacturers agree that small strokes and high speeds are more acceptable for small openings, whereas large openings require large strokes and relatively slow speeds for optimum operation.

The ranges of stroke, speed and, in the case of inclined screens, the slope as shown on these tables, are to be used as a guide and are adequate for most conditions. There are, however, special conditions such as clay or other sticky substance materials which reduce its screenability. This requires a change in throw and speed to increase the intensity of vibration and, hopefully, obtain good screening. Screens normally operated horizontally can be put on a slope of up to 10 degrees to help in overcoming plugging problems. This may allow them to be operated at smaller strokes than shown in Figure 1.2 .

These tables give a basis for operation of screens under average conditions. They can however be modified to suit particular conditions. The screen manufacturer should be consulted before changing either the stroke or the speed of an existing screen to be sure no mechanical problems will occur because of the change.

Fig. 1.1

INCLINED SCREENS

STROKE, SPEED AND SLOPE SELECTION

FOR DRY 100 LB. PER CUBIC FOOT MATERIAL & FLOW MECHANISM ROTATION

STROKE (in)	NOMINAL SPEED (RPM)	TOP DECK OPENING 35M TO 50M	20M TO 35M	10M TO 20M	4M TO 10M	1/2″ TO 4M	1″ TO 1/2″	2″ TO 1″	3″ TO 2″	4″ TO 3″	6″ TO 4″	8″ TO 6″	ABOVE 8″	SLOPE RANGE (degree)
03	3500	Preferred	Acceptable											24-30
05	2600	Acceptable	Preferred	Preferred										24-30
06	2100	Acceptable	Preferred	Preferred	Acceptable									22-28
3/32	1800		Acceptable	Preferred	Preferred	Acceptable								22-26
1/8	1600		Acceptable	Preferred	Preferred	Acceptable								22-26
3/16	1400			Acceptable	Preferred	Preferred	Acceptable							20-25
1/4	1000			Acceptable	Preferred	Preferred	Acceptable							18-25
5/16	900					Preferred	Preferred	Preferred						18-25
3/8	850					Acceptable	Preferred	Preferred	Preferred	Preferred				18-25
7/16	750								Acceptable	Preferred	Preferred			18-25
1/2	700										Acceptable	Preferred	Preferred	18-25

PREFERRED (cross-hatched bar) ACCEPTABLE (vertical-bar pattern)

Fig. 1.2

HORIZONTAL SCREENS

Stroke & Speed Selection

For Dry 100 lb. per Cubic Foot Material

STROKE (in.)	NOMINAL SPEED (RPM)	TOP DECK OPENING					
		LESS THAN 10M	4M TO 10M	1/2″ TO 4M	1″ TO 1/2″	2″ TO 1″	4″ TO 2″
3/8	950	Consult VSMA Member	XXXX	XXXX	IIII		
7/16	900		IIII	XXXX	XXXX		
1/2	850			IIII	XXXX	XXXX	
5/8	800			IIII	IIII	XXXX	XXXX
3/4	750				IIII	IIII	XXXX

PREFERRED XXXX ACCEPTABLE IIII

Chapter 7

ENGINEERING DATA

vsma

QUALITY / INTEGRITY

ENGINEERING DATA

SECTION 1 - BEARING LIFE

Bearing manufacturers have long known that vibrating screen applications are among the most severe bearing environments encountered in machinery construction. The bearings used on vibrating screens are exposed to all of the adversities which make their job difficult. These adversities include:

1. Heavy impact loads.
2. High accelerations.
3. High speeds.
4. Wide temperature ranges.
5. Contamination hazards.
6. Misalignment.
7. Inaccessability.

Design and material improvements developed from actual field experience, combined with modern manufacturing equipment and techniques, have produced bearings that withstand these severe conditions.

There are two types of bearings used in vibrating screens, cylindrical and spherical roller bearings. The cylindrical roller bearing has a higher radial load carrying capacity. It also is separable, that is the outer race and rollers can be separated from the inner race or vice versa. This feature simplifies mounting and dismounting. The cylindrical roller bearing is more sensitive to misalignment than the spherical roller bearing.

The spherical roller bearing is the most widely used bearing for vibrating screens. Bearing manufacturers have, therefore, spent the most effort in refining this bearing. Consequently, they have developed a bearing that provides reliability and long life for extremely difficult vibrating screen applications.

They are continuing their development and now offer races made of vacuum–degassed or vacuum remelted steel. Under ideal conditions, bearings made with this steel have five times the fatigue life of standard screen bearings. This may or may not be true under actual operating conditions because most bearings on screens fail primarily because of contamination rather than fatigue.

Bearing manufacturers express the life of a bearing in the number of hours the bearing will operate at a given speed and load before any evidence of fatigue develops. Life may vary from one bearing to another but stabilizes into a predictable pattern when considering a large group of the same size and type. The rated life of a group of such bearings is defined as the number of hours at a constant speed and load that 90% of the tested bearings will exceed before the first evidence of fatigue develops. This life is called B-10, L-10 or Minimum Expected Life. Bearing manufacturers have also determined that the average life of a group of bearings is approximately five times the Minimum Expected Life.

The formula for figuring B-10, L-10 or Minimum Expected Life can be expressed as follows:

$$\text{Rated life} = \frac{\left(\frac{C}{P}\right)^{\frac{10}{3}} (16{,}667)}{S}$$

$$P = \frac{WRS^2 f}{35200\ (N)}$$

C = Basic dynamic capacity of bearing (lbs.).
W = Eccentric weight of screen (lbs.).
R = Radius of eccentricity (inches).
S = RPM of screen.
f = Application factor.
N = Number of eccentric bearings in mechanism.

The C, W, R, S and N factors in the above formula are constant for a screen operating with a given stroke and speed.

The f or application factor varies with different screen manufacturers. Most VSMA members use 1.2 for this factor, but there are two that use 1.0. Those who use 1.0 as the application factor, compensate for this by establishing a higher required minimum B-10 or L-10 bearing life for their screens. The range for VSMA members is from 8,000 to over 100,000 hours.

As can be seen from the preceding formula, the three factors that are under the control of the vibrating screen manufacturer are the speed, stroke and weight of the screen. The weight of the screen is, more or less, controlled by the application so that leaves the speed and stroke as the factors that affect the load on the bearings.

Since in the formula the speed is squared, a relatively small increase in speed will greatly affect the B-10 or L-10 life of a screen. Screen operators are, therefore, cautioned to check with the screen manufacturer before changing the speed at which their screen is operated. A relatively small increase of, say, 100 RPM could cut in half the B-10 or L-10 life of a screen.

The screen manufacturer should also be consulted before making changes in the stroke of a screen. Changes in the stroke can also reduce the B-10 or L-10 life.

SECTION 2 - LUBRICATION

Successful operation of a vibrating screen depends on adequate bearing life. The high speeds and high specific loads of the bearing impose special requirements on the lubricants used. Many screen bearings do not reach their potential design life because of severe lubrication problems and abrasive wear.

The primary need for a lubricant is to support the rotating eccentric load while keeping the surfaces of the bearing races and rollers from touching each other. Secondary requirements are to prevent corrosion and flush out or shield against contaminants.

The two types of lubrication of vibrating screen bearings are grease and oil. We will examine each of these separately.

GREASE LUBRICATION

Grease is a manufactured product consisting of an oil plus a thickener and various additives. There are innumerable combinations of these ingredients used to make different greases, however, the more important considerations are the following:

> The base oil should be a good grade of oxidation resistant mineral oil. Various synthetic oils are unnecessary and are more expensive.
>
> Of the many available thickeners, the usual ones used are soaps of calcium, sodium or lithium. Calcium soap greases can be used if they contain anti-corrosive additives. Sodium or lithium soap greases are better for use where moisture condensation may be a problem. Complexing agents are frequently added to the metallic salt thickeners. These will raise the upper operating temperature limit.
>
> Additives are materials introduced in small amounts to a grease to improve one or more of its properties. In general, the additives needed for screen bearings use are anti-corrosive and extreme pressure agents.

Without attempting to get into a highly technical discussion, grease lubrication is used because it is relatively inexpensive and because it forms an easily replaceable shield against contaminants.

The primary function of the grease in supporting the rotating load is directly affected by the temperature at the load carrying surfaces. This temperature is a combination of the ambient temperature plus increases due to operating speed, screen load, and shearing and churning of the grease.

The National Lubricating Grease Institute (NLGI) class number gives a comparison of a grease's ability to support the bearing load. Class 2 is specified for use at ambient temperatures occurring during the summer. At the much lower ambient temperature occurring for outdoor operation in the winter, Class 1 and sometimes Class 0 grease must be used. These greases have the softness or fluidness at very low temperatures which is equivalent to that of Class 2 grease at summer temperatures. When the grease is too stiff there is increased frictional resistance to movement which results in an increased load on the motor. In addition, the grease does not flow to the load-carrying surfaces to supply them with sufficient lubricant.

As a secondary function, in some oil lube mechanisms, grease is used to fill the space in the labyrinth seal to help seal against the entry of contaminants. In this application there is no load-carrying requirement. The grease recommended for use in labyrinth seals is heavier NLGI Class 3 grease with calcium soap thickener with anti-corrosive agents. If Class 3 grease is unavailable, Class 2 grease is generally acceptable. The difference in sealing ability is usually slight.

Vibrating screen bearings should be lubricated frequently with relatively small amounts of grease. Screens operating in extremely dusty and hot atmospheres will require more frequent greasing than those used in wet screening applications where dust contamination and overheating are not factors.

Grease addition can be accomplished in either of two ways, manual or automatic. The most common is manual greasing.

When machines are greased manually, care must be taken to be sure all points are greased, and inaccessible ones are not missed.

Also, the proper amount must be added each time to each fitting. It does no good to under grease one time and over grease the next time. The lubricant quantity has only to be inadequate during one portion of its life to permanently damage the bearing. Additionally, the grease fittings must be clean and free from dust, dirt, sand, etc., to avoid introducing contaminants.

An automatic grease system will insure adequate grease additions at fixed intervals to all bearings and seals. Care must be taken to inspect the flexible connections between the screen and the stationary parts of the system to insure breaks and leaks do not occur.

OIL LUBRICATION

The primary advantage of oil lubrication is the ability to operate at higher speeds and temperatures.

Viscosity is one of the key considerations in selecting the proper oil. Bearing manufacturers have generally recommended a viscosity of 100 to 105 SSU minimum at the bearing operating temperature. This temperature cannot be measured in practice, therefore, as a practical guide, viscosity ranges are given on the basis of a temperature of 70° to 90° F. above the ambient temperature, or approximately 30°F. above the bearing housing temperature and/or the oil temperature.

A number of additives or combinations of additives have been developed to modify various properties of the oil. Among these are viscosity index improvers, pour point depressants, wear preventatives, anti-foaming, anti-oxidants and extreme pressure agents. Generally all of these additives are helpful and are used in the high grade lubricants.

A pour point depressant will keep an oil from solidifying down to a temperature that may be 50° F. lower than its usual pour point value.

Anti-foaming agents can reduce the formation of foam and/or help the air to escape from the oil if it does become entrained. In a mechanism the oil is splashed about and air may be entrained easily. Foam does not flow easily so oil flow is restricted and the bearing surfaces may receive insufficient oil.

Wear preventative agents are divided into several groups. Fatty oils, organic compounds and phosphate esters act to reduce the coefficient of friction between surfaces and are called medium-duty anti-wear agents. Extreme pressure additives are used where the spot pressure may be expected to rise above 100,000 PSI. These additives, which now are compounds of sulfur and phosphorus and, sometimes, chlorine instead of lead, act to prevent metal to metal contact by forming antiweld lubricating films by a reaction between the extreme pressure agent and the metal surface. These films take effect when the normal oil film is broken by chemically forming a new film to separate the metal surfaces.

Viscosity index shows the degree of change in viscosity or fluidity of the oil as its temperature changes. A high viscosity index shows less change and is, therefore, more desirable. Viscosity index improvers thus make an oil usable over a wider temperature range.

All of these additives, in general terms, are helpful and desirable but there can be drawbacks. Occasionally an oil with pour point depressant may revert to a higher temperature pour point. All mechanisms should be regularly checked for proper amount of oil. At the same time the oil should be examined to be sure that it has not deteriorated. Deterioration or degradation usually occurs through oxidation of the oil. Deterioration is indicated by changes in fluidity, color and/or smell. Extreme pressure agents are chemically active and may contribute to the deterioration of the oil. Corrosive wear will occur from deteriorated oil.

The most common method of oil lubrication is splash lubrication. It is a convenient way if there are gears involved such as on a horizontal screen.

Another type of oil lubrication is the circulating oil system. Here oil is pumped through the bearings and filtered. Circulating oil is generally used to remove heat and to filter out abrasive particles, rather than merely lubricate the bearings. The screen bearing load zone temperature may be 20-25° F. above the outlet temperature. Oil circulating systems lend themselves to the addition of oil cooling devices (air, water or refrigerants) and safeguards such as flow indicators, oil level indicators, etc.

A third type of lubrication is the drip method where measured amounts of oil are introduced to the bearings at prescribed intervals.

A fourth type is oil mist where atomized oil is introduced to the bearing under pressure. This approach eliminates entry of contaminants and promotes cooling.

SEALS

Grease lubricated mechanisms are generally only protected by a labyrinth seal. This seal can be independently lubricated or can be lubricated by spent grease from the bearing. It is important the seal be kept full of grease to keep out contaminants.

Oil lubricated mechanisms generally incorporate a combination of seals. A labyrinth grease seal can be used to keep out contaminants and a lip type oil seal to retain the oil. Another approach is the use of flinger rings instead of labyrinth grease seals.

It is extremely important to maintain the oil seal as even a small leak will eventually drain the oil and cause bearing failure. The seals are the first thing to check at the sign of an oil leak. The bearing lubricant reservoir should be vented to atmosphere to prevent seal failure.

Your screen manufacturer, along with the bearing and lubrication manufacturers have spent considerable effort developing the proper components and lubricants for the extreme duty of vibrating screens. These lubricants and the recommended schedules are outlined in the screen manufacturers' instruction books.

SECTION 3 - TYPES OF DRIVES

There is a wide variety of power sources for driving vibrating equipment. The most popular methods used for vibrating screens are electric motors, hydraulic motors and combustion engines.

The electric motor is the most commonly used vibrating screen power source. The reasons are that the electric motor is easy to install and to maintain, and is commercially available in most locations. It is also the most dependable and cost efficient.

The motor can be either AC or DC, depending on the application. AC is normally used for constant speed operation. When variable speed operation is desired, AC motors will normally be used for 10 horsepower and below while DC motors will frequently be used for above 10 horsepower. The reason for this difference is primarily the present initial higher cost of the AC motor control.

The AC motor is typically an induction motor with synchronous speed of either 1800 RPM or 1200 RPM. Depending upon the application, the motor is generally of the totally enclosed, fan cooled, ball bearing type. Open drip proof motors are occasionally used.

When hydraulic power is used on other related equipment, a hydraulic motor might be considered instead of an electric motor. One advantage of the hydraulic motor is its variable speed capability.

Combustion engines are available in both gasoline and diesel types. They are often used in remote locations where electric power is not readily available, and on portable screening plants where a completely self-contained plant is desired or required. Often under these circumstances, the engine is used to power either an electric generator or a hydraulic pump, and the screen is driven by either an electric or hydraulic motor. The primary reason for this latter approach is that it is difficult to locate the engine close to the screen. The smaller motor can also be mounted either on a pivoted motor base or on the screen itself, resulting in a less complicated drive.

After selecting the power source, the next consideration is the method of transferring the drive force to the vibrating screen mechanism. The most common drive consists of V-belts and sheaves. Other types of drives include flexible couplings, timing belts, flexible shaft, gear reducer, and a jack shaft arrangement.

The V-belts and sheaves method is the most economical means of operating the screen at a speed different from that of the power source. It is easy to maintain and, if necessary, to change.

Some screen manufacturers counterweight the ends of the motor shaft and use the motor as the vibrator eliminating the use of separate drives.

Flexible couplings are the least expensive drive but do not permit speed change. A flexible shaft may be used in the same manner but, likewise, does not permit speed change.

Timing belts are normally used only where phasing of the exciter shafts is desired.

Gear reducers permit operating the screen at a speed different from the power source but are expensive, take up more space than a V-belt drive and still require an attachment to the exciter shaft. For these reasons they are infrequently used.

A jack shaft arrangement permits either operating the screen at a speed different from the power source, or of decreasing or eliminating transfer of vibration from the screen to the power source. The jack shaft must be connected through a drive to both the screen and the power source. This is normally accomplished by a V-belt drive or a flexible connection/V-belt drive combination.

The method of mounting the power source is another consideration. When a motor is used as the power source, it can be mounted on the screen with a sliding motor base for belt take-up, or separate from the screen with provision for belt tensioning.

On the single shaft four-bearing screen, the motor can be mounted on the stationary base (main frame) of the screen in which case a sliding motor base is used. Motors are frequently mounted directly on horizontal screens with a sliding type base. When mounted external to the horizontal screen, the motor is normally mounted on a pivoted base. When the stroke is small or the V-belt drive is perpendicular to the screen action, the motor may be mounted on a sliding base. On two-bearing screens, motors are mounted separate from the screen, generally on a pivoted base. A slide rail base may be used if the stroke is 5/16" or less.

Location of the motor is important to minimize loading the motor shaft and the V-belt drive. The angle of the drive for horizontal screens should preferably be perpendicular to the line of action of the screen. On a four-bearing inclined screen, the motor may be located anywhere around the 360° circumference. On a two-bearing screen, the motor is generally located below the shaft center line at an angle of 15-45°.

When either flexible couplings or flexible shafts are used, the motor shaft must be in line with the exciter shaft.

SECTION 4 - ISOLATING VIBRATION PRODUCED BY VIBRATING SCREENS

All vibrating screens have a tendency to transmit some of the vibration they produce into their supporting structures. Some types transmit a great deal more than others. This will be discussed at length later in the chapter.

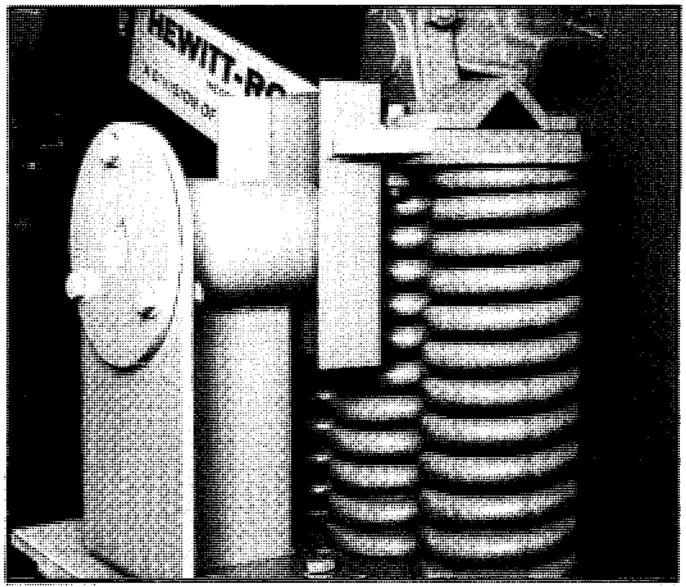
It should be noted that any vibration transmitted from the screen into the supporting structures (defined as Dynamic Loading) creates potential problems, such as (1) fatigue in building structural members, (2) innacurate scale readings, (3) electrical shorts in starters, wiring, etc. All screen manufacturers equip their units with an isolation system utilizing some type of elastic component with the exception of four-bearing screens as indicated below. Some go so far as to produce screens that can be so finely balanced that there is no perceptible escaping vibration. However, this ideal balancing system is delicate and easily upset by fluctuations in screen loadings, changes in screen decking, etc. It should be noted that as a GENERAL RULE, four-bearing positive stroke screens, when properly balanced, do not need a supplementary isolating system. Because this ideal cannot always be realized, units of this type may come equipped with a supplementary system of springs or elastic elements to minimize transmitting vibration. Conversely, some screens, which produce all their motion from rotating unbalanced weights, can never have their motion totally isolated although somewhere between 90% and 98% can usually be isolated by the use of:

1. Compression Type Coil Springs
2. Leaf or Formed Flat Springs
3. Air Bags, sometimes called Air Rides
4. Rubber-in-Shear
5. Rubber-in-Compression
6. Beehive Type Tension Springs

An example of each of the six types is shown in Photos 1 through 6, respectively.

This subject of vibration isolation, or lack of it, is of serious concern, or should be, to the designer of the screening station. Therefore, the selected screen manufacturer should be consulted as to what static and dynamic loads can be expected at each spring cluster location, usually at each of the four corners of the screen. The static load at each corner is of interest only so that the structure is adequate for supporting the dead load of the screen when it is not vibrating. To this static load, the structural designer must add the reversal or dynamic loads produced as the screen moves up and down on its springs. This dynamic load is usually stated as plus or minus a given number of pounds, depending on the spring rate of the isolating device or medium.

Methods for calculating the loads that the screen will impose on the structure and procedures for designing the structures are given in Section 11 of this chapter.



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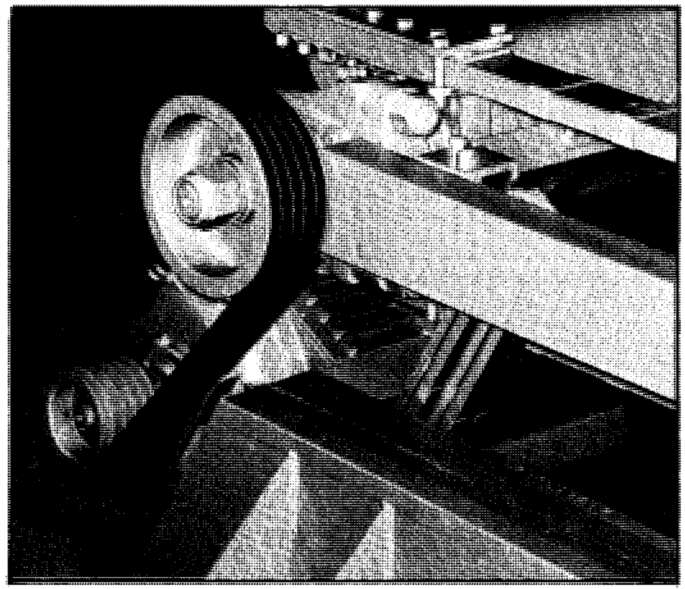

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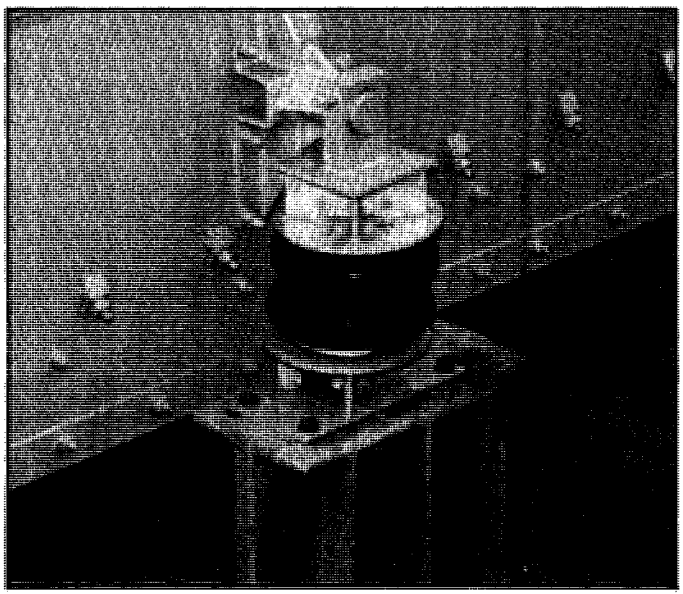

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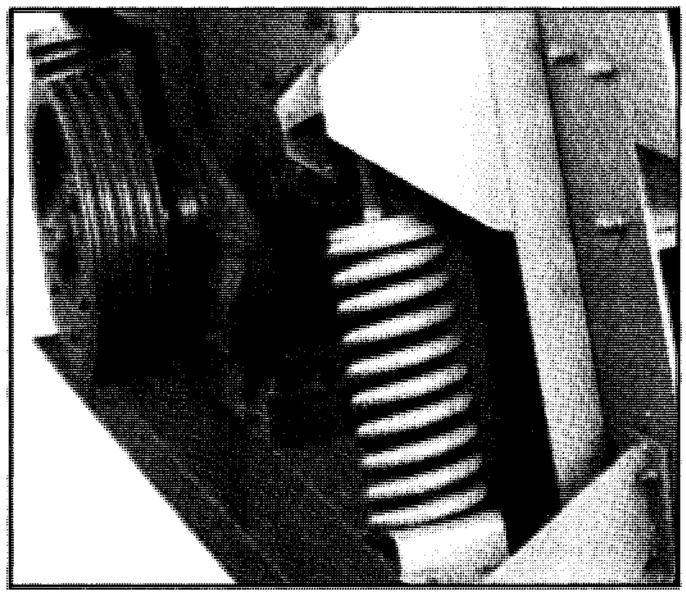

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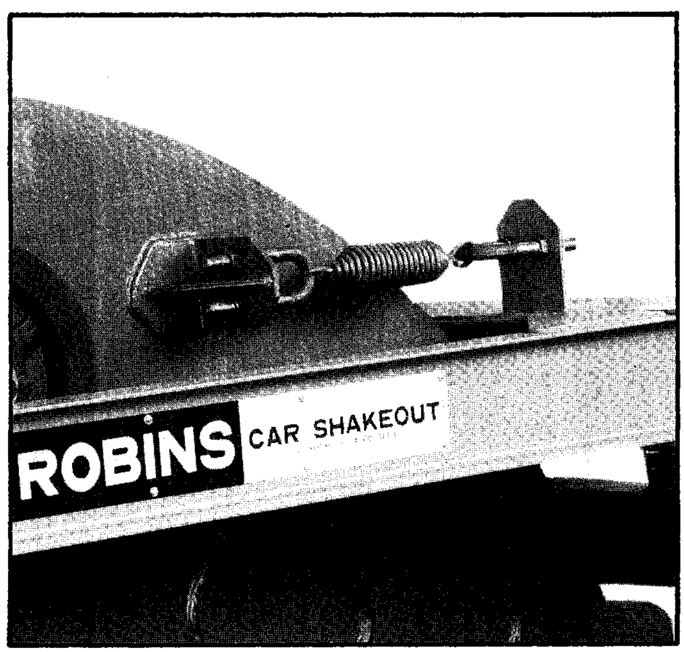

6

SECTION 5 - SCREEN BALANCE CONSIDERATIONS

DEFINITION OF BALANCE

Screen balance is a subject frequently misunderstood. Balance, as related to vibrating screens, is the equating of the machine moment and the balance moment. This balancing can only be accomplished on four-bearing, single shaft screens.

All vibrating screens consist of a body to which are attached screen decks and one or more shafts with unbalanced weight. This unbalanced weight produces the exciting force when it revolves resulting in screen vibration.

On four-bearing screens, the unbalanced weight is a counter weight or balance weight which offsets the machine imbalance. Vibration is accomplished (multiple shaft) through a machined shaft offset. On two-bearing and horizontal multiple shaft screens, vibration is produced by unbalanced weight on a rotating shaft, therefore, these types of screens work on an unbalanced principle.

FOUR-BEARING SCREENS

The four-bearing screen is a positive displacement screen. The eccentric shaft serves as a crank arm. The balance weight is incorporated in or attached to this eccentric shaft. The offset crank shaft design produces vibration when it rotates. The balancing moment (attached to the shaft) is equivalent to the eccentric moment of the body of the screen and is 180° opposed to it resulting in little, if any, vibration transfer to the screen supporting frame. Balance is achieved by adjusting the balancing moment to assure that it equals that of the screen.

TWO-BEARING AND HORIZONTAL SCREENS

The rotating unbalanced weight produces the exciting force. The screen reacts to this force by vibrating at the frequency of the rotating unbalanced weight with the vibration amplitude or stroke seeking a point of equilibrium. If the stroke is incorrect, unbalance weight must be added to increase the stroke or conversely taken away to decrease the stroke. Support springs are used to isolate the supporting structure from the screen vibration.

METHOD OF ACHIEVING BALANCE ON FOUR-BEARING SINGLE SHAFT SCREENS

As previously described, the shaft balance weight is designed to equal the screen weight times the desired eccentricity (1/2 stroke).

This design can be achieved in numerous ways. Refer to (Fig. 5.1) ·

(1) The total balance weight is machined integral with the shaft.
(2) The shaft is symmetrical, either round or square, and balance weights are bolted along its length.
(3) Flywheels or segments are attached to each end of the shaft and balance weights added.
(4) Any combination of two or three of the above.

CONFIGURATIONS OF ECCENTRIC SHAFTS WITH BALANCE WEIGHTS FOR FOUR BEARING SINGLE SHAFT SCREENS

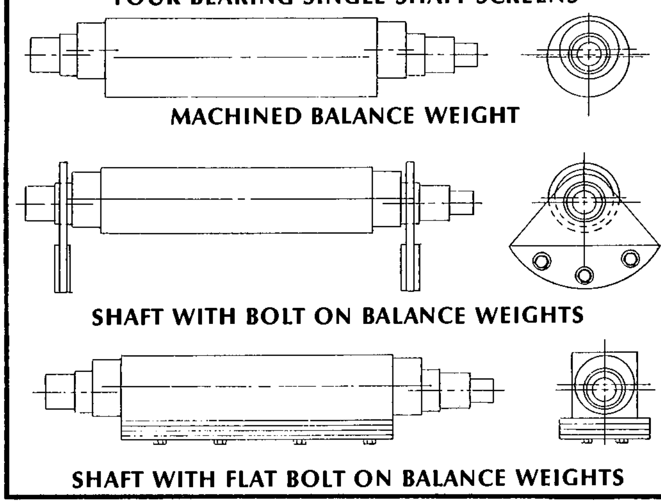

Fig. 5.1

SECTION 6 - DETERMINATION OF CRITICAL FREQUENCY

Critical frequency is the natural frequency of an object. When applied to screening, critical frequency evidences itself by one or more of the screen components vibrating at different stroke and frequency from the screen. In other words, the vibration of one or more of the components is not in unison with the screen. Another type of critical frequency experienced with screens is that of the spring mass system. Critical frequency can be both detrimental to screen performance and reduce the expected life of the screen components and in the case of spring/mass critical frequency cause excessive start/stop bounce.

Determination of critical frequency can be achieved either empirically or theoretically. Empirical determination is the easier and more commonly used approach.

EMPIRICAL DETERMINATION

Empirical analysis is normally conducted by the screen manufacturer during testing following completion of screen assembly and prior to shipment. Visual observation by trained personnel will detect most instances of critical frequency. Evidence is erratic vibration of a particular area or component of the screen. The most common areas which exhibit these problems are the side plates and the deck cross members.

Most manufacturers attach a stroke card to the four corners of the side plates (feed end and discharge end of both side plates) and record the stroke configuration, angle and amplitude at each corner. The strokes at each corner are then compared. Differences indicate the possibility of critical frequency problems and corrective action should be taken. The stroke cards are often retained on file in the event problems subsequently develop in the field.

Similar empirical analysis can be conducted in the field. Normally it is only required when the operating speed is changed or items added to or removed from the screen (eg. addition of liners, side extensions, or discharge lips and deletion of stiffeners or braces). These changes alter the critical frequencies of the specific components involved.

THEORETICAL DETERMINATION

Prior to the current widespread usage of the computer in equipment design, theoretical determination of critical frequency was not possible because of the extensive time required. Use of the computer has made theoretical frequency determination possible, though impractical because of the complexity of the screens, variations in the fabrication techniques, and computer programs required.

In computer analysis, the normal approach is to use finite element analysis. This approach consists of dividing each component into extremely small (finite) sections (elements) and analyzing the stresses acting upon each of these finite elements. The computer program must be validated by measuring vibration and deflection at various points and comparing the results with the theoretical indications. Because of the wide variety of types and sizes of screens and the frequency of minor design changes, computer analysis is seldom used.

CORRECTIVE ACTION

When critical frequency is encountered, there are several approaches to correcting the problem including changing operating speeds, adding stiffeners, adding weight, reducing stiffness and reducing weight.

Changing operating speed is the most common and easiest approach and usually achieves the desired result. Changing speed often takes the screen away from the critical frequency of the component and hence eliminates the erratic motion of the component. Caution must be exercised to assure that performance is not adversely affected. When speed increases are made, the new speed must not exceed that recommended by the screen manufacturer for minimum bearing life and maximum "G" loading.

Adding stiffeners increases critical frequency and is the second most frequently used approach for eliminating critical frequency in side plates. Adding weight also increases critical frequency but may result in additional stress in the weight added area.

Deletion of stiffeners and/or weight reduces critical frequency and while possibly eliminating the critical frequency problem, may also weaken the screen to the point where failure occurs.

When a critical frequency problem is suspected,it is best to contact the screen manufacturer for assistance.

SECTION 7- ATTACHMENT OF SCREENING MEDIA

To assure maximum life of screening media, proper attachment is important. The two basic ways of attachment are tensioning over a crowned support frame or bolting to a flat frame.

Tensioning can be done either from the sides of the screen (side tensioning) or from the ends of the screen (end tensioning). In either method a hook is formed on opposite edges of the screening media (Fig. 7.1) The media is then stretched over the support bars of a support frame by tension members and pulled so it is not only taut but also fits snugly against the support bars.

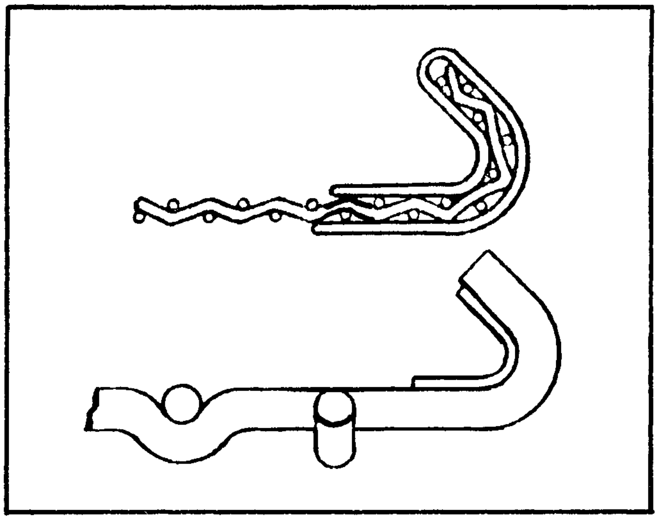

Fig. 7.1

Pressure to pull the screening media taut is supplied by the tension bolt. This bolt can be furnished with or without a spring. Springs may be used with bolts for smaller wire diameters (normally .120" or less) to maintain tension on the screen cloth as the wires stretch. Springs are also useful for hot applications.

The tension bolt can also be a wedge bolt. In this instance, the bolt is slotted and the tension on the screen media is supplied by a wedge in the slot. The advantage of this type of bolt is that it is easy to loosen and can be tightened by a hammer while the screen is operating. Illustrations of tension bolts with springs and wedge bolts are shown in (Fig.7.2) and (Fig. 7.3).

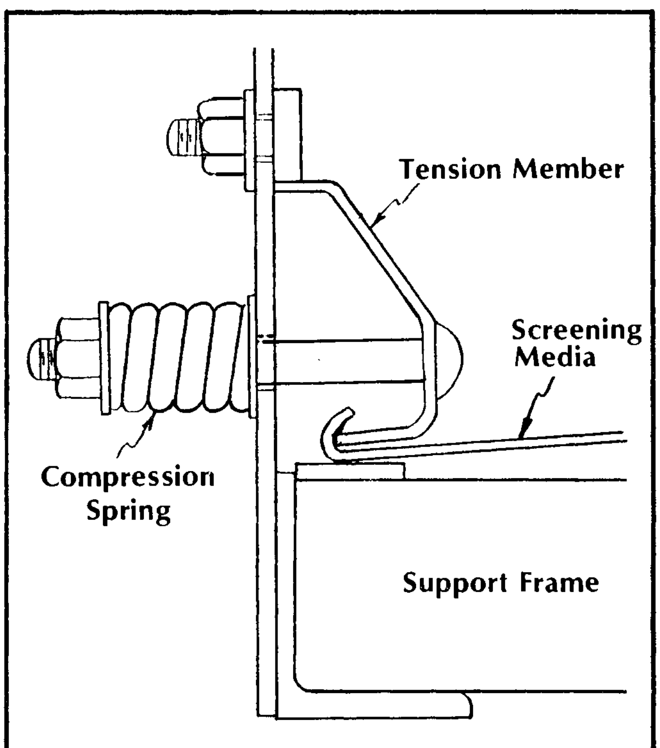

Fig. 7.2

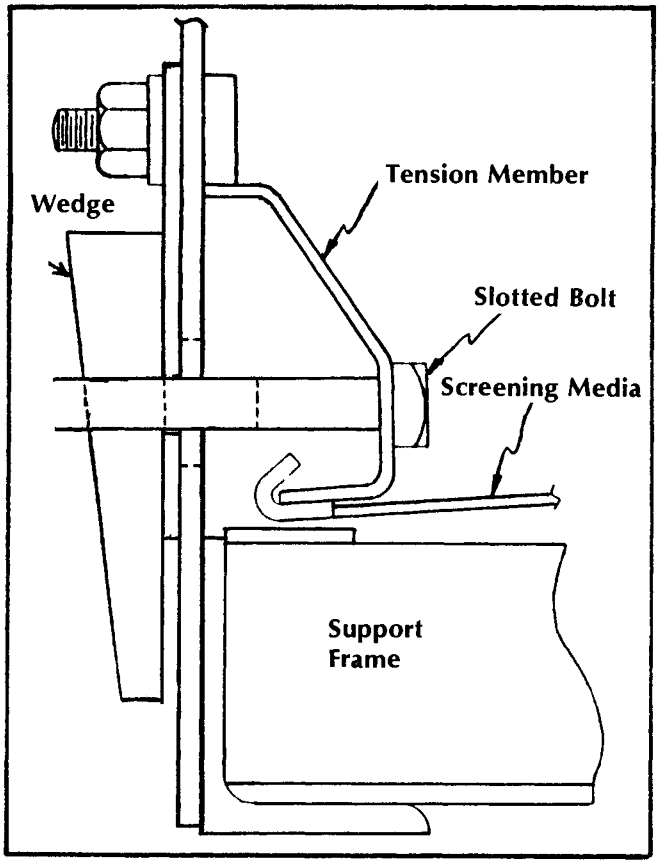

Fig. 7.3

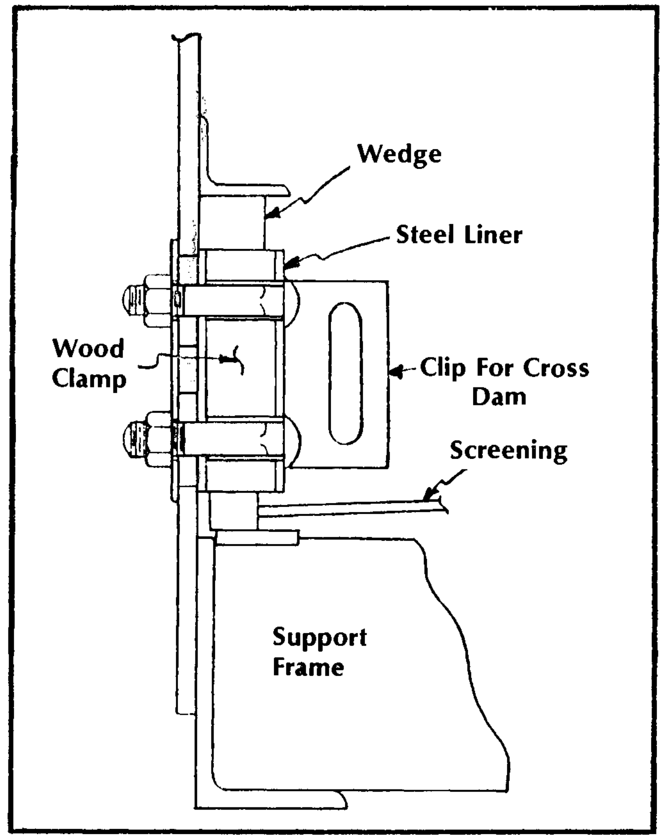

Fig. 7.5

In some instances, the screening media is so heavy or rigid, it cannot be tensioned but stillneeds to be installed on a crowned support frame. In these cases a tension plate (Fig.7.4) or wood clamp bars with wedges (Fig.7.5) are used to clamp the screening media in place. Some screening media such as cast and perforated plate decks are so thick that they cannot be bent over a crowned support frame. These heavy screen surfaces are either (1) bolted directly to a flat support frame with counter-sunk bolts or (2) held in place with clamp plates (Fig. 7.6) These types of hold-downs are used for grizzly bars, profile rod decks, louvered plate decks and semi-rigid polymer decks.

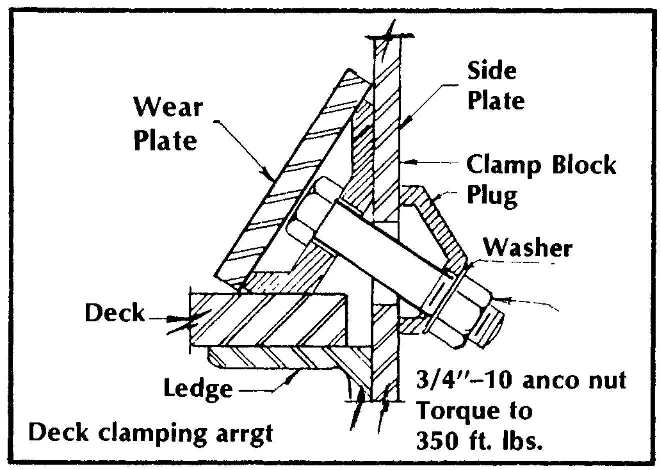

Fig. 7.6

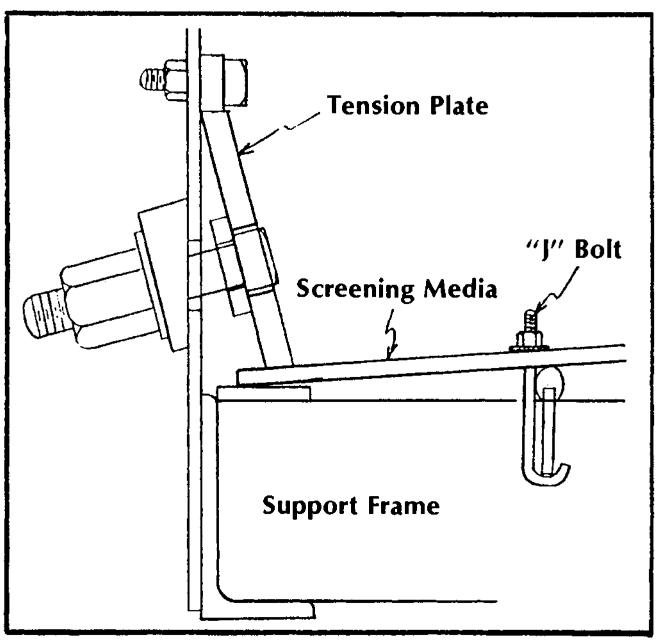

Fig. 7.4

Regardless of how the screening media is attached, the most important consideration should be to keep it tight against the support. Any movement between the screening media and its support will lead to wear and fatigue, shortening the life of the media and/or the deck support frame.

SECTION 8 - TEMPERATURE CONSIDERATIONS (ENVIRONMENT & MATERIALS)

A. GENERAL COMMENTS

The standard vibrating screen produced by most manufacturers is designed for ambient temperatures ranging from minus 20° F. through 110° F. and for material temperatures through 200° F.

B. **MATERIAL TEMPERATURES**

1. **Deck Considerations**

When material temperatures exceed 200° F. early failure of common rubber buffer strips (provided to cushion the screen cloth) can be expected. When material temperatures between 200° F. and 300° F. are contemplated, special rubber compounds such as those listed below or other heat resistant elastomers should be specified for the buffer strips:

a. Butyl — 115° F. Max.
b. Buna N — 250° F. Max.
c. Nordel — 350°F. Max.
d. Neoprene — 250° F. Max.
e. Silicone — 450°F. Max.
f. Viton — 400° F. Max.

When material temperatures range between 300° F. and 400° F., such as when screening hot asphalt stone, it is generally appropriate to cap the support bars with half rounds of "soft" mild steel such as AISA C-1010. When the temperature of the material screened exceeds 400°F., conventional woven wire screen cloth, supported as above, usually must be replaced by stainless steel or flat decks made from cast steel or special alloy perforated plates. It should be noted that at these higher temperatures it is necessary to use special compensating springs on the cloth tension bolts because of expansion and contraction.

These latter two deck preparations should be so designed that they are largely self-supporting and can be clamped in place rather than side or end tensioned as in the case of woven wire. Conventional deck materials and special clamping methods are usually successful when temperature does not exceed 600° F. When material temperature exceeds 600° F., the deck and deck clamping components must be a special design that allows for expansion without the loss of the clamping effect of the deck components. It follows that the deck clamping members, the deck supporting members and the deck itself should be machined in the clamping areas to permit expansion of the deck as the temperature increases beyond 600° F. A typical clamping arrangement allowing for expansion is shown in (Fig. 8.1).

For materials substantially hotter than 600° F., it is often necessary to select special metals for the deck and its components which have a low coefficient of expansion such as stainless plate, high chrome iron, or stainless castings. Properly designed decks can accommodate material temperatures in the 1700 to 2000° F. range.

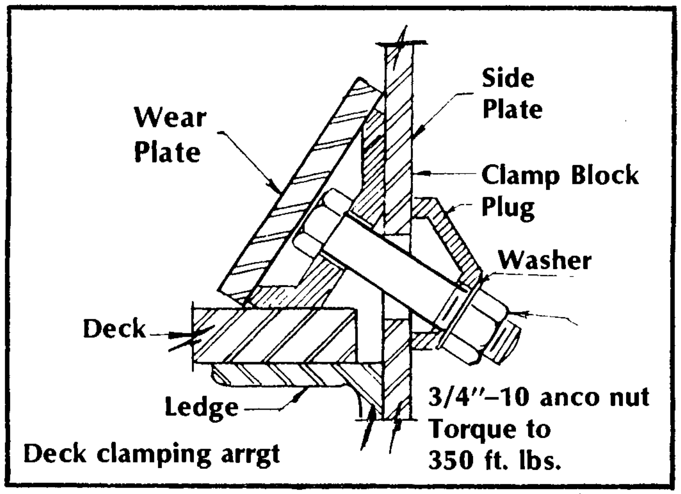

Fig. 8.1

There are many other considerations that must go into the manufacture of screens to be used in these extremely high temperature applications such as live frame and vibrator designs. These are discussed in the paragraphs that follow.

2. **Vibrator Considerations**

When the temperature of material handled ranges from 200° F. to 400° F., and the vibrator is directly exposed to these materials, the machine will withstand these temperatures better if the vibrator is continuously oil lubricated. Greases can also withstand these conditions, but most greases break down and need frequent replenishment which is sometimes difficult unless an automatic greasing system is provided.

At temperatures exceeding 400° F., it is normally mandatory to provide a water jacket on the vibrator through which ambient water (50° to 70° F.) can be circulated. Suprisingly little water is required to carry away the vibrator heat, often in the range of only 5 to 10 gpm. In some designs it may be advisable to use refrigerated water.

3. **Live Frame Considerations**

At temperatures from −30° F. through 400° F., most live frames made from conventional A36 grade steel will survive without special considerations. With the use of special steels and using water-cooled cross members, material with temperatures up to 1700-2000° F. can be handled. Designs for temperature above 600° F. require very careful consideration of each component, especially deck tensioning or clamping devices. Since the side plates are at least partially "insulated" from the material by side deck clamping devices, they usually do not get as hot as those live frame components in the direct flow of the material.

hardness of 321 or 360 Brinnel, in which case all other specification properties are waived.

(c) Yoloy—A Youngstown Sheet and Tube product for use in certain corrosive atmospheres.

(d) R-100—Republic Steel's equivalent of T-1. Minimum is 360 Brinnel.

(e) Jalloy—Jones and Laughlin's product for abrasion resisting applications. Available in a variety of hardnesses.

C. **Low Temperature Steels (Cryogenic Steels)**

These steels are normally selected for applications where low ambient temperatures are anticipated. They provide increased ductility and toughness and are best selected in the low carbon range because their impact value increases when moving from the high carbon into the low carbon ranges. Sometimes castings are specified with 2-1/2% nickel content to increse their ductility at low temperatures.

D. **High Temperature Steels**

These steels provide exceptional creep strength. T-1, or its equivalent, is good to about 600° F. Cast stainless steel alloys provide the ultimate in creep strength.

E. **Abrasion Resistant Steels**

The variety is almost limitless. The common quality apparent in each designation is hardness, usually specified by a "Brinnell" number or a "Rockwell C" designation, Generally speaking, the higher the carbon content the more abrasion resistance provided.

Specifically, Abrasion Resisting Steel is a carbon-manganese-silicon steel which contains hardening elements that provide maximum ductility consistant with hardness, permitting certain machining, forming, and welding operations, following prescribed practice. This steel has from 2 to 10 times the life of ordinary carbon steels and is suited for applications such as liners for side plates, feed boxes, discharge lips and cross members where severe abrasion is encountered. The typical chemical analysis is as follows:

Element	**Per Cent**
Carbon	.35/.50
Manganese	1.40/2.00
Phosphorus	.05 max
Sulphur	.05 max
Silicon	.15/.30

F. **Manganese Steels (Hadfield Formula)**

Most manganese steels, rolled or cast, have a very low resistance to abrasion but are reasonably tough. Placed in an application where the managanese component can be work-hardened by impact, they can develop a hardness difficult to match or surpass.

G. **Cast Hi-Chrome Iron**

This material, almost exclusively used in deck materials where extreme abrasion is encountered, comes in several grades. It can be cast with openings as small as 1/4" slots with thicknesses that range up to 1" and in large 3" or 4" openings with thicknesses up to several inches. Some grades are identified below:

A532-67 Type III—24-28% Chrome, .5 Nickel. 470,000-95,000 Tensile Strength. 550 Minimum Brinnell Hardness in Hardened Condition.

A532-67 Type II—14-18% Chrome, .5 Nickel. 70,000-95,000 Tensile Strength. 600 Minimum Brinnell Hardness in Hardened Conditioned.

H. **Cast ACI-HF (Stainless) Steels**

ACI-HF is employed for deck and deck components where extreme heat and good wear resistance are simultaneously needed. This type material has a very low coefficient of expansion. Some available grades are:

ACI-HF & AZ97-67 (Type 320-B)—19% Chrome, 9% Nickel, 70,000 lbs. Tensile Strength. Maximum use temperature 1600° F. Good corrosion resistance in the range of 1200-1600° F.

ACI-HK—25% Chrome, 20% Nickel. Tensile Strength 65,00 lbs. Maximum use temperature 2100° F..

II. VIBRATING SCREEN PROTECTIVE MATERIALS

Many materials are available to protect major screen components from abrasion and corrosion. The primary ones are:

A. **Structural Component Liners**

To extend their useful life, such portions of a screen as side plates, cross members, deck holddown, etc. may be provided with one or more of the following liner materials:

1. Rubber Liners—These come in various types and grades such as:

(a) Natural Rubber—excellent abrasion resistance when used to cover decks, tension plates, cross members and vibrator tubes.

In some cases it may be necessary to spring load the side clamping devices as previously indicated.

For temperatures below −30° F., it is desireable to use special low'temperature steels.

4. **Supporting Spring Considerations**

Since the springs should never be exposed to the flow of material and are only exposed to the heat conducted through the side plates, no special design would be required in this area. However, when temperatures exceeding 400° F. are experienced in the spring area, special spring steels such as nickel chrome alloys are available and can be provided by your screen manufacturer.

5. **Environmental Considerations**

When the ambient temperature surrounding the total screen unit, including the springs, is above 400° F., every component of the screen needs to be evaluated to determine its suitability to perform under the expected temperature. In these cases it may be necessary to cool the vibrator and live frame members with circulating water. The side plates and other appurtenances such as feed boxes may need to be jacketed with air or water cooling devices such as corrugated vanes through which water or refrigerated air is passed.

SECTION 9 - SPECIAL CONSTRUCTION MATERIALS

INTRODUCTION

Most manufacturers build their vibrating screen live frames from medium tensile strength steels. When vibrating screen components are required to withstand high reversal stresses, (5.0G to 7.0G) special high stength steels may be used. Screens may also be subjected to abrasive, corrosive and/or extreme hot or cold temperature conditions. For these reasons, this chapter will be devoted to discussing some of the specific construction materials employed by the various screen manufacturers, namely:

I. VIBRATING MACHINE CONSTRUCTION MATERIALS

A. Stainless Steels

There are many types of stainless steels. The types most commonly used in the construction of vibrating machines and their specific benefits are:

Type 302—General purpose stainless with good mechanical properties and excellent resistance to atmospheric corrosion and a large number of corrosive media. 17-19% Chrome. 8-10% Nickel.

Type 304—Low carbon variation of T-302. Minimizes carbide precipitation during welding. Like T-302, it offers excellent resistance to a wide range of corrosive and atmospheric exposures. 18-20% Chrome, 8 10% Nickel.

Type 316—Best corrosion resistance of the standard stainless steels. Resists pitting and most chemicals used in paper, textile and photographic industries. High temperature strength. 16-18% Chrome. 10-14% Nickel.

Type 410—Low Cost general purpose heat treatable stainless steel. Used widely where corrosion is not as severe and greater abrasion resistance is desired. 410A, with lower carbon, offers improved weldability but lower hardenablity. 11.5-13.5% Chrome.

B. High Strength Alloy Steels

There are many varieties of high strength steels. Every major steel company has its own family of these steels. Some of the better known and more commonly used are identified by trade name. The names used are not intended to be restrictive or limiting.

(a)

Cor-Ten—These steels are a group of premier, atmospheric corrosion-resistant high-strength low-alloy steels intended principally for applications requirin durability, reduced weight and mair tenance. Cor-Ten Steels are often used in the bare condition to provide either a desired appearance after weathering or to provide savings in maintenance. Cor-Ten A Steel has 5 to 8 times the atmospheric corrosion resistance of structural carbon steel. Paint and protective coatings will last twice as long on Cor-Ten A Steels as on carbon steel.

(b)

T-1 Steel is a high strength steel. Its higher initial cost is offset by weight reduction in structures of all kinds. Its toughness has enabled vibrating equipment to last longer without breakage even in cold weather. It also offers increased impact and abrasion resistance. Its weldability has opened new avenues of design at high working-stress levels. T-1 Constructional Alloy Steel is furnished in the quenched and tempered condition with a minimum yield strength of 100,000 psi and a tensile strength in the range of 115,000 to 135,000 psi. These minimum strength levels apply to T-1 Steel plates from 3/16" to 2-1/2" thick. Plates over 2 1/2" to 6", have a minimum yield strengt of 90,000 psi and a tensile strength from 105,000 to 135,000 psi. For maximum resistance to impact abrasion, T-1 Steel may be ordered to a minimum

(b) Synthetic Rubber—can be compounded to give good results in many high abrasion areas.

(c) Butyl Rubber—particularly adapted to higher than average temperature applications (up to 300° F.)

(d) Hypalon—Although it does not have ideal abrasion resistance, it can withstand temperatures to 800° F.

2. Metal Liners—Many Abrasion Resistance (AR) steels are readily formed and fabricated to prevent wear on screen components such as side plates, tension plates and cross members. Most construction materials discussed at the outset of this chapter lend themselves to use as liners or protective materials.

3. Polyurethane Liners—This material, although similar to rubber, is available in many grades and compounds. Polyurethanes are available in (a) sheets varying from 1/8" to several inches thick, (b) in cast form having about the same thicknesses as the sheets and (c) also as a spray coating up to 1/4" or thicker.

4. Polyethelene Liners—Available in many grades and compounds. They offer good abrasion and stick-resistance.

5. Ceramic Liners—An excellent solution where sliding abrasion is a prime consideration and there is an absence of impact. Ceramics can be purchased in several grades with some approaching the hardness of industrial diamonds. Ceramics can be attached by several methods, the more popular attach to extreme wear areas with special cements. They also attach to backing plates by welding inserts supplied as part of the ceramic block and referred to as "Weld-a-lets."

B. **Coatings**

1. Paints and Enamels—This broad category encompasses all the corrosion and abrasion resistant materials that can be brushed, dipped or baked onto vibrating screen components. These include sophisticated epoxys, rubber-based materials and fired enamels that may be used when extreme hygienic and anti-corrosion conditions must be observed.

SECTION 10 - FASTENERS

Fasteners are devices used to hold screen components together in one complete assembly. Any conventional fastener can be used in screen assemblies provided stress within an acceptable range is maintained. The more common screen fasteners include conventional bolts, Huck bolts and wedges (for tensioning screen cloth).

Conventional bolts are used in all grades with flat washers, lock washers, plain nuts and lock nuts. The more popular types of conventional bolts used are fitted bolts in reamed holes and grade 5 high strength bolts. They must be torqued properly at assembly. Screen vibration frequently causes nuts to loosen or members to nest more closely producing the same effect as a loose bolt and nut. Because of this loosening, the nuts and bolts should be periodically checked and retorqued as required.

Huck bolts are a more positive fastening system and do not require torquing, checking or retightening. When replacement of a screen component is required, the Huck bolts are normally burned off and replaced with new Huck bolts or conventional bolts and nuts. A disadvantage of Huck bolts is the requirement for special tooling for fastening.

Wedges are used only for screen cloth tensioning or fastening of deck coverings as described in Section 7 of this chapter. They represent a quick means of fastening. They are not normally used for fastening other screen components except attaching certain types of dust enclosure panels.

In addition to fasteners, screen components can also be welded together. Welding eliminates the need for checking and retorquing as does Huck bolting. Normally the welded components are not designed for disassembly, but rather consist of complete sub-assemblies which can be replaced in their entirety when they wear out or fail.

SECTION 11 - VIBRATING SCREEN INSTALLATION

INTRODUCTION:

A mechanical Vibrating Screen properly installed, operated and maintained will provide relatively long life and safe, trouble-free operation. As with any heavy, power-driven machine, the vibrating screen must be properly operated to insure personnel safety.

Generally, individuals familiar with vibrating screens are employed for the design of structural supports and chutework attendant to the screen. They ascertain that the structure is adequate and free from vibratory response to the screening motion, that chutes are large enough and correctly sloped and are sufficiently clear of moving screen parts. They make certain that clearances and work platforms are adequate and provide access to all portions of the machine normally inspected and maintained. They should insure that adequate space is provided for handling and renewing wire cloth or other screening media.

CHUTES AND HOPPERS

The vibrating screen will function if it is properly fed. Provision must be made for proper distribution of the material to the deck of the vibrating screen. This can be accomplished either by a vibrating feed hopper supplied as part of the screen by the manufacturer or a stationary feed hopper designed by the plant engineer or purchaser. In any event, care must be taken to assure that the hopper properly distributes the material across the entire width of the vibrating screen.

If the vibrating screen is not equipped with a vibrating feed hopper, under no circumstances should the user attempt to design and attach a feed hopper to the vibrating screen.

Vibrating screens are designed to meet specific operating conditions. Normally these operating conditions are primarily centered around the separation of the material. If it is necessary to collect material, either from the discharge end or beneath the vibrating screen, this should be done with chutes. No chutes, hoppers or additions should be welded onto the vibrating screen without first consulting the manufacturer.

Care should be taken in designing stationary hoppers, feed and discharge spouts to assure that adequate clearance is provided between the non-vibrating and vibrating machinery in accordance with the manufacturer's recommendations. Either the manufacturer or an engineering company should be consulted on the proper clearances and design of these chutes.

SUPPORTING STEEL

Some manufacturers offer formulas to help the user design the supporting steel for the vibrating screens. It is strongly recommended that the user consult an engineering company or the vibrating screen manufacturer to be certain all conditions have been taken into consideration.

SPRAY PIPING

Water sprays and weir boxes are used for wet screening of material. The use of water is known to improve the efficiency of separation up to 30% depending upon the application, and can increase the screen capacity by an equal amount.

It is essential for good operation that proper installation be made of spray pipes or weir boxes.

There are two types of spray pipe installations used with vibrating screens.

1. Vibrating—i.e., attached to and vibrating with the screen

2. Stationary—i.e., mounted from the stationary structure that supports the vibrating screen, and not to the screen itself.

VIBRATING INSTALLATION

Spray pipes are fastened to the screen body by some type of clamp arrangement, such as a "U-bolt". It is important when installing the spray pipes that the customer follow the manufacturer's recommendation to insure that pipes will not loosen during vibration and damage the vibrating screen. Proper size is important. The manufacturer's recommendation must be used to insure that the pipes will be strong enough to withstand vibration.

Installation requires flexible rubber hose between the water header and the spray pipe due to the spray pipe being attached to and vibrating with the screen. Rubber hose should be a minimum length of 18".

STATIONARY INSTALLATION

Spray pipes are fixed to the screen supporting structure and do not vibrate with the screen. In this type of installation, the spray pipes usually attach to the water header and either pass through 5" to 9" diameter holes in the side plates or above the side plates of the screen. Good practice requires that the screen manufacturer's recommended clearances be maintained to insure that there is no interference during starting, stopping and operating the vibrating screen.

When spray pipes are added to an existing installation, the customer should consult with the screen manufacturer. Many field installations of spray pipes have been made, using a cutting torch to make holes in the side plates, causing these side plates to crack and fail. All sharp corners should be ground smooth to eliminate areas of high stress which might cause cracks.

In addition to these two methods of mounting spray pipes, there is the weir box method that can be used to supply water to the deck of the vibrating screen.

A weir box is a deep troughlike container with water running in it. The water is allowed to cascade over the weir outlet onto the bed of screen material. The weir box is used to add a large volume of water in wet screening applications. It is able to use water with a greater amount of solids than can be used with spray pipes.

Installation of weir boxes requires proper clearances between the vibrating screen and the weir box to insure that there is no interference during starting, stopping and operating.

V-BELT DRIVE INSTALLATION

Proper V-belt installation is essential to good belt life.

The screen manufacturer's recommendation should be followed when installing the V-belt drive.

Proper installation of any V-belt drive requires that the drive and the driven sheave be in line, not staggered, to assure that the V-belts are running true in the sheave grooves.

Matched sets of multiple V-belts should be used to prevent excessive slippage during starting and stopping but not overtensioned causing the vibrating screen to be pulled out of alignment on the spring supports or decreasing both motor and screen bearing life. Some manufacturers use auxiliary tension spring assemblies pulling in the opposite direction of the V-belt drive (especially on cable suspended screens) to prevent pulling the screen out of alignment on the spring support. Some manufacturers furnish screens with banded belts eliminating the need for keeping the individual belts matched.

Proper drive sheave position with respect to the driven sheave is essential to good performance.

Vibrating screens should be operated with the V-belt drive properly guarded to protect the operator from injury.

V-belt drives for free-floating screens, positive drive screens and horizontal screens will be discussed next.

INCLINED FREE-FLOATING VIBRATING SCREENS

The drive on 2-bearing screens without pivoted motor bases should be placed on the horizontal centerline of the driven sheave, either at the feed or discharge end of the screen, so load variations on the screen will not tighten or loosen the V-belt.

When no pivoted motor base is used, the manufacturer should have the driven sheave designed so that the sheave is running true, that is, operating on the center of gyration.

This type of drive on free-floating 2-bearing inclined screens is used when the stroke is 1/4" or less, with no surge loading on the screen.

Pivoted motor bases are a fulcrum motor support allowing the weight of the motor to tension the V-belt; allowing the belt tension to be maintained during surge loading, and preventing belts from becoming overtensioned during screen starting and stopping. Spring loaded motor bases are also available to accomplish the same belt tensioning.

Proper tensioning of the pivoted spring-loaded motor bases is essential to its operation. The screen supplier's installation instructions should be followed; otherwise, the spring or pivoted motor base may not perform properly.

INCLINED POSITIVE SCREENS

The drive of an inclined 4-bearing screen may either be mounted separately or attached to the subbase frame when received from the factory. Follow the screen supplier's installation procedures for proper drive alignment.

HORIZONTAL VIBRATING SCREENS

Horizontal screen drive should be located at an angle perpendicular to the line of screen action when the drive motor is stationary and not vibrating on the screen. This allows the belts to pivot on the neutral axis of the line of action.

When the motor is attached to and vibrating with the screen, the manufacturer has already properly positioned the motor on the screen. Follow their recommendations for proper maintenance.

Regardless of the type of drive used on your particular vibrating screen, proper alignment and tension with periodic inspection, per the screen manufacturer's recommendation, will insure maximum drive performance.

GUARDS

Many manufacturers supply the vibrating screen with guarded counterweights and/or rotating weight wheels. These drive components must be guarded to safeguard the operating personnel. Moving weights present hazards to operating personnel if the manufacturer does not provide guards.

Most manufacturers offer V-belt guards either as a standard item with the vibrating screen or as an accessory item. If these guards are supplied with the vibrating screen, they must be installed prior to operating the machine. If for some reason you have elected not to purchase guards from the manufacturer, then GUARDS MUST BE INSTALLED PRIOR TO OPERATING THE MACHINERY. OSHA or MSHA regulations, whichever apply to your industry, should be consulted for proper guard design.

Chapter 8

SAFETY

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SAFETY DEVICES FOR VIBRATING SCREENS

FORWARD:

FIRST: Carefully read the manufacturer's operating manual and review General Dimension Drawing.

SECOND: Review your Plant Engineer's Installation Drawings.

THIRD: Select the correct hoisting and rigging equipment for placing the screen in operating position.

A. MACHINERY PROTECTION

1. After placing screen in operating position be sure to level all mounting elements such as corner or overhead coil spring pads or structural base frame. Allow as much room for inclination angle adjustment as practical.

2. Check motor nameplate for proper voltage and phase prior to wiring motor. Be sure motor is grounded. After driving motor is wired, check motor rotation without V-belts, making sure motor will turn vibrator in manufacturer's recommended direction.

3. Check alignment of drive and driven sheaves with a straight edge before determining final position of motor and screen.

4. If screen is cable suspended , install and adjust inertia weights to minimize cable whip. Also, install tag lines to be certain tension produced by the driving components does not pull screen severely out of alignment. In addition, install independent safety cables to support screen in case one of the primary support cables fails.

5. Check that the slope is correct, as recommended by the manufacturer, and that there is sufficient room for installing and removing screen decks, wire cloth, perforated plate, etc., and performing necessary maintenance.

6. At this point, determine that there is adequate clearance between vibrating screen and stationary structures such as feed chute, discharge shutes and collecting hopper(s), as recommended by manufacturer. **DO NOT** alter the vibrating screen in any way without consulting manufacturer.

7. Check all bolted connections for tightness and tighten as required to manufacturer's specified torque.

8. Drain any preservative oil or grease from unit, refill and make sure that bearings are properly lubricated in accordance with the vibrating screen manufacturer's recommended lubricant.

9. Check actual screen speed and direction of rotation and compare to manufacturer's recommendations.

10. Operate screen without material and check for structural interference and loose parts.

11. Check that there is no abnormal vibration is screen supports. If structures are vibrating, request plant design engineer to add bracing or reinforcing required.

12. Make sure that the angles in hoppers and chutes are sufficient for material to flow freely and not back up or contact the screen.

13. After a two to four hour operating period, retension screen deck and check bearing temperatures for overheating.

14. Avoid welding on your screen framework. When it can't be avoided, be sure to properly ground the live frame to prevent arcing thru the bearings. Be certain that conveyor belt, oily rags, wood, rubber and any other combustable materials adjacent to cutting or welding tools are removed or covered to prevent fires.

B. PERSONNEL PROTECTION

1. Provide "Remote Start Warning" device and "Emergency Stop" control at the screen. Provide safety lockout at the Control panel.

2. Provide an adequate electrical equipment ground. Screens mounted on rubber isolators will require a static electricity ground.

3. Be sure that all rotating parts such as sheaves, flywheels, countershafts, couplings and V-belts are guarded and that guards are in place and secure.

4. Do not perform maintenance or lubricate a screen that is operating.

5. Check for material bouncing out of screen. If necessary provide spill guards independent of screen.

6. Keep the screen area clean, spills shoveled away; remove spilled lubricants, discarded screening surfaces, bolts, nuts and roller bearings.

Chapter 9

PROBLEMS and SOLUTIONS

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Operating Problems and Solutions

General Information

This chapter outlines some of the most common problems that the user may encounter during the operation of a vibrating screen.

— Note any unusual noises, operation and trouble. Refer to the following chart to aid in determining probable cause.

— Follow a procedure which insures that the most obvious causes are checked first and the easiest solution is applied to save time and trouble. Do not disassemble the vibrator assembly or components until all other possible causes and remedies for a specific problem have been examined.

— It is recommended that only one step at a time be taken in correcting a problem instead of implementing changes simultaneously. This practice minimizes unnecessary corrective action.

— After a mechanical failure has been corrected, locate and correct the cause of the trouble so the failure will not recur.

— *Caution:* A vibrating screen is a self-destructing piece of equipment but is designed to withstand normal operating stresses. Improper or unapproved installation, use, modifications or additions to the screen body will result in premature fatigue failures.

— Manufacturer should be consulted prior to making any modifications to the vibrating screen to minimize possible damage or premature failure.

Trouble	**Probable Cause**	**Possible Remedy**
Screen will not start	Power failure.	Check power supply.
	Starter inoperative.	Check fuses, breakers, holding coil, heater.
	Motor does not operate.	Refer to motor section.
	Shaft assembly or vibrator assembly frozen or damaged.	With drive belts removed check vibrator mechanism for freedom to rotate; see bearing trouble.
	Material interference with screen body or motor base.	Clear build up from screen body or motor base.
Motor does not operate.	Insufficient line voltage.	Check electrical supply for sufficient line voltage.
	Fuse or circuit breaker blown.	Replace or reset.
	Defective power cable.	Check cable for broken conductors—replace if defective.
Motor hums but does not start.	Defective motor.	Replace defective motor.
	Bearing lubricant too heavy.	Clean bearings and relubricate with proper lubricant.
	Bearing frozen or damaged. Motor too small.	Replace damaged bearing. Install correct size motor.
Motor overheats.	Incorrect bearing lubricant.	Clean bearings and relubricate with proper lubricant.
	Motor wired incorrectly. Motor too small.	Correct wiring—consult MFG. for proper size.
	Bearing failing.	Replace damaged bearing.
	Defective motor.	Replace or rewind defective motor.
	Power circuit wire too small.	Install power circuit with correct wire size.

Manufacturer should be consulted prior to making any modifications to the vibrating screen to minimize possible damage or premature failure.

Trouble	Probable Cause	Possible Remedy
Motor overheats.	Power circuit overloaded.	Install heavier circuit or reduce load on power circuit.
	Trouble with vibrator assembly.	Refer to vibrator sections.
Overheating of Vibrator	Too little lubricant.	Check for leakage, damaged seals; relubricate.
	Too much lubricant.	Remove lubricant to proper level, allow lubricant to purge from system if so designed.
	Improper lubricant. High ambient temperature, hot material, hot environment.	Replace with proper lubricant. Ventilate area, use high temperature lubricant, consult screen manufacturer.
	Bearing failure.	Replace bearing.
	Improper bearing clearance.	Replace bearing, and check for contamination in lubricant.
	Material build-up on bearing housings.	Remove build-up.
	Insufficient clearance on Labyrinth seals.	Check seal clearances.
Vibrator will not rotate.	Motor inoperative.	Refer to motor section.
	Bearing or seal components frozen or damaged.	Replace damaged bearings or seals.
	Lubricant too heavy.	Remove lubricant, relubricate with recommended lubricant.
	Drive belts are loose.	Tighten V-Belts.
	Vibrator assembled incorrectly.	Review assembly procedure.
Lubricant leakage.	Excessive operating temperature.	Use high temperature lubricant. Consult screen manufacturer.
	Excessive lubricant.	Restore lubricant to proper level.
	Drain plugs omitted.	Install drain plugs.
	Damaged or worn seals.	Inspect seals and replace.
Noisy bearing	Bearing failure.	See bearing trouble.
	Loose in the bearing housing.	Replace housing, bolts and properly torque, check bearing, insure that damage to the housing or fastener holes hasn't occurred. Make sure bearing is not turning in the housing.
	Improper bearing clearance.	Consult screen manufacturer.
Bearing failures	Normal fatigue failure.	Replace bearing according to manufacturer's assembly instructions.
	Overloading, excessive stroke or speed combination.	Return screen to original operating mode and replace bearing.
	Overheating from lack of lubricant, excessive lubricant or high ambient temperature, incorrect lubricant.	Restore correct lubricant level; use lubricant recommended for the ambient temperature, replace bearing, use correct lubricant.
	Spalling from dirt or water entering bearing.	Flush housings and lubrication system, replace bearing and replace or clean air breathers, seals.
	Brinnelling from storage in an area where vibration is present, loose bearing housing, or dropping screen or bearings.	Replace bearing and correct cause.
	Improper float or allowance for expansion in vibrator assembly.	Replace bearing; reassemble per the manufacturer's instructions.

Manufacturer should be consulted prior to making any modifications to the vibrating screen to minimize possible damage or premature failure.

Trouble	Probable Cause	Possible Remedy
Bearing failures	Arcing through the bearing during welding with improper ground.	Always ground properly.
Excessive structure vibration.	Support structure too weak.	Add structural support.
	Shipping blocks not removed.	Remove shipping blocks.
	Insufficient clearance between screen and structure or material build-up.	Provide adequate clearance and/or remove build-up material.
	Fatigued suspension parts.	Replace components and check other components for damage.
Excessive screen vibration.	Screen out of balance.	See out-of-balance troubles.
	Damaged suspension.	Replace damaged parts.
	Screen operating speed too fast. Wrong stroke/speed combination.	Return screen to original operating mode; Consult manufacturer.
	Improper or surge feeding.	Control feed of material.
Erratic vibration.	Slipping drive belts, or over tensioned drive belts.	Adjust belts per the manufacturer's recommendation. Replace worn, frayed or stretched belts.
	Voltage drop.	Check power supply.
	Broken suspension parts.	Replace suspension parts.
	Throwing of drive belts.	Check belt alignment, check snubbers or plugging parts. Check belt lengths.
	Loose drive or body bolts.	Replace or properly torque bolts.
	Screen operating near the natural frequency of the support structure.	Install brace on the supports.
	Screen operating at or near critical speed.	Change speed per manufacturer's recommendations.
	Counterweight settings changed and do not match.	Match counterweights.
Excessive Screen cloth breakage.	Incorrect screen tension.	Periodically check screen tension system.
	Corrosive material.	Switch to corrosion resistant cloth.
	Worn tension rails; insufficient to support bolting pressure.	Replace tension rails.
	Loose screen media bolts.	Properly torque or replace.
	Unbalanced feed condition or feed concentrated at one point.	Distribute feed evenly across surface.
	Worn buffer support rubber.	Replace as required.
Insufficient screening.	Screen blinding, or plugging.	See blinding trouble.
	Material feed exceeds design capacity.	Decrease feed rate.
	Screen media open area too little.	Use media with more open area.
	Material travel rate across screen too rapid.	Change feed configuration. Operate screen counterflow and decrease feed rate.
	Material feed analysis different than originally defined for duty.	Adjust openings, feed rate, travel rate, direction of Flow.
	Stroke reduction due to material build-up.	Remove build-up.
Excessive fines in oversize.	Material travel rate too rapid.	Reduce screen angle or operate counterflow.
	Improper distribution of feed material.	Revise feed arrangement.
	Excessive feed.	Reduce feed.
	Unit operating out of balance.	Restore Balance.
	Excessive throw for media opening.	Adjust speed/throw to deck opening.

Manufacturer should be consulted prior to making any modifications to the vibrating screen to minimize possible damage or premature failure.

Trouble	Probable Cause	Possible Remedy
Excessive fines in oversize.	Operating speed below recommended.	Restore proper speed.
	Moisture piggyback of fines.	Dry material prior to screening. Wash material during screening.
	Bearing failing.	Replace bearing.
	Opening too small.	Use larger opening.
	Insufficient open area.	Use media with more open area.
Screen blinding or Plugging.	Inclined screen too flat.	Increase angle of operation.
	Material moisture.	Change cloth size or type. Heat cloth.
	Wrong deck preparation.	Use different screening media.
	Carrot shaped particles plugging openings.	Larger stroke required; consult mfg. Slotted openings, tapered stepped deck openings required.
	Screen operating speed may be slow.	Increase speed at manufacturer recommendations.
	Excessive near size particles in feed.	Adjust crusher openings to reduce near size. Use different opening.
	Shaft rotating in wrong direction.	Reverse shaft rotation.
	Loose screening media.	Periodically check tension or integrity of screen media.
Screen out of balance	Material build-up on screen.	Remove build-up.
	Installation of heavier screen media than originally furnished.	Rebalance screen. Consult mfg.
	Chutes, hoppers added to screen body.	Remove chutework additions.
Material travels diagonally across screen	Drive belts too tight	Adjust drive belts.
	Main bearing failing.	Replace bearing.
	Damaged suspension.	Repair suspension.
	Screen out of level side to side.	Level screen.
	Machine racking or off motion.	See racking trouble.
	Unevenly balanced vibrator weights.	Match vibrator weights.
Machine racking.	Loose body components or bolts.	Retighten all body fasteners.
	Damaged suspension.	Repair suspension.
	Broken or damaged structural members, broken welds.	Replace non-conforming parts.
	Operating at or near critical speed.	Consult manufacturing.
Fatigue failure of screen body.	Field modifications by user, welding, cutting, etc., which concentrate abnormal stresses.	Include design requirements in initial specification. Replace failed components.
	Corrosion and wear.	Replace damaged parts.
	Screen operating out of balance.	Restore balance.
	Operating screen at or near critical speed.	Change speed, Consult MFG. See erratic vibration section.
	Excessive feed rate.	Reduce feed.
	Oversize feed materials.	Reduce maximum size of feed.
	Interference w/structure or material build-up.	Eliminate interference of build-up.
Material travels in wrong direction.	Screen installed too flat.	Consult manufacturer.
	Gear driven units may be incorrectly timed.	Consult manufacturer.
	Unit running in wrong direction.	Reverse motor direction.

Manufacturer should be consulted prior to making any modifications to the vibrating screen to minimize possible damage or premature failure.

Chapter 10

CRUSHER CIRCUITS

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CRUSHER CIRCUITS

In many industries vibrating screens are used in conjunction with various types of crushers. The screens are used with the crushers to remove the material that is less than the crusher setting. This increases the efficiency of the crusher. With some types of crushers it is necessary to remove these fines to make the crusher operate properly.

Screens are also used after the crushers to remove the products made by the crusher or to close circuit the crusher. Closed circuits introduce a factor known as circulating loads. This factor can drastically increase the feed rate to a vibrating screen and must be examined carefully.

Circulating load is a factor in sizing of screens to be used as part of crushing circuits where the product must be 100% minus a given product top size. A problem exists because crushing machines do not reduce all their feed to a size equal to or smaller than the crusher setting. In normal practice, the crusher is set at a smaller setting (opening) than the screen deck opening, to obtain a good balance between net finished product (100% minus product top size) and circulating load.

The amount of crusher throughput that is oversize and must be recrushed is expressed as the % of oversize in the crusher product. It continues to be recirculated through the crusher until it is reduced to a size that will pass the screen opening. This is called "closed circuiting."

With each pass through the crusher an additional amount of oversize will be reduced to undersize. The number of passes for any given batch of material, with no addition of new feed, before 100% reduction is achieved, is infinite. The percent of oversize remaining after each pass through the crusher and over the screen deck diminshes in a geometric progression.

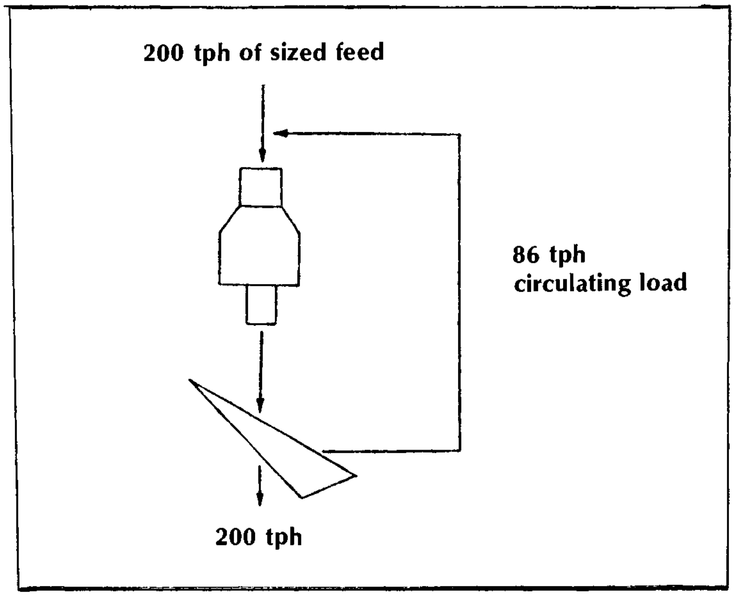
By definition, circulating load = total feed to the crusher minus original crusher feed. It is expressed in % of original feed to the crusher.

The formula for % circulating load is:

$$R = \frac{100}{\frac{e}{r} - 1}$$

Where: R = % circulating load to crusher
e = % screen efficiency
r = % oversize in crusher product

The following example will help to explain circulating load and the effect of screening efficiency. This example assumes 100% screen efficiency, and 30% oversize in the crusher product.



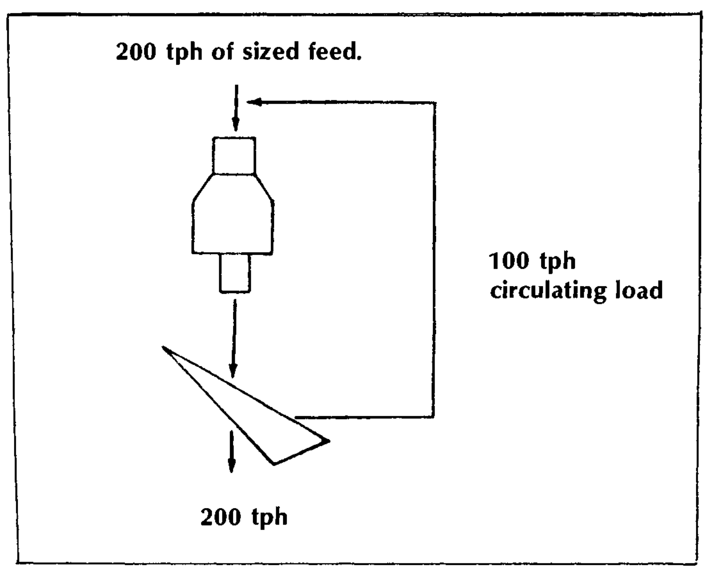
For this example the geometric progression of crusher oversize would be:

Pass thru crusher		TPH
1	200x.30	= 60.00
2	200x.30x.30	= 18.00
3	200x.30x.30x.30	= 5.40
4	200x.30x.30x.30x.30	= 1.62
5	200x.30x.30x.30x.30x.30	= .49
6	200x.30x.30x.30x.30x.30x.30	= .15
	etc.	
		85.66 or 86 tph

By formula: $R = \frac{100}{\frac{e}{r} - 1} = \frac{100}{\frac{100}{30} - 1} = \frac{100}{2.33} = 42.9\%$

Circulating load = new feed to crusher x R
200 x .429 = 85.8 or 86 tph

Look at the same example, with a change of screen efficiency. Assume 90% screen efficiency—other factors the same.



With 90% screen efficiency, the geometric progression of crusher oversize would be:

Pass thru crusher		TPH
1	$200\,(.30\text{x}\,\frac{1}{.90})$	= 66.67
2	$200\,(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})$	= 22.22
3	$200\,(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})$	= .741
4	$200\,(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})$	= 2.47
5	$200\,(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})$	= .82
6	$200\,(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})(.30\text{x}\,\frac{1}{.90})$	= .27
		99.86 or 100 tph

By formula: $R = \frac{100}{\frac{e}{r} - 1} = \frac{100}{\frac{90}{30} - 1} = \frac{100}{2} = 50\%$

Circulating load = 1200 x .50 = 100 tph

To simplify circulating load calculations, Table 1 has been established for various percentages of crusher oversize product and screen efficiency, based on formula

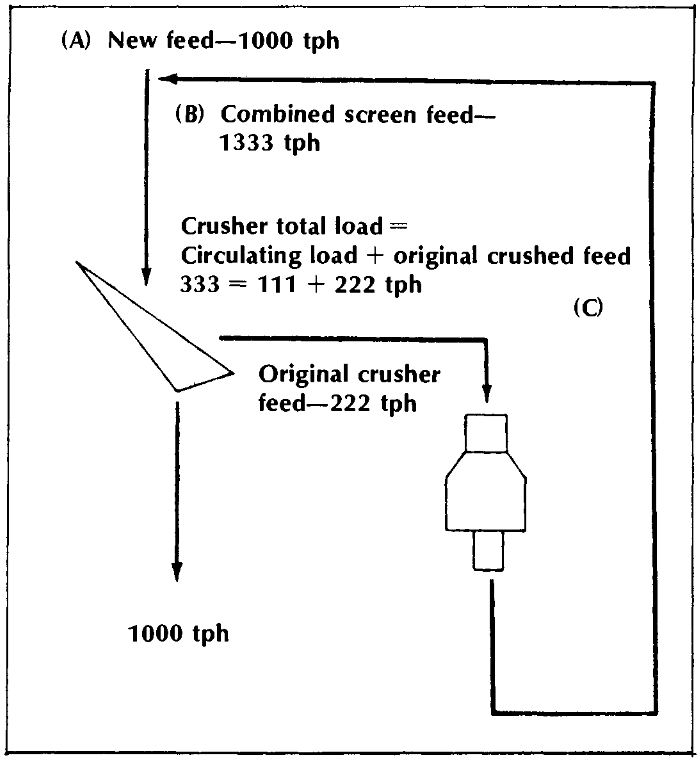
$$R = \frac{100}{\frac{e}{r} - 1}$$

These tables are based on theoretical values and should by no means be used as a basis for direct guarantees as the actual circulating loads will undoubtedly vary somewhat from the theoretical calculations contained herein.

Additional percentages for intermediate oversize percentages may be calculated from the formulae. Do not interpolate from tables as this is not a straight line variation between points.

For simple explanation of screen efficiency, the previous example assumed that the original feed to the crusher was sized. It contained no fines or materials of lesser size than the desired crusher product. To do this in actual practice would mean that feed would have to be screened before going to the crusher, as in the example:

Assumptions:
90% screen efficiency
30% oversize in crusher product
20% oversize in new feed



Original crusher feed = 1000(A) x .290/.90 = 222 tph
Circulating load = original crusher feed x % circulating load (R). (Refer to Table 1 for 30% oversize in crusher product and 90% screen efficiency.)

R = 50.3.

Circulating load = 222 x .503 = 111 tph

Total load to crusher = original feed to crusher plus circulating load
= 222. « 111 = 333 tph(C)

Combined feed to screen
= new feed + crusher total load
= 1000 + 333 = 1333 tph(B)

Table 1—Circulating Loads (R) $= \frac{100}{\frac{e}{r} - 1}$

Percent Undersize in Crusher Product	(r) Percent Oversize in Crusher Product	Screen Efficiency (e) Percent 100	Percent 95	Percent 90	Percent 85	Percent 80	Percent 75	Percent 70
95	5	5.3	5.7	5.9	6.3	6.7	7.1	7.7
90	10	11.2	11.8	12.6	13.3	14.2	15.4	16.8
85	15	17.7	18.8	20.0	21.5	23.1	25.0	27.3
80	20	25.0	26.7	28.6	30.7	33.4	38.3	40.0
75	25	33.4	35.8	38.7	42.0	45.4	50.0	55.5
70	30	42.9	46.3	50.3	54.7	60.0	66.7	74.5
65	35	53.9	58.5	63.8	70.0	77.8	87.7	100.0
60	40	66.7	73.0	80.0	89.0	100.0	114.3	133.5
55	45	81.8	90.5	100.0	112.5	128.5	150.0	181.0
50	50	100.0	111.4	125.0	143.0	166.7	203.0	250.0
45	55	122.2	137.5	158.0	183.5	219.5	276.0	365.0
40	60	150.0	172.0	200.0	240.0	300.0	400.0	600.0
35	65	186.0	216.0	261.0	326.0	425.0	652.0	1290.0
30	70	233.0	280.0	351.0	568.0	700.0	1416.0	.....
27.5	72.5	.....	.....	.....	.....	963.0	.....	.....
25	75	300.0	374.0	498.0	747.0	.....	.....	.....
20	80	400.0	537.0	802.0	.....	.....	.....	.....
15	85	567.0	852.0	.....	.....	.....	.....	....

The following five examples of flow diagrams show possible variations of crushing and screening selections for the products of both coarse and fine aggregate as used in the construction and road building industries. These examples are intended to denote typical equipment arrangements based on current industry practice when processing the raw materials shown. Many alternative arrangements exist. Substituting other equipment for that shown can be done depending on economic conditions such as size of contract, extent of reserves, environmental restrictions, and financial conditions of the owner-operator. Selection of equipment is primarily based on the abrasiveness of the raw material and the size of the plant or tonnage handled per hour.

These five examples show various types of crushers. A brief explanation of the application of these crushers and reason why each is used in a particular part of the circuit is given in the following paragraphs.

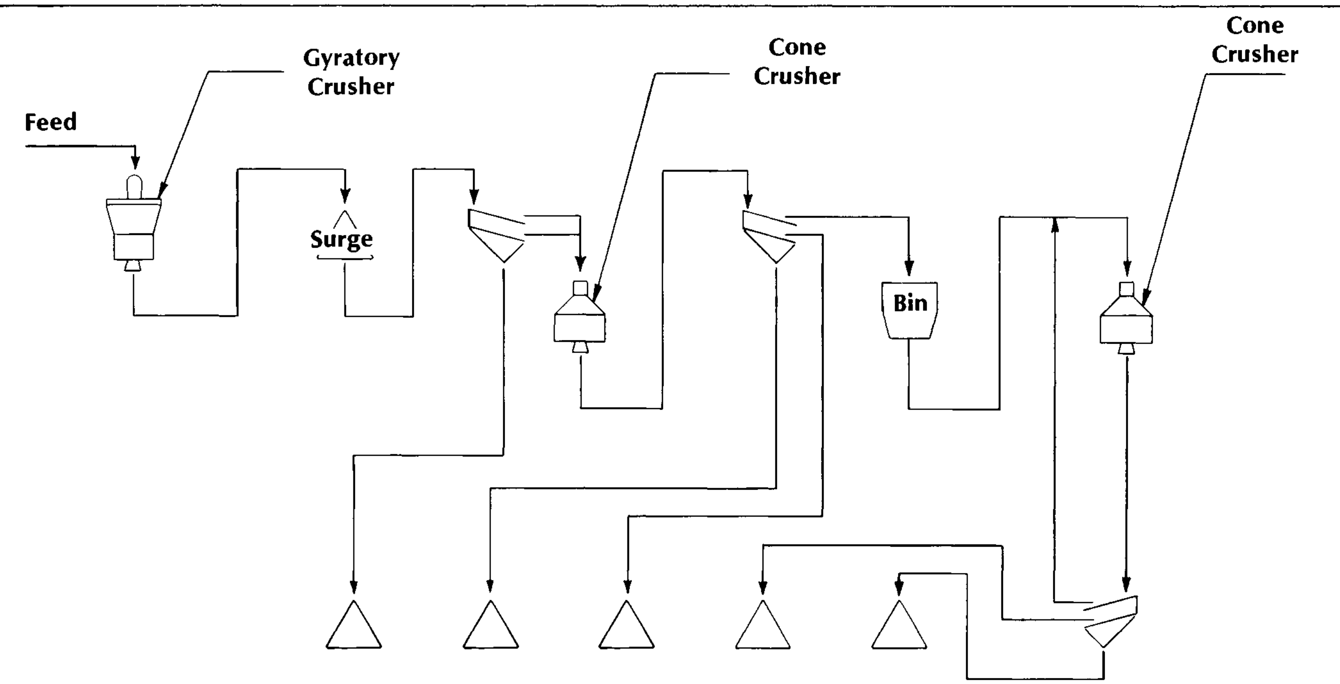


Fig. 1

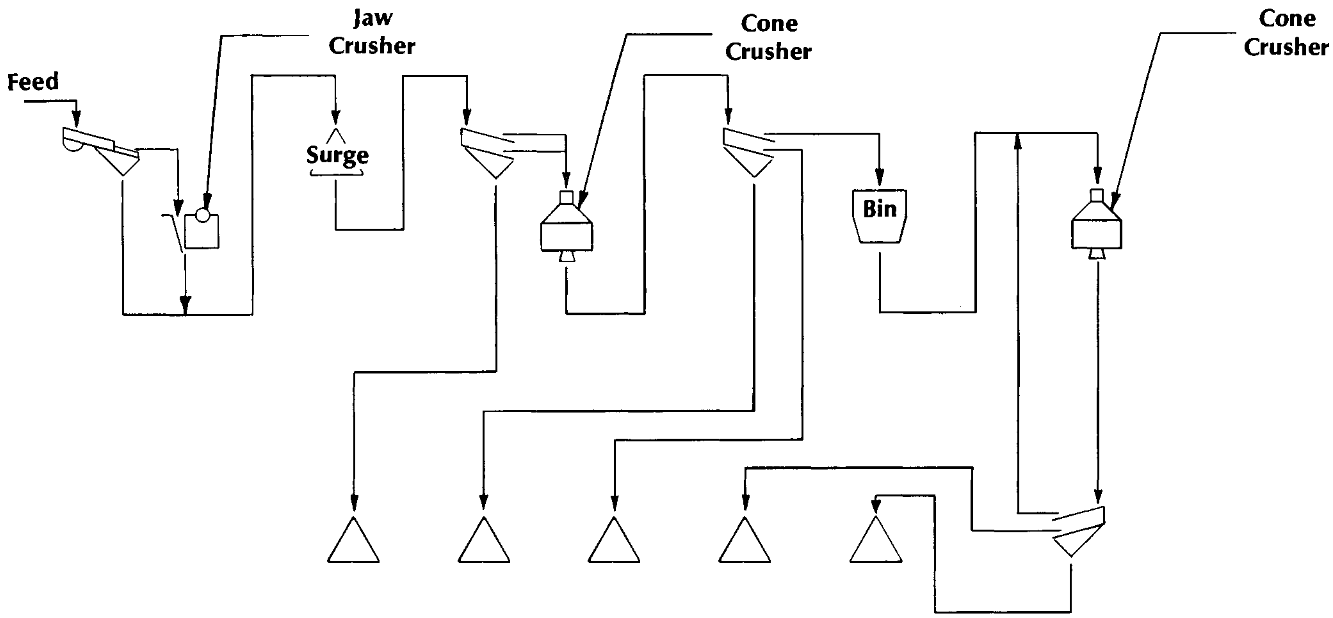

Jaw
Crusher
Cone
Crusher
Cone
Crusher
Feed
Surge
Bin

Fig. 2

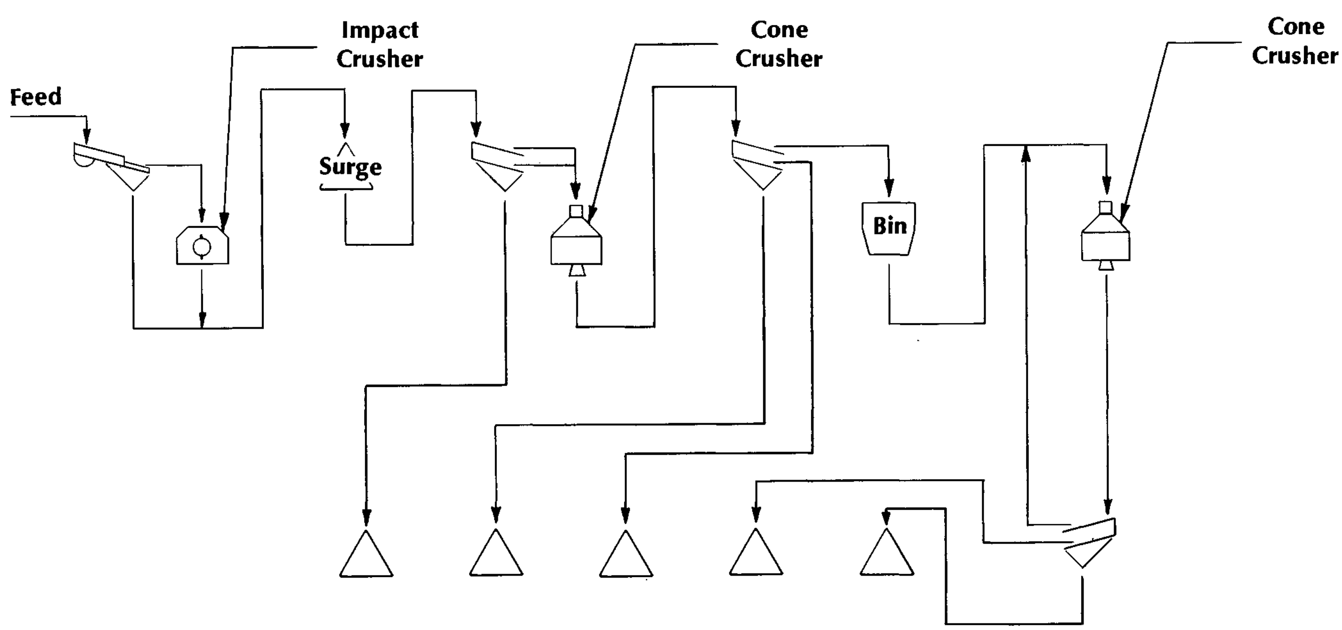
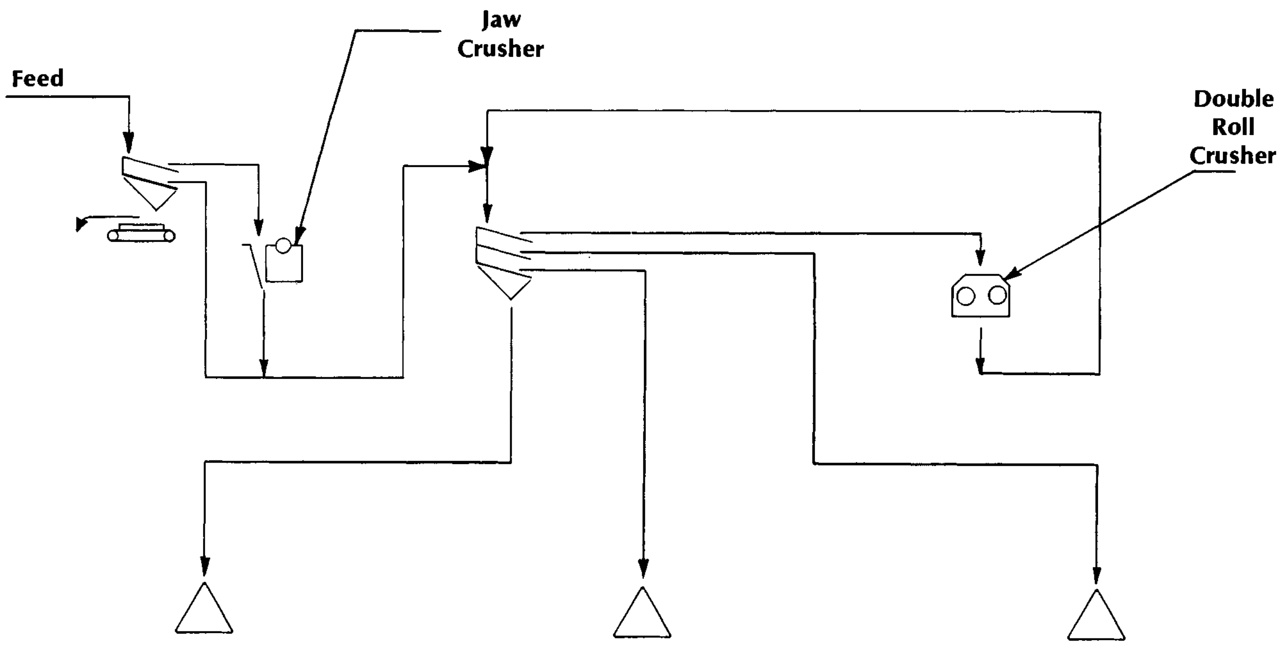
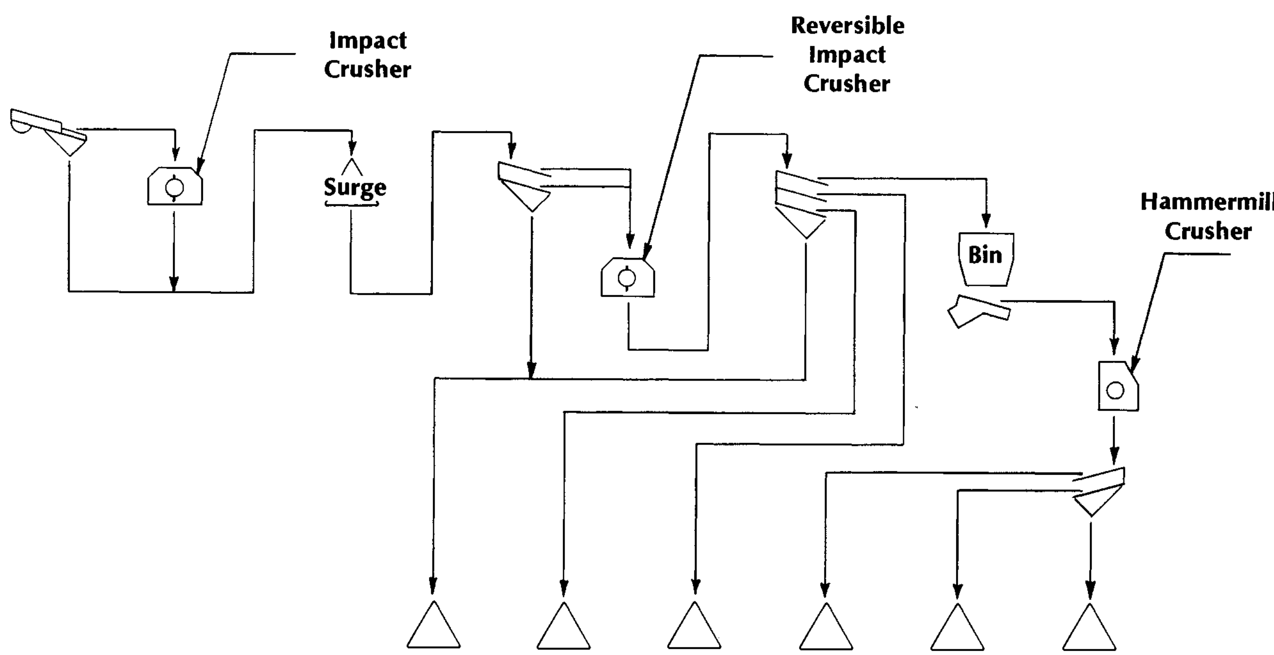

Impact
Crusher
Cone
Crusher
Cone
Crusher
Feed
Surge
Bin

Fig. 3



Jaw
Crusher
Feed
Double
Roll
Crusher

Fig. 4



Impact
Crusher
Reversible
Impact
Crusher
Surge
Bin
Hammermill
Crusher

Fig. 5

PRIMARY CIRCUIT

This is the first (and sometimes only) crusher in the circuit. It must be able to reduce the largest particle size received and must be sized to handle the required capacity. The primary circuit is normally an open circuit where material is processed through the crusher and is not returned to the crusher. For feed size in excess of 12" and depending on the maximum size and abrasiveness of the material, it is common to find gyratory, jaw, impactor or hammermill primary crushers.

Gyratory Crushers are popular for very large feed sizes (up to 72"), large tonnages (up to 8000 TPH) in material of high or low compressive strength and requires no scalping or flow control feeding device.

Jaw Crushers are popular for tonnages within their design range (up to 2000 TPH) and where overall height of installation is important. Pre-screening (scalping) or the feed is common and is usually accomplished with a vibrating grizzly feeder or by a vibrating or stationary grizzly. Jaw Crushers operate more efficiently when material smaller than the closed side crusher setting is removed prior to crushing and when the feed rate is constant.

Impact Crushers are popular for large feed sizes (3" to 96" or more), large tonnages (up to 2000 TPH) where the abrasiveness of the material is low enough to permit crushing with acceptable wear and maintenance. As with jaw crushers, the feed is often controlled and pre-screened by a vibrating grizzly feeder or a vibrating or stationary grizzly. The impactor offers high capacity for low initial investment, produces a more cubical product, handles surges well, and features a higher reduction ratio than either a gyratory or jaw crusher. This reduces the amount of secondary crushing required.

Hammermill Crushers, like the impactor, work best with low abrasive material. Feed sizes to 48" and capacities to 2000 TPH are available. The cubical product and greatest reduction ratio of any crusher have increased the popularity of this type of crusher for primary applications. Special hammermill designs also allow them to handle wet, sticky materials better than some other types of primary crushers. The feed is not always pre-screened or scalped, but can be. It is not normally considered a primary crusher in materials, other than coal.

Single Roll Crushers are used in soft material and perform well when sticky clay is present. Reduction ratios are about 6:1 and capacities to 2000 TPH are possible. Scalping is not normally required. They are used as a primary crusher only when crushing soft material such as coal.

CONE crushers are not usually used as primary crushers. They can however, be used as a primary crusher if the top size of the material does not exceed 12". Cone crushers are similar to gyratory crushers except that the angle of the chamber is much flatter. The feed size, type and dampness is therefore, more critical. Scalping by the use of a vibrating grizzly feed or vibrating screen is required ahead of cone crushers.

SECONDARY CIRCUIT

This is the second stage in crushing and with the exception of the single roll crusher, all of the primary types may be found in smaller versions. Cone and hammermill crushers are widely used, along with double and triple roll crushers. Cage mills and vertical shaft impact crushers are also used as secondary crushers.

In general, the function of secondary crushing is to produce products, or to prepare material for the next stage of crushing. It is here that vibrating screens come into use both to produce end product gradations and/or to remove material produced from the primary circuit that is smaller than the secondary crusher setting. When desired product gradations are coarse enough to be produced in the secondary circuit, a *closed* circuit system is sometimes used whereby the crusher product is screened and any oversized material not reduced in the first pass will be screened out and returned to the crusher for further reduction. It sometimes takes several passes or cycles to reduce this material to the size of the crusher setting. This returned material is referred to as the circulating load and appears at the secondary crusher and scalping screen combined with the original feed. When selecting the secondary crusher and screen, the original feed plus circulating load must be considered to insure that the equipment has sufficient capacity. In some circuits, the crusher return is screened separately to attain a higher quality product or to relieve the scalping screen load.

TERTIARY CIRCUIT

This is the third stage in crushing and many types of crushers are used. Fine head cone crushers, double and triple roll crushers, single and multiple cage mills, high speed hammermills, and even rod and ball mills find application. It is in this stage of crushing that the closed circuit is most often used and where the circulating load assumes great importance in both crusher and screen selection. It is especially important at this stage to pre-screen and remove any material from the tertiary crusher feed that is smaller than the desired product. Because gradations are finer, the crushers must be more accurate as to settings and screens must be capable of screening fine material. Circulating loads must be accurately calculated to arrive at the total feed in order to select the proper size and number of tertiary crushers and screens.

QUATERNARY CIRCUIT

This is the fourth stage of crusher and it is here that the types of crushers used in the previous three stages give way to grinding mills, ball mills, multi-cage mills, etc. Also, vibrating screens become specialized for fine screening applications and often are replaced in their application by air separators or in the case of wet milling, by cyclones.

Chapter 11

TECHNICAL DATA

VSMA
QUALITY / INTEGRITY

VIBRATING SCREEN MANUFACTURERS ASSOCIATION

INTRODUCTION

It is common policy for companies to seek several bids when considering a major purchase. Included in this purchasing category are vibrating screens.

Normally the investigation begins with the inquirer sending performance and design requirements to a list of recognized suppliers of vibrating screens. In addition, there usually is an accompaniment of forms to be completed by the bidder. These forms are intended to provide details of the vibrating screen being quoted and are also used to compare one model screen to the other. Presently most inquirers have their own forms. Some forms are very cumbersome and quite expensive to complete. They often request information that is superfluous and not pertinent to the vibrating screen being considered for purchase.

The Vibrating Screen Manufacturers Association (VSMA), recognizing many advantages of common forms for both the inquirer and the bidder, has developed the attached forms. VSMA form #1000 covers applications details only. VSMA form #1001 is devoted completely to the technical and design details of a vibrating screen.

These forms, together or separately, provide relevant details needed for anyone to evaluate the features and benefits of one model screen to the other. The VSMA encourages these forms to be used as accepted forms when requesting a bid on a vibrating screen. They can be used by the inquirer to stipulate specific requirements when issuing a Request For Quotation and/or they can be used in reply by the bidder when submitting a proposal.

The VSMA requests that you join the group that accepts and uses these forms for vibrating screens.

MEMBER

VIBRATING SCREEN
MANUFACTURERS ASSOCIATION

VIBRATING SCREEN APPLICATION DETAILS

VSMA FORM #1000

____
(date prepared)

____
Prepared by

Bidder: ________________ Inquirer: ________________

Bidder Reference ________________ Inquirer Reference ________________

Equipment Reference ________________

1.0 Quantity, Type, Size and Model of Screens

1.1 a) Quantity______ b) Width______ c) Length______ d) No. of Decks______

1.2 a) Type: 2 Bearing Inclined______ b) 4 Bearing Inclined______ c) Horizontal______ d) Other______

2.0 Description of Material to be fed to screen(s)

2.1 Material________________ 2.2 Bulk Density________________ lbs. $ft.^3$

2.3 Condition when fed to screen:

Dry______ Damp______ Clayey______ Wet______ Hot______ Sticky______

2.4 If damp ______% moisture

2.5 If slurry ______gpm ______% solids by weight ______% solids by volume

2.6 If hot: Temperature MIN. ______°F. ______°C.

MAX.______°F. ______°C.

2.7 Other pertinent characteristics of material not contained in Item 2 above:

3.0 Specified Screening Conditions

3.1 Dry_______ 3.2 Wet_______ With water spray bars_______

Without water spray bars_______ (see Item 2)

3.3 Other pertinent screening conditions not included above:

____

____

____

4.0 Product Sizes Required

− +

− +

− +

− +

− +

5.0 Operating Schedule:

5.1 Hours per day_______ 5.2 Days per week_______ 5.3 Weeks per year_______

6.0 Feed Rate (Including Circulating Load if Applicable)

6.1 MIN._______STPH _______LTPH _______MTPH

6.2 MAX._______STPH _______LTPH _______MTPH

6.3 AVG._______STPH _______LTPH _______MTPH

6.4 Other pertinent details regarding feed rate:

____

____

____

____

7.0 Sieve Analysis of Feed (Item 6)

Opening Size	**Cumulative % Passing**

7.1 Maximum Size Piece_______

8.0 Test Sieve Series: Square_______ Round_______ U.S._______ Tyler_______

Other_______

9.0 Type of Media:

		DECK LOCATION			
		1st	2nd	3rd	4th
a) Wire cloth	SQ. FT.				
b) Perforated Plate	SQ. FT.				
c) Profile wire	SQ. FT.				
d) Elastomer	SQ. FT.				
e) ____________	SQ. FT.				
f) ____________	SQ. FT.				

10.0 Other comments and/or requirements:

MEMBER

VIBRATING SCREEN
MANUFACTURERS ASSOCIATION

VIBRATING SCREEN TECHNICAL DATA SUMMARY

VSMA FORM #1001

______________________ (date prepared)

______________________ Prepared by

Bidder: ______________________ Inquirer: ______________________

______________________ ______________________

______________________ ______________________

Bidder Reference: ______________________ Inquirer Reference: ______________________

Equipment Reference: ______________________

1. Description and Design Data:

Size and Identification

Quantity_______ Width_______ Length_______ Number of Decks_______

Type: 2 Bearing Inclined_______ 4 Bearing Inclined_______ Horizontal_______ Other_______

Manufacturer Trade Name______________________ Model Designation______________________

2. Operating Data:

Vibrator stroke_______ Vibrator speed_______

Motion pattern: Elliptical _______ Circular_______ Straight line_______

Is stroke adjustable:_______ MAX._______ MIN._______

Operating slope: Recommended _______° MIN._______° MAX._______°

3. Weight:

Total screen weight _______ lbs. Heaviest weight for servicing _______ lbs.

Static loading: Each corner feed end_______ Each corner discharge end_______

Dynamic loading: Each corner feed end_______ Each corner discharge end_______

General dimension drawing(s) included: Yes_______ No_______

General dimension drawing number(s) ______________________

____

____

4. **Vibrating Frame Details:**

Sideplates

Material ________________________________ Thickness_______ Height_______Sloped_______

Rectangular_______

Describe Stiffeners: ____

Sideplate Wear Liners

Location: 1st Deck_______ 2nd Deck_______ 3rd Deck_______ 4th Deck_______

Standard_______ Optional_______ Extra Charge $_______ Material ________________________

Thickness_______ Bolted on_______ Welded on_______

Feed Box

Standard_______ Optional_______ Extra Charge $_______ Length_______

Material ________________________ Thickness_______

Feed Box Liners

Standard_______ Optional_______ Extra Charge $_______

BOTTOM LINER material__________________ Thickness_______

SIDE LINER material __________________ Thickness_______

BACK LINER material __________________ Thickness_______

Bolted on_______ Welded on_______

Backplates

Location: 1st Deck_______ 2nd Deck_______ 3rd Deck_______ 4th Deck

Standard_______ Optional_______ Extra Charge $_______

Material ________________________ Thickness_______

Discharge Lips

Standard_______ Optional_______ Extra Charge $_______

Material ____ Thickness_______ Length_______

Discharge Lip Wear Liners

Standard_______ Optional_______ Extra Charge $_______

Material______________________________ Thickness_______ Bolted on_______ Welded on_______

Screening Surface Support Frame 1st Deck

Surface contour: Flat_______ Single Crown_______ Double Crown_______ Other_______

Screening Surface Support Frame 1st Deck, continued

If crowned: Crown is accross width_______ Longitudinal_______

Fabricated Modules_______ Quantity per deck_______

Individual cross members_______ Quantity per deck_______

Description of cross members ____

Bolted to sideplate_______ Welded to sideplate_______

Surface support bar dimensions_______ Quantity per deck_______ Buffer strip material ____________________

5. **Screening Surface (Media) & Method of Mounting 1st Deck:**

Included_______ Not Included_______ Extra Charge $_______

Type	Space Opening	% Open Area
Wire cloth Wire diameter	____________________	__________
Perforated plate Plate thickness	____________________	__________
Rubber-clad perforated plate Total thickness	____________________	__________
Perforated rubber Rubber thickness	____________________	__________
Rods Rod diameter	____________________	__________
Cast plate Plate thickness	____________________	__________
Polyurethane Thickness	____________________	__________
Grizzly bars Fixed spacings	____________________	__________
Adjustable spacings	____________________	__________
Profile deck Wire identifcation	____________________	__________

Screening surface specifications 1st deck

____

____

____

____

Screening Surface Attachment—1st Deck

Side Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Longitudinal Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Fixed Mounted: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Tension Plates 1st Deck

Standard________ Optional________ Extra Charge $________

Material ________________ Thickness________

Tension Plate Liners

Standard________ Not Required________ Optional________ Extra Charge $________

Material ________________ Thickness________

Method of attachment ________________

Screening Surface Support Frame—2nd Deck

Surface contour: Flat________ Single Crown________ Double Crown________ Other________

Fabricated modules________ Quantity per deck________

Individual cross members________ Quantity per deck________

Description of cross members ________________

Bolted to sideplate________ Welded to sideplate________

Surface support bar dimensions________ Quantity per deck________

Buffer strip material ________________

Screening Surface (Media) & Method of Mounting 2nd Deck

Included________ Not Included________ Extra Charge $________

Type	Space Opening	% Open Area
Wire cloth Wire diameter	________	________
Perforated plated Plate thickness	________	________
Rubber-clad perforated plate Total thickness	________	________

Type	Space Opening	% Open Area
Perforated rubber Rubber thickness	____________	____________
Rods Rod diameter	____________	____________
Cast plate Plate thickness	____________	____________
Polyurethane Thickness	____________	____________
Grizzly bars Fixed spacings	____________	____________
Adjustable spacings	____________	____________
Profile deck Wire identification	____________	____________

Screening Surface Specifications—2nd Deck

____

____

____

____

Screening Surface Attachment—2nd Deck

Side Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ____________

Longitudinal Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ____________

Fixed Mounted: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ____________

Tension Plates 2nd Deck

Standard______ Not Required______ Optional______ Extra Charge $______

Material ______________________ Thickness______

Tension Plate Liners

Standard______ Optional______ Extra Charge $______

Material ______________________ Thickness______

Method of attachment ______________________________

Surface Support Frame—3rd Deck

Surface contour: Flat_______ Single Crown_______ Double Crown_______ Other_______

Fabricated_______ Quantity per deck_______

Individual cross members_______ Quantity per deck_______

Description of cross members ______________________________

Bolted to sideplate_______ Welded to sideplate_______

Surface support bar dimensions_______ Quantity per deck_______

Buffer strip material ______________________________

Screening Surface (Media) & Method of Mounting 3rd Deck:

Included_______ Not Included_______ Extra Charge $_______

Type	Space Opening	% Open Area
Wire cloth Wire diameter	__________	_______
Perforated plate Plate thickness	__________	_______
Rubber-clad perforated plate Total thickness	__________	_______
Perforated rubber Rubber thickness	__________	_______
Rods Rod diameter	__________	_______
Cast plate Plate thickness	__________	_______
Polyurethane Thickness	__________	_______
Grizzly bars Fixed spacings	__________	_______
Adjustable spacings	__________	_______
Profile deck Wire identification	__________	_______

Screening Surface Specifications—3rd Deck

____

____

____

____

Screening Surface Attachment—3rd Deck

Side Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Longitudinal Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Fixed Mounted: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Tension Plates 3rd Deck

Standard________ Not Required________ Optional________ Extra Charge $________

Material ________________________ Thickness________

Tension Plate Liners

Standard________ Optional________ Extra Charge $________

Material ________________________ Thickness________

Method of attachment ____

Screening Surface Support Frame—4th Deck

Surface contour: Flat________ Single Crown________ Double Crown________ Other________

Fabricated modules________ Quantity per deck________

Individual cross members________ Quantity per deck________

Description of cross members ____

Bolted to sideplate________ Welded to sideplate________

Surface support bar dimensions________ Quantity per deck________ Buffer strip material ________________

Screening Surface (Media) & Method of Mounting 4th Deck:

Included________ Not Included________ Extra Charge $________

Type	**Space Opening**	**% Open Area**
Wire cloth Wire diameter	________________	________
Perforated plate Plate thickness	________________	________
Rubber-clad perforated plate Total thickness	________________	________
Perforated rubber Rubber thickness	________________	________

Type	Space Opening	% Open Area
Rods		
Rod diameter	________	________
Cast plate		
Plate thickness	________	________
Polyurethane		
Thickness	________	________
Grizzly bars		
Fixed spacings	________	________
Adjustable spacings	________	________
Profile deck		
Wire identification	________	________

Screening Surface Specifications—4th Deck

____

____

____

____

____

Screening Surface Attachment—4th Deck

Side Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Longitudinal Tensioning: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Fixed Mounted: Threaded Bolts ________ Wedges ________

Longitudinal hold down bar(s) ________

Tension Plates 4th Deck

Standard________ Not Required________ Optional________ Extra Charge $________

Material ________________ Thickness________

Tension Plate Liners

Standard________ Optional________ Extra Charge $________

Material ________________ Thickness________

Method of Attachment ________________________________

6. **General Assembly of Components:**

All Welded_______ All Bolted_______ Combination welded/bolted_______

Describe other pertinent details of vibrating frame construction

____

____

Clearance between and above decks

Top of deck 1 crown and top of sideplates: _______________________

Between underside of deck 1 support cross member and top of deck 2 crown _______________

Between underside of deck 2 support cross member and top of deck 3 crown _______________

Between underside of deck 3 support cross member and top of deck 4 crown _______________

Vibrator Tube Location

Above all decks _______________________________

Below all decks _______________________________

Between decks #_______ and #_______

End Mounted_______________________

Minimum Clearance Between Vibrating Tube and Deck(s)

Deck Above: _____________________ Below: _____________________

7. **Support Arrangement:**

Feed End

Base supported_____________________ Overhead suspension_____________________

Discharge End

Base supported_____________________ Overhead suspension_____________________

Vibration Isolators

Steel coil springs_______ Air springs_______ Rubber-in-shear_______

Rubber-in-compression_______ Leaf springs_______ Other ______________________

Describe location, quantity and method of attaching to vibrating frame:

____

____

____

____

____

Snubbers/Friction checks

Standard_______ Optional_______ Extra Charge $_______ Not required_______

8. Vibrator Mechanism:

Location: Overhead_______ Between decks_______ Underslung_______ End Mounted_______

Vibrator Shaft

Rough or semi-machined_______ Finished machined_______ Maximum diameter_______

Material_______________________________________ Eccentric_______ Concentric_______

Bearing housings

Quantity_______ Material_______________________________

Bearings

Quantity_______ Type_______ Size (mm)_______ Series_______

Bearing life L10 _______________________________

Bearing seals

Describe: ____

____

____

____

Vibrator shaft casing

Material _______________________ Thickness_______ Wear Liner Material _______________________

Thickness_______ Completely enclosed_______ Access covers_______

9. Lubrication:

Oil_______ Grease_______ Automatic_______

Description: ____

____

____

____

10. Recommended Motor Specifications:

Included_______ Optional_______ Extra Charge $_______ Type_______

AC_______ DC_______ HP_______ RPM_______ Open type_______ TEFC_______ Other _______________

Volts_______ Phase_______ Hertz_______ NEMA design_______ NEMA frame_______

Service factor_______

Motor Base

Included_______ Optional_______ Extra Charge $_______

Automatic/Pivoted_______ Sliding base_______ Other____

11. **Screen Drive:**

Standard_______ Optional_______ Extra Charge $_______

Hand of Drive: RH_______ LH_______ EITHER_______ BOTH_______

Description of Drive:

____

____

____

____

____

12. **Safety Guards:**

Included_______ Optional_______ Extra Charge $_______

Guard(s) comply with specs of: OSHA_______ MSHA_______ OTHER _______________________________

13. **Optional Requirement:**

List and describe all optional equipment included with screen(s) quoted but not covered in these summary sheets:

____

____

____

____

____

____

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____

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____

____

____