SELECTION OF SCREEN SIZE AND TYPE

eening is defined as "a mechanical process which ccomplishes 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.

) 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, me very reliable capacity criteria has been developed 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: $\text{Screening Area} = \dfrac{U}{A \times B \times C \times D \times E \times F \times G \times H \times J}$

***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)

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

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 ____

Slivery ____ Slabby/Flake ____

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

ibrating screen used to remove a small amount of oversize from a feed which is predominantly finer without regard for ished 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.

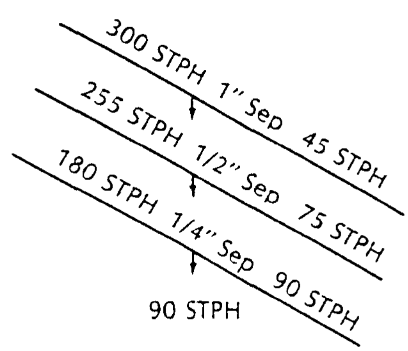
EXAMPLE
CALCULATING SCREEN AREA
Application Details from Screen Questionnaire

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



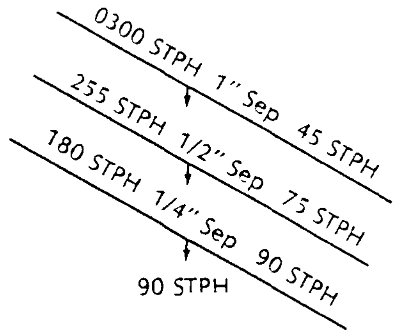
Formula:

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

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



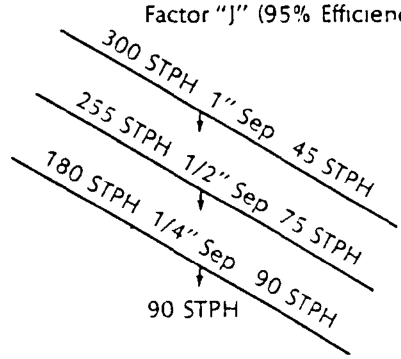
Area 1" Separation =
$$\frac{255}{3.56 \times 1.08 \times 1.40 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.00} = \frac{255}{5.38} = 48 \text{ Sq. Ft.}$$
"A" "B" "C" "D" "E" "F" "G" "H" "J"

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 =
$$\frac{180}{2.47 \times 968 \times 90 \times 90 \times 1.00 \times 1.00 \times 1.00 \times 1\ 00 \times 1\ 00} = \frac{180}{1.94} = 93 \text{ Sq. Ft.}$$
"A" "B" "C" "D" "E" "F" "G" "H" "J"

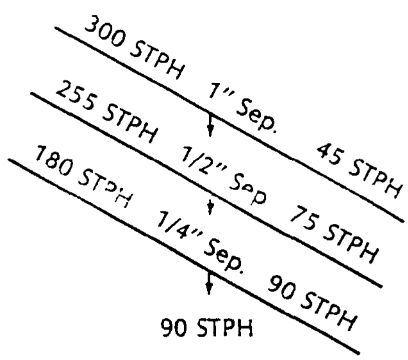
EXAMPLE

CALCULATIONS FOR THIRD DECK

.eoretical Sieve Analysis of Feed to 3rd Deck

Opening	Cumulative % Passing	STPH Passing	Conditions for Third Deck
1/2"	**100%**	**180 STPH**	**Feed to 3rd Deck** = 180 STPH
3/8"	75%	135 STPH	Factor "A" (for 1/4") = 1 60
1/4"	50%	90 STPH	Factor "B" (for + 1/4") = 79 90 STPH = 50%
3/16'	37%	66 STPH	Factor "C" (for − 1/8") = 70 45 STPH = 25%
1/8"	25%	45 STPH	
#10	10%	18 STPH	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

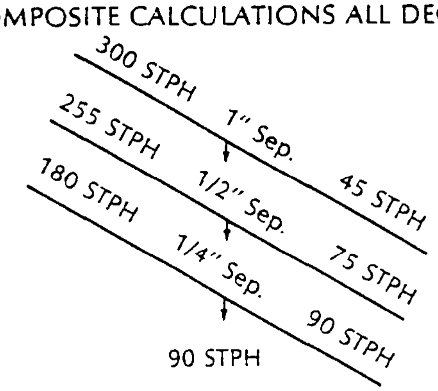


Area 1/4" Separation $= \dfrac{90}{1.6 \times .79 \times .70 \times .80 \times 1.00 \times 1.00 \times 1.00 \times 1.00 \times 1.15} = \dfrac{90}{.81} = 111$ Sq. Ft.

"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"

Area 1/2" Separation =

$$\frac{180}{\underset{\text{"A"}}{2\ 47} \times \underset{\text{"B"}}{968} \times \underset{\text{"C"}}{90} \times \underset{\text{"D"}}{90} \times \underset{\text{"E"}}{1\ 00} \times \underset{\text{"F"}}{1\ 00} \times \underset{\text{"G"}}{1\ 00} \times \underset{\text{"H"}}{1\ 00} \times \underset{\text{"J"}}{1\ 00}} = \frac{180}{1\ 94} = 93 \text{ Sq Ft}$$

Area 1/4" 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

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

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

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

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

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.

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												SLOPE RANGE (degree)
		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″	
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-hatch) ACCEPTABLE (bars)

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	Preferred	Preferred	Acceptable		
7/16	900		Acceptable	Preferred	Preferred		
1/2	850			Acceptable	Preferred	Preferred	
5/8	800			Acceptable	Acceptable	Preferred	Preferred
3/4	750				Acceptable	Acceptable	Preferred

PREFERRED XXX ACCEPTABLE |||||