Screening – Making The Right Stuff

QUARRY ACADEMY

Improving Processes. Instilling Expertise.

DYNO
Dyno Nobel

SANDVIK

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“Theory of Screening”

Often described as “not so much a science but a black art”

So let’s see what we can make of it.

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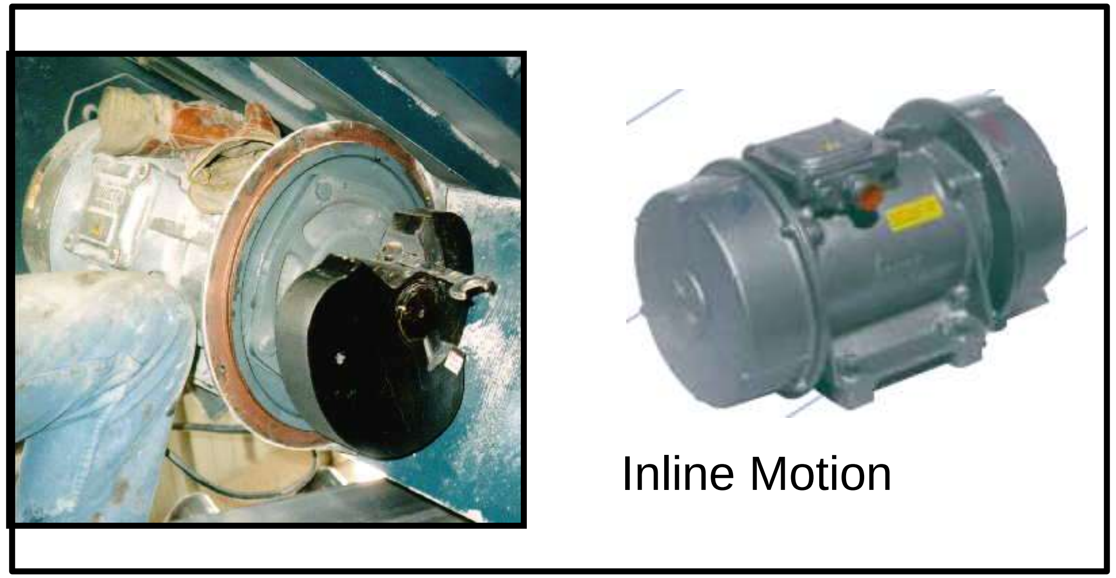
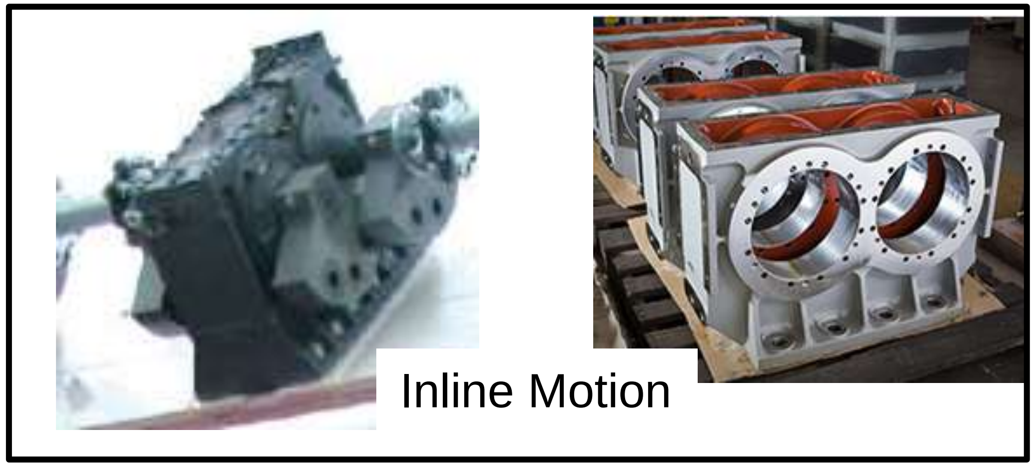
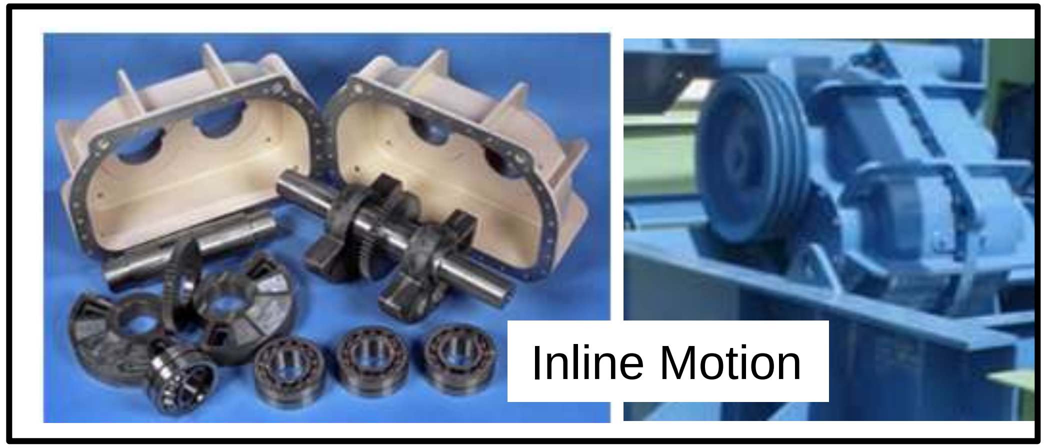
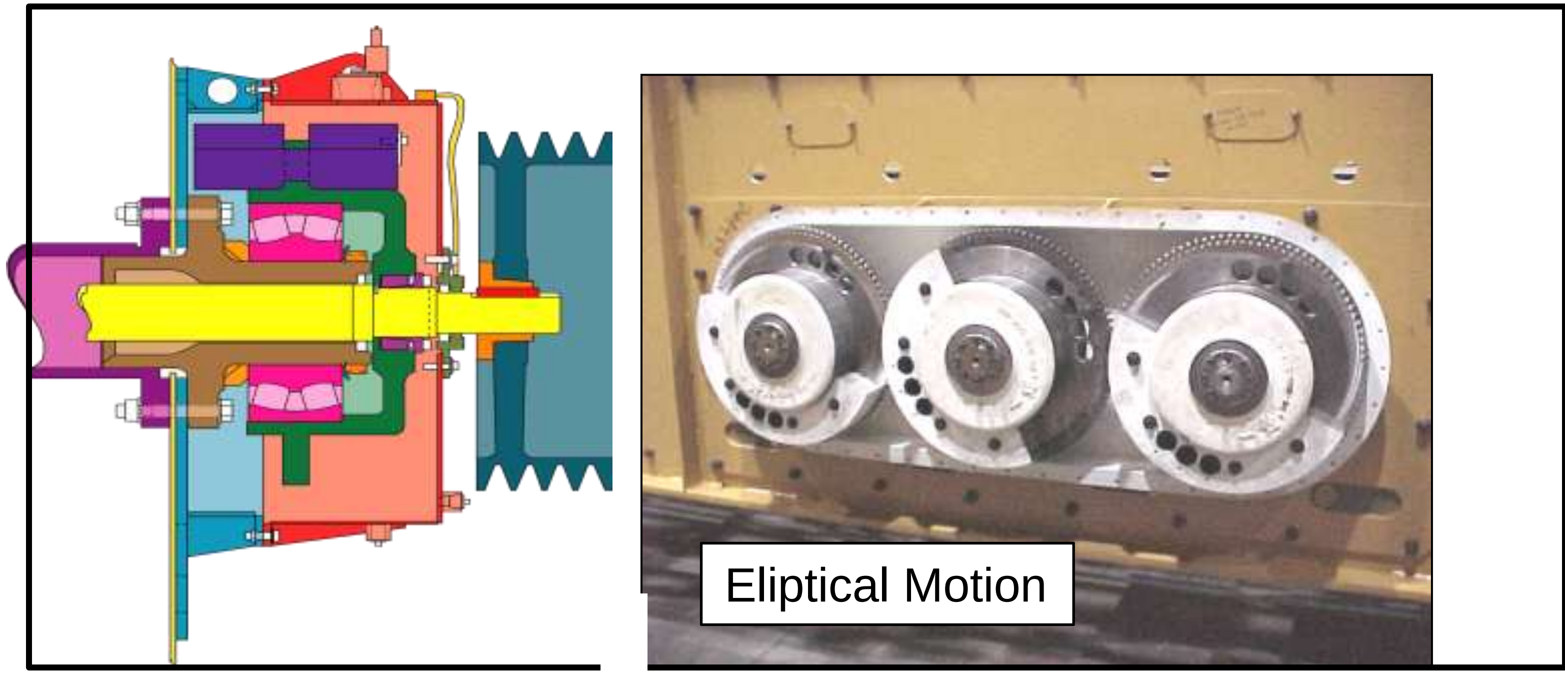
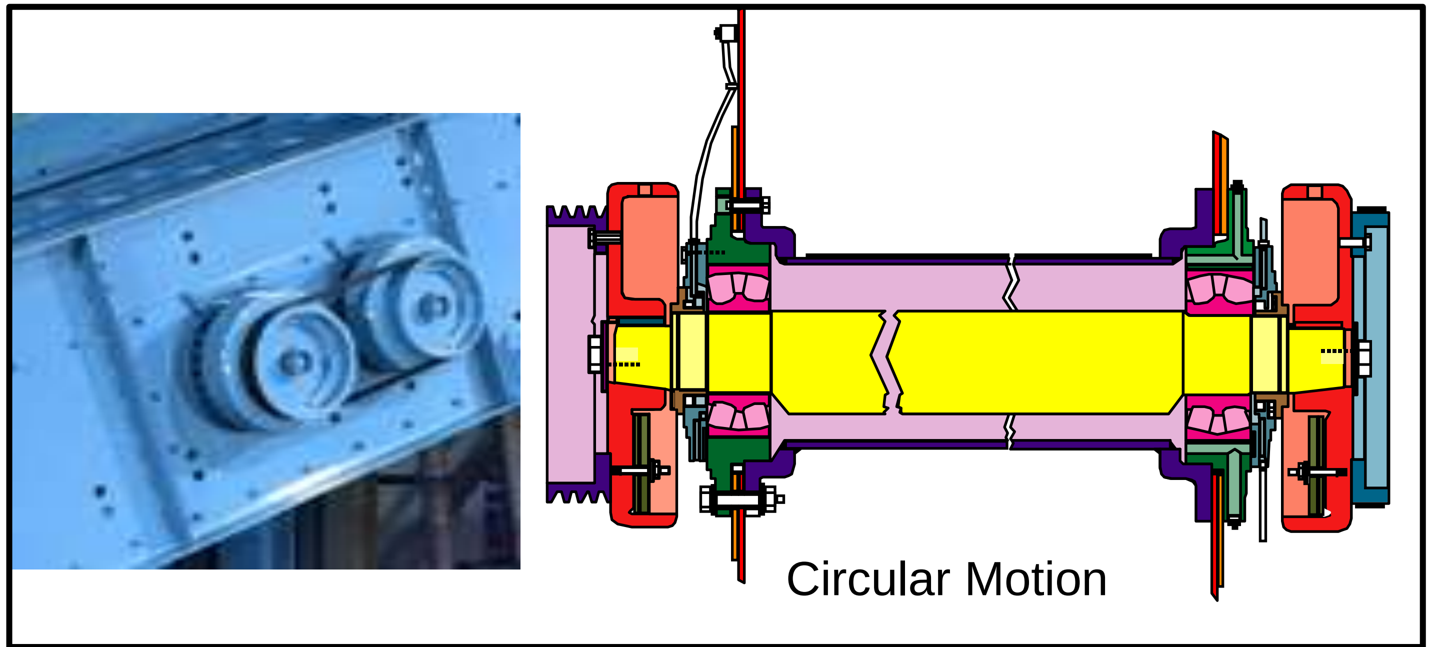

Inline Motion


Inline Motion

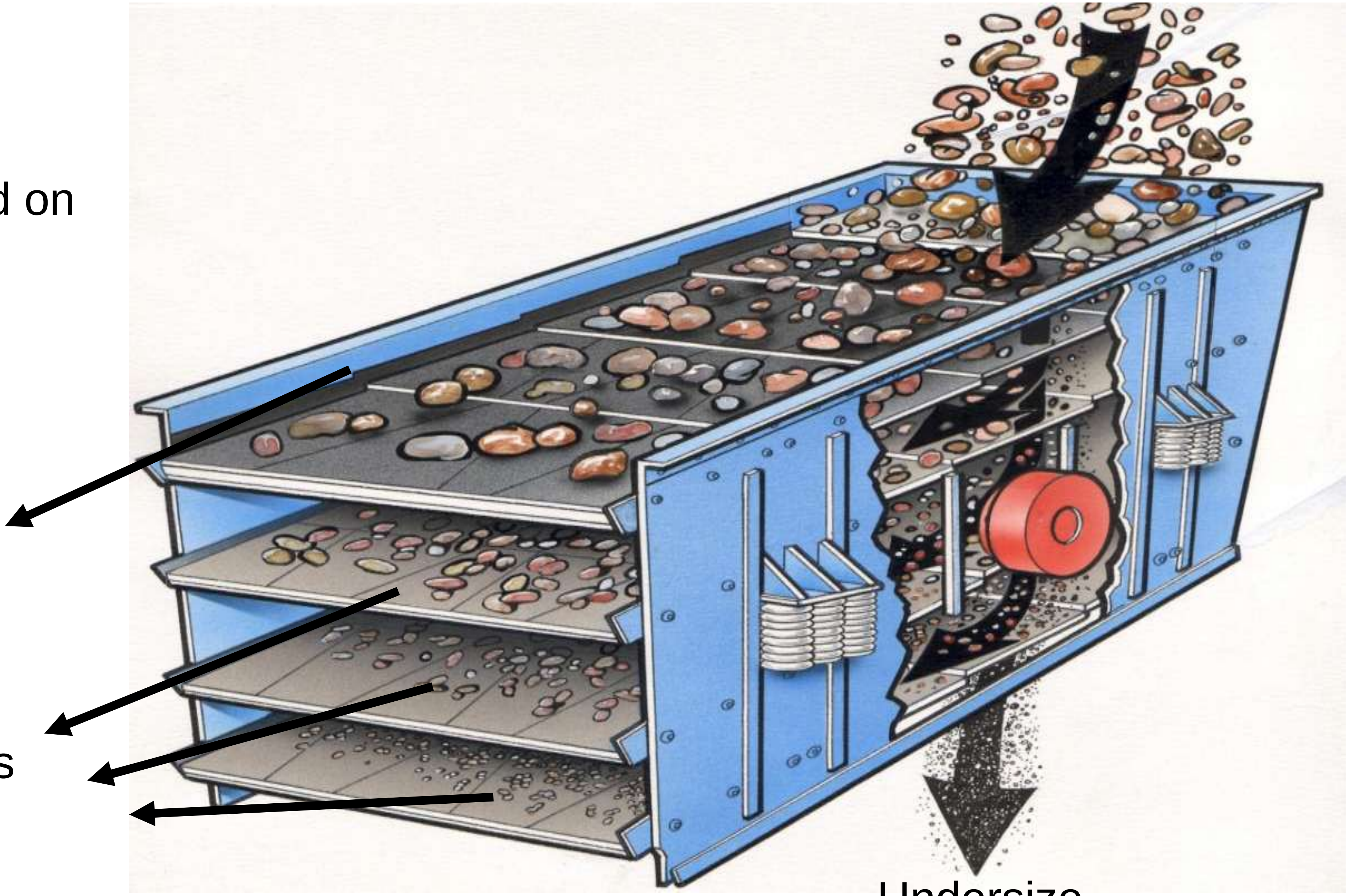

Inline Motion


Eliptical Motion


Circular Motion

Screens
Basics of Screening

- What is screening?
  - Particles being classified based on their size



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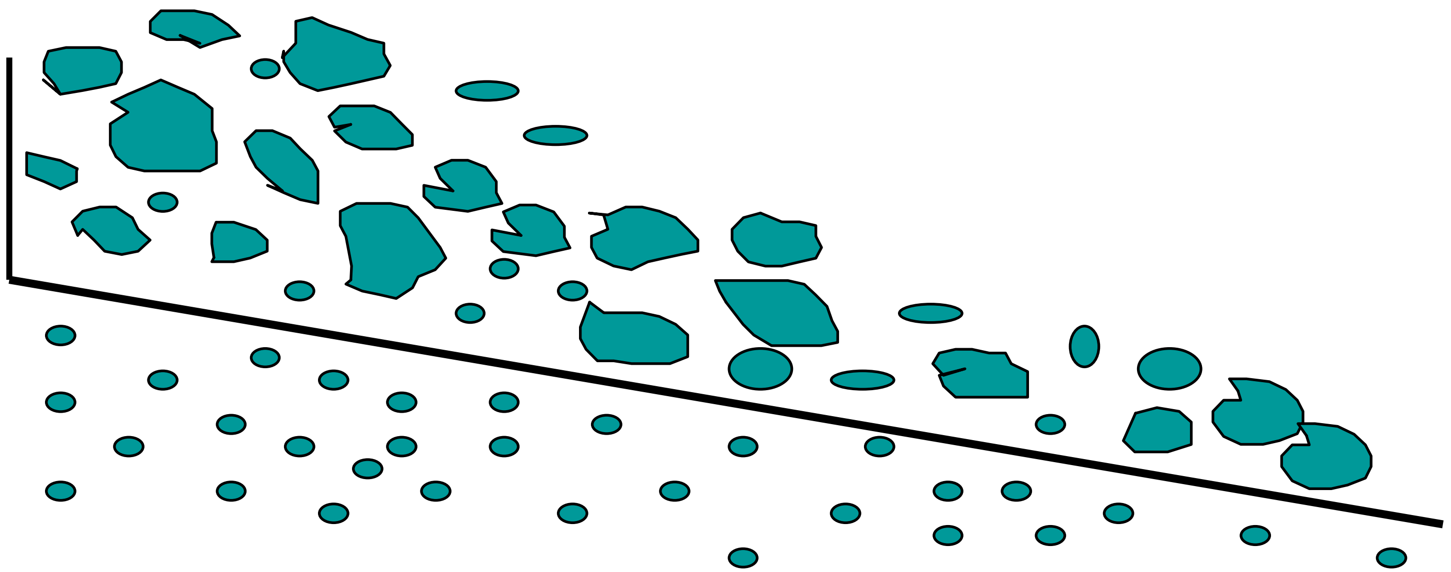
Screening Theory

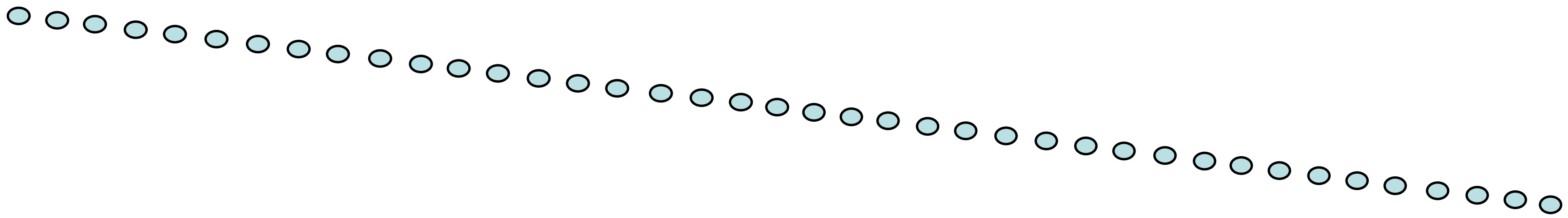
STRATIFICATION

- Large particles rise to the top
- Smaller particles sift through the voids and find their way to the bottom
- A material bed is required for effective screening



Screens
Basics of Screening

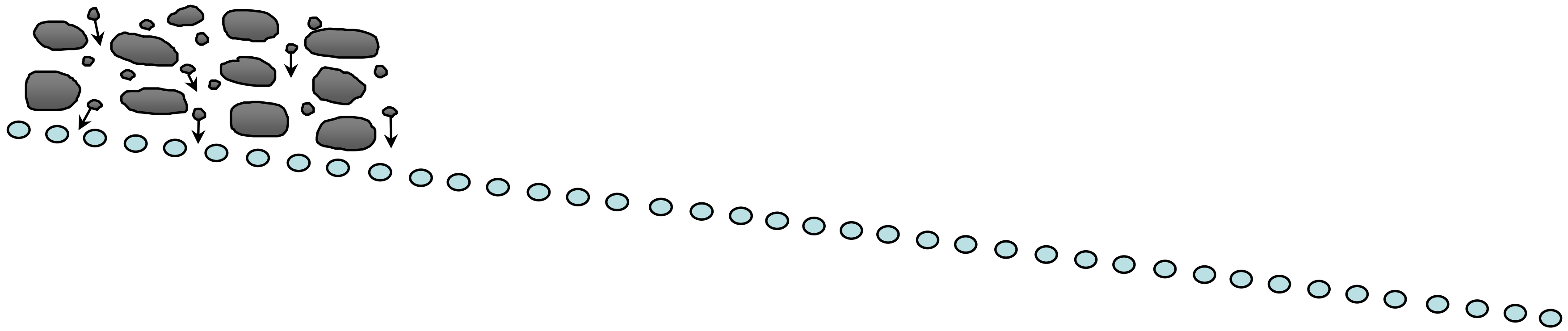
<u>What is conventional-screening?</u>



Screens
Basics of Screening

What is conventional-screening?

Material is fed onto the screen.



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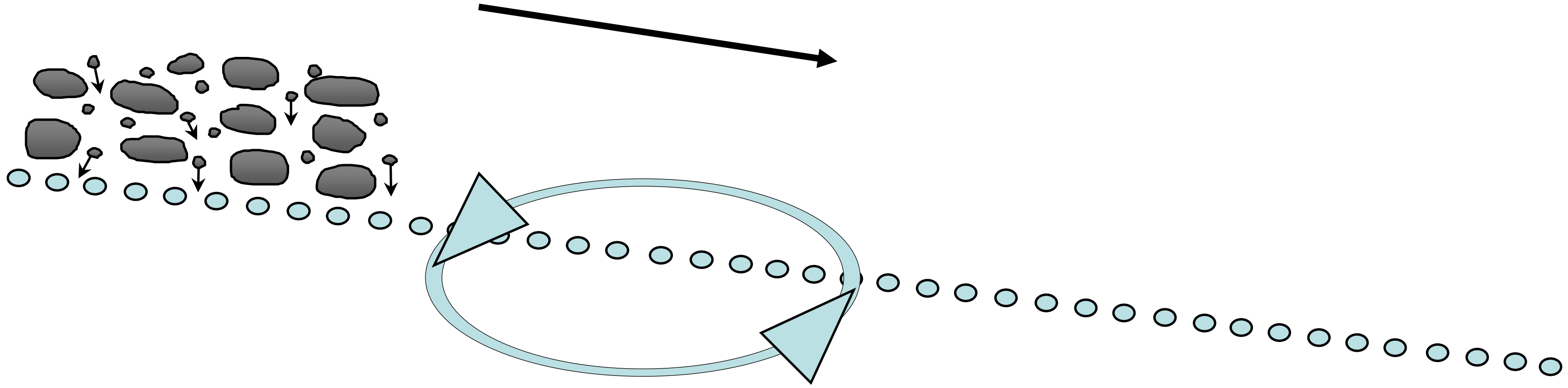
Screens
Basics of Screening

What is conventional-screening?

Material moves along the screen due to gravity and the motion of the screen



Conventional screening is based on stratification

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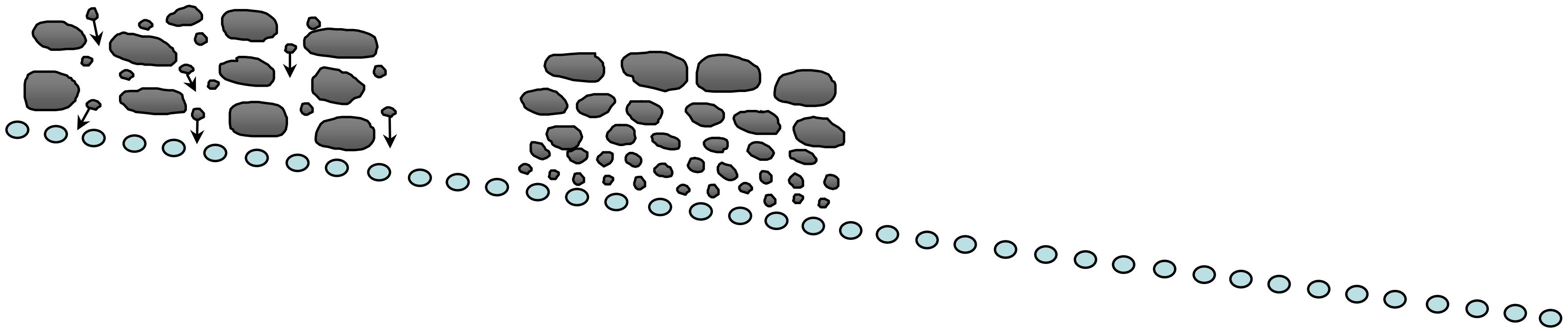
Screens
Basics of Screening

What is conventional-screening?

Particles of the same size end up in the same layer, this is called stratification



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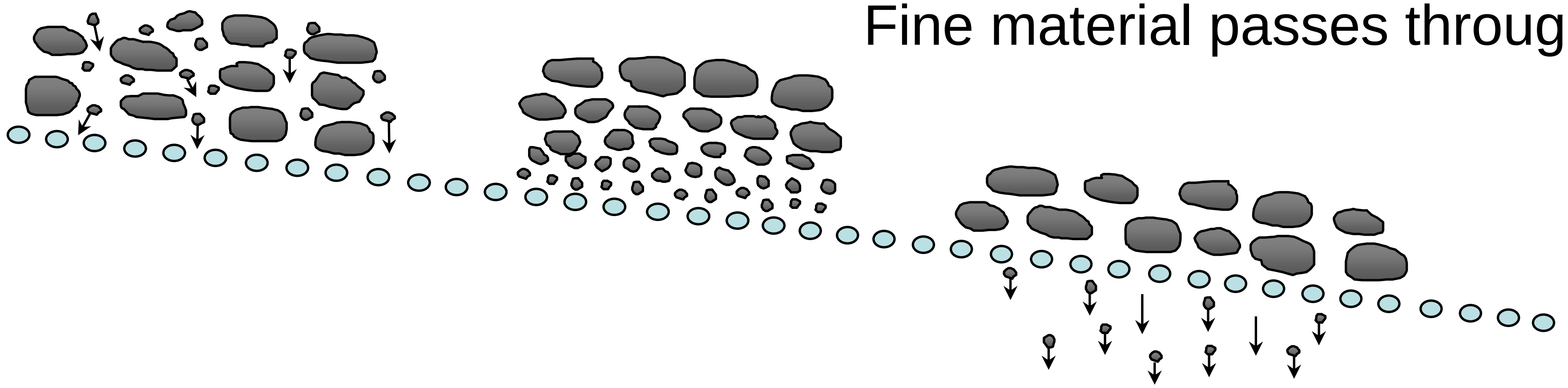
Screens
Basics of Screening

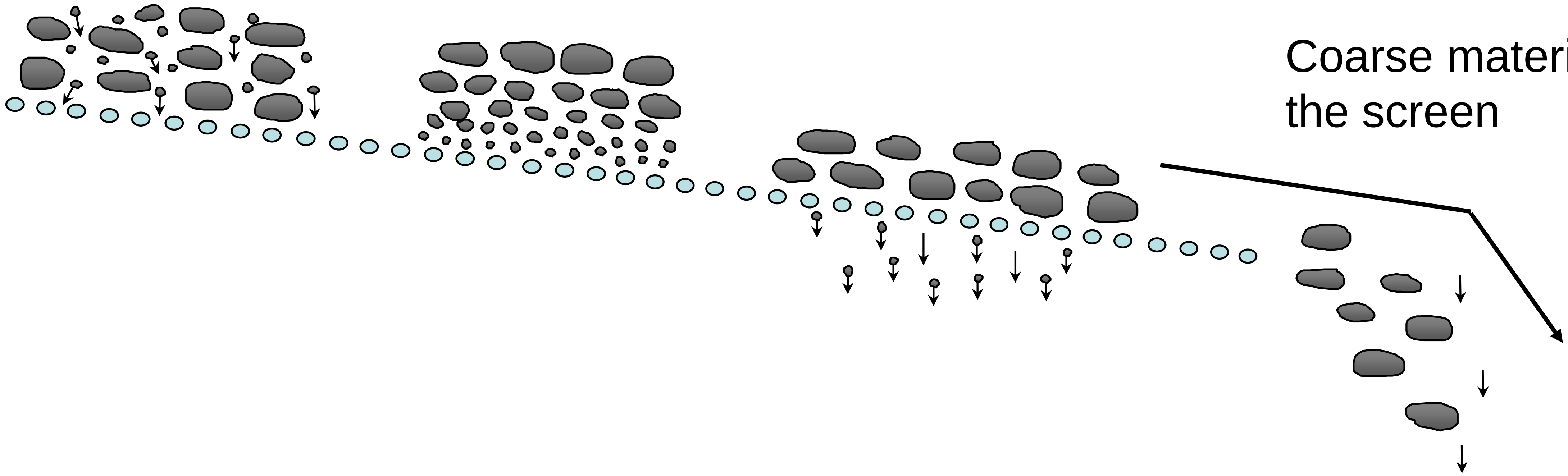
<u>What is conventional-screening?</u>

Fine material passes through the screen



Screens
Basics of Screening

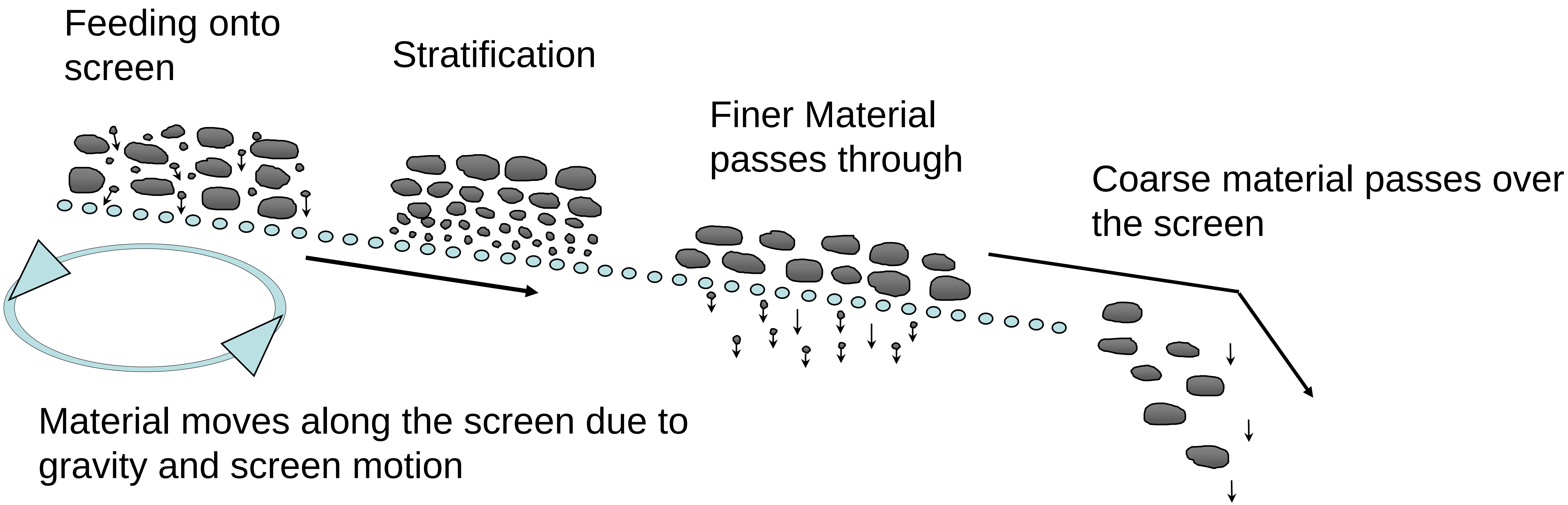
<u>What is conventional-screening?</u>



Coarse material passes over the screen

Screens
Basics of Screening

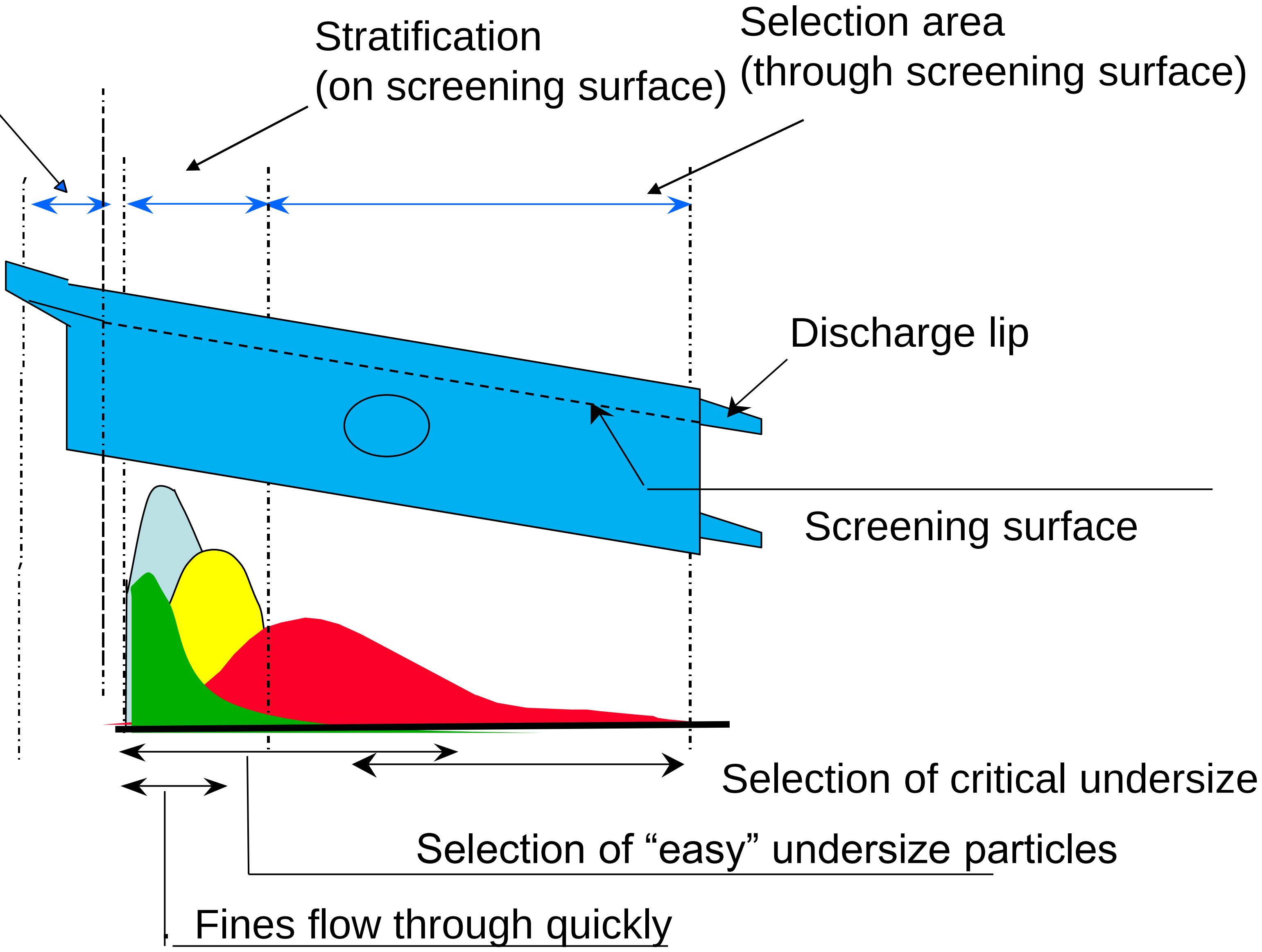
<u>Conventional Screening – based on stratification</u>



Screens

Basics of Screening

Throughput along the length of a screen



= Fines < 25% of hole size

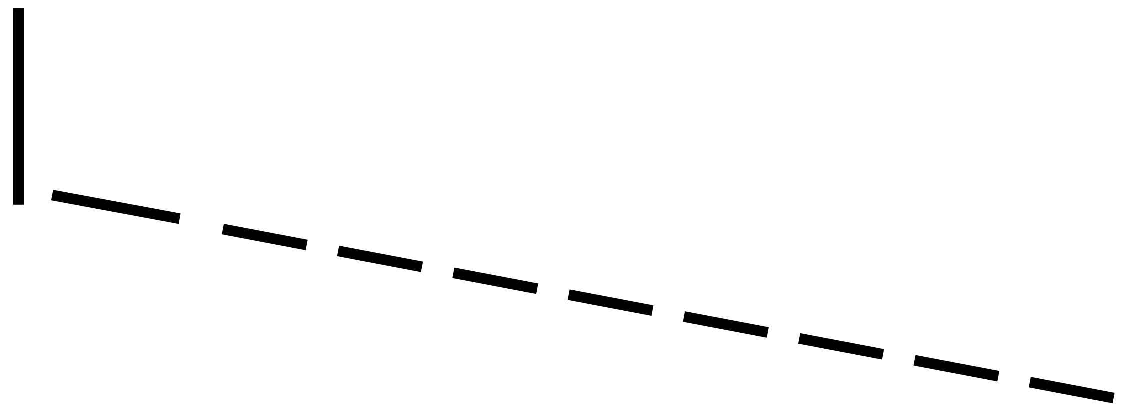
= Easy undersize <70% of hole size

= Critical nearsize 70-100% of hole size

= High volume < 70% of hole size

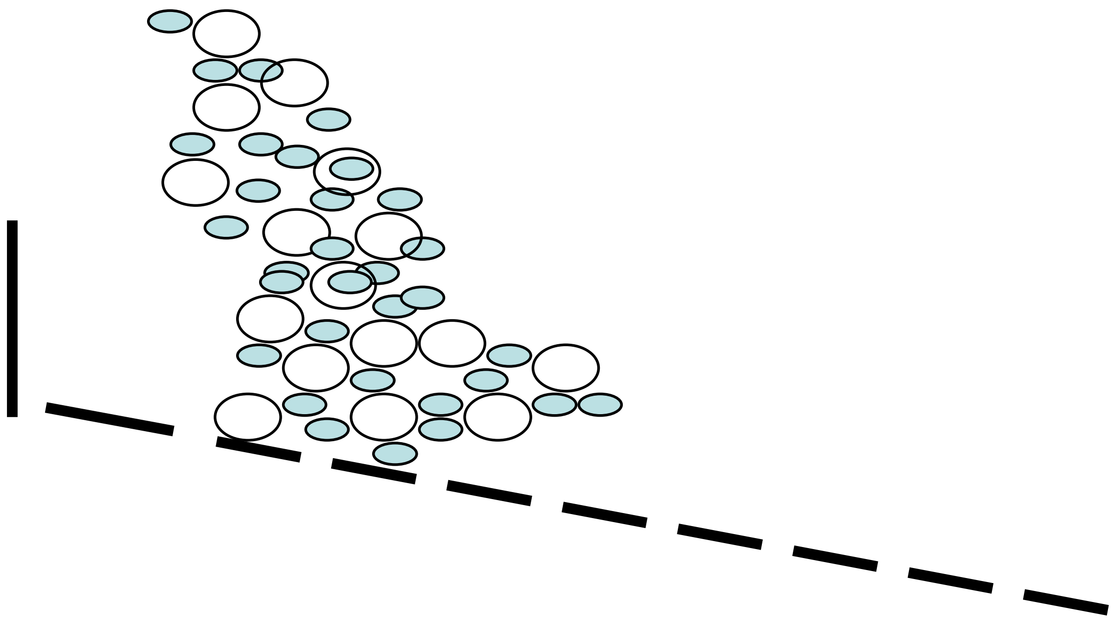
Screens
Basics of Screening

What is free-fall screening?



Screens

Basics of Screening



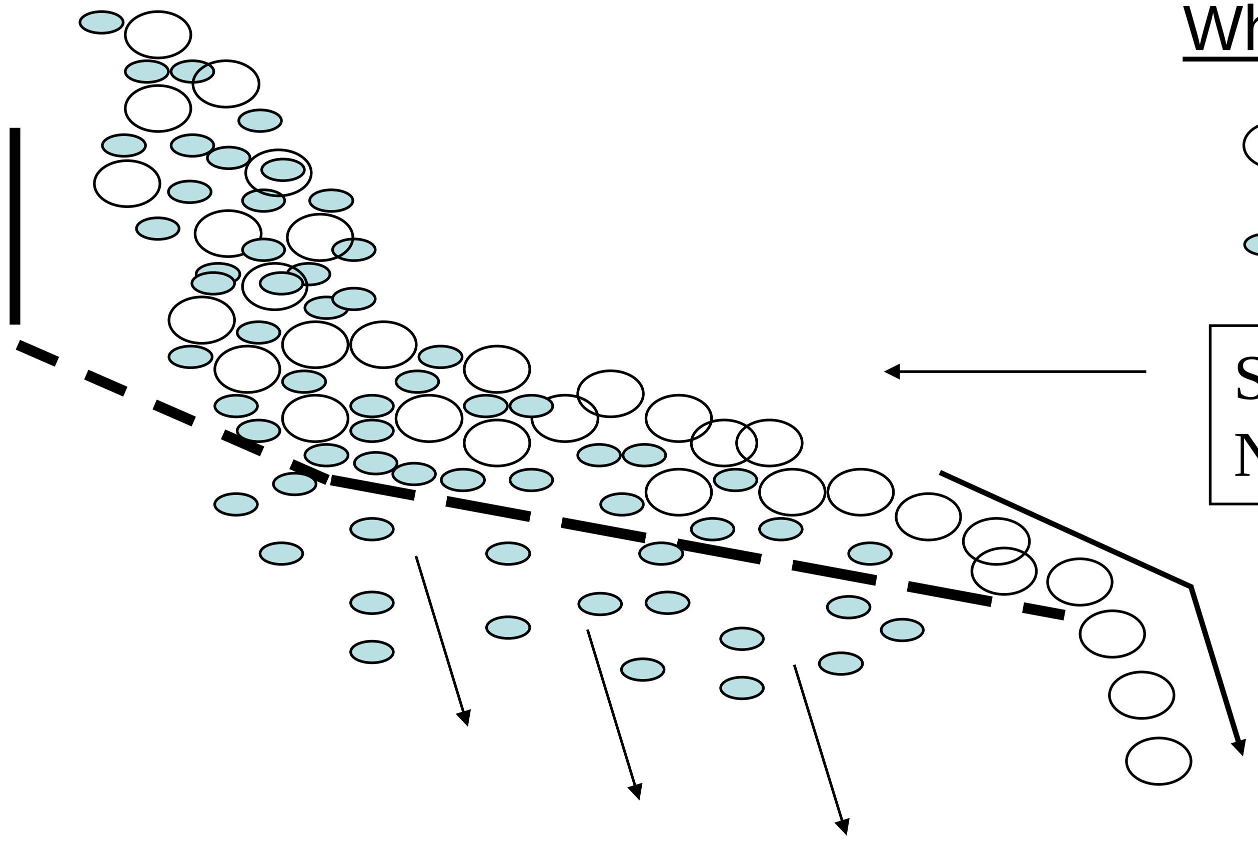
<u>What is free-fall screening?</u>

Coarse material

Fine material

Screens

Basics of Screening



What is free-fall screening?

Coarse material

Fine material

Stratification of material on deck NOT required

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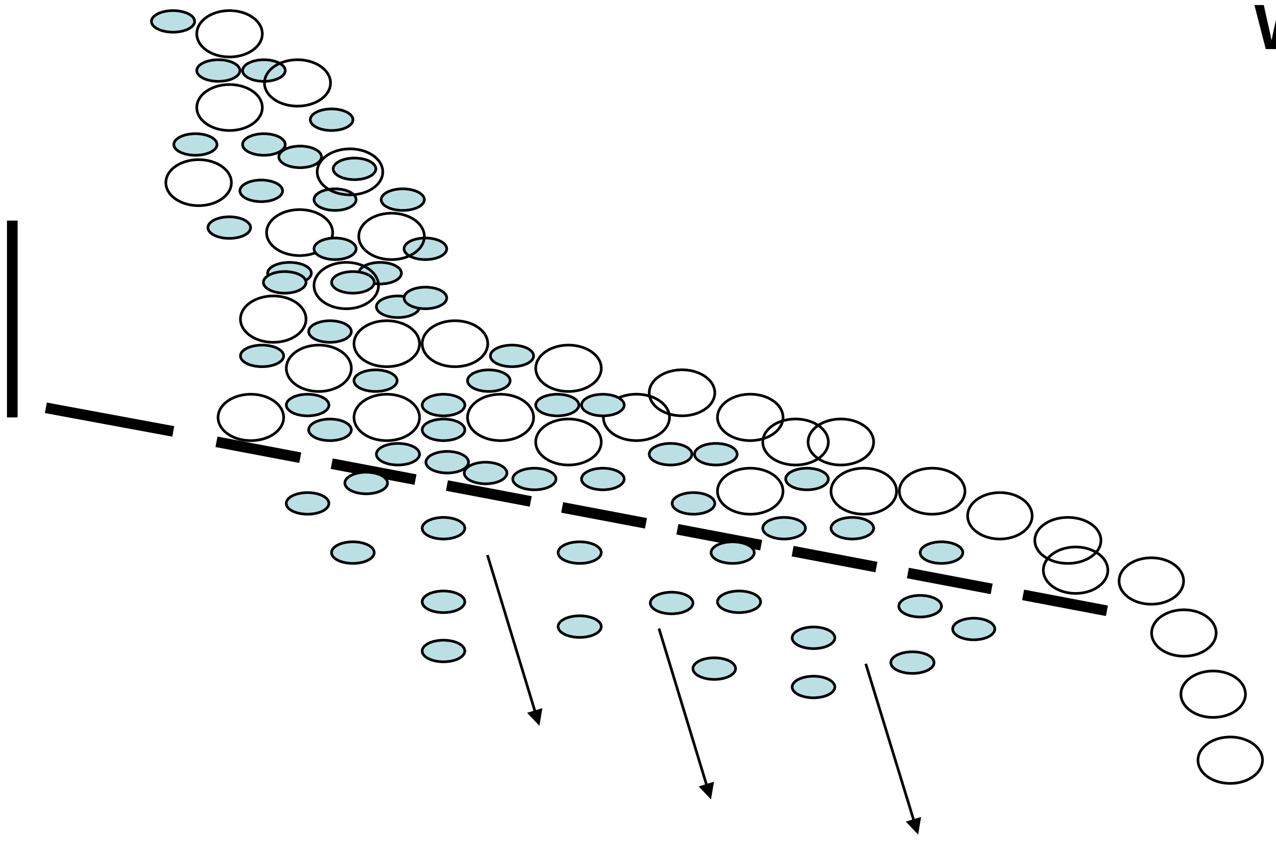
Screens
Basics of Screening



What is free-fall screening?

- ◯ Coarse material
- ⬭ Fine material

>70% passing through

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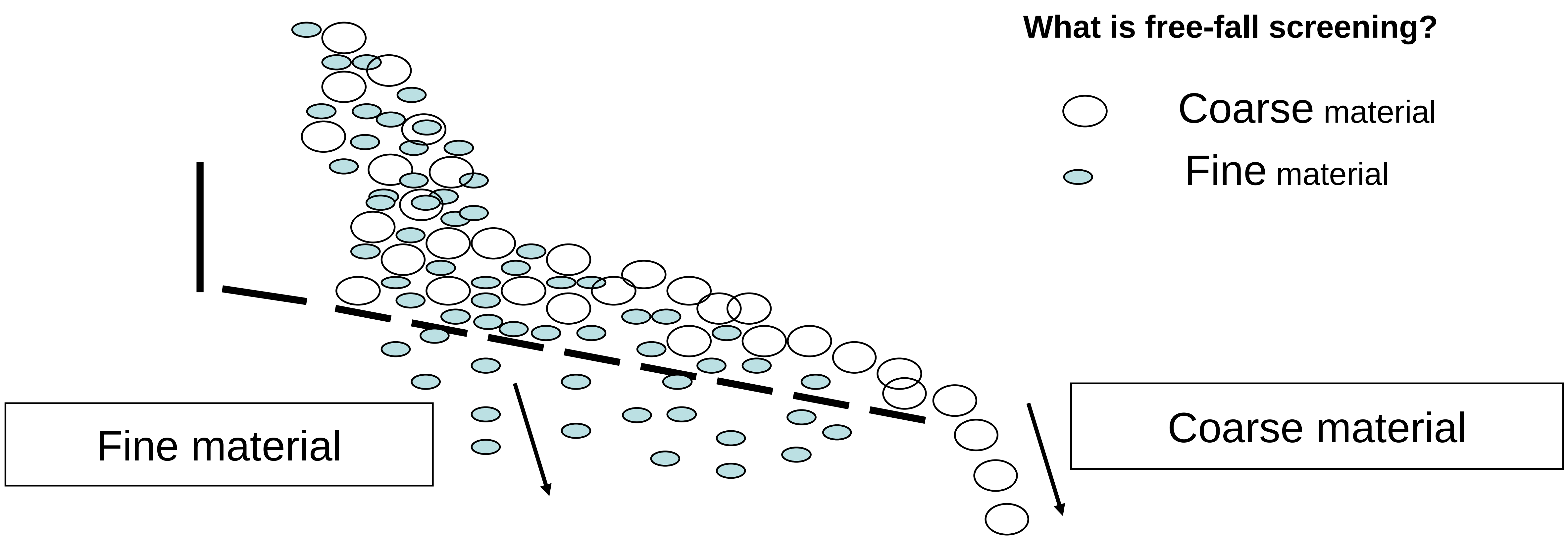
Screens
Basics of Screening



- Free-fall screening is based on principle of free-flow of the material trough and over the deck.
- Optimal free-fall screening demands at least 70 % of the feed through the deck.

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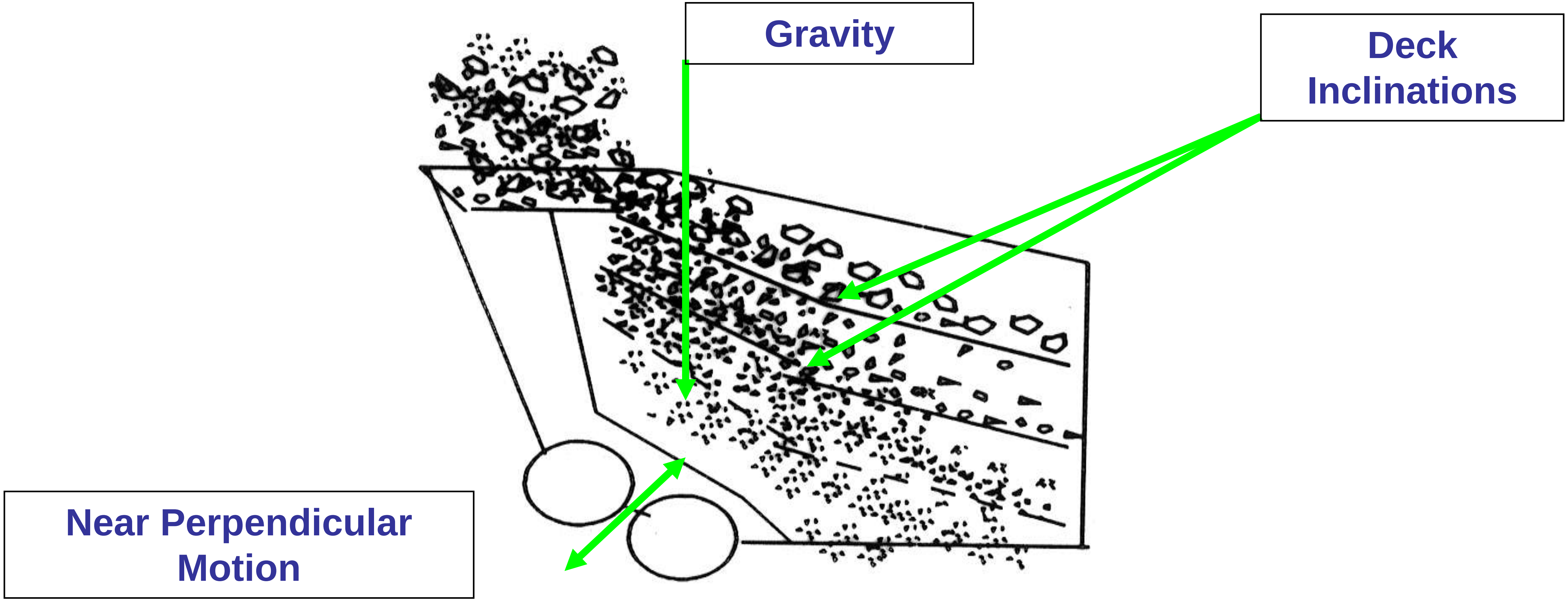
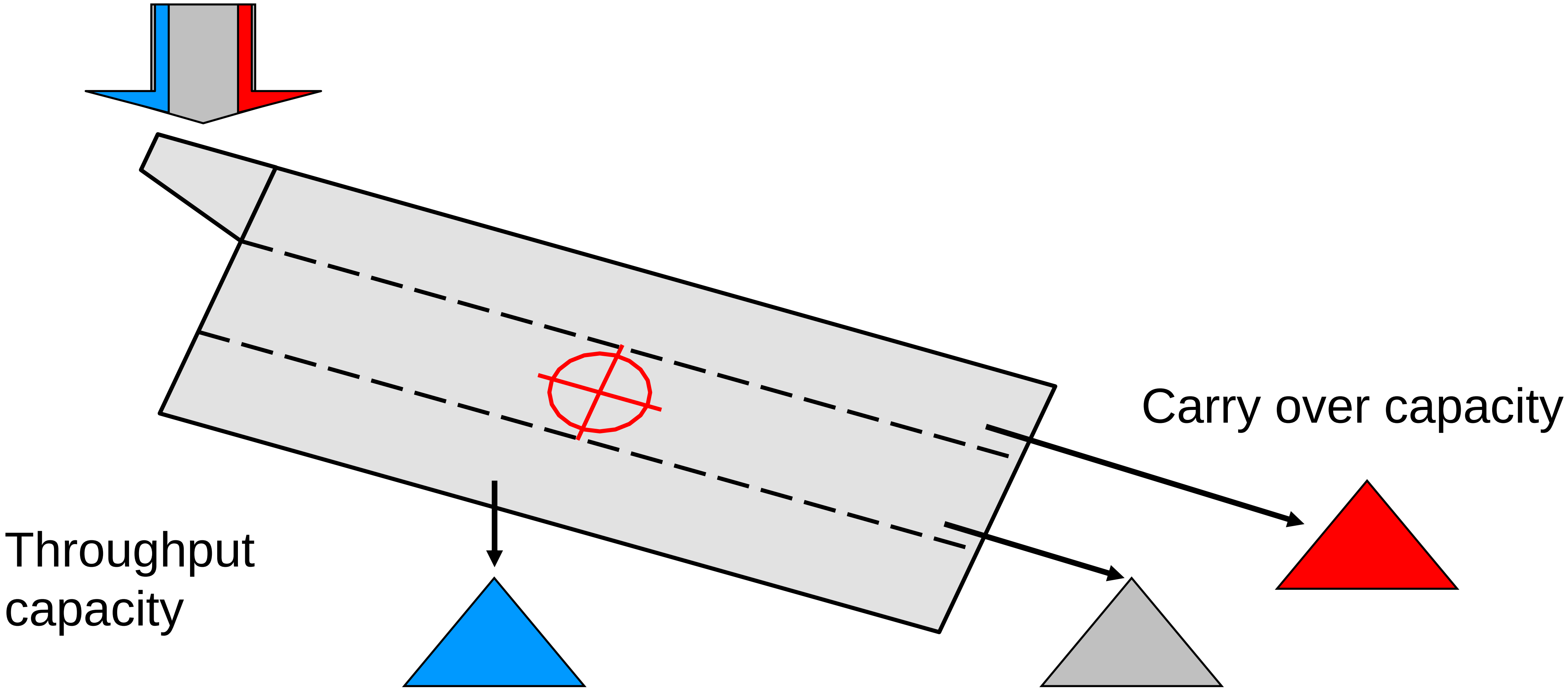
Screening Theory

FREE FALL SCREENING



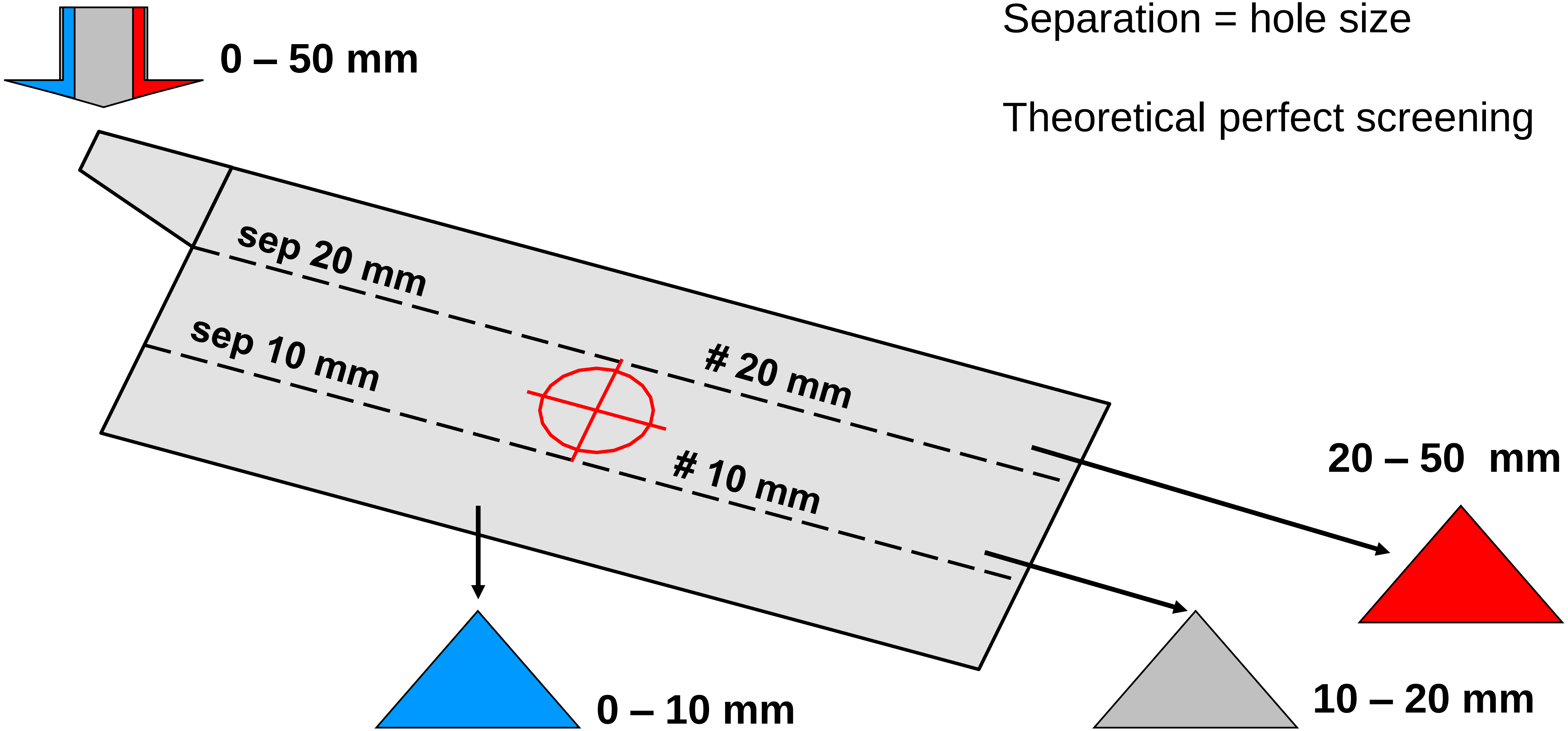
Screens
Screening accuracy



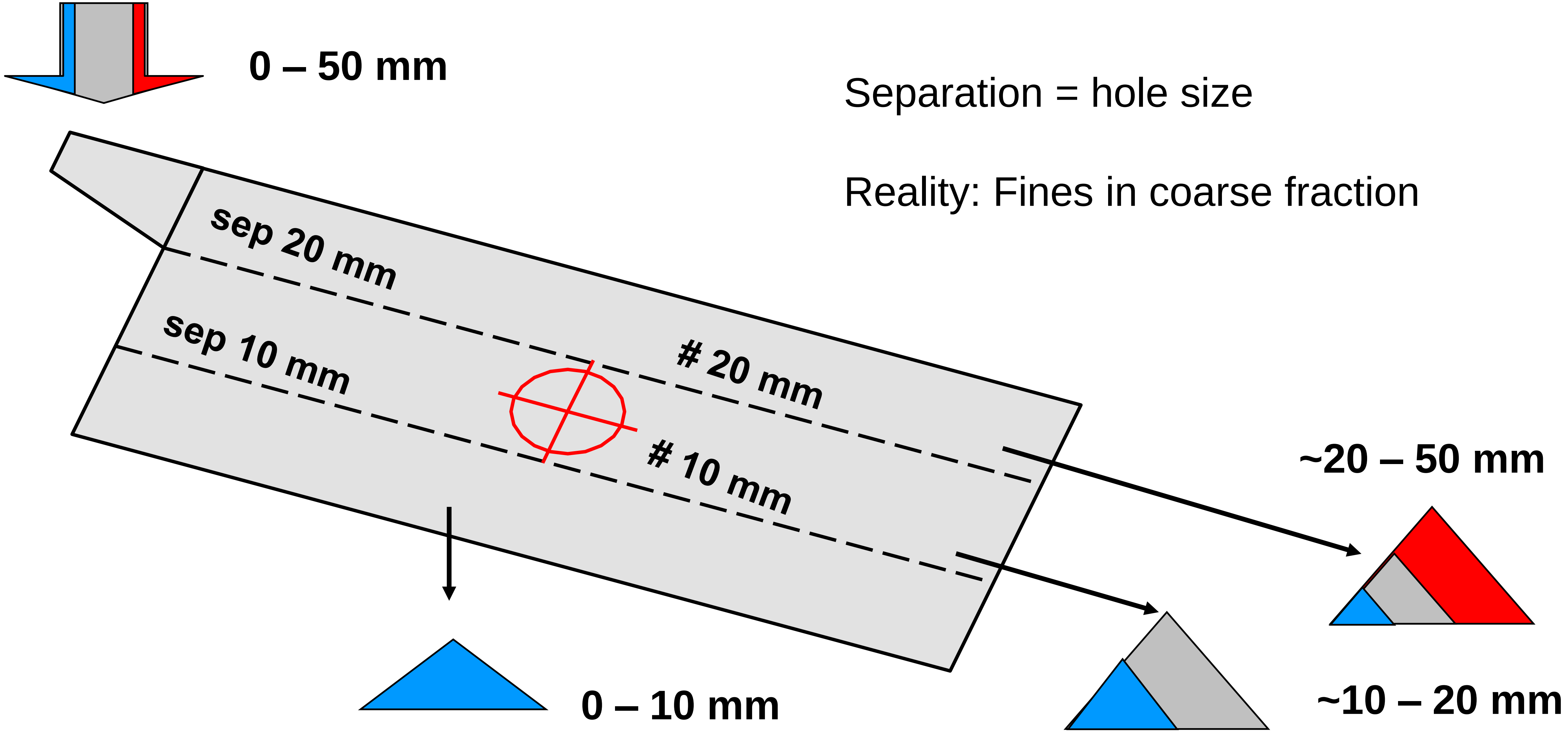
Screens
Screening accuracy

Separation = hole size

Theoretical perfect screening



Screens
Screening accuracy

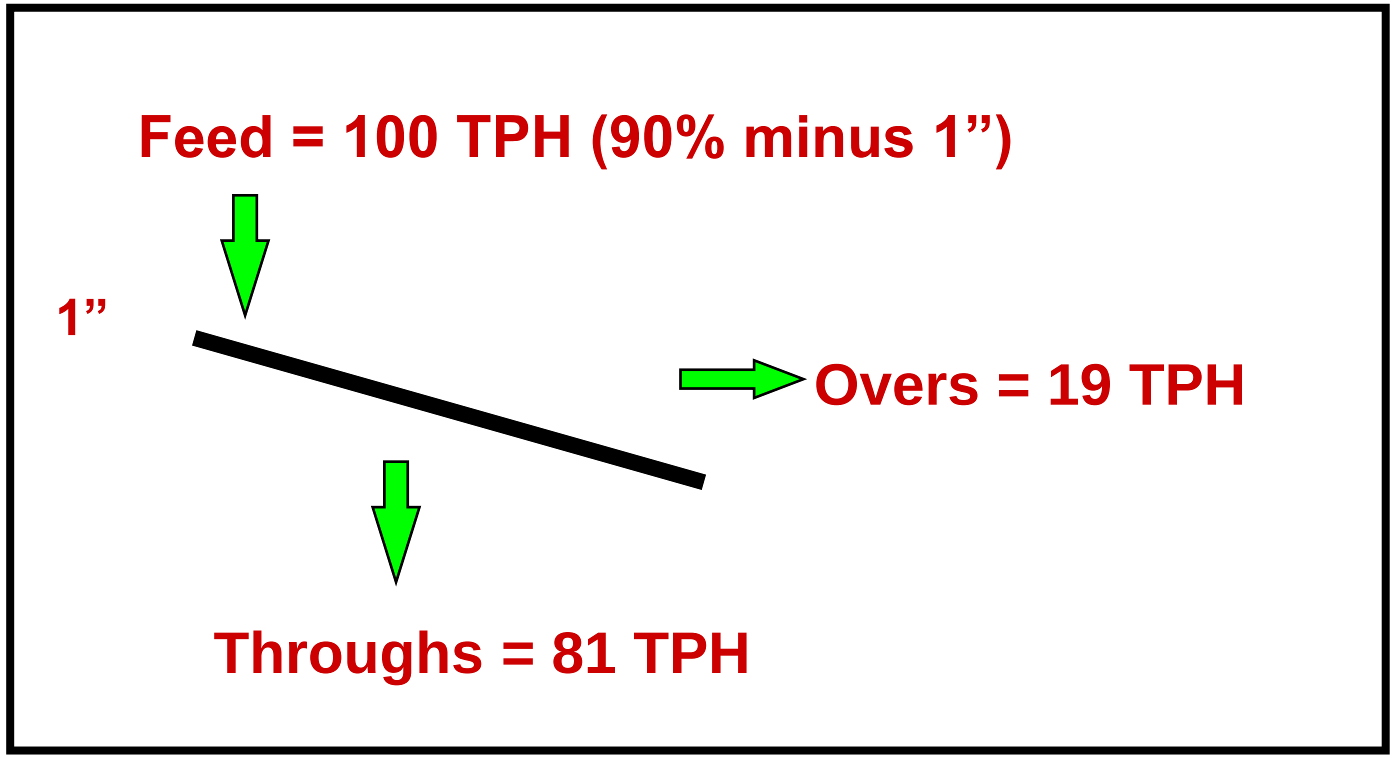


Separation = hole size

Reality: Fines in coarse fraction

Screening Efficiency…is a measure of the accuracy at which a screening machine is able to separate particles smaller than the screen deck openings from particles larger than the screen deck openings.

Screening Efficiency



Efficiency of undersize RECOVERY

E = (81/90)100
= 90%

E = (9/10)100
= 90%

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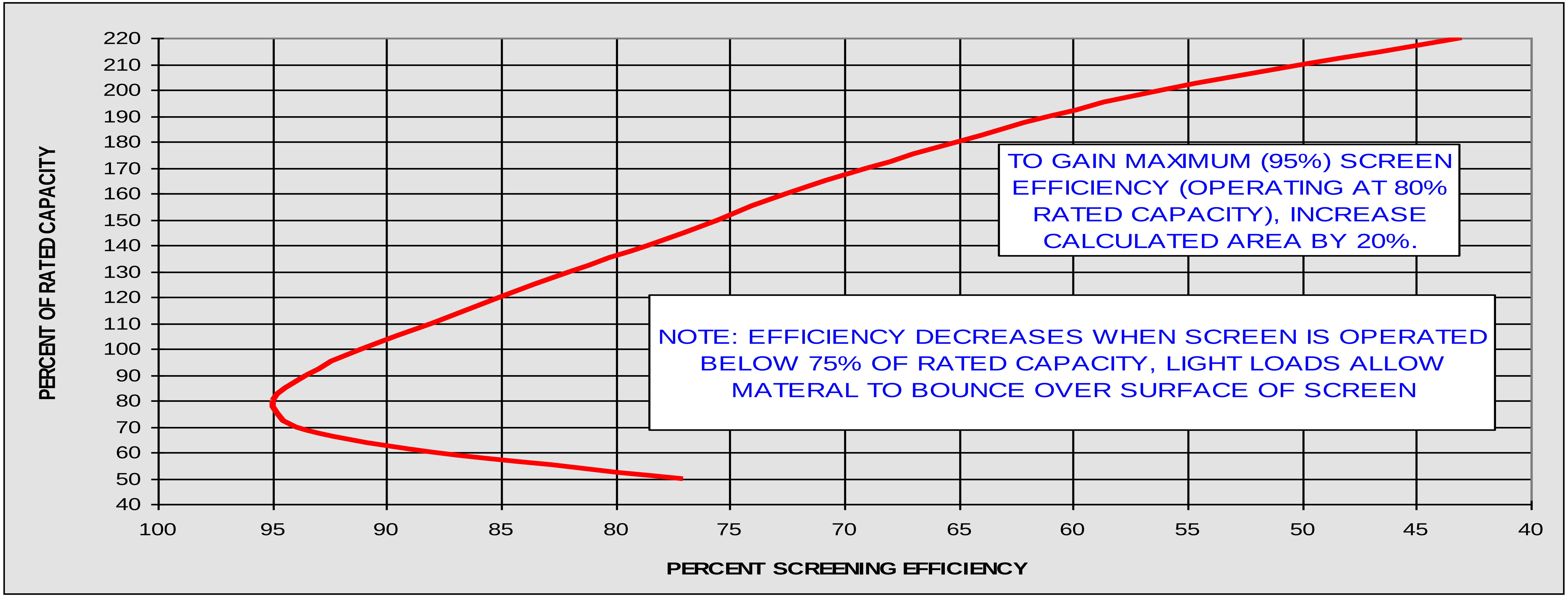
Screening Efficiency

SCREEN EFFICIENCY AS AFFECTED BY LOAD



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Screening Efficiency

MAKING IMPROVEMENTS

How Can Screening Efficiency Be Increased?

- Lower angle of incline
- Lower material bed depth
- Increase efficiency of screen media
  - More open area
  - More flexibility
- Reverse rotation of inclined screen
- Wet screening
- Optimize speed and/or throw

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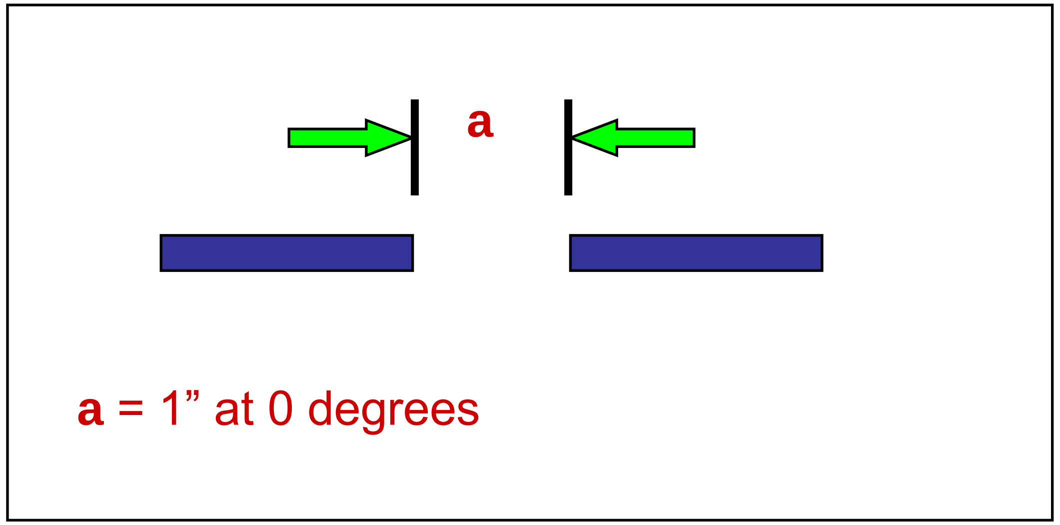
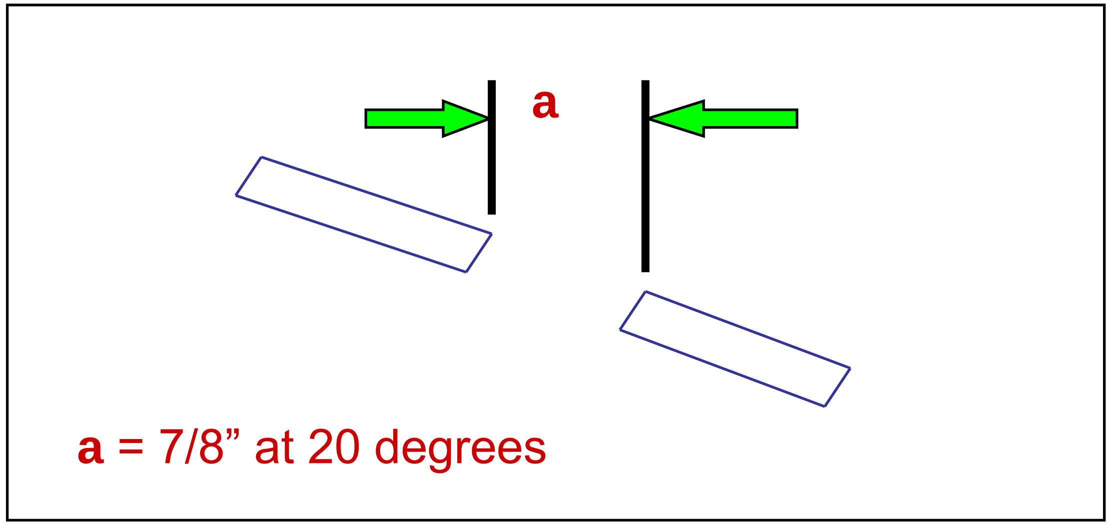
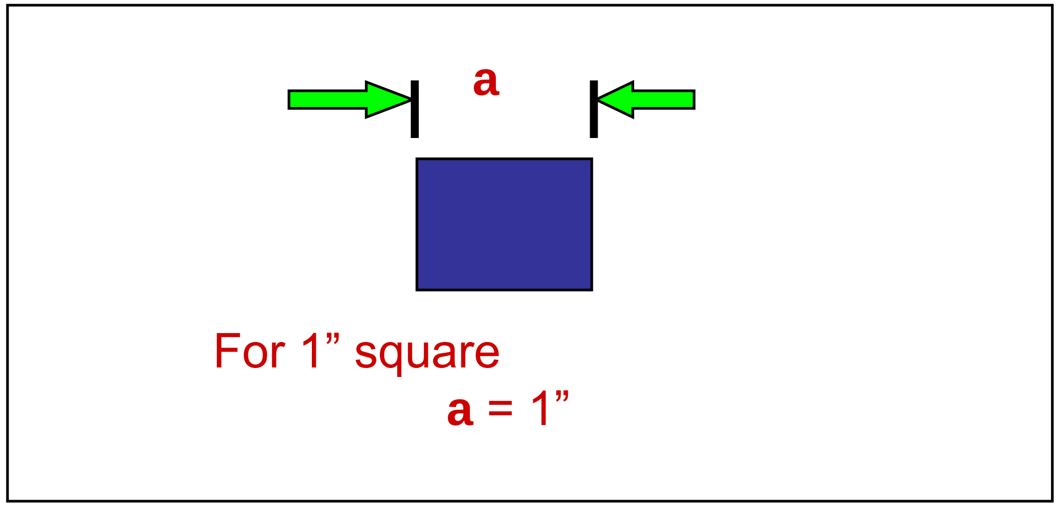
Screening Theory

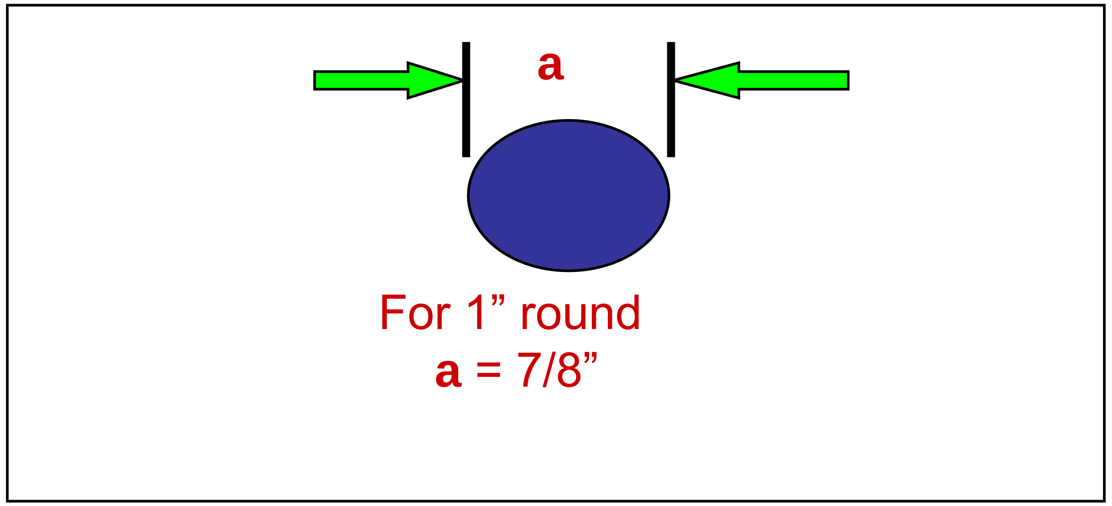
CHOOSING AN OPENING

a = Separation Size









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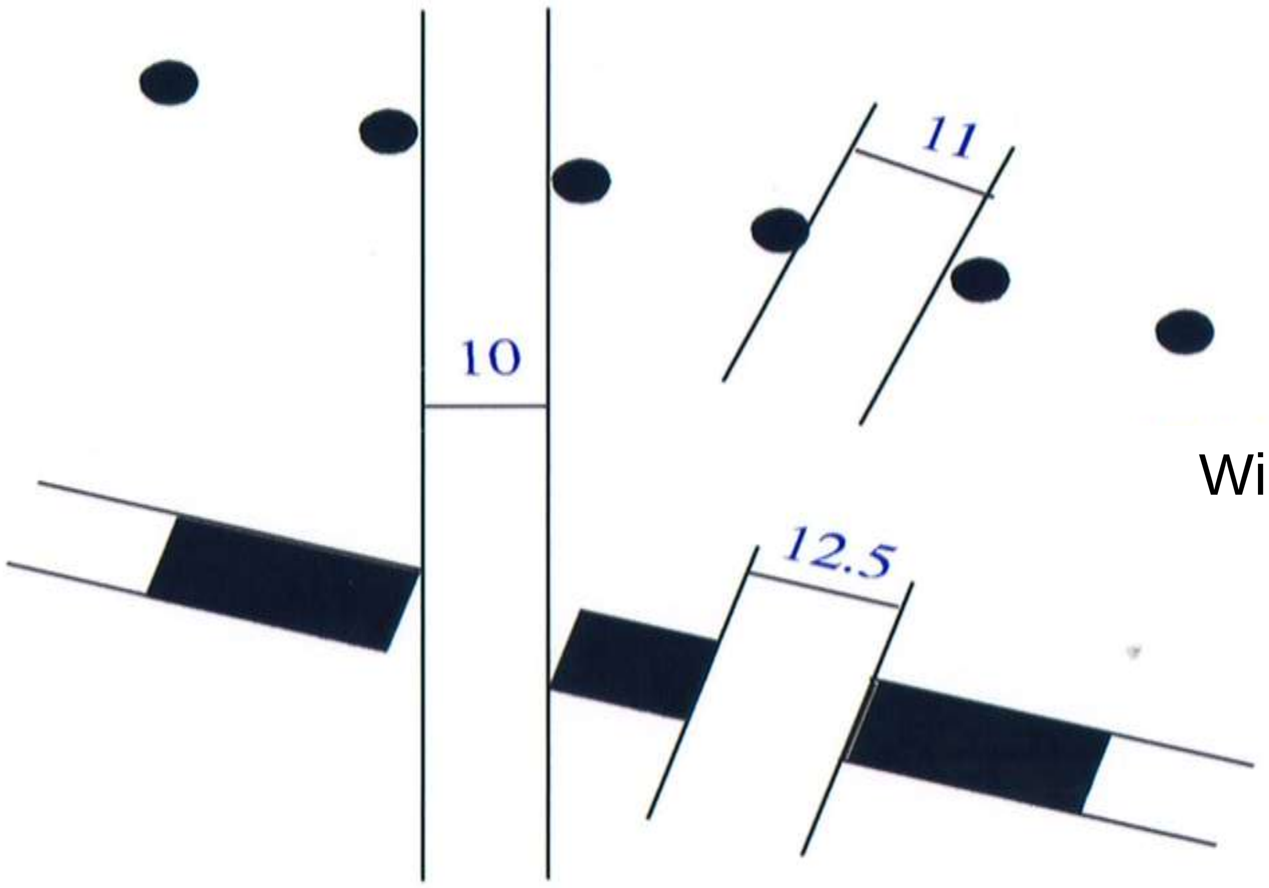
Screens
Screening accuracy

Hole size – Rubber vs Wire



Wire

Rubber

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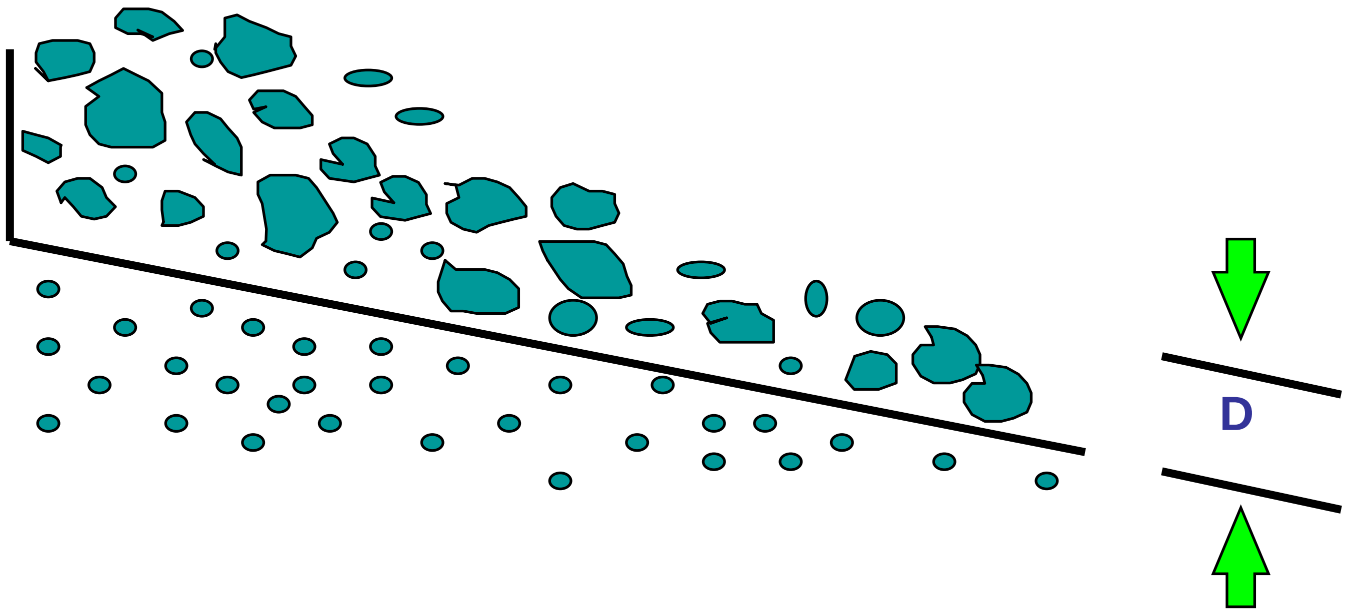
Screening Theory

MAXIMUM MATERIAL BED

D = No more than <u>4 times</u> the opening for Aggregate

D = No more than <u>3 times</u> the opening for Raw Coal

D = No more than <u>3 inches</u> for Drain & Rinse or De-sliming



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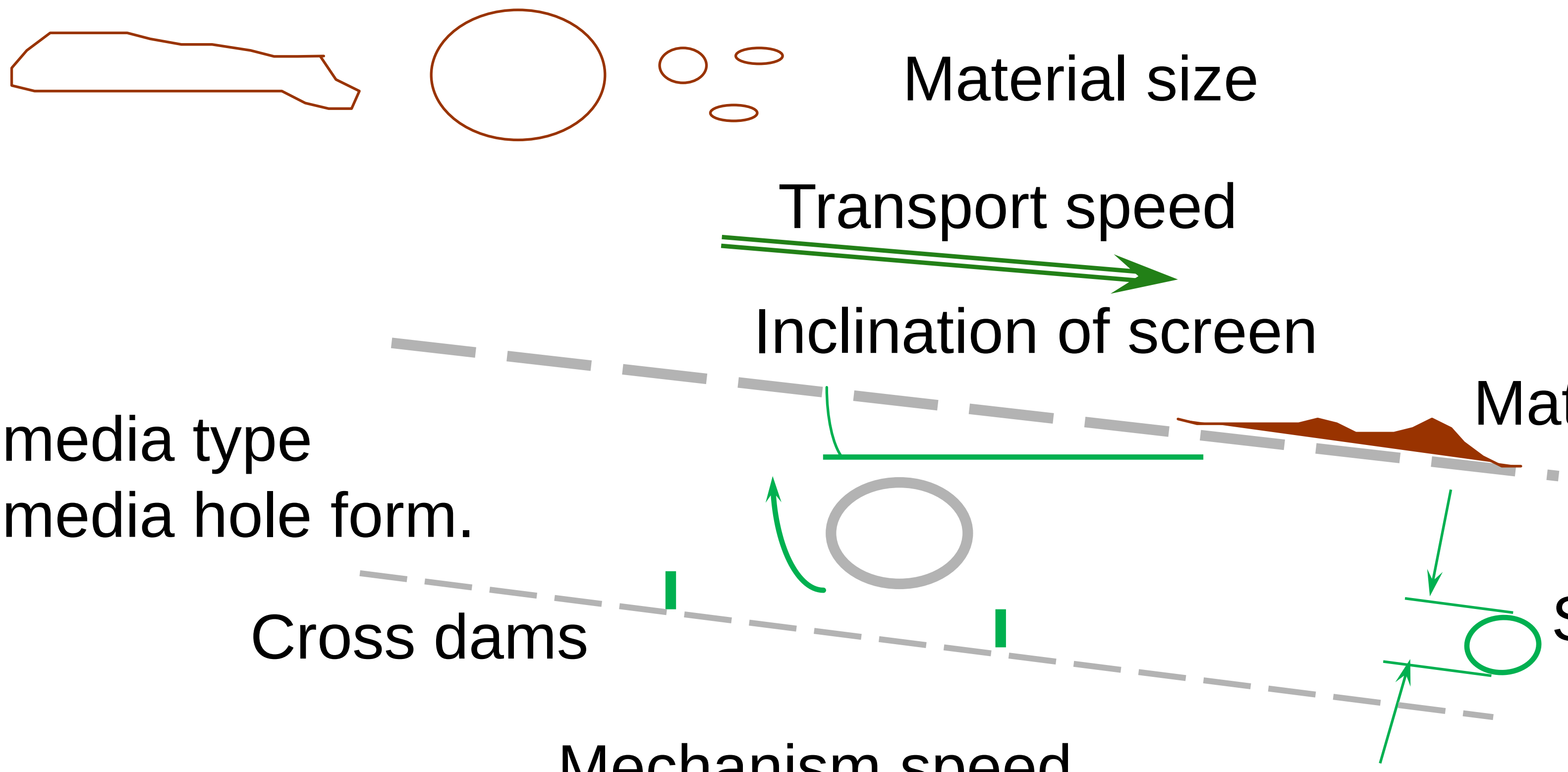
Factors Affecting Material Speed & bed depth.



Gravity Free Fall = 9.81m/s

$$\text{G force} = \frac{\text{RPM}^2 \times \text{Throw (mm)}}{1788200}$$

$$\text{G force} = \frac{800^2 \times 11}{1788200} = 3.94$$

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Mechanical Limits

ACCELERATION

Directly Related to Speed and Throw of Screen

- **G-FORCE = $\{(RPM)^2 \times THROW\} / 70{,}400$**

Application Dependent

- **Coarse Separation - Low Speed and High Throw**
- **Fine Separation - High Speed and Low Throw**

AFFECTS THE OPERATING STRESS LEVELS OF THE SCREEN BODY

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Mechanical Limits

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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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.
- Can promote bouncing and critical size carry-over.

A thick bed:

- Can reduce accuracy.
- Overload the screen – carrying capacity.
- Can prevent segregation and fines carry-over

Bed-depth has to be right—not too thick not too thin!!!!

Screens

Calculation of screen area

Basic formula for through put in conventional screening (t/h per ft^2):

Screening Area ft^2 = U / (A x B x C x D x E x F x G x H)

- A: Nominal capacity for separation
- B: Oversize (0.45 … 1.04)
- C: Halfsize (0.5 … 3.5)
- D: Deck Location (1.0 ...0.8)
- E: Wet screening (1.0 … 2.0)
- F: Material Weight (1.5 ....0.3)
- G: Open area of screen media
- H: Shape of Opening (1.0 ...1.2)
- U: Undersize stph smaller than opening

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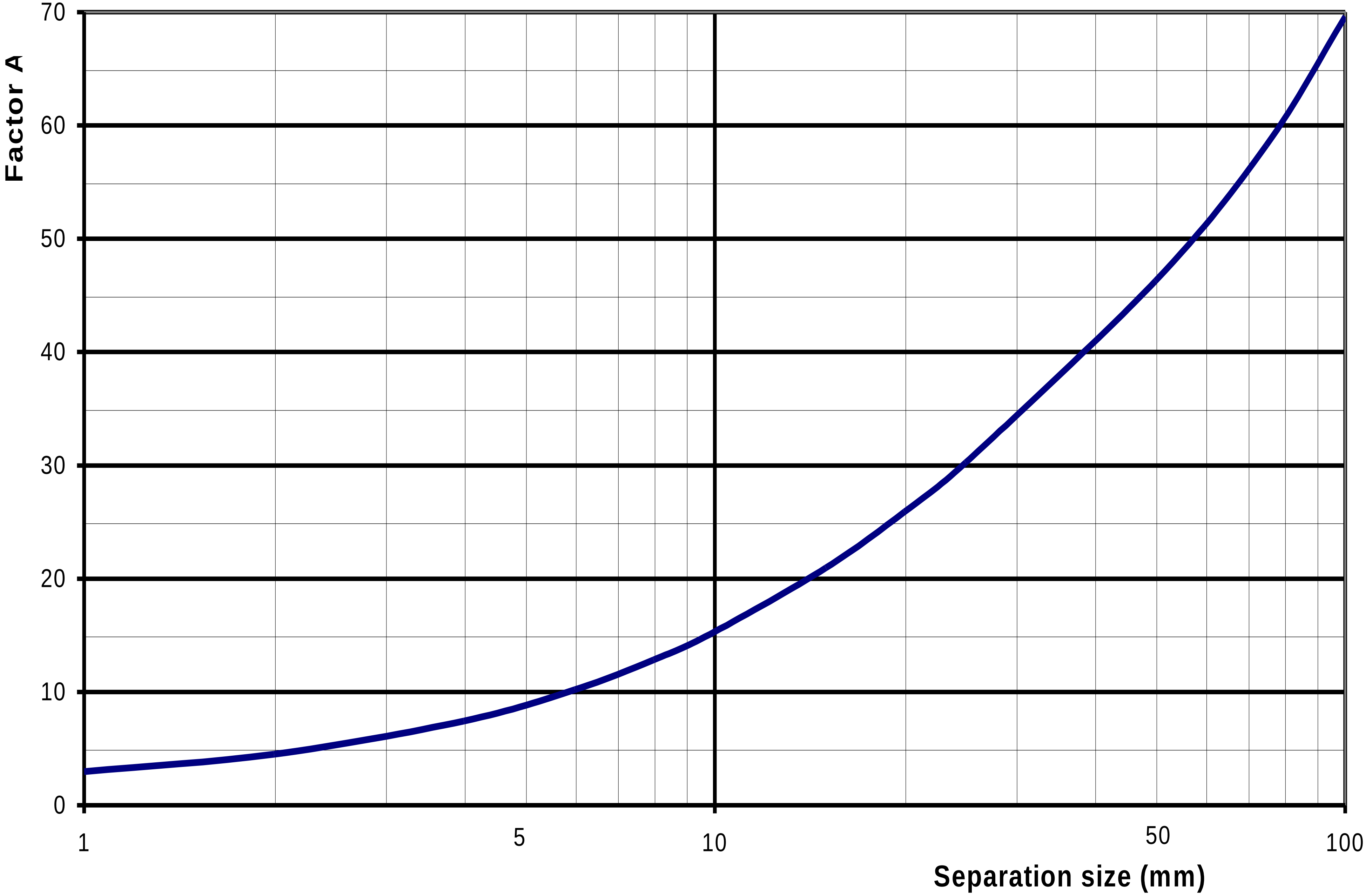
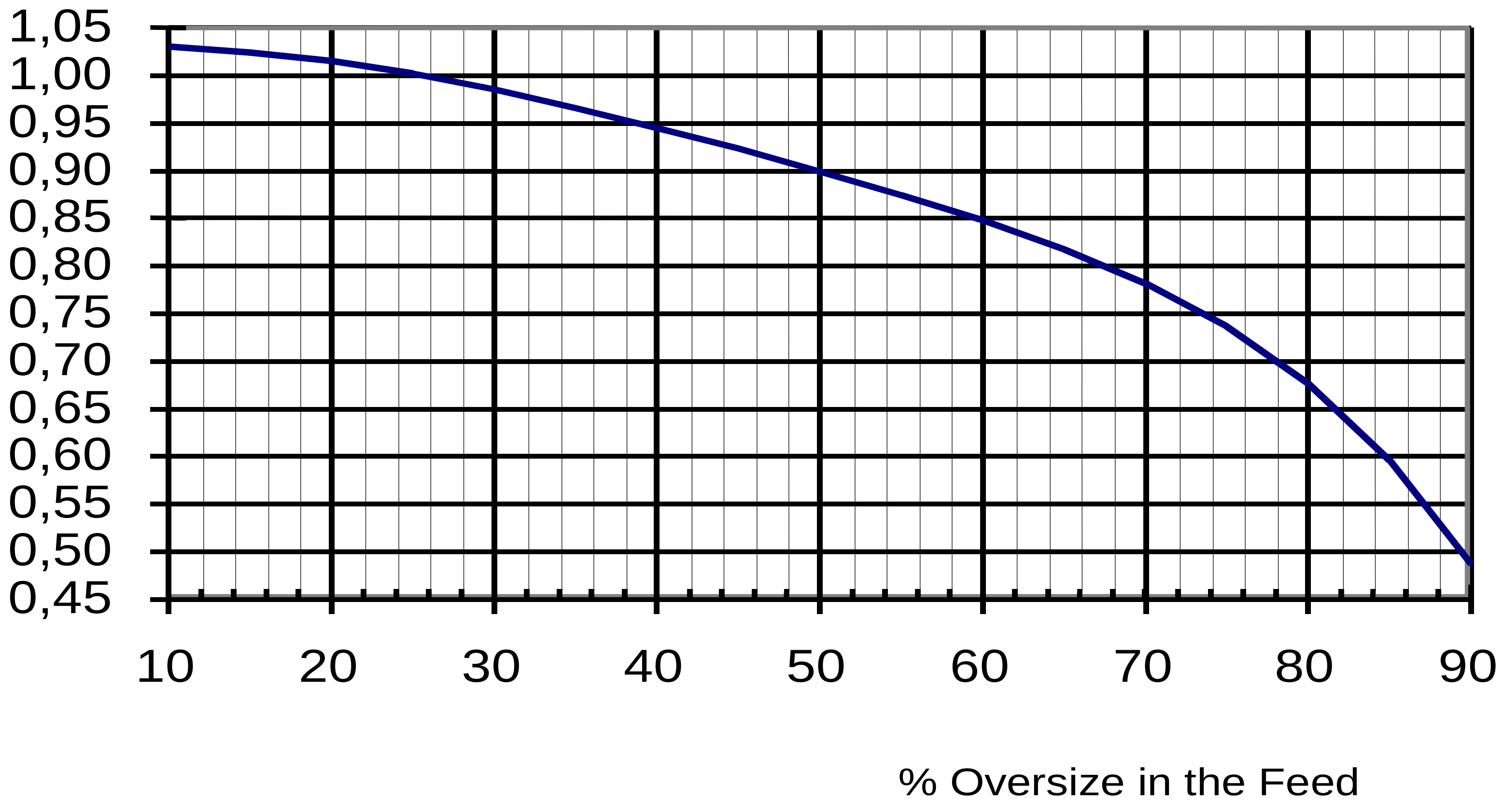
Basic factor A; nominal capacity



Factor B; amount of oversize

- ☺ Oversize stop bouncing
- ☹ Oversize is ”in the way” for small particles to get through the bed



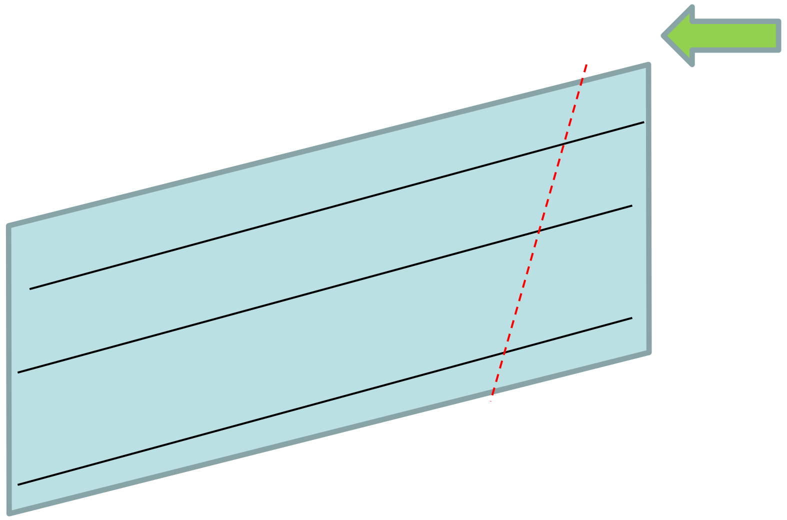
Factor C; Amount of half size

- Halfsize is % smaller than 1/2 the separation in through put
  - Small stones pass easily
  - Big stones goes over easily
  - Nearsize stones needs a lot of area to ”select” an opening

Factor D; Deck position

Deck Position	Factor: I
1	1.0
2	0.9
3	0.8
4	0.7

- The material reaches the lower decks later
- Especially a problem for some short four deck screens



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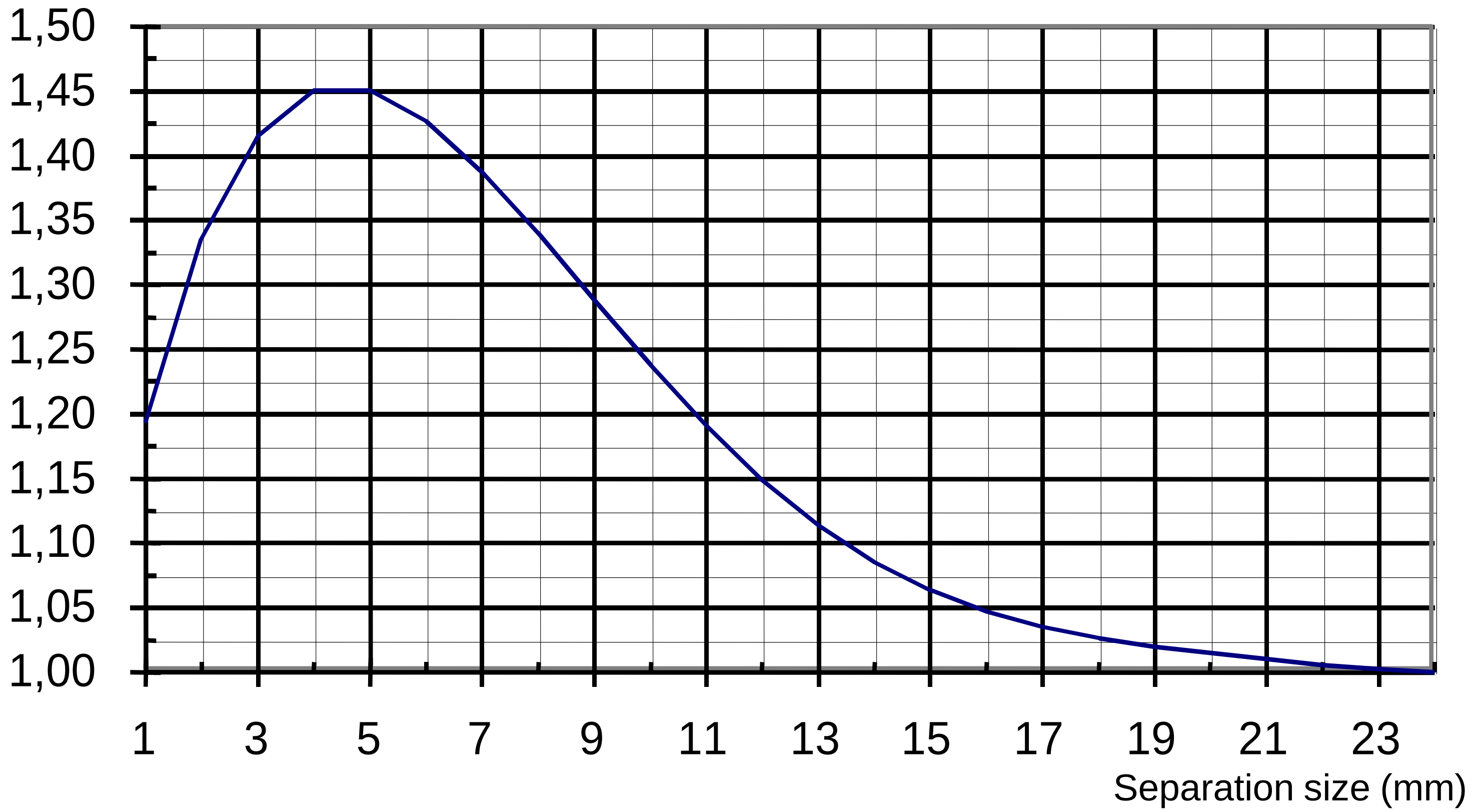
Factor E; wet screening

- Water helps small particles sift through, flushes the fines through the holes

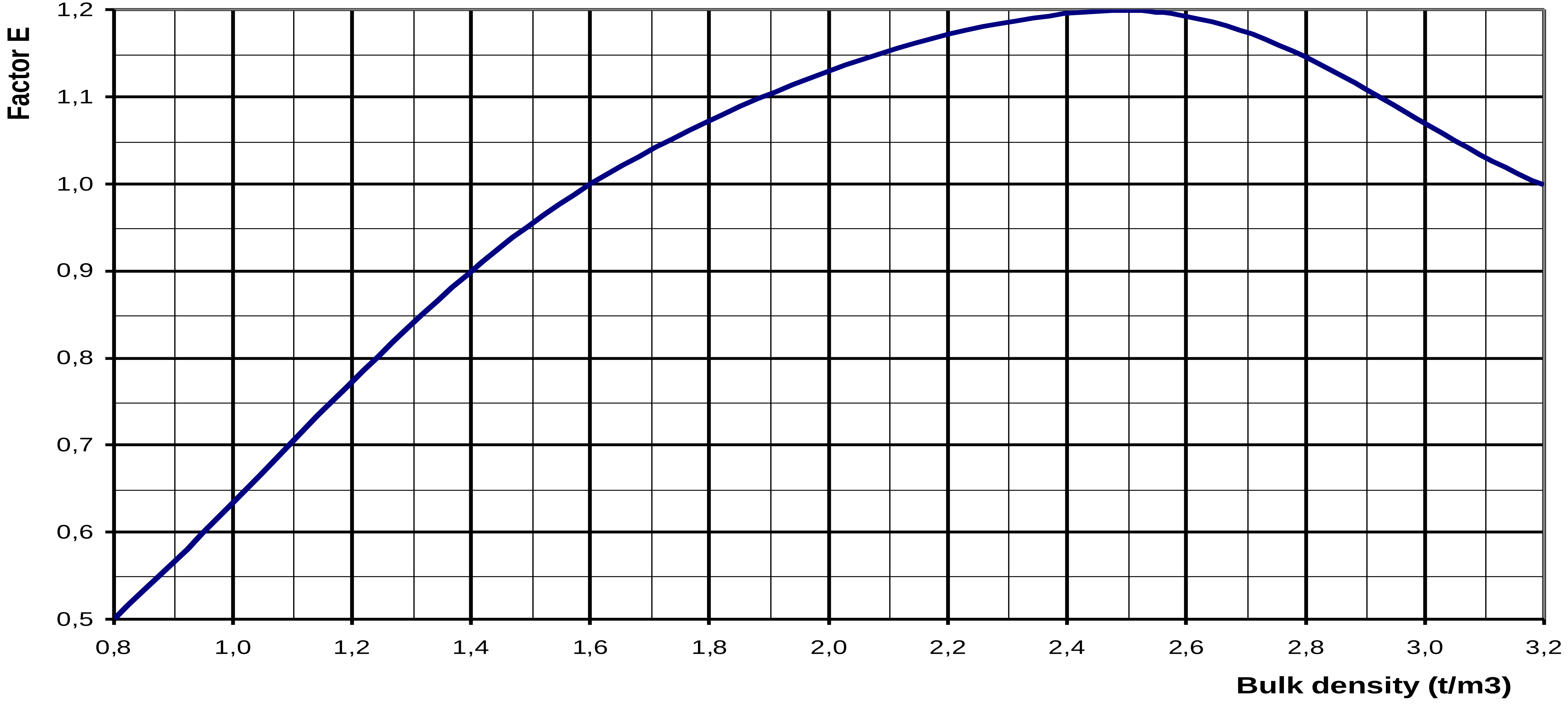
- Big stones are less influenced by water

- Water amount, where it is added, pressure & type of nozzles is important



In dry screening and >25 mm separation, E=1

Factor F; bulk density



- Not linear, neither “practical” (especially over 1.6 t/m3 density)

Factor G; Open area of screen media

$$G = \frac{\%\ \text{open area available}}{\text{Base area (50)}}$$

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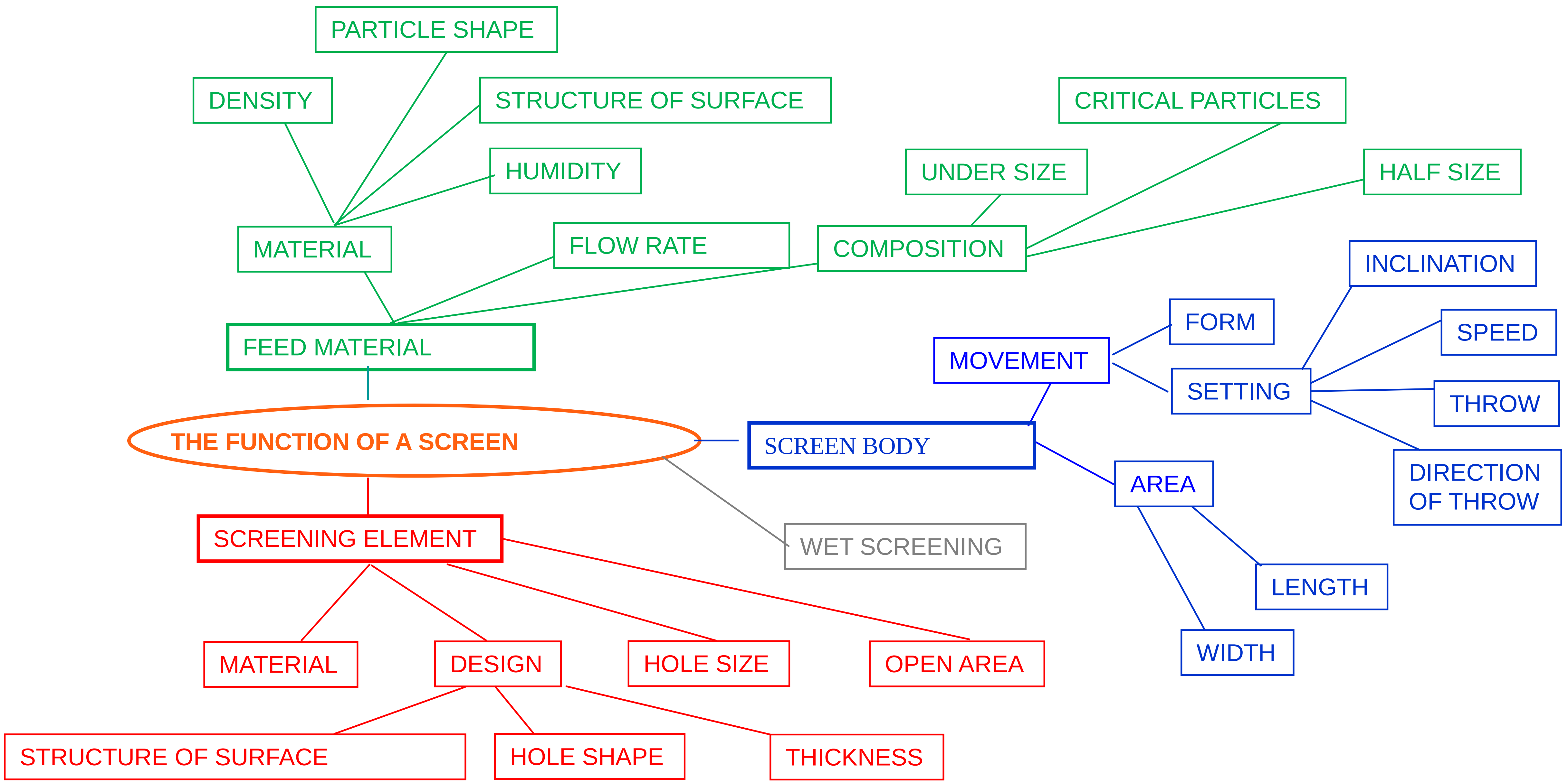
Factor H ; Surface Opening Shape

Square	1.0
Round	0.8
2:1	1.15
3:1	1.2
4:1	1.25

Factors influencing screen performance



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Resonant Frequencies

Resonant Frequencies

WHY WE TEST

- If operating speed is near a natural frequency, a state of resonance will occur causing self destruction
- Resonance frequencies vary on different sizes and types of screens
- To fine tune a finite element analysis model
- To eliminate trial and error

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Resonant Frequencies

WHEN WE TEST

Industry Changes Require New Designs such as:

- **Larger screens**
- **Synthetic surfaces**
- **Different speeds**
- **Higher “G” force**
- **Increased production**
- **Special options**

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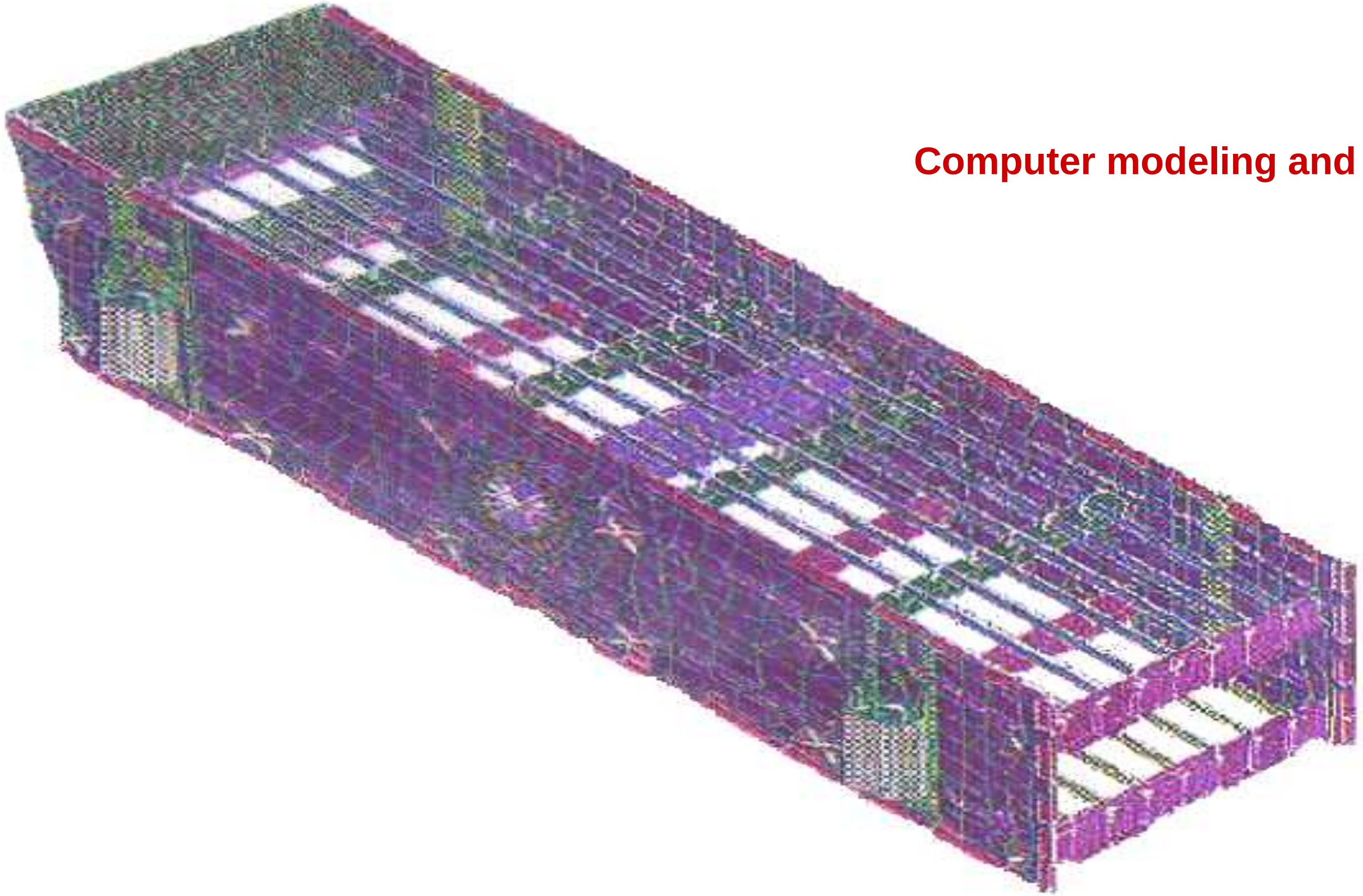
Resonant Frequencies

FINITE ELEMENT ANALYSIS



Computer modeling and FEA testing of screen

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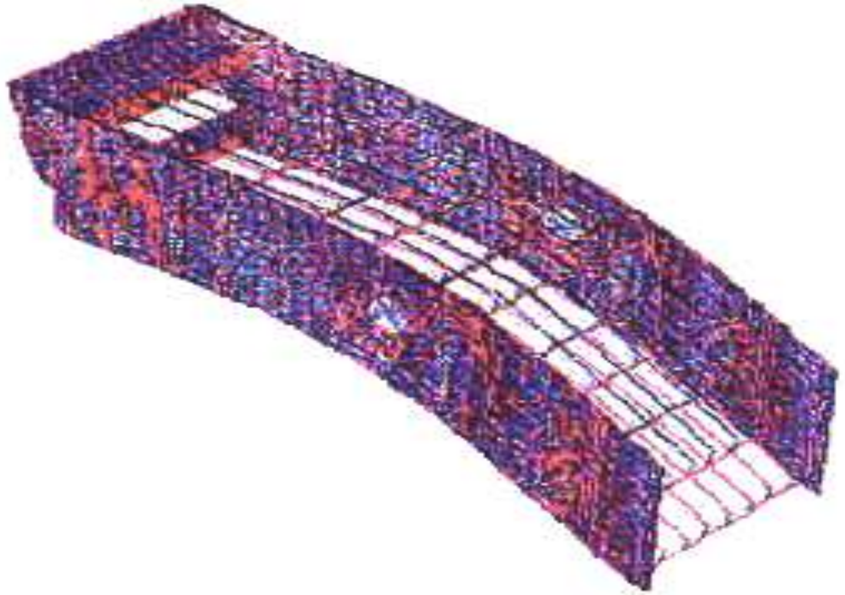
Resonant Frequencies

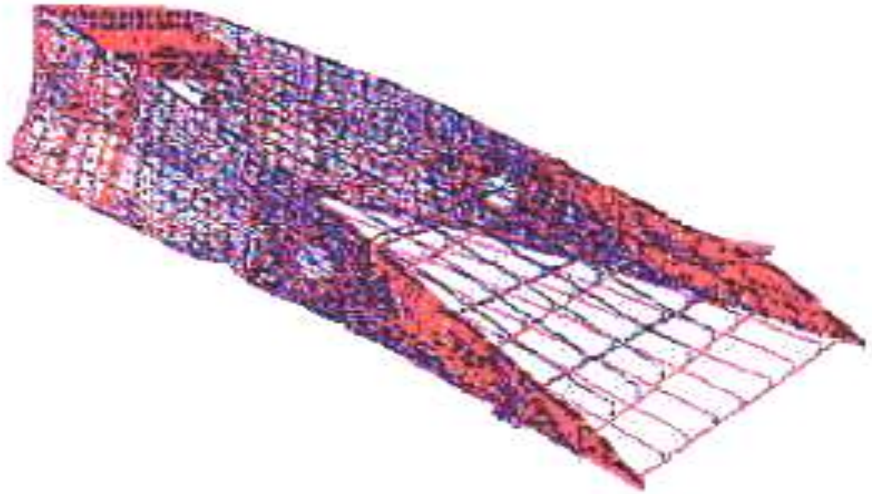
FINITE ELEMENT ANALYSIS

Side Plate Bending

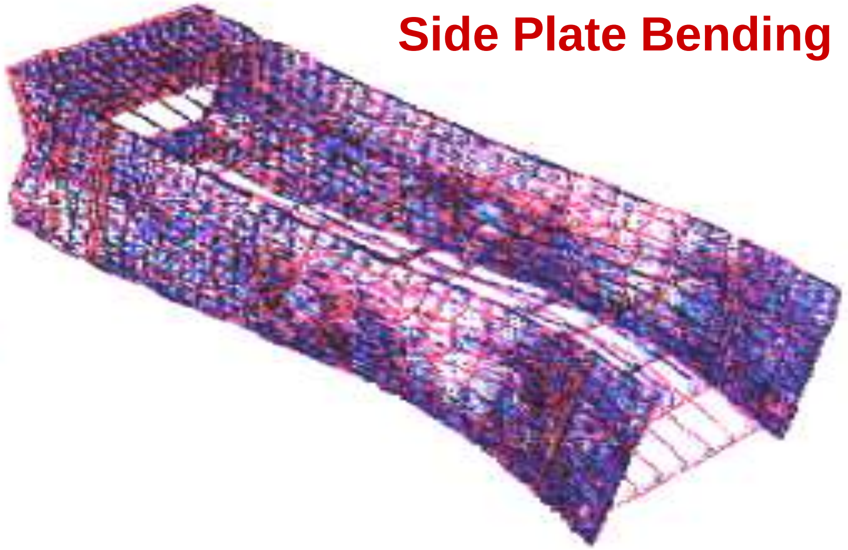


Paralleling Mode

Torsional Mode



Side Plate Bending



Resonant Frequencies

THROW CARDS

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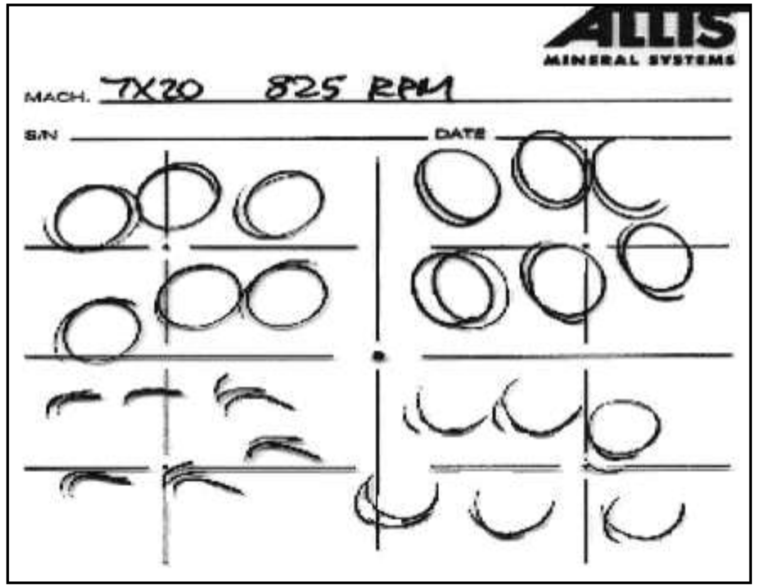
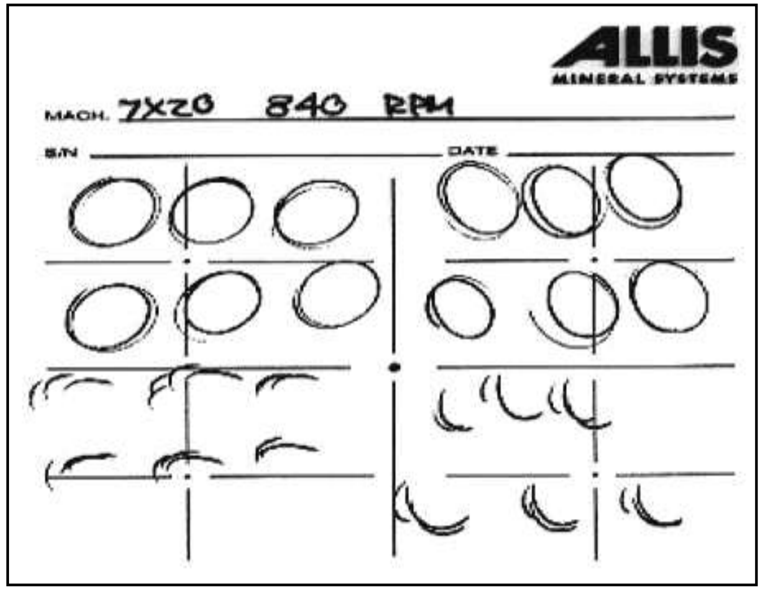
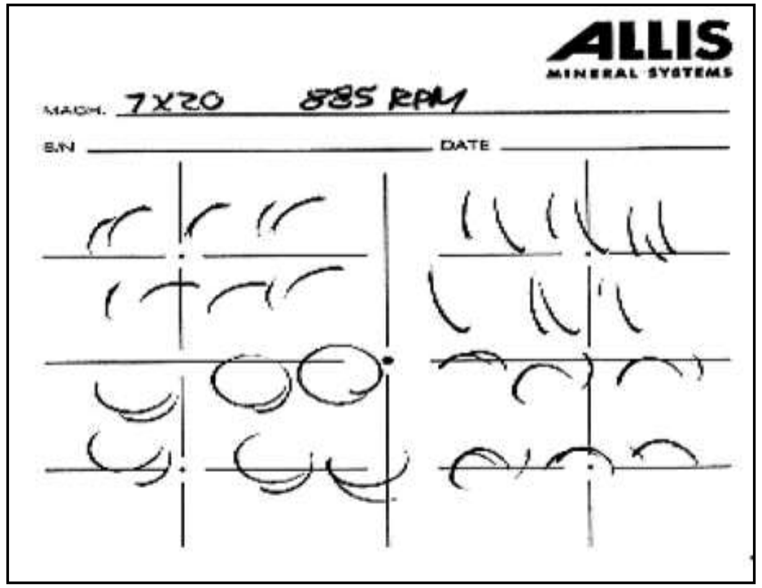
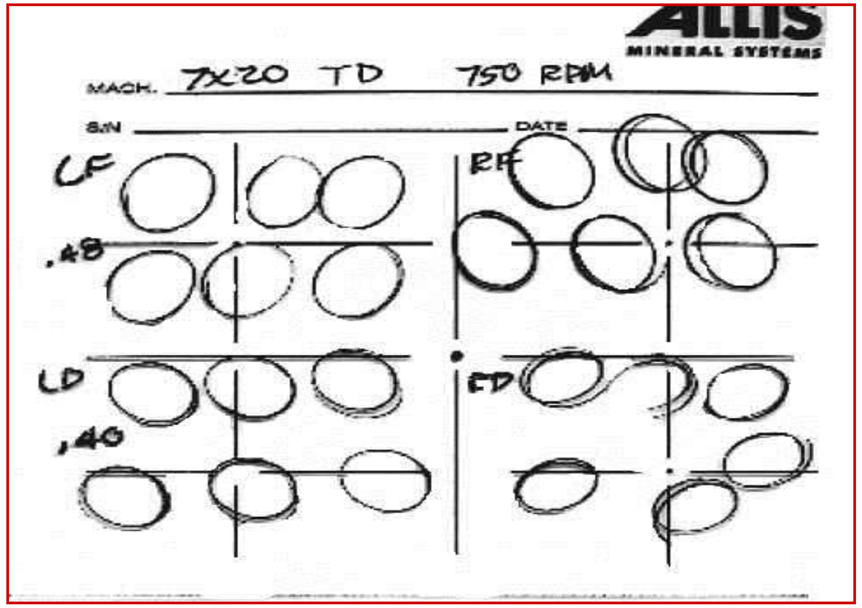
Resonant Frequencies

THROW CARDS









Critical frequencies at 840, 885 and 825 RPM.

Operating speed at 750 RPM.

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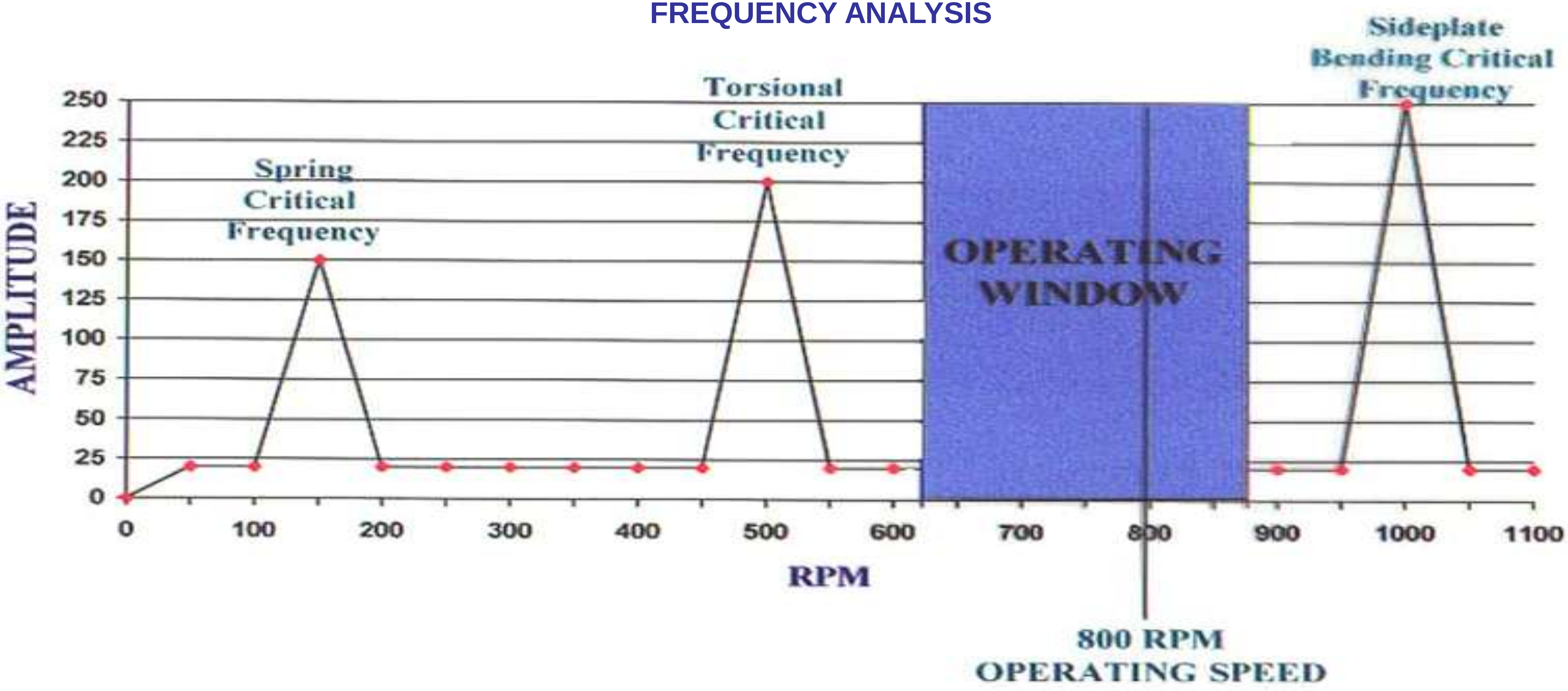
Resonant Frequencies

Analyzer Detects Critical Frequencies

Resonant Frequencies

ANALYZER

FREQUENCY ANALYSIS



Resonant Frequencies

RESULTS, ANALYSIS & CORRECTIVE POSSIBILITIES

Results Indicate Large Operating Window:

- **No changes required**

Results Indicate Small or No Operating Window:

- **Speed change**
- **Structural change**

SPEED CHANGE REQUIRES THROW ADJUSTMENT OR MECHANISM CHANGE

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