Principles of Screening and Sizing

Presented By: George Schlemmer

QUARRY ACADEMY

Today’s Agenda

- Provide you with information to promote a safer, more cost efficient operation.
- Topics covered to include:
  - Performance and carrying capacity.
  - Review external factors (type of material, amount of near size in the material, shape of material).
  - Review the screen sizing formula and the effects that each of the above can have on the sizing process.
  - Review speed, stroke and slope.
  - Media options available to today's producers and there applications.
  - Troubleshooting guidelines and items to review at the quarry.

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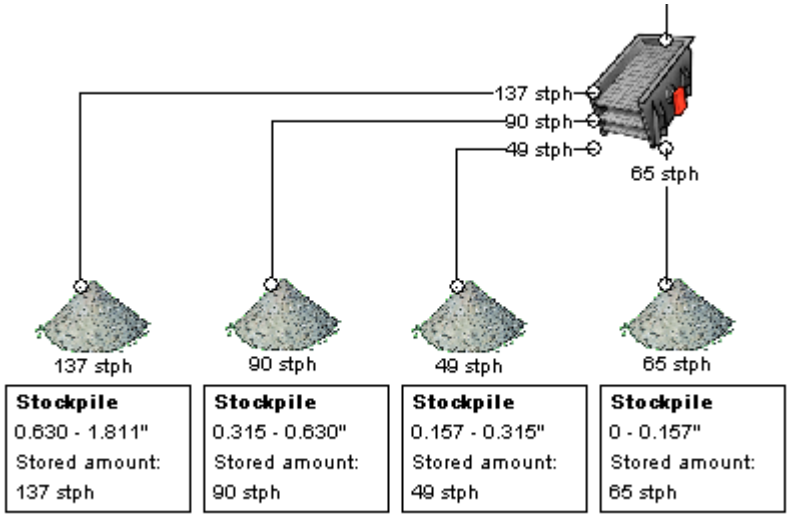
Screen Duties

- To prepare a sized product.



- Take home message: Final product sizing.

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Screen Duties

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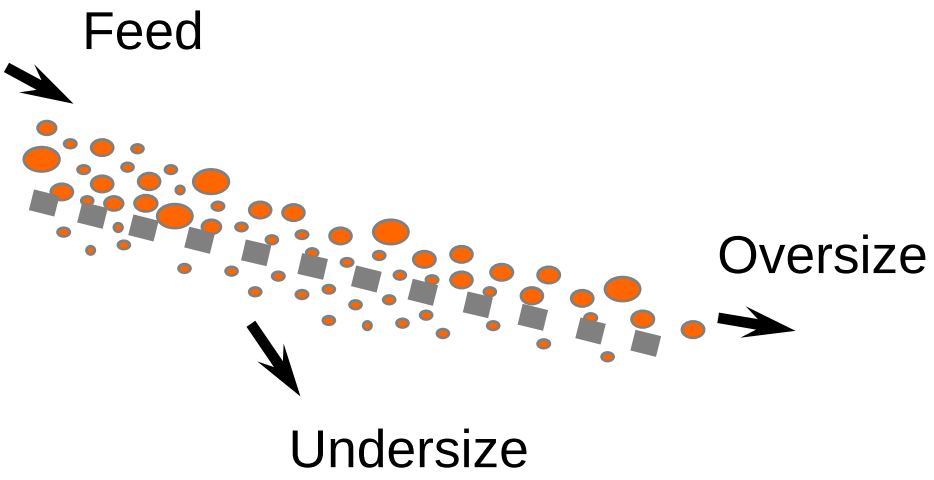
Screen Performance

- Stratify the material.
- Prevent pegging.
- Prevent blinding.
- Separate the material into two or more fractions.
- Transport the material to provide the screen its carrying capacity!



Carrying Capacity…the amount of material a screening machine can carry over the decks before the momentum of the screen body is overcome by the weight of the material.

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Carrying Capacity

- Carrying Capacity - amount of material a vibratory screen can carry over the decks before the momentum of the screen body is overcome by the weight of the material.
- Factors for carrying capacity calculations include:

$$\text{CARRYING CAPACITY} = \frac{m \times v \times s^2 \times n^2}{C \times l}$$

- **m = moving mass in screen body**
- **v = speed of material over the deck**
- **s = stroke length**
- **n = rotational speed (RPM)**
- **l = length of screen**
- **C = constant derived from performance data**

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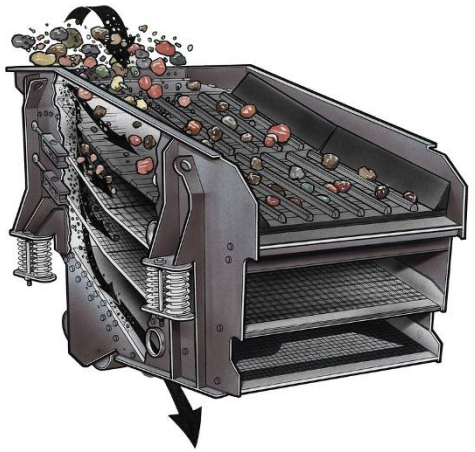
Information Required to Measure Screen Performance and Solve Problems

- Application factors
  - Material characteristics (Wet, dry, slivers, openings)
- Screen set-up
  - Speed, stroke, slope, direction of rotation, etc.
- Feed rate (stph) and material bed depth
- Media
  - Media type, open area, wire diameter, opening shape
- Maintenance & Installation
  - Natural frequency vs. operating frequency
  - Tension on v-belts
  - Correct installation of motor base(s)
  - Springs
  - Proper torque for all fastening hardware
  - Level



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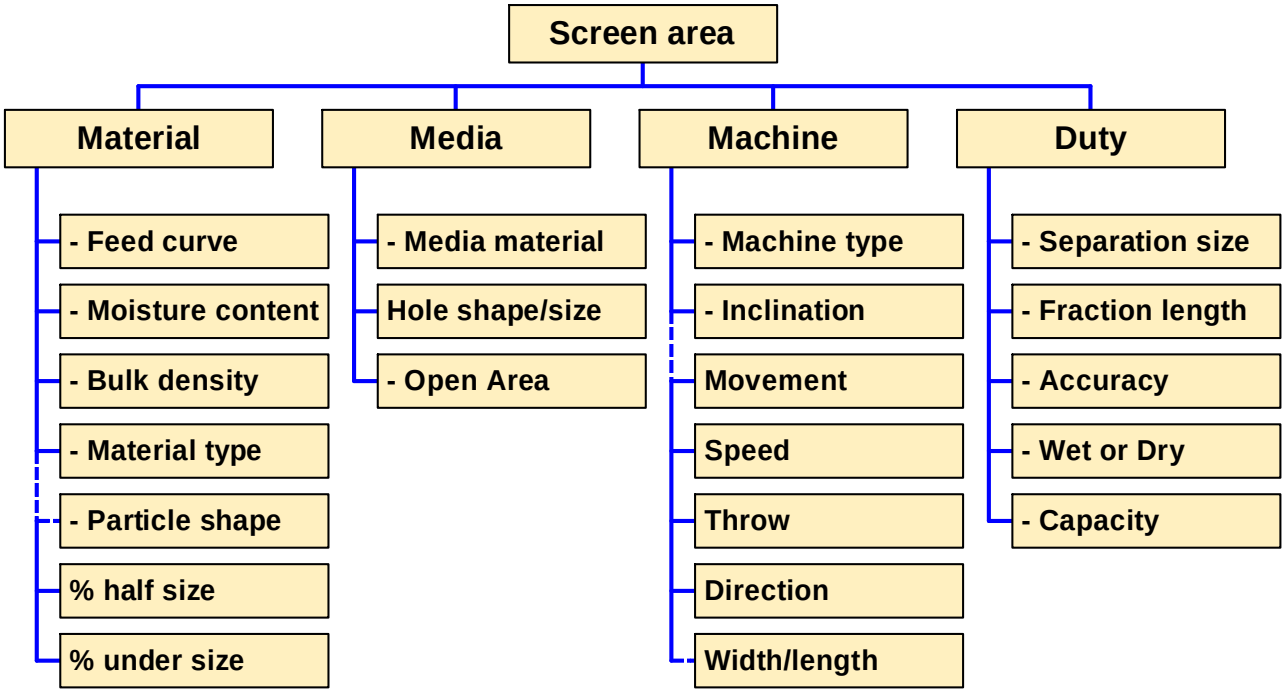
Factors Which can Effect Screening



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How Application Factors Affect Capacity and Accuracy

Application / modifying factors:

- Half size in feed – Higher % of half size increases capacity
- Oversize in feed – Lower % of oversize increases capacity
- Wet screening – Increases capacity
- Slotted openings – Increases capacity
- Finer wire diameter < open area – Increases capacity & efficiency
- Reduce efficiency rate – Increase capacity
- Moisture – Reduces capacity & efficiency
- Elongated particle shape – Reduces capacity & efficiency
- Near size material – Reduces capacity & efficiency

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Determining Screen Capacity

- **Each opening has a volumetric throughput capacity:**
  - Basic capacity figure is expressed as **tph per sq.ft.**
  - Figure is multiplied by the sq. footage of the screen deck.
  - Calculation gives the basic capacity of each deck and the total capacity of the vibrating screen.
- **The vibrating screen capacity is determined:**
  - Using a standard sizing formula (9 variables).
    - Basic capacity of each deck opening.
    - Unique factors of that application.
    - Maximum bed depth allowed for the openings and particle size.

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Screen Area Calculation

Basic formula for calculating screen area (per deck)

Screening Area = U / (A x B x C x D x E x F x G x H x J)

- U: Required screening area (Sq.ft.)
- A: Nominal capacity for separation
- B: % Oversize (.33 – 1.21)
- C: % Halfsize (.40 – 2.40)
- D: Deck location (.80 – 1.0)
- E: Wet screening (1.0 – 1.25)
- F: Material weight (.30 – 1.50) lbs/cu.ft
- G: Open area of media
- H: Shape of opening
  (1.00 – 1.20) sq-short-long
- L: Accuracy (.70 – 1.70)

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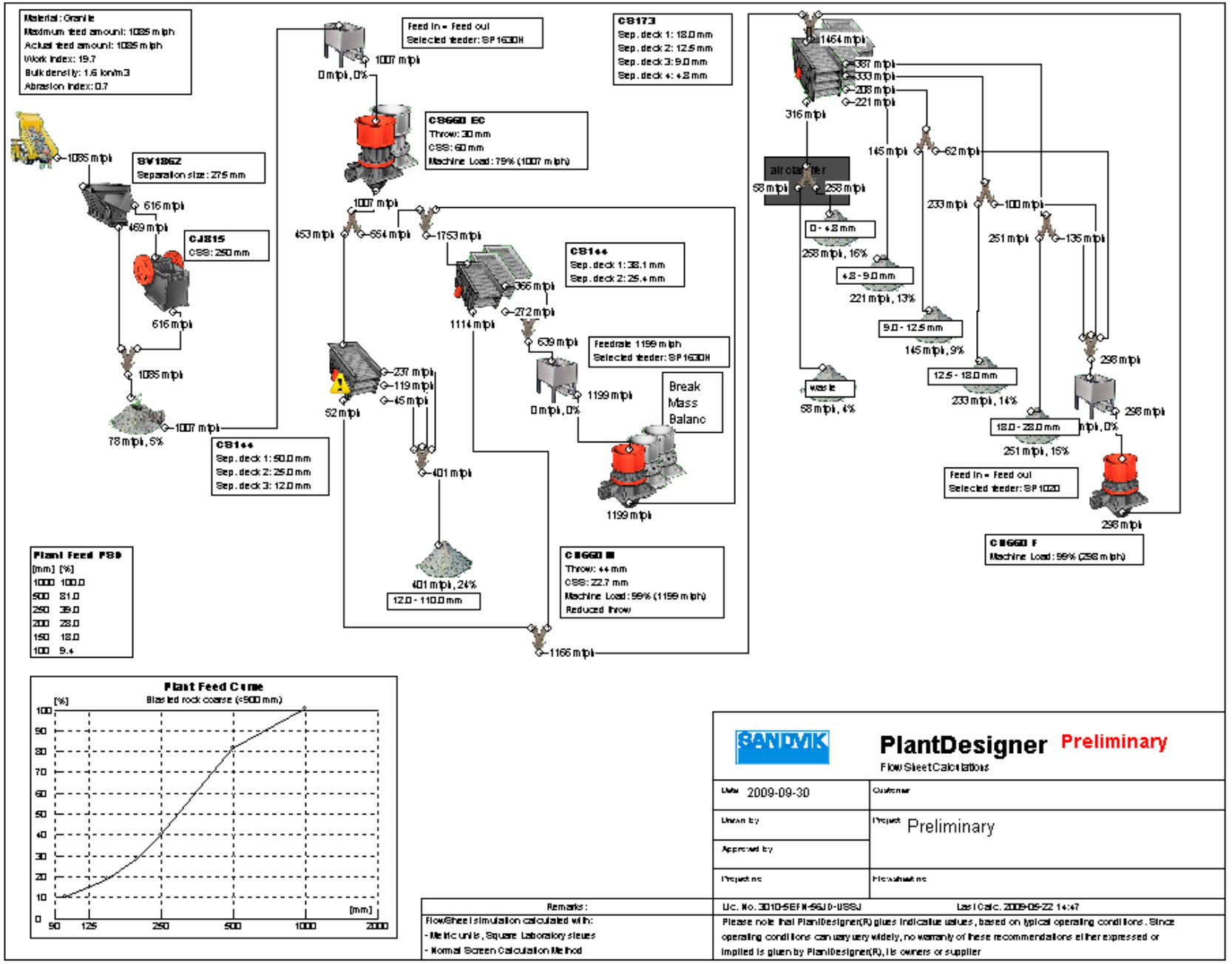

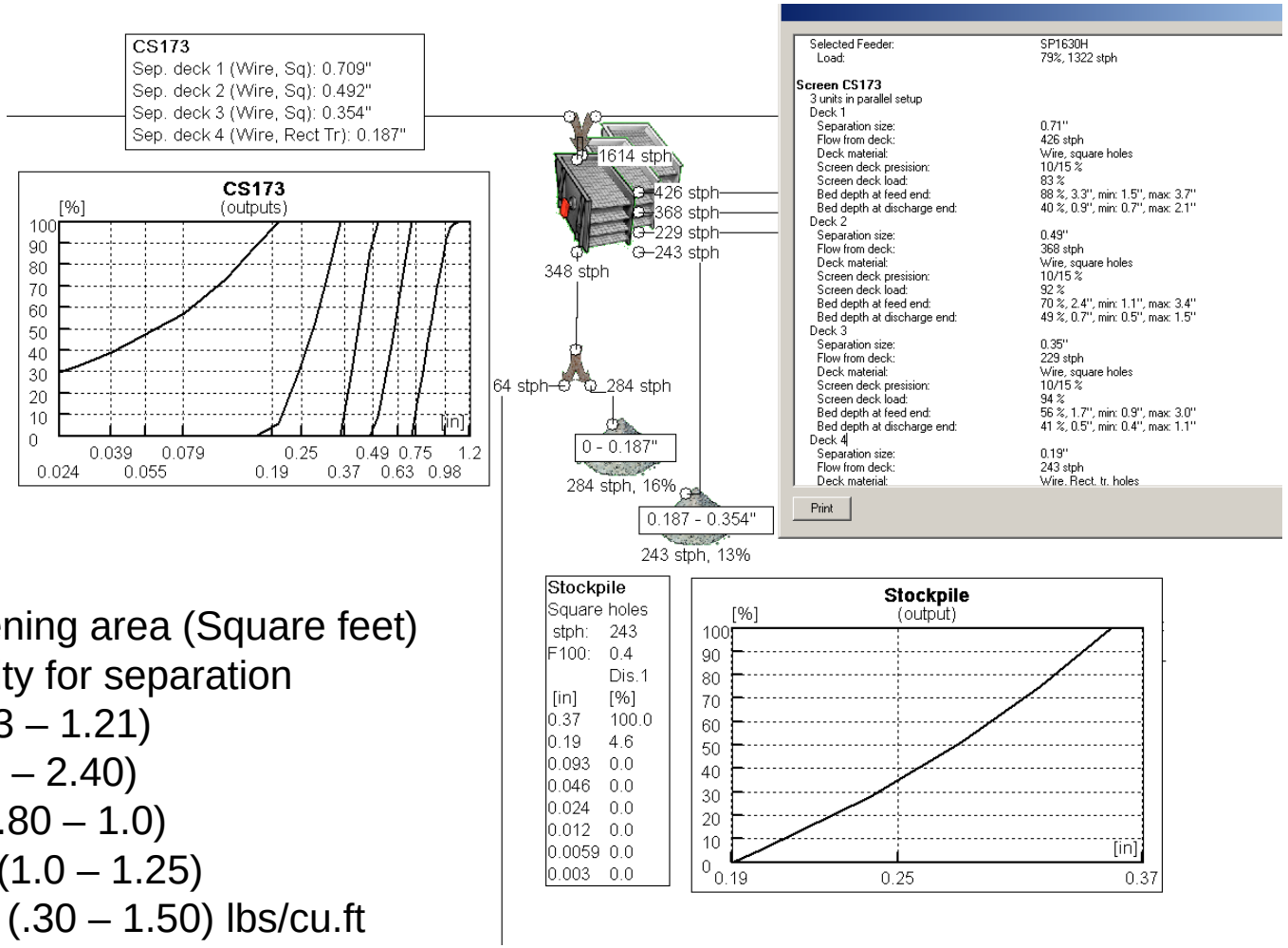

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L: Accuracy (.70 – 1.70)

8x20 = 160 sq.ft. per deck

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Common Factors which can Reduce Capacity and Accuracy

- Basic capacity figure is based on two key factors:
  - Feed with a maximum of 25% oversize
  - Minimum of 40% half-size
- Basic capacity is modified:
  - Increased or decreased based on the actual factors in each application.
- Material bed depth:
  - At discharge end; should not be deeper than 4x the deck opening.
    - Example: ½” opening x 4 = 2” material bed depth.
  - If bed depth exceeds this ratio, accuracy is reduced.

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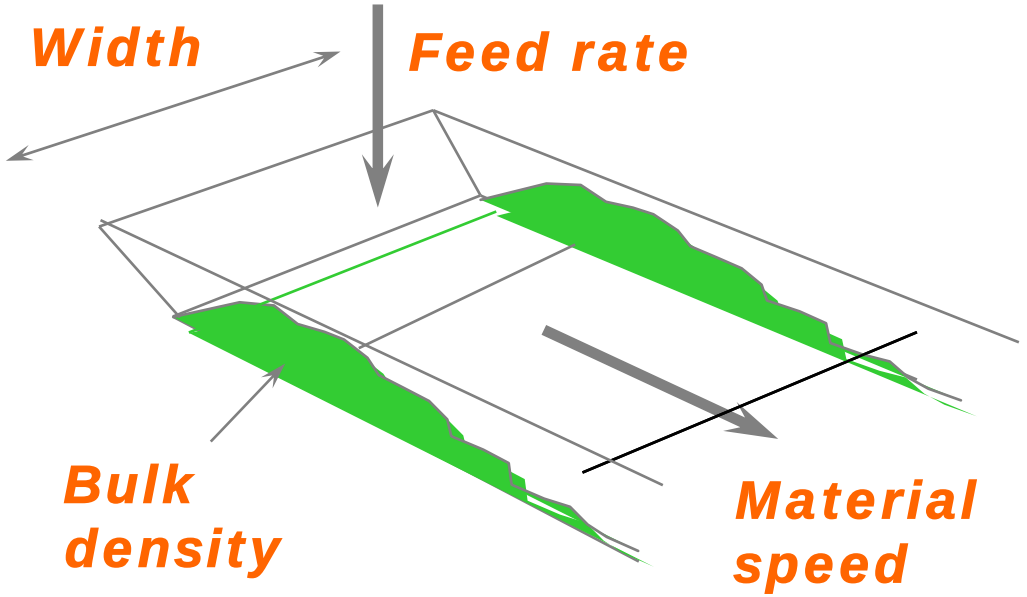
Screen Width

- Screen width controls material bed depth which allows material stratification and separation to take place.

- **Width = Capacity, Length = Accuracy**

- Material bed depth gauge:
  - Should not exceed 4x the deck opening at the discharge end.
  - Ideally you should be able to see the last few feet of media.



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Screening Theory

Accuracy defined:

- The degree of correctness of a quantity, expression, etc.
  - Expressed as the ratio of allowable percentage of maximum oversize and undersize in the final product. I.e. 10/10, 10/20, 15/20…

Efficiency defined:

- The percentage of work done.
  - Normally expressed as; 80%, 85%, 90%, 95% objective screening efficiency, with no specific or defined reference to the allowable percentage of oversize or undersize in the product.

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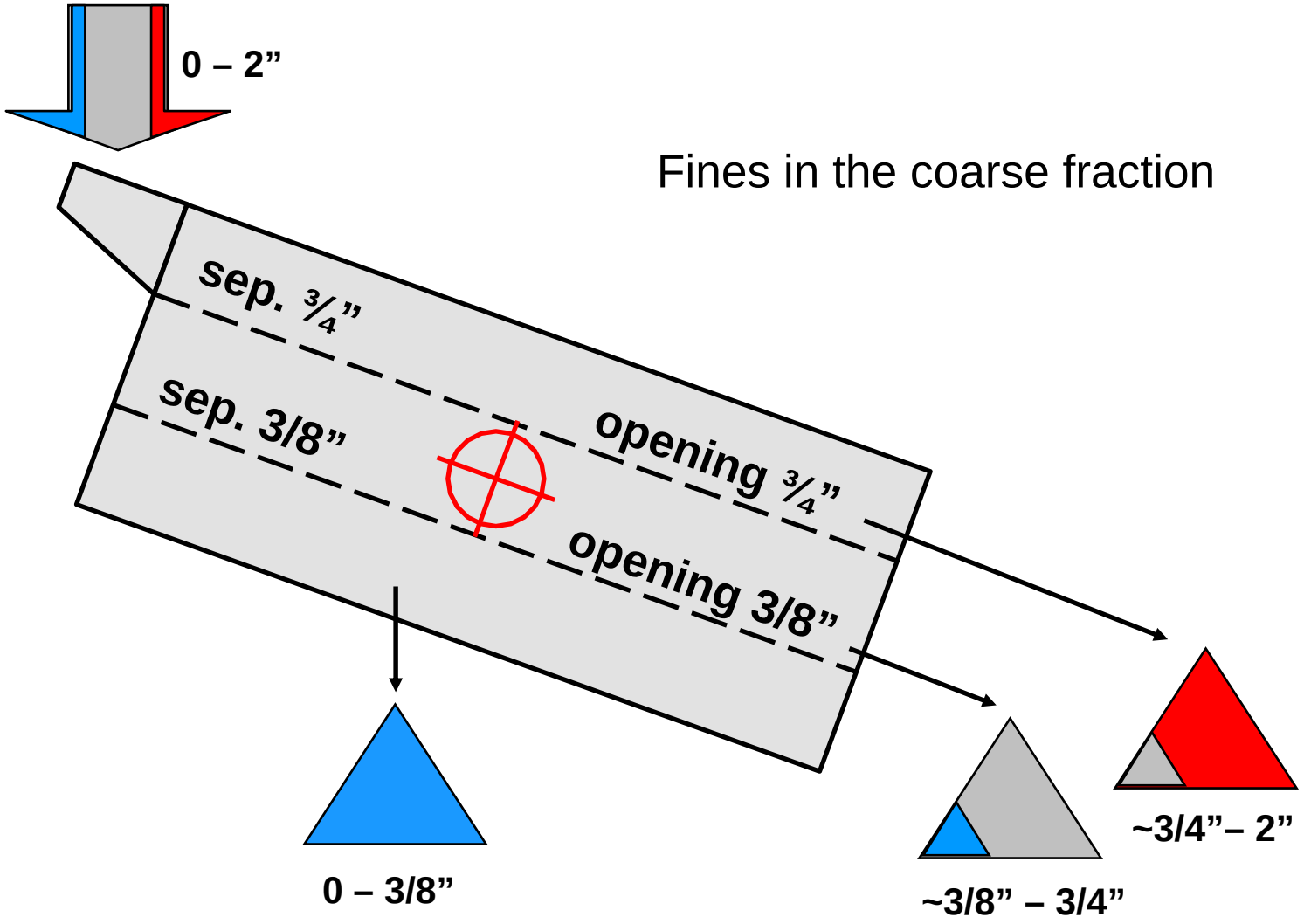
True Screening – Example A



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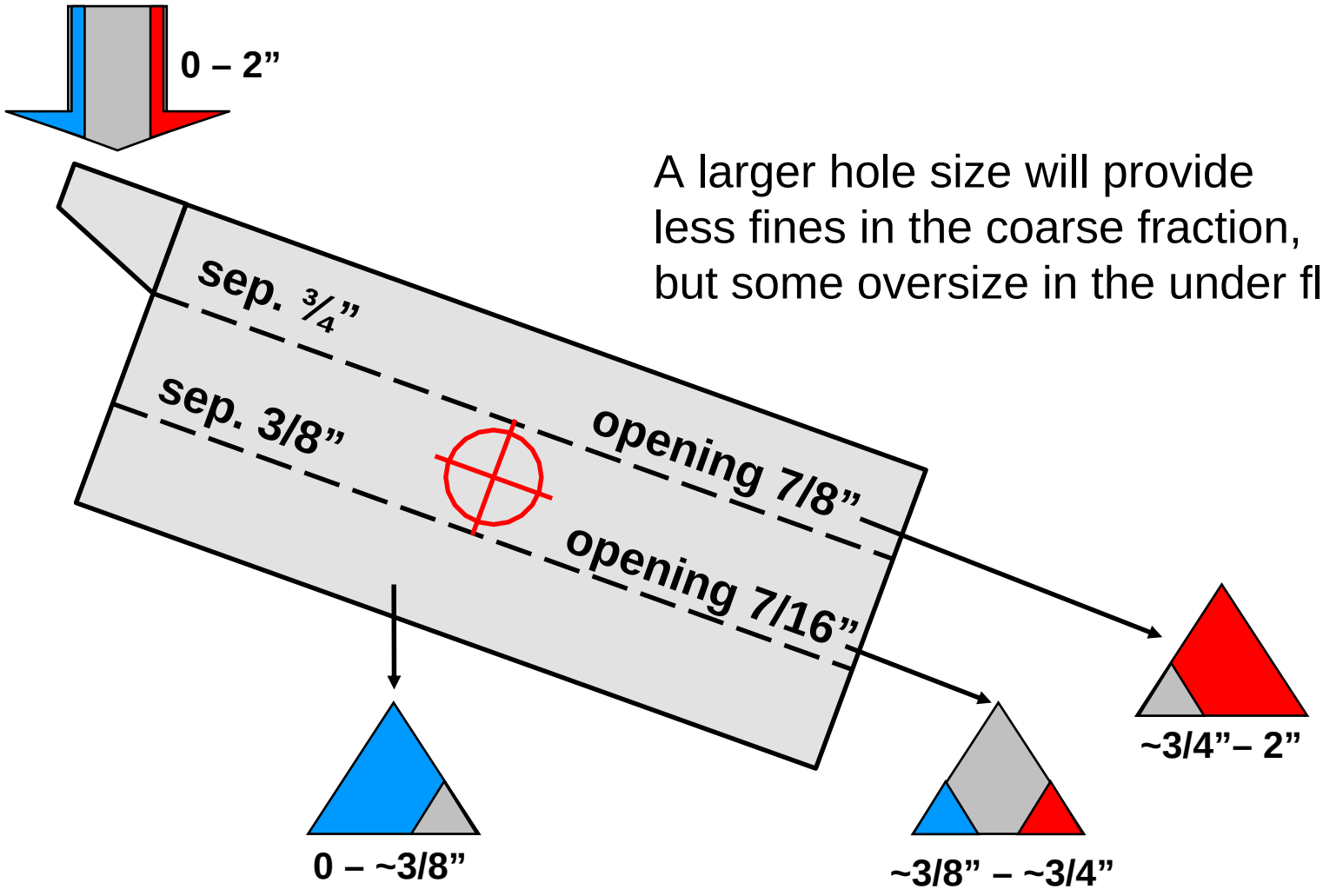
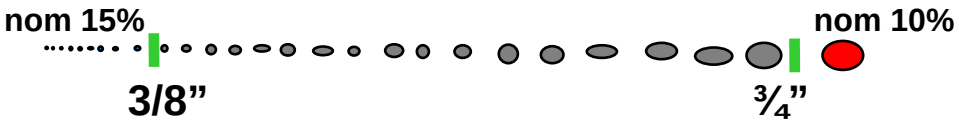
True Screening – Example B



A larger hole size will provide less fines in the coarse fraction, but some oversize in the under flow



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Screening Theory

Accuracy demand

Max Over/Undersize	Factor: L
10/10	0.7
10/15	1.0
10/20	1.2
15/20	1.3
20/25	1.5
20/30	1.7

- Take home message: Accuracy of the fraction produced by the deck. A true representation of the real world limits in which screens operate and aggregate specifications are written.

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Which bed depth is right for stratification?

- ***A thin bed:***

  - Becomes easily fluid, helps stratification.
  - Shorter distance for fine particles to sift down to the deck.
  - Less pegging tendency, stones are not forced down.

- ***A thick bed:***

  - Can reduce accuracy.
  - Overload the screen – carrying capacity.

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Which Bed Depth is Correct for Accuracy?
(Discharge end)

- Maximum bed depth at discharge end is 4x the separation.
  - If too thick, probability is decreased for sized aggregate to properly stratify and pass through an opening.

- Minimum bed depth is 1x the separation.
  - If too thin, material can bounce, stay suspended and not stratify or find an opening, thus reducing accuracy.

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Screen Operation

- After correct screen size is selected, optimal performance results from appropriate operation.

- Unit must be operated at the best combination of the below variables:
    - Speed
    - Stroke
    - Slope
    - Direction of rotation

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Screen Speed and Stroke in Combination with Deck Openings

- Speed = RPM (800 RPM).
- Stroke = Diameter of circular motion (.375” Diameter).
- Material is stratified, separated and screened.

- Large openings = Large stroke and slower speed.
- Small openings = Small stroke and higher speed.

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INCLINED SCREENS
Stroke, Speed and Slope Selection

Stroke (in.)	Nominal Speed (RPM)	Top Deck Opening												Slope Range (degree)
		35M–50M	20M-35M	10M-20M	4M-10M	½”-4M	1”-1/2”	2”-1”	3”-2”	4”-3”	6”-4”	8”-6”	Above 8”	
03	3500													24-30
05	2600													24-30
06	2100													22-28
3/32	1800													22-26
1/8	1600													22-26
3/16	1400													20-25
1/4	1000													18-25
5/16	900													18-25
3/8	850													18-25
7/16	750													18-25
1/2	700													

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For dry 100 lbs/cu.ft. material and flow mechanism rotation.

Horizontal Screens and Feeders
Stroke and Speed Selection

Stroke (in.)	Nominal Speed (RPM)	Top Deck Opening					
		Less than 10M	4M to 10M	½" to 4M	1" to ½"	2" to 1"	4" to 2"
3/8	950	Consult VSMA Member					
7/16	900						
1/2	850						
5/8	800						
3/4	750						

Vibrating Feeders

1/2" to 5/8" stroke is common, 700 – 800 RPM

For dry 100 lbs/cu.ft. material and flow mechanism rotation.

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Vibrating Feeders – Approximate Capacity

	30” (.76 m) Wide		36” (.91m) Wide		42” (1.07m) Wide		50” (1.27m) Wide		60” (1.5m) Wide	
RPM	TPH	mt/h	TPH	mt/h	TPH	mt/h	TPH	mt/h	TPH	mt/h
600									828	754
650							623	568	898	818
700			315	287	473	431	671	611	967	881
750	270	246	337	307	507	462	720	656	1035	943
800	290	264	360	328	541	493	767	698		
850	305	278	382	348	575	524				
900	325	296	404	368	609	555				
950	345	314	427	389	642	585				
1000	365	332								

Angle Downhill	0°	2°	4°	6°	8°	10°
Multiplier	1.0	1.15	1.35	1.6	1.9	2.25

Capacity multipliers for feeder pan mounting angles from 0° to 10°

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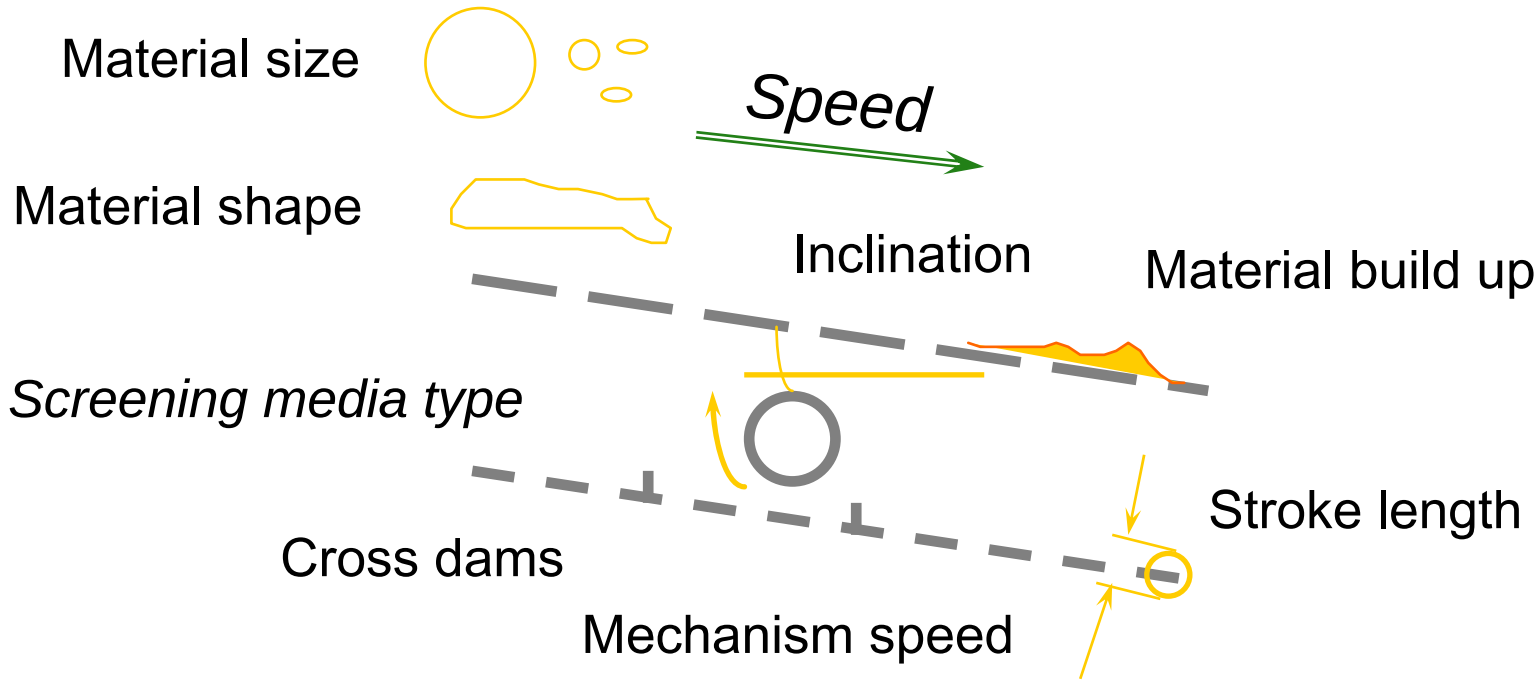
Factors Affecting Material Speed



Gravity Free Fall = 32.2 ft/second

$$G_{force} = \frac{RPM^2 \times Throw}{70418} \qquad G_{force} = \frac{800^2 \times 7/16"}{70418} = 3.9$$

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Direction of Rotation

- With-flow rotation is always preferred.
  - (always consult manufacturer before reversing rotation)

- Counter-flow rotation can produce higher screening accuracy, but can also limit overall capacity due to slower travel speed and high bed depth.

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Speed and Stroke Combination Summary

- **Speed & stroke** are interrelated and selected in standard combinations to offer optimum screening.

- **Speed** is selected to help create a **sufficient material travel rate** to produce a shallow enough bed depth that allows the fines to sift through the material bed and screen out.

- **Stroke** is selected to be **sufficient to prevent plugging** but not so great that it affects the life of the frame, mechanism, screen media, or interferes with the screening process.

- B10 Life = Minimum 10,000 hours.

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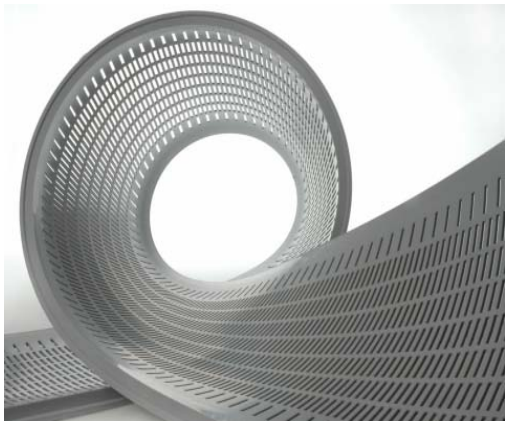
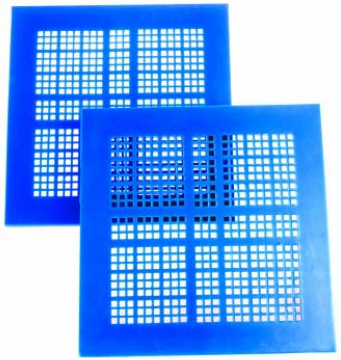
Screening Media





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Screening Media

- Woven wire cloth
- Plastic (Monofilament)
- Piano wire
- Rod deck
- Grizzly bar
- Louvered deck
- Profile deck
- Polyurethane(PU)
- Rubber
- Perforated plate
- Cast plate deck
- Rubber clad perforated plate

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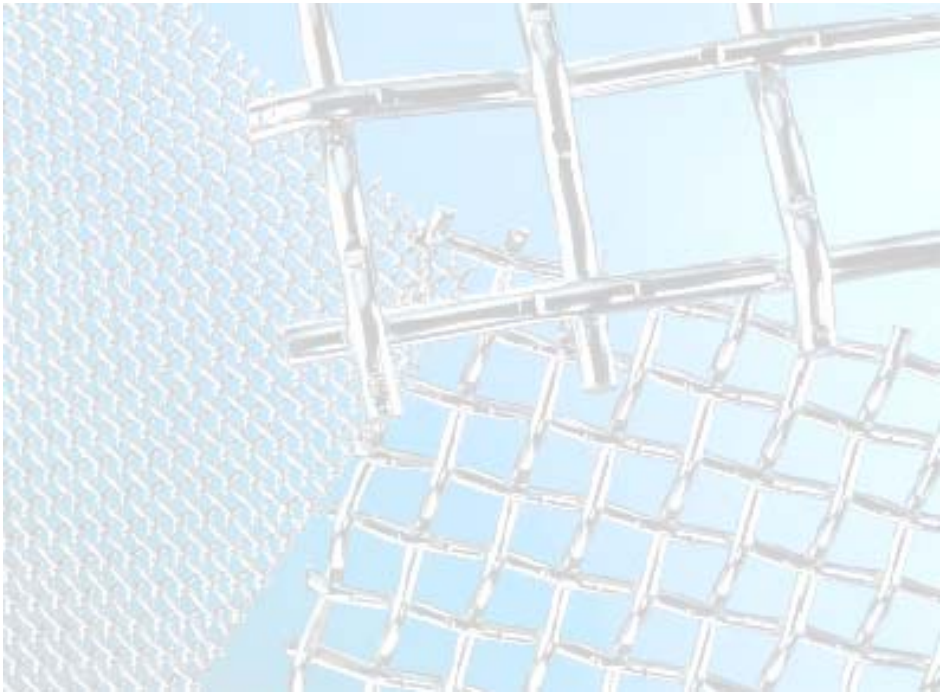
Screening Media – Woven Wire

- Woven wire cloth - openings
  - Square (clear opening / mesh)
  - Long slot
  - Short slot
  - Z slot
  - S slot
  - L slot



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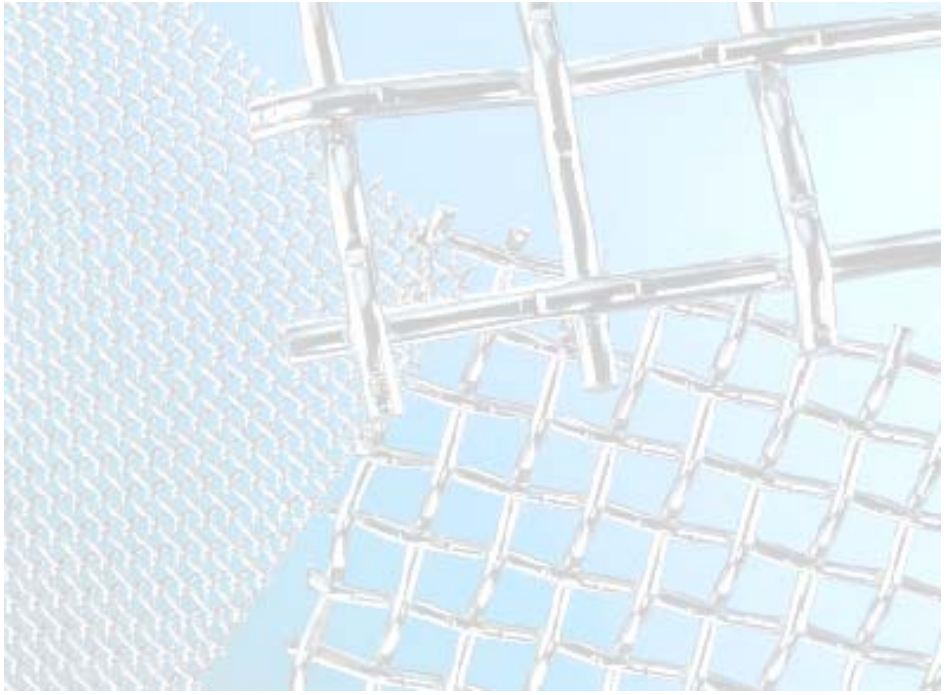
Screening Media – Woven Wire

- Woven wire cloth - weave
  - Plain weave
  - Semi-crimp
  - Double crimp
  - Press lock crimp
  - Intermediate crimp
  - Flat top weave
  - Press crimp



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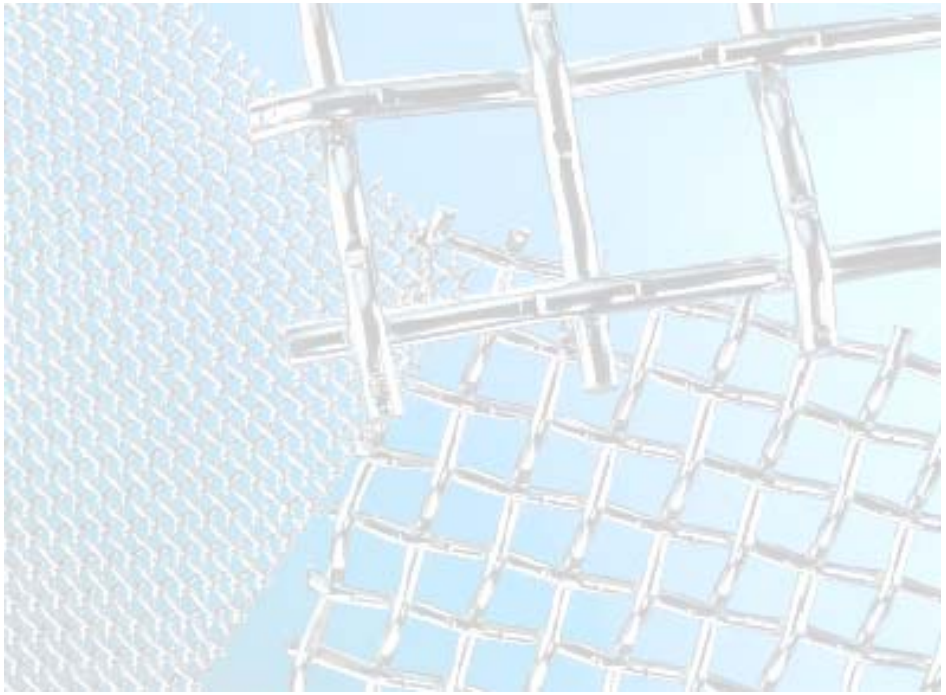
Screening Media – Woven Wire

- Material
  - Stainless steel alloys
  - Heat resistant alloys
  - Copper alloys
  - Aluminum
  - Nickel alloys
  - High carbon steel
    - Oil tempered



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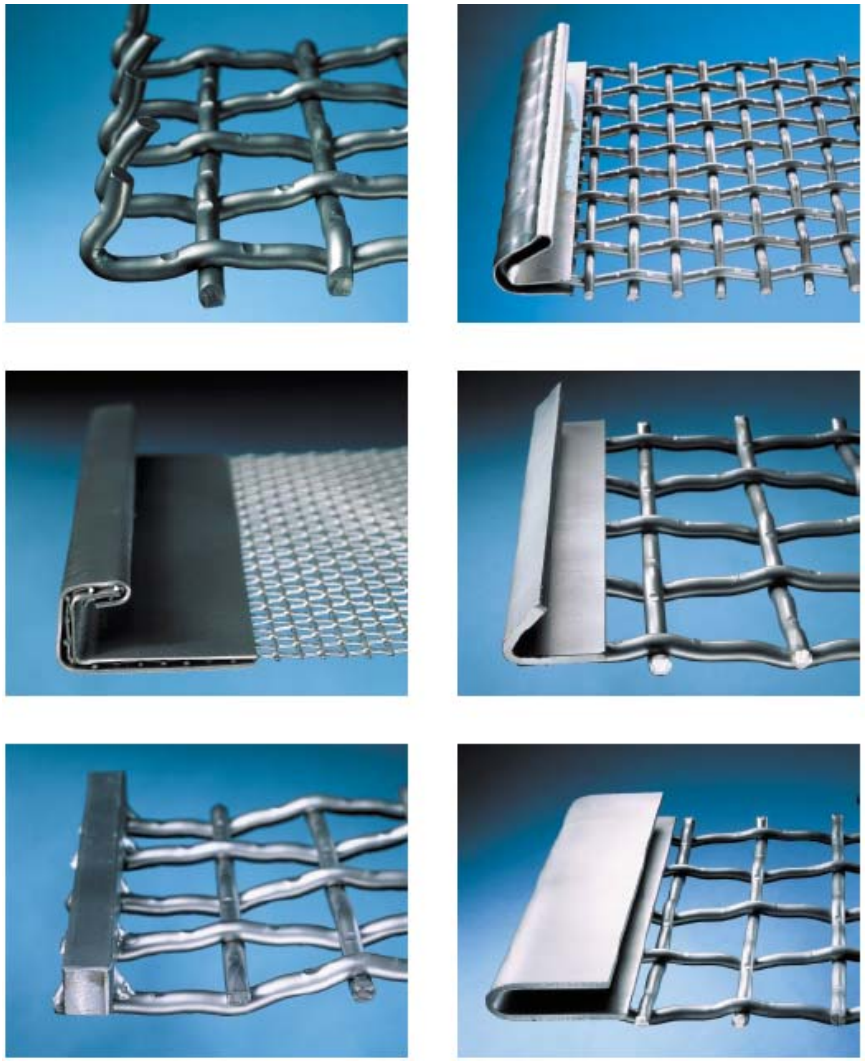
Screening Media – Woven Wire

- Hook strips
  - Hooked edge – 45°
  - Single reinforcing
  - Square
  - Welded insert
  - Welded square bar
  - U-hook strip



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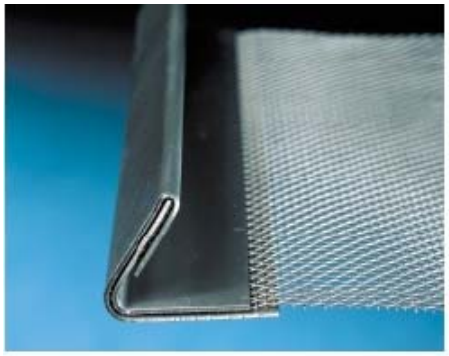
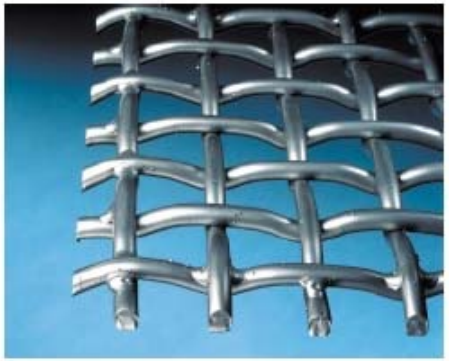
Screening Media – Woven Wire

- Hook strips
  - Double reinforced
  - Welded insert
  - Knuckled Edge
  - Welded edge wire
  - Folded hook strip
  - 90° Welded plate
  - Taped edge…



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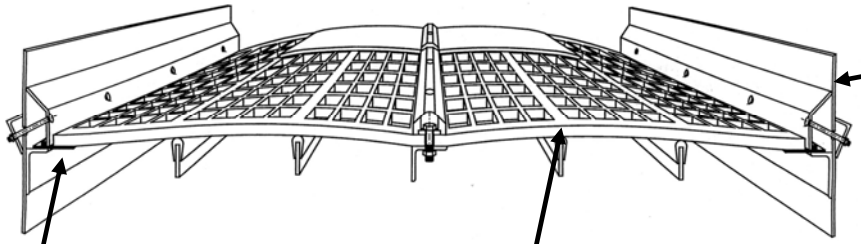
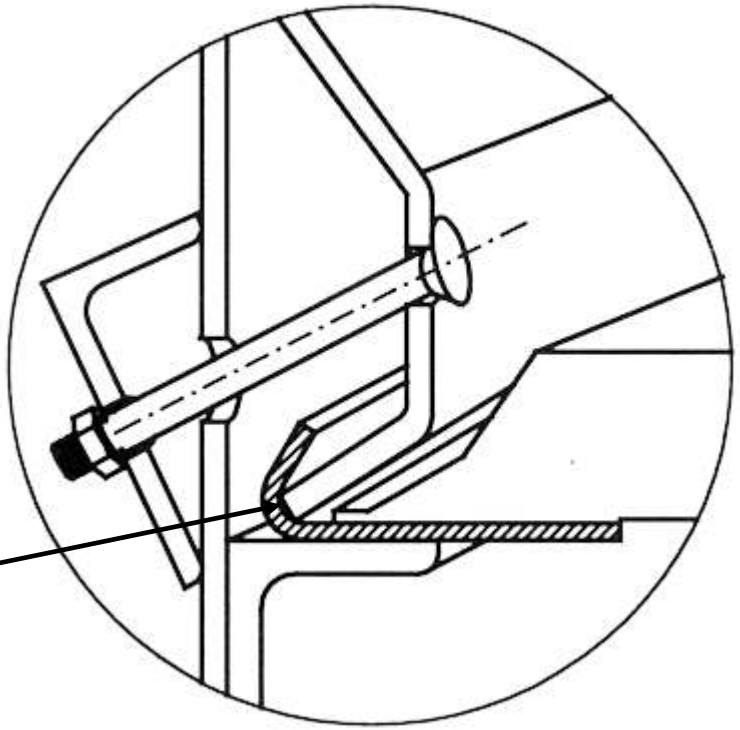
Media Installation

Check installation of clamp rail



Alignment - open area

Media length and hook



Proper alignment of media hook strip

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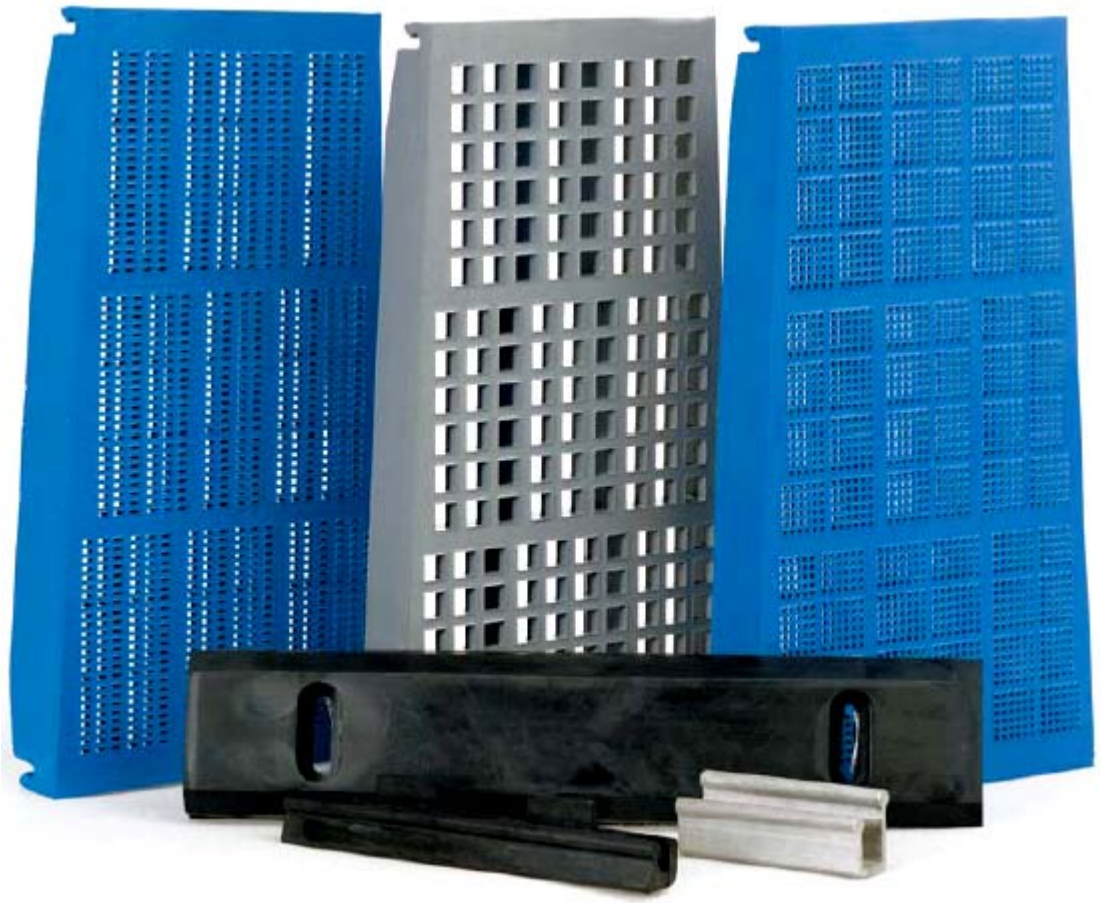
Screening Media – PU

A modular screening media for fine to medium coarse screening in wet applications.



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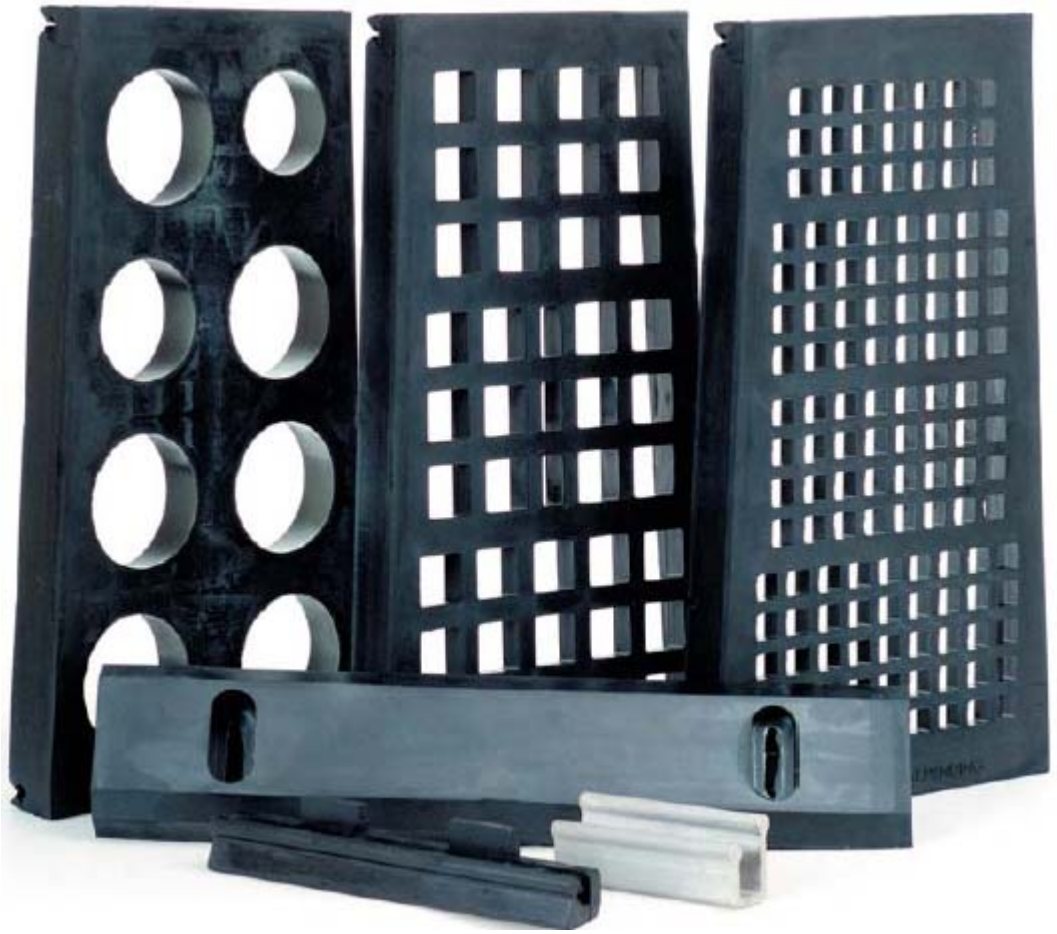
Screening Media – Rubber

A modular screening media for fine to medium coarse screening in dry applications.



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Screening Media – Rubber (40 Duro)

A modular screening media of soft rubber for fine screening in difficult applications.

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Screening Media – Synthetic PU or Rubber

Tensioned PU or rubber screening media for fine to medium coarse screening in wet or dry applications.

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Screening Media Selection Guide

	Modular rubber screening media	Modular anti-blinding screening media	Modular PU screening media	Tensioned anti-blinding PU screening media	Tensioned rubber screening media	Tensioned PU screening media	Pre-tensioned rubber screening media	Pre-tensioned PU screening media	Flat self-supporting rubber screening media	Self-supporting rubber screening media with skidbars	Special screening media
Screening duty	Intermediate and final	Final	Intermediate and final	Final	Intermediate and final	Intermediate and final	Secondary, intermediate	Intermediate and final	Primary, secondary	Primary, secondary	Final
Max feed size (mm)	20 - 150	10 - 50	10 - 100	20 - 50	20 - 150	10 - 100	30-250	10 - 100	150 - 300	75 - 400	10 - 50
Separation	10 - 63	2 - 16	1 - 31,5	2 - 16	5,6 - 63	1 - 45	16 - 90	1 - 45	45 - 120	45 - 120	2 - 25.4
Application	Dry	Dry / anti-blinding	Wet / dry	Dry / anti-blinding	Dry	Wet / dry	Dry	Wet / dry	Dry	Dry	Wet / dry / antiblinding
Dewatering	No	No	Yes	No	No	Yes	No	Yes	No	No	No
Deck design	Special	Special	Special	Cambered	Cambered	Cambered	Cambered	Cambered	Flat	Flat	Special
Panel type	Modular	Modular	Modular	Tensioned	Tensioned	Tensioned	Pre-tensioned	Pre-tensioned	Self supporting	Self supporting	Special
Material	Rubber	Soft rubber	Polyurethane	Soft Poyurethane	Rubber	Polyurethane	Rubber	Polyurethane	Rubber	Rubber	Polyurethane
Aperture	Moulded and punched	Punched	Moulded	Punched	Punched	Moulded	Punched	Moulded	Moulded and punched	Moulded	Punched
Most common thickness (mm)	8, 11, 15, 20, 25, 30, 35 and 45	2.5, 3.5, 5.5, 8, 11 and 15	Hole size dependent	2.5, 3.5, 5.5 and 8	5, 7, 10, 12, 15, 20, 25, 30, 35, 40 and 50	Hole size dependent	15, 20, 25, 30, 35, 40, 50 and 60	Hole size dependent	40, 50, 60 and 70	55+20, 70+50 and 70+60	2, 3, 4, 5, 6, 7, 8, and 9
Fastening	Snap-on	Snap-on	Snap-on	Cross- or length tensioned	Cross- or length tensioned	Cross- or length tensioned	Clamp down	Clamp down	Clamp down	Clamp down	Wedged or bolted depending on screen design
Accessories	Side liner and side liner spacer	Side liner and side liner spacer	Side liner and side liner spacer	Centre hold down, Centre hold down spacer and Capping	Centre hold down and Capping	Centre hold down and Capping	Side hold down, Centre hold down and Capping	Side hold down, Centre hold down and Capping	Side hold down and Centre hold down	Side hold down and Centre hold down	Wedge

Bulk density max. 1.8 metric ton/m^3

If your application falls outside the limits specified above, please contact your Sandvik Mining & Construction representative.

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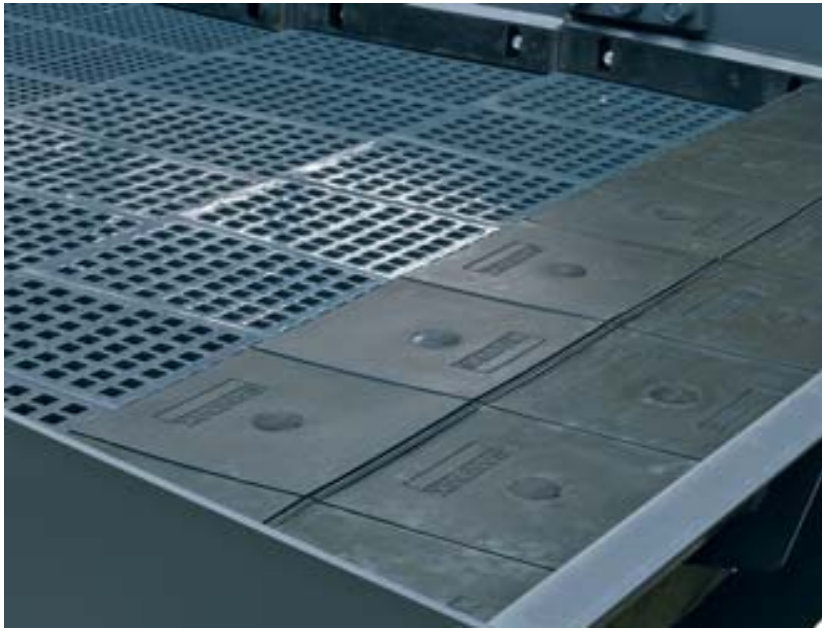
Wear Protection in the Feed Box, Discharge Lips and Side Liners

- AR steel
- Steel-backed rubber
- PU
- Ceramics



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Wear Protection for Feeders and Hoppers

- AR steel
- Mild Steel
- Rubber and steel backed rubber
- Cast or fabricated grizzly bars

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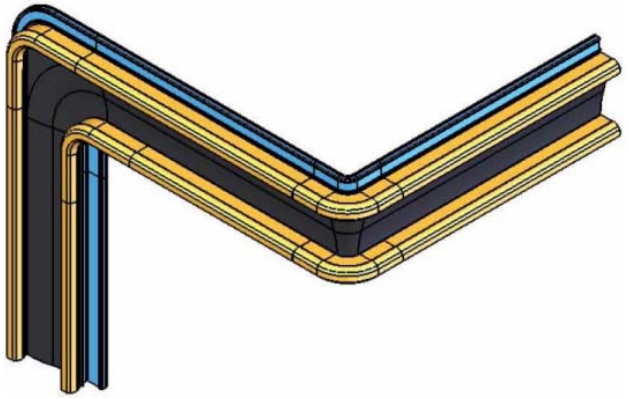
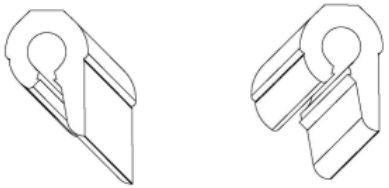
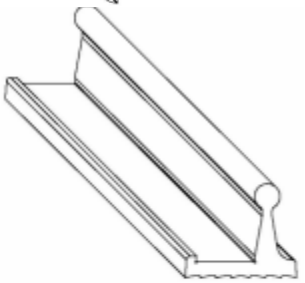
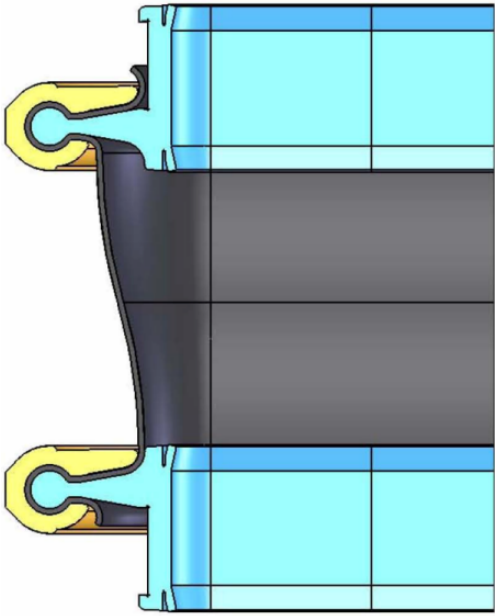
Options: Dust Encapsulation

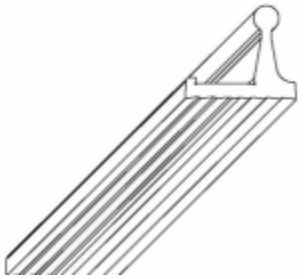
- Safety
- Good neighbor
- Sound
- Dust

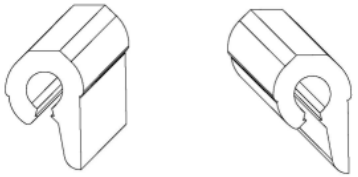












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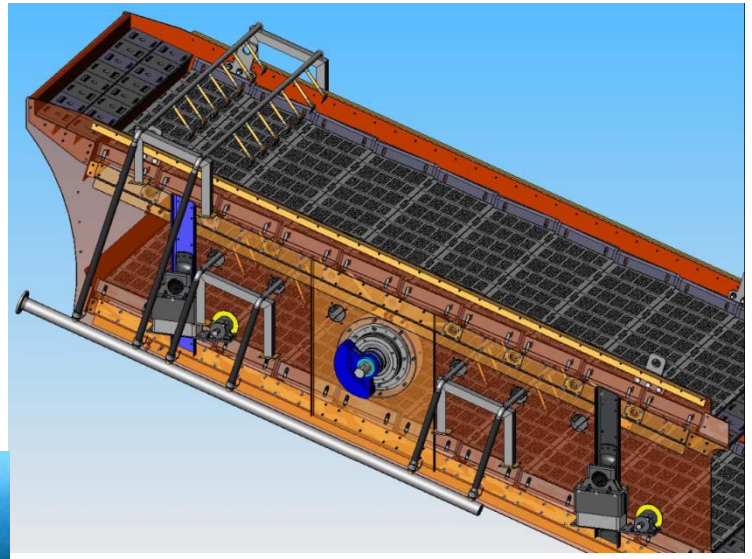
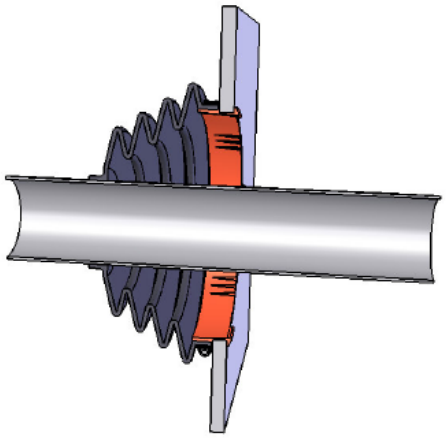
Options: Spray System

- Wash – clean – spec stone
- Stationary or live mounted
- Rule of thumb:
  - 4-6 gpm / ton of feed





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Options

- Base Frame
- Media
- Cardan shaft drive
- Liners
- Motor(s)
- Special paint or coating
- Steel structure.....

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Steps to Improving Screen Performance

- Identify the improvement you want or determine the problem that you have with your vibrating screen.
  - *Examples: Increase tph, improve screen efficiency, cleaner product, reduce re-circulating load…*
- If you have a new problem, determine if something has changed in the circuit, material characteristics, crusher setting, screen opening, screen speed and stroke.
- Gather specific application data as it applies to that unit and seek assistance from the manufacturer or dealer.

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Solving Plugging and Blinding with Speed & Stroke

- Make sure you have the correct speed & stroke for the openings. There is normally a speed & stroke adjustment which can be made to help.

- For plugging, increasing the stroke normally helps to kick out the near size or elongated material.

- For blinding, increasing the speed normally helps and sometimes increasing the stroke also helps. Sometimes blinding problems start out as plugging problems.

Always consult with the factory before making any changes!

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Determining Speed & Stroke

Speed: Electronic RPM Meter

OR

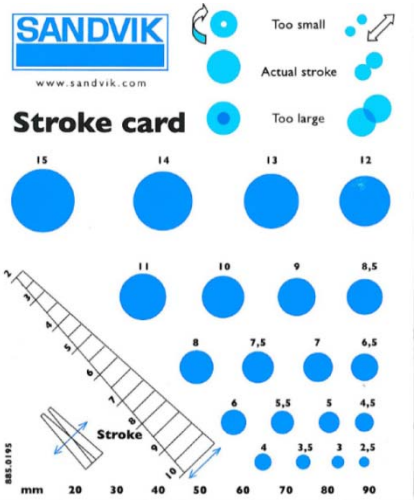
Drive sheave dia. divided by driven sheave x motor RPM.

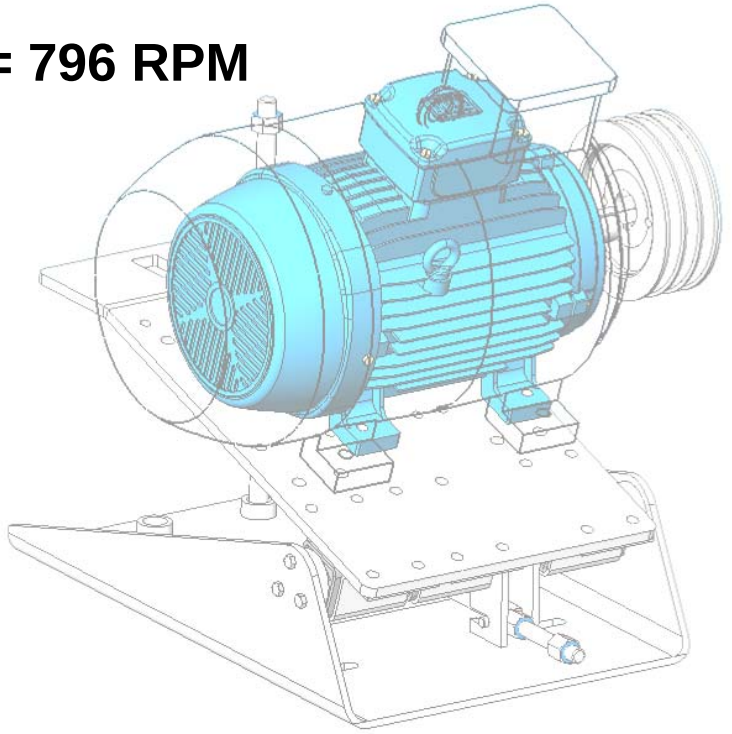
Example:

Motor sheave **5**”, Screen sheave **11**”, Motor RPM **1750**

5 divided by 11 = .455 x 1750 = 796 RPM

Stroke: Stroke Card





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V-Belt Drive

- Check alignment of sheaves. Shafts must be parallel.

- Maintain uniform tension. When idle, belts should appear snug. In motion, there will be a slight movement on slack side when using a pivoted motor base.

- Keep drives well ventilated. Avoid heat build-up.

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V-Belt Drive

- Use new belts of the same make.
- Always use matched sets of belts – never mix.
- Never use belt dressing.
- Worn sheaves reduce belt life. Check sheaves frequently.
- Oil Carefully. Excessive oil on belts causes rubber to swell and belts to fail prematurely.
- Never force belts onto sheaves. Release take-up.

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Start-up / Commissioning Form

Customer Representative/Title	Phone
Address	
City, State, Zip	
Sandvik M & C Distributor	
Contact	Phone
Application: ☐ Rock ☐ Gravel ☐ Recycling Ambient Temperature: _____ °C _____ °F	

A. Prior to actual starting of screen:	OK	NOTE
1.a. Oil level	☐	☐
1.b. Oil sight glass in proper location	☐	☐
1.c. Type of lubricant	☐	☐
1.d. Check appropriate grease filling locations	☐	☐
2. Screen cloth tightness	☐	☐
3. Foundation design adequate to support screen	☐	☐
4. Adequate clearance from chute and structure	☐	☐
5. Proper chute design to prevent build up	☐	☐
6. Screen installed level	☐	☐
7. Tighten loose bolts or wedges	☐	☐
8. Springs vertical at horizontal support	☐	☐
9. Proper alignment of motor sheave in relation to drive sheave	☐	☐
10. V-belt tension correct	☐	☐
11. Bin level indicator if mounted directly over bin	☐	☐
ACCESSORIES		
Automatice lubrication unit		
12. Check adjustment	☐	☐
13. Check grease outflow	☐	☐
14. Check hose fixings and linings	☐	☐

B. Screen no load operation observation		
1. RPM	☐	☐
2. Stroke correcty for application amount _____	☐	☐
3. Counterweight setting	☐	☐
4. No oil leaks	☐	☐

	OK	NOTE
5. Screen rotating proper direction for application	☐	☐
6. No load amps _____	☐	☐
7. Water spray provisions	☐	☐
8. Platform and guards	☐	☐
9. Slope angle	☐	☐

C. Operation performance loaded		
1. Even feed distribution	☐	☐
2. Feed size max_____min_____	☐	☐
3. Loaded amps _____	☐	☐
4. Bearing temperature normal	☐	☐
5. Approximate bed depth	☐	☐
6. Material flow rate _____	☐	☐
7. Indicator cards for motion	☐	☐
8. Feed rate checked: Constant _____ Surging _____	☐	☐
9. Cloth size	☐	☐
Top_____2nd_____3rd_____4th_____		
10. Feed analysis checked	☐	☐

D. Operation training		
1. Training of safety issues	☐	☐
2. Operating the screen	☐	☐
3. Daily maintenance of the screen	☐	☐
4. Name / Company of attendees in training		
a. _____		
b. _____		

NOTES: _____

(Please additional notes on back of this paper)

Customer Date	SMC/Distributor Service Eng. Date	SMC Service Manage Date

Daily – Weekly – Monthly: Safety and service check list

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Maintenance Check List

- Establish a maintenance schedule based upon manufacturer's recommendation.
- Set a daily time period and routine for lubrication, inspecting cloth for condition and tension, inspection of cloth support rubber, etc.
- Do not inspect or lubricate vibrating equipment that is running.
- Check all bolted connections for proper torque on a routine basis.
- Use check-off lists to aid in insuring completion of maintenance duties. Keep good maintenance records.

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Maintenance Check List

Before Start-up:

- Check the screening surface for material build-up. Starting with excessive material on the screen deck may damage the vibrating screen.
- Check the screening surface for breaks or worn areas.
- Make sure there is a 2” minimum clearance between any part of the body and any stationary chute, hopper, or any of the support structure. Guards in-place.
- Pay particular attention to oil levels, breathers, pumps, line strainers, warning signals, and pressure hose assemblies. Refer to manufacturer’s manuals.

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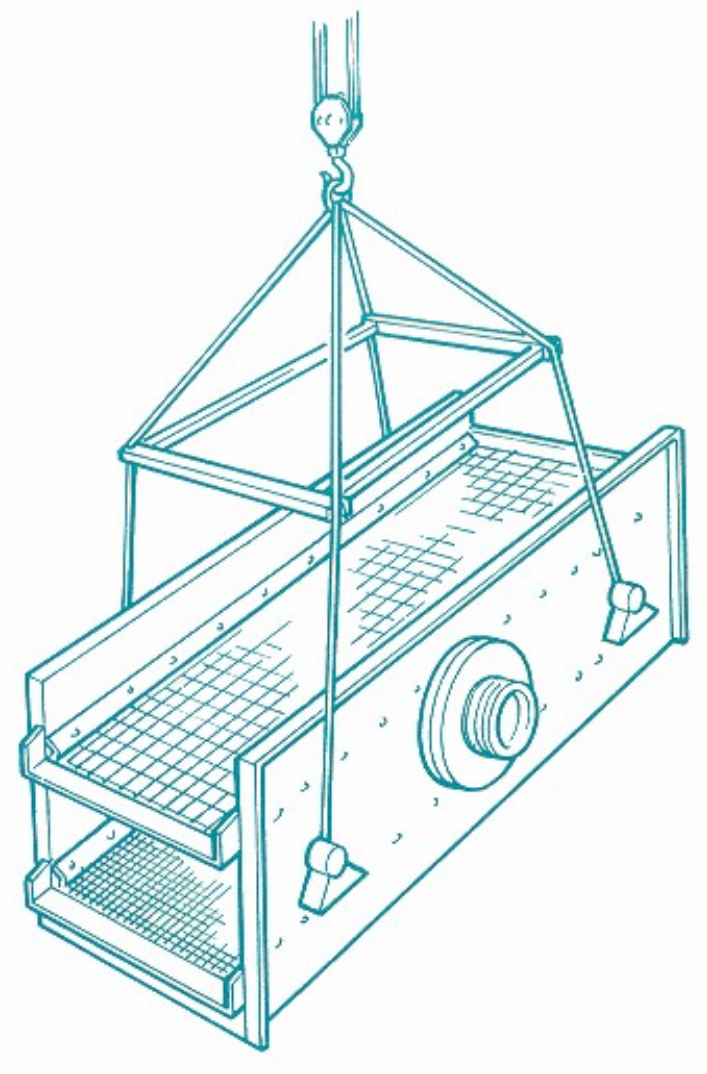
Safe Installation Procedures

READ THE MANUFACTURE'S INSTRUCTION BOOK FIRST.

- Safety always.
- Select crane or hoist and lifting tackle based on manufacturer’s weights for screen.
- Provide means for hoisting and handling largest usual repair part.
- Provide adequate clearance and headroom for making repairs.
- Provide means for handling wire cloth, or other screening surfaces.



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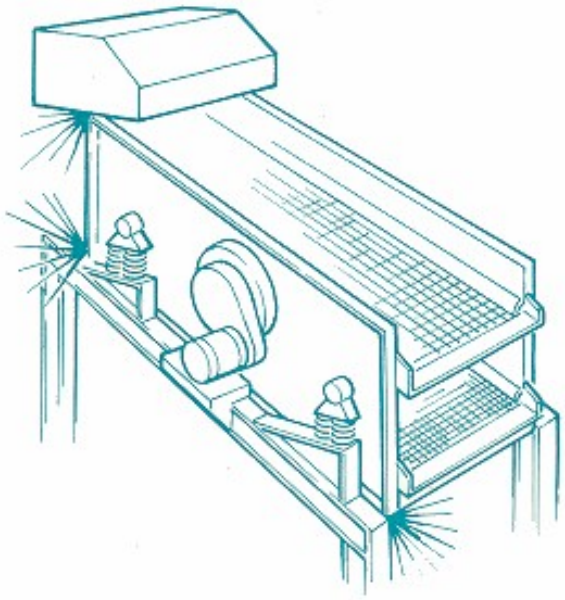
Safe Installation Procedures



- Check complete installation for compliance with all Federal, state and local regulations for ladders, walkways, rails and platforms, color coding, hazard warnings, guarding, enclosing drives and rotating parts.

- Do not weld any attachments onto screen body or base without consulting the manufacturer.

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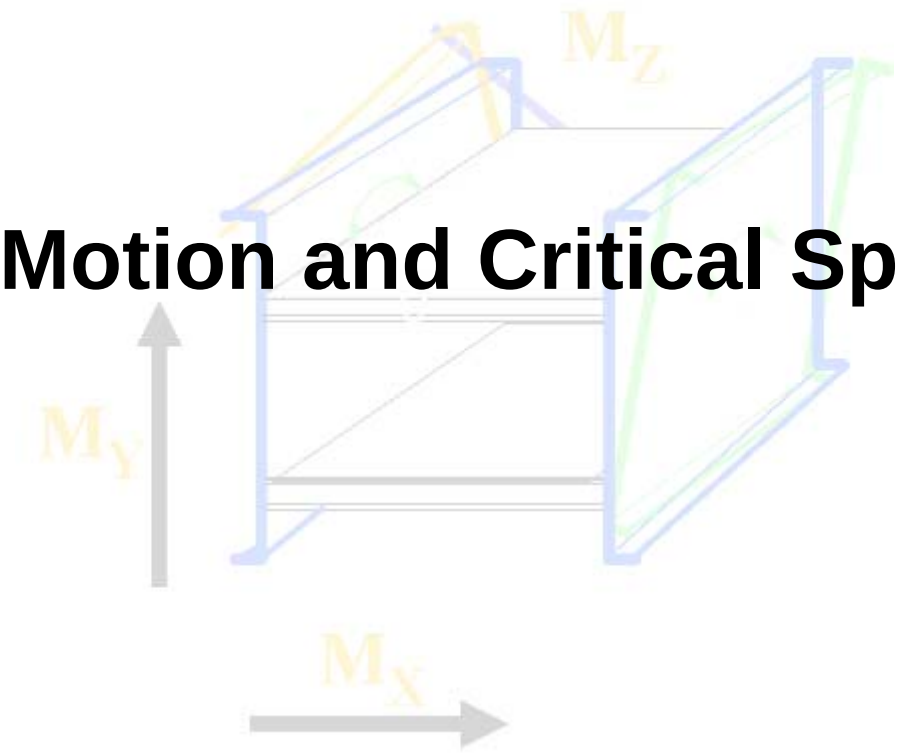
Off-Motion and Critical Speed



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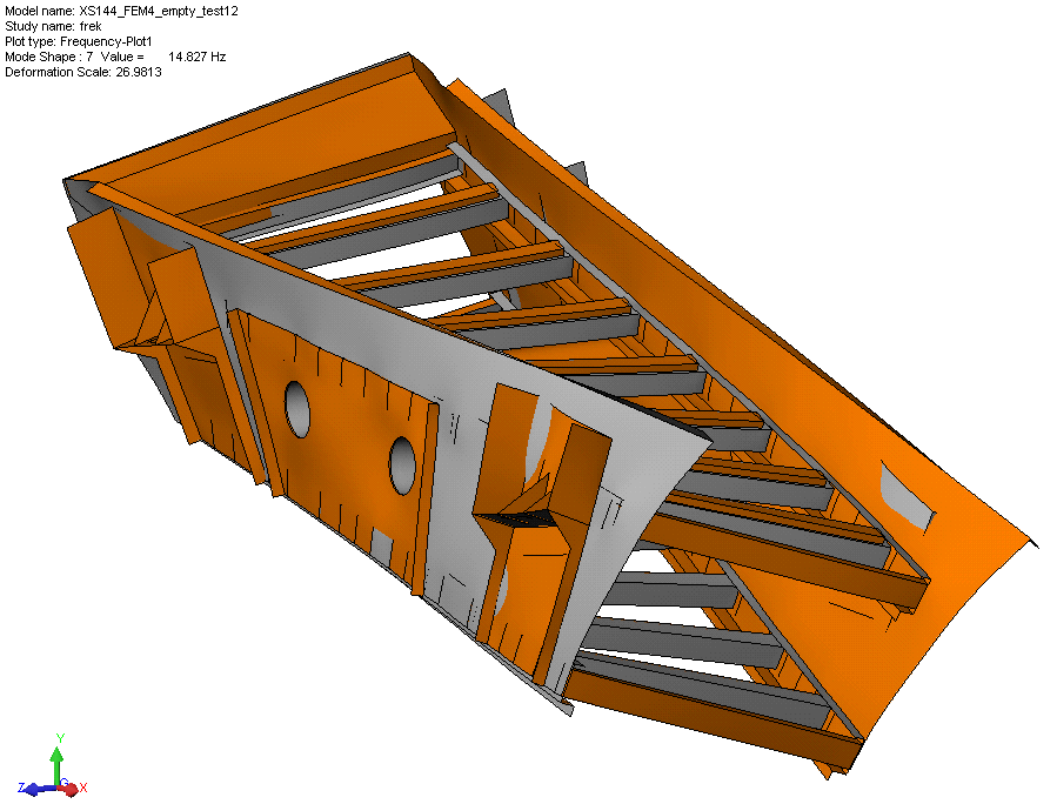
Off-Motion and Critical Speed



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Off-Motion & Critical Speed

What is Off-Motion?

- When the vibrating screen of feeder is not going through its true design motion but instead is running with severely distorted and varying motions throughout the body of the unit.

How to check for Off-Motion?

- Select an area on the side plates and observe the motion pattern.
- Check for “mirror image” pattern, one side compared to the other.
- Stand at the end of the of the vibrating unit and determine if all frame members are moving straight up and down rather than at a sideways angle.

What is Critical Speed?

- Each screen body has its own natural frequency. If the machines operational frequency is too close to the natural frequency the stress can cause off-motion and reduce the life of the screen.

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What Causes Off-Motion?

- Unit not installed level (unequal corner spring deflection).
- Broken / worn springs or rubber mounting units.
- Loose fasteners.
- Material build-up on deck or decks.
- Side loading.
- Overloading.
- Plugging and blinding.
- Speed.
- Inadequate support structure.
- Inadequate body design.
- V-Belt tension.
- Vibration dampening adjustments.

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Conclusion

- This information was presented to provide you with information to promote a safer, more cost efficient operation.

- My best advice is safety first. When a screening issue arises, always look for the obvious (broken spring, belt too tight, broken cross member, loose bolting hardware).

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