Crushing and Screening Handbook

metso
Expect results

FIFTH EDITION

Preface to the Fifth Edition

Rock is the most used natural resource in the world. The two main types of natural aggregates are 1) crushed rock and 2) sand and gravel. As a main ingredient in asphalt and concrete, these aggregates are used in the construction of highways and bridges, as well as in both residential and nonresidential buildings. The widespread use of aggregates results not only from its general availability but also from economic considerations. The cost of aggregate is not, in itself, a major factor in most applications, but its impact on the use of more expensive components, such as cement in concrete or bitumen in asphalt, is quite essential. For that reason, it is important to understand those factors in aggregate processing that have the greatest impact on quality and costs. This calls for an understanding of the entire process, from solid rock to its final application.

Metso's Mining and Construction Technology has published this book in order to help those involved in the quarrying business. The main target group is quarry managers, but we hope the book will be a valuable source of information for all who deal with the quarrying industry or who are studying these subjects. Of course, the book also contributes to mining, especially in terms of crushing and screening, and for those seeking a greater focus on mining, Metso's minerals processing handbook is also available.

This is an updated version of the Metso Crushing and Screening Handbook, the first edition of which was published a couple of years ago. The changes in this 5th edition involve only minor updates and corrections. The content is almost identical to the 4th edition.

We at Metso's Mining and Construction Technology hope that this book contributes to an improved understanding of quarrying operations and thus helps us all to achieve profitable business. Quite a few people have contributed to the book, and I wish to express my thanks to these individuals.

Keijo Viilo
Editor-in-chief
Research Director

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Metso's Mining and Construction Technology in brief

To be successful in today's quarry and sand and gravel operations, you need a partner to supply competitiveness, not just equipment. This translates into a comprehensive source of global knowledge, financial resources, innovative technologies and systems, and skilled people in worldwide locations. Only one organization in the world has the resources to bring you all these capabilities for efficient aggregates process management.

Around 10,000 Metso's Mining and Construction Technology people operate in sales and manufacturing facilities and service shops in over 100 countries, covering all continents. They supply you with world-class equipment, complemented by comprehensive service solutions aimed at increasing your operational reliability. In short, we do everything possible to help ensure your success.

Your trusted partner

Your partner of choice, Metso is the trusted and preferred supplier in the rock processing industry. Our highest priority and personal commitment is to provide lifetime support and service for your aggregates processing operations.

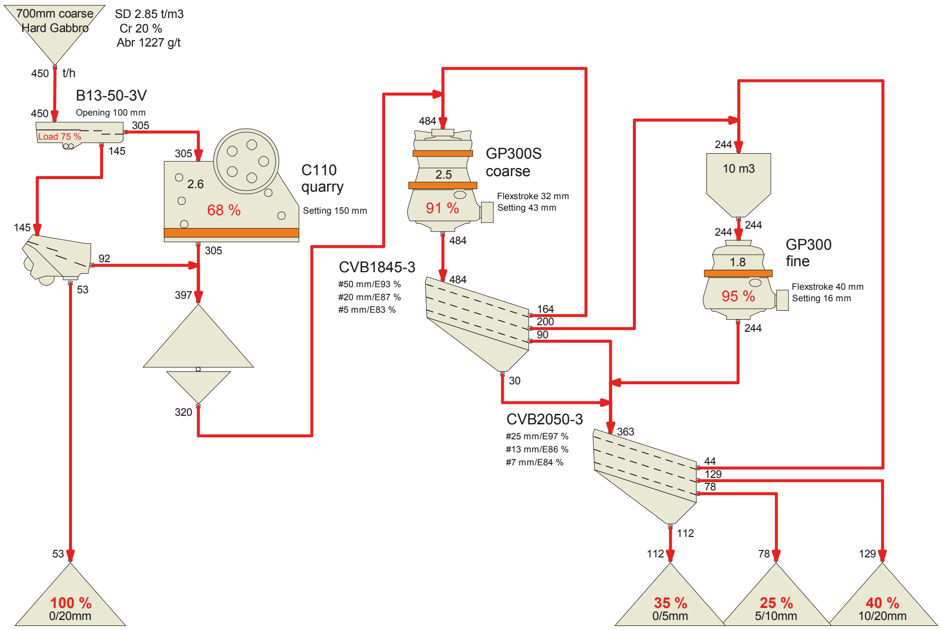
Whether you need a single crusher, a multi-stage process or a complete plant, we assist you with the right design for the most cost-effective crushing process. We are the world's leading supplier of both unit machines and complete aggregates processing systems.

Comprehensive process solutions

Your system may involve a whole series of processes, such as crushing and screening, conveying, classifying, washing and pretreatment, stockpiling, storage, loading and unloading, automation, environmental control and wear protection.

Using sophisticated project tools, our experienced engineers will arrange the appropriate equipment into a balanced system to provide you the high quality end-products you require, at the lowest cost per ton. We also provide site preparation, structural design, and supply and erection plans.

When designing a new plant, we balance raw material characteristics with the required production rate and the size and shape of the finished product. After careful selection of each piece of equipment from final screening to primary crushing your process characteristics are optimum quality, productivity and reliability.



Process simulation technology

The computerized "Bruno" process calculation system has already become the proven standard in the crushing industry. Rock quality, feed grading and selected machines are entered to simulate the expected production capacities and product gradings. Contact minerals.bruno@metso.com for more information.

Complete stationary or mobile plants

Besides offering complete stationary installations, Metso is the pioneer in fully mobile in-pit crushing operation. Integrating two or three mobile crushing plants combined with a mobile screen and a mobile conveying system results in improved efficiency and end-product accuracy.

METSO'S MINING AND CONSTRUCTION TECHNOLOGY

We have the expertise to build a fleet of track mounted crushing and screening plants for primary, secondary and tertiary stages according to your application. Moving along the quarry face the track-mounted units replace dump truck haulage, thus achieving substantial savings. The whole mobile plant can be moved from site to site on standard trailers. This is one example of how our worldwide process know-how can serve your crushing, screening and conveying needs.

Broad product range

Feeders – a wide range of heavy duty feeders designed to absorb impact, meter material to the crusher and scalp out fines.

Primary gyratory crushers – ideally suited to all high-capacity primary hard rock crushing applications.

Jaw crushers – we have more installed jaw crushers than anyone in the world. The leading choice due to their high reduction ratio and heavy duty design.

Cone crushers – capacities available to suit all secondary, tertiary or quarternary crushing applications. High performance technology.

Impact crushers – primary and secondary machines for soft and medium-hard materials. High reduction ratios. Can eliminate need for a tertiary crushing stage.

Spare and wear parts – genuine parts always close to you, no matter where you are located worldwide.

Vertical shaft impactors – helps shape the rock to high-quality aggregates. Rock on rock crushing.

Stationary screens – an extensive range of complete screening solutions for scalping, closed circuit screening, final sizing and dewatering. Single inclination, double, triple and horizontal models.

Sand and gravel washing – to produce special quality rock materials for demanding construction projects, such as bridges.

Crusher automation – ensures consistent and efficient operation. Improves productivity and product quality while reducing maintenance costs by preventing overload situations.

Stationary conveyors – a complete range of belt conveyors. Wide variety of widths, lengths, accessories and options. Various models incorporate truss frames that are simple, compact and fast to dismantle, transport and erect.

Track-mounted crushing plants – fully mobile jaw, cone or impact crushing plants, with or without screens, and equipped with open or closed circuit and discharge conveyors. Easily transportable on standard trailers.

Portable crushing plants – excellent transportability between sites and fast installation, in addition to high crushing capacities. Can be fitted with jaw, cone or impact crushers, with or without screens, and equipped with open or closed circuit and discharge conveyors.

Mobile screens – track-mounted units for excellent mobility and high performance on-site. Ideal for a wide range of applications. Also mobile screens on wheels which incorporate on-board conveyors and travel over roadways without special permits.

Mobile conveyors – mobile conveyors link a Lokotrack primary mobile crushing plant to further processing stages. They are able to follow the primary unit as it moves along the quarry face, replacing costly dump truck haulage.

Plant automation systems – monitor and control all crushing, screening, storing and conveying with real-time accuracy. Maintain maximum production capacity by adjusting process parameters on-line.

Original wear and spare parts – using original Metso wear parts is the key to a successful crushing process. The design of our certified wear parts starts with CAD simulations of the crusher cavity, which is the heart of the crushing process. By computer based planning and continuous quality control of the casting we can guarantee premium material quality, which translates into improved wear life and a higher operational capacity and reliability.

Customer Service Products – Metso's Mining and Construction Technology, using its long-term experience of crushing equipment and crushing processes, has developed an expert service offering aimed at improving the reliability and productivity of customer operations. Metso's certified customer service organization is available worldwide to add customer value through customer-specific solutions. Customer success and satisfaction are cornerstones of Metso services.

Brands served

The brand and trade names owned by Metso include: A.C. Hoyle, Allis Chalmers, Allis Mineral Systems, Altairac, Ambassador, Armstrong Holland, Babbitless, Barmac, Bergeaud, Big Bite, Boliden Allis, Cable Belt, Citycrusher, Citytrack, Combi-Screen, Conrad Scholtz, Denver, Dominion, Dragon, Dravo Wellman, Ellivar, Faço, Flexowell, G-Cone, GfA, Goodwin Barsby, Grizzly King, Gyradisc, Hewitt-Robins, Hummer, Kennedy Van Saun (KVS), Kue-Ken, Laser, Lennings, Lindemann, Lokolink, Lokomo, Lokotrack, Loro & Parisini, Ludlow Saylor, Marcy, Masterskreen, McCully, McDowell Wellman, McKiernan Terry (MKT), McNally, McNally Wellman, Meade Morrison, Morgårdshammar, Neyrtec, Nordberg, Nordpactor, Nordwheeler, Omnibelt, Omnicone, Omnimatic, Orion, Pyrotherm, Reed, Sala, Scanmec, Screen-All, Seco, Senator, Simplicity (slurry pumps), Skega, Stansteel, Stephens-Adamson, Strachan & Henshaw, Superior, Supersteel, Supralok, Svedala, Symons, Thomas, Tidco, Trellex, Waterflush, W.S. Tyler, Yernaux. The list is only indicative, since the actual number of brand and trade names includes many more widely known and historic names.

Metso figures

Metso's Mining and Construction Technology is a global supplier of solutions, equipment and services for rock and minerals processing. Its expertise covers the production of aggregates, the processing of ores and industrial minerals, as well as construction.

Headquartered in Helsinki, Finland, Metso's Mining and Construction Technology has annual net sales of over € 2.2 billion (2010). We have a local presence in over 100 countries. Personnel number 10,200.

Metso is a global supplier of sustainable technology and services for mining, construction, power generation, automation, recycling and the pulp and paper industries. We have about 28,500 employees in more than 50 countries, with 2010 net sales of EUR 5,5 billion.

METSO'S MINING AND
CONSTRUCTION TECHNOLOGY

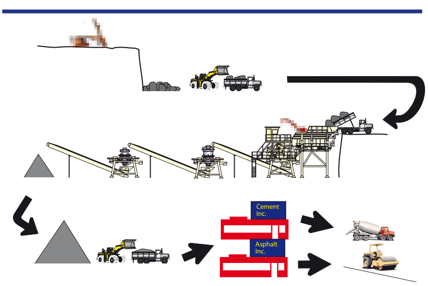
Quarry process and its development

In quarrying, the main activities are:

- Drilling
- Blasting
- Boulder handling
- Crushing & screening
- Material loading
- Hauling

Quarry processes can be either stationary or mobile, as shown in Figure 1.

Stationary quarry



Mobile quarries

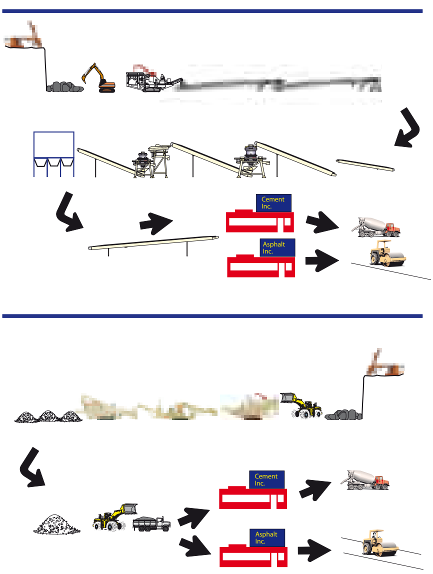
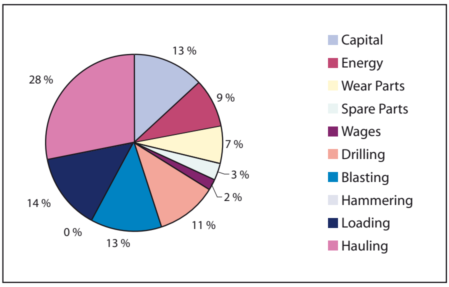


Figure 1: Quarry types

These are the main determiners of quarrying costs, and thus understanding these costs, how to influence them directly, and how they impact each other is the key to successful quarry development.

It is important to have a basic understanding of this process because it is the 'world' where those in quarry work live and do business. In order to have a good overall picture, it is useful to look at the typical cost structure of quarry operations. These are shown in Figure 2, which shows two cases: a stationary one and a case where the primary section is mobile = inpit crushing, which in many cases can yield remarkable benefits because material hauling costs can be reduced considerably. This issue is reviewed later, in the LT section of this book.

Stationary:



Primary crusher mobile:

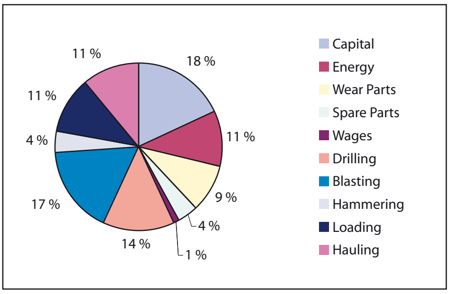


Figure 2: Examples of cost structure in quarrying

In quarrying, it is important to understand that many activities impact each other, so that

<u>Optimised (blasting + crushing + screening) = max. ($$$)</u>

And it is NOT

<u>Opt. (blasting) + opt. (crushing) + opt. (screening)</u>

This calls for a so-called integrated approach. The blasting process has to be adjusted to different types of rock, because they have different properties and the result will be different fragmentation. An integrated approach at its best includes the steps shown in Figure 3.

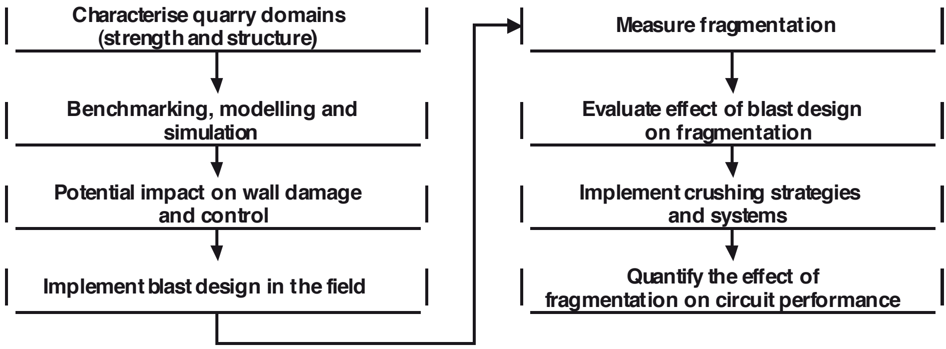


Figure 3: Integrated methodology in quarrying

The target in quarry development is to maximise the yield with respect to production costs according to Figure 4.

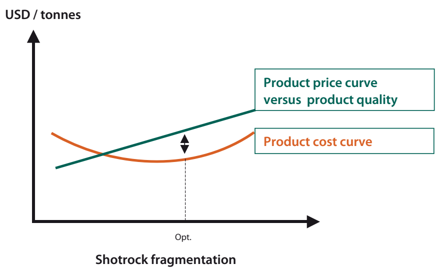


Figure 4. Target in quarry development

Actually, optimising quarrying from the end-product yield and cost point of view can be very complicated, and justified to do in detail in cases where the scope of operation is great enough. In most cases, it is enough to understand the basic guidelines on how drilling & blasting, crushing, hauling, etc. impact each other. So let's have a look at some highlights of these key elements in quarrying:

Drilling and blasting

Figures 5 and 6 show the basic impact of drillhole diameter on costs and also on some key parameters with importance for the later stages in the process as well as end-product yield and quality.

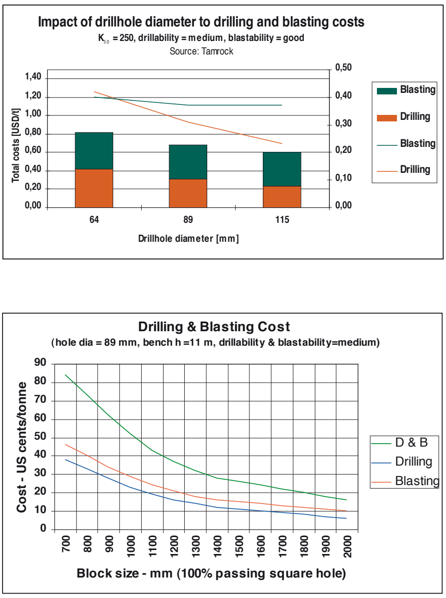


Figure 5: Costs vs. drillhole diameter and boulder size

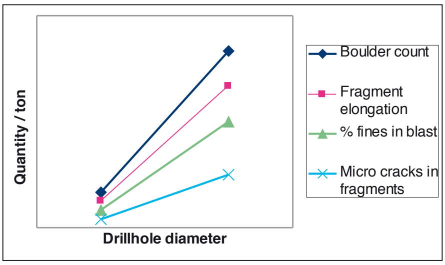


Figure 6. Impact of drillhole diameter on some important process & quality parameters

Crushing & screening

Crushers and screens will be reviewed more later in this book, but the following factors must be stressed:

- Handling of oversize boulders. These should never be allowed to enter the feeder for breakage (Figure 7), because it in many cases means that the later stages in the process are starved of material and economy will be poor. Breakage of boulders should be done outside the crushing process, preferably close to the quarry face.
- Role of process planning: By using the same equipment, process capacity can be doubled but at the cost of quality.
- Selection of stationary vs. mobile configuration.
- Selection of the right type of crusher and screen for the application in question.

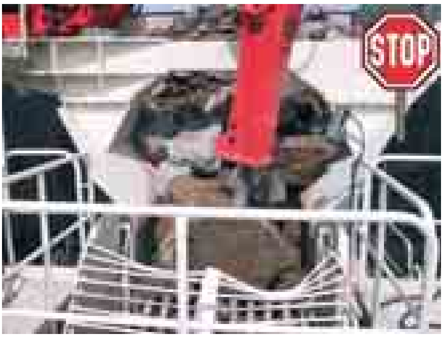


Figure 7: No oversize breaking in crushing process

Loading and hauling

Loading and hauling are one of the major costs in the quarry process. These could be characterised by figures 8 and 9. In these graphs, the K_{50} value shows the percentage passing. So K_{50} = 250 mm means that 50% of blast distribution is passing 250 mm. Reasons that costs increase greatly with coarse blasts are that:

- Material is more difficult to load due to
  - toe problems being more likely
  - bigger boulders
- The scope of equipment is changed due to more difficult and/or longer cycle times
- In the equipment there is
  - more wear
  - more maintenance

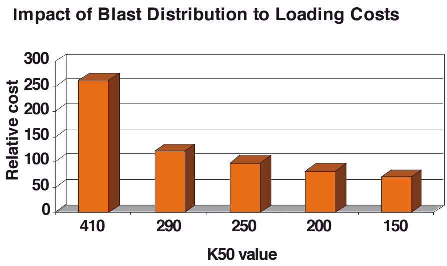


Figure 8: Influence of blasting on loading costs

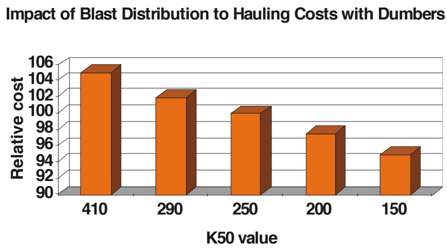


Figure 9: Influence of blasting on loading costs

Summary of quarry development

Quarry development could be summarised as follows:

- There is optimal shotrock fragmentation from the total product cost point of view.
- Oversize boulder frequency has a significant impact on capacity and cost.
- Smaller drillhole diameter produces less fines. In many cases, this is considered to be a waste.
- Crushing cost share is almost unchanged with different K_{50} values when the crushing method is the same. Optimum selection depends on:
  - Rock type due to abrasion
  - 'Case-specific factors' like life of the quarry, investment possibilities, etc.
- Optimisation of the whole quarry process instead of sub-optimisation of individual components.
- Inpit crushing can give remarkable benefits.

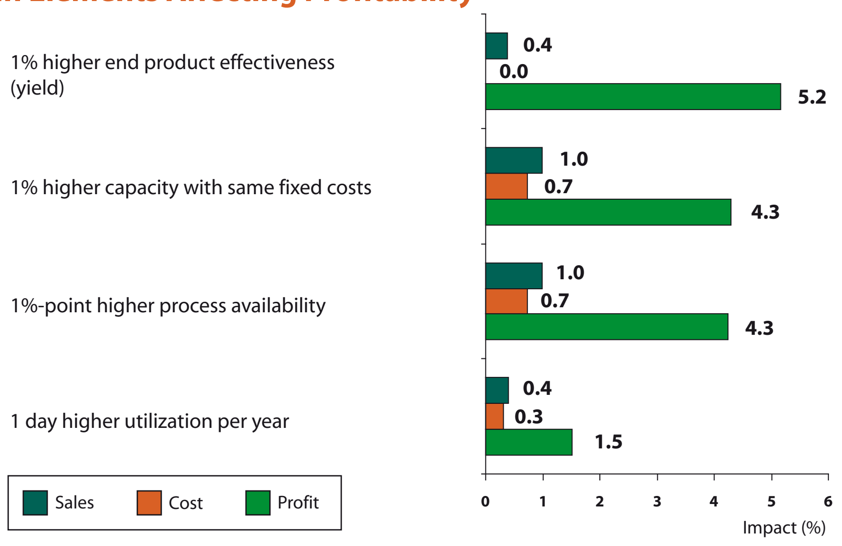
Finally, as a practical aid to memory, Table 1 can be presented.

Table 1: Impact of dependencies

+ = increase, - = decrease, 0 = minor impact						
	INCREASE OF					
IMPACT ON	**Drillhole diameter**	**Drill Pattern**	**Drillability index**	**Shotrock frag.size**	**Blastability index**	**Work index**
Drilling costs	- -	- - -	- -	- - -	+ +	+
Blasting costs	+ +	- - -	0	- - -	+ + +	+
Total excavation costs	- -	- - -	-	- - -	+ +	+
Hammering costs	+	+ + +	0	+ + +	+ +	+
Loading costs	0	+ + +	0	+ + +	0	0
Hauling costs	0	0	0	+	0	0
Crushing costs	-	+ +	0	+ +	+	+
Amount of fines	+ +	- -	+	- -	+ +	+
Number of boulders	+	+ + +	0	+ + +	+	0
Amount of micro-cracks	++	- -	0	- -	+ +	+
Size of primary crusher	+	+ +	0	+ +	+	0
Amount of scalps	++	- -	+	- -	+ +	+
Shotrock fragment cubicity	- -	++	+	+ +	- -	-
TOTAL COSTS	-	+	-	+	+ +	+

Profit impact of higher output is a lot bigger...

Main Elements Affecting Profitability



Metso's Mining and Construction Technology offers a wide range of feeders for primary sections, reclaiming, and controlled-quantity feed applications for bulk material handling in mineral processing and the aggregates industry.

The wide variety in the types and models offered allows for selection of the best feeder for each specific case. The table below of this page gives the main characteristics and range of application of the feeders.

GENERAL CHARACTERISTICS (for STPH multiply by 1.1)

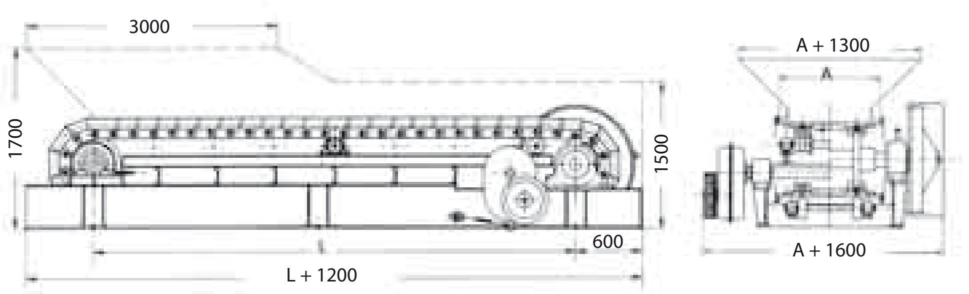
Machine	Apron feeder	Vibrating feeder
Capacity range	Up to 10,000 t/h	Up to 2,000 t/h
Max. size of material	Up to 50% of chain width	Up to 80% of table width
Main applications	- Heavy-duty use - Primary feed - Reclaiming of large volumes	- Heavy-duty use - Feeding of primary crushers - Reclaiming where large sizes are involved
Advantages	- High impact strength - High load per unit area - High availability - Good flow control - Ability to lift the material - Length according to needs - Reduction of plant height - Good handing of clayey materials with high moisture content	- High operating safety - Pre-separation of fines - Easy and reduced maintenance - Good feed control - Low purchase cost
Disadvantages	- High purchase cost - Bad sealing (accumulates fines requiring a belt or a chain conveyor for maintaining cleanness) - Does not classify or scalp fines	- Inability to be used to lift material - Limited length - High installed power - Lower capacity with material that is clayey or has higher moisture content; may become inoperative under certain conditions

APRON FEEDERS

The apron feeders have been designed for all kinds of applications. They can be used with dry, wet, or sticky materials and operate in polluted or corrosive environments.

Metso feeders are available in a wide variety of sizes and meet material handling needs in feeding and controlled-quantity applications in mining, quarrying, and basic industrial operations.

Our products are based on the many years of solid experience Metso's Mining and Construction Technology has in designing and manufacturing minerals processing equipment. The company can therefore ensure the right choice of feeder model and size for optimal performance while investment and maintenance costs are kept to a minimum.



FEED CAPACITY

The feed capacity depends on the feeder width, material layer height, conveyor speed, material type and size, and fill factor.

$$\mathbf{Q = 60\, B \cdot D \cdot \rho_S \cdot v \cdot \varphi}$$

Where
Q = feed capacity (t/h)
B = hopper width (m)
D = height of the layer of material to be conveyed 8 (m)
$\boldsymbol{\rho_S}$ = bulk density (t/m^3)
v = conveyor speed (m/min)
$\boldsymbol{\varphi}$ = fill factor

POWER CALCULATION

The forces resisting the movement of the conveyor are:

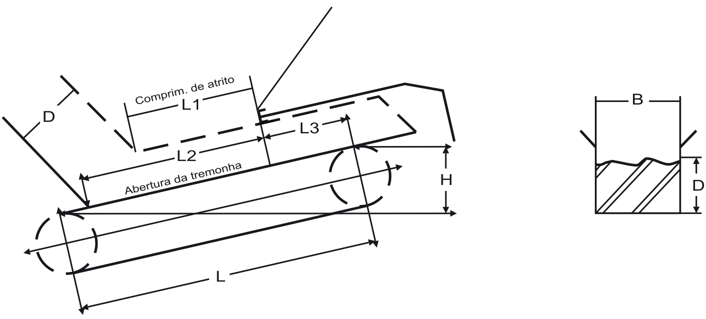
$$\mathbf{F_t = F_1 + F_2 + F_3 + F_4}$$

Where
$\mathbf{F_t}$ = total force (kN)
$\mathbf{F_1}$ = force due to roller friction (kN)
$\mathbf{F_2}$ = force due to material friction with the hopper (kN)
$\mathbf{F_3}$ = force due to friction between moving and idle material (kN)
$\mathbf{F_4}$ = force due to raising material

FEED CAPACITY

Chain speed (m/min)	Chain width							
	750 mm		1000 mm		1200 mm		1500 mm	
	t/h*	m³/h	t/h*	m³/h	t/h*	m³/h	t/h*	m³/h
3	64	40	107	67	150	93	240	150
5	107	67	178	111	248	155	400	250
7	150	93	248	155	350	218	560	350
9	192	120	320	200	448	280	720	450
11	235	147	390	244	550	343	880	550

** Always considering materials with bulk density of 1.6 t/m³*
For STPH multiply by 1.1
For ft³ multiply by 35.3



$$\mathbf{F_1 = 10\, f \cdot (1.2\, B^2 \cdot L_2 \cdot \rho_S + B \cdot D \cdot L_3 \cdot \rho_S + m)}$$

$$\mathbf{F_2 = \frac{F_S \cdot L}{100}}$$

$$\mathbf{F_3 = 9\, B^2 \cdot L_1 \cdot \rho_S \cdot S_F}$$

$$\mathbf{F_4 = 10\, \rho_S \cdot B \cdot D \cdot H}$$

Where
B, D, H, L, $\mathbf{L_1}$, $\mathbf{L_2}$, $\mathbf{L_3}$ = dimensions (m)

f = coefficient of friction for the rollers (0.1 for feeders with manganese steel pans, 0.14 for other feeders)

γa = material bulk density (t/m^3)

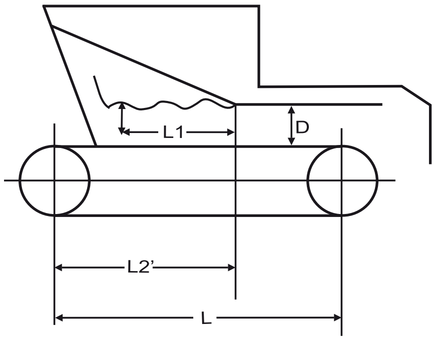
m = weight of moving elements (t)

Fs = resistance from material friction with the hopper per feeder metre (kg/m) – see table on page 2-4

Sf = shear factor, a correction factor – related to the type of material, moisture, and maximum size – that is used for more precise determination of the power required; for safe initial estimates, use Sf = 1.0

NOTE: For large-sized material boulders and open hoppers, consider L3 = 0 and L1 = 1/3 L2'.

L2' = length of the material slope in the feeder hopper



Fs values (daN/m)

D (m)	ρ_S (t/m³)			
	0,8	**1,2**	**1,6**	**2,4**
0,30	7,5	12,0	16,5	24,0
0,45	18,0	27,0	35,5	53,5
0,60	32,5	49,0	65,5	98,0
0,75	50,5	76,0	101,0	152,0
0,90	71,0	107,0	143,0	214,0
1,00	98,0	147,0	196,0	294,0
1,20	128,0	192,0	256,0	383,0
1,40	165,0	248,0	330,0	495,0
1,50	198,0	297,0	397,0	595,0
1,80	287,0	431,0	575,0	862,0

For ft multiply by 3.28

The power needed to overcome all these forces is calculated as follows:

$$\mathbf{N} = \frac{F_t \cdot v}{60\,\eta} \quad [\mathrm{kW}]$$

where:

N = required power (kW)

$\mathbf{F_t}$ = total force (kN)

v = conveyor speed (m/min)

η = mechanical efficiency

VIBRATING FEEDERS

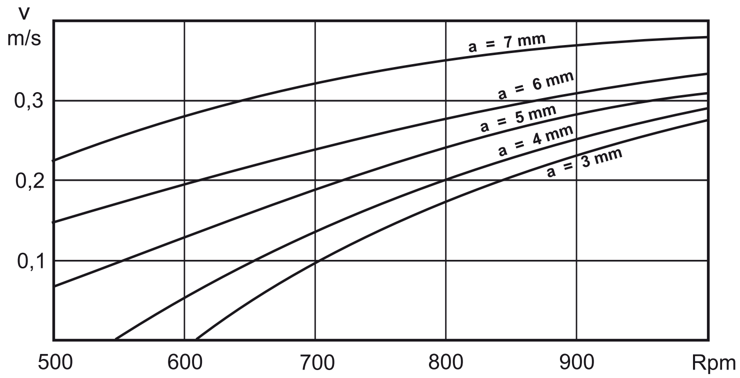
FEED CAPACITY

The capacity of vibrating feeders is calculated according to the following formula:

Q = 3600 x φ1 x φ2 x v x L x H (m³/h)

Where
φ1 = size factor
- **φ1** = 1 for sand
- **φ1** = 0.8 to 0.9 for crushed stone up to 6″
- **φ1** = 0.6 for sizes over 6″

φ2 = moisture factor
- **φ2** = 1 for dry material
- **φ2** = 0.8 for wet material
- **φ2** = 0.6 for clayish material



For ft/s multiply by 3.28
For inches divide by 25.4

L = table width

H = height of the material layer on the table, which depends on the load type and the size of the material and which may not exceed the following:

H ≤ **0.5** x **L** for large stones

H ≤ **0.3** x **L** for crushed stone up to 6″

H ≤ **0.2** x **L** for sand and small stones

v = speed of the flow of material on the vibrating plate according to the graph below, as a function of rotation (rpm) and amplitude (mm)

In Metso vibrating feeders, amplitude 'a' can be adjusted from 3 mm to 7 mm by changing the eccentric weights. NOTE: The amplitude corresponds to half of the movement.

For an inclined table, the downward speed will increase proportionally as follows:

$\alpha = 5°$ → multiply by 1.3

$\alpha = 10°$ → multiply by 1.6

VIBRATING FEEDERS

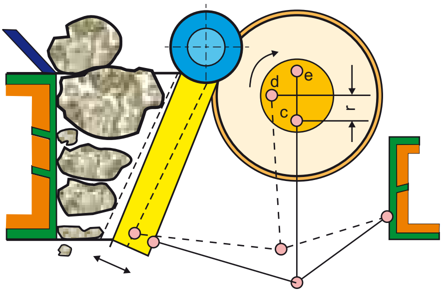
These feeders have been designed for large-size material and are mainly used to feed primary crushers.

Equipped with grizzly sections, they also remove the fines to bypass the primary crusher.

Robust and versatile, they have a low purchase cost when compared to apron feeders. These feeders are available in different sizes, with a capacity range of 25 to 1500 t/h (15 to 1000 m^3/h).

All crushers can be classified as falling into two main groups:
- Compressive crushers, which compress the material until it breaks.
- Impact crushers, which use the principle of quick impacts to crush the material.

Jaw, cone, gyratory, and roller crushers operate according to the compression principle, and impactors and hammer mills use the impact principle.



Double toggle crusher

COMPRESSIVE CRUSHERS

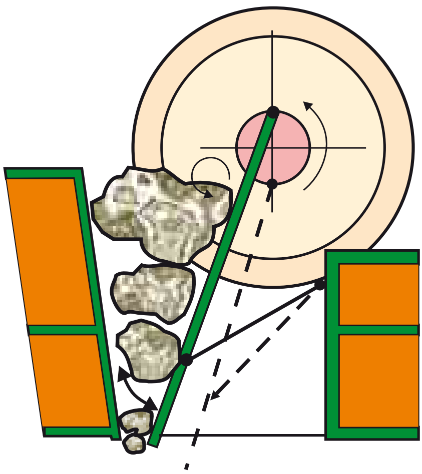
Jaw crushers

Jaw crushers are mainly used as primary crushers. Their main purpose is to produce material that can be transported by belt conveyors to the next crushing stages.

The crushing process takes place between a fixed and a moving jaw. The moving jaw dies are mounted on a pitman that has a reciprocating motion. The jaw dies must be replaced regularly due to wear.

There are two basic types of jaw crushers: single toggle and double toggle.

In the single toggle jaw crusher, an eccentric shaft is on the top of the crusher. Shaft rotation causes, along with the toggle plate, a compressive action. A double toggle crusher has, basically, two shafts and two toggle plates. The first shaft is a pivoting shaft on the top of the crusher, while the other is an eccentric shaft that drives both toggle plates. The moving jaw has a pure reciprocating motion toward the fixed jaw.


Single toggle crusher

The chewing movement, which causes compression at both material intake and discharge, gives the single toggle jaw better capacity, compared to a double toggle jaw of similar size. The jaw crusher is reliable and robust equipment, and therefore quite popular in primary crushing plants.

Cone and gyratory crushers

Both cone and gyratory crushers have an oscillating shaft. The material is crushed in a crushing cavity, between an external fixed element (bowl liner) and an internal moving element (mantle) mounted on the oscillating shaft assembly.

An eccentric shaft rotated by a gear and pinion produces the oscillating movement of the main shaft. The eccentricity causes the cone head to oscillate between o.s.s. (= open side setting) and c.s.s. (= closed side setting) discharge opening. In addition to c.s.s., eccentricity is one of the major factors that determine the capacity of gyratory and cone crushers.

The fragmentation of the material results from the continuous compression that takes place between the liners around the chamber. An additional crushing effect occurs between the compressed particles, resulting in less wear of the liners. This is called interparticular crushing also.

The gyratory crushers are equipped with a hydraulic setting adjustment system, which adjusts c.s.s. and thus affects product gradation.

Depending on cone type, setting can be adjusted in two ways. The first way is for setting adjustment to be done by rotating the bowl against the threads so that the vertical position of the outer wear part (concave) is changed. One advantage of this adjustment type is that liners wear more evenly. Another principle is that of setting adjustment by lifting/lowering the main shaft. An advantage of this is that adjustment can be done continuously under load.

To optimise operating costs and improve the product shape, as a rule of thumb it is recommended that cones always be choke-fed, meaning that the cavity should be as full of rock material as possible. This can be easily achieved by using a stockpile or a silo to regulate the inevitable fluctuation of feed material flow. Level monitoring devices detect the maximum and minimum levels of the material, starting and stopping the feed of material to the crusher, as needed.

Gyratory crushers

Primary gyratory crushers are used in the primary crushing stage. Secondary gyratory crushers are normally used in the second crushing stage, but, in some cases, they can be used in the primary stage if the material has a size that fits the feed opening. Compared to the cone-type secondary crusher, a gyratory crusher has a crushing chamber designed to accept feed material of a relatively large size in relation to the mantle diameter. Therefore, the cone head angle is smaller than that of a gyratory type of cone crusher.

Secondary & tertiary & quaternary cone crushers

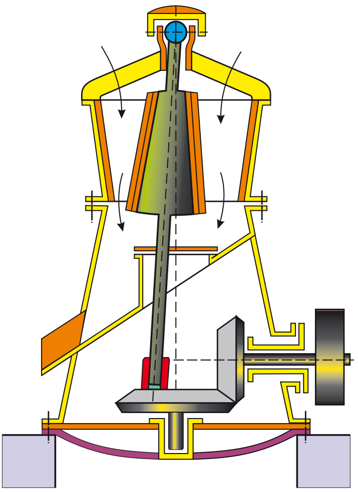
These cone crushers are used for intermediate or fine crushing, and/or to obtain a product with good cubical shape. The feed material receives primary crushing in previous stages. In the case of gravel, Mother Nature has done the primary crushing, and therefore the cone-type secondary crusher can, sometimes, carry out the complete crushing process.

The key factor for the performance of a cone-type secondary crusher is the profile of the crushing chamber or cavity. Therefore, there is normally a range of standard cavities available for each crusher, to allow selection of the appropriate cavity for the feed material in question.

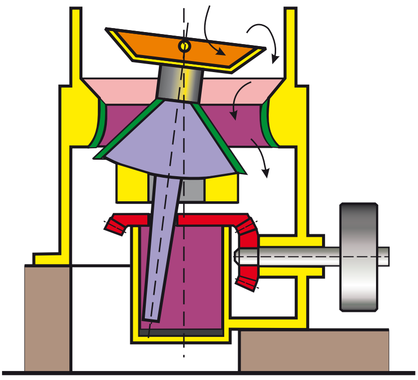
IMPACT CRUSHERS

The two main types (horizontal-shaft and vertical-shaft impactors) are characterised by a high reduction ratio and cube-shaped product. The impactors can also be used for selective crushing, a method that liberates hard minerals from the waste material.

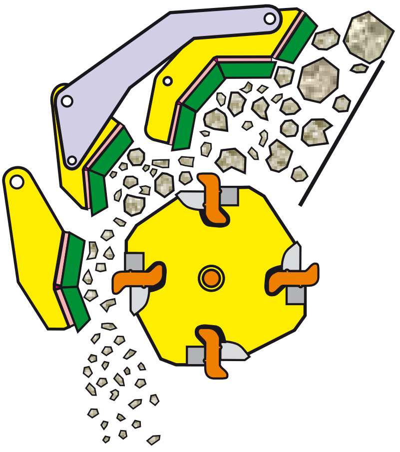
The impactor consists of a steel plate body containing a shaft and rotor assembly. The number of moving parts is quite small.



Gyratory crusher



Cone crusher



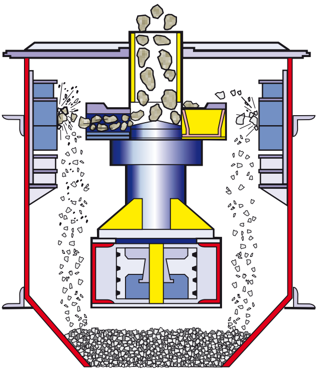
Impactor (HSI)

Horizontal-shaft impactors (HSI)

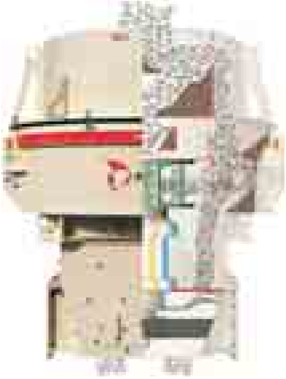
The feed material is crushed by highly intensive impacts originating in the quick rotational movement of hammers/bars fixed to the rotor. The particles produced are then further crushed inside the crusher as they collide against crusher parts and against each other, producing a finer, better-shaped product.

Vertical-shaft impactors (VSI)

The vertical-shaft impactor can be considered a 'stone pump' that operates like a centrifugal pump. The material is fed through the centre of the rotor, where it is accelerated to high speed before being discharged through openings in the rotor periphery. The material is crushed as it hits of the outer body at high speed and also due to the rock-on-rock action.



Impactor (VSI)

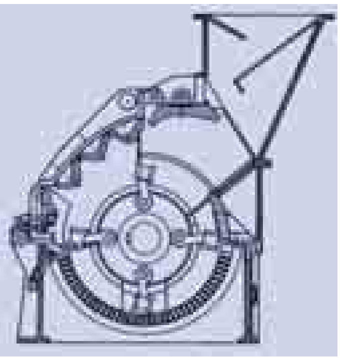


Impactor (VSI) rock-on-rock action

The VSI impactors produced by Metso are autogenous VSI crushers that use the rock-on-rock crushing principle, thus minimising wear costs. The VSI crushers with metal liners around the inner part of the body are used for low-abrasion material grinding applications. These crushers offer higher reduction ratios at a lower energy consumption than that of autogenous models. The VSI crushers are mainly used in the production of fine materials, including sand, with a good cubical shape.

Hammer mills

Hammer mills are quite similar to impactors. The difference is that the hammer mill rotor has many pivoted hammer attached to it and the discharge openings consist of a grate through which the material has to pass, thus contributing to the reduction process. Hammer mills are used to grind and pulverise materials that are not too hard or abrasive. The rotor speed and the grate spacing can be optimised to suit different applications.



Hammer mill

CRUSHING EQUIPMENT SELECTION

Some who are familiar with the technique for selecting crushing equipment are of the opinion that it is possible to make a selection merely based on calculations. However, theoretical conclusions must always be counterbalanced by practical experience with the different materials as well as the operational, maintenance and – last but not least – economic aspects of the various solutions.

PRIMARY CRUSHING

The main purpose of a primary crusher is to reduce the material to a size that allows its transportation on a conveyor belt. In most crushing installations producing aggregates, a jaw crusher carries out the primary crushing. Plants with very high capacities normally use a primary gyratory crusher. When the material is easy to crush and not very abrasive, an impact crusher may be the best choice for primary crushing.

One of the most important characteristics of a primary crusher is its capacity for accepting feed material without bridging. A large primary crusher is, naturally, more expensive than a smaller one. Therefore, the investment cost calculations for primary crushers are compared together against the total costs of primary stages, including quarry face clearing, blasting, and drilling costs. In many cases, dump trucks transport the rock to a stationary primary crusher. This may be an expensive solution. Amortisation, fuel, tyres, and maintenance costs can be included when the vehicles are in high demand. In modern operations, the use of mobile primary crushers that can move alongside the rock face is, in many cases, the most economical solution.

A stationary primary crusher can be transformed into mobile equipment with the help of a track system (with crawlers). A track-mounted primary crusher may be an interesting solution economically in cases where the equipment needs to be constantly repositioned in the quarry. However, it can be a slightly more expensive solution in terms of investment and maintenance. There may be potential for cost savings in material loading and transportation. If these savings are realised, the potential savings over traditional methods could be up to 25%. All this means that these matters have to be analysed case by case, and there are effective tools available for this.

Jaw crushers

In terms of the size of the feed opening, the client gets a better return on investment when the primary crusher is a jaw crusher. That means less drilling and blasting because the crusher accepts larger boulders. The disadvantage of this type of crusher, when high capacity is required, is the relatively small discharge width, limiting the capacity as compared with the discharge circuit of a gyratory crusher. Jaw crushers are mainly used in plants producing up to approximately 1600 t/h.

Primary gyratory crushers

The primary gyratory crusher offers high capacity thanks to its generously dimensioned circular discharge opening (which provides a much larger area than that of the jaw crusher) and the continuous operation principle (while the reciprocating motion of the jaw crusher produces a batch crushing action). The gyratory crusher has no rival in large plants with capacities starting from 1200 t/h and above. To have a feed opening corresponding to that of a jaw crusher, the primary gyratory crusher must be much taller and heavier. Also, primary gyratories require quite a massive foundation.

Impactors

The primary impact crusher offers high capacity and is designed to accept large feed sizes. The primary impact crushers are used to process from 200 t/h up to 1900 t/h and feed sizes of up to 1830 mm (71") in the largest model. Primary impact crushers are generally used in nonabrasive applications and where the production of fines is not a problem. Of all primary crushers, the impactor is the crusher that gives the best cubical product.

INTERMEDIATE CRUSHING

The purpose of intermediate crushing is to produce several coarse-grade products – for example, road base aggregates – or to prepare material for final recrushing. If the intermediate crushing is done with the purpose of producing railway ballast, the quality of the product is important. In other cases, normally there are no quality requirements, except that the product be suitable for fine crushing. In most cases, the goal is to obtain the best possible size reduction at the lowest cost.

Cone crushers are often used for intermediate crushing, due to their high capacity and low operating costs.

FINE CRUSHING AND CUBICISING

These crushing stages determine the quality of the final products. Quality specifications are precise for the final products, especially in the aggregates industry.

Common demands from clients in aggregate production as well as in mining operations are capacity and quality (gradation). The aggregates industry has additional quality demands also, such as for the cubical shape of the particles.

In most cases, fine crushing and cubicising are combined in a single crushing stage. The selection of a crusher for this job requires practical experience and theoretical knowledge. This is where the Metso Mining and Construction Technology can help.

Two main types of crushers for fine crushing and cubicising

The user will have to choose between the two main types of crushers for fine crushing and cubicising – i.e., cone and impact crushers. The decisive factors for selection of the most appropriate equipment are the abrasiveness and crushability of the material, as well as the desired gradation curve.

Cone crushers

Due to their design, cone crushers are generally a more expensive investment than impactors are. However, when correctly used, a cone crusher offers lower operating costs than a conventional impact crusher. Therefore, clients crushing hard or abrasive materials are advised to install cone crushers for the final crushing and cubicising stage. Cone crushers can in most cases also give a good cubic shape to fine grades. Cone crushers can be adapted to different applications. This is an important factor, as client-specific needs often change during a crusher's lifetime.

For cone crushers there are few rules to be followed of optimum cubical shape. These 'Ten Golden Rules' are:

1. Full crushing chamber. This means that cone head must be covered by rock.
2. Stable and continuos feed.
3. Material below setting in the feed 10-30% (but no filler and fines 0-4 mm normally).
4. Maximum feed size. Reduction ratio must be limited to 3 (-4). Recommended max feed size is 50 mm.
5. Correct feed distribution. Feed distribution should be non segregated and evenly distributed around crushing cavity.
6. Setting closer to required product
7. Correct choke point. This means the right selection of cavities for feed in question.
8. Crusher itself. New generation cones will produce considerably better shape than so called old generation. This is due to improved crusher kinematics and shape of cavity.
9. Closed circuit. This improves shape by attrition, gives constant feed curve and recrushing of flaky product In secondary stages closed circuit calibrates feed to tertiaries.
10. Flow sheet in general. Important, especially in production of very high quality (shape) aggregate is that selective circuits are used, meaning that secondary and tertiary products are not mixed.

Impactors

The impactor family consists of two main types of impact crushers.

The conventional type has horizontal shaft configuration, known as HSI. The other type consists of a centrifugal crusher with vertical shaft, generally known as VSI. Impactor operation is based on the principle of rapid transfer of impact energy to the rock material. Impactors produce cubic products, and they can offer high reduction ratios as long as the feed material is not too fine. This means that in certain cases it is possible to use a single impact crusher to carry out a task normally done in several crushing stages using compressing crushers (i.e., jaw, gyratory, and/or cone crushers). Impactors are mostly used for nonabrasive materials.

The two main types of impactors can be further subdivided, into various groups.

Conventional horizontal-shaft impact crushers are available in various sizes and models, from high-capacity primary crushers for large limestone quarries to specially designed machines for the crushing of materials such as slag.

There are two main categories of VSI crushers – machines with impact wear parts around the body and machines that use a layer of accumulated material. The first type is in many respects similar to the conventional impactor with horizontal shaft and rotor. The second type became quite popular in the past decade and is known as the Barmac crusher. The difference between a conventional impactor and a VSI of the Barmac type is that the latter offers lower operating costs, but its reduction ratio is lower also. In a Barmac VSI, the material undergoes an intense rock-on-rock crushing process. In the other crushers, most of the reduction is done by the impact of stone against metal.

Customers operating old, rebuilt, or expanded plants often have problems with the shape of the product. In these cases, the addition of a Barmac VSI in the final crushing stage offers a solution to product shape problems.

The same applies to many mobile crushing units. As the number of crushing stages is normally small with this type of plant, it is almost impossible to obtain a good product shape unless the rock is relatively soft and thus more suited for the production of cubic product. A centrifugal crusher in the final stage can help to solve the problem.

The plant's capacity and the size of the feed material are the main factors in selection of a primary crusher. To ensure good performance of the primary plant and prevent production losses, it is necessary to have an adequate correlation between the size of the feed material and the dimensions of the crusher feed opening. This means that the maximum size of feed material should be in the range of 60 to 80% of the crusher intake opening's size. Factors that may have an effect on the choice include the type of feeder used, material flow to the crusher, and the availability of the necessary means (like breakers) to remove large-sized boulders in the event of bridging at the material intake opening. In cases where capacity requirements are very high, the natural choice is a primary gyratory crusher.

Naturally, a large intake opening is always an advantage. However, in practice, the limit is set by the capacity of the plant and the budgeted investment.

Crushing – Calculation of Reduction Ratio

All crushers have a limited reduction ratio meaning that size reduction will take place in stages. The number of stages is guided by the size of the feed and the requested product, example see below.

Feed Material Size: F^{80} = 400 mm
Blasted rock, 80% smaller than 400 mm

Product Size: P^{80} = 16 mm
Road aggregates or rod mill feed 80% smaller than 16 mm

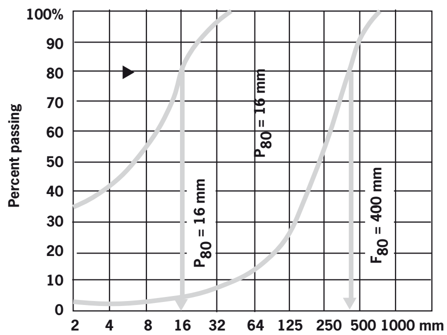
Total reduction ratio (R) F^{80}/P^{80} 400/16 = **25**

Reduction ratio in the primary crushing stage
R1 = **3**
Reduction ratio in the secondary crushing stage
R2 = **4**

Total in 2 crushing stages gives
R1xR2 = 3x4 = **12**
This is not sufficient. We need a third crushing stage.*

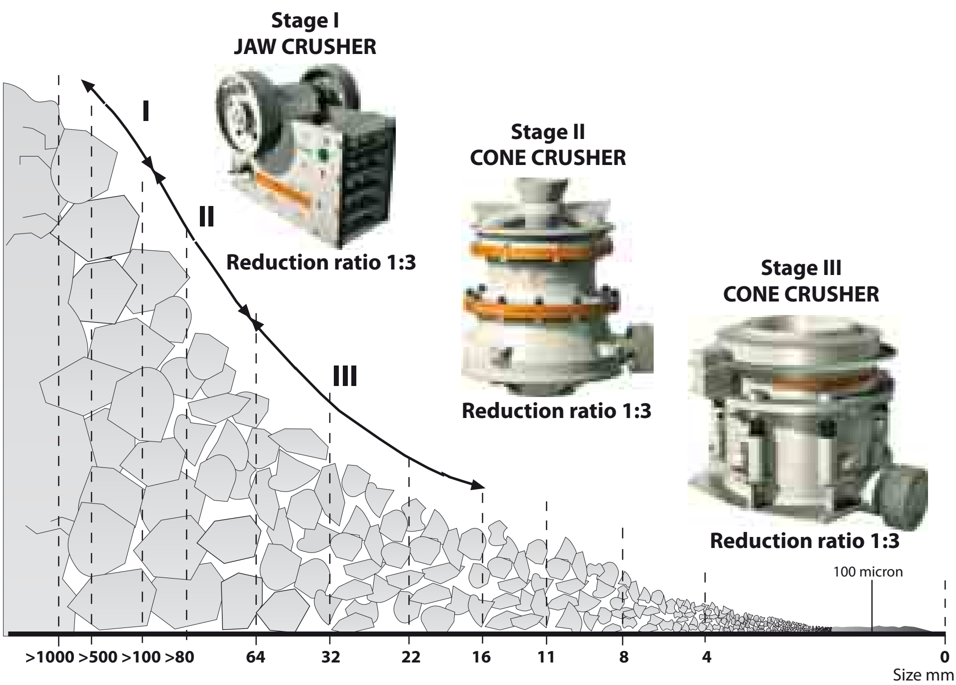
For example:	Reduction first stage	R1 = 3
	Reduction second stage	R2 = 3
	Reduction third stage	R3 = 3

Together these three stages give R1xR2xR3 = 3x3x3 = **27** = sufficient reduction



**As we have to use three stages, we can reduce the reduction ratio a bit in every stage, giving more flexibility to the circuit!*

The same size reduction with soft feed (below mohs 5) is done with two stages of HSI (horizontal shaft impactors) as they can easily reduce 1:10 in each stage giving max reduction possibility of 1:100.

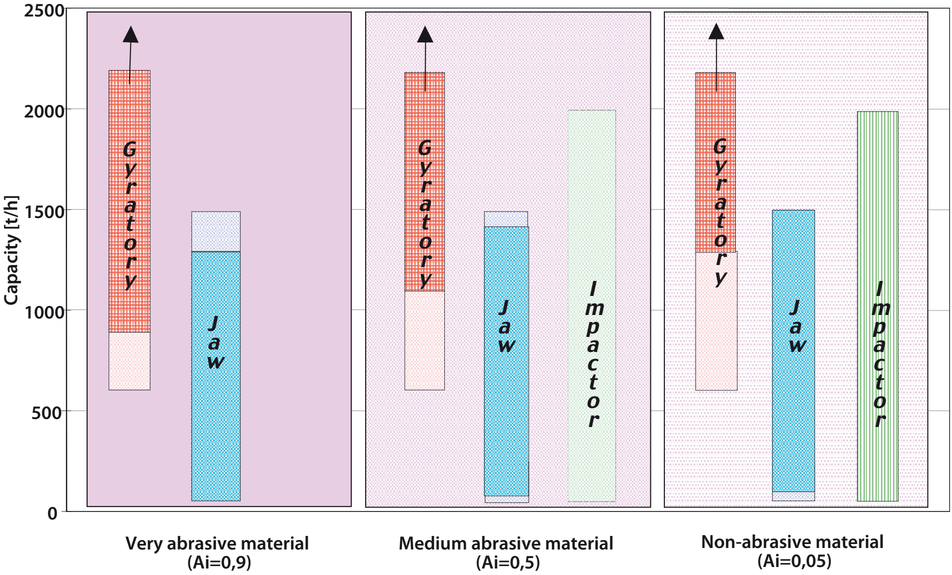


For inches divide by 25.4

Crushing Equipment

CRUSHING EQUIPMENT
CRUSHER SELECTION

In the table below there are some very basic guidelines for crusher applications. The information in the table below is only indicative and not a rigid rule. Primary crusher selection can also be summarized as shown in the diagram below.



Major Crusher type	Typical process stage	Feed size up to (mm)	Typical max. endproduct size (mm)	Typical capacities (t/h)	Abrasiveness		Amount of fines produced	Product shaping
					low	high		
Gyratory crusher (large)	primary	1500	200-300	over 1200		x	low	
Jaw crusher	primary	1400	200-300	up to 1600		x	low	
Horizontal impact crusher	primary/ secondary	1300	200-300	up to 1800	x		medium/ high	yes
Cone gyratory crusher	secondary	450	60-80	up to 1200	x	x	low	
Cone gyratory crusher	tertiary	300	0-30	up to 1000	x	x	low/ medium	yes
VSI Barmac, B series	tertiary	40	0-30	up to 600	x	(x)	high	yes

For inch divide by 25.4   For STPH multiply by 1.1

Indicative Impact of Different Parameters

The impact of rock characteristics and the operational parameters of crushers on the final product is complicated. In many cases, the impact of single factors depends on the combined effect of several others. The table opposite presents a simplified summary of the effects of some variables on the end product and crusher performance. As implied above, in many cases the impact of a parameter can be the opposite of that expected, depending on another parameter. A practical example is the influence of the cone crusher stroke on the shape. If feed contains smaller fractions than the crusher setting, a larger stroke is good for the product shape. But if the feed fraction is narrow, without factions smaller than the setting, then, from perspective of the end product shape, a smaller stroke is the better choice. At any rate, with this kind of configuration such an end product quality can never be achieved with a wider feed with fractions < setting. For this reason, the aforementioned simultaneous effects occur and should be taken into account.

+ = value increases
- = value decreases

Increase of		EFFECT ON: Product – Share of 0/4	Product – 80% point	Product – Curve Steepness	Product – Capacity	Product – Flakiness index	Crusher – Power	Crusher – Crushing force
Feed material	Feed 80% point	-	+		-	+		
Feed material	Share of below setting in feed				+			+
Feed material	Crushability	+	-	-	-	-	-	
Feed material	Moisture	+	-		-			
Feed material	Flakiness in feed	+	-	-	+	+		
Crushers	**Jaws**							
Crushers	Setting		+	+	+		-	-
Crushers	Speed		-	-		+	+	
Crushers	Nip Angle				-			
Crushers	**Cones**							
Crushers	Setting	-	+	+	+		-	-
Crushers	Stroke			-	+		+	+
Crushers	Speed	+	-	-			+	
Crushers	Nip Angle				-			
Crushers	**Horizontal Shaft Impactors**							
Crushers	Speed	+	-	-		-	+	
Crushers	Setting		+		+	+	-	
Crushers	Number of Hammers		-			-	+	
Crushers	Number of Breaker Plates	+	-		-	-		
Crushers	Feed rate	-	+		+		+	
Crushers	**Vertical Shaft Impactors**							
Crushers	Speed	+	-	-	-	-	+	
Crushers	Cascade	-	+		+	+	-	
Crushers	Number of Ports				-			
Crushers	Feed Rate	-			+		+	

CRUSHING – GENERAL CONCEPTS CAPACITY

Crushers' capacities

The production capacities given in the performance tables on the pages that follow were prepared as a tool to aid in the correct use of the crushers. The capacities (t/h) indicated are based on materials with a bulk density of 1,600 kg/m^3.

The crusher is only one component of the crushing circuit. Therefore, its performance will also depend on the right choice and correct operation of feeders, conveyors, screens, frames, electric motors, drives, and silos.

For good performance, all the factors below should be taken into account:

1 – Selection of an appropriate crushing chamber for the material.
2 – Feed curve with adequate size distribution.
3 – Feed rate control.
4 – Adequate material distribution over the 360° of the crushing chamber in the case of cone crushers.
5 – Appropriate dimensioning of the discharge conveyor as regards crushers' maximum capacity.
6 – Correct dimensioning of scalping and classifying screens in closed circuits.
7 – Automation.
8 – Adequate crusher discharge area.

The factors listed below, when not taken into consideration, may affect the capacity and the performance of the crusher.

1 – Presence of sticky material in the crushers' feed.
2 – Presence of fines in the feed (0-5 mm) exceeding 10% of the crusher capacity.
3 – Excessive humidity.
4 – Segregation of feed in the crushing chamber.
5 – Uneven distribution of feed around the crushing chamber, in the case of cone crushers.
6 – Lack of feed control.
7 – Wrong motor size.
8 – Insufficient capacity of the crusher's discharge conveyor.
9 – Insufficient capacity of scalping and/or circuit closing screens.
10 – Insufficient crusher discharge area.
11 – Material for crushing being extremely difficult to crush or hard.
12 – Crusher operating at a rotation speed below specifications.

To determine the effect of one characteristic alone, please consult Metso.

Crusher Performance Simulation

Rock crusher performance consists of size reduction, throughput capacity, energy consumption and quality (grading and particle shape).

Crusher performance has several parameters
- Processed rock material characteristics
- Feed material size distribution
- Material characteristics
- Moisture etc.
- Crusher parameters
- Crusher kinematics
- Crushing chamber geometry

Reliable crusher performance simulation
- Enables crushing chamber and kinematics optimisation
- Serves as a problem solving tool

Simulation Model Background

The first prediction models for jaw and gyratory crusher performance were published in the 1950s. These models calculated the flow of material into the crushing chamber, the result being an estimation of crusher capacity.

Models developed later were based on equations of motion and took account of selection and breakage functions derived from laboratory tests.

The model developed by Mesto's Mining and Construction Technology research is also based on the laws of mechanics and predicts size reduction using selection and breakage functions. Empirical selection and breakage functions are obtained through extensive laboratory test series, including both single particle and particle layer compression tests for different materials. Simulation is fine-tuned to high accuracy through hundreds of full-scale crushing tests conducted by Mesto's Mining and Construction Technology research.

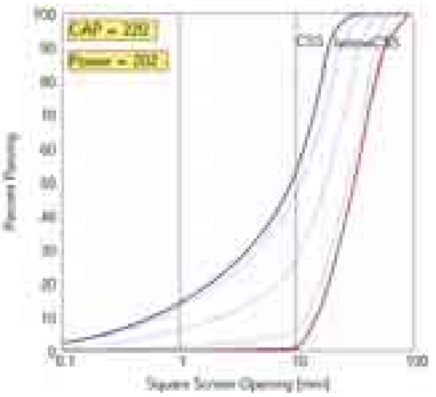
Simulation Program Input and Output Parameters

Simulation program input parameters are divided into two categories, crusher and feed material parameters. Crusher parameters are:
- Crushing chamber geometry

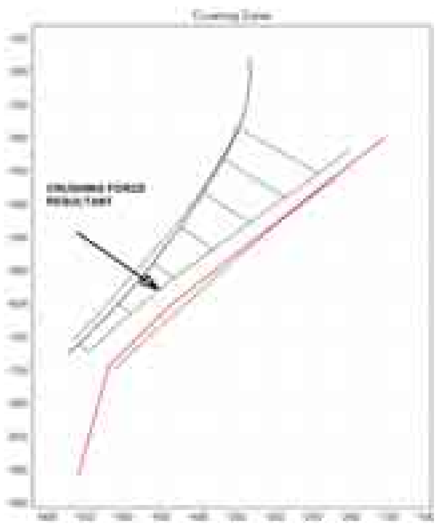
- Crusher
- setting
- stroke
- eccentric speed

A size reduction model needs input data from the flow model and material characteristics:
- Feed size distribution
- Feed material crushability
- Feed specific gravity

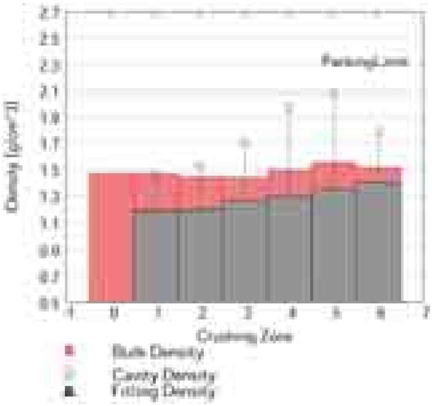
Simulation program output:
- Product grading
- Throughput capacity
- Power draw
- Material density in crushing chamber
- Estimation of wear profile in cavity
- Crushing pressure/force
- Key values for estimating product quality

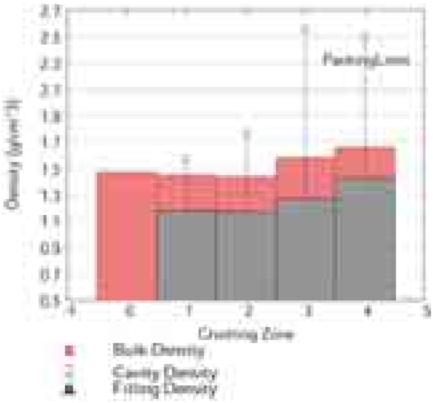


Examples of calculation results. Product grading, capacity and power draw.

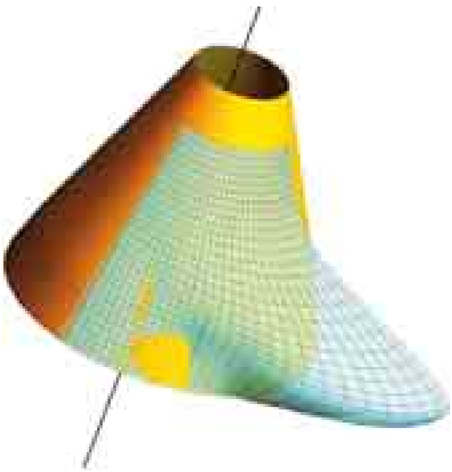


Examples of calculation results using a cone crusher. Crushing zones, crushing force and estimation of wear profile after 10% of liner life used.





Examples of calculation results, material density in crushing zones. Depicts a normal situation where cavity density remains below the packing limit and an undesirable case where the crusher is packing, leading to a high crushing force and, usually, fluctuations in crusher production.



Example of calculation results, cone crusher. Crushing pressure distribution on mantle.

C-series Jaw Crusher

The world's favourite jaw crusher

Metso, the world's leading rock and mineral processing group, has installed over 10 000 jaw crushers since the 1920s. Today the Nordberg C Series is indisputably the world's favourite jaw crusher.

All C Series jaw crushers are based on a revolutionary modular, non-welded frame construction. This design offers owners the highest possible fatigue strength, excellent reliability and numerous mounting possibilities. This, combined with high-quality cast steel components and premium spherical roller bearings, means exceptionally high crusher availability, cost-efficient crushing and low cost per ton.

World-class craftsmanship and materials

C Series crushers are premium class crushers due to their design as well as to the materials that are used to produce them. Good examples are the oversized high quality bearings and eccentric shaft. Attention has been paid to even the smallest details, so as to ensure the highest possible functionality and reliability, without any compromises.

Modular, non-welded construction

A uniquely modular, non-welded frame construction is a state-of-the-art design with two hot-rolled steel side plates joined to high-quality cast steel frames through robust, precision-machined bosses secured with bolts. The absence of stress inducers such as weld seams ensures excellent durability against shock loads.

The right cavity design

C Series jaw crushers are literally designed "from the inside out" because the cavity is the heart and only purpose of the jaw crusher. That is why over the years great attention has been paid to the feed opening dimensions as well as to the cavity height. The right feed opening width to depth ratio ensures minimum blockage and eliminates unnecessary height from the crusher.

Many types of jaws have been developed over the years in order to optimize the performance of Nordberg C Series crushers in a very wide range of applications, including conventional quarries, mines, gravel pits, and recycling of demolition material and asphalt. The tooth profiles as well as the thickness of the jaws are optimized and combined with the right manganese steel alloys to maximize throughput and minimize operating costs.

Aggressive kinematics and high power

In addition to the right cavity dimensions, the right kinematics must be applied. That is why C Series jaw crushers have a large eccentric throw coupled with a steep toggle plate angle that magnifies the effective stroke at the crusher discharge. The large stroke, combined with the right speed, aggressive nip angle, flywheel inertia and high available crusher power result in truly high crusher performance.

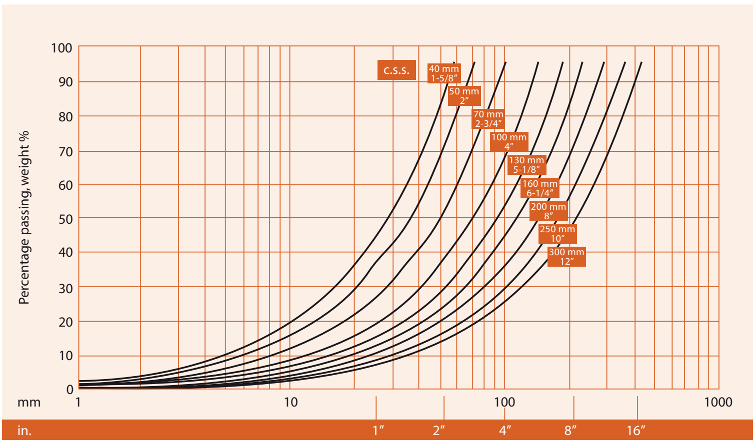
Capacities & Technical specifications

		C80	C100	C96	C106	C116	C3054
Feed opending width mm (in)		800 (32)	1000 (40)	930 (37)	1060 (42)	1150 (45)	1375 (54)
Feed opening depth mm (in)		510 (20)	760 (30)	580 (23)	700 (28)	800 (32)	760 (30)
Power kW (HP)		75 (100)	110 (150)	90 (125)	110 (150)	132 (175)	160 (200)
Speed (rpm)		350	260	330	280	260	260
Product size mm (in)	Closed side setting mm (in)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)
0-30	20						
0-1 1/8	3/4						
0-35	25						
0-1 3/8	1						
0-45	30						
0-1 3/4	1 1/8						
0-60	40	55 - 75					
0-2 3/8	1 5/8	60 - 80					
0-75	50	65 - 95					
0-3	2	75 - 100					
0-90	60	80 - 110		105 - 135			
0-3 1/2	2 3/8	90 - 120		115 - 150			
0-105	70	95 - 135	125 - 175	125 - 155	150 - 185	165 - 205	210 - 270
0-4 1/8	2 3/4	110 - 145	140 - 190	135 - 170	160 - 205	180 - 225	230 - 295
0-120	80	110 - 150	145 - 200	140 - 180	165 - 215	180 - 235	240 - 300
0-4 3/4	3 1/8	120 - 165	160 - 215	155 - 200	185 - 240	200 - 260	260 - 330
0-135	90	125 - 175	160 - 220	160 - 220	190 - 235	205 - 225	260 - 330
0-5 3/8	3 1/2	140 - 190	175 - 240	175 - 220	205 - 260	225 - 280	285 - 360
0-150	100	140 - 190	180 - 250	175 - 225	205 - 265	225 - 285	285 - 365
0-6	4	150 - 210	200 - 275	195 - 250	230 - 295	245 - 315	315 - 400
0-185	125	175 - 245	220 - 310	220 - 280	255 - 325	270 - 345	345 - 435
0-7	5	195 - 270	245 - 340	240 - 310	280 - 360	295 - 380	375 - 480
0-225	150	210 - 290	265 - 365	265 - 335	305 - 385	320 - 405	405 - 515
0-9	6	230 - 320	290 - 400	290 - 370	335 - 428	350 - 450	445 - 565
0-260	175	245 - 335	310 - 430	310 - 390	355 - 450	370 - 465	465 - 595
0-10	7	270 - 370	340 - 270	340 - 430	390 - 495	405 - 515	515 - 650
0-300	200		355 - 490		395 - 500	410 - 520	530 - 670
0-12	8		390 - 535		445 - 560	460 - 580	580 - 740

Capacities & Technical specifications

		C110	C125	C140	C145	C160	C200
Feed opending width mm (in)		1000 (44)	1250 (49)	1400 (55)	1400 (55)	1600 (63)	2000 (79)
Feed opening depth mm (in)		850 (34)	950 (37)	1070 (42)	1100 (43)	1200 (47)	1500 (59)
Power kW (HP)		160 (200)	160 (200)	200 (250)	200 (300)	250 (350)	400 (500)
Speed (rpm)		230	220	220	220	220	200
Product size mm (in)	Closed side setting mm (in)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)	Mtph (Stph)
0-60	40						
0-2 3/8	1 5/8						
0-75	50						
0-3	2						
0-90	60						
0-3 1/2	2 3/8						
0-105	70	160 - 220					
0-4 1/8	2 3/4	175 - 240					
0-120	80	175 - 245					
0-4 3/4	3 1/8	195 - 270					
0-135	90	190 - 275					
0-5 3/8	3 1/2	215 - 300					
0-150	100	215 - 295	245 - 335				
0-6	4	235 - 325	270 - 370				
0-185	125	260 - 360	295 - 405	325 - 445	335 - 465		
0-7	5	285 - 395	325 - 445	355 - 490	370 - 510		
0-225	150	310 - 430	345 - 475	380 - 530	395 - 545	430 - 610	
0-9	6	340 - 470	380 - 525	420 - 580	435 - 600	475 - 670	
0-260	175	350 - 490	395 - 545	435 - 605	455 - 625	495 - 695	630 - 890
0-10	7	390 - 540	435 - 600	480 - 665	500 - 690	545 - 765	695 - 980
0-300	200	405 - 555	445 - 615	495 - 685	510 - 710	560 - 790	710 - 1000
0-12	8	445 - 610	490 - 675	545 - 750	565 - 780	615 - 870	780 - 1100
0-340	225		495 - 685	550 - 760	570 - 790	625 - 880	785 - 1105
0-13	9		545 - 750	605 - 835	630 - 870	685 - 965	860 - 1215
0-375	250		545 - 755	610 - 840	630 - 870	685 - 965	865 - 1215
0-15	10		600 - 830	670 - 925	695 - 960	755 - 1060	950 - 1340
0-410	275				690 - 950	745 - 1055	940 - 1320
0-16	11				760 - 1045	820 - 1160	1030 - 1455
0-450	300					815 - 1145	1015 - 1435
0-18	12					895 - 1260	1120 - 1575

Indicative product gradation



* Smaller closed side settings can be often used depending on application and production requirements. For a performance estimation for your specific application, please contact Metso.

The above figures are based on feed material with an average specific gravity of 2.7, with a maximum feed size that will readily enter the crushing chamber without bridging. The capacities may vary depending on the feeding method and on feed characteristics such as gradation, bulk density, moisture, clay content and crushability. Measurement of the crusher's closed side setting varies depending on the jaw profile that is being used and has an impact on the crusher's capacity and product gradation. The following factors will enhance crusher capacity and performance:

1. Proper selection of the jaws.
2. Proper feed gradation.
3. Controlled feed rate.
4. Sufficient feeder capacity and width.
5. Adequate crusher discharge area.
6. Discharge conveyor sized to convey maximum crusher capacity.

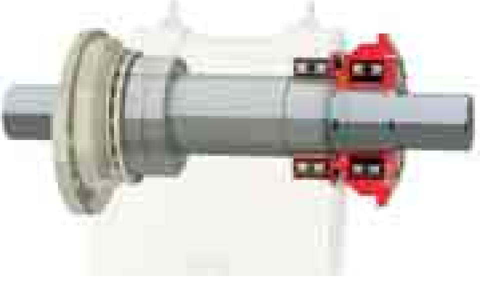
Fast and safe setting adjustment systems

All C Series crushers are equipped with a proven, rugged and fast wedge setting adjustment system. The crusher's setting can be manually adjusted in a matter of minutes. Alternatively, the crusher's setting can be changed in seconds, with the optional hydraulic setting adjustment.

Lower foundation loads

Rubber dampers and stoppers effectively decrease crushing loads to the foundation by absorbing peak shock loads and allowing the crusher to move vertically and longitudinally. This unique and innovative system eliminates the need for anchor bolts. The C-series jaw crusher is well balanced, this combined with the rubber dampers and stoppers decreases the dynamic loads on the foundation.

The most durable bearings available



All C Series jaw crushers incorporate larger and sturdier eccentric shaft bearings than other crushers of comparable size. Their higher load bearing capacity and effective labyrinth seals result in considerably longer bearing lifetimes.

Lifetime of wear parts

To optimize the durability and performance of the crusher wear parts, several different jaw die profiles, manganese steel alloys and thickness are available. The optional intermediate plate and the spacer maximize the utilization of the manganese jaws.

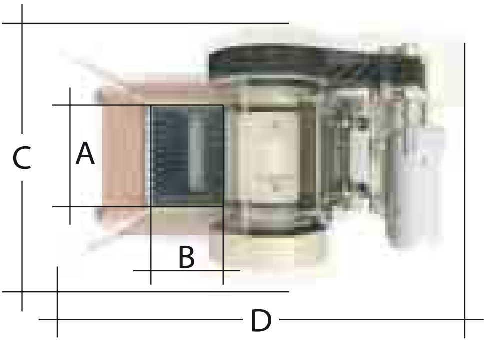
Versatile integral motor base

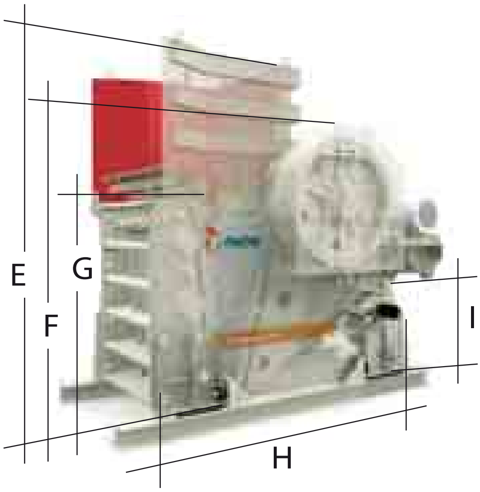
An optional integral motor base is mounted on the main frame of the crusher, thereby reducing the need for space, additional motor foundation and excessively long v-belts. V-belt lifetime is prolonged because there is no differential movement between the crusher and the integral motor base. The integral motor base allows the use of standard flywheel guards, thereby eliminating the need for local engineering and fitting.

Other excellent cost saving features

There are several additional features that will assist you in reaching lower operating and installation costs. Amongst these features are: an automatic grease lubrication system, different mounting brackets to accommodate different feeding heights, temperature and speed sensors and casting protection plates.

Contrary to popular belief, not all jaw crushers are the same. This is certainly the case for Nordberg C Series jaw crushers, and there is no secret to this success.





Dimensions & Weights

		C80	C100	C96	C106	C116	C3054	C110	C125	C140	C145	C160	C200
A	mm	800	1000	930	1060	1150	1380	1100	1250	1400	1400	1600	2000
	in.	32	40	37	42	45	54	44	50	56	56	63	79
B	mm	510	760	580	700	800	760	850	950	1070	1100	1200	1500
	in.	21	30	23	28	32	30	34	38	43	44	48	60
C	mm	1526	2420	1755	2030	2400	2640	2385	2800	3010	3110	3700	4040
	in.	61	96	70	80	95	104	94	111	119	123	146	160
D	mm	2577	3670	2880	3320	3600	3540	3770	4100	4400	4600	5900	6700
	in.	102	145	114	131	144	140	149	162	174	182	233	264
E	mm	1990	2890	1610	2075	2675	2470	2890	3440	3950	4100	4580	4950
	in.	79	114	64	82	105	98	114	136	156	162	181	195
F	mm	1750	2490	1460	2005	2730	2470	2750	2980	3140	3410	3750	4465
	in.	69	99	58	79	107	98	109	118	124	135	148	176
G	mm	1200	1700	755	1135	1790	1080	1940	2100	2260	2430	2650	2800
	in.	48	67	30	45	71	43	77	83	89	96	105	111
H	mm	2100	2965	2500	2630	2885	2950	2820	3470	3755	3855	4280	4870
	in.	83	117	99	104	114	117	112	137	148	152	169	192
I	mm	625	775	465	700	1255	690	580	980	1050	1050	1300	1400
	in.	25	31	19	28	50	28	23	39	42	42	52	56
Basic crusher	kg	7 670	20 060	9 759	14 350	18 600	25 900	25 800	37 970	47 120	54 540	71 330	121 510
weight[1)]	lbs	16 900	44 240	21 520	31 650	40 920	57 100	56 880	83 730	103 900	120 260	157 280	267 930
Fully equipped	kg	9 520	23 300	11 870	17 050	21 500	30 300	29 500	43 910	54 010	63 190	83 300	137 160
crusher weight[2)]	lbs	21 000	51 390	26 170	37 590	47 300	66 800	65 050	96 830	119 100	139 330	183 680	302 440

1) Crusher without options
2) Crusher, hydraulic setting adjustment, flywheel guards, integral motor support, feed chute, automatic grease lubrication system, and typical electric motor.
Certified general arrangement, foundation and service space requirement drawings are available from Metso.

The high capacity and low operating cost of the SUPERIOR MK-II primary gyratory crushers meet the demand for improved efficiency. Mine managers, maintenance and operators know what they want for today…and tomorrow. We have listened and provide the SUPERIOR gyratory crusher with features required by demanding applications.

The SUPERIOR MK-II design is based on a century's worth of experience in crushing technology. Worldwide, over 1,500 SUPERIOR crushers have been installed in mines and quarries.

The features include high capacities due to increased speed and efficiency, the SUPER SPIDER concept and better balancing, thus allowing lower installation costs.

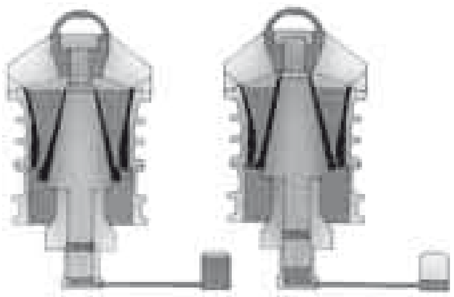
The SUPER SPIDER concept consists of the use of an additional Topshell using the same base to obtain a larger feed opening and higher capacity. The improved Spider arm design with increased extra coarse material passing space reduces bridging and increases productivity.

High production and strength

The Spider, Topshells and Bottomshell are constructed of shock-resistant, high strength cast steel, allowing the use of more powerful drive motors, and therefore, higher production than similar models.

Mainshaft position control provides peak crushing efficiency

The Mainshaft Position System (MPS) – successfully used for decades, is a hydraulic method of vertical adjustment to compensate for wear and maintain product size. It consists of a pump, operated by a push-button and a heavy-duty hydraulic cylinder that supports and adjusts the Mainshaft assembly.



This MPS is also used to clear the crushing chamber. If a sudden power failure stalls the crusher under load, the mantle can be lowered to release the load…no more digging out.

The SUPERIOR MK-II primary crusher is equipped with a balance cylinder that protects the step bearing and piston by keeping them in contact with the Mainshaft assembly when any upward movement of the Mainshaft occurs.

SUPERIOR MK-II primary gyratory crushers are fitted with a Mainshaft position sensor probe. This gives a direct indication of the Mainshaft position, enabling the operator to maintain the crusher setting, provide a consistent product and monitor liner wear.

Features for better crushing economy

- Exceptionally high capacity and maximum liner life provided by the steep crushing chamber and long crushing surfaces.

- Long life and reliable operation provided by an extra heavy-duty frame, large diameter integral Mainshaft assembly and high-performance bearing alignment.

- Optimized production for your application provided by a computer-designed crushing chamber.

- Versatility of changing the Eccentric throw – crusher capacity can be matched to plant requirements simply by changing the Eccentric bushing

– Easy maintenance and service…
  - Automatic spider lubrication
  - Modular lubrication system
  - Mainshaft position indicator system
  - Easy adjustment of backlash
  - Optional hydraulic spider separation

Crushing chamber provides even wear

Many years of design experience and accumulated operating data have led to the SUPERIOR MK-II crusher design. Thousands of crushing chambers have been evaluated to optimize crushing performance.

We have developed a unique crushing chamber concept providing:

– Greater product uniformity

– Better distribution of wear throughout the entire chamber – fewer service problems and lower operating cost

– Reduced liner change intervals – less wear costs per ton of product

– Improved energy efficiency

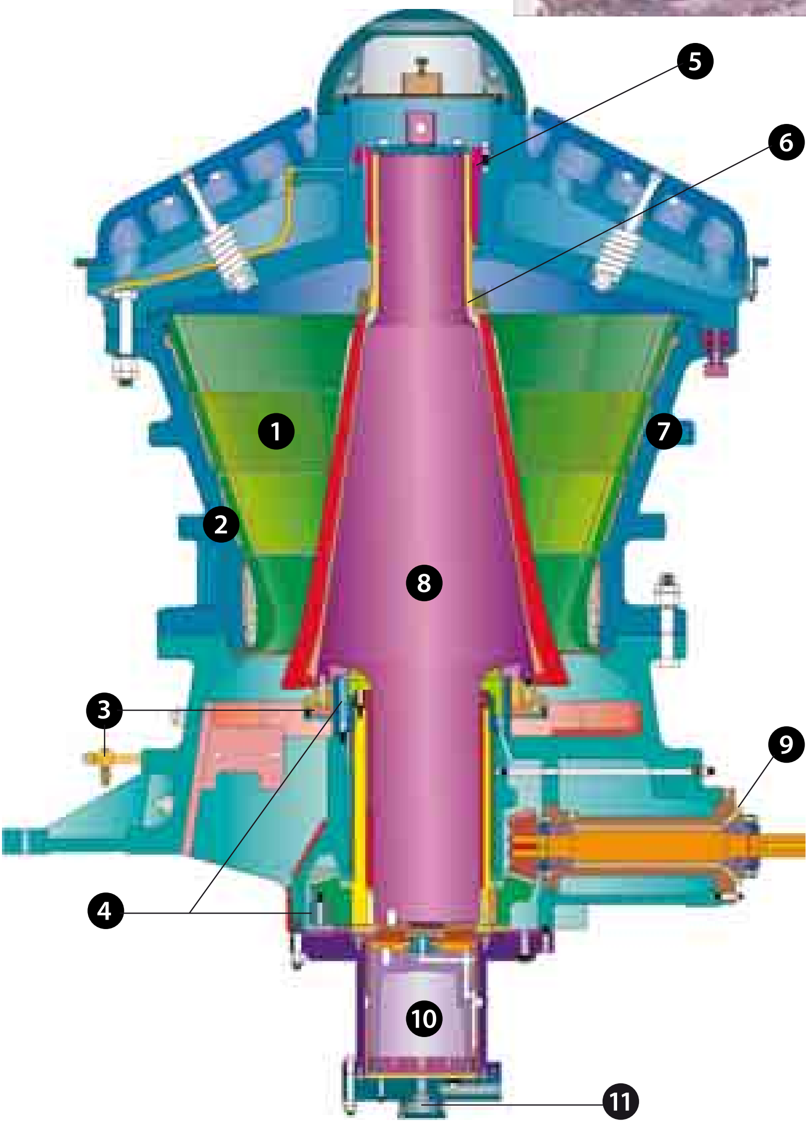
Heavy-duty Mainshaft design

The Mainshaft is forged in one piece. There is no risk of loosening head centers, thereby reducing downtime. The headnut threads are on the patented, replaceable alloy steel mainshaft sleeve – no threads to damage on the shaft. Threads cannot act as stress risers on the shaft, increasing reliability. The large, highly polished radius between the shaft upper journal diameter and the taper strengthens the Mainshaft, providing long life. The self-tightening headnut tightens the mantle automatically during crushing. The large upper journal diameter provides extra strength for severe crushing applications.

SUPERIOR MK-II Primary Gyratory Crusher features

1. **Crushing chambers** are matched to each individual application, optimizing crushing performance.
2. **Manganese wearing parts** are standard – chrome alloy steel liners are optional.
3. **Efficient dust seal** – Equipped with an overpressure air blower to keep dust out of the Eccentric and drive, increasing crusher bearing life.
4. **Counterbalanced design** is ideal for all applications, mobile or stationary, and minimizes the forces transmitted to the supporting structure.
5. **The spider bushing and seal** can be replaced without removing the Spider – reducing manpower, time, equipment and lost production due to downtime.
6. **Heavy-duty integral Mainshaft** with a patented alloy steel threaded sleeve reduces stresses on the Mainshaft.
7. **High-strength shell design**, proven in the toughest applications, provides trouble-free operation and long life.
8. **Mainshaft and head center** are forged in one integral piece, eliminating the possibility of the head center separating during operation.
9. **External gear and pinion adjustment** simplifies and speeds up the backlash adjustment.

10. **The Mainshaft Position System (MPS)** provides easy adjustment of the Mainshaft to compensate for liner wear and maintains the product size.
11. **Internally-mounted Mainshaft position sensor** provides a direct indication of the Mainshaft position, allowing the operator to maintain the crusher setting and monitor liner wear.



Superior MK-II gyratory crusher capacities in metric tons per hour (STPH)

				Open Side Settings of Discharge Opening – Millimeters (Inches)										
Machine Size	Feed Opening mm (in)	Pinion RPM	Maximum KW (HP)	125 mm (5.0")	140 mm (5.5")	150 mm (6.0")	165 mm (6.5")	175 mm (7.0")	190 mm (7.5")	200 mm (8.0")	215 mm (8.5")	230 mm (9.0")	240 mm (9.5")	250 mm (10.0")
42-65	1065 (42)	600	375 (500)		2010 (2220)	2335 (2575)	2515 (2775)	2870 (3165)						
50-65	1270 (50)	600	375 (500)			2395 (2645)	2780 (3065)	2935 (3240)						
54-75	1370 (54)	600	450 (600)			2885 (3185)	2985 (3295)	3145 (3470)	3335 (3680)	3485 (3845)				
62-75	1575 (62)	600	450 (600)			2890 (3190)	3615 (3985)	3815 (4210)	4205 (4640)	4330 (4775)				
60-89	1525 (60)	600	600 (800)				4195 (4625)	4540 (5005)	5080 (5600)	5295 (5840)	5530 (6100)	5805 (6400)		
60-110E	1525 (60)	600	1200 (1600)					5535 (6100)	6945 (7655)	7335 (8085)	7570 (8345)	8280 (9130)	8595 (9475)	8890 (9800)

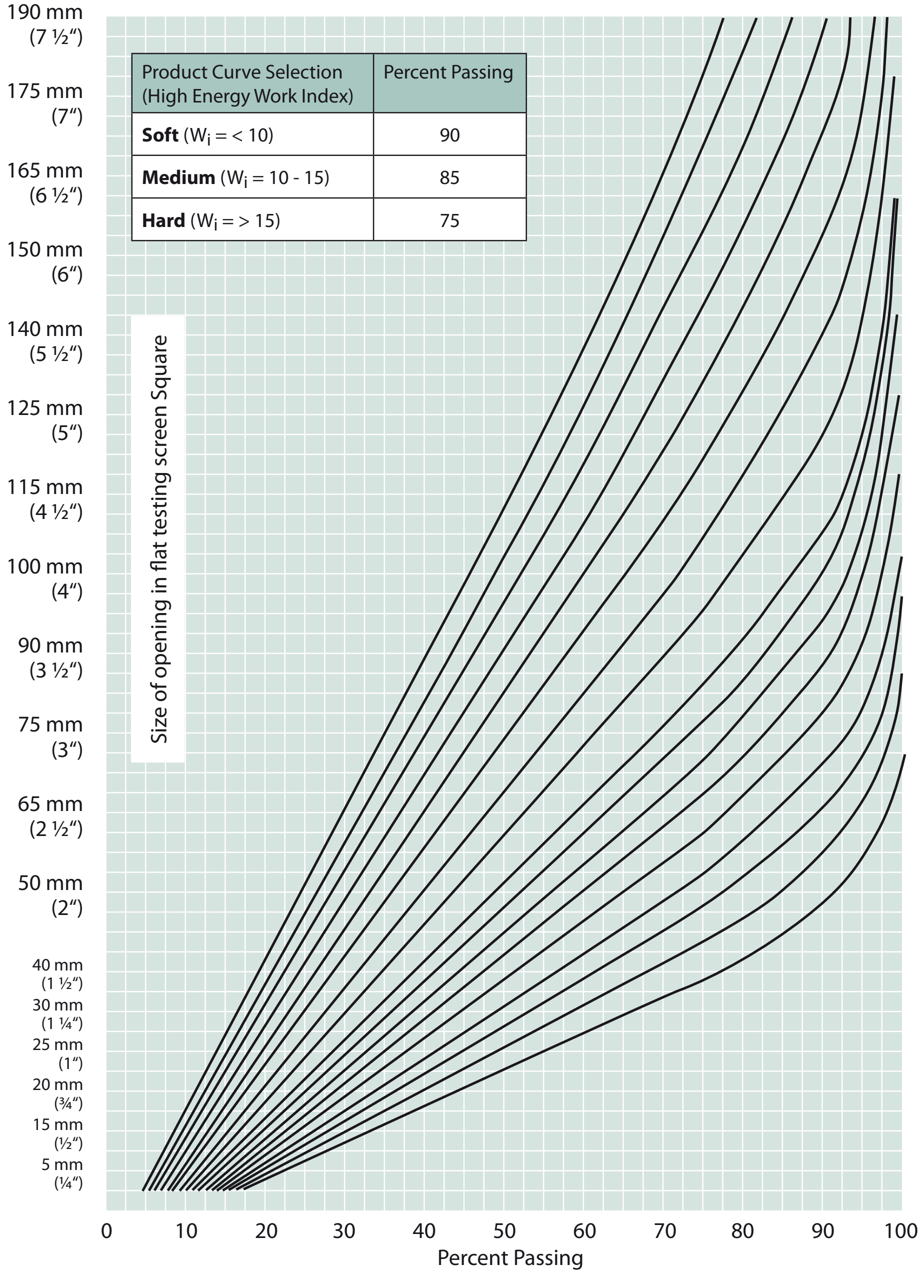
The above capacities are based on an assumed feed where 100% of the feed passes 80% of the feed opening, 80% of the feed passes 60% of the feed topsize, and 50% of the feed passes a sieve size that is 10% of the topsize. The capacities are for feed materials with a bulk density of 1.6 metric tons per cubic meter (100 pounds per cubic foot). All capacities are calculated at maximum throw for each respective machine. All capacities are relative to individual application. Material characteristics, feed size distribution, work index, percent moisture, and feed method are factors when considering total crusher capacity. Please consult Metso to verify your capacity requirements.

Technical Specifications

Model		42-65	50-65	54-75	62-75	60-89	60-110E
Feed Opening	mm	1065	1270	1370	1575	1525	1525
	Inch	42	50	54	62	60	60
Total Weight	kg	119 400	153 300	242 200	302 500	398 300	529 440
	lbs	263 300	338 000	534 000	666 800	878 000	1 167 210
Shaft Complete	kg	23 000	28 120	38 600	42 200	66 200	102 600
	lbs	50 600	62 000	85 000	93 000	146 000	226 200
Bottomshell Assembly Installation Weight	kg	29 570	29 570	62 140	62 140	82 780	89 720
	lbs	65 200	65 200	137 000	137 000	182 500	197 800
Power (Electric)	kW	375	375	450	450	600	1 200
	HP	500	500	600	600	800	1 600
Pinion speed	RPM	600	600	600	600	600	600

SUPERIOR MK-II PRIMARY GYRATORY CRUSHERS – PRODUCT GRADATION

Product Curve Selection (High Energy Work Index)	Percent Passing
Soft (W_i = < 10)	90
Medium (W_i = 10 - 15)	85
Hard (W_i = > 15)	75



GP Series Cone Crushers

The cone crusher to meet the production requirements

Metso Mining and Construction, the world's leading rock and mineral processing group, has installed close to 3 000 GP cone crushers since the 1970s. GP cone crusher with its' innovative features and state of the art performance is number one choice for many aggregate producers all around the world.

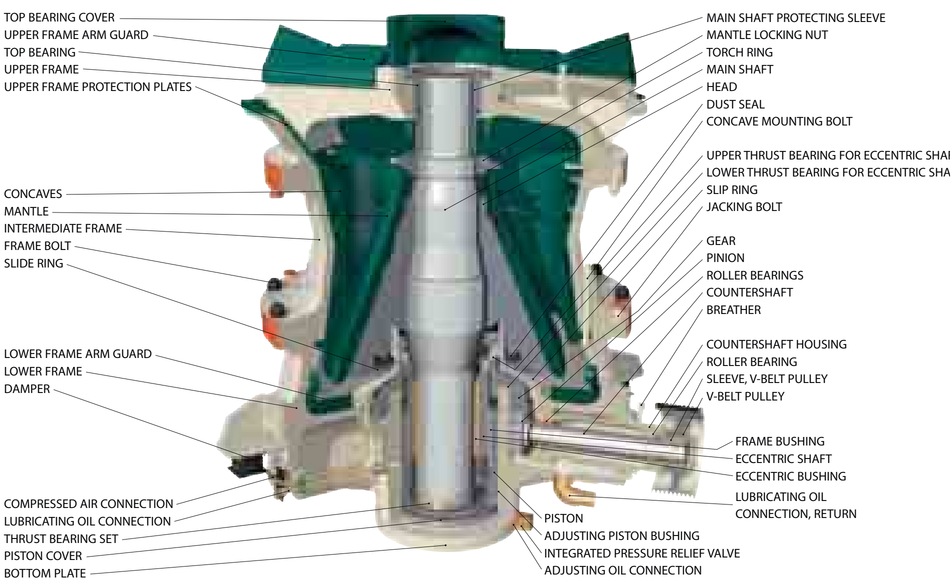
The GP cone crusher heavy-duty design is based on two-point supported main shaft that allows high performance steep cavity designs. Main shaft is vertically supported with a hydraulic cylinder that is used for holding or moving the main shaft vertically to adjust crushing process automatically and continuously under load. This strong design allows high crushing performance due to high power and crushing force levels utilized.

GP-series includes S-models that are designed particularly for low cost efficient secondary or primary (gravel) crushing applications. GP-S cone crushers provide maximum feed opening for undisturbed operation with big feed calibrating material to constant easy to process size for the rest of the plant.

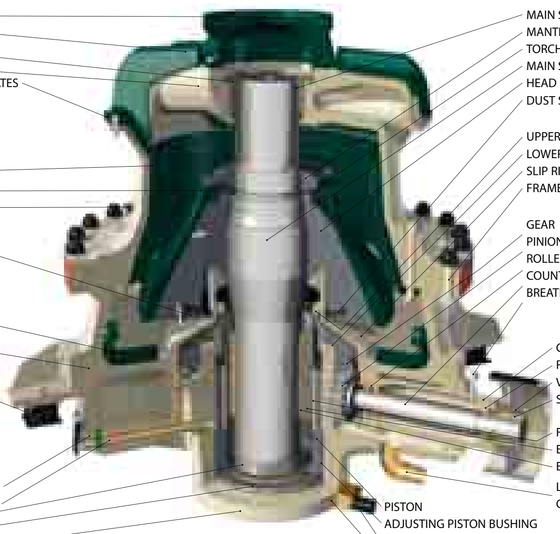
High Production and Reliability - Superior know how in compressive crushing

Metso Mining and Construction is using significant resources to research compressive crushing in our own test crushing plant and studying customer operations in different kinds of application all around the world. The conclusions of this research work are found in solutions utilized with GP cone crushers.

GP Secondary Cone Crusher



GP Fine Cone Crusher



GP cone crushers can be easily adjusted to different types of production requirements with change of cavities, eccentric strokes, counter shaft speeds and different control methods. Metso Mining and Construction customer service specialist have the know how to recommend optimum parameters to maximize production of desired end products meeting required quality levels.

Simple strong two-point supported shaft design ensures mechanical reliability. IC50 automation system monitors continuously crusher load and operating parameters to ensure optimal operating condition maximizing availability.

1. Three GP500s operating in 4,2 Mtons/year aggregate quarry producing high quality aggregates in Norway

2. Nordberg GP500S operating as a secondary crusher following C160 primary crusher

3. Track mounted three stage crushing plant with secondary and tertiary GP-cones

Value adding features and innovation

Dynamic setting adjustment
Crusher setting can be continuously adjusted under load based on power draw or crushing force measurement controlled by IC50/IC5000 automation system (Standard for GP200/S, GP300/S, GP550, GP500S, optional for other models). With automation system mode can be selected between two options; setting mode or load mode. When setting mode is selected crusher keeps a constant setting. When load mode is selected IC50/IC5000 automation system adjusts setting trying to maintain high power draw and crushing force maximizing crushing work.

Stable performance trough liner life
Due to cavity design feed opening is maintained and wear part profile change is minimized through liner life. This ensures stable crusher throughput capacity and plant operation trough wear part life.

Low installation height due to patented piston design (valid for GP200/S, GP300/S, GP550, GP500S)
GP and GP-S cone crushers have patented piston design. The main benefit of this design is lower installation height. Lower height reducers installation costs with smaller support structures and shorter conveyors needed and makes GP and GP-S cones excellent solution for mobile applications.

IC50/IC5000 automation system as standard part of delivery (valid for GP200/S, GP300/S, GP550, GP500S) IC50/IC5000 complete easy to use crusher automation system that maximizes production, ensures trouble free operation and makes initial installation simple and trouble free. IC50/IC5000 controls all the cone crusher related functions e.g.; crusher setting – load, feed capacity, lubrication, oil heating and cooling, correct start and stop sequences…
For GP-models same machine can be used as secondary, tertiary or quaternary machine with a liner change
GP cone crusher can be used in several different applications with a liner change. Every model has a good selection of optimized liner design to ensure ideal operation in different types of applications.

Can be operated with on/off feed
Due to crusher kinematics, low head spin when machine running empty and long cavities GP and GP-S cone can be used with partial feed. Because of this feature GP and GP-S cones are an excellent choice for application where choke feed condition can't be ensured – e.g. mobile two stage crushing plants with out surge pile between primary and secondary crushers.

No packing material needed for liner fixing
GP and GP-S cones do not require use of packing material for liner fixing. This makes liner changes quicker. Also costs are saved because there is no need for handling packing material.

Easy maintenance - all service from above
GP and GP-S cones can be disassembled from above. All heavy components can be lifted up which makes disassembling easy and safe.

Technical Specifications, GP Secondary Cone Crushers

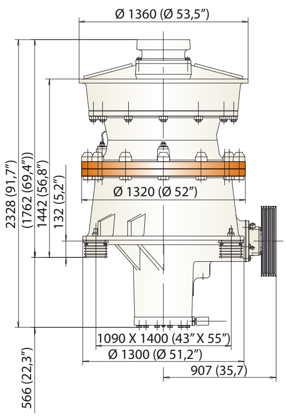
Crusher	GP100S	GP200S	GP300S	GP500S
Motor size	75 - 90 kW 100 - 125 hp	110 - 160 kW 150 - 250 hp	132 - 250 kW 200 - 350 hp	200 - 315 kW 250 - 400 hp
Strokes	16, 20, 25 mm $^{5}/_{8}$, ¾, 1"	18, 25, 28, 32, 36 mm ¾, 1, 1 $^{1}/_{8}$, 1 ¼, 1 ½"	18, 25, 28, 32, 36 mm ¾, 1, 1 $^{1}/_{8}$, 1 ¼, 1 ½"	18, 25, 28, 32, 36, 40 mm ¾, 1, 1 $^{1}/_{8}$, 1 ¼, 1 ½, 1 $^{5}/_{8}$"
Max lift during liner change	2 500 kg 5 600 lbs	3 500 kg 7 700 lbs	5 200 kg 11 500 lbs	11 000 kg 24 300 lbs
Total weight (approx.)	7 350 kg 16 200 lbs	10 900 kg 24 000 lbs	16 000 kg 35 300 lbs	33 000 kg 72 500 lbs

Nominal Feed Opening, GP Secondary Cone Crushers

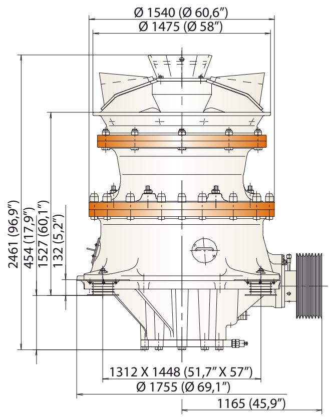
Crusher / Cavity	GP100S	GP200S	GP300S	GP500S
M	200 mm 8"			
C	250 mm 10"	250 mm 10"	280 mm 11"	380 mm 15"
EC		330 mm 13"	380 mm 15"	500 mm 20"

Main Dimensions, GP Secondary Cone Crushers

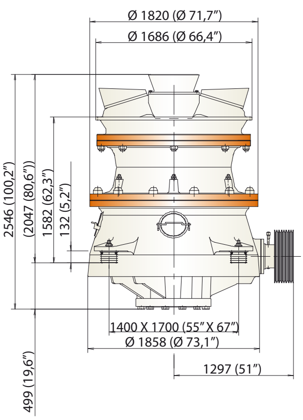
GP100S



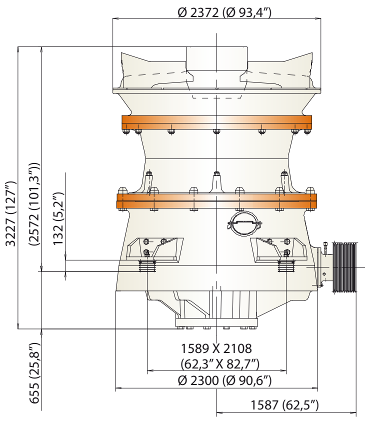
GP200S



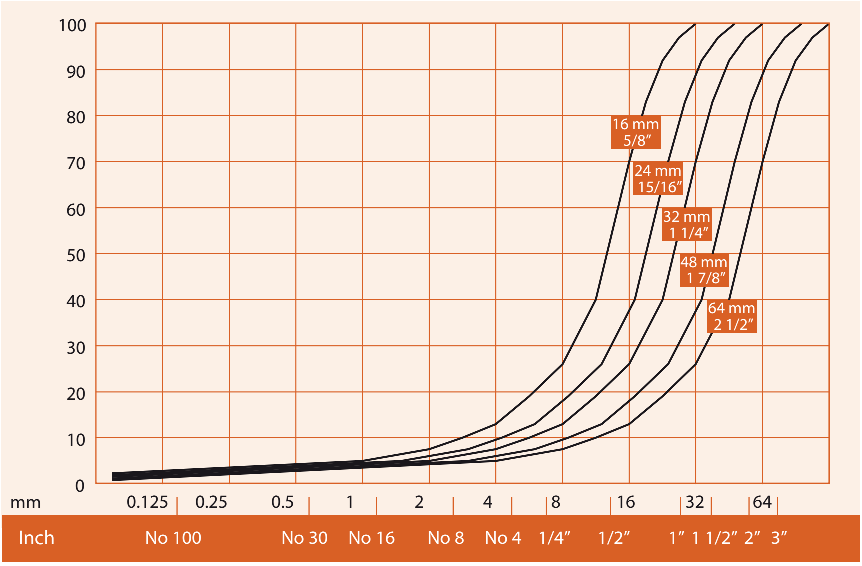
GP300S



GP500S



Indicative Gradation Curves



Indicative Crusher Capacities, GP Secondary Cone Crushers

GP100S	Capacity metric t/h						
	Setting (c.s.s.)	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm
stroke	16 mm	80-90	105-115	120-130	135-145	145-165	155-175
stroke	20 mm		120-130	145-155	160-180	170-200	185-215
stroke	25 mm			185-195	200-220	210-230	
	Capacity short t/h						
	Setting (c.s.s.)	¾"	1"	1 ¼"	1 ½"	1 ¾"	2"
stroke	⅝"		115-125	135-145	155-170	160-190	
stroke	¾"		135-145	165-175	190-215	200-230	
stroke	1"			200-220	235-260		

GP200S	Capacity metric t/h							
	Setting (c.s.s.)	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm	50 mm
stroke	18 mm		110-140	140-170	160-190	180-210	200-230	230-260
stroke	25 mm			170-220	190-240	210-260	230-280	
stroke	32 mm				230-280	270-320	280-350	
	Capacity short t/h							
	Setting (c.s.s.)	¾"	1"	1 ¼"	1 ½"	1 ¾"	2"	
stroke	¾"		130-160	155-185	180-210	200-230	250-280	
stroke	1"			200-250	225-275	250-275		
stroke	1 ¼"				260-310	310-380		

Capacity and minimum setting figures are indicative for materials of 1.6 t/m³ (100 lbs/ft³).
Actual results may vary, depending on feed, grading, rock type, moisture content etc.

GP300S		Capacity metric t/h						
	Setting (c.s.s.)	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm	50 mm
stroke	18 mm		170-190	170-210	190-230	210-255	235-275	255-295
stroke	25 mm				255-315	290-345	320-350	
stroke	32 mm				360-400	380-420	400-440	
		Capacity short t/h						
	Setting (c.s.s.)	¾"	1"	1 ¼"	1 ½"	1 ¾"	2"	
stroke	¾"		200-220	190-240	225-270	255-300	285-320	
stroke	1"			260-320	300-350	350-400	385	
stroke	1 ¼"				380-430	430-480		

GP500S		Capacity metric t/h							
	Setting (c.s.s.)	45 mm	50 mm	55 mm	60 mm	65 mm	70 mm	75 mm	80 mm
stroke	18 mm	300-350	325-375	375-425	400-450	425-475	450-500	500-550	550-600
stroke	25 mm		500-550	550-600	600-650	650-700	700-750	750-800	
stroke	32 mm		650-700	700-750	750-800	825-875	900-950	950-1000	
		Capacity short t/h							
	Setting (c.s.s.)	1 ½"	1 ¾"	2"	2 ¼"	1 ½"	2 ¾"	2"	3 ¼"
stroke	¾"		330-380	350-400	400-460	460-520	520-580	560-620	620-680
stroke	1"			550-600	620-680	580-740	750-810	840-900	
stroke	1¼"			(720-780)	800-860	860-920	940-1000	1040-1100	

Capacity and minimum setting figures are indicative for materials of 1.6 t/m^3 (100 lbs/ft^3).
Actual results may vary, depending on feed, grading, rock type, moisture content etc.

Technical Specifications, GP Fine Cone Crushers

Crusher	GP100	GP200	GP300	GP550	GP11F	GP11M
Motor size	75 - 90 kW 100 - 125 hp	110 - 160 kW 150 - 250 hp	160 - 250 kW 250 - 300 hp	250 - 315 kW 300 - 400 hp	132 - 160 kW 300 - 400 hp	132 - 160 kW 300 - 400 hp
Strokes	16, 20, 25 mm 5/8, ¾, 1"	18, 25, 28, 32, 36, 40 mm ¾, 1, 1 1/8, 1 ¼, , 1 ½, 1 5/8"	25, 28, 32, 36, 40 mm 1, 1 1/8, 1 ¼, , 1 ½, 1 5/8"	25, 28, 32, 36, 40 mm 1, 1 1/8, 1 ¼, , 1 ½, 1 5/8"	20, 25, 30 mm ¾, 1, 1 ¼"	20, 25, 30 mm ¾, 1, 1 ¼"
Max lift during liner change	1 600 kg 3 500 lbs	3 500 kg 7 700 lbs	3 200 kg 7 100 lbs	6 100 kg 13 500 lbs	2 700 kg 6 000 lbs	3 000 kg 6 600 lbs
Total weight (approx.)	5 700 kg 12 600 lbs	9 100 kg 20 000 lbs	13 100 kg 28 900 lbs	25 000 kg 55 100 lbs	10 500 kg 23 200 lbs	11 500 kg 25 300 lbs

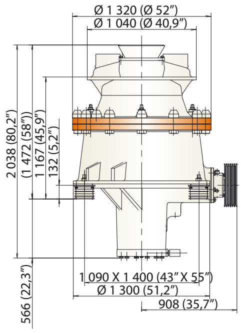
Nominal Feed Opening, GP Fine Cone Crushers

Crusher / Cavity	GP100	GP200	GP300	GP550	GP11F	GP11M
EF	40 mm 1 ½"	40 mm 1 ½"	40 mm 1 ½"	65 mm 2 ½"	40 mm 1 ½"	–
F	50 mm 2"	70 mm 2 ¾"	60 mm 2 ½"	55 mm 2 ¼"	80 mm 3"	–
MF	100 mm 4"	–	100 mm 4"	115 mm 4 ½"	–	–
M	130 mm 5"	130 mm 5"	130 mm 5"	150 mm 6"	120 mm	–
C	150 mm 6"	–	180 mm 7"	190 mm 7 ½"	200 mm 8"	180 mm 7"
EC	–	210 mm 8 ½"	260 mm 10"	300 mm 12"	–	220 mm 9"

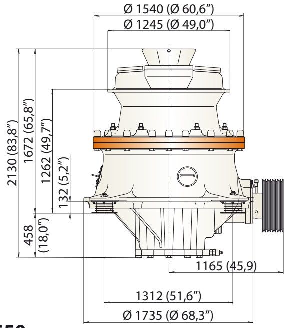
Note: EF = extra fine, F = fine, MF = medium fine, M = medium, C = coarse, EC = extra coarse.

Main Dimensions, GP Fine Cone Crushers

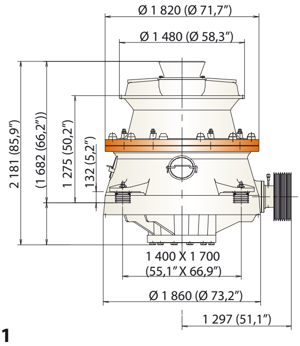
GP100



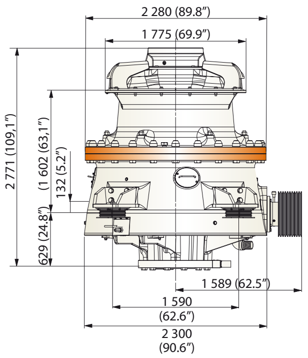
GP200



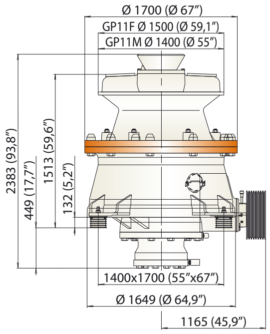
GP300



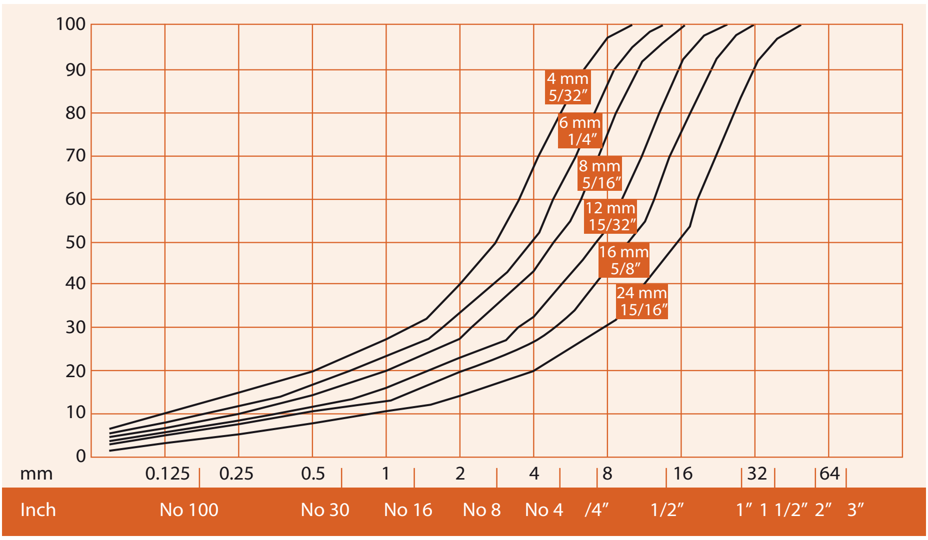
GP550



GP11



Indicative Gradation Curves, GP Fine Cone Crushers



Indicative Crusher Capacities, GP Fine Cone Crushers

GP100		Capacity [metric t/h]						
	Setting (c.s.s.)	7 mm	10 mm	13 mm	16 mm	19 mm	22 mm	25 mm
stroke	16 mm	35-45	45-55	55-65	65-75	75-85	80-90	85-95
stroke	20 mm	45-50	50-60	60-70	70-85	90-100	100-110	
stroke	25 mm		55-65	65-75	75-90	100-115		
		Capacity [short t/h]						
	Setting (c.s.s.)	¼"	3/8"	½"	5/8"	¾"	7/8"	1"
stroke	5/8"	40-50	50-60	55-65	65-75	70-80	80-90	90-100
stroke	¾"		55-65	65-75	75-85	85-95	100-110	
stroke	1"		65-75	75-85	90-105	110-125		

GP200		Capacity [metric t/h]						
	Setting (c.s.s.)	8 mm	10 mm	15 mm	20 mm	25 mm	30 mm	33 mm
stroke	18 mm	60-70	70-90	80-105	100-125	135-150	160-175	170-185
stroke	25 mm		90-110	110-130	130-155	160-180	185-210	
stroke	32 mm			140-160	170-190	190-220		
stroke	40 mm				200-220	220-240		
		Capacity [short t/h]						
	Setting (c.s.s.)	5/16"	13/32"	19/32"	13/16"	1"	1 ¼"	1 3/8"
stroke	¾"	65-80	80-100	90-115	110-140	150-165	180-195	190-205
stroke	1"		100-120	120-140	145-170	180-200	205-235	
stroke	1 ¼"			155-175	185-205	210-240		
stroke	1 5/8"				210-240	230-260		

GP300		Capacity [metric t/h]								
	Setting (c.s.s.)	8 mm	12 mm	16 mm	20 mm	24 mm	28 mm	32 mm	36 mm	40 mm
stroke	25 mm	100-120	120-140	140-160	160-180	180-200	200-220	220-245	245-265	265-290
stroke	32 mm	100-130	130-160	170-200	195-225	220-250	250-280	275-305	305-335	
stroke	40 mm		160-190	215-245	245-275	280-310	315-345	335-365		
		Capacity short t/h								
	Setting (c.s.s.)	3/8"	½"	5/8"	¾"	7/8"	1"	1 1/8"	1 ¼"	1 ½"
stroke	1 "	110-140	135-165	150-180	165-195	175-205	205-230	225-250	240-270	260-290
stroke	1 ¼"	150-170	170-190	190-210	210-240	250-270	275-295	300-320	310-330	330-360
stroke	1 5/8"	180-190	195-215	215-235	260-290	305-325	235-355	365-385	380-400	395-415

GP550		Capacity [metric t/h]								
	Setting (c.s.s.)	8 mm	12 mm	16 mm	20 mm	24 mm	30 mm	35 mm	40 mm	45 mm
stroke	25 mm	150-170	165-185	190-210	230-250	250-270	280-300	320-340	340-370	370-390
stroke	32 mm		200-220	230-250	270-290	300-330	370-390	420-430	470-490	
stroke	40 mm		230-250	260-280	320-350	375-405	420-450	470-500		
		Capacity short t/h								
	Setting (c.s.s.)	3/8"	½"	5/8"	¾"	7/8"	1"	1 1/8"	1 ¼"	1 ½"
stroke	1 "	160-180	175-195	200-220	215-240	230-260	250-280	270-300	320-350	360-390
stroke	1 ¼"	195-215	225-245	250-280	270-300	290-310	310-330	330-350	350-370	370-400
stroke	1 5/8"		250-280	280-300	330-360	360-390	390-420	420-450	450-480	500-550

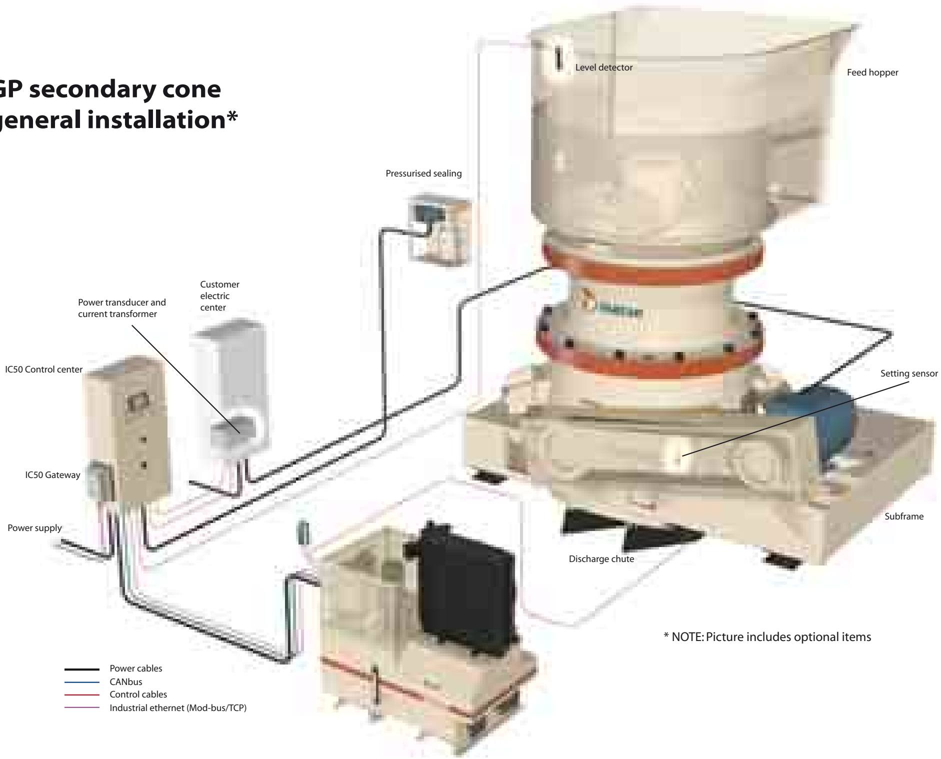
Capacity and minimum setting figures are indicative for materials of 1.6 t/m^3 (100 lbs/ft^3).
Actual results may vary, depending on feed, grading, rock type, moisture content etc.

GP11F	Capacity [metric t/h]							
	Setting (c.s.s.)	8 mm	10 mm	15 mm	20 mm	25 mm	30 mm	33 mm
stroke	20 mm	80-100	85-105	105-125	120-145	150-170	(170-190)	
stroke	25 mm		100-120	130-150	160-180	180-210		
stroke	30 mm			160-180	190-210	(210-230)		
	Capacity [short t/h]							
	Setting (c.s.s.)	5/16"	13/32"	19/32"	13/16"	1"	1 3/16"	1 5/16"
stroke	¾"	85-105	95-115	120-140	130-155	165-185	(185-205)	
stroke	1"		110-130	140-175	175-195	195-225		
stroke	1 ¼"			175-195	210-230	(230-250)		

GP11M	Capacity [metric t/h]							
	Setting (c.s.s.)	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm
stroke	20 mm	105-125	120-145	150-170	170-190	180-200	200-220	220-250
stroke	25 mm		160-180	180-210	200-230	220-250	250-280	280-310
stroke	30 mm		190-210	210-230	240-270	270-310	300-340	330-360
	Capacity [short t/h]							
	Setting (c.s.s.)	19/32"	13/16"	1"	1 3/16"	1 3/8"	1 9/16"	1 ¾"
stroke	¾"	120-140	130-155	165-185	185-205	200-220	220-240	240-275
stroke	1"		175-195	195-225	220-250	230-270	270-300	300-340
stroke	1 ¼"		210-230	230-250	260-295	295-340	330-370	360-390

Capacity and minimum setting figures are indicative for materials of 1.6 t/m³ (100 lbs/ft³). Actual results may vary, depending on feed, grading, rock type, moisture content etc.

GP secondary cone general installation*



* NOTE: Picture includes optional items

Productivity

The MP series unique design incorporates the best in process technology to produce the highest crushing force in the industry. With field-proven technology in demanding mining operations, the MP1250, MP1000 and MP800 can process more ore at the same reduction, or the same quantity of ore to a finer reduction, than any competitive unit. Yet each crusher is designed to fit onto a 7 ft. Symons cone crusher foundation. That translates into higher productivity with substantial savings in plant modifications or building and foundation costs.

The recently introduced MP1250 crusher takes the MP Series to the next level. Up to thirty percent more production from the same platform as the MP1000 gives customers even more options.

Consistency

Consistent performance means a crusher can accept feed variations while delivering product uniformity. The MP Series can be relied on for unparalleled consistency due to a number of features. Hydraulic controls allow the crushers to hold a constant setting while achieving unusually high reductions. A rotating bowl provides even wear in the crushing cavity while enabling crusher setting uniformity and consistent size reduction. The automatic tramp release passes tramp material without stalling the crusher, permitting an uninterrupted return to the production setting. Thus uniform reduction is maintained. Each of these features also contributes to an efficient use of crushing energy, which makes the entire mining operation more profitable.

Adaptability

The MP Series is designed to operate at various speed and cavity combinations to meet a wide range of application requirements. One head for all cavities further enhances the MP Series' application capabilities, while reducing standby spares. The crushers' large unrestricted feed opening with a high pivot point creates an active feed opening that is able to adapt to increasing feed size. This is a critical feature for secondary crushing or pebble crushing where feed size can vary dramatically. Plus the commonality of spares and the ability of the short head bowl to accept coarse feed translate into low-cost spares support.

For customers who want more from their existing MP1000 crushers, a retro-fit kit is available to convert an MP1000 into an MP1250. By replacing as few as five parts, increased capacities result from the improved crushing dynamics. Designed with retro-fit options in mind, the new counterweight maintains similar out of balance forces, thereby requiring no changes to the existing foundation.

Reliability

Time spent during disassembly and maintenance is time lost in production. The MP1250, MP1000 and MP800 incorporate features such as hydraulic cavity clearing and easy setting adjustment. These minimize downtime, helping ensure that the crushers are available whenever they are needed. The MP Series makes routine maintenance simple with user-friendly components. Push a button and watch the crusher either adjust or disassemble for maintenance. All aspects of the MP Series have been designed to maximize cost effective operation.

To improve on the already reliable operation of the MP Series, a more resilient Eccentric is standard on the MP1250 crusher. This Eccentric features a steel sleeve that is more tolerant of extreme conditions and is replaceable. If the Eccentric sustains damage in an overload event, simply replace the sleeve and keep running. No need to replace the core Eccentric. The sleeved Eccentric is also available for the MP1000 and MP800 crushers.

Uniform Production

The MP Series' rotating bowl compensates for feed segregation or uneven feed rates, while helping to maintain a choke-fed condition. Uniform wear in the crushing cavity avoids localized restriction of the feed opening, maintains a uniform crusher setting, and achieves consistent size reduction. The hydraulic motor and gear drive adjustment provides fine control of the setting and the setting can be easily adjusted to compensate for liner wear.

High Availability

The fully automated hydraulic tramp release passes uncrushables without interruption. The release system maintains the crushing force and automatically returns the crusher to its production setting after a tramp event. A more reliable automated tramp release is not found on any other crusher. The crusher's availability is further enhanced by its hydraulic clearing system. Its large vertical stroke allows material to fall easily. And the large release and clearing stroke capability remains the same throughout liner life. Hydraulic rotation of the bowl provides additional cavity clearing, if needed.

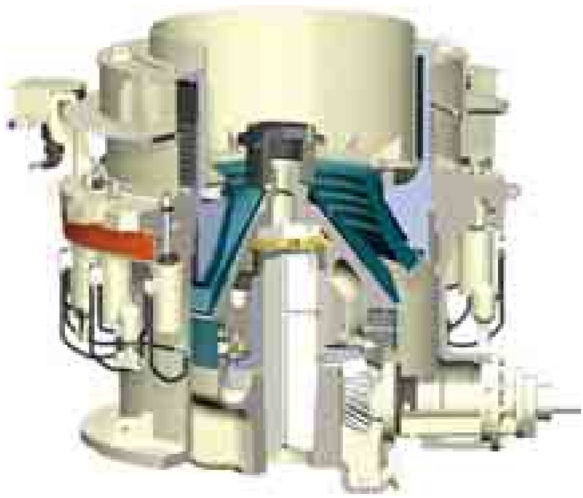
Ease of Operation

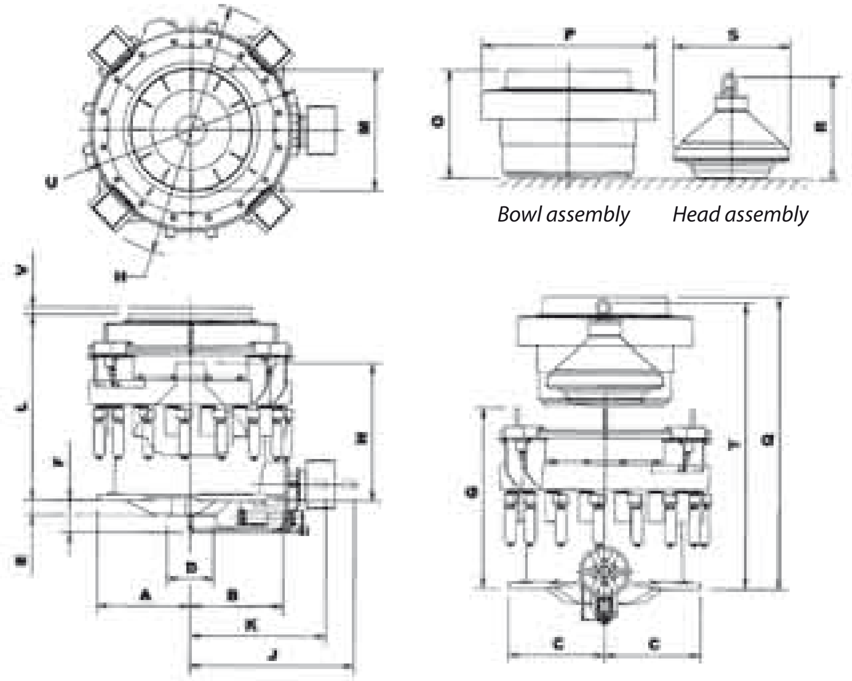
Push-button controls help make the MP1250, MP1000 and MP800 easy to operate. The hydraulic motor permits setting adjustments in small increments to compensate for wear. Adjustments can also be made remotely via a control system. In addition, force sensors pioneered by Metso indicate that safe operation continues after setting adjustment is initiated either by the operator or expert system.

Simple Maintenance

The MP Series features push-button disassembly for routine maintenance. If necessary, modular components can be easily replaced. Durable bronze bushings used throughout the crushers ensure superior load capability in the demanding crushing environment. Proven wedge retention of the bowl liner provides a secure and simple method of retaining the liner. It also allows for easy and efficient liner replacement.

Now available as standard on the MP1250, a simple, easy to use jackbolt style locknut is provided. This new locknut eliminates the need for a massive wrench and swinging weight. Simple, common hand tools are all that is required to remove and install the new locknut. Repeatable, accurate preloads are possible with the jackbolt style locknut, providing the same torque every time. The jackbolt locknut is also available for the MP1000 and MP800 crushers.





Bowl assembly Head assembly

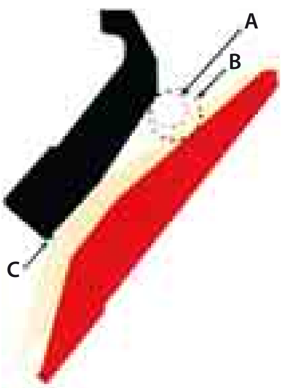
Clearance Dimensions	MP1250		MP1000		MP800	
	Standard	Shorthead	Standard	Shorthead	Standard	Shorthead
A. Crusher Centerline to Mainframe Flange	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1750 mm (5' 8-7/8")	1750 mm (5' 8-7/8")
B. Crusher Centerline to Counter-shaft Housing Face	2000 mm (6' 6-3/4")	2000 mm (6' 6-3/4")	2000 mm (6' 6-3/4")	2000 mm (6' 6-3/4")	1750 mm (5' 8-7/8")	1750 mm (5' 8-7/8")
C. Crusher Centerline to Mainframe Flange	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1950 mm (6' 4-3/4")	1750 mm (5' 8-7/8")	1750 mm (5' 8-7/8")
D. Main Frame Hub Diameter	975 mm (3' 2-3/8")	975 mm (3' 2-3/8")	975 mm (3' 2-3/8")	975 mm (3' 2-3/8")	875 mm (2' 10-7/16")	875 mm (2' 10-7/16")
E. Base to Bottom of Main Frame Hub	310 mm (1' 0-3/16")	310 mm (1' 0-3/16")	310 mm (1' 0-3/16")	310 mm (1' 0-3/16")	280 mm (11")	280 mm (11")
F. Base to Bottom of Oil Piping	670 mm (2' 2-3/8")	670 mm (2' 2-3/8")	670 mm (2' 2-3/8")	670 mm (2' 2-3/8")	762 mm (2' 6")	762 mm (2' 6")
G. Base to Top of Turning Brackets	3660 mm (12' 0-1/8")	3660 mm (12' 0-1/8")	3660 mm (12' 0-1/8")	3660 mm (12' 0-1/8")	3385 mm (11' 1-1/4")	3385 mm (11' 1-1/4")
H. Adjustment Ring Maximum Diameter	5360 mm (17' 7")	5360 mm (17' 7")	5360 mm (17' 7")	5360 mm (17' 7")	4550 mm (14' 11-1/8")	4550 mm (14' 11-1/8")
J. Clearance Required to Remove Counter-shaft Assembly	4320 mm (14' 2-1/16")	4320 mm (14' 2-1/16")	4320 mm (14' 2-1/16")	4320 mm (14' 2-1/16")	3881 mm (12' 8-13/16")	3881 mm (12' 8-13/16")
K. Crusher Centerline to End of Counter-shaft	2855 mm (9' 4-3/8")	2855 mm (9' 4-3/8")	2855 mm (9' 4-3/8")	2855 mm (9' 4-3/8")	2538 mm (8' 3-15/16")	2538 mm (8' 3-15/16")
L. Maximum Height From Base to Top of Feed Hopper	3926 mm (12' 10-9/16")	3993 mm (13' 1-3/16")	3926 mm (12' 10-9/16")	3993 mm (13' 1-3/16")	3860 mm (12' 8")	3752 mm (12' 3-3/4")
M. Inside Diameter of Feed Hopper	2530 mm (8' 3-5/8")	2490 mm (8' 2-1/16")	2530 mm (8' 3-5/8")	2490 mm (8' 2-1/16")	2210 mm (7' 3")	2110 mm (6' 11-1/16")
N. Base to Top of Feed Plate	3026 mm (9' 11-1/8")	2935 mm (9' 7-9/16")	3026 mm (9' 11-1/8")	2935 mm (9' 7-9/16")	2758 mm (9' 0-5/8")	2758 mm (9' 0-5/8")
O. Overall Height of Bowl Assembly	2186 mm (7' 2-1/16")	2180 mm (7' 1-13/16")	2186 mm (7' 2-1/16")	2180 mm (7' 1-13/16")	2133 mm (7' 0")	1964 mm (6' 5-5/16")
P. Adjustment Cap Maximum Diameter	3550 mm (11' 7-3/4")	3550 mm (11' 7-3/4")	3550 mm (11' 7-3/4")	3550 mm (11' 7-3/4")	3170 mm (10' 4-13/16")	3170 mm (10' 4-13/16")
Q. Clearance required for Removing Bowl Assembly	5896 mm (19' 4-1/8")	5890 mm (19' 3-7/8")	5896 mm (19' 4-1/8")	5890 mm (19' 3-7/8")	5518 mm (18' 1-1/4")	5399 mm (17' 8-9/16")
R. Overall Height of Head Assembly	2323 mm (7' 7-7/16")	2127 (6' 11-3/4")	2323 mm (7' 7-7/16")	2127 (6' 11-3/4")	2110 mm (6' 11-1/16")	2110 mm (6' 11-1/16")
S. Head or Mantle Maximum Diameter	2392 mm (7' 10-3/16")	2369 mm (7' 9-1/4")	2392 mm (7' 10-3/16")	2369 mm (7' 9-1/4")	2114 mm (6' 11-1/4")	2083 mm (6' 10")
T. Clearance Required for Removing Head Assembly	6033 mm (19' 9-1/2")	5837 mm (19' 1-13/16")	6033 mm (19' 9-1/2")	5837 mm (19' 1-13/16")	5495 mm (18' 0-3/8")	5545 mm (18' 0-3/16")
U. Tramp Release Side to Side	4644 mm (15' 2-13/16")	4644 mm (15' 2-13/16")	4610 mm (15' 1-1/2")	4610 mm (15' 1-1/2")	4280 mm (14' 0-1/2")	4280 mm (14' 0-1/2")
V. Additional Upward Travel Due to Clearing Stroke	150 mm (5-15/16")	150 mm (5-15/16")	150 mm (5-15/16")	150 mm (5-15/16")	163 mm (6-7/16")	163 mm (6-7/16")

Weights - Complete Crusher and Assemblies

Standard and Short Head	MP1250		MP1000		MP800	
	Lb.	Kg.	Lb.	Kg.	Lb.	Kg.
Crusher Complete	336 210	152 504	331 779	150 494	265 850	120 570
Main Frame Assembly, including Main Frame, Main Shaft and Main Frame Liners	107 814	48 904	103 177	46 801	91 400	41 450
Bowl Assembly, including Bowl, Bowl Liner, Adjustment Cap and Hopper	73 000	33 112	73 000	33 112	57 340	26 000
Adjustment Ring, Clamping Ring, Clamping Cylinders and Adjustment Mechanism	68 960	31 280	68 322	30 990	37 825	17 157
Head Assembly, Mantle and Lifting Plate	41 083	18 635	38 742	17 573	35 200	15 960
Countershaft Box, Countershaft and Crusher Sheave	9 067	4 113	9 067	4 113	7 045	3 195
Eccentric Assembly including Counterweight	20 723	9 400	19 445	8 820	17 604	7 985
Mantle	12 209	5 538	12 209	5 538	13 320	6 000
Bowl Liner	12 869	5 837	12 869	5 837	16 450	7 460
Hydraulic Power Unit	2 756	1 250	2 756	1 250	2 566	1 164
Oil Capacity of Hydraulic Power Unit is 568 Liters (150 Gallons)	1 065	483	1 065	483	1 065	483
Package Lube System (Air Cooled) — Dry Weight (No Oil)	7 700	3 492	7 700	3 492	7 700	3 492
Package Lube System (Water Cooled) — Dry Weight (No Oil)	8 920	4 046	8 920	4 046	8 920	4 046
Oil Capacity of Package Lube System is 1,893 Liters (500 Gallons)	3 700	1 678	3 700	1 678	3 700	1 678
Skid Mounted Air Coolers (Dual)	6 020	2 730	6 020	2 730	4 600	2 087

All weights can vary ± 5%

Crusher Cavity Selection	Closed Feed Opening A (mm)	Open Feed Opening B (mm)	Closed Side Setting Dimension C (mm)
MP800			
Shorthead Fine	43	94	8
Shorthead Medium	71	120	10
Shorthead Coarse	113	162	12
Standard Extra Fine	144	193	19
Standard Fine	241	282	19
Standard Medium	308	347	25
Standard Coarse	343	384	32
MP1000			
Shorthead Fine	63	120	8
Shorthead Medium	90	150	10
Shorthead Coarse	140	203	12
Shorthead Extra Coarse	235	285	19
Standard Extra Fine	241	295	22
Standard Fine	242	300	25
Standard Medium	343	390	32
Standard Coarse	360	414	38
MP1250			
Shorthead Fine	71	154	8
Shorthead Medium	98	184	10
Shorthead Coarse	148	237	12
Shorthead Extra Coarse	243	319	19
Standard Extra Fine	249	329	22
Standard Fine	250	334	25
Standard Medium	351	424	32
Standard Coarse	368	448	38



For inch, divide by 25.4

Crusher Capacities (MTPH)

Model	Closed Side Setting (mm)				
	50	38	25	19	13
MP800	1460 - 1935	1100 - 1285	735 - 980	580 - 690	495 - 585
MP1000	1830 - 2420	1375 - 1750	915 - 1210	720 - 900	615 - 730
MP1250	2290 - 3025	1720 - 2190	1145 - 1510	900 - 1125	770 - 915

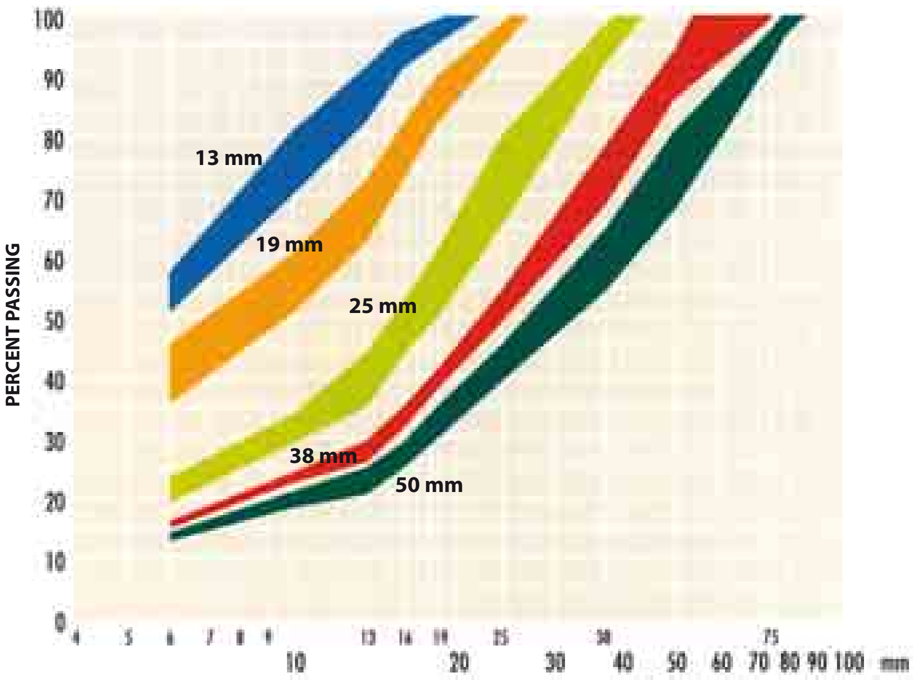
For inch, divide by 25.4
For STPH, multiply by 1.1

Product Gradations

Sieve (mm)	Closed Side Setting (mm)				
	50	38	25	19	13
100	100				
75	92 - 98	100			
50	67 - 81	86 - 94	100		
38	54 - 64	68 - 78	92 - 98	100	
25	38 - 54	48 - 54	65 - 80	94 - 98	100
19	30 - 35	37 - 42	51 - 62	82 - 90	96 - 99
16	25 - 29	31 - 35	43 - 53	73 - 82	92 - 97
13	22 - 25	26 - 29	35 - 44	63 - 73	83 - 93
10	18 - 21	22 - 24	28 - 34	52 - 61	70 - 91
6	13 - 14	15 - 16	19 - 23	36 - 44	50 - 57

For inch, divide by 25.4

Gradation Curves



For high productivity, low operating and wear costs, long service life and high efficiency, providing high quality product, there is no better choice than a Nordberg HP Series cone crusher. Metso is the market leader with its ”High Performance” crushers for aggregate and mining operations.

The Nordberg HP Series cone crushers are characterized by the optimized combination of crusher speed, eccentricity, and cavity profile. This combination has proved revolutionary, providing higher capacity, better product quality and suitability to a wider range of applications. From limestone to compact hematite, from ballast to manufactured sand production, and from small portable plants to large mining plants, the HP cone crushers are unbeatable in secondary, tertiary, and quaternary applications.

Using the hydraulic motor setting adjustment makes it easy to balance the crushing circuit and optimize crusher productivity. The addition of a hydraulic motor position transducer system to keep track of crusher setting is all that's required to connect the crusher to an electronic automation system.

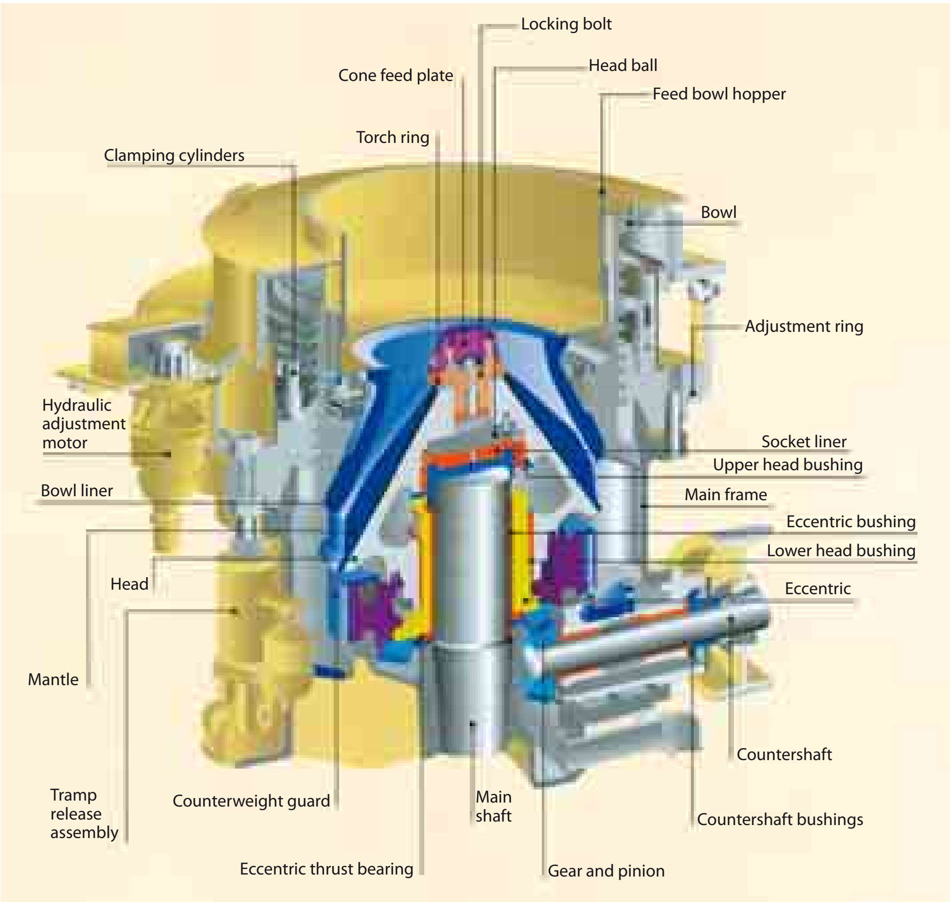
The Nordberg HP Series cone crusher hydraulic release system with double-acting cylinders allows passing of non-crushable materials that would block most of the crushers in the market. The large clearing stroke independent of liner wear reduces the effort required to empty the crusher cavity, reducing downtime and increasing productivity and operational safety.

The hydraulic motor that rotates the bowl for fine adjustment of the opening also rotates the bowl completely out of the adjustment ring threads, facilitating liner changes greatly. Advanced liner tightening technology contributes to a better reliability.

The HP cone crusher cavity can be converted from extra-fine to extra-coarse cavity simply by replacing the mantle, bowl liner, adapter ring, and wedge bolts. In this way, the crusher is easily adapted to feed and desired product requirements.

MANUFACTURED SAND

HP cone crushers are also excellent crushers for the production of manufactured sand. The combination of high speed and large eccentricity, together with crushing chamber, which promotes intense interparticular crushing, produces manufactured sand with high cubicity particles and excellent gradation for concrete. Due to its good properties manufactured sand produced in HP cone crushers has replaced partly or totally natural sands, with many advantages. In manufactured sand production, HP cone crushers can offer advantages over other crushing methods. HP cones offer higher production with the same installed power and less micro-fines. The high quality of manufactured sand produced by HP cone crushers can be witnesses in many plants around the world.


Locking bolt
Head ball
Cone feed plate
Feed bowl hopper
Torch ring
Clamping cylinders
Bowl
Adjustment ring
Hydraulic adjustment motor
Socket liner
Upper head bushing
Bowl liner
Main frame
Eccentric bushing
Lower head bushing
Head
Eccentric
Mantle
Countershaft
Tramp release assembly
Counterweight guard
Main shaft
Countershaft bushings
Eccentric thrust bearing
Gear and pinion

CAPACITIES

Closed side setting													
Model	**Tone/ hour**	**6 mm (1/4")**	**8 mm (5/16")**	**10 mm (3/8")**	**13 mm (1/2")**	**16 mm (5/8")**	**19 mm (3/4")**	**22 mm (7/8")**	**25 mm (1")**	**32 mm (1 1/4")**	**38 mm (1 1/2")**	**45 mm (1 3/4")**	**51 mm (2")**
HP 100	Mtph stph	45-55 50-60	50-60 55-65	55-70 60-75	60-80 65-90	70-90 80-100	75-95 85-105	80-100 85-110	85-110 95-120	100-140 110-155			
HP 200	Mtph stph			90-120 100-130	120-150 130-165	140-180 155-200	150-190 165-210	160-200 175-220	170-220 185-240	190-235 210-260	210-250 230-275		
HP 300	Mtph stph			115-140 125-155	150-185 165-205	180-220 200-240	200-240 220-265	220-260 240-285	230-280 255-310	250-320 275-355	300-380 330-420	350-440 385-485	
HP 400	Mtph stph			140-175 155-195	185-230 205-255	225-280 250-310	255-320 280-355	275-345 305-380	295-370 325-410	325-430 360-475	360-490 395-545	410-560 450-625	465-630 510-700
HP 500	Mtph stph			175-220 195-240	230-290 255-320	280-350 310-385	320-400 355-440	345-430 380-475	365-455 400-500	405-535 445-595	445-605 490-670	510-700 560-775	580-790 640-880
HP 800	Mtph stph			260-335 285-370	325-425 360-470	385-500 425-550	435-545 480-600	470-600 520-660	495-730 545-805	545-800 600-800	600-950 550-1045	690-1050 760-1155	785-1200 865-1320

Crusher instantaneous capacity in t/h with material of bulk density of 1.6 t/m³.

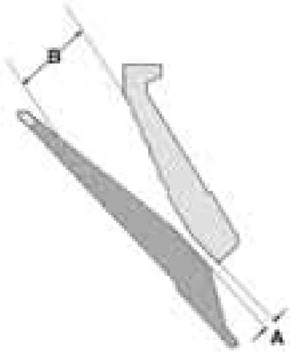
HP CONE CRUSHERS CRUSHER CAVITY SELECTION

Model	**Cavity**	**Standard**		**Short head**	
		Minimum setting "A" mm (inches)	**Feed opening "B" mm (inches)**	**Minimum setting "A" mm (inches)**	**Feed opening "B" mm (inches)**
HP 100	Extra fine Fine Medium Coarse Extra coarse			6 (0,24") 9 (0,35") 9 (0,35") 13 (0,51") 21 (0,83")	20 (0,79") 50 (1,97") 70 (2,76") 100 (3,94") 150 (5,91")
HP 200	Extra fine Fine Medium Coarse Extra coarse	— 14 (0,55") 17 (0,67") 19 (0,75") —	— 95 (3,74") 125 (4,92") 185 (7,28") —	6 (0,24") 6 (0,24") 6 (0,24") 10 (0,39") —	25 (0,98") 25 (0,98") 54 (5,91") 76 (2,99") —
HP 300	Extra fine Fine Medium Coarse Extra coarse	— 13 (0,51") 16 (0,63") 20 (0,79") 25 (0,98")	— 107 (4,21") 150 (5,91") 211 (8,31") 233 (9,17")	6 (0,24") 6 (0,24") 8 (0,24") 10 (0,39") —	25 (0,98") 25 (0,98") 53 (2,09") 77 (3,03") —
HP 400	Extra fine Fine Medium Coarse Extra coarse	— 14 (0,55") 20 (0,79") 25 (0,98") 30 (1,18")	— 111 (4,37") 198 (7,80") 252 (9,92") 299 (11,77")	6 (0,24") 6 (0,24") 8 (0,31") 10 (0,39") —	30 (1,18") 40 (1,57") 52 (2,05") 92 (3,62") —
HP 500	Extra fine Fine Medium Coarse Extra coarse	— 16 (0,63") 20 (0,79") 25 (0,98") 30 (1,18")	— 133 (5,24") 204 (8,03") 286 (11,26") 335 (13,19")	6 (0,24") 8 (0,31") 10 (0,39") 13 (0,51") —	35 (1,38") 40 (1,57") 57 (2,24") 95 (3,62") —
HP 800	Extra fine Fine Medium Coarse Extra coarse	16 (0,63") 16 (0,63") 25 (0,98") 32 (1,26") 32 (1,26")	187 (7,36") 219 (8,62") 267 (10,51") 297 (11,69") 353 (13,90")	— 5 (0,20") 10 (0,39") 13 (0,51") —	— 33 (1,30") 92 (3,62") 155 (6,10") —

1. *The minimum setting is that at which the crusher will operate without causing ring bounce. Depending on the type of material, this setting can change.*

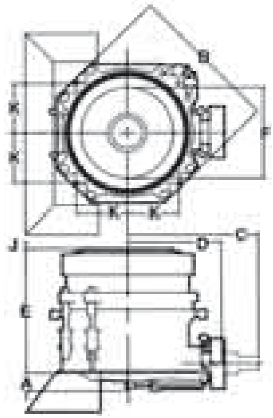
2. *Feed opening «B» corresponds to minimum setting «A».*

3. *Maximum feed size vary from 80 to 100% of "B" depending on machine model and material.*



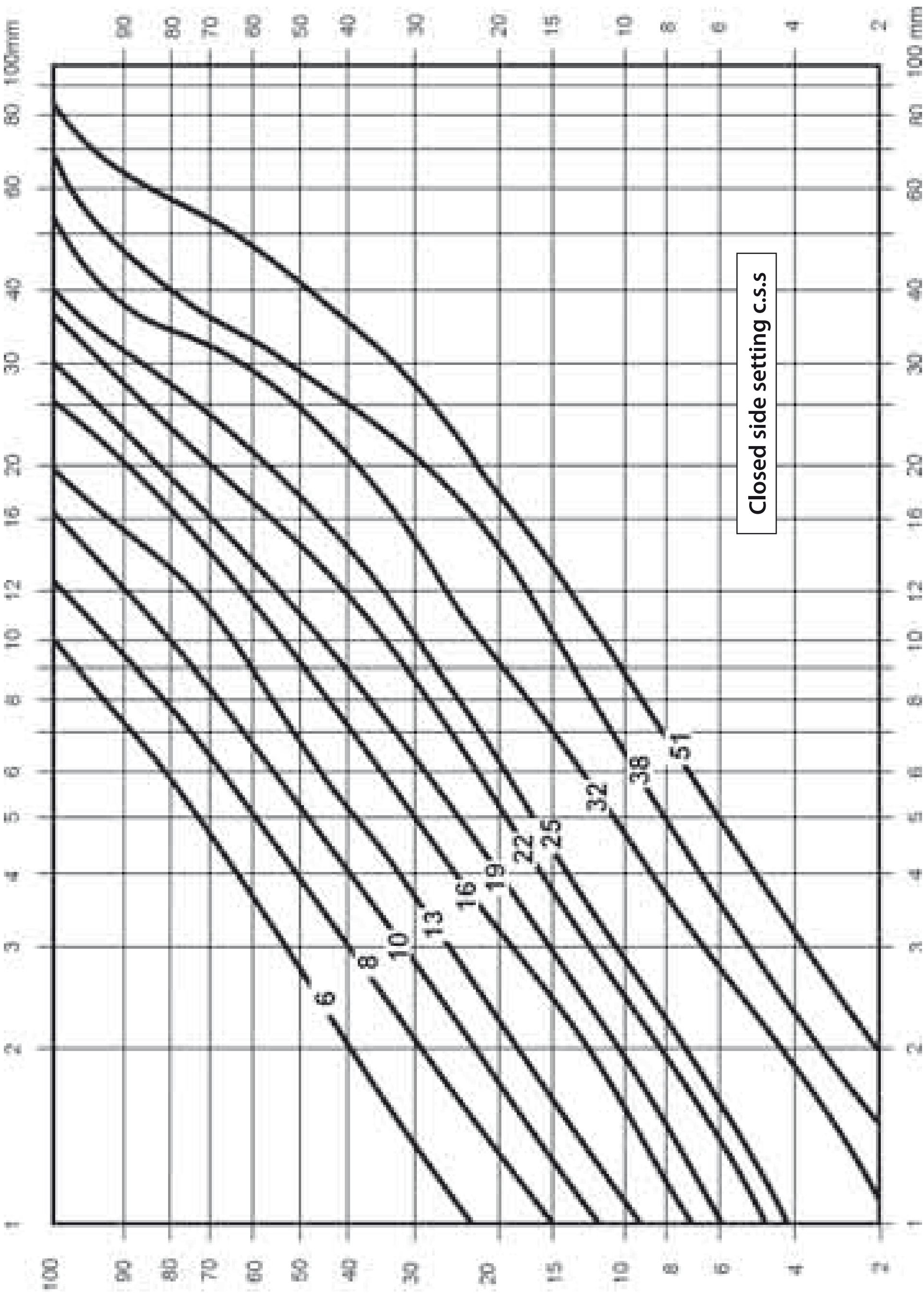
HP CONE CRUSHERS – WEIGHTS AND DIMENSIONS

Model	HP 100	HP 200	HP 300	HP 400	HP 500	HP 800
Crusher complete	5 400 kg 11 900 Lbs	10 400 kg 22 960 Lbs	15 810 kg 33 490 Lbs	23 000 kg 50 600 Lbs	33 150 kg 73 000 Lbs	68 650 kg 151 200 Lbs
Bowl and bowl liner	1 320 kg 2 910 Lbs	2 680 kg 5 915 Lbs	3 525 kg 7 765 Lbs	4 800 kg 10 575 Lbs	7 200 kg 15 800 Lbs	17 350 kg 38 220 Lbs
Mantle and feed plate	600 kg 1 325 Lbs	1 200 kg 2 650 Lbs	2 060 kg 4 550 Lbs	3 240 kg 7 130 Lbs	5 120 kg 11 280 Lbs	10 800 kg 23 790 Lbs
Maximum recommended power	90 kW 120 hp	150 kW 200 hp	200 kW 268 hp	315 kW 422 hp	355 kW 476 hp	600 kW 800 hp
Countershaft speed (rpm)	750–1200	750–1200	700–1200	700–1000	700–950	700–950



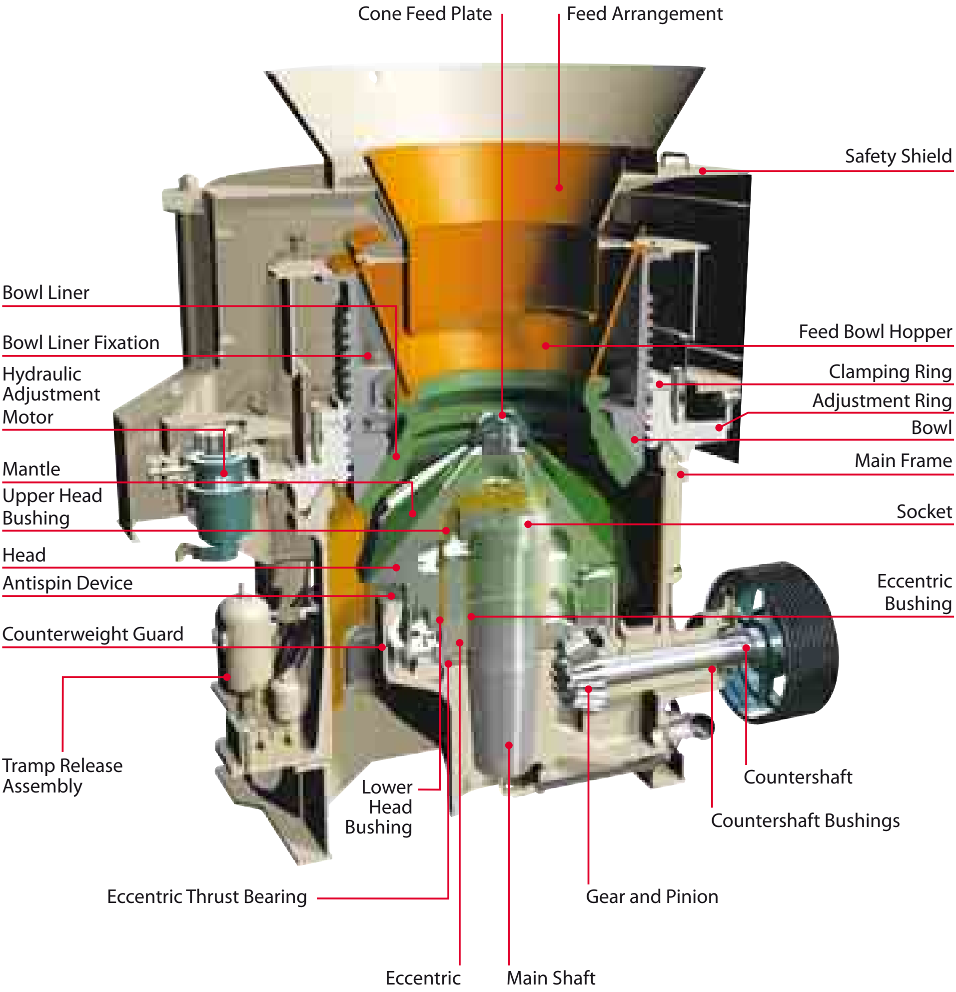
Model	HP 100	HP 200	HP 300	HP 400	HP 500	HP 800
A. Distance to bottom of oil piping	293	297	328	240	425	722 (28-1/16")
B. Adjustment ring maximum diameters	1 505 mm (59-1/4")	1 652 mm (64-3/4")	2 207 mm (86-7/8")	2 370 mm (93-3/8")	2 730 mm (107-1/2")	3 702 mm (145-3/4")
C. Clearance required for removing countershaft assembly	1 560 mm (61-7/16")	1 840 mm (72-7/76")	2 020 mm (79-1/2")	2 470 mm (97-1/4")	2 650 mm (104-3/8")	3 450 mm (135-13/16")
D. To end of countershaft	950 mm (37-3/8")	1 160 mm (45-11/16")	1 347 mm (53")	1 645 mm (64-3/4")	1 760 mm (69-1/4")	2 225 mm (81-5/8")
E. Maximum height to top	1 290 mm (50-13/16")	1 630 mm (64-3/4")	1 865 mm (73-7/16")	2 055 mm (80-7/8")	2 290 mm (90-1/8")	3 538 mm (139-1/4")
F. Inside diameter of feed hopper	694 mm (27-5/16")	914 mm (36")	1 078 mm (42-7/16")	1 308 mm (51-1/2")	1 535 mm (60-1/2")	1 863 mm (73-3/8")
Clearance required for removing bowl assembly	1 725 mm (67-15/16")	2 140 mm (84-1/4")	2 470 mm (97-1/4")	2 650 mm (104-3/8")	3 300 mm (129-7/8")	4 854 mm (191-1/8")
Clearance required for removing head assembly	1 700 mm (66-15/16")	2 165 mm (84-1/4")	2 455 mm (96-5/8")	2 715 mm (106-3/8")	3 165 mm (124-5/8")	4 364 mm (171-3/4")
J. Lift of feed hopper during emptying operation	65 mm (2-9/16")	70 mm (2-3/4")	85 mm (3-3/8")	105 mm (4-1/8")	125 mm (4-15/16")	159 mm (6-1/4")
K. Mounting holes location	NA	545 mm (21-1/2")	660 mm (26")	830 mm (32-11/16")	882 mm (34-3/4")	1 130 mm (44-1/2") and/or 1 245 mm (49")
Main frame discharge opening diameter	970 mm (38-3/16")	1 240 mm (48-13/16")	1 470 mm (57-7/8")	1 726 mm (68")	2 040 mm (80-1/2")	2 420 mm (95-1/4")

HP CONE CRUSHERS – GRADATION CURVES



New Nordberg HP4 & HP5 – designed for your needs

The HP4 is a crusher with a heavy-duty design for hardest applications. Its unique features for highest reduction ratios, maximum versatility and lowest maintenance requirements guarantees highest levels of productivity and minimized operating costs.



Highest Performance

With a combination of optimized speed and large throw, HP4 provides the highest reduction ratios of any current cone crusher. Due to its high efficient crushing action, the HP4 has the best power utilization per cone diameter. It offers advantages like lower kWh per ton of crushed end product and lower recirculation load. A higher cavity density improves interparticular crushing action for end products with more consistent gradation and superior shape (cubicity).

Less Downtime

Dual-acting hydraulic tramp release cylinders let the HP4 pass tramp iron that would stall, or damage, many other crushers. And if the crusher does stop under load, those dual-acting cylinders provide a large clearing stroke, independent of liner wear, to quickly clear the crushing cavity.

An advanced fastening system for mantle and bowl liner makes backing material unnecessary, and makes liner changes faster. Thicker liners mean longer liner life. When liners are changed or the crusher is reconfigured, the same hydraulic motor that rotate the bowl for setting adjustment will rotate the bowl completely out of the adjustment ring threads, greatly simplifying liner replacement.

A new fixed counterweight guard protects the counterweight and seals out dust.

Versatility

Due to its strength, speed range and ease of converting from coarse to extra fine applications, the HP4 provides application flexibility that was unheard of until now.

- Save stockpile space by recrushing excess or slow-moving products without an intermediate crushing stage.
- Converting from coarse to extra fine application and back again just by changing liners and rpm.
- Liner and rpm combinations go from secondary applications to sand manufacturing.

Asset Protection

The new tramp release design also protects the main frame from uncrushables by smoothing out the impact forces and it's returning the bowl to its original position after passing tramp iron. Inside, a new fixed guard protects counterweight and seals out dust. An optional cover around the crusher protects employees from casual contact with adjustment and tramp release mechanisms. It also helps protecting the workplace with reduced dust emissions. The environment benefits too from the advanced fastening system for mantle and bowl liner that do not require backing material.

Closed Side Setting											
Size	CSS	8 mm (5/16")	10 mm (3/8")	13 mm (½")	16 mm (5/8")	19 mm (¾")	22 mm (7/8")	25 mm (1")	32 mm (1 ¼")	38 mm (1 ½")	45 mm (1 ¾")
HP4	Mtph	135-175	155-210	195-265	235-315	260-345	285-375	300-400	310-440	360-500	400-555
	stph	150-190	170-230	215-290	260-345	285-380	315-410	330-440	340-485	395-550	440-610
HP5	Mtph		220-300	280-380	335-450	370-490	410-535	430-570	440-630	515-715	570-790
	stph		245-330	310-415	370-495	410-540	450-590	470-630	490-690	565-785	630-870

Technical Data

HP Model	Nominal feed opening:	Motor size up to:	Crusher weight:	Complete crusher weight*:
HP4	252 mm (9.93")	315 kW (400 hp)	19 810 kg (43 586 lbs)	23 672 kg (52 084 lbs)
HP5	330 mm (13.0")	450 kW (600 hp)	33 000 kg (73 000 lbs)	44 500 kg (98 200 lbs)

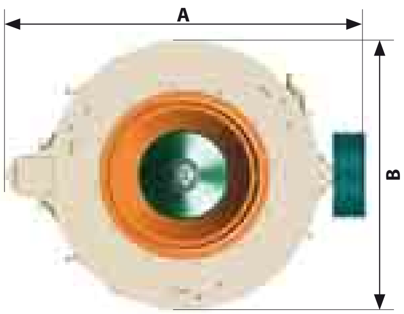
Cavities

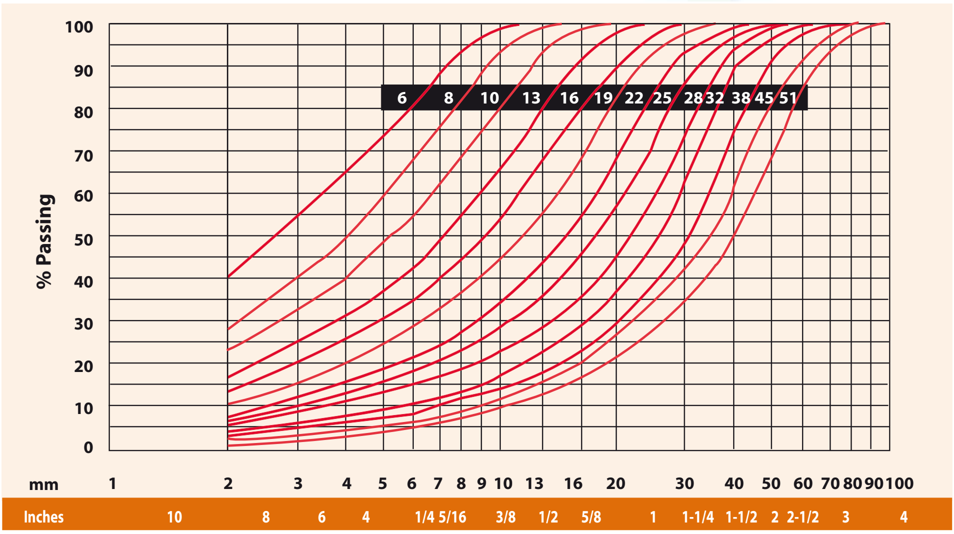
HP Model	Cavity	Minimum setting	Feed opening
HP4	Extra Coarse Medium Fine Extra Fine	28 mm (1.10") 16 mm (0.63") 10 mm (0.39") 8 mm (0.31")	252 mm (9.93") 169 mm (6.66") 116 mm (4.55") 74 mm (2.93")
HP5	Extra Coarse Coarse Medium Fine Extra Fine	30 mm (1.20") 25 mm (1.00") 18 mm (0.71") 12 mm (0.47") 9 mm (0.35")	330 mm (13.0") 290 mm (11.4") 205 mm (8.10") 112 mm (4.40") 56 mm (2.20")

Complete crusher weight: crusher + subframe, motor sub frame, covers, feed and discharge arrangement.*

Dimensions

HP Model	A	B	C	D
HP4	2 955 mm (9'8 - 3/8")	2 250 mm (7'4 - 5/8")	2 156 mm (7'0 - 7/8")	2 549 mm (8'4 - 8/8")
HP5	3 854 mm (12'7 - 3/4")	3 062 mm (10' - 1/2")	3 522 mm (11'6 - 5/8")	3 953 mm (12'11 - 5/8")





Nordberg NP Series Impact Crushers

Nordberg NP Series impact crushers feature a unique combination of heavy rotor design, wear material and crushing chamber design. This combination has proved revolutionary in improving capacity, product quality and in reducing operating and wear costs.

NP Series impact crushers are characterised by a unique hammer fixing system providing a higher degree of hammers reliability. NP Series impact crushers have been designed to minimise maintenance and improve all adjustment operations.

NP Series impact crushers deliver unbeatable performances in primary, secondary, tertiary and recycling applications.

Higher capacity

NP Series of impact crushers are the solution for current and future operating conditions in which output and productivity demands are increasingly stringent. Our engineers have optimised machine layout to maximise loading, with a bigger crushing chamber, optimised liners and specific rotors to boost productivity in every type of application.

A lot of effort has gone into redesigning the rotor to increase swing-weight, improve crushing reduction and obtain extra capacity. NP series of impact crushers enable to achieve a higher reduction with fewer crushing stages, lowering your capital costs and saving energy.

Higher quality

Starting from the idea of identical rotors for primary and secondary crushers, we oversized our primary rotors to be able to use the same hammers.

Permanent collaboration with many research laboratories has now made it possible to bring you state of the art technical innovations in terms of the durability of wear parts (hammers, screen liners, side liners...) and the reliability of the mechanical components making up the crushers (shaft lines, bearings).

A range for every type of application

The strength of NP impact crushers makes them ideal for every kind of application in many different configurations. NP impact crushers have demonstrated their effectiveness in a host of missions from crushing low abrasive materials to industrial applications and recycling.

Unique hammer attachment system

Over and above the different grades of wear-resistant steel available throughout the range, NP impact crusher is characterised by a unique attachment unit.

Hammers are fixed to rotors by a single wedge assembly delivering higher tightening torque than any other manufacturer. Combined with perfect hammer alignment on rotor contact faces, this guarantees the enormous advantage of eliminating gaps between the rotor and the hammers. This reduces risks of hammer breakage and makes it possible to push the use of cast iron for hammers beyond conventional limits.

Easy to maintain with high security level

The same hydraulic power unit opens the frame and adjusts of the liners. Protected doors located all around the frame make it possible to reach the interior of the crusher.

Hammers can be changed vertically or horizontally which enables the machine to adapt to many implementation possibilities.

Particular attention has been paid to the degree of the modularity of wear parts to make it possible to significantly reduce the number of part references.

Moreover, as, on a given machine, parts do not all wear at the same rate and can be moved around the crusher, the number of spare and repair parts in stock can be reduced.

Additionally, sensors on the frame make all the maintenance interventions safe by forbidding machine start up.

Application flexibility, easy to operate

No drastic modifications are required if, for any reason, you decide to change your NP impact crusher tasking. By the simple addition of options like the hydraulic assistance, hydraulic adjustment, a third breaker plate, the use of different grades of wear resistant steel (hammers, liners, side liners), NP impact crushers can be adapted to every kind of application. Once set up for a specific mission, no fine tuning is needed to maximise NP impact crushers' performances.

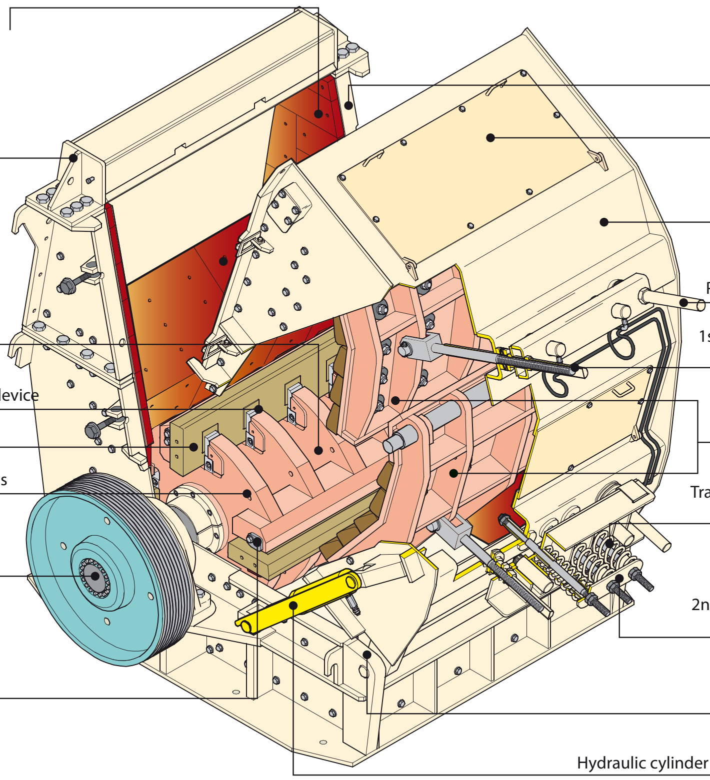
Automation of the settings

An optional automatic setting allows to change the setting of the impact crusher from a distance and without human intervention. The principle consists in gauging and setting the lower breaker plate to the required value. The higher breaker plate is then automatically set to a calculated value depending on the setting of the lower breaker plate and the feed size. As a result the machine is adaptable to compensate for wear of for any evolution of the application.

How to operate your impactor

		Effect		
		Specific power consumption	Product gradation fineness	Product shape
Adjustment	Decreasing the setting	↑	↑	↗
	Decreasing the feeding	↘	↗	↗
	Increasing the speed	↑	↑	↗
	Softening the feed material	→	↑	↗

This table gives you some hints how to adjust your impactor to optimize production and power consumption. It also shows you how feed material crushability is affecting.



Technical data

NP Model		Feed opening	Maximum feed size	Nominal installed power (kW / HP)	Maximum installed power[1] (kW / HP)
Primary range	NP1313	1320 x 1225 mm / 52" x 48.2"	900 mm / 35.4"	200 / 250	250 / 350
	NP1415	1540 x 1320 mm / 60.6" x 52"	1000 mm / 39.4"	250 / 350	315 / 400
	NP1620	2040 x 1634 mm / 80.3" x 64.3"	1300 mm / 51.2"	400 (2x200) / 500 (2x250)	500 (2x250) / 700 (2x350)
	NP2023	2310 x 1986 mm / 91" x 78.2"	1500 mm / 59.1"	1000 (2x500) / 1300 (2x650)	1000 (2x500) / 1300 (2x650)
Secondary range	NP1110	1020 x 820 mm / 40.2" x 32.3"	600 mm / 23.6"	160 / 200	200 / 250
	NP1213	1320 x 879 mm / 52" x 34.6"	600 mm / 23.6"	200 / 250	250 / 350
	NP1315	1540 x 930 mm / 60.6" x 36.6"	600 mm / 23.6"	250 / 350	315 / 400
	NP1520	2040 x 995 mm / 80.3" x 39.2"	700 mm / 27.6"	400 (2x200) / 500 (2x250)	500 (2x250) / 700 (2x350)

(1) For higher installed power, please contact the factory.

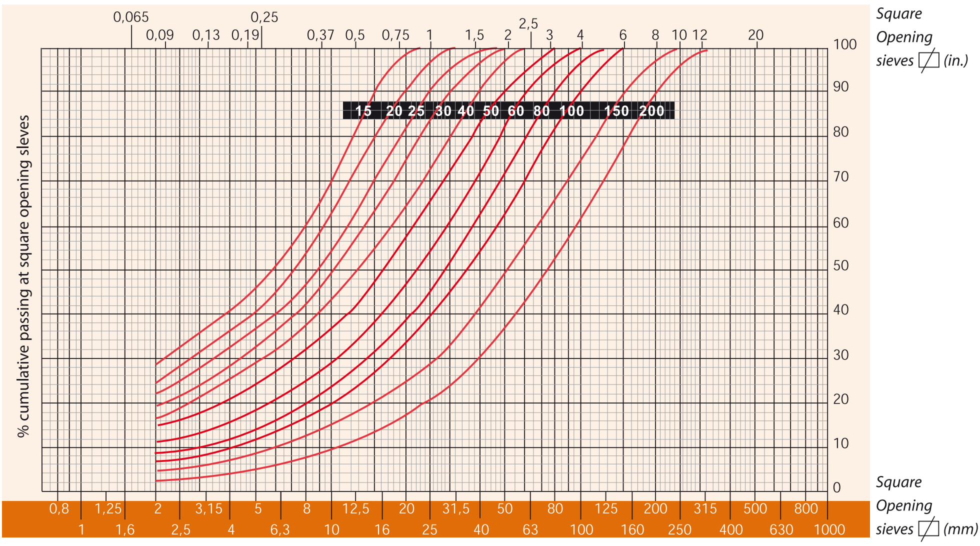
Crusher capacities (1)

NP Model		Top Feed Size 800 mm - 32 inch		Top Feed Size 600 mm - 24 inch	
		End Product 200 mm - 8 inch	End Product 100 mm - 4 inch	End Product 200 mm - 8 inch	End Product 100 mm - 4 inch
Primary range	NP1313	450 mtph / 500 stph	300 mtph / 340 stph	480 mtph / 540 stph	320 mtph / 360 stph
	NP1415	560 mtph / 630 stph	365 mtph / 410 stph	600 mtph / 670 stph	400 mtph / 450 stph
	NP1620	870 mtph / 970 stph	570 mtph / 640 stph	930 mtph / 1040 stph	620 mtph / 690 stph
	NP2023	1780 mtph / 1990 stph	1160 mtph / 1300 stph	1970 mtph / 2200 stph	1270 mtph / 1400 stph

NP Model		Top Feed Size 400 mm - 16 inch		Top Feed Size 200 mm - 8 inch	
		End Product 60 mm - 2 1/2 inch	End Product 40 mm - 1 1/2 inch	End Product 40 mm - 1 1/2 inch	End Product 20 mm - 3/4 inch
Secondary range	NP1110	190 mtph / 210 stph	150 mtph / 170 stph	210 mtph / 230 stph	130 mtph / 140 stph
	NP1213	250 mtph / 280 stph	200 mtph / 220 stph	280 mtph / 310 stph	180 mtph / 200 stph
	NP1315	315 mtph / 350 stph	250 mtph / 280 stph	350 mtph / 390 stph	225 mtph / 250 stph
	NP1520	500 mtph / 560 stph	400 mtph / 450 stph	560 mtph / 630 stph	360 mtph / 400 stph

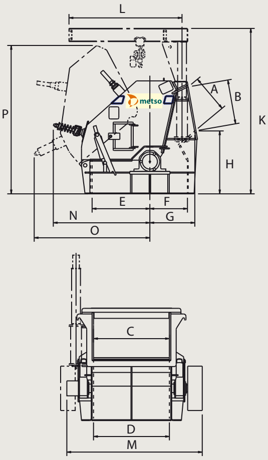
[1] *Represents capacity through crusher based "instantaneous" product sample.*

Production curves*



** The gradation and capacities shown are dependent on feed gradation, material density and its crushability.*

Technical data



NP Model		Crusher complete	Rotor complete	Rotor diameter	Rotor width
Primary range	NP1313	17 800 kg 39 249 Lbs	6 340 kg 13 980 Lbs	1 300 mm 51.2 in	1 300 mm 51.2 in
	NP1415	21 815 kg 48 102 Lbs	8 165 kg 18 004 Lbs	1 400 mm 55.1 in	1 500 mm 59.1 in
	NP1620	40 500 kg 89 303 Lbs	15 980 kg 35 236 Lbs	1 600 mm 63 in	2 000 mm 78.7 in
	NP2023	74 230 kg 163 677 Lbs	28 280 kg 62 357 Lbs	2 000 mm 78.7 in	2 300 mm 90.6 in
Secondary range	NP1110	9 250 kg 20 396 Lbs	3 065 kg 6 758 Lbs	1 100 mm 43.3 in	1 000 mm 39.4 in
	NP1213	12 780 kg 28 180 Lbs	4 850 kg 10 694 Lbs	1 200 mm 47.2 in	1 300 mm 51.2 in
	NP1315	16 130 kg 35 567 Lbs	6 370 kg 14 046 Lbs	1 300 mm 51.2 in	1 500 mm 59.1 in
	NP1520	27 100 kg 59 756 Lbs	10 400 kg 22 932 Lbs	1 500 mm 59.1 in	2 000 mm 78.7 in

Clearance dimensions (mm/inch)

NP Model		A	B	C-D	E	F	G	H	K	L	M	N	O	P
Primary range	NP1313	1 050 41.3	1 225 48.2	1 320 52.0	1 305 51.4	760 30.0	632 24.9	1 386 24.5	3 765 148.2	2 100 82.7	2 560 100.8	2 340 92.1	2 764 108.8	3 405 134.0
	NP1415	1 140 44.9	1 320 52.0	1 540 60.6	1 305 51.4	800 31.5	605 23.8	1 430 56.3	4 000 157.5	2 295 90.3	2 790 109.8	2 380 93.7	2 790 109.8	3 600 141.7
	NP1620	1 400 55.1	1 634 64.3	2 040 80.3	1 600 63.0	920 36.2	850 33.5	1 772 69.8	4 950 194.9	3 000 118.1	3 600 141.7	2 630 103.5	3 085 121.5	4 400 173.2
	NP2023	1 720 67.7	1 986 78.2	2 310 91.0	2 210 87.0	1 140 44.9	1 631 64.2	2 273 89.5	6 000 236.2	3 930 154.7	4 424 174.2	3 520 138.6	4 100 161.4	5 514 217.0
Secondary range	NP1110	710 28.0	820 32.3	1 020 40.1	1 105 43.5	652 25.6	796 31.3	1 125 44.3	3 055 120.3	1 800 70.9	2 106 82.9	1 830 72.0	2 030 80.0	2 716 107.0
	NP1213	750 29.5	879 34.6	1 320 52.0	1 120 44.1	705 27.8	864 34.0	1 212 47.7	3 145 123.8	2 100 82.7	2 529 100.0	1 945 76.6	2 306 90.8	2 882 113.5
	NP1315	800 31.5	930 36.6	1 540 60.6	1 172 46.1	765 30.1	915 36.0	1 291 50.8	3 395 133.7	2 295 90.3	2 750 108.3	1 960 77.2	2 350 92.5	3 055 120.2
	NP1520	850 33.5	995 39.2	2 040 80.3	1 368 53.9	885 34.8	1 055 41.5	1 518 59.8	3 950 155.5	3 000 118.1	3 400 133.9	2 336 92.0	2 763 108.8	3 540 139.4

The Complete VSI Range

Barmac Vertical Shaft Impactors

Metso Minerals markets Vertical Shaft Impactor (VSI) crusher lines. The world famous Barmac B-Series rock-on-rock VSI, previously known as the Barmac Duopactor, offering a complete VSI range for secondary, tertiary and quaternary applications.

With nearly 4000 units operating in aggregate and mineral processing installations around the world, Barmac VSI crushers have established a track record of cost savings, durability and unmatched performance in a variety of tasks to which they been applied. These include the production of high quality aggregates for a range of applications, manufactured sand to all specifications and a range of mineral and recycling operations.

Barmac B-Series VSI

The Barmac B-series VSI is an excellent third and fourth stage reduction unit and has demonstrated a unique ability to operate in many demanding and diverse crushing operations within the construction industry. This is possible because of the unique free impact crushing and grinding action and the ability to fine-tune this process by simply changing rotor speed or cascade ratio.

Coupled with low wear costs, the result has seen the Barmac B-Series VSI finds applications not only in traditional quarrying operations but also a large range of specialist crushing plants.

Options	B5100SE	B6150SE	B7150SE	B9100SE
Roof Lifter	*	•	•	•
Rotor Service Crane		•	•	•
Support Frame Kit	•	•	•	•
Electric Hydraulic Cascade Control	•	•	•	•
Automatic Lubrication	•	•	•	•
Automation	•	•	•	•
VSI Operational Control System	*	*	*	*
Safety Interlock	•	•	•	•

* Part of standard offering.

The Barmac VSI has a competitive capital cost, especially when compared with conventional crushing equipment. Barmac VSIs require minimum support structure and are also utilised in a mobile configuration, ensuring installation is quick and easy.

Mobile crushing

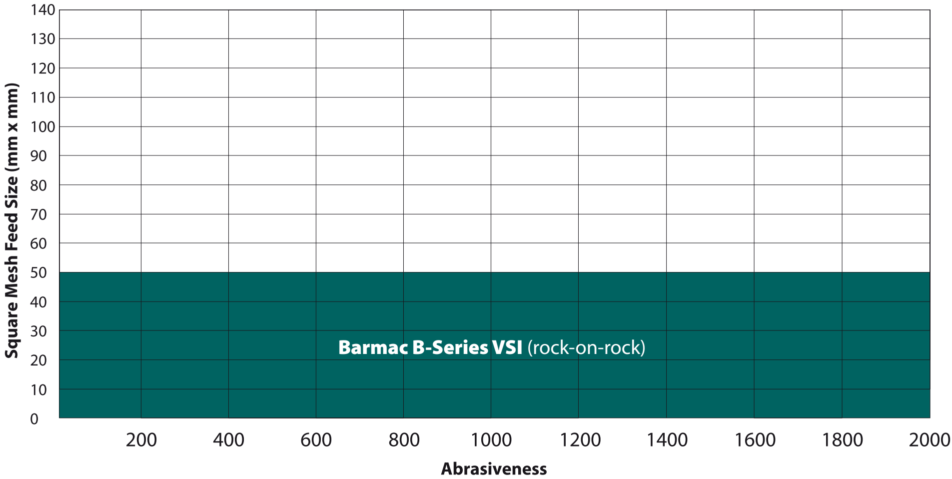
The popularity of mobile crushing amongst our customers has seen the world's Number 1 VSI range go mobile. Barmac VSI crushers have been installed on both chassis and Lokotrack configurations to improve their versatility. The Barmac VSI is offered as a final phase crusher to provide either high reduction ratios or to provide shaping to improve aggregate quality.

Barmac VSI application

The choice of which Barmac VSI to recommend is dependant on feed top size and the abrasiveness of the source rock. In medium to high abrasive rocks the B-Series will offer the lowest cost per tonne and offer excellent shaping over the range of product produced.

The B-series take a smaller feed size. The figure below shows the recommended configuration given the feed top size and the abrasiveness of the feed material.

Barmac VSI Application Guidelines



Aggregate production

The aggregate market has been the traditional home of the Barmac VSI crusher. The impact crushing action of the Barmac VSI produces a product that is cubical in nature and performs well in concrete, asphalt, block and mortar applications. When applied, these aggregates provide superior quality of product, maximum strength concrete with no added cement, bitumen savings in asphalt and high quality blocks.

Manufactured sand

The Barmac VSI product range produces excellent manufactured sand for concrete, asphalt, block and mortar applications. The impact crushing action produces sand where all the particles sizes are well represented, which ensures it performs well in a range of applications. Just as important is the cubical shape of sand, which limits the water required in concrete mixtures improving strength and other hardened concrete properties. In asphalt, good quality manufactured sand reduces the bitumen demand while providing higher stability and resistance to rutting.

Crusher Optimisation

VSI Operational Control System (VOCS)

The VOCS has been designed to provide the Barmac VSI operator with constantly updated information on the operating condition of the vital mechanical components of the equipment. Three areas are monitored; Vibration caused by an unbalanced rotor, bearing cartridge running temperature and motor winding temperature. This monitoring allows any operator to operate the crusher at the maximum efficiency, maximising product quality and yield.

Crusher Automation -IC3000

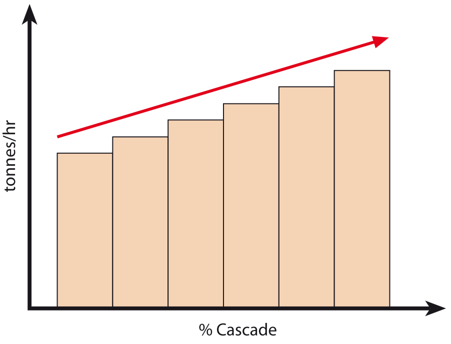
The Barmac VSI also offers advanced automation technology as a tool to maximise crusher capacity and effectiveness. The system ensures consistent and efficient operation of the Barmac VSI where correct crusher operation has the most significance – the final product and plant energy consumption. The automation system monitors and controls crusher load and cascade levels when used.

Cascade feed system

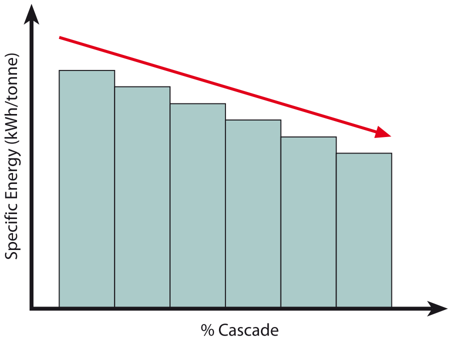
The Barmac B-Series VSI uses a unique feed system with the ability to introduce a second stream of material directly into the crushing chamber turbulence. This results in a supercharging of the particle population within the chamber, increasing the chance of rock-on-rock collision. This feature enables the operator to make optimal use of the power available and to manipulate the product grading and shape to best suit their requirements.

The primary path for feed material is through the rotor. Material is accelerated to up to 90m/s (295ft/s) before being discharged into the crushing chamber. Additionally, material may be introduced into the crushing chamber via cascade, thus bypassing the rotor. Cascading material combines with material from the rotor, forming a denser particle population, which optimises reduction. This most efficient use of the rock-on-rock crushing action leads to improved crusher efficiency and increased throughput.

Final Product (at constant power draw)

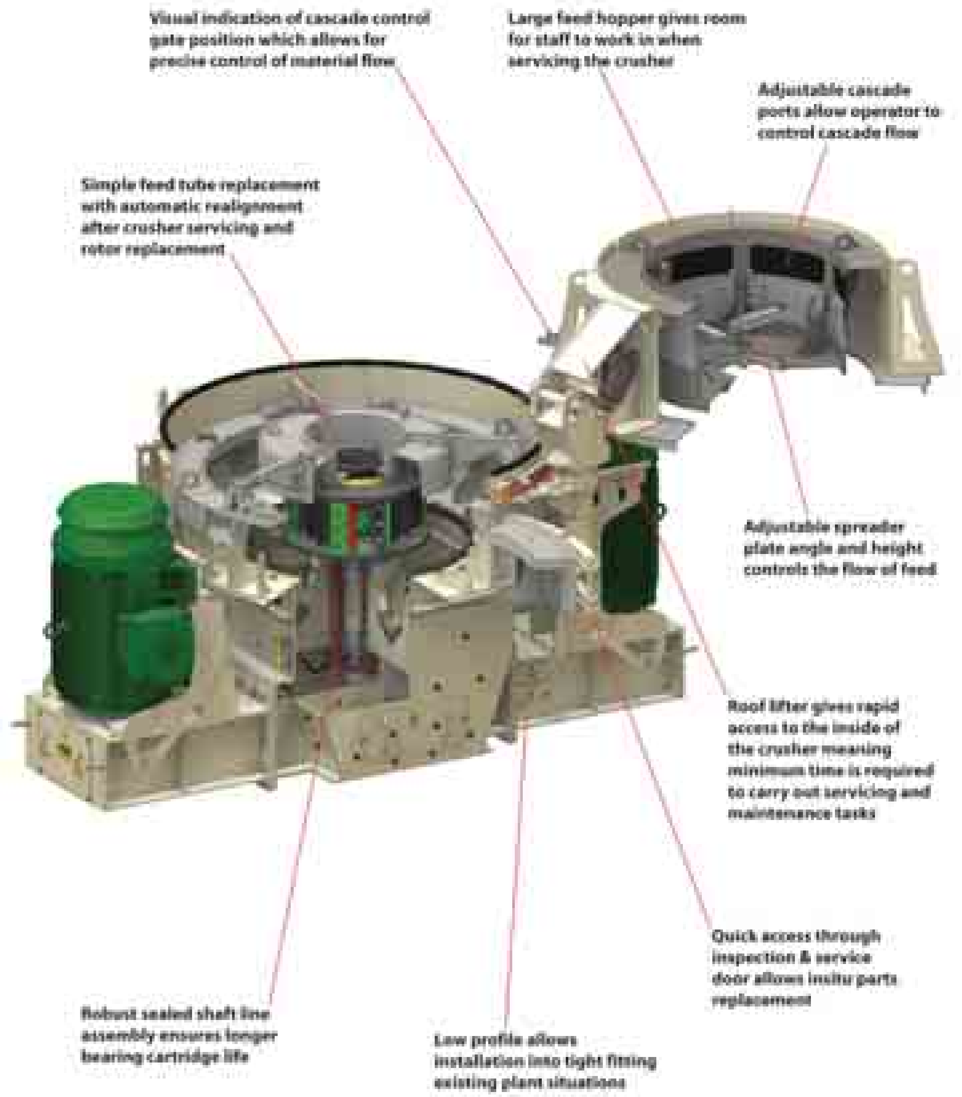


Cascade % vs. Specific Energy



These graphs are indicative examples of the effect cascade has on productivity and power consumption.

Increasing material through cascade is similar to slowing the rotor. This has the effect of changing the product curve and product shape is altered as different amounts of cascade is utilised. Up to 10% cascade can be utilised with no measurable change in product gradation or quality. That means 10% extra product for no extra power use or wear part consumption. It is important to remember that increasing the cascade percentage may affect product shape.


Visual indication of cascade control gate position which allows for precise control of material flow
Large feed hopper gives room for staff to work in when servicing the crusher
Adjustable cascade ports allow operator to control cascade flow
Simple feed tube replacement with automatic realignment after crusher servicing and rotor replacement
Adjustable spreader plate angle and height controls the flow of feed
Roof lifter gives rapid access to the inside of the crusher meaning minimum time is required to carry out servicing and maintenance tasks
Quick access through inspection & service door allows insitu parts replacement
Robust sealed shaft line assembly ensures longer bearing cartridge life
Low profile allows installation into tight fitting existing plant situations

The Complete Package – Services

Spare and wear parts wherever and whenever you need them

Metso provides a complete service support package for the Barmac VSI range. The skills and knowledge acquired from over 30 years of manufacturing, applying and servicing the Barmac VSI allow the best solutions to be given to the customer to help maximise the potential of their operation.

To ensure the best service to Barmac VSI customers, Metso provides a comprehensive product support team of dedicated professionals, based at the factory and in strategic locations around the globe.

Genuine quality

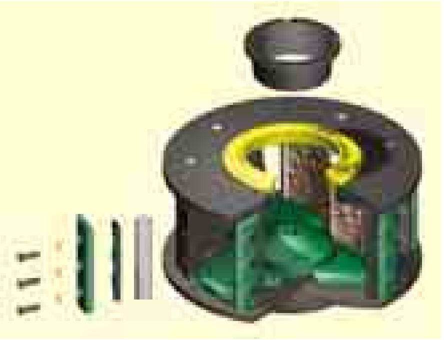
Because we have a larger installed equipment and customer base than anyone in the industry, we always carry high levels of spare and wear parts, and have more expert service personnel across the globe ready to serve you. This means when you choose a Barmac VSI you have the security of knowing that every piece of equipment is backed by unmatched parts availability and service, no matter how remote your location.

Our genuine, high quality parts give you the assurance of correct metallurgy, precise engineering and ideal suitability for trouble-free operation, so you can produce the quality products your equipment is designed to produce, providing value for you and your customers.

The heart of the Barmas VSI

The heart of the Barmac VSI is the rotor.

The development of deep rotor technology, combined with long wear life parts and segmented tip assemblies, dramatically reduces down time associated with wear parts replacement. The deep rotor is designed with serviceability and optimal rotor and wear part life in mind.



Power consumption and rotor wear are both reduced by creating more room for material to enter and pass through the rotor. Since running an AC motor at less than full load current is inefficient power savings can be made in three ways:

- Increase rotor throughput – leads to gains in product quantity.
- Increase rotor speed – leads to increased product quality.
- Install a smaller motor – provides gains in power saving.

This will give the customer:

- Lower wear costs per tonne. In some cases average wear part lives have increased by 50%. This means less maintence time and higher crusher availability.
- Lower power consumption/draw per tonne.
- Higher throughput for a given power consumption.
- Lower power consumption for a given throughput.
- Higher capacity. A denser particle population in the chamber will cause more effective reduction and improved shape.
- Improved flowability due to the higher clearance height within the rotor, especially with coarser feeds.

Deep rotor technology has increased crusher throughput, in some cases by up to 30% over standard rotors. It has also led to a reduction in downtime, service labour costs and wear costs. These lead to very real monetary advantages.

HARD Tungsten
Medium abrasion resistance.
High impact resistance.

TYPE OF HOLDER:

EXTRA HARD Tungsten
High abrasion resistance.
Medium impact resistance.

XX HARD Tungsten
Very High abrasion resistance.
Low impact resistance.

690, 760, 840, 990 Rotors

Hanger (Not available for 760 rotors)
Promotes good build-up inside the rotor. Use with dry, bony feed or when moisture in the feed tends to wash the build-up out.

RED | YELLOW

Extended Hanger
Promotes less build-up than hanger style. Silver best first selection. Repositions the tungsten insert to cope with wear on the periphery of the tip assembly. Allows the use of extra life tungsten inserts.

SILVER | WHITE

Extra Life

PURPLE | BROWN

Laminated (840 and 990 rotors only)
This tip has proved successful in extending tip life in applications where the feed material or tramp steel results in chipping of the wear resistant inserts of the standard tip options.

WHITE | BLACK

300 Rotor

Hanger
Promotes good build-up inside the rotor. Best first selection. Use with dry, bony feed or when moisture in the feed tends to wash the build-up out.

GREEN

Tile
For use in high abrasive applications. Repositions the tungstens to give improved life and protection to the periphery of the tip assembly.

YELLOW

500 Rotor

Hanger
Promotes good build-up inside the rotor. Best first selection. Use with dry, bony feed or when moisture in the feed tends to wash the build-up out.

GREEN

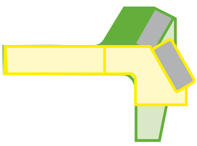
Hanger
Promotes good build-up inside the rotor. Best first selection. Use with dry, bony feed or when moisture in the feed tends to wash the build-up out. Larger Tungsten utilized

Extra Life

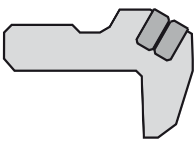
Tile
For use in high abrasive applications. Repositions the tungstens to give improved life and protection to the periphery of the tip assembly.

SILVER | WHITE

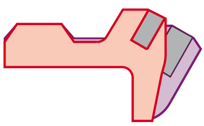
The examples below show how rotor tip shape varies, which can affect build-up in rotor



TILE (Yellow)
HANGER (Green & Orange)



LAMINATED



HANGER (Red)
EXTENDED HANGER - EXTRA LIFE
(Purple & Orange)

RPM v Rotor Speed

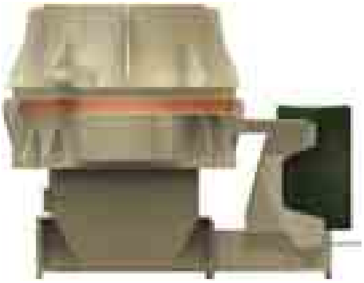
Tip Speed m/s (ft/s)	500 (20") Std Tip	500 (20") Tile Tip	690 (27")	760 (30")	840 (33")	990 (39")	1200 (48")
45 (148)	2046	1829	1535	1264	1228	1013	803
50 (164)	2274	2082	1705	1404	1364	1125	892
55 (180)	2501	2235	1876	1545	1501	1237	982
60 (197)	2728	2438	2046	1685	1637	1350	1071
65 (213)	2956	2641	2217	1826	1773	1461	1160
70 (230)	3183	2844	2387	1966	1910	1573	1249
75 (246)	3410	3048	2558	2106	2046	1685	1339

Barmac B-Series VSI Technical Specifications

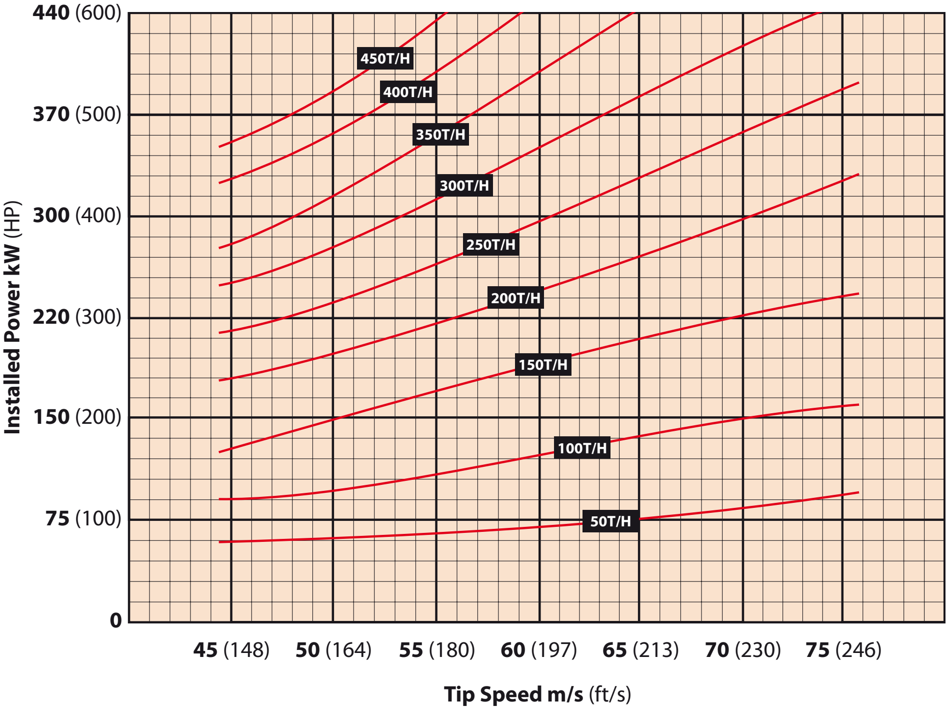
	B5100SE	B6150SE	B7150SE	B9100SE
Max. feed size* mm (inch)	30 (1⅛)	37 (1½)	57 (2¼)	64 (2½)
Max. square mesh mm (inch)	30 (1⅛)	37 (1½)	45 (1¾)	50 (2)
Rotor size mm (inch)	500 (20)	690 (27)	840 (33)	840 (33)/ 990 (39)
Installed Power kW (hp)	37 - 55 (50 -70)	75 - 132 (100 - 175)	185 - 300 (250 - 400)	370 - 600 (500 - 800)
Rotor RPM range	1500 to 3600	1500 to 2500	1100 to 2000	1000 to 1800
Throughput capacity range ** t/h	15 - 60	60-217	110 - 424	180 - 704
Typical dry weight kg (lb) (including motors)	3037	6371	12395	14357

For lbs divide by 0.45

**These figures refer to maximum particle dimension.*
***The nominal capacities shown in this table will alter with changes to the selected operating parameters of the crusher and variations in the physical characteristics of the feed material. They represent the capacity passing the crusher. In case of closed circuit, the final product capacity will depend on the sieve closing the circuit and the screening efficiency. Check with engineering for each specific case.*

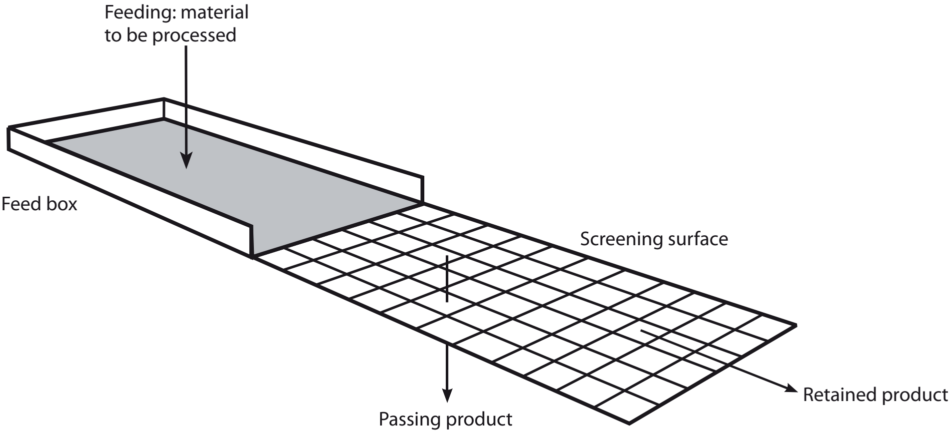


Power Requirements



For ft/s multiply by 3.28
For kW divide by 1.36

SCREENING



Screening principles for vibrating screens are basically the same for any application. Material to be screened, when launched on the feed box or directly on the screening surface, loses its vertical velocity component and is submitted to change in direction of travel. Through vibration, the bed of material tends to develop a fluid state.

Once the material is on the screening surface, two processes occur, which together make classification possible:

STRATIFICATION

This is the process whereby the large-sized particles rise to the top of the vibrating material bed due to the vibrating motion effect, while the smaller particles sift through the gaps and go to the bottom of the bed.

Interrelated factors that affect stratification are:

1. Material travel flow: a function of the material stratification, bed thickness, stroke characteristics, and screen slope
2. Stroke characteristics: amplitude, direction, rotation, type of motion, and frequency
3. Surface particle moisture – high surface moisture content makes stratification difficult

CLASSIFICATION – GENERAL CONCEPTS

SEPARATION PROBABILITY

This is the process by which the particles reach the wire mesh and are rejected if larger than the openings or, if smaller, pass through them.

The separation probability of a particle is a function of the ratio between its size and the screen opening. The larger the difference in size, the easier it is for them to pass through or to be rejected, and vice-versa.

Particles measuring $d > 1.5\ a$ (where a = mesh opening) have little relevance for the screening result. The relative presence of these influences mainly the wear and power consumption. Particles with $d < 0.5\ a$ are also of lesser importance, since they readily pass through the mesh.

Particles of $0.5\ a < d < 1.5\ a$ are called ‘critical class’ and determine both efficiency and capacity, since:

a) Particles where $0.5\ a < d < a$ quite often require several attempts before passing through the mesh

b) Particles of $a < d < 1.5\ a$ clog many openings before finally leaving the mesh as retained material

MECHANISM – CLASSIFICATION

The rate of material flow through the screen-opening surface varies according to the degree of stratification and probability.

When material is introduced at the feed end of the screening surface, the vibration causes the material stratification (see graphic below). This section is between points a and b, with maximum stratification at b. Maximum particle removal occurs from b to c (the saturation screening section), the point of highest probability, because of the high percentage of fines. The following section presents a low probability, from point c to d.

In this section, the probability of the particle passing through the opening is less because of the larger percentage of particles within the critical class.

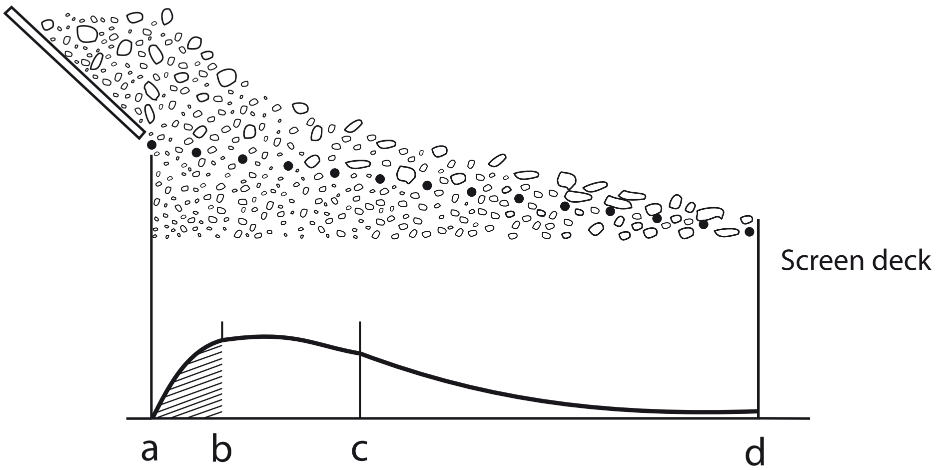
With a typical simple screen separation, as shown in the above-mentioned figure, perfect separation (100% efficiency) is not commercially feasible because from point d onward, the probability of particles passing through the opening becomes extremely low. Theoretically, for absolutely perfect separation, the screen would have to be infinitely long because the curve of the figure becomes asymptotic to the screen length axis.

In commercial terms, 'perfect screening' is normally regarded as around 90 to 95% efficiency.

'Perfect separation' is determined in lab analysis for testing periods ranging from one to three minutes. Commercially, this is equivalent to having the material travel down the length of a 30-to-60-metre-long screen while an eight-metre length is the longest single screen currently being manufactured.

CLASSIFICATION – GENERAL CONCEPTS

Feeding



a–b: stratification near the feeding end

b–c: saturated screening

c–d: separation by repeated trials

Figure: Stratification and separation on the screen: particle flow rate through the deck v. screen length

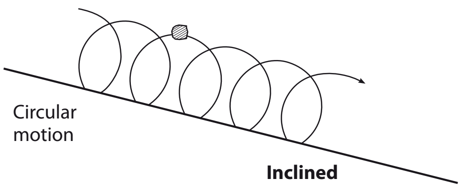
VIBRATING MOTION

Vibrating motion is generally produced by vibrating mechanisms based on eccentric masses with amplitude of 1.5 to 5 mm and operating in a range of 700 to 1000 rpm.

For good separation quality, a good ratio between amplitude and frequency is necessary. It is desirable that when the material travels on the screen it neither fall on the same opening nor jump over many openings. Therefore, the following should be kept in mind:

- Larger openings: higher amplitude – lower speed
- Smaller openings: lower amplitude – higher speed

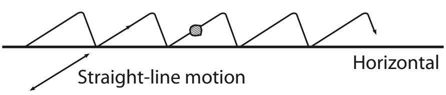
In inclined screens, the vibrating motion is circular on a vertical plane. Vibration lifts the material, producing stratification, and the particles travel on the screening surface due to the vibrating motion impulse and inclination.



CLASSIFICATION – GENERAL CONCEPTS

With horizontal screens, the motion should be capable of conveying the material without the assistance of gravity.

Straight-line motion at an angle of approximately 45 degrees to the horizontal produces a lifting component for stratification and a conveying component.



SCREENING EFFICIENCY

One of the major concerns in classification is screening efficiency. Basically, efficiency is the separation quality achieved by the screen.

A screen operating at low efficiency can cause serious problems, among which we mention:

1. Overload of the closed crushing circuit: a screen operating at low efficiency generates more re-circulating load as part of the material that should pass through the screen returns to the circuit, reducing actual crusher output and overloading belt conveyors and other auxiliary equipment.

2. Products non-compliant with specifications: a final classification screen operating at low efficiency can generate products contaminated with particles of size non-compliant with specifications.

Evaluation of screening process results is achieved by determining efficiency factors and through contamination of separated fractions.

There are two efficiencies we must take into account, depending on the product being considered:

1. EFFICIENCY OF UNDERSIZE REMOVAL

If the oversize is considered to be the product on the screen, it is desirable to have a minimum of undersize material.

The efficiency of undersize removal is given by the following formula:

$$E_1 = 100 - b \quad (1)$$

Where:

b = % of undersize present in the product

$$E_1 = \frac{\text{\% (or tph) retained in the feeding*}}{\text{\% (or tph) really retained feeding**}} \times 100 \quad (2)$$

* This value is obtained through feed analysis

** This value is obtained from oversized material on the deck

2. EFFICIENCY OF UNDERSIZE RECOVERY

If the undersize is considered to be the product of the screen, it is desirable to recover the maximum undersize material existing in the feeding. This efficiency is given by the following formula:

$$E_2 = \frac{\text{\% (or tph) of feeding really passes*}}{\text{\% (or tph) of feeding that should pass**}} \times 100 \quad (3)$$

* This value is obtained through analysis of the retained material on the screen

** This value is obtained through feed analysis

$$E_2 = \frac{100\,(a - b)}{a\,(100 - b)} \times 100 \quad (4)$$

Where:

a = % of undersize in feed as a % of feed

b = % of undersize in the over product as a % of the over

Contamination of retained product
This is obtained from the percentage of passing material in reject (acceptable normal values: 5–20%).

Contamination of passing product
This is determined from the percentage of rejected material within the passing product (acceptable normal values: 2–10%).

Examples:

Through analysis of the screen feed (100 tph) with a test screen, it is observed that 90% (or 90 tph) is smaller than 1" but only 81 tph goes through the screening media. Thus, we have the following data:

90% = undersize in feed (should have passed)
10% = oversize in feed (should be retained)
81% = actually passes
100 - 81 = 19% is actually retained
19 - 10 = 9% passing material that is 'retained', contaminating it
a = 90%
b = (9:19) x 100 = 47

Efficiencies according to the formulas presented are:

- **Efficiency of undersize removal**

By formula 1,
E_1 = 100% - 47% = 53%
By formula 2,
E_1 = (10 : 19) x 100 = 53%
Where:
10 is the % of feed that is oversize
19 is the % of feed actually retained

- **Efficiency of undersize recovery**

By formula 3,

E2 = (81:90) x 100 = 90%
81% actually passes
90% should have passed

By formula 4,

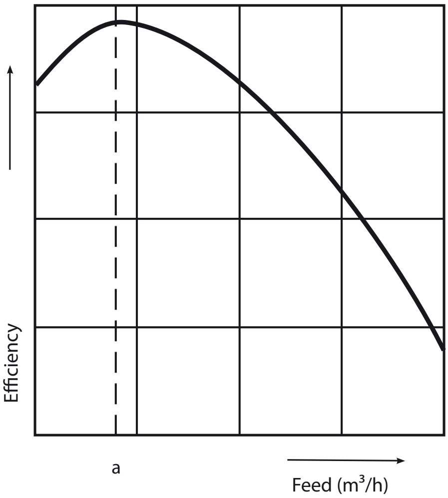
$$E_2 = \frac{100\,(90 - 47)}{90\,(100 - 47)} \times 100 = 90\%$$

Important remark

According to what we can notice from the results obtained, we can have for the same screen quite divergent efficiencies, depending on which product is considered. This is due to the characteristics of the feeding, and in most cases it does not indicate inefficient screen performance. In case oversize or passing material in the feed is less than 20%, the values calculated for efficiency of 'passing' material removal or recovery efficiency of the same do not always reflect actual efficiency. This is due to the fact that even for small amounts 'passing', material that is retained on the screen interferes significantly with efficiency. It is recommendable in these cases to increase the screen area by about 20% in relation to the calculated area.

EFFICIENCY X FEED RATE

For a given set of screen and material features, the efficiency fundamentally depends on feed rate, as shown by the chart below (efficiency here is referred to as the efficiency of undersize recovery).



For low feed rates, to the left of point ”a”, the actual efficiency increases with increased feed. The oversize (material larger than screen opening) bed on marginal-size particles prevents excessive jumping, increasing the number of attempted passes and also forcing these particles through the screening media.
Beyond point a, the efficiency rapidly decreases with increased feed rate, as the screen lacks the capacity to separate all the undersize material contained in the feed.

Note: In inefficient screening conditions, stratification should be inspected, as the artifices of counterflow rotation, amplitude, and frequency reduction, aiming at a longer stay of the material on the screen, can generate too thick a material bed over the screen, thus making efficiency even lower.

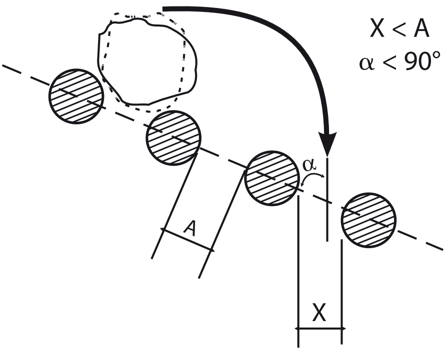
It is not possible to determine a fixed value for the efficiency. A final classification screen, operating to give products that are within strict specifications, should work with an efficiency of 90% or more. However, in the same plant, 60–70% efficiency might be sufficient for intermediate classification. In most cases, efficiencies in the 90 to 95% range can be considered commercially perfect.

CHOICE OF MESH OPENING RELATED TO THE DESIRED SEPARATION SIZE

The vibrating screen function consists in separating materials into size fractions, avoiding the excessive contamination of one fraction with particles belonging to another.

The product sizes thus obtained are measured in laboratory screens where the screening media are oriented horizontally and very long screening time warrants the passage of all particles with dimensions below those of the mesh opening used.

The actual separation process in vibrating screens differs from the laboratory equipment performance. The screen slope and the particle trajectory travel reduce the projection (X) of the free passing area (A) according to this figure:



Consequently, the passing particles are slightly smaller than the mesh opening itself.

Also, the thickness and material of the separating media influence the passing material size.

In order to obtain well-defined separation, the mesh opening must always be slightly larger than the specified separation size.

In summary, we have the following definitions:

Product size – the lab screen mesh opening through which the tested material passes

Equivalent opening – vibrating screen-opening mesh that achieves a specified product size

Equivalent opening > product size
For practical reasons, it is considered acceptable that a product contain 3 to 5% material with dimensions slightly greater than those for the specified size, and this is taken into account in vibrating screen capacity determination factors.

For example, if we wish to obtain a 20-mm product, the screen opening mesh has to be larger and the product will contain 3% particles of slightly larger than 20 mm.

On the other hand, if we decide to use an opening mesh equal to the desired size, 20 mm, the passing material should be contamination-free; however, what is retained will be highly contaminated with fines and never reach an acceptable efficiency.

The reason for this phenomenon is that actually we reduce the product size, and the efficiency should be measured in relation to the smaller separation size.

Aiming to facilitate a correct choice of vibrating screen mesh opening for obtaining desirable products, we can use the next table.

APPROXIMATE RELATIONSHIP BETWEEN PRODUCT SIZE AND SCREEN MESH OPENING

Product size measured in lab	Type of screening media and opening shape			
	Wire / square hole	Wire / rectangular opening (1/3)	Plastic, rubber, steel plate / square hole	Plastic, rubber, steel plate / rectangular opening (1/3)
mm	mm	mm	mm	mm
2	3	1,5 x 5	4,5	2 x 6
3	4	2 x 6	6	2,5 x 8
4	5	3 x 9	7	4 x 12
5	6,5	4 x 12	8,5	5 x 15
6	8	5 x 15	9,5	6 x 18
8	10	6 x 18	12	8 x 24
10	12,5	8 x 24	14,5	10 x 30
12	15	9,4 x 30	17	12 x 36
14	17	11 x 33	19	14 x 42
16	19	12 x 36	21,5	16,5 x 50
18	21	13,5 x 40	23,5	18,5 x 58
20	23	15 x 45	25,5	21 x 60
22	25	16,5 x 50	27	22 x 65
24	27	18 x 54	31	24 x 70
26	30	19,5 x 60	34	26 x 75
28	32,5	21 x 63	36,5	28 x 85
30	35	22,5 x 70	39	31 x 90
32	37		41	
34	40		44	
36	42		48	
40	46		50	
44	51		55	
48	56		59	
52	60		65	
56	65		70	
60	70		75	
64	75		80	
68	80		85	
72	84		90	
76	88		94	
80	94		100	
84	98		105	
88	103		110	
92	107		115	
100	117		125	

For inch divide by 25.4

RECOMMENDED WIRES AND FREE OPENING OF MEDIA (METRIC)

Mesh	Light type			Standard type			Heavy type		
	Wire	Screening media weight kg/m³	Free opening %	Wire	Screening media weight kg/m³	Free opening %	Wire	Screening media weight kg/m³	Free opening %
3	1,2	4,4	51	1,6	7,1	43	1,8	8,6	39
4	1,6	5,8	51	2,0	8,5	44	2,5	12,2	38
5	2,0	7,3	51	2,5	10,6	44	3,0	14,3	39
6	2,0	6,4	56	2,5	9,3	50	3,0	12,7	44
8	2,0	5,1	64	2,5	7,6	58	3,0	10,4	53
10	3,0	8,8	59	3,5	11,5	55	4,0	14,5	51
12	2,5	5,5	69	3,0	7,6	64	4,0	12,7	56
14	2,5	4,8	72	3,5	8,9	64	4,5	13,9	57
16	3,0	6,0	71	4,0	10,2	64	5,0	15,1	58
19	4,0	8,8	68	5,0	13,2	63	6,0	18,3	58
22	4,0	7,8	72	5,0	11,8	66	6,0	16,3	62
25	4,0	7,1	74	5,0	11,0	70	6,0	14,8	65
28	5,0	9,5	72	6,0	13,3	68	8,0	22,1	60
32	5,0	8,6	75	6,0	12,0	71	8,0	20,5	64
36	5,0	7,7	77	6,0	10,7	73	8,0	18,2	67
40	6,0	9,8	76	8,0	16,6	70	10,0	25,9	64
45	6,0	8,9	78	8,0	15,0	72	10,0	23,4	67
50	6,0	8,0	80	8,0	14,2	74	10,0	20,9	70
56	8,0	12,6	77	10,0	19,7	72	12,0	26,6	68
63	8,0	11,9	79	10,0	17,3	75	12,0	24,9	71
71	10,0	16,0	77	12,0	23,1	73	15,0	33,3	68

RECOMMENDED WIRES AND FREE OPENING OF MEDIA (IMPERIAL)

Mesh (in)	Light type			Standard type			Heavy type		
	Wire (in)	Screening media weight kg/m³	Free opening %	Wire (in)	Screening media weight kg/m³	Free opening %	Wire (in)	Screening media weight kg/m³	Free opening %
1/8	0,054	6,0	45	0,072	8,9	40	0,092	15,1	29
3/16	0,080	7,6	51	0,092	10,2	45	0,120	16	38
1/4	0,105	9,8	49	0,120	13,1	46	0,135	16,4	40
5/16	0,120	11,4	52	0,135	13,5	49	0,148	16,4	46
3/8	0,135	12,5	53	0,148	14,0	51	0,162	15,8	47
7/16	0,148	13,2	55	0,162	14,6	53	0,177	17,8	50
1/2	0,162	13,9	57	01,77	15,4	54	0,192	18,6	52
5/8	0,177	12,5	62	0,192	14,8	58	0,225	20	56
3/4	0,192	13,2	64	0,207	14,7	61	0,250	26	56
7/8	0,207	13,0	65	0,225	15,3	63	0,250	18,6	59
1	0,225	14,8	66	0,250	16,4	64	0,3125	26,5	57
1 1/8	0,225	13,6	69	0,250	14,9	67	0,3125	24	61
1 1/4	0,250	13,4	70	0,3125	20,5	64	0,375	30	60
1 3/8	0,250	12,6	72	0,3125	18,9	66	0,375	29	62
1 1/2	0,250	12,0	73	0,3125	17,6	68	0,375	28	63
1 3/4	0,3125	16,7	73	0,375	21,6	68	0,4375	28	64
2	0,3125	15,2	74	0,375	18,8	70	0,4375	25	67
2 1/4	0,375	17,5	74	0,4375	23,2	70	0,500	28	68
2 1/2	0,375	16,8	76	0,4375	21,2	72	0,500	27	70
2 3/4	0,375	16,8	78	0,4375	19,5	74	0,500	24	72
3	0,4375	20	76	0,500	23,2	73	0,625	33	68

COMPARATIVE TABLE OF STANDARD SCREENS

Openings, in mm	ASTM / ASA / USS	TYLER / MESH	ABNT - EB - 22 - R
101,6	4"	—	—
88,96	3 1/2"	—	—
76,2	3"	—	76
63,5	2 1/2"	—	—
50,8	2"	—	50
44,4	1 3/4"	—	—
38,1	1 1/2"	—	38
31,7	1 1/4"	—	—
25,4	1"	—	25
19,1	3/4"	—	19
15,9	5/8"	—	—
12,7	1/2"	—	—
9,52	3/8"	—	9,5
7,93	5/16"	—	—
6,35	1/4"	—	—
5,66	3,5	3,5	—
4,76	4	4	4,8
4,00	5	5	—
3,36	6	6	—
2,83	7	7	—
2,38	8	8	2,4
2,00	10	9	2
1,68	12	10	—
1,41	14	12	—
1,19	16	14	1,2
1,00	18	16	—
0,84	20	20	—
0,71	25	24	—
0,59	30	28	0,6
0,50	35	32	—
0,42	40	35	0,42
0,35	45	42	—
0,297	50	48	0,30
0,250	60	60	—
0,210	70	65	—
0,177	80	80	—
0,149	100	100	0,15
0,125	120	115	—
0,105	140	150	—
0,088	170	170	—
0,074	200	200	0,075
0,062	230	250	—
0,053	270	270	—
0,044	325	325	—
0,037	400	400	—

Basics of Screen Selection and Influencing Performance

Screens play a very important role in crushing circuits, with several functions within the process, mainly depending on which part of the process they occupy. The screening functions, basic requirements and the most common screen types in the crushing process are:

Scalping
- Normally before entry into the primary crusher in order for material smaller than the setting to be bypassed
- No requirements for screening efficiency
- Grizzly feeders or inclined screens (primary version)

Screening on a closed circuit with a crusher
- No difficult efficiency requirements, except 2-stage plants, where the same screen is used for product screening
- Process balancing
- Inclined or horizontal screens

Product screening
- Tough efficiency requirements, measured in terms of the share of undersized/oversized material in a product
- Mainly double and triple slope or horizontal screens

Screens also play an important role in improving end product quality, such as

Screening out waste material, which can be done in different stages
- Before entry into the primary crusher in order to extract the waste from feed material
- After exiting the primary crusher, in order to remove flaky product from primary
- After exiting the secondary crusher, to remove flaky product from secondary

Process balancing with a screen
- Defining the right feed material for fine crushers

Crushing in a closed circuit
- More support material in the crusher chamber to improve the shape
- Possibility to crush a share of finished products, for example 20-30% of 11-16 and 16-22 mm

The major screening parameters affecting screen performance are:
- Feed characteristics and environmental factors.
- Characteristics of screen and
- Characteristics of screening element (screen mesh)

Characteristics of screen parameters:

Stroke length and material amplitude height

Together, the stroke length, rotation speed, stroke angle and screen inclination form parameters which affect the operation of the screen. These fundamental factors must be in proportion to each other.

Stroke length and material amplitude have an effect on:

- How the feeder material starts to separate in the feed box and on the screen element. The separation and blending of the material bed are effective with a long stroke.

- How the holes of the element stay unblocked. If the stroke length is too small the material amplitude also remains too small and the element becomes blocked. This problem arises when the hole size is large (50 mm or more).

In practice, the stroke used in a horizontal screen is 7 - 20 mm. A small stroke can be used when screening with a small hole size. Because of mixing and separation, a large stroke is recommended.

The stroke is defined by the swinging mass and flywheel movement of the vibration unit. The rotation speed has no visible effect on the stroke.

Rotation speed and acceleration

- The acceleration of the screen box can be calculated based on the stroke and rotation speed. When the stroke angle and inclination are included in the calculation, the vertical acceleration can be found. Vertical acceleration has an effect on the screening efficiency and rate of travel.

- The acceleration should be 4.5-5.5 x G (G=9.81 m/s^2) using horizontal screens to achieve a good screening result. To avoid structural damage to the screening unit, no acceleration greater than 6-7 times G is allowed.

Stroke angle

The stroke angle has an effect on the material amplitude and rate of travel. The most suitable stroke angle for horizontal screens is 55-60 degrees. Too upright a position can reduce the rate of travel. A horizontal stroke angle can improve the rate of travel but reduces screening efficiency. It also increases the wear rate of the mesh.

Surface inclination

Speed of travel can be increased by inclining the screening surface. If the surface is greatly inclined, the stroke must be short to prevent material sliding over the mesh too quickly. The inclination of the surface can keep the mesh holes open more easily.

Speed of travel

Speed of travel has an effect on screening efficiency and capacity. Increasing the speed of travel can lower the bed of material and improve the screening efficiency.

Length and width of the screen

The phases of screening are:
– Stratification of the feedplate
– Extraction of fines at the beginning of the screening surface
– Separation of the wanted fraction at the end of the surface

The bed of material may not exceed a height of more than 3-5 times the size of the mesh hole on the discharge side of the screening surface. A higher bed of material will reduce the screening efficiency. The feeding capacity for each mesh size depends on the width of the screen. For efficient screening results, the depth of the material bed must be at least 2 times the mesh hole diameter on the end side of the surface. Then, the oversize volume will determine the width of the screen.

The depth of the material bed should be within allowable limits at the beginning and end of the surface when choosing the screen. The screening area is not the only dominant parameter in screen selection. In practice, the length is 2-3 times the width.

Deck factor

A deck factor should be used when calculating lower decks in multideck screens. In lower decks, the feed drops not only at the beginning of the deck, but also later in the direction of the flow. That is why material close to separation size will not be screened out.

Effective screening area

The effective screening area is the area on which material can drop down through the surface. This effective surface area is about 0.7-0.9 times the whole area. The whole area is determined by the inside parameters of the screening unit: length times width.

The impact of different parameters can be summarized as shown in the following table. This table is indicative only and is based on standard parameters under normal operating conditions.

Effect on...	Screening efficiency			Feeding capacity	Cloth efficiency of Plugging	Cloth efficiency of Sticking
Parameter:	Fine mesh	Medium mesh	Coarse mesh			
Rotation speed increased	++	++	+	+	+	++
Stroke lenght increased	-	+	++	++	++	+
Stroke angle increased	+	+	+	-	+	+
Inclination increased	-	-	-	++	++	0

++ Very favorable effect
\+ Favorable effect
\- Unfavorable effect
No remarkable effect

Characteristics of Screen Mesh

The selection of a screen mesh is based on several factors. The following table summarizes the basic suitability of different screen cloths in some major applications.

Screening Application	Wire Cloth	Punch plate	Urethane	High Durometer Rubber	Low Durometer Rubber
Primary Scalping (dry)	Fair	Good-Excellent	Not Recommended	Excellent	Not Recommended
Primary Scalping (wet)	Fair	Good	Good-Excellent	Good-Excellent	Not Recommended
Secondary (dry)	Fair-Good	Good-Excellent	Fair-Good	Excellent	Excellent
Secondary (wet)	Fair-Good	Fair-Good	Excellent	Good-Excellent	Good
Tertiary (dry)	Good	Fair-Good	Good	Good-Excellent	Excellent
Tertiary (wet)	Good	Good	Excellent	Good-Excellent	Good-Excellent
De-Watering	Fair	Fair	Excellent	Not Recommended	Fair
Fine (4-8 mm)	Excellent	NR	Good-Excellent	Not Recommended	Fair

Screening Media

Legend	
Excellent	+++++
Not so convenient	+

		Tensione Media				
		Metallic			Synthetic	
		Woven Wire	Zig Zag	Harp	Rubber	PU
Cost		+++++	+++	++++	++	++
Material Abrasivity	low	++++	++++	++++	+	+
	medium	++	++	++	++	++
	high	+	+	+	++++	++++
Max feed size		150 mm	Case by Case	Case by Case	200 mm	150 mm
Mas aperture size		80 mm	20 mm	40 mm	80 mm	80 mm
Open area		+++	+++	++++	++	++
Against Pegging		+	+++	To remove flat particle	++	++
Against clogging		+	+++	++++	++	++
Precise separation		++++	++++	+	+++	++++
Noise level reduction		+	+	+	++++	++++
Comments			Fine and dry screening, recommended for split < 6 mm, and necessar for split < 3mm	Difficult screening of material with clay, mud, etc.		Recommended for wet screening

SELECTION AND DIMENSIONING

NECESSARY DATA

a) Features of material to be screened:
- Density
- Maximum feed size
- Product granulometry
- Particle shape
- Moisture content
- Presence or lack of clayey material
- Temperature etc.

b) Capacity

c) Product separation ranges

d) Desired efficiency

e) Type of job:
- Washing
- Final classification
- Intermediate classification etc.

f) Existence or not of room and weight limitations

g) Degree of knowledge of the material and desired product

SCREEN SELECTION

Screens are selected, basically, according to the feed properties and type of job.

DIMENSIONING

Selection of the screen size is based on screening area and screen width.

The screen width, in its turn, is calculated to achieve a bed thickness on the screen compatible with the screen mesh used.

SCREEN AREA CALCULATION

The screening area is given by the following formula:

$$\text{Area} = \frac{Q_u \cdot S}{Q_{spec}} \ [m^2]$$

Where **Qu** is the amount [t/h] of undersize particles in the feed.

Q_{spec} = specific screening capacity

S = safety factor between 1-1.4 and depending on how well the screening material is known.

In mining plants where material data, screen opening size, and capacity are well-known and trustworthy, S a factor of 1 can be adopted.

$$Q_{spec} = A \cdot B \cdot C \cdot D \cdot E \cdot F \cdot G \cdot H \cdot I \cdot J \cdot K \cdot L$$

Where:

A = basic capacity for required separation in metric tons per hour per square meter of screen area. Diagram on coming pages.

B = factor for oversize fractions. See diagram on coming pages.

C = factor related to the percentage of material in the feed smaller than half of the required separation size. See diagram on coming pages.

D = deck position

Deck position	1	2	3	4
D	1	0,9	0,8	0,7

E = wet screening

Separation [mm]	1 - 6	6 - 12	12 - 25	26 - 40	41 - 50	51 - 75	+75
E	1.4	1.3	1.25	1.2	1.15	1.1	1

F = material weight

F is applicable for 0 –based gradings.

Solid density [t/m³]	1.35	2.7	5.4
F	0.5	1	2

G = surface open area

$$G = \frac{\text{Actual open area [\%]}}{50\%}$$

H = shape of surface opening

Opening	Round	Square	Rectangular
H	0.9	1	1.05

I = particle shape

Shape	Rounded	Cubical	Flaky
I	1.2	1	0.9

J = efficiency

Efficiency [%]	70	75	80	85	90	92	94	96
J	1.4	1.25	1.1	1.05	1	0.98	0.95	0.9

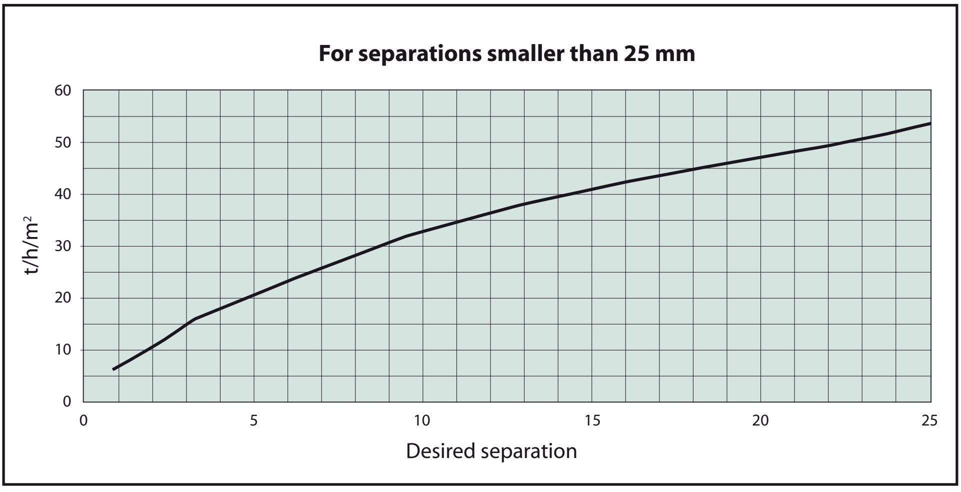
K = screen type

	Horizontal		Inclined			Multislope			
Deck	Straight	Straight	Straight	Straight	Straight	Multis-lope	Triple slope	Dual slope	Dual slope
Vibration	Linear	Constant elliptical	Circular	Variable elliptical	Linear	Linear	Variable elliptical	Linear	Variable elliptical
K	0.9	1.1	1	1.1	1	1.3	1.4	1.1	1.3

L = moisture

Moisture [%]	- 3	3 – 5	6 – 8
L	1	0.85	0.7

SPECIFIC SCREENING THROUGHPUT CAPACITY (A)



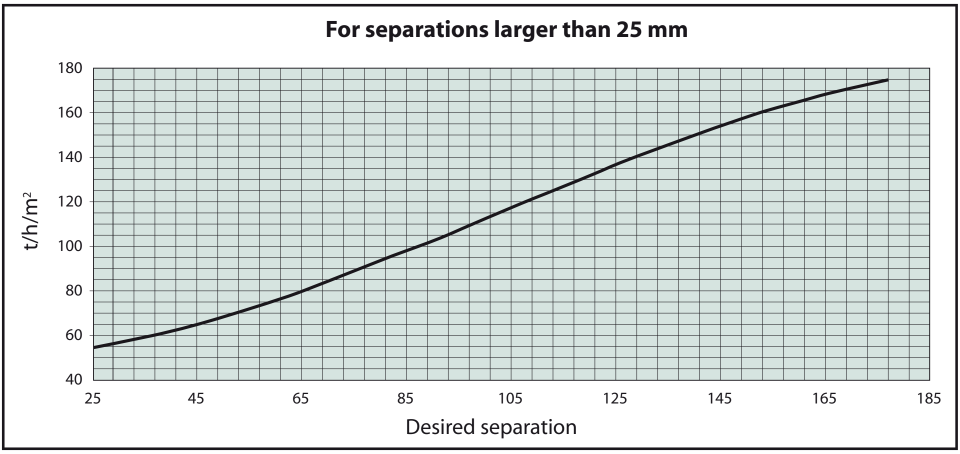


CHART C – RETAINED MATERIAL FACTOR (B)

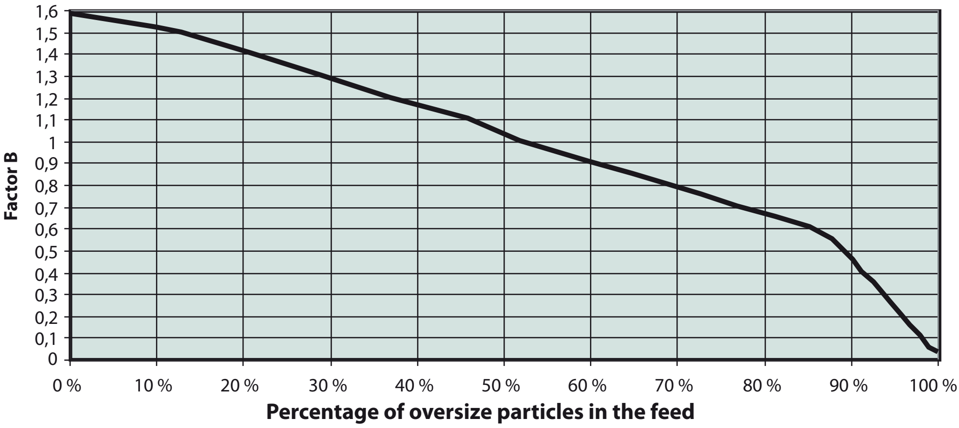
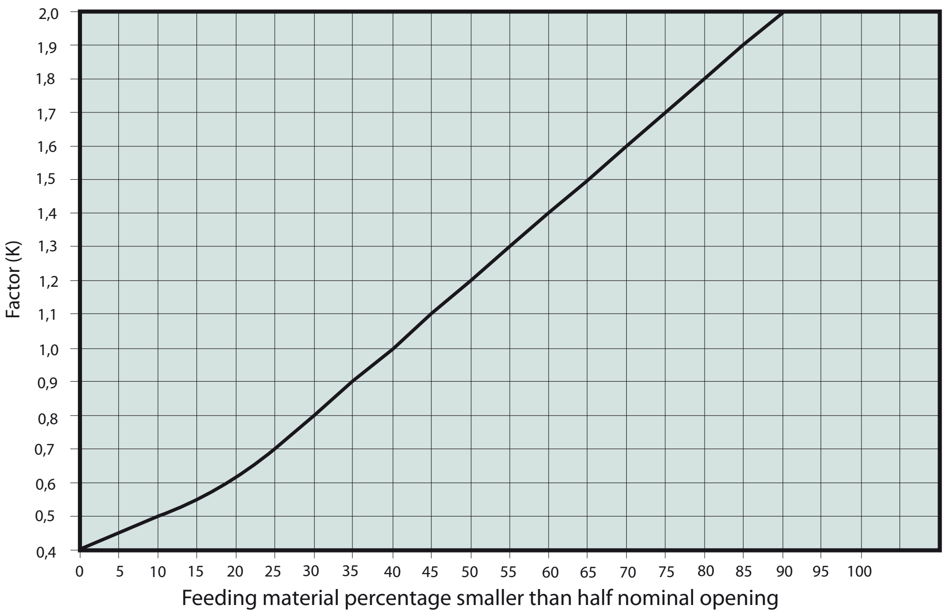


CHART D – HALF SIZE FACTOR (C)



Remark: In the calculation methodology presented, a 90% classification efficiency and a 5% product contamination level were assumed.

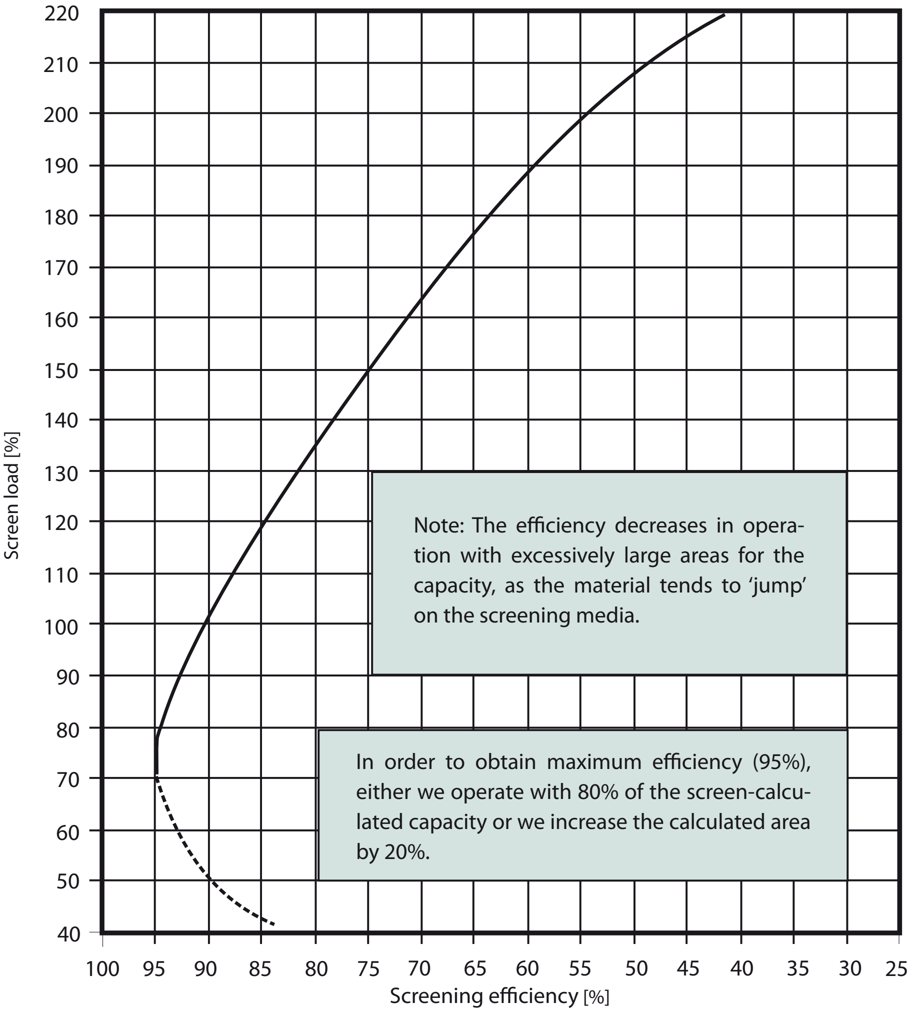
The interpretation of these figures is the following:

90% of passing material smaller than the separation size passed through the screen.

As the screen opening mesh is always larger than the product's desired size, it will always be contaminated with 5% of larger particles.

If the desired efficiency is different from these assumed values, the screen capacity may be altered according to the indications of the chart below. This can works also as reversed.

EFFECT OF THE LOADING ON THE EFFICIENCY



Once the necessary active screening surface is calculated, the next stage consists of choosing the equipment size.

As Metso screen dimensions are indicated in feet (1 ft = 304 mm), in order to facilitate the choice, the table below indicates the deck active areas for each machine.

Model	Active area (m^2)	Width (m)	Length (m)
4 x 10	3,24	1,2	3
4 x 12	3,9	1,2	3,6
5 x 12	5	1,5	3,6
5 x 14	5,83	1,5	4,2
6 x 16	8,2	1,8	4,9
7 x 20	11,9	2,15	6,1
8 x 16	11	2,45	4,9
8 x 20	13,8	2,45	6,1
8 x 24	16,5	2,45	7,3
10 x 20	17,4	3,05	6,1
10 x 24	21	3,05	7,3

For FT multiply by 3.3
For FT^2 multiply by 10.7

DEFINITION OF THE MINIMUM SCREEN WIDTH

An efficient separation process requires adjustment of screening area and transported material layer thickness for the capacity handled.

The calculation previously presented defines the screening area in m^2; however, this can be distributed in several rectangular shapes.

For example, a 10-m^2 screen can be formed by 2 x 5 or 2.5 x 4 rectangles. Apparently, a longer machine should offer a higher efficiency, but the performance may be affected by the material's exaggerated layer thickness.

The general formula for the screen width is:

$$B = \frac{Q}{3.6 \cdot v \cdot d} + 0.15 \text{ (m)}$$

Or, for a specific width, the layer thickness in mm:

$$d = \frac{Q}{3.6 \cdot v \cdot (B - 0.15)} \text{ (mm)}$$

Where:

d = material layer thickness (mm)

Q = capacity in m^3/h (divide capacity in tons/h by the material's apparent density in tons/m^3)

v = material transport speed (m/s)

B = nominal screen width (m)

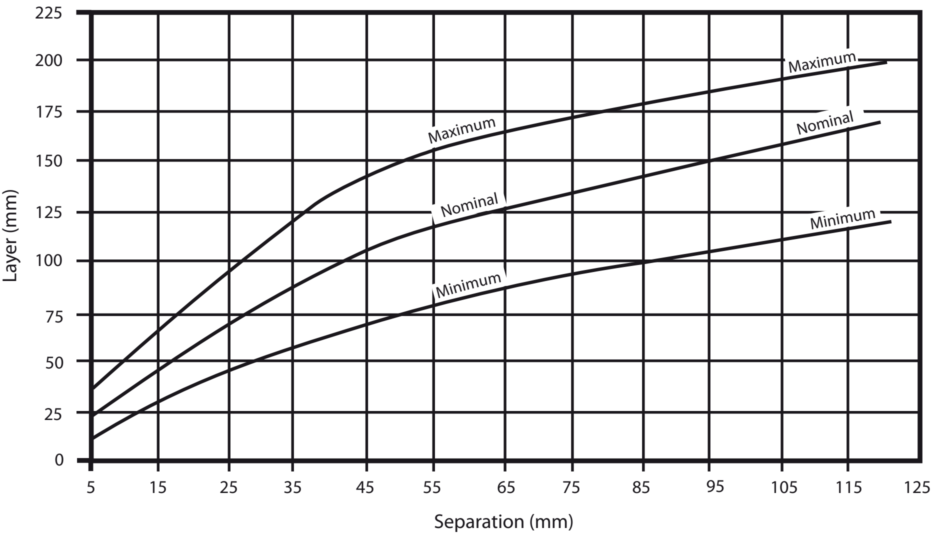
Calculation must be done for all decks at the screen's beginning as well as at the final end.

MATERIAL TRANSPORT SPEED

Screen type	Speed, in m/min
Horizontal screen, linear motion	12 – 15
Inclined screen at 20 degrees, circular motion (coarse classification)	30 – 35
Inclined screen at 20 degrees, circular motion (final classification)	25 – 30
CBS banana screen of variable slope, circular motion	Initial: 45; end: 25
Banana screen of high slope, circular motion	Initial: 60; end: 20–30
F screen – for fines of high frequency, linear motion	9 – 10

For FT/min multiply by 3.3

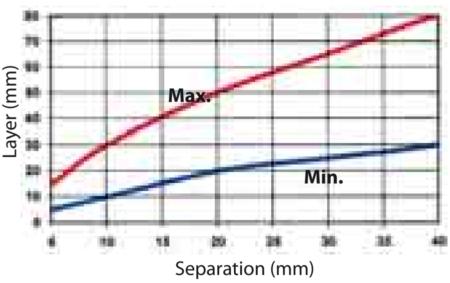
RECOMMENDED FEED LAYER THICKNESS IN THE FIRST DECK



For inches divide by 25.4

In order to guarantee the separation efficiency of the material layer at the discharge, one of the decks must be within the following limits:

Recommended layer thickness at the deck exit



If the value is lower than the recommended minimum, we should reduce the screen width, even exceeding the recommended value of the feed layer. If the value is higher, the screen width should be increased.

The rule presented may be difficult to follow for multi-decks, as, in order to maintain a load of material higher than minimum, in all decks, it is not always possible; however, it is recommended that at least in the most critical deck, the rule be obeyed.

EXAMPLE OF SCREEN SELECTION AND DIMENSIONING

It is desired to select a screen for the following application:

Data:

a) Feed = 380 tons/h
b) Material features

- Feed granulometry

Wire mesh (mm)	100	25	13	10	5
% passing	100	75	45	30	22

- Solid density: 2.7 t/m^3
- Maximum feed size: 100 mm
- Moisture content: 3%
- Particle shape: Flaky

c) Dry screening process
d) No room limitations
e) Desired products: larger than 25 mm, between 10 and 25 mm, and smaller than 10 mm

Screen selection

75% of passing material in the first deck. Passing material percentage through the second deck (10 mm) is related to its loading and is 30/75 x 100 = 40%.

As the passing percentage for both decks is high, it is recommended to use the MF multislope screen.

The Flaky material shape leads to the choice of a square-opening screen.

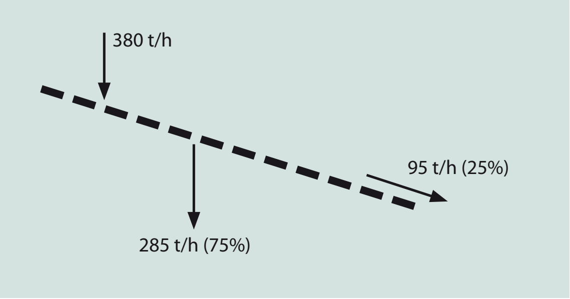
We assume the use of rubber screening media.

Dimensioning

Feed: 380 t/h

First deck: separation of 25 mm

Flowchart:



To obtain 25-mm separation, the square opening in rubber screen mesh must be 33 mm. Open area of rubber screen with 33 mm opening is 43%.

$$\textbf{Area} = \frac{\mathbf{Q_u \cdot S}}{\mathbf{Q_{spec}}}$$

$\mathbf{Q_u}$ = 380 t/h x 0,75 = 285 t/h
S = 1
$\mathbf{Q_{spec}}$ = A x B x C x D x E x F x G x L x I x J x K x L (page **4**-14)
A = 53 (chart B for 25 mm separation)
B = 1,35 (chart C for 25 % oversize)
C = 1,1 (chart D for 45 % halfsize)
D = 1 (first deck)
E = 1 (dry screening)
F = 1 (2,7 t/m³)

$$\mathbf{G} = \frac{43\%}{50\%} = 0{,}86$$

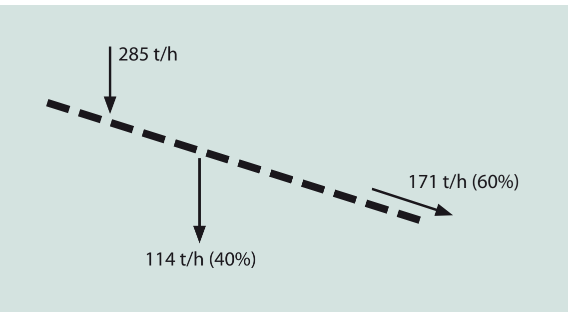
L = 1 (square opening)
I = 0,9 (Flaky)
J = 1 (assumed 90% efficiency)
K = 1,3 (MF screen)
L = 1 (3% moisture)

$$\textbf{Area} = \frac{\mathbf{285 \cdot I}}{\mathbf{79{,}2}} = \mathbf{3{,}6\ m^2}$$

Second deck: separation of 10 mm

The procedure is analogous to the preceding calculations, considering that the feed is the passing material from the upper deck.

Flowchart:



For obtaining 10-mm separation using a rubber screen with a square opening, the dimension should be 14.5 mm.

Second deck

Q_u = 114 t/h
S = 1
A = 33
B = 0,9 (60 % oversize)
C = 0,79 (29 % halfsize)
D = 0,9 (second deck)
E = 1
F = 1

$$\mathbf{G} = \frac{36\%}{50\%} = 0{,}72$$

H = 1 (square opening)
I = 0,9
J = 1,0
K = 1,3
L = 1

$$\textbf{Area} = \frac{\mathbf{114 \cdot 1}}{\mathbf{17{,}8}} = \mathbf{6{,}40\ m^2}$$

The MF 1800 x 6100 DD screen with 11 m² active area, meets the capacity requirements.

The next step is the verification of material layer thickness, well as at the discharge of both decks.

The general formula for layer thickness is:

$$\mathbf{d} = \frac{\mathbf{Q_{discharge} \cdot 1000}}{\mathbf{\rho_s \cdot B \cdot v \cdot 3600}} = \mathbf{(mm)}$$

Where:
$Q_{discharge}$ = transported capacity (t/h)
v = material travel speed (m/s)
B = screen width (m)
ρ_s = material bulk density (t/m³)

Data and calculation results for this case are shown in the table below, which also contains the transport speeds.

Deck	Capacity (t/h)	Transport speed (m/s)	Calculated layer (mm)	Recommended max. layer 4 x separation size
One-deck – discharge	95	0,6	15	100
Two-deck – discharge	171	0,6	26	40

The values determined comply with the requirements, thus confirming the choice of screen size.

Identify the duty

Fine tune the selection with expected working conditions.

sD

Standard Duty

Ideal for low abrasion index material (0 to 800 gr/ton) and classical working conditions. From 1 to 2 shifts per day.
Construction

HD

Heavy Duty

Hard working conditions with high abrasion index material (800 to 2000 gr/ton); from 1 to 3 shifts per day.
Mining & ConstructionXHD

XHD

Extra Heavy Duty

Extreme working conditions (24/7) with high abrasion index material. (More than 2000 gr/ton.)
Mining

OPTI-FLO™										
Products	Primary feeding 1	Grizzly scalping 2	Primary screening 3	Technical final sizing 4	Washing screen 5	Dewatering screen 6	SAG discharge screening 7	Ball mill sizing 8	Drain & rinse screening 9	Trash & carbon recovery screening 10
Banana screens										
DF				X						
DF-P			X							
DS				X						
TS				X	X					
MF			X	X	X			X	X	
Inclined screens										
CVB				X	X					
CVB-P			X	X	X					
RF				X	X					
RF-P			X	X	X					
Horizontal screens										
FS				X	X					
LH				X	X	X	X	X	X	X
Feeders and Grizzly's										
LH.G	X	X								
TK	X	X								
PF	X									
VF	X									
VG		X								
HRBM	X									

Identify the process type

After having chosen the category and duty, the third step is to select the range and suitable machine from the following tables. Then you'll find detailed descriptions for each product.

Product comparison

	Machine specification			Installation		Maintenance		Performance		
Products	Duty	Deck design	Motion	Easy installation	Low dynamic loads	Easy screening media & liners replacement	Machinery service	Capacity	Efficiency	Energy saving
Banana screens										
DF	sD	Curved	Linear	+++	++	++	+	+	++	+++
DF-P	sD	Curved	Linear	+++	++	++	+	++	+	++
DS	sD-HD	Curved	Elliptical	+	++	++	+++	++	++	+++
TS	sD-HD	Curved	Elliptical	+	++	+++	+++	+++	+++	+++
MF	HD-XHD	Curved	Linear	+	+++	+++	+++	+++	+++	+
Inclined screens										
CVB	sD-HD	Inclined	Circular	++	+++	++	++	++	++	++
CVB-P	sD-HD	Inclined	Circular	++	+++	++	++	++	++	++
RF	HD-XHD	Inclined	Circular	++	++	++	+	+++	++	++
RF-P	HD-XHD	Inclined	Circular	++	++	++	+	+++	++	++
Horizontal screens										
FS	sD-HD	Horizontal	Elliptical	+++	+	++	+	++	+++	+
LH	HD-XHD	Horizontal	Linear	++	+++	+++	+++	+++	++	+
Feeders and Grizzly's										
LH.G	HD-XHD	Flat	Linear	++	+++	+++	+++	+++	++	+
TK	sD-HD	Flat	Linear	++	++	+	+++	+	++	++
PF	sD-HD	Flat	Linear	++	++	+	++	++	+++	++
VF	sD-HD	Flat	Linear	++	++	+	++	++	++	++
VG	sD-HD	Flat	Linear	++	++	+	++	+++	+++	++
HRBM	HD-XHD	Flat	Linear*	++	+++	+	+	+++	+++	+

SEPARATION PROCESS EXCELLENCE

Excellence – a new measure of efficiency

The concept of efficiency is usually associated with the idea of maximum performance, closeness to perfection, and achievement of limits, among other factors. Efficiency is commonly a value compared to an ideal and not necessarily an attainable value.

Where the screening classification operation is concerned, it is rather vague, and it is even difficult to choose a precise definition for the efficiency concept. The ideal goal, or the perfect performance, is difficult to establish and quantify.

Whenever we wish to separate bulk material, which is theoretically made of distributed particles in a continuous way (containing all possible particle dimensions within a certain range), the first problem is to set the cutting reference – that is, the nominal cutting value.

As an illustrative example, let us assume the manufacture of a part containing machined components, since this is a common situation in our business sector. The machined dimensions are normally indicated by a nominal measure and a tolerance margin. As the word 'tolerance' indicates, we accept variation within certain spans. This is due to the impossibility of attaining the nominal value with zero deviation. When we manufacture a part whose nominal dimensions and corresponding tolerances are known, we can measure it at the end of the process and decide whether or not it meets specifications. If we try to proceed otherwise, as, for example, trying to produce a drawing from dimensions taken from a finished part, we face many difficulties in establishing the nominal value and the accepted tolerances for each of these measurements.

Whenever we analyse the result of a screening operation – and in this example we will restrict this operation to a single deck or a single screen – we verify that the passing material presents a specific granulometric distribution that has a minimum size equal to the minimum for the feed material and a maximum value near (but not equal to) the opening size of the screen utilised. Similarly, the retained material also presents a granulometric distribution with a maximum size equal to the feeding and a minimum size lower than the screen opening size.

When we wish to separate a material into two fractions, we normally adopt a screen with an opening equal to or around the measurement of the desired size, and we carry on with the process. The important issues that arise are: Have we obtained the desired separation? How do we check it? How are we to evaluate the performance? If we change the screen type or the opening, how should we compare the results?

It is reasonable to state that we always know the screen opening size in the screening operation from which we collect the fractions under study; however, let us assume that this information is not available. Under these circumstances, we may ask: Which is the effective classification value for this particular material? What is the cutting value for this screen?

Metso proposes for these issues the adoption of a new parameter, named EXCELLENCE.

We introduce this new definition in order to promote separation efficiency evaluation that is more objective than are the traditional measurements regarding over and undersizes.

The ideal separation process should divide the feeding material into two fractions, of different sizes, as shown in Chart I.

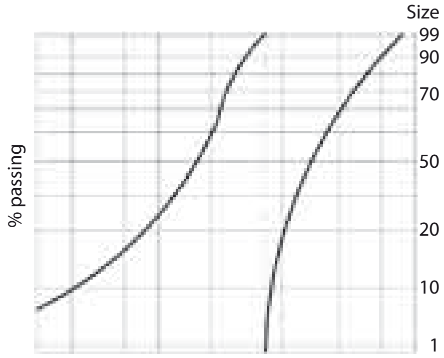


Chart I

However, in practice, it is always the case that some particle quantities of the same size range are included in the retained and/or the passing material, giving rise to an overlap of the two curves.

As we have already mentioned, among the classic definitions, both the separation size and the efficiency can have several interpretations.

In Chart II, which represents the actual granulometric distributions of the passing and retained material, we can state that the classification is made at 8 mm, with 80% efficiency in relation to the undersize (80% passing < 8 mm) and 100% efficiency in relation to oversize (100% of retained material > 8 mm).

We can also state that the separation is made at 12 mm, with 100% efficiency in relation to undersize and 75% in relation to oversize.

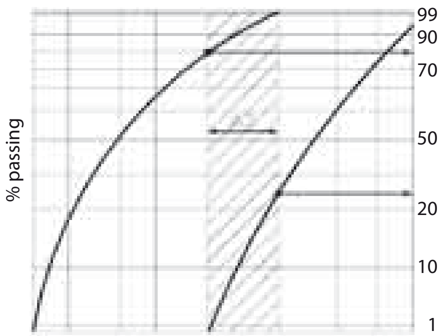


Chart II

Depending on our choice, we can define any size between 8 and 12 mm as the cutting point, with the corresponding classification efficiency, but this will always be a subjective evaluation.

What really describes the separation quality is the overlap between the passing and retained material curves. If there is no overlap, ideal excellence is attained.

The proposed formula to measure excellence is the following:

E = 1 - x [1 - ΔD / (D + d)]

Where:
D = dimension corresponding to 99% passing (99% undersize is < D)

d = dimension that corresponds to 99% of the retained material (99% of oversize is > d)

Δ = (D - d), the extension of the overlap zone

An efficient separation process should keep the excellence at levels ranging from 80 to 90%.

The use of thick rubber and polyurethane screening media with rectangular or slotted openings implies excellence values lower than those obtainable with wire steel mesh.

Some of these excellence features or properties are that:
– Excellence can be expressed as % and has a similar meaning to efficiency.

– The lower the span value – i.e., the closer the values of d and D are – the higher the excellence will be, meaning that the separation was more accurate or less scattered.

– If some conditions of a particular screening plant are changed, such as the screen type (perforated plate, steel wire, rubber, polyurethane, etc.) or the opening type (round, square, rectangular, etc.), the new excellence value enables evaluating whether there has been an improvement or not from previous results.

– The average separation value (d + D)/2 is indicative of the effective separation or cutting size.

– As the variation span ΔD increases, the average separation value (separation size) deviates more from the opening screen size, increasing the oversize content in the passing and the undersize in the retained, indicating the existence of more contaminants in both fractions.

TRELLEX SYNTHETIC SCREENING MEDIA

Trellex Modular Screening Solutions

Trellex Modular Screening Solutions has now been developed and supplemented to suit practically all screens with mounting both along the length and across the width.

Unique step function. More efficient!

Trellex Modular Screening Solutions has a step function which gives increased, more efficient production.

The Trellex Modular Screening Solutions is available in rubber and polyurethane to optimize both wear resistance and performance. The following product ranges are available:

Trellex 300/305 LS is compatible with the most common support frames on the market. With upgrade strips, screen decks can be arranged Stepped or Flat.

Trellex 300 LS

System for longitudinal attachment where distance between girders in the screen is 300mm. Typical module lengths are 500mm or 610mm (2′) that can be arranged flat or stepped. Upgrade strips are available to fit directly onto support frames adapted for competitor solutions.

Trellex 305 LS

System for longitudinal attachment where distance between girders in the screen is 305mm (1′). Typical module 610mm (2′) that can be arranged flat or stepped. Upgrade strips are available to fit directly onto support frames adapted for competitor solutions such as angle bars and pipe-top stringers.

Trellex 300 TS is available in rubber, poly-urethane or with wire cloth insert.

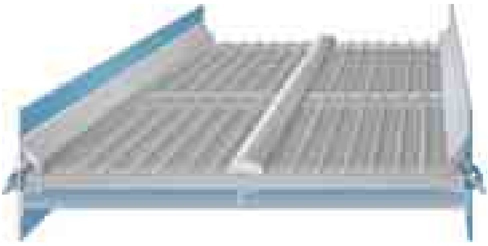
Trellex 300 TS

Known also as Trellstep/Stepflex. Designed for transversal attachment with snap-on and step configuration. Module dimension 300x600mm.

Trellex Rubber Panel System

Trellex PCO

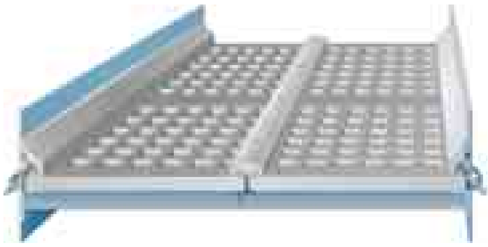
Used mainly in the separation of coarse material. An integral steel and cord reinforcement is vulcanized within each panel. The moulded apertures are available in a wide range. Aperture shape is designed to minimize the risk of pegging and maximize the through-put. The thickest panels also have rider bars on the upper surface to increase life in coarse applications.



Trellex PCO

Trellex PSS

Self-supporting screening medium (similar to PCO) with heavy-duty steel reinforcement, mainly for coarse screening. It is manufactured in a range of standard thicknesses with practically any aperture size and type. Since the self-supporting panels do not need longitudinal supports, the screening area can be fully utilized. The same fastening devices, center hold down and side hold down can be used on both PSS and PCO panels.

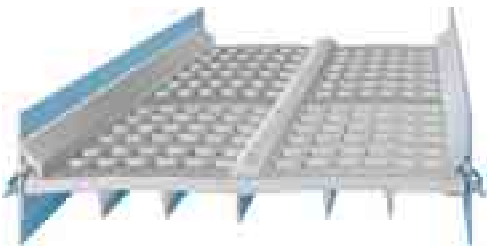


Trellex PSS

Trellex PUS

Used in coarse and intermediate screening, but can also be used for separations down to 15 mm. It is therefore a very versatile and useful screening medium designed for screens with support frames for side-tensioning. The panels are held in place by the same type of attachment as used for PCO and PSS without tensioning.

Available in a wide range of thicknesses and a large range of aperture types and sizes. A very wide range of applications – a favorite in the aggregate industry.



Trellex PUS

Trellex tensioned rubber screen cloths for fine and medium material

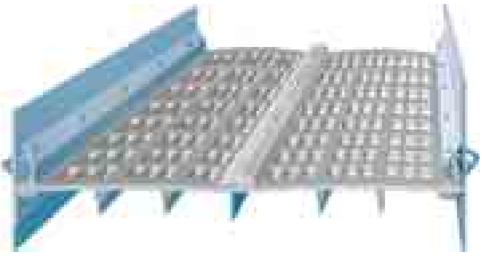
Trellex TCO

Trellex TCO is manufactured with easy handling tension hooks and is installed similarly to woven wire cloth, and can be installed either in transversal or longitudinal tensioning. It was developed mainly for 4 to 100 mm final separations. Longlife thanks to the reinforcements of pre-stretched cords and Trellex T60 rubber.

For screen widths in excess of 1200 mm center hold-downs should be used. These rubber screening media are normally used in thicknesses of 5 to 35 mm. The Trellex TCO is always supplied with the required tensioning hooks.

Advantages

- Tailor made with tension hooks adequate to your screen
- Wide range of thickness to handle up to 250 mm feed size
- Less down time, reducing maintenance costs
- Adequate for application in quarries, gravel pits, mining and metallurgical plants
- Made of T60 Trellex rubber wear resistant, developed for applications in the mineral processing industries
- Wide accessory line available, such as, rubber center hold-downs and crown bar channel rubber.



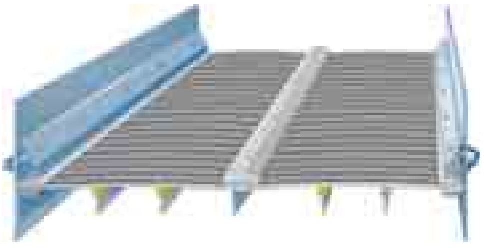
Trellex TCO

Trellex offers different hook types for both side and longitudinal tensioned cloths

Trellex NH element (centre hold down) to be used if screen cloth is wider than 1200 mm (4').

Self-cleaning Screening Media for Fines and Sticky Material

A complete system distinctively designed for fine screening of materials that tend to cause conventional wire cloth to blind over. The secret of TFX is its thin and flexible rubber cloth, similar to a membrane, supported and reinforced by rubber profiles, which achieves separations with high accuracy. The highly flexible membrane counteracts blinding.



Trellex TFX

Trellex TFX

The best solution for solving blinding problems. Available in various thicknesses with molded or punched apertures. TFX is installed on screens with longitudinal support, and can be installed on both transversal and longitudinal tensioning. It has light tension hooks that can be directly installed on the screen. Requires no deck modification for its installation.

Trellex offers different hook types for both side and longitudinal tensioned cloths

Total Package Concept

TFX is offered as a complete system, including rubber panel, tension hooks, special capping strips and center hold-downs (if necessary).

New Capping Strip Enhances Performance and Boosts Lifetime

TFX performance has been elevated with the addition of new polyurethane capping. The capping holds the cloth in place and eliminates unwanted motions that can cause wear on the cloth. This results in an impressive improvement in product longevity. The capping lifts the panel from the supports and unpunched areas over the supports are thus not required. This results in more open area on the screen deck.

Trellex TFX maximizes stratification

Trellex TFX with flexible rubber avoids aperture blockage

Trellex NH element (centre hold down) to be used if screen cloth is wider than 1200 mm (4').

Trellex Polyurethane Panels

Trellex PUS PU and Trellex TCO PU are manufactured with highly wear resistant polyurethane and are available in a range of types and hardness grades for different applications, all with tailor made steel reinforcements.

They fit all vibrating screens in the same manner as conventional rubber screen panels; no modification on the support frame is needed. The configuration of each panel can be manufactured to suit your needs. Apertures are either slotted or square. Precision molded apertures ensure consistently accurate sizing and are mainly used for medium to fine screening. Our ability to provide a variety of premium polyurethane compounds and our large expertise allow us to recommend the ideal product for your specific screening application.

Trellex TCO PU

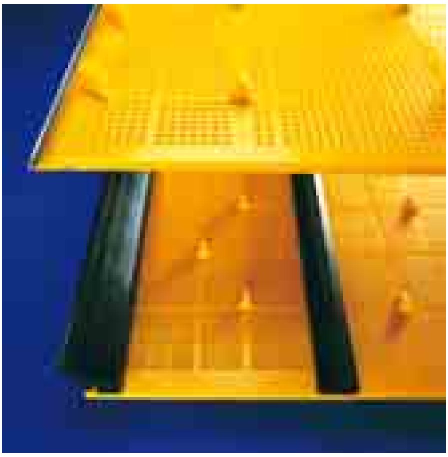
Tensioned exactly as a wire mesh panel since it is reinforced by steel cables and the elongation is practically zero. A wide range of standard side hooks is available to suit your requirements.

Trellex PUS PU

Can be fastened in various ways by special side hold downs, wedge systems or bolted to the support frame. Trellex PUS PU achieved special success in the trommel screen application area.

Advantages

- Increased longevity
- Reduced noise emission
- Good self-cleaning properties
- Exact sizing
- Fits every screen without modification



Trellex TCO PU and Trellex PUS PU.

Trellex Dust Control

Dust emission in the environment is an acknowledged hazard to health. It accelerates wear on machinery and equipment, as well as corrosion. It makes maintenance and repair more difficult and more time consuming.

Metso supplies standardized solutions for dust control of screens, feeders, chutes and other equipment that handle dust. The elasticity of Trellex rubber enables it to be resistant to vibration and allows sealing to virtually any type of equipment.

The combination of Trellex dust sealing rubber and standard metallic profiles, STMs, enables construction of easily and efficient opened inspection covers and ensures a long service life for the dust-sealing system.

Unique Features

A Trellex dust-sealing system gives you virtually total encapsulation, provides almost total effectiveness and is the closest you can come to a 100% dust-sealed operation.

With simple, standardized components, Trellex dust sealing system can be tailored to your equipment at an optimum cost/benefit ratio, and you can seal a combination of machines, such as screens, crushers, etc.

As additional advantage, the Trellex dust-sealing systems achieve substantial noise reduction.

Simple and Cost Effective Solution

Several decades ago, Metso began delivering dust-sealing systems that achieve dramatic improvements to equipment handling dust. These systems are mainly based on three types of components:

- Trellex dust-sealing cloth and fabric
- Rubber grip strips
- STM steel profiles

The drawings next page show how a typical screen can be totally encapsulated with a Trellex dust sealing system, which effectively prevents dust from escaping out into the environment and into the drive mechanism and the motor.

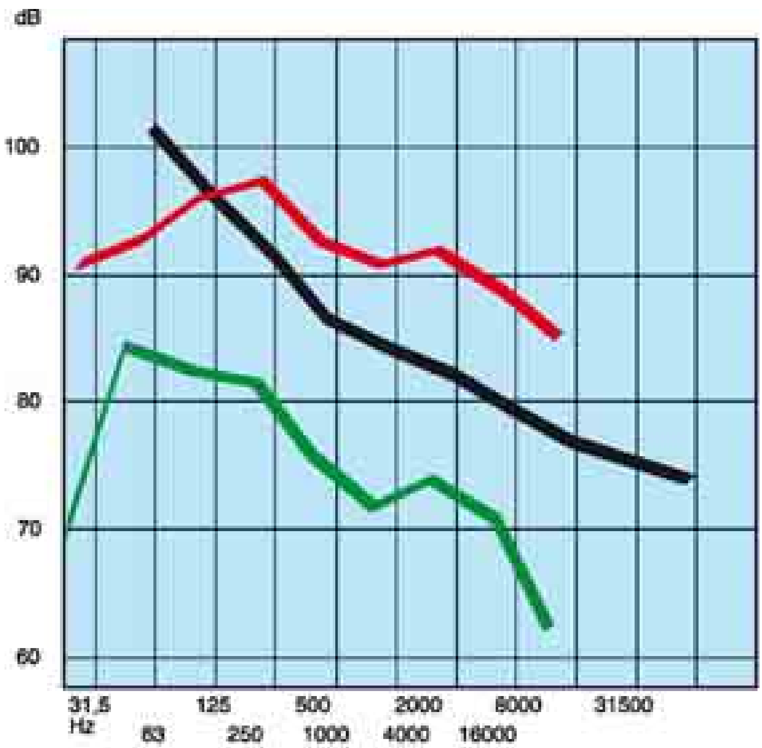
When the screening elements have to be replaced, the lightweight inspection covers and part of the top frame can be easily removed.

In principle, the seals are mounted around the space where the dust arises. STMs are used to simplify positioning of the rubber and the grip strips. The rubber cloth or fabric is clamped in place by the grip strips to form an enclosure.

No Need to Extract Dust

A quarry (capacity 600 ton/hr) with a very high content of silica in its rock, reduced the need for extract air from 530 thousand m^3/hr to 35 thousand m^3/hr, the dust content from 25 mg/m^3 to 0.5 mg/m^3 and the noise level from 95dB to 76 dB using Trellex dust seals, screening media and chute linings.

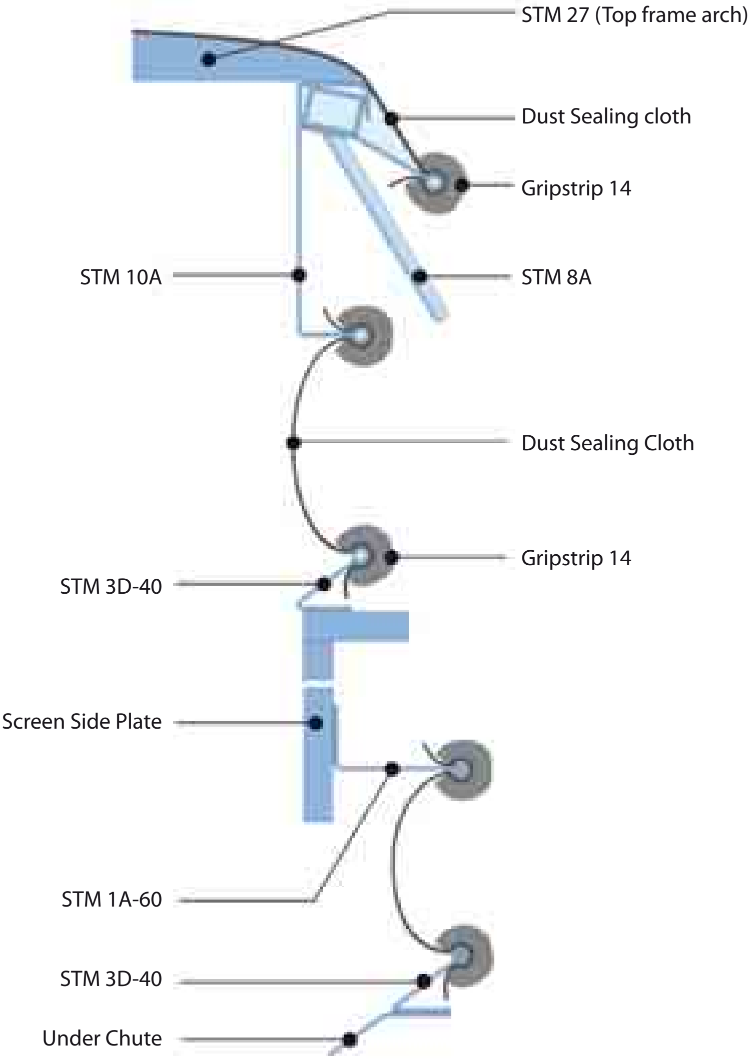
Considerable noise reduction



Green = Noise levels with Trellex dust sealing system and synthetic screening elements

Red = No dust seals and wire mesh

Black = Permissible noise levels



Section (typical) of dust sealed screen

Trellex Dust Control - Example of the top canopy construction with arches

There are several ways to assemble a dust control system. Depending on the conditions, the profi les can easily be adapted for every type of screen. Above a so called "French solution".

WASHING PROCESS

The ever-growing need for obtaining a clean product, in aggregate production for civil construction and its intensive wet process use in mining, justifies the great importance placed on washing equipment and processes in crushing and screening plants.

The purposes of washing are:

- Removal of undesirable material: clay, soft stone, roots, etc.
- Classification
- Dewatering

Washing is usually accomplished through the following processes:

- Coarse material – direct washing on vibrating screens or scrubbers, when clay content is very high or its plasticity is high
- Materials extremely difficult to disaggregate – may be treated in log washers before screening
- Fine materials – in screw washers

WASHING ON-SCREEN

Washing on-screen is used to remove undesirable material, mostly clay and extremely fine particles. It is also employed for the classification of fines and/or moist materials whose screening is very difficult without washing.

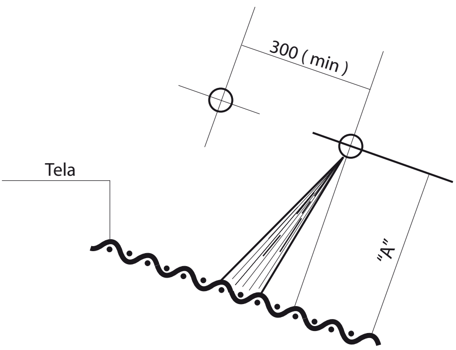
Washing is performed by applying water jets through spray nozzles directed as a water curtain and under pressure at the material being classified, aiming to remove the impure particles adhering to the material.

The nozzles are installed in metallic pipes placed cross-sectionally in relation to the material flow.

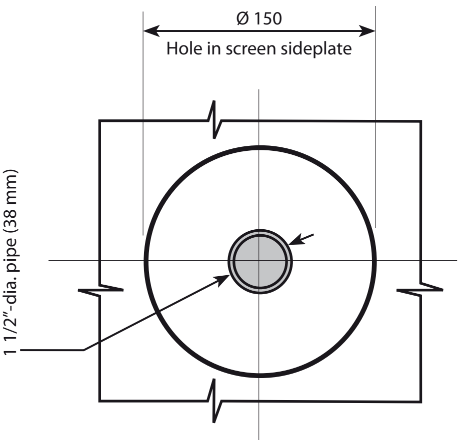
For recovering fines (smaller than 3/8"), dewatering screens, screw washers, or spiral classifiers, one may use cyclones, filters, collectors, thickeners, and so on.

Data for washing on-screen

- Water pressure at nozzle: 1 to 3 atm
- Water volume: 1 to 3 times the volume of screened material, being: a) 0.5 to 1.5 times for relatively clean material and b) 1 to 3 times for material with clay or very fine content
- Piping arrangement in the screen: the pipes must be distributed in quantities that are approximately equal for each deck and placed in such a way that the first pipe of a deck is placed after the last pipe of the previous deck; the positioning should follow a typical arrangement as shown in the figure below:
- In relation to the screening media, the pipes should be positioned as shown below:



'A' recommended for pipes = 350 mm
'A' minimum = 200 mm



WASHING SYSTEM DESCRIPTION

The washing system is a set of metallic pipes 1 1/2" in diameter (minimum), sealed at one end, with special nozzles installed every 300 mm, on average, to create a continuous water curtain. Each pipe should be connected to a flexible hose and to a common pipe, through an individual valve for each pipe.

The pipe flow rate capacity will depend on the spray nozzle type and quantity installed in each pipe.

For the Trellex Trellspray nozzle type, there are four sizes. What varies among them is the water passage hole diameter and the pressure applied – and, therefore, the unitary flow rate, expressed in litres per minute. For this, see the corresponding curves on chart page 4-38.

SPRAYS

The Trellex Trellspray nozzles have a good performance under high or low water pressures in the range of 0.3 to 3.0 bar (4 to 40 PSI). The nozzles give a sharply defined, fan-shaped water jet providing efficient material washing. They are also ideal for dust control applications.

Manufactured from polyurethane, they are economical and are abrasion- and corrosion-resistant. They are available in four-hole diameters that, in order to facilitate identification, follow a colour scheme: green for 5 mm, blue for 7 mm, yellow for 9 mm, and red for 11 mm. Due to their shape, they are known as duck beak.

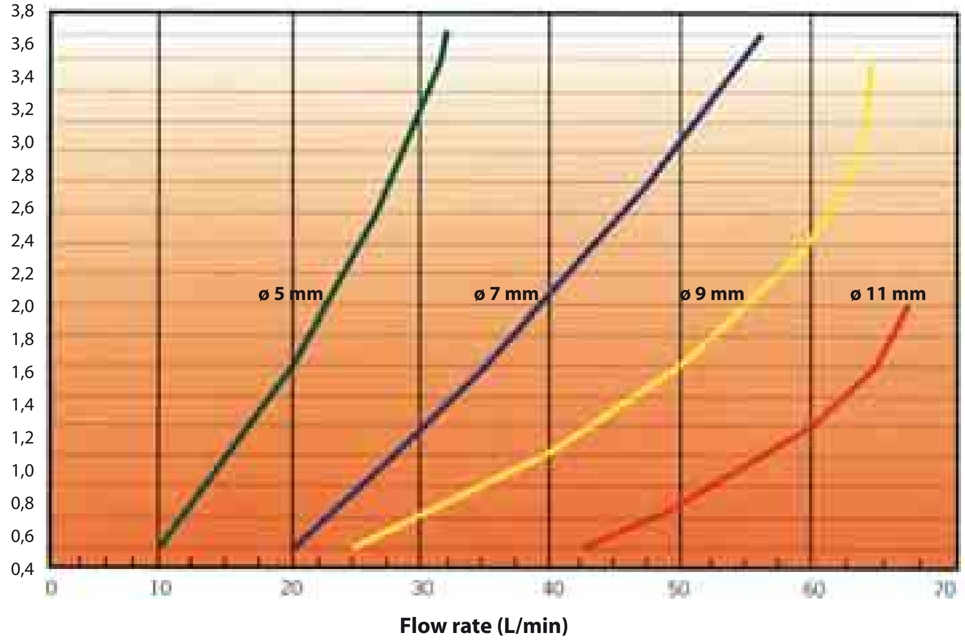
The standard screw measurement for fitting of the Trellspray nozzle to the pipe is 19 mm (3/4") BSP.

Jet width (mm)									
Vertical distance between nozzle and screen media (mm)	Nozzle hole ø	5 mm		7 mm		9 mm		11 mm	
	bar	1,5	2,5	1,5	2,5	1,5	2,5	1,5	2,5
200		600	700	600	800	600	800	600	800
300	mm	750	850	800	1000	600	800	600	800
400		900	1000	1000	1200	1000	1200	1000	1200

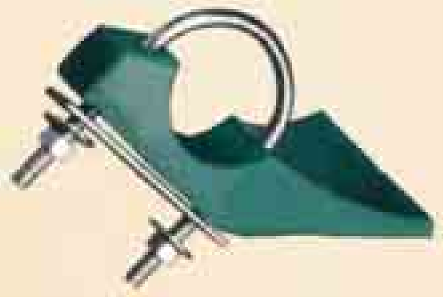
For inch divide by 25.4

Water pressure 0.5 bar

Water pressure 2.5 bar

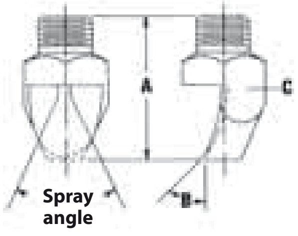


Also on the market is the spray nozzle known as beaver-tail type, using a bracket in the pipe fitting. Such a fitting has proved to be tougher and practical during erection, as it does not require pipe-fitting welding.



STAINLESS STEEL SPRAY NOZZLES

Also available are spray nozzles manufactured of stainless steel that provide a standard fan-shaped jet with high impact and small spraying angles.



DIMENSIONS

Spray angle at 3 bar	NPT or BSPT (M) nozzle inlet fitting 1/8	1/4	3/8	1/2	3/4	Capacity	Nominal hole diameter (mm)	Flow rate (litres per minute) 1 bar	2 bar	3 bar	4 bar	5 bar	6 bar	7 bar	10 bar	Spray angle 1 bar	3 bar	7 bar	Dimensions A: mm	B: deflection angle	C: bar size (square metres)	Net weight (kg)
50°		●				**5010**	2.0	2.3	3.2	3.9	4.6	5.1	5.6	6.0	7.2	34°	50°	60°	31	60°	15.9	0.03
		●	●			**5025**	2.8	5.7	8.1	9.9	11.4	12.7	14.0	15.1	18.0	42°	50°	59°	41.5	42°	19.1	0.09
		●	●			**5040**	3.6	9.1	12.9	15.8	18.2	20	22	24	29	39°	50°	60°	47	45°	19.1	0.09
			●			**5060**	4.8	13.7	19.3	24	27	31	33	36	43	42°	50°	53°	55	37°	25.4	0.14
			●			**50100**	6.0	23	32	39	46	51	56	60	72	43°	50°	55°	72	40°	31.8	0.33
			●			**50125**	6.7	28	40	49	57	64	70	75	90	38°	50°	59°	72	38°	31.8	0.31
			●			**50160**	7.5	36	52	63	73	82	89	96	115	44°	50°	55°	72	37°	31.8	0.31
			●			**50200**	8.3	46	64	79	91	102	112	121	144	46°	50°	53°	72	32°	31.8	0.31
40°			●			**4040**	3.6	9.1	12.9	15.8	18.2	20	22	24	29	31°	40°	50°	60.5	35°	22.2	0.14
			●			**4050**	4.0	11.4	16.1	19.7	23	25	28	30	36	31°	40°	49°	63.5	33°	25.4	0.20
			●			**4060**	4.4	13.7	19.3	24	27	31	33	36	43	32°	40°	49°	72	33°	25.4	0.23
			●			**4070**	5.2	16.0	23	28	32	36	39	42	50	32°	40°	49°	75.5	29°	25.4	0.26
			●			**4080**	5.2	18.2	26	32	36	41	45	48	58	32°	40°	48°	77	26°	25.4	0.26
			●			**4090**	5.6	21	29	36	41	46	50	54	65	34°	40°	44°	77	28°	25.4	0.23
			●			**40100**	6.0	23	32	39	46	51	56	60	72	35°	40°	44°	86.5	28°	25.4	0.26
35°	●					**3504**	1.2	0.91	1.3	1.6	1.8	2.0	2.2	2.4	2.9	20°	35°	41°	23	40°	11.1	0.01
		●				**3510**	2.0	2.3	3.2	3.9	4.6	5.1	5.6	6.0	7.2	18°	35°	39°	36.5	36°	15.9	0.06
		●	●			**3520**	2.8	4.6	6.4	7.9	9.1	10.2	11.2	12.1	14.4	24°	35°	40°	42	30°	19.1	0.06
			●			**3525**	2.8	5.7	8.1	9.9	11.4	12.7	14.0	15.1	18.0	24°	35°	39°	49	28°	19.1	0.09
			●			**3530**	3.2	6.8	9.7	11.8	13.7	15.3	16.7	18.1	22	26°	35°	41°	52.5	28°	19.1	0.09
			●			**3540**	3.6	9.1	12.9	15.8	18.2	20	22	24	29	28°	35°	38°	58	26°	22.2	0.11
			●			**3550**	4.0	11.4	16.1	19.7	23	25	28	30	36	31°	35°	38°	63.5	23°	22.2	0.14
				●		**3560**	4.4	13.7	19.3	24	27	31	33	36	43	29°	35°	39°	73	27°	25.4	0.23
				●		**3580**	5.2	18.2	26	32	36	41	45	48	58	26°	35°	40°	81	24°	25.4	0.26
				●		**35100**	6.0	23	32	39	46	51	56	60	72	26°	35°	40°	89	19°	25.4	0.26
					●	**35160**	7.5	36	52	63	73	82	89	96	115	26°	35°	40°	114	23°	31.8	0.57
					●	**35200**	8.3	46	64	79	91	102	112	121	144	25°	35°	40°	122	22°	31.8	0.57
25°		●				**2540**	3.6	9.1	12.9	15.8	18.2	20	22	24	29	15°	25°	34°	65	25°	19.1	0.11
15°		●				**1510**	2.0	2.3	3.2	3.9	4.6	5.1	5.6	6.0	7.2		15°	23°	47.5	22°	15.9	0.06
		●				**1520**	2.8	4.6	6.4	7.9	9.1	10.2	11.2	12.1	14.4		15°	19°	54	19°	15.9	0.06
			●			**1530**	3.2	6.8	9.7	11.8	13.7	15.3	16.7	18.1	22	6°	15°	24°	72	25°	19.1	0.11
			●			**1540**	3.6	9.1	12.9	15.8	18.2	20	22	24	29	8°	15°	21°	92	18°	22.2	0.23
			●			**1550**	4.4	11.4	16.1	19.7	23	25	28	30	36	9°	15°	20°	90.5	15°	22.2	0.17
				●		**1560**	4.8	13.7	19.3	24	27	31	33	36	43	10°	15°	19°	125	14°	25.4	0.34
				●		**1580**	5.2	18.2	26	32	36	41	45	48	58	11°	15°	18°	130	14°	25.4	0.34
				●		**15100**	6.0	23	32	39	46	51	56	60	72	11°	15°	18°	137	14°	25.4	0.40
					●	**15200**	8.3	46	64	79	91	102	112	121	144	12°	15°	18°	191	14°	31.8	0.91

WASHING SYSTEM CALCULATION

Washing pipe quantity selection 'Nt':

The quantity of nozzles per pipe is

Nb = B/0.3, where B = screen width in metres (m).

The water flow rate for the screen is V = K x Q, where Q = screen feeding in m^3/hour and K = factor depending on the material to be washed:
a) K = 0.5 to 1.5 for relatively clean material, and
b) K = 1 to 3 for material with high clay content.

When we know the quantity of nozzles per pipe (Nb), we calculate the flow per pipe (Vt) in m^3/h for each combination of nozzle type / pressure and quantity of pipes (Nt).

Nt = V / Vt = 5 x (K x Q) / (Nb x Vb)

V = K x Q

Vt = Nb x Vb = (B/0.3) x Vb x (60/1000)

Vt = B x Vb/5 (in m^3/h)

Where:
K = material factor
Q = screen capacity (m^3/h)
B = screen width (m)
Vb = flow rate per nozzle (L/min)

Note: Three- and four-deck screens do not have much space in the second and fourth deck for the pipe installation. An average of three pipes is recommended for each of these decks.

PUMP SELECTION

WATER FLOW

V = QK (m^3/h)

Where:
Q = screen production capacity (m^3/h)
K = factor depending on material type

TOTAL PRESSURE

Pm = P nozzle + 0.8 + 0.01 x a x L + 0.1 x DH (atm)

Where:
P nozzle = pressure at nozzle outlet in atmospheres (bar)
DH = level difference between screen and water source (H screen - H source), in metres
a = load loss factor taken from opposite chart
L = piping length from water source to screen, in metres

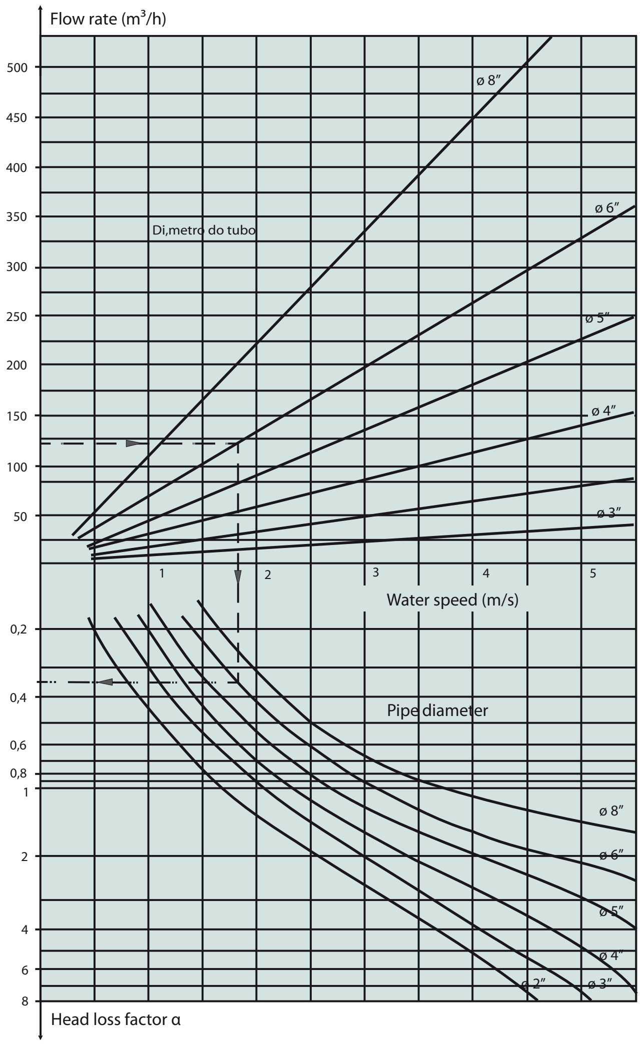
Note: To obtain factor a, the following procedures should be used: With the calculated V flow, the pipe diameter is chosen, observing the water speed limits. From this speed, a vertical line is drawn until it crosses a line corresponding to the same diameter in the lower part of the chart and with a horizontal line to find the value of a. For more clarification, follow the arrow on the next chart.

Note: Maximum recommended speeds are:
- for pipes larger than 5" dia.: 4 m/s
- for pipes of less than 5" dia.: 2.5 m/s

PUMP POWER

$$W = \frac{V \times Pm}{27} \text{ (kW)}$$

HEAD LOSS FACTOR



For US gal/h multiply by 26.4
For ft/sec multiply by 3.28

PIPING

Data on commercial pipes (manufacturer reference: Mannesmann)

Test pressure with cold water: 50 kg/cm². The pressure refers only to the pipe and not to the fittings. Weights in the following lists are theoretical.

DIN 2440
Seamless, non-galvanised or galvanised steel pipes for water and gas, according to DIN 2440 standards.

Inside nominal diameter		External diameter	Wall thickness	Pipe weight
in	mm	mm	mm	kg/m
1/2	15	21,25	2,75	1,25
3/4	20	26,75	2,75	1,63
1	25	33,50	3,25	2,42
1½	40	48,25	3,50	3,86
2	50	60,00	3,75	5,20
2½	65	75,50	3,75	6,64
3	80	88,25	4,00	8,31
4	100	113,50	4,25	11,50
5	125	139,00	4,50	14,90
6	150	164,50	4,50	17,80
8	200	216,00	6,50	33,60

DIN 2441
Seamless, non-galvanised steel pipe for steel, according to DIN 2441 standards.

Inside nominal diameter		External diameter	Wall thickness	Pipe weight
in	mm	mm	mm	kg/m
1/2	15	21,25	3,25	1,44
3/4	20	26,75	3,50	2,01
1	25	33,50	4,00	2,91
1½	40	48,25	4,25	4,61
2	50	60,00	4,50	6,16
2½	65	75,50	4,50	7,88
3	80	88,25	4,75	9,78
4	100	113,50	5,00	13,40
5	125	139,00	5,50	18,10
6	150	164,50	5,50	21,60
8	200	216,00	7,50	38,60

For inches divide by 25.4

TECHNICAL DATA FOR ASTM-A 120-6IT, SCHEDULES 40 AND 80

Material: Steel of grade A or B, according to ASTM standards.

Test pressures refer only to the pipe, not to the fittings. Weights in the following lists are theoretical and refer only to non-galvanised pipes.

In order to obtain the theoretical weight of the galvanised pipes, we should increase the theoretical weight of the non-galvanised pipes by about 7%.

ASTM-A 120-61T, SCHEDULE 40

Seamless, non-galvanised or galvanised steel pipes, extra-strong

Inside nominal diameter	External diameter		Wall thickness		Weight of non-galvanised pipe without sleeves weight		Weight of non-galvanised pipe with sleeves		Cold water test pressure			
									Grade-A steel		Grade-B steel	
in	mm	in	mm	in	kg/m	lbs/ft	kg/m	lbs/ft	kg/cm²	lbs/in²	kg/cm²	lbs/in²
1/2	21,34	0,840	2,77	0,109	1,265	0,85	1,29	0,87	49	700	49	700
3/4	26,67	1,050	2,87	0,113	1,682	1,13	1,72	1,16	49	700	49	700
1	33,40	1,315	3,38	0,133	2,500	1,68	2,56	1,72	49	700	49	700
1¼	42,16	1,660	3,56	0,140	3,378	2,27	3,45	2,31	70	1000	77	1100
1½	48,26	1,900	3,68	0,145	4,048	2,72	4,18	2,81	70	1000	77	1100
2	60,33	2,375	3,91	0,154	5,432	3,65	5,60	3,76	70	1000	77	1100
2½	73,03	2,875	5,16	0,203	8,617	5,79	8,76	5,90	70	1000	77	1100
3	88,90	3,500	5,49	0,216	11,280	7,58	11,60	7,80	70	1000	77	1100
3½	101,60	4,000	5,74	0,226	13,560	9,11	14,11	9,50	84	1200	91	1300
4	114,30	4,500	6,02	0,237	16,060	10,79	16,81	11,30	84	1200	91	1300
5	141,30	5,563	6,55	0,258	21,760	14,62	22,67	15,23	84	1200	91	1300
6	168,30	6,625	7,11	0,280	28,230	18,97	29,59	19,90	84	1200	91	1300
8	219,10	8,625	8,18	0,322	42,490	28,55	44,66	30,00	91	1300	91	1300
10	273,05	10,750	9,27	0,365	60,2	40,48	—	—	84	1200	98	1400

ASTM-A 120-61T, SCHEDULE 80

Seamless, non-galvanised or galvanised steel pipes, extra-strong

Inside nominal diameter	External diameter		Wall thickness		Weight of non-galvanised pipe without sleeves weight		Weight of non-galvanised pipe with sleeves		Cold water test pressure			
									Grade-A steel		Grade-B steel	
in	mm	in	mm	in	kg/m	lbs/ft	kg/m	lbs/ft	kg/cm²	lbs/in²	kg/cm²	lbs/in²
1/2	21,34	0,840	3,73	0,147	1,622	1,09	1,66	1,15	60	850	60	850
3/4	26,67	1,050	3,91	0,154	2,188	1,47	2,24	1,50	60	850	60	850
1	33,40	1,315	4,55	0,179	3,229	2,17	3,31	2,22	60	850	60	850
1¼	42,16	1,660	4,85	0,191	4,465	3,00	4,56	3,07	105	1500	112	1600
1½	48,26	1,900	5,08	0,200	5,402	3,63	5,56	3,74	105	1500	112	1600
2	60,33	2,375	5,54	0,218	7,471	5,02	7,67	5,15	105	1500	112	1600
2½	73,03	2,875	7,01	0,276	11,400	7,66	11,76	7,90	105	1500	112	1600
3	88,90	3,500	7,62	0,300	15,250	10,25	15,75	10,55	105	1500	112	1600
3½	101,60	4,000	8,08	0,318	18,615	12,51	19,27	12,95	120	1700	127	1800
4	114,30	4,500	8,56	0,337	22,290	14,98	23,19	15,55	120	1700	127	1800
5	141,30	5,563	9,52	0,375	30,921	20,78	32,02	21,50	120	1700	127	1800
6	168,30	6,625	10,97	0,432	42,512	28,57	44,15	29,70	120	1700	127	1800
8	219,10	8,625	12,70	0,500	64,564	43,39	67,16	45,10	120	1700	169	2400
10	273,05	10,750	12,70	0,500	81,500	54,74	—	—	112	1600	134	1900

Metso Wet Equipment

Complete process

Metso Mining and Construction Technology is the world's leading supplier of crushing and screening equipment, complete crushing systems and crushing solutions for the rock and minerals processing industries. Our production program includes all facilities required for washing (SW log washers, LD washing barrels) and for a cost-effective production of gravel and sand (SF sand traps and DEA bucket wheels).

For recycling of process water for recirculation, which has become of growing importance, Mining and Construction Technology is able to integrate water clarification and sludge thickening units.

Metso provides also a full range of robust slurry- and gravel pumps in horizontal and vertical design as well as slurry hoses.

Sand traps

Sand traps are the classic machines for recovery of sand from the discharge water from slurries.

Metso sand traps produce high sand recovery (from 100 to 120µ) to increase production with a low running cost.

Sand traps require only low drive power and are distinguished by operation with a minimum of maintenance and wear.

Process Description

Sand and water mixture is fed into the Sand trap through a central inlet below the dewatering screen. The material enter the trough in a non turbulent section on the dewatering wheel.

The sand then settles on the bottom of the trough. A slow moving screw transports the material to the dewatering wheel.

The waste water flows over a weir at the opposite end of the machine.

The dewatering wheel discharges the product into a dewatering screen.

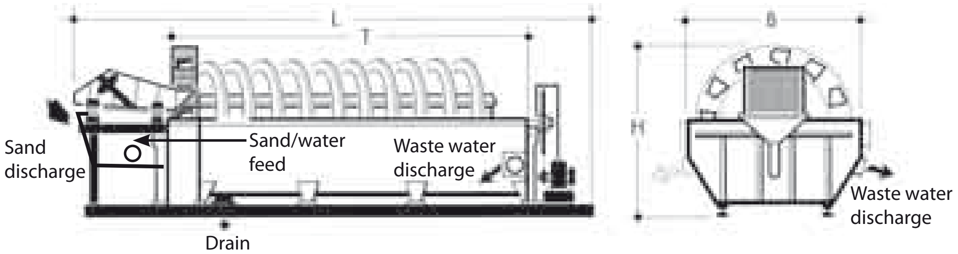
To achieve higher dewatering effect, a Metso dewatering screen type ESU is integrated into the machine.

Technical features:

- Extremely economical operation costs
- Large trough
- Heavy dewatering wheel.
- Screw conveyor which runs extremely slowly.
- Low wear even for abrasive material.
- Optional electronic load dependant frequency controller which controls the speed according to the feed capacity, for optimal sand discharge with efficient dewatering effect.

Range		SF 2360	SF 2850	SF 2870	SF 2960	SF 2975
Dewaterer type		ESU 8020	ESU 1220	ESU 1220	ESU 1525	ESU 1530
Dewaterer drive	(kW)	2 x 0.9	2 x 1.7	2 x 1.7	2 x 1.9	2 x 3.0
Sand capacity	(t/h)	50-70	80-100	90-120	140-150	150-180
Feed capacity sand	(m^3/h)	35-40	50-60	60-65	70-80	80-100
Water required	(m^3/h)	175	175	240	220	270
Power	(kW)	4	7.5	7.5	9.2	11
Length T	(mm)	6 000	5 000	7 000	6 000	7 500
Length L	(mm)	8 810	7 870	9 870	9 520	11 710
Width B	(mm)	2 570	3 000	3 000	3 150	3 150
Height H	(mm)	2 720	3 000	3 000	3 000	3 100
Rotation speed	(rpm)	From 2.6 to 3.0				
Weight	(kg)	9 000	10 500	11 700	12 500	14 000
Operating weight	(kg)	27 000	33 000	35 000	38 000	42 000

For inches divide by 25.4
For STPH multiply by 1.1
For HP multiply by 1.34
For lbs divide by 0.45
For ft^3 multiply by 35.3



Sand trap in operation

Double-Shaft Log Washers

Log washers are used for cleaning gravel and crushed stone containing clay or other contaminations.

According to the material and capacity, the correct Log washer can be chosen within the Metso range.

Process Description

Metso Log washers use a double shaft for a better efficiency in cleaning. The dirty mineral is fed in at the lower end of the trough which is mounted in an inclined position. The trough is inclined at about 7.5°.

The material is then transported to the upper trough discharge by the rotating spiral blade shafts working in opposite directions. The interacting blades create a lifting and friction action on the conveyed material. This movement causes friction between the stones and the blades. During this process clay (contaminates) will be washed from the material and dissolved in the water.

The dirt/clay dissolved in the water leaves the trough at the feed end water outlet. The clay content of the feed material should be less than 10% and the clay must be water-soluble.

The cleaned material is discharged at the upper end of the trough. In the case of higher percentage of organic material - like wood - an effective removal of lighter contamination can be achieved by the setting of the upstream device in series with the log washers.

Construction of the machine

Metso Log washers are of heavy and solid design. The trough is made of formed steel and completely welded with bolted wear plates at the feed and discharge ends. This increases the machine lifetime.

The machine is driven by two electric motors, V-belt drive and spur gears. The synchronous running of both blade shafts is achieved by a set of timed gears which are enclosed in an oil bath.

The log shafts have spherical roller bearings, which are mounted in generously dimensioned bearing housings.

The blades are arranged in a spiral to avoid impacts or power peaks in the transmission system.

To achieve a long lifetime of replaceable blades, which are made of special wear-resistant steel, shafts are run at low speed.

Characteristics

– Substantial trough design with wear plates at the face walls.

– Rigid log shafts in heavy duty spherical roller bearings.

– Replaceable blades made of wear resistant steel.

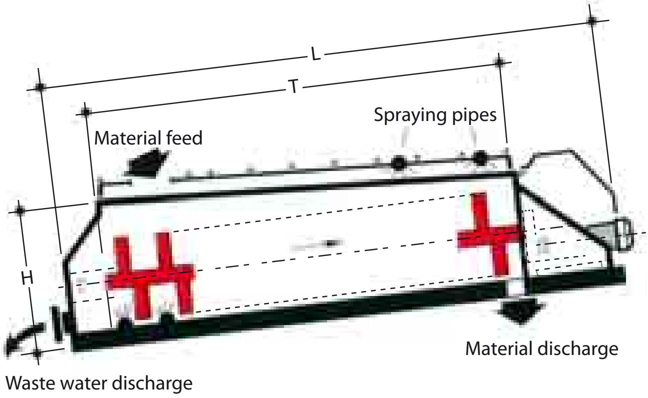
– Individually replaceable shaft journals.

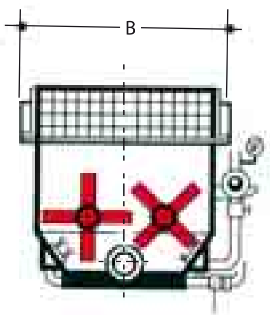
– Reliable gear reducers.

Log washer in operation.

Range		SW 0840	SW 1160	SW 1165	SW 1260	SW 1370
Diameter of logs	(mm)	850	1 100	1 170	1 240	1 446
Feed size	(mm)	From 2 to 50 mm				
Capacity range	(t/h)	65-90	110-150	140-180	170-220	220-300
Speed rotation	(rpm/min.)	24-30	23-29	23-29	23-30	23-32
Power	(kW)	2 x 7.5	2 x 18.5	2 x 22	2 x 30	2 x 45
Length T	(mm)	4 210	6 000	6 000	6 000	7 000
Length L	(mm)	5 500	7 290	7 350	7 680	8 703
Width B	(mm)	1 640	2 190	2 330	2 500	2 990
Height H	(mm)	1 196	1 496	1 496	1 720	1 896
Water required	(m^3/h)	15-45	35-105	45-135	60-180	100-260
Weight of Logwasher	(kg)	5 400	9 500	10 800	12 500	18 400
Operating weight	(kg)	16 200	28 500	32 400	37 500	55 200

For inches divide by 25.4
For STPH multiply by 1.1
For HP multiply by 1.34
For lbs divide by 0.45
For ft^3 multiply by 35.3





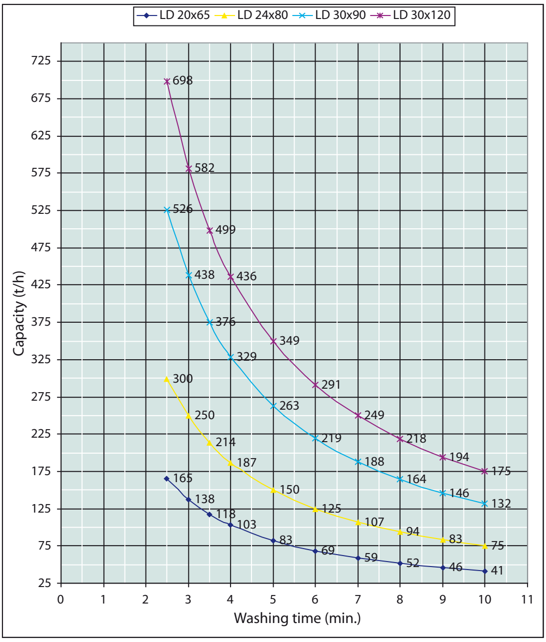
Rotating washing barrels

Metso Mining and Construction Technology offers a comprehensive range of rotating washing barrels based on: direct current technology.

Then it is possible to choose the most suitable process on both considerations technical and economical, with the most suitable size.

		LD 20 x 65	LD 24 x 80	LD 30 x 90	LD 30 x 120
Capacity (time: 5' - 3')	(m^3/h)	50-86	94-156	165-274	220-360
Capacity (5' - 3') d= 1.6	**(t/h)**	**80-140**	**150-250**	**260-430**	**350-550**
Theoretical max. capacity	(m^3/h)	130	215	340	430
Alimentation max.	(mm)	240	290	360	360
Power	(kW)	4 x 11	3 x 30	3 x 45	4 x 45
Speed rotation	(rpm)	9,3	10	8,8	8,8
Barrel diameter	(mm)	2000	2400	3000	3000
Barrel length	(mm)	6500	8000	9000	12000
Ø entry opening	(mm)	800	950	1200	1200
Ø exit opening	(mm)	1250	1500	1850	1850
water demand	(m^3/h)	100-150	200-250	300-400	400-550
Max. water demand	(m^3/h)	390	645	1020	1300
Weight without liners	(Kg)	11000	22000	31000	45000
Weight with liners	(Kg)	**15500**	**28000**	**39000**	**56000**

For inches divide by 25.4
For STPH multiply by 1.1
For HP multiply by 1.34
For lbs divide by 0.45
For ft³ multiply by 35.3



Bucket wheel dewaterers

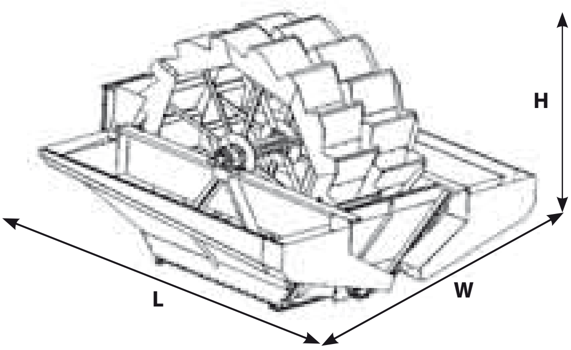
Process description:

- A solids and water mixture is fed into the trough, in a low turbulent flow, where the decantation take place.
- The material feed is located in opposite side of the product discharge.
- The solids settle.
- The trough has sloping walls to collect these solids in the trough center.
- The buckets from the rotating wheel dredge these solids and then drop from the buckets into the discharge chute.

The water flowing towards the overflow.

Technical features:

- Main components
- Trough with feed box.
- Discharge chute.
- Double sided overflow box.
- Transversal beam which support the drive assembly and bucket wheels.
- Electronic load dependant frequency controller which controls the speed according to the feed capacity, for optimal sand discharge with efficient dewatering effect.
- Low wear
- Low energy consumption



		DEA 1030	DEA 1430	DEA 1540
Feed size	(mm)	0-6 mm		
Wheel diameter	(mm)	3000	3000	4000
Wheel width	(mm)	1000	1400	1500
Area	(m^2)	6,1	10,6	16,6
Though capacity	(m^3)	6,33	8,5	18
Power	(kW)	2,2	3	4
Speed	(rpm/min.)	1,3	1,3	1,2
Material capacity (dewatered)*	(t/h)	85	120	200
Material capacity (dewatered)	(m^3/h)	50	70	110
Water consumption	(m^3/h)	120	200	330
Weight	(Kg)	4000	4500	6500
Operating weight	(Kg)	12000	13500	19500
Dimensions Width W	(mm)	3000	3900	4500
Length L	(mm)	3900	4400	5700
Height H	(mm)	3200	3200	4300

** Capacity can be adjusted by a frequency variator add by the customer*

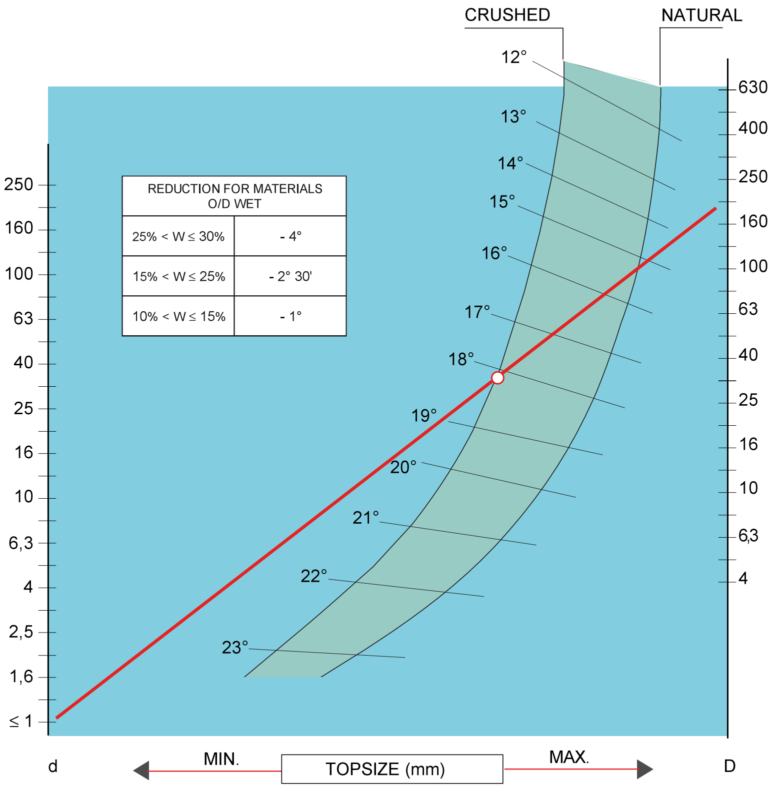
For inches divide by 25.4
For stph multiply by 1.1
For hp multiply by 1.34
For lbs divide by 0.45
For ft³ multiply by 35.3
For ft² multiply by 10.7

With over one hundred years of experience, and tens of thousands of conveyors in operation, Metso offers a range of conveyors answering different requirements for safe, reliable and easy to maintain equipment.

Being a world leader for supplying crushing equipment, Metso will improve your competitiveness with an improved reliability.

Conveyor selection guide – Nordberg NB, TBC, TEC and EBC conveyors

Maximum conveyor slope according type of material



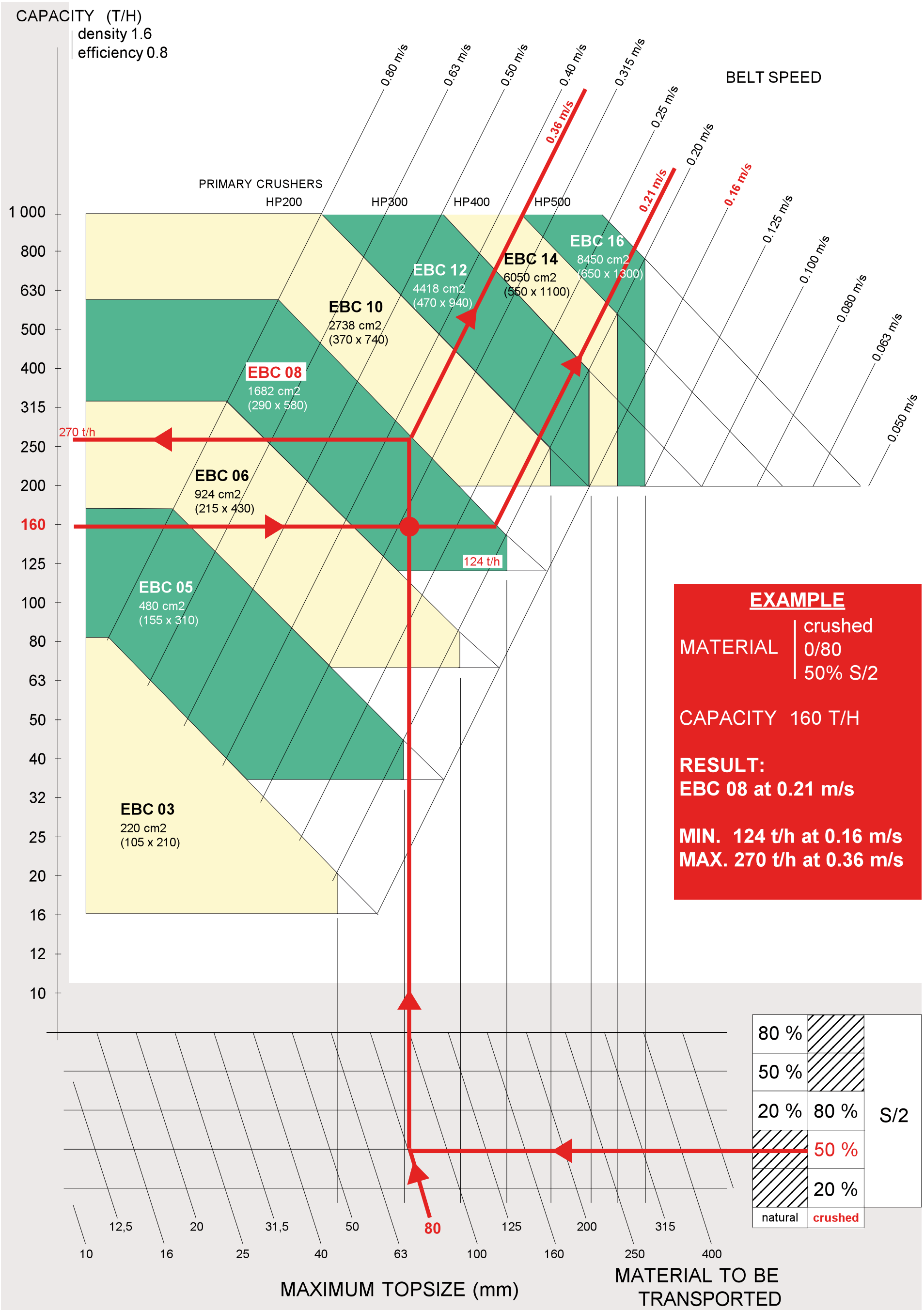
Belt width and belt quality

GENERAL RULE FOR CONVEYOR BELT WIDTH SELECTION ACCORDING NATURE OF MATERIAL AND BELT SPEED

Belt width (mm)	**Primary material** v (belt speed) = 1,4 m/s	**d / D & > 80 mm** v (belt speed) = 1,4 m/s	**0/80 mm max** v (belt speed) = 1,8 m/s	**0/50 max** v (belt speed) = 2,2 m/s
500	100 t/h of 0-100 mm	115 t/h	150 t/h	180 t/h
650	150 t/h of 0-150 mm	200 t/h	260 t/h	300 t/h
800	350 t/h of 0-200 mm	460 t/h	600 t/h	700 t/h
1000	600 t/h of 0-250 mm	700 t/h	900 t/h	1 050 t/h
1200	850 t/h of 0-300 mm	1 000 t/h	1 300 t/h	1 500 t/h

Table valid for the following feed gradation : 50% half size passing
For inches divide by 25.4,   For ft/s multiply by 3.25,   For stph multiply by 1.1

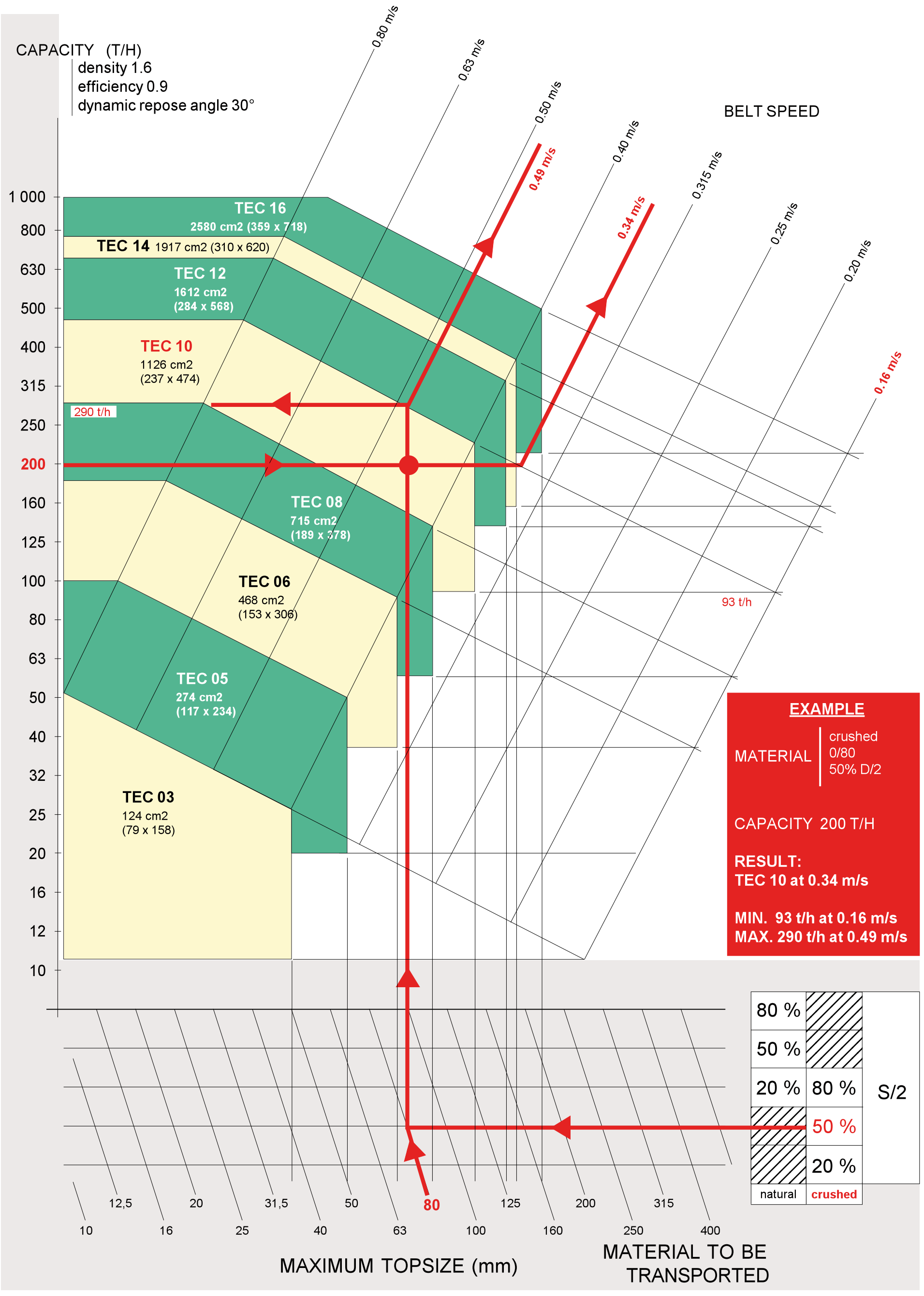
EBC Belt Feeder/Selection chart



S = max size of material

For STPH multiply by 1.1
For inches divide by 25.4

TEC Belt Feeder/Selection chart



S = *max size of material*

For STPH multiply by 1.1

For inches divide by 25.4

Conveyors

Nordberg Conveyors – NC Series

		NC05	NC06	NC08	NC10	NC12
Belt width	(mm)	500	650	800	1000	1200
Belt speed range	(m/s)	1.4 – 1.8 – 2.2				
Power range	(kW)	4 to 11	4 to 150		7.5 to 150	
Carry Idlers diameter	(mm)	89		133		
Carry idlers shaft diameter	(mm)	20				
Number of carry idlers per set		3				
Return idler diameter	(mm)	89				
Return idler shaft diameter	(mm)	20				
Number of return idler per set		1				
Carry idlers trough angle	(°)	35	45			
Tail drums diameter	(mm)	324 (4 to 11kW)	324 (4 to 37kW)		324 (7.5 to 11kW)	
			406 (45 to 60kW)		406 (15 to 60kW)	
			508 (75 to 90kW)		508 (75 to 90kW)	
					630 (110 to 150kW)	
Head drums diameter	(mm)	340 (4 to 11kW)	340 (4 to 11kW)		422 (7.5 to 11kW)	
			422 (15 to 37kW)		524 (15 to 60kW)	
			524 (45 to 60kW)		646 (75 to 90kW)	
			646 (75 to 90kW)		840 (110 to 150kW)	
Walkways widths *NC-HD: heavy duty option* *NC-S: standard option*	(mm)	Floor: NC-HD: 700 – NC-S: 600				
		Way: NC-HD: 800 – NC-S: 700				
		Stairs floor: NC-HD: 700 – NC-S: 600				
		Stairs way: NC-HD: 800 – NC-S: 700				
Belts 250/2 – 315/2		X	X		X	
Belts 400/3 – 500/3		X	X		X	
Belts 630/3 – 800/3			X		X	
Belts 1000/4 – 1250/4					X	
Scrapers		Trellex : T-HMS ; P-HMS ; P-ABC71				
		Bellebanne: URT, HV				

		NC05	NC06	NC08	NC10	NC12
Belt width	mm	500	650	800	1000	1200
Belt speed range	m/s	1.4 - 1.8 - 2.2				
Capacity range (speed 1.8 m/s - trough angle 45° - conveyor angle > 15°)	tph	150	250	450	700	1000
Carry idler diameter	mm	89			133	
Return idler diameter	mm	89				
Trough angle	Degree	35	45			
Power range	kW	4 to 11	4 to 150		7.5 to 150	
Head drums diameter	mm	340	340 - 422 - 524 - 646 - 840			

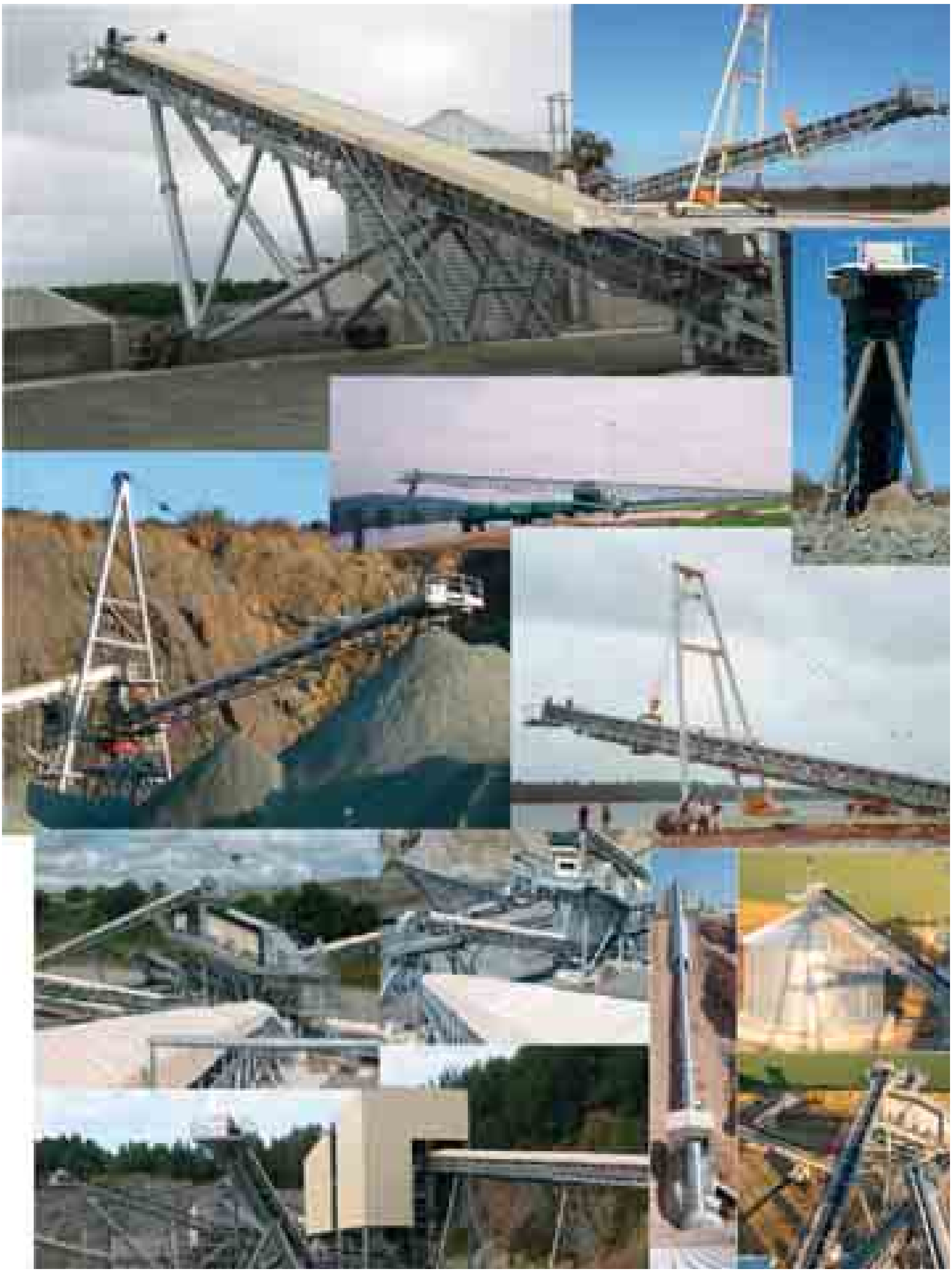
Nordberg Conveyors – Compact Series

	Belt width		mm	350	500	650	800	1000	1200	1400	1600
Frame	Widths x heights		mm	520 x 160	700 x 175	870 x 200	1030 x 215	1270 x 235	1530 x 270	1780 x 290	2000 x 330
	Thicknesses		mm	4	5	6	6	8	8	10	10
	Maximum spacer between support points		mm	10 000							
	Maximum overhang	without discharge chute	mm	3000 with motor reduction / 4000 without reduction gear							
		with discharge chute	mm	2000 with motor reduction / 3000 without reduction gear							
Drums	Drum lengths		mm	390	560	720	870	1080	1280	1500	1700
	Drum diameters	drive	mm	184	210	235	261	289	340	372	422
		return	mm	168	194	219	245	273	324	356	406
Bearings	ISO 113 II Bore		mm	35	40	50	55	65	65	75	85
	Distance between centers		mm	450	630	796	950	1175	1390	1620	1830
Belt tension	Adjustment clearance		mm	Centre distances < 5 m = 150 mm / spacing > 5 m = 300 mm							
Idler supports	Distance between idlers	Conveyors	mm	Maximum 1000 (250 to 375 under feeder)							
		Extractors	mm	250	250	250	250	250	250	250	250
		Conveyors-extractors	mm	Maximum 500 (250 to 375 under feeder)							
	Distances between centres on return idlers		mm	Maximum 3000							
	Number of idlers per support			2	3	3	3	3	3	4	4
	Trough angles	TBC/TEC		15°	28°	29°	30°	30°	30°	30°	30°
		EBC		3°	3°	3°	3°	3°	3°	3°	3°
	Tramming lengths		mm	250	500	500	500	750	750	1000	1000
Idlers	Diameter x length x thickness		mm	70 x 200 x 2	89 x 200 x 3	89 x 250 x 3	89 x 315 x 3	89 x 380 x 3	133 x 430 x 4	133 x 380 x 4	133 x 430 x4
	Spindles = diameter x length		mm	15 x 226	20 x 226	20 x 276	20 x 341	20 x 406	20 x 456	20 x 406	20 x 456
	Flat = lengths x distances between centres		mm	8 x 208	14 x 208	14 x 258	14 x 323	14 x 388	14 x 436	14 x 388	14 x 436
	Bearing type			6202	6204	6204	6204	6204	6204	6204	6204
	Guiding idlers		mm	Ø 54 x 100				Ø 89 x 120			
Belts	TBC/TEC	Breaking strength / nb of folds	daN / cm	250/2	250/2	315/2	315/2	400/3	400/3	500/3	500/3
		Coating thickness	mm	3+1	3+1	4+2	4+2	4+2	4+2	6+2	6+2
		Total thickness	mm	7	7	9	9	10	10	12	12
	EBC	Breaking strength / nb of folds	daN / cm	250/2	315/2	400/3	400/3	500/3	500/3	500/3	500/3
		Coating thickness	mm	3+1	4+2	6+2	6+2	6+2	6+2	8+3	8+3
		Total thickness	mm	7	9	11	11	12	12	15	15
Gear box	Conveyors	Power	kW	1.5	3	4	5.5	7.5	9.2	9.2	11
		Rotation speed	t/mn	166	146	130	117	106	90	82	72
		Bore diameter	mm	32	38	38	48	48	60	60	80
	Extractors	Power	kW	1.5	3	4	5.5	7.5	7.5	9.2	9.2
		Rotation speed	t/mn	83	73	65	59	53	28	19	12
		Bore diameter	mm	32	38	38	48	60	60	70	80
	Conveyors-extractors	Power	kW	1.5	3	4	5.5	7.5	9.2	11	11
		Rotation speed	t/mn	83	73	65	59	53	45	41	34
		Bore diameter	mm	32	38	38	48	60	60	70	80
	Belt speed		m/s	TBC 1.6 m/s - TEC-EBC 0.8 m/s to 50 Hz							
Hoppers	Panel thickness + liners		mm	4+5	4+5	5+6	5+6	6+8	6+8	6+8	6+8
	Flap cross-sections	Conveyors	45 shore	80 x 6	100 x 6	120 x 6	150 x 6	200 x 10	200 x 10	200 x 10	200 x 10
		Extractors	45 shore	50 x 20	50 x 20	100 x 20	100 x 20	100 x 20	100 x 20	100 x 20	100 x 20
		Conveyors-extractors	45 shore	80 x 10	100 x 10	100 x 10	120 x 10	150 x 10	150 x 10	150 x 10	150 x 10
	Feed hopper length	TBC	mm	750	1000	1000	1000	1250	1250	1500	1500
		EBC/TEC	mm	extension along machine length							
	Width: (inside, top)	Belt Feeder TBC/TEC/EBC	mm	170-240	250-370	368-498	518-648	650-824	850-1024	986-1204	1186-1404
		Conveyors-extractors	mm	210	310	430	580	740	940	1100	1300
Scrapers	Trellex Scrapers			T-HNS, P-ABC HNS, P-ABC70							
	Bellbanne Scrapers			URT-M							

For inches divide by 25.4 For HPs multiply by 1.36 For ft multiply by 3.28

Conveyors

Nordberg Conveyors – Realisation



Process examples and planning basics

Process planing basics

Application

The planning of process starts from the application: the products that are needed, and the properties of feed material have to be known. The most important properties of feed material that effect on the crushing process planning are feed fraction, moisture content, material density, material crushability and material abrasiveness.

For primary stage of crushing circuit, either compressive type of crusher, or horizontal shaft impactor can be selected. Impact crushers are performing well in high crushability (> 40 %) i.e. soft rock, and low abrasiveness (< 500 g/ton) applications and compressive type crushers are performing very well in hard rock, high abrasiveness applications. They can be also used for low abrasiveness rock, soft and hard. Secondary stage follows typically the same rules as the primary, then compressive type of crusher being best performing in high abrasiveness and low crushability applications.

In fine crushing applications there are more possibilities for crusher selection depending on the application. For high crushability, low abrasivenss, for example Limestone, there are rock-on-anvil VSI crusher and HSI crusher that would suit to the job. For good shape requirement, rock-on-rock VSI crusher is performing well in all kinds of applications regardless of the high abrasivenss. The maximum feed size is then limiting the use of rock-on-rock VSI crusher. The fine cone crushers are flexible what comes to feed maximum size, as there are different size of liners available.

Cones are performing very well with all kind of rock types. The only factors that are limiting the use of cones in fine crushing are fine aggregate in the feed and moisture content. As a rule of thumb, minus 5 mm particles aren't recommended to be fed into cone crusher, and max. recommended moisture content in the feed is 3%.

Crushing ratio

Crushing ratio, i.e. the total reduction from feed to products, is a factor that sets the needed number of crushing stages. Also, the rock type effects on the reduction ratio, the harder the rock, the lower the reduction ratio in each crushing stage. In the other words, more stages are needed while crushing harder rock compared to softer rock. Typical reduction ratios (calculated between feed 80-% passing point and product 80-% passing point) in each crusher type are listed in table below:

Crusher	Reduction Ratio (F80/P80)
Primary gyratory	6-8
Jaw crusher	3-5
Horizontal shaft imapactor	5-8
Secondary cone crusher	3-4
Tertiary cone crusher	2-3.5
Vertical shaft impactor, rock-on rock	1.5-2
Vertical shaft impactor, rock-on anvil	1.5-3

Crushing ratio effect also on product shape. As the high reduction ratio in compressive type of crushers is made mainly by cleavage type of breakage, i.e. breakage between liners, it cannot produce good shape aggregates. Also, too rough impact type of breakage ruins the particle shape.

Instead of this, the attrition between particles is the key to make cubical or even spherical aggregates. However, reduction ratio with attrition type of breakage remains very low. With compressive type of crusher the reduction ratio, adjusted mainly by the feed fragmentation and crusher closed side setting has to be 1,5-2,5 to achieve best possible end product shape. Vertical shaft Impactors utilise mainly the attrition type of breakage. It means, that the reduction ratio is very small, but the shape of aggregate is excellent.

Crusher load in different crushing stages

The feed into crushing process varies a lot quite often. It's a very important factor to consider while designing a crushing process. In the primary stage, the feed into crusher varies from very fine feed to big blocks even in the same quarry. Thus, the capacity of primary stage isn't stable all the time. For successful and continuous crushing operation, it's important to have last crushers full all the time (see chapter choke feed). This is possible, if the external variation caused by the feed fragmentation is controlled. In practice, the use of stockpiles, screens, silos, buffers and process automation standardises the feed to final crusher, which give a chance to make consistent quality aggregates.

As a rule of thumb, crushing circuit should be designed so that the final crushing stage is under 100% load all the time. This comes true, if the secondary stage is under 80% load and primary under 70% load. This gives some extra capacity to early stage of crushing circuit to handle the interruptions caused by feed variation.

Feed fraction

It's essential to select right crusher feed opening depending on the feed size in each stage. This enables continuous and economical crushing, because

- there are less interruptions due to blockages in the feed opening
- the utilization of liners is better in compressive type of crushers
- the lifetime of rotor wearparts in HSI and VSI crushers is longer

Feed fraction into crusher effect on the crusher performance, end product fragmentation and end product shape.

Choke feed

As mentioned earlier, the closer the 100% load in the last stage of the crushing process the better. The following table shows the pros and cons of full cavity filling level (choke feed) and half full cavity filling level (non-choke feed) in cone crusher.

When the rock-on-rock VSI is loaded with full capacity, the crusher chamber is full of material and the build-up in the chamber stays in good shape. This enables consistent and cost effective crushing.

Cavity filling level

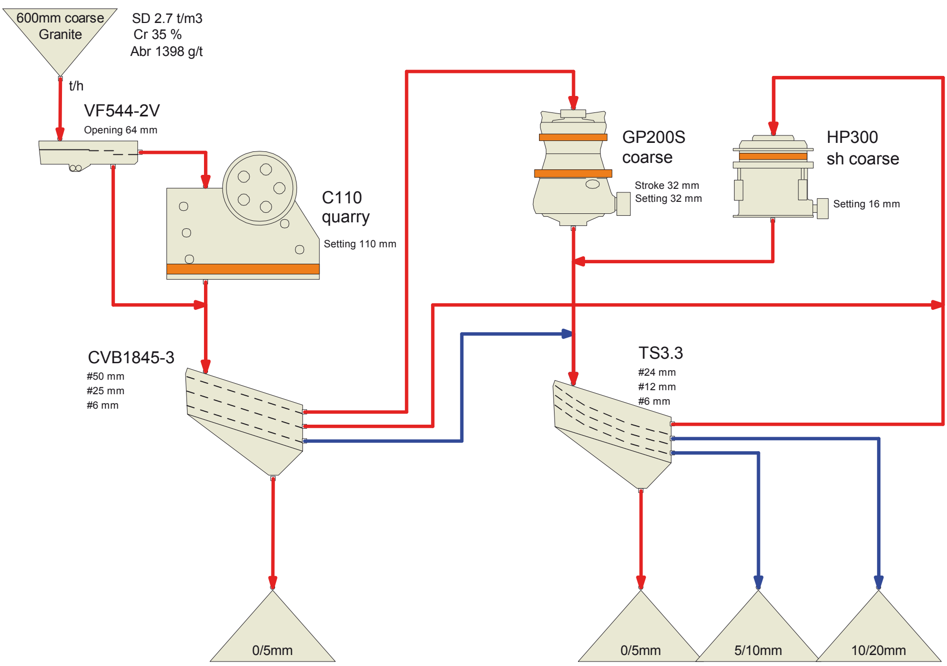
	Half full	Full
• Amount of product bigger than c.s.s.	▲	▼
• Power need/kW	▼	▲
• Capacity/tph	▼	▲
• Nominal power need/kWh/ton	▲	▼
• Shape of aggregates	▼	▲
• Wear part consumption/g/ton	▲	▼
• The crusher frame load	▲	▼

▲ Grow/improve
▼ Decrease/worse

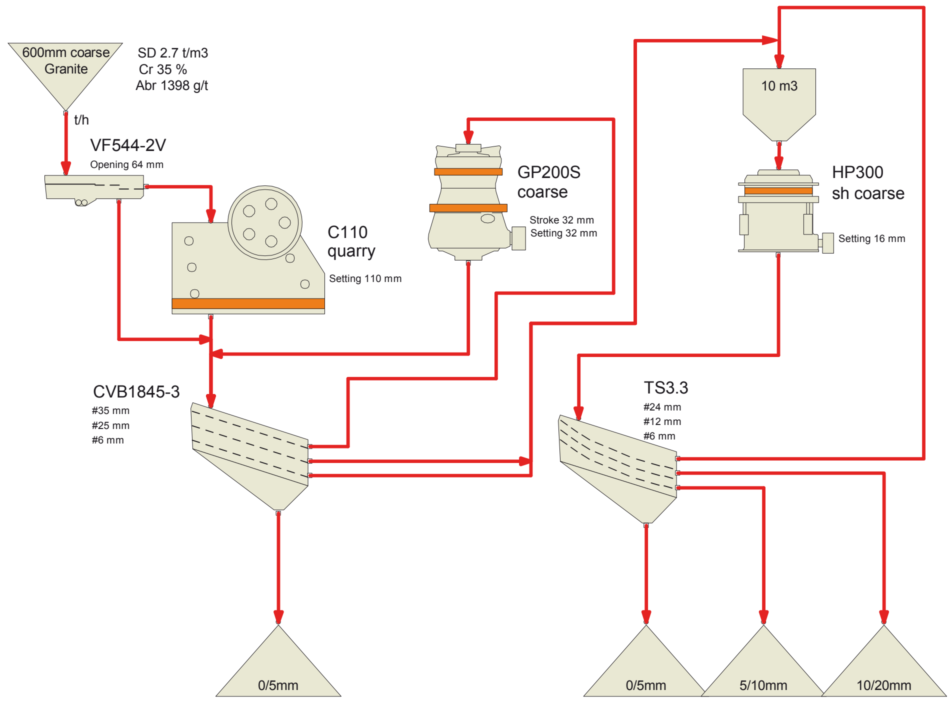
Example crushing circuits

Previously mentioned process planning basics have been shown in following crushing circuits. Each of the circuit are examples and the usage of flow sheet and crushers should be considered separately. Crusher selection is highly influenced by local application requirements.

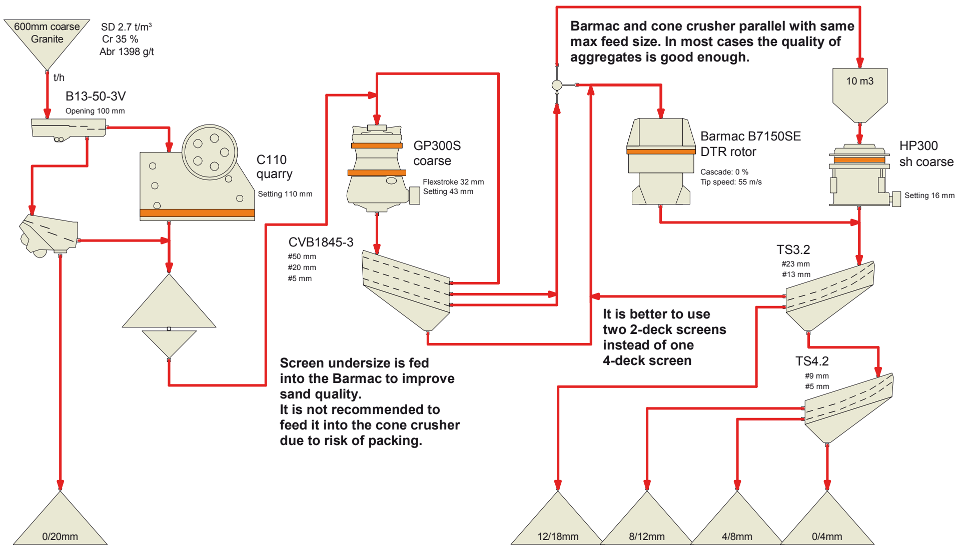
1. Three stage crushing plant, **maximizing the capacity**. All –20 mm particles screened directly into products. Capacity 320 tph



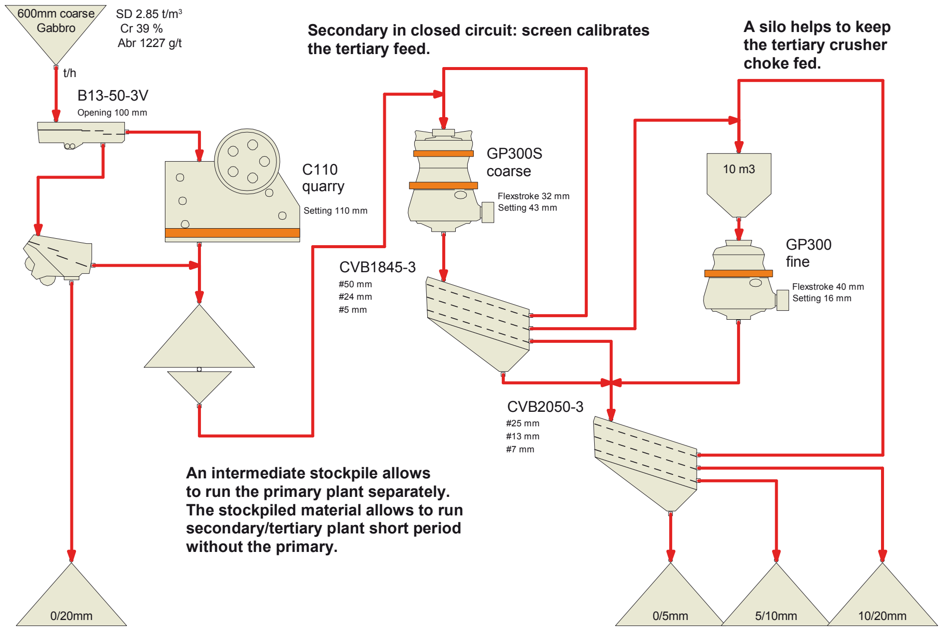
2. Three stage crushing plant, **maximizing the quality**. All products done by tertiary cone. Capacity 200 tph. Crushing equipment is same as in process example 1.



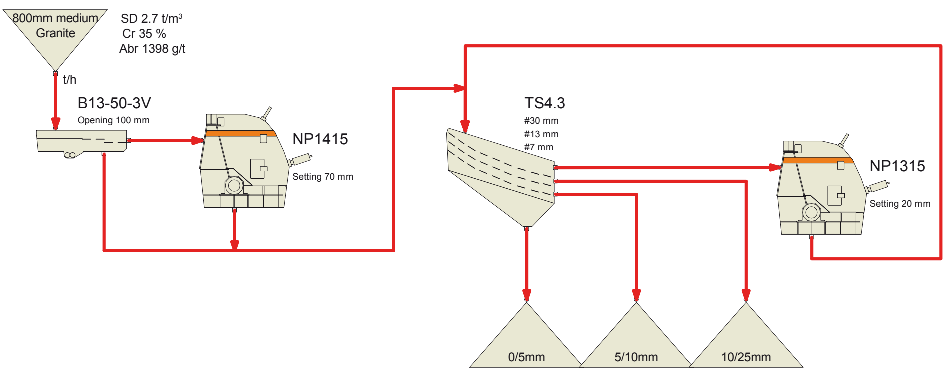
3. Example process producing concrete aggregates – 330 tph



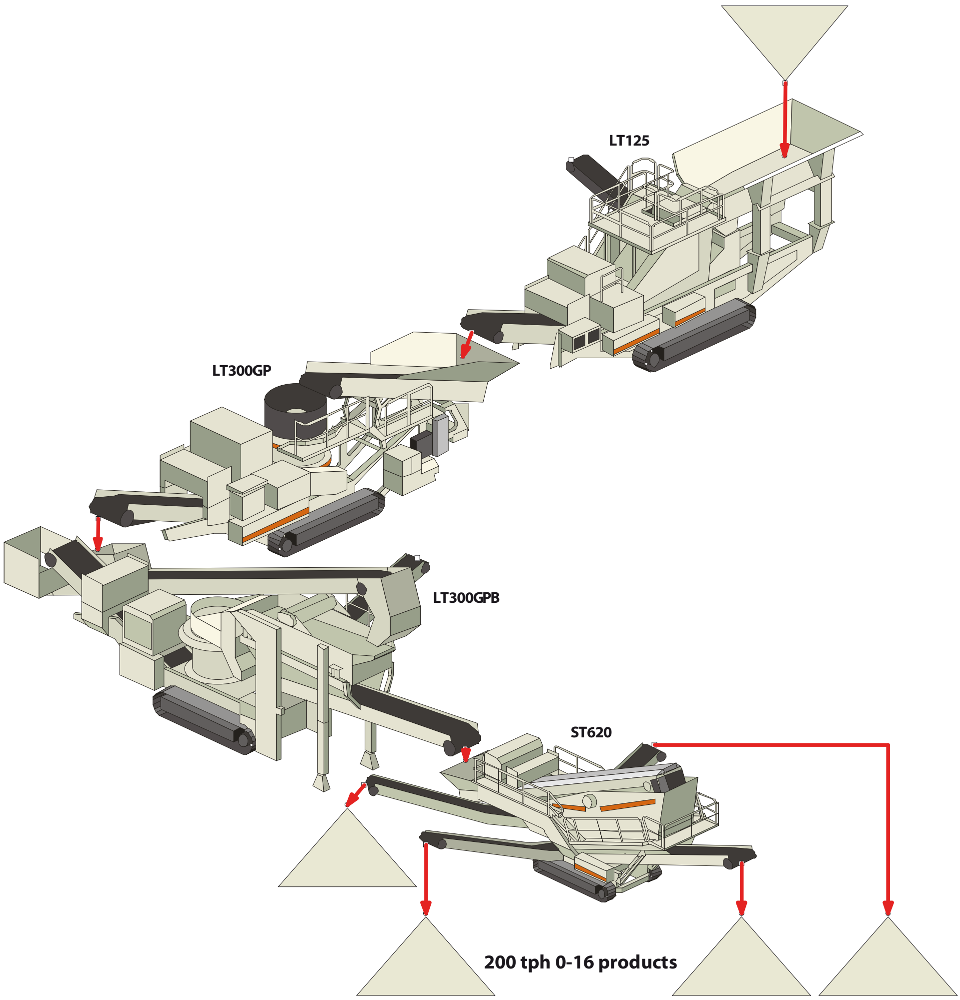
4. Example process producing asphalt aggregates – 330 tph



5. General construction aggregates – Limestone application – 400 tph



6. General construction aggregates – mobile application – 200 tph.



Example of the effect of process optimization

In order to illustrate the importance of process optimization following practical example can be made.

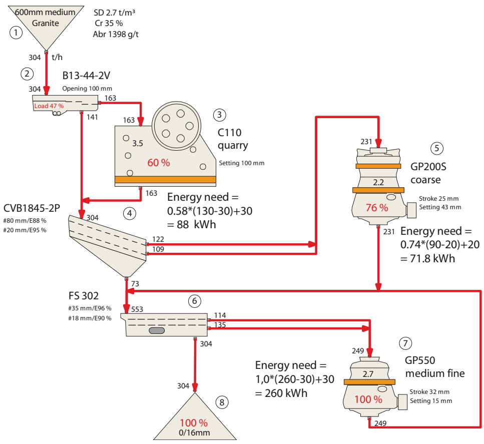
In three stage plant maximum production of 0-16mm fraction is needed without any specific quality requirements. Process would be as shown below.

Production of 0-16mm product can vary from about 220 t/h to 300 t/h depending on running parameters of crushers and screens in the process. Lowest capacity is got with large settings in the crushers so that there is lots of circulation in the tertiary stage. Highest capacity is achieved by tightening the settings in the crushers so that circulation is reduced, screening optimized and setting corresponds the maximum yield for 0-16mm fraction.

Economical consequences are quite dramatic as can be seen from the table below. In this table case 1 is worst and case 5 the best one.

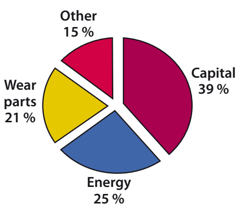
So with 10% 'investment' sales revenue improvement can be up to 30% better. So message is clear: process optimization really pays off. Key issues are then

- run equipment constantly with optimum parameters, and here modern automation can give great contribution.
- keep plant availability up. This requires the removal of all kinds of process based disturbances (like oversize boulders entering into crushers) based on proper process planning and management as well as preventive maintenance type of actions.



		Case 1	Case 2	Case 3	Case 4	Case 5
Income	Production 0-16 (t/h)	227	257	265	271	293
	Sales price of aggregate (euro/ton)	4	4	4	4	4
	Annual production, 1600h (ton)	363200	411200	424000	433600	468800
	Relative annual sales value (Meuroa)	1,4528	1,6448	1,696	1,7344	1,8752
	Difference to case 1	**0**	**13%**	**17%**	**19%**	**29%**
Expences	Depreciation & interests 1)	300000	300000	300000	300000	300000
	Total power draw of crushers (kW) 2)	279	362	382	378	389
	Annual energy consumption 1600h (kWh)	446400	579200	611200	604800	622400
	Yearly energy consumption, 0,15 euro/kWh (euro)	66960	86880	91680	90720	93360
	Annual wear parts (euro) 3)	56246	72979	77011	76205	78422
	Others 4)	114000	114000	114000	114000	114000
	Total relative annual costs (drilling, hauling not includeded)	537206	573859	582691	580925	585782
	Difference to case 1	**0**	**7%**	**8%**	**8%**	**9%**

1) 1,5 Meuro investment. Interest 5%, depric. Time 6 years
2) Estimated from reduction ratio. Medium hard rock
3) 84% of energy costs taken acc.to the pie ->
4) 38% of depreciation cost taken acc.to the pie. ->

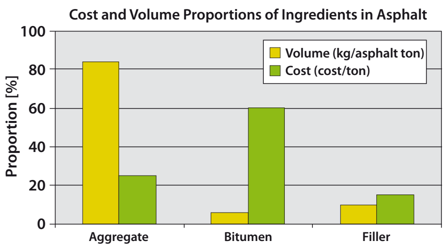


Some application related information

There are issues worth noting with respect to two major applications in which most aggregate is being used: roads and general construction. These key issues are summarised below.

Road construction

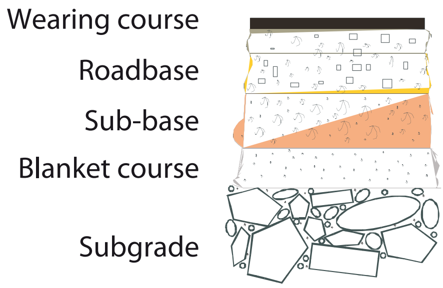
If we combine the costs with aggregate consumption on the surface layer, we get the following graph. This demonstrates that the cost of bitumen determines the cost of the surface layer. So, if the use of higher quality aggregate can extend the life of a road, it represents an investment which will pay itself back.



Meaning of aggregate:
- increases resistance against wear (and saves on maintenance costs)
- improved workability
- internal friction for resisting loads on surface

Related aggregate requirements:
- angular shape, but not flaky or elongated
- constant gradation
- high voids ratio in bulk material

Depending on the geographical area, there can be several layers in a road construction.

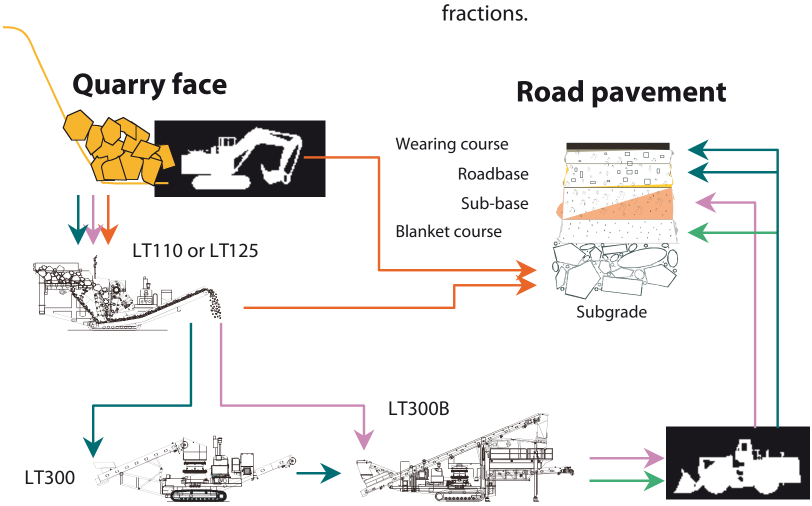


Typical aggregate consumption on a high quality 10-meter-wide road is given in the table below.

Layer	Thickness [mm]	Weight [tons/km]
Wearing Course	20 – 200	320 – 3200
	100 – 250	1600 – 4000
Sub-base	300	4800
Blanket course	150 – 300	2400 – 4800
Subgrade	– 1000	16 000

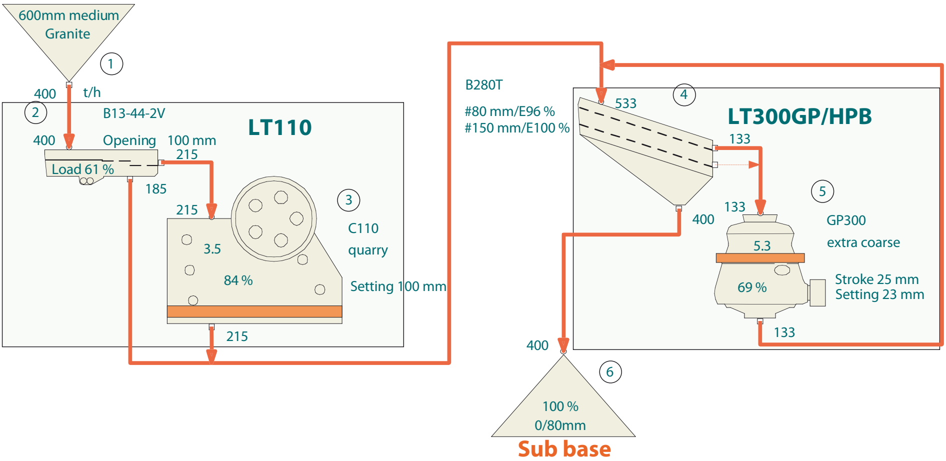
The layer in question and the rock characteristics have a major influence on the process used. The figure below gives an indication of how many crushing stages are needed for different layers.

A subgrade can be produced with a single two-stage plant, when layers closer to the surface require at least two and, in some cases, even four stages for the production of high quality fractions.

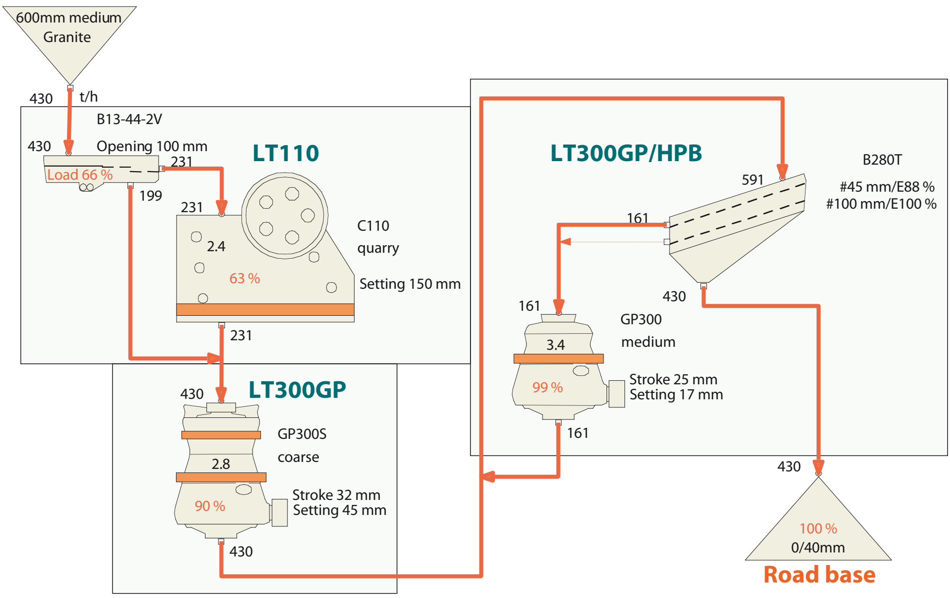


As mobile model processes, these layers can be presented as shown in the flow diagrams below.

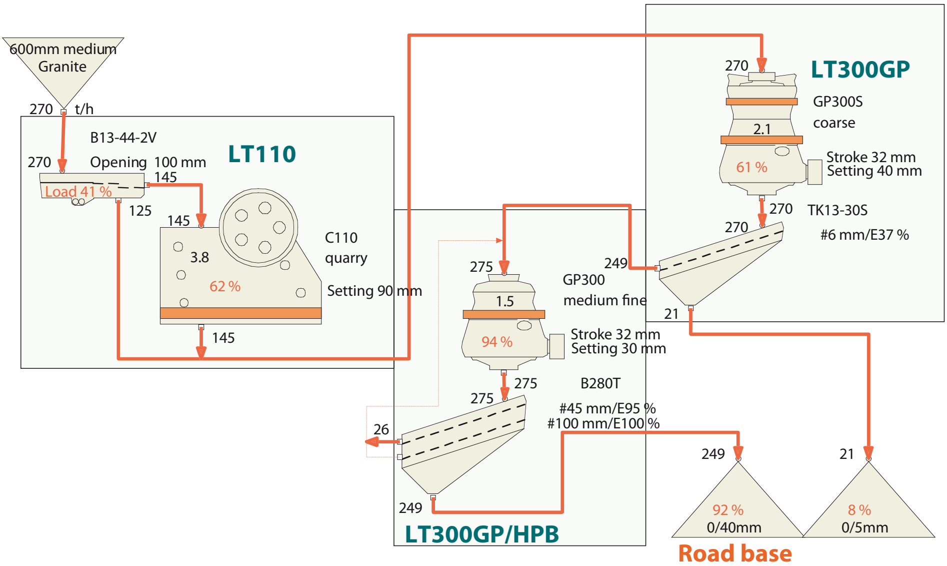
Sub-base layer:



Road base layer (easy material):



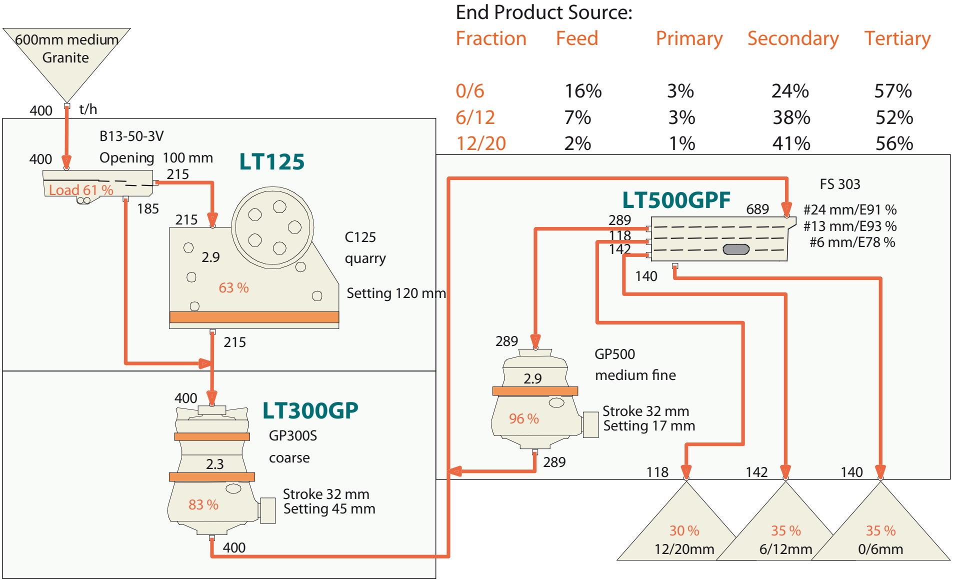
Road base layer (difficult material)



Asphalt layer (easy material)

End Product Source:

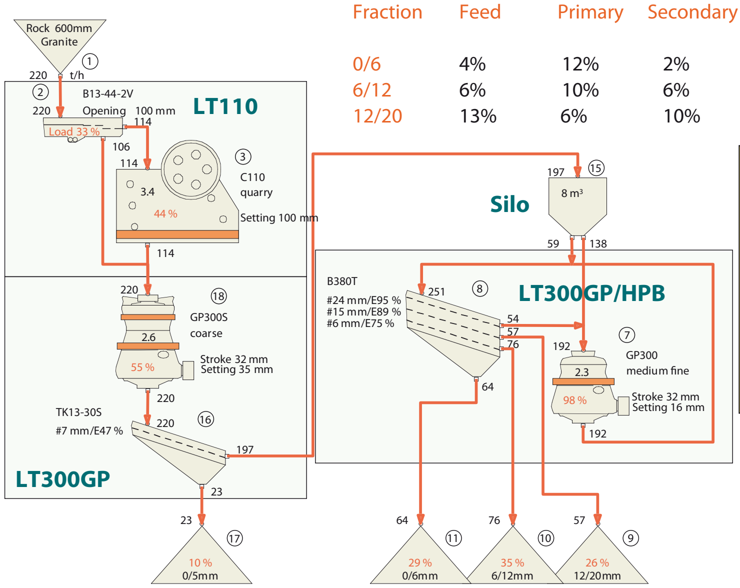
Fraction	Feed	Primary	Secondary	Tertiary
0/6	16%	3%	24%	57%
6/12	7%	3%	38%	52%
12/20	2%	1%	41%	56%



Asphalt layer (medium difficult material)

End Product Source:

Fraction	Feed	Primary	Secondary	Tertiary
0/6	4%	12%	2%	82%
6/12	6%	10%	6%	78%
12/20	13%	6%	10%	71%

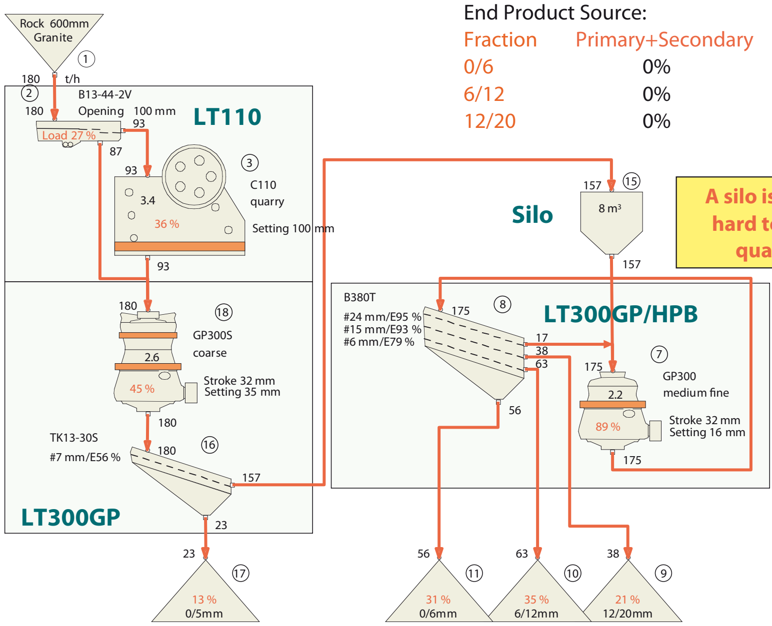


Part of the Secondary product could be led to final screening, if the quality is acceptable

Asphalt layer (difficult material)

End Product Source:

Fraction	Primary+Secondary	Tertiary
0/6	0%	100%
6/12	0%	100%
12/20	0%	100%



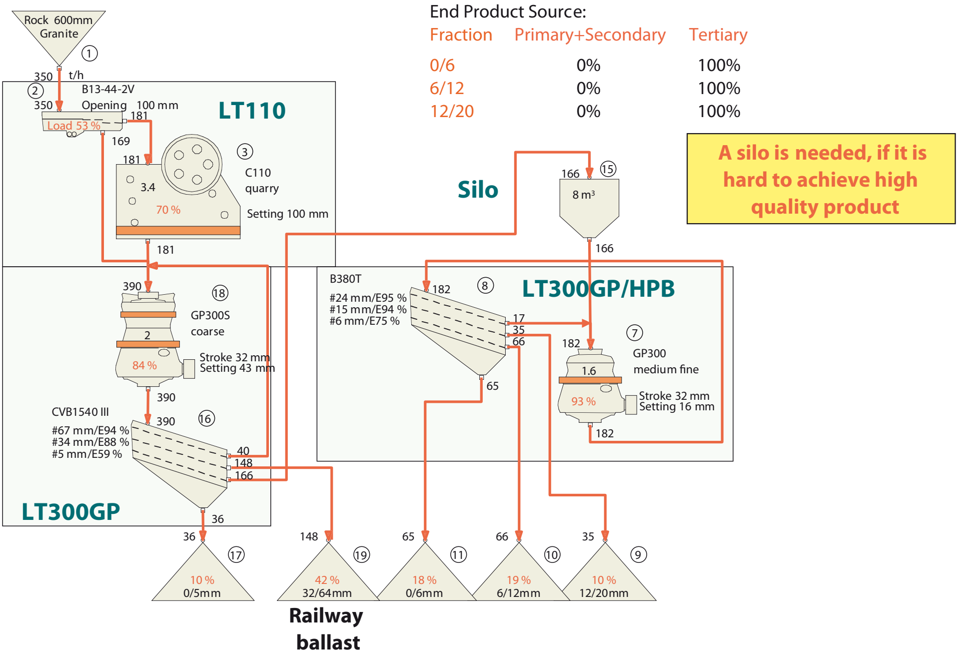
A silo is needed, if it is hard to achieve high quality product

Process Planning and Examples

Asphalt layer + railway ballast (difficult material)

End Product Source:

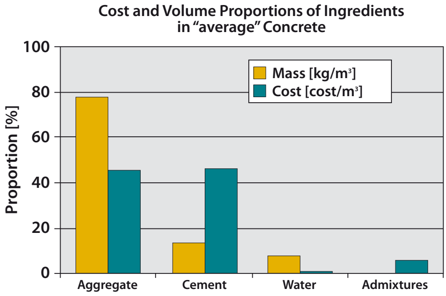
Fraction	Primary+Secondary	Tertiary
0/6	0%	100%
6/12	0%	100%
12/20	0%	100%



In the four last flow diagrams, it can be seen how big a share of the final product comes from different crushers. In the most difficult case, 100% of the final product has passed through all three crushing stages.

General constructions, such as houses

From the same perspective, we can review aggregate in concrete applications. This is shown in the next figure which demonstrates a very similar situation to that of asphalt.



Meaning of aggregate:
- decreases cement content (=> price decreases)
- improves workability, and thus
- increases strength of hardened concrete

Related aggregate requirements:
- spherical, cubical ("smooth face") particle shape (not flaky or elongated)
- even gradation
- low specific surface of sand particles and
- low voids content in 0/4
- controlled microfines content; clay and other organic microfines are harmful in concrete

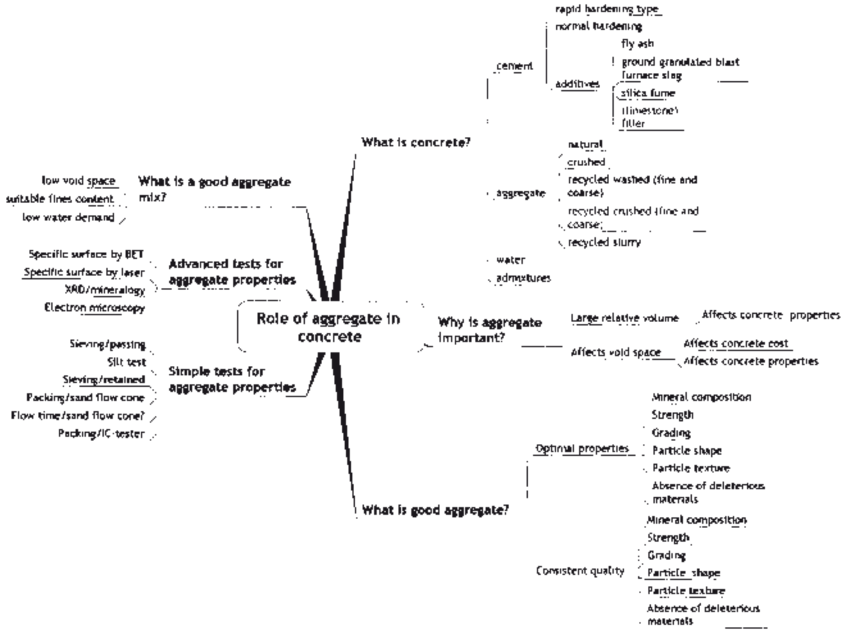
Photo of a poor concrete flow.

Different strength class concrete has a number of requirements, summarised in Table 1.

The photo above provides an example of what happens when poor concrete flow ruins a surface. This can be avoided by improving aggregate quality based on the correct water/cement (W/C) ratio.

Role of aggregate in concrete

Source: Consolis 2005



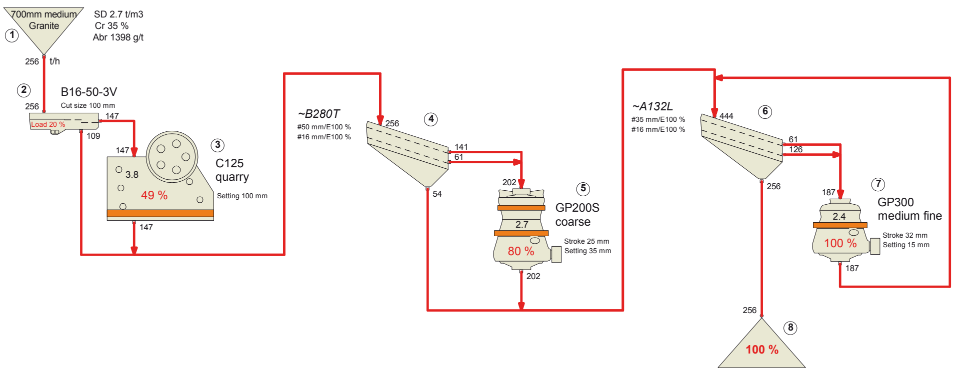
+' = impact to citeria or its meaning increases

	Strength class for concrete					
	<30 Mpa / Typical products			30-50 Mpa / Typical products		>50MPa / Typical products
Issues	**readymix concrete**	**Light weight concrete blocks**	**Mortars**	**Concrete elements**	**Self compacting concrete - SCC**	**prestressed concrete slabs**
Est market volume (m³) %		50		30		20
Relative cost of final product	100	120	150	150		>200
Cement amount kg/m³	250	250	250	300	300	350-450
Water - Cement ratio W/C	0,7	0,7	0,7	0,5-0,6		0,4-0,45
Relative meaning of aggregate cost	+++	+++	++	+	+	+
Additives used	+	0	0	++	++	+++
Typical aggregate fractions	0-32mm	0-32mm	0-4mm	0-16mm	0-16mm	0-16mm
Amount of fines <0,075 in fine aggregate (0-4mm)	0-15% depening on standard	0-15% depening on standard	10-20%	0-10% depening on standard	high (> 10%)	0-5%
Importance of aggregate shape >4mm	++	++	n/a	++	+++	+++
Importance of aggregate shape <4mm	+	+	+++	++	+++	+++
Importance of aggregate surface texture	+	+	+	+++	+++	+++
Mineral composition	+	+	++	++	++	+++
Consistency of aggregate	+	+	++	++	++	+++
Typical specifications	ASTM, EN, etc	ASTM, EN, etc	ASTM, EN, etc	ASTM, EN, etc		Manuf.own
Complexness of concrete manuf. process	+	++	+	+++	+++	+++
Washing dust away in coarse aggregate process	less common	less common	less common	more common		more common
Need for sand treatment	+	+	+	++	++	++

Table 1

Example of process influence to end product quality

Let us consider a few examples, reviewing the proportion of the final product, 0-16mm, produced at different stages of the process. Figure below displays these proportions.



Production of 0-16mm at a maximum rate of 256 t/h

By examining the production of 0-16mm more closely, table 2 can be created:

Origin of End Product					
	Feed	**C125**	**GP200S**	**GP300**	**Product**
0-4	18,8 t/h	4,5 t/h	13,1 t/h	47,8 t/h	84,2 t/h
0-16	22,7 t/h	7,9 t/h	46,0 t/h	95,4 t/h	172,0 t/h
0-4	22,3 %	5,3 %	15,6 %	56,8 %	100,0 %
0-16	13,2 %	4,6 %	26,7 %	55,5 %	100,0 %

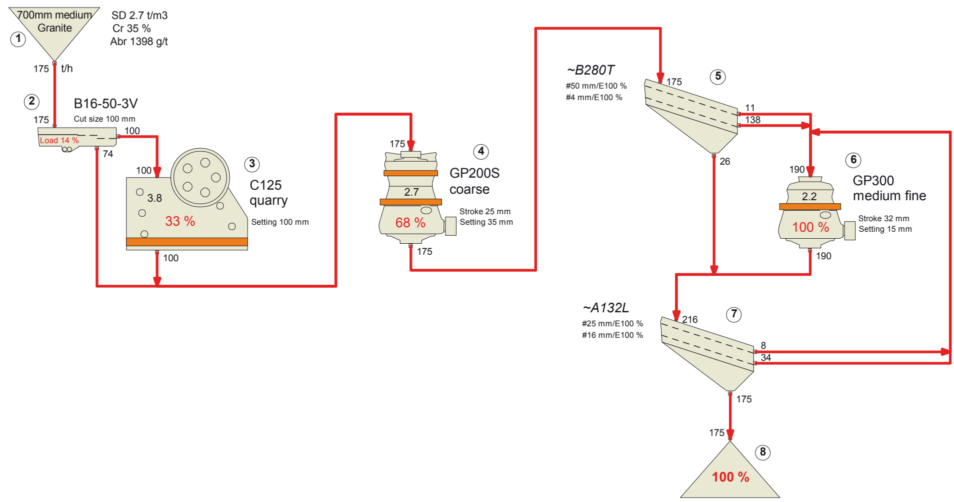
For STPH multiply by 1.1

Product Flakiness					
	Feed	**C125**	**GP200S**	**GP300**	**Product**
Origin of 4-16 fraction	13,2 %	4,6 %	26,7 %	55,5 %	100,0 %
Amount of 4-16 fraction	22,7 t/h	7,9 t/h	46,0 t/h	95,4 t/h	172,0 t/h
Estimated flakiness of 4-16 fraction	50%	50%	35%	20 %	
Amount of flaky particles	11,4 t/h	4,0 t/h	16,1 t/h	19,1 t/h	50,5 t/h
Product flakiness					**29,3 %**

Origin of end product and its flakiness

From these tables, it can be seen that a major portion of the final product, 4-16mm, is produced in stages other than the tertiary one. Some 20% of the final product originates either in feed or primary crushing, which explains the poor flakiness of the final product, since the flaky primary product spoils the higher quality aggregate emerging from the tertiary stage.

On the other hand, the process could be conducted differently, as shown in the next figure.



Production of 0-16mm at a maximum rate of 175 t/h

The tonnage of 0-16mm is 80 tons/h less than in the previous example, but its quality is considerably better. As can be seen from table 3, the reason for this lies in the origin of the 4-16 mm product being 100% tertiary cone, while 4-16 mm fraction from the feed and the primary crusher is not allowed to enter the final product and spoil it. On the contrary, this product is recrushed to achieve a better shape which, since this uses up capacity, makes the total tonnage 80 t/h less.

Origin of End Product					
	Feed	**C125**	**GP200S**	**GP300**	**Product**
0-4	0,0 t/h	0,0 t/h	26,4 t/h	49,6 t/h	76,0 t/h
4-16	0,0 t/h	0,0 t/h	0,0 t/h	98,8 t/h	98,8 t/h
0-4	0,0 %	0,0 %	34,7 %	65,3 %	100,0 %
4-16	0,0 %	0,0 %	0,0 %	100,0 %	100,0 %

For STPH multiply by 1.1

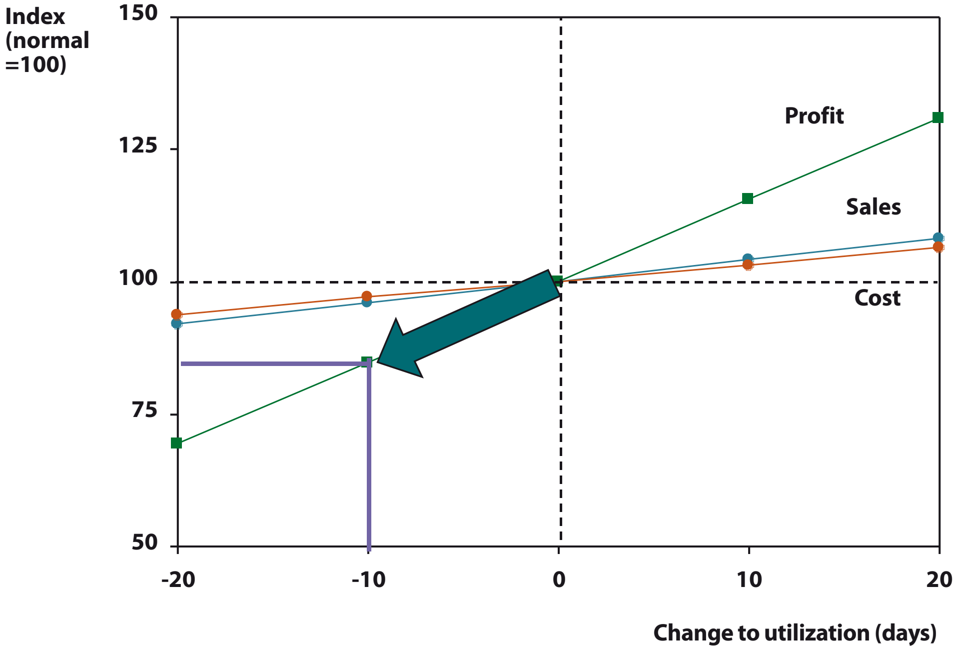
Product Flakiness					
	Feed	**C125**	**GP200S**	**GP300**	**Product**
Origin of 4-16 fraction	0,0 %	0,0 %	0,0 %	100,0 %	100,0 %
Amount of 4-16 fraction	0,0 t/h	0,0 t/h	0,0 t/h	98,8 t/h	98,8 t/h
Estimated flakiness of 4-16 fraction	50 %	50 %	30 %	14 %	
Amount of flaky particles	0,0 t/h	0,0 t/h	0,0 t/h	13,8 t/h	13,8 t/h
Product flakiness					**14,0 %**

Origin of end product and its flakiness

Conclusion regarding process optimization and influencing to end product

These few, simplified examples clearly indicate two main findings:

- The flowsheet and lay-out must be correct in order to produce the right aggregate amounts and fulfill the specifications. If this is not performed correctly in the first instance, later modifications, albeit possible, will prove expensive.
- Running the process using optimal parameters in the equipment can make a real difference in terms of financial success. Achieving this requires the continuous monitoring and adjustment of the equipment and process. Additionally, high availability and utilization rates are a MUST, otherwise the process will become non-viable with a few days. Figure below presents a simplified illustration of this process, based on a €4.5M plant investment.



Impact of utilization on profit

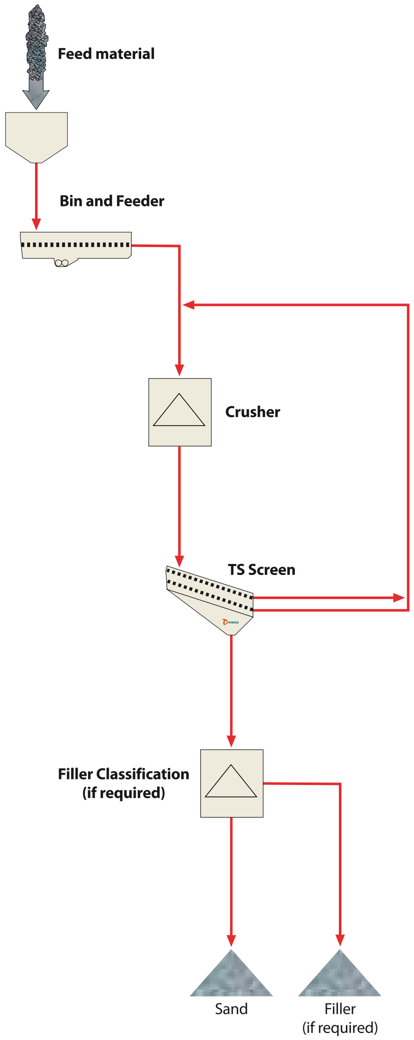
As seen above, the changes in utilization have a strong impact on profit, entailing that a ten day stoppage can wipe out the entire annual profit.

Metso Sand Solution

Globally, the access to natural sand is becoming more difficult and increasingly costly. To meet the shortfall, Metso Minerals has developed the most comprehensive solution offering to meet all customers' requirements for sand production. We have drawn on our global experience in providing world-class manufactured sand solutions that will provide products to enhance our customers' marketability.

Circuit Selection

To ensure the highest quality of sand is produced, all feed material must pass the crusher at least once, as shown in figure below. The selection of crusher is detailed below in next table. The preferred circuit selection is post screen closed circuit. Over-sized material is re-circulated back to the crusher for further reduction.



Circuit Selection
The TS range of elliptical motion screens is the preferred screen due to their high efficiency in material throughput and accurate separation.

Manufactured sand typically contains too much fines in the region between 0-0,25mm compared to concrete grading specification envelope widely used in the industry.

This is outside the practical operation range for most conventional vibrating screens, so the traditional way to remove these fines has been using wet process equipment such as sandwheels or hydrocyclones.

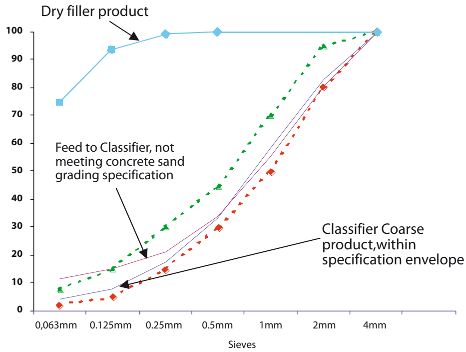
The Nordberg AC Series Air Classifier range uses air instead of water to remove the excess fines out of manufactured sand. The advantages are mainly:

No need for water and subsequently no need for water treatment or recovery, which can be a costly procedure.

Dry end products means potential savings in production cost as there is less need for drying for example in asphalt production.

Operating principle of the AC27/AC30 Gravitational Inertial Classifier.

Two AC 27 working in parallel with a joint capacity of 150 tph.



Typical particle size distributions of feed and products using gravitational inertial air classifier.

Crusher Selection

Crusher selection is based on the abrasiveness of the source rock, feed fraction to the circuit and the nature of the sand required. In an application where there is a long feed curve (i.e. X-0mm) then VSI crushing is the preferred method. Where the feed fraction is shorter (i.e. X –Y) then high speed compression crushing can be applied. Next table 1 shows the range of parameters for selection of a suitable crusher.

Key criteria in selection of crushing equipment, which are heavily related to final application like concrete and asphalt, are:

- Product quality
- Consistency
- Yield
- Operating costs
- Filler generation

Application: Concrete / Mortar						
Sand Requirement:		**Rounded Cubical Shape**				
	Minus 5mm	**Minus 12.5mm**	**Minus 25mm**	**Pea Gravel**	**12.5 -5mm**	**25 - 5mm**
Soft Rock*						
Medium Rock**	Barmac B-series					
Hard Rock***						

Application: Concrete / Mortar						
Sand Requirement:		**Angular Cubical Shape**				
	Minus 5mm	**Minus 12.5mm**	**Minus 25mm**	**Pea Gravel**	**12.5 -5mm**	**25 - 5mm**
Soft Rock*				HP / GP		
Medium Rock**	Barmac B-series			HP / GP		
Hard Rock***				HP / GP		

Application: Asphalt						
Sand Requirement:		**Angular Shape**				
	Minus 5mm	**Minus 12.5mm**	**Minus 25mm**	**Pea Gravel**	**12.5 -5mm**	**25 - 5mm**
Soft Rock*				HP / GP		
Medium Rock**	Barmac B-series			HP / GP		
Hard Rock***				HP / GP		

For inches divide by 25,4

Notes:
** Abrasiveness <500 g/t*
*** Abrasiveness 500 –1000 g/t*
**** Abrasiveness >1000 g/t*

Barmac B-series: rock on rock configuration
HP / GP: Metso high performance cone crushers
Pea Gravel: consists of small, smooth, rounded stones. Typically 3-12,5 mm by size.

Influencing crushing plant costs & revenues

The flowsheet below depicts a typical mobile plant which is capable of producing different fractions depending on the screen openings. The fractions produced by this plant are as follows:

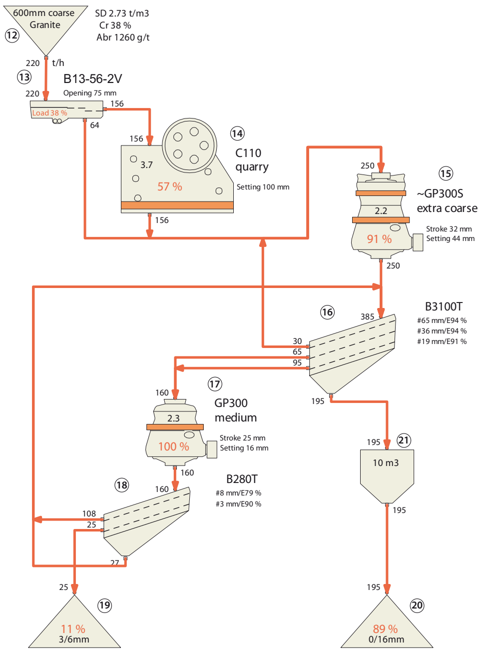
- 0-12 mm and 8-16 mm
- 3-6 mm and 0-16 mm
- 3-6 mm and 0-31 mm
- 8-16 mm and 0-63 mm
- 8-16 mm and 0-90 mm

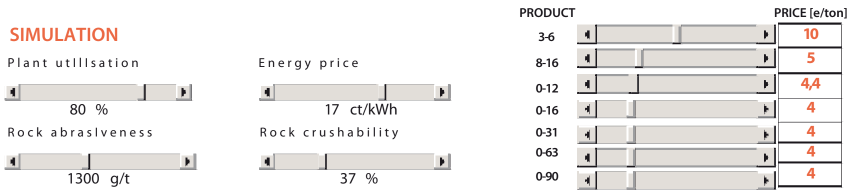
The variables used in the analysis are as follows:

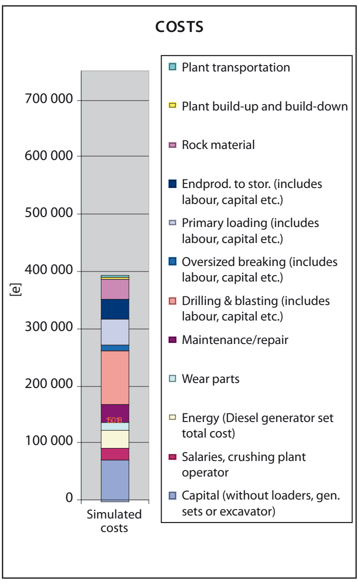
- plant utilization rate or availability
- energy cost
- abrasiveness of the rock
- hardness of the rock

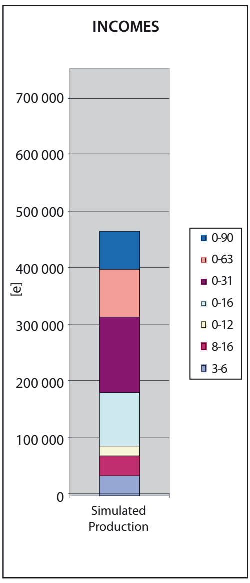
Plant production was 110,000 tons at an 80% utilization rate and the production amounts of different fractions were constant.

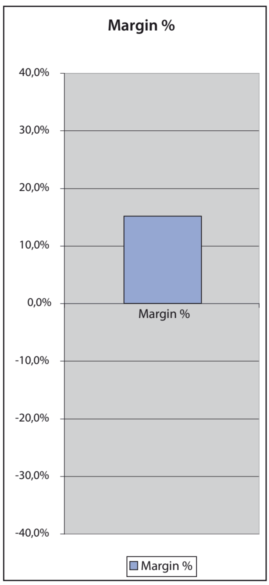
As a basis for the plant's configuration, the configuration economy was as follows





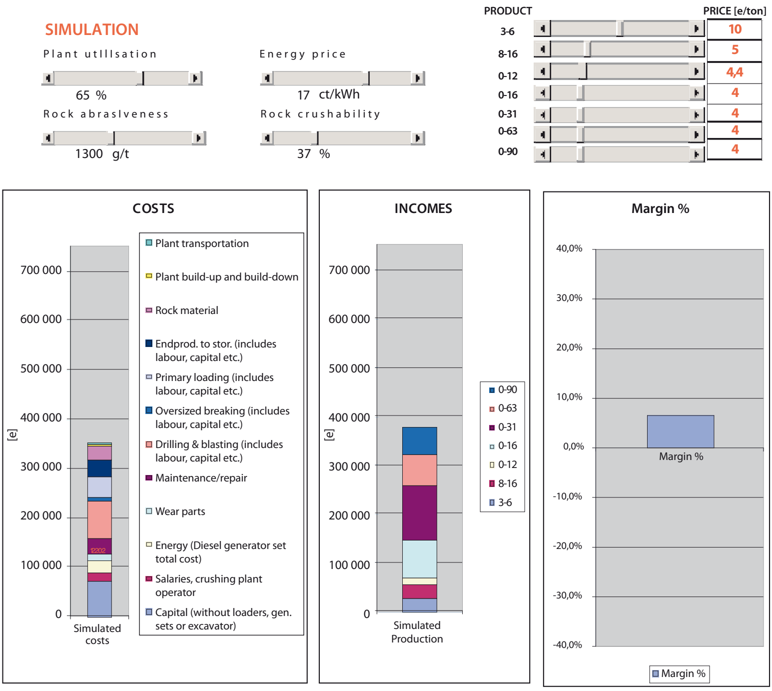




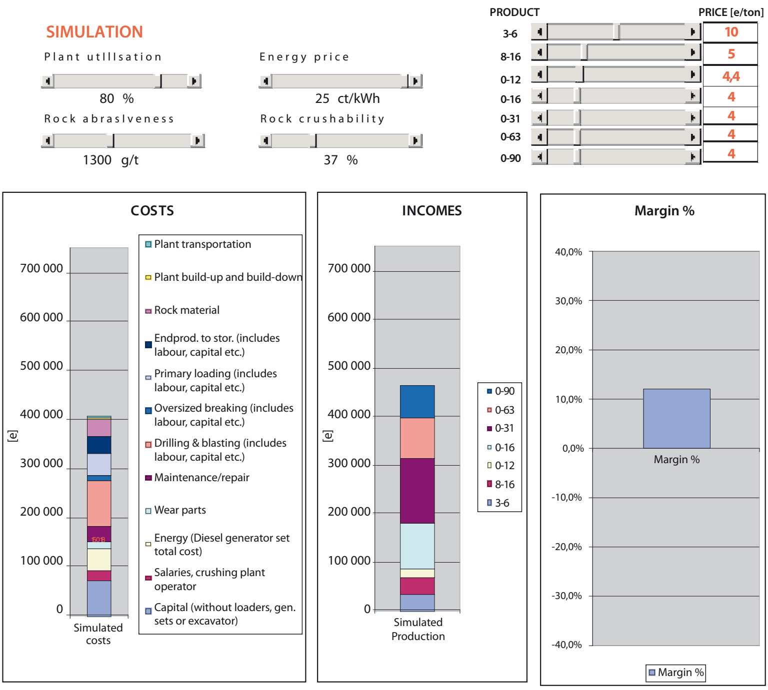


In the following figures, the changes given below were made:

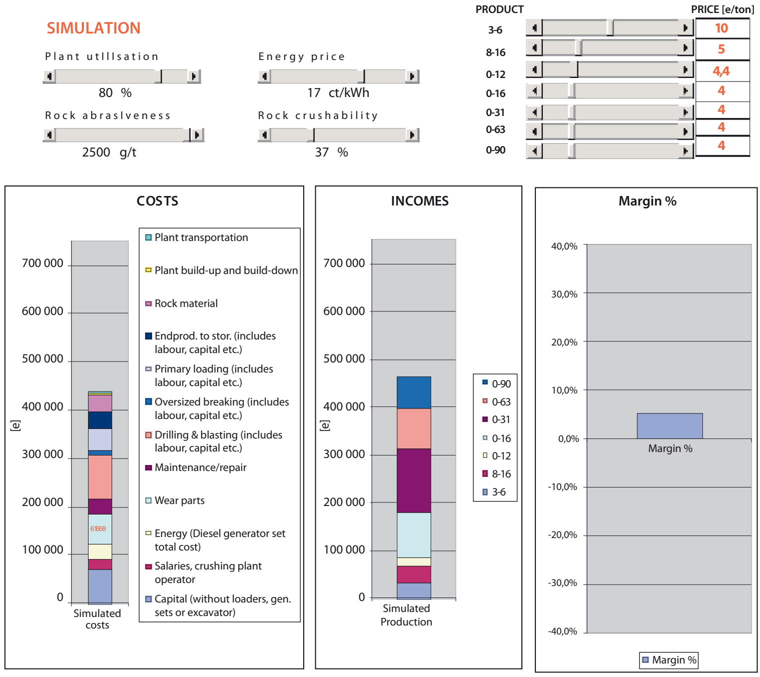
- utilization rate of 80% -> 65%
- energy price +50%
- Abrasiveness of rock +50% (from medium to high abrasiveness)
- Hardness of rock from medium to hard



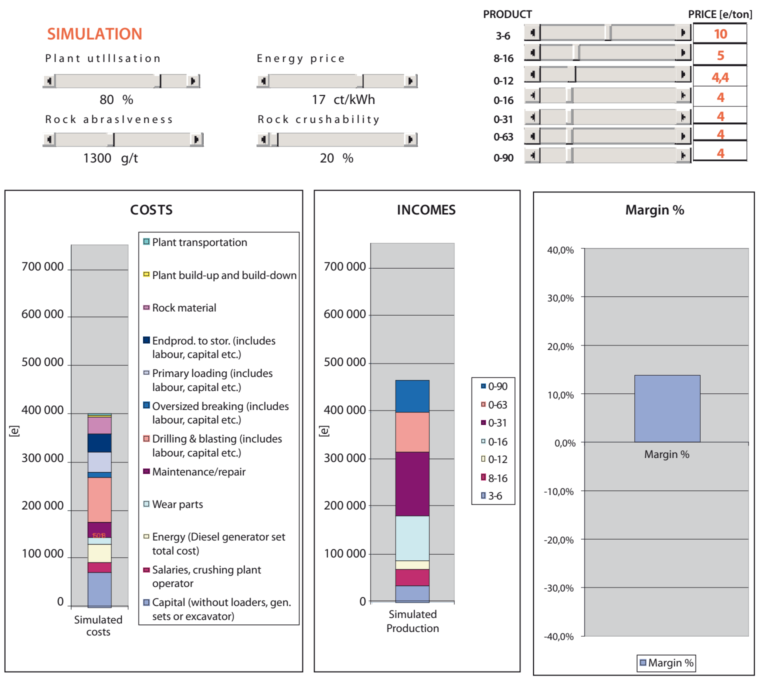
Utilization rate of 80% -> 65%



Energy price +50%



Abrasiveness of rock +50% (from medium to high abrasiveness)



Hardness of the rock from medium to hard

In conclusion, two major factors determine profitability with a given production split and sales price between different fractions. These factors are plant utilization rate/availability and wear part costs, both of which place a great deal of pressure on the timing of wear part changes, so that wear parts are used as much as possible and plant downtime is kept to a minimum. A reduction in the utilization rate can easily prove fatal to annual profitability. Of course, this varies depending on the plant setup and cost structure.

Bruno crushing process simulation

The basic objective of crushing process planning is to be able to define a process that fulfils the end-product quality and quantity requirements reliably and economically. The increasing mobility of crushing equipment sets new requirements. The machines initially optimized for certain process are also expected to fit in other applications with acceptable performance.

Bruno is an easy-to-use software tool for planning and simulating the crushing process. With Bruno you can quickly explore various machine combinations for certain application or find out whether the existing machines are suitable for other applications.

The calculation model

The core knowledge in Bruno is reliable modelling of a unit machine. The basis is extensive amount of field test data of all types of crushers in various applications. The tests revealed the process of turning the feed into the product. The process outcome is called machine performance.

There are two leading principles in modelling a machine performance in Bruno:

1. The performance depends on the same settings and adjustments as in real life.
2. The performance related variables are all linked together.

In Bruno there are two sets of input parameters (Figure 1), machine parameters and process parameters. In real life some of them can be controlled and the rest depend on the crushing site, application etc. Nevertheless the parameters together determine the crusher performance, which is described by product grading, throughput, and power consumption.

Because all the parameters are linked together, the change in just one of them has effect on all three performance key figures. Naturally every input parameter does not have similar impact on the results, but there is no such parameter that would change only one of the key figures.

In the figure 2, only change is feed material crushability. It reduces throughput by 25%, it makes the product finer and power requirement becomes 45% lower.

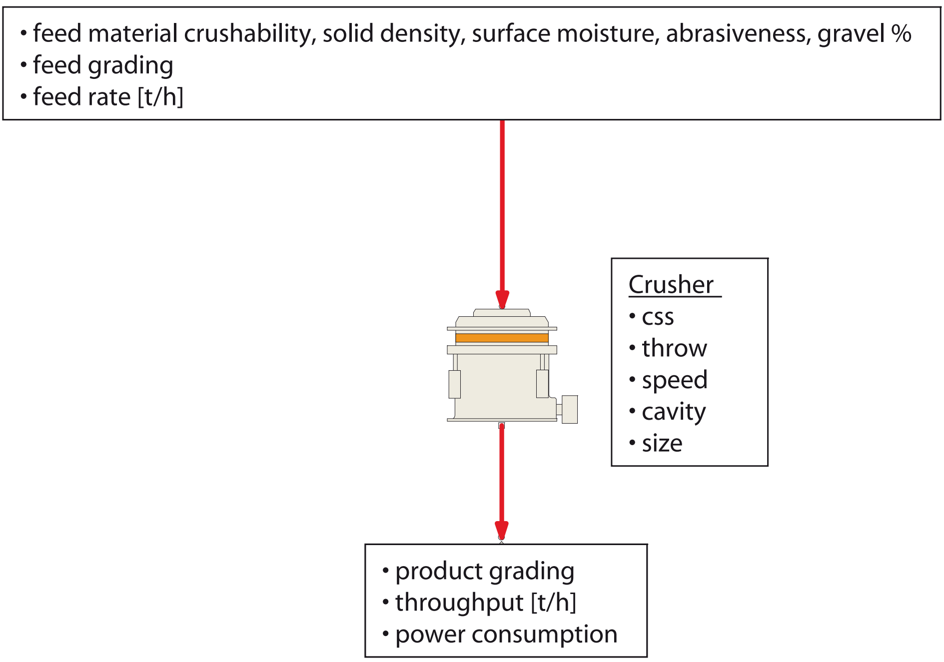


Figure 1. Inputs and outputs of a crusher performance calculation model.

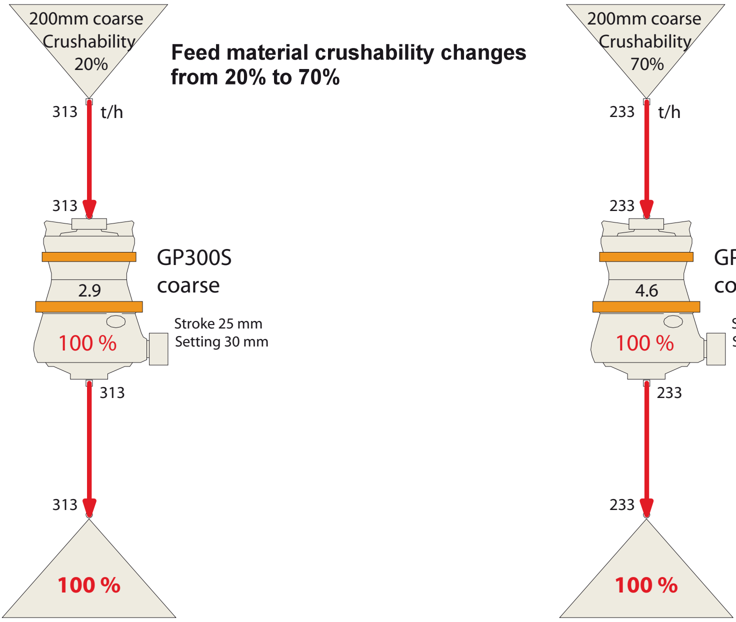


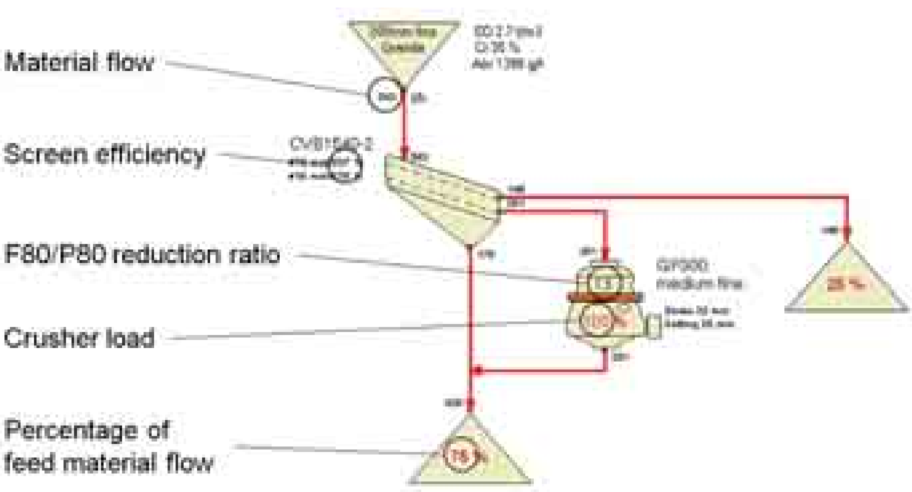
Figure 2. Change in feed material crushability.

When unit machines are compiled as a process, the importance of realistic results will be emphasized. The process parameters – the feed related parameters – come from the preceding process. If there is a clear error in some result, it will affect the process performance.

Process simulation

Bruno can handle basically any crushing process a user can define. User can also use process library to find applicable process configuration for certain purpose. Bruno finds a mass balance of the process and calculates the following results:

- Material flow for each connection between process machines
- Load for each screen and crusher in the process
- Particle size distribution for each material flow
- Power consumption for each machine
- Screening efficiency for screens and grizzly feeders



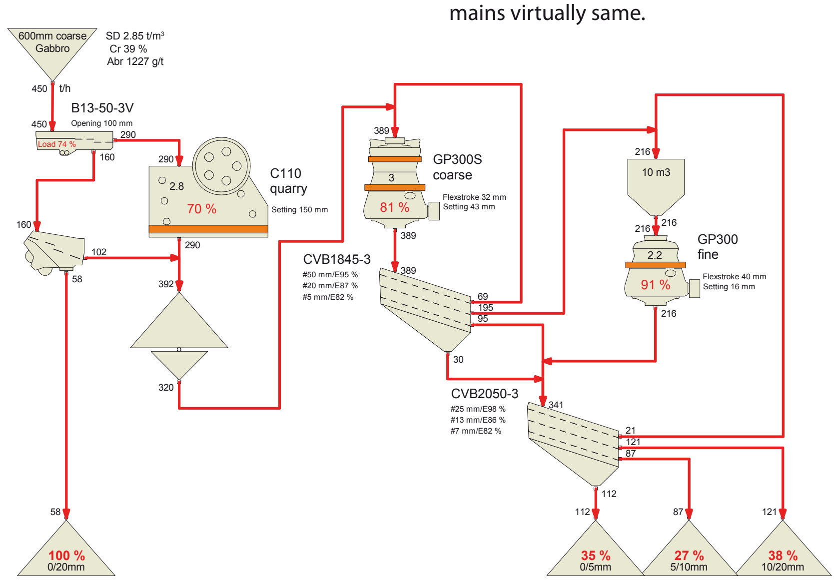
From the results it is easy to see how well the process meets the planned requirements. Typically the most interesting result is the amount of each product. Crusher loads and material flows in the closed circuits reflect the process balancing. Crusher load and reduction ratio together gives an indication of attainable product shape.

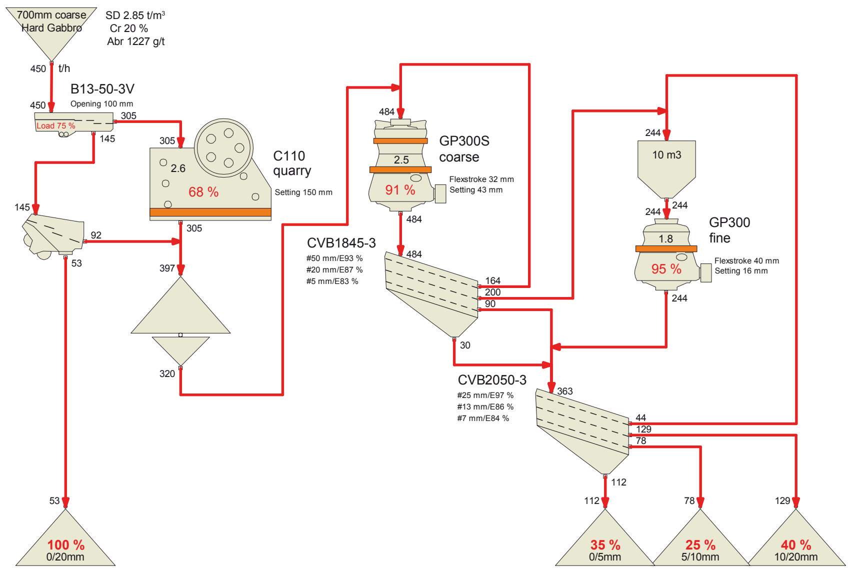
Bruno does not evaluate the process usefulness as such, but it gives warnings about exceeding machines' physical limits such as maximum intake particle size. If the process can not be balanced, it also causes on error. Other deficiencies have to be interpreted from the results.

The example process has originally been designed for 320t/h capacity producing asphalt aggregates from crushability 40 Gabbro and 0 - 600mm feed.

When feed material crushability changes from 40% to 20% and feed grading becomes 0 - 700mm, secondary and tertiary crusher loads increase. Harder material turns crusher product coarser, which increases the load of the closed circuits. Also kW/ton of product raises due to harder material.

When only final products are considered, the change in feed properties does not have significant effect. The amount of each product remains virtually same.





Complete systems engineered to different applications

In over a quarter century of operations, Metso has provided crushing solutions to an immensely broad range of customers. As a result, we've certainly learned a few things along the way when it comes to identifying what works best and what doesn't.

Our systems have been engineered to suit an incredibly diverse spectrum of applications in the mining and aggregates industries. And because our engineers have been busy designing systems for customers more than a century, it's more than likely that Metso has the system that's just right for application in question.

Customer can benefit of our engineering expertise

Great benefit of engineering expertise is that has been developed to match to different regional standards. Customers get machines and parts that have been built to precise engineering specifications that are tried, tested and proven, thus reducing investment risk factor. Erection and commissioning lead times are significantly reduced, leading to a faster return on investment and also lower operating costs as a result of these reduced operating costs per ton.

Technology and quality to give the lowest cost per ton

Customers are invited to participate in the creation of their crushing plant throughout the entire project. They will participate in the initial system application development, engineering design, project planning, plant commissioning, operations and maintenance training and the final handover and acceptance of the project.

New, complete systems always require considerable investment. Customers need total commitment from your supplier to support the whole project application requirements, capacity plans and payback time. Metso fully commits to a plant design that will optimize the investment, and will ensure an economical payback period.

Efficient cost control of a complete installation is a vital issue after the commissioning of a plant. Based on large volumes of data gathered from complete systems through many decades, Metso is able to reach the operating costs discussed during the initial plant design stage.

Automation systems for remote controlling

Crushing plants in most cases are remote from the management's view. Metso is creating automation systems that allow management to follow the process from remote places using the latest communication technology.

In joining the cost reduction race, customers are demanding more sophisticated technology to perform real time plant diagnosis that will allow them to optimize their plant maintenance and reduce down time. Metso automation systems provide plants with the right tools to monitor the whole process accurately.

To assist in maintenance planning, our plant automation systems can provide real time plant process data and also monitor machine parameters, all of which are necessary input for the proper planning and control of plant maintenance. Production reporting is also available as part of this automation package.

Proven design expertise

Metso has the experience of several decades in planning of complete crushing and screening systems. This makes us the most proven provider of plant design.

With each plant being different, Metso uses state of the art digital design to lay out and

adapt each customer's plant design to his unique site. Our modern Valpro software guarantees quicker and more accurate plant design.

Quality certified manufacturing management

Being ISO9001-V2000 certified and working to these standards, Metso ensures the same quality and professionalism to the systems projects as seen in our production facilities.

Thorough rock fragmentation knowledge

Input from our extended sales network and our global expertise provides Metso with a thorough knowledge base of plant feed materials and their characteristics.

This information enables Metso to predict how the customers feed material will react to the communication process and is considered and incorporated in all design aspects of a plant system.

The use of latest technology in the crushing and screening process continues to push plant design boundaries. Metso can provide flowsheet design that combines creativity and cost effectiveness.

More and more markets around the world are demanding that their end products meet stringent shape and calibration standards. Metso is capable of achieving these standards using their high quality crushing equipment.

Complete stationary or mobile plants

Besides offering complete stationary installations, Metso is the pioneer in fully mobile in-pit crushing operation. Integrating two or three mobile crushing plants combined with a mobile screen and a mobile conveying system results in improved efficiency and end-product accuracy.

We have the expertise to build a fleet of track mounted crushing and screening plants for primary, secondary and tertiary stages according to application. Moving along the quarry face the track-mounted units replace dump truck haulage, thus achieving substantial savings. The whole mobile plant can be moved from site to site on standard trailers.

This is one example of how our worldwide process know-how can serve crushing, screening and conveying needs.

Minerals research and test centers

Our minerals research and test centers provide both in-house and field testing data on capacity, product distribution and the amount of power required to crush specific material. Crushing and grinding of customer materials are conducted on in-house crushing circuit facilities.

Sophisticated and highly accurate test procedures on customer rock and mineral samples determine material characteristics such as crushability, impact strength, abrasion resistance, brittleness and flakiness. All this valuable information is used to match the right reduction machinery precisely to the material being tested.

Universities, government agencies and scientific institutions also turn to Metso for our research expertise.

Mobile crushing and screening plants

Mobile crushing equipment can not only replace stationary systems – it can also eliminate the use of haulers and reduce staffing.

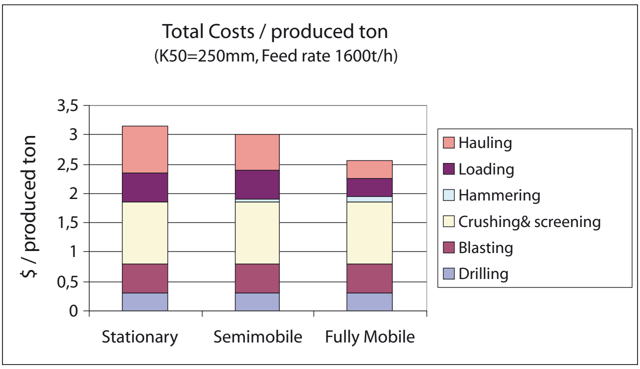
The current trend in quarrying is targeting broadly towards mobile systems and solutions. Current may be an exaggeration, as mobile tracked crushing plants that work at the rock face have been around for 20 years, but the quarrying and mining businesses doesn't like to rush into things, and only now are mobile crushers challenging stationary crushing plants.

Stationary primary crushers, as their name suggests, are permanently located in one site, often some distance from the quarry or mine work face, and are serviced with rock/ore by a system of attendant off-highway haulers. Although effective, one issue with this approach is the cost of the haulage – which can represent more than half of *all* costs (drilling, blasting, loading, crushing etc).

With a continual need to increase efficiency and reduce costs, mine and quarry owners have, rightly, seen haulage as an area where cost reductions can be made. These savings have been achieved by moving the fixed primary crusher into the quarry/pit – thereby reducing the haul distance – and replacing older smaller haulers with larger, newer ones. But this is, at best, only a halfway measure – why not eliminate the haul (and the haulers) altogether? Mobile crushing equipment allows this to happen.

On the move

The main advantages of mobile, track-mounted primary crushing plants are their ability to maximise productivity and reduce operating costs – while at the same time increasing safety and reducing environmental impact. While the concept of mobile and semi mobile primary crushers has been around for a long time, many of these were so heavy (up to 1,500 t) and needed so much planning to move them that they were



seldom relocated – making them once again effectively permanent facilities.

Mobility is no substitute for effective crushing and tracked mobile crushers should meet the same basic criteria as stationary plants. The ability to crush the largest lumps normally received, to the desired cubicity and at the desired rate are all 'must-have' rather than 'nice-to-have' attributes. The plants should also be easy to use and maintain - and enjoy high availability and a long life cycle. The basic components of a mobile tracked crushing plant are almost the same as for a stationary one (jaw or impactor crusher, power unit, vibrating grizzly feeder, feed hopper etc) but with the added advantage of complete mobility – even up slopes as steep as 1:10 incline.

But it doesn't have to be just the primary crusher that is mobile – Metso's Lokotrack mobile crushing plants can be built with two, three or even four different crushing and screening stages. While it is true that in terms of spares and maintenance there are more hydraulics, engine and electronic components with mobile crushers, these are generally well supported by the OEM engine manufacturer or the crusher manufacturers themselves.

Intelligent controlling technology provides optimum, continuous screening results

Metso is the first manufacturer to incorporate the revolutionary SmartScreen™ technology into it's track-mounted mobile screens (Lokotrack ST272, ST352, ST358, ST458, ST620 and ST620F). With its intelligent controller, the IC system supervises and adjusts the unit automatically for optimum, continuous screening results.

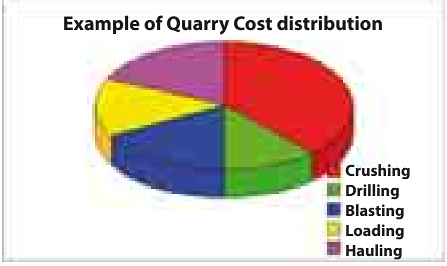
For the customer, this automation technology provides increased efficiency and reliability, higher production, easier operation, a reduced need for manpower and thus more profitable screening contracts.

IC technology also means it is possible to link the whole mobile crushing and screening process together with this intelligent control system.

Quick and easy positioning

But where track-mounted crushing systems really come into their own is their ability to be positioned right at the work face; and then be relocated (when blasting, for example) – under their own power - in as little as 20 minutes. It is intuitively a good solution, in terms of optimised productivity and lowest operating costs, for the crushing equipment to be sited at the rock face.

Using haulers can be very inefficient: especially when the largest haulers can expend up to 60% of their energy just propelling the vehicle's own weight – with only 40% used for moving the blasted rock. When you also consider that by default the hauler is empty for half its operational cycle their inherent inefficiencies becomes apparent.



Conveyors are much more economical than using haulers (at 80% efficiency) and there is no limit on their length (30 km+ is not uncommon

in open cast mines). But even here tracked mobile conveyors can play a part, in providing the flexible link between mobile crushing plant and stationary conveyor. They work over shorter distances (in the Lokolink Belt Conveying System they are built up in 42 m sections) than stationary conveyors and contain far fewer parts - as well as having a lower spare parts consumption – than off highway haulers.

The main benefit, however, is their ability to be quickly relocated - made possible by connecting the Lokolink conveyor to the Lokotrack crushing plant, which in turn moves the whole assembly. This rapid relocation reduces downtime when blasting and changing location within the pit.

Over 30% cost savings available

The potential cost savings from using a mobile crushing and conveying system based at the rock face are significant: a study conducted by Tampere University in Finland found a 31% cost saving over semi-mobile installations in similar applications. The savings over using haulers is greater, as the excavators or wheel loaders used for feeding the haulers can be downsized (to ones more suited to the crusher rather than the hauler); labour costs are reduced too as there are no longer hauler operators to employ. In terms of manpower, the excavator or wheel loader operator can control the complete crushing operation. Fuel usage is also drastically reduced and there is also no longer a need to build elaborate and well maintained haul roads – a significant additional (and ongoing) expense.

With a similar lifespan to that of stationary systems (the first LT160 unit Metso supplied generated 65,000 hours over 10 years, with still a 'second life' ahead of it away from front line operation) mobile plants have few disadvantages. There are even significant environmental advantages of using a mobile system: eliminating haulers reduces noise, vibrations and emissions - and fuel. Safety too is enhanced, as fast moving vehicles play a significant role in site accident statistics.

Mobile systems will not totally replace the stationary variety. In quarries where supply is large (>500,000 tpa) and constant in a small radius the stationary plant *is* justified. But where supply is not large then mobile plants have the advantage of being able to circulate between locations and build up stockpiles. In mining, the advantages of having a primary crusher feeding a conveyor system are becoming more recognised as an effective solution.

Once this is fully established the industry will move to a mobile second stage and finally third stage of crushing. The UK is already at this third stage, whereas the US has been catching up fast from a late start.

Worldwide, Metso has sold well over 5,000 tracked crushing plants since it introduced the concept in the mid 1980s. The adoption of a Lokotrack/Lokolink/Field Conveyor system at a quarry in the UK for client Tarmac has delivered savings of over 50% compared to the previous blast and haul method.

With their lower capital and operating costs, flexibility of siting and elimination of the need for haulers and haul roads, mobile crushing plants offer an attractive alternative to the traditional stationary crusher & hauler system. The reduction in manpower, fuel usage and pollution is mirrored by an increase in health and safety.

Offering higher productivity and low cost per tonne production, truly mobile tracked crushing plants are destined to become a more common sight in quarries and mines worldwide.


JCB

Lokotrack

Lokotrack LT110

- modern, modular design for easy use and service
- proven C110 jaw crusher
- several feeder options
- newest process controlling with IC700 automation system
- wide range of options to suit each application

Unit components

Crusher

Nordberg C110 jaw crusher

– Feed opening	1100 x 850	mm	(44 x 34 in)
– Setting range	70-170	mm	(2 3/4"–7") (hard rock)
– Setting range	40-170	mm	(1 1/2"–7") (recycling)

Feeder

Feed hopper

– Volume	7	m^3	(9 yd^3)
– Width	2750	mm	(108")

Nordberg VF544-2V grizzly feeder

– Length	4 400	mm	(14'5")
– Width	1 300	mm	(51")

PF525 pan feeder & VG527-2V scalper (option)

– PF525 length:	2 500	mm	(8'3")
– PF525 width:	1 300	mm	(51")
– VG527-2V length:	2 700	mm	(8' 10")
– VG527-2V width:	1 300	mm	(51")

Main discharge conveyor H14-12

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11'6")

Main discharge conveyor H14-16 (option)

– Belt width	1 400	mm	(55")
– Discharge height	4.7	m	(15'5")

Side conveyor H8-10

– Belt width	800	mm	(32")
– Discharge height	3,7	m	(12'1")

Engine

- – Caterpillar C-13
- – Power 310 kW (415 hp)
- – Tier 3 approved
- – Crusher is driven directly
- – Other drives hydraulic

Max capacity: 900 mtph (1000 stph)

Dimensions

(Transport, standard unit)

Length:	17 400	mm	57'
Width:	3 500	mm	11' 6"
Height:	3 800	mm	12' 6"
Weight:	66 000	kg	145.500 lbs.

Quarry Lokotracks

Lokotrack

Lokotrack LT3054

- modular design for easy use and service
- proven C3054 wide jaw crusher
- several feeder options
- newest process controlling with IC700 automation system
- wide range of options to suit each application

Unit components

Crusher

Nordberg C3054 jaw crusher

– Feed opening	1375 x 760	mm	(54 x 30")
– Setting range	70-170	mm	(2 3/4"–7") (hard rock)

Feeder

Feed hopper

– Volume	7	m³	(9 yd³)
– Width	2750	mm	(108")

Nordberg VF544-2V grizzly feeder

– Length	4 400	mm	(14'5")
– Width	1 300	mm	(51")

PF525 pan feeder & VG527-2V scalper (option)

– PF525 length:	2 500	mm	(8' 3")
– PF525 width:	1 300	mm	(51")
– VG527-2V length:	2 700	mm	(8' 10")
– VG527-2V width:	1 300	mm	(51")

Main discharge conveyor H14-12

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11' 6")

Main discharge conveyor H14-16 (option)

– Belt width	1 400	mm	(55")
– Discharge height	4.7	m	(15' 5")

Side conveyor H8-10

– Belt width	800	mm	(32")
– Discharge height	3,65	m	(11' 12")

Engine

– Caterpillar C-13

– Power 310 kW (415 hp)

– Tier 3 approved

– Crusher is driven directly

– Other drives hydraulic

Max capacity: 900 mtph (1000 stph)

Dimensions

(Transport, standard unit)

Length:	17 400	mm	57'
Width:	3 500	mm	11' 6"
Height:	3 800	mm	12' 6"
Weight:	66 000	kg	143.000 lbs.

Lokotrack

Lokotrack LT125

- superior versatility in its class
- heavy duty design and ease of transportation from site to site
- "Split" model available for rapid installation
- high performance and flexibility
- a wide range of options

Unit components

Crusher
Nordberg C125 jaw crusher
– Feed opening 1250 x 950 mm (49 x 34 in)

Feeder
B13-44-2V

Feed hopper		
– Volume	7 m³	(10 yd³)
– Width	3100 mm	(10' 2")

Nordberg B13-44-2V grizzly feeder		
– Length	4 400 mm	(14' 5")
– Width	1 300 mm	(51")

Main discharge conveyor H14-11		
– Belt width	1 400 mm	(55")

Side conveyor H6.5-8		
– Belt width	650 mm	(25")
– Conveyor height	3100 mm	(120")

Engine		
– Caterpillar C-12		
– Power	317 kW	(430 hp)

Feeder
B13-50-3V

Feed hopper		
– Volume	11 m³	(15 yd³)
– Width	3350 mm	(11')

Nordberg B13-50-3V grizzly feeder		
– Length	5 000 mm	(16' 5")
– Width	1 300 mm	(51")

Main discharge conveyor H14-11		
– Belt width	1 400 mm	(55")

Side conveyor H6.5-8		
– Belt width	650 mm	(25")
– Conveyor height	3100 mm	(120")

Engine		
– Caterpillar C-12		
– Power	317 kW	(430 hp)

Dimensions

(Transport, standard unit)

Length:	15 430 mm	50' 7"
Width:	3 500 mm	11' 6"
Height:	3 800 mm	12' 6"
Weight:	86 000 kg	189.000 lbs.

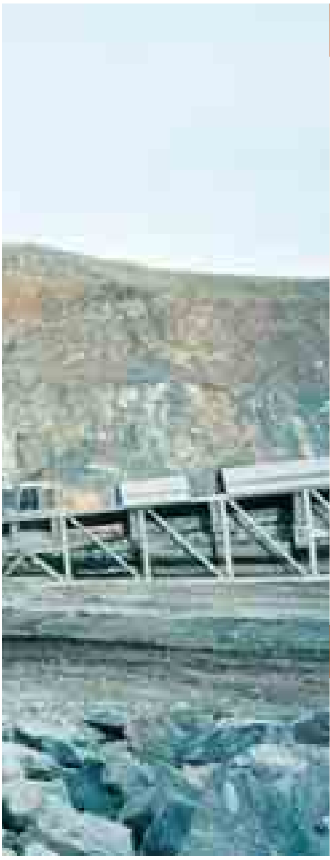
(Transport, standard unit)

Length:	16 000 mm	52' 6"
Width:	3 500 mm	11' 6"
Height:	4 430 mm	14' 6"
Weight:	86 000 kg	189.000 lbs.

Lokotrack

Lokotrack LT140

- a perfect combination with the LL mobile conveyor
- exceptional crushing capacity with the powerful C140 jaw crusher
- robust and reliable technology
- substantial savings in in-pit crushing applications



Unit components

Crusher
Nordberg C140 jaw crusher

– Feed	1400x1070 mm	(37x49 in)

Feeder
Feed hopper

– Volume	12 m³	(17 yd³)
– Width	3430 mm	(11' 3")

Nordberg B16-50-3V grizzly feeder

– Length	5 000 mm	(16' 5")
– Width	1 600 mm	(63")

Main discharge conveyor H14-11

– Belt width	1 400 mm	(55")

Side conveyor

– Belt width	800 mm	(31")
– Conveyor height	3300 mm	(130")

Engine
– Caterpillar C-15

– Power	390 kW	(530 hp)

Dimensions

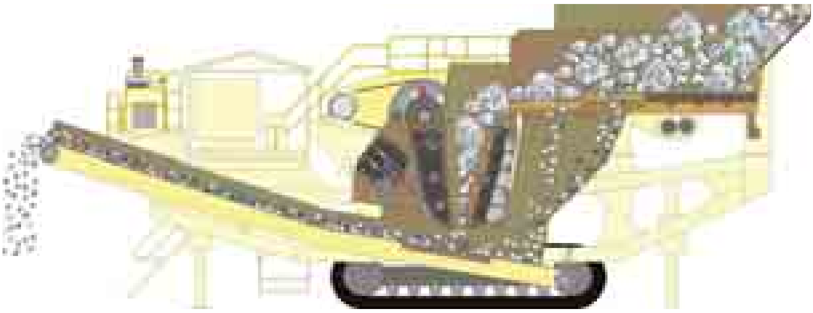
(Transport, standard unit)

Length:	15 700 mm	51' 9"
Width:	3 500 mm	11' 6"
Height:	3 800 mm	12' 6"
Weight:	111 000 kg	245.000 lbs

Lokotrack

Lokotrack LT160

- high capacity for large scale quarrying and mining operations
- extra heavy duty but still fully mobile
- highly efficient mobile crushing
- reliability in demanding, continuous operations



Unit components

Crusher
Nordberg C160 jaw crusher

– Feed	1600x1200 mm	(47x63 in)

Feeder
Feed hopper

– Volume	20 m³	(27 yd³)
– Width	3800 mm	(12' 6")

Nordberg B20-66-2V grizzly feeder

– Length	6 600 mm	(21' 8")
– Width	2 000 mm	(79")

Main discharge conveyor H18-13

– Belt width	1 800 mm	(71")

Side conveyor

– Belt width	800 mm	(31")
– Conveyor height	4000 mm	(155")

Engine
– Caterpillar C-16

– Power	445 kW	(605 hp)

Dimensions

(Transport, standard unit)

Length:	19 500 mm	63' 1"
Width:	3 500 mm	11' 6"
Height:	3 800 mm	12' 6"
Weight:	215 000 kg	473.000 lbs.

Quarry Lokotracks

Lokotrack

Lokotrack LT1315

- modern, modular design
- powerful NP1315M impact crusher
- advanced IC700 automation system
- several feeder options

Unit components

Crusher

Nordberg NP1315 impact crusher

– Feed opening	1540x930	mm	(60 x 36 in)
– Setting range (quarrying):	60-150	mm	(2 2/4" – 6")
– Rotor speed:	450-560	rpm	

Feeder

Feed hopper

– Volume	8	m^3	(10 yd^3)
– Width	2750	mm	(108")

PF525 pan feeder & VG527-2V scalper (option)

– PF525 length:	2 500	mm	(8' 3")
– PF525 width:	1 300	mm	(51”)
– VG527-2V length:	2 700	mm	(8' 10")
– VG527-2V width:	1 300	mm	(51")

Main discharge conveyor H14-12

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11' 6")

Main discharge conveyor H14-10R & TK14-27 (option)

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11' 6”)

Side conveyor H8-10

– Belt width	800	mm	(32")
– Discharge height	3,65	m	(11' 12")

Engine

- – Caterpillar C-15
- – Power 403 kW (540 hp)
- – Tier 3 approved
- – Crusher is driven directly
- – Other drives hydraulic

Max capacity: 900 mtph (1000 stph)

Dimensions

(Transport, standard unit)

Length:	18 000	mm	60'
Width:	3 500	mm	11' 6"
Height:	3 800	mm	12' 6"
Weight:	60 000	kg	132.000 lbs.

Lokotrack

Lokotrack LT1415

- proven, reliable and modular design
- an impactor with a feed size of up to 1000 mm
- high capacity for quarry and in-pit operations
- advanced IC700 automation system
- easy service and hammer change

Unit components

Crusher

Nordberg NP1415 impact crusher

– Feed opening	1540x1320	mm	(60x52 in)
– Setting range (quarrying):	60-200	mm	(2 3/4" – 8")
– Rotor speed:	450-560	rpm	

Feeder

Feed hopper

– Volume	8	m³	(10 yd³)
– Width	2750	mm	(108")

PF525 pan feeder & VG527-2V scalper (option)

– PF525 length:	2 500	mm	(8' 3")
– PF525 width:	1 300	mm	(51")
– VG527-2V length:	2 700	mm	(8' 10")
– VG527-2V width:	1 300	mm	(51")

Main discharge conveyor H14-12

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11' 6")

Main discharge conveyor H14-10R & TK14-27 (option)

– Belt width	1 400	mm	(55")
– Discharge height	3.5	m	(11' 6")

Side conveyor H8-10

– Belt width	800	mm	(32")
– Discharge height	3,65	m	(11'12")

Engine

- – Caterpillar C-15
- – Power 403 kW (540 hp)
- – Tier 3 approved
- – Crusher is driven directly
- – Other drives hydraulic

Max capacity: 900 mtph (1000 stph)

Dimensions

(Transport, standard unit)

Length:	18 000	mm	60'
Width:	3 500	mm	11' 6"
Height:	4 250	mm	13' 11"
Weight:	66 000	kg	145.500 lbs.

Lokotrack

Lokotrack LT1418

- proven, reliable and modular design
- an impactor with a feed size of up to 1000 mm
- high capacity for quarry and in-pit operations
- advanced IC700 automation system
- easy service and hammer change

Unit components

Crusher

Nordberg NP1418 impact crusher	
Feed opening:	1840 x 1320 mm
Setting range (quarrying):	60-200 mm (2 3/4" - 8")
Rotor speed:	450 - 560 rpm

Feeder

Feed hopper	
Volume:	20 m^3 (27yd^3)
Width:	3 300 mm (130")
PF635 pan feeder & VG635-3V scalper	
PF 635 length:	3 500 mm (11' 8")
PF635 width:	1 600 mm (5' 3")
VG635-3V length:	3 500 mm (11' 8")
VG635-3V width:	1 600 mm (5' 3")
Main discharge conveyor H16-12	
Belt width	1 600 mm (63")
Discharge height	3.5 m (11' 6")
Side conveyor H8-10	
Belt width	800 mm (32")
Discharge height	3.65 m (11' 12")

Engine Caterpillar C-18 552 kW / 1900 rpm

Max capacity: 1200 tph (1330 stph)

Dimensions

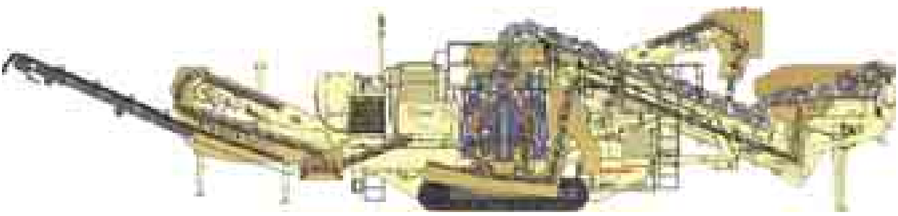
(Transport,standard unit)

Length:	20 300 mm (66' 7")
Width:	3 850 mm (12' 8")
Height:	4 500 mm (14' 9")
Weight:	85 500 kg (188 500 lbs)

Lokotrack

Lokotrack LT300HP

- built around the proven HP300 cone crusher
- crusher cavity can be selected accurately
- IC600 crusher automation as standard
- wide variety of optional equipment available



Unit components

Crusher

Performance

Feed size up to:	240	mm	(9.5 in)
Product size up to:	75	mm	(3 in)
Capacity up to:	550	tph	(600 stph)
Travelling speed:	1	km	(0.6 mph)
Climbing grade:	20°		(35%)

Equipment — basic unit

Cone crusher (1)	HP300
Setting control unit	IC600
Feed hopper	7 m³
Belt feeder	H12-6
Main conveyor	H12-9
Tracks	D57
Engine, Caterpillar	C-15
– power	403 kW-540 hp
AC generator and panel	71 kVA, 50 Hz

Alternative equipment — basic unit

Main conveyor	H12-12

Max capacity: 550 mtph (600 stph)

Dimensions

(Transport, standard unit)

Length:	16 300	mm	56' 6"
Width:	3500	mm	11' 6"
Height:	3800	mm	12' 6"
Weight:	43 000	kg	95 000 lbs.

Quarry Lokotracks

Lokotrack

Lokotrack LT300GP

- robust construction for the toughest of hard rock crushing sites
- the crusher can be selected according to the specific application requirements
- easy transportability on a trailer allows cost effective contracting
- the grizzly feeder module allows the fines to be by-passed or to be discharged
- the screen module allows screening of the crushed (and by-passed) material into two separate fractions
- LT300GP can also be equipped with a king pin and transport bogie attachment

Unit components

Crusher

Performance

Feed size up to:	320	mm	(13 in)
Product size up to:	75	mm	(3 in)
Capacity up to:	550	tph	(600 stph)
Travelling speed:	1	km	(0.6 mph)
Climbing grade:	20°		(35%)

Equipment — basic unit

Cone crusher (1)	GP300S
Setting control unit	IC50
Lifting conveyor	H12-7
Main conveyor	H12-9
Tracks	D6B
Engine, Caterpillar	C-12
– power	317 kW-423 hp

AC generator and panel71 kVA, 50 Hz

Alternative equipment — basic unit

Cone crusher	GP300
Main conveyor	H12-12

Max capacity: 550 mtph (600 stph)

Dimensions

(Transport, standard unit)

Length:	16 200	mm	53'
Width:	3500	mm	11' 6"
Height:	3800	mm	12' 10"
Weight:	42 000	kg	93 000 lbs.

Lokotrack

Lokotrack LT300GPB

- built around the proven GP cone crusher
- self-propelled mobile unit
- robust construction
- highly manouverable due to a powerful undercarriage
- LT300GP can also be equipped with a king pin and transport bogie attachment

Unit components

Crusher
Nordberg GP300 cone crusher

Screen
Horizontal, 3 deck screen B380 T

Screen size	1600 x 5450 mm	(5' 3" x 17' 8")

Optionally horizontal , 3 deck screen B 3100 T

Screen size	2800 x 6850 mm	(9' 3" x 22' 6")

Optionally horizontal, 2 deck screen B 2100 T

Screen size	2800 x 6850 mm	(9' 3" x 22' 6")

Performance

Feed size up to:	210 mm	(8")
Max capacity up to	450 tph	(500 stph)

Dimensions

(Transport, standard unit with side conveyors)

Length:	21 700 mm	(71' 2")
Width:	3 500 mm	(11' 6")
Height:	3 800 mm	(12' 5")
Weight:	60 600 kg	(133,600 lbs)

Lokotrack

Lokotrack LT300HPB

- built around the proven HP300 cone crusher
- self-propelled mobile unit
- robust construction
- highly manouverable due to a powerful undercarriage

Unit components

Crusher
Nordberg HP300 cone crusher

Screen
Horizontal, 3 deck screen B380 T

Screen size	1600 x 5450 mm	(5' 3" x 17' 8")

Optionally horizontal , 3 deck screen B 3100 T

Screen size	2800 x 6850 mm	(9' 3" x 22' 6")

Optionally horizontal, 2 deck screen B 2100 T

Screen size	2800 x 6850 mm	(9' 3" x 22' 6")

Performance

Feed size up to:	240 mm	(9.5")
Max capacity up to	440 tph	(485 stph)

Dimensions

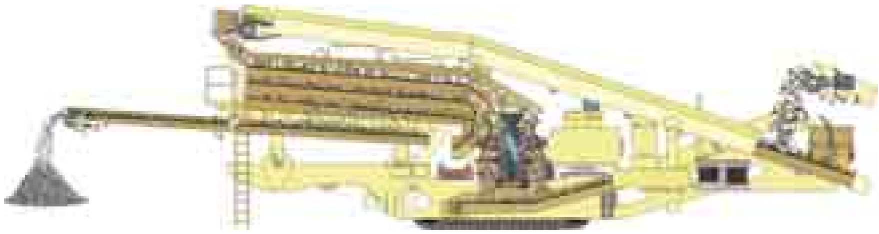
(Transport, standard unit with side conveyors)

Length:	19 400 mm	(63' 8")
Width:	3 500 mm	(11' 6")
Height:	3 800 mm	(12' 5")
Weight:	63 000 kg	(138,900 lbs)

Lokotrack

Lokotrack LT550GPF

- high capacity mobile unit
- powerful GP550 cone crusher
- easily transportable



Unit components

Crusher
Nordberg GP550 cone crusher

Screen
Horizontal 3-deck screen FS303CL

Screen size	1936 x 6100 mm	(6' 4" x 20')

Performance

Feed size up to:	250 mm	(10")
Max capacity up to	600 tph	(660 stph)

Dimensions

(Transport,standard unit)

Length:		20 300 mm	(66' 7")
Width:		3 985 mm	(13' 1")
Height:		4 750 mm	(15' 7")
Weight:	Basic unit	76 500 kg	(168,700 lbs)
	Screen unit	22 800 kg	(50,300 lbs)
	Side conveyor	1 300 kg	(2,860 lbs)

Nordberg LL series mobile conveyors

Model	Belt width	Length between drum centers	Power	Weight	Capacity	Maximum feed size	Compatibility
LL12	1200 mm (48")	24 and 36 m (80 and 120 ft)	37 kW (50 hp)	16 t (35.000 lbs)	1200 t/h	300 mm (12")	LT125, LT140, LT1415(LL)
LL16	1600 mm (63")	24 and 36 m (80 and 120 ft)	2 x 37 kW (2 x 50 hp)	28 t (60.000 lbs)	2000 t/h	350 mm (14")	LT160

Optional transport bogie for Lokotracks

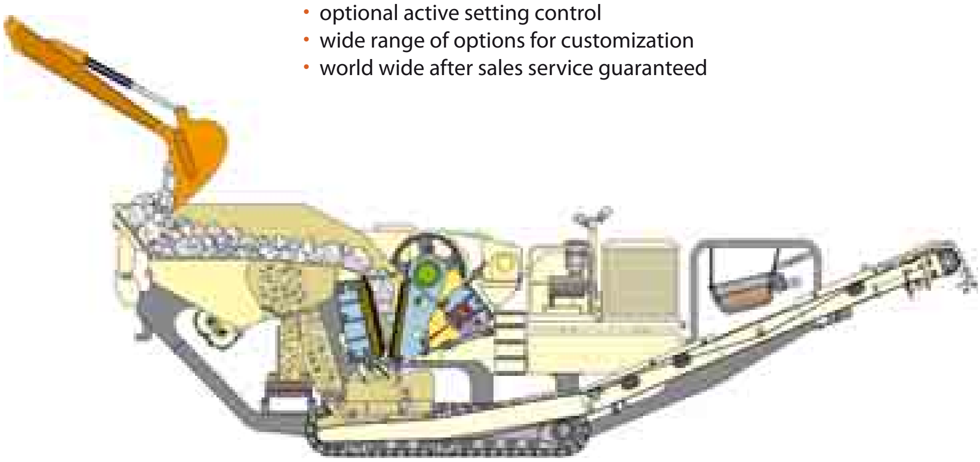
Transport bogie helps to reduce the weight and height of the combination transported, and thereby recuces the transport cost between the sites.

Transport bogie is available as an option to the following Lokotrack models:
Primary LT's : LT110, LT3054, LT125, LT1315 and LT1415.
Secondary LT's : LT300GP/HP, LT300GPB/HBP

Lokotrack

Lokotrack LT96

- highly advanced intelligence as standard
- true mobility with compact dimensions
- high capacity C96 jaw crusher
- optional active setting control
- wide range of options for customization
- world wide after sales service guaranteed



Unit components

Crusher
Nordberg C96 jaw crusher

- intake width	930 mm (37")
- intake depth	580 mm (23")

Feeder
Feed hopper

- 4 m^3: width	2700 mm (8' 10")
- 6 m^3: width	3400 mm (11' 2")

Nordberg TK9-32-2V vibrating feeder

- length	3200 mm (10' 6")
- width	950 mm (3' 1")

Engine	CAT C6.6
- power	168 kW (225 hp)

Max capacity up to	350 tph (385 stph)

Dimensions

(Transport, standard unit)

Length:	12 450 mm (40' 10")
Width:	2500 mm (8' 3")
Height:	3100 mm (10' 2")
Weight:	27 800 kg (61 300 lbs)

Contractor Lokotracks

Lokotrack

Lokotrack LT96S

- screen with counter rotation
- screen with counter rotation
- easy, hydraulic screen opening system
- excellent weight/productivity ratio
- classified, clean end products
- proven C96 jaw crusher

Unit components

Crusher
Nordberg C96 jaw crusher

- intake width	930 mm (37")
- intake depth	580 mm (23")

Feeder
Feed hopper

- 4 m^3: width	2700 mm (8' 10")
- 6 m^3: width	3400 mm (11' 2")

Nordberg TK9-32-2V vibrating feeder

- length	3200 mm (10' 6")
- width	950 mm (3' 1")

Screen
Nordberg TK11-20-S screen

- length	2000 mm (6' 7")
- width	1100 mm (3' 7")

Engine	CAT C6.6
- power	168 kW (225 hp)
Max capacity up to	350 tph (385 stph)

Dimensions

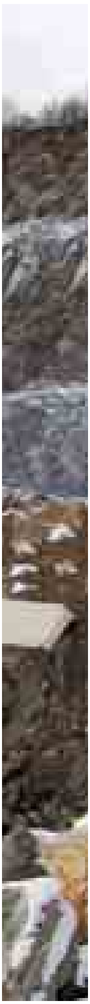
(Transport, standard unit)

Length:	14 800 mm (48' 7")
Width:	2500 mm (8' 2")
Height:	3100 mm (10' 2")
Weight:	31 200 kg (68 800 lbs)

Lokotrack

Lokotrack LT106

- smart crushing with IC700 intelligent controller
- advanced user friendliness
- single unit for hard rock and recycle materials
- top capacity with C106 jaw crusher
- versatile feeding options



Unit components

Crusher
Nordberg C106 jaw crusher

- intake width	1060 mm (42")
- intake depth	700 mm (28")

Feeder

Feed hopper	6 m³/9 m³ (8 yd³/12 yd³)
- width	2600 mm (8' 6")

Nordberg TK11-42-2V vibrating feeder

- length	4150 mm (13' 8")
- width	1100 mm (3' 7")

Engine	CAT C9
- power	224 kW (300 hp)

Max capacity up to	400 tph (440 stph)

Dimensions

(Transport, standard unit)

Length:	14 200 mm (46' 7")
Width:	2800 mm (9' 2")
Height:	3400 mm (11' 2")
Weight:	40 000 kg (88 200 lbs)

Lokotrack

Lokotrack LT106S

- two end products simultaneously
- top versatility in recycling
- built with proven components
- compact transport dimensions
- intelligent IC700 controls

Unit components

Crusher
Nordberg C106 jaw crusher

- intake width	1060 mm (42")
- intake depth	700 mm (28")

Feeder

Feed hopper	6 m³/9 m³ (8 yd³/12 yd³)
- width	2600 mm (8' 6")

Nordberg TK11-42-2V vibrating feeder

- length	4150 mm (13' 8")
- width	1100 mm (3' 7")

Screen
Nordberg TK11-30 S screen

- length	3000 mm (9' 10")
- width	1100 mm (3' 7")

Engine	CAT C9
- power	224 kW (300 hp)
Max capacity up to	400 tph (440 stph)

Dimensions

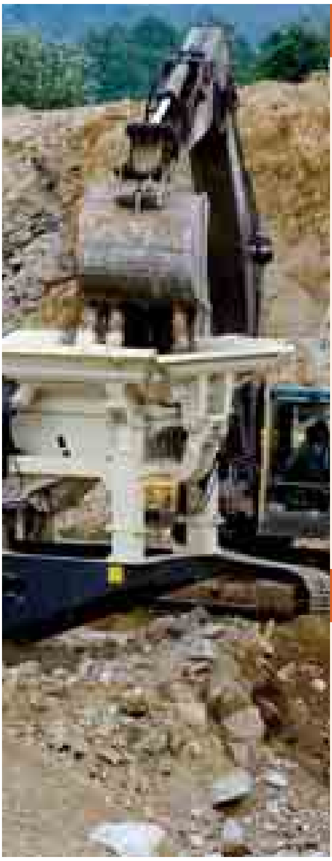
(Transport, standard unit)

Length:	16 000 mm (52' 6")
Width:	2800 mm (9' 2")
Height:	3400 mm (11' 2")
Weight:	42 000 kg (99 200 lbs)

Lokotrack

Lokotrack LT116

- built around the high performance C116 jaw crusher
- excellent crushing capacity and mobility
- efficient screen module available



Unit components

Crusher	
Nordberg C116 jaw crusher	
- intake width	1150 mm (45")
- intake depth	800 mm (32")
Feed hopper	
- length	3500 mm (11' 5")
- width	2600 mm (8')
- capacity	6 m^3/9 m^3 (8 yd^3/12 yd^3)
Feeder	
- length	4200 mm (13' 9")
- width	1100 mm (43")
Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	450 tph (496 stph)

Dimensions

(Transport, standard unit)

Length	15 500 mm (50')
Width	3000 mm (9' 10")
Height	3600 mm (11' 10")
Weight	50 000 kg (110 000 lbs)

Contractor Lokotracks

Lokotrack

Lokotrack LT116S

- two end products simultaneously
- screen with two rotation directions
- unbeatable recycling versatility
- customizable through options

Unit components

Crusher	
Nordberg C116 jaw crusher	
- intake width	1150 mm (45")
- intake depth	800 mm (32")
Feed hopper	
- length	3500 mm (11' 5")
- width	2600 mm (8')
- capacity	6 m³/9 m³ (8 yd³/12 yd³)
Feeder	
- length	4200 mm (13' 9")
- width	1100 mm (43")
Screen	
- length	3000 mm (10')
- width	1300 mm (4')
- screen area	3.9 m³ (4.2'³)
Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	450 tph (496 stph)

Dimensions

(Transport, standard unit)

Length	18 100 mm (59' 5")
Width	3000 mm (9' 10")
Height	3600 mm (11' 10")
Weight	55 000 kg (121 000 lbs)

Lokotrack

Lokotrack LT110C

- proven high-capacity C110 crusher
- excellent mobility and transportability
- suitable for hard rock and recycling applications
- modern control system for flexible and constant process
- efficient screen module available as option

Unit components

Crusher	
Nordberg C110 jaw crusher	
- intake width	1100 mm (43")
- intake depth	850 mm (34")
Feed hopper	
- length	3500 mm (11' 5")
- width	2600 mm (8')
- capacity	6 m^3/9 m^3 (8 yd^3/12 yd^3)
Feeder	
- length	4200 mm (13' 9")
- width	1100 mm (43")
Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	500 tph (550 stph)

Dimensions

(Transport, standard unit)

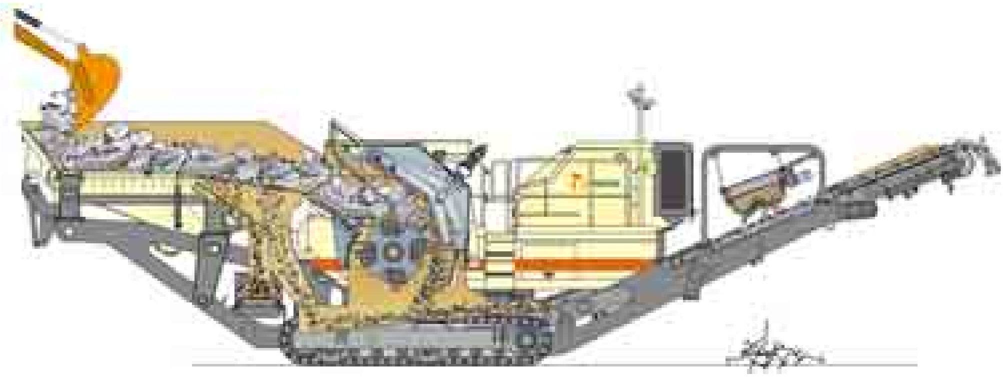
Length	15 500 mm (50')
Width	3000 mm (9' 10")
Height	3850 mm (12' 8")
Weight	58 000 kg (128 000 lbs)

Contractor Lokotracks

Lokotrack

Lokotrack LT1110

- built around powerful NP1110 crusher
- intelligent productivity with IC700 controller
- low operating noise levels with modular design
- wide range of options available
- compact transport dimensions



Unit components

Crusher
Nordberg NP1110M impact crusher
- feed opening 1040 x 800 mm (41 x 31")
- feed opening, mobile application 1040 x 650 mm (41 x 24")
- hydraulic drive

Feeder
Feed hopper
- 5 m^3: width 2600 mm (8' 6")
- 8 m^3: width 3400 mm (11' 2")

Nordberg TK9-42-2V vibrating feeder
- length 4200 mm (13' 8")
- width 930 mm (3' 1")
- hydraulic folding of hopper walls as standard

Engine CAT C9
- power 242 kW (325 hp)

Max capacity up to 300 tph (330 stph)

Dimensions

(Transport, standard unit)

Length:	14 900 mm (49')
Width:	2500 mm (8' 2")
Height:	3400 mm (11' 2")
Weight:	32 000 kg (70 500 lbs)

Active Setting Control as option

A new, advanced Active Setting Control for Lokotrack LT96(S) and LT106(S) is now available. The new system acts as a setting adjustment system and releases the crusher cavity to open in the event of hitting non-crushable, oversized material.

The new protective system adds greatly to crusher availability, especially in recycling applications.

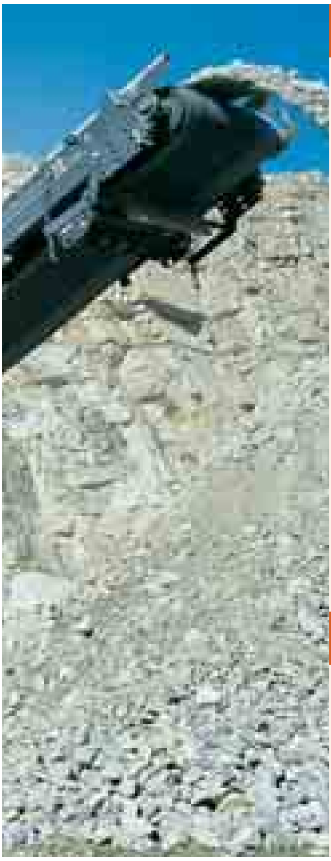
The active control system is based on three hydraulic cylinders and an ultrasonic sensor attached to the rear of the crusher. In cases where non-crushable material like a piece of iron enters the crusher cavity and generates a high pressure, the relief valve is opened and releases the hydraulic oil from the cylinders.

As a result, the crusher cavity opens and the noncrushable material will fall out of the crusher. After opening, the ultrasonic sensor returns the closed-side setting automatically to the preset, original value.

Lokotrack

Lokotrack LT1110S

- detachable screen with two-directional rotation
- powerful impact crusher designed for mobiles
- intelligent process streering with IC700
- wide selection of options avaible



Unit components

Crusher
Nordberg NP1110M impact crusher
- feed opening 1040 x 800 mm (41 x 31")
- feed opening, mobile application 1040 x 650 mm (41 x 24")
- hydraulic drive

Feeder
Feed hopper
- $5m^3$: width 2600 mm (8' 6")
- $8m^3$: width 3400 mm (11' 2")

Nordberg TK9-42-2V vibrating feeder
- length 4200 mm (13' 8")
- width 930 mm (3' 1")
- hydraulic folding of hopper walls as standard

Screen
Nordberg TK11-30S screen
- length 3000 mm (9' 10")
- width 1100 mm (3' 7")

Engine CAT C9
- power 242 kW (325 hp)

Max capacity up to 300 tph (330 stph)

Dimensions

(Transport, standard unit)

Length:	17 700 mm (58' 1")
Width:	2750 mm (9')
Height:	3400 mm (11' 2")
Weight:	36 200 kg (79 800 lbs)

(without H5-9 return conveyor, transported separately)

Lokotrack

Lokotrack LT1213

- built around the proven NP Series impact crusher
- two feeder options available
- optional vibrating feeder under crusher
- environmentally friendly diesel motor

Unit components

Crusher
Nordberg NP1213M impact crusher

- feed opening	1320 x 900 mm (52 x 35 ½")
- crusher speed	450-600 rpm
- hydraulic drive	

Feeder

Feed hopper	6 m^3/9 m^3 (8 yd^3/12 yd^3)
- width	2600 mm (8' 6")
Nordberg TK11-42-2V feeder	
- length	4200 mm (13' 9")
- width	1100 mm (3' 7")

Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	400 tph (440 stph)

Dimensions

(Transport, standard unit)

Length:	14 700 mm (48')
Width:	3000 mm (9' 10")
Height:	3400 mm (11' 2")
Weight:	40 000 kg (110 000 lbs)

Contractor Lokotracks

Lokotrack

Lokotrack LT1213S

- complete process plant on tracks
- can be used both in open and closed circuits
- on-board transportable screen module
- hydraulic opening makes servicing of the screen easy

Unit components

Crusher	
Nordberg NP1213M impact crusher	
- feed opening	1320 x 900 mm (52 x 35 ½")
- crusher speed	450-600 rpm
- hydraulic drive	
Feeder	
Feed hopper	6 m^3/9 m^3 (8 yd^3/12 yd^3)
- width	2600 mm (8' 6")
Nordberg TK11-42-2V feeder	
- length	4200 mm (13' 9")
- width	1100 mm (3' 7")
Screen	
Nordberg TK13-30S screen	
- length	3000 mm (9' 10")
- width	1300 mm (4' 3")
Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	400 tph (440 stph)

Dimensions

(Transport, standard unit)

Length:	17 200 mm (56' 1")
Width:	3000 mm (9' 10")
Height:	3400 mm (11' 2")
Weight:	50 000 kg (110 000 lbs)

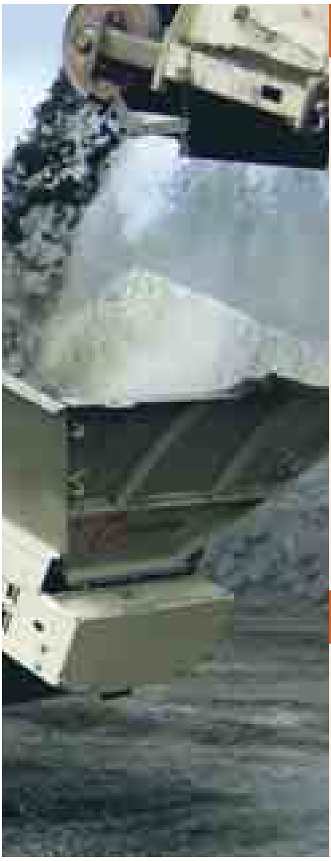
(incl. optional recirculating conveyor)

Contractor Lokotracks

Lokotrack

Lokotrack LT200HP

- built around the proven HP200 cone crusher
- process controlled with IC600 cotrol system
- full versatility with other LT and ST models
- maximized availability
- easy to transport between sites



Unit components

Crusher
Nordberg HP200 cone crusher
- max. feed opening up to 210 mm (8.27")
- hydraulic drive with adjustable speed

Belt feeder H10-6

- belt width	1000 mm (39")
- length	6000 mm (20')
- feed hopper size	5.0 m^3 (6.5 yd^3)
- hydraulic drive	

Main conveyor H8-10

- belt width	800 mm (32")
- discharge height	3000 mm (9' 10")
- hydraulic drive	

Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	250 tph (275 stph)

Dimensions

(Transport, standard unit)

Length:	16 750 mm (54' 11")
Width:	3000 mm (9' 10")
Height:	3400 mm (11' 2")
Weight:	30 000 kg (66 100 lbs)

Lokotrack

Lokotrack LT200HPS

- one or two-deck screens available
- built around the proven HP200 cone crusher
- full versatility with other Lokotracks

Unit components

Crusher
Nordberg HP200 cone crusher
- max. feed opening up to 210 mm (8.27")
- hydraulic drive with adjustable speed

Screen	1 deck, TK13-30S	2 decks, TK15-30-2S
- screen width	1,3 m (4' 3")	1,5 m (4' 11")
- screen lenght	3,0 m (9' 10")	3,0 m (9' 10")

Belt feeder H10-6
- belt width 1000 mm (39")
- feed hopper size 5.0 m³ (6.5 yd³)
- hydraulic drive

Main conveyor H8-10
- belt width 800 mm (32")
- hydraulic drive

Engine CAT C13
- power 310 kW (415 hp)

Max capacity up to 250 tph (275 stph)

Dimensions

(Transport, standard unit)

Length	19 000 mm (62' 3")
Width	3100 mm (122")
Height	3600 mm (11' 10")
Weight	40 000 kg (88 000 lbs)

Lokotrack

Lokotrack LT7150

- producer of high quality aggregates and sand
- quick and easy operation & maintenance
- low wear parts costs
- crusher speed adjustable using control panel

Unit components

Crusher
Vertical shaft impactor Barmac B7150M

Belt feeder H10-6	
- belt width	1000 mm (39")
- length	6000 mm (20')
- feed hopper size	5.0 m^3 (6.5 yd^3)
- hydraulic drive	
Main conveyor H8-10	
- belt width	800 mm (32")
- discharge height	3020 mm (9' 11")
- hydraulic drive	
Engine	CAT C13
- power	310 kW (415 hp)
Max capacity up to	250 tph (275 stph)

Dimensions

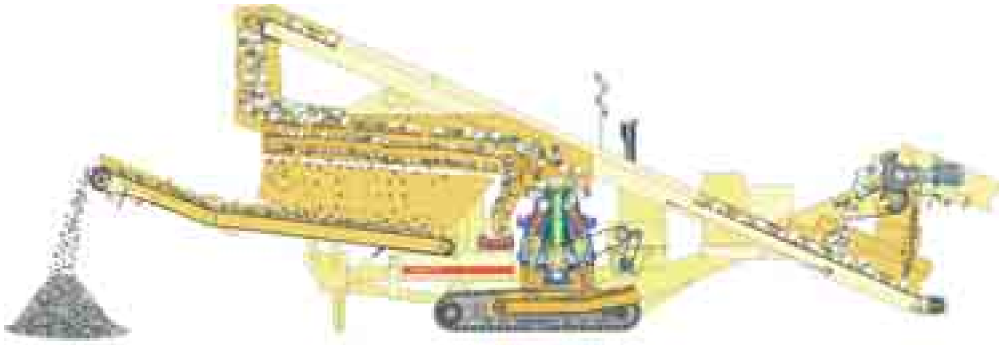
(Transport, standard unit)

Length:	16 800 mm (55')
Width:	3000 mm (10')
Height:	3400 mm (11' 2")
Weight:	30 000 kg (66 100 lbs)

Lokotrack

Lokotrack LT1100

- sturdy yet mobile construction
- proven, powerful GP11 cone crusher
- excellent ground clearance
- world wide after sales services provided by Metso



Unit components

Crusher
Nordberg GP11F or GP11M cone crusher
- Nominal feed openings:

GP11F coarse:	200 mm (8")
GP11M coarse:	180 mm (7")
Extra coarse:	220 mm (9")

Screen
Horizontal, 3 deck screen B380T
- screen size 1600 x 5450 mm (5' 3" x 17' 8")

Engine	CAT C13
- power	310 kW (415 hp)

Performance

Feed size up to:	190 mm (7 ½")
Product size up to:	75 mm (3")
Max capacity up to	350 tph (385 stph)

Dimensions

(Transport, standard unit with side conveyors)

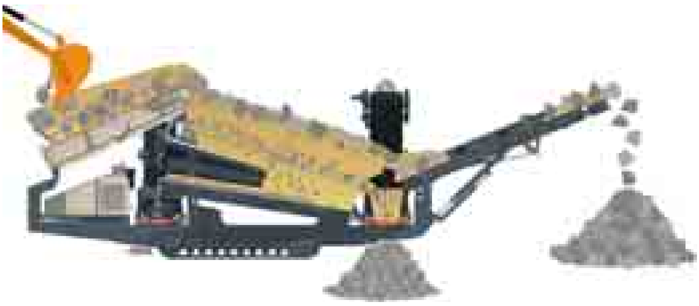
Length:	18 500 mm (60' 9")
Width:	3 500 mm (11' 6")
Height:	3 800 mm (12' 6")
Weight:	51 200 kg (113 000 lbs)

Contractor Lokotracks

Lokotrack

Lokotrack ST272

- large two-deck, two-bearing screen with wide range of screening media
- highly versatile unit applicable from primary crusher feed preparation to end product screening
- ease of use and maximized production, thanks to intelligent automation system
- unmatched reliability provides maximum machine availability



Unit components

Apron feeder	
Loading height:	3505 mm (11' 6")
Loading width:	3000 mm (9' 10")
Feeder width:	1200 mm (4')
Screen	
Screen size	4870 x 1520 mm (16' x 5')
Two bearing screen	
Conveyors	
Overflow conveyor	
- width	1200 mm (4' 11")
- discharge height	2700-3700 mm (8' 10"-12' 2")
Side conveyors (2)	
- width	800 mm (2' 7")
- discharge height	3870 mm (12' 7")
Fines conveyor	
- width	1200 mm (3' 11")
- length	4000 mm (13' 1")
Engine	CAT C4.4
- power	106 kW (141 hp)

Dimensions

(Transport, standard unit)

Lenght	14 100 mm (46' 3")
Width	3000 mm (9' 10")
Height	3560 mm (11' 8")
Weight	34 240 kg (75 486 lbs)

Lokotrack

Lokotrack ST3.5

- high-capacity 11' 7″ x 5' screen
- proven 2-bearing screen with adjustable screen angle
- easy access to all service points
- quick transportation due to patented conveyor folding mechanism

Unit components

Screen	
Number of decks	2
Screen size	3580 x 1500 mm (11' 7" x 5')
Screen area / top deck	7.9 m² (9.5 yd²)
Hopper & conveyors	
Hopper capacity	5.5 m³ (7.2 yd³)
Loading height with grid	3290 mm (10' 9")
Conveyor discharge heights:	
Undersize conveyor	3149 mm (10' 6")
Top deck wing conveyor	3860 mm (12' 9")
Bottom deck wing conveyor	3860 mm (12' 9")
Engine	CAT C4.4
- power	75kW (100 hp)

Dimensions

(Transport, standard unit)

Length	14 350 mm (47' 1")
Width	3000 mm (9' 6")
Height	3460 mm (11' 3")
Weight	23 230 kg (51 106 lbs)

Lokotrack

Lokotrack ST3.8

- effective and precise screening even in heavy loads due to high power (106 kW)
- high-capacity hopper with low loading height
- large two-deck, two-bearing screen
- complete process control and user friendly operation through advanced automation
- built with proven, first-class components

Unit components

Screen	
Number of decks	2
Screen size	5480 x 1524 mm (18' x 5')
Screen area / deck	7.9 m² (9.5 yd²)
Hopper & conveyors	
Hopper capacity	7.5 m³ (9.6 yd³)
Loading height with grid	3345 mm (11')
Loading height without grid	2315 mm (7' 7")
Conveyor discharge heights:	
Undersize conveyor	4400 mm (14' 3")
Top deck wing conveyor	4440 mm (14' 7")
Bottom deck wing conveyor	4160 mm (13' 7")
Engine	CAT C4.4
- power	106 kW (141 hp)

Dimensions

(Transport, standard unit)

Length	18 300 mm (60')
Width	3190 mm (10' 6")
Height	3420 mm (11' 3")
Weight	28 000 kg (61 600 lbs)

Mobile Screens

Lokotrack

Lokotrack ST4.8

- large three-deck, two-bearing screen
- optimal capacity trough advanced automation
- easy and quick service
- built with proven, first-class components

Unit components

Screen

Number of decks	3
Screen size	5480 x 1524 mm (18' x 5')
Screen area / top deck	7.9 m² (9.5 yd²)

Hopper & Conveyors

Hopper capacity	7.5 m³ (9.6 yd³)
Loading height with grid	3345 mm (11')
Loading height without grid	2315 mm (7' 7")

Conveyor discharge heights:

Undersize conveyor	4300 mm (14' 4")
Top deck wing conveyor	4440 mm (14' 7")
Middle deck wing conveyor	3880 mm (12' 9")
Bottom deck wing conveyor	4165 mm (13' 8")

Engine	CAT C4.4
- power	106 kW (141 hp)

Dimensions

(Transport, standard unit)

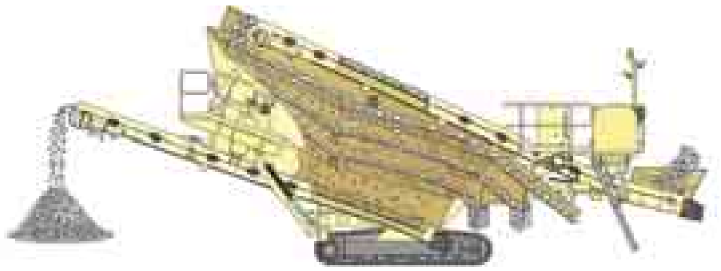
Length	18 320 mm (60' 1")
Width	3190 mm (10' 6")
Height	3630 mm (11' 11")
Weight	32 250 kg (70 950 lbs)

Mobile Screens

Lokotrack

Lokotrack ST620

- high continuous screening capacity
- easy to use with mobile crushing applications
- user-friendly "one button" process start-up
- proven, efficient triple-deck screen
- guaranteed Metso customer service



Unit components

Screen
Nordberg DS303 triple-deck screen

- deck width:	1800 mm (5' 11")
- deck length:	6000 mm (19' 8")
- area:	11 m²/deck (118'²)

Conveyors

Lifting conveyor:	H12-11 (feed onto the screen)
- belt width:	1200 mm (3' 11")
Discharge conveyor:	H12-9 (underflow from lower deck)
- belt width:	1200 mm (3' 11")
Side conveyor:	H8-8 (overflow from upper deck)
- belt width:	800 mm (2' 7")
Side conveyors	H6,5-8 (overflow from middle and lower screen decks)
- belt width:	650 mm (2' 2")

Engine:	CAT C6.6 ACERT
- power:	130 kW (175 hp)

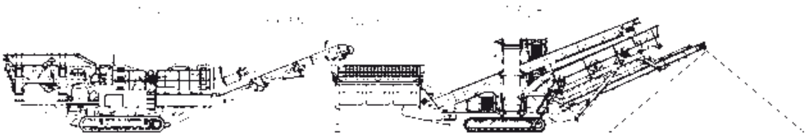
Dimensions

(Transport, standard unit)

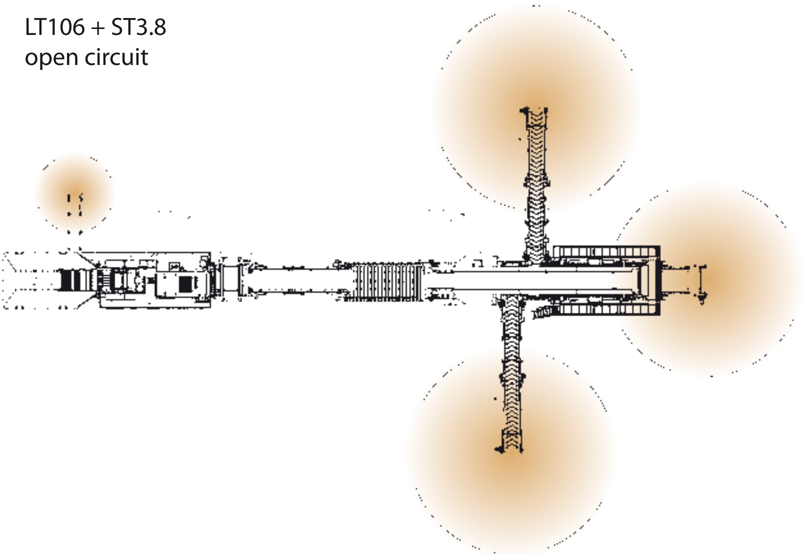
Length:	14 900 mm (48' 10")
Width:	3000 mm (9' 10")
Height:	3800 mm (12' 5")
Weight:	27 600 kg (60 720 lbs)
Side conveyors (three units):	3900 kg (8580 lbs)

Mobile Screens

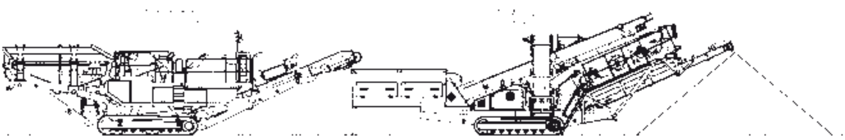
Jaw plants & mobile screens



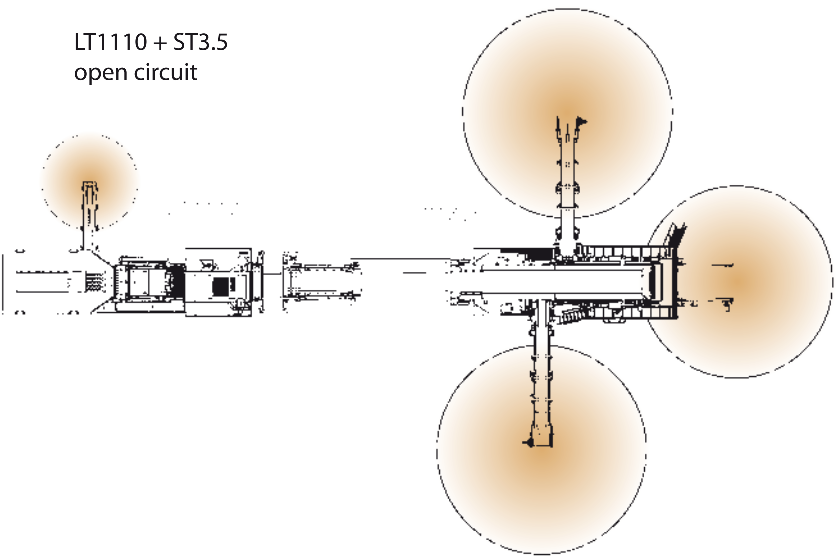
LT106 + ST3.8
open circuit

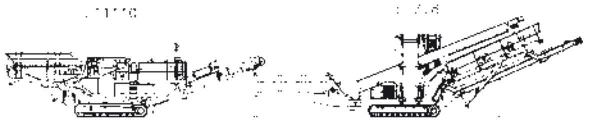


Impactor plants & mobile screens

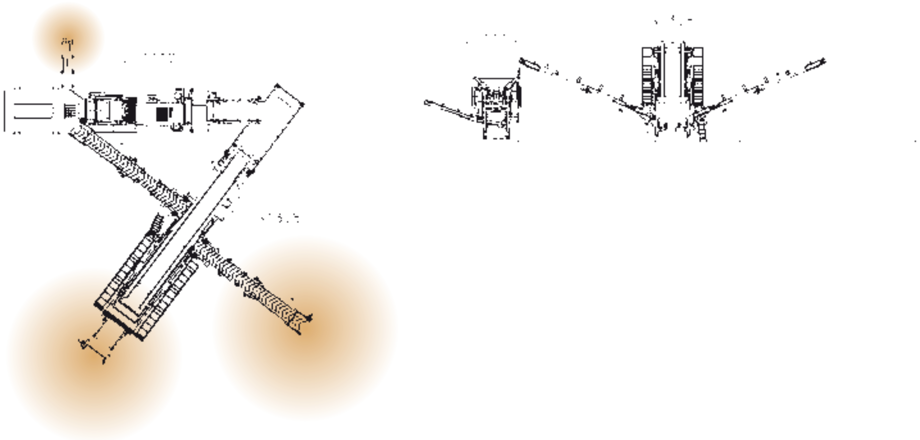


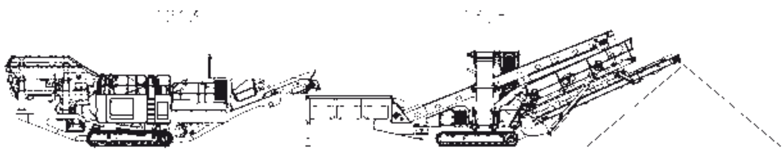
LT1110 + ST3.5
open circuit



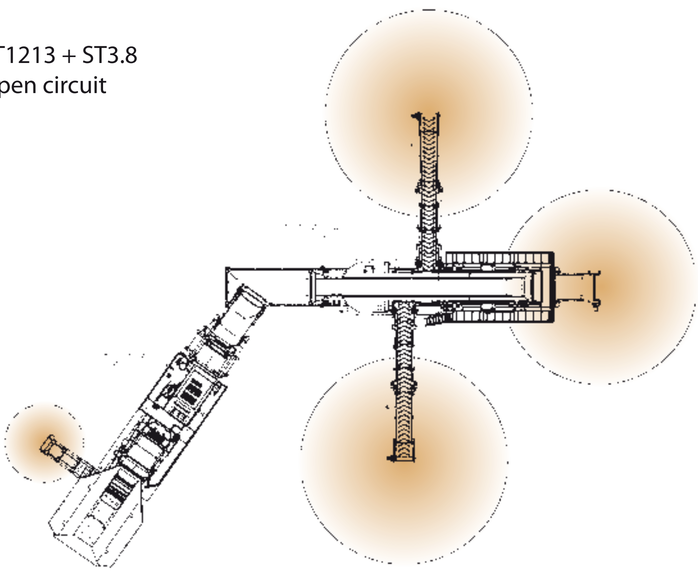


LT1110 + ST3.8 closed circuit



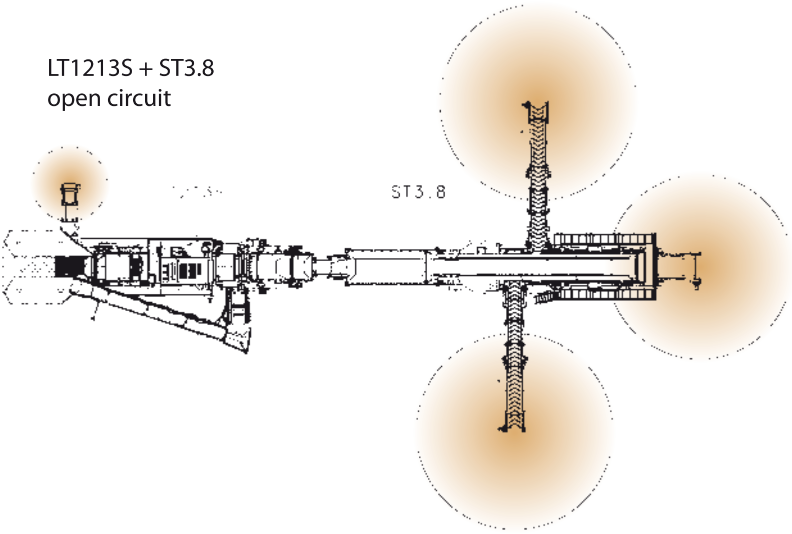


LT1213 + ST3.8
open circuit

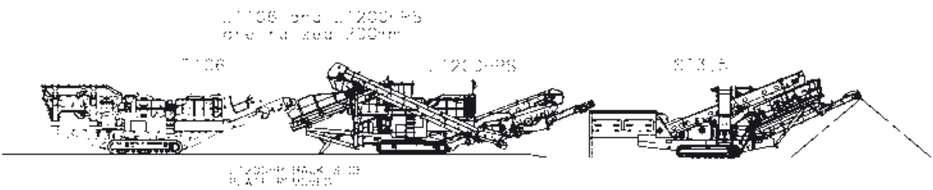


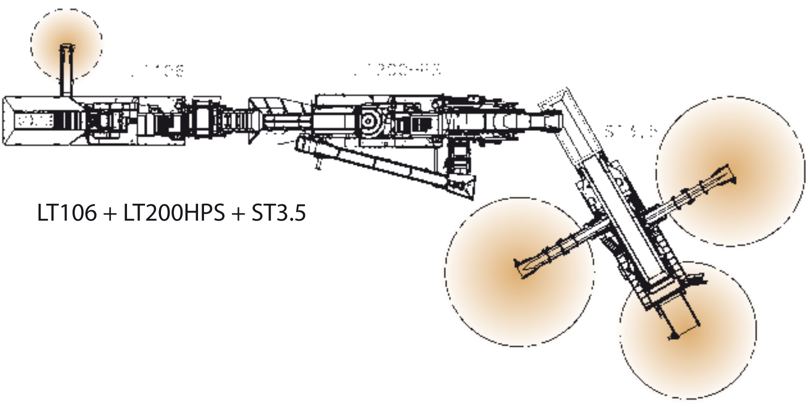
Impactor plant & mobile screens

LT1213S + ST3.8
open circuit



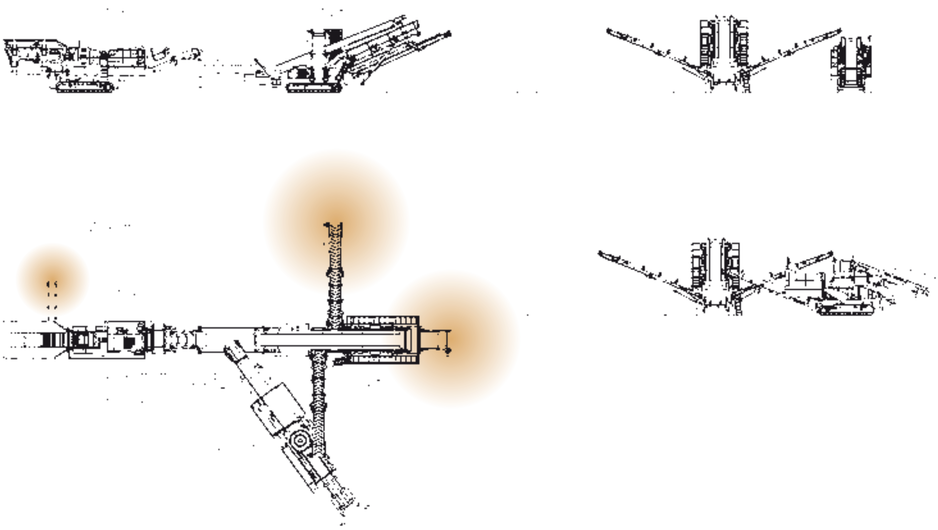
Jaw and cone plants & mobile screens



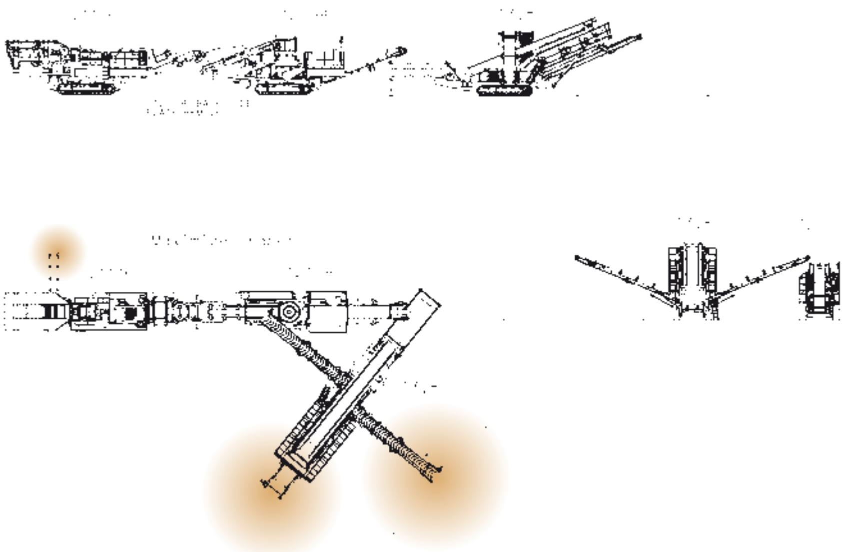


LT106 + LT200HPS + ST3.5

LT106 + LT200HP + ST3.8 closed circuit



LT106 + LT200HP + ST3.8 closed circuit



NORDBERG NW SERIES PORTABLE PLANTS

General

Nordberg NW series portable plants are the most convenient way to build even complex crushing and screening processes. They are very easy to move from site to site. If process needs to be changed it is very easy to add, remove or relocate units.

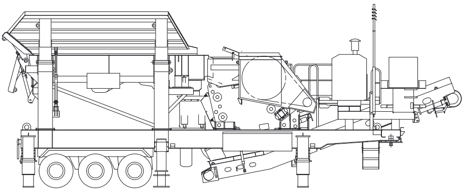
NW series portable units can be used as single units or multi stage crushing and screening systems.

NW series portable plants can be equipped with various jaw, cone, horizontal and vertical impact crushers, screens and feeders.

High quality components make the units very reliable and productive.

Primary plants

These plants are composed of a C Series jaw crusher or NP Series impact crusher, vibrating feeder with grizzly and a product belt conveyor. The basic arrangement uses a feeder with grizzly, provided with a large hopper destined to the wheel loader feeding. Back dump truck loading is also available with self standing extended hopper.



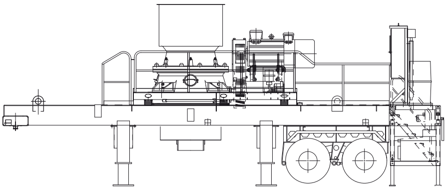
Feed stations

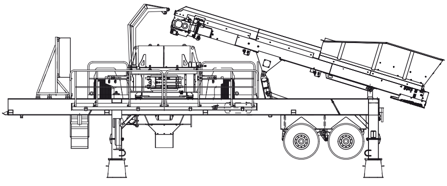
Plants composed of bin, vibrating feeder and generally fed by front loaders. Destined to raw material handling, such as natural gravel and blasted or crushed fine rock.

Cone and vertical impactor plants without screen

These plants with a single crusher are composed of a cone crusher (HP or GP line), Barmac, fitted to the chassis.

They are fully mobile plants, of modular design, prepared for ready-to-use operation in the job site.





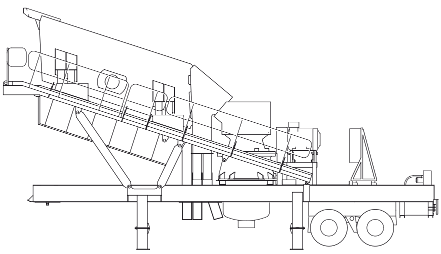
Secondary and tertiary crushing plants with screen

Basic arrangement: Screen, GP or HP cone or Barmac crusher.

Available sizes for 100 and 200 cone and 6150 and 7150 Barmac crushers.

Screen used is inclined CVB screen with 4 decks to be able to produce 4 products and recirculate the oversize material

Conveyors are separate, they do not travel with the plant.



Screen plants

Nordberg portable screening units are very efficient for all screening processes. There are available many different versions, with FS or CVB screens, from 2 deck to 4 deck, depending on the model.

Two-stage Crushing and Screening Plants in Closed Circuit

Two-step compact crushing unit in closed circuit able to produce fines up to four separation ranges, plus natural fines, available in three basic models

NW80 100HPS composed of C80 and HP100 crushers, horizontal screens with elliptical movement and 42" centrifugal belt conveyor in-loop.

NW80 200HPS is a similar arrangement provided with a HP200 secondary cone crusher.

Third model is NW96 200HPS having bigger jaw crusher for increased capacity and bigger feed size.

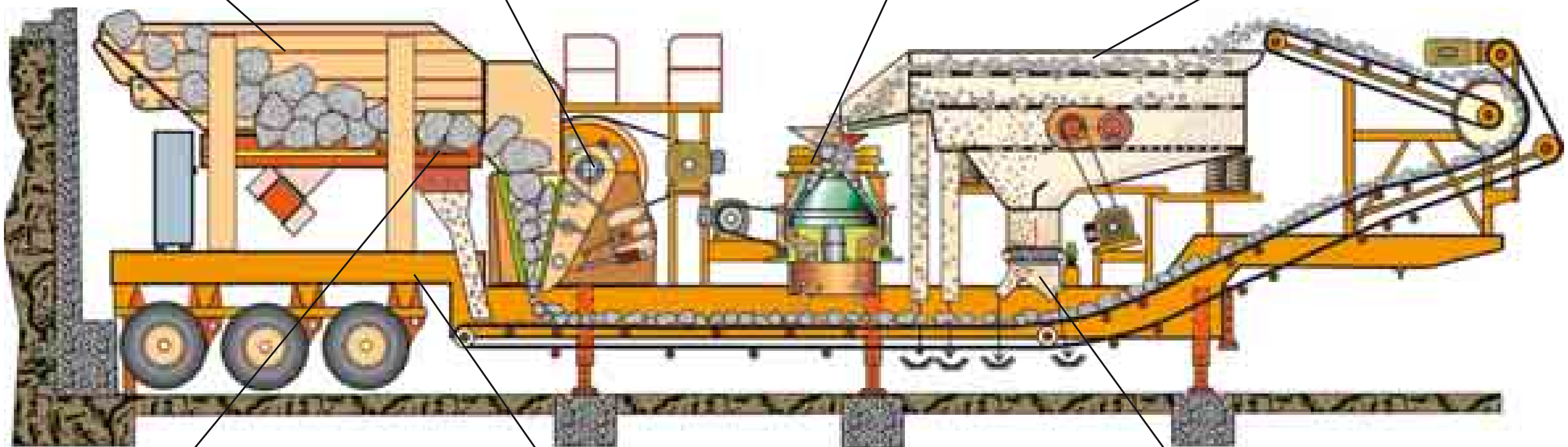
These plants are used for an intermediate or final crushing in mid or large size installations.

Variable speed feeder
MW35080 vibrating feeder with a large sturdy hopper. Feed control converter for continuous speed variation.

C80 or C96 Nordberg jaw crusher
This design offers the highest possible fatigue strength, excellent reliability and exceptionally high crusher availability, cost-efficient crushing and low cost per ton.

HP100 or HP200 Nordberg cone secondary crusher
Excellent productivity, low operating costs and wear costs, long service life, high product yield and high quality products are some of the benefits offered by the HP (High Performance) Series.
The hydraulic setting adjustment system ensures the conditions to balance the crushing circuit and optimize the plant productivity. Excellent feed size acceptance thanks to the extra coarse cavity design. Its major secondary crushing capacity and a wider acceptance entry do not limit the outlet aperture of the primary crusher. The low height of the secondary crusher also allows the return of the second screen deck, facilitating the product distribution adjustment.

Horizontal vibrating screen
High capacity vibrating screen with elliptical movement and three 1.5 m x 3.6 m (5'x14') decks provides a large screening surface free of rear access. Easy amplitude and vibrating angle settings by means of the smart speed system®. The elliptical movement provides more efficient and no-clogging separation ranges for three or four products.



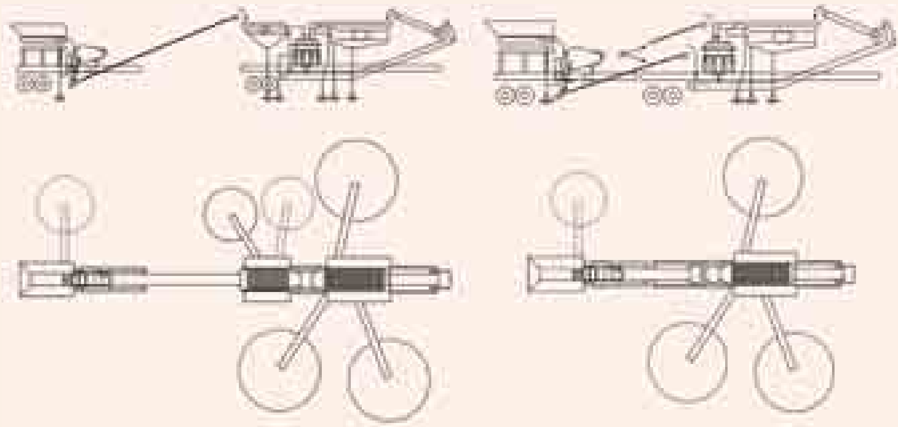
Scalp grizzly
of natural fines increases the crusher capacity. One can remove this material and pile it by means of optional equipment.

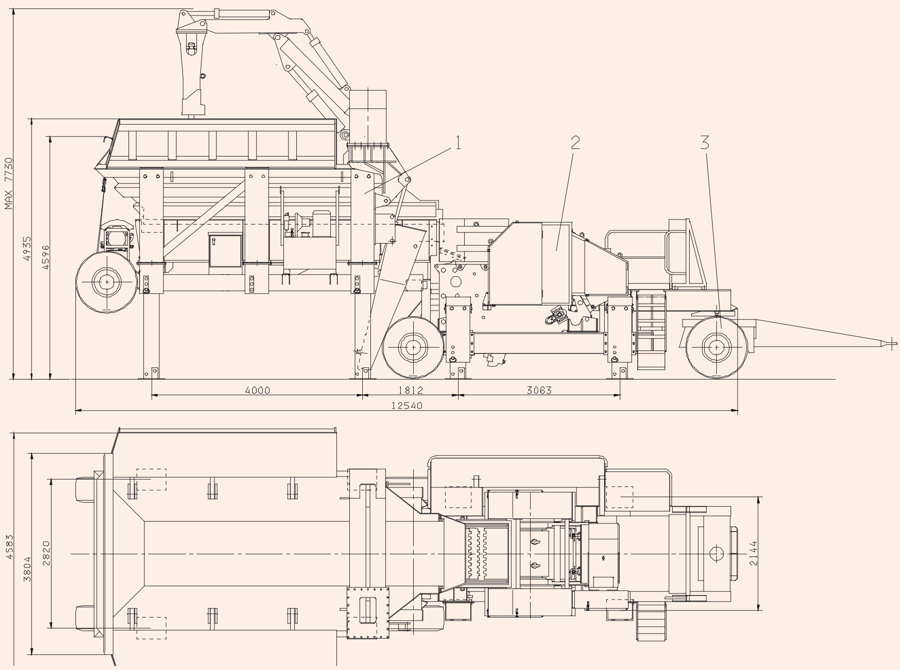
Stiff and robust chassis
This strong frame supports all equipment and reduces vibrations. Suspension composed of three axles and twelve 11R22.5 tyres. Provided with air brakes and brake lights. Displacements even to difficult access places thanks to its high stability and low weight.

* Without the outlet conveyors, however including all unit electrical engines
Indicated dimensions and weights herein are approximate and exclusively for informative purposes. For installation/erection, Metso Minerals provides certificated drawings. Performance figures are based on granite with a bulk density of 1600 kg/m^3 (100 lb/ft^3) and are also approximate and give an indication of what the plant can produce. The recommended setting depends on feed size, feed material crushability (Wi) and capacity required. Consult Metso for specific applications.

Special portable plants

Metso is able to design special mobile plants according to specific application needs as the following examples show.





NW100UG
For underground mining application, to be transported in narrow and low tunnels.

NW106 with primary grizzly on the feed hopper.
To prevent oversize material enter to the crusher. Alternative for the hydraulic rock breaker.

Nordberg NW Series Jaw Plants

Type	NW80	NW96	NW106	NW116	NW110	NW3054	NW125	NW140
Transport dimensions							*	*
Length	9 400 mm	12 000 mm	13 500 mm	15 300 mm	15 000 mm	15 100 mm	17 500 mm	17 500 mm
Width	2 500 mm	2 500 mm	3 000 mm	3 500 mm	3 500 mm	3 320 mm	3 500 mm	3 500 mm
Height	4 050 mm	3 300 mm	3 700 mm	4 100 mm	4 500 mm	4 100 mm	4 500 mm	4 500 mm
Weight	19 600 kg	26 000 kg	35 500 kg	47 000 kg	62 300 kg	58 000 kg	74 000 kg	76 800 mm
Axle weight	9 100 kg	16 000 kg	20 000 kg	30 800 kg	41 000 kg	36 500 kg	44 000 kg	46 300 kg
King pin weight	10 400 kg	10 000 kg	15 500 kg	16 200 kg	21 000 kg	21 500 kg	30 000 kg	30 500 kg
Crusher	C80	C96	C106	C116	C110	C3054	C125	C140
Feed opening								
- intake width	800 mm	930 mm	1 060 mm	1 150 mm	1 100 mm	1 375 mm	1 250 mm	1 400 mm
- intake depth	510 mm	580 mm	700 mm	800 mm	850 mm	760 mm	950 mm	1 070 mm
Setting range	40-175 mm	60-175 mm	70-200 mm	70-200 mm	70-200 mm	70-200 mm	100-250 mm	125-250 mm
Motor power	75 kW	90 kW	110 kW	132 kW	160 kW	160 kW	160 kW	200 kW
Feeder	TK8-27-2V	TK8-32-2V	TK11-42-2V	TK11-48-2V	VF561-2V	VF561-2V	VF561-2V	B16-50-3V
- length	2 700 mm	3 200 mm	4 200 mm	4 800 mm	6 100 mm	6 100 mm	6 100 mm	5 000 mm
- width	800 mm	800 mm	1 100 mm	1 100 mm	1 300 mm	1 300 mm	1 300 mm	1 600 mm

** Feeder unit removed   For inches divide by 25.4   For lbs divide by 0.45   For ft³ multiply by 35.3*

Nordberg NW Series GP and HP Cone Plants

Type	NW100GPC	NW100HPC	NW200GPC	NW200HPC
Transport dimensions				
Length	12 600 mm	16 400 mm	13 300 mm	13 500 mm
Width	2 500 mm	2 500 mm	2 900 mm	2 980 mm
Height	4 060 mm	4 000 mm	4 315 mm	4 370 mm
Weight	25 400 kg	25 000 kg	34 400 kg	35 000 kg
Axle weight	12 000 kg	11 700 kg	19 000 kg	19 500 kg
King pin weight	13 400 kg	13 300 kg	15 400 kg	15 000 kg
Crusher	GP100, GP100S	HP100	GP200, GP200S	HP200
Feed opening	40-150 mm (GP100)	20-150 mm	40-210 mm (GP200)	95-185 mm
	200-250 mm (GP100S)	-	250-330 mm (GP200S)	-
Setting range	15-22 mm (GP100)	6-21 mm	10-30 mm (GP200)	14-19 mm
	-	-	24-52 mm (GP200S)	-
Motor Power	90 kW	90 kW	160 kW	132 kW
Feeder	CVB1540-4	CVB1540-4	CVB 1845-4	CVB 1845-4
- length	4 000 mm	4 000 mm	4 500 mm	4 500 mm
- width	1 500 mm	1 500 mm	1 800 mm	1 800 mm

Type	NW100GP	NW200GP	NW300GP	NW550GP	NW500GP
Transport dimensions					
Length	10 000 mm	10 600 mm	10 700 mm	13 000 mm	15 000 mm
Width	2 500 mm	3 000 mm	3 500 mm	3 500 mm	3 500 mm
Height	4 150 mm	4 000 mm	4 300 mm	4 300 mm	4 500 mm
Weight	14 000 kg	20 200 kg	30 000 kg	43 800 kg	54 500 kg
Axle weight	8 700 kg	14 100 kg	20 000 kg	28 000 kg	35 800 kg
King pin weight	5 300 kg	6 100 kg	10 000 kg	15 800 kg	18 700 kg
Crusher	GP100, GP100S	GP200, GP200S	GP300	GP550	GP500S
Feed opening	40-150 mm (GP100)	40-210 mm (GP200)	40-260 mm (GP300)	40-275 mm	380-500 mm
	200-250 mm (GP100S)	250-330 mm (GP200S)	280-380 mm (GP300S)	-	-
Setting range	6-22 mm (GP100)	10-30 mm (GP200)	22-41 mm (GP300)	8-46 mm	30-77 mm
	24-46 mm (GP100S)	24-52 mm (GP200S)	28-53 mm (GP300S)	-	-
Motor Power	90 kW	160 kW	250 kW	315 kW	315 kW

Type	NW100HP	NW200HP	NW300HP	NW4HP	NW400HP	NW500HP
Transport dimensions						
Length	10 000 mm	10 600 mm	13 700 mm	13 500 mm	13 500 mm	15 000 mm
Width	2 500 mm	3 000 mm	3 500 mm	3 500 mm	3 500 mm	3 500 mm
Height	4 150 mm	3 600 mm	4 300 mm	4 400 mm	4 400 mm	4 500 mm
Weight	14 000 kg	23 000 kg	35 000 kg	39 500 kg	39 500 kg	52 500 kg
Axle weight	8 700 kg	15 000 kg	22 000 kg	24 500 kg	24 500 kg	35 000 kg
King pin weight	5 300 kg	8 000 kg	13 000 kg	15 000 kg	15 000 kg	17 500 kg
Crusher/Screen	HP100	HP200	HP300	HP4	HP400	HP500
Feed opening	20-150 mm	25-185 mm	25-233 mm	74-252 mm	30-299 mm	35-335 mm
Setting range	6-35 mm	6-40 mm	6-50 mm	8-45 mm	10-65 mm	8-65 mm
Motor Power	90 kW	132 kW	200 kW	315 kW	315 kW	355 kW

For inches divide by 25.4 For lbs divide by 0.45 For hp multiply by 1.36

Nordberg NW Series VSI Plants

NW VSI PLANTS	NW7150	NW9100	NW6150C	NW7150 C
Transport dimensions				
Length	11 605 mm	11 605 mm	12 560 mm	12 400 mm
Width	2 990 mm	2 990 mm	2 500 mm	2 990 mm
Height	4 410 mm	4 410 mm	4 060 mm	4 280 mm
Weight	26 300 kg	26 300 kg	24 200 kg	28 500 kg
Axle weight	16 700 kg	16 700 kg	11 200 kg	14 500 kg
King pin weight	9 600 kg	9 600 kg	13 000 kg	14 000 kg
Crusher	Barmac 7150SE	Barmac 9100SE	Barmac 6150SE	Barmac 7150SE
Max feed size	66 mm	66 mm	43 mm	66 mm
Throughput capacity range	200-424 mtph	420-703 mtph	77-202 mtph	150-345 mtph
	220-466 stph	462-774 stph	85-222 stph	165-375 stph
Feed hopper volume	9 m^3	9 m^3	-	-
Motor power	2 x 160 kW	2 x 350 kW	132 kW	200 kW
Screen	-	-	Nordberg CVB1540-4	Nordberg CVB1845-4
- length	-	-	4 000 mm	4 500 mm
- width	-	-	1 500 mm	1 800 mm
- number of decks	-	-	4	4

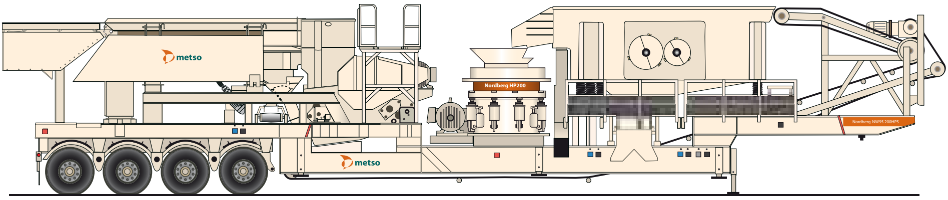
Nordberg NW Series Screen Plants

NW SCREEN PLANTS	NW302FS	NW303FS	NW353FS	NW403FS	NW1845CVB	NW2060CVB
Transport dimensions					*	*
Length	16 700 mm	17 600 mm	16 400 mm	13 400 mm	12 500 mm	12 500 mm
Width	3 500 mm	3 500 mm	3 500 mm	3 500 mm	3 000 mm	3 000 mm
Height	4 450 mm	4 250 mm	4 495 mm	4 500 mm	4 400 mm	4 500 mm
Weight	32 200 kg	35 500 kg	39 300 kg	32 900 kg	25 000 kg	28 000 kg
Axle weight	26 300 kg	21 000 kg	24 350 kg	20 500 kg	16 100 kg	18 000 kg
King pin weight	5 900 kg	14 500 kg	14 950 kg	12 400 kg	8 900 kg	10 000 kg
Screen	FS302	FS303	FS353	FS403	CVB1845	CVB2060
- length	6 100 mm	6 100 mm	6 100 mm	6 100 mm	4 500 mm	6 000 mm
- width	2 242 mm	2 242 mm	2 242 mm	2 547 mm	1 800 mm	2 000 mm
- number of decks	2	3	3	3	2, 3 or 4	2, 3 or 4

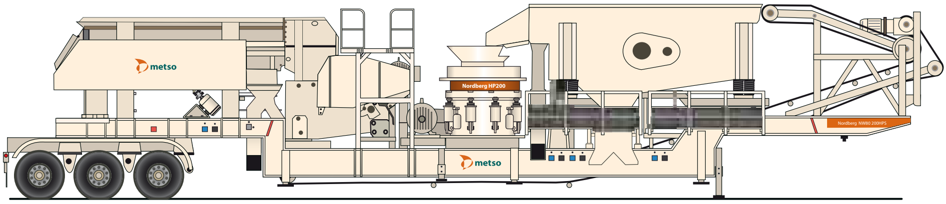
** four deck version*   *For inches divide by 25.4*   *For lbs divide by 0.45*   *For ft³ multiply by 35.3*   *For stph multiply by 1.1*

Nordberg NW Series Cone Plants for Closed Circuit Crushing

NW96 200HPS



NW80 100HPS – NW80 200HPS



Model	Total weight * t (lb)	Power kW (hp)	Transport Dimensions mm (ft/in)			Operation Dimensions mm (ft/in)		
			Height	Width	Length	Height	Width	Length
NW80 100HPS	47,5	265,35	4.000	2.500	19.530	4.636	4.077	18.430
	105.200	355,84	13'-1 1/2"	8'-2 3/8"	64'-7/8"	15'-2 1/2"	13'-4 1/2"	60'-5 5/8"
NW80 200HPS	52,9	328,34	4.000	2.500	19.530	4.636	4.077	18.430
	116.960	440,31	13'-1 1/2"	8'-2 3/8"	64'-7/8"	15'-2 1/2"	13'-4 1/2"	60'-5 5/8"
NW96 200HPS	61,1	351,44	4.130	2.630	20.460	5.347	4.087	19.913
	134.680	471,30	13'-6 1/2"	8'-7 1/2"	8'-7 1/2"	17'-6 1/2"	13'-4 7/8"	65'-4"

* Without discharge conveyors, although including all electric motors of the unit. Dimensions and weights herein are approximate and exclusively for informative purposes. For installation/ erection, Metso provides certificated drawings.

Model	Product Size and Capacity (mtph)			
	38 mm (1 1/2 in)	32 mm (1 1/4 in)	25 mm (1 in)	19 mm (3/4 in)
NW80 100HPS	120 - 150	100 - 130	90 - 120	75 - 100
NW80 200HPS	140 -180	120 - 160	105 - 140	95 - 125
NW96 200HPS	150 - 220	130 - 180	110 - 160	100 - 140

Performance figures are based on granite with a bulk density of 1600 kg/m≥ (100 lb/ft≥) and are also approximate and give an indication of what the plant can produce. The recommended setting depends on feed size, feed material crushability (Wi) and capacity required. Consult Metso for specific applications.

NW trains

The NW train concept provides unique solutions for all crushing and screening needs, from single-stage crushing and screening to complex multistage NW trains. The NW train concept consists of a large number of different NW modules combined with high-quality and reliable Metso feeders, screens, crushers, and conveyors, along with all accessories necessary to build an NW train that meets needs for high capacity and high end-product quality.

Portable NW trains are operated on electrical power. This environmentally friendly and reliable approach enables utilization of main power networks or generator stations, depending on availability. Operation on electrical power yields huge savings in operating and maintenance costs.

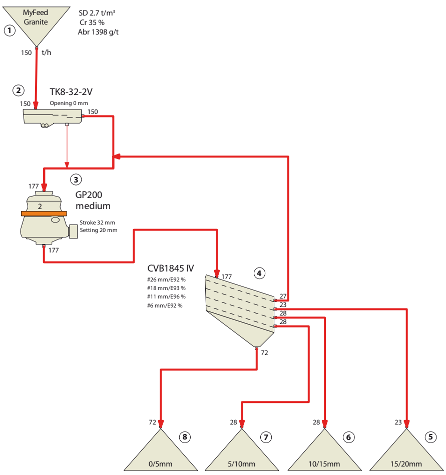
An NW train is a perfect solution when both mobility and maximum flexibility are required. A set of NWs can be regrouped as modules to fulfill the requirements of several different crushing and screening processes. The NW train concept provides numerous ways of arranging open and closed circuits, mixing material flows after screening, and distributing product stockpiles. The purpose of this unique concept is to meet the process requirements of any crushing and screening process by using standard high-quality portable NW train modules. Metso portable conveyors are a key part of this concept. These conveyors are available in different lengths and widths to accommodate all capacity classes. The conveyors are designed specifically for NW trains, to enable easy installation and full process flexibility.

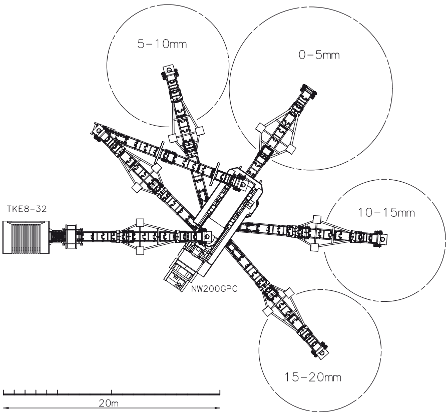
The Metso Bruno process simulation software is an indispensable tool in exploiting the flexibility provided by the NW train concept. By inputting the feed material information to the Bruno process simulation software, even a complicated crushing and screening process flow can be easily created and simulated. This makes selection and arrangement of equipment convenient and reliable.

To make selection of equipment easy, Metso has developed standard NW trains for common crushing and screening processes. These standard trains are proven solutions that can be safely applied as they are or used as starting points in configuration of customized NW trains.

NW Train example 1

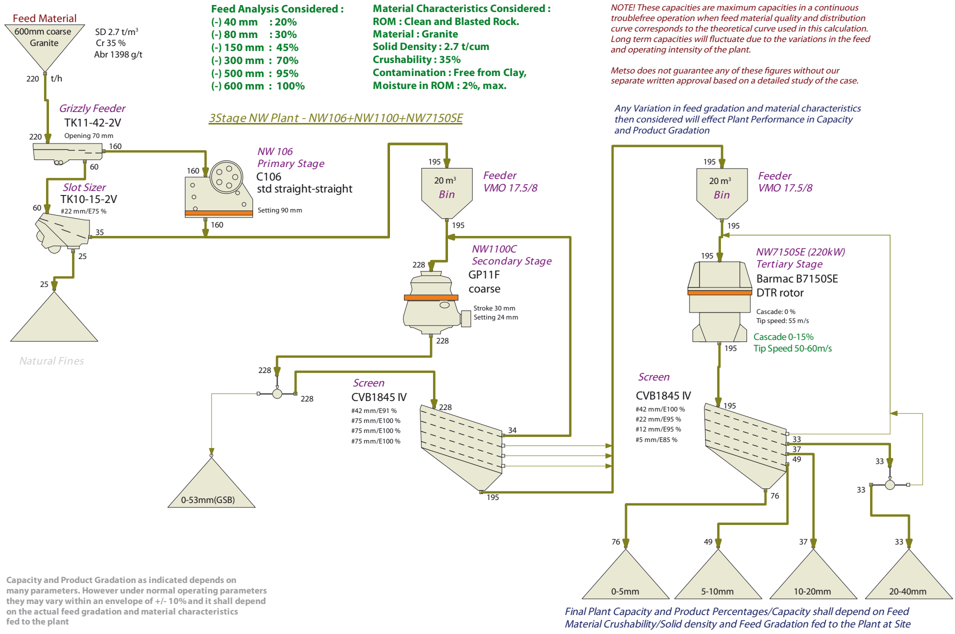
Single stage plant used commonly to make the asphalt fractions near the asphalt plant. Feed is secondary crushed material. Capacity 150 tph.



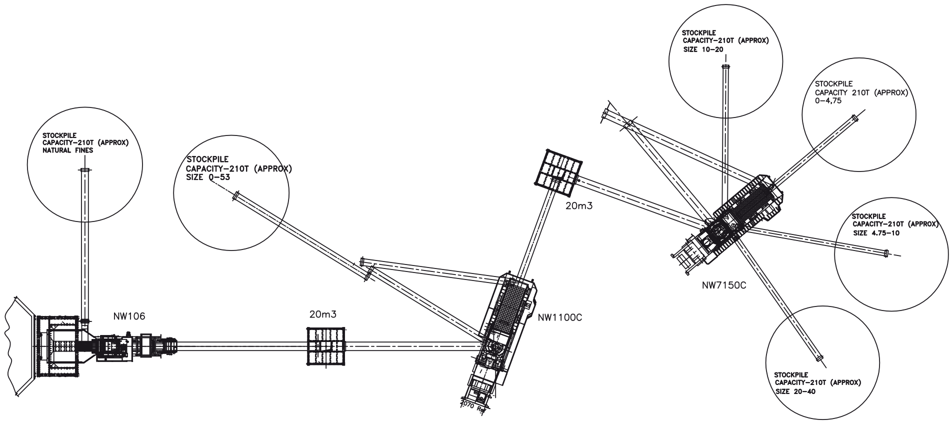


NW Train example 2

High quality road construction aggregates produced in three stages thanks to Barmac B-series tertiary unit. Also base material can be produced in two stages. Capacity 200 tph.

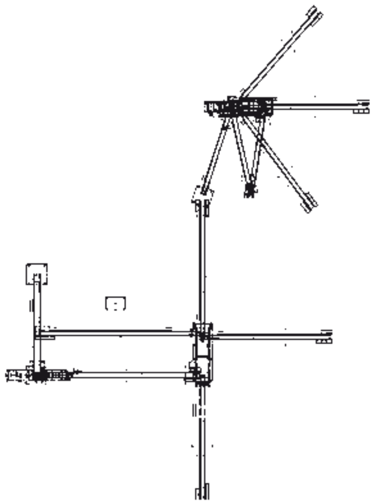


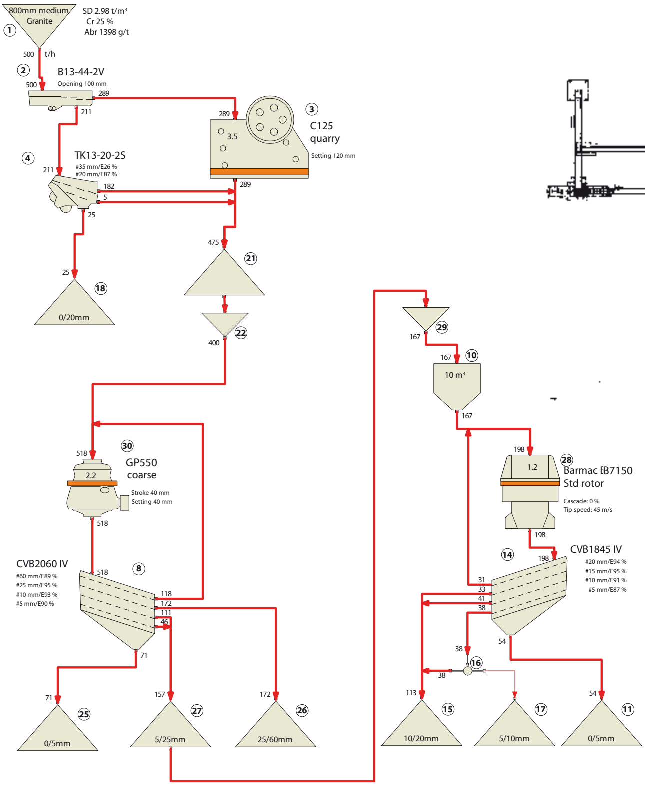
Capacity and Product Gradation as indicated depends on many parameters. However under normal operating parameters they may vary within an envelope of +/- 10% and it shall depend on the actual feed gradation and material characteristics fed to the plant



NW Train example 3

High capacity NW Train for construction materials. Can produce 400 tph high quality aggregates.





OVERVIEW

To guarantee the perfect functioning, it is indispensable to choose the right electrical components.

MOTORS

Electric features

Motor insulations can be of various classes: A, E, B, F or H. Motor life depends on environmental conditions and insulation class. Metso recommends using class F or H motors.

Service shift

Is the degree of load regularity applied on the motor.

Efficiency

It is the relationship, in percentage, between the actual power produced by a motor and the power it absorbs from the electric line.

Power factor

Power Factor (PF) is defined as the ratio between the active power (kW) and the apparent power (kVA) consumed by an electric device.

$$PF = \frac{kW}{kVA}$$

Some of the disadvantages of the low Power Factor in an industrial unit are:

- Larger amperage, increasing losses in the unit
- Larger voltage drops
- Reduction of the current conducting capacities of the electric conductors
- Payment of an extra fee in the consumed electric energy bill

Service factor

Service factor (DF) is the factor, which applied to the rated power, indicates the permissible load that can be continuously applied to the motor under specified conditions. It should be noted that this refers to a continuous overload capacity, i.e., a power reserve that makes the motor more capable of enduring unfavorable operating conditions.

Service factor should not be mistaken for the capacity of taking in transient overloads for a few minutes.

A service factor (DF) = 1.0 means that the motor was not designed to operate continuously above its rated power. This, however, does not change its capacity of withstanding transient overloads.

Protection degrees

Motor protection degrees are standardized by ABNT in a code made up of the letters IP followed by a two-digit number.

They define the type of protection a motor has against the entrance of water or strange bodies.

1st digit: indicates the degree of protection against the penetration of solid strange bodies and accidental contact.

0 – without protection
1 – strange bodies larger than 50 mm
2 – idem, larger than 12 mm
3 – idem, larger than 2.5 mm
4 – idem, larger than 1 mm
5 – protection against dust collection, hazardous to the motor
6 – protection against penetration of dust

2nd digit: indicates the degree of protection against the penetration of water inside the motor.

0 – without protection
1 – vertical water drops
2 – water drops with a slope of up to 15° with vertical axis
3 – Rain water with slope up to 60° with vertical axis
4 – drops from all directions
5 – water jets from all directions
6 – water from large waves
7 – temporary submersion
8 – permanent submersion

The combination between two digits, i.e., between two protection criteria, are summarized on the following table:

		First digit		Second digit
Motor	**Protection classes**	**Protection against contact**	**Protection against strange bodies**	**Protection against water**
OPEN MOTORS	IP00	None	None	None
	IP02	None	None	Water drops with slope up to 15º with vertical axis
	IP11	Accidental hand contact	Solid strange bodies with dimensions higher than 50 mm	Vertical water drops
	IP12	Accidental hand contact	Solid strange bodies with dimensions higher than 50 mm	Water drops with slope up to 15º with vertical axis
	IP13	Accidental hand contact	Solid strange bodies with dimensions higher than 50 mm	Water drops with slope up to 60º with vertical axis
	IP21	Contact with fingers	Solid strange bodies with dimensions higher than 12 mm	Vertical water drops
	IP22	Contact with fingers	Solid strange bodies with dimensions higher than 12 mm	Water drops with slope up to 15º with vertical axis
	IP23	Contact with fingers	Solid strange bodies with dimensions higher than 12 mm	Water drops with slope up to 60º with vertical axis
CLOSED MOTORS	IP44	Contact with tools	Solid strange bodies with dimensions higher than 1 mm	Drops from all directions
	IP54	Total protection against contacts	Protection against accumulation of hazardous particles	Drops from all directions
	IP55	Total protection against contacts	Protection against accumulation of hazardous particles	Water jets from all directions
	IP(w)55	Total protection against contacts	Protection against accumulation of hazardous particles	Rain Damp sea breeze

STARTING METHODS

Direct start

It is the simplest method achieved by connecting the motor to the electric supply line at full voltage. Whenever possible, a squirrel-cage rotor three-phase motor should be started directly. Torque curves and amperage are fixed, regardless of the starting difficulty degree.

Application: Normally used for small power motor. In plants where the electric supply line and other components can withstand considerable peaks, motors can have direct on-line start.

Advantage: Maximum starting torque

Disadvantage: High starting amperage

Star-delta start

This system is used only for motors having rated voltage for delta connections equal to voltage between the electric supply line phases. The motors should have at least 6 connection terminals.

Application: This system is used for light-load start or when loading torque at start does not exceed 50% of the nominal motor torque.

Advantage: Low starting amperage (starting current is reduced to 25 to 30% of the delta-connection's starting current).

Disadvantage: Starting torque is only 1/3 of rating. Six wires (two cables) are required for the electric connection to the motor.

Normal three phase motors winding connections

Windings	Rated voltage	Star-delta start
230 / 400 230 / 400	230 V 400 V	Possible with 230 V Impossible
230 / 440 / 230 / 460 230 / 440 / 230 / 460	230 V/ 230 V 440 V/ 440 V	Impossible Impossible
230 / 400 / 440 230 / 400 / 440 230 / 400 / 440	230 V 400 V 440 V	Possible with 230 V Impossible Impossible
400 / 660	400 V	Possible with 400 V
230 / 400 / 440 / 760 230 / 400 / 440 / 760 230 / 400 / 440 / 760	320 V 400 V 440 V	Possible with 230 V Impossible Possible with 440 V

Self-compensated starter

Used for "heavy load" start.

Application: For high-powered start motors, providing start with rather favorable features.

Advantages: Limits starting current by avoiding electric supply line overload, however, leaving enough motor torque for start and acceleration. Normally, the autotransformer has two output taps corresponding to 65% and 80% of nominal voltage.

Disadvantages: High acquisition cost, limited frequency of operations, and autotransformer size causing higher volume.

Rheostat start for slip-ring rotor motors

This starting system is universal as it permits matching starting torque and corresponding amperage peaks during start with their own needs for each specific case.

Application: For heavy machines

Advantages: Starting with maximum torque and reduced current peaks. Speed can be varied through the rheostat.

Disadvantages: High acquisition cost; resistor overheating limits the permissible number of starts per hour.

Soft-starter

Advances in electronics enabled the creation of solid state start-key that consists of a set of pair of thyristors (SCR) (or combinations of thyristors/diodes), one at each phase of the motor. The angle of elevation of each thyristor pair is electronically controlled to apply a variable voltage to the winding of the motor during start. At the end of the start period, typically adjustable within 2 and 30 seconds, voltage reaches its highest peak after a soft-start or an ascending ramp, instead of being submitted to increments of sudden jumps. Therefore, we keep the start amperage (on line) close to the nominal and with soft variation.

Besides the advantage of voltage control (current) during start, the electronic switch also presents the advantage of not having movable parts or arc generating as the mechanical switches. This is one of the strong assets of the electronic switches, for their life becomes longer.

MOTOR CLASS SELECTION

Crushers in general

Although there is a great variety of crushing types and models, some features and specifications of electric motors are common to all of them, among these are the following:

- Continuous use,
- Totally closed external ventilation,
- Service factor: 1.00,
- Torque: approximately 125% at the start and 200% at the maximum torque,
- Type: squirrel-cage induction motor,
- Capacity to withstand radial tension, in 360°, of V-belts,
- Voltage variation: ± 10%,
- Adjustable base by sliding.

For the best indication of the motor, according to Metso Engineering, it is necessary to gather the following data:

- Working voltage, frequency and altitude,
- Crusher type and model,
- Special features, if required by the user,
- The motor bearing must be properly dimensioned to withstand the weight of the pulley and the belt tensioning. The motor shaft diameter must be adequate to resist the peak torque and simultaneously bending caused by the belt tensioning and the weight of the pulley. The length of the shaft must be minimum and according to the dimensional solicitation of the motor pulley of the specified drive.

Conveyors

Motors of up to 75 HP are usually from the "N" class, with direct on-line start for small and mid-size motors. For motors with power above 75 HP, slip-ring rotor motor, or squirrel-cage class "N" or "H" motor with hydraulic couplings are recommended, which limits the torque, yielding soft starts.

CABLES

Installation Type

Type and size of the cable depends on environmental conditions. There are five common types of installation for electric cables.

1. Directly buried

Advantages: Good mechanical protection and thermal dissipation. During installation, cable pulling is not necessary.

Disadvantages: Difficult maintenance and cable replacement.

2. Steel cable ducts

Advantages: Excellent mechanical protection, easy maintenance and cable replacement.

Disadvantages: Low thermal dissipation as compared to buried cables. High cost.

3. Trenches

Advantages: Easy maintenance and replacement.

Disadvantages: Less mechanical protection, bad thermal dissipation.

4. Trays

Advantages: Easy maintenance and replacement, good thermal dissipation.

Disadvantages: Subject to mechanical damage.

5. Aerial

Advantages: Easy maintenance and low cost.

Disadvantages: Subject to mechanical damage.

Insulation

The following points should be considered when selecting electric cable insulation: operating voltage, temperature, overloads, short-circuits, resistance to acids, salts, alkalis, ozone, and organic chemical agents.

For crushing plants, thermoplastic insulation cables are recommended, such as the ones based on PVC (polyvinyl chloride), Pirelli sintenax, Ficap fisec (for 0.6/1 kV, or similar).

Automation is a key tool for increasing productivity also in crushing & screening business today. To get the maximum performance and profit from the equipment and plants, Metso has to offer a broad range of automation solutions from small stand-alone machine controllers to huge plant-wide production systems,

What is automation?

Automatisation basically means making things without continuous human participation. This can be achieved in many ways: electrically, hydraulically or even mechanically. Before the dawn of programmable logic controllers in the early 70's and in some simple systems still today, machine automation was made typically by electromechanical relays, sequencers, unit controllers and hard wiring. Today due to higher demands for performance and flexibility, the relays and wiring have been replaced with programmable controllers.

The purpose and benefits of automation are commonly known and generic. Automation is a tool for increasing productivity by improving capacity and quality, reducing operational costs like labour, downtime and maintenance/repair. Automation improves process' performance by keeping its operational state at the optimal point which reduces wear, waste and inefficient use of resources i.e. people, equipment, time, raw material and energy. Automation can increase safety by acting faster and more reliably than us, also at places where we cannot enter. Automation also has a key role in improving work conditions by providing better operator ergonomics and diagnostics. Systems can monitor machines with high sampling speed and detect emerging problems before they cause damages, and collect data for later analysis e.g. after incidents. Automation is everywhere from power plants, paper mills, workshops, transportation and buildings to communication and yes, in mining- and construction machines and processes too.

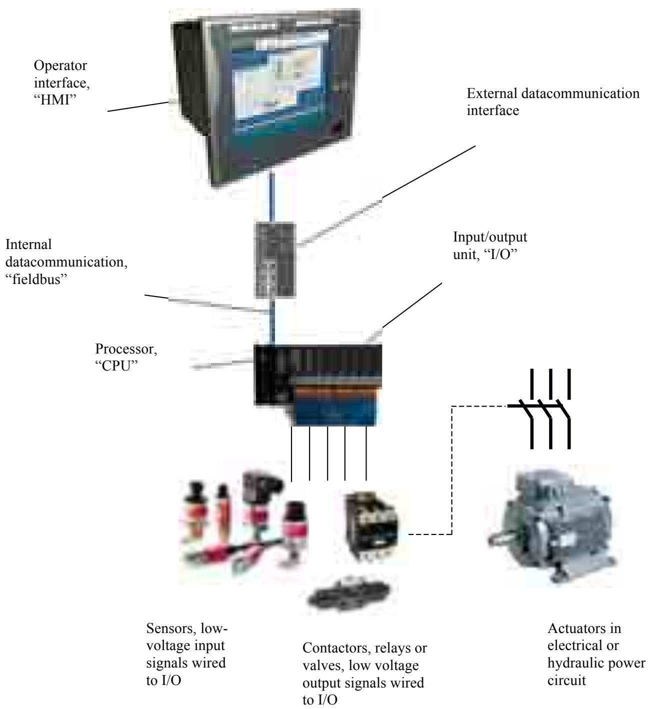
Automation systems

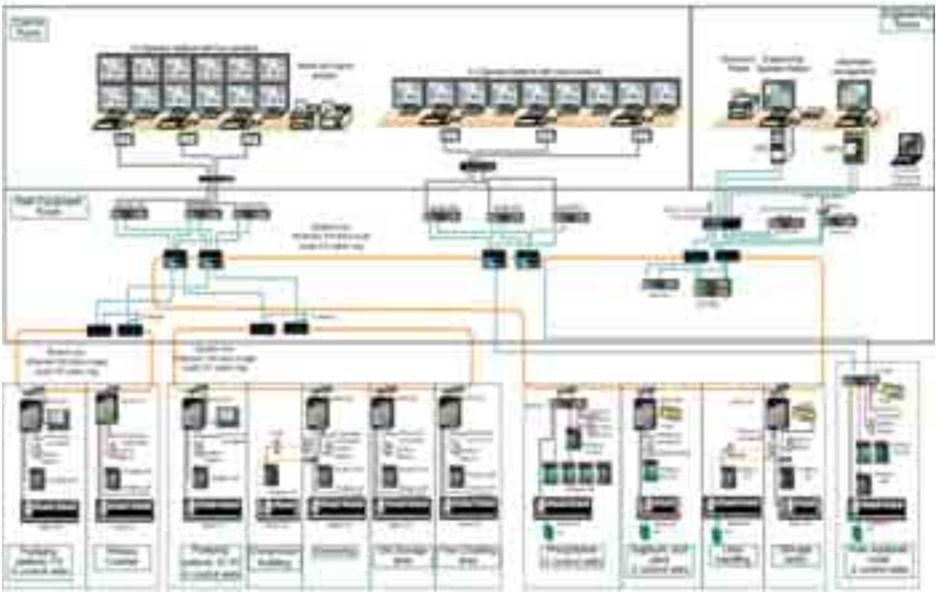
Automation system is a system that
1. Senses its environment with sensors
2. Collects the sensed data and processes it to information
3. Reacts according its program logic through its actuators
4. Interacts (enables visualisation of machine state and possibility to feed user requests to the system) with user through Human-Machine Interface which can be e.g. lamps and buttons or a display screen.

Control systems also distribute data internally and externally. Internal datacommunication is needed to exchange data inside the system's parts like controllers, input/output units and display screens. External datacommunication is needed to link the system to other systems, like other machines or supervisory control and data acquisition systems.

Systems can be built in many ways. They can be from tiny to huge, distributed or centralized or something in between, but these main elements are always present regardless of are they built into one or separate units or subsystems.

An example of small standalone single machine control system.





An example of large networked system with information management in a mine with crushing & screening controls.

Automation benefits

Capacity

Maximizing the capacity of the plant starts usually from feeding as much as possible feed material to the process. Then bottlenecks further in the process are opened as far as possible, most often to the point where final processing stages are at 100% load, and finally the situation is stabilized to this optimal point where there's max capacity but without sacrificing quality, wear, energy consumption or other key process parameters. To get to the optimum and especially in staying in there regardless of interferences, the perfect tool to the job is automation. Automatic control decreases process stops and variations which sacrifice the capacity. Automatic control reduces the need for human participation, which decreases the operator's possible limiting impact on performance. While equipment operate at their nominal values, i.e. close to their designed best performance point, usually also the product quality and machine wear are optimal.

Product Quality

Full-choke level feeding, around the total circumference of the chamber, contributes to much better efficiency and lower costs. Metso automation systems help to maintain full-choke level feeding and a constant load, offering the benefits of inter-particle crushing, which guarantees a product of better shape, with minimal liner wear and lower energy consumption per ton produced. Also, utilizing the correct CSS (closed side setting) in crusher, keeping it constant regardless of wear and balancing the setting within the whole process between the crushers plays an important role in product quality optimisation.

Better Availability

Metso automation systems allow operation of the crusher at its maximum capacity within safety margins, avoiding underproduction resulting from the safety limits required by manual operation or over-cautiousness of the operators. By avoiding overload and subsequent mechanical failures, the automation also reduces downtime for maintenance.

Maximum Efficiency

Constant maximisation of production and minimal re-circulation of load contribute to a reduction in production costs. Other benefits include lower costs of wear material, not only in crusher liners but also in screens, spouts, belts, and so on. Metso automation systems optimise process control while at the same time reducing crusher maintenance costs, ensuring maximal crushing capacity, and maximising the availability of the crusher. The result is the lowest possible cost per ton produced.

Optimised Control

Metso automation systems compare continuously measured values with pre-set values and react immediately to changes in the load. This reduces the need for human monitoring and, therefore, valuable man-hours.

Operation Monitoring

Versatile monitoring and collection of data, including average, cumulative, and expected crushing values, provide a large amount of information, which can be used as a management tool to improve production.

Alarms

All systems include clearly visible alarm messages, which give warnings of abnormal operating conditions and indicate the reason for a break or failure in the sensor system. These occurrences, including all relevant operational measurements, are recorded during a certain period of time to ensure the rapid solution of the problem.

Automation for stationary crushers

Today, production managers prefer suppliers who provide solutions and not just products. Bearing this in mind, Metso has developed ICx000 Crusher automation series that aim at providing better flexibility and versatility to meet the needs of crushing plants, while facilitating the plant's operation and maintenance.

Automation for mobile systems

The ICx00 series for mobile systems has been designed for ease of use, the servicing of LTs and increased productivity. It provides the necessary information and control functions enabling the operator to optimize the utilization of the machine and fault diagnostics troubleshooting. The ICx00 series improves the protection of users and equipment.

The main functions of the ICx00 series are:
- Protection of the users and the machine
- Machine and process control
- Diagnostics of the control system and the machine
- Monitoring of the control system and the machine
- Data communication with other machines and systems

The control system provides protection against overloads, misuse, device faults and environmental conditions. The control system monitors temperatures, pressures, speeds, engine information etc. System diagnostics includes alarm and parameter logs, I/O statuses and sensor values and engine trouble codes. The system controls all of the LT's process-related devices.

Remote monitoring and data collection

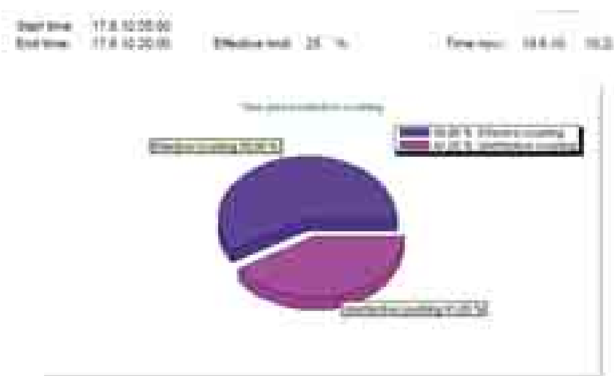
Mobile and wireless datacommunication technologies have developed very quickly within past decade. Also, the need for management's instant anywhere access to performance data of plants and equipment has emerged. With Metso's technology, it is possible to get all that data wirelessly onto any computer over the Internet. Your plant data can be monitored as live or through readymade reports, totally secure protected with user access rights. You can see for example information on features such as running hours, crushing availability, fuel/energy consumption and total production in tons.

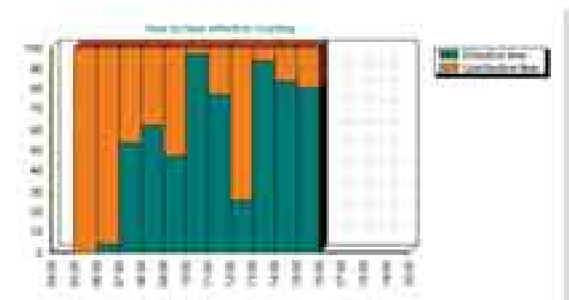
While viewing the collected data using a PC, different reports can easily be selected and read from the contents hierarchy. You can search the reports by using the calendar function and also print out the data in pdf format or copy it into excel.

Using the system, a wide variety of functions can be chosen. For example, features such as effective crushing time, crusher power consumption and temperature, and tons-per hour capacity measured from the conveyor, can be reported. If required, other types of tailor-made report contents can also be provided.

Process automation

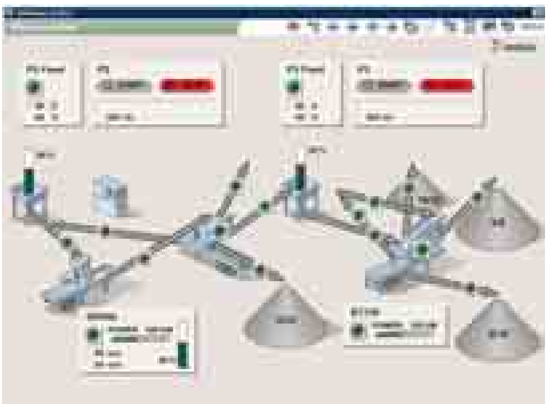
Modern production plants demand for more productivity, capacity, quality, safety, environmental friendliness, accurate on-time reporting, good cost per ton ratio, properly timed maintenance and efficient asset management, just to name a few. With Metso's own state-of-art process automation platform, this all can be easily achieved. Metso DNA automation system





provides reliable machine and process controls, performance optimisation, networking, data collection and analyzing tools and remote monitoring capabilities all in one platform. System is extremely scalable from small standalone crusher controller to plant wide control and information system – and all the time staying as the same Metso system which provides the customers best in the market life-cycle support: Starting from professional project execution and commissioning with local teams near the customer, continuing from spares and repair to maintenance, training, operator support, easy expands & updates, local availability support & improvent services as well as constant process performance enhancements.

Through own automation technology and its industry focused development, as well as automation oriented operations for project execution and customer support, Metso is capable to offer the most comprehensive, reliable, user friendly and productive solutions to the crushing & screening industry today.



CRUSHER AUTOMATION WITH VISIOROCK™

VisioRock™ is an advanced online vision technology for measuring particle size distribution, shape, color and other properties of rocks or ore on a conveyor belt. VisioRock™ technology is widely used in the mineral industry, either as a standalone measurement device or as an integrated part of advanced control systems.

VisioRock™ functions
As a standalone instrument, VisioRock™ estimates rock size distribution online by analyzing the images of a camera located above a conveyor belt, often over the discharge of a crusher, where it acts as a crusher opening sensor, or over the feed to a SAG mill, where it helps to optimize mill operation. VisioRock™ cameras are also installed over apron feeders in some plants.

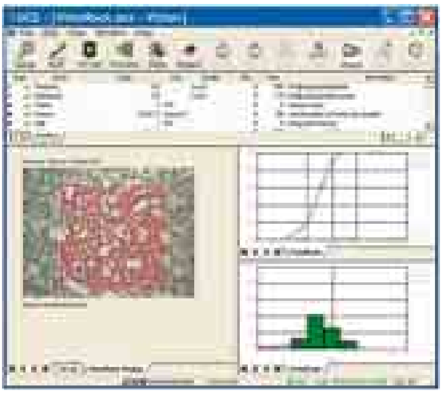
In a secondary crusher circuit, VisioRock™ combined with an expert control logic in Metso OCS© software triggers adjustments of the crusher setting when needed. In some cases the entire operation of the crushing circuit, including feedrate, is controlled by OCS©. The automatic decisions to adjust the crusher gap are based on crusher product size but also take into account other aspects such as crusher feeding conditions and power draw. Fuzzy logic is typically used in this type of applications.

In some cases VisioRock™ can be used as a rock type sensor, combining different sources of information for identifying rock type or ore type automatically.

VisioRock™ hardware
The hardware for a standard VisioRock™ system or a VisioRock™ Oversize Detector usually comprises:

- One or several IP cameras. Each camera is housed in a waterproof dustproof IP67 stainless steel enclosure equipped with an air barrier that prevents dust from sticking to the front window.
- A shielding and a lighting system. The measurement area is protected from direct daylight or other lights by a shielding. The lighting system consists of LED spotlights located inside the shielding and arranged in order to provide optimized illumination of the area.
- Hardware for communication between the camera(s) and the computer(s). The IP signal is conveyed through a LAN usually with optic fibers.
- One or if needed several quad core computers or workstations or servers.

VisioRock™ software
The complete rock size distribution is calculated for each image, many times per second, and the cumulated size curves are displayed for each image on OCS© graphic interface. An average size distribution and other averaged measurements are calculated at the end of each cycle. The duration of a cycle is configurable from one second up to several minutes. At each cycle the averaged values are sent to the DCS/PLC. Artificial intelligence modules in OCS© (expert system, fuzzy logic, model-based optimization techniques) can be configured to further analyze the situation and automate complex actions.



Visiorock

VisioRock™ Oversize Detector
VisioRock™ Oversize Detector is a variant of VisioRock™, dedicated to the detection of abnormal objects or oversized particles, for instance in a screened product. The core of VisioRock™ Oversize Detector software is a fast processing algorithm, in order to analyze the entire belt in real time. When VisioRock™ Oversize Detector "sees" an abnormal or oversize object, it triggers a configurable alarm, possibly stops the process, or generates more sophisticated automated action plans. The history of the detections and the images are archived and can be replayed at any time, for instance to analyze an oversize event.

VisioTruck™
VisioTruck™ is a variant of VisioRock™ essentially designed for analyzing the material discharged by the trucks at the primary crusher. It estimates the size distribution of the rocks generated by blasting, which is of major importance for optimizing the drilling and blasting process and rationalize the operation of the crusher. Just like with VisioRock™ Oversize Detector the size distributions and the images are archived and can be replayed at any time.

VisioRock-Studio©
Contrarily to the other software of the VisioRock™ range of products, VisioRock-Studio© is a software used offline for analyzing images of piles of rocks, muck piles, or conveyor belts or trucks, taken with a standard digital camera or even a cell phone. Those images are usually taken with non controlled lighting and present perspective challenges. With VisioRock-Studio©, in a few minutes it is possible to produce an evaluation of the size distribution of the rocks or the ore in a pile, with colored pictures and graphics.

Introduction

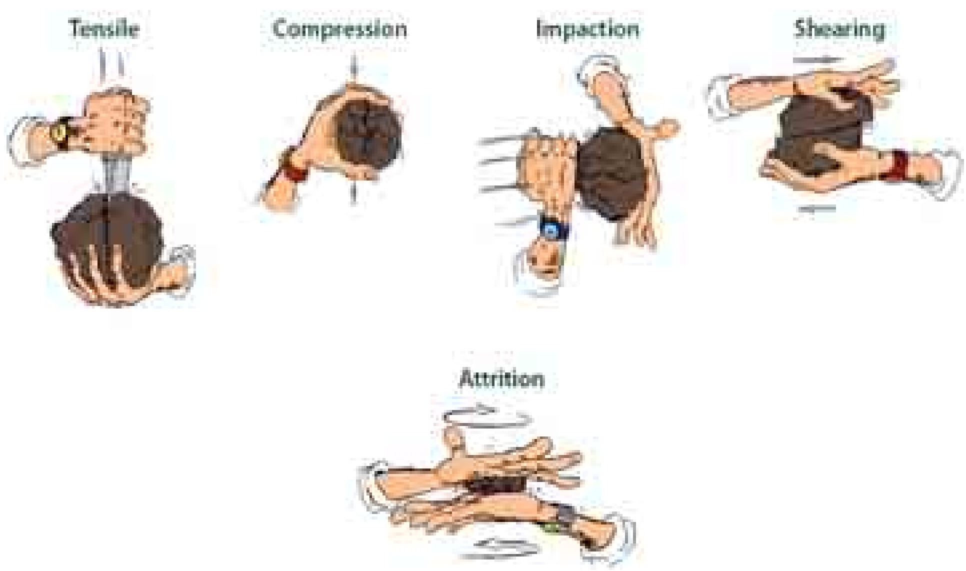
Mineral processing activities unavoidably result in wear. And wear costs money. Often lots of money. This is related to the structure of rock, ore or minerals, being crystals normally both hard and abrasive.

Why wear at all?

Wear is caused by the normal rock stress forces

- Tensile
- Compression
- Impaction
- Shearing
- Attrition

in combination with **mineral hardness and energy!**



Wear in operation

caused by

COMPRESSION	IMPACTION HIGH VELOCITY >7m/s	IMPACTION LOW VELOCITY <7m/s	SLIDING

protected by

METALS
Manganese Steel
Ni hard Ni-Cr white iron
High Crome Cr white iron

Polymers
Rubber
Polyurethane
CERAMICS

Wear by Compression

COMPRESSION | IMPACTION HIGH VELOCITY >7m/s | IMPACTION LOW VELOCITY <7m/s | SLIDING

Metals

- Manganese Steel
- Ni hard Ni-Cr white iron
- High Crome Cr white iron

Applications:

Crushers: **Gyratory**, **Cone**, **Jaw**

Metals and compression

Manganese steel: The first option for compression wear is manganese steel. This alloy has a very special property, being self hardening and self healing when exposed to large amounts of compression and impact energy.

Normal standard is a 14% Mn alloy which is first option in most crushing applications.

18 % Mn alloy is a harder but also a more brittle alloy used in applications where the rock is softer (limited self hardening) but very abrasive.

Restrictions:
When installed in applications without work hardening service life will be poor!

The alloys of cast ”white iron” type (High-chrome and Ni- hard) shall be avoided in crushers submitted to heavy compression.

Wear by Impaction (high)

COMPRESSION | IMPACTION HIGH VELOCITY >7m/s | IMPACTION LOW VELOCITY <7m/s | SLIDING

Metals

- Manganese Steel
- Ni hard Ni-Cr white iron
- High Crome Cr white iron

Applications:

Impactors: **HSI**, **VSI**

Grinding Mills

Slurry Pumps

Metals and impaction

The metals can be classified as:

Manganese: Needs high impaction for self hardening. If impaction is getting lower and sliding is increasing Manganese is not suitable.
High Chrome: Opposite to manganese, can take heavy sliding but is more fragile and therefore limited against impaction.
Ni-hard: Somewhere between the two materials above.
Cr-Mo: Used in grinding when High Crome is too brittle

Note! *The use of chrome steel (less brittle than chrome iron) is increasing for liners, curtains and hammers.*

Wear by Impaction (low)

COMPRESSION | IMPACTION HIGH VELOCITY >7m/s | IMPACTION LOW VELOCITY <7m/s | SLIDING

Rubber and impaction
For low velocity impaction (material speed less than 7 m/s) SBR, styrene butadiene rubber (60 ShA) is always the first choice and will give the best cost effectiveness. The material is also very tolerant to material size and is excellent for use in grinding mills, dump trucks and primary hoppers.

Restrictions:
Look out for aromatic and fuel oils.
Impact angles have to be considered.

Polymers
Rubber
Polyurethane
CERAMICS

Applications:
Dump Trucks, Feeder hoppers, Transfer points, Grinding Mills Slurry pumps

Wear by Sliding

COMPRESSION | IMPACTION HIGH VELOCITY >7m/s | IMPACTION LOW VELOCITY <7m/s | SLIDING

Rubber and sliding
Natural rubber is an outstanding option for the sliding abrasion of small, hard and sharp particles. Also for wet conditions.

Restrictions:
If sliding speed is exceeding 7 m/s (dry applications) temperature can start to rise and cause damage. Besides temperature oil is always a threat.

Polyurethane and sliding
Best option for tough sliding applications when particle size is lower than 50 mm. Excellent in wet applications. Tolerant to chemicals and oil.

Restrictions:
Large sizes and high velocity might cause problems.

Polymers
Rubber
Polyurethane
CERAMICS

Applications:
Chutes, Spouts

Ceramics and sliding
The natural choice when mission is too hard for the options above. Hardness, resistance to temperature and corrosion plus low weight gives a masterpiece for sliding.
Al203 (Aluminium oxide) is the most cost-effective material.

Restrictions:
Impaction is dangerous for ceramics (cracking) and must be avoided. Combination ceramics + rubber is an option. Composition and quality can vary from supplier to supplier.

Metso Certified Wearparts

Metso has several modern foundries destined to manufacture wear and impact resistant parts. The permanent development of new alloys and profiles provides the Metso wear parts and liners unequalled performance and productivity levels and the best cost/benefit ratio.

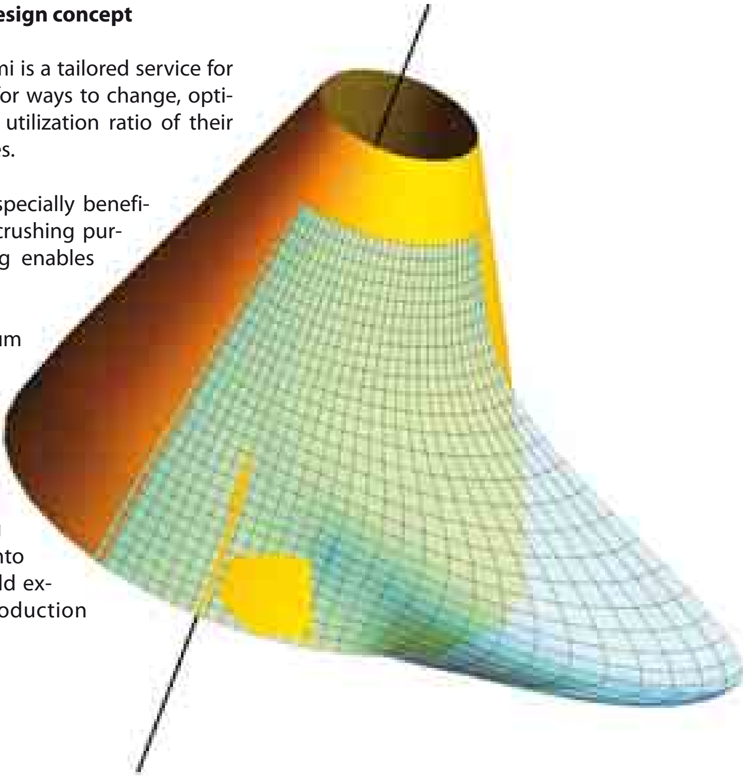
Cast in austenitic manganese steel or other alloys for special applications, Metso wear parts and liners are designed to guarantee a perfect crusher performance. Produced under a rigorous quality control, they are manufactured in several profiles, for use in accordance to the features of the material to be crushed.

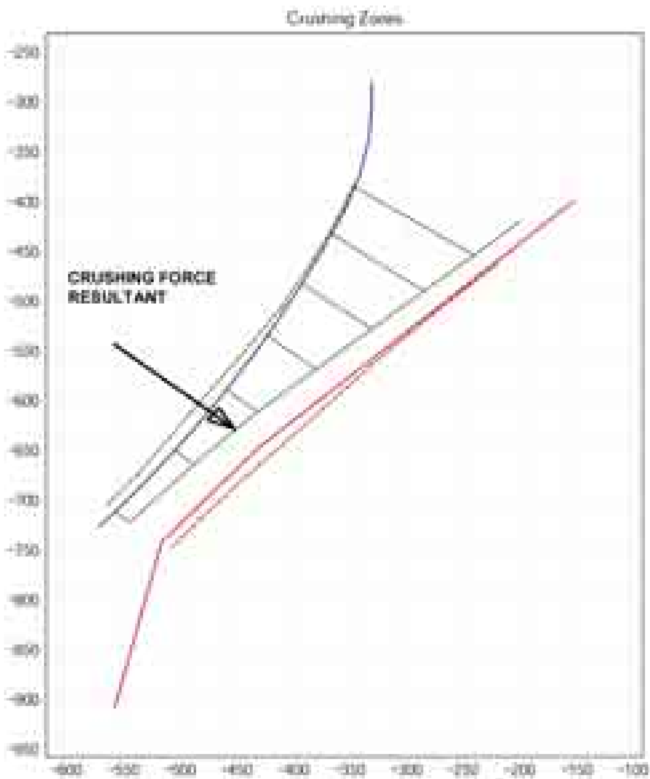
Customized cavity design concept

Metso Chamber Optimi is a tailored service for customers who look for ways to change, optimize or enhance the utilization ratio of their size crushing processes.

Chamber Optimi is especially beneficial for high-volume crushing purposes, where tailoring enables increased production.

For developing optimum cavities, Metso uses a state-of-the-art, computer-controlled simulator that has been developed in-house during several decades. Using this tool and taking into account the latest field experience, the set production targets are achieved.





Customized cavity design concept

Metso applies a six-step process to customize an optimum cavity design for its crushing customers.

Data collection

In the **data collection phase**, our local specialists conduct plant audits to verify such factors as feed gradation, material samples, power draw, foam castings of wear patterns and crusher settings.

Analyzing

The next step is **analyzing**, where our competence center network focuses on crushing process simulation, material characteristics, improvement potential and global benchmarking.

Re-engineering

In **re-engineering**, we utilize Metso global know-how in wear materials metallurgy, state-of-the-art computer simulations and cavity design experience.

Manufacturing

Manufacturing takes place in Metso's own global foundries, whereby we have full control of the supply chain. This ensures consistent quality, perfect fit and high availability.

Delivery and installation

In the **delivery and installation** phase, we are able to offer efficient logistics with local know-how and service – boosted by our sales, manufacturing and service facilities in over 100 countries.

Follow-up

Inspections by Metso local specialists supported by our remote monitoring facilities ensure an efficient **follow-up** – meaning more uptime, increased capacity, longer wear life and lower cost per ton for our customers.

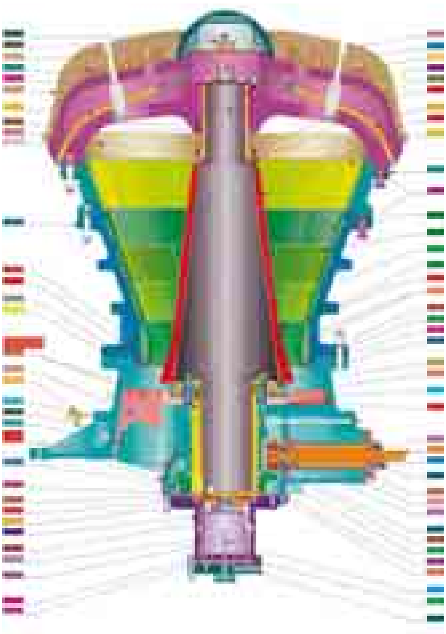
Crusher Wearparts

Primary Gyratory Crusher Liners

The crushing chamber, also known as the crusher cavity, is composed of a Mantle and Concave segments. Concave may be one-, two- or three piece type, depending on the crusher size and design.

Concave profiles are designed taking into account the best combination of the nip angle, power draw, crushing force and capacity requirements. Focal point is in maximizing the crusher productivity, as well as providing the best exploitation of the wear material.

There is a wide variety of metallic alternatives and wear part profiles to ensure your productivity and operational costs to be optimized for each application type.



Jaw crushers

Typical solution is to start with manganese steel linings to run the process up to target capacity and gradation. The maximizing of chamber life takes place when the process is stable.

Several low alloys of quenched and tempered steel as well as tool steel and chromium iron are available for specific applications.

Jaw Plates for Jaw Crushers

The crushing chamber is composed of a Stationary /Fixed Jaw (frame side) and a Movable/ Swing Jaw (pittman side), and they may be one piece or more, depending on the crusher size and design.

Its longitudinal profiles are designed taking into account the best combination of the nip angle, differentiated wear profiles between stationary/swing, therefore maximizing the crusher productivity, as well as providing the best exploitation of the wear material.

There is a wide variety of transversal tooth profiles to ensure your productivity and operational costs to be optimized for each application type.

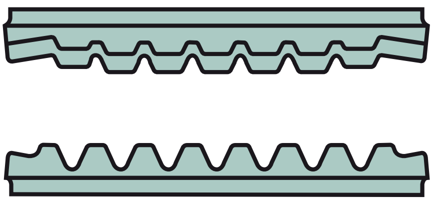
It is important to have similar transversal profiles for the used pairs (stationary and swing jaws) so that we may obtain the correct combination to avoid any harmful effort to the equipment, as well as to achieve the best product quality.

Following, you many find charts of the main transversal profiles and their corresponding features.

C Crusher product Line

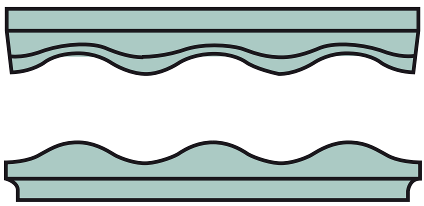
Standard Profile

- Suitable for both rock and gravel crushing,
- Well balanced wear life, power requirements and crushing stresses,
- Typical factory installation



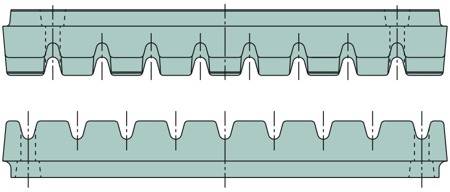
Recycling Profile

- Suitable for concrete crushing,
- Fine material flows easily through the cavity along the large grooves.



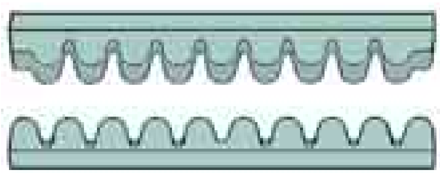
Quarry Profile

- Suitable for blasted rock crushing in quarries,
- The flat teeth have a better performance with abrasive materials (more wearable tooth material),
- Causes high stresses and increases power requirements.



Super Teeth Profile

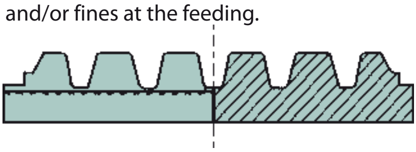
- Suitable for general use and especially a good choice for gravel crushing,
- Large mass and special design of the teeth provide long wear life and make fine material flow down through the cavity along the grooves without wearing the teeth.



Classic ie, old Product Line

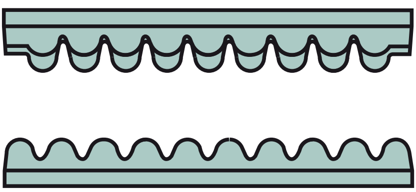
WT (Wide Tooth) Profile

- Strong transversal profiles,
- Larger amount of wear material,
- High exploitation of the wear material,
- Excellent production,
- Recommended for abrasive material with dirt and/or fines at the feeding.



Corrugated Profile

- Rounded teeth,
- High production,
- Large quantity of wear material,
- High exploitation in weight,
- Recommended for feeding with dirt and/or fines.

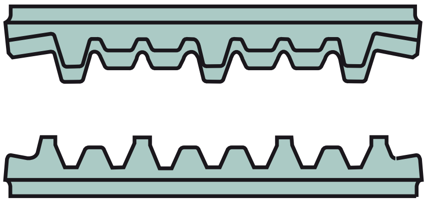


HD (Heavy-duty) Profile

- Smooth with expansion grooves for manganese steel,
- High resistance due to large thickness,
- Recommended for extremely hard, barely lamellar, low abrasiveness and small fines content materials at the feeding.

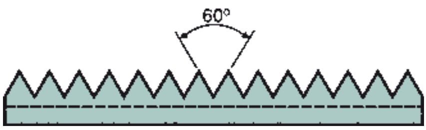
Thick Tooth Profile

- 90° triangular dented profile,
- Partially reduces lamelarity,
- Recommended for small and medium settings.



Fine Tooth Profile

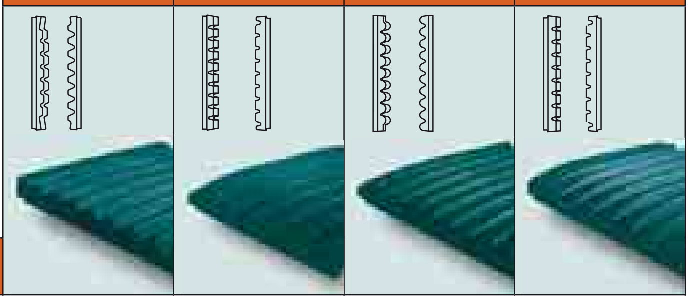
- 60° triangular dented profile,
- Partially reduces lamellarity,
- Recommended for small settings,
- Applicable to small size crushers.



Note:

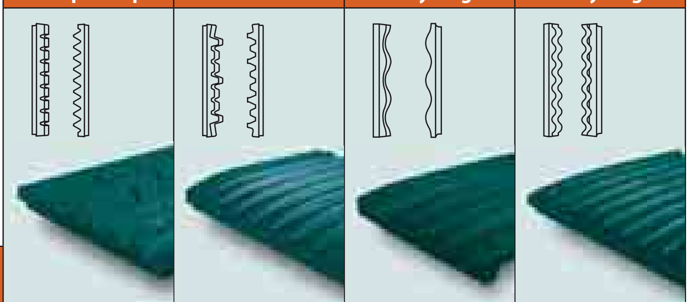
Not all profiles are available for all crusher models. For more detailed information please consult your nearest Metso contact point.

To produce top quality end products with the highest efficiency and reliability, at the lowest cost, you have to select wear parts that are optimized for your particular crushing application. This guide gives basic recommendations for selecting the best wear parts for your Nordberg C Series Jaw Crushers. We offer our well proven XT710 wear resistant steel as standard material and our new XT810 Supersteel for specially demanding hard rock applications. We at Metso will be pleased to give you more detailed guidance - let us contribute to your success!



Feed material types	Standard	Quarry	Superteeth	Special + Quarry
Hard rock, UCS >160 Mpa	●	● ● ●	● ●	● ●
Soft rock, UCS <160 Mpa	● ●	● ● ●	● ●	●
Gravel	● ●	●	● ● ●	●
Slabby soft rock, UCS <160 Mpa	●			
Slippery rocks	●	●	● ●	●

Note: The more orange bullets the better choice.



Feed material types	Quarry + Super Grip	Anti-Slab	Wavy like Recycling	Corrucated Recycling
Hard rock, UCS >160 Mpa	●			
Soft rock, UCS <160 Mpa	● ●			
Gravel	● ●	● ● ●		
Slabby soft rock, UCS <160 Mpa	●			
Slippery rocks	● ● ●			
Asphalt recycling			● ● ●	
Concrete recycling				● ● ●
Demolition waste recycling				● ● ●

Note: The more orange bullets the better choice.

Liners for Cone Crushers

The selection of the liner type for cone crushers is fundamental to ensure its desired performance through life. The liners must be chosen according to the material size at the feeding and the required product, so that all liner surface extension may be used. Otherwise, by using for example liner for coarse cavity with fine feeding, crushing will concentrate only at the lower part of the liner, and the highest part will remain non-exploited, causing premature wear.

The liner set is composed of the mantle at moving side, and bowl liner or concave at stationary side.

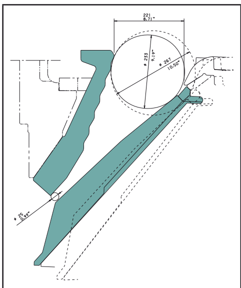
A wide variety of liners cover all Metso brands of crushers.

The combination between the mantle and the bowl liner defines the crushing cavity. Therefore, once we choose a certain set, parameters like the feeding opening, the crusher chamber profile and the closed side setting (CSS) are established.

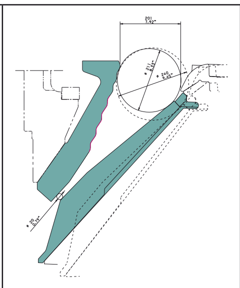
In the case of cone crushers the choice of the set must be made according to the feeding size and required product. This is fundamental to ensure the set longer lifetime with a more regular parts wear, a better exploitation of the wear material weight, higher crusher efficiency and a better quality of the required product.

Below, a generic illustration of the several possibilities for crushing cavities for cone crushers.

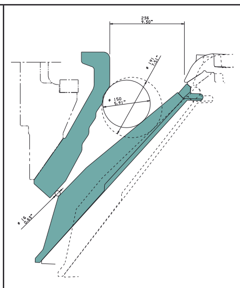
HP CONE; STANDARDS



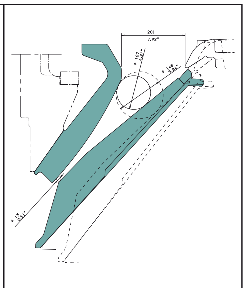
STD Extra Coarse



STD Coarse

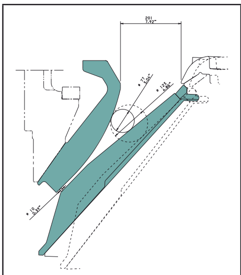


STD Medium

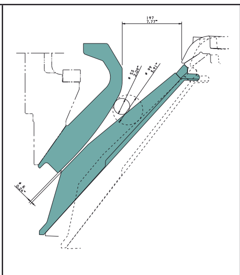


STD Fines

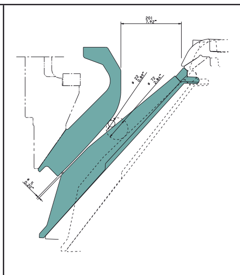
HP CONE; SHORT-HEAD



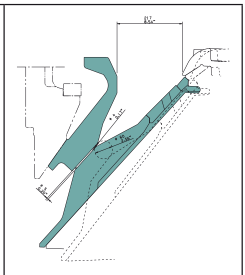
SH Coarse



SH Medium



SH Fines



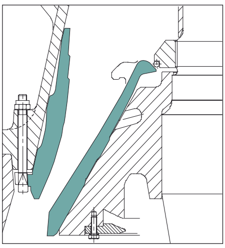
SH Extra Fines

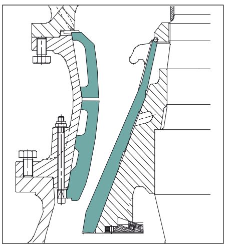
Rock properties

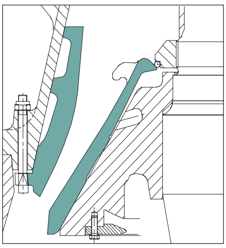
	Very difficult	Difficult	Medium	Easy	Very easy
Los Angeles Crushability UCS/MPa	-12 -20 300-	12-17 20-30 220-300	17-22 30-40 150-220	22-27 40-50 -90-150	27- 50- -90
Machine Types					
Secondary Cones					
- HP small/medium (HP100-HP500)	XT720	XT720	XT720	XT510	XT510
	XT710	XT710	XT710	XT710	XT710
- HP large (> HP500)	XT510	XT510	XT510	XT510	XT510
	XT520	XT520	XT520	XT520	XT520
		XT610	XT610		
Fine Cones					
- HP small/medium (HP100-HP500)	XT720	XT720	XT720	XT510	XT510
	XT710	XT710	XT710	XT710	XT710
- HP large (> HP500)	XT510	XT510	XT510	XT510	XT510
	XT520	XT520	XT520	XT520	XT520
		XT610	XT610		

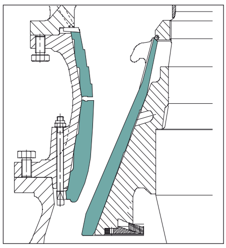
= *Initial material*

GP CONE; SECONDARY AND TERTIARY CAVITY SELECTION

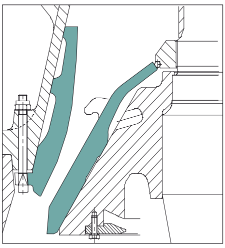

Extra Coarse S

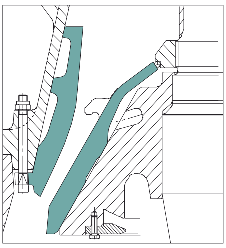

Coarse S

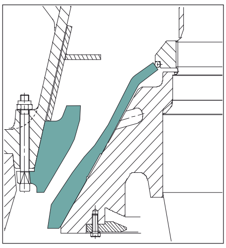

Coarse

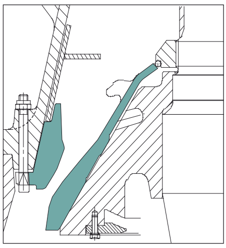

Coarse Medium

G- CONE; SECONDARY AND TERTIARY CAVITY SELECTION


Medium


Medium Fine


Fine


Extra Fine

GP Cones:

In tertiary crushing, use XT510 material for abrasiveness less than 1000 g/t.

For abrasiveness higher than 1000 g/t XT710 material is recommended.

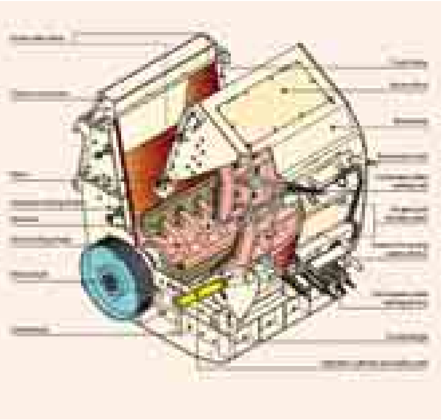
Liners for Impact Crushers

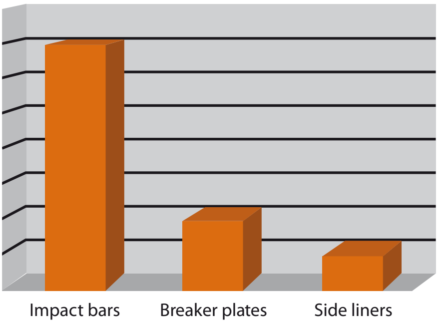
The selection of the liner type and material for Impact crushers is fundamental to ensure its desired performance. The liners must be chosen according to the material type, abrasion, foreign elements and size at the feeding and the required product, so that best properties of different metallic alternatives may be used.

Choices for material are austenite, martensitic steel and white chromium iron. Recently a metal matrix composite product has been added to the selection. Barmac has special wear tips in the crusher.

Continuous impact resistance is vital for finer crushing applications and shock resistance is needed in primary applications and cases in recycling crushing area where metal scrap is entering the crushing chamber.

It is important to choose material that under normal operating circumstance offers the best wear life. Consult your nearest Metso contact in Impactor wear material issues.





Distribution of wear (or wear cost) of an HSI.

Wear material selection

		Crushed mineral properties				
		Very difficult	Difficult	Medium	Easy	Very easy
Los Angeles		-12	12-17	17-22	22-27	27-
Crushability		-20	20-30	30-40	40-50	50-
UCS/MPa		300-	220-300	150-220	90-150	-90
Application	Primary	XT510	XF510	XF210	XF210	XF210
	Secondary	XF210	XF210	XF210	XF310	XF310
	Tertiary	XF310	XF310	XF310	XF310	XF310

Area where special wear resistant XF210T and XF310T materials are applicable

From productivity point of view, choosing the right impact bars is most essential. We have also a full range of other wear parts. Please ask our offering for other makes as well.

STEEL QUALITY

Besides the profile and other dimensional features, the steel quality has a great influence in the wear part lifetime. The austenitic manganese steel is the most commonly used in the manufacture of the main jaw crusher and cone crusher wear parts.

Metso Foundries are following the Metso standards for manufacturing. The Metso standard is stricter than the ASTM A128 Standard in purity.

XT series of austenites have been developed to offer the properties needed in a variety of crushing applications and machinery using different levels of force and power. Martensitic steels and chromium irons follow strictly defined process limits in production process.

Depending, therefore, on the type and size of the machine, wear part profiles and crushed material features, Metso Engineering Division will choose the ideal alloy for each application. The choice is confirmed via Metso laboratory and pilot plant tests.

Moreover, our foundries adopt strict norms to approve parts, involving visual, dimensional and superficial defect controls.

In case of jaws, for example, inaccurate dimensions may provoke part locking in the crusher frame due to manganese expansion or in fixing problems.

Absence of flatness at the jaw seat side may provoke damages to the jaw or to the frame due to bad effort distribution or reduce part lifetime due to irregular seating. Our foundry guarantees the correct flatness of your jaw plates, by using modern and proper industrial processes.

In gyratory and cone liners, the good performance will depend on other cares, such as machining in seating and fine crushing sections, correct thickness, absence of ovalization and, above all, correct and functional profiles.

For this intent, Metso has developed computer programs that simultaneously analyze factors of great influence, such as eccentricity, rotation, slopes and openings.

Metallographic and mechanical exams guarantee the steel properties and quality.

EFFICIENCY AND DURABILITY CRITERIA

According to the cost and benefit philosophy, the current trend has been to evaluate efficiency and durability of a wear part within four criteria, listed according to their importance:

The good performance of a part must:

1st - Not jeopardize the mechanical integrity of the equipment

2nd - Maximize the hourly production within the desired granulometry

3rd - Maximize the accumulated production throughout the lifetime

4th - Maximize exploitation so that the scrap weight is the least possible.

Implications of each criterion

1st criterion – It is known that a prolonged downtime for equipment maintenance implies in great losses. Hence, we insure safety in acquiring original Metso parts, designed and produced by those who manufacture the equipment and also take into account the mechanical aspect.

2nd criterion – An incorrect profile damages the hourly production and the product granulometry. Hence, the importance of having as supplier a company that relies on Application Engineering and ore analysis laboratory that enables you to get important data, such as the Work and Abrasion Indexes in order to develop and recommend the most adequate alloys and profiles.

3rd criterion – The most accurate evaluation of the part lifetime consists in establishing a relationship between wear and consumed power (hours x average power of the operating motor). However, for machines that operate under constant conditions of setting, the part lifetime, measured in hours or in produced tonnage, may be used as quality evaluation and wear parts durability parameters.

4th criterion – Some users adopt the procedure of using the liner to the end. This practice is not as economic as it may seem. There can be expensive consequences, such as damages on the machine's liner seating, overload due to compaction, and drop in the hourly production or in the product quality. Therefore, in many cases, it is better to replace the part before it is exhausted, observing its performance curve. Metso may recommend the economical point to replace the wear part.

Example of excessive liner use

Metso Life Cycle Services - adding customer value

Metso, using its long-term experience of crushing equipment and crushing processes, has developed an expert service offering aimed at improving the reliability and productivity of customer operations. Metso certified customer service organization is available worldwide to add customer value through customer-specific solutions.

Inspection Services

Metso Inspection Service helps the customer to improve the reliability and availability of operations by reducing costs of falling production or unplanned downtime.

Metso Inspection Service includes:

– Equipment performance and condition analysis done by Metso Service engineer including the measurement of degree of wear and estimation of parts lifetime.

– Advising and assisting in planning preventive maintenance activities.

– Inspection report on findings and recommendations.

Inspection Service can take place as one-time only arrangement or at agreed intervals.

Experience has shown that Inspection Service provided by Metso experts promotes the availability of the equipment and cost efficiency of customer operations by preventing equipment failure.

Metso Customer Service products help in optimizing the equipment´s total life cycle productivity. According to some of Metso studies, 1% improvement in availability can increase profits by 4%.

Wear Parts Replacement Service

Metso Wear Parts Replacement Service consists of the delivery and replacement of wear parts. Metso professional crew will replace the wear parts safely and efficiently, and in addition to this, evaluate the condition and wear of the equipment. An inspection report will provide expert recommendations for maintenance and repair operations.

Metso Inspection Service Sample (48/137)

			Check
Feeder/Screen	Vibrating machinery	1	Breather condition
		2	Temperature of hydraulic motor
		3	Speed range of feeder max/min
		4	Bearing of vibr.machine right, temperature
		5	Left 1 & 2 (according to material flow)
		6	Bearing of vibr.machine left, temperature
		7	Right 1 & 2 (according to material flow)
		8	Is the vibrating machinery leaking? Oil level?
		9	Oil change frequency
	Frame	10	General condition of the frame of the feeder
		11	Transport lockings functionality
		12	Stroke lengths and angles, see comment 1)
		13	Condition of vibrating chute. Visual check.
		14	Springs and finger protection condition
		15	Free movement
		16	Grizzly bar condition/ Screen deck condition
C jaw crusher	Crusher is running idle	17	Speed of the crusher
		18	Temperature of frame bearings (right & left)
		19	Temperature of pitman bearings(right and left)
		20	Temperature of jack shaft bearings
		21	Jack shaft flexible coupling condition
		22	Right frame bearing, ShockPulseMeter control
		23	Right pitman bearing, SPM control,comm. 5)
		24	Left frame bearing, SPM control
		25	Left pitman bearing, SPM control
		26	Grease flow out of labyrinths
		27	Movable and fixed jaw dies in crushing
		28	Setting adjustment, see comment 4) below
		29	Movement and sound of setting adjustment
		30	V-belt tightness and condition
		31	Coast down-time (only with Katsa gearbox)
	Crusher is stopped	32	Tightness of frame bolts
		33	Locking of bearing housing bolts
		34	Locking of flywheel cover bolts
		35	Clearance of frame guide pins
		36	Condition of frame guide covers (only LT110)
		37	Flywheel position / mounting/gib keys
		38	Clearance of flywheel/labyrinth ring
		39	Cleaness of flywheel
		40	Clearance of adjustment wedge guiding piece
		41	Bolts and clearance of labyrinth seal
		42	Condition of toggle plate and bearings
		43	Toggle plate alignment and guides
		44	Toggle plate condition
		45	Return rod/ return cylinder pressure limits
		46	Nitrogen accumulator pressure & attachment
		47	Tightness of jaw die bolts
		48	Space between upper/lower jaw dies

Repair and Maintenance Services

Metso service network is available to provide regular and corrective maintenance services. Metso repair facility network offers an extensive range of services stretching from bearing replacement to complete equipment reconditioning. The repair facilities have highly skilled personnel and the latest technology for equipment repairs.

Training Services

Metso training seminars focus on proper operation and maintenance procedures in the knowledge that skilled operators and maintenance crews keep plants operating profitably.

Participants are coached by Metso experienced professionals and all training seminars are organized in a wide variety of languages and locations worldwide.

Example of Nordberg C Series Jaw Training Seminar

Operation and Maintenance

Nordberg C Series Jaw Crushers

This training seminar is designed for service engineers and experienced plant operators, offering skills development opportunity in an advanced level.

Scope

- C Series Jaw Crusher construction
- Technical performance
- Foundation and mounting
- Crusher operation
- Maintenance and repair
- Automatic lubrication device
- Safety issues

Process Optimization and Performance-based Services

Metso also supports customers in evaluating the best way to perform operations and maintenance activities with the process optimization services. Metso has the process expertise to recommend improvements such as liner design optimization and upgrades for existing equipment – all to improve productivity. The objective of performance-based services is to assist in the achievement of the agreed performance values and operational targets.

Metso Plant Operation Services

Metso offers plant operation services where Metso employees are responsible for the planning, supervision, operational support, maintenance, and follow-up of the Metso equipment at the customer's site.

Metso Life Cycle Services cover all areas of the crushing, size reduction, and classifying process and are aimed at improving the customer's end–product value.

Please contact your local sales unit or dealer for more information.

Standards in most common aggregate applications

Standardization is needed to create common working methods and to allow communication between supplier, end user and authority more easily. Standardization increases the compatibility of different products, improves safety in all stages of production, and protects the end user and environment. In addition to the previous points, it also creates a common language for internal and international business.

In the crushing and screening business there are end product standards that effect on the crushing plant design. Usually, **asphalt** and **concrete** are the applications, where specifically demand for aggregates is followed by standards. For these applications, crushing and screening process can effect the end product **shape** and **particle fragmentation**, i.e. gradation. There are also dozens of other demands and specifications for aggregates, but feed material properties and rock type generally effect them.

Specifications (standard codes) for aggregates used in concrete, asphalt and railway ballast has been collected in the following table. As there are different standards in different countries and regions, most common ones has been shown in this table. The table helps to detect the actual code and helps to determine which standard is valid in a country.

TABLE 1. Few examples of application standard codes of different standards.

COUNTRY ID	Standard	Concrete Aggregates	Asphalt Aggregates	Railway Ballast
1	EN	EN 12620	EN 13043	EN 13450
2	ASTM	C 33	D 692	AREMA / C 33
3	IS	IS:383-1970 and MOST / MORTH	MOST/ MORTH	INDIAN RAILWAY STANDARD
4	BS	BS 882	BS 63	
5	GOST	GOST 8287-93	GOST 8287-93	GOST 7392-85
6	JIS	JIS A 5005-1987		
7	GB/T	GB/T 14685-93	JTJ 014-97	
COUNTRY ID	**Countries as example**			
1	Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom			
2	U.S.A.			
3	India			
4	UAE			
5	Russia			
6	Japan			
7	China			

As can be seen in table above, there are different specifications available in the world. It has lead to different shape measurement methods in each standard. The following table shows an indicative relation between shape values defined by the different specification. The EN 933-3 flakiness index is set to 10. As an example, EN933-3 Flakiness index 10-% equals roughly BS-812 12% flakiness index. All the given values indicate the share of unfavorable particles in the product fragmentation.

TABLE 2. Shape measurement methods in different standards.

Specification	**Flakiness Measurement**	**VALUE**	**MIN:MEAN SIZE**
EN 933-3	Flakiness Index	10	0,55:1
GOST 8269-97, chapter 7.2	Flaky particles	8	0,42:1
BS 812 : Part 1	Flakiness Index	12	0,59:1
IS 2386	Flakiness Index	12	0,59:1
ASTM D4791	Flat Particle Test	10	0,55:1
GB/T 14685-93	Flakiness Index	7	0,40:1
Specification	**Elongation Measurement**	**VALUE**	**MIN:MAX SIZE**
EN 933-4	Shape Index	15	1:3
GOST 8269-97, 1:3 measurement	Elongation	15	1:3
ASTM D4791	Flat and Elongated	15	1:3
Specification	**Elongation Measurement**	**VALUE**	**MEAN SIZE:MAX**
BS 812 : Part 1	Elongation Index	35	1:1,8*
IS 2386	Indian Elongation	35	1:1,8*
GB/T 14685-93	Elongation Index	8	1:2,4**
Specification	**Combined Measurement**	**VALUE**	
GB/T 14685-93	China EFI	10	
IS 2386	Indian EFI	40	

** In reality MEAN:MAX dimension can vary between 1:1,5….1:2,3*
*** In reality MEAN:MAX dimension can vary between 1:1,8….1:3,6*

The calipers of some shape measurement methods have been shown in following pictures:

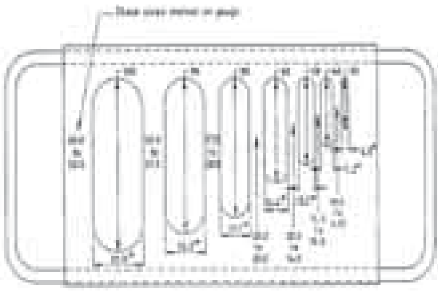
EN933-3 FLAKINESS INDEX

MIN: MIDDLE = 0,55:1

EN 933-4 SHAPE INDEX

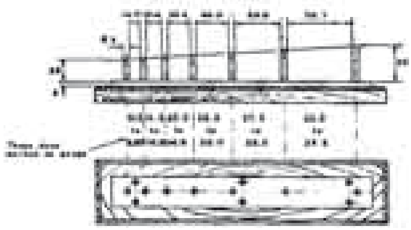
MIN:MAX = 1:3

BS 812 and IS 2386 FLAKINESS INDEX



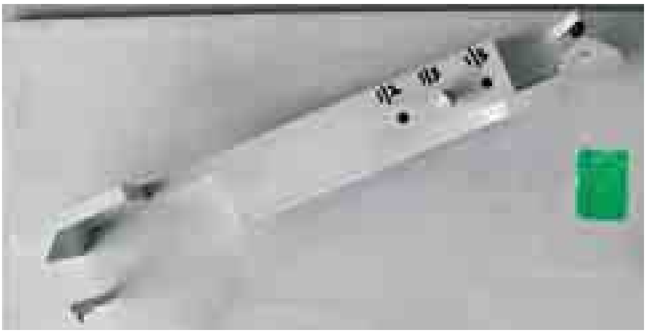
MIN: MIDDLE = 0,59:1

BS812 and IS 2386 ELONGATION INDEX



MIDDLE : MAX = 1: 1,8

ASTM D4791, FLAT AND ELONGATED PARTICLES



STORAGE PILES

SYMBOLS USED

α = angle of repose of material when forming pile (dynamic friction)

β = angle of repose of material when reclaiming under pile (static friction)

H = pile height (m)

D = pile diameter (m)

V_t = total pile volume (m^3)

V_u = usable pile volume (m^3)

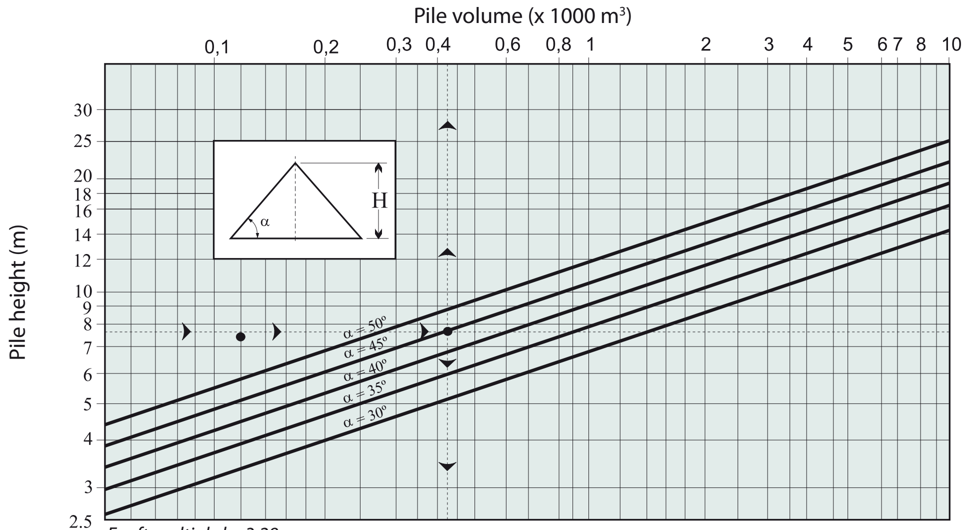
P = usable percentage of the pile

ρ_s = bulk density (ton/m^3)

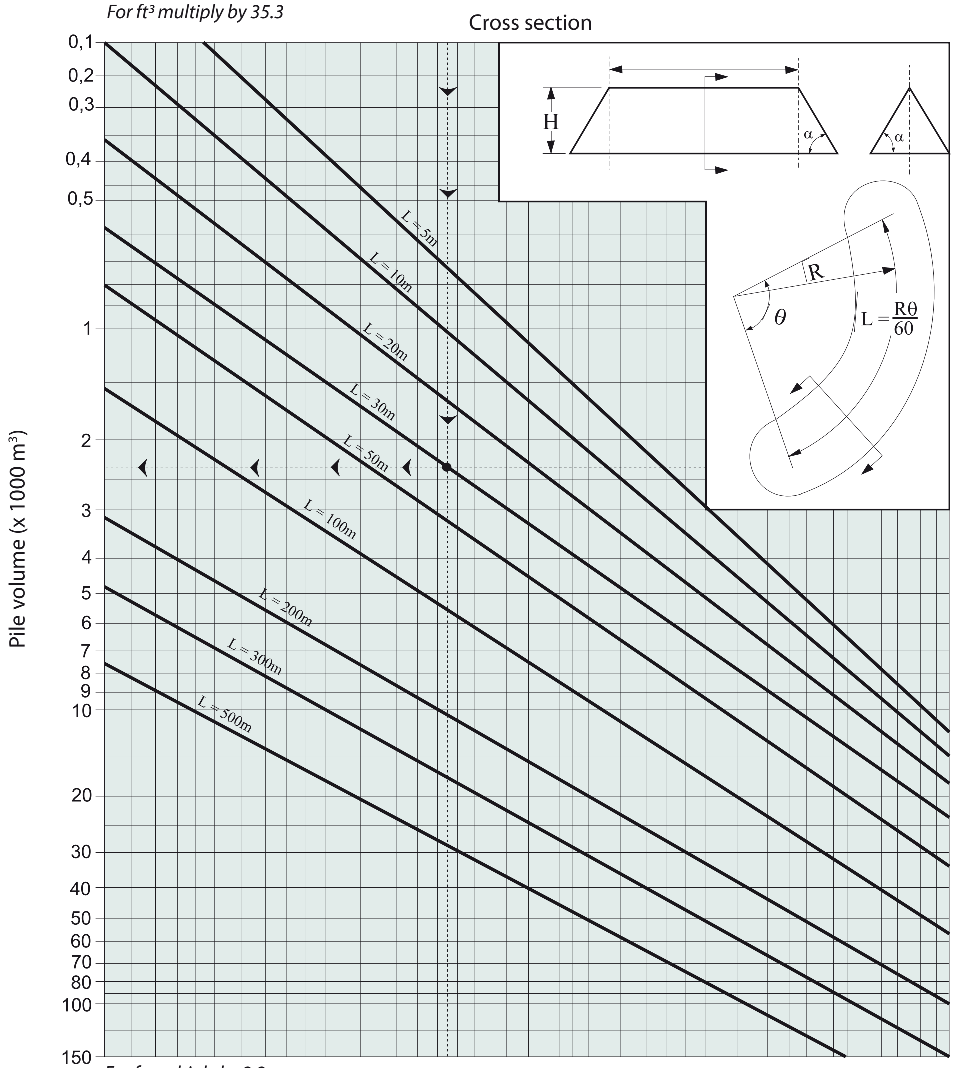
S = distance between outlets (m)

MATERIAL FEATURES

MATERIAL	PARTICLE SHAPE	SIZE (mm)	ρ_s (ton/m^3)	α (deg)	β (deg)
Natural sand	Round	0-3	1,6	35	40
Manufactured sand	Cubic	0-3	1,6	35	40
Crushed stone	Cubic	0-63	1,5	40	45
Crushed stone	Slabby	0-63	1,4	40	45
Crushed stone	Cubic	0-25	1,4	45	55
Crushed stone	Slabby	0-25	1,5	30	35
Pebbles	Round	0-63	1,5	30	35
Dry earth	–	–	1,4	40	40
Iron ore	Slabby	0-63	2,7	40	45
Coal	–	0-100	0,9	30	35



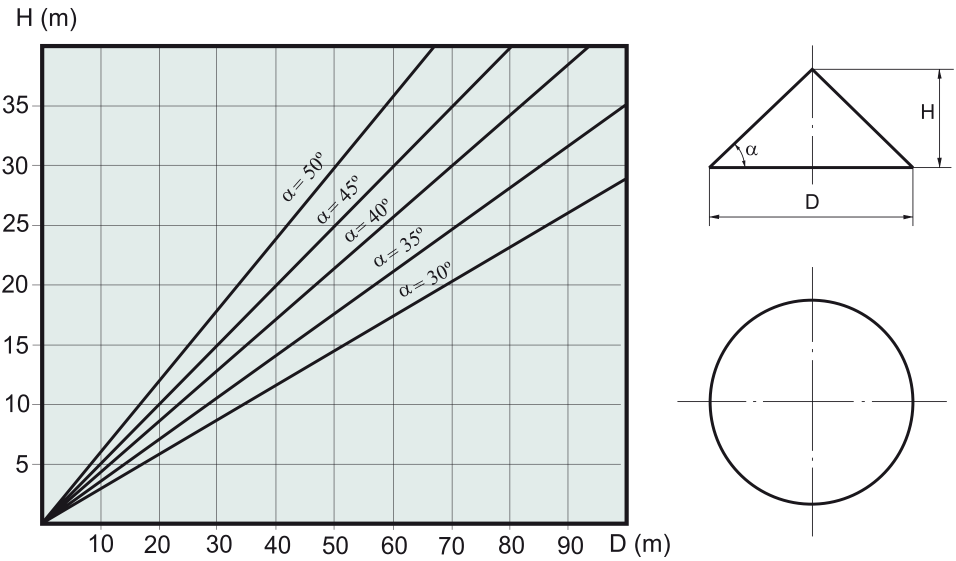
For ft multiply by 3.28
For ft³ multiply by 35.3



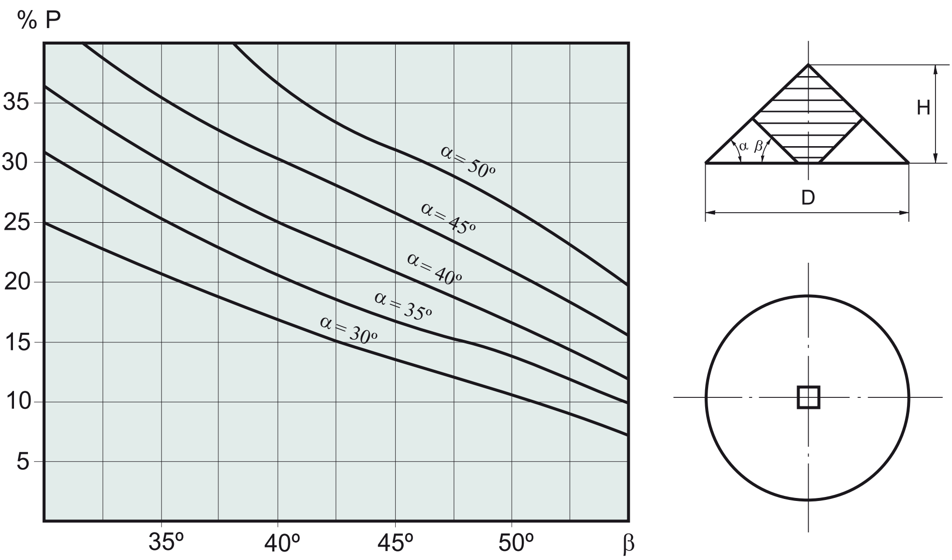
For ft multiply by 3.3

Technical Information

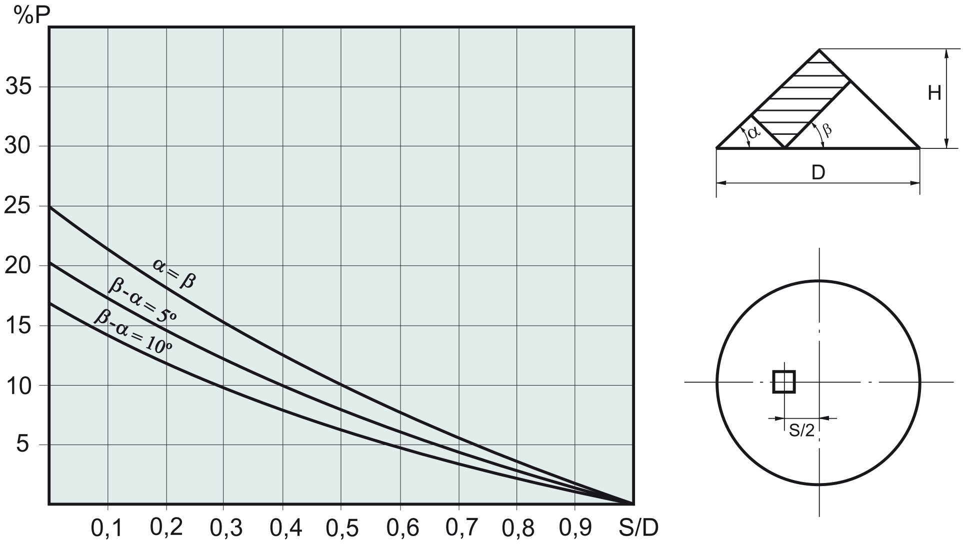
Relation between pile height H and the diameter D as a function of repose angle α



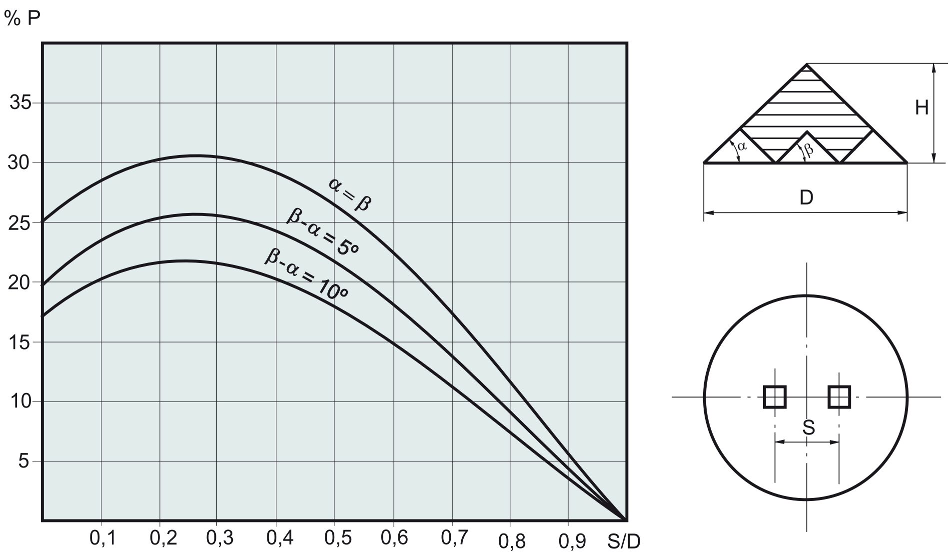
Percentage of total pile volume that can be unloaded by the central outlet, as a function of angles α and β



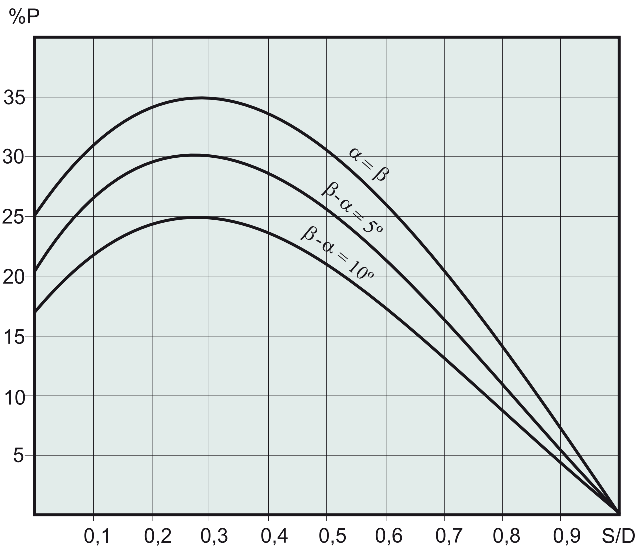
Percentage of the total pile volume that can be unloaded by an outlet off-set from center S/2, as a function of S/D and the difference between angles β and α

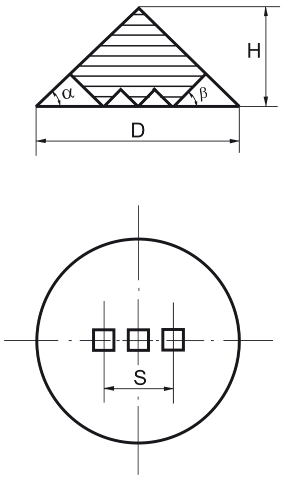


Percentage of the total pile volume that can be unloaded by two outlets with spacing S, as a function of the difference between angles β and α

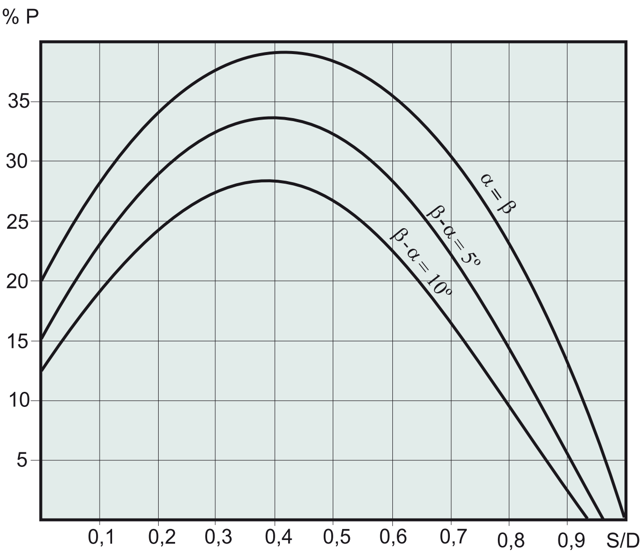


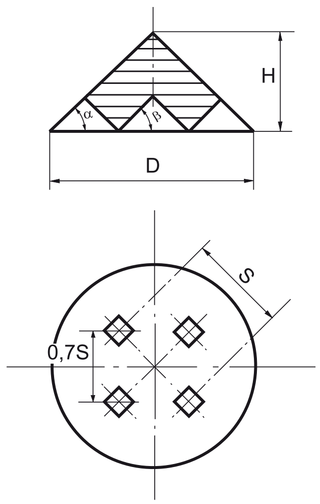
Percentage of the total pile volume that can be unloaded by three outlets, with spacing S, as a function of the difference between angles β and α



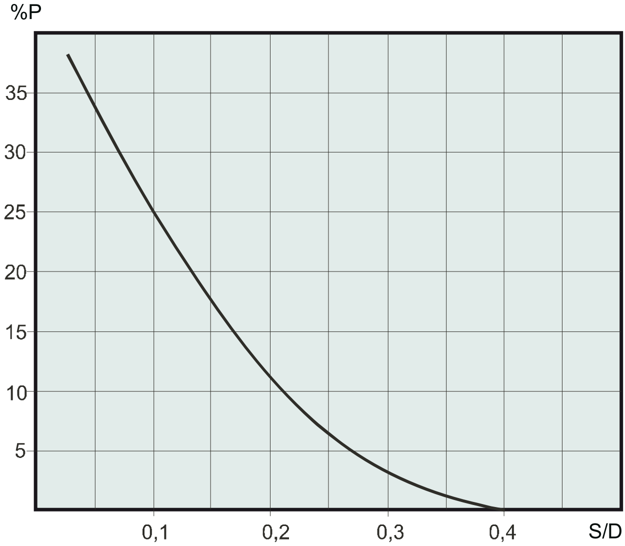


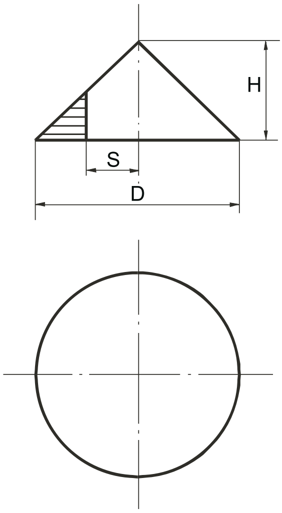
Percentage of the total pile volume that can be unloaded by four outlets with spacing S, as a function of the difference between angles β and α



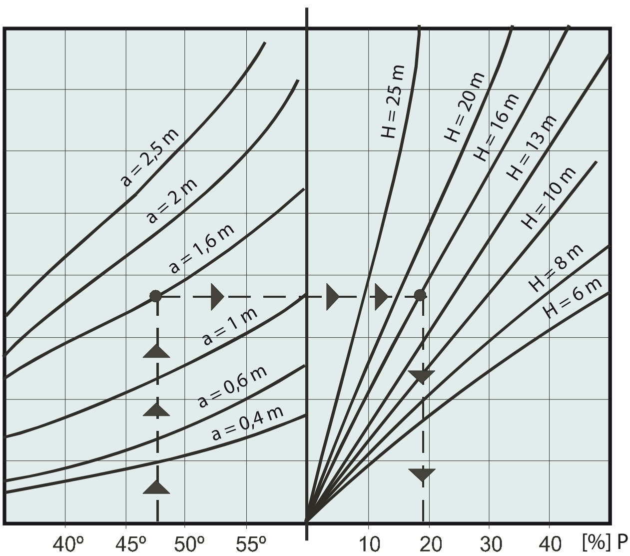


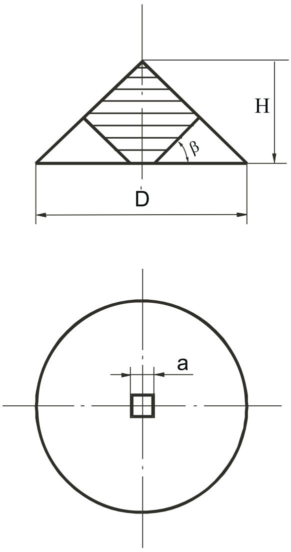
Percentage of the volume cut by a lateral wall, as a function of S/D





Percentage increase of the volume unloaded by the bottom outlet, as a function of outlet hole size. This chart is valid for any number of outlets. To calculate usable volumes, multiply the percentagefound on the charts on the previous pages by the percentage of increase on the chart below.





UNIT CONVERSION

To convert from	To	Multiply by
Technical atmosphere	kg/cm^2	1
Bar	kg/cm^2	1,02
CV	HP	0,9863
CV	kW	0,7355
Gallon (US)	Gallon (British)	0,83267
Gallon (US)	Liter	3,785
Gallon (US)	in^3	231
Gallon/min	l/sec	0,06308
Degrees Celsius	Degrees Fahrenheit	(°C*9/5) + 32
Degrees Fahrenheit	Degrees Celsius	(°F-32) * 5/9
HP	kcal/hr	641,2
HP	kW	0,7457
J (kg * m^2)	GD^2 (kg * m^2)	39,24
Yard	M	0,914
Cubic yard	m^3	0,7646
Pound/ft^3	kg/m^3	16,02
Pound	kg	0,453
Pound	Ounce	16
Pound * in^2 (PSI)	kg * m^2	6,060
Liter	Gallon	0,2642
Liter	in^3	61,02
Pound * ft	kgm	0,1383
Pound/ft^2	kg/m^2	4,882
Mega Pascal (MPa)	kg/cm^2	10,2
Meter	Yard	1,094
Meter	Foot	3,281
Cubic meter	Gallon (US)	264,2
Cubic meter	Cubic yard	1,309
Cubic meter	ft^3	35,31
Square meter	ft^2	10,76
Square meter	in^2	1550
Meter * kilogram	lb * ft	7,233
Land mile	m	1609
Newton	kg	0,102
Ounce	g	28,349
Pascal	kg/cm^2	1,02*10^{-5}
Inch	cm	2,54
Square inch	m^2	0,0929
Ft	cm	30,48
Cubic ft	Gallon (liquid)	7,4805
Cubic ft	Liter	28,32
Cubic ft/s	Gallon/min	448,831
Kilogram	lb	2,205
Kilogram/cm^2	lb/ft^2	2048
Kilogram/cm^2	lb/in^2	14,22
Kilometer	Yard	1094
Kilometer	Mile	0,6214
Kilocalorie	BTU	3,9685
Kilocalorie	HP * hr	1,560*10^{-3}
Kilowatt	HP	1,341
Kilowatt x hr	Kilocalorie	860,5
Ton (short)	Pound	2000
Ton (short)	kg	907,18
Ton (metric)	Pound	2240
Ton (metric)	Kg	1016
Ton	Pound	2205
Ton (metric)	Ton (short)	1,12
Wk^2	GD^2	4

Operation and Environment – Introduction

From environmental, health and safety point of view most mineral processing operations have some negative affects on the working environment.

The main problems are related to

- **Dust (dry plants)**
- **Noise (wet and dry plants)**
- **Pollution (emissions other than dust to air and water)**

Dust

Dust - size

When energy is introduced to rock, ore or mineral crystals will generate a dust emission. With dust in mineral processing we practically understand particles below 100 micron in size. Above this size dry particles are easy to control and are quite harmless.

Dust - Chemical composition

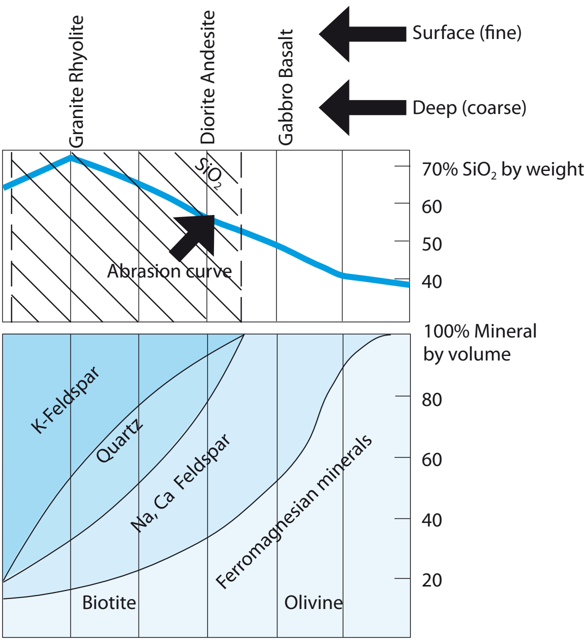
A parameter of interest is the chemical composition. Hard rock in many cases is hazardous due to the silica content.

Free quartz (SiO_2) is extremely dangerous and so are the rocks containing quartz like granite, gneiss a.o, see figure below. Fine silica can cause silicosis, a deadly lung disease. Mg-silicate of asbestos type is also very dangerous when inhaled, causing lung cancer.

As many of the silicates are hard and abrasive these dust fractions also are causing heavy wear when exposed to bearings, motors etc.

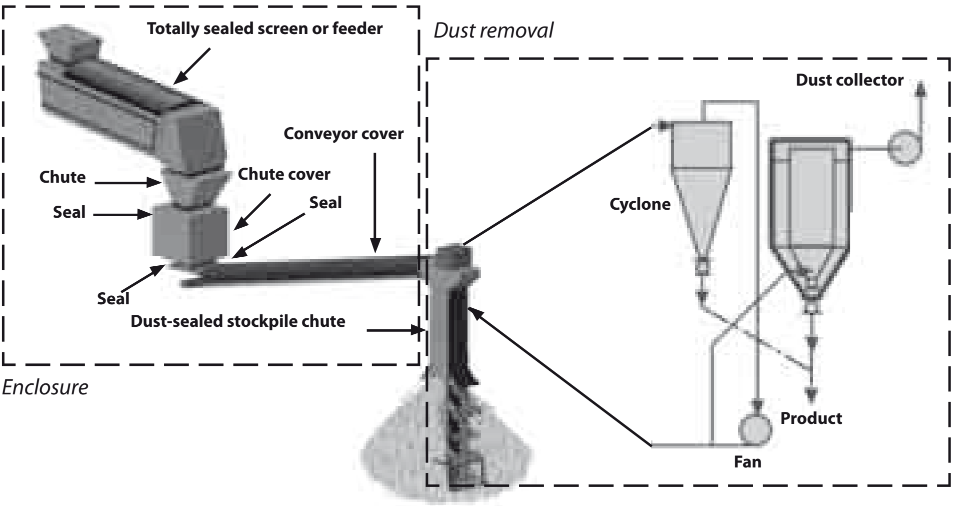
Dust – SiO_2 levels

Dust fractions of non-silica type are normally not too dangerous for the operators and give more like a "housekeeping" problem.



SiO_2 levels in magmatic rock

Dust Control – Basic



Some guidelines

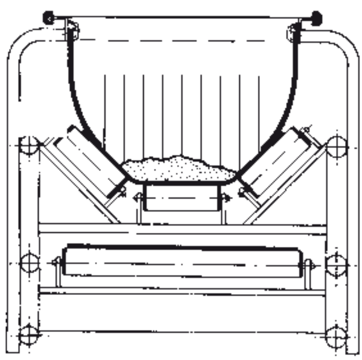
1. Let dust flow with the rest of material or use dust suppression systems.

2. Suppression by water or foam is cheap and handy but can only take care of the coarser dust. Fine dust will remain a problem. If too much water is used the dust will turn to sticky clay, causing down time in operation and freezing in cold climate.

3. Enclosures of machines are very effective provided that you only encapsulate the dust emitting part of the machine, not drives or other moving parts. Enclosures are also very effective against wind emission of fines from conveyors and for sealing off transfer points, see below.

4. Dust removal by ventilation is used when the dust is the product (dry grinding of filler fractions) or when dust is not allowed in the final product or in the processing system, see ventilation criteria below.

Equipment enclosure



Wind enclosure

Ventilation criteria
Dust capture velocity in m/s (ft/min)

= Ventilation criteria **(Vc)** in $m^3/s/m^2$ ($ft^3/min/ft^2$)
= Air volume needed per open area of enclosure

Calculation of ventilation systems for dust removal is a tricky thing. Some estimation figures below:

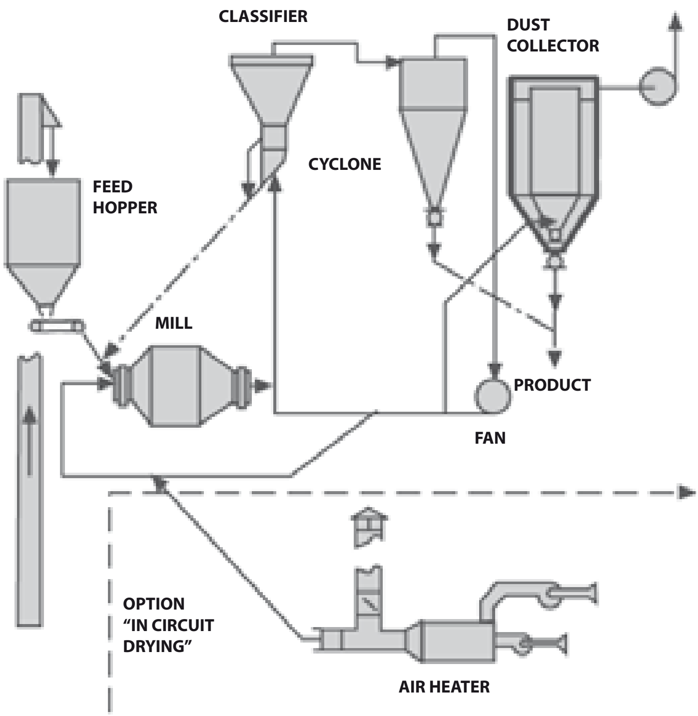
Application	Vc	Comments
Feeders, surge bin openings	1,02 (200)	General value for low-energy operations
Transfer points	2,33 (1500)	per enclosure area
Screens	0,26 (50)	per screen area
Crushers and dry mills	1,5 (300)	not for air swept mills

Dust collection

The dust removal and dust collecting systems are very similar to a normal dry classification circuit. Dry classification is in fact a dust removal system where the max size of the dust is controlled by a classifier (or ventilation criteria), See below.

Primary recovery of dust is normally done in a cyclone taking the major part. The final recollection is done in a wet scrubber or a fabric filter

Wet scrubber has an advantage over fabric filter when the dust is combustible. In all other cases the dry fabric filtration is more effective as no sludge handling is required (being the case with wet scrubbers).



Technical Information

Noise

General

In mineral processing there are a number of machines considered to be very noisy (crushers, screens and grinding mills are typical).

By definition noise is an "undesirable" sound. As sound is **air borne sound pressure variations,** we have to find a sound pressure level, which can be tolerated by the operators. Noise is not only harmful to the hearing but also affects the heart action and the ability of concentration. It also restricts verbal communication and the observation of warning signals or dangerous situations.

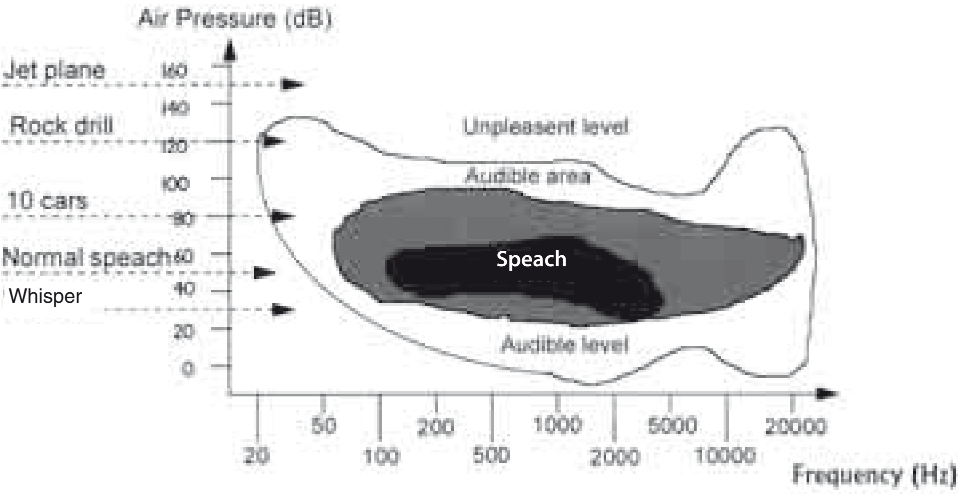
Sound – basic

The human sound pressure range from lowest sound to be heard and highest sound to stand without pain is
from 0,00002Pa (2µPa) to 20 Pa.
(1 psi = 6,89kPa).

To be more practical the sound pressure range above is converted to a sound pressure level by the formula:

Lp = 20x log P/Po (Po = 2 µPa) converting the range above over to 0-120 dB (decibel)!

Experienced sound	change of dB
Double sound level	+ 10dB
Double sound sources	+ 3 dB
Double the distance to sound source	– 6 dB



Hearing range for a normal ear

The lower limit is called the threshold of hearing and has a maximum sensitivity around 3500 Hz (resonance frequency of the ear).

The upper line is the 120 dB sound pressure line (the pain line)

Mechanical noise is measured in dB (A) indicating that an A-filter is used, damping lower frequencies (of less harm to the operators).

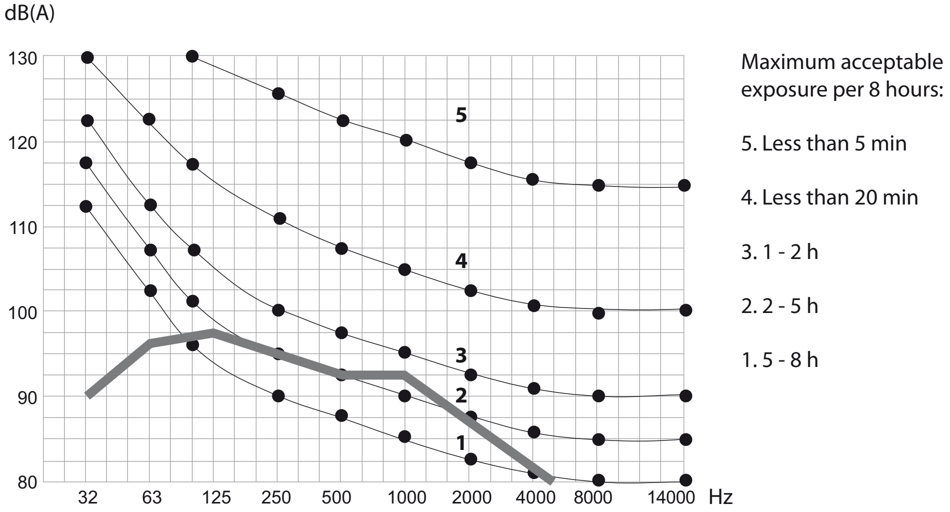
Infra-sound is sound with a frequency below 22 Hz. (Can be harmful at longer exposures)

Ultra-sound is sound with a frequency above 18 kHz. (Can be harmful at longer exposures)

Noise – exposure risks

For continuous sound with a wide frequency range, a sound level below 85 dB(A) is acceptable for an 8 hour exposure per day with respect to the risk of hearing damage.

If the sound level is higher an octave band analysis is necessary. This curve is compared to the standard risk curves, see below.



= middle frequency of octave Band (Hz) (Impact crusher on 1 m distance).

Noise Reduction

There are 4 main ways to reduce the noise levels for processing systems including crushers, mills and screens.

- Optimum operation
- Use of "internal" polymers (wear material and wear products)
- Use of "external" polymers (dust enclosures)
- Enclosure with noise reduction walls

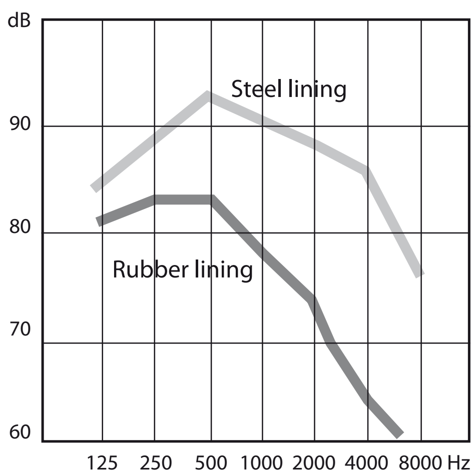
Optimum operation

Mass flow equipment like crushers and screens are normally lower in noise when they are operated under optimum conditions and the material flow is absorbing part of the noise (e.g. choke fed cone crushers). Reduced circulating loads also lead to reduced noise levels.

Internal polymers

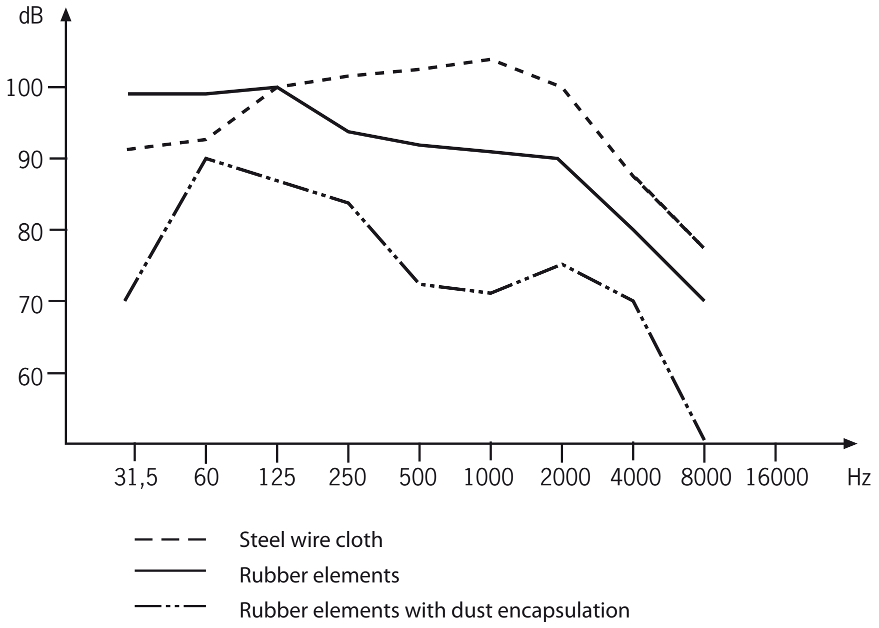
The use of polymers as mill liners, screening media and wear protection in material handling systems (chutes and transfer points) have a dramatic effect on noise reduction.

For grinding mills a rubber lining can reduce the noise level up to 10 dB(A) compared to a steel lining.



External polymers

Using polymers as dust sealing enclosures of crushers, screens, conveyors, chutes, transfer points etc. will give a noise reduction of approx. 5-10 dB (A). The difference for a screen with steel wire deck and rubber deck is shown below.



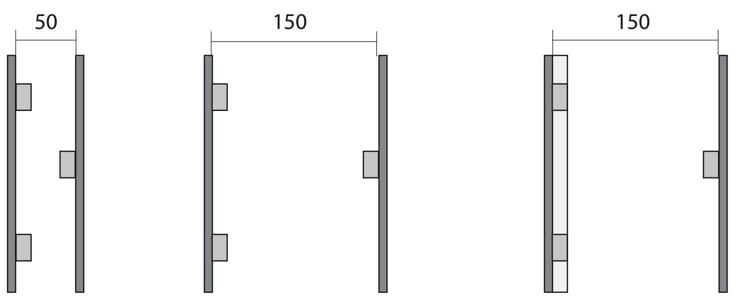
A simple rule: The more polymers used for various purposes in the mineral process systems the lower the noise levels!

Noise reduction walls

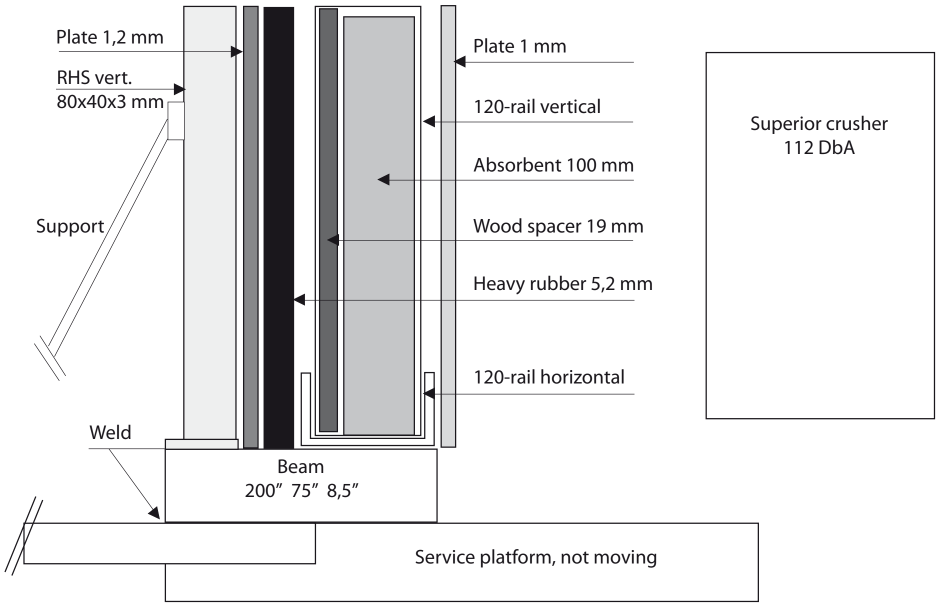
Enclosure is an effective way of reducing noise. Enclosure can be more or less extensive (enclosure of drive or machine or both). With a total enclosure noise levels can drop by 10-15 dB (A).

Depending on duty the design of the noise reduction walls can differ in design:

Light and medium duty walls



Heavy duty crusher wall , cross section



Ear Protection

When working in environments with continuous and high noise levels it is important to use ear protection all the time. Also at sound levels of 75-80 dB (A) it is to be recommended to use ear protection even if recommendation says something else. Reason is that long exposure also at these levels can cause impairment of hearing.

Good rules about ear protection:

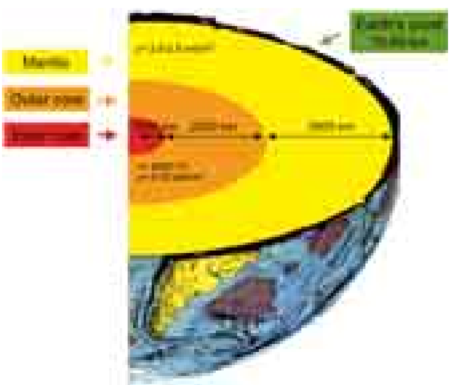
- Take some "noise breaks" now and then
- Go for regular hearing tests
- Check your ear protection equipment at certain intervals

MINERALS AND ROCKS

1 Geology

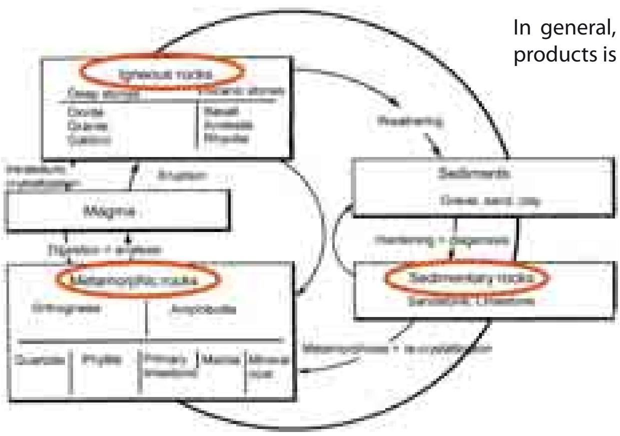
According to the prevailing assumption, our own solar system began forming from dust around 4,600 million years ago. This has been concluded from fallen meteorites. The oldest rock types, about 3,930 million years in age, have been found in Antarctica.

The structure of the globe has four main elements: the inner core, outer core, mantle and earth's crust. The Earth's radius is about 6,370 km, its iron-nickel core accounting for 3,400 km, while the average density of the Earth is 5,500 kg/m^3. Because the density of rock in the earth's crust is 2,800 kg/m^3, the inner areas must have a very high density, up to 10,000 kg/m^3.

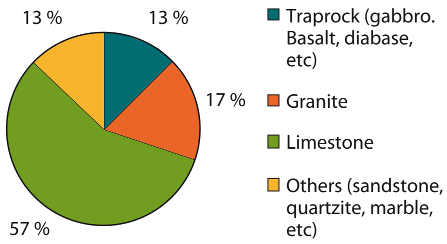


Source: Internet

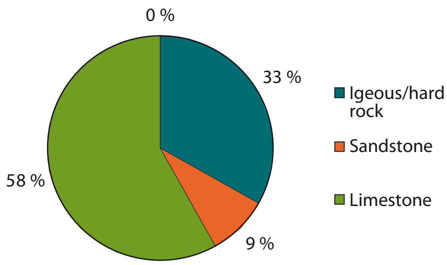
The origin of different rocks can be summarized as shown in the following diagram:



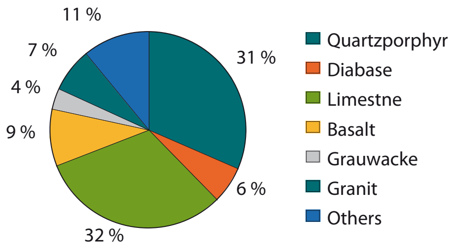
The occurrence of different types of rock varies geographically. For example, in the US, UK and Germany, the distribution of aggregate products is as follows:



U.S. Crushed stone production, by stone type. Source: **U.S**. Geological Survey.



Crushed rock production, in **UK**. Source: Quarry Product Association. Statistical Year Book.

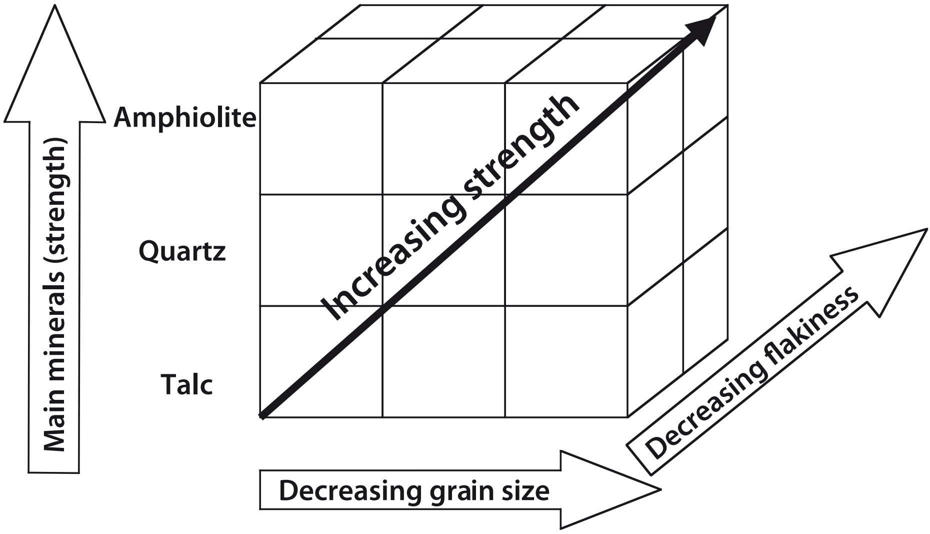


Quarried rock types in **Germany**. Source: Naturestein Ind. Statistics.

In general, it can be said that 2/3 of all rock products is limestone.

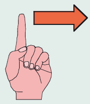
The strength of rock depends mainly on the mineral composition and rock structure. Granite, for example, mainly comprises hard feldspar and quartz grains which interlock, creating relatively strong rock. Shale is mainly soft clay minerals with a platy structure which flakes easily -> relatively soft.

A general rule of thumb is that igneous and metamorphic rock = fairly hard; clastic sedimentary rock = fairly soft; limestone varies e.g. chalk = soft, other types of limestone can be quite hard. A simplified approach involves summarizing the impact of different variables on a 3-D cube.



The hardness of the minerals varies in accordance with the graph.

Hardness of minerals in geology are defined based on MOHS hardness-scale:

Hardness and mineral			Can be marked with:
1	talc	$Mg_3(OH)_2Si_4O_{10}$	 nail
2	gypsum	$CaSO_4 \cdot 2H_2O$	
3	calcite	$CaCO_3$	
4	fluorite	CaF_2	 coin
5	apatite	$Ca_5(F,Cl,OH)(PO_4)_3$	
6	orthoclase	$KAlSi_3O_8$	 glass
7	quartz	SiO_2	
8	topaz		hard metal
9	corundum	Al_2O_3	
10	diamond		

2 Minerals

Mineral is a natural inorganic substance precisely defined according to its physical and chemical characteristics.

2.1 Rock

Is an aggregate of one or several minerals, forming the great mass of the earth's crust. In certain cases rock may consist of one single mineral as in the cases of limestone, which consists only of calcite, stratified clayish rock and quartzite layers, etc. Rocks may be solid, like granite, or unconsolidated like sand. Normally, rocks are formed by more than one mineral. Some of the minerals are predominant and form the essential components, and others, in smaller proportions, constitute the accessory minerals.

2.2 Ore

An ore is a mineral or rock containing metal ore mineral concentrations that can be economically extracted. The ore is the source from where the metal or other mineral substances are extracted.

2.3 Rocks

Rocks are divided into three main groups:

a) Magmatic, eruptive or igneous
b) Sedimentary
c) Metamorphic

2.3.1 Igneous Rocks

Igneous rocks are formed by the cooling of molten magma. According to the place of formation they are divided into:

a) Intrusive, plutonic or abyssal, formed deep in the earth's crust. Due to the slow cooling, they present large crystals, with phaneritic textures, i.e. coarse crystals. Examples: granite, pegmatite, etc.
b) Extrusive, volcanic or effusive, formed at the surface of the earth's crust through eruption. Due to the fast cooling (solidification) they present small crystals, with aphanitic texture. These rocks are often composed of glass. Examples: Basalt, felsites, etc.

Sometimes an intermediate group is included:

c) Hypabyssal – formed in shallow subsurface environment, they present intermediate characteristics between the intrusive and extrusive types. Example: diabase.

A common classification for igneous rocks is the one based on the silica content.
The meaning of the terms acid and base do not correspond to that used in chemistry.

2.3.2 Sedimentary Rocks

Sedimentary rocks can be divided into three groups:

a) Clastic, mechanical or detritic – formed from fragments of pre-existing rock
b) Chemical – rocks formed by the precipitation of elements dissolved in water
c) Organic – formed by deposit and digenesis of vegetal or animal organic remains

2.3.3 Metamorphic Rocks

Metamorphic rock is the result of the action of metamorphism agents on sedimentary and igneous rock, changing their texture and mineral composition. The main metamorphism agents are pressure and temperature.

Classification	% Silica	Quartz	Example
Acid	> 65	Present	Granite, pegmatite obsidian
Neutral	52 – 65	Small or non-existent	Syenite, diorite
Basic	45 – 52	Very rare	Gabbro, diabase, basalt
Ultra basic	< 45	Non-existent Scarce feldspar	Periodotite, dunite, pyroxenite

Minerals by Value

- **Minerals**
  - **Industrial Minerals**
    - **Abrasives**: Corundum, Quartz, Diamond a.o.
    - **Glass**: Quartz, Feldspar, Calcite, Dolomite a.o.
    - **Plastic**: Calcite, Kaolin, Talc, Wollastonite, Mica a.o.
    - **Ceramics**: Quartz, Kaolin, Feldspar a.o.
    - **Fertilisers**: Phosphate, Potash, Calcite, Dolomite a.o.
    - **Fillers and Pigment**: Barite, Bentonite, Calcite, Dolomite, Feldspar, Talc a.o.
    - **Refractories**: Wollastonite, Calcite, Dolomite, Corundum a.o.
  - **Mineral Fuels**
    - Coals
    - Oil shale
    - (Oil sand)
  - **Rock**
    - **Aggregate, Sand & Gravel**
      - Concrete ballast
      - Asphalt ballast
      - Rock fill
      - Industrial sand
      - a.o.
  - **Ores**
    - **Non-ferrous**
      - **Base Metals**: Copper, Lead, Zinc a.o.
      - **Light Metals**: Aluminium, Magnesium, Titanium
      - **Precious Metals**: Gold, Silver, Platinum a.o.
      - **Rare Metals**: Uranium, Radium, Beryllium a.o.
    - **Ferrous Alloy**
      - **Alloying Metals**: Chromium, Vanadium, Molybdenum, Tungsten, a.o.
    - **Ferrous**
      - **Iron**

Rock	Formation	W1 Impact	Specific weight (t/m³)	Bulk density (t/m³)	Abrasion Index (A_i)	Compressive strength (MPa)	Granulation	Color
Andesite	Igneous	16 ± 2	2,6 - 2,8	1,6	0,5	170 - 300	Fine	Black / Ash
Amphibole	Metamorphic	16 ± 3	2,8 - 3,0	1,7	0,2 - 0,45	-	Average to coarse	Dark green or black
Sandstone	Sedimentary	10 ± 3	2,7	1,6	0,1 - 0,9	30 - 180	Average to coarse	White / Ash
Basalt	Igneous	20 ± 4	2,9 - 3,0	1,8	0,2 ± 0,1	300 - 400	Fine< 0,1 mm	Black / Ash
Limestone	Sedimentary	12 ± 3	2,7	1,6	0,001 - 0,03	80 - 180	Fine to coarse	White to dark
Carbon	Sedimentary	14 ± 4	1,0 - 1,8	0,8	-	-	Fine	Ash to black
Clinker	-	-	-	1,2	-	-	Fine	Ash
Coke	-	-	-	0,6	-	-	Fine	Ash to black
Diabase	Igneous	19 ± 4	2,8 - 2,9	1,7	0,3 ± 0,1	250 - 350	Average to coarse	Black to ash
Diorite	Igneous	19 ± 4	2,7 - 2,8	1,6	0,4	170 - 300	Coarse	Black with white spots or ash
Dolomite	Sedimentary	12 ± 3	2,7	1,6	0,01 - 0,05	50 - 200	Fine to coarse	White or ash, reddish brown
Gabbro	Igneous	20 ± 3	2,9 - 3,0	1,8	0,4	170 - 300	Coarse > 2 mm	Dark ash to black
Gneiss	Metamorphic	16 ± 4	2,7	1,6	0,5 ± 0,1	200 - 300	Average to coarse	Ash or rose with dark layers
Granite	Igneous	16 ± 6	2,7	1,6	0,55 ± 0,1	200 - 300	Coarse > 2 mm	White / ash to reddish brown
Hematite	Sedimentary	-	5,1	2,2 - 2,4	0,35 ± 0,2	-	Fine	Dark
Magnetite	Sedimentary	-	5,7	2,2 - 2,4	0,50 ± 0,2	-	Fine	Dark
Marble	Metamorphic	12 ±3	2,7	1,6	0,001 - 0,03	80 - 180	Average to coarse	White, yellow, red green or black
Porphyre	Igneous	18	2,7	1,6	0,1 - 0,9	180 - 300	Coarse > 2 mm	Dark ash to black, reddish brown or purplish
Quartzite	Metamorphic	16 ± 3	2,7	1,6	0,75 ± 0,1	150 - 300	Average	White, ash or reddish
Syenite	Igneous	19 ± 4	2,7 - 2,8	1,6	0,4	170 - 300	Coarse	Red or black / greenish ash
Silex (Homfels)	Metamorphic	18 ± 3	2,8	1,65	0,7	150 - 300	Fine	Ash, blue, green or black

Mechanical properties of some minerals

3 Physical Properties of Minerals

As the comminuting process is the interaction between machines and minerals, one needs to know well the characteristics of each of these two elements. This chapter focuses on the most important physical characteristics of the minerals from the point of view of crushing.

D – relative hardness – Mohs scale
ρ – solid density – t/m^3
ρ_b – bulk density – t/m^3
CR – crushability – %
ABR – abrasiveness – g/t
Ai – abrasion index –
Wi – work index – kWh/st
LA – Los Angeles value
UCS – uniaxial compressive strength – N/mm^2
particle size gradation
particle shape

Metso has several modern research and test laboratories where the behavior of materials in comminuting processes can be determined.

3.1 Mohs Scale of Hardness

In 1812 the Mohs scale of mineral hardness was defined by the German mineralogist Friedrich Mohs (1773-1839). This is a relative scale with which the minerals are classified by comparing their hardness with that of the reference minerals. Each mineral scratches the preceding ones and is scratched by the subsequent.

Reference mineral	Hardness	Absolute hardness
Talc	1	1
Gypsum	2	2
Calcite	3	9
Fluorite	4	21
Apatite	5	48
Orthoclase Feldspar	6	72
Quartz	7	100
Topaz	8	200
Corundum	9	400
Diamond	10	1500

Table. Mohs scale of hardness.

3.2 Solid Density (ρ)

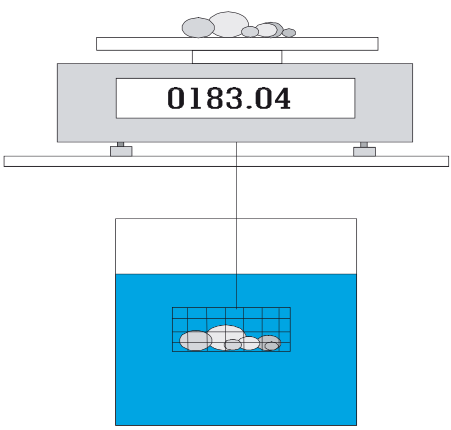
Solid density is defined as the mass of a sample divided by its solid volume (t/m^3). Solid density and specific gravity are often ambiguous terms. Specific gravity is dimensionless, equal to the density of the material divided by the density of water.

Since water's density is 1000 kg/m^3 in SI units, the specific gravity of a material is approximately the solid density of the material measured in t/m^3. Accurate density of water at 1 atm and 20 °C is 998.2 kg/m^3 and it varies little according to the temperature.

The reason that specific gravity is measured in terms of the density of water is because that that is the easiest way to measure it in the field. With an irregularly shaped rock, the volume can be very difficult to accurately measure. The most accurate way is to put it in a water-filled graduated cylinder and see how much water it displaces. It is also possible to simply hang the sample from a scale and weigh it under water.

A practical method uses two measurements. First the rock sample is weighed dry in air (m_1). Same time a container hanging from the scale is empty and sunken in water. Secondly the rock sample is moved to the container and weighed again with the sample immersed (m_2). The specific gravity result is the dry sample weight divided by subtraction of the dry sample weight and the weight of the sample immersed. In SI units the result is also the solid density in t/m^3.

$$\rho = m_1/(m_1 - m_2)$$



Measurement of specifig gravity.

3.3 Bulk Density (ρ_b)

The most common method to determine loose bulk density uses a dry and clean container. The aggregate sample shall be dried at 110 °C to constant mass. The container is weighed (m_1). The container is gently filled to overflowing with the aggregate. Whilst filling the container the segregation have to be minimized. Any surplus aggregate have to be removed with a straightedge, taking care not to compact any part of the upper surface. The filled container is weighed (m_2).

The loose bulk density is the specimen mass divided by the volume of the container.

$$\rho_b = (m_2 - m_1)/V$$

Tapped or packed bulk density is always greater than or equal to loose bulk density. Due to variation in degree of compactness the bulk density value is not so accurate than the solid density.

Bulk density is not only a measure of rock physical property but an aggregate product measure. It also depends on the gradation and the shape of the product.

3.4 Abrasiveness (ABR) and Crushability (CR)

The purpose of test is to establish Abrasiveness and Crushability. The Abrasiveness gives an indication of the abrasiveness of the rock material. The Crushability value can be used for estimating degree of difficulty to crush tested material.

Tester consists of an inner hub, which rotates the test paddle vertically inside a cylindrical bowl. The hub with test paddle rotates 4500 RPM. The inner diameter of the bowl is 90 mm and depth 100 mm.

The paddle of 50 mm x 25 mm x 5 mm must be dry and cleaned before the test. It will be weighed before the test. Rock sample for the test is 500 g of 4/6.3 mm fraction.

The paddle is clamped in the slot of the hub. A 500 g sample of material to be tested is placed in the drum. The paddle rotates for 5 minutes. After 5 minutes rotation the drum is emptied and the tested material is screened by 1.6 mm screen. Material which passes 1.6 mm screen is weighed. The test paddle is also cleaned and weighed.

3.4.1 Result Calculation

$$ABR = (M_{before} - M_{after}) * 1000 / 0.5 \quad [g/t]$$

ABR = Abrasiveness
M_{before} = the mass of the cleaned and dried test paddle before the abrasion test [g]
M_{after} = the mass of the cleaned and dried test paddle after the abrasion test [g]

$$CR = m_{1.6} / M \quad [\%]$$

CR = Crushability
$m_{1.6}$ = the mass of the particles smaller than 1.6 mm produced during the test
M = the mass of the material subjected to the test

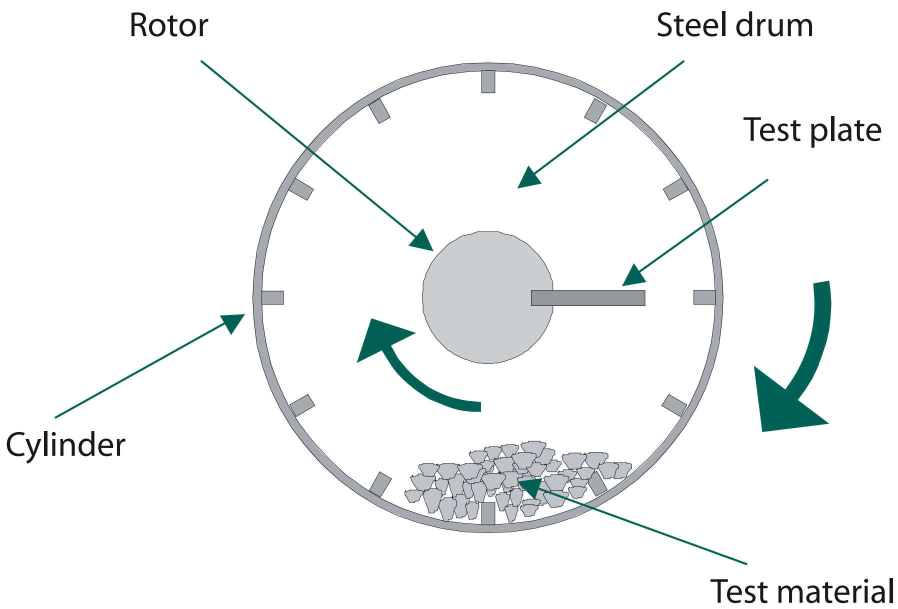
Abrasiveness/Crushability is Metso standard method to test rock material abrasiveness and crushability.

Abrasion meter.

3.5 Abrasion Index (Ai)

The abrasion index is a parameter showing the abrasion power of a material, normally proportional to the percentage of free silica content.

The test is carried out in a small rotating drum with concentric rotor, to which is attached a standard steel plate. The objective is to wear the plate by driving the drum and the rotor together with the sample. The abrasion index is numerically equal to the weight loss (grams) of the plate.



Pennsylvania (Bond) abrasion machine.

The diameter of the outer cylinder is 305 mm and the diameter of the inner hub is 110 mm. In the surface of the cylinder there is 12 small shelf plates. When the drum rotates these shelf plates picks up material and carrying it until it is dropped and hit against the test paddle or the bottom of steel drum.

Paddle preparation: Before the test the paddle is dressed with a fine file for any burrs and sharp edges. The cleaned and dry paddle is weighed.

Rock sample: The material to be tested is a composition of 200 g of 12/16 mm fraction and 200 g of 16/19 mm fraction. Total amount 4x400 g = 1600 g of 12/19 mm fraction.

Test Procedure: The paddle is clamped in the slot of the inner hub. A 400 g sample of material to be tested is placed in the drum. The drum and the test paddle rotate for 15 minutes. The paddle rotates to the same direction than the drum but about nine times faster. After 15 minutes rotation the drum is emptied and the process is repeated three times with a new material so that the paddle is subjected to wear for an hour. After an hour rotation the paddle is removed, cleaned and dried. The paddle is weighed. The weight loss in grams is the Abrasion Index (Ai) of the tested material.

3.6 Work Index (Wi)

Energy demand is one of the most important factors in all size reduction processes. In addition to its high cost, the energy needed to perform the work is also a decisive factor in the selection and dimensioning of some of the main process equipment.

Several methods have been developed to calculate the energy required for the fragmentation of minerals. The best known, and probably the most accurate and largely proven is the method developed by F. C. Bond, in the Allis Chalmers test center.

According to the F. C. Bond method the power requirements of mineral grinding processes are determined by the factor known as “Work index” (Wi).

This factor expresses in kWh, the value of the work required to reduce the size of a short ton of material with a theoretically infinite feed size to a product with a passing percentage of 80 % in a 100 µ sieve.

Twin pendulum breakage device.

The empirical formula to calculate the energy required for reducing one short ton is the following:

$$E = 10 * Wi * [1/\sqrt{P} - 1/\sqrt{F}]$$

E = required energy (kWh/st)
Wi = work index (kWh/st)
P = mesh in microns through which passes 80 % of the product
F = mesh in microns through which passes 80 % of the feed

The Wi factor is determined with a twin pendulum breakage device or in ball or rod mills.

12"x24" Rod mill (Bond rod mill)

12"x12" Ball mill (Bond ball mill)

3.7 Los Angeles Value (LA)

This test is a measure of degradation of mineral aggregates of standard grinding procedure. This test has been widely used in aggregate quality measurement. Standards related to this test method: ASTM C 131, ASTM C 535, EN 1097-2.

The Los Angeles machine consists of a cylinder having an inside length of 508 mm and 711mm internal diameter. Its axis of rotation is mounted horizontally. An internal shelf, 90 mm in depth and 25 mm thick, is mounted across the inside of the cylinder.

A sample of aggregate, weighing 5000 g, is introduced into the cylinder through a hatch. A charge of 6, 8, 11 or 12 steel balls depending on the sample gradation, each about 46.8 mm in diameter, is also added. The hatch lid is then closed and the cylinder rotated for 500 revolutions at a rate of 30-33 rpm. The hatch is opened and the contents of the cylinder are emptied into a tray set underneath the opening. The balls are removed and the aggregate is then sieved through a 1.70 mm (1.6 mm EN 1097-2) sieve. The fraction retained on the sieve is dried to constant mass and weighed. The result, the Los Angeles Value, is calculated as:

LA = (5000-m)/50

where: m is the mass retained on a 1.70 mm sieve, in grams.

Los Angeles Value is not only a measure of rock physical property but an aggregate product measure. It also depends on the shape of the product.

3.8 Uniaxial Compressive Strength (UCS)

Uniaxial (or unconfined) compressive strength is a common measure what is used for many purposes in mining and crushing fields. The common method uses cylindrical core specimens. The length of the specimen must be at least 2.5 times the diameter and the ends are parallel. The sample is then compressed with slow speed until it break down and the compressive load decreases. The force and the displacement are recorded during the test. UCS is calculated as follows:

UCS = F / A

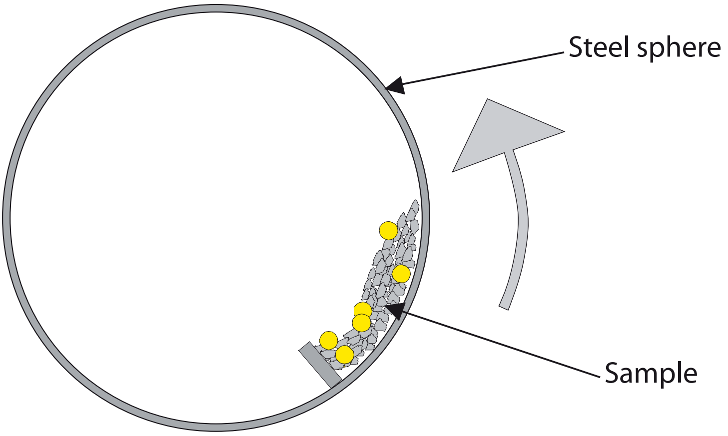
Where
F is the peak compressive force (N)
A is the cross-sectional area of the specimen (mm^2)

The Young's modulus can be determined from the stress-strain curve. It is very useful measure when estimating the toughness of the rock. Advanced compressive loading machines can also measure the Poison's ratio of the rock.

3.9 Statistics

When measuring rock properties the sampling action and the sample preparing are very decisive reasons for the results. In these laboratory tests the size of the sample is always small and the results are valid only for the sample. This must keep in mind when taking the sample.

Metso laboratories have tested thousands of rock samples. Following tables show the statistics of different test results and give a baseline for the rock evaluation.

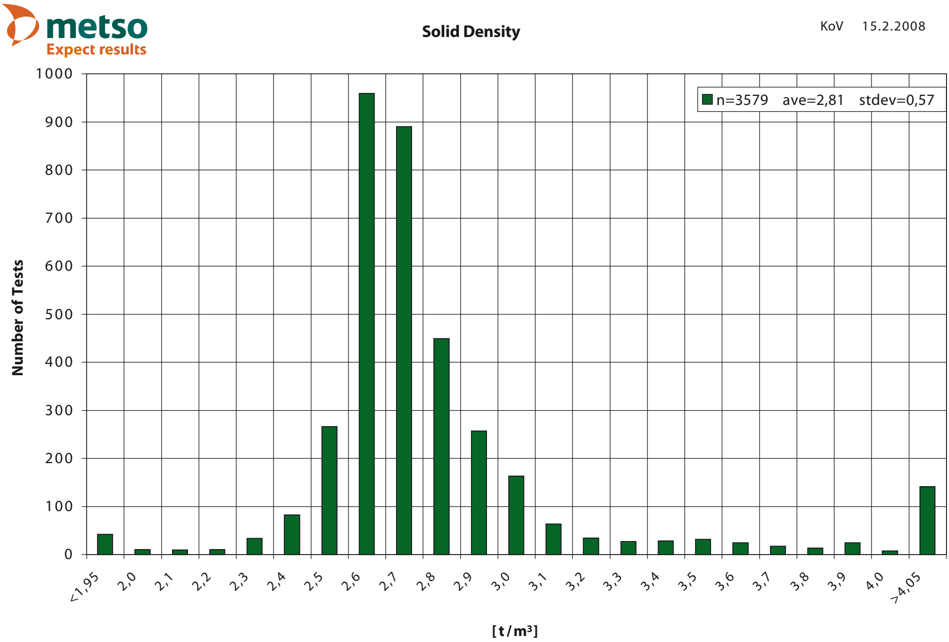


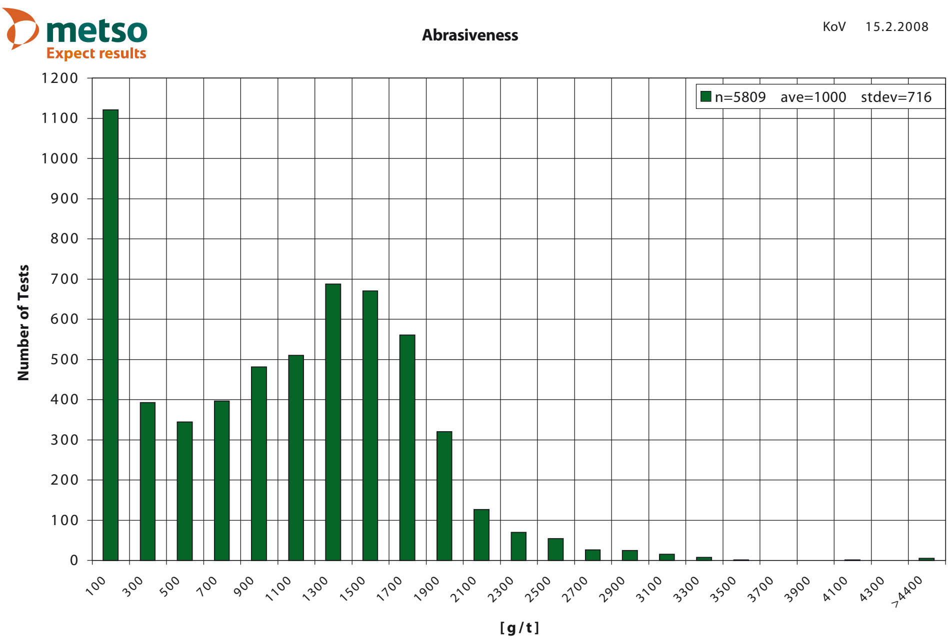
Los Angeles test machine.

Testing at Metso Mining and Construction Technology laboratories

Test Methods	Laboratory/ Test Plant						Purpose of Use												General			
	Tampere (Finland)	Macon (France)	Sorocaba (Brazil)	Ahmedabad (India)	Danville (U.S.)	York (U.S.) Mining	Crushing Process Planning	Milling Process Planning	Crusher Selection	Mill Selection	Screen Selection	Screen Media Selection	Capacity	Product Gradation	Product Shape	Power Consumption	Wear Part Lifetime	Customer Acceptance for end product	Sample Size (kg)	Test Time (h)	Reproducibility (0…5; 0=low, 5=high)	Test Goodness (0…5)
Solid Density	X	X	X	X	X	X	X	X	X	X	X		X						1	1	5	5
Bulk Density	X	X	X	X	X	X	X		X		X		X					X	2	1	4	4
Humidity	X	X	X		X	X	X		X		X	X	X				X	X	1	1	4	4
Bond Crushability Work Index	X	X			X				X				X			X			20	4	1	1
Bond Ball Mill Work Index			X			X		X		X									20			
Bond Rod Mill Work Index			X			X		X		X									20			
Crushability (French crushability standard)	X	X	X	X	X		X		X				X	X	X	X	X		2	1	4	4
Abrasiveness (French abrasiveness standard)	X	X	X	X	X		X		X			X					X	X	2	1	4	4
Abrasion Index (Bond)	X		X		X	X	X		X			X					X	X	2	2	4	4
Los Angeles Value	X						X		X				X	X	X	X	X	X	20	2	2	3
Unconfined Compression Strength				(X)					X							X		X				
Shatter Index	X						X		X				X	X	X	X	X	X	3			
Dynamic Fragmentation		X					X		X				X	X	X	X	X		2	1	4	4
Lab Jaw (crushability)			X																	2	3	2
Lab Cone	X						X		X				X	X	X	X	X					
Particle Size Analysis	X	X	X	X	X	X					X	X						X		2	4	4
Particle Shape	X	X	X								X	X						X		1	4	4
Sand Equivalent		X																X	1	2	3	3
Void Content	X																	X	3	2	4	4
Sand Flow (New Zealand)	X														X			X	3	2	4	4
Sand Flow (EN)		X													X			X	1	1	4	4
Acid Disolution		X							X									X	1	1	4	4
Pilot testing	X		X			X	X		X		X	X	X	X	X	X	X					
Screening Capacity Test			X				X			X	X											
Point Load Index	X		X				X	X												1	2	2
Drop Weight Test			X				X	X							X							
Sag Mill Comminution			X				X	X	X													
Viscosity						X																
Blaine Specific Surface Area						X																
Malvern Analysis						X																
Hardgrove Grindability Index Test						X																
Special Jar Ball Mill Grindability Test						X																
SMD test						X																

(shaded) = stardard tests


metso
Expect results
Solid Density
KoV 15.2.2008
n=3579 ave=2,81 stdev=0,57
Number of Tests
1000
900
800
700
600
500
400
300
200
100
0
<1,95
2,0
2,1
2,2
2,3
2,4
2,5
2,6
2,7
2,8
2,9
3,0
3,1
3,2
3,3
3,4
3,5
3,6
3,7
3,8
3,9
4,0
>4,05
[t/m³]


metso
Expect results
Abrasiveness
KoV 15.2.2008
n=5809 ave=1000 stdev=716
Number of Tests
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
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3300
3500
3700
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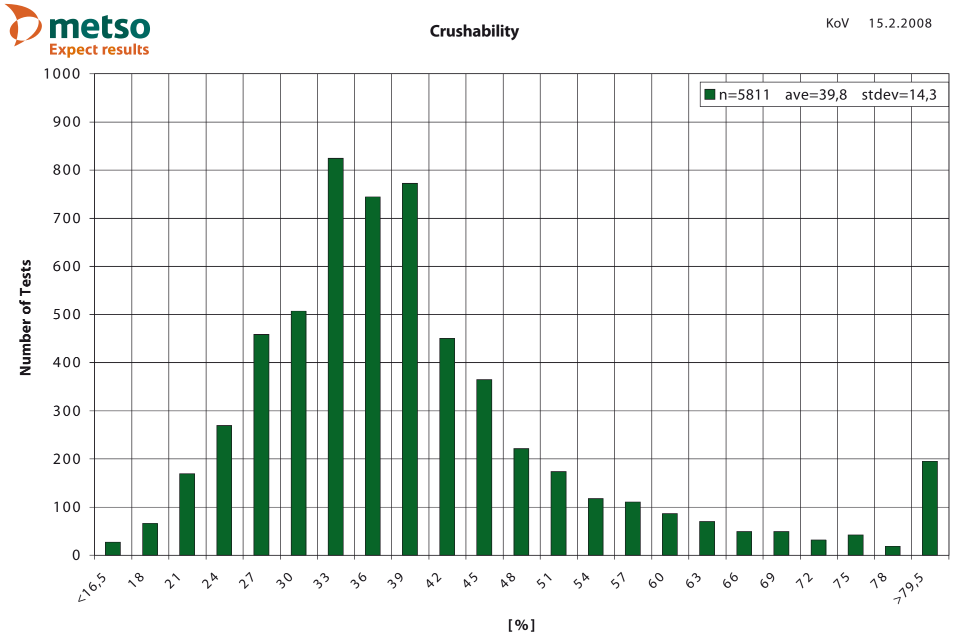
4300
>4400
[g/t]


metso
Expect results
Crushability
KoV 15.2.2008
n=5811 ave=39,8 stdev=14,3
Number of Tests
[%]
<16,5
18
21
24
27
30
33
36
39
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48
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54
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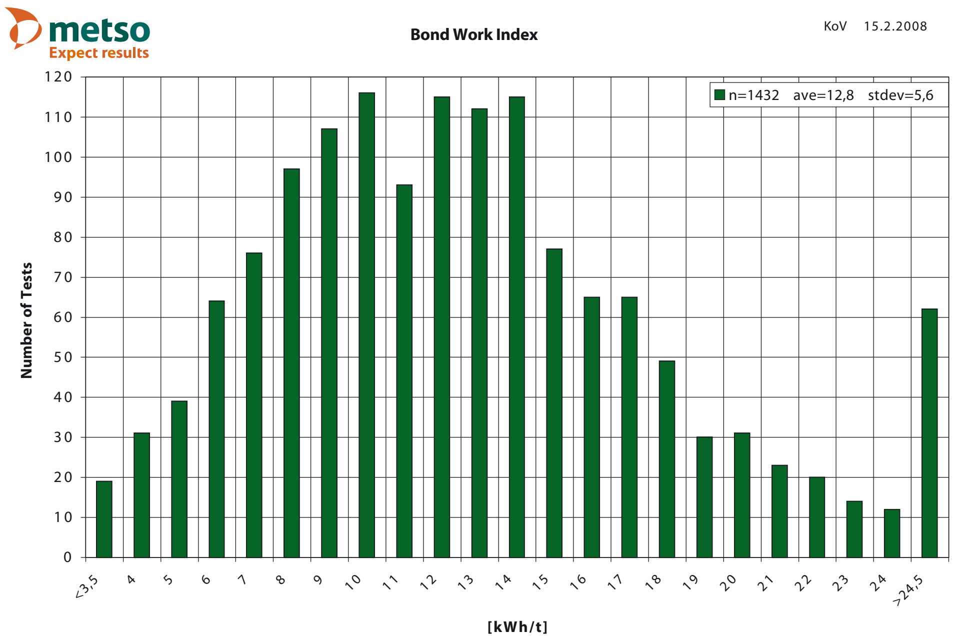
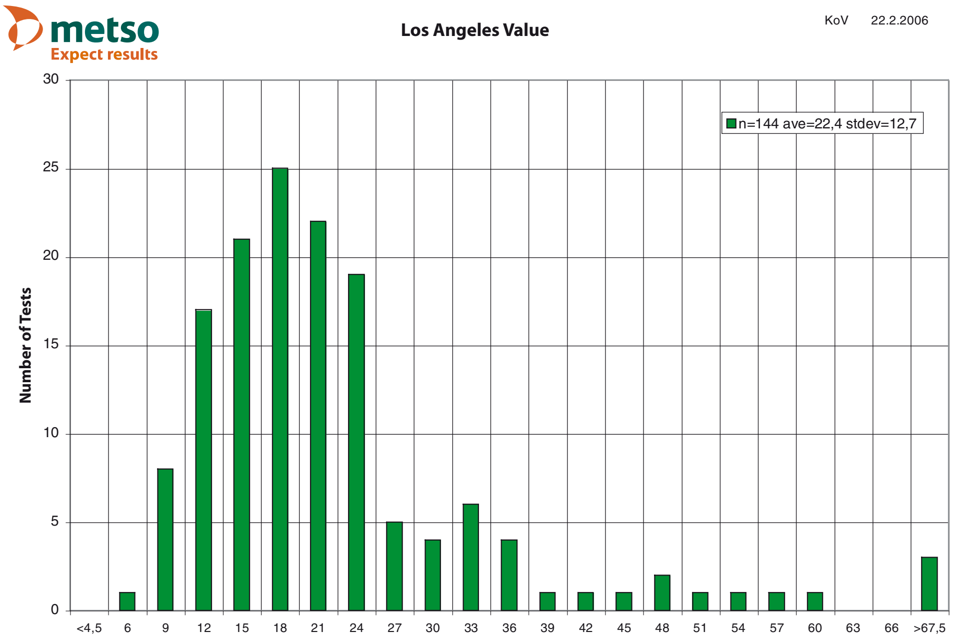
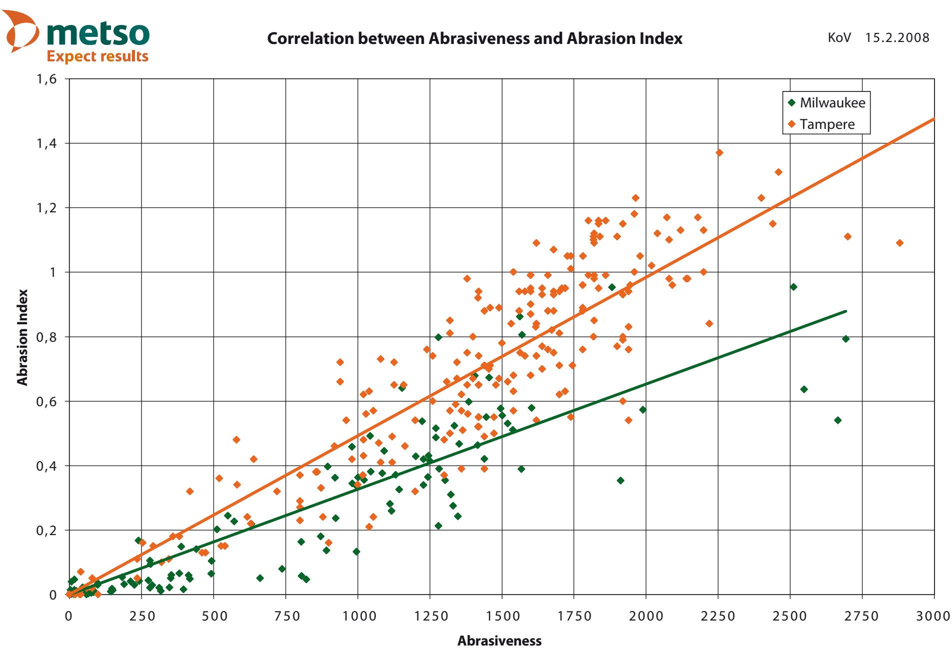
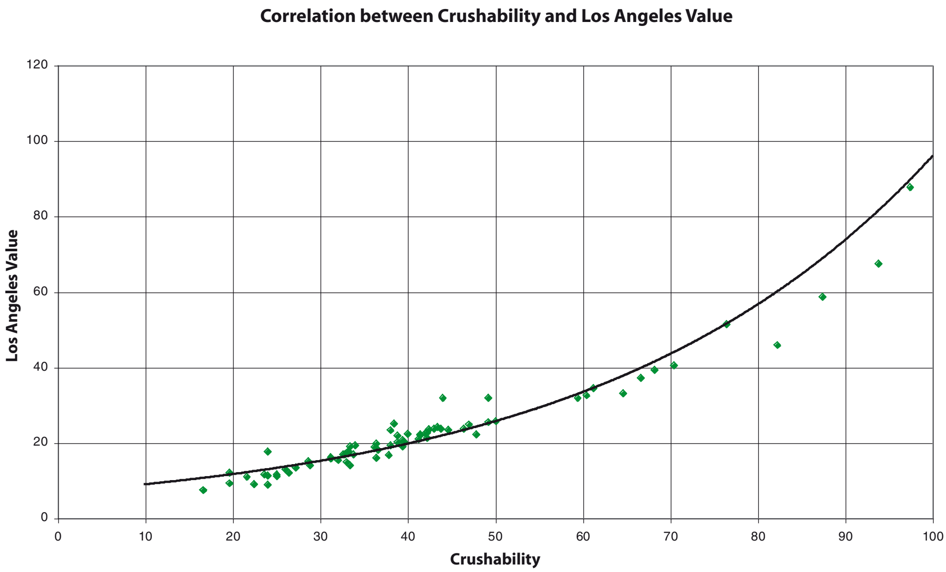
60
63
66
69
72
75
78
>79,5

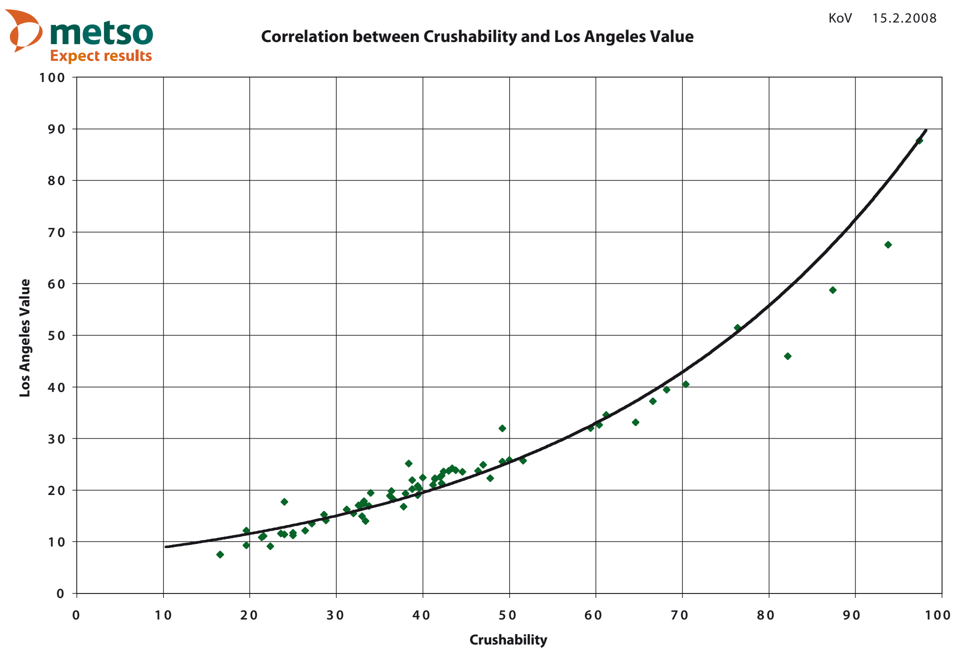

metso
Expect results
Bond Work Index
KoV 15.2.2008
n=1432 ave=12,8 stdev=5,6
Number of Tests
[kWh/t]
<3,5
>24,5

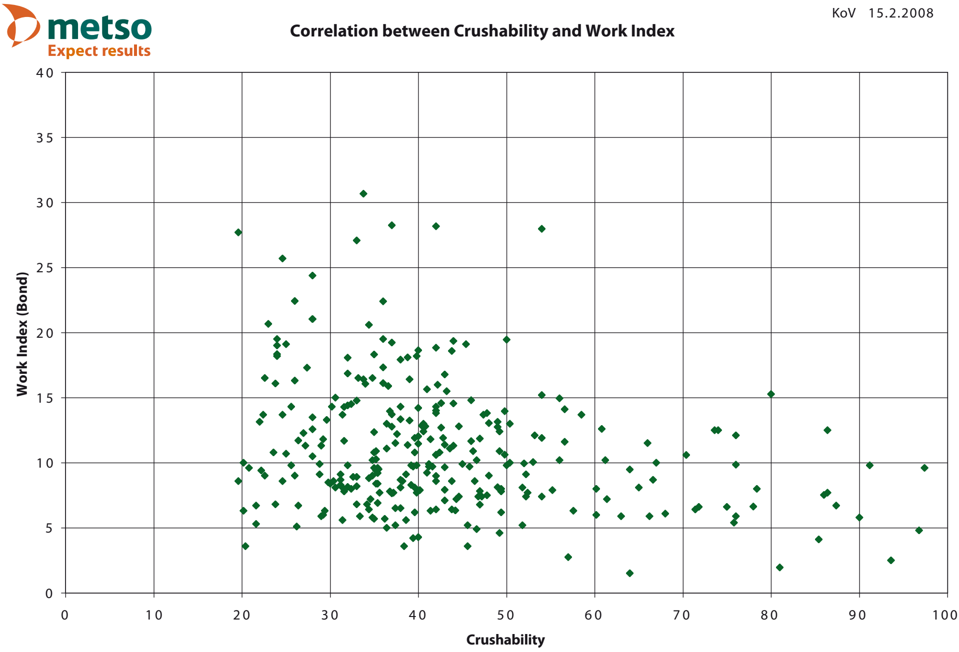


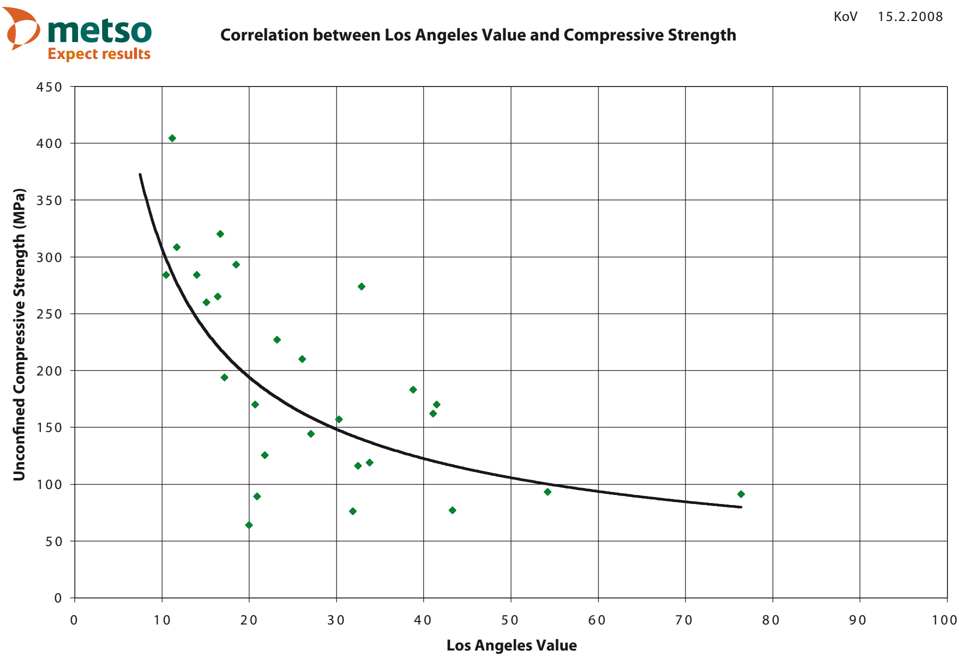
2.10 Correlations

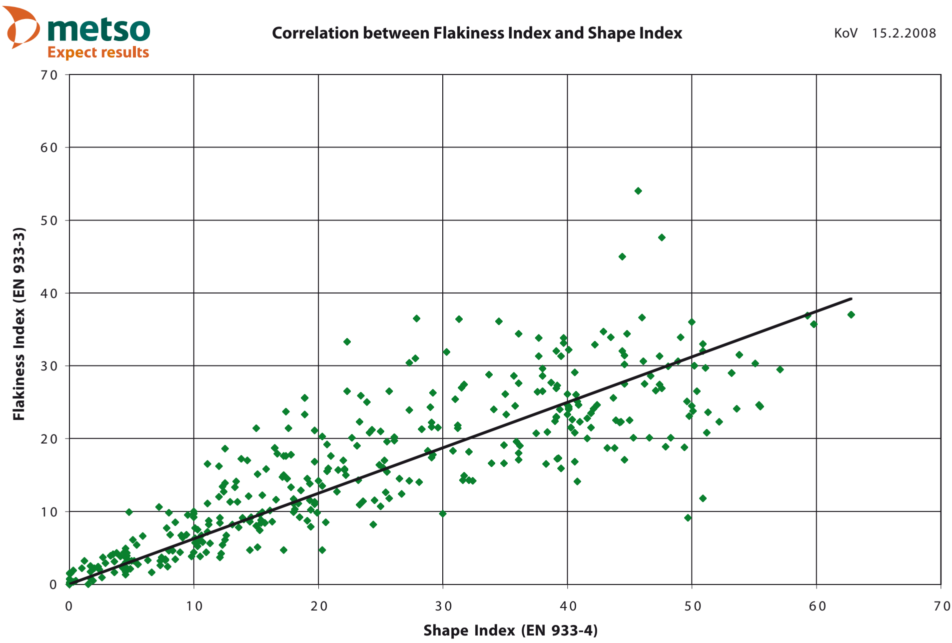



Correlation between Crushability and Los Angeles Value
Los Angeles Value
Crushability
0
20
40
60
80
100
120
0
10
20
30
40
50
60
70
80
90
100


metso
Expect results
KoV 15.2.2008
Correlation between Crushability and Los Angeles Value
Los Angeles Value
Crushability
0
10
20
30
40
50
60
70
80
90
100
0
10
20
30
40
50
60
70
80
90
100


metso
Expect results
Correlation between Crushability and Work Index
KoV 15.2.2008
Work Index (Bond)
Crushability
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90
100


metso
Expect results
Correlation between Los Angeles Value and Compressive Strength
KoV 15.2.2008
Unconfined Compressive Strength (MPa)
Los Angeles Value
0
50
100
150
200
250
300
350
400
450
0
10
20
30
40
50
60
70
80
90
100



The correlation between Abrasiveness and Abrasion Index is satisfactory and the thumb rule is that Abr = 2000 * Ai.

The correlation between Crushability and Los Angeles Value is very good but Work Index seems to measure different property than Crushability.

Crushability Classification

	Bond Work Index [kWh/t]
very easy	0-7
easy	7-10
medium	10-14
difficult	14-18
very difficult	18-

	Crushability [%]
very easy	50-
easy	40-50
medium	30-40
difficult	20-30
very difficult	-20

	Los Angeles value
very easy	27-
easy	22-27
medium	17-22
difficult	12-17
very difficult	-12

	Ai- 8mm product
very easy	60-
easy	45-60
medium	30-45
difficult	15-30
very difficult	-15

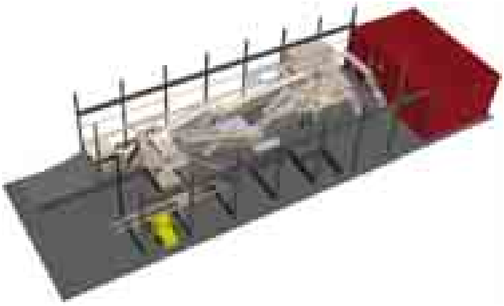
	Shatter Index
very easy	40-
easy	35-40
medium	30-35
difficult	25-30
very difficult	-25

Abrasiveness Classification

	French Abrasiveness [g/ton]
non abrasive	0-100
slightly abrasive	100-600
medium abrasive	600-1200
abrasive	1200-1700
very abrasive	1700-

	Abrasion Index
non abrasive	-0.1
slightly abrasive	0.1-0.4
medium abrasive	0.4-0.6
abrasive	0.6-0.8
very abrasive	0.8-

Metso Mining and Construction Technology Research



Metso Mining and Construction Technology has several full-scale test plants, up to 500kW in power, in different locations. These test plants are used both for product development and full-scale pilot tests. Additionally, it has rock laboratories all over the world. In testing, most modern methods, such as image analysis for gradation distributions and Taguchi type methods for statistically reliable testing, are used. Modern on-site usable measurement and data collection equipment are in continuous use.

Typical Research Support & Services

- Development of simulation tools for process and cavity calculations
- Process consultation & optimization
- Rock testing
- Full-scale pilot testing with dedicated machines
- Crusher kinematics and cavity analysis
- Prototype testing in test plant and field
- Strain gauge measurements
- Training support
- Publications, such as this book

Crushing and Screening Terminology

Crushing terminology

Choke feeding:
A type of feeding arrangement for the crusher, which keeps the crushing cavity full.

Choke point:
The point in the crushing cavity where the volume of material to be crushed is smallest. This determines the capacity of the crusher.

Closed circuit:
A crushing process feature, in which part of the material produced by the crusher is circulated back to the same crusher for further crushing.

Cone head:
A conical part which supports the liner.

Concave:
The external part of the tools used for crushing.

Critical speed:
The speed is critical when the cone head oscillation speed is the same as the falling speed of the crushed material.

Crushing cavity:
The space between the liner and concave, where the crushing action itself takes place.

Crushing ratio:
The ratio between the size of the feed and the emerging product. This is normally measured at the 80% point; Crushing ratio = Feed 80/Product 80, describing the work done with respect to the comminution of the feed into the finished product.

CSS:
Closed side setting – the minimum distance between the liner and concave at the discharge end of the cavity.

Cubicity:
Describes the shape of rock. There are different standards available and, in this thesis, the DIN standard is used.

Flakiness index:
Describes the shape of the rock, very similar to cubicity.

Interparticular Crushing:
Rock crushing is achieved by crushing particles against each other, not only the crushing tools.

Liner / Mantle:
The inner part of the tools used for crushing. Fitted onto the cone head.

Nip angle:
The angle between the liner and concave when rock is caught, or nipped, between them.

OSS:
Open side setting, the maximum distance between the liner and concave at the discharge end of the cavity.

Packing:
Occurs when rock is compressed to the extent that its density increases to the point of solidity.

Reduction ratio:
See crushing ratio.

Segregated feed:
Feed into the crusher in such a way that fine and coarse particles in the feed are led to different sides of the crushing cavity.

Stroke:
Difference between OSS and CSS.

Screening terminology

Coarse fraction
Particles which pass over the screen deck.

Fine fraction
Particles which pass through the screen deck.

Separation size:
Split size: Particle size at which feed separates into two products (coarse fraction and fine fraction).
Overflow/Oversize: Material larger than the hole size.
Underflow/Undersize: Material smaller than the hole size.
Half size: Material smaller than half of the hole size.

Screening capacity (Q)
The amount of material passing through the screen deck in tons/hour.

Feeding capacity
The amount of material fed into the screen deck in tons/hour.

Efficiency of screening (efficiency of undersize recovery)
Amount of material smaller than the hole size in undersize compared to the total amount of material smaller than the hole size in the feed.

REMARKS

REMARKS

REMARKS

REMARKS

REMARKS

Expect results

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