OAIMA ANNUAL MEETING & TRADE SHOW 2015

Maximizing Productivity Through Proper Operation & Maintenance

Cost effective aggregate production begins with employees who are knowledgeable about the maintenance requirements and the operational parameters of the cone crusher(s) that they operate. This presentation will share important cone crusher maintenance and operational tips.

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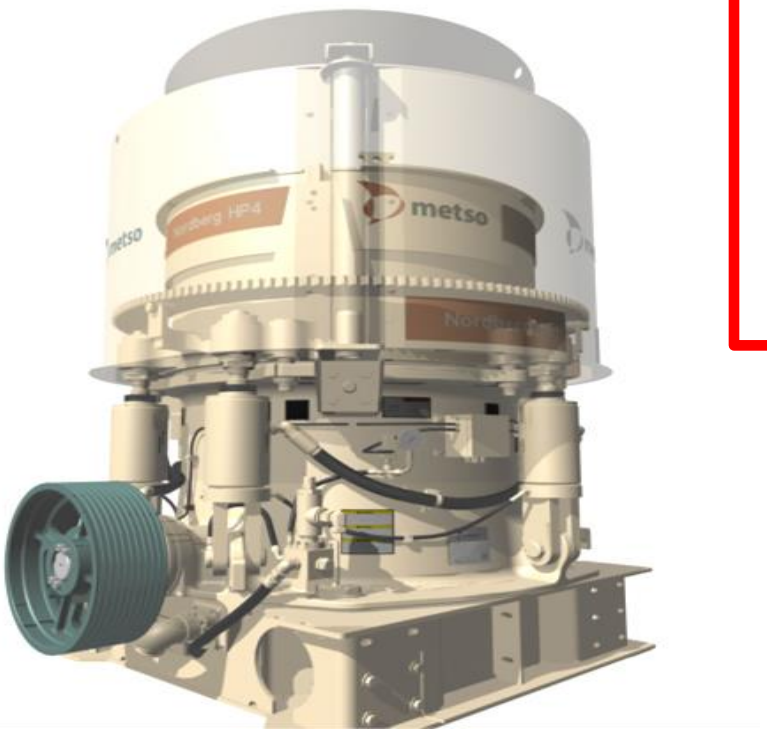
Cone Operational & Maintenance Tips

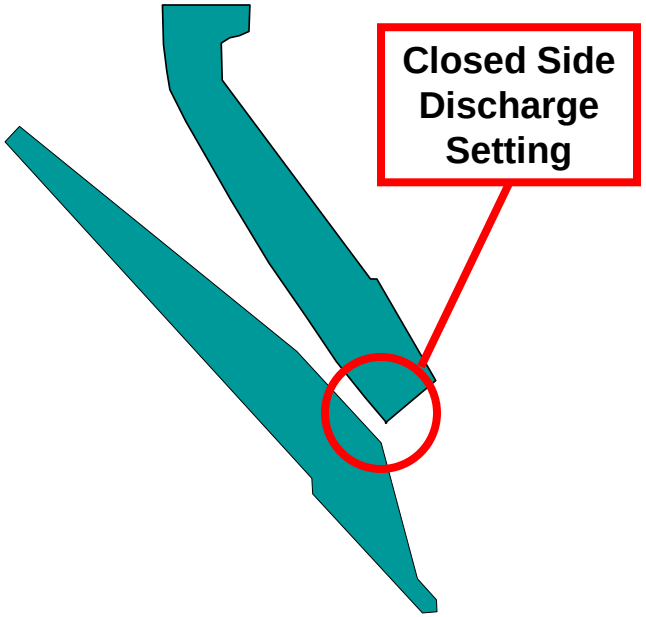
General cone crusher operational tips



CONE CRUSHER "OPERATIONAL" TIPS

Cone Operational & Maintenance Tips

Operate at a consistent closed side discharge setting



- In order to maintain a consistent product quantity, product quality and a balanced circuit, you must operate at a consistent crusher setting.
- If a crusher is allowed to operate at a wider then optimum setting for even a short period of time, the result will be less amount of product produced and an increase in the production of over-sized material.
- Over-sized product can create circuit flow problems.

Action	Capacity	Reduction	Shape	Power	Force
Decrease CSS	↓	↑	↓	↑	↑
Increase CSS	↑	↓	↑	↓	↓

- Understanding the Effect on Crusher Setting -

Cone Operational & Maintenance Tips

Operate at a consistent crusher setting

Closed Side Setting

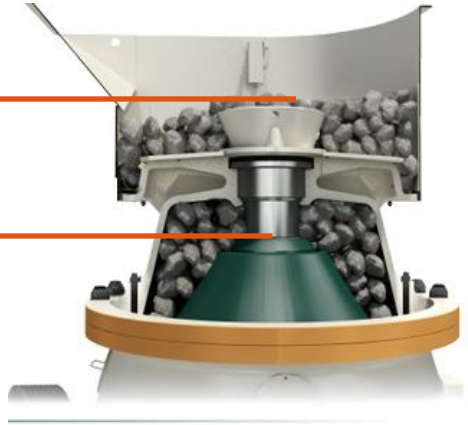
Sieve Size	6 (1/4")	8 (5/16")	10 (3/8")	13 (1/2")	16 (5/8")	19 (3/4
100 (4")	100	100	100	100	100	10(
75 (3")	100	100	100	100	100	10(
63 (2-1/2")	100	100	100	100	100	10(
51 (2")	100	100	100	100	100	10(
38 (1-1/2")	100	100	100	100	100	10(
32 (1-1/4")	100	100	100	100	100	10(
25 (1")	100	100	100	100	98	9
22 (7/8")	100	100	100	100	95	8
19 (3/4")	100	100	100	98	92	8
16 (5/8")	100	100	99	92	80	6
13 (1/2")	100	99	92	78	66	5
10 (3/8")	100	93	81	66	55	4
8 (5/16")	94	82	69	55	45	3
6 (1/4")	82	67	55	43	36	2
4 (#5)	65	49	40	32	26	2
2 (#8)	40	28	23	17	13	1

- Maintaining a consistent Crusher setting throughout the shift is very important.
- A small increase in Crusher setting due to liner wear will result in a product gradation change.
- Example, if target setting is 3/8” but setting is not checked and it wears open to 1/2”, the result is a 15% decrease in the -3/8” material size.

Cone Operational & Maintenance Tips

Operate at a consistent cavity level

Cone Style Crusher

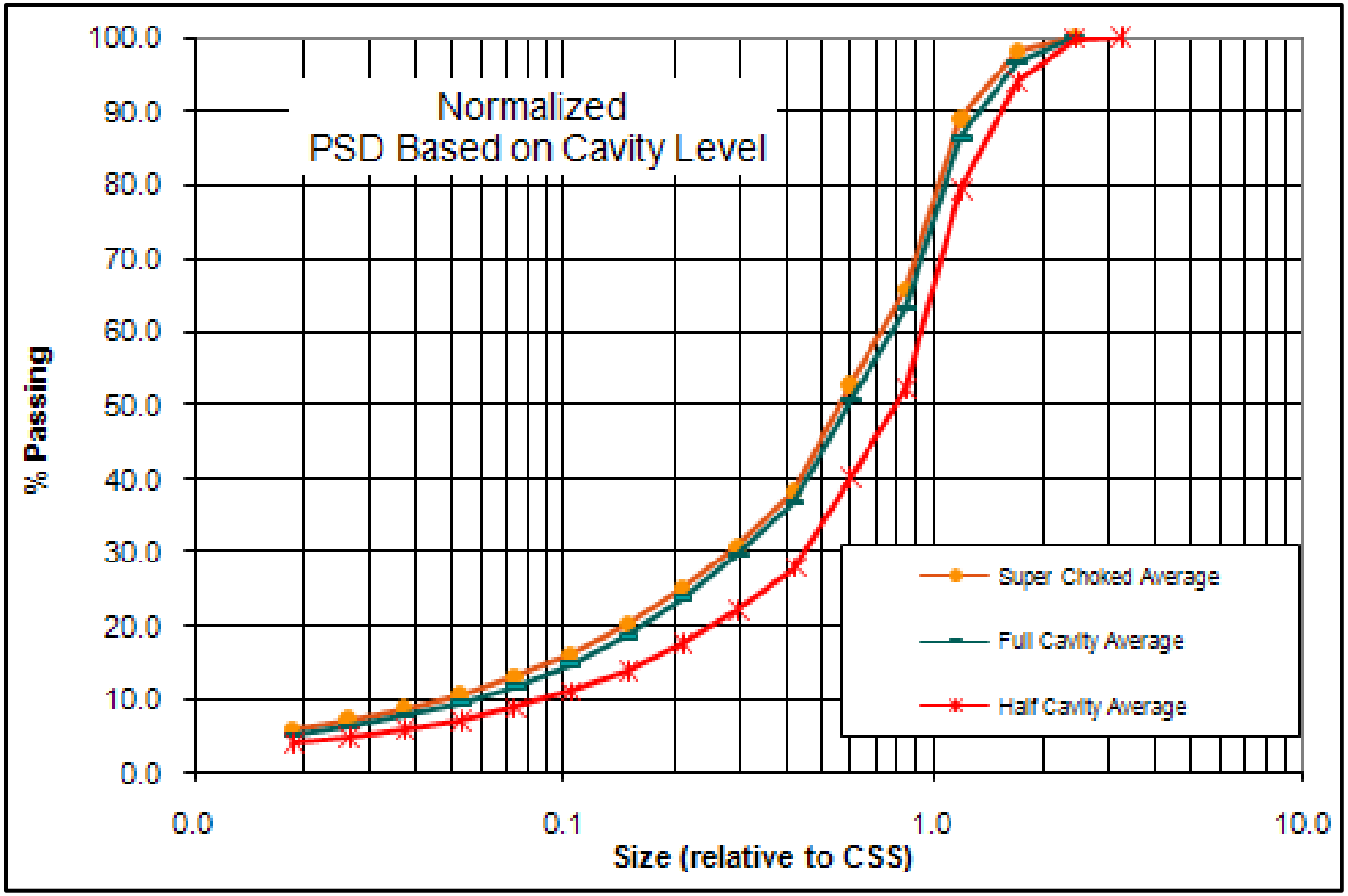


Hydrocone Style Crusher

- In order to maintain consistent product quantity, product quality and a balanced circuit, you must operate at a consistent crusher cavity level.
- If a crusher is allowed to operate at varying cavity levels for even a short period of time, the result will be a inconsistent product shape.
- This tip is particularly important to the short head crushers in the circuit.

Cone Operational & Maintenance Tips

Operate at a consistent cavity level



Cone Operational & Maintenance Tips

Make certain that the feed is evenly distributed

Example of Poorly Distributed Feed

- All incoming feed should be properly distributed.
- Incoming feed should be directed vertically into the center of the crusher.
- Poor distribution results in a low crusher throughput, elongated and oversize product.
- Poor distribution results in adjustment ring movement and a tilted adjustment ring (due to rock-on-rock compaction).

Cone Operational & Maintenance Tips

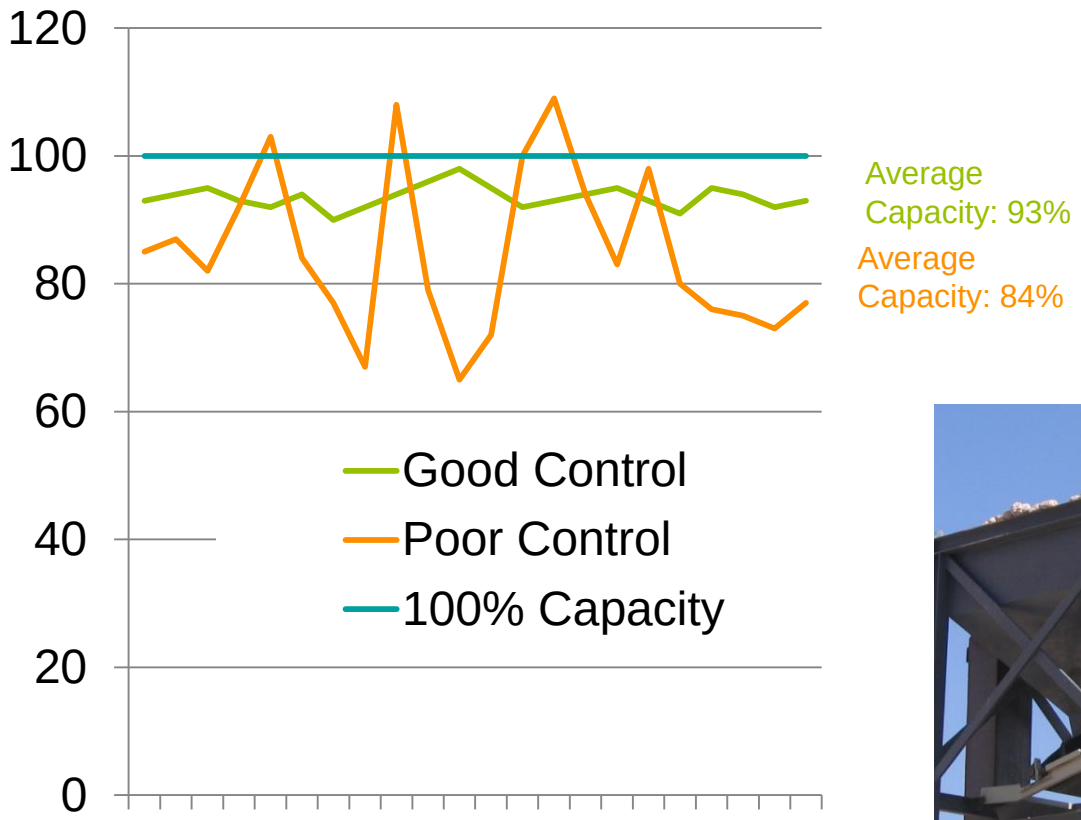
Make certain that the feed is not segregated

Example of Segregated Feed

- All incoming feed should be well mixed and homogenous.
- Segregated feed results in a low crusher throughput (because you have to open the setting to get away from the ring movement).
- Segregated feed results in oversize product (due to the increase in setting).
- Segregated feed results in adjustment ring movement and a tilted adjustment ring.

Cone Operational & Maintenance Tips

Minimize surge loading for a more efficient circuit



Average Capacity: 93%

Average Capacity: 84%

- Surge loading of a crusher is a “production enemy”.
- Surge piles and feed hoppers can easily increase productivity by at least 10%.

Cone Operational & Maintenance Tips

Understanding the design limitations of the cone crusher

1) The crusher is "volumetrically" limited

- Each crushing cavity has a volume limit which determines maximum throughput
- A choke fed crusher is operating at it's volumetric limit
- Volume limit exceeded when feed material overflows the crusher

2) The crusher is "horsepower "limited

- Each crusher is designed for a maximum power draw
- Power draw increases as the feed rate increases and as material is crushed finer
- Power limit is exceeded when the crusher draws more power than it is rated for

3) The crusher is "crushing force" limited

- Each crusher is designed for a maximum crushing force
- Crushing force increases as the feed rate increases and as material is crushed finer
- The force limit is exceeded when the adjustment ring bounces, wiggles, or moves

Cone Operational & Maintenance Tips

Operate within the crusher design limitations

If the adjustment ring bumps or moves or power draw is excessive……

- Open the crusher setting slightly (but stay choke fed)
- Decrease the feed rate

Typical reasons for ring movement or excessive power draw……

- Tramp events - steel, rubber, wood, plastic
- Poor distribution of the feed - one side of the crusher is full, opposite is empty
- Segregation of the feed - finer feed to one side, coarser feed to the other
- Too many fines in the feed - feed that is already smaller then the closed side setting
- High moisture content - wet, sticky feed (in excess of 4% moisture)
- Wrong liners - large feed opening with small feed
- Crusher setting is too tight - set below the minimum setting

THE GOAL OF THE OPERATIONS STAFF!

Maximize Productivity While Operating the Crusher Within it's Design Limits

Cone Operational & Maintenance Tips

Monitor and maintain proper crusher speed

- If proper drive belt tension is “not maintained”, the belts will slip and the crusher will slow down.
- A slowing crusher will cause incredibly high power peaks at a very low crusher throughput.
- Improper drive maintenance will result in a high horsepower consumption at a low crusher throughput tonnage, this inefficient use of connected horsepower will result in a higher energy cost per ton of material crushed (kW/hr per ton).
- A speed sensor can be used to monitor speed.

Tonnage Reduction due to Belt Slip (%)	Actual Tonnage (STPH)	Tonnage Lost per year (STPY)	Lost Revenue per Year
0	400	0	$0
10	360	80,000	$480,000
15	340	120,000	$720,000
20	320	160,000	$960,000

Based on 400 STPH, crushing 8 hrs day, 5 days week, 50 weeks year, avg. product sale price $6.00/ton.

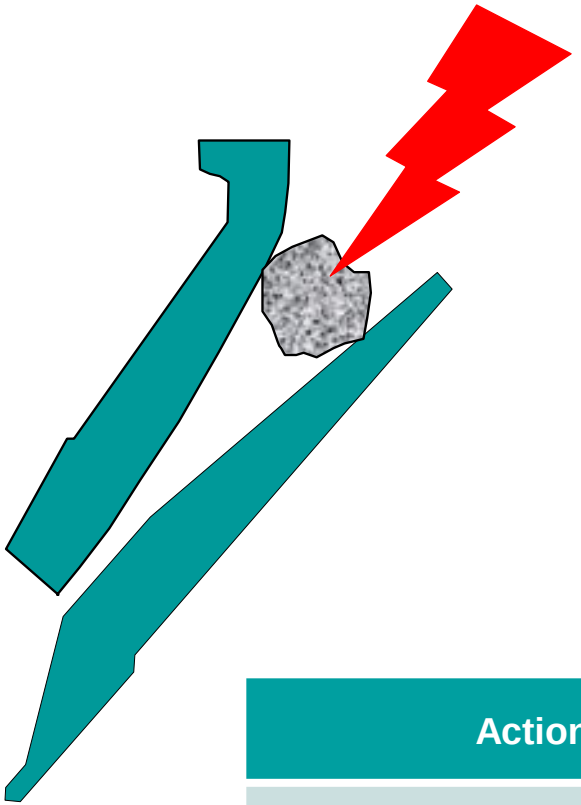
Cone Operational & Maintenance Tips

Determine the percentage of fines in the feed

- Fines in the crusher feed is defined as material that is already equal to or smaller than the crushers closed side discharge setting.
- As a rule-of-thumb, the maximum number of fines in the crusher feed should not exceed 25% for secondary crushers or 10% for tertiary crushers.
- Re-crushing and re-handling product size material due to improper screen maintenance leads to inefficient use of connected crusher horsepower and a higher energy cost per ton of material crushed (kW/hr per ton).
- Screening problems may include…….
  - ✓ *Blinding*
  - ✓ *Pegging*
  - ✓ *High material travel rate*
  - ✓ *Exceeding maximum bed depth*
  - ✓ *Poor distribution of screen feed*
  - ✓ *Incorrect stroke & speed combination*
  - ✓ *Operating with off-motion*
  - ✓ *Operating with loose screen cloth*

Cone Operational & Maintenance Tips

Limit the height that the feed material drops from

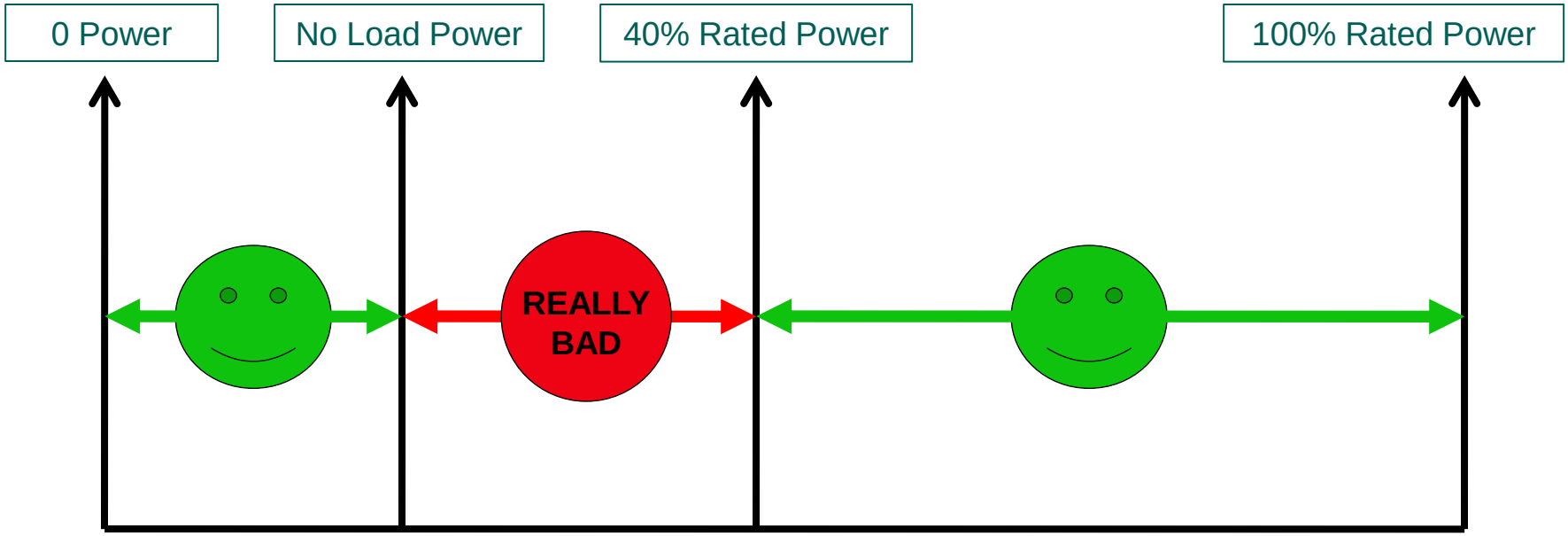


- The maximum distance that the feed should fall from is 3’ (1m) above the bowl hopper.
- When feed drops from a greater distance, “high velocity wedging” can occur.
- This can result in power overloads, force overloads, or both.
- This action puts undue strain on the crusher components and results in increased maintenance repair costs and poor productivity.

Action	Downtime	Cost / Ton	Production
High Velocity Wedging	⇧	⇧	⇩

Cone Operational & Maintenance Tips

Don't trickle feed the cone crusher



- Trickle feeding results in poor productivity and poor product shape.
- To obtain proper bearing alignment and to maximize productivity, operate above 40% rated power but below 100% rated power of the crusher drive motor (trickle feeding can result in damaged upper head bushings).
- Never exceed 110% rated power.

Cone Operational & Maintenance Tips

Eight keys to maximize product quantity, quality & uniformity

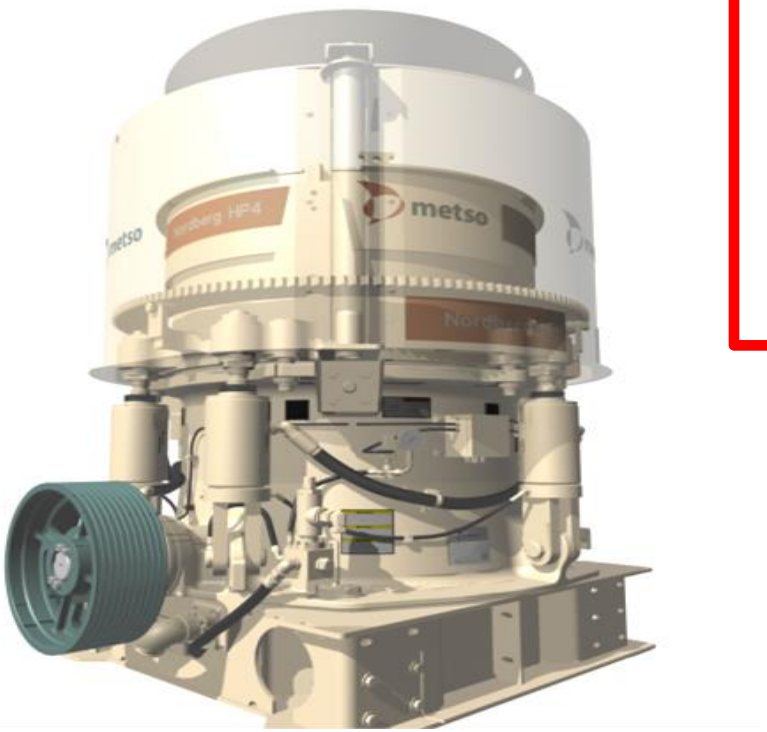
1. Must have good feed control with continuous stream of feed (no surge loading).
2. Operate at a consistent “choke fed” cavity level.
3. Operate at a consistent closed side discharge setting.
4. Must have some fines in the feed but not too much (material smaller then c.s.s.).
5. Feed material should be “well graded” (gap graded feed should be avoided).
6. Must have proper feed distribution (good centered feeding).
7. Must avoid segregation (fine feed to one side, coarse to the other).
8. Don’t exceed the maximum feed size.

“Quality is the elimination of variation”

W.E.Deming (1900-1993), American quality expert

Cone Operational & Maintenance Tips

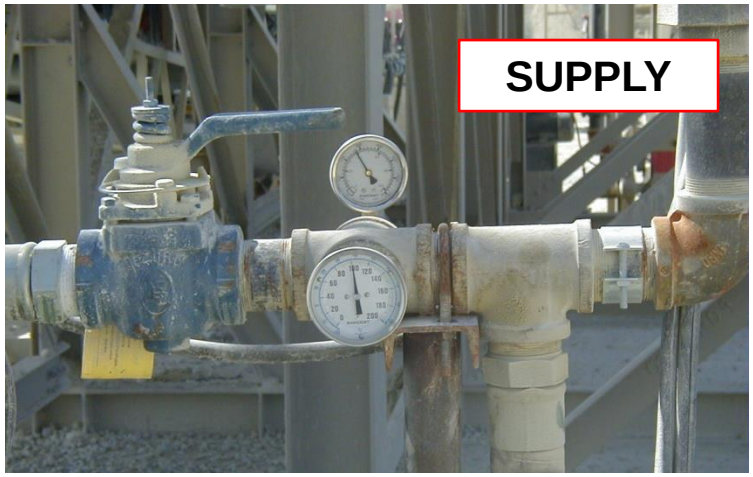
General cone crusher maintenance tips



CONE CRUSHER "MAINTENANCE" TIPS

Cone Operational & Maintenance Tips

Monitor you lube oil temperature



- A lot can be learned about your crusher just by watching the supply oil temperature and comparing it to the return oil temperature.
- Return oil temperature should be in the range of 60°F (16°C) to 140°F (60°C) , although preferably, the temperature should be in the range of 100°F (38°C) to 130°F (54°C).
- Oil temperature should be monitored throughout the shift.
- Once you learn the crushers normal drain line oil temperature and the normal temperature differential, an abnormal condition would warrant an investigation.

Cone Operational & Maintenance Tips

Monitor your lube oil pressure

- A lot can be learned about your crusher just by watching the oil pressure at the countershaft box.
- The oil pressure should be monitored throughout the shift.
- Once you learn your crushers normal oil pressure, an abnormal oil pressure would warrant an investigation.

Cone Operational & Maintenance Tips

Inspect your lube oil tank return screen

- An oil tank return screen (typically about 10 mesh) is fitted into the oil tank.
- All returning oil will flow through this screen.
- OIL is the only thing that should go through this screen, any unusual looking debris would warrant an investigation.
- The oil tank return screen should be inspected daily (8 hours).

Cone Operational & Maintenance Tips

Commit to the oil analysis program

Contaminant	Average PPM	High PPM
Copper (Cu)	100	210
Aluminum (Al)	5	10
Iron (Fe)	20	50
Chromium (Cr)	0.5	1.5
Lead (Pb)	70	190
Silver (Ag)	0	5
Nickel (Ni)	5	15
Tin (Sn)	15	30
Sodium (Na)	30	60
Water	0.1%	1.0%
Silica (Si)	25	65
Total Solids	0.1%	0.2%

- An active drain line oil sample should be taken once per month (200 hours) and sent in for analysis.
- The results are reviewed looking for any unusual increase in contamination level over the previous samples.
- The table to the left shows average part per million (PPM) contaminate levels and high part per million (PPM) contaminate levels.

Cone Operational & Maintenance Tips

Maintain clean crusher air breathers

- The countershaft box air breather and the oil tank air breather work together to allow the crusher, oil tank and a properly pitched drain line tube to maintain atmospheric conditions.
- Clean air breathers assures free unrestricted drainage of the lube oil and helps prevent dust infiltration through the head sealing arrangement.
- The air breathers should be inspected weekly (40 hours).

Cone Operational & Maintenance Tips

Monitor your crushers coast down time

- Coast down time is the amount of time in seconds that it takes the crusher sheave to come to a stop after the crusher drive motor has been stopped.
- Coast down time gives you an idea just how free the crusher is.
- Minimum coast down time for most mid-size to small cone crushers is 30 seconds.
- Coast down time should be documented at the end of every day.
- Once you learn your crushers normal coast down time characteristic, a decrease from normal would warrant an investigation.

Cone Operational & Maintenance Tips

Inspect the under crusher discharge area daily

- Some of the heaviest damage that can occur to a cone crusher is caused by a build-up of material below the crusher.
- For this reason, inspect the area under the crusher once per day.
- Check for material buildup on the crusher arms and the countershaft box.

Other Items to Look at…..

- condition of the mantle and bowl liner
- condition of the counterweight guard
- condition of the main frame liners
- condition of the arm guards
- condition of the lube oil piping

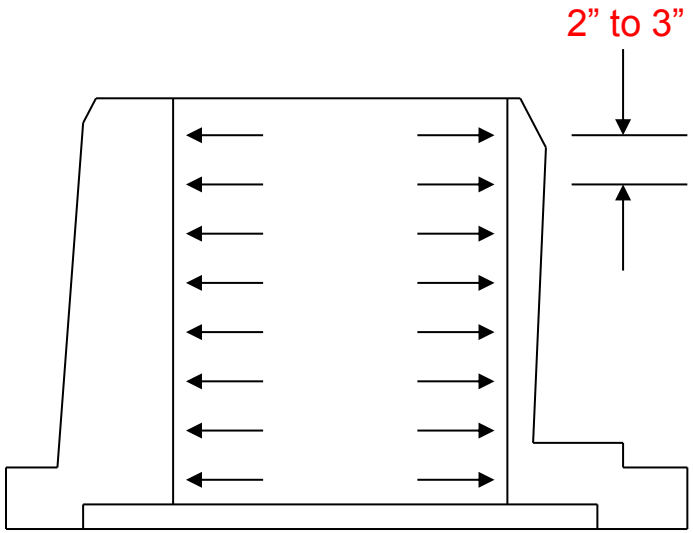
Cone Operational & Maintenance Tips

Lubricate your bowl threads weekly

- The bowl threads should be lubricated weekly (40 hours).
- The proper lubricant to use is an NLGI #1 with at least 5% molybdenum disulfide (by weight).
- The threads should be lubricated once when the bowl is clamped tight in a crushing position, and once when the bowl clamping pressure has been released.
- In non-abrasive applications, rotate your bowl open and closed a full revolution on a monthly basis (200 hours).
- The consequences of not lubricating the threads properly is a stuck bowl.

Cone Operational & Maintenance Tips

Measure the “bore” prior to installing a new bronze bushing



"X" = In-line with load zone

"Y" = 90° opposite load zone

- Every time that a bronze bushing has been burned black in color, there is a good possibility that the steel bore has become pulled in, egg shaped or distorted.
- If a new bronze bushing is installed into a damaged bore, the softer bronze bushing will take the same shape as the damaged bore.
- This will lead to a reoccurring bushing failure.
- Make certain to measure the bore with a micrometer prior to installing a new bushing.
- If the dimensions taken show that there is distortion in the bore, corrective action is required.

Cone Operational & Maintenance Tips

Keep a daily operators log sheet on every crusher

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OPERATORS DAILY CRUSHER LOG

Date	Time	Operators Initials	Ambient Temperature - °F (°C)	Oil Temperature - °F (°C)		CS Box Oil Pressure - PSI (Bar)	Power Draw - Amps (kw)		Closed Side Setting - Inches (mm)	Alarms Been Checked Y or N	Coast Down Time (seconds)	Tramp Release Oil Pressure - PSI (Bar)	Checked Discharge Area Y or N	Air Breathers Cleaned	
				Feed Line	Drain Line		No Load	Load						Crusher	Oil Tank
				X	X	X	X				X				

- A properly interpreted daily operators log sheet can help predict a problem with the crusher prior to a failure.
- Entries should be made into the log sheet at least once per shift but preferably twice per shift.
- The log sheet is used to learn the crusher's normal operating trends, once this has been established, red flags will pop up when something abnormal has occurred.

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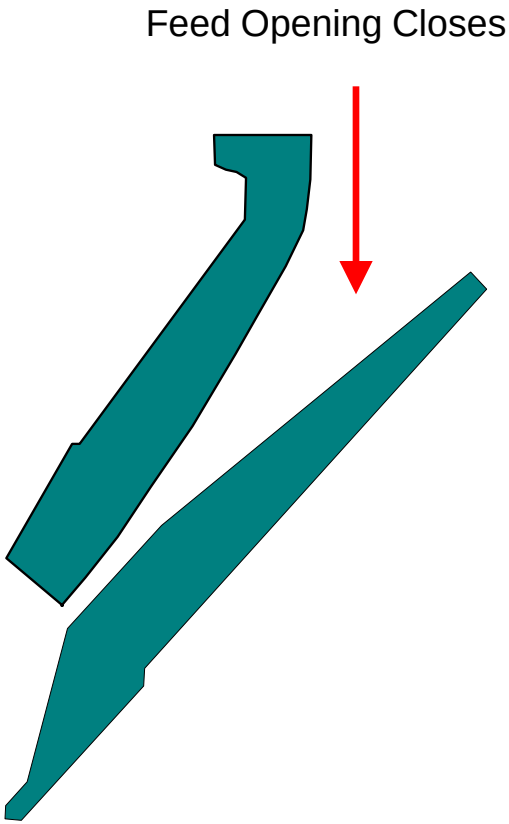
Cone Operational & Maintenance Tips

Change your liners on-time to maximize productivity



Change the Liners at the Same Time by Watching for a Reduction in Throughput Caused by the Closing Off of the Liners Feed Opening.

- The volumetric area of the liner decreases late in liner life as the feed opening closes off.
- This results in lower throughput and a substantial loss in salable product.
- An excellent time to change liners is when a 10% loss of product being produced is noticed, the immediate increase in productivity far outweighs the little bit of gain you get in manganese utilization.

Cone Operational & Maintenance Tips

Implement a preventive maintenance program

- Prepare a written preventive maintenance program that fits your plant
- Include specific dates when maintenance work will be done
- Have it approved by management
- Do it on the dates scheduled, regardless of production requirements

PM Program Should Include…..

- daily, weekly, monthly and yearly checks recommended by the manufacture
- liner changes on time
- oil analysis program
- operators daily log sheet
- walk around inspections

Preventive Maintenance Pays Off!

Cone Operational & Maintenance Tips

Commit to employee training and education

- Without a doubt, producers who incorporate technical crusher training into their yearly activities reap huge benefits, most notably, increased productivity, improved product shape, increased crusher on-line availability and decreased maintenance repair costs.
- Crusher training venues include manufacturer training seminars, regional training seminars and private training seminars.
- Talk to me about which program might suit your needs the best.

Additionally, employee training……

- ✓ *Improves employee safety*
- ✓ *Increases employee confidence*
- ✓ *Improves employee performance*
- ✓ *Lowers employee turnover*

“THANK YOU” FOR ATTENDING

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