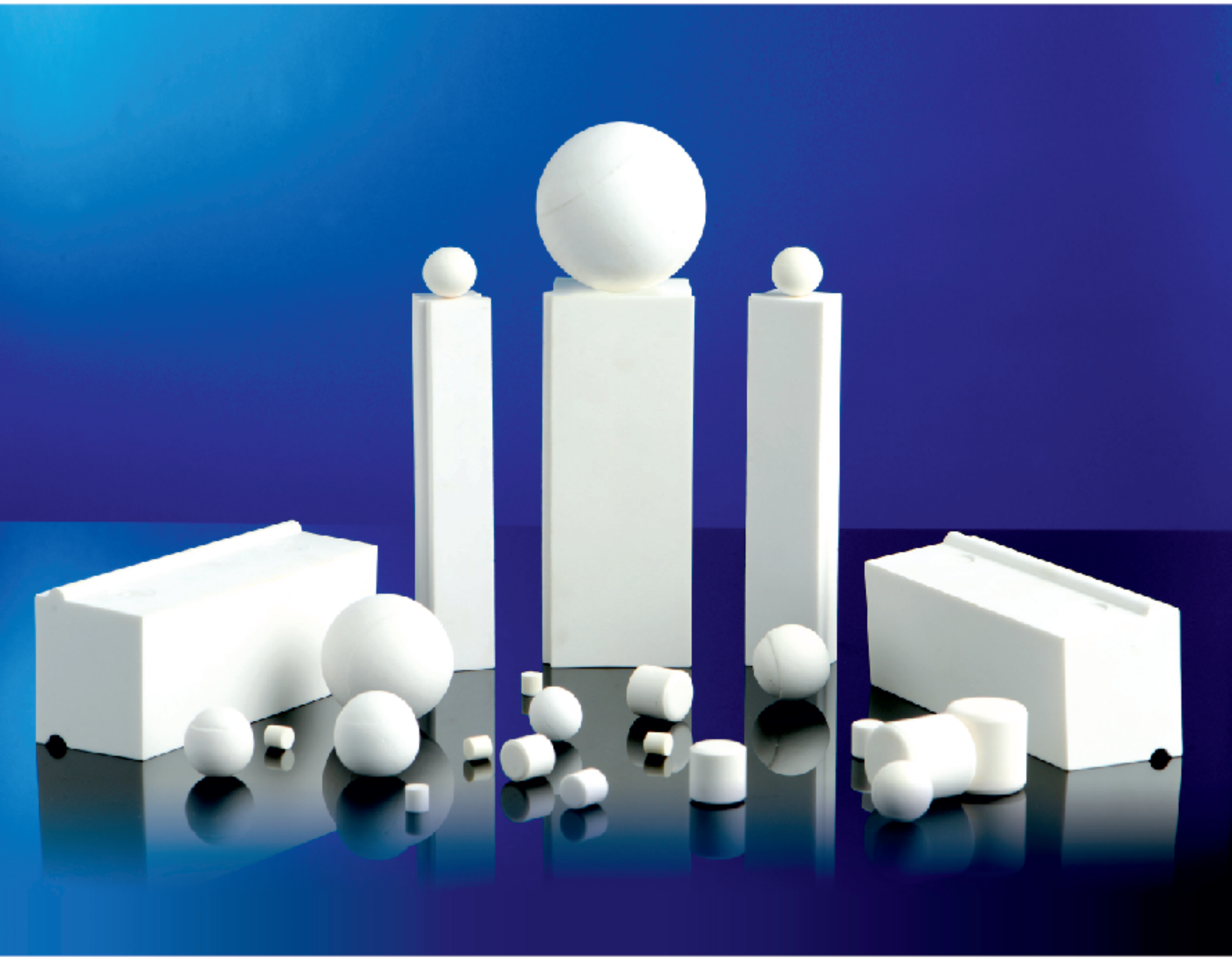
Duralox®

CERAMIC GRINDING MEDIA
AND BALL MILL LINING

SUPERIOR QUALITY MILL LINING AND GRINDING MEDIA FOR AN OPTIMIZED MILLING PERFORMANCE.



JYOTI® CERAMIC

Our Founder
Late Mr. Shyam Merani

THE COMPANY

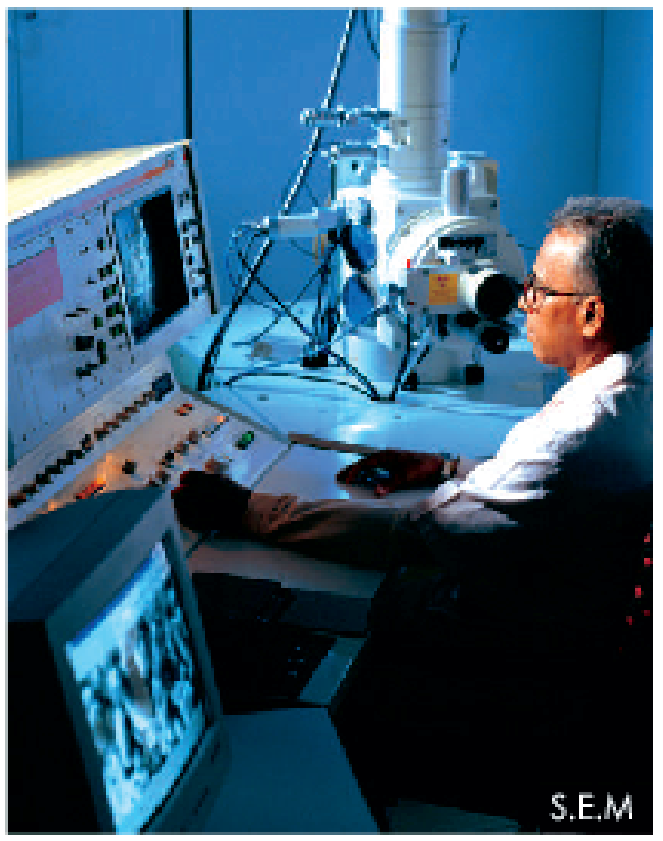
Jyoti Ceramic Industries Pvt. Ltd. was founded in 1970 by late Mr. Shyam Merani, who pioneered manufacturing of industrial ceramics in India. During this journey of over 4 decades, Jyoti Ceramic Industries has garnered rich manufacturing experience and is considered today to be amongst the global leaders in this field.

Our manufacturing plants are of international standards, equipped with the latest-generation machinery and are well supported by state-of-the-art R&D laboratory and engineering workshop. We have developed many proprietary ceramic body formulations viz. Zirconia, Alumina, Cordierite, Frosterite and Steatite. We also manufacture a wide range of technical ceramics used for an extensive range of industrial applications, i.e. Ceramic micro macro milling media for particle size reduction, Wear-resistant lining tiles, Blocks and Coating compounds, L.T. electrical switch and fuse gear components, Heater parts, Lamp parts, Mechanical pump seal rings, Ceramic grinding media and Ball Mill Linings for contamination-free milling of formulations, and Custom ceramic components. Zirconox, Zircosil, Alu-Cera, Duralox, Zircoat and Jyodent are some of our registered leading brands.

We aim to be the first, most preferred and trusted choice for all customers. We shall continue to build lasting relations by delivering to the global market, best in quality yet cost effective solutions and world-class products.

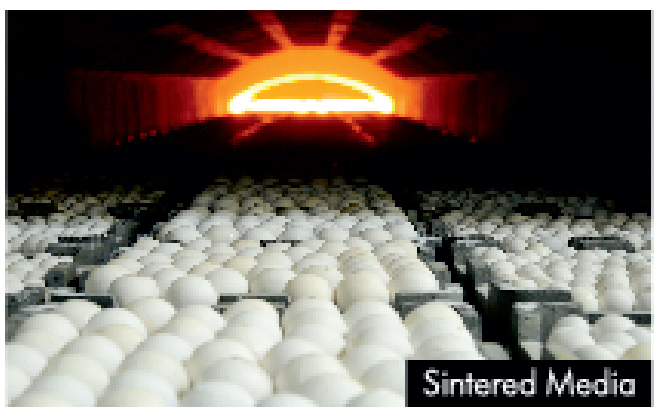

Plant


Micro processor controlled high temp. 1650°C gas fired tunnel Kiln


S.E.M


Press Shop


E.D.X.R.F


Sintered Media

Duralox® is a registered brand name of a specially developed proprietary composite by Jyoti Ceramic from which ball mill lining bricks, wear resistant lining tiles, grinding media and other components are manufactured.

The true value of ball mill lining is determined by its length of trouble free service in relation to the mill's production output, irrespective of mill's type, size and shape. The criteria for selection of lining and grinding material must take into consideration not only the required output and expected service life, but also construction of ball mill, it's drive and motor power before switching over to materials of high density such as Duralox.

Duralox® 92W CERAMIC BALL MILL LINING BRICKS AND GRINDING MEDIA

Duralox 92W mill lining bricks and grinding media have been developed by Jyoti Ceramic after many years of R & D with the intention of enhancing the former's performance. Duralox 92W lining bricks and Duralox 92W grinding media complement each other's performance and best results are obtained when both are used together.

TYPICAL PHYSICAL & CHEMICAL PROPERTIES OF Duralox® 92W CERAMIC:

PHYSICAL PROPERTIES	
Colour	White
Density	3.70 ± 0.05 gms/cc
Bulk Density	2.1 ± 0.05 kgs/lt
Water Absorption	0.00 %
Flexural Strength	250 Mpa
Compressive Strength	2000 Mpa
Hardness on Vicker's Scale	1300 Hv_{10}
Hardness on Moh's Scale	9+
Coefficient of linear thermal expansion (20°C - 1000°C)	7.6 X 10^{-6}/°C
Safe operating temperature	1,400°C
Cum. wear loss / hr after 120 hrs of wear test	0.016%

CHEMICAL PROPERTIES	
OXIDE	%
Al_2O_3	92.30%
SiO_2	2.55%
MgO	2.45%
CaO	2.10%
Na_2O	0.30%
BaO	0.15%
Fe_2O_3	0.05%
TiO_2	0.10%

*Duralox 92W is resistant to all acids and alkalis except Hydrofluoric Acid

VERSATILE INDUSTRIAL APPLICATIONS OF DURALOX 92W GRINDING MEDIA AND MILL LINING:

Ceramic Tile Industry

Grinding of Minerals

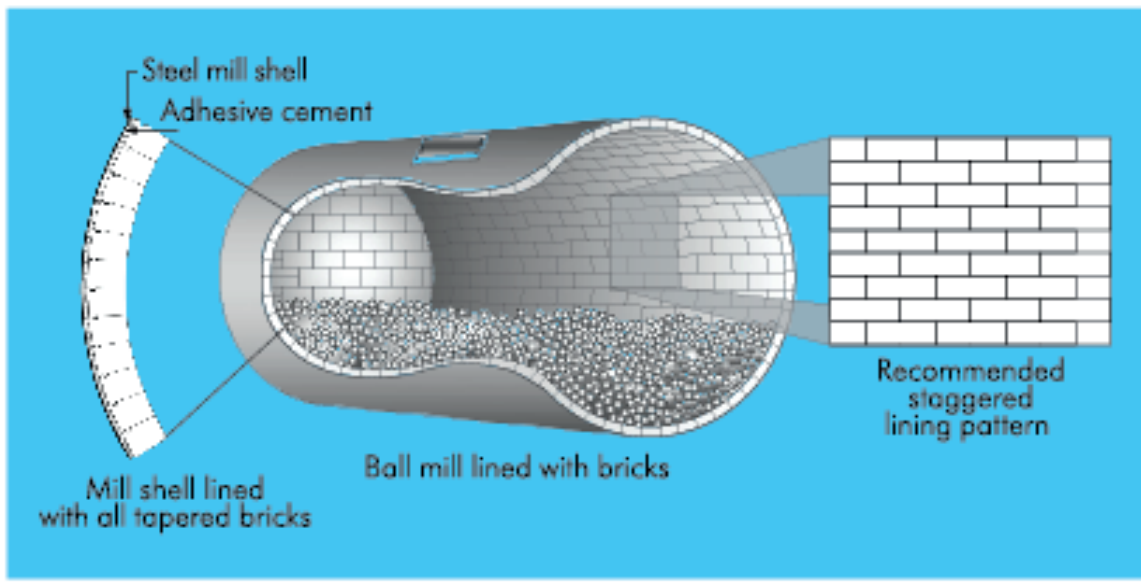
Glass Industry

Cement Industry

Duralox® 92W CERAMIC TAPERED AND FLAT MILL LINING BRICKS

Duralox ceramic mill lining bricks protect the steel ball mill shell and provide high purity grinding. Following features and benefits are worth considering while using Duralox Ball mill linings for milling substances of hardness below 9.0 Moh's Scale:

- Chemically inert and non-reactive to chemicals except Hydrofluoric acid.
- Wear rate of lining is negligible and more constant as compared to traditional ceramic lining materials. With tongue and groove design it produces an interlocking lining pattern, which holds the bricks inseparably.
- Dimensional stability: Duralox ceramic mill lining bricks are uniform and stable in dimensions. With controlled dimensions and sharp edges, requirement of adhesive/cement for fixing and filling of narrow joints is minimum, which prevent bricks from chipping and spalling of their edges.
- Easy to install: installation of Duralox lining in a ball mill can be carried out easily and speedily by any skilled or semiskilled mason under supervision of civil / mechanical engineer.
- Hard and tough, resists high impact, high abrasion and corrosion wear.



- Substantial increase in mill volume due to lesser thickness as compared to traditional stone lining. A strong thin Duralox ceramic lining brick increases the working volume in a mill than thick natural stone lining blocks. A 1800mm dia. x 1800mm L Ball Mill a 50 mm thick Duralox brick lining will increase mill working volume by 30% as compared to the 125 mm thick conventional natural stone lining blocks.
- Duralox mill linings have excellent service life under normal working conditions. Duralox mill linings last about 12-15 times longer than steel, rubber etc. and 25 to 30 times longer than stone and other conventional ceramic lining materials.


Duralox Pre-Engineered Mill Lining bricks

To calculate lining for a cylindrical mill (flanges are lined first and feed door openings are not considered) Formulae to be used are:

1. Straight bricks for flanges

$$N1 = \frac{1.5715 \times D^2}{a1 \times b1}$$

where: N1 = Number of straight bricks a1 = Length of straight brick in cms
b1 = width of straight brick in cms D = Internal dia. of mill in cms

2. Tapered bricks for cylindrical face

$$N2 = \frac{3.143 \times D \times L}{a2 \times b2} \text{ Nos.}$$

where: N2 = Number of tapered bricks a2 = Length of tapered brick in cm
b2 = width of tapered brick in cm D = Internal Dia of the mill in cm
L = Internal length of the mill after lining in cm

Example: To calculate number of bricks required for Dia 6' x 6' Long (Dia. 180cm x 180cm L) cylindrical ball mill (flanges are lined first)

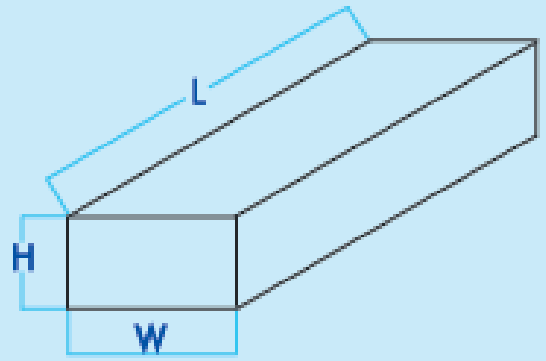
Here a1 = a2 = 150mm = 15cm
b1 = b2 = 50mm = 5cm
D = 180cm L = 170cm

Therefore:-

$$N1 = \frac{1.5715 \times 180 \times 180}{15 \times 5} = 679 \text{ nos.}$$

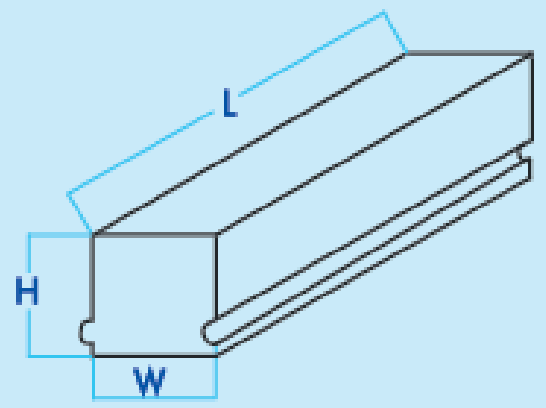
$$N2 = \frac{3.143 \times 180 \times 170}{15 \times 5} = 1283 \text{ nos.}$$

FLAT BRICKS FOR CONTINUOUS TYPE MILLS



Brick Number	Dimensions in mm.			Weight in kgs.
	H	W	L	
ALCM-150-100	50	100	150	2.775
ALCM-75-100	50	100	75	1.387

STRAIGHT BRICKS

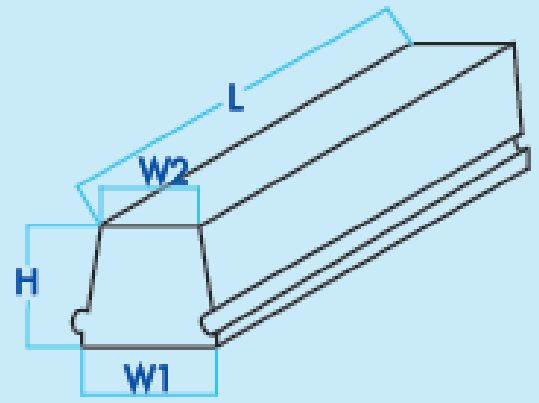


Brick Number	Dimensions in mm.			Weight in kgs.
	H	W	L	
ALF-150-25	25	25	150	0.348
ALF-115-25	25	25	115	0.265
ALF-75-25	25	25	75	0.173
ALF-35-25	25	25	35	0.08
ALF-150-40	40	40	150	0.888
ALF-115-40	40	40	115	0.68
ALF-75-40	40	40	75	0.444
ALF-35-40	40	40	34	0.207
ALF-150-50	50	50	84	1.388
ALF-115-50	50	50	115	1.05
ALF-75-50	50	50	75	0.67
ALF-35-50	50	50	35	0.323
ALF-150-65	65	62	150	2.219
ALF-115-65	65	62	115	1.715
ALF-75-65	65	62	75	1.118
ALF-35-65	65	62	35	0.522
ALF-150-75	75	62	150	2.58
ALF-115-75	75	62	115	1.978
ALF-75-75	75	62	75	1.29
ALF-35-75	75	62	35	0.602

DIMENSION AND WEIGHTS OF STANDARD SIZE MILL LINING BRICKS.

Dimensional tolerances ±0.5mm or 2.0% whichever is greater, Bow allowance maximum 0.5% of length.

TAPERED BRICKS



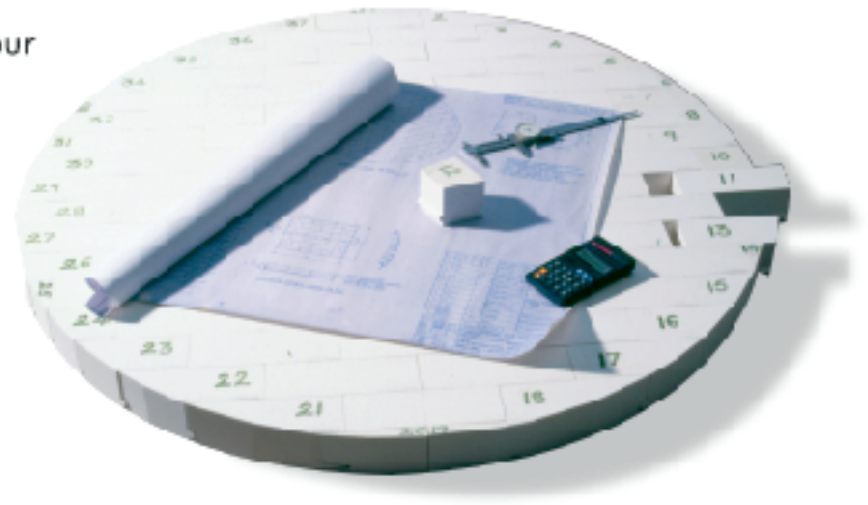
Brick Number	Dimensions in mm.				Weight in kgs.
	H	W1	W2	L	
ALT-150-27	25	32	27	150	0.410
ALT-115-27	25	32	27	115	0.314
ALT-75-27	25	32	27	75	0.204
ALT-35-27	25	32	27	35	0.096
ALT-150-33	40	40	33	150	0.812
ALT-115-33	40	40	33	115	0.621
ALT-75-33	40	40	33	75	0.405
ALT-35-33	40	40	33	35	0.189
ALT-150-50	50	56	50	150	1.448
ALT-115-50	50	56	50	115	1.11
ALT-75-50	50	56	50	75	0.67
ALT-35-50	50	56	50	35	0.343
ALT-150-53	50	56	53	150	1.517
ALT-115-53	50	56	53	115	1.159
ALT-75-53	50	56	53	75	0.74
ALT-35-53	50	56	53	35	0.352
ALT-150-58	65	62	58	150	2.16
ALT-115-58	65	62	58	115	1.66
ALT-75-58	65	62	58	75	1.083
ALT-35-58	65	62	58	35	0.505
ALT-150-57	75	62	57	150	2.48
ALT-115-57	75	62	57	115	1.9
ALT-75-57	75	62	57	75	1.24
ALT-35-57	75	62	57	35	0.59

Duralox® BRICK LINING
INSTALLATION MADE CUSTOMER-FRIENDLY

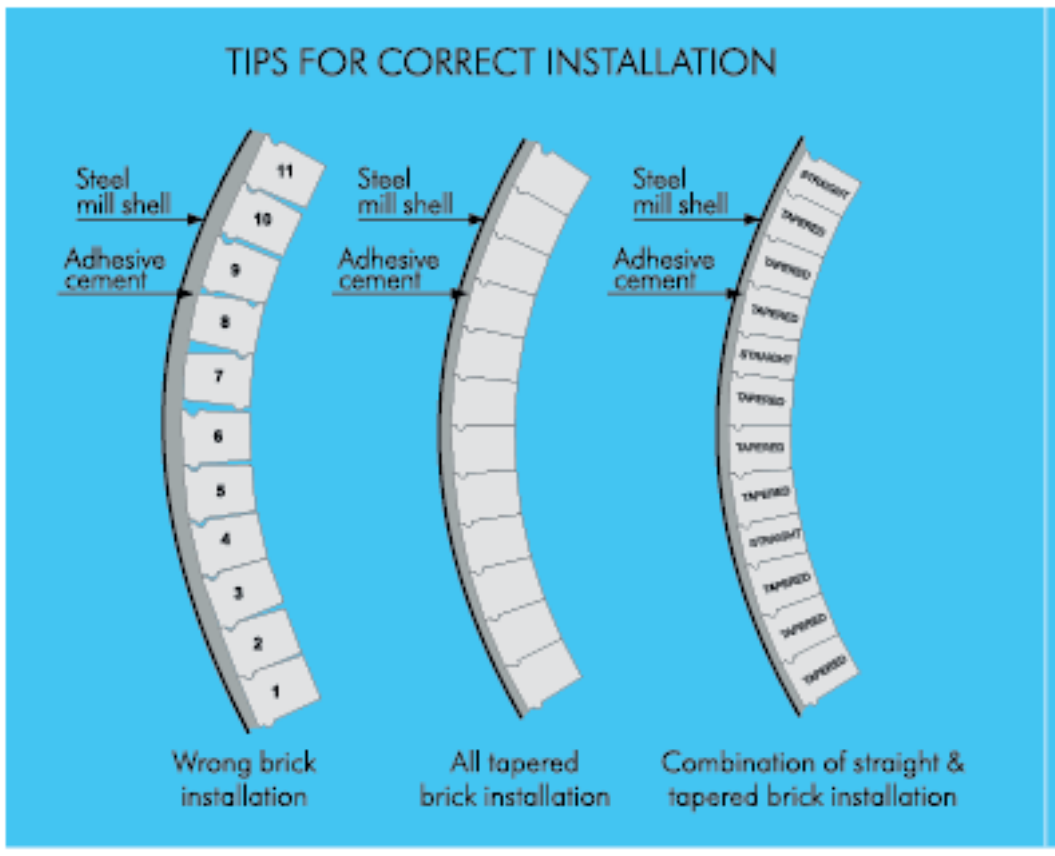
With over 4 decades of manufacturing experience in technical ceramics coupled with modern manufacturing facilities, we at Jyoti Ceramic offer CAD/CAM designed, custom engineered mill lining brick sets, to fit ball mills without requiring any cutting, chipping or grinding of bricks at customers' end. Duralox ceramic lining bricks are sapphire hard and therefore, most difficult to cut, chip, grind to the shape or size after sintering. Our suggestion to our esteemed customers is to select plant engineered lining bricks which are machined as per ball mill dimensions.

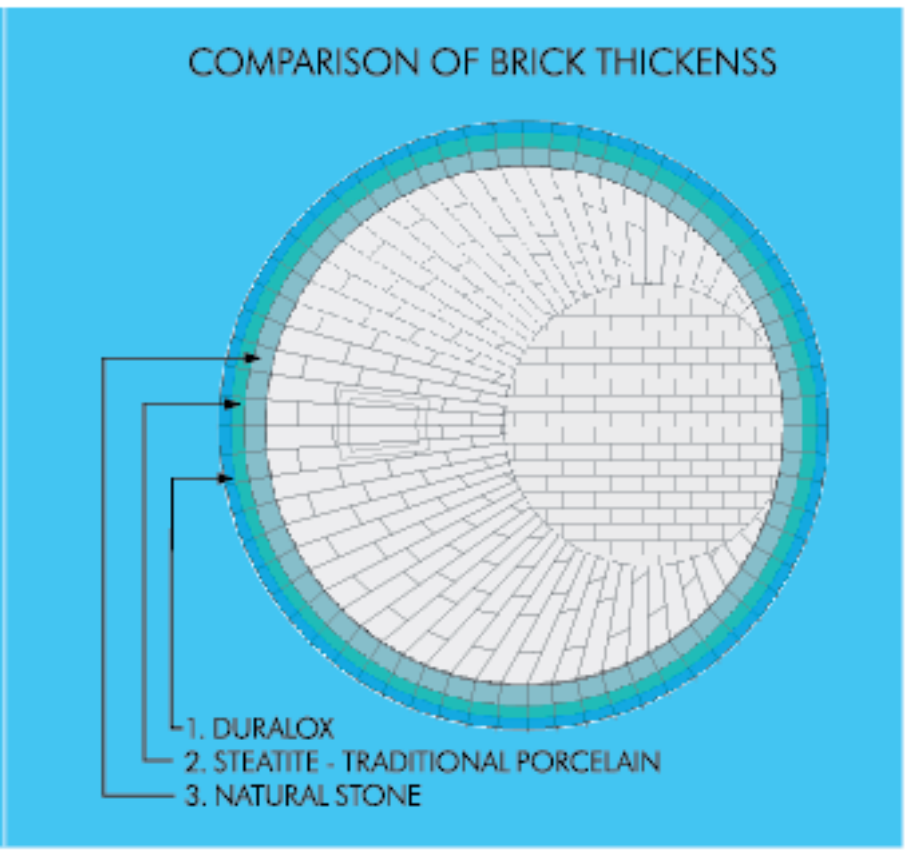
To manufacture pre-engineered mill lining, all our engineers require is a copy of the mill drawing showing precise inner dimensions of the mill shell, door, lid and frame to design the correct size lining bricks for your mills. Duralox 92W lining bricks fit close and tight in the mills as they are match marked in the pre-sintered stage itself, taking into account allowance for shrinkage during sintering. These mill lining bricks come with detailed step-by-step drawing for installation, hence can be easily installed by a skilled or even semi-skilled mason under supervision of a civil/ mechanical engineer by merely referring to the brick installation drawing corresponding to the bricks duly match marked.

CUSTOM DOOR LININGS: Duralox 92W pre-engineered lining bricks fit frames and doors or lip-over design doors and eliminate contamination from both door and steel frame. Each door and frame assembly is custom-designed to ensure longer trouble free service life.



Engineered match marked lining bricks for end flange of mill.





Fixowel-F is a specially formulated epoxy based proprietary adhesive matrix developed by Jyoti Ceramic for fixing alumina ceramic mill lining bricks, wear resistant tiles etc. to a metal surface or ceramic surface. Fixowel adhesive cures within 24 hours at ambient temperature in natural atmosphere and the mill can be put into operation within 26 - 28 hours after installation of lining bricks. Duralox bricks with tongue and groove design, when fixed with Fixowel adhesive, ensure the highest stability and long lasting service life of mill lining.

Duralox® 92W
CERAMIC GRINDING MEDIA

Duralox ceramic grinding media and ball mill lining bricks are manufactured from the same fine grained composite and have proven to be ideal partners for high performance, since they retain their shape better and last longer than flint / river pebbles, natural stones, porcelain, steatite, etc.

ADVANTAGES OF Duralox® 92W CERAMIC GRINDING MEDIA

1. Higher Density hardness and sphericity - As compared to flint river pebbles, natural stones and Steatite. Due to their higher density, hardness, toughness and higher degree of sphericity, Duralox ceramic grinding media save over 35% milling time.

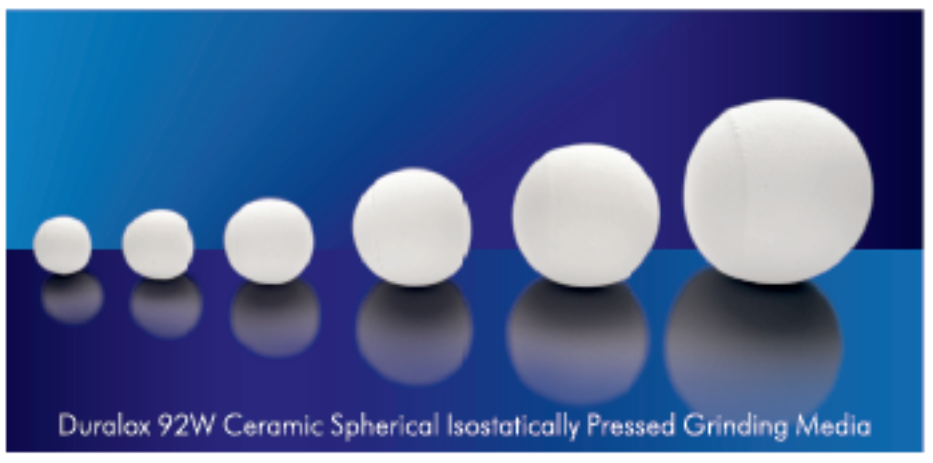
2. Easy to use - Duralox grinding media are fully vitrified, non-porous and smooth as compared to other materials.

3. Longer milling life - As Duralox grinding media has dense, homogeneous internal microstructure, it offers superior wear resistance as compared to other conventional media.

4. Wide range of sizes - Duralox spherical isostatically pressed grinding media are available in 6 assorted sizes from Ø 20mm to Ø 60mm to fulfill most demanding applications for dispersion and particle size reduction. Duralox cylinders with radius corners are available in 8 assorted sizes from Ø 6mm to Ø 30x30mm length.

5. Uniform quality - Duralox grinding media are manufactured in the most modern plant under stringent quality control checks at various stages to ensure that the final product is consistently of highest quality level.

TYPES OF DURALOX GRINDING MEDIA



Duralox 92W Ceramic Spherical Isostatically Pressed Grinding Media

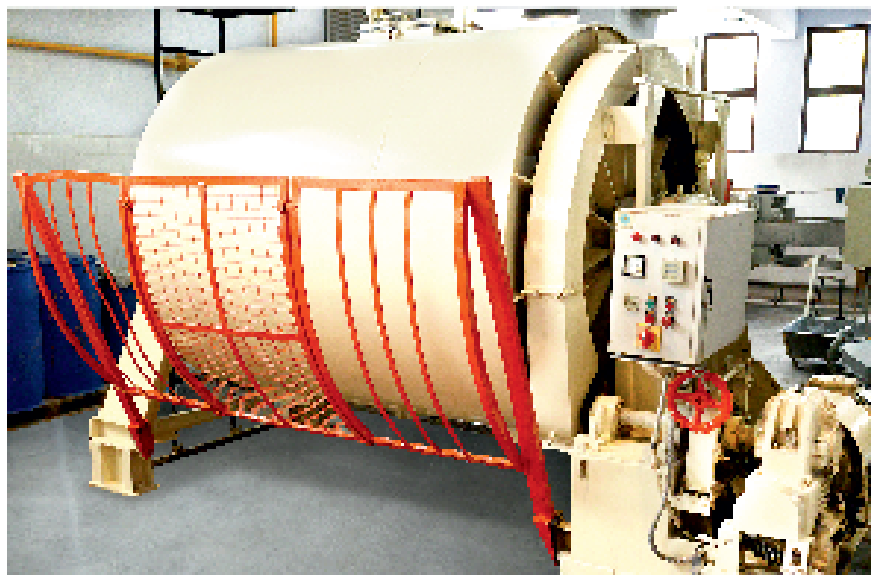
Duralox 92W Ceramic Cylindrical Grinding Media

Duralox 92W Ceramic Spherical & Cylindrical Grinding Media for various types of mills.

BALL MILLS: are most commonly used mills to accomplish particle size reduction. A revolving vessel, the 'drum', lined with ceramic bricks, contains the grinding media and the raw material to be ground.

BALL MILLS ARE CLASSIFIED INTO:

BATCH TYPE AND CONTINUOUS TYPE - Batch Type Ball Mills are versatile and most widely used. Particle size reduction takes place by impact over the material with the tumbling grinding media and by abrasion between the media and the mill wall.



Selection of Grinding Media:

For fresh charges it is most general practice to use three different ball sizes. 25% of large size, 50% of medium size and 25% of small size. There might be cases where using 2 to 4 different sizes of grinding balls may be necessary. This will require change in the proportions for each size used. For topping of mill, we suggest selection of the largest dia balls.

Recommended charge of material to be ground and Grinding Media :

Charge of material to be ground : There are no hard and fast rules about charging of mills; some general rules are adopted from experiences of operators which helps in achieving the optimum milling efficiency at economical cost.

In most cases the quality of material to be ground should be 25% - 35% of the mills useful volume. Non-observance of these limits can lead to high wear rate of grinding media and the mill lining or to a considerably longer grinding time.

Recommended quality of Grinding Media:

To obtain the optimum grinding efficiency, we recommend:

1) For batch type mill: Grinding media should fill 55% of the mill's useful volume.

2) For continuous type mill: Grinding media should fill 35% of mill's useful volume.

To calculate media charge for cylindrical mill, the formulae are given as below:

1. For batch type ball mill:

$M = 0.000929 \times D^2 \times L$

where: M = Weight of the grinding media charge in Kgs.
D = Mill internal dia in cms after lining.
L = Internal length of the mill in cms after lining.

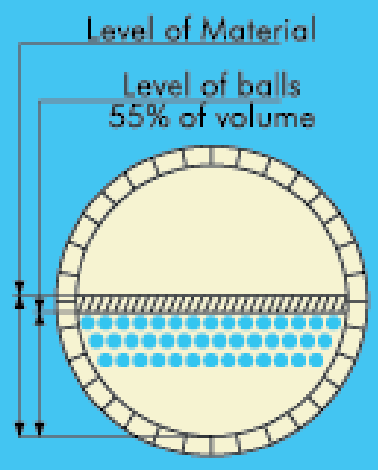
Example: To calculate grinding media charge for a Duralox brick lined batch type mill size: Dia. 6' x 6' Long (Dia. 180cms x 180cms L) (Mill openings are not considered).

Thickness of tapered bricks = 5.0cms.
Thickness of straight bricks = 5.0cms.
Therefore D = 180 – 10 = 170cms.
L = 180 – 10 = 170cms.
M = 0.000929 x (170)2 x 170.0

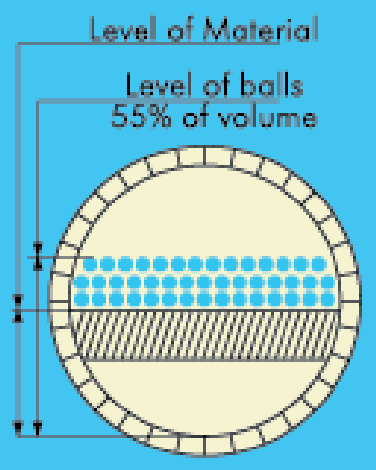
Grinding media quantity = 4564kgs

2. For continuous type ball mill:

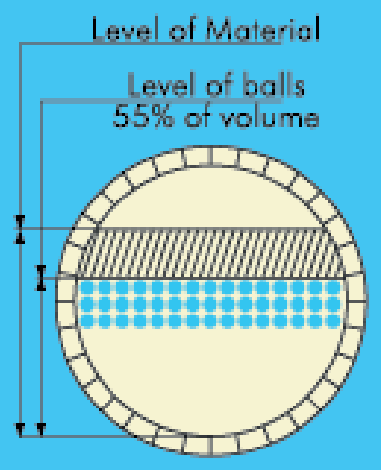
$M = 0.000503 \times D^2 \times L$



CORRECT



INCORRECT
Excess quantity balls result in high wear rate of lining.



INCORRECT
Excess quantity balls result in longer milling time.

Recommended suitable Duralox mill lining thickness, media quantity, media sizes, and mill rotating speed for cylindrical batch type ball mills of the same dia. x same length

Mill I.D. mm	Mill I.D. inch	Lining thickness (mm)	Usable volume of Mill (ltr)	Media quantity @ 55% vol (kgs)	Media size & quantity	Speed (rpm)
300	12	25	12.30	14	100 % Ø 20 mm	46-47
450	18	25	50.31	60	100 % Ø 20 mm	37-38
600	24	25	130.70	155	100 % Ø 25 mm	32-33
750	30	25	269.50	320	50% Ø 20 mm + 50% Ø 25 mm	30-31
900	36	40	433.20	512	25% Ø 25 mm + 50% Ø 30 mm & 25 % Ø 40 mm	27-28
1050	42	40	717.10	848	25% Ø 25 mm + 50% Ø 30 mm & 25 % Ø 40 mm	25-26
1200	48	40	1103.90	1305	25% Ø 25 mm + 50% Ø 30 mm & 25 % Ø 40 mm	23-24
1350	54	50	1534.70	1815	25% Ø 30 mm + 50% Ø 40 mm & 25 % Ø 50 mm	21-22
1500	60	50	2156	2550	25% Ø 30 mm + 50% Ø 40 mm & 25 % Ø 50 mm	20-21
1800	72	50	3860.40	4564.	25% Ø 30 mm + 50% Ø 40 mm & 25 % Ø 50 mm	18-19
2100	84	65	6007.40	7103	25% Ø 40 mm + 50% Ø 50 mm & 25 % Ø 60 mm	16-17
2400	96	65	9191	10868	25% Ø 40 mm + 50% Ø 50 mm & 25 % Ø 60 mm	15-16
2700	108	65	13337	15772	25% Ø 40 mm + 50% Ø 50 mm & 25 % Ø 60 mm	14-15
3000	120	75	18189	21508	25% Ø 40 mm + 50% Ø 50 mm & 25 % Ø 60 mm	13-14
3600	144	75	32265	38154	25% Ø 40 mm + 50% Ø 50 mm & 25 % Ø 60 mm	12-13

* Media charge @ 50% to 55%, material charge @ 30% to 45%, liquid to adjust the solid content @ 50% to 70% of the material charge.

Recommended mill rotation speed:

Mill rotating speed is an important parameter for optimizing grinding efficiency:

1) Using proper speed has a cascading effect where the charge and grinding balls roll over one another, thus developing maximum milling action with minimum wear of grinding media and lining.

2) If the ball mill rotates at an excessive speed there will be centrifugal effect and no particles size reduction will take place.

3) If the speed is too slow it result in purring effect where the charge is lifted to a small angle and balls tend to slide back on the lining hence the grinding action is poor.

Calculations for mill motor power,& mill speed:

Considering the weight of mill lining and grinding media, work out the motor power required, in consultation with the mill manufacturer.

To calculate the motor power required for a cylindrical type ball mill, the following formula can be applied:

$$W = 0.04116 \times D^3 \times L \times n \times (0.6d + 0.4d1)$$

where: W = Required motor power in HP
D = Internal dia. of the mill in mtrs.
L = Internal Length of the mill in mtrs.
d = Specific gravity of grinding media
d1 = Specific gravity of substance
n = Speed of ball mill in rpm.

Example: Let the internal dia. of the mill be 1.8mtrs. and internal length be 1.8mtrs. If Duralox grinding media is used density d = 3.7gms/cc If milling substance is alumina in slurry form with around 70% solids
then d1 = 1.8

d = 3.7 and d1 = 1.8 then

$$W = 0.04116 \times (1.8)^3 \times 1.8 \times 19 \times (0.6 \times 3.7 + 0.4 \times 1.8) = 24.13 \text{ HP}$$

To calculate the speed of the mill use the following formula:

$$Nc = \frac{76.6}{\sqrt{D}}$$

where: Nc = Critical speed
D = Internal dia. in ft.

Actual speed of the mill should be approximately 62% of the Nc for wet milling and 75% of Nc for dry milling.

CORRECT
Operational speed
Cascade effect Efficient grinding

INCORRECT
Excessive speed
Centrifugation No grinding

INCORRECT
Very low speed
Purring fall No grinding

Table indicating the optimum mill speed and motor power of ball mill:

Inside dia. (mm)	Inside length (mm)	Dry grinding with Duralox Media		Dry grinding with Duralox Media	
		Speed (RPM)	Motor Power (HP)	Speed (RPM)	Motor Power (HP)
300	300	54	1/2	38	1/2
450	450	44	1/2	31	1/2
600	600	38	1	27	1
750	750	34	1½	24	1½
900	900	31	3	22	3
1050	1050	29	5	20	5.0
1200	1200	27	7½	19	7.5
1350	1350	25	15	18	12.5
1500	1500	24	15	17	15
1800	1800	22	30	16	25
2100	2100	20	40	15	40
2400	2400	19	75	14	50
2700	2700	18	100	13	100
3000	3000	17	150	12	125

JAR MILL:

Particle size reduction takes place by impact over the material with the tumbling grinding media and by abrasion between the media and the mill wall. It works on the same principle as batch type ball mill.

Recommended grinding media:
Balls of Ø 12.5mm to 20mm

VIBRO MILLS:

Find their cheap advantage in fine grinding by producing particle size less than 1 micron and finer. The high impact of conventional ball mills is not needed in vibro mills. Instead a large number of low energy impacts are necessary using small grinding media with high vibration or rotation rate.

Recommended grinding media:
Cylinders, size Ø 6.0mm to Ø 20.0mm

Recommended media charge:
60 - 70% of mill's useful volume

Calculation of Media Load:

Example:

Vibro mill net volume is 350 ltr charging with Ø 12.5 mm cylinders.

60% of mill's vol = 210 ltr x 2.1 Kgs/ltr
(Bulk density of Duralox media)

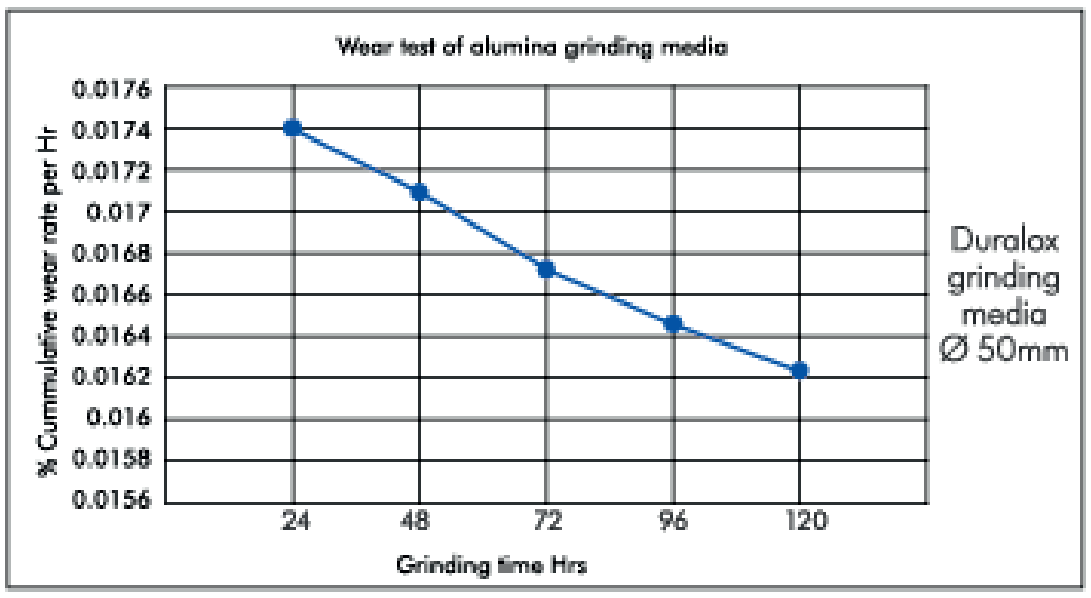
That is 441 Kgs of Duralox grinding media required for 350 ltr capacity Vibro mill.

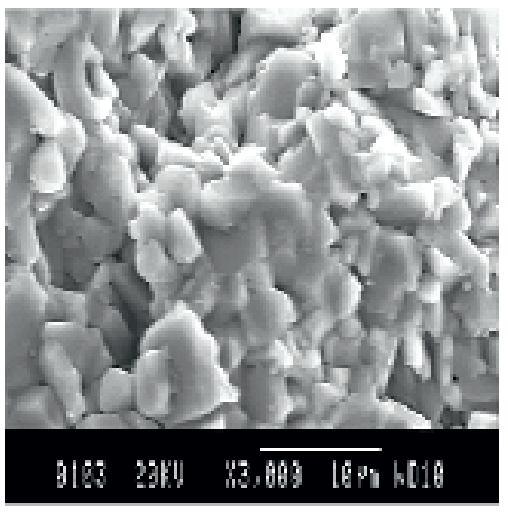
Wear Rate Test Procedure

Jar	20 ltr. capacity rubber lined
Speed	55 rpm.
Grinding media charge	**Duralox 92W** grinding media Ø 50 mm
Material charge	5 kg. Silica sand of 0.3 mm size. Quantity: 2784.36 gms
Water	5 ltrs.

% Cum wear loss/hr after 120hrs of wear: 0.01624

Grinding media is weighed on Electronic Balance of 10mg resolution, loaded into the jar mill along with silica sand and water, then milled for 24 hrs. After milling grinding media is unloaded, washed, dried thoroughly and weighed again. Weight loss percentage per hour is calculated. This process is repeated every 24 hours for a total of 120 hours. Graph of wear rate versus time is drawn. It is inferred from the graph that the wear rate reduces with time up to around 0.01624% per hour for Duralox grinding media and then remains almost constant.





S.E.M micrographs of Duralox Grinding Media

Mode of Packaging:

Ceramic Macro grinding media are packed in strong double lined HDPE plastic bags.

Each bag contains grinding media of net weight 25kgs / 50kgs.

For exports such 40 bags = 1000kgs are repacked in strong sea-worthy wooden pallet type crates.

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