Facts & Figures

KPI-JCI ASTEC COMPANIES

ASTEC MOBILE SCREENS

Kolberg-Pioneer, Inc.

Johnson Crushers Intranational, Inc.

Astec Mobile Screens, Inc.

Kolberg-Pioneer, Inc. (KPI), Johnson Crushers International, Inc. (JCI) and Astec Mobile Screens, Inc. have led the way as manufacturers for the aggregate, mining, industrial, construction and recycling industries for over 90 years. As part of Astec Industries, we set ourselves apart by designing, manufacturing and selling the most innovative, productive, reliable and safe equipment for the industries we serve, coupled with unparalleled customer service. We take pride in knowing our products provide unmatched, comprehensive solutions. We are pleased to offer a complete line of crushing, screening, conveying, washing and classifying, and track equipment ideal for a diverse range of applications.

SIXTH EDITION

Aggregate production is based on mathematical relationships, volumes, lengths, widths, heights and speeds. Because of widely-varying field conditions and characteristics of material processed, information herein relating to machine capacities and gradations produced are estimates only. Much of this data of special interest to producers and their employees has been included in this valuable booklet. We at KPI-JCI and Astec Mobile Screens hope you find this resource a valuable tool in your organization and operations.

KPI-JCI ASTEC COMPANIES ASTEC MOBILE SCREENS

RELATIVE WORLD PRODUCTION BY VALUE

Sand and gravel, and crushed stone, are the number one and two ranked mineral resources (exclusive of energy resources) worldwide in terms of both amount and value.

Courtesy of USGS

Modified after Lawatscheck, 1990

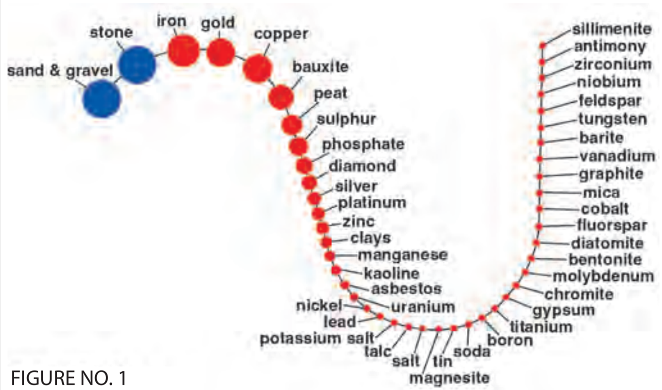


FIGURE NO. 1

INDEX

NOTES:

GENERAL INFORMATION ON THE AGGREGATE INDUSTRY

Modern civilization is based on the use of inert minerals for concrete and asphaltic products. Aggregate production is the largest single extractive industry in the United States, with more than 2.8 billion tons of sand, gravel and crushed rock are produced annually. Because aggregates play such a vital role in the continuing growth of the nation and the world, demand for all types can be expected to increase substantially in the years ahead.

The earth sciences tell us a compelling story of the evolution of the earth's mantle and its minerals, which man has found so valuable to the civilizing processes on his planet. Since the earliest Ice Age, erosion of the continental rock by earth, wind, rain and fire has resulted in fractions being carried down the mountains by wind and water, the grains settling in an almost natural grading process. Other natural events such as floods and upheavals caused rivers and streams to change courses, burying river beds that have become high production sand and gravel operations in our time. Evaporation, condensation, precipitation and chemical actions, percolation and fusions have formed other rock materials that have become valuable aggregates in modern times. Advancements in geology and technology aid the industry in its progress to greater knowledge about these building blocks of all ages and civilizations.

Locating these minerals has become much easier, too—and just in time, as recently the nation has acknowledged the state of neglect of hundreds of thousands of miles of state and county roads. The massive interstate program has dominated the expenditure of roadbuilding funds at the expense of these rural highways, so that today there are vast amounts of repair, reclamation and replacement of roads to be done. And, of course, locating nearby sources of roadbed materials wherever possible will affect the economy of construction, and in some cases, even the kind of construction as well.

Rapid field investigations for possible sources of minerals have been made very simple and relatively inexpensive by the use of portable seismic instruments and earth resistivity meters. The latter are especially effective in locating sand, gravel and ground water by measuring the inherent electrical characteristics of each. Briefly, an alternating current is applied across electrodes implanted at known spacings in the surface soil; the potential drop of the current between the electrodes indicates whether the subsurface geology includes any high-resistance areas, indicating sand, gravel or water. Another tool, the portable seismic instrument, is used to measure the velocity of energy transmitted into the earth as deep as 1,000 feet. The velocity of the energy waves travels through the subsurface geologic structure to indicates the density or hardness of each layer or strata. For example, the velocity of topsoil may be 3,000 feet-per-second, while limestone, granite and other potentially useful inert materials may have velocities beyond 12,000 feet-per-second. Thus, where the occurrence of aggregate material is not always convenient to the shortest haul routes or major population centers, locating and utilizing them have benefitted greatly by modern technology.

CLASSES OF AGGREGATES

There are two main classes of aggregates.

1. **Natural aggregates,** in which forces of nature have produced formations of sand and gravel deposits, may include silts, clays or other foreign materials that can be difficult to reject. Further, gradations may be quite different than those required for commercial sales. To meet such requirements, it becomes necessary to process or beneficiate natural aggregate deposits.
2. **Manufactured aggregates** are obtained from deposits or ledges of sedimentary rock (formed by sediments) or from masses of igneous rock (formed by volcanic action or intense heat). These are blasted, ripped or excavated and then crushed and ground to specified gradations. These deposits, too, may include undesirable materials such as shales, slates or bodies of metamorphic or igneous rock. Such deleterious materials must be removed in the processing operations.

PROCESSING OF AGGREGATES

Much of the equipment used in the processing of raw aggregates has been adapted from other mineral processing techniques and modified to meet the specific requirements of the crushed stone, sand and gravel industry. Other types of equipment have been introduced to improve efficiency and final product. The equipment is classified in four groups.

1. Reduction equipment: jaw, cone, roll, gyratory, impact crushers and mills; these reduce materials to required sizes or fractions
2. Sizing equipment: vibratory and grizzly screens to separate the fractions in varying sizes
3. Dewatering equipment: sand sorters, log washers, sand and aggregate preparation and fine and coarse material washers
4. Sorting equipment: various kinds of feeder traps and conveyor arrangements to transfer, stockpile or hold processed aggregates

As to method, there are two types of operations at most sand and gravel pits and quarry operations. They include:

1. Dry process: material is excavated by machines or blasted loose and is hauled to a processing plant without the use of water
2. Wet process: involves pumping (dredge pumps) or excavation (draglines) of the aggregate material from a pit filled with water, material enters the processing operation with varying quantities of water

The ideal gradation is seldom, if ever, met in naturally occurring sand or gravel. Yet the quality and control of these gradations is absolutely essential to the workability and durability of the end use.

The aggregate has three principal functions:

1. To provide a relatively cheap filler for cementing or asphaltic materials
2. To provide a mass of particles that will resist the action of applied loads, abrasion, percolation of moisture and water
3. To reduce the volume changes resulting from the setting and hardening process and from moisture changes

The influence of the aggregate on the resulting product depends on the following characteristics:

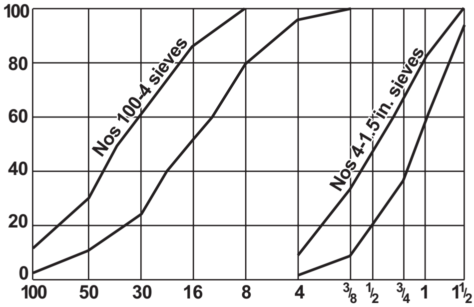
1. The mineral character of the aggregate as related to strength, elasticity and durability
2. The surface characteristics of the particles, particularly as related to workability and bonding within a hardened mass
3. Aggregate with rough surfaces or angular shapes does not place or flow as easily into the forms as smooth or rounded grains
4. The gradation of the aggregates, particularly as related to the workability, density and economy of the mix

Of these characteristics, the first two are self-explanatory and inherent to a particular deposit. In some cases, an aggregate can be upgraded to an acceptable product by removing unsound or deleterious material, using benefication processes.

Gradation, however, is a characteristic that can be changed or improved with simple processes and is the usual objective of aggregate preparation plants.

SIEVE ANALYSIS ENVELOPE

Percent passing by weight



Standard sizes of square-mesh sieves
Curves indicate the limits specified in ASTM for fine and coarse aggregate
FIGURE NO. 2

EXAMPLE OF ALLOWABLE GRADATION ZONE IMPORTANCE OF GRADATION—CONCRETE

To improve workability of concrete, either the amount of water or the amount of fine particles must be increased. Since the water-to-cement ratio is governed by the strength required in the final cured concrete, any increase in the amount of water would increase the amount of cement in the mix. Since cement costs are much greater than aggregate, it is evident that varying the gradation is more economical. Most of the formula used for proportioning the components of the concrete have been worked out as the results of actual experimentation. They are based on two fundamentals.

1. To obtain a sound concrete, all voids must be filled either with fine aggregates or cement paste
2. To obtain a sound concrete, the surface of each aggregate particle should be covered with cement paste

An ideal mix is a balance between saving on cement paste by using fine aggregates to fill the voids, and the added paste required to cover the surfaces of these additional aggregate particles.

ACTUAL GRADATION

The ideal gradation is seldom, if ever, met in naturally-occurring sand or gravel. The quality of the gradation of the aggregate, the workability of the concrete, cement and asphalt requirements must be balanced to achieve strength and other qualities desired, at minimum total cost.

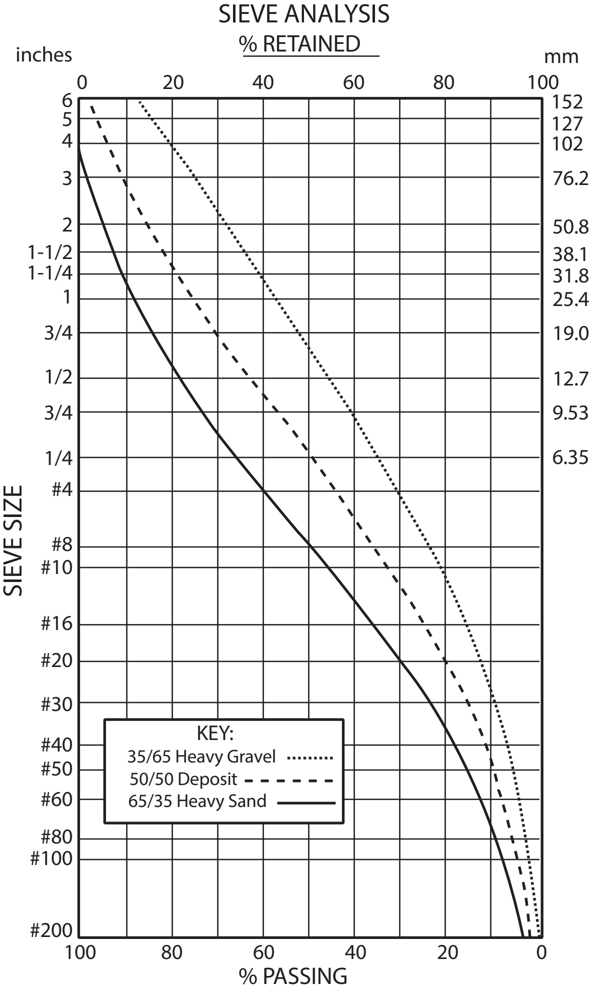
Sizing of material larger than No. 8 sieve is best and most economically done by the use of mechanical screens of various types, either dry or wet. In actual practice, however, the division between coarse aggregates, which require different equipment for sizing, is set at No. 4 sieve (Figure 3).

Sieve No.	Percent Weight Retained			
	Allowable		Sample Tested	
	Cumulative		Individual	Cumulative
	Min.	Max.		
⅜″	0	0	0	0
4	0	10	4	4
8	10	35	11	15
16	30	55	27	42
30	55	75	28	70
50	80	90	18	88
100	92	98	8	96
Pan	100	100	4	100

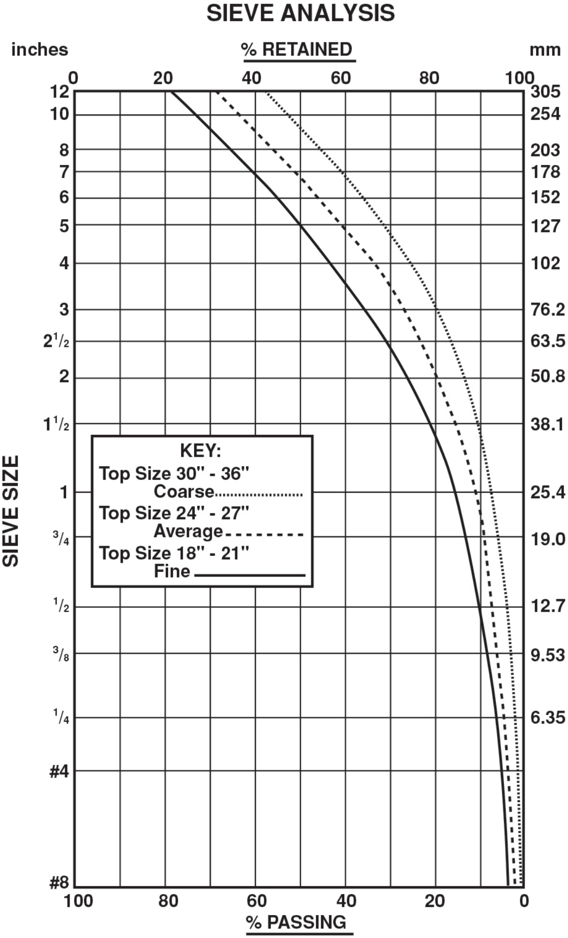
FIGURE 3

Tables have been published to facilitate these calculations, and are based on the maximum size of the coarse aggregate, which can be used for the specific type of construction planned.

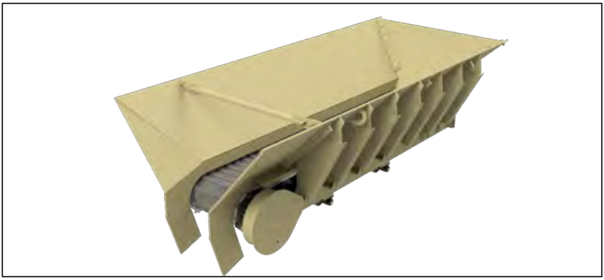
TYPICAL GRADATION CURVES FOR GRAVEL DEPOSITS



TYPICAL GRADATION CURVES FOR LIMESTONE QUARRY RUN



APRON FEEDERS



Particularly suited for wet, sticky materials, the Apron Feeder provides positive feed action while reducing material slippage. Feeder construction includes heavy-duty and extra-heavy-duty designs, depending upon the application.

STANDARD HOPPER APPROXIMATE CAPACITIES—APRON FEEDERS

	6ft	1.83m	8ft	2.44m	10ft	3.05m	12ft	3.66m	14ft	4.27
Width	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3
30" (762 mm) Apron Feeder w/o Extension	2.1	1.6	3.2	2.4	4.3	3.3	5.4	4.1	-	-
30" (762 mm) Apron Feeder w/ Extension	3.3	2.5	5.8	4.4	8.3	6.4	10.8	8.2	-	-
36" (914 mm) Apron Feeder w/o Extension	2.4	1.8	3.6	2.8	4.8	3.7	6.0	4.6	7.2	5.5
36" (914 mm) Apron Feeder w/ Extension	3.6	2.8	6.3	4.8	9.0	6.9	11.7	8.9	14.5	11.1
42" (1067 mm) Apron Feeder w/o Extension	2.6	2.0	3.9	3.0	5.3	4.0	6.6	5.0	7.9	6.0
42" (1,067 mm) Apron Feeder w/ Extension	3.9	3.0	6.8	5.2	9.7	7.4	12.6	9.6	15.6	11.8
48" (1,219 mm) Apron Feeder w/o Extension	-	-	4.4	3.4	5.8	4.4	7.3	5.6	8.8	6.7
48" (1,219 mm) Apron Feeder w/ Extension	-	-	7.4	5.6	10.5	8.0	13.6	10.4	16.7	12.8

RECIPROCATING PLATE FEEDERS

Model Number	Size		Type of Service	Approx. Capacity* at 60 RPM	Hopper Size		Hopper Capacity		Weight (with Hopper)	
	in	mm			ft^2	m^2	yd^3	m^3		
25 RP	24	610	Standard	100-200 TPH (90.7 - 181 mt/h)	6	1.83	1.7	1.3	2,050lbs	931kg
31 RP	30	762	Standard	150-300 TPH (136-272 (mt/h)	6	1.83	1.7	1.3	2,165lbs	983kg
30 RP	30	762	Heavy Duty	150-300 TPH (136-272 mt/h)	6	1.83	1.7	1.3	2,550lbs	1,158kg
37 RP	36	914	Standard	215-430 TPH (195-390 mt/h)	7	2.14	2.6	1.99	3,175lbs	1,441kg
36 RP	36	914	Heavy Duty	215-430 TPH (195-390 mt/h)	7	2.14	2.6	1.99	3,950lbs	1,793kg
42 RP	42	1,067	Heavy Duty	300-600 TPH (272-544 mt/h)	7	2.14	2.6	1.99	4,710lbs	2,136kg

NOTE: *Range varies depending on the application.

APPROXIMATE PER HOUR CAPACITIES OF APRON FEEDERS ACCORDING TO WIDTH

Pan Travel (ft per min)	30″ Wide		36″ Wide		42″ Wide		48″ Wide		60″ Wide		72″ Wide	
	yds^3	Tons	yds^3	Tons	yds^3	Tons	yds^3	Tons	yds^3	Tons	yds^3	Tons
10	55	74	80	108	109	147	143	192	222	300	320	432
15	83	112	120	162	164	222	214	289	333	450	480	648
20	110	148	160	216	218	294	284	384	444	600	650	864
25	138	186	200	270	273	369	357	482	555	750	800	1,080
30	165	223	240	324	327	442	427	577	667	900	960	1,296
35	193	260	280	378	382	516	500	673	778	1,050	1,120	1,,512
40	220	296	320	432	436	588	572	768	888	1,200	1,280	1728

NOTE: Considerable variance will always be encountered when calculating the capacities of feeders. Usually, experience is the best guide to what a feeder will handle under given conditions of material, rate of travel of the feeder pans, and depth of loading. The table above is based on a depth of material equal to half the feeder width, and tons are based on material weighing 2,700 pounds per cu. yd. A feeding factor of .8 has been introduced to compensate for voids, resistance to flow, etc. This factor, too, will vary with the type of material and its condition when fed.

The following formula can be used to calculate the approximate capacity in cubic yards of a feeder of given width where the feeding factor is determined to be other than .8:

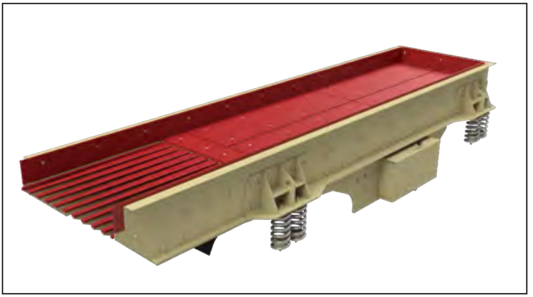
Cu. Yds per Hr. = 2.22 (d x w x s x f); where

d = depth of load on feeder, in feet: s = rate of pan travel, in feet per minute;
w = width of feeder, in feet; f = feeding factor.

To convert cu. yds. to tons; multiply cu. yds. by 1.35.

Pan Travel (meters per minute)	.762m Wide		.914m Wide		1.07m Wide		1.22m Wide		1.52m Wide		1.83m Wide	
	m^3	mt	m^3	mt	m^3	mt	m^3	mt	m^3	mt	m^3	mt
3.05	42	67	61	98	83	133	109	174	170	272	245	392
4.57	63	102	92	147	125	201	164	262	254	408	367	588
6.10	84	134	122	196	167	267	217	348	339	544	489	784
7.62	105	169	153	245	209	335	273	437	424	680	611	908
9.14	126	202	183	293	250	401	326	523	510	816	734	1,176
10.67	147	236	214	343	292	468	382	610	594	953	856	1,372
12.19	168	269	245	392	333	533	437	697	679	1089	978	1,568

VIBRATING FEEDERS



Designed to convey material while separating fines, Vibrating Feeders provide smooth, controlled feed rates to maximize capacity. Grizzly bars are tapered to self-relieve with adjustable spacing for bypass sizing. Feeder construction includes heavy-duty deck plate with optional AR plate liners. Heavy-duty spring suspension withstands loading impact and assists vibration.

VIBRATING FEEDERS—APPROXIMATE CAPACITY*

	30″ (.76m) Wide		36″ (.91m) Wide		42″ (1.07m) Wide		50″ (1.27m) Wide		60″ (1.5m) Wide	
RPM	tph	mtph	tph	mtph	tph	mtph	tph	mtph	tph	mtph
600									828	754
650							623	568	898	818
700			315	287	473	431	671	611	967	881
750	270	246	337	307	507	462	720	656	1,035	943
800	290	264	360	328	541	493	767	698		
850	305	278	382	348	575	524				
900	325	296	404	368	609	555				
950	345	314	427	389	642	585				
1,000	365	332								

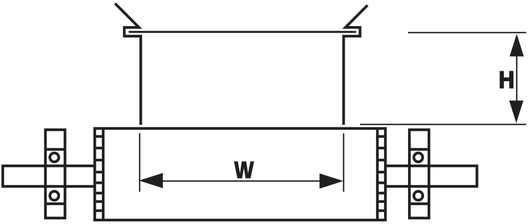
CAPACITY MULTIPLIERS FOR VARIOUS FEEDER PAN MOUNTING ANGLES FROM 0° TO 10° DOWN HILL—ALL VIBRATING FEEDERS

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

NOTE: *Capacity can vary ±25% for average quarry installations—capacity will usually be greater for dry or clean gravel. Capacity will be affected by the methods of loading, characteristics and gradation of material handled, and other factors.

(4° and more consult with Factory)

BELT FEEDER CAPACITY (TPH)



	H (in)	Belt Speed feet per minute					
		10	20	30	40	50	60
24" BELT FEEDER (W = 18")	8	30	60	90	120	150	180
	9	34	68	101	135	169	203
	10	38	75	113	150	188	225
	11	41	83	124	168	206	248
	12	45	90	135	180	225	270
	13	49	98	146	195	244	293
	14	53	105	158	210	262	315
30" BELT FEEDER (W = 24")	8	40	80	120	160	200	240
	9	45	90	135	180	225	270
	10	50	100	150	200	250	300
	11	55	110	165	220	275	330
	12	60	120	180	240	300	360
	13	65	130	195	260	325	390
	14	70	140	210	280	350	420
36" BELT FEEDER (W = 30")	8	50	100	150	200	250	300
	9	56	113	169	225	281	338
	10	62	125	187	250	312	375
	11	69	137	206	275	344	412
	12	75	150	225	300	375	450
	13	81	162	244	325	406	487
	14	87	175	262	350	437	525
42" BELT FEEDER (W = 36")	8	60	120	180	240	300	360
	9	68	135	203	270	338	405
	10	75	150	225	300	375	450
	11	83	165	248	330	413	495
	12	90	180	270	360	450	540
	13	98	195	293	390	488	585
	14	105	210	315	420	525	630

NOTE: Capacities based on 100 lb./cu. ft. material

$$TPH = \frac{3 \times H\ (in.) \times W\ (in.) \times FPM}{144}$$

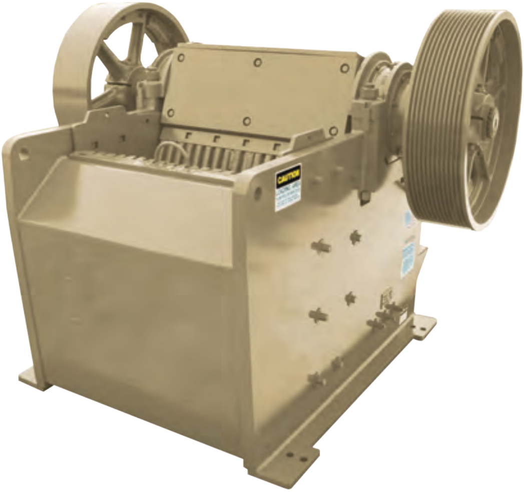
JAW CRUSHING PLANTS

Wheel-Mounted

Track-Mounted

Stationary

LEGENDARY JAW CRUSHER



For almost a century, jaw crushers have been processing materials without objection. Used most commonly as a primary crusher, but also as a secondary in some applications, these compression crushers are designed to accept all manner of materials including hard rock, gravels and recycle pavements, as well as construction and demolition debris.

JAW CRUSHERS
APPROXIMATE JAW CRUSHERS GRADATION
OPEN CIRCUIT

Test Sieve Sizes (in)	APPROXIMATE GRADATIONS AT PEAK TO PEAK CLOSED SIDE SETTINGS													Test Sieve Sizes (mm)
	¾″	1″	1 ¼″	1 ½″	2″	2 ½″	3″	3 ½″	4″	5″	6″	7″	8″	
	19 mm	25.4 mm	31.8 mm	38.1 mm	50.8 mm	63.5 mm	76.2 mm	89.1 mm	102 mm	127 mm	152 mm	178 mm	203 mm	
12′											100	98	95	305
10″										100	97	95	90	254
8″									100	96	92	85	75	203
7″		Values Are Percent Passing						100	97	92	85	76	65	178
6″							100	98	93	85	74	65	53	152
5″						100	97	95	85	73	62	52	40	127
4″					100	96	90	85	70	56	45	38	28	102
3″				100	93	85	75	65	50	38	32	27	23	76.2
2 ½″			100	95	85	73	62	52	38	31	24	22	17	63.5
2″		100	96	85	70	55	47	39	28	24	20	17	13	50.8
1 ½″	100	93	85	67	49	39	33	27	21	18	15	13	10	31.8
1 ¼″	96	85	73	55	39	31	27	23	17	15	13	10	8	38.1
1″	85	69	55	40	29	24	20	17	14	12	10	8	6	25.4
¾″	66	49	39	28	21	18	15	13	11	9	8	6	5	19.0
½″	41	29	24	19	14	12	10	9	7	6	6	5	4	12.7
⅜″	28	21	18	14	11	9	8	7	5	5	5	4	3	9.53
¼″	18	14	12	10	7	7	6	5	4	4	4	3	2	6.35
#4	12	10	9	7	5	5	4	4	3	3	3	2	1	#4
#8	6	6	5	5	4	4	3	3	2	2	2	1	0.5	#8

The chart on this page is particularly useful in determining the percentages of various sized particles to be obtained when two or more crushers are used in the same setup. It is also helpful in determining necessary screening facilities for making size separations. Here is an example designed to help show you how to use the percentage charts:

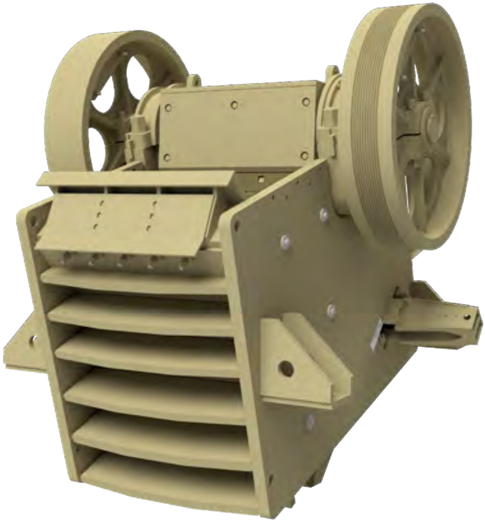
To determine the amount of material passing 1¼″ (31.8 mm) when the crusher is set at 2″ (50.8 mm) closed side setting, find 2″ (50.8 mm) at the top, and follow down the vertical line to 1¼″ (31.8 mm). The horizontal line shows 39% passing, or 61% retained.

LEGENDARY JAW CRUSHERS—HORSEPOWER REQUIRED AND APPROXIMATE CAPACITIES IN TPH

SIZE	HP REQUIRED (MINIMUM)			APPROXIMATE CAPACITIES AT PEAK TO PEAK CLOSED SIDE SETTINGS (IN TPH)*																
				¾″	1″	1 ¼″	1 ½″	2″	2 ½″	3″	3 ½″	4″	5″	6″	7″	8″	9″	10″	11″	12″
	Elect.	Diesel	RPM	19mm	25mm	32mm	38mm	51mm	64mm	76mm	89mm	102mm	127mm	152mm	178mm	203mm	228mm	254mm	279mm	304mm
***1016	15	25		10	12	14	19	24	28											
***1024	25	40	290	15	18	22	29	36	44											
***1036	40	60	290	22	27	33	44	55	67											
1047		110		29	36	44	59	73	89											
1524	40	60	290				36	45	54	63	72									
1536	75	110	290				54	68	81	95	109	136								
1654	125	175	290				81	102	122	142	163	204								
***1830	60	90	275					61	74	86	98	123								
2036	100	140	275						109	124	139	156	187							
**2436	100	150	260						123	136	153	171	205	239	273					
2148	125	170	260						145	165	186	207	248							
***2649	150	190							165	188	211	235	282							
2854	200	250	260							213	241	268	323	378	433					
**3042	150	190	260								200	223	268	313	357					
3163	200	250								290	330	370	450	530	610	690				
**3350	200	250									275	302	350	407	465	522				
**3546	200	250	235								275	302	350	407	465	522				
**4248	250	310	225									324	376	438	500	562	625	688	752	875

NOTE: *Based on material weighing 2,700 lbs. per cubic yard. Capacity may vary as much as ±25%.
**Larger settings may be obtained with other than standard toggle plate. Consult factory.
***Indicates jaw sizes that are no longer standard production models.

PIONEER® JAW CRUSHER



Today's hard rock producer requires massive crushing energy and hydraulic closed-side-setting adjustment to increase productivity and reduce downtime. Used most commonly as a primary crusher, but also as a secondary in some applications, these compression crushers are designed to accept a variety of materials including hard rock, gravels and recycle pavements, as well as construction and demolition debris.

PIONEER® JAW CRUSHERS
HORSEPOWER REQUIRED AND APPROXIMATE CAPACITIES IN TPH

SIZE	HP REQUIRED (MINIMUM)			APPROXIMATE CAPACITIES AT PEAK TO PEAK CLOSED SIDE SETTINGS (IN TPH)*																
				¾″	1″	1 ¼″	1 ½″	2″	2 ½″	3″	3 ½″	4″	5″	6″	7″	8″	9″	10″	11″	12″
	Elect.	Diesel	RPM	19mm	25mm	32mm	38mm	51mm	64mm	76mm	89mm	102mm	127mm	152mm	178mm	203mm	228mm	254mm	279mm	304mm
2056	125	160	285					128-170	150-195	170-225	190-250	212-280	255-335							
2742	150	190	275						133-175	150-200	171-225	190-250	228-300							
2650	150	190	260						157-206	179-235	200-264	223-294	268-353							
3055	200	250	250							252-331	285-375	317-418	382-503	447-589	502-660					
3144	150	190	260							201-265	228-300	254-334	304-400	354-466	405-533					
**3165	200	250	250							252-331	290-381	353-465	436-574	504-663	580-764	657-865				
3365	200	265	250							260-341	300-393	364-480	450-595	520-685	595-790	680-892				
**3552	200	250	225								302-398	342-450	395-520	460-605	525-691					
4450	250	310	225									402-529	467-615	545-718	621-818	698-919	775-1,020			

NOTE: *Based on material weighing 2,700 lbs. per cubic yard. Capacity may vary with the material characteristics.
**Larger settings may be obtained with other than standard toggle plate. Consult Factory.

HSI PLANTS

Track-mounted Andreas

Portable Andreas

Portable New Holland

PRIMARY IMPACT CRUSHERS
(New Holland Style)

Making a cubical product necessary for asphalt and concrete specifications poses many equipment problems for the aggregate producer. Among these problems are abrasive wear, accessibility for hammer maintenance or breaker bar changes and bridging in the crushing chamber.

Impact crusher units are designed to help overcome problems faced by producers and at the same time to provide maximum productivity for existing conditions.

PRIMARY IMPACT CRUSHERS (NEW HOLLAND STYLE)—APPROXIMATE PRODUCT GRADATION—OPEN CIRCUIT

Test Sieve Sizes (in)	3850		4654		6064		Test Sieve Sizes (mm)
	Normal Setting	Close Setting	Normal Setting	Close Setting	Normal Setting	Close Setting	
6″	Values are percent passing				100		152
5″			100		97	100	127
4″	100		98	100	90	98	102
3″	96	100	89	96	75	89	76.2
2½″	90	97	80	90	66	80	63.5
2″	77	89	67	77	56	67	50.8
1½″	64	75	56	64	48	56	38.1
1¼″	57	67	50	57	43	50	31.8
1″	50	58	44	50	38	44	25.4
¾″	41	47	37	41	31	37	19.1
½″	32	37	28	32	24	28	12.7
⅜″	26	30	23	26	19	23	9.53
¼″	20	23	17	20	14	17	6.35
#4	17	19	15	17	12	15	#4
#8	12	14	10	12	8	10	#8
#16	8	9	6	8	5	6	#16
#30	5	6	4	5	3	4	#30
#50	3	4	3	3	2	3	#50
#100	2	3	2	2	1	2	#100

	Recommended HP		Approx. Capacities		Maximum Feed Size
Model	Electric	Diesel	TPH	MTPH	
3850	250-300	350-450	250-450	227-409	24″
4654	300-400	450-600	400-750	364-682	30″
6064	400-600	600-900	600-1,200	545-1,091	40″

NOTE: *Capacity depends on feed size and gradation, type of material, etc. Approximate product gradation can be expected as shown on chart. The product will vary from that shown depending on the size and type of feed, adjustment of lower breaker bar, etc.

5054 HYBRID HORIZONTAL SHAFT IMPACT CRUSHER

The 5054 hybrid HSI combines the large feed opening and expansion chamber of the primary New Holland style HSI with the precise top-size control of the Andreas HSI to provide the best of both crushers. The hybrid 5054 comes standard with hydraulic apron adjustment and apron position monitoring, as well as the convenience of Andreas HSI style replaceable blow bars and bolt-in liners. This crusher is well-suited for primary crushing applications in limestone and other large, non-abrasive feed materials and features an optional feed lip "bridge breaker" to help alleviate internal bridging from oversized feed material.

5054 HYBRID HSI —APPROXIMATE PRODUCT GRADATION—OPEN CIRCUIT

Test Sieve Sizes (in)	CSS (apron to blow bar clearance)				Test Sieve Sizes (mm)
	8"	6"	5"	4"	
15″	100	100	100	100	381
12"	100	100	100	100	304.8
10"	96	100	100	100	254
8"	88	97	100	100	203.2
6"	77	90	98	100	152.4
5"	65	78	91	99	127
4"	54	66	79	92	101.6
3"	42	56	67	80	76.2
2"	25	43	58	67	50.8
1"	13	24	44	57	25.4
½″	10	14	23	43	12.7
⅜″	9	11	17	22	9.53
¼″	7	8	13	18	6.35
#4	6	7	9	16	#4
#8	5	6	7	10	#8
#16	4	5	6	8	#16
#30	3	4	5	6	#30
#50	2	3	3	5	#50
#100	1	2	2	3	#100
#200	1	1	1	2	#200

	Recommended HP		Approx. Capacities*		Maximum Feed Size
Hybrid Model	Electric	Diesel	TPH	MTPH	
5054	300-400	450-600	400-800	364-728	40"

NOTE: *Capacity depends on feed size and gradation, type of material, etc. Approximate product gradation may vary depending on material characteristics.

ANDREAS-STYLE IMPACT CRUSHERS

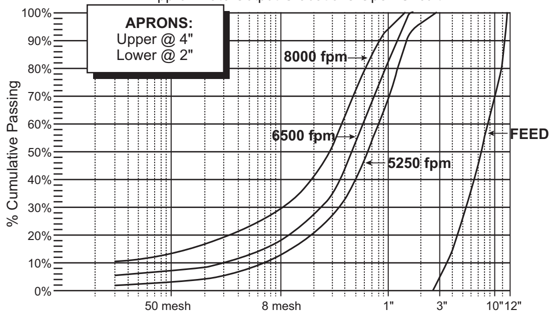
Andreas-Style impact crushers are designed for recycling concrete and asphalt, as well as traditional aggregate crushing applications. The Maximum Performance Rotor (MPR) offers the mass of a solid design with the clearances of an open configuration.

ANDREAS IMPACT CRUSHERS
HORIZONTAL SHAFT IMPACT CRUSHER

	Recommended HP		Approx. Capacities	
Size	Electric	Diesel	TPH	MTPH
4233	100	165	up to 200	up to 181
4240	150	190	up to 250	up to 227
4250	200	265	up to 300	up to 272
5260 - 3 bar	300	390	up to 450	up to 408
5260 - 4 bar	300	390	up to 450	up to 408

	Maximum Feed Size**			Min Lower/ Upper Appron Setting
Size	Recycle	Limestone	Hard Rock	
4233	24″x24″x12″	up to 18″	up to 16″	1″ / 2″
4240	27″x27″x12″	up to 21″	up to 18″	1″ / 2″
4250	30″x30″x12″	up to 21″	up to 21″	1″ / 2″
5260 - 3 bar	36″x36″x12″	up to 24″	up to 21″	1″ / 2″
5260 - 4 bar	36″x36″x12″	up to 21″	up to 18″	1″ / 2″

Approximate Output Gradations-Open Circuit



NOTE: *Capacity depends on feed size and gradation, type of material, etc.
** Limestone and hard rock feed sizes are based on secondary applications.

CONE CRUSHERS

Track-mounted Kodiak® Plus Plant

Portable Kodiak® Plus Plant

Stationary Kodiak® Plus Plant

KODIAK® PLUS AND LS CONE CRUSHER NOTES

1. Capacities and product gradations produced by cone crushers will be effected by the method of feeding, characteristics of the material, speed of the machine, power applied and other factors. Hardness, compressive strength, mineral content, grain structure, plasticity, size and shape of feed particles, moisture content and other characteristics of the material also affect production capacities and gradations.

2. Gradations and capacities shown are based on a typical well-graded choke feed to the crusher. Well-graded feed is considered to be 90-100% passing the closed side feed opening, 40-60% passing the midpoint of the crushing chamber on the closed side (average of the closed side feed opening and closed side setting) and 0-10% passing the closed side setting. Choke feed is considered to be material located 360 degrees around the crushing head and approximately 6" above the mantle nut.

3. Maximum feed size is the average of the open side feed opening and closed side feed opening.

4. A general rule of thumb for applying cone crushers is the reduction ratio. A crusher with coarse-style liners would typically have a 6:1 reduction ratio. Thus, with a ¾" closed side setting, the maximum feed would be 6 x ¾ or 4.5 inches. Reduction ratios of 8:1 may be possible in certain coarse crushing applications. Fine liner configurations typically have reduction ratios of 4:1 to 6:1.

5. Minimum closed side setting may be greater than published settings since it is not a fixed dimension. It will vary depending on crushing conditions, the compressive strength of the material being crushed and the stage of reduction. The actual minimum closed side setting is that setting just before the bowl assembly lifts minutely against the factory recommended pressurized hydraulic relief system. Operating the crusher above the factory recommended relief pressure will void the warranty, as will operating the crusher in a relief mode (bowl float).

KODIAK® PLUS CONE CRUSHERS

K200+

K300+

K350+

K400+

K500+

KODIAK® PLUS OPERATING PARAMETERS

The following list outlines successful operating parameters for the Kodiak® Plus line of crushers. These are not prioritized in any order of importance.

Material

1. Material with a compressive strength greater than 40,000 pounds per square inch should be reviewed in advance by the factory.
2. No more than 10% of the total volume of feed material is sized less than the crusher closed side setting.
3. The crusher feed material conforms to the recommended feed size on at least two sides.
4. Moisture content of material is below 5%.
5. Feed gradation remains uniform.
6. Clay or plastic material in crusher feed is limited to prevent the formation of compacted material.

Mechanical

1. Crusher operates at factory recommended tramp iron relief pressures without bowl float.
2. Crusher support structure is level and evenly supported across all four corners. In addition, the support structure provides adequate strength to resist static and dynamic loads.
3. Crusher is operated only when all electrical, lubrication and hydraulic systems are correctly adjusted and functioning properly.
4. Lubrication low flow warning system functions correctly.
5. Lubrication oil filter functions properly and shows adequate filtering capacity on its indicator.
6. Crusher drive belt(s) are in good condition and tensioned to factory specifications.
7. Crusher lubrication reservoir is full of lubricant that meets factory required specifications.
8. Any welding on the crusher or support structure is grounded directly at the weld location.
9. Crusher input shaft rotates in the correct direction.
10. Manganese wear liners are replaced at the end of their expected life.

11. Crusher cone head is properly blocked prior to transport.
12. Only authorized OEM parts or factory-approved wear parts are used.

Application

1. Reduction ratio limited to 6:1 below 1″ closed side setting and 8:1 above 1″ closed side setting provided no bowl float occurs.
2. Manganese chamber configuration conforms to the factory recommended application guidelines.
3. Crusher is operated at the factory recommended RPM for the application.
4. Crusher feed is consistent with an even flow of material, centered in the feed opening and covering the mantle nut at all times.
5. Crusher input horsepower does not exceed factory specifications.
6. Crusher discharge chamber is kept clear of material buildup.
7. If the crusher cannot be totally isolated from metal in the feed material, a magnet should be used over the crusher feed belt.
8. Crusher is never operated at zero closed side setting.

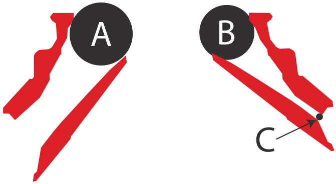
KODIAK® CONE CRUSHERS GRADATION CHART

Prod-uct Size	Crusher Closed Side Setting											
	5⁄16″	3⁄8″	7⁄16″	1⁄2″	5⁄8″	3⁄4″	7⁄8″	1″	1 1⁄4″	1 1⁄2″	1 3⁄4″	2″
	7.94 mm	9.52 mm	11.11 mm	12.7 mm	15.87 mm	19.05 mm	22.22 mm	25.4 mm	32 mm	38.1 mm	44.5 mm	50.8 mm
4″												100
3 1⁄2″											100	96
3″										100	95	90
2 3⁄4″										98	92	86
2 1⁄2″									100	95	88	81
2 1⁄4″									97	91	83	74
2″								100	94	86	76	65
1 3⁄4″							100	99	89	79	66	55
1 1⁄2″						100	99	97	82	68	56	45
1 1⁄4″					100	99	95	90	72	56	46	38
1″				100	99	95	87	79	60	45	36	29
7⁄8″			100	99	95	88	80	70	49	38	30	25
3⁄4″		100	97	95	91	83	71	61	41	32	26	21
5⁄8″	100	98	94	90	85	73	58	49	34	28	22	18
1⁄2″	99	95	89	85	75	63	50	42	28	23	19	16
3⁄8″	91	85	75	69	63	51	42	33	21	17	14	12
5⁄16″	85	75	65	61	56	43	35	27	19	15	13	10
1⁄4″	74	63	52	50	45	37	29	23	16	13	11	9
4M	58	51	42	36	33	28	21	18	14	11	9	7
5⁄32″	50	42	36	30	28	23	18	15	12	10	8	6
8M	40	35	30	26	24	20	16	12	9	7	5	4
10M	35	31	26	22	20	17	14	10	8	6	4	3
16M	28	24	21	17	15	13	10	8	6	4	3	2
30M	21	18	15	11	9	8	6	5	4	3	2	1.5
40M	18	15	13	10	8	7	5	4	3	2	1.5	1
50M	14	12	11	8	7	6	4	3	2	1.5	1	0.8
100M	11	9	8	7	6	5	4	3	1.5	1	0.5	0.5
200M	8	7	6	6	5	4	3	2	1	0.5	0.5	0.3

Estimated product gradation percentages at setting shown.

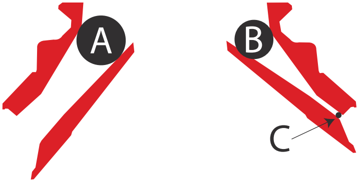
K200+ MANGANESE CONFIGURATION

K200+ Coarse Chamber



A	B	C
8 ¾" (222.2mm)	7 ¾" (196.9mm)	⅞" (22.2mm)
9" (228.6mm)	8" (203.2mm)	1" (25.4mm)
9 ¼" (234.9mm)	8 ¼" (209.6mm)	1 ¼" (31.8mm)
9 ½" (241.3mm)	8 ½" (215.9mm)	1 ½" (38.1mm)
10" (254mm)	9" (228.6mm)	2" (50.8mm)

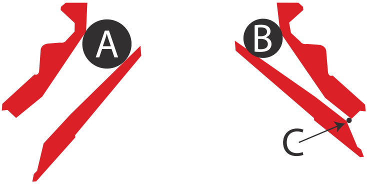
K200+ Medium Chamber with Feed Slots



A	B	C
7 ¾" (196.8mm)	6 ¾" (171.5mm)	⅝" (15.9mm)
7 ⅞" (200mm)	6 ⅞" (174.6mm)	¾" (19mm)
8" (203.2mm)	7" (177.8mm)	⅞" (22.2mm)
8 ¼" (209.5mm)	7 ¼" (184.2mm)	1 ⅛" (28.6mm)
8 ½" (215.9mm)	7 ½" (190.5mm)	1 ¼" (31.8mm)

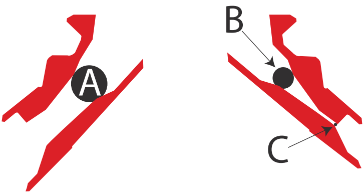
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K200+ Medium Chamber



A	B	C
6 ¼″ (158.8mm)	5″ (127mm)	⅝″ (15.9mm)
6 ⅜″ (161.9mm)	5 3⁄16″ (131.8mm)	¾″ (19mm)
6 ½″ (165.1mm)	5 ¼″ (133.4mm)	⅞″ (22.2mm)
6 ¾″ (171.5mm)	5 ¾″ (146mm)	1 ⅛″ (28.6mm)
7″ (177.8mm)	5 ¾″ (146mm)	1 ¼″ (31.8mm)

K200+ Fine Chamber

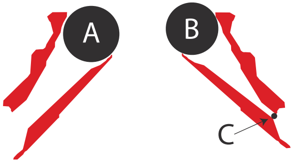


A	B	C
4 ½″ (114.3mm)	2 ¾″ (69.9mm)	⅜″ (9.5mm)
4 ½″ (114.3mm)	2 ⅞″ (73mm)	½″ (12.7mm)
4 ½″ (114.3mm)	3″ (76.2mm)	⅝″ (15.9mm)
4¾″ (120.7mm)	3 ⅛″ (79.4mm)	⅞″ (22.2mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

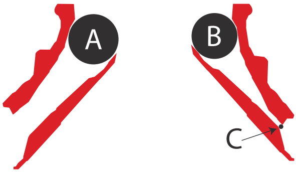
K300+ MANGANESE CONFIGURATION

K300+ Coarse Chamber



A	B	C
10 ⅛″ (257.2mm)	9 ¼″ (235mm)	¾″ (19mm)
10 ¼″ (260.4mm)	9 ⅜″ (238.1mm)	⅞″ (22.2mm)
10 ⅜″ (263.5mm)	9 ½″ (241.3mm)	1″ (25.4mm)
10 ½″ (266.7mm)	9 ⅝″ (244.5mm)	1 ¼″ (31.8mm)
10 ¾″ (273mm)	9 ¾″ (247.7mm)	1 ½″ (38.1mm)
11″ (279.4mm)	10″ (254mm)	1 ¾″ (44.5mm)
11 ¼″ (285.8mm)	10 ¼″ (260.4mm)	2″ (50.8mm)

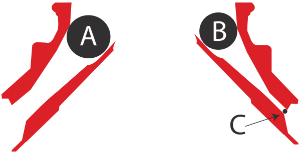
K300+ Medium Coarse Chamber



A	B	C
8 ¾″ (222.3mm)	7 ¾″ (196.9mm)	¾″ (19mm)
9″ (228.6mm)	7 ¾″ (196.9mm)	⅞″ (22.2mm)
9″ (228.6mm)	8″ (203.2mm)	1″ (25.4mm)
9 ⅜″ (238.1mm)	8 ¼″ (209.6mm)	1 ¼″ (31.8mm)
9 ⅝″ (244.5mm)	8 ½″ (215.9mm)	1 ½″ (38.1mm)
9 ⅞″ (250.8mm)	8 ¾″ (222.3mm)	1 ¾″ (44.5mm)

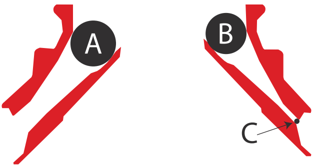
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K300+ Medium Chamber with Feed Slots



A	B	C
8 ⅞″ (225.4mm)	7 ⅞″ (200mm)	⅝″ (15.9mm)
9″ (228.6mm)	8″ (203.2mm)	¾″ (19mm)
9 ⅛″ (231.8mm)	8 ⅛″ (206.4mm)	⅞″ (22.2mm)
9 ¼″ (234.9mm)	8 ¼″ (209.6mm)	1″ (25.4mm)
9 ½″ (241.3mm)	8 ½″ (215.9mm)	2″ (50.8mm)

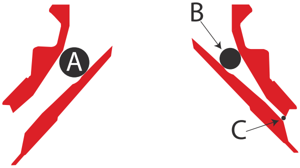
K300+ Medium Chamber



A	B	C
7 ⅝″ (193.7mm)	6 ½″ (165.1mm)	⅝″ (15.9mm)
7 ¾″ (196.9mm)	6 ⅝″ (168.3mm)	¾″ (19mm)
7 ⅞″ (200mm)	6 ¾″ (171.5mm)	⅞″ (22.2mm)
8″ (203.2mm)	6 ⅞″ (174.6mm)	1″ (25.4mm)
8 ¼″ (209.6mm)	7 ⅛″ (180.9mm)	1 ¾″ (44.5mm)

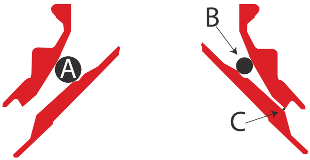
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K300+ Medium Fine Chamber



A	B	C
5 ⅛″ (130.2mm)	3 ⅝″ (92mm)	½″ (12.7mm)
5 ¼″ (133.4mm)	3 ¾″ (95.3mm)	⅝″ (15.9mm)
5 ⅜″ (136.5mm)	3 ⅞″ (98.4mm)	¾″ (19mm)
5 ½″ (139.7mm)	4″ (101.6mm)	⅞″ (22.2mm)
5 ⅝″ (142.9mm)	4 ⅛″ (104.8mm)	1″ (25.4mm)

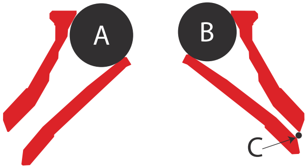
Kodiak 300+ Fine Chamber



A	B	C
4 ⅜″ (111.1mm)	2 ¾″ (69.9mm)	¼″ (6.4mm)
4 ½″ (114.3mm)	2 ⅞″ (73mm)	⅜″ (9.5mm)
4 ⅝″ (117.5mm)	3″ (76.2mm)	½″ (12.7mm)
4 ¾″ (120.7mm)	3 ⅛″ (79.4mm)	⅝″ (15.9mm)
4 ⅞″ (123.8mm)	3 ¼″ (82.6mm)	¾″ (19mm)
5″ (127mm)	3 ⅜″ (85.7mm)	⅞″ (22.2mm)

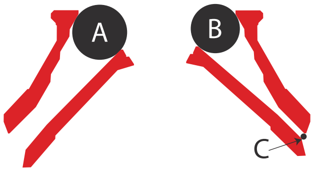
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K350+ Coarse Chamber



A	B	C
10 ⅞″ (276.2mm)	9 13⁄16″ (249.2mm)	¾″ (19.1mm)
11″ (279.4mm)	10″ (254mm)	⅞″ (22.2mm)
11 ⅛″ (282.6mm)	10 ⅛″ (257.2mm)	1″ (25.4mm)
11 7⁄16″ (290.5mm)	10 7⁄16″ (265.1mm)	1 ¼″ (31.8mm)
11 ¾″ (298.5mm)	10 ¾″ (273.1mm)	1 ½″ (38.1mm)
12″ (304.8mm)	11″ (279.4mm)	1 ¾″ (44.5mm)
12 ¼″ (311.2mm)	11 5⁄16″ (287.3mm)	2″ (50.8mm)

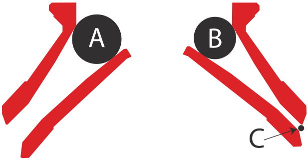
K350+ Medium Coarse Chamber



A	B	C
9 ¼″ (235mm)	8 ¼″ (209.6mm)	¾″ (19mm)
9 ⅜″ (238.1mm)	8 ⅜″ (212.7mm)	⅞″ (22.2mm)
9 ½″ (241.3mm)	8 ½″ (215.9mm)	1″ (25.4mm)
9 ¾″ (247.7mm)	8 ¾″ (222.3mm)	1 ¼″ (31.8mm)
10″ (254mm)	9″ (228.6mm)	1 ½″ (38.1mm)
10 ¼″ (260.4mm)	9 5⁄16″ (236.5mm)	1 ¾″ (44.5mm)
10 ½" (266.7mm)	9 ⅝" (244.5mm)	2″ (50.8mm)

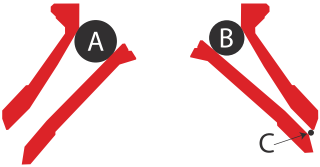
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K350+ Medium Chamber



A	B	C
8″ (203.2mm)	6 ¾″ (171.5mm)	⅝″ (15.9mm)
8 ⅛″ (206.4mm)	6 15⁄16″ (176.2mm)	¾″ (19.1mm)
8 ½″ (215.9mm)	7″ (177.8mm)	⅞″ (22.2mm)
8 ¾″ (222.3mm)	7 ¼″ (184.2mm)	1″ (25.4mm)
8 15⁄16″ (227mm)	7 ½″ (190.5mm)	1 ¼″ (31.8mm)

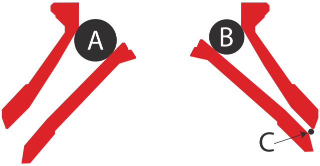
K350+ Medium Medium Chamber



A	B	C
6 ¾″ (171.5mm)	5 ½″ (139.7mm)	⅝″ (15.9mm)
6 ⅞″ (174.6mm)	5 ⅝″ (142.9mm)	¾″ (19.1mm)
7″ (177.8mm)	5 ¾″ (146.1mm)	⅞″ (22.2mm)
7 ⅛″ (181mm)	5 ⅞″ (149.2mm)	1″ (25.4mm)
7 ⅜″ (187.3mm)	6 ⅛″ (155.6mm)	1 ¼″ (31.6mm)

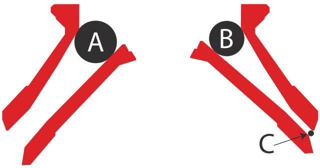
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K350+ Medium Fine Chamber



A	B	C
4 ¾″ (120.7mm)	3 ⅛″ (79.4mm)	⅜" (9.5mm)
4 ⅞″ (123.8mm)	3 ¼″ (82.6mm)	½" (12.7mm)
5″ (127mm)	3 ⅜″ (85.7mm)	⅝" (15.6mm)
5 ⅛″ (130.2mm)	3 ½″ (88.9mm)	¾″ (19.1mm)
5 ¼″ (133.4mm)	3 ¹¹⁄₁₆″ (93.7mm)	⅞″ (22.2mm)
5 ½″ (139.7mm)	4″ (101.6mm)	1″ (25.4mm)

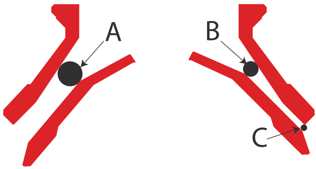
K350+ Medium Fine Medium Chamber



A	B	C
4″ (101.6mm)	2 ⅜″ (60.3mm)	⅜" (9.5mm)
4 ³⁄₁₆″ (106.4mm)	2 ½″ (63.5mm)	½" (12.7mm)
4 ⁵⁄₁₆″ (109.5mm)	2 ¹¹⁄₁₆″ (68.3mm)	⅝" (15.9mm)
4 ⁷⁄₁₆″ (112.7mm)	2 ¾″ (69.9mm)	¾″ (19.1mm)
4 ½″ (114.3mm)	2 ¹⁵⁄₁₆″ (74.6mm)	⅞″ (22.2mm)
4 ⅝″ (117.5mm)	3 ⅛″ (79.4mm)	1″ (25.4mm)

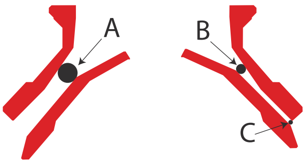
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K350+ Fine Chamber



A	B	C
3 ¹¹⁄₁₆" (93.7mm)	2" (50.8mm)	⅜" (9.5mm)
3 ¹³⁄₁₆" (96.8mm)	2 ¹⁄₁₆" (52.4mm)	½" (12.7mm)
3 ⅞" (98.4mm)	2 ³⁄₁₆" (55.6mm)	⅝" (15.9mm)
4" (101.6mm)	2 ¼" (57.2mm)	¾" (19.1mm)
4 ⅛" (104.8mm)	2 ⅜" (59.1mm)	⅞" (22.2mm)
4 ³⁄₁₆" (106.4mm)	2 ½" (63.5mm)	1" (25.4mm)

K350+ Extra Fine Chamber

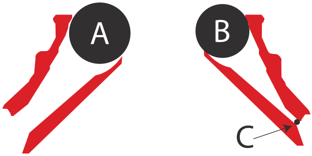


A	B	C
3" (76.2mm)	1 ¼" (31.8mm)	¼" (6.4mm)
3 ¹⁄₁₆" (77.8mm)	2 ⅜" (60.3mm)	⅜" (9.5mm)
3 ³⁄₁₆" (81mm)	2 ⁷⁄₁₆" (61.9mm)	½" (12.7mm)
3 ¼" (82.6mm)	2 ½" (63.5mm)	⅝" (15.9mm)
3 ⅜" (85.7mm)	2 ⅝" (66.7mm)	¾" (19.1mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

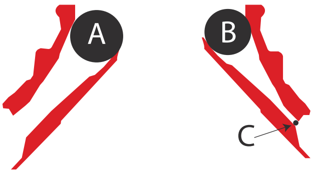
K400+ MANGANESE CONFIGURATION

K400+ Coarse Chamber



A	B	C
11 ½″ (292.1mm)	10 ¼″ (260.4mm)	¾″ (19.1mm)
11 ⅝″ (295.3mm)	10 ⅜″ (263.5mm)	⅞″ (22.2mm)
11 ¾″ (298.5mm)	10 ½″ (266.7mm)	1″ (25.4mm)
12″ (304.8mm)	10 ¾″ (273.1mm)	1 ¼″ (31.8mm)
12 ¼″ (311.2mm)	11 ⅛″ (282.6mm)	1 ½″ (38.1mm)
12 ½″ (317.5mm)	11 ⅜″ (288.9mm)	1 ¾″ (44.5mm)
12 ¾″ (323.9mm)	11 ½″ (292.1mm)	2″ (50.8mm)

K400+ Medium Chamber with Feed Slots



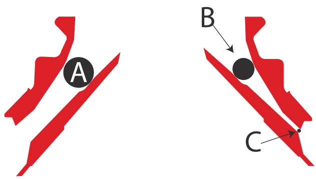
A	B	C
9 ½″ (241.3mm)	8 ⅛″ (206.4mm)	⅝″ (15.9mm)
9 ⅝″ (244.5mm)	8 ¼″ (209.6mm)	¾″ (19.1mm)
9 ¾″ (247.7mm)	8 ⅜″ (212.7mm)	⅞″ (22.2mm)
9 ⅞″ (250.8mm)	8 ½″ (215.9mm)	1″ (25.4mm)
10 ¼″ (260.4mm)	8 ¾″ (222.3mm)	1 ¼″ (31.8mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K400+ Medium Chamber

A	B	C
8 ⅛″ (206.4mm)	6 ⅝″ (168.3mm)	⅝″ (15.9mm)
8 ¼″ (209.6mm)	6 ¾″ (171.5mm)	¾″ (19.1mm)
8 ⅜″ (212.7mm)	6 ⅞″ (174.6mm)	⅞″ (22.2mm)
8 ½″ (215.9mm)	7 (177.8mm)	1″ (25.4mm)
8 ¾″ (2223mm)	7 ⅜″ (187.3mm)	1 ¼″ (31.8mm)

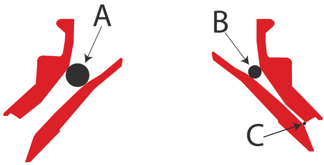
K400+ Medium Fine Chamber



A	B	C
5 ¼″ (133.4mm)	3 ½″ (88.9mm)	½″ (12.7mm)
5 ⅜″ (136.5mm)	3 ¾″ (95.3mm)	⅝″ (15.9mm)
5 ½″ (139.7mm)	3 ⅞″ (98.4mm)	¾″ (19.1mm)
5 ¾″ (146.1mm)	4" (101.6mm)	⅞″ (22.2mm)
5 ⅞″ (149.2mm)	4 ⅛″ (104.8mm)	1 (25.4mm)

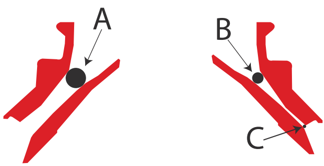
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K400+ Fine Chamber



A	B	C
3 ⅞″ (98.4mm)	2 ⅛″ (54mm)	¼″ (6.4mm)
4″ (101.6mm)	2 ¼″ (57.2mm)	⅜″ (9.5mm)
4 ⅛″ (104.8mm)	2 ⅜″ (60.3mm)	½″ (12.7mm)
4 ¼″ (108mm)	2 ½″ (63.5mm)	⅝″ (15.9mm)
4 ⅜″ (111.1mm)	2 ⅝″ (66.7mm)	¾″ (19.1mm)

K400+ Extra Fine Chamber

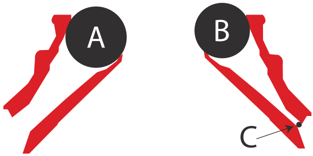


A	B	C
3 ½″ (88.9mm)	1 ¾″ (44.5mm)	¼″ (6.4mm)
3 ⅝″ (92.1mm)	1 ⅞″ (47.6mm)	⅜″ (9.5mm)
3 ¾″ (95.3mm)	2″ (50.8mm)	½″ (12.7mm)
3 ⅞″ (98.4mm)	2 ⅛″ (54mm)	⅝″ (15.9mm)
4″ (101.6mm)	2 ¼″ (57.2mm)	¾″ (19.1mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

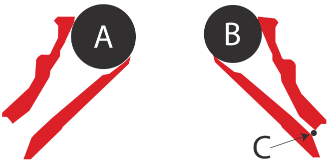
K500+ MANGANESE CONFIGURATION

K500+ Extra Coarse Chamber



A	B	C
14″ (355.6mm)	13″ (330.2mm)	1 ¼″ (31.8mm)
14 ¼″ (362mm)	13 1/16″ (331.8mm)	1 ½″ (38.1mm)
14 ⅜″ (365.1mm)	13 ⅜″ (339.7mm)	2″ (50.8mm)
14 ¾″ (374.7mm)	13 ⅞″ (352.4mm)	2 ½″ (63.5mm)
15 1/16″ (382.6mm)	14 1/16″ (357.2mm)	3″ (76.2mm)

K500+ Coarse Chamber



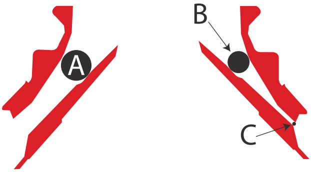
A	B	C
12 ½″ (317.5mm)	11 ⅛″ (282.6mm)	¾″ (19.1mm)
12 ⅝″ (320.7mm)	11 ½″ (292.1mm)	1" (25.4mm)
12 15/16″ (328.6mm)	11 ¾″ (298.5mm)	1¼″ (31.8mm)
13 ¼″ (336.6mm)	12 ⅛″ (308mm)	1½″ (38.1mm)
13 ¾″ (349.3mm)	12 ¾″ (323.9mm)	2″ (50.8mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K500+ Medium Chamber

A	B	C
11 ¾″ (298.5mm)	10 ½″ (266.7mm)	⅝″ (15.9mm)
11⅞″ (301.6mm)	10 ⅝″ (269.9mm)	¾″ (19.1mm)
12″ (304.8mm)	10 ¾″ (273.1mm)	⅞″ (22.2mm)
12 ⅛″ (308mm)	10 ⅞″ (276.2mm)	1″ (25.4mm)
12 ⅜″ (314.3mm)	11 ⅛″ (282.6mm)	1¼″ (31.8mm)

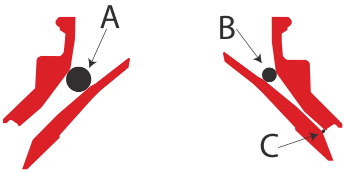
K500+ Medium Fine Chamber



A	B	C
6 ⅜″ (161.9mm)	4 ⅝″ (117.5mm)	½″ (12.7mm)
6 ½″ (165.1mm)	4 ¾″ (120.7mm)	⅝″ (15.9mm)
6 ⅝″ (168.3mm)	4 ⅞″ (123.8mm)	¾″ (19.1mm)
6 ¾″ (171.5mm)	5 1⁄16″ (128.6mm)	⅞″ (22.2mm)
6 ⅞″ (174.6mm)	5 ¼″ (133.4mm)	1″ (25.4mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

K500+ Extra Fine Chamber



A	B	C
4 ½″ (114.3mm)	2 ⅝″ (66.7mm)	¼″ (6.4mm)
4 ⅝″ (117.5mm)	2 ¾″ (69.9mm)	⅜″ (9.5mm)
4 ¾″ (120.7mm)	3″ (76.2mm)	½″ (12.7mm)
4 ⅞″ (123.8mm)	3 ⅛″ (79.4mm)	⅝″ (15.9mm)
5″ (127mm)	3 ¼″ (82.6mm)	¾″ (19.1mm)

A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

NOTES:

KODIAK® PLUS SERIES CONE CRUSHER PROJECTED CAPACITY AND GRADATION CHARTS

Open Circuit Capacities

Closed-side Setting (CSS)	1/2" (13mm)	5/8" (16mm)	3/4" (19mm)	7/8" (22mm)	1" (25mm)	1 1/4" (32mm)	1 1/2" (38mm)	1 3/4" (44mm)	2" (51mm)
K200+	125-165 tph (113-150 mtph)	140-195 tph (127-177 mtph)	165-220 tph (150-200 mtph)	180-245 tph (163-222 mtph)	220-320 tph (200-290 mtph)	240-345 tph (218-313 mtph)	260-365 tph (236-331 mtph	285-365 tph (259-331 mtph)	300-385 tph (272-350 mtph)
K300+	170-210 tph (154-191 mtph)	190-240 tph (172-218 mtph)	215-270 tph (195-245 mtph)	240-300 tph (218-272 mtph)	270-330 tph (245-299 mtph)	310-385 tph (281-350 mtph)	330-415 tph (299-376 mtph)	350-440 tph (318-399 mtph)	370-460 tph (335-417 mtph)
K350+	187-231 tph (170-210 mtph)	209-264 tph (190-240 mtph)	237-297 tph (215-269 mtph)	264-330 tph (240-299 mtph)	297-363 tph (269-329 mtph)	341-424 tph (309-385 mtph)	363-457 tph (329-415 mtph)	385-484 tph (349-439 mtph)	407-506 tph (369-459 mtph)
K400+	210-260 tph (191-236 mtph)	250-315 tph (227-286 mtph)	290-365 tph (263-331 mtph)	315-395 tph (286-358 mtph)	340-425 tph (308-386 mtph)	405-505 tph (367-458 mpth)	440-550 tph (399-499 mtph)	475-595 tph (431-540 mtph)	500-625 tph (454-567 mtph)
K500+	270-330 tph (245-299 mtph)	320-395 tph (290-358 mtph)	375-445 tph (340-404 mtph)	390-495 tph (354-449 mtph)	425-520 tph (386-472 mtph)	485-585 tph (440-531 mtph)	545-670 tph (494-608 mtph)	595-735 tph (540-667 mtph)	650-830 tph (590-753 mtph)

Recommended Pinion RPM ranges:
Coarse crushing: 750-850RPM
Medium crushing: 800-900RPM
Fine crushing: 850-950RPM
Consult factory for specific application recommendations

KODIAK® PLUS SERIES CONE CRUSHER PROJECTED CAPACITY AND GRADATION CHARTS

Closed Circuit Capacities

Closed Side Setting (CSS)	1/2" (13mm)	5/8" (16mm)	3/4" (19mm)	7/8" (22mm)	1" (25mm)	1 ¼" (32mm)	1 ½" (38mm)	1 ¾" (44mm)	2" (51mm)
K200+	106-140 tph (95-127 mtph)	119-166 tph (108-150 mtph)	137-183 tph (124-166 mtph)	144-196 tph (131-178 mtph)	174-253 tph (158-229 mtph)	174-248 tph (158-225 mtph)	176-248 tph (158-223 mpth)	188-241 tph (169-217 mtph)	195-250 tph (175-225 mtph)
K300+	145-179 tph (131-162 mtph)	162-224 tph (147-185 mtph)	178-224 tph (162-203 mtph)	192-240 tph (174-218 mtph)	213-261 tph (194-237 mtph)	223-277 tph (202-251 mtph)	224-282 tph (202-254 mtph)	231-290 tph (208-261 mtph)	240-299 tph (216-269 mtph)
K350+	159-196 tph (144-178 mpth)	178-224 tph (162-203 mtph)	197-247 tph (179-224 mtph)	211-264 tph (191-240 mtph)	235-287 tph (213-260 mtph)	246-305 tph (223-277 mtph)	247-311 tph (222-280 mtph)	254-319 tph (228-287 mtph)	264-329 tph (237-296 mtph)
K400+	179-221 tph (162-200 mtph)	213-268 tph (193-243 mtph)	241-303 tph (218-275 mtph)	269-336 tph (229-287 mtph)	269-336 tph (244-305 mtph)	292-364 tph (265-330 mtph)	299-374 tph (269-336 mtph)	313-393 tph (282-354 mtph)	325-406 tph (292-365 mtph)
K500+	230-281 tph (208-254 mtph)	272-336 tph (247-305 mtph)	311-369 tph (282-335 mtph)	312-396 tph (283-359 mtph)	336-411 tph (305-373 mtph)	349-421 tph (317-382 mtph)	370-455 tph (333-409 mtph)	393-485 tph (354-436 mtph)	422-539 tph (380-485 mtph)

Recommended Pinion RPM ranges:
Coarse crushing: 750-850RPM
Medium crushing: 800-900RPM
Fine crushing: 850-950RPM
Consult factory for specific application recommendations

KODIAK® PLUS SERIES CONE CRUSHER PROJECTED CAPACITY AND GRADATION CHARTS

Recirculating Load

Closed-Side Setting (CSS)	⅜″ (10mm)	½″ (13mm)	⅝″ (16mm)	¾″ (19mm)	⅞″ (22mm)	1″ (25mm)	1¼″ (32mm)	1½″ (38mm)	1¾″ (44mm)	2″ (51mm)
Recirculating Load	15%	15%	15%	17%	20%	21%	28%	32%	34%	35%

Minimum closed side setting is the closest setting possible that does not induce bowl float.
Actual minimum closed side setting and production numbers will vary and are influenced by factors like nature of feed material, ability to screen out fines, manganese condition, etc.

IMPORTANT: Estimated results may differ from published data due to variations in operating conditions and application of crushing and screening equipment. This information does not constitute an expressed or implied warranty but shows estimated performance based on machine operation within recommended design parameters. Use this information for estimating purposes only.

NOTES:

1200 / 1400 LS CONE CRUSHER PROJECTED CAPACITY AND GRADATION CHARTS

Open Circuit Capacities in Tons-Per-Hour

Closed-side Setting (CSS)	1/2" (13mm)	5/8" (16mm)	3/4" (19mm)	7/8" (22mm)	1" (25mm)	1 1/4" (32mm)	1 1/2" (38mm)	1 3/4" (44mm)	2" (51mm)
1200LS Gross Throughput	125-165 tph (113-150 mtph)	140-195 tph (127-177 mtph)	165-220 tph (150-200 mtph)	180-245 tph (163-222 mtph)	200-270 tph (181-245 mtph)	220-320 tph (200-290 mtph)	240-345 tph (218-313 mtph)	260-365 tph (236-331 mtph)	270-385 tph (245-349 mtph)
1400LS Gross Throughput	170-215 tph (154-195 mtph)	200-255 tph (181-231 mtph)	225-285 tph (204-259 mtph)	230-305 tph (209-277 mtph)	240-350 tph (218-318 mtph)	265-390 tph (240-354 mtph)	295-405 tph (268-367mtph)	315-450 tph (286-408 mtph)	330-480 tph (299-435 mtph)

Closed Circuit Capacities in Tons-Per-Hour

Closed-side Setting (CSS)	1/4" (6mm)	5/16" (8mm)	3/8" (10mm)	1/2" (13mm)	5/8" (16mm)	3/4" (19mm)	7/8" (22mm)	1" (25mm)
Recirculating Load	15%	15%	16%	20%	20%	20%	26%	28%
1200LS Gross Throughput	75-90 tph (68-82 mtph)	90-105 tph (82-95 mtph)	115-145 tph (104-132 mpth)	145-190 tph (132-172 mtph)	165-220 tph (150-200 mpth)	185-250 tph (168-227 mtph)	205-275 tph (186-250mtph)	225-300 tph (204-272 mtph)
1200LS Net Throughput	64-77 tph (58-70 mtph)	77-90 tph (70-82 mtph)	97-122 tph (88-111 mtph)	116-152 tph (105-138 mtph)	132-176 tph (120-160 mtph)	148-200 tph (134-181 mtph)	152-204 tph (138-185 mtph)	162-216 tph (147-196 mtph)
1400LS Gross Throughput	-	115-145 tph (104-132 mtph)	145-190 tph (132-172 mtph)	190-235 tph (172-213 mtph)	225-280 tph (204-254 mtph)	240-315 tph (218-286 mtph)	245-335 tph (222-304 mtph)	265-375 tph (240-340 mtph)
1400LS Net Throughput	-	98-123 tph (89-112 mtph)	122-160 tph (111-145 mtph)	152-188 tph (138-171 mtph)	180-224 tph (163-203 mpth)	192-252 tph (174-229 mtph)	181-248 tph (164-225 mtph)	191-270 tph (173-245 mtph)

Minimum closed side setting is the closest setting possible that does not induce bowl float.
Actual minimum closed side setting and production numbers will vary and are influenced by factors like nature of feed material, ability to screen out fines, manganese condition, low relief system pressure, etc.

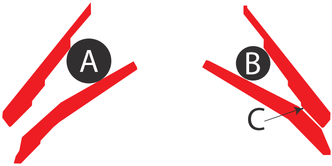
1200 / 1400 LS CONE CRUSHER GRADATION CHART

Product Size	Crusher Closed Side Setting											
	5/16″	3/8″	7/16″	1/2″	5/8″	3/4″	7/8″	1″	1 1/4″	1 1/2″	1 3/4″	2″
	7.94 mm	9.52 mm	11.11 mm	12.7 mm	15.87 mm	19.05 mm	22.22 mm	25.4 mm	32 mm	38.1 mm	44.5 mm	50.8 mm
4″												100
3 1/2″											100	96
3″										100	95	90
2 3/4″										98	92	86
2 1/2″									100	95	88	81
2 1/4″									97	91	83	74
2″								100	94	86	76	65
1 3/4″							100	97	88	79	66	55
1 1/2″						100	96	91	80	68	56	45
1 1/4″					100	97	90	83	70	56	46	38
1″				100	99	90	82	72	58	45	36	29
7/8″			100	99	93	86	74	64	48	38	30	25
3/4″		100	97	94	87	80	65	54	40	32	26	21
5/8″		98	94	87	80	69	55	46	34	28	22	18
1/2″	100	95	88	80	69	58	47	39	28	23	19	16
3/8″	91	84	73	63	52	44	37	28	21	17	14	12
5/16″	85	74	63	54	46	37	31	25	19	15	13	10
1/4″	74	61	50	44	36	32	26	21	16	13	11	9
4M	58	48	42	35	32	26	21	18	14	11	9	7
5/32″	50	41	36	30	28	23	18	15	12	10	8	6
8M	40	35	30	26	24	20	16	12	9	7	5	4
10M	35	31	26	22	20	18	14	10	8	6	4	3
16M	28	24	21	17	15	13	10	8	6	4	3	2
30M	20	18	15	11	9	8	6	5	4	3	2	1.5
40M	18	15	14	10	8	7	5	4	3	2	1.5	1
50M	14	12	12	8	7	6	4	3	2	1.5	1	0.8
100M	11	9	9	7	6	5	4	3	1.5	1	0.5	0.5
200M	8	7	6	6	5	4	3	2	1	0.5	0.5	0.3

Estimated product gradation percentages at setting shown.

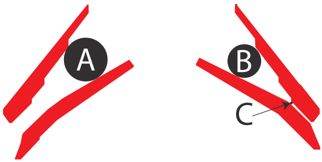
LS SERIES CRUSHER MANGANESE CONFIGURATIONS

1200LS Enlarged Feed Coarse Chamber



A	B	C
10″ (254mm)	8¾″ (222mm)	2″ (51mm)
9½″ (239mm)	8⅜″ (213mm)	1½″ (38mm)
9¼″ (235mm)	8⅛″ (206mm)	1¼″ (32mm)
9″ (229mm)	7⅞″ (200mm)	1″ (25mm)

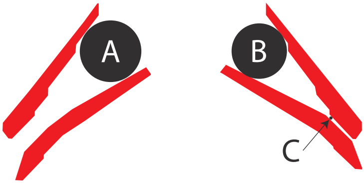
1200LS Coarse Chamber



A	B	C
9¾″ (248mm)	9″ (229mm)	2″ (51mm)
9½″ (241.3mm)	8½″ (216mm)	1½″ (38mm)
9¼″ (235mm)	8¼″ (210mm)	1¼″ (32mm)
9″ (229mm)	8″ (203mm)	1″ (25mm)

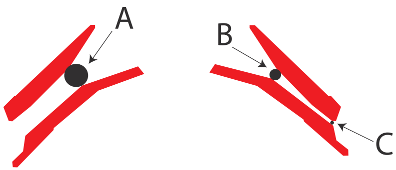
A = Open-side feed opening | B = Closed-side feed opening | C = Closed-side setting

1200LS Medium-Fine Chamber



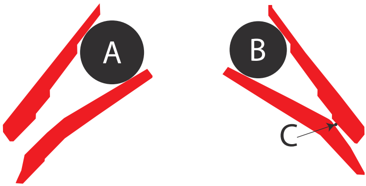
A	B	C
5¼" (133mm)	4" (102mm)	1" (25mm)
5⅛" (130mm)	3⅞" (98mm)	⅞" (22mm)
5" (127mm)	3¾" (95mm)	¾" (19mm)
4¾" (121mm)	3¾" (95mm)	½" (13mm)

1200LS Fine Chamber



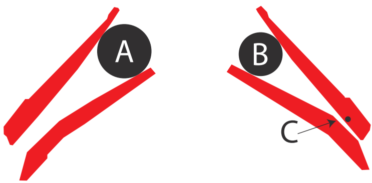
A	B	C
3" (76 mm)	1⅜" (35mm)	⅜" (10mm)
3¼" (83mm)	1⅝" (41mm)	⅝" (16mm)
3½" (89mm)	1⅞" (48mm)	⅞" (22mm)
3⅝" (92mm)	2" (51mm)	1⅛" (29mm)
4⅜" (111mm)	2¾" (70mm)	2" (51mm)

1400LS Coarse Chamber



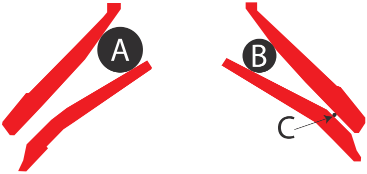
A	B	C
12" (305mm)	11¼" (286mm)	2" (51mm)
11¼" (286mm)	10¾" (273mm)	1½" (38mm)
11" (279mm)	10½" (267mm)	1¼" (32mm)
10¾" (273mm)	10¼"(260mm)	1" (25mm)

1400LS Medium Chamber



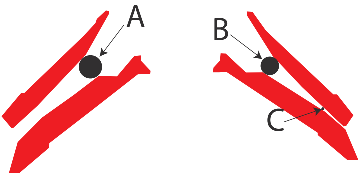
A	B	C
9½" (241mm)	8¾" (222mm)	1¼" (32mm)
9¼" (235mm)	8½" (216mm)	1" (25mm)
9⅛" (232mm)	8⅜"(213mm)	⅞" (22mm)
9" (229mm)	8¼" (210mm)	¾" (19mm)

1400LS Medium-Fine Chamber



A	B	C
5½" (140mm)	4" (102mm)	1" (25mm)
5¼" (133mm)	3¾" (95mm)	⅞" (22mm)
5⅛" (130mm)	3⅝" (92mm)	¾" (19mm)
5" (127mm)	3½" (89mm)	⅝" (16mm)

1400LS Fine Chamber

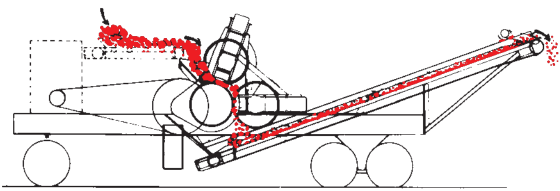


A	B	C
5½" (140mm)	4" (102mm)	1" (25mm)
5¼" (133mm)	3¾" (95mm)	⅞" (22mm)
5⅛" (130mm)	3⅝" (92mm)	¾" (19mm)
5" (127mm)	3½" (89mm)	⅝" (16mm)

ROLL CRUSHERS
APPROXIMATE TWIN AND TRIPLE ROLL CRUSHER GRADATION—OPEN CIRCUIT

Test Sieve Sizes (in.)	Roll Crusher Settings											Test Sieve Sizes (in.)
	¼″ 6.35 mm	⅜″ 9.53 mm	½″ 12.7 mm	¾″ 19 mm	1″ 25.4 mm	1¼″ 31.8 mm	1½″ 38.1 mm	2″ 50.8 mm	2½″ 63.5 mm	3″ 76.2 mm	4″ 102 mm	
8″		Values Shown are										203
6″		Percent Passing										152
5″												127
4″											85	102
3″										85	63	75.2
2½″									85	70	50	63.5
2″								85	69	54	36	50.8
1½″							85	62	50	37	26	38.1
1¼″						85	70	50	40	31	22	31.8
1″					85	70	52	38	31	25	17	25.4
¾″				85	65	50	36	27	24	19	14	19
½″			85	60	40	29	24	20	16	14	10	12.7
⅜″		85	65	40	27	22	19	15	13	11	8	9.53
¼″	85	58	41	24	19	16	14	11	9	8	5	6.35
#4	61	39	26	18	15	13	11	9	7	6	4	#4
#8	31	20	16	12	10	8	7	6	5	4	3	#8
#16	16	12	9	7	6	5	4	3	2	2	2	#16
#30	9	7	5	4	3	3	3	2	1	1	1	#30
#50	6	4	3	3	2	2	2	1	0.5	0.5	0.5	#50
#100	4	3	2	2	1	1	1	0.5	0	0	0	#100

Gradation result may be varied to greater fines content by increasing feed and corresponding horsepower.

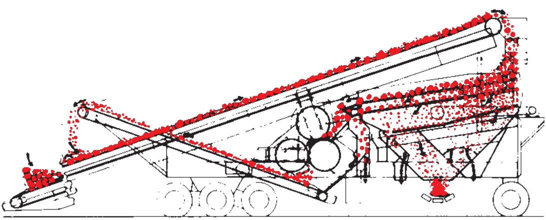


ROLL CRUSHERS APPROXIMATE TWIN AND TRIPLE ROLL CRUSHER GRADATION CLOSED CIRCUIT WITH SCREEN

Test Sieve Sizes (in.)	Roll Crusher Settings											Test Sieve Sizes (in.)
	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	
	6.35 mm	9.53 mm	12.7 mm	19 mm	25.4 mm	31.8 mm	38.1 mm	50.8 mm	63.5 mm	76.2 mm	102 mm	
4″											100	102
3″										100	79	76.2
2½″									100	91	64	63.5
2″								100	85	75	48	50.8
1½″							100	79	63	55	35	38.1
1¼″						100	90	63	50	44	29	31.8
1″					100	85	75	46	39	34	23	25.4
¾″				100	80	66	55	33	28	25	18	19
½″			100	75	55	41	33	22	20	18	13	12.7
⅜″		100	80	55	36	28	24	18	16	14	10	9.53
¼″	100	75	53	33	23	19	18	13	11	10	7	6.35
#4	80	55	35	22	17	15	14	10	9	8	5	#4
#8	40	25	19	14	12	10	9	7	6	5	3	#8
#16	18	14	11	8	7	6	5	4	3	3	2	#16
#30	11	8	6	5	4	4	3	3	2	2	1	#30
#50	7	5	4	3	3	3	2	2	1	1	.5	#50
#100	4	3	3	2	2	2	1	1	.5	.5	0	#100

Values Shown are Percent Passing

Gradation result may be varied to greater fines content by increasing feed and corresponding horsepower.



TWIN ROLL CRUSHERS RECOMMENDED HP

Size	Electric	Diesel (Continuous)
**2416	50	75
**3018	100	150
3024	125	175
**3030	200	300
**4022	150	200
4030	250	325
4240	300	400
**5424	250	325
**5536	350	475

APPROXIMATE CAPACITIES IN TPH FOR OPEN CIRCUIT

(Use 85 percent of these values in closed circuit)

	Roll Settings								
Size	¼″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″
**2416	16	31	47	63	79	94			
**3018	25	50	75	100	125	150	200		
3024	33	66	100	133	166	200	266		
**3030	41	82	125	166	207	276	344	414	
**4022	34	69	103	138	172	207	276	344	414
4030	53	106	160	213	266	320	426	532	640
4240	70	141	213	284	354	426	568	709	853
**5424	44	87	131	175	228	262	350	437	525
**5536	65	130	195	261	326	390	522	652	782

*Based on 50% of theoretical ribbon of material of 100# / ft.^{3} Bulk Density–capacity may vary as much as ± 25%. The capacity at a given setting is dependent on HP, slippage, type of shells and feed size. To find Yd.^{3} /Hr., multiply by .74. For larger settings, consult factory.

MAXIMUM FEED SIZE VS. ROLL SETTING* (INCHES)

Roll Setting	24" Dia. Rolls	30" Dia. Rolls	40" or 42" Dia. Rolls	54" or 55" Dia. Rolls
¼	½	½	⅝	¾
⅜	¾	¾	1	1⅛
½	1	1	1¼	1½
¾	1½	1½	1⅞	2¼
1	2	2	2½	3
1¼	2⅜	2⅜	2⅞	3⅜
1½	2¾	2¾	3⅛	3¾
2		3½	3¾	4½
2½			4⅜	5¼
3			5	6

*With smooth shells   No beads   Bead one shell   Bead two shells

** Not current production models

TWIN ROLL CRUSHERS RECOMMENDED HP

Size	Electric	Diesel (Continuous)
**2416	50	75
**3018	100	150
3024	125	175
**3030	200	300
**4022	150	200
4030	250	325
4240	300	400
**5424	250	325
**5536	350	475

APPROXIMATE CAPACITIES IN MT/H* FOR OPEN CIRCUIT

(Use 85 percent of these values in closed circuit)

	Roll Settings								
Size	6.35mm	12.7mm	19mm	25.4mm	31.7mm	38.1mm	50.8mm	63.5mm	76.2mm
**2416	14	28	43	57	72	85			
**3018	23	45	68	91	113	136	181		
3024	30	60	91	121	150	181	241		
**3030	37	74	113	150	188	227	301		
**4022	31	62	93	125	156	188	250	312	375
4030	48	96	145	193	241	290	386	483	580
4240	64	128	193	257	321	386	514	644	773
**5424	40	79	119	159	207	238	317	396	476
**5536	59	118	177	237	296	354	473	591	709

*Based on 50% of theoretical ribbon of material of 1600 kg / m^3 Bulk Density–capacity may vary as much as ± 25%. The capacity at a given setting is dependent on HP, slippage, type of shells and feed size. To find cubic meters per hour, multiply by 1.6. For larger settings, consult factory.

MAXIMUM FEED SIZE VS. ROLL SETTING* (MILLIMETERS)

Roll Setting	610mm Dia. Rolls	762mm Dia. Rolls	1,016 or 1,066 mm Dia. Rolls	1,372 or 1,397mm Dia. Rolls
6.35	12.7	12.7	15.9	19
9.52	19	19	25.4	28.8
12.7	25.4	25.4	31.7	38.1
19	38.1	38.1	47.6	57.1
25.4	50.8	50.8	63.5	76.2
31.7	60.3	60.3	73	85.7
38.1	69.8	69.8	79.4	95.2
50.8		88.9	95.2	114
63.5			111	133
76.2			127	152

*With smooth shells   No beads   Bead one shell   Bead two shells

** Not current production models

TRIPLE ROLL CRUSHERS RECOMMENDED HP

Size	Electric	Diesel (Continuous)
**3018	125	175
3024	150	200
**3030	250	375
**4022	200	275
4030	300	400
4240	400	525
**5424	300	400
**5536	450	600

APPROXIMATE CAPACITIES IN TPH* FOR OPEN CIRCUIT—SINGLE FEED

(Use 85 percent of these values in closed circuit single feed only)

	Roll Settings							
Size	¼″	½″	¾″	1″	1¼″	1½″	2″	2½″
**3018	37	75	112	150	187	225		
3024	52	104	156	208	260	312		
**3030	65	130	195	260	325	390		
**4022	58	117	176	234	292	350	468	584
4030	79	159	238	318	398	476	636	796
4240	105	212	317	424	530	634	848	1,061
**5424	65	131	198	262	328	392	524	655
**5536	97	195	293	391	489	586	782	977

*Based on 75% of theoretical ribbon of material of 100# / ft.^{3} Bulk Density–capacity may vary as much as ± 25%. The capacity at a given setting is dependent on HP, slippage, type of shells and feed size. To find Yd.^{3} / Hr., multiply by .74. For larger settings, consult factory.

MAXIMUM FEED SIZE VS. ROLL SETTING* (INCHES)

Smaller Setting	30" Dia. Rolls		40" or 42" Dia. Rolls		54" or 55" Dia. Rolls	
	Larger Setting	Max. Feed	Larger Setting	Max. Feed	Larger Setting	Max. Feed
¼	½	1	9⁄15	1¼	⅝	1½
⅜	¾	1½	13⁄16	1⅞	15⁄16	2¼
½	1	2	1⅛	1⅞	15⁄16	2¼
¾	1½	3	1 11⁄16	3¾	1 13⁄16	4½
1	1⅞	3½	2¼	5	2 7⁄16	6
1¼	2	3½	2½	5	2 7⁄16	6
1½	2	3½	2¾	5	3	6
2			3	5	3	6
2½			3	5	3	6

*With smooth shells No beads Bead one shell Bead two shells

** Not current production models

TRIPLE ROLL CRUSHERS RECOMMENDED HP

Size	Electric	Diesel (Continuous)
**3018	125	175
3024	150	200
**3030	250	375
**4022	200	275
4030	300	400
4240	400	525
**5424	300	400
**5536	450	600

APPROXIMATE CAPACITIES IN MT/H* FOR OPEN CIRCUIT—SINGLE FEED

(Use 85 percent of these values in closed circuit single feed only)

	Roll Settings							
Size	6.35mm	12.7mm	19mm	25.4mm	31.7mm	38.1mm	50.8mm	63.5mm
**3018	33	68	102	136	170	204		
3024	47	94	141	189	236	283		
**3030	59	118	177	236	295	354		
**4022	53	106	160	212	265	317	424	530
4030	72	144	216	288	361	432	577	722
4240	96	192	288	384	481	576	769	962
**5424	59	119	180	238	297	356	475	594
**5536	88	177	266	355	444	532	709	886

*Based on 75% of theoretical ribbon of material of 1600 kg / m^3 Bulk Density–capacity may vary as much as ± 25%. The capacity at a given setting is dependent on HP, slippage, type of shells and feed size. To find cu. meters per hour, multiply by 1.6. For larger settings, consult factory.

MAXIMUM FEED SIZE VS. ROLL SETTING* (MM)

Smaller Setting	762mm Dia. Rolls		1,016mm or 1,066mm Dia. Rolls		1,372mm or 1,397mm Dia. Rolls	
	Larger Setting	Max. Feed	Larger Setting	Max. Feed	Larger Setting	Max. Feed
6.35	12.7	25.4	14.3	31.7	15.9	38.1
9.52	19	38.1	20.6	47.6	23.8	57.1
12.7	25.4	50.8	28.6	63.5	31.7	76.2
19	38.1	76.2	42.9	95.2	46	114
25.4	47.6	88.9	57.1	127	61.9	152
31.7	50.8	88.9	63.5	127	69.8	152
38.1	50.8	88.9	69.8	127	76.2	152
50.8			76.2	127	76.2	152
63.5			76.2	127	76.2	152

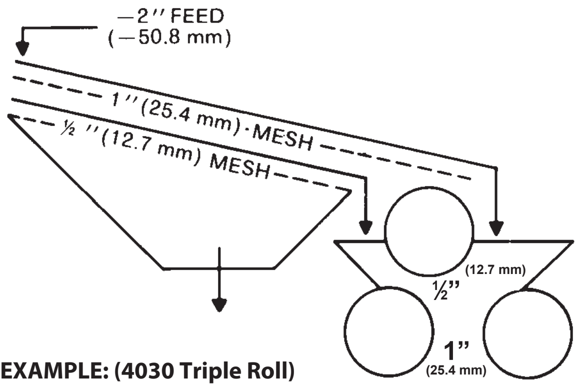
*With smooth shells No beads Bead one shell Bead two shells

** Not current production models

CAPACITY MULTIPLIERS FOR OPEN CIRCUIT TWIN FEED VS. SINGLE FEED TRIPLE ROLLS

Triple roll twin feed capacities are obtained by selecting a multiplier from the chart (depending on coarse/fine feed ratio) and applying the same to the single feed triple roll capacity. Roll crusher capacities at given settings will vary depending on horsepower available, slippage of feed on shells in crushing chamber, type of shells and size of feed. Based on a reduction ratio of 2:1 in each stage.

Feed Split Ratio Coarse/Fine	Capacity Through Crusher	Capacity That is Product Size
20/80	0.83	0.73
30/70	0.97	0.77
40/60	1.13	0.85
50/50	1.35	0.95
60/40	1.66	1.12
67/33	2	1.3
70/30	1.95	1.24
80/20	1.75	1.04
90/10	1.55	0.82



EXAMPLE: (4030 Triple Roll)

(1) Single feed capacity for ½"—(12.7 mm—) Product = 159 TPH (144 t/h).

(2) Twin feed capacity with "feed split ratio coarse/fine" 67/33 is 159 x 2 = 318 TPH (144 x 2 = 288 mt/h).

(3) Single feed open circuit product 159 x .85 = 135 TPH (144 x .85 = 122 mt/h).

(4) Twin feed open circuit product is 159 x .85 x 1.3 = 175 TPH (144 x .85 x 1.3 = 159 mt/h).

DETAIL DATA FOR ROLL CRUSHER PERFORMANCE (TWIN ROLLS)

Unit	No. of Teeth		Counter-shaft RPM	Shell FPM	Rubber Tires Working Centers (in)	Star Gears Working Centers, Inches	No. of Springs Per Roll
	Pinion	Gear					
**2416	15	68	270	346	—	22¼-25¾	2
**3018	17	82	325	530	—	28¼-33	2
3024	17	82	325	530	30-32 (7 x 18)	28¼-33	2
**3030	19	73	300	623	30-32 (7 x 18)	—	8
**4022	18	103	325	600	39-42 (10 x 22) 40-43 (11 x 22)	37½-42½	8
4030	19	91	310	680	39-42 (10 x 22) 40-43 (11 x 22)	37½-42½	8
4240	17	88	320	680	41-45	—	8
**5424	19	118	310	700	53-58 (12 x 36)	53-57	8 8 8
**5536	17	88	250	700	53-58 (12 x 36)	—	12

DETAIL DATA FOR ROLL CRUSHER PERFORMANCE (TRIPLE ROLLS)

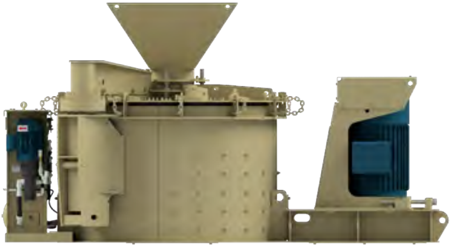
Unit	No. of Teeth		Counter-shaft RPM	Shell FPM	Rubber Tires Working Centers, In.	Star Gears Working Centers, Inches	No. of Springs Per Roll
	Pinion	Gear					
** 3018	17	82	325	530	—	28¼-33	2 2 2
3024	18	82	325	555	30-32 (7 x 18)	28¼-33	2
** 3030	19	73	300	623	30-32 (7 x 18)	—	8
** 4022	19	91	310	680	39-42 (10 x 22) 40-43 (11 x 22)	37½-42½	8 8 8
4030	19	91	310	680	39-42 (10 x 22) 40-43 (11 x 22)	37½-42½	8 8
4240	17	88	320	680	41-45	—	12
** 5424	19	118	310	700	53-58 (12 x 36)	53-57	8 8 8 8
** 5536	17	88	250	700	53-58 (12 x 36)	—	12

** Out-of-production models

VERTICAL SHAFT IMPACT CRUSHER

Portable

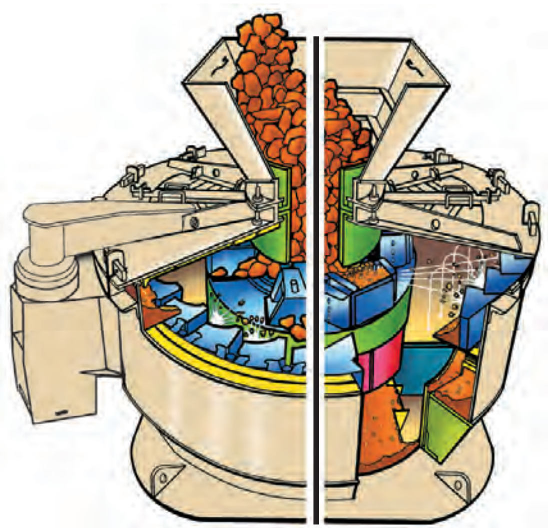
Stationary Plant



Bare Unit

VERTICAL SHAFT IMPACT CRUSHER OPERATION

These vertical shaft impact crushers are best applied in tertiary and quaternary applications and various secondary applications. Rock fed to the crusher's accelerator mechanism (table or rotor) is flung outwards by centrifugal force against the stationary anvils or hybrid rock shelf for free-body impacting. The proper chamber configuration is application dependent.



VERTICAL SHAFT IMPACT CRUSHER—Specifications and Production Characteristics

Model	Maximum Feed Size (1)		Minimum Recommed Closed Circuit	Feed Tube Diameter	Capacity Effective Crushing Range (2)		Standard Impeller Table Speed Range	Recommend-ed Electric Horsepower	Table/Anvil Clear-ance		Explosion Chamber Volume	EV-Models WK^2	Approximate Weight (Electric Shown)	
	in.	mm	Mesh	in.	tph	mtph	RPM	HP	in.	mm	in^3	lb/ft	lb	kg
1500 (H)	2	50	#16	8½	75-125	67-112	720-2,000	75-150	10.4	260	4,635	1,100	13,200	6,000
1500 (A)	2	50	#4	8½	75-150	67-135	720-2,000	150	—	—	4,635	1,100	13,700	6,000
2500 (H)	3	75	#16	11⅜	150-250	135-223	700-1,400	250	8.8	220	10,120	2,400	18,000	8,182
2500 (A)	2	50	#4	11⅜	150-300	135-267	700-1,400	300	—	—	10,120	2,400	19,000	8,182
82	3	75	#16	14	250-400	227-356	800-1,200	400-500	8.7	218	10,940	3,200	24,000	11,000
3500(H)	3	75	#16	14	250-400	227-356	800-1,200	400-500	8.7	218	10,940	3,200	24,000	11,000
3500(A)	2	50	#4	14	250-400	227-356	800-1,200	400-500	8.7	218	10,940	3,200	24,000	11,000
4500 (H)	3	75	#4	16	300-450	267-401	800-1,200	400-500	10.25	256	17,360	3,830	29,600	13,320
4500 (H)	5	125	⅜″	16	300-450	267-401	800-1,200	400-500	11.75	294	17,360	3,830	29,600	13,320
4500 (A)	2 ½	63	#4	16	300-500	267-445	800-1,200	400-500	—	—	17,360	3,500	29,100	13,320
120	6	150	⅜″	18	300-500	267-445	800-1,080	400-600	14.75	369	26,020	5,600	32,100	14,595

NOTE: (H) in the model number denotes hardparts configuration also referred to as "standard configuration." (A) in the model number denotes autogenous configuration. The specification and production rates shown apply to semi- and fully-autogenous configurations. (1) Max feed size restriction can vary with regards to material density, crushability, elongation and impeller table speed or configuration. (2) Feed size and throughput tonnage based on material weighing 100 lbs. per cubic foot.

Secondary			AVERAGE MATERIALS CRUSHER OUTPUT, (2) USING 3-SHOE/4-SHOE IMPELLER		
			Max. Speed	80% of Max. Speed Output	50% of Max. Speed Ouput
Sieve Size (in)	Sieve Size (mm)	Feed Scalped at 1½" (1)	% Passing		
6″	152mm				
5″	125mm				100%
4″	100mm			100%	99
3″	75mm		100%	99	97
2″	50mm		96	91	86
1½″	37.5mm		90	81	70
1¼″	31.5mm		86	77	63
1″	25.0mm		78	68	52
⅞″	22.4mm		74	64	48
¾″	19.0mm		68	56	40
⅝″	16.0mm		62	51	36
½″	12.5mm		53	42	30
⅜″	9.5mm		44	34	24
¼″	6.3mm		35	27	19
#4M	4.75mm		29	24	16
#8M	2.36mm		17	15	11
#16M	1.18mm		14	13	8
#30M	600um		10	9	6
#50M	300um		7	6	4
#100M	150uM		5	4	3
#200M	75uM		3	2	2

	Model 4500	Model 120
Max Feed Size Range “Cubed”	4-5″ (100-125 mm)	5-6″ (125-150 mm)
Crusher Throughput	300-450 TPH	300-500 TPH

SECONDARY CRUSHING AVERAGE MATERIALS (BASALT, HARD LIMESTONE, GRAVEL/DOLOMITE) W/ STANDARD CONFIGURATION

NOTE:

(1) Feeds shown are typical feed gradations when following a primary jaw set at 3″ to 4″ or a primary impactor set at 2″ to 3″ with product-sized material removed.

(2) Crusher outputs show average values based on field experience- and are taken before screening product-sized material out. The figures are provided for estimating required screen areas and tertiary crushing equipment when used with the expected tonnage of crusher throughput. Values will differ with each specific crushing application; these figures are not guarantees. Factors that can affect output gradation include: feed gradation, feed tonnage, feed friability, impeller table configuration, impeller speed, moisture content, closed circuit screen cloth opening, available screen area, horsepower, etc.

Typical Limestone in Standard Configuration

PRODUCING A COARSE GRADED MATERIAL, EMPHASIS ON CHIPS, POPCORN AND DIMENSIONAL PRODUCTS

	Maximum Feed Size: "Cubed"	Crusher Throughput Capacity
Model 1500H	2" (50mm)	75-125 TPH
Model 2500H	3" (75mm)	150-250 TPH
Model 82	3" (75mm)	250-400 TPH
Model 3500H	3" (75mm)	250-400 TPH

Typical coarse gradations require 50-80% maximum speed and 3- or 4-shoe table. Typically dense gradations require 70-100% maximum speed, 4- or 5-shoe table.

Tertiary

		Models 1500H, 2500H, 82H					
		3" Feed		2" Feed		1" Feed	
Sieve Size (in)	Sieve Size (mm)	Feed	Typical Output	Feed	Typical Output	Feed	Typical Output
3"	75mm		100%				
2"	50mm		98		100%		
11/2"	37.5mm		94		98		
1"	25mm		83		90		100%
3/4"	19mm		69		78		95
1/2"	12.5mm		52		60		80
3/8"	9.5mm		40		46		62
1/4"	6.3mm		28		33		40
#4M	4.75mm		20		24		30
#8M	2mm		14		15		15
#16M	1.18mm		9		10		10
#30M	600uM		6		7		7
#50M	300uM		4		5		5
#100M	150uM		3		4		4
#200M	75uM		2		3		3

Tertiary		Models 1500H, 2500H, 82H					
Sieve Size (in)	Sieve Size (mm)	3″ Feed		2" Feed		1" Feed	
		Feed	Typical Output	Feed	Typical Output	Feed	Typical Output
3″	75mm		100%				
2″	50mm		98				
1½″	37.5mm		95		100%		
1″	25mm		87		94		100%
¾″	19mm		79		85		99
½″	12.5mm		68		73		90
⅜″	9.5mm		57		62		78
¼″	6.3mm		46		49		63
#4M	4.75mm		37		40		52
#8M	2mm		26		27		33
#16M	1.18mm		17		18		21
#30M	600uM		11		12		15
#50M	300uM		7		8		10
#100M	150uM		5		6		6
#200M	75uM		4		4		4

Typical Limestone in Standard Configuration

PRODUCING A DENSE GRADED MATERIAL, EMPHASIS ON FINES FOR BASE, ASPHALT MATERIAL, SAND SUPPLEMENT, ETC.

Feeds: Typical feeds shown have been screened to take out product-sized material and are initial feed plus recirculating load.

Outputs: These outputs show average values based on field experience crushing tough material and indicate crusher output before screening product-sized material out. Gradation change is due to increased impeller speed from 50 to 100% of maximum and a difference of impeller table configuration. Values will differ for each specific crushing application. Factors that can affect output gradation include: feed gradation, feed tonnage, feed friability, impeller table configuration, impeller speed, moisture content, closed circuit screen cloth opening, available screen area, horsepower, etc.

Quaternary		Models 1500H, 2500H, 82H				
Sieve Size (in)	Sieve Size (mm)	Approx. Crusher Output				
		Feed	Low Range	High Range	Average	High Range Screened at #4M*
1″	25mm		100%	100%	100%	
¾″	19mm		95	99	97	
½″	12.5mm		80	90	85	
⅜″	9.5mm		62	78	70	
¼″	6.3mm		40	63	52	
#4	4.75mm		30	52	41	100%
#8	2.36mm		15	33	24	75
#16	1.18mm		10	21	15	48
#30	600uM		6	15	11	34
#50	300uM		5	10	7	22
#100	150uM		4	6	5	13
#200	75uM		3	4	3	9

Typical Limestone in Standard Configuration

1" FEED SIZE APPLICATIONS

Models 1500H, 2500H, 82, 3500H

Crushing 1″ top feed size for chips, popcorn, fracture count or a manufactured sweetener.

Low Range

Resulting from:

- Tough feed material
- Impeller speeds 50-80% of max.
- Crusher choke-fed
- 3- or 4-shoe table

High Range

Resulting from:

- Moderately tough to moderately friable feed material
- Impeller speeds 80-100% of max
- Crusher fed 85% of choke-feed rate, or less
- 5-shoe table

* Shows high range with the effect of normal field screening inefficiencies. A proportional return of the coarse screen through fractions and hydraulic classification to remove a portion of the #100 mesh minus is usually required to meet ASTM C-33 specifications regarding a #4M minus gradation.

Quaternary			Models 1500A, 2500A, 4500A	
		1½" Feed	Fully Autogenous 100% Speed	Semi-Autogenous 100% Speed
2″	50mm			
1½″	37.5mm		100%	
1¼″	31mm		99	100%
1″	25mm		95	96
¾″	19mm		90	90
½″	12.5mm		70	76
⅜″	9.5mm		56	58
¼″	6.3mm		38	45
#4M	4.75mm		31	37
#8M	2mm		22	25
#16M	1.18mm		15	17
#30M	600uM		11	13
#50M	300uM		8	8
#100M	150uM		6	5
#200M	75uM		4	3

Typical Sand and Gravel in Autogenous and Semi-Autogenous Configuration

	Maximum Feed Size: "Cubed"	Crusher Throughput Capacity
Model 1500A	2″	75-150 TPH
Model 2500A	2″	150-300 TPH
Model 3500A	2″	250-400 TPH
Model 4500A	2½″	300-500 TPH

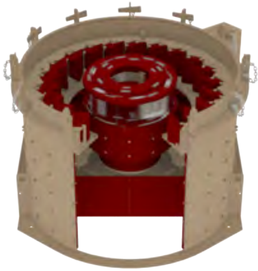
Based upon material weighing 2,700 lbs. per cubic yard (1600 kg/m^3). Capacities may vary as much as ±25% dependent upon methods of loading, characteristics and gradation of material, condition of equipment and other factors.

VERTICAL SHAFT IMPACT CRUSHER CRUSHING CHAMBER TERMINOLOGY

FULLY AUTOGENOUS

ROTOR & HYBRID ROCK SHELF

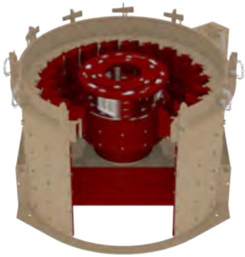
Rock-on-rock crushing; rotor flings rock against rock bed on outer hybrid rock shelf, and exposed portion of anvils lining the hybrid rock shelf for free-body impacting. Variable reduction ratios up to 12:1.



SEMI-AUTOGENOUS

ROTOR & ANVIL

Crushing chamber has autogenous rotor and standard stationary anvils for specialized crushing and materials problems; 1½-2″ feed sizes and variable reduction ratios up to 12:1.



STANDARD CONFIGURATION

SHOE & ANVIL

Impeller shoes in chamber fling rock at true right angles to stationary anvils; rock gradations controlled by impeller table speed. Variable reduction ratios up to 12:1.

SCALPING SCREEN SIZING FORMULA

$$\text{Scalping area} = \frac{\text{Tons / hour of undersized material in the feed}}{\text{Capacity per square feet ("C") x modifying factors "O" and "F"}}$$

CAPACITY FACTOR "C" SIZE OF OPENING (IN.)	FACTOR "C"	
	PERFORATED PLATE	GRIZZLY BARS
2	4.1	6.1
3	5.4	8.1
4	6.7	10.0
5	8.6	15.0
6	9.8	17.2
7	10.9	19.1
8	11.6	23.2
9	12.5	25.0
10	13.5	27.0

MODIFYING FACTOR "O" FOR PERCENT OF OVERSIZED MATERIAL IN THE FEED

%	FACTOR
10	1.05
20	1.01
30	.98
40	.95
50	.90
60	.86
70	.80
80	.70
85	.64
90	.55

MODIFYING FACTOR "F" FOR PERCENT PASSING HOLES HALF-SIZE OF OPENING

%	FACTOR
10	.55
20	.70
30	.80
40	1.00
50	1.20
60	1.40
70	1.80
80	2.20
85	2.50
90	3.00

STANDARD HOPPER APPROXIMATE CAPACITIES VIBRATING FEEDERS

Standard Feeder Size			yd^3	m^3
30" x 12'	(762mm x 3.7m)	-	5.5	4.2
30" x 12'	(762mm x 3.7m)	Extension	7.2	5.5
36" x 14'	(914mm x 4.3m)	-	7.2	5.5
36" x 14'	(914mm x 4.3m)	Extension	12.6	9.6
36" x 16'	(914mm x 4.9m)	-	8.2	6.3
36" x 16'	(914mm x 4.9m)	Extension	14.4	11.0
42" x 15'	(1,067mm x 4.6m)	-	9.0	6.9
42" x 15'	(1,067mm x 4.6m)	Extension	18.0	13.8
42" x 17'	(1,067mm x 5.2m)	-	10.2	7.8
42" x 17'	(1,067mm x 5.2m)	Extension	20.4	15.6
42" x 18'	(1,067mm x 5.5m)	-	10.0	8.2
42" x 18'	(1,067mm x 5.5m)	Extension	21.6	16.5
42" x 20'	(1,067mm x 6.2m)	-	12.0	9.2
42" x 20'	(1,067mm x 6.2m)	Extension	24.0	18.4
50" x 16'	(1,270mm x 4.9m)	-	11.0	8.4
50" x 16'	(1,270mm x 4.9m)	Extension	21.6	16.5
50" x 18'	(1,270mm x 5.5m)	-	12.6	9.6
50" x 18'	(1,270mm x 5.5m)	Extension	24.3	18.6
50" x 20'	(1,270mm x 6.1m)	-	14.0	10.7
50" x 20'	(1,270mm x 6.1m)	Extension	27.0	20.6
60" x 24'	(1,524mm x 7.3m)	-	19.6	15.0
60" x 24'	(1,524mm x 7.3m)	Extension	43.0	32.9

SCREENING THEORY

Screening is defined as a mechanical process that separates particles on the basis of size. Particles are presented to a multitude of apertures in a screening surface and rejected if larger than the opening, or accepted and passed through if smaller. The feed material is delivered to one end of the screening surface. Assuming that the openings in the screening media are all the same size, movement of the material across the surface will produce two products. The material rejected by the apertures (overs) discharges over the far end, while the material accepted by the apertures (throughs) pass through the openings.

As a single particle approaches the screening media, it could come into contact with the solid wire or plate that makes up the screen media, or pass completely through the open hole. If the size of the particle is relatively small when compared to the openings, there is a high degree of probability that it will pass through one of them before it reaches the end of the screen. Conversely, when the particle is relatively large, or close to the same size as the opening, there is a high degree of probability that it will pass over the entire screen and be rejected to the overs. If the movement of the particle is very rapid, it might bounce from wire to wire and never reach an aperture for sizing. The velocity of the particle, the incline of the screen and the thickness of the wire all tend to reduce the effective dimensions of the openings and make accurate sizing more difficult. It becomes apparent that this simplified screen would perform much better if the following conditions prevailed:

1. Each particle is delivered individually to an aperture.
2. The particle arrives at the opening with zero forward velocity.
3. The particle traveled normal to the screen surface.
4. The smallest dimension of the particle was centered on the opening.
5. Screening surface has little or no thickness.

As material flows over a vibrating screening surface, it tends to develop fluid-like characteristics. The larger particles rise to the top, while the smaller particles sift through the voids and find their way to the bottom of the material bed. This phenomenon of differentiation is called stratification. Without stratification of the material, there would be no opportunity for the small particles to get to the bottom of the material bed and pass through the screen apertures causing separation of material by size.

After the material has been stratified to allow the passage of throughs, the apertures are then blocked with oversize particles that were above the fines in the material bed. Before passage of more fines can occur, the bed must be re-stratified so the fines are again at the bottom of the bed and available for passage. Thus, the process must be repeated successively until all fines are passed.

Potential occurrences that can prevent successful screening include:

1. Arrival of several particles at an aperture, with the result that none succeed in passing even though all are undersized
2. Oversized particles plugging the openings so that undersized cannot pass though
3. Undersized particles blinding the apertures by sticking to the screening media, which reduces the opening and prevents undersized particles from passing
4. Oblique impact of near-sized particles bouncing off the sides of the aperture, reducing efficiency

There are two basic styles of vibrating gradation screens manufactured to perform the material separation process. These include inclined screens and horizontal screens. Within these two broad definitions are many different variations, which affect the screening action and mounting systems.

Incline Screens are most commonly built with single eccentric shafts that create a circular motion. Dual-shaft incline screens may be considered for heavier-duty applications. Incline screens utilize gravity, as well as the circular eccentric motion, to perform the screening operation. Depending on the application, incline screens run at angles of 10-45 degrees. The high frequency screen, a type of incline screen, typically operates at a very steep angle with fine openings. A primary feature of the incline screen is its low operating cost. It may also have a lower operating cost by using less horsepower and having fewer shafts and bearings.

Facts about Incline Screens:

1. Incline screens have an operating angle of typically 10-35 degrees.
2. Incline Screens produce a higher material travel speed and a thinner bed depth than a flat screen, reducing the potential for material spill-over from volumetric surges.
3. Size-for-size, incline screens are more economical in terms of capital expenditure than a flat screen, and requires fewer shaft assemblies and parts to maintain and replace.
4. The increased profile height provides more accessibility for maintenance, screen media changes, etc.
5. The circular stroke pattern produces fewer "G's" than flat screens, providing more of a "tumbling" motion. The material has a tendency to pick up velocity as it moves down the deck.
6. Incline Screens can be configured to retain material on the decks longer by rotating the screen's direction, essentially throwing the material backwards.

Based on this data, an Inclined Screen is recommended when the following conditions exist:

- The producer has a relatively consistent feed volume and gradation to the screen.
- The desired results can be achieved with the stroke pattern being produced by a single or dual shaft assembly.
- The material is relatively dry (in dry applications) and does not plug the opening.
- All of the above are true and the producer does not require a low-profile height.
- Large volumetric surges of material that could potentially

spill over the rear and sides of flat screens are frequent.

- A replacement screen is required to fit within existing or fixed screen towers/structures.
- The economics of capital expenditure and maintenance are top priority.

Horizontal Screens are utilized as a low-height, aggressive action screening devices. Horizontal screens are built with a dual shaft, (creating a straight line action at approximately 45 degrees to the horizontal) or triple shaft (creating an oval action with adjustable stroke angle typically between 30 and 60 degrees from horizontal). A primary feature of the horizontal screen is its aggressive action in applications where blinding or plugging of the screen media openings can occur.

Facts about Horizontal Screens:

1. Horizontal screens provide a lower profile height for increased suitability on portable plants.
2. Horizontal screens generate more "G" force required to dislodge particles that might potentially blind incline screens.
3. Horizontal screens produce an oval stroke pattern that can be adjusted to suit the application for increased flexibility through manipulating stroke length and timing angle.
4. The triple-shaft assembly distributes the load over more bearings and larger bearings; extending the life of the shaft assembly components.
5. Horizontal screens produce a consistent material travel speed along the entire length of the deck. The screen can also be configured to enable a slower travel speed than incline screens for higher efficiency.
6. The relationship of the trajectory to the screening media is at a true right angle, where incline screens essentially reduce the amount of open area. Incline screen operators often compensate for this by installing cloth with slightly larger openings than the desired top size.

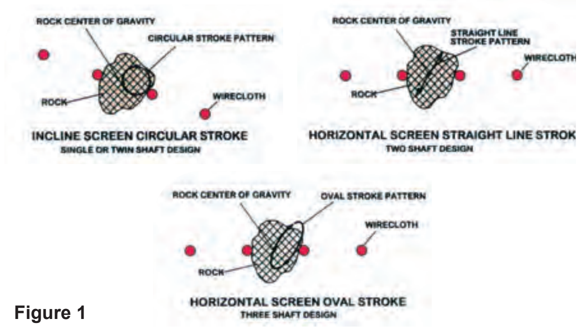


Figure 1

Based on this data, a Horizontal Screen is recommended when the following conditions exist:

- The producer requires portability to move between various sites or a lower profile height is required.
- The incoming feed gradation is inconsistent.
- When screening efficiency/reduced carryover is a priority.
- The screen is to be used in more than one application.
- A slow, consistent material travel speed is required on any or all of the decks.
- The material has a tendency to plug or blind the screen cloth.

The variations in the stroke patterns of incline and horizontal screens are illustrated in Figure 1.

Screening Revelations

In 2001, Johnson Crushers International, Inc. (JCI) performed a side-by-side test between flat and incline screens in an effort to better understand the benefits and limitations of both designs. This data has led to the development of the new combo screen design, which was also tested and compared. Listed below is a general recap of the observations that were made.

Multi-Slope Combo Screen

The combo screens utilize both inclined panels and horizontal panels:

1. Inclined panel sections increase material travel speed, thus producing thinner bed depths enabling fines to be introduced to the horizontal bottom deck faster, which increases the bottom deck screening capacity, or bottom deck factor used in the VSMA screen calculation.
2. Increased travel speed produced by incline sections reduces potential for material spillover caused by volumetric surges.
3. Horizontal panels reduce travel speed and provide high screening efficiency and reduced carryover, similar to a flat screen.
4. The combo screen is the only multi-slope design that utilizes a triple-shaft assembly, producing oval screening motion with the ability to adjust stroke length, stroke angle, and RPM speed to best suit the conditions of the application.
5. A hybrid punch-plate in the feed area provides an additional 10% of screening area, thereby removing a percentage of fines before being introduced to the actual deck.

Based on this data, a combo screen is recommended when the following conditions exist:

- A high percentage of fines exists in the feed material that must be separated efficiently.
- Increased screen capacity is required within the same structure of "footprint."
- An incline screen cannot produce the desired screening efficiency of separation found on horizontal screens.
- Producers need to reduce material "spillover" caused by volumetric surges of feed coupled with a slower travel speed of a flat screen.
- A single "dual purpose" screen is required to separate both coarse and fine particles.
- An incline screen is preferred, but cannot be installed due to height restrictions or limitations.

NOTES:

VSMA FACTORS FOR CALCULATING SCREEN AREA

Formula: Screening Area = $\dfrac{U}{A \times B \times C \times D \times E \times F \times G \times H \times J}$

***Basic Operating Conditions**

Feed to screening deck contains 25% oversize and 40% halfsize
Feed is granular free-flowing material
Material weighs 100 lbs. per cu. ft.
Operating slope of screen is: Inclined Screen 18° - 20° with flow rotation
Horizontal Screen 0°
Objective Screening Efficiency—95%

**Furnished by VSMA

U = STPH Passing Specified Aperture

FACTOR "A"

Surface Square Opening	% Open Area	STPH Passing A sq. ft.
4″	75%	7.69
3½″	77%	7.03
3″	74%	6.17
2¾″	74%	5.85
2½″	72%	5.52
2″	71%	4.9
1¾″	68%	4.51
1½″	69%	4.2
1¼″	66%	3.89
1″	64%	3.56
⅞″	63%	3.38
¾″	61%	3.08
⅝″	59%	2.82
½″	54%	2.47
⅜″	51%	2.08
¼″	46%	1.6
3⁄16″	45%	1.27
⅛″	40%	0.95
3⁄32″	45%	0.76
1⁄16″	37%	0.58
1⁄32″	41%	0.39

FACTOR "B"

(Percent of Oversize in Feed to Deck)

% Oversize	5	10	15	20	25	30	35
Factor B	1.21	1.13	1.08	1.02	1	0.96	0.92
% Oversize	40	45	50	55	60	65	70
Factor B	0.88	0.84	0.79	0.75	0.7	0.66	0.62
% Oversize	75	80	85	90	95		
Factor B	0.58	0.53	0.5	0.46	0.33		

FACTOR "C"

(Percent of Halfsize in Feed to Deck)

% Halfsize	0	5	10	15	20	25	30
Factor C	0.4	0.45	0.5	0.55	0.6	0.7	0.8
% Halfsize	35	40	45	50	55	60	65
Factor C	0.9	1	1.1	1.2	1.3	1.4	1.55
% Halfsize	70	75	80	85	90		
Factor C	1.70	1.85	2	2.2	2.4		

FACTOR "D"

(Deck Location)

Deck	Top	Second	Third
Factor D	1.00	.90	.80

FACTOR "E"

(Wet Screening)

Opening	1⁄32″	1⁄16″	⅛″	3⁄16″	¼″	⅜″	½″	¾″	1″
Factor E	1.00	1.25	2	2.5	2	1.75	1.4	1.3	1.25

FACTOR "F"

(Material Weight)

Lbs./cu.ft.	150	125	100	90	80	75	70	60	50	30
Factor F	1.5	1.25	1	0.9	0.8	0.75	0.7	0.6	0.5	0.3

FACTOR "G"

(Screen Surface Open Area)

Factor "G" = $\dfrac{\text{\% Open Area of Surface Being Used}}{\text{\% Open Area Indicated in Capacity}}$

FACTOR "H"

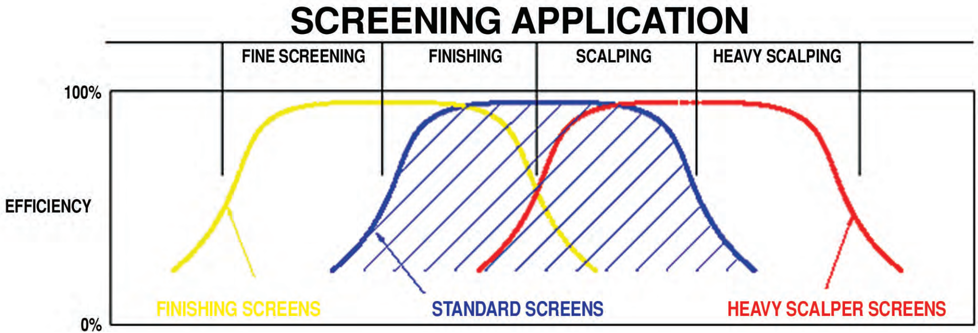
(Shape of Surface Opening)

Square	1.00
Short Slot (3 to 4 times Width)	1.15
Long Slot (More than 4 Times Width)	1.20

FACTOR "J"

(Efficiency)

95%	1.00
90%	1.15
85%	1.35
80%	1.50
75%	1.70
70%	1.90



Small rock (0 - 3/16”)	⟷	Big rock (+ 24”)
Small opening (-8 MESH)	⟷	Large Opeing (+ 7”)
High speed (+ 1600 RPM)	⟷	Slow speed (- 650 RPM)
Small stoke (- 1/32”)	⟷	Large stroke (+ 3/4”)
More slope (+ 45°)	INCLINE SCREEN ⟷	Less slope (0 - 10°)
Steeper timing angle (more vertical)	HORIZONTAL SCREEN ⟷	Flatter timing angle (more horizontal)

NOTE: The above are general screening guidelines only. Application and material characteristics will vary each operating parameter to achieve maximum screening efficiency.

SCREEN MATRIX

MODEL	FINE SCREENING	STANDARD SCREENING	LIGHT SCALPING	MEDIUM SCALPING	HEAVY SCALPING	MAXIMUM MATERIAL SIZE (IN.)a	MAXIMUM OPENING SIZE (IN.)	SPEED RPMb	MAXIMUM STROKE (INCHES)g	SLOPE (DEGREES)
JCI SCREENS “SI” Inclined (single shaft)	x	x	x			10	4	800-1150	3/8b	15-25
“DI” Inclined (dual shaft)	x	x	x			10	4	750-1050	1/2b	15-25
Cascade Incline	x	x				10	4	750-1000	1/2b	10-25
“XH” Flat Extra Heavy Scalper			x	x	x	24	8 grizzly bar	575-775	7/8	2 on top 0 on bottom
“LP” Flat Standard Screen	x	x	x			10	5f	675-875	3/4	0
“CS” Combo Screen	x	x	x	x		10	5	675-875	3/4	multiple
“MS” Flat Medium Scalper		x	x	x		14	5	675-875	3/4	2 on top 0 on bottom
“HS” Flat Heavy Scalper			x	x	x	18	6	575-775	7/8	2 on top 0 on bottom
“FS” Flat Finishing Screen	x	x				8	2	875-1075	1/2	0
Mesabi			x	x	x	36	grizzly bar	800	7/16	12

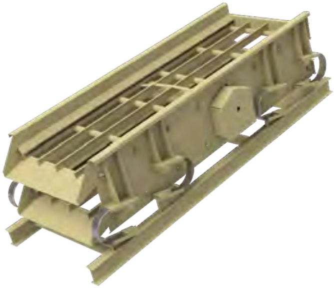
a - controlled feed drop height required, <24” drop for material size to 12”, <18” drop for material size to 36” **b** - slower speed must be used with maximum stroke, stroke must be less with higher speeds **c** - grizzly bar opening can be wider dependent on bar design **d**- 5” max opening on 5x14, 5x16, 6x16 screens; 4” max opening on 6x20, 7x20, 8x20 **e** - maximum stroke is dependent upon various factors such as media weight.

SCREEN MATRIX

MODEL	FINE SCREENING	STANDARD SCREENING	LIGHT SCALPING	MEDIUM SCALPING	HEAVY SCALPING	MAXIMUM MATERIAL SIZE (IN.)a	MAXIMUM OPENING SIZE (IN.)	SPEED RPM	MAXIMUM STROKE (INCHES)	SLOPE (DEGREES)
KOLBERG SCREENS										
71 Standard Inclined	X	X				5	2.5	1,100-1,500	1/4	10-15
72 Desander Inclined	X	X				5	2.5	1,100-1,300	3/16	25-35
72 Grizzly Inclined		X				10	3c	1,000-1,200	5/16	10-15
PIONEER SCREENS										
High Inclined	X	X				6	3	950-1,050	3/16	18-22
Standard Inclined	X	X	X			12	4	850-950	3/8	10d
Mesabi Standard Duty			X	X	X	24	6c	950-1,000	3/8e	10-12
Mesabi Heavy Duty			X	X	X	36	7c	900	3/8e	10-15

a - controlled feed drop height required, <24″ drop for material size to 12″, <18″ drop for material size to 36″ **b** - slower speed must be used with maximum stroke, stroke must be less with higher speeds **c** - grizzly bar opening can be wider dependent on bar design **d** - 8x20 screen operates at 15 degrees **e** - single shaft with 4 bearings, fixed stroke **f** - 5″ max opening on 5x14, 5x16, 6x16 screens; 4″ max opening on 6x20, 7x20, 8x20 **g** - maximum stroke is 5/8″ to 3/4″ depending on screen speed

INCLINE SCREENS



Series 70: screens are two bearing inclined screens and include base frame with C spring suspension and electric motor drives. These screens are a medium/light-duty screens and are typically used to size material down to #4 mesh and up to 3" maximum. They are available in a range of sizes from 2′ x 4′ to 5′ x 12′.

Series 71 screens are "Conventional" screens and are available in single, double- or triple-deck configurations. Each deck has side-tensioned cloth. They operate at an incline of approximately 15°.

SINGLE DECK

Model	Size	Speed (RPM)	Motor
71-1D244	24″ x 4′	15-1,700	2 hp
71-1D366	36″ x 6′	14-1,600	3 hp
71-1D368	36″ x 8′	14-1,600	3 hp
71-1D486	48″ x 6′	14-1,600	3 hp
71-1D488	48″ x 8′	13-1,500	5 hp
71-1D4810	48″ x 10′	13-1,500	5 hp
71-1D4812	48″ x 10′	13-1,500	7½ hp
71-1D6010	60″ x 10′	13-1,500	5 hp
71-1D6012	60″ x 12′	13-1,500	7½ hp
71-1D6014	60″ x 14′	11-1,300	10 hp

DOUBLE DECK

Model	Size	Speed (RPM)	Motor
71-2D366	36″ x 6′	14-1,600	3 hp
71-2D486	48″ x 6′	13-1,500	5 hp
71-2D488	48″ x 8′	13-1,500	7½ hp
71-2D4810	48″ x 10′	11-1,300	10 hp
71-2D4812	48″ x 12′	11-1,300	10 hp
71-2D6010	60″ x 10′	11-1,300	10 hp
71-2D6012	60″ x 12′	11-1,300	10 hp
71-2D6014	60″ x 14′	11-1,300	10 hp

TRIPLE DECK

Model	Size	Speed (RPM)	Motor
71-3D366	36″ x 6′	13-1,500	5 hp
71-3D488	48″ x 8′	11-1,300	10 hp
71-3D4810	48″ x 10′	11-1,300	10 hp

Series 72 screens are de-sanders and are available in a double-deck configuration. The top deck cloth is side-tensioned and the bottom deck cloth is end tensioned – harp wire type. They operate at an incline of 15° to 50°.

DOUBLE DECK

Model	Size	Speed	Motor
72-2D488	48″ x 8′	11-1,300	7½ HP
72-2D4810	48″ x 10′	11-1,300	10 HP
72-2D4812	48″ x 12′	11-1,300	10 HP
72-2D6010	60″ x 10′	11-1,300	10 HP
72-2D6012	60″ x 12′	11-1,300	10 HP

Series 77 screens are vibrating grizzly screens and are available in single- or double-deck configurations. Grizzly bars are available in fixed or adjustable configurations. Single-deck configurations include grizzly bars only. Double-deck configurations include grizzly bars on the top deck and side-tensioned screen cloth on the bottom deck. Coil impact springs are mounted inside of the C springs. They operate at an incline angle of approximately 15°.

SINGLE DECK

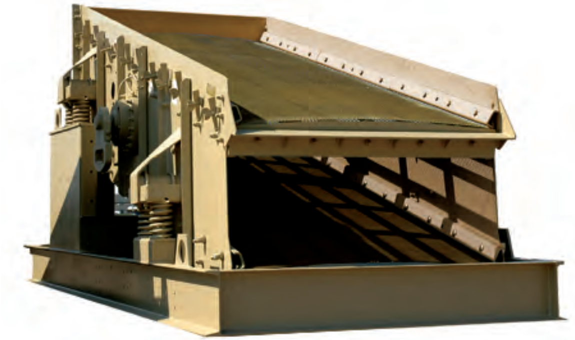
Model	Size	Speed	Motor
77-1DG-(F or A) 366	36″ x 6′	13-1,500	7½ hp
77-1DG-(F or A) 488	48″ x 8′	11-1,300	10 hp

DOUBLE DECK

Model	Size	Speed	Motor
77-2DG-(F or A) 488	48″ x 8′	11-1,300	15 hp
77-2DG-(F or A) 4810	48″ x 10′	11-1,300	15 hp

Note: F = Fixed grizzly bars
A = Adjustable grizzly bars

22° INCLINE SCREENS



These economy screens run at lower speeds and utilize gravity to assist the motion created by the eccentric shaft for moving material. The single-shaft, two-bearing design is recommended for light- to standard-duty applications.

SINGLE DECK

Model	Size	Speed (RPM)	Motor
2D4812	48″ x 12′	950-1,050	7½ hp
2D6012	60″ x 12′	950-1,050	10 hp
2D6014	60″ x 14′	950-1,050	15 hp
2D6016	60″ x 16′	950-1,050	15 hp
2D7216	72″ x 16′	950-1,050	20 hp

DOUBLE DECK

Model	Size	Speed (RPM)	Motor
3D4812	48″ x 12′	950-1,050	10 hp
3D6012	60″ x 12′	950-1,050	15 hp
3D6014	60″ x 14′	950-1,050	20 hp
3D6016	60″ x 16′	950-1,050	20 hp
3D7216	72″ x 16′	950-1,050	30 hp

10° INCLINE SCREENS

The 10-degree incline screen combines the economy of the single-shaft, two-bearing incline screens with the heavy-duty, aggressive action of the horizontal screens. Perfect for portable applications and in situations where headroom is limited, the screen has a 3/8 inch circular stroke and runs at an RPM around 950. The heavy-duty pan and deck construction make it perfect for applications ranging from standard to heavy-duty.

DOUBLE DECK

Model	Size	Speed (RPM)	Motor
2D3610	36″ x 10′	850-950	7½ hp
2D4810	48″ x 10′	850-950	10 hp
2D4812	48″ x 12′	850-950	15 hp
2D6012	60″ x 12′	850-950	20 hp
2D6014	60″ x 14′	850-950	25 hp
2D6016	60″ x 16′	850-950	30 hp
2D7216	72″ x 16′	850-950	30 hp
2D7220	72″ x 20′	850-950	30 hp
*2D9620	96″ x 20′	850-950	40 hp

TRIPLE DECK

Model	Size	Speed (RPM)	Motor
3D3610	36″ x 10′	850-950	10 hp
3D4810	48″ x 10′	850-950	15 hp
3D4812	48″ x 12′	850-950	20 hp
3D6012	60″ x 12′	850-950	25 hp
3D6014	60″ x 14′	850-950	30 hp
3D6016	60″ x 16′	850-950	40 hp
3D7216	72″ x 16′	850-950	40 hp
3D7220	72″ x 20′	850-950	40 hp
*3D9620	96″ x 20′	850-950	50 hp

NOTE: *2D9620 and 3D9620 screens operate at 15° incline.

INCLINE SCREENS

Incline screens feature heavy-duty side and reinforcing plates, a huck bolted construction, an adjustable operating incline from 15-25 degrees, adjustable stroke amplitudes, AR-lined feed boxes and heavy-duty, double-roll bronze cage spherical roller bearings.

Incline screens are available in both single- and dual-shaft arrangements, two- and three-deck configurations, and are available in sizes ranging from 6′ x 16′ to 8′ x 24.′

SINGLE-SHAFT INCLINED SCREENS

Single-shaft incline screens are well-suited for stationary installations, applications where the feed gradation to the screen is constant or when a circular stroke pattern will provide the desired results. Incline screens also enable a lower bed depth of material due to an increased material travel speed that minimizes power consumption while maximizing access for maintenance.

Screen size: 6162 & 6163
6202 & 6203
7202 & 7203
8202 & 8203

CASCADE SCREEN

The Cascade Incline Screen from Johnson Crushers International is a field-proven and reliable design featuring an externally-mounted vibrating assembly engineered for efficiency and reduced cost of operation. The screen is available in two- or three-decks and various sizes. Additionally, the screens are available with either oil or grease lubrication and optional speed/stroke combinations, which allow for optimum separation and increased efficiency. As your screen ages, it is not always cost-effective to replace or modify the entire support structure or chassis so Johnson Crushers International is willing to collect data on your aging machine assembly and design and manufacture a replacement "drop-in" unit to minimize any interruption to your production.

Screen Size	Horsepower	Weight	Decks
5162-26 SIC	25 hp	12,000 lb	2
5163-26 SIC	25 hp	15,500 lb	3
6162-26 SIC	25 hp	13,000 lb	2
6163-26 SIC	25 hp	16,620 lb	3
6202-32 SIC	25 hp	15,750 lb	2
6203-32 SIC	30 hp	19,850 lb	3

DUAL SHAFT INCLINED SCREENS

In addition to the benefits described of the single shaft incline designs, dual-shaft incline screens will provide increased bearing life as compared to a single-shaft arrangement, due to the load being distributed over additional bearing surface. In some cases, dual-shaft screens will also provide the benefit of a more aggressive screen action in applications where the feed end of the screen becomes “top heavy” with a high volume of material.

Screen size: 6162 & 6163
6202 & 6203
7202 & 7203
8202 & 8203
8243

SCALPING SCREENS

Mesabi type, single-shaft 4-bearing standard duty

DOUBLE DECK

Model	Size	Speed (RPM)	Motor
2D4810	48″ x 10′	950-1,000	20 hp
2D4812	48″ x 12′	950-1,000	25 hp
2D6012	60″ x 12′	950-1,000	30 hp
2D6014	60″ x 14′	950-1,000	40 hp
2D7216	72″ x 16′	950-1,000	50 hp

HEAVY DUTY

Model	Size	Speed (RPM)	Motor
2D488	48″ x 8′	900	30 hp
2D6014	60″ x 14′	900	40 hp
2D7214	72″ x 14′	900	50 hp

HORIZONTAL VIBRATING SCREENS

Horizontal screens are of a triple-shaft design that provides a true oval vibrating motion, and feature a huck-bolted basket assembly, fully-contained lubrication system, and rubber springs to reduce basket stress. Their low profile height makes them ideal for portability, and their adjustment capabilities of speed, stroke length, and stroke angle enable them to be well-suited for both fine and coarse screening applications. Horizontal screens can be retrofitted with either wire cloth or urethane panels, and can be easily converted to wet screen applications.

Horizontal screens are available in several configurations in sizes up to 8' x 24' in two-, three- and four-deck designs.

FINISHING SCREENS

The finishing screen maximizes screening efficiency and productivity in fine separation applications by using a reduced stroke and a higher frequency that provides an optimal sifting action.

Adjustable stroke length (Amplitude) (Stroke reduced by removing weight plugs)	min ⅜″ to max ½″
Adjustable stroke angle (timing angle)	30 to 60 degrees
Operating speed range	875-1,075 rpm
Maximum feed size	8″
Maximum top deck opening	All model screens = 2″

Screen size: 5142-32FS & 5143-32FS
5162-32FS & 5163-32FS
6162-32FS & 6163-32FS
6202-32FS & 6203-32FS
7202-38FS & 7203-38FS
8202-38FS & 8203-38FS

LOW-PROFILE SCREENS

The Low-Profile series is best-suited for the widest array of applications ranging from fine to coarse material separation applications.

Adjustable stroke length (Amplitude) (Stroke reduced by removing weight plugs)	min ⅝″ to max ¾″
Adjustable stroke angle (Timing angle)	30 to 60 degrees
Operating speed range	675-875 rpm
Maximum feed size	10″
Maximum top deck opening	514, 516 & 616 = 5″ 620, 720, 820 & 824 = 4″

Screen size: 5142-32LP & 5143-32LP
5162-32LP & 5163-32LP
6162-32LP & 6163-32LP
6202-32LP & 6203-32LP
7202-38LP & 7203-38LP
8202-38LP & 8203-38LP
8243-38LP

*All screen sizes listed above are available in 2 ½ degree slope models

Screening

MEDIUM SCALPER SCREENS

The medium scalper screen is an excellent machine for coarse screening and light-duty scalping applications. Medium scalper screens also feature thicker side plates and a heavy-duty crowned top deck .

Adjustable stroke length (amplitude)	min 9⁄16″ to max ¾″
Adjustable stroke angle (timing angle)	30 to 60 degrees
Operating speed range	675-875 rpm
Maximum feed size*	14″
Maximum top deck opening	All model screens = 5″

Screen size: 5142-32MS & 5143-32MS
5162-32MS & 5163-32MS
6162-32MS & 6163-32MS
6202-32MS & 6203-32MS
7202-38MS & 7203-38MS
8202-38MS & 8203-38MS

HEAVY SCALPER SCREENS

The heavy scalper screens are designed for heavy-duty scalping applications with the lowest frequency and most aggressive stroke length in the family of horizontal screens. Heavy scalper screens also feature the heaviest-duty construction that can accept up to 18″ feed sizes and 24″ in the extra-heavy step deck model.

PATENT PENDING

Adjustable stroke length* (Amplitude) (Stroke reduced by removing weight plugs)	min ¾″ to max ⅞″
Adjustable stroke angle (Timing angle)	30 to 60 degrees
Operating speed range*	575-775 rpm
Maximum feed size*	18″
Maximum top deck opening*	All model screens = 6″

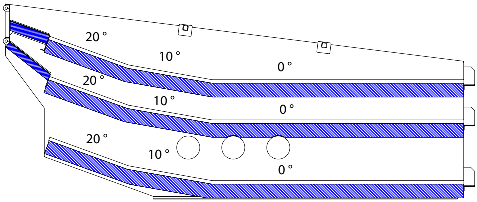
Screen size: 5142-32HS & 5143-32HS
5162-32HS & 5163-32HS
6162-38HS & 6163-38HS
6202-38HS & 6203-38HS
7202-38HS
8202-38HS

EXTRA-HEAVY SCALPER SCREENS

The extra-heavy scalper screens are also available with a stepped grizzly bar top deck designed to handle up to 24″ feed size.

Screen size: 5142-32XH
5162-32XH
6162-38XH
6202-38XH
7202-38XH
8202-38XH

MULTI-ANGLE SCREENS



Combo screens combine the advantages of both an inclined screen and a horizontal screen. The screen is equipped with inclined panel sections that begin with a 20-degree section, flatten to a 10-degree section, and the remaining deck area is at zero degrees.

By installing sloped sections at the feed end, material bed depth is reduced, since gravity will increase the travel speed of the material. This reduced bed depth minimizes spillover and enables fine particles to stratify through the coarser particles and onto the screening surface much faster, where it can then find more opportunities to be passed through screen openings. This design also enables fines to be introduced to the bottom deck faster, which increases the bottom deck screening capacity, or bottom deck factor used in the VSMA screen calculation.

A punch plate section was designed into the feed plate itself, thereby increasing the total screening area of the top deck by an additional 10%. This punch plate will remove a high percentage of fine particles before they are even introduced to the actual screen deck, thereby increasing production volumes.

The coarse near-sized and oversized particles that are not initially separated on the middle and top decks gradually slow down as the deck panels flatten out to the horizontal section towards the discharge end of the screen. This material's reduced travel speed, combined with the optimum angle of trajectory in relationship to the screen opening, provides a high screening efficiency upon which oval motion horizontal screens have built their reputation.

The combo screen is also the only multi-slope screen that features a triple-shaft design. This design provides an optimal oval screening motion that has proven effective. In addition to the features of the combo design, producers will also benefit by having the ability to adjust stroke length, stroke angle and RPM speed to best suit the conditions of the application.

The end result is a machine that:

1) Provides increased feed production by as much as 20% over standard flat or incline screens
2) Maintains or improves the screening efficiency of separation found on horizontal screens
3) Reduces material spillover at the feed end from high volumes or surges of feed material
4) Improves the bottom screen deck's utilization, thereby increasing volume and efficiency

Although not as portable as the traditional horizontal screens, the combo design will be an ideal screen for a variety of both scalping and product sizing applications. The design is especially well-suited for accepting large volumetric feed surges, deposits containing a high percentage of fines that must be removed, installations where screening capacity must be increased within the same structural or mounting footprint, or in closed circuit with crushers.

Combo screens are available in both standard and finishing configurations with three or four decks and sizes ranging from 6′ x 20′ to 8′ x 20′. These screens feature a huck-bolt construction, inclined deck panels that slope from 0-20 degrees and adjustable stroke amplitudes. Combo screens also have a hinged tailgate rear section for maintenance access and a perforated feed box for additional screening area. These screens can be installed with either standard wire cloth or urethane/rubber deck panels.

COMBO SCREEN

Adjustable stroke length* (Amplitude) (Stroke reduced by removing weight plugs)	min ⅝″ to max ¾″
Adjustable stroke angle (timing angle)	30 to 60 degrees
Operating speed range	675-875 RPM
Maximum feed size	10″
Maximum top deck opening	4″

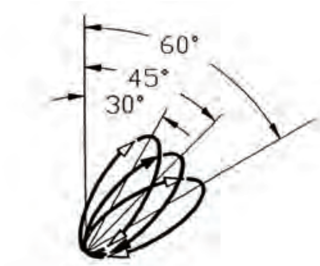
Screen size: 6202-32CS & 6203-32CS
7202-38CS & 7203-38CS
8202-38CS & 8203-38CS

COMBO FINISHING SCREENS

The finishing screen maximizes screening efficiency and productivity in fine separation applications by using a reduced stroke and a higher frequency that provides an optimal sifting action.

Adjustable stroke length* (Amplitude) (Stroke reduced by removing weight plugs)	min ⅜″ to max ½″
Adjustable stroke angle (Timing angle)	30 to 60 degrees
Operating speed range	875-1,075 RPM
Maximum feed size	8″
Maximum top deck opening	All model screens = 2″

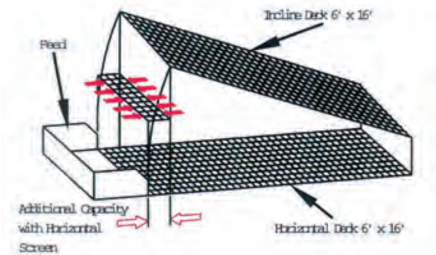
Screen size: 6202-32CF & 6203-32CF
7202-38CF & 7203-38CF
8202-38CF & 8203-38CF

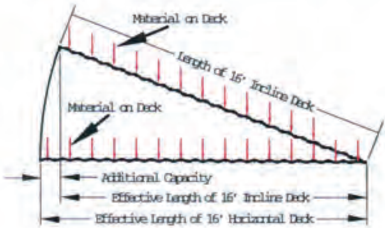


GUIDELINES FOR STROKE ADJUSTMENTS

Figure 2

Size of Material	Plug Configuration	RPM of Screen	Timing Angle
Coarse 1¼" Plus	3 Plug Each Wheel ¾" Approx.	Very Slow 740 RPM	45° - 55°
Medium ¾" - 1¼"	2 Plug Each Wheel 11/16" Approx	Slow ¾" to 1¼" 785 RPM	40° - 50°
Fine ¾" - 1¼"	1 Plug Each Wheel ⅝" Approx.	Fast ¾" to 1¼" 830 RPM	35° - 45°
Extra Fine ⅜" Minus	No Plugs Each Wheel 9/16" Approx. Minimum Stroke	Very Fast 875 RPM	30° - 40°



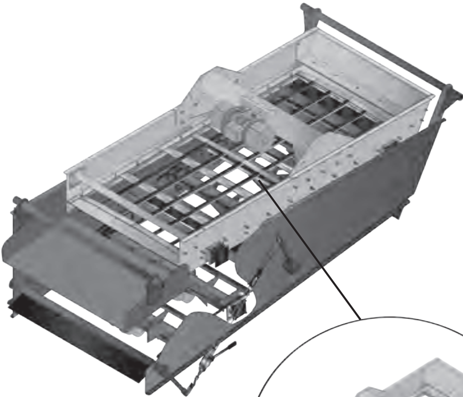


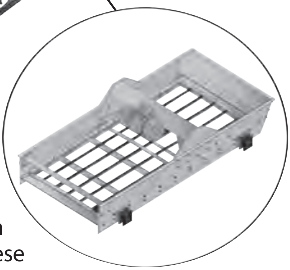
HIGH FREQUENCY SCREENS

The Astec Mobile Screens high frequency line includes the Vari Vibe and Duo Vibe screens. There are many advantages a high frequency screen provides, from higher production capabilities to more efficient sizing as compared to conventional screens. The higher production is achieved by an aggressive screen vibration directly applied to the screen media. The high level of vibrating RPMs allows material to stratify and separate at a much faster rate as compared to conventional screens.

Multiple configurations for the screens are available in stationary, portable and track-mounted assemblies. Both screens provide producers with increased production, waste stockpile reduction and more salable product.

The Vari Vibe screens are ideal for post-screening applications and offer high frequency vibration on all decks. These screens achieve the highest screen capacity in the market for fines removal, chip sizing, dry manufactured sand and more.





The Duo Vibe screens are ideal for pre-screening applications by offering a scalper top deck with conventional frequency mounted over high frequency bottom deck(s). These screens improve production needs earlier in the circuit by removing fines from coarser materials.

1612V CAPACITY
(6’ x 12’ Single Deck Vari Vibe High Frequency Screen)

Basic Capacity Table — 1612V

Through Deck, Slotted Screen	B/C, TPH sq. ft.	TPH, 72 sq. ft.
¾″	4.6	331.2 TPH
⅝″	4.2	302.4 TPH
½″	3.81	274.3 TPH
⅜″	3.33	239.8 TPH
¼″	2.91	209.5 TPH
3/16″ (4M)	2.43	175.0 TPH
⅛″ (6M)	1.6	115.2 TPH
3/32″ (8M)	1.18	85.0 TPH
5/64″ (10M)	0.9	64.8 TPH
1/16″ (12M)	0.7	50.4 TPH
3/64″ (16M)	0.55	39.6 TPH
1/32″ (20M)	0.43	31.0 TPH
3/128″ (30M)	0.33	23.8 TPH
1/64″ (40M)	0.22	15.8 TPH

* Tonnages will vary depending on application, size and type of screens used, weight of product and moisture content.

** This chart is to be used for estimation purposes only. This chart is based on material weight of 100 lbs/cu. ft. Do not guarantee tonnages without consideration of all possible variables.

2618VM CAPACITY
(Modified 6' x 18' Double Deck Vari Vibe High Frequency Screen)

Basic Capacity Table — 2618VM

Through Deck, Slotted Screen	B/C, TPH sq. ft.	Pre-Screen Deck Section A (TPH, 36 sq. ft.)	Chip Deck Section B (TPH, 72 sq. ft.))	Post Screen Fine Deck Section C 9TPH, 72 sp. ft.)
¾"	4.6	165.6 TPH	301.5 TPH	265.0 TPH
⅝"	4.2	151.2 TPH	274.5 TPH	241.9 TPH
½"	3.81	137.1 TPH	247.5 TPH	219.5 TPH
⅜"	3.33	119.9 TPH	216.0 TPH	191.8 TPH
¼"	2.91	104.8 TPH	189.0 TPH	167.6 TPH
3⁄16" (4M)	2.43	87.5 TPH	157.5 TPH	140.0 TPH
⅛" (6M)	1.6	57.6 TPH	103.5 TPH	92.2 TPH
3⁄32" (8M)	1.18	42.5 TPH	76.5 TPH	68.0 TPH
5⁄64" (10M)	0.9	32.4 TPH	58.5 TPH	51.8 TPH
1⁄16" (12M)	0.7	25.2 TPH	45.0 TPH	40.3 TPH
3⁄64" (16M)	0.55	19.8 TPH	36.0 TPH	31.7 TPH
1⁄32" (20M)	0.43	15.5 TPH	27.9 TPH	24.8 TPH
3⁄128" (30M)	0.33	11.9 TPH	21.4 TPH	19.0 TPH
1⁄64" (40M)	0.22	7.92 TPH	14.3 TPH	12.7 TPH

* Tonnages will vary depending on application, size and type of screens used, weight of product and moisture content.

** This chart is to be used for estimation purposes only. This chart is based on material weight of 100 lbs/cu. ft. Do not guarantee tonnages without consideration of all possible variables.

TROUBLESHOOTING GUIDE:
HIGH FREQUENCY SCREENS

It is a good rule of thumb to ask yourself the following questions if you are seeing a change in the gradation.

1. Has the moisture of the material changed?
2. Is the spread of material correct?
3. Is the GPM flow rate to vibrators correct?
4. Does the angle of screen need to be changed?
5. Has the feed gradation changed?
6. Is there screen cloth wear?
7. Has the feed rate changed?
8. If electric vibrators, is the overload protection tripped?

It is Astec Mobile Screens' recommendation to closely monitor the following items as conditions change.

MATERIAL CARRY-OVER OF INEFFICIENT SCREENING

CAUSE	SOLUTION
1. Bed of material is too deep	1. Decrease tonnage rate
2. Screen cloth open area too small	2. Increase open area of cloth
3. Screen cloth is blinded	3. Clean screen cloth
4. Screen cloth is blinding on the sides of panels	4. Adjust side seal strips to the same height as tappets
5. Screen angle may need to be steeper	5. Increase angle of screen (not to exceed 43°)
6. Oil flow to vibrators is not set properly	6. Check and adjust vibrators to proper settings
7. Weights in vibrators need to be increased	7. Adjust weights to a higher setting

TROUBLESHOOTING GUIDE: HIGH FREQUENCY SCREENS *(cont.)*

CAUSE	SOLUTION
1. Material is too wet for the feed rate	1. Reduce feed rate
2. Oil flow to vibrator is not set properly	2. Check and adjust vibrators to proper settings
3. Screen angle may need to be steeper	3. Increase angle of screen (not to exceed 43°)
4. Spread of material is not spread evenly across screen panel	4. Material needs to be across entire screen panel
5. Weights in vibrators need to be increased	5. Adjust weights to a higher setting

MATERIAL FLOWS DOWN CENTER OR TO ONE SIDE OF SCREEN

CAUSE	SOLUTION
1. Material is not centered on feed conveyor	1. Center material on feed conveyor
2. Aggregate spreader needs to be adjusted	2. Adjust position of aggregate spreader in or out to headpulley of feed conveyor Adjust angle irons on aggregate spreader to achieve proper spread on screen
3. Side seal strips set too high	3. Adjust side seal strips to the same height as the tappets
4. Screening plant may not be level	4. Check level of plant

TROUBLESHOOTING GUIDE: HIGH FREQUENCY SCREENS *(cont.)*

BREAKING SCREEN CLOTH

CAUSE	SOLUTION
1. Wire diameter of screen cloth is too small for size of material	1. Increase wire diameter or decrease material size
2. Material impact on screen cloth	2. Install rubber strips across width of cloth at impact zone to protect screen cloth
3. Improper tension of screen cloth	3. Screen cloth is either too loose or too tight (depending on wire diameter); make sure anchor ends are evenly tensioned
4. Bucker rubber on tappets is worn out	4. Install new bucker rubber on tappets
5. Improper weave or crimp of screen panel	5. Contract screen manufacturer
6. Screen panel is too long and hook end turned over too far	6. Contact screen manufacturer

MATERIAL IS "POPCORNING" AS IT FLOWS DOWN SCREEN

CAUSE	SOLUTION
1. Fines have been removed from material	1. Adjust oil flow on the vibrators where this is occurring Install dams to knock materials down (contact Astec Mobile Screens)
2. Feed rate to screen is too slow	2. Increase feed rate

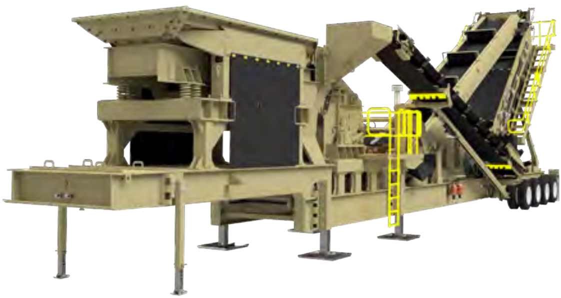
NOTES:

FRACTIONATING RAP

Price increases in liquid asphalt and virgin aggregates have led the industry to re-evaluate the use of recycled asphalt pavement (RAP) in hot mix asphalt (HMA) designs. Consider that recycled asphalt has rock the same age as the aggregate coming from the rock quarry today and liquid asphalt coming from the refined oil from oil wells. Most RAP processed today is ½" x 0, since it is coming from milled material, which is generally surface mix.

Processing RAP includes crushing and/or screening. The fractionation process typically separates RAP into two or three sizes, ½" x ⅜", ⅜" x 3⁄16", and -3⁄16". The coarser material (fractions) will have lower asphalt content and dust content versus the finer material (fractions), which enables the mix designer to have greater control over the amount of RAP being introduced into the mix.

Under the assumption that recycled materials are worth what they replace, producers are realizing extraordinary financial benefits by fractionating RAP material.

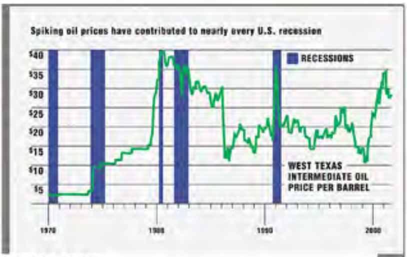


INTRODUCTION TO RAP

Asphalt mixes first appeared in the United States in the late 1800s. Natural asphalt from Trinidad Lake was placed in drums and imported into the United States where drums were heated and the asphalt melted to be mixed with combinations of aggregate of various sizes to produce a smooth, quiet road. Professor Alonzo Barber of Harvard College obtained a franchise from the British Government to bring Trinidad Lake asphalt into the United States and distribute it. From these early beginnings, asphalt roads have grown to become the major pavement of choice, with approximately 94% of the roads in America being surfaced with asphalt.

In the early 1900s, due to the high cost of Trinidad Lake material, recycling of old pavements was common. During the 1920s, with more and more automobiles becoming available, the demand for roads increased. Concurrent with this was the need for more fuel, and as oil was discovered in Pennsylvania and California, Trinidad Lake asphalt was replaced by a less expensive product, the residue from the refining process (the bottom of the barrel) and the roads were made from asphalt being derived from the oil refining process. Due to the fact that liquid asphalt was difficult to handle, sticky, and at low temperatures a rubbery-like substance, oil refineries just wanted to be free of the material and basically gave it away initially. Due to the abundance of crude oil in Texas and other areas of the United States, asphalt and oil remained relatively cheap through the '50s, '60s and into the early '70s.

During the 1950s and '60s, liquid asphalt sold for approximately \$20/ton. Since an average of 5% asphalt was used to glue the aggregate together to form a road, the glue or asphalt only costs approximately \$1/ton and aggregate was approximately \$1/ton, leading to a virgin material costs of the hot mix asphalt of approximately \$2/ton. By the early '70s, liquid asphalt had increased to approximately \$30/ton, with the asphalt or glue at \$1.50/ton and aggregate to about \$1.50/ton, resulting in material costs of \$3/ton.



CRUDE OIL PRICES F1

F1 In 1973, crude oil prices escalated due to the first oil embargo in the United States and liquid asphalt prices escalated to \$80/ton in a very short time period. Typically, asphalt prices per ton are usually 6 times the price of a barrel of crude oil, i.e. 6 x $30/ barrel equals $180/ton liquid asphalt. This also resulted in higher aggregate prices (due to higher fuel prices) and liquid asphalt prices of approximately $4/ton of mix (5% of $80/ton). And thus resulting in a total virgin material cost of $6-$7/ton.

Again in 1979, **F1**, crude climbed to $30/barrel and liquid asphalt prices escalated to $180/ton with the second oil embargo.

This resulted in material costs for the asphalt portion of hot mix at $9/ton and aggregate costs had escalated to approximately $4-$5/ ton resulting in a total virgin material costs of $13/ton.

In 1975, two things came together that made recycling again economically feasible. First, the prices of liquid asphalt and aggregate had escalated as mentioned above and secondly, a machine called a road planer or milling machine was developed (**F2**), that would remove as little as a 1/4" or as much as 6" of material from the roadway in one pass. This revolutionary new machine allowed numerous benefits to the road building industry.

A few of them are as follows:

MILLING MACHINE F2

RUTTED HIGHWAY F3

• Rutted roads could be milled to a level surface, resulting in a more uniform and higher-quality pavement when placed over a flat surface, **F3**.

• Drainage could be maintained on city streets by milling the road surface prior to placement of another lift of mix eliminating stacking of layer on layer of resurfacing material, **F4**.

• Milling eliminated the raising of utilities and manholes and maintained proper drainage to the curb, **F5**.

• Milling eliminated the reduction in clearance under overpasses, **F6**.

• Milling eliminated the increase of weight on bridges caused by adding layer after layer.

While all of these advantages helped the public works designers to establish and maintain elevations, clearances, etc., it also generated an enormous amount of reclaimed pavement that could be recycled.

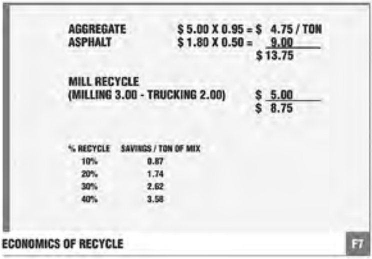
CITY STREET DRAINAGE F4

UTILITIES F5

MILLING ALLOWS CLEARANCES TO REMAIN CONSTANT F6

A second contribution of milling machines to the asphalt industry was the reduction in cost of obtaining recycled material versus complete pavement removal. Early milling costs were in the \$4/ton range, but currently milling costs of \$2-\$3/ton, depending whether on highway or in city work, is normal. With the combination of higher virgin material costs and lower removal costs, hot mix asphalt has become the highest volume recycle product in the United States. The low cost of milling material versus the higher costs of virgin material produces a differential that gives recycle a tremendous economic advantage. Basically, recycling is worth what it replaces. **F7** shows the economic benefit of adding recycle based on the various percentages used.

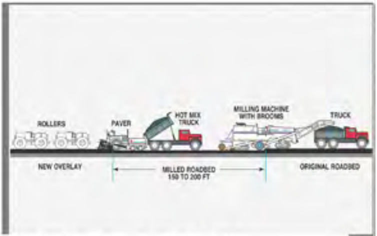
While recycling is often looked at in many industries as an inferior product to new materials, in hot mix asphalt it is often found to be a superior product, since the liquid asphalt available today is often not of the same quality as it was a number of years ago. Current specifications allow the artificial softening of harder asphalts and lead to liquids with high percentages of volatiles and less binding strength than the original liquid. Even where current liquids are used today, the light oils are generally evaporated during mixing and placement and over a period of time resulting in purer asphalt occurring in the recycled product.



In addition, aggregates that tend to be absorptive only absorb the liquid asphalt one time. The recycled product, when combined with new aggregate, often will have a thicker film because absorption occurs only once in the RAP portion of the mix. Perhaps the best description of recycling could be summed up by the words of a Japanese customer (who was the first to recycle in Japan). When asked what he told his customers concerning recycle, he said “it’s all the same age.”

AVAILABILITY OF RECYCLED ASPHALT PRODUCTS (RAP)

Due to the benefits of milling in cities and on highways, more recycle is becoming available. Inlays are becoming commonplace in most states where 1-1/2" to 2" of material is milled and a new surface is installed in the removed area without increasing the elevation of the road. This type of construction is very beneficial since the inlay area allows containment of the new mix on each side, resulting in superior joints. Also, it permits construction to be done at night with minimum disruption to the traveling public, **F8**. This type of construction results in enough material being available to produce 100% recycle mix and although this is not practical, it results in increasing quantities of RAP.



INLAID PAVING WITH MILLING MACHINE & PAVER F8

In addition, with rebuilding of sewers, electrical lines, and other utilities below the roadway, numerous amounts of ripped-up material is available. Milling on parking lots is often done rather than complete removal, since material can be milled to an exact elevation and the price of milling is much less than total excavation and re-grading prior to placing a new surface. This also results in a large quantity of material being available. With the passage of each year, it is our opinion that the amount of recycle available will increase steadily and more efforts must be made to increase the quality of recycle placed into hot mix asphalt without sacrificing quality.

PROCESSING RAP MATERIAL

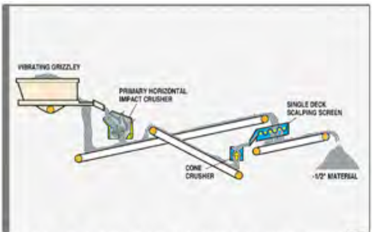
Hot mix asphalt producers generally have two types of recycle asphalt that is available: ripped up material being brought in by customers and mill material from highway projects, parking lots, city streets, etc. Typically, mill material is placed in recycle bins and the oversized mill material passes over a single- or multiple-deck screen. The bulk of the material is fed directly to the plant without processing. When RAP is screened over 1-1/2" to 2" screens, unless the asphalt plant has a long mixing time, the RAP cannot be totally melted and homogeneously mixed with the new virgin aggregate and asphalt.

VOLUME OF RAP % F9

Some plants are equipped with closed circuit crushing systems that crush the oversized material that does not pass through the screen and returns it to the top of the screen as shown in **F9**.

RAP CRUSHING F10

Ripped up material has been crushed through various types of crushing plants **F9** and F**10.**



TWO-STAGE RAP CRUSHER CIRCUIT PRODUCING ONE PRODUCT F11

For percentages of RAP of less than 15-20%, feeding one size of material is generally adequate, but as the percentage of recycle increases, and the quality of mix is more scrutinized, it has become more obvious that multiple sizes of RAP will be required. Logic dictates that RAP should be treated like any other aggregate that is sized and fed to the plant in multiple sizes, if the quality of the final product is to be ensured. On most mixes designed in the United States in the last 50 years, a film thickness of 9 to 10 microns has been commonplace. By sizing the material into specific size ranges, the amount of liquid asphalt in each of these materials is much more consistent. Trying to produce a product using 30, 40 or 50% RAP with one size results in segregation of the material and wide variations in liquid asphalt content, making it very difficult for the plant to produce a high-quality mix.

1/4" x 0" RAP (left), 1/2" + (right) F12

1/2" x 1/4" RAP F13

FOLD 'N GO F14

The most economical way of processing RAP into multiple sizes is to screen it first. Since most of the mill material is surface mix, it is 1/2 inch or 12.5 mm minus material. With mill material, 70-80% of the material will pass a 1/2 inch screen and, if sized into two sizes, a 1/4″ x 0″ **F12**, and 1/2″ x 1/4″ **F13**, the consistency and the percentage of RAP that can be used increases significantly. **F14** shows a portable, high-frequency screen. It is self-contained with its own engine and hydraulic drives that allow pre-screening of RAP into three sizes, one oversized and two finished products. Since 70-80% of the material will pass 1/2″ minus opening, only 20-25% of the oversized material requires crushing. A highly-mobile unit such as this can be moved quickly between multiple plants sizing the material and reducing the amount of material required to be crushed.

It is estimated that pre-screening the material, as shown here in **F15**, can be done for $.50 to $.75 per ton, therefore reducing the cost of crushing significantly, since only 20-25% of the material will be required to be crushed. A crusher, as shown in **F16**, can then be used to feed the material directly into a pre-screening unit, again sizing the material into two different sizes.

- **DEPRECIATION**
  (Based upon 5 yr. depreciation $150,000 costs; 200,000 TPY)....................0.15
- **MAINTENANCE**
  (Including Screen Cloth)....................0.15
- **LOADER & LABOR**
  ($70,000/yr.)....................0.35

0.65 / TON

COST OF SCREENING F15

CRUSHER AND 5030 SCREENING PLANT F16

ECONOMICS

By processing the material into two different sizes, higher percentages of RAP can be accurately blended producing not only additional savings, but also resulting in a higher quality, more consistent mix. With the more restrictive gradation requirements of the Superpave mix design procedure, producers often find it difficult to insert more than 10% RAP when using only a single size. By separating the RAP into two sizes, producers are successfully increasing RAP quantities to as high as 40% while also improving the quality of the mix. **F17** shows a 12.5 mm Superpave mix with 15% recycle.

SIEVE SIZE		12.5 mm SUPERPAVE MIX WITH 15% RAP	12.5 mm SUPERPAVE MIX WITH 40% FRACTIONATED RAP
IN	mm		
3/4	19.00	100.0	100.0
1/2	12.50	96.7	95.2
3/8	9.50	86.1	78.2
4	4.75	65.0	57.3
8	2.36	45.9	44.9
16	1.18	33.4	35.2
30	0.60	24.5	26.9
50	0.30	15.0	18.7
100	0.15	8.2	8.8
200	0.075	5.2	5.4

COMBINED GRADATION 12.5 mm SUPERPAVE MIX F17

By fractionating the RAP, the percentage of recycle can be increased to 40%. The savings through increased recycle is shown in **F18**. **F19** shows a mix with RAP increased from 10% to 35%. **F20** shows the savings by increasing the RAP percentages from 10% to 35% and **F21** shows a 9.5 mm mix with RAP increased from 15% to 40%. **F22** shows the savings by increasing the RAP percentages from 15 to 40%. Innovative operators have used the pre-screening plants for producing a large number of multiple sizes. Where SMA mixes are required, minus-16 mesh RAP can be processed, producing a minus-16 mesh product and feeding it directly into the asphalt plant while also producing two additional sizes of product that can be used in mixes at a later date. By using the minus 16 mesh or minus-4 mesh product to replace mineral filler and a portion of

INGREDIENT	$ / TON	APPROVED DESIGN		DESIGN WITH FRACTIONATED RAP	
		% USED	$ / TON	% USED	$ / TON
RAP (5.7% AC)	3.00	15	0.45		
PLUS #4 RAP (3.7% AC)	3.65			14	0.52
MINUS #4 RAP (7.9% AC)	3.65			26	
NEW AGGREGATE	8.00	85	6.80	60	4.80
OPTIMUM AC (%)		5.7		5.7	
AC FROM RAP		0.86		2.34	
NEW AC	175.00	4.84	8.47	3.36	5.08
MIX COSTS			15.27		12.15
GAIN BY USING FRACTIONATED RAP					3.57

12.5 mm SUPERPAVE MIX F18

SIEVE SIZE		12.5 mm SUPERPAVE MIX WITH 10% RAP	12.5 mm SUPERPAVE MIX WITH 35% FRACTIONATED RAP
IN	mm		
3/4	19.00	100.0	100.0
1/2	12.50	95.9	94.2
3/8	9.50	88.6	80.0
4	4.75	61.4	57.2
8	2.36	41.4	41.8
16	1.18	28.9	31.7
30	0.60	21.6	24.3
50	0.30	13.5	14.0
100	0.15	7.8	7.7
200	0.075	5.2	5.0

COMBINED GRADATION 12.5 mm RAP MIX F19

the polymerized asphalt, the cost of mix can be reduced significantly. **F23** shows the gradations and asphalt content of the two RAP products. **F24** shows the savings that result.

F25 shows how the RAP actually improves the rutting performance. When using minus-16 mesh RAP, the material should be fed directly from the screen to the RAP feeder on the asphalt plant due to its high asphalt content. **F26** shows a screening plant feeding directly to a RAP bin. The other two sizes are stockpiled for future use. Since the percentage of liquid varies with the size of RAP, 1/4" x 0" RAP may have as high as 7% liquid, while 1/2" x 1/4" may have less than 4% liquid. Some states place limits on the percentage of RAP before the grade of liquid is changed. Using finer RAP allows a significant reduction of new liquid without exceeding the percentage of RAP required. Most important when considering the use of multiple sizes of RAP is the improvement in quality. One producer, using 3/4" minus RAP, was limited to 20% and continuously experienced penalties for quality.

INGREDIENT	$ / TON	APPROVED DESIGN		FRACTIONATED RAP	
		% USED	$ / TON	% USED	$ / TON
RAP (5.7% AC)	3.00	10	0.30		
PLUS #4 RAP (3.7% AC)	3.65			15	0.55
MINUS #4 RAP (7.0% AC)	3.65			20	0.73
NEW AGGREGATE	8.00	90	7.20	65	5.20
OPTIMUM AC (%)		5.83		5.83	
AC FROM RAP		0.57		1.96	
NEW AC	175.00	5.26	9.21	3.87	6.77
6.55					
MIX COSTS			16.71		13.25
GAIN BY USING FRACTIONATED RAP					3.46

12.5 mm SUPERPAVE MIX **F20**

SIEVE SIZE		9.5 mm SUPERPAVE MIX WITH 15% RAP	9.5 mm SUPERPAVE MIX WITH 40% FRACTIONATED RAP
IN	mm		
3/4	19.00	100.0	100.0
1/2	12.50	100.0	100.0
3/8	9.50	98.5	97.8
4	4.75	72.6	77.2
8	2.36	44.1	44.9
16	1.18	33.2	35.1
30	0.60	24.2	25.5
50	0.30	12.7	12.4
100	0.15	8.0	8.2
200	0.075	6.2	6.3

COMBINED GRADATION 9.5 mm SUPERPAVE MIX **F21**

INGREDIENT	$ / TON	APPROVED DESIGN		DESIGN WITH FRACTIONATED RAP	
		% USED	$ / TON	% USED	$ / TON
RAP (5.7% AC)	3.00	15	0.45		
PLUS #4 RAP (3.7% AC)	3.65			20	0.73
MINUS #4 RAP (7.0% AC)	3.65			20	0.73
NEW AGGREGATE	8.00	85	6.80	60	4.80
OPTIMUM AC (%)		5.4		5.4	
AC FROM RAP		0.86		2.14	
NEW AC	175.00	4.54	7.95	3.26	5.71
MIX COSTS			15.20		11.97
GAIN BY USING FRACTIONATED RAP					3.23

9.5 mm SUPERPAVE MIX **F22**

SIEVE SIZE	#4 RAP	#16 RAP	POND SAND
1	100	100	100
3/4	100	100	100
1/2	98	100	100
3/8	97	100	100
4	84	100	100
8	68	100	100
16	56	92	100
30	45	71	99
50	33	49	97
100	21	31	82
200	13	21	42
AC CONTENT	7.9%	8.9%	

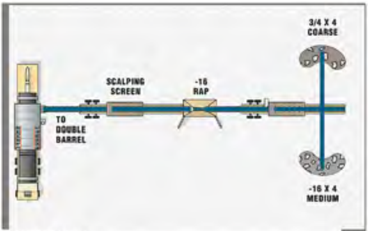
GRADATION OF RAP **F23**

INGREDIENT	$ / TON	APPROVED DESIGN		#4 RAP		#16 RAP	
		% USED	$ TON	% USED	$ TON	% USED	$ TON
# 4 RAP (7.9% AC)	3.65			15	0.55		
#16 RAP (8.9% AC)	3.65					15	0.55
NEW AGGREGATE	8.00	91	7.28	81	6.48	81	6.48
MINERAL FILLER	30.00	9	2.70	4	1.20	4	1.20
FIBER STABILIZER	400.00	0.35	1.40	0.35	1.40	0.35	1.40
OPTIMUM AC (%)		5.9		6.3		6.3	
AC FROM RAP				1.19		1.34	
NEW PMAC	275.00	5.90	16.23	5.11	14.05	4.96	13.64
MIX COSTS			27.61		23.00		23.27
GAIN BY USING REFRACTIONATED RAP					3.93		4.34

12.5 mm SMA VIRGIN MIX COMPARED TO MIXES USING VARIOUS RAP F24

INGREDIENT	VIRGIN MIX	#4 RAP	#16 RAP
# 4 RAP (7.9% AC)		15	
# 16 RAP (8.9% AC)			15
NEW AGGREGATE	91	81	81
MINERAL FILLER	9	4	4
FIBER STABILIZER	0.35	0.35	0.35
AIR VOIDS IN BEAMS %	7.5	6.2	5.9
RUT DEPTH IN THE ASPHALT PAVEMENT ANALYZER (mm)	7.8	5.0	5.7
50 BLOW MARSHALL MIX DESIGN PROPERTIES			
OPTIMUM AC %	5.9	6.3	6.3
AIR VOIDS %	3.5	4.3	4.0
VMA %	79.5	79.9	72.7
SALVAGED MATERIAL USED			
FINES FROM RAP %	0.0	15	15
ASPHALT FROM RAP %	0.0	1.19	1.34

12.5mm SMA MIXTURES WITH RAP AND PG 64-22 BINDER F25



EXAMPLE LAYOUT F26

By sizing the RAP, the percentage has increased to 40% and penalties have disappeared.

Screening

CONCLUSION

With each passing year, the amount of recycled materials available continually increases. The economic benefits of adding recycle are obvious. An increase of 10% recycle can be shown to reduce the cost (based on the economics in **F7**). This significant savings certainly justifies processing RAP and treating it like any other material. High-frequency screening plants can reduce the cost of processing RAP significantly. These highly-portable plants make multiple sizes of recycle available to allow the production of high-quality mixes. The savings can result in paybacks in just a few months on the screening plant while improving the quality of the finished product and resulting in better, smoother, higher-quality roads for the traveling public to use.

MATERIAL HANDLING

Belt conveyors are designed to carry material the shortest distance between the loading and unloading points. When required, belt conveyors can operate continuously without loss of time and are capable of handling tonnages of bulk materials that would be more costly and often impractical to transport by other means.

Choosing the right conveyor starts with looking at the five basic considerations: material characteristics, conveyor length and/or discharge height, TPH feed, conveyor width and horsepower requirements.

1. Material Characteristics

a. Variables include: particle shape, and size, moisture, angle of repose, lump size and percentage fines and weight. Characteristics typically used as a rule of thumb include: 100 lbs. per cubic foot density, 37° angle of repose and less than 25% of a max. 3" lump.

RECOMMENDED MAXIMUM ALLOWABLE INCLINE FOR BULK MATERIALS

Material	Angle Incline	% Grade
Alumina	10.0-12.0	17.6-21.2
Ashes, Coal, Dry, ½" and Under	20-25	36.4-46.6
Ashes, Coal, Wet, ½" and Under	23-27	42.4-50.4
Ashes, Fly	20-22	36.4-40.4
Bauxite, Ground, Dry	20	36.4
Bauxite, Mine Run	17	30.6
Bauxite, Crushed 3" and Under	20	36.4
Borax, Fine	20-25	36.4-46.6
Cement, Portland	23	42.4
Charcoal	20-25	36.4-46.6
Cinders, Blast Furnace	18-20	32.5-36.4
Cinders, Coal	20	36.4
Coal		
Bituminous, Run of Mine	18	32.4
Bituminous, Fines Only	20	36.4
Bituminous, Lump Only	16	28.6
Anthracite, Run of Mine	16	28.6
Anthracite, Fines	20	36.4
Anthracite, Lump Only	16	28.6
Anthracite, Briquettes	12	21.3
Coke—Run of Oven	18	32.4
Coke, Breeze	20	36.4
Concrete—Normal	15	26.8
Concrete—Wet (6" Slump)	12	21.3
Chips—Wood	27	50.9
Cullet	20	36.4
Dolomite, Lumpy	22	40.4
Grains—Whole	15	26.8
Gravel—Washed	15	26.8
Gravel and Sand	20	36.4
Gravel and Sand Saturated	12	21.3
Gypsum, Dust Aerated	23	42.4
Gypsum, 1/2" Screening	21	38.3
Gypsum, 1-1/2" to 3" Lumps	15	26.8
Earth—Loose and Dry	20	36.4
Lime, Ground, 1/8" and Under	23	42.4
Lime, Pebble	17	30.6
Limestone, Crushed	18	32.5
Limestone, Dust	20	36.4
Oil Shale	18	32.5
Ores—Hard—Primary Crushed	17	30.6
Ores—Hard—Small Crushed Sizes	20	36.4
Ores—Soft—No Crushing Required	20	36.4
Phosphate Triple Super, Ground Fertilizer	30	57.7
Phosphate Rock, Broken, Dry	12-15	21.2-26.8
Phosphate Rock, Pulverized	25	46.6
Rock, Primary Crushed	17	30.6
Rock, Small Crushed Sizes	20	36.4
Sand—Damp	20	36.4
Sand—Dry	15	26.8
Salt	20	36.4
Soda Ash (Trona)	17	30.6
Slate, Dust	20	36.4
Slate, Crushed, 1/2" and Under	15	26.8
Sulphate, Powder	21	38.3
Sulphate, Crushed—1/2" and Under	20	36.4
Sulphate, 3" and Under	18	32.5
Taconite—Pellets	13-15	23.1-26.8
Tar Sands	18	32.5

NOTE: *When mass slips due to water lubrication rib type belts permit 3-5 degrees increase.

b. Material characteristics can affect other elements of conveyor selection.

- Heavier material or large lumps may require more horsepower, a heavier belt, closer idler spacing and impact idlers at feed points
- Abrasiveness may require wear liners or special rubber compositions
- Moisture may require steeper hopper sides, wider belts, anti-buildup return idlers and special belt wipers
- Dust content may require special discharge hoods and chutes, slower belt speeds and hood covers
- Sharp materials may require impact idlers, wear liners, special belt and plate feeder
- Lightweight materials may require wider belts and less horsepower

c. Conveyor Belt

Conveyor belts consist of three elements: top cover, carcass and bottom cover.

The belt carcass carries the tension forces necessary in starting and moving the loaded belt, absorbs the impact energy of material loading and provides the necessary stability for proper alignment and load support over idlers, under all operating conditions.

Because the primary function of the cover is to protect the carcass, it must resist the wearing effects of abrasion and gouging, which vary according to the type of material conveyed. The top cover will generally be thicker than the bottom cover because the concentration of wear is usually on the top or carrying side.

The belt is rated in terms of “maximum recommended operating tension” pounds per inch of width (PIW). The PIW of the fabric used in the belt is multiplied by the number of plies in the construction of the belt to determine the total PIW rating of the belt.

d. Idlers

Idler selection is based on the type of service, operating condition, load carried and belt speed.

CEMA IDLER CLASSIFICATION

Classification	Former Series No.	Roll Diameter (in)	Description
A4	I	4	Light Duty
A5	I	5	Light Duty
B4	II	4	Light Duty
B5	II	5	Light Duty
C4	III	4	Medium Duty
C5	III	5	Medium Duty
C6	IV	6	Medium Duty
D5	NA	5	Medium Duty
D6	NA	6	Medium Duty
D7	VI	7	Heavy Duty
E6	V	6	Heavy Duty

2. Length

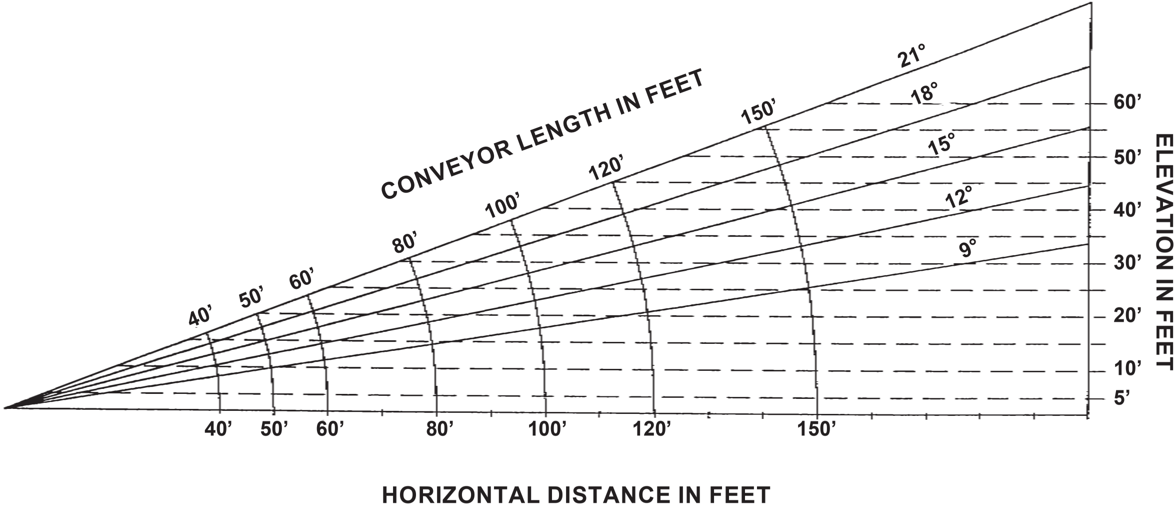
Length is determined one of three ways:

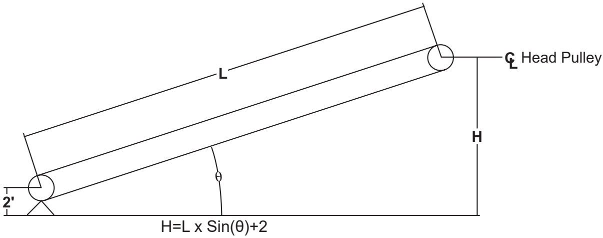
a. Lift height required: When lift height is the determining factor, as a rule of thumb, an 18-degree incline is used, where 3 x height needed approximates the conveyor length required. Particle size, moisture and other factors affect the maximum incline angle. If the material tends to have a conveyable angle that is less than 18 degrees, a longer conveyor needs to be selected to achieve the desired lift height.

b. Distance to be conveyed

c. Stockpile capacity desired

CONVEYOR ELEVATION CHART



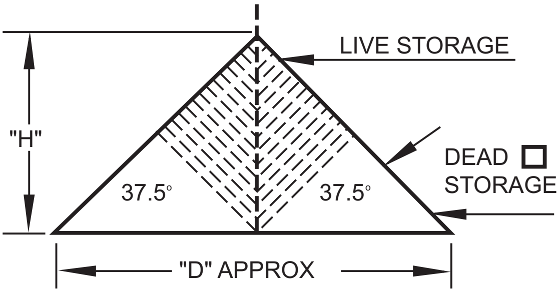


CONVEYOR ELEVATION

Conveyor Legth (ft)	Conveyor Angle (degrees)	Height (ft)
40	12	10.3
	15	12.4
	18	14.4
	21	16.3
60	12	14.5
	15	17.5
	18	20.5
	21	23.5
80	12	18.6
	15	22.7
	18	26.7
	21	30.7
100	12	22.8
	15	27.9
	18	32.9
	21	37.8
125	12	28
	15	34.4
	18	40.6
	21	46.8
150	12	33.2
	15	40.8
	18	48.4
	21	55.8

CONICAL STOCKPILE CAPACITY

H	D	Volume		H	D	Volume	
		Cu. Yds.	Tons (100lb/cu. ft.)			Cu. Yds.	Tons (100lb/cu. ft.)
6	16	14	19	26	68	1,158	1,563
8	21	34	46	28	73	1,446	1,952
10	26	66	89	30	78	1,779	2,401
12	31	114	154	35	91	2,824	3,813
14	36	181	244	40	104	4,216	5,691
16	42	270	364	45	117	6,003	8,104
18	47	384	519	50	130	8,234	11,116
20	52	527	711	55	143	10,960	14,795
22	57	701	947	60	156	14,228	19,208
24	63	911	1,229				



Live capacity is the part of pile that can be removed with one feed chute at the center of pile. Approximately ¼ of gross capacity of pile.

Gross Volume = ⅓ Area Base x Height
*Gross Volume, (V_1) Cu. Yd. = .066 (Height, Ft.)^3
*Gross Capacity, Tons = 1.35 x Volume, Cu. Yd. (100#/Cu. Ft.)
*Based on an angle of repose of 37.5°

APPROXIMATE VOLUME OF CIRCULAR STOCKPILE

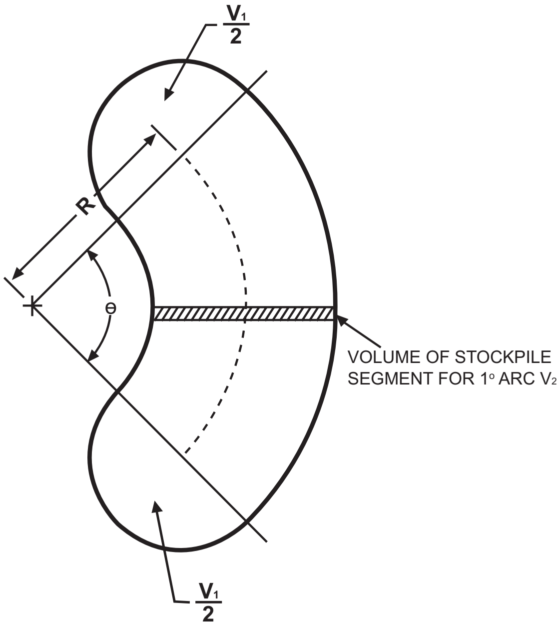
$V_3 = V_1 + V_2\theta$

V_3 = Total volume of stockpile - in cu. yds.
V_1 = volume of ends (volume of conical stockpile) - in cu. yds.
V_2 = Volume of stockpile for 1° Arc - in cu. yds.

$$V_2 = \frac{H^2R}{1{,}187}$$

H = Height of stockpile - in feet
R = Radius of arc (Centerline Pile to Centerline Pivot) - in feet
R = cos 18° x conveyor length L

NOTE: V_2 based on 37.5° angle of repose
θ = Angle of arc - in degrees



V_2 = Volume of Stockpile Segment for 1 degree Arc (cu. yds.)

Radius (ft)	Stockpile Height (H) (ft)									
	10	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**
25	2.1									
30	2.5									
35	2.9	6.6								
40	3.4	7.6								
45	3.8	8.5								
50	4.2	9.5	16.8							
55	4.6	10.4	18.5							
60	5.1	11.4	20.2	31.6						
65	5.5	12.3	21.9	34.2						
70	5.9	13.3	23.6	36.9						
75	6.3	14.2	25.3	39.5	56.9					
80	6.7	15.2	27	42.1	60.7					
85	7.2	16.1	28.6	44.8	64.4	87.7				
90	7.6	17.1	30.3	47.4	68.2	92.9				
95	8	18	32	50	72	98				
100	8.4	19	33.7	52.7	75.8	103.2	134.8			
105	8.8	19.9	35.4	55.3	79.6	108.4	141.5			
110	9.3	20.9	37.1	57.9	83.4	113.5	148.3	187.7		
115	9.7	21.8	38.8	60.6	87.2	118.7	155	196.2		
120	10.1	22.7	40.4	63.2	91	123.8	161.8	204.7	252.7	
125	10.5	23.7	42.1	65.8	94.8	129	168.5	213.2	263.3	
130	11	24.6	43.8	68.4	98.6	134.2	175.2	221.8	273.8	
135	11.4	25.6	45.5	71.1	102.4	139.3	182	230.3	284.3	344
140	11.8	26.5	47.2	73.7	106.1	144.5	188.7	238.8	294.9	356.8
145	12.2	27.5	48.9	76.3	109.9	149.6	195.5	247.4	305.4	369.5
150	12.6	28.4	50.5	79	113.7	154.8	202.2	255.9	315.9	382.3

Examples:

L	H	R	V1	V1	V2	V2	V3	V3
Feet	Feet	Feed	Cu. Yds.	Tons	Cu. Yds.	Tons	90° Stockpile Cu. Yds.	90° Stockpile Tons
60	20.5	57	567	766	20.2	27.3	2,385	3,223
80	26.7	76	1,254	1,693	45.6	61.6	5,358	7,237
100	32.9	95	2,346	3,167	86.6	116.9	10,140	13,688
120	39.1	114	3,938	5,316	146.8	198.2	17,150	23,154
150	48.4	142.5	7,469	10,083	281.2	379.6	32,777	44,247

3. TPH Feed

See belt carrying capacity chart. As a rule of thumb, at 350 fpm, 35-degree troughing idlers and 100 lbs/cu. ft. material, a 24” belt carries 300 TPH, a 30” belt carries 600 TPH and a 36” belt carries 900 TPH.

CONVEYOR BELT CARRYING CAPACITY AT VARIOUS SPEEDS

Belt Width (in)	Capacity in TPH										
	Belt Speed (fpm)										
	100	150	200	250	300	350	400	450	500	550	600
18	69	103	138	172	207	241	276	310	345	379	414
24	132	198	264	330	396	462	528	594	660	726	792
30	215	322	430	537	645	752	860	967	1,075	1,182	1,290
36	318	477	636	795	954	1,113	1,272	1,431	1,590	1,749	1,908
42	441	661	882	1,102	1,323	1,543	1,764	1,984	2,205	2,425	2,646
48	585	877	1,170	1,462	1,755	2,047	2,340	2,632	2,925	3,217	3,510
54	748	1,122	1,496	1,870	2,244	2,618	2,992	3,366	3,740	4,114	4,488
60	932	1,398	1,864	2,330	2,796	3,262	3,728	4,194	4,660	5,126	5,592
72	1,360	2,040	2,720	3,400	4,080	4,760	5,440	6,120	6,800	7,480	8,160

NOTE: *Capacity is based on material weighing 100 lb./cu. ft. with 37.5 degree angle of repose, 3-roll, 35 degree idlers and no skirt boards.
***Capacity is theoretical based on a full cross section. To use for conveyor sizing, use 75%-80% of the capacity listed above.**

4. Conveyor Width

There are a number of factors that affect width. These include TPH feed, future considerations, lump size and the percentage of fines, cross-section of how the material settles on the belt and material weight.

a. Normally, portable conveyors are set up to run at 350 feet per minute, as this is accepted as the best speed for the greatest number of types of material and optimum component life. When it is desirable to run at a different speed, this will usually be a factory decision based on the material and the capabilities requested by the customer. These variations are generally applicable on engineered systems.

RECOMMENDED MAXIMUM BELT SPEEDS

Material Bing Conveyed	Belt Speeds (fpm)	Belt width (in)
Grain or other free-flowing, nonabrasive material	500	18
	700	24-30
	800	36-42
	1,000	48-96
Coal, damp clay, soft ores, overburden and earth, fine-crushed stone	400	18
	600	24-36
	800	42-60
	1,000	72-96
Heavy, hard, sharp-edged ore, coarse-crushed stone	350	18
	500	24-36
	600	Over 36
Foundry sand, preared or damp; shakeout sand with small cores, with or without small castings (not hot enough to harm belting)	350	Any width
Prepared foundy sand and similar damp (or dry abrasive) materials dischared from belt by rubber-edged plows	200	Any width
Nonabrasive materials dischared from belt by means of plows	200 except for wood pulp, where 300 to 400 is preferable	Any width
Feeder belts, flat or troughted, for feeding fine, nonabreasive, or midly abrasive materials from hopper and bins	50-100	Any width

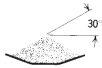
b. Lump size and the percentage of fines can have a major effect on width selection. As a rule of thumb, for a 20-degree surcharge angle, with 10 percent lumps and 90 percent fines, the recommended maximum lump size is one third of the belt width (BW/3). With all lumps and no fines, the recommended maximum lump size is one fifth of the belt width (BW/5). For a 30-degree surcharge angle, with 10 percent lumps and 90 percent fines, the recommended maximum lump size is one sixth of the belt width (BW/6). With all lumps and no fines, the recommended maximum lump size is one tenth of the belt width (BW/10). Belts must be wide enough so any combination of lumps and fine material does not load the lumps too close to the edge of the belt.

c. The cross section of how the material settles on a moving belt can have a major effect on expected tonnage for a given width conveyor.

FACTORS AFFECTING THE CROSS SECTION:

- The **angle of repose** of a material is the angle that the surface of a normal, freely formed pile, makes to the horizontal.
- The **angle of surcharge** of a material is the angle to the horizontal that the surface of the material assumes while the material is at rest on a moving conveyor belt. This angle usually is 5° to 15° less than the angle of repose, though in some materials it may be as much as 20° less.
- The **flowability of a material**, as measured by its angle of repose and angle of surcharge, determines the cross-section of the material load that can safely be carried on a belt. It is also an index of the safe angle of incline of the belt conveyor. The flowability is determined by such material characteristics as size and shape of the fine particles and lumps, roughness or smoothness of the surface of the material particles, proportion of fines and lumps present and moisture content of material.

FLOWABILITY—ANGLE OF SURCHARGE—ANGLE OF REPOSE

Very Free Flowing	Free Flowing	Average Flowing		Sluggish
5° Angle of surcharge	10° Angle of surcharge	20° Angle of surcharge	25° Angle of surcharge	30° Angle of surcharge
				
0°-19° Angle of repose	20°-29° Angle of repose	30°-34° Angle of repose	35°-39° Angle of repose	40°-up Angle of repose
MATERIAL CHARACTERISTICS				
Uniform size, very small rounded particle, either very wet or very dry, such as dry silica sand, cement, wet concrete, etc.	Rounded, dry polished particles, of medium weight, such as whole grain or beans.	Irregular, granular or lumpy materials of medium weight, such as anthracite coal, cottonseed meal, clay, etc.	Typical common materials such as bituminous coal, stone, most ores, etc.	Irregular, stringy, fibrous, interlocking mateial, such as wood chips, bagasse, tempered foundry sand, etc.

d. The material weight affects the volume, which affects the width. Most aggregate weighs between 90-110 lbs. per cubic foot. When the weight varies significantly, it can have a dramatic effect on expected belt width needed to achieve a given tonnage.

5. Horsepower Requirements

The power required to operate a belt conveyor depends on the maximum tonnage handled, the length of the conveyor, the width of the conveyor and the vertical distance that the material is lifted. **Factors X + Y + Z (from tables below) = Total HP Required at Headshaft**. The figures shown are based on average conditions with a uniform feed and at a normal operating speed. Additional factors such as pulley friction, skirtboard friction, material acceleration and auxiliary device frictions (mechanical feeder, tripper, etc.) may require an increase in horsepower.

Drive efficiency is taken into consideration to determine the motor horsepower required. This can be an additional 10-15% above the headshaft horsepower. The ability to start a loaded conveyor will also require an additional horsepower consideration.

FACTOR X - HORSEPOWER REQUIRED TO OPERATE EMPTY CONVEYOR AT 350 FPM										
Conveyor Width	Center-Center of Pulleys									
	25′	50′	75′	100′	150′	200′	250′	300′	350′	400'
18″	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.7	1.8	2
24″	0.9	1.1	1.2	1.4	1.6	1.8	2	2.1	2.3	2.5
30″	1.4	1.6	1.8	1.9	2.2	2.5	2.8	3	3.2	3.5
36″	1.8	2	2.1	2.6	2.9	3.1	3.4	3.8	4.2	4.4
42″	2.1	2.5	2.7	3	3.5	3.7	4.2	4.6	5.3	6
48″	2.7	2.8	3.2	3.4	3.7	4.2	5.3	5.6	6.2	6.7

FACTOR Y - ADDITIONAL HP REQUIRED TO OPERATE LOADED CONVEYOR ON THE LEVEL										
TPH	Center-Center of Pulleys									
	25′	50′	75′	100′	150′	200′	250′	300′	350′	400′
100	0.5	0.6	0.7	0.8	0.9	1	1.1	1.3	1.4	1.5
150	0.8	0.9	1	1.1	1.3	1.5	1.7	1.9	2.1	2.3
200	1	1.2	1.3	1.5	1.7	2	2.2	2.5	2.8	3
250	1.3	1.5	1.6	1.9	2.1	2.5	2.8	3.1	3.5	3.8
300	1.5	1.8	2	2.3	2.6	3	3.3	3.8	4.2	4.5
350	1.8	2.1	2.3	2.6	3	3.5	3.9	4.4	4.9	5.3
400	2	2.4	2.6	3	3.4	4	4.4	5	5.6	6
500	2.5	3	3.3	3.8	4.3	5	5.5	6.3	7	7.5
600	3	3.6	3.9	4.5	5.1	6	6.6	7.5	8.4	9
700	3.5	4.2	4.6	5.3	6	7	7.7	8.8	9.8	10.5
800	4	4.8	5.2	6	6.8	8	8.8	10	11.2	12
900	4.5	5.4	5.9	6.8	7.7	9	9.9	11.3	12.6	13.5
1,000	5	6	6.5	7.5	8.5	10	11	13	14	15

FACTOR Z - HORSEPOWER REQUIRED TO LIFT LOAD ON BELT CONVEYOR										
TPH	Lift									
	10′	20′	30′	40′	50′	60′	70′	80′	90′	100′
100	1	2	3	4	5	6	7	8	9	10
150	1.5	3	4.5	6	7.5	9	10.5	12	13.5	15
200	2	4	6	8	10	12	14	16	18	20
250	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
300	3	6	9	12	15	18	21	24	27	30
350	3.5	7	10.5	14	17.5	21	24.5	28	31.5	35
400	4	8	12	16	20	24	28	32	36	40
500	5	10	15	20	25	30	35	40	45	50
600	6	12	18	24	30	36	42	48	54	60
700	7	14	21	28	35	42	49	56	63	70
800	8	16	24	32	40	48	56	64	72	80
900	9	18	27	36	45	54	63	72	81	90
1,000	10	20	30	40	50	60	70	80	90	100

HOW TO DETERMINE CONVEYOR BELT SPEED

Five factors are required to determine conveyor belt speed.

A = Motor RPM
B = Motor sheave diameter (inches)
C = Reducer sheave diameter (inches)
D = Reducer ratio
E = Diameter of pulley (inches)

A x B ÷ C = Reducer input speed (RPM)

Reducer input speed (RPM) ÷ D = drive pulley RPM

Drive Pulley RPM x 0.2618 x E = conveyor belt speed (FPM)

Example: Determine conveyor belt speed of a 30″ x 60′ conveyor with a 15 HP, 1,750 RPM electric motor drive, 16″ head pulley, 6.2″ diameter motor sheave, 9.4″ diameter reducer sheave and a 15:1 reducer.

A = 1,750 RPM
B = 6.2
C = 9.4
D = 15
E = 16

1,750 x 6.2 ÷ 9.4 = 1,154 RPM (Reducer input)

1,154 RPM ÷ 15 = 77 RPM (Pulley speed)

77 RPM x 0.2618 x 16 = **322 FPM Conveyor belt speed**

NOTE:

1. To increase conveyor belt speed, a smaller reducer sheave could be used or a larger motor sheave could be used.
2. To decrease conveyor belt speed, a larger reducer sheave could be used or a smaller motor sheave could be used.

Kolberg-Pioneer manufactures a variety of portable and stationary conveyors designed to meet the customer's requirements. As a rule of thumb, conveyors are designed with a Class I Drive, 220 PIW 2-ply belt, 5" CEMA B idlers and a belt speed of 350 fpm. At 350 fpm belt speed, basic capacities are: 24" belt width up to 300 TPH; 30" belt width up to 600 TPH; 36" belt width up to 900 TPH.

Conveyor options include: belt cleaners, vertical gravity take-up, horizontal gravity take-up, snub pulley, return belt covers, full hood top belt covers, impact idlers, self-training troughing idlers, self-training return idlers, 220 PIW 2-ply belting with 3⁄16" top covers and 1⁄16" bottom covers, 330 PIW 3-ply belting with 3⁄16" top covers and 1⁄16" bottom covers, CEMA C idlers, walkway with handrail, toeplate and galvanized decking, safety stop switch with cable tripline, discharge hood, wind hoops, balanced driveshaft, backstops, etc.

RADIAL STACKERS

Portable, standard-duty, lattice frame conveyors are most often used as radial stacking conveyors a top folding option is available for road portability.

SUPERSTACKER® TELESCOPING STACKER

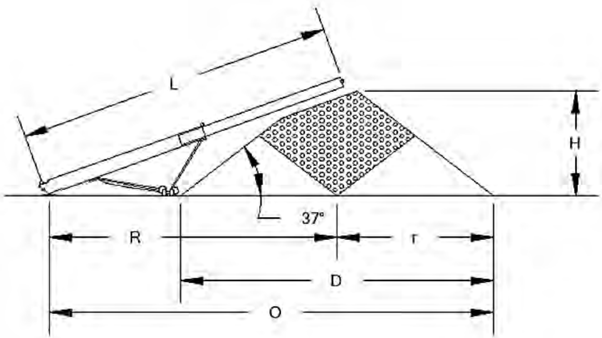
SuperStacker® telescoping stackers are portable, heavy-duty radial stacking conveyors. Because of the stacker's ability to move in three directions (raise/lower, radial and extend/retract), it is effective in reducing segregation and degradation of material stockpiles.

Its unique axle arrangement allows for quick set-up. Road travel suspension of eight (8) 11:00-22.5 tires on tandem walking beam axle. Gull wing radial stockpiling axle assembly of four (4) 385/65D-19.5 tires. Gull wing is hydraulically actuated to lift travel tires off the ground for radial stockpiling. Two (2) hydraulic planetary power travel drives are included.

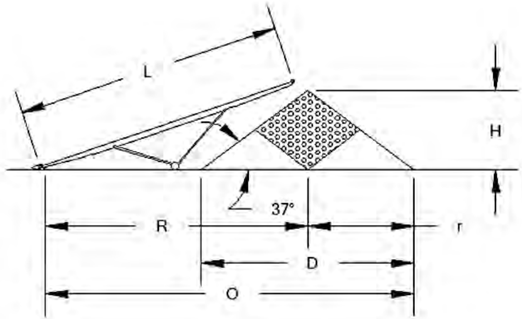
Automated stockpiling with PLC controls is available on all models.

STOCKPILE VOLUMES

SUPERSTACKER® CONVEYOR



CONVENTIONAL RADIAL STACKER



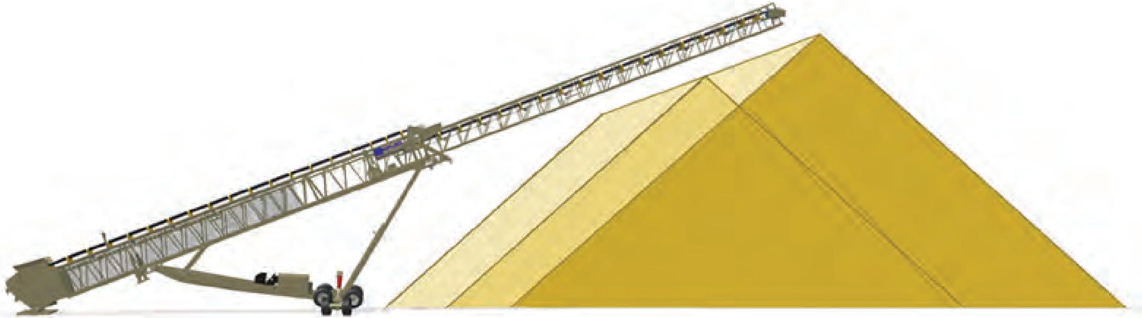
CONVENTIONAL RADIAL STACKERS

Dimensions (ft)						Conical Pile Colume			Volume for One Degree Arc		90° Stockpile Volume		180° Stockpile Volume		270° Stockpile Volume	
L	R	H	D	r	O	Cu. Yd.	Ton	Live Stor.T	Cu. Yd.	Ton	Cu. Yd.	Ton	Cu. Yd.	Ton	Cu. Yd.	Ton
40	38	14.4	37	19	57	195	264	66	7	9	790	1,067	1,385	1,870	1,980	2,673
50	47.6	17.5	45	23	70	351	474	118	12	16	1,449	1,956	2,547	3,438	3,645	4,920
60	57.1	20.5	54	27	84	572	772	193	20	27	2,398	3,237	4,223	5,701	6,049	8,166
70	66.6	23.6	62	31	97	871	1,176	294	31	42	3,690	4,981	6,509	8,787	9,327	12,592
80	76.1	26.7	70	35	111	1,259	1,700	425	46	62	5,378	7,261	9,498	12,822	13,617	18,382
100	95.1	32.9	86	43	138	2,351	3,173	793	87	117	10,157	13,712	17,963	24,250	25,769	34,788
125	118.9	40.6	106	53	172	4,426	5,975	1,494	165	223	19,304	26,060	34,182	46,145	49,059	66,230
150	142.7	48.4	126	63	206	7,461	10,072	2,518	281	379	32,750	44,212	58,039	78,352	83,327	112,492

SUPERSTACKER® CONVEYORS — MAXIMUM STOCKPILE

Dimensions (feet)						Conical Pile Volume		Volume for One Degree Arc		90° Stockpile Volume		180° Stockpile Volume		270° Stockpile Volume	
L	R	H	D	r	O	Cu. Yd.	Ton	Cu. Yd.	Ton	Cu. Yd.	Ton	Cu. Yd.	Ton	Cu. Yd.	Ton
SS130	116.7	44	125.3	62.6	179.3	5,810	7,843	242	326	27,563	37,201	49,316	66,559	71,069	95,917
SS136	122.3	42	128	63.6	185.9	5,605	7,567	231	312	26,386	35,620	47,167	63,673	67,948	91,726
SS150	132.8	51	152	75.7	208.5	9,964	13,452	380	511	44,164	59,442	78,364	105,432	112,564	151,422
SS170	158.3	60	160.3	80.2	238.5	14,064	18,986	502	677	59,224	79,952	104,389	140,925	149,554	201,898
SS190	172	66	178	89	261	20,000	27,000	741	1,000	86,667	117,000	153,333	207,000	220,000	297,000

SUPERSTACKER® TELESCOPING STACKER



Larger Stockpile Capacity: The telescoping action of the SuperStacker® conveyor coverage makes it capable of creating stockpiles with up to 30% more capacity than a standard radial stacker of the same length.

HOPPER/FEEDERS

- **Gravity feed hoppers** are used primarily in free-flowing materials and are installed directly over the conveyor tail end. They are used with top loading equipment.
- **Feeder hoppers** generally provide a more accurate metering of material than a gravity hopper.
- **Belt feeders/hoppers** are commonly used and recommended for handling sand, gravel and sticky materials, like clay or topsoil that tend to build-up in other types of feeders. A hopper is mounted above the feeder for use with top loading equipment.
- **Reciprocating plate feeders/hoppers** are used for free-flowing sand and gravel to minimize impact directly to the conveyor belt. A hopper is mounted above the feeder for use with top loading equipment.
- **Gravity feed dozer traps** are used primarily for free-flowing materials when push loading material with a dozer. Material feeds directly to conveyor belt.
- **Belt feeder/dozer traps** include a belt feeder as described above with feed coming from a dozer, pushing material into the dozer trap.
- **Plate feeder/dozer traps** include a plate feeder as described above with the feed coming from a dozer , pushing material into the dozer trap.

PUGMILLS & PUGMILL PLANTS

(Model 52 shown)

Kolberg-Pioneer pugmill plants feature an aggressive mixing action and portability. The continuous mix pugmill includes two counter rotating shafts with paddles, along with timing gears that provide optimum speed to obtain the quality mix desired. Controlled blending and automatic proportioning ensure your end product is the consistency you require. Multiple configurations of ingredient feed systems ensure maximum flexibility and unparalleled ease of operation.

Pugmills can be sold as a bare unit or as a plant.

AVAILABLE MODELS:

Model	Primary Hopper	Top Opening	Secondary Hopper	Top Opening	Pugmill Size	Capacity
52 Plant	9 cu. yd.	12'x6'	6.5 cu. yd.	12'x6'	48" x6'/ 60 hp	up to 300 TPH
52S Plant	15 cu. yd.	14'x7	8 cu. yd.	14'x7'	48"x8'/ 100 hp	up to 500 TPH
50-486	-	-	-	-	48" x6'/ 60 hp	-
50-488	-	-	-	-	48"x8'/ 75 hp	-

Material Handling

WASHING AND CLASSIFYING

INTRODUCTION

Clean aggregates are important to the construction industry, yet producers are frequently hard-pressed to meet all requirements for cleanliness. Materials engineers constantly strive to improve concrete and bituminous mixes and road bases. While hydraulic methods are the most satisfactory for cleaning aggregates to achieve the desired result, they are not always perfect. It is still necessary to accept materials on the basis of some allowable percent of deleterious matter.

In the broadest terms, construction aggregates are washed to meet specifications. However, there is more to processing aggregates than just washing. Among these functions are:

1. Removal of clay and silt
2. Removal of shale, coal, soft stone, roots, twigs and other deleterious material
3. Sizing
4. Classifying/separating
5. Dewatering

There is no washing method that is perfect and some materials require too much time and money to process. It is important, therefore, to test the source thoroughly beforehand to ensure the desired finished aggregates can be produced at reasonable cost.

The project materials engineer can be of immeasurable help in determining the economic suitability of the material, and generally must approve the source before production begins. Many manufacturers of washing equipment will examine and test samples to determine whether their equipment can do the job satisfactorily.

The ideal gradation is seldom, if ever, met in naturally occurring deposits, yet the quality and control of these gradations is absolutely essential to the workability and durability of the end use. Gradation is a characteristic that can be changed or improved with simple processes and is the usual objective of aggregate preparation plants.

Crushing, screening and blending are methods used to affect the gradations of aggregates. However, even following these processes, the material may still require washing to meet specification for cleanliness and for separation very small material.

Washing and classifying of aggregates can be considered in two parts, depending on the size range of material.

Coarse material - generally above 3/8″ (sometimes split at 1/4″ or 4 mesh). The washing process typically removes foreign, objectionable material, including the finer particles.

Fine aggregates - from 3/8″ down. In this case, washing is used to to remove dirt and silt while retaining sand down to 100-200 mesh.

GRADATION OF AGGREGATES

Gradation is used to denote the distribution of sizes of the particles of aggregates. It is represented by a series of percentages by weight of particles passing one size of sieve but retained by a smaller size. The distribution is determined by a mechanical analysis performed by shaking the aggregate through a series of nested sieves or screens, in descending order of size of openings. Round openings are used for larger screens, square ones for the smaller sieves. Prescribed methods and prescribed openings of the screens and sieves have been established by the ASTM (American Society for Testing Materials). The normal series of screens and sieves is: 1½", ¾", ⅜", Numbers 4, 8, 16, 30, 50, 100, 200 mesh.

SIEVES FOR TESTING PURPOSES

Screen or Sieve Designation	Nominal Opening Equivalents		
	mm	in	microns
4"	101.6		
3"	76.2		
2"	50.8		
1½"	38.1		
1"	25.4		
¾"	19.1		
½"	12.7		
⅜"	9.52		
¼"	6.35		
No.4	4.76	0.187	4,760
6	3.36	0.132	3,360
8	2.38	0.0937	2,380
12	1.68	0.0661	1,680
16	1.19	0.0469	1,190
20	0.84	0.0331	840
30	0.59	0.0232	590
40	0.42	0.0165	420
50	0.297	0.0117	297
70	0.21	0.0083	210
100	0.149	0.0059	149
140	0.105	0.0041	105
150	0.1	0.0039	100
200	0.074	0.0029	74
270	0.053	0.0021	53
400	0.037	0.0015	37

GRADING REQUIREMENTS FOR COARSE AGGREGATES

Size Number	Normal Size (Sieves with Square Opening)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Weight Percent												
		4 in. (100mm)	3½ in. (90mm)	3 in. (75mm)	2½ in (63mm)	2 in. (50mm)	1½ in. (37.5mm)	1 in. (25.0mm)	¾ in. (19.0mm)	½ in. (12.5mm)	⅜ in. (9.5mm)	No. 4 (4.75mm)	No. 8 (2.36mm)	No. 16 (1.18mm)
1	3½ - 1½ in. (90 - 37.5 mm)	100	90 - 100		25 - 60		0 - 15		0 - 5					
2	2½ - 1½ in. (63 - 37.5 mm)			100	90 - 100	35 - 70	0 - 15		0 - 5					
3	2 - 1 in. (50 - 25.0 mm)				100	90 - 100	35 - 70	0 - 15		0 - 5				
357	2 in - No. 4 (50 - 4.75 mm)				100	95 - 100		35 - 70		10 - 30		0 - 5		
4	1½ - ¾ in. (37.5 - 19.0 mm)					100	90 - 100	20 - 55	0 - 15		0 - 5			
467	1½ in - No. 4 (37.5 - 4.75 mm)					100	95 - 100		35 - 70		10 - 30	0 - 5		
5	1 - ½ in. (25.0 - 12.5 mm)						100	90 - 100	20 - 55	0 - 10	0 - 5			
56	1 - ⅜ in. (25.0 - 9.5 mm)						100	90 - 100	40 - 85	10 - 40	0 - 15	0 - 5		
57	1 in. - No. 4 (25.0 - 4.75 mm)						100	95 - 100		25 - 60		0 - 10	0 - 5	
6	¾ - ⅜ in. (19.0 - 9.5 mm)							100	90 - 100	20 - 55	0 - 15	0 - 5		
67	¾ in. - No. 4 (19.0 - 4.75 mm)							100	90 - 100		20 - 55	0 - 10	0 - 5	
7	½ in. - No. 4 (12.5 - 4.75 mm)								100	90 - 100	40 - 70	0 - 15	0 - 5	
8	⅜ in. - No. 8 (9.5 - 2.36 mm)									100	85 - 100	10-30	0 - 10	0 - 5

SAND SPECIFICATIONS

Common sand specifications are ASTM C-33 for concrete sand and ASTM C-144 for mason sand. These specifications are often written numerically and also shown graphically.

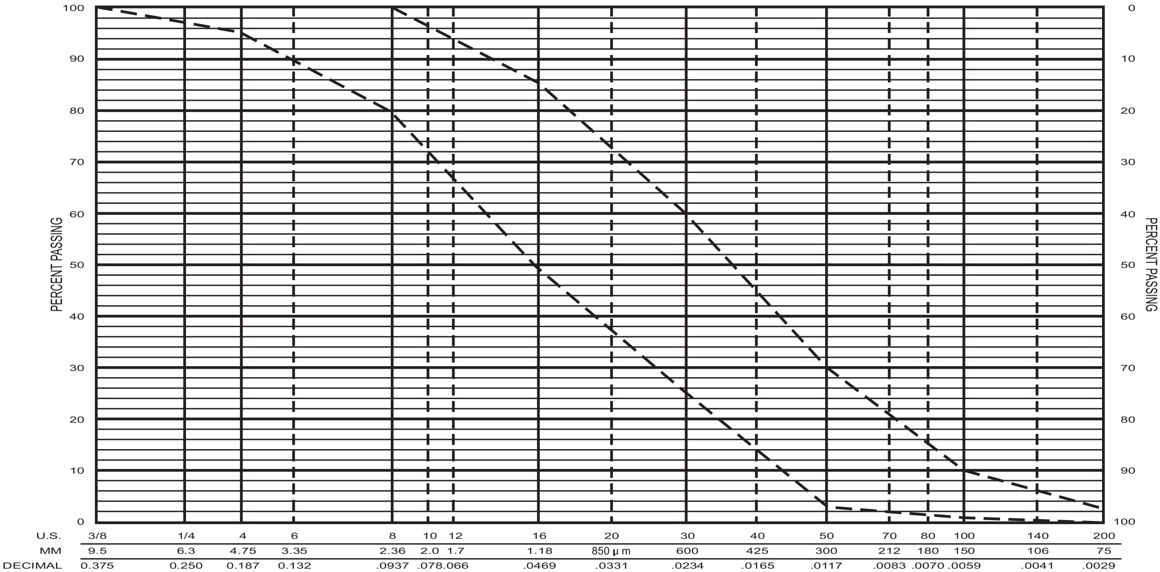
ASTM C-33

Sieve	Limits % Passing	Center Spec % Passing
3/8"	100	100
No. 4	95 -100	97.5
8	80 -100	90
16	50 - 85	67.5
30	25 - 60	42.5
50	5 - 30	17.5
100	0 - 10	5
200	0 - 3	1.5

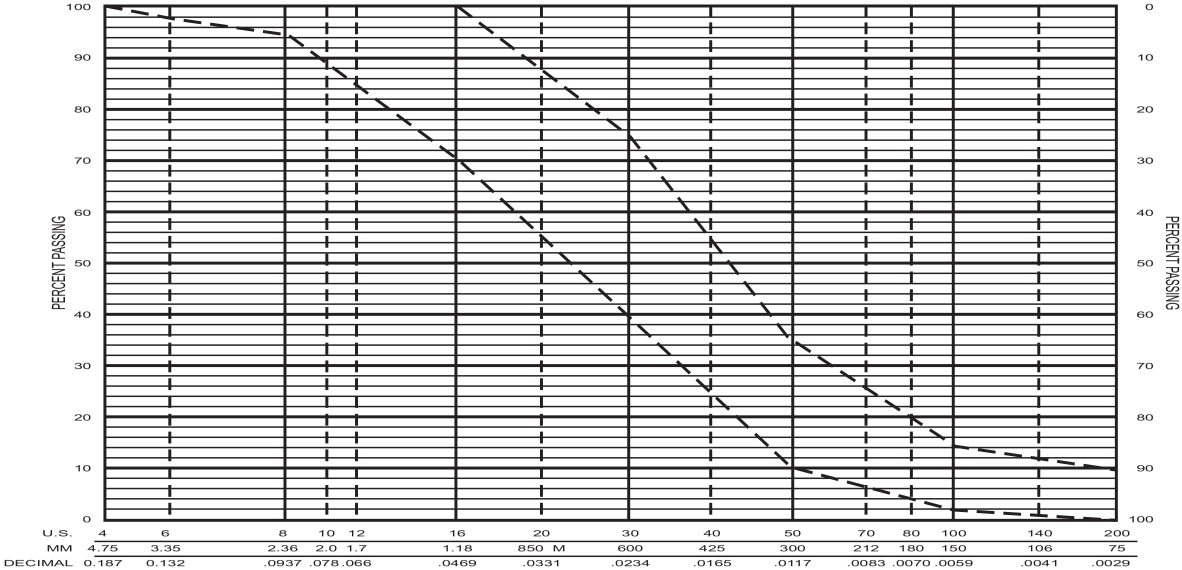
ASTM C-144

Sieve	Limits % Passing	Center Spec % Passing
3/8"	100	100
No. 4	100	100
8	95 - 100	97.5
16	70 - 100	85
30	40 - 75	57.5
50	10 - 35	22.5
100	2 - 15	8.5
200	0 - 10	5

ASTM C-33


PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
0
10
20
30
40
50
60
70
80
90
100
U.S.
MM
DECIMAL
3/8 9.5 0.375
1/4 6.3 0.250
4 4.75 0.187
6 3.35 0.132
8 2.36 .0937
10 2.0 .078
12 1.7 .066
16 1.18 .0469
20 850 µ m .0331
30 600 .0234
40 425 .0165
50 300 .0117
70 212 .0083
80 180 .0070
100 150 .0059
140 106 .0041
200 75 .0029

ASTM C-144


PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
0
10
20
30
40
50
60
70
80
90
100
U.S.
4 6 8 10 12 16 20 30 40 50 70 80 100 140 200
MM
4.75 3.35 2.36 2.0 1.7 1.18 850 M 600 425 300 212 180 150 106 75
DECIMAL
0.187 0.132 .0937 .078 .066 .0469 .0331 .0234 .0165 .0117 .0083 .0070 .0059 .0041 .0029

FM AND SE

The factor called **fineness modulus (FM)** serves as a quick check for samples to meet specifications without checking each sieve size of material against the standards set for a particular job. FM is determined by adding the cumulative retained percentages of sieve sizes #4, 8, 16, 30, 50 and 100 and dividing the sum by 100.

Sieve	% Passing	% Retained
#4	97	3
#8	81	19
#16	59	41
#30	36	64
#50	15	85
#100	4	96
		308 / 100 = 3.08 (FM)

Different agencies will require different limits on the FM. Normally, the FM must be between 2.3 and 3.1 for ASTM C-33 concrete sand with only 0.1 variation for all the material used throughout a certain project.

The **sand equivalent test (SE)** is more complex than the FM test. The "equivalent" refers to the equivalent quantities of fine versus coarse particles in a given sand sample. The test is performed by selecting a given quantity of a sand sample and mixing it in a special solution. The chemicals in the solution contain excellent wetting agents. These wetting agents will rapidly dissolve any deposits of semi-insoluble clays or plastic clays, which are clinging to the individual sand particles. After a specified period of agitation, either by hand or by machine, the sample is allowed to stand in a graduated tube for a specified time period. A weighted plunger is slowly lowered into the settled sand-solution mixture, and the depth to which the weight descends is noted from the graduations on the tube. A formula is supplied with the testing apparatus and from that formula the "SE" is determined.

In general, the finer the sand, the deeper the weight will penetrate. The wetting agents that dissolve the clay make a seemingly coarse material much finer because the clays are now a separate, very fine product. This extra fine material acts as a lubricant and the weight will descend deeper into the sample. Because of this, it is possible that a sample with an acceptable FM is rejected for failure to pass the SE test.

COARSE MATERIAL WASHING

In order to produce aggregate at the most economical cost, it is important to quickly remove any size fraction that can be considered ready for use. The basic process consists of crushing oversized material, scrubbing or washing coatings or entrapped materials, sorting and dewatering. Beneficiation of some coarse aggregate fractions may be necessary. When scrubbing or washing coarse material is required, it is generally a consideration of the material size, the type of dirt, clay or foreign material to be scrubbed and the target tons-per-hour rate that will determine when coarse material washing equipment to use.

LOG WASHERS

Purpose: In the aggregate industry, the log washer is known best for its ability to remove tough, plastic soluble clays from natural and crushed gravel, crushed stone and ore feeds. The log washer will also remove coatings from individual particles, break up agglomerations, and reduce some soft, unsound fractions by a form of differential grinding.

Design: The log washer consists of a trough or tank of all welded construction set at an incline (typically 6-10°) to decrease the transport effect of the paddles and to increase the mass weight against the paddles. Each "log" or shaft (two per unit) is fitted with four rows of paddles that are staggered and timed to allow each shaft to overlap and mesh with the paddles of the other shaft. The paddles are pitched to convey the material up the incline of the trough to the discharge end.

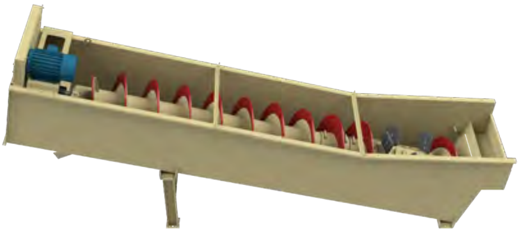
Kolberg-Pioneer's is unique paddle design is set in a spiral pattern around the shaft; instead of in a straight line. This design feature provides many benefits, including: 1) reduced intermittent shock loading of the log, 2) a portion of the mass is in motion at all times, reducing power peaks and valleys and overall power requirements, 3) reduced wear and 4) more effective scrubbing. Other important features of the log washer include two large tank drain/clean-out ports, rising current inlet, overflow ports on each side of the unit, cast ni-hard paddles with corrugated faces, readily-available, externally-mounted lower end bearings and a custom-designed and manufactured single-input dual-output gear reducer.

Application: The majority of the scrubbing action performed by the log washer is caused by the abrasion of one stone particle on another, rather than paddles on material. With this scrubbing action and feed material characteristics like solubility, the log washer can handle a wide range of capacities. In a typical application, the log washer will be followed by a screen with spray bars to remove fines and clay coatings from the stone.

LOG WASHERS

Model	Capacity (TPH)	Motor (hp)	Water Required. (GPM)	Maximum Feed Size (in)	Approx. Dead Load (lb)	Approx. Live Load (lb)
8024-18	25-80	40	25-250	3″	12,500	15,000
8036-30	85-200	100	50-500	4″	34,000	45,000
8048-30	125-300	150	100-800	5″	47,500	70,000
8048-35	125-400	200	100-800	5″	53,000	83,000

COARSE MATERIAL WASHERS



Purpose: The coarse material washer is used to remove a limited amount of deleterious material from a coarse aggregate. This deleterious material includes shale, wood, coal, dirt, trash and some very soluble clay. A coarse material washer is often used as final wash for coarse material (typically -2½" x +⅜") following a wet screen. Both single and double spiral units are available, depending on the capacity required.

Design: The coarse material washer consists of a long, vertical-sided trough or tank of all welded construction set at a 15° incline. The shaft(s) or spiral(s) of a coarse material washer begin with one double-pitch spiral flight with replaceable ni-hard outer wear shoes and AR steel inner wear shoes. Following this single flight is a variable number of bolt-on paddle assemblies. Standard units include four sets of paddle arms with ni-hard tips. Two sets of arms replace one full spiral. The balance of the spiral(s) consists of double-pitch spiral flights with replaceable ni-hard outer wear shoes and AR steel inner wear shoes.

Other important features of the coarse material washer include a rising current manifold, adjustable full width overflow weirs, readily-available, externally-mounted lower end bearing(s) and upper end bearing(s) and shaft mounted gear reducer with v-belt drive assembly (one drive assembly per spiral).

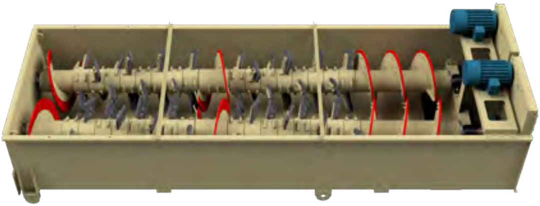
Application: As previously noted, the number of paddle assemblies vary. The number of paddle assemblies installed on a particular unit is dependent on the amount of water turbulence and scrubbing action required to suitably clean the feed material. As the number of paddles is increased, the operational characteristics of the unit change, including increased scrubbing action, increased retention time, reduced capacity and increased power requirements.

COARSE MATERIAL WASHERS

Model	Capacity (TPH)	Motor (hp)	Water Required (GPM)	Max Feed Size (in)	Approx. Dead Load (lb)	Approx. Live Load (lb)
SINGLE SPIRAL CONFIGURATIONS						
6024-15S	60-75	15	300-400	2½″	6,200	9,000
6036-19S	150-175	25	400-600	2½″	10,400	19,000
6048-23S	200-250	40	500-700	3″	15,600	38,500
TWIN SPIRAL CONFIGURATIONS						
6036-19T	300-350	25	700-900	2½″	17,000	37,000
6048-23T	400-500	40	800-1,000	3″	28,500	78,000

NOTE: Two motors required on twin units. 24″ diameter unit offered only in single spiral configuration.

BLADEMILLS



Purpose: Similar in design to the coarse material washer, the blademill is used to pre-condition aggregates for more efficient wet screening. Blademills are generally used prior to a screening and washing application to break up small amounts of soluble mud and clay. Typical feed to a blademill is 2½" x 0". Units are available in both single- and double-spiral designs, depending on the capacity required.

Design: The blademill consists of a long vertical sided trough or tank of all welded construction set at a variable incline (typically 0-4°), depending on the degree of scrubbing or pre-conditioning required. The shaft(s) or spiral(s) of a blademill begin with one double pitch spiral flight with replaceable ni-hard outer wear shoes and AR steel inner wear shoes. Following this single flight is a combination of bolt-on paddle and flight assemblies, which can be varied, depending on the amount of scrubbing required. The flight assemblies include replaceable ni-hard outer wear shoes and AR steel inner wear shoes. The paddle assemblies are fitted with replaceable cast ni-hard paddle tips. Other important features of the blademill include readily-available, externally-mounted lower end bearing(s) and upper end bearing(s) and shaft mounted gear reducer with v-belt drive assembly (one drive assembly per spiral).

Application: The number of paddle and flight assemblies, as well as the angle of operation, can be varied depending on the amount of scrubbing or pre-conditioning required. As the number of paddles or angle of operation is increased, the operational characteristics of the unit change, including increased scrubbing action, increased retention time, reduced capacity and increased power requirements.

Capacities/specifications: Blademill capacity is indirectly a function of retention time. Each application will indicate a required period of time for effective washing, which actually determines the capacity of the unit. As a rule of thumb, a blademill can be expected to process in the range of a coarse material washer with respect to raking capacity in TPH and requires approximately ¼ to ⅓ of the water required in a coarse material washer. If sufficient information is not available with regards to clay content and solubility, the lower end of the coarse material washer range should be used. Blademills are offered in single or twin screw configurations of the same size.

BLADEMILLS

Model	Capacity (TPH)	Motor (hp)	Water Required (GPM)	Max Feed Size (in)	Approx. Dead Load (lb)	Approx. Live Load (lb)
SINGLE SPIRAL CONFIGURATIONS						
6524-15S	60-75	15	75-150	2½″	6,900	7,500
6536-19S	150-175	25	100-200	2½″	9,800	15,800
6548-23S	200-250	40	125-250	3″	17,700	30,700
TWIN SPIRAL CONFIGURATIONS						
6536-19T	300-350	25	175-350	2½″	17,200	28,300
6548-23T	400-500	40	200-400	3″	31,100	57,600

NOTE: Two motors required on twin units. 24″ diameter unit offered only in single spiral configuration.

FINE MATERIAL WASHING AND CLASSIFYING

INTRODUCTION

Aside from washing sand to remove dirt and silt, hydraulic methods are employed to size the material and to classify or separate it into the proper particle designation. After these steps, the product is usually dewatered.

Washing aggregates to clean them is not new. However, much closer attention has been given to both the cleanliness and the gradation of the fines in construction aggregates. This has developed new techniques for processing of fine aggregates. These techniques require more technical know-how and methods more precise than those usually associated with washing gravel and rock. At the same time, it has been necessary to advance the procedure in a practical way so as to produce material at a reasonable price.

Screening is the best way to separate coarse aggregates into size ranges. With fine materials, however, screening on less than #8 mesh is usually impractical. This necessitates a split between ⅜" and #4 mesh, putting everything finer into the category of requiring hydraulic separation for best gradation control.

With hydraulic separation, a large amount of water is used. Here, separation depends on the relative buoyancies of the grain particles and on their settling rates under specific conditions of water flow and turbulence. In some cases, separation depends on the relative specific gravity difference between the materials to be separated and the hydraulic medium. In a certain sense, this applies when water is used to separate particle sizes of sands. Perhaps it would be more apt to say this separation of sands is based on relative densities or that the process separates by gravity.

In its strictest sense, however, classifying means that several sizes of sand products of equal specific gravity can be separated while rejecting slimes, silt and similar deleterious substances. But sand particles are not necessarily always of the same specific gravity, so frequently both specific gravity and particle size affect the rate of settling. Consequently, you cannot always estimate the probable gradation of the final products without preliminary tests on the material. Nor can you be sure of product quality without analysis and tests after processing.

In any hydraulic classification of sand, the amount of fines retained with the final product will be dependent upon:

1. Area of settling basin
2. Amount of water used
3. Extent of turbulence in settling area

The area of the settling basin generally will be fixed. The amount and size of fines to be rejected will be determined by regulating the water quantity and turbulence.

FINE MATERIAL WASHERS

Purpose: Fine material washers, also frequently called screw classifiers or screw dehydrators, are utilized to clean and dewater fine aggregates (typically –⅜″ or -#4 mesh), fine-tune end products to meet specifications and to separate out slimes, dirt and fines (typically -#100 mesh or finer). Available in both single and twin configurations, fine material washers are most often used after a sand classifying/blending tank or after a wet screening operation.

Design: The fine material washer consists of an all-welded tub set at an incline of approximately 18.5° (4:12 slope) and includes a full-length curved bottom with integral rising current manifold designed to control fines retention and the water velocity within the pool. The lower end of the tub or tank is flared to provide a large undisturbed pool, which provides accurate material classification. Long adjustable weirs around the top of the sides and end of the tub's flared portion are designed to handle large volumes of slurry and to control the pool level for uniform overflow. Also incorporated into the design of the tub is a chase water line to clear the drain trough for better dewatering and an overflow flume.

The shaft(s) or spiral(s) of the fine material washer consist of a double-pitch, solid flight spiral, complete with AR steel inner wear shoes and urethane outer wear shoes, to provide protection of the entire flight (cast ni-hard outer wear shoes are optional).

Other important features of the fine material washer include:

- Readily-available, externally-mounted lower end bearings and upper end bearings
- Shaft-mounted gear reducer with v-belt assembly (one drive assembly per spiral)
- Center feed box with internal and external baffles to reduce the velocity of the material entering the fine material washer and to reduce pool turbulence for enhanced fines retention

Application: Two important elements must be considered when sizing a fine material washer for an application: 1) calculation of overflow capacities and 2) calculation of sand raking capacity. Overflow capacity is critical to ensure that the unit has sufficient capacity to handle the water required for proper dilution of the feed material, which allows for proper settling to occur and to produce the desired split point. The requirements for water in a fine material washer are to have approximately 5 GPM of water for every 1 STPH of total sand feed or 50 GPM of water for every 1STPH of silt (-#200 mesh). The larger of these two figures and the desired mesh split to be produced within the fine material washer are then used to assist in sizing of the unit. This process allows for proper dilution of the sand so that the material will correctly settle in the tub.The raking capacity of a fine material washer is governed by the fineness of the material to be dewatered. Generally speaking, the finer the material to be raked, the slower the spiral speed must be, to ensure adequate dewatering and reduced pool turbulence. The following tables are provided to assist in the proper selection of a fine material washer.

PERCENT SCREW SPEED vs. PERCENT FINES (in the product)

% SCREW SPEED (RPM)	% PASSING 50 MESH	% PASSING 100 MESH	% PASSING 200 MESH
100%	15	2	0
75%	20	5	0
50%	30	10	3
25%	50	25	8

FINE MATERIAL WASHERS
RAKING & OVERFLOW CAPACITY TABLE

Model	Capacity Single/ Twin (TPH)	Spiral Speed %	Spiral Speed (RPM)	Minimum Motor HP Req. / Spiral	Overflow Capacities (GPM) Single/Twin		
					100 Mesh	150 Mesh	200 Mesh
*5024-25	50	100%	32	7.5	500	225	125
	37	75%	24	5			
	25	50%	16	5			
	12	25%	8	3			
*5030-25	75	100%	25	10	550	275	150
	55	75%	19	10			
	38	50%	13	7.5			
	18	25%	7	5			
5036-25	100/200	100%	21	15	700/1,200	325/600	175/300
	75/150	75%	15	10			
	50/100	50%	12	7.5			
	25/50	25%	6	5			
5044-32	175/350	100%	17	20	1,500/2,700	750/1,300	400/750
	130/260	75%	13	15			
	85/170	50%	9	10			
	45/90	25%	5	7.5			
5048-32	200/400	100%	16	20	1,650/2,900	825/1,450	450/825
	150/300	75%	12	15			
	100/200	50%	8	10			
	50/100	25%	4	7.5			
5054-34	250/500	100%	14	30	1,800/3,200	900/1,600	525/900
	185/370	75%	11	25			
	125/250	50%	7	15			
	60/120	25%	4	10			
5060-35	325/650	100%	13	30	2,200/3,600	1,000/1,800	550/950
	250/500	75%	9	25			
	165/330	50%	5	20			
	85/170	25%	3	15			
5066-35	400/800	100%	11	40	2,400/4,000	1,100/2,000	625/1,000
	300/600	75%	8	30			
	200/400	50%	5	25			
	100/200	25%	3	15			
5072-38	475/950	100%	11	60	2,600/4,400	1,250/2,200	700/1,200
	355/710	75%	8	50			
	235/475	50%	5	30			
	120/240	25%	3	15			

NOTE: Two motors required on twin units.
*24″ & 30″ dia. units offered only in single spiral configuration.

FINE MATERIAL WASHER WEIR OVERFLOW RATES

NOTE: All flows shown are in GPM. ***Bold italicized*** flows depict overflow rates required for 200, 150 & 100 mesh splits respectively.

MODEL	WEIR LENGTH	AVERAGE DEPTH OVER WEIR									
		¼″	½″	¾″	1″	1¼″	1½″	1¾″	2″	2¼″	2½″
		125 ***225***		***500***							
5024-25S	15′3″	92	229	397	564	717	991	1,205	1,449	1,678	1,983
		150	***275***	***550***							
5030-25S	15′9″	95	236	410	583	740	1,024	1,244	1,496	1,733	2,048
		175	***325***		***700***						
5036-25S	16′3″	98	244	423	601	764	1,056	1,284	1,544	1,788	2,113
			300	***600***		***1,200***					
5036-25T	19′9″	119	296	514	731	928	1,284	1560	1,876	2,173	2,568
			400	***750***			***1,500***				
5044-32S	22′0″	132	330	572	814	1,034	1,430	1738	2,090	2,420	2,860
				750		***1,300***			***2,700***		
5044-32T	26′0″	156	390	676	962	1,222	1,690	2,054	2,470	2,860	3,380
			450		***825***		***1,650***				
5048-32S	22′3″	134	334	579	823	1,046	1,446	1,758	2,114	2,448	2,893
				825		***1,450***			***2,900***		
5048-32T	26′9″	160	401	696	990	1,257	1,739	2,113	2,541	2,943	3,478
			525	***900***			***1,800***				
5054-34S	26′0″	156	390	676	962	1,222	1,690	2,054	2,470	2,860	3,380
				900		***1,600***			***3,200***		
5054-34T	31′0″	186	465	806	1,147	1,457	2,015	2,449	2,945	3,410	4,030
			550		***1,000***			***2,200***			
5060-35S	26′6″	159	398	689	981	1,246	1,723	2,094	2,518	2,915	3,445
				950		***1,800***				***3,600***	
5060-35T	31′6″	189	473	819	1,166	1,481	2,048	2,489	2,993	3,465	4,095
			625		***1,100***			***2,400***			
5066-35S	27′3″	164	409	709	1,008	1,281	1,771	2,153	2,589	2,998	3,543
				1,000		***2,000***				***4,000***	
5066-35T	32′9″	197	491	852	1,212	1,539	2,129	2,587	3,111	3,603	4,258
			700		***1,250***			***2,600***			
5072-38S	27′9″	167	416	722	1,027	1,304	1,804	2,192	2,636	3,053	3,608
				1,200		***2,200***				***4,400***	
5072-38T	34′3″	206	514	891	1,267	1,610	2,226	2,706	3,254	3,768	4,453

CLASSIFICATION METHODS APPLIED TO FINE AGGREGATES

INTRODUCTION

Classification is the sizing of solid particles by means of settling. In classification, the settling is controlled so that the fines, silts and clays will flow away with a stream of water or liquid, while the coarse particles accumulate in a settled mass.

Washing and classifying equipment is manufactured in many different configurations depending on the natural material characteristics and the end product(s) desired. Although the general definition of aggregate classifying can be applied to coarse material (+⅜"), it is most commonly applied to the material passing ⅜". Included in the fine material classifying equipment are the sand screws, counter-current classifiers, sand drags and rakes, hydro-cyclones, hydro-classifiers, bowl classifiers, hydro-separators, density separators, and scalping/classifying tanks.

All the above-mentioned classifiers, except the scalping/classifying tank, are generally single product machines that can only affect the gradation of the end product on the very fine side (the overflow separation size). This separation size, due to the mechanical means employed, is never a knife-edge separation. However, the aim of modern classification methods is to approach a clean-cut differentiation. Many material specifications today call for multiple sizes of sand with provisions for blending back to obtain the gradations required. It is rare to find the exact blend occurring naturally or to economically manufacture the blend to exact specifications. In either case, the accepted procedure is to screen out the fine material from which the sand specifications will be obtained. This material is processed in a water scalping/classifying tank for multiple separation by grain sizes or particle specific gravity.

There is no mystery connected with classifying tanks. They are merely long settling basins capable of holding large quantities of water. The water and sand mix (slurry) is introduced into the tank at the feed end. The slurry, which often comes from dredging or wet screening operations, flows toward the overflow end, and as it does, solids settle to the bottom of the tank. Weight differences between sand particles allow coarser material to settle first while lighter material progressively settles out further along the tank length.

PRINCIPLES OF SETTLING

The specific gravity of aggregates varies according to the nature of the minerals in the rock. "Bulk" specific gravity is used in aggregate processing and indicates the relative weight of the rock or sand, including the natural pores, voids and cavities, as compared to water (specific gravity = 1.0). In the case of fine aggregates, the specific gravity is about 2.65. As a consequence, the weight of grains of sand will be directly proportional to their volume. All grains of sand of a given size will therefore weigh the same, and the weight can be measured in relation to the opening of the sizing sieve.

A second basic consideration is that of the density or specific gravity of the slurry itself. Dilution is usually expressed in percentages by weight of either the solid or of the water. Since the specific gravity of water is 1.00 and that of sand is assumed to be 2.65, a simple calculation will give the specific gravity, or density, of the slurry mixture.

CALCULATION OF SLURRY OR PULP

The following method of calculating slurry or pulp is quick, accurate and requires no reference tables. It may be used for any liquid-solid mixture.

Basic equation, for a single substance or mixture:

$$\text{GPM} = \text{TPH} \times \frac{4}{\text{SG}}$$

For water: GPM Water = TPH Water x 4

For solids: $\text{GPM Solids} = \text{TPH Solids} \times \frac{4}{\text{SG Solids}}$

For solids SG 2.65-2.70 (sand, gravel, quartz, limestone):
GPM solids = TPH Solids x 1.5

For slurry: $\text{GPM Slurry} = \text{TPH Slurry} \times \frac{4}{\text{SG Slurry}}$

To solve for Specific Gravity:

$$\text{SG slurry} = \frac{\text{TPH Slurry} \times 4}{\text{GPM Slurry}}$$

Example:
Given: 10 TPH of sand @ 40% solids (by weight)
Find: GPM and SG of slurry
Use this matrix to calculate your data

	% Weight	TPH	SG	GPM
Water			1.0	
Solids	40	10	2.67	
Slurry	100			

Fill in as follows:
1) Convert % weight to decimel form: 40% = 0.40
2) TPH slurry = TPH solids divided by 0.40 = 25
3) TPH water = TPH slurry - TPH Solids = 15
4) GPM water = TPH water x 4 = 60
5) GPM solids = TPH solids x 1.5 = 15
6) GPM slurry = GPM water + GPM solids = 75
7) SG slurry = TPH slurry x 4/GPM slurry = 1.33

	% Weight	TPH	SG	GPM
Water	60	15	1.0	60
Solids	40	10	2.67	15
Slurry	100	25	1.33	75

The tablulation can be solved for all unknowns if "SG solids" and two other principal quantities are given.

If "GPM slurry", "% solids" and "SG solids" are given, solve for 1 TPH and divide total GPM slurry by resultant GPM slurry to obtain TPH solids.

Rework tabulation with this figure to check the result.

Percent solids by volume may be calculated directly from GPM column.

GPM column may also be extended to any other unit desired; e.g., cubic feet per second.

NOTE:

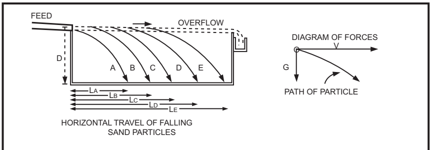
1) The equation is based on U.S. gallon and std. (short) ton of 2,000 lbs.
2) The difference in result by using 2.65 or 2.70 "SG solids" is negligible compared to the inaccuracy usually inherent in given quantities.
3) For sea water, use SG 1.026. In this case, the difference is appreciable.

CONVERSION FACTORS

To Obtain	Multiply	By	Based On
TPH	Cu. Yd/Hr.	1.35	Sand 100#/cu. ft., dry.
Short TPH	Long TPH	1.12	2,240lb ton
Short TPH	Metric TPH	1.1023	Kilo = 2.2046lb
US GPM	British GPM	1.201	
US GPM	Cu. Ft./Min.	7.48	
US GPM	Cu. FT./Sec.	448.5	

The third consideration is that of viscosity. Viscosity can be compared to friction in that it is a resistance to movement between liquid particles and between solid and liquid particles.

In a continuous process, such as in the production of fine aggregates, the slurry flows into and out of the classifying tank at a measurable rate, which determines its velocity of flow through the tank. The solids settle out, due to their weight, at a speed that is expressed as rate of fall or settling. It is the interrelationship between these two movements which governs the path of the falling particle.



Settling From A Surface Current

In the figure above, directions of the current and of the free fall of the particle are at right angles. The actual path of a falling particle is a parabola; the height of fall (D) and the length of horizontal travel (L) are determined by use of well-known formula. **This is called settling from a surface current.**

While a particle is in suspension, one force acts on it to make it fall, while others act to limit the fall. Gravity acts to move the particle downward, while the viscosity of the liquid may slow the fall. The difference between free settling and hindered settling is relative to the forces acting on the particle. In free settling, the downward component is much greater than those slowing the fall. In a hindered setting, the downward component is only slightly greater than those slowing the fall.

Apart from the multiple sizing, the scalping tank serves to eliminate the surplus water prior to discharging the product to a screw-type classifier. By so doing, the amount of water handled by the screw classifier can be regulated better for the mesh size of fines to be retained. It becomes apparent, then, that a water scalping tank will be followed by as many screw classifiers as there are sizes of sand products to be made.

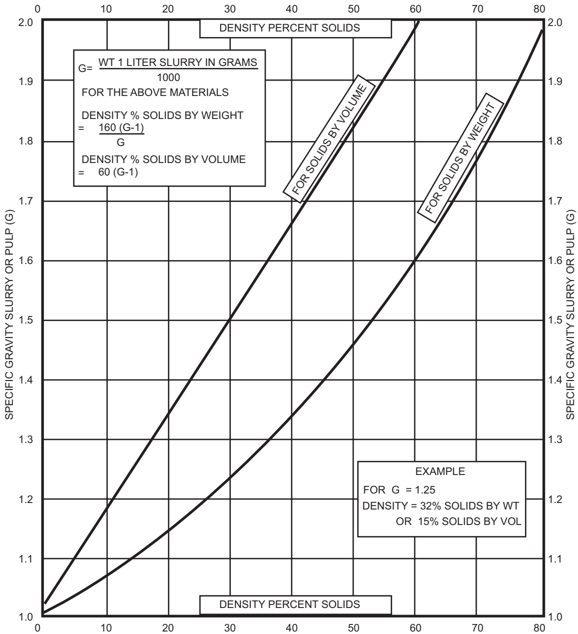
Adjustable weirs on the scalping tank regulate the rate and velocity of overflow to provide the size separations required. Clays, silt and slime, which are lighter than the finest mesh sand, remain suspended in the water and are washed out over the tank weirs for discharge into a settling pond.

In order to re-blend sand fractions into a specification product, settling stations are located along the bottom length of the tank. The best classifying occurs with more length to the classifying tank. It is recommended to use a minimum of a 28′ tank. Shorter tanks will work when the material is very consistent in gradation and close to the product specification to be made.

Build up or "silting in" of the classifying tank will occur as the specific gravity of the overflow slurry goes beyond 1.065. The ideal slurry is between 1.025 and 1.030. At this point, maximum efficiency occurs. Additional water will carry away more fines unless the tank area is oversized.

DENSITY—SPECIFIC GRAVITY RELATIONSHIP

FOR WATER SLURRY OF SAND, GRAVEL,
QUARTZ OR LIMESTONE
(SOLID S.G. 2.65-2.70)



NOTE:

1) Most dredge and pump suppliers work with percent solids by weight.
2) A few dredge suppliers work with percent solids by volume.
3) ALL MACHINES ARE RATED ON PERCENT SOLIDS BY WEIGHT.

SAND CLASSIFYING TANKS

Purpose: Classification is the sizing of solid particles (typically –⅜" or -#4 mesh) by means of settling. In classification, the settling is controlled so that the fines, or undersized material, will flow away with a stream of water or liquid, while the coarse, or oversized material, accumulates in a settled mass. By applying the principles of settling and classification in the classifying/water scalping tank, the following functions are performed:

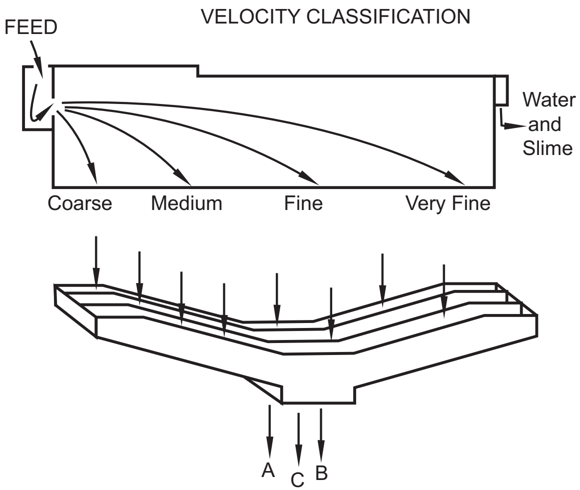
1) Reject undesirables like clay, silt, slime and excess fine particles
2) Separate desirable sand particles so that they can be controlled
3) Reblend separated material into correct gradation specifications
4) Production of two different specification products simultaneously and an excess product
5) Remove excess water

Feed to a classifying tank is typically in the form of a sand and water slurry. The slurry feed can come from several sources, but is generally from a dredging or wet screening operation.

CLASSIFYING TANKS ARE NECESSARY WHEN ANY ONE OF THE FOLLOWING CONDITIONS EXISTS:

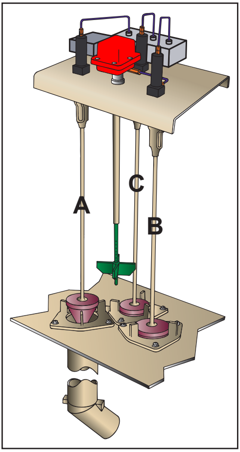
1) Feed material gradations fail to meet the allowable minimums or maximums when compared to the material specifications to be produced
2) Sand feed gradations vary within a deposit
3) More than one specification product is desired
4) Excessive water is present, such as from a dredging operation

Design: A classifying tank consists of an all-welded tank with sizes ranging from 8′ x 20′ to 12′ x 48′. The slurry feed is introduced into the tank through a feed box, which includes an integral curved liner for improved slurry flow control. As the slurry flows toward the discharge end of the tank, weight differences between sand particles allow coarser material to settle first while the lighter material settles progressively further down the tank. Clays, silt and slime, which are lighter than the finest mesh sand, remain suspended in the water and are washed out over the adjustable tank weirs for discharge into a settling pond. Sand fractions are then reblended into two specification products and an excess product, via settling stations (6 to 11, depending on tank length) located along the bottom of the tank. Discharge valves (typically three) at each station serve to "batch" the sand into a collecting/blending flume located below the tank.



Sand discharge is controlled with a SpecSelect® controller, (see section on SpecSelect® Classifying Tank Controllers) which receives a signal from an adjustable height sensing paddle located at each station. The sensing paddle controls the amount of material that accumulates at each station before a valve opens to discharge the sand and water slurry. The valves consist of self-aligning urethane dart valves and urethane seats, providing uniform flow at the maximum rate, positive sealing and long service life. The urethane dart valve is connected to an adjustable down rod to ensure optimum seating pressure and provide leak resistant operation. The valves are activated by an electric/hydraulic mechanism in response to signals received from the controller and sensing paddle. Once discharged, the slurry flows through product down pipes, which include urethane elbows for improved flow and wear into a collecting/blending flume for transport to the appropriate dewatering screw.

The electric/hydraulic mechanism is mounted within a bridge that runs lengthwise with the tank. This system includes an electric/hydraulic pump, reservoir, accumulator, individual ball, and check valves at each station. Also included, is a toggle switch box with a 3-position switch for each valve at a station that can be "plugged in" to an individual station, providing maximum flexibility in troubleshooting and servicing. Other important features of the classifying tank include stainless steel hydraulic tubing with O-ring face seal fittings, optional rising current cells to create hindered settling, optional recirculating pump to reduce overall water requirements and complete pre-wiring of the tank to a NEMA 4 junction box/control enclosure located on the bridge.



Washing & Classifying

Application: Several factors affect the sizing and application of a classifying tank:

- Dry feed material rate
- Material density
- Feed gradation
- Product gradations or specs desired
- Feed source
- Amount of water entering the tank with the feed material
- Other material characteristics

Of these factors, four items must be known to properly size a classifying tank:

- Feed rate (TPH)
- Feed gradation
- Feed source (conveyor, dredge)
- Product gradations or specifications desired

Given the above, the classifying tank is sized based on its water handling capacity. The requirements for water in a classifying tank are to have approximately 10 GPM of water for every 1 TPH of total sand feed or 100 GPM of water for every 1 TPH of silt (-#200 mesh). The larger of these two figures and the desired mesh split to be produced within the tank are then used to size the classifying tank. This process allows for proper dilution of the sand so that the material will correctly settle in the tank for proper classification. The following table is provided to assist in the proper selection of a classifying tank.

CLASSIFYING TANKS

Size	Approx. Dead Load (lb)	Approx. Live Load (lb)	Water Capacities (GPM)			Number of Discharge Stations
			100 Mesh	150 Mesh	200 Mesh	
8′ X 20′	17,600	89,620	2,300	1,200	700	6
8′ X 24′	19,400	108,340	2,800	1,400	800	7
8′ X 28′	21,300	126,800	3,200	1,600	900	8
8′ X 32′	22,825	146,120	3,500	1,800	950	9
10′ X 24′	23,100	119,110	3,500	1,800	950	7
10′ X 28′	24,800	140,650	4,100	2,100	1,100	8
10′ X 32′	26,500	161,060	4,700	2,400	1,250	9
10′ X 36′	29,100	182,100	5,300	2,700	1,400	10
10′ X 40′	31,800	202,010	5,900	3,000	1,550	11
12′ X 48′	43,000	275,960	8,100	4,200	2,150	11

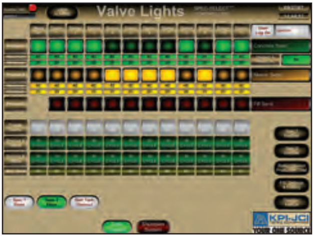
NOTE: Approximated weights include three cell flume, rising current cells & manifold, discharge down pipes and handrails around tank bridge. Approximated weights **DO NOT** include support structure, access (stairs or ladder) and recirculating pump.

CLASSIFYING TANK WEIR OVERFLOW RATES

MODEL	WEIR LENGTH	AVERAGE DEPTH OVER WEIR								
		¼″	½″	¾″	1″	1¼″	1½″	1¾″	2″	2¼″
8′ x 20′	32′	225	480	***700*** 800	***1,200*** 1,150	1,690	***2,300*** 2,225	2,720	3,360	4,400
8′ x 24′	40′	280	600	***800*** 1,000	***1400*** 1,440	2,120	***2,800*** 2,800	3,400	4,200	5,000
8′ x 28′	48′	336	***900*** 720	***1,600*** 1,200	1,720	2,550	***3,200*** 3,350	4,070	5,040	6,000
8′ x 32′	56′	392	***950*** 840	***1,800*** 1,400	2,010	***3,500*** 2,960	3,920	4,750	5,880	7,000
10′ x 24′	42′	295	***950*** 630	1,050	1,520	***1,800*** 2,230	2,940	***3,500*** 3,570	4,400	5,250
10′ x 28′	50′	350	750	***1,100*** 1,250	***2,100*** 1,800	2,650	3,500	***4,100*** 4,250	5,240	6,250
10′ x 32′	58′	410	880	***1,250*** 1,450	***2,400*** 2,080	3,060	4,060	***4,700*** 4,930	6,080	7,250
10′ x 36′	66′	465	990	***1,400*** 1,650	***2,700*** 2,380	3,500	4,630	***5,300*** 5,610	6,920	8,250
10′ x 40′	74′	520	***1,550*** 1,110	1,850	***3,000*** 2,660	3,920	5,180	***5,900*** 6,290	7,760	9,250
12′ x 48′	80′	562	1,200	***2,150*** 2,000	2,876	***4,200*** 4,238	5,600	6,800	***8,100*** 8,390	10,000

NOTE: All flows shown are in gpm. ***Bold italicized*** flows depict overflow rates required for 200, 150 & 100 mesh splits, respectively.

SPECSELECT® CONTROLLERS



Purpose: SpecSelect® controllers are utilized in conjunction with a classifying tank to control the blending of the various sand fractions into one or two specification products plus an excess product. SpecSelect® controllers are also a valuable source of information when troubleshooting or monitoring the activity occurring within a classifying tank.

Design: SpecSelect® controllers consist of an industrial-quality PLC (programmable logic controller) housed in the NEMA 4 junction box/control enclosure located on the bridge of the classifying tank and a desktop PC HMI. An optional industrial PC HMI with color touchscreen housed in a NEMA 4 enclosure is also available for outdoor installation in lieu of the desktop PC. Easy-to-use Windows-based controls allow operators to proportion the amount of material discharging from each station to the appropriate collecting/blending flume for transport to the dewatering device. EEPROM memory in the PLC and the hard drive of the PC provide permanent storage for PLC logic, operating parameters and recipes.

Application: Two modes of controlling the tank discharge are utilized in conventional classifying tanks. The SpecSelect® I mode of operation is the simplest method to operate a classifying tank and is the same in theory as the manual splitter box type classifying tanks. It is an independent control of each station by a percentage method to determine the amount of material discharged to each of the three product flumes. The system operates on a 10-second cycle that is repeated over and over from product “A” to “B” to “C”. The mode of operation works best in a fairly consistent pit, where the feed gradation does not vary too much. Monitoring the product gradations informs the operator of variances in the feed. Changes to the percentage settings at each station can be made quickly at the controller to maintain the product specification.

The SpecSelect® II mode of operation is a dependent method of operation utilizing minimum and maximum timer settings at each station to control the material discharge, and ensure that product specifications are met on a consistent basis. This system not only controls the discharge valves at each station, but also controls all of the settling stations relative to each other. The minimum and maximum timer settings are determined by the gradation of the material settling out at each station and relating this to the product specification limits. In effect, the SSII mode of operation is making batches of specification sand continuously. Each "A" or "B" valve at a given station discharges sand on a time basis between its minimum and maximum timer settings. No valve can begin a new batch until every other valve has discharged at least its minimum in the present batch being made. When a valve reaches its maximum timer setting and one or more of the other valves for that product have not yet met their minimum settings, the controller automatically directs the material to one of the other product valves and flumes. It is important to remember, in this mode of operation, the potential to waste or to direct sand to a non-spec product where it is not desired is increased and should be carefully considered when operating a tank by this method. This mode of operation is typically used when the feed gradation and/or feed rate vary widely.

All currently manufactured models of SpecSelect® controllers are capable of operating in either the SpecSelect® I or the SpecSelect® II mode of operation.

SCREENING/WASHING PLANTS

Purpose: Screening/washing plants are used to rinse and size up to three stone products while simultaneously washing, dewatering and fine-tuning a single sand product. Specific stone product gradations can typically be met with the use of blending gates between the screen overs chutes while sand product gradations are adjusted with screw speed and water overflow rates.

Design: Traditional Series 1800 screening/washing plants consist of a heavy-duty, three-deck incline (10°) or horizontal wet screen mounted above a fine material washer on either a semi-portable skid support structure or a heavy-duty portable chassis. Important features of the screening/washing plant include the capability to fit three radial stacking conveyors under the screen overs chutes, complete water plumbing with single inlet connection and wide three-sided screen access platform, as well as all the features of the industry-leading screens and the fine material washers.

Also available, are the model 1822PHB and model 1830PHB portable screening/washing plants, which incorporate a blademill ahead of the horizontal screen, all on a single, heavy-duty, portable chassis. This addition serves to pre-condition the raw feed material for more efficient wet screening.

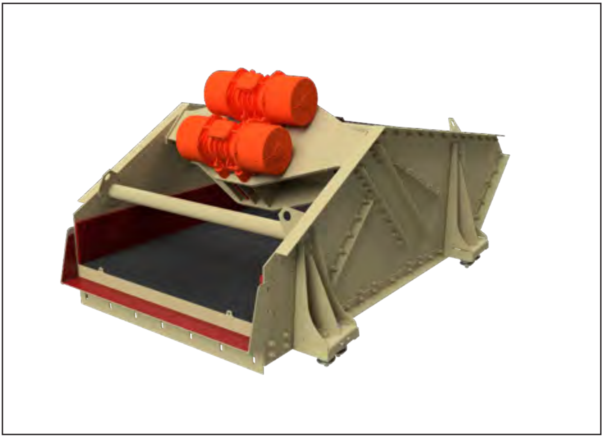
Application: Review of the feed material gradation, products desired and TPH to be processed will determine the screen and screw combination best-suited for the application.

1800 SERIES SCREENING/WASHING PLANTS

Description	Model 1814	Model 1822	Model 1830	Model 1822PHB	Model 1830PHB
Screen Size	5′ x 14′ (incline only)	6′ x 16′	6′ x 20′	6′ x 16′ (horizontal only)	6′ x 20′ (horizontal only)
Fine Material Washer Size	36″ x 25′ single	36″ x 25′ twin	44″ x 32′ twin or 36″ x 25′ twin	36″ x 25' twin	44″ x 32′ twin
Blademill Size	N/A	N/A	N/A	24″ x 12′ twin	36″ x 15' twin
Plant Capacity	Consult Factory	Consult Factory	Consult Factory	Consult Factory	Consult Factory
Water Requirements	Up to 700 US-GPM	Up to 1,200 US-GPM	Up to 2,700 US-GPM	Up to 1,200 US-GPM	Up to 2,700 US-GPM
Optional Equipment (Portabel and Skid Plants)					
Wedge Bolts (for screen cloth retention)	Yes	Yes	Yes	Yes	Yes
AR or Urethane Chute & Hopper Wear Liners	Yes	Yes	Yes	Yes	Yes
Feed/Slurry Box	Yes	Yes	Yes	Yes	Yes
Wire Mesh Screen Cloth	Yes	Yes	Yes	Yes	Yes
Deck Prepara-tion for Ure-thane Screen Media	No	Yes	Yes	Yes	Yes
Electrical Pkg.	Yes	Yes	Yes	Yes	Yes
Blending Gates	Yes	Yes	Yes	Yes	Yes
Optional Equipment (Skid Plants Only)					
Stair vs. Ladder Access	Yes	Yes	Yes	N/A	N/A
Roll-Away Chutes	Yes	Yes	Yes	N/A	N/A
Optional Equipment (Portable Plants Only)					
Landing Gear	No	Yes	Yes	Yes	Yes
Hydraulic Run-on Jacks	No	Yes	Yes	Yes	Yes
Gas/Hyd. or Elec./Hyd. Power Pk.	No	Yes	Yes	Yes	Yes
Hyd. Screen Adjust (incline Screens only)	No	Yes	Yes	N/A	N/A
Cross Conveyors	No	Yes	Yes	Yes	Yes
Remote Grease	Yes	Yes	Yes	Yes	Yes
Flare Mountin in King Pin Area	N/A	N/A	Yes	N/A	Yes
Hinged Folding Flares	N/A	N/A	Yes	N/A	Yes

NOTES: Model 1814, 1822 and 1830 available in both portable and skid-mounted configurations. Additional options exist, consult factory for further details. Skid-mounted plants can be configured to include a number of different screen and screw combinations, consult factory for details. For further capacity or specification information on screens, fine material washers and blademills, see the corresponding sections of this book relating to those pieces of equipment.

SERIES 9000 DEWATERING SCREENS



Purpose: Dewatering screens are utilized to dewater fine aggregates (typically, minus 3/8" or smaller) prior to stockpiling. Feed to a dewatering screen can come from a variety of sources including cyclones, conventional wet screens, density classifiers, classifying tanks and even directly from fine material washers. Depending on the gradation of the product to be produced, dewatering screens will typically produce a finished product with a moisture content as low as 8 – 15 percent by weight.

Design: Dewatering screens are single-deck, adjustable incline (0-5°) linear motion screens available in sizes ranging from 2' wide x 7' long to 8' wide x 16' long with processing rates up to 400 STPH. The units include a predominately bolted screen frame assembly, integral stiffener tubes with lifting lugs, steel coil springs, a sloped feed section, an adjustable discharge dam to control bed depth, bolt-in UHMW pan side liners, modular urethane screen media available in sizes ranging from #10 - #150 mesh, a stress-relieved fabricated motor bridge, engineered motor mounting studs and two adjustable stroke 1,200 rpm vibrating motors. Dewatering screens can also be configured to produce two different sand products from one unit through the installation of a divider down the length of the unit and dual discharge/blending chutes.

Application: Several important elements must be considered when sizing a dewatering screen: product gradation, feed rate in STPH and the percent solids-by-weight of the slurry feed. Generally speaking, a finer product requires a reduction in the screen stroke and a reduction in the capacity of the unit. Also, a finer product will typically have a higher moisture content than a coarse product.

POWER REQUIREMENTS & APPROXIMATE CAPACITIES

Model	HP	Capacity (STPH)	
		Feed Size (assumes a 2.67 S.G.)	
		Fine Sand (-#50 x +#325)	Coarse Sand (-#4 x +#150)
DWS 27	2 @ 2.7	13	43
DWS 38	2 @ 3.9	20	65
DWS 410	2 @ 4.7	43	144
DWS 513	2 @ 8.4	65	216
DWS 613	2 @ 9.4	78	259
DWS 716	2 @ 11.0**	106	353
DWS 816	2 @ 12.7**	121	403

NOTES: . Capacities provided are estimates only. Consult factory for specific applications.
**Denotes 900RPM motor.

SERIES 9000 PLANTS

The Kolberg-Pioneer Series 9000 and 1892 plants combine all the features of the Series 9000 dewatering screens, cyclones, slurry pumps, the conventional Series 1800 plants and custom-engineered chassis or skid-mounted support structures into one complete, compact aggregate processing package.

- The Model 9400 plants are designed for aggregate producers requiring a fines recovery plant to support their existing operations by reducing the volume of fine material (typically, minus #100 mesh x plus #400 mesh) reporting to the settling pond without the use of flocculants.
- The Model 9200 plants are designed to dewater and fine-tune one or two sand products to a level typically not possible with traditional sand dewatering equipment.
- The Model 1892 plants are designed for aggregate producers requiring a single plant to rinse and size up to three stone products while simultaneously washing, dewatering and fine-tuning one or two sand products.

Available in portable, semi-portable or stationary configurations, these plants are custom-built to meet application requirements and can be configured with various types and quantities of cyclones, various pump sizes, various dewatering screen sizes and various incline or horizontal screen sizes. Other custom features include dual inlet slurry sumps with bypass and overflow capabilities, electrical packages with variable frequency drives as required, air suspension axle assemblies, hydraulic leveling jacks, hydraulically -folding cyclone support system, electric/hydraulic or gas/hydraulic power packs, roll-away or swing-away screen overs chutes, blending chutes, cross conveyors and multiple liner options.

NOTES:

JAW PLANTS

Our track-mounted jaw plants are built for maximum jaw crushing mobility. Featuring Pioneer® Series Jaw Crushers, these plants offer up to 25 percent more capacity than competitive models and are equally effective in aggregate or recycling applications. These plants allow stationary and portable producers to benefit from on-site mobility.

Model	Crusher (in/mm)	Feeder (in x ft/ mm)	Grizzly (ft/cm)	Production (tph/mtph)	Max Feed (in/mm)	Weight * (lbs/kg)
FT2650	26 x 50 / 660 x 1,270	50 x 15 / 1,270 x 4,572	5 / 152 (step deck)	400 / 363	21 / 533	96,000 / 43,545
FT3055	30 x 55 / 762 x 1,397	50 x 15 / 1,270 x 4,572	5 / 152	700 / 635	24 / 610	124,000 / 56,245
GT125	26 x 40 / 660 x 1,012	40 x 14 / 1,016 x 4,267	4 / 122 (straight)	325 / 295	21 / 533	83,000 / 37,648

*These weights should not be used to determine shipping costs. For exact weights, please consult the factory.

KODIAK® PLUS CONE PLANTS

Johnson Crushers International cone plants are engineered for maximum cone crushing productivity. Each plant features a Kodiak® Plus cone crusher that delivers efficient material sizing, making them perfect for both mobile and stationary producers who need quick, effortless on-site movement.

MODEL	CRUSHER	SCREEN	BELT FEEDER		Production		Weight	
			in	mm	TPH	MTPH	lb	kg
FT200CC	K200+	6' x 12' 2-deck	48	1,219	385	350	111,000	50,350
FT200DF	K200+	NA	36	914	385	350	80,000	36,290
FT300DF	K300+	NA	48	1,219	460	417	99,000	44,905
FT400DF	K400+	NA	60	1,524	625	567	116,000	52,620

*These weights should not be used to determine shipping costs. For exact weights, please consult the factory.

IMPACTOR PLANTS

Kolberg-Pioneer track-mounted impactor plants are engineered for maximum impact crushing versatility. Featuring Andreas Series impact crushers, these plants come equipped with our standard overload protection system (OPS). Delivering exceptional performance with an easy-to-adjust interface, aggregate producers and recyclers alike will benefit from the availability of open or closed circuit configurations, complete with a screen and recirculating conveyor.

Model	Crusher (in/mm)	Feeder (in x ft/ mm)	Grizzly (ft/cm)	Production (tph/ mtph)	Weight* (lbs/kg)
GT440CC	42 x 40 / 1,067 x 1,016	40 x 14 / 1,016 x 4,267	4/122 (straight)	325 / 295	94,000 / 42,638
GT440OC	42 x 40 / 1,067 x 1,016	40 x 14 / 1,016 x 4,267	4/122 (straight)	325 / 295	81,000 / 36,741
FT4250CC	42 x 50 / 1,067 x 1,270	50 x 15 / 1,270 x 4,572	5/152 (step deck)	400 / 363	112,500 / 51,029
FT4250OC	42 x 50 / 1,067 x 1,270	50 x 15 / 1,270 x 4,572	5/152 (step deck)	400 / 363	99,000 / 44,906
FT5260	52 x 60 / 1,321 x 1,524	50 x 15 /1,270 x 4,572	5/152 (step deck)	750 / 680	112,500 / 51,029

*These weights should not be used to determine shipping costs. For exact weights, please consult the factory.

Tracks

SCREEN PLANTS

KPI-JCI and Astec Mobile Screens track-mounted screens are engineered to provide higher production capacities and more efficient sizing compared to conventional screens. Featuring triple-shaft, oval motion screens, these plants offer better bearing life, more aggressive screening action for reduced plugging and blinding and a consistent material travel speed that does not accelerate through gravity for a higher probability of separation. As such, these highly-efficient plants are perfect for both portable and stationary producers who need quick, effortless on-site movement and reduced down time.

Model	Screen Size (ft/cm)	Decks	Production (tph/mtph)	Weight* (lbs/kg)
FT3620	6 x 20 / 183 x 609	3	700 / 635	81,000 / 36,741
FT6203OC	6 x 20 / 183 x 609	3	800 / 726	83,000 / 37,648
FT6203CC	6 x 20 / 183 x 609	3	800 / 726	86,000 / 39,009
FT710 KDS	7 x 10 / 2,134 x 3,048	2	200 / 181	35,000 / 15,876

*These weights should not be used to determine shipping costs. For exact weights, please consult the factory.

HIGH FREQUENCY SCREEN PLANTS

Astec Mobile Screens high frequency screens are engineered to provide higher production capacities and more efficient sizing compared to conventional screens. High frequency screens feature aggressive vibration applied directly to the screen that allows for the highest capacity in the market for removal of fine material, as well as chip sizing, dry manufactured sand and more.

Model	Screen Size (ft/cm)	Production (tph/mtph	Weight* (lbs/kg)
FT2618V	6 x 18 / 183 X 547	350 / 318	62,000 / 28,123
FT2618VM	6 x 18 / 183 x 547	350 / 318	60,000 / 27,216

*These weights should not be used to determine shipping costs. For exact weights, please consult the factory.

TRACK SCREENING PLANTS

Mobile screening plants feature double- or triple-deck screens for processing sand and gravel, topsoil, slag, crushed stone and recycled materials. They provide easy-to-reach engine controls and grease points for routine service, simple-to-use hydraulic leveling gears, hydraulic plant controls and screen angle adjustment. Tethered track remote control is standard with an optional wireless remote track control available.

Model	Hopper Capacity (yd/m)	Screen Size (ft/m)	Power (hp/kw)
GT145	10.5 / 8.03	5 x 14 / 1.52 x 4.27	129 / 96
GT205	10.5 / 8.03	5 x 20 / 1.52 x 6.10	129 / 96

Model	Capacity (tph/mtph)	Overs Conveyor (in/mm)
GT145	650 / 540	24 / 610
GT205	650 / 540	30 / 762

TRACK DIRECT FEED PLANTS

Direct feed plants provide a rugged, mobile screening tool in a highly portable configuration. They were designed to provide a versatile screening plant that would handle high volumes of material in both scalping and sizing applications. The large loading hopper with a HD variable speed apron pan feeder can withstand heavy loads while metering feed material to the screen to optimize screening production and efficiency.

Model	Belt Feeder (in/mm)	Screen Size (ft/m)	Power (hp/kw)	Capac-ity (tph/ mtph)	Overs Conveyor (in/mm)
GT104	42 / 1,050	4 x 9 / 1.2 x2.7	74 / 55	220 / 200	42" / 1,050
GT165	54 / 1,372	5 x 16/ 1.52 x 4.5	129 / 96	650 / 540	54 / 1,372
GT206	60 / 1,500	6 x 20 / 1.8 x 6.1	173 / 130	700 / 635	64 / 1,600

Tracks

GLOBAL TRACK CONVEYOR

These units are a self-contained, track-mounted, mobile conveyors that can be used as a transfer or stacking conveyors with portable or track crushing and screening equipment.

Capable of carrying loads of up to 750TPH with adjustable speed and discharge height, these units are a perfect tool when quick set-up, mobility and flexibility are required.

Model	Belt Width (in / mm)	Belt Length (ft / m)	Diesel Power (hp / kw)
GT3660	36 / 900	60 / 18.25	60 / 45
GT3680	36 / 900	80 / 24	75 / 56
GT4260	42 / 1,100	60 / 18.25	136 / 101

Model	Capacity (tph / mtph)	Discharge Height (ft/ m)
GT3660	750 / 675	24 / 7.315
GT3680	500 / 454	32 / 9.58
GT4260	700 / 635	29 / 8.8

RAILROAD BALLAST

Ballast is a relatively coarse aggregate that provides a stable load-carrying base for trackage, as well as quick drainage. Ballast normally would be crushed quarry or slag material, free of clay, silt, etc.

Two typical specifications follow, to provide some idea as to general gradations:

Sieve Opening	Example "A" Percent Passing	Example "B" Percent Passing
3″ (76.2 mm)	100	-
2½″ (63.5 mm)	90 -100	100
2″ (50.8 mm)	-	96 -100
1½″ (38.1 mm)	25 - 60	35 - 70
1″ (25.4 mm)	-	0 - 15
¾″ (19.0 mm)	0 - 13	-
½″ (12.7 mm)	0 - 5	0 - 5

NOTE: The above are typical. However, there are many other ballast sizes dependent on job specifications. Note also that ballast is most usually purchased on a unit volume rather than tonnage basis.

Quantities of Cement, Fine Aggregate and Coarse Aggregate Required for One Cubic Yard of Compact Mortar or Concrete

Mixtures			Approx. Quantities of Material				
Cement	F.A. (Sand	C.A. (gravel or Stone	Cement in Stacks	Fine Aggregate		Coarse Aggregate	
				cu. ft	cu. yd	cu. ft	cu. yd
1	1.5		15.5	23.2	0.86		
1	2		12.8	25.6	0.95		
1	2.5		11	27.5	1.02		
1	3		9.6	28.8	1.07		
1	1.5	3	7.6	11.4	0.42	22.8	0.85
1	2	2	8.3	16.6	0.61	16.6	0.61
1	2	3	7	14	0.52	21	0.78
1	2	4	6	12	0.44	24	0.89
1	2.5	3.5	5.9	14.7	0.54	20.6	0.76
1	2.5	4	5.6	14	0.52	22.4	0.83
1	2.5	5	5	12.5	0.46	25	0.92
1	3	5	4.6	13.8	0.51	23	0.85

1 sack cement = 1 cu. ft.; 4 sacks = 1 bbl.; 1 bbl. = 376 lbs.

RIPRAP

Riprap, as used for facing dams, canals and waterways, is normally a coarse, graded material. Typical specifications would call for a minimum 160 lb./ft.3 stone, free of cracks and seams with no sand, clay, dirt, etc. A typical specification will probably give the percent passing by particle weight such as:

Percent Passing	15" Blanket	24" Blanket
100	165 lbs.	670 lbs.
50 - 70	50 lbs.	200 lbs.
30 - 50	35 lbs.	135 lbs.
0 - 15	10 lbs.	40 lbs.

In order to relate the above weights to rock size, refer to the following size/density chart:

Weights of Riprap—Pounds

Cubical Size(in.)	Solid Rock Density - lb per ft^3 (appprox.)								
	145	**150**	**155**	**160**	**165**	**170**	**175**	**180**	**185**
5	10	11	11	12	12	12	13	13	13
6	18	19	19	20	21	21	22	23	23
7	29	30	31	32	33	34	35	36	37
8	43	44	46	47	49	50	52	53	55
9	61	63	65	68	70	72	74	76	78
10	84	87	90	93	95	98	101	104	107
11	112	116	119	123	127	131	135	139	142
12	145	150	155	160	165	170	175	180	185
13	184	191	197	203	210	216	222	229	235
14	230	238	246	254	262	270	278	286	294
15	283	293	302	312	322	332	342	351	361
16	344	356	367	379	391	403	415	426	438
17	412	426	440	454	469	483	497	511	526
18	489	506	523	539	556	573	590	607	624
19	575	595	615	634	654	674	694	714	734
20	671	694	717	740	763	786	810	833	856
22	893	925	954	985	1,016	1,047	1,078	1,108	1,139
24	1,160	1,200	1,239	1,279	1,319	1,359	1,399	1,439	1,479
25	1,475	1,526	1,575	1,626	1,677	1,728	1,779	1,830	1,881
28	1,842	1,905	1,967	2,031	2,094	2,158	2,222	2,285	2,349
30	2,265	2,343	2,419	2,498	2,576	2,654	2,732	2,811	2,889
32	2,749	2,844	2,936	3,031	3,126	3,221	3,316	3,411	3,506
34	3,298	3,412	3,522	3,636	3,750	3,864	3,978	4,092	4,206
36	3,914	4,050	4,180	4,316	4,451	4,586	4,722	4,857	4,992
39	4,978	5,150	5,321	5,493	5,664	5,836	6,008	6,179	6,351

NOTE: The above is given as general information only; each job will carry its individual specification.

MOTOR WIRING AT STANDARD SPEEDS

From National Electrical Code

HP	Full Load Amp. Per Phase	††Min. Size wire AWG Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses	Full Load Amp. Per Phase	††Min. Size Wire AWG Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses
Single Phase Induction Motors								
	120 Volts				230 Volts			
½	7	14	½	25	3.5	14	½	15
¾	9.4	14	½	30	4.7	14	½	15
1	11	14	½	35	5.5	14	½	20
1½	15.2	12	½	45	7.6	14	½	25
2	20	10	¾	60	10	14	½	30
3	28	8	¾	90	14	12	½	45
5	46	4	1¼	150	23	8	¾	70
7½					34	6	1	110
10					43	5	1¼	125

HP	Full Load Amp. Per Phase	††Min. Size wire AWG Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses		††Min. Size Wire AWG Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses
3 Phase Induction Motors								
	230 Volts				460 Volts			
1	3.3	14	½	* 15	1.7	14	½	* 15
1½	4.7	14	½	* 15	2.4	14	½	* 15
2	6	14	½	* 20	3	14	½	* 15
3	9	14	½	* 30	4.5	14	½	* 15
5	15	12	½	* 45	7.5	14	½	* 25
7½	22	8	¾	† 60	11	14	½	† 30
10	27	8	¾	† 70	14	12	½	† 35
15	38	6	1¼	† 80	19	10	¾	† 50
20	52	4	1¼	†110	26	8	¾	† 70
25	64	3	1¼	†150	32	6	1¼	† 70
30	77	1	1½	†175	39	6	1¼	† 80
40	101	00	2	†200	51	4	1¼	†100
50	125	000	2	†250	63	3	1¼	†125
60	149	200,000 C.M.	2½	†300	75	1	1½	†150
75	180	0000	2½	†300	90	0	2	†200
100	245 ‡	500	3	†500	123	000	2	†250
125	310 ‡	750	3½	†500	155	0000	2½	†350
150	360 ‡	1,000	4	†600	180	300 ‡	2½	†400
200	480				240	500 ‡	3	†500
250	580				290			
300	696				348			

††,** Where high ambient temperature is present, it may, in some cases, be necessary to install next larger size thermal overload relay.

MOTOR WIRING AT STANDARD SPEEDS, *(Continued)*

From National Electrical Code

HP	Full Load Amp. Per Phase	††Min. Size wire AWG Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses	Full Load Amp. Per Phase	††Min. Size Wire AWG ‡ Rubber Covered	Size Conduit (in)	**Max. Rating of Branch Circuit Fuses
Direct Current Motor								
	115 Volts				230 Volts			
1	8.4	14	½	15	4.2	14	½	15
1½	12.5	12	½	20	6.3	14	½	15
2	16.1	10	¾	25	8.3	14	½	15
3	23	8	¾	35	12.3	12	½	20
5	40	6	1	60	19.8	10	¾	30
7½	58	3	1¼	90	28.7	6	1	45
10	75	1	1½	125	38	6	1	60
15	112	0	2	175	56	4	1¼	90
20	140	0	2	225	74	1	1½	125
25	184	300 ‡	2½	300	92	0	2	150
30	220	400 ‡	3	350	110	00	2	175
40	292	700 ‡	3½	450	146	0000	2½	225
50	360	1,000 ‡	4	600	180	300 ‡	2½	300
60					215	400 ‡	3	350
75					268	600 ‡	3½	450
100					355	1,000 ‡	4	600

‡ M.C.M.

† In order to avoid excessive voltage drop where long runs are involved, it may be necessary to use conductors and conduit of sizes larger than the minimum sizes listed above.

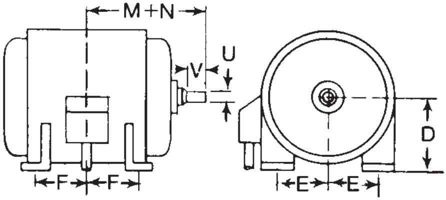
**Branch-circuit fuses must be large enough to carry the starting current, hence they protect against short-circuit only. Additional protection of an approved type must be provided to protect each motor against normal operating overloads.

*For full-voltage starting of normal torque, normal starting current motor.

†For reduced-voltage starting of normal torque, normal starting current motor, and for full-voltage starting of high-reactance, low starting current squirrel-cage motors.

NEMA Frame Numbers for Polyphase Induction Motors

Horsepower	"T" Frame	
	1800 RPM	1200 RPM
2	145T	184T
3	182T	213T
5	184T	215T
7½	213T	254T
10	215T	256T
15	254T	284T
20	256T	286T
25	284T	324T
30	286T	326T
40	324T	364T
50	326R	365T
60	364T	404T
75	365T	405T



DIMENSIONS, IN INCHES, OF ELECTRIC MOTORS

By NEMA Frame Number

	M + N	D	E	F	U	V	Keyway
182T	7¾	4½	3¾	2¼	1⅛	2½	¼ x ⅛
184T	8¼	4½	3¾	2¾	1⅛	2½	¼ x ⅛
213	9¼	5¼	4¼	2¾	1⅛	2¾	¼ x ⅛
213T	9⅝	5¼	4¼	2¾	1⅜	3⅛	5⁄16 x 5⁄32
215	10	5¼	4¼	3½	1⅛	2¾	¼ x ⅛
215T	10⅜	5¼	4¼	3½	1⅜	3⅛	5⁄16 x 5⁄32
254T	12⅜	6¼	5	4⅛	1⅝	3¾	⅜ x 3⁄16
254U	12⅛	6¼	5	4⅛	1⅜	3½	5⁄16 x 5⁄32
256T	13¼	6¼	5	5	1⅝	3¾	⅜ x 3⁄16
256U	13	6¼	5	5	1⅜	3½	5⁄16 x 5⁄32
284T	14⅛	7	5½	4¾	1⅞	4⅜	½ x ¼
284U	14⅜	7	5½	4¾	1⅝	4⅝	⅜ x 3⁄16
286T	14⅞	7	5½	5½	1⅞	4⅜	½ x ¼
286U	15⅛	7	5½	5½	1⅝	4⅝	⅜ x 3⁄16
324T	15¾	8	6¼	5¼	2⅛	5	½ x ¼
324U	16⅛	8	6¼	5¼	1⅞	5⅜	½ x ¼
326T	16½	8	6¼	6	2⅛	5	½ x ¼
326U	16⅞	8	6¼	6	1⅞	5⅜	½ x ¼
364T	17⅜	9	7	5⅝	2⅜	5⅝	⅝ x 5⁄16
364U	17⅞	9	7	5⅝	2⅛	6⅛	½ x ¼
365T	17⅞	9	7	6⅛	2⅜	5⅝	⅝ x 5⁄16
365U	18⅜	9	7	6⅛	2⅛	6⅛	½ x ¼
404T	20	10	8	6⅛	2⅞	7	¾ x ⅜
404U	19⅞	10	8	6⅛	2⅜	6⅞	⅝ x 5⁄16
405T	20¾	10	8	6⅞	2⅞	7	¾ x ⅜
405U	20⅝	10	8	6⅞	2⅜	6⅞	⅝ x 5⁄16
444U	23⅜	11	9	7¼	2⅞	8⅜	¾ x ⅜
445U	24⅜	11	9	8¼	2⅞	8⅜	¾ x ⅜

CURRENT CARRYING CAPACITIES AND CABLE DIAMETER SIZES FOR THE PORTABLE CABLES

AWG Size	Type SO Cord				3 Conductor Type "G"		4 Conductor Type "W:	
	Amp Capacity	Diameter (in)			Amp Capacity	Diameter (in)	*Amp Capacity	Diameter (in)
		2 Cond.	3 Cond.	4 Cond.				
250 MCM					275	2.39		
4/0					245	2.04	210	2.26
3/0					220	1.89	190	2.07
2/0					190	1.75	170	1.93
1/0					160	1.65	145	1.79
1					145	1.51	125	1.68
2					130	1.34	110	1.48
3					110	1.24	95	1.34
4					95	1.17	85	1.27
6					75	1.01	60	1.1
8					55	0.91	50	0.99
10	25	0.64	0.69	0.75				
12	20	0.605	0.64	0.67				
14	15	0.53	0.56	0.605				
16	10	0.405	0.43	0.485				
18	7	0.39	0.405	0.435				

Above Data from Western Insulated
Wire Co. fro Bronco 66 Certified Cable

*When using 4 conductor type "W" cable on 3 phase circuit with 4th conductor used as ground, use amp capacity for 3 conductor type "G" cable.

GENERATOR SIZE TO POWER ELECTRIC MOTORS ON CRUSHING AND SCREENING PLANTS

The minimum generator size to power a group of motors should be selected on the basis of the following rules, which allow all motors to operate simultaneously with complete freedom of starting sequence.

A. GENERATOR KW—0.8 x total electric name plate horsepower.
B. GENERATOR KW—2 x name plate horsepower of the largest electric motor with across-the-line starter.
C. GENERATOR KW—1.5 x name plate horsepower of the largest electric motor with reduced voltage starting (with 80 percent starting voltage).
D. GENERATOR KW—2.25 x name plate horsepower of the largest electric motor with part winding starting.

For across-the-line starting, use the larger of the two values determined from A and B.

For reduced voltage starting, use the larger of the two values determined from A and C.

For part winding starting, use the larger of the two values determined from A and D.

For combinations of the above starting types, use the largest value determined from A, B, C, and D as they apply.

DREDGE PUMP

SIZE	SLURRY (GPM)	TPH
4	680	38
6	1,500	85
8	2,700	153
10	4,100	233
12	5,900	335
14	7,300	414
16	9,670	550
18	12,280	696
20	15,270	866

20% Solids @ 100 lb./cu. ft.

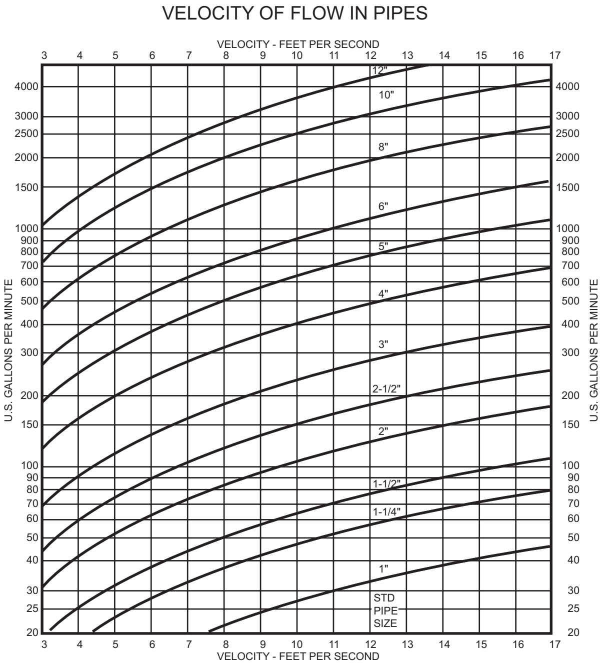
(% Solids by Weight)

NOTE: GPM ÷ 17.6 = TPH
TPH X 17.6 = GPM

Above information can be used as a guide in preliminary selection of material handling components. For plants charged by dredge pumps, proper selection of sand processing components is in part controlled by maximum amount of water in the slurry.

Prior to final selection of machinery, complete information must be assimilated so sound judgement can be exercised.

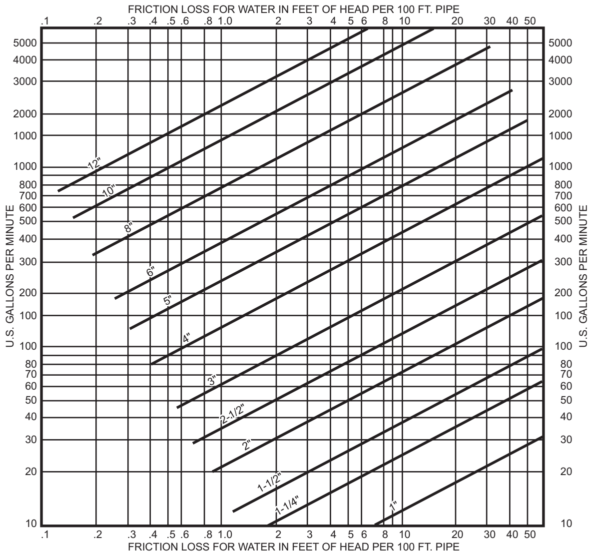
VELOCITY OF FLOW IN PIPES



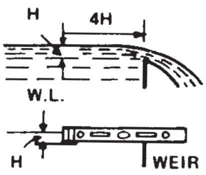
NOTE: Based on following ID's for Std. Wt. W:I or Steel Pipe

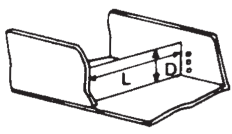
1″	1.049″	2½″	2.469″	6″	6.065″
1¼″	1.380″	3″	3.068″	8″	7.981″
1½″	1.610″	4″	4.026″	10″	10.020″
2″	2.067″	5″	5.047″	12″	11.938″

FRICTION LOSS IN PIPES



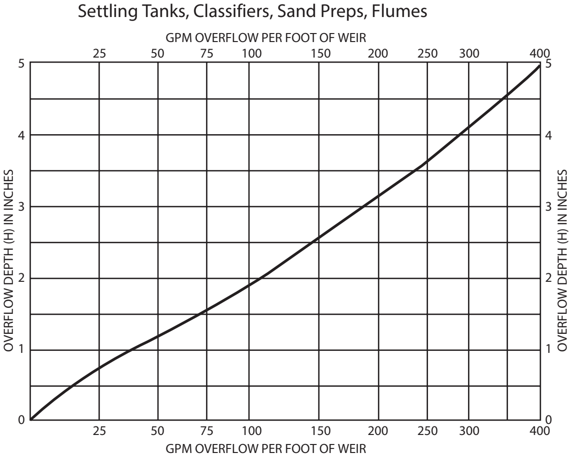
NOTE: Based on new, Standard Weight Wrought Iron or Steel Pipe.





FLOW OVER WEIRS

Settling Tanks, Classifiers, Sand Preps, Flumes



GENERAL

Measure overflow depth (h) at a distance back of weir at least four times h. Use a flat strip taped to the end of a carpenter's level.

Multiply figure from curve by length of weir.

FLUME OR LAUNDER

Use a bevel-edge steel plate or board with sharp edge upstream.

L(weir length) and D (depth of water behind weir) must each be at least three times h.

Water or slurry must fall free of weir; i.e., with air space underneath. If possible, drill air holes in side of launder on downstream side of weir plate.

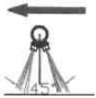
Curve does not apply to triangular or notched weirs.

SPRAY PIPE DESIGN

AMOUNT OF WATER REQUIRED TO WASH ROCK

As a guideline use (5 - 10 gallons/minute) per (yard/hour) or for 100 pund per cubic foot rock. As a guideline use (3.7 - 7.4 gallons/minute) per (ton/hour). **Example** (200 ton/hour) x (3.7 gallons/minute) per (ton/hour) = 740 gallons/minute

STANDARD NOZZLE ORIFICE SIZE ¼"



Nozzle Spray Pipe Dual Flat Spray Pattern Standard Orifice Size ¼"

	Less Protector	With protector	Less nozzles
5ft	516074 pipe 1¼ STD	516510 pipe 1¼ STD	516511 pipe 1¼ STD
6ft	620310 pipe 1¼ STD	616341 pipe 1¼ STD	616476 pipe 1¼ STD
7ft	720141 pipe 1¼ STD	720556 pipe 1¼ STD	720557 pipe 1¼ STD
8ft	Not available	820061 pipe 1½ STD	820783 pipe 1½ STD

Less protector w/ ball valve	With protector w/ ball valve
617372 pipe 1¼ nozzle ¼	xxxxx
720734 pipe 1¼ nozzle ¼	xxxxx
Not available	821274 pipe 1½ nozzle ¼
	821243 pipe 1½ nozzle 5/32

STANDARD NOZZLE ORIFICE SIZE ¼"

Screen Model	Pipes/Deck				Total pipes per screen	Total nozzles per screen	Gallons per screen at 20 psi ¼" orifice	Gallons per screen at 30 psi ¼" orifiace	Gallons per screen at 40 psi ¼" orifiace
	TOP	CTR	B/C	BT					
8243-38	7	6	-	5	15	414	2,939	3,602	4,140
8203-38	6	6	-	5	17	391	2,776	3,402	3,910
8202-38	6	-	-	5	11	253	1,796	2,201	2,530
7203-38	6	6	-	5	17	340	2,414	2,958	3,400
7202-38	6	-	-	5	11	220	1,562	1,914	2,200
6204-32	6	6	5	3	20	320	2,272	2,784	3,200
6203-32	6	6	-	5	17	272	1,931	2,366	2,720
6202-32	6	-	-	5	11	176	1,250	1,531	1,760
6163-32	5	5	-	4	14	224	1,590	1,949	2,240
6162-32	5	-	-	4	9	144	1,022	1,253	1,440
5163-32	5	5	-	4	14	196	1,392	1,705	1,960
5162-32	5	-	-	4	9	126	895	1,096	1,260
5143-24	4	4	-	4	12	168	1,193	1,462	1,680
5142-24	4	-	-	4	8	112	795	974	1,120

NOZZELS SIZES

090085 9/64 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 2.1 gal/min
At 30psi nozzle capacity is 2.6 gal/min
At 40psi nozzle capacity is 3.0 gal/min

090327 11/64 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 3.5 gal/min
At 30psi nozzle capacity is 4.3 gal/min
At 40psi nozzle capacity is 5.0 gal/min

090248 3/16 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 4.2 gal/min
At 30psi nozzle capacity is 5.2 gal/min
At 40psi nozzle capacity is 6.0 gal/min

090461 5/32 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 2.8 gal/min
At 30psi nozzle capacity is 3.5 gal/min
At 40psi nozzle capacity is 4.0 gal/min

090328 13/64 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 4.9 gal/min
At 30psi nozzle capacity is 6.1 gal/min
At 40psi nozzle capacity is 7.0 gal/min

Standard 090016 1/4 Orifice 3/8NPT 40° Fan
At 20psi nozzle capacity is 7.1 gal/min
At 30psi nozzle capacity is 8.7 gal/min
At 40psi nozzle capacity is 10 gal/min

Standard 090278 13/64 Orifice 1/4NPT 50° Fan
At 20psi nozzle capacity is 4.9 gal/min
At 30psi nozzle capacity is 6.1 gal/min
At 40psi nozzle capacity is 7.0 gal/min

NOZZLES PER PIPE

8' spray pipe has 23 nozzles per pipe
7' spray pipe has 20 nozzles per pipe
6' spray pipe has 16 nozzles per pipe
5' spray pipe has 14 nozzles per pipe

SPRAY NOZZLES FOR VIBRATING SCREENS

The introduction of water under pressure over the vibrating screens often improves screening efficiency as well as aids in the removal of deleterious materials on the individual aggregate particles. We utilize type WF flat spray nozzles over the screens to produce a uniform, flat spray pattern without hard edges at pressures of 5 psi and up. Tapered edges of the spray pattern permits pattern overlap with even distribution of the spray. The impact of spray is generally greater with narrower spray angles, assuming the same flow rate.

AVAILABLE SPRAY ANGLES Nozzle Size		
0°	—	All sizes
15°	—	All sizes thru WF 150
25°	—	All sizes thru WF 150
40°	—	All sizes thru WF 150
50°	—	All sizes thru WR 200
65°	—	All sizes
80°	—	All sizes
90°	—	All sizes thru WF 250

TYPE WF CAPACITY CHART

Nozzle Number—Capacity at 40 PSI

Nozzel Number		Equiv. Orif. Dia.	Pipe Size					Capacity - GPM at PSI pressure												
Male	No.		1/8	1/4	3/8	1/2	3/4	40	60	80	100	150	200	300	400	500	600	700	800	1000
WFM	2	0.034						0.2	0.24	0.28	0.32	0.39	0.45	0.55	0.63	0.71	0.77	0.84	0.89	1
WFM	4	0.052						0.4	0.49	0.57	0.63	0.77	0.89	1.1	1.3	1.4	1.6	1.7	1.8	2
WFM	4.5	0.055						0.45	0.55	0.64	0.71	0.87	1	1.2	1.4	1.5	1.7	1.9	2	2.2
WFM	5	0.057						0.5	0.61	0.71	0.79	0.97	1.1	1.4	1.6	1.8	1.9	2.1	2.2	2.5
WFM	5.5	0.06						0.55	0.67	0.78	0.87	1.1	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.8
WFM	6	0.062						0.6	0.73	0.85	0.95	1.2	1.3	1.6	1.9	2.1	2.3	2.5	2.7	3
WFM	6	0.064						0.65	0.8	0.92	1	1.3	1.5	1.8	2.1	2.3	2.5	2.7	2.9	3.3
WFM	7	0.067						0.7	0.86	0.99	1.1	1.4	1.6	1.9	2.2	2.5	2.7	2.9	3.1	3.5
WFM	8	0.072						0.8	0.98	1.1	1.3	1.5	1.8	2.2	2.5	2.8	3.1	3.4	3.6	4
WFM	8.5	0.074						0.85	1.1	1.2	1.3	1.6	1.9	2.3	2.7	3	3.3	3.6	3.8	4.2
WFM	9	0.076						0.9	1.1	1.3	1.4	1.7	2	2.5	2.8	3.2	3.5	3.8	4	4.5
WFM	10	0.08						1	1.2	1.4	1.6	1.9	2.2	2.7	3.2	3.5	3.9	4.2	4.5	5

Shaded columns indicate most available sizes.

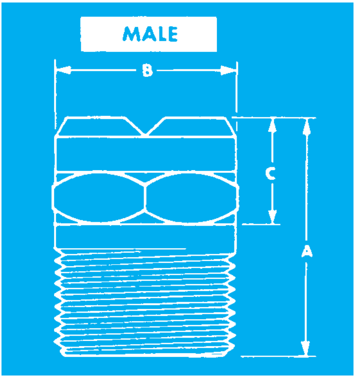
TYPE WF CAPACITY CHART—Nozzle Number—Capacity at 40 PSI

Nozzel Number		Equiv. Orif. Dia.	Pipe Size					Capacity - GPM at PSI pressure												
Male	No.		1/8	1/4	3/8	1/2	3/4	10	15	20	30	40	60	80	100	150	200	300	400	500
WFM*	15	3/32						0.75	0.92	1.1	1.3	1.5	1.8	2.1	2.4	2.9	3.4	4.1	4.7	5.3
WFM	20	7/64						1	1.2	1.4	1.7	2	2.5	2.8	3.2	3.9	4.5	5.5	6.3	7.1
WFM	30	9/64						1.5	1.8	2.1	2.6	3	3.7	4.2	4.7	5.8	6.7	8.2	9.5	10.6
WFM	40	5/32						2	2.5	2.8	3.5	4	4.9	5.7	6.3	7.7	9	11	12.7	14.2
WFM	50	11/64						2.5	3.1	3.5	4.3	5	6.1	7.1	7.9	9.7	11.2	13.7	15.8	17.7
WFM	60	3/16						3	3.7	4.2	5.2	6	7.3	8.5	9.5	11.6	13.4	16.4	19	21.2
WFM*	70	13/64						3.5	4.3	4.9	6.1	7	8.6	9.9	11.1	13.5	15.7	19.2	22.2	24.8
WFM	80	7/32						4	5	5.6	5.8	8	9.8	11.4	12.6	15.4	17.9	21.9	25.3	28.3
WFM	100	1/4						5	6.1	7.1	8.6	10	12.2	14.1	15.8	19.4	22.3	27.4	31.6	35.3
WFM	150	19/64						7.5	9.2	10.6	13	15	18.4	21.2	23.7	29	33.5	41.1	47.4	53.1
WFM	200	11/32						10	12.2	14.1	17.3	20	24.5	28.3	31.6	38.7	44.3	54.7	63.3	70.8
WFM	250	25/64						12.5	15.7	17.7	21.6	25	30.5	35.4	39.4	48.4	55.8	68.4	79	88.4
WFM	300	27/64						15	18.4	21.2	26	30	36.8	42.4	47.4	58	66.9	82.1	94.8	106
WFM	400	1/2						20.2	24.4	28.2	34.6	40	49	56.6	63.2	77.4	89.5	110	127	141

Shaded columns indicate most available sizes.

DIMENSIONS AND WEIGHTS FOR TYPE WF

		Dimensions (in)			
Pipe Size	Type	A	B	C	Weight (oz)
1/8	WFM	11/16	7/16	5/16	0.4
1/4	WFM	31/32	9/16	3/8	0.7
3/8	WFM	1	11/16	7/16	1.1
1/2	WFM	1 17/64	7/8	1/2	3
3/4	WFM	1 27/64	11/16	5/8	5



WATER VOLUME REQUIRED FOR WASHING AGGREGATES

The amount of water required for washing aggregates under average conditions is 3 to 5 GPM of water for each TPH of material fed to a washing screen. The finer the feed gradation, the more GPM of water required.

GETTING MAXIMUM WASHED PRODUCT FROM A VIBRATING SCREEN

Screen efficiency can be greatly increased by applying water directly to the feed box located ahead of the vibrating screen. Water volume applied must be sufficient to form a slurry in the feed box so that effective screening begins immediately when the wet product contacts the screen.

WEIGHTS AND MEASURES—UNITED STATES

Linear Measure

1 mile	=	8 furlongs 80 chains 320 rods 1,760 yards 5,280 feet	1 chain	=	4 rods 22 yards 66 feet 100 links
1 furlough	=	10 chains 220 yards	1 rod	=	5.5 yards 16.5 feet
1 station	=	6.06 rods 33.3 yards 100 feet	1 yard	=	3 feet 36 inches
			1 foot	=	12 inches

Gunter's or Surveyor's Chain Measure

1 link = 7.92 inches

1 statute mile = 80 chains

1 chain = 100 links; 4 rods; 66 feet; 22 yards

Land Measure

1 township	=	36 sections 36 sq. miles	1 sq. rod	=	272¼ sq. feet 30¼ sq. yards
1 sq. mile	=	1 section 640 acres	1 sq. yard	=	1,296 sq. inches 9 sq. feet
1 acre	=	4,840 sq. yards 43,560 sq. feet 160 sq. rods	1 sq. foot	=	144 sq. inches

Cubic Measure

1 cubic yard	=	27 cubic feet	1 cu. ft.	=	1,728 cu. in.
1 cord (wood)	=	4x4x8 ft. = 128 cu. ft.	1 bushel	=	2,150.42 cu. in.
1 ton (shipping)	=	40 cubic ft.	1 gallon	=	231 cu. in.

Weights (Commercial)

1 long ton = 2,250 lbs.

1 short ton = 2,000 lbs.

1 pound = 16 ounces

1 ounce = 16 drams

Troy Weight (For Gold and Silver)

1 pound	=	12 ounces 5,760 grains	1 ounce	=	20 pennyweights 480 grains

1 pennyweight = 24 grains

Liquid Measure

1 pint (pt.)	=	4 gills (gl.) 28.875 cu. in.	1 hogshead	=	63 gallons
			1 barrel	=	311/2 gallons
1 quart (qt.)	=	2 pints 57.75 cu. in.	1 cu. ft. water	=	7.48 U.S. gals. 1,728 cu. in. 62½ lbs. @ 62°F
1 gallon (gal.)	=	4 quarts 8 pints 32 gills 231 cu. in. 8½ lbs. @ 62°F			

WEIGHTS AND MEASURES—UNITED STATES

Dry Measure

(When necessary to distinguish the dry pint or quart from the liquid pint or quart, the word "dry" should be used in combination with the name or abbreviation of the dry unit.)

1 quart (qt.)	=	2 pints (pt.) 67.20 cu. in.	1 bushel (bu.)	=	4 pecks 32 quarts 2150.42 cu. in.
1 peck (pk.)	=	8 quarts 16 pints 537.605 cu. in.			

Mariner's Measure

1 fathom	=	6 feet	1 marine league	=	3 marine miles
1 cable length	=	120 fathoms			
1 nautical mile	=	6,080 feet	1 statute mile	=	7½ cable lengths 5,280 feet

Measures of Power

1 BTU per minute	=	.0236	horsepower
		17.6	watts
		.0176	kilowatts
		778	foot lbs. per min.
1 ft. lb. per minute	=	.0226	watts
		.001285	BTU per min.
1 horsepower	=	746	watts
		.746	kilowatts
		33,000	ft. lbs. per min.
		42.4	BTU per min.
1 watt	=	.00134	horsepower
		.001	kilowatts
		44.2	ft. lbs. per min.
		.0568	BTU per min.
1 kilowatt	=	1.341	horsepower
		1,000	watts
		44.250	ft. lbs. per min.
		56.8	BTU per min.

WEIGHTS AND MEASURES—METRIC

Area Measure

1 sq. centimeter (cm^2)	=	100 sq. millimeters (mm^2)	1 are (a)	=	100 m^2
1 sq. meter (m^2)	=	1,000,000 mm^2 10,000 cm^2	1 hectare (ha)	=	10,000 m^2 100 a
			1 sq. kilometer (km^2)	=	1,000,000 m^2 100 ha

Linear Measure

1 centimeter (cm)	=	10 millimeters (mm)	1 dekameter (dkm)	=	10 m
1 decimeter (dm)	=	100 mm 10 cm	1 hectometer (hm)	=	100 m 10 dkm
1 meter (m)	=	1,000 mm 10 dm	1 kilometer (km)	=	1,000 m 10 hm

Weight

1 centigram (cg)	=	10 milligrams (mg)	1 hectogram (hg)	=	100g 10 dkg
1 decigram (dg)	=	100 mg 10 cg	1 dekagram (dkg)	=	
			10 g		
1 gram (g)	=	1,000 mg 10 dg.			1,000 g
			1 kilogram (kg)	=	10 hg
			1 metric ton (1)	=	1,000 kg

Cubic Measure

1 cubic centimeter (cm^3)	=	1,000 cubic millimeters (mm^3)
1 cubic decimeter (dm^3)	=	1,000,000 mm^3 1,000 cm^3
1 cubic meter (m3)	=	1 stere 1,000,000,000 mm^3 1,000,000 cm^3 1,000 dm^3

Volume Measure

1 centiliter (cl)	=	10 milliliters (ml)	1 dekaliter (dkl)	=	10 l
1 deciliter (dl)	=	100 ml 10 cl	1 hectoliter (hl)	=	100 l 10 dkl
1 liter* (l)	=	1,000 ml 10 dl	1 kiloliter (kl)	=	1,000 l 10 hl

*The liter is defined as the volume occupied, under standard conditions, by a quantity of pure water having a mass of 1 kilogram.

Power

1 metric horsepower	=	.986 U.S. horsepower 736 watts .736 kilowatts	 32,550 ft. lbs. per min. 41.8 BTU per min.

METRIC-U.S. CONVERSION FACTORS
(Based on National Bureau of Standards)

Area

Sq. cm.	x 0.1550	= sq. ins.	Sq. ins.	x 6.4516	= sq. cm
Sq. m.	x 10.7639	= sq. ft.	Sq. ft.	x 0.0929	= sq. m
Ares	x 1076.39	= sq. ft.	Sq. ft.	x 0.00093	= ares
Sq. m	x 1.1960	= sq. yds.	Sq. yds.	x 0.8361	= sq. m
Hectare	x 2.4710	= acres	Acre	x 0.4047	= hectares
Sq. km	x 0.3861	= sq. miles	Sq. miles	x 2.5900	= sq. km

Flow

Cu. ft. per min.	x 0.028314	= cu. m per min.
Cu. m per min.	x 35.3182	= cu. ft. per min.

Length

Centimeters	x 0.3937	= inches	Inches	x 2.5400	= centimeters
Meters	x 3.2808	= feet	Feet	x 0.3048	= meters
Meters	x 1.0936	= yards	Yards	x 0.9144	= meters
Kilometers	x 0.6214	= miles*	Miles*	x 1.6093	= kilometers
Kilometers	x 0.53959	= miles**	Miles**	x 1.85325	= kilometers

*Statute miles **Nautical miles

Power

Metric horsepower	x .98632	= U.S. horsepower
U.S. horsepower	x 1.01387	= metric horsepower

Pressure

Kgs per sq. cm	x 14.223	= lbs. per sq. in.
Lbs. per sq. in.	x 0.0703	= kgs per sq. cm
Kgs per sq. in.	x 0.2048	= lbs. per sq. ft.
Kgs per sq. m	x .204817	= lbs. per sq. ft.
Lbs. per sq. ft.	x 4.8824	= kgs per sq. m
Kgs per sq. m	x .00009144	= tons (long) per sq. ft.

METRIC-U.S. CONVERSION FACTORS *(Continued)*

Pressure *(Continued)*

Tons (long) per sq. ft.	x 10940.0	= kg per sq. m
Kgs per sq. mm	x .634973	= tons (long) per sq. in.
Tons (long) per sq. in.	x 1.57494	= kg per sq. mm
Kgs per cu. m	x .062428	= lbs. per cu. ft.
Lbs. per cu. ft	x 16.0184	= kgs per cu. m
Kgs per m	x .671972	= lbs. per ft.
Lbs. per ft.	x 1.48816	= kgs per m
Kg/m	x 7.233	= ft. lbs.
Ft. lbs.	x .13826	= kg/m
Kgs per sq. com	x 0.9678	= normal atmosphere
Normal atmosphere	x 1.0332	= kgs per sq cm

Weight

Grams	x 15.4324	= grains	Grains	x 0.0648	= g
Grams	x 0.0353	= oz.	Oz.	x 28.3495	= g
Grams	x 0.0022	= lbs.	Lbs.	x 453.592	= g
Kgs	x 2.2046	= lbs.	Lbs.	x 0.4536	= kg
Kgs	x 0.0011	= tons (short)	Lbs.	x 0.0004536	= tons*
Kgs	x 0.00098	= tons (long)	Tons (short)	x 907.1848	= kg
Tons*	x 1.1023	= ton (short)	Tons (short)	x 0.9072	= tons*
Tons*	x 2204.62	= lbs.	Tons (long)	x 1016.05	= kg

Volume

Cu. cm.	x 0.0610	= cu. in.	Cu. ins.	x 16.3872	= cu. cm
Cu. m	x 35.3145	= cu. ft.	Cu. ft.	x 0.0283	= cu. m
Cu. m	x 1.3079	= cu. yds.	Cu. yds.	x 0.7646	= cu. m
Liters	x 61.0250	= cu. in.	Cu. ins.	x 0.0164	= liters
Liters	x 0.0353	= cu. ft.	Cu. ft.	x 27.3162	= liters
Liters	x 0.2642	= gals. (U.S.)	Gallons	x 3.7853	= liters
Liters	x 0.0284	= bushels (U.S.)	Bushels	x 35.2383	= liters

Liters x {
1,000.027 = cu. cm
1.0567 = qt. (liquid) or 0.9081 = qt. (dry)
2.2046 = lb. of pure water at 4°C = 1 kg.

Miscellaneous Conversion Factors

Board feet	x 144 sq. in. x 1 in.	= cubic inches
Board feet	x .0833	= cubic feet
Cubic feet	x 6.22905	= gallons, Br. Imp.
Cubic feet	x 2.38095 x 10^{-2}	= tons, Br. shipping
Cubic feet	x 0.025	= tons, U.S. shipping
Degrees, angular	x 0.0174533	= radians
Degrees, F. (less 32°F)	x 0.5556	= degrees, Centigrade
Degrees, centigrade	x 1.8 plus 32	= degrees, F.
Gallons, Br. Imp.	x 0.160538	= cubic feet
Gallons, Br. Imp.	x 4.54596	= liters
Gallons, U.S.	x 0.13368	= cubic feet
Gallons, U.S.	x 3.78543	= liters
Liters	x 0.219975	= gallons, Br. Imp.
Miles, statute	x 0.8684	= miles, nautical
Miles, nautical	x 1.1516	= miles, statute
Radians	x 57.29578	= degrees, angular
Tons, long	x 1.120	= tons, short
Tons, short	x 0.892857	= tons, long
Tons, Br. shipping	x 42.00	= cubic feet
Tons, Br. shipping	x 0.952381	= tons, U.S. shipping
Tons, U.S. shipping	x 40.00	= cubic feet
Tons, U.S. shipping	x 1.050	= tons, Br. shipping

Note: Br. Imp = British Imperial

APPROXIMATE WEIGHT OF MATERIALS

Material	Weight (lb/ft^3)	Weight (lb/yd^3)	Weight (kg/m^3)
Andesite, Solid	173	4,660	2,771
Ashes	41	1,100	657
Basalt, Broken	122	3,300	1,954
Solid	188	5,076	3,012
Caliche	90	2,430	1,442
Cement, Portland	100	2,700	1,602
Mortar, Portland, 1:2½	135	3,654	2,162
Cinders, Blast Furnace	57	1,539	913
Coal, Ashes and Clinkers	40	1,080	641
Clay, Dry Excavated	68	1,847	1,089
Wet Excavated	114	3,080	1,826
Dry Lumps	67	1,822	1,073
Wet Lumps	100	2,700	1,602
Compact, Natural Bed	109	2,943	1,746
Clay and Gravel, Dry	100	2,700	1,602
Wet	114	3,085	1,826
Concrete, Asphaltic	140	3,780	2,243
Gravel or Conglomerate	150	4,050	2,403
Limestone with Portland Cement	148	3,996	2,371
Coal, Anthracite, Natural Bed	94	2,546	1,506
Broken	69	1,857	1,105
Bituminous, Natural Bed	84	2,268	1,346
Broken	52	1,413	833
Cullett	80-100	2,160-2,700	1,281-1,602
Dolomite, Broken	109	2,940	1,746
Solid	181	4,887	2,809
Earth, Loam, Dry Excavated	78	2,100	1,249
Moist Excavated	90	2,430	1,442
Wet Excavated	100	2,700	1,602
Dense	125	3,375	2,002
Soft Loose Mud	108	2,196	1,730
Packed	95	2,565	1,522
Gneiss, Broken	116	3,141	1,858
Solid	179	4,833	2,867
Granite, Broken or Crushed	103	2,778	1,650
Solid	168	4,525	2,691
Gravel, Loose, Dry	95	2,565	1,522
Pit Run, (Gravelled Sand)	120	3,240	1,922
Dry ¼ - 2″	105	2,835	1,682
Wet ½ - 2″	125	3,375	2,002
Gravel, Sand & Clay, Stabilized, Loose	100	2,700	1,602
Compacted	150	4,050	2,403
Gypsum, Broken	113	3,054	1,810
Crushed	100	2,700	1,602
Solid	174	4,698	2,787
Halite (Rock Salt) Broken	94	2,545	1,506
Solid	145	3,915	2,323
Hematite, Broken	201	5,430	3,220
Solid	306	8,262	4,902
Limonite, Broken	154	4,159	2,467
Solid	237	6,399	3,028
Limestone, Broken or Crushed	97	2,625	1,554
Solid	163	4,400	2,611
Magnetite, Broken	205	5,528	3,284
Solid	315	8,505	5,046
Marble, Broken	98	2,650	1,570
Solid	160	4,308	2,563
Marble Wet Excavated	140	3,780	2,243
Mica, Broken	100	2,700	1,602
Solid	180	4,860	2,883

APPROXIMATE WEIGHT OF MATERIALS

Material	Weight (lb/ft^3)	Weight (lb/yd^3)	Weight (kg/m^3)
Mud, Fluid	108	2,916	1,730
Packed	119	3,200	1,906
Dry Close	80-110	2,160-32,970	1,282-1,762
Peat, Dry	25	675	400
Moist	50	1,350	801
Wet	70	1,890	1,121
Phosphate Rock, Broken	110	2,970	1,762
Pitch	71.7	1,936	1,148
Plaster	53	1,431	848
Porphyry, Broken	103	2,790	1,650
Solid	159	4,293	2,547
Sandstone, Broken	94	2,550	1,506
Solid	145	3,915	2,323
Sand, Dry Loose	100	2,700	1,602
Slightly Damp	120	3,240	1,922
Wet	130	3,500	2,082
Wet Packed	130	3,510	2,082
Sand and Gravel, Dry	108	2,916	1,730
Wet	125	3,375	2,022
Shale, Broken	99	2,665	1,586
Solid	167	4,500	2,675
Slag, Broken	110	2,970	1,762
Solid	132	3,564	2,114
Slag, Screenings	92	2,495	1,474
Slag, Crushed (3⁄4”)	74	1,998	1,185
Slag, Furnace, Granulated	60	1,620	961
Slate, Broken	104	2,800	1,666
Solid	168	4,535	2,691
Stone, Crushed	100	2,700	1,602
Taconite	150-200	4,050-5,400	2,403-3,204
Talc, Broken	109	2,931	1,746
Solid	168	4,535	2,691
Tar	71.6	1,936	1,148
Trap Rock, Broken	109	2,950	1,746
Solid	180	4,870	2,883

NOTE: The above weights may vary in accordance with moisture content, texture; etc.

MISCELLANEOUS USEFUL INFORMATION

Area of circle: Multiply square of diameter by .7854.
Area of rectangle: Multiply length by breadth.
Area of triangle: Multiply base by ½ perpendicular height.
Area of ellipse: Multiply product of both diameters by .7854.
Area of sector of circle: Multiply arc by ½ radius.
Area of segment of circle: Subtract area of triangle from area of sector of equal angle.
Area of surface of cylinder: Area of both ends plus length by circumference.
Area of surface of cone: Add area of base to circumference of base multiplied by ½ slant height.
Area of surface of sphere: Multiply diameter^2 by 3.1416.
Circumference of circle: Multiply diameter by 3.1416.
Cubic inches in ball or sphere: Multiply cube of diameter by .5236.
Cubic contents of cone or pyramid: Multiply area of base by ⅓ the altitude.
Cubic contents of cylinder or pipe: Multiply area of one end by length.
Cubic contents of wedge: Multiply area of rectangular base by ½ height.
Diameter of circle: Multiply circumference by .31831.

APPROXIMATE WEIGHTS IN POUNDS PER CUBIC YARD OF COMMON MINERAL AGGREGATES WITH VARIOUS PERCENTAGES OF VOIDS (SPECIFIC GRAVITY OF 1 = APPROX. 1685 LBS.)

Material	Specific Gravity	Percentage of Voids					
		25%	30%	35%	40%	45%	50%
Trap Rock	2.8	3,540	3,300	3,070	2,830	2,600	2,360
	2.9	3,660	3,420	3,180	2,930	2,690	2,440
	3.0	3,790	3,540	3,290	3,030	2,780	2,530
	3.1	3,910	3,650	3,390	3,130	2,870	2,610
Granite and Limestone	2.6	3,280	3,060	2,850	2,630	2,410	2,190
	2.7	3,410	3,180	2,960	2,730	2,500	2,270
	2.8	3,540	3,300	3,070	2,830	2,600	2,360
Sandstone	2.4	3,030	2,830	2,630	2,420	2,020	2,020
	2.5	3,160	2,950	2,740	2,520	2,310	2,100
	2.6	3,280	3,060	2,850	2,630	2,410	2,190
	2.7	3,410	3,180	2,960	2,730	2,500	2,270
Slag	2.0	2,530	2,360	2,190	2,020	1,850	1,680
	2.1	2,650	2,470	2,300	2,120	1,950	1,770
	2.2	2,780	2,590	2,410	2,220	2,040	1,850
	2.3	2,900	2,710	2,520	2,320	2,120	1,940
	2.4	3,030	2,830	2,630	2,420	2,220	2,020
	2.5	3,160	2,950	2,740	2,520	2,310	2,100
Granulated Slag	1.5	1,890	1,770	1,640	1,510	1,390	1,260
Gravel Sand	2.65	3,350	3,120	2,900	2,680	2,450	2,230

NOTE: Most limestone, gravel and sand will absorb one percent or more water by weight. Free water in moist sand approximates two percent, moderately wet 4 percent, and very wet seven percent.

DUMPING ANGLES

Angles at which different materials will slide on steel

Ashes, Dry........33°
Ashes, Moist........38°
Ashes, Wet........30°
Asphalt........45°
Cinders, Dry........33°
Cinders, Moist........34°
Cinders, Wet........31°
Cinders & Clay........30°
Clay........45°
Coal, Hard........24°
Coal, Soft........30°
Coke........23°
Concrete........30°
Earth, Loose........28°
Earth, Compact........50°
Garbage........30°
Gravel........40°
Ore, Dry........30°
Ore, Fresh Mined........37°
Rubble........45°
Sand, Dry........33°
Sand, Moist........40°
Sand & Crushed Stone...27°
Stone........30°
Stone, Broken........27°
Stone, Crushed........30°

DECIMAL EQUIVALENTS OF FRACTIONS

Inch		Millimeter
1/64	0.015625	0.39687
1/32	0.03125	0.79375
3/64	0.046875	1.1906
1/16	0.0625	1.5875
5/64	0.078125	1.9844
3/32	0.09375	2.3812
7/64	0.109375	2.7781
1/8	0.125	3.1750
9/64	0.140625	3.5719
5/32	0.15625	3.9687
11/64	0.171875	4.3656
3/16	0.1875	4.7625
13/64	0.203125	5.1594
7/32	0.21875	5.5562
15/64	0.234375	5.9310
1/4	0.25	6.35
17/64	0.265625	6.7469
9/32	0.28125	7.1437
19/64	0.296875	7.5406
5/16	0.3125	7.9375
21/64	0.328125	8.3344
11/32	0.34375	8.7312
23/64	0.359375	9.1281
3/8	0.375	9.5250
25/64	0.390626	9.9219
13/32	0.40625	10.319
27/64	0.421875	10.716
7/16	0.4375	11.112
29/64	0.453125	11.509
15/32	0.46875	11.906
31/64	0.484375	12.303
1/2	0.5	12.7

Inch		Millimeter
33/64	0.515625	13.097
17/32	0.53125	13.494
35/64	0.546875	13.891
9/16	0.5625	14.287
37/64	0.578125	14.684
19/32	0.59375	15.081
39/64	0.609375	15.478
5/8	0.625	15.875
41/64	0.640625	16.272
21/32	0.65625	16.669
43/64	0.671875	17.066
11/16	0.6875	17.462
45/64	0.703125	17.859
23/32	0.71875	18.256
47/64	0.734375	18.653
3/4	0.75	19.05
49/64	0.765625	19.447
25/32	0.78125	19.844
51/64	0.796875	20.241
13/16	0.8125	20.637
53/64	0.828125	21.034
27/32	0.84375	21.431
55/64	0.859375	21.828
7/8	0.875	22.225
57/64	0.890625	22.622
29/32	0.90625	23.019
59/64	0.921875	23.416
15/16	0.9375	23.812
61/64	0.953125	24.209
31/32	0.96875	24.606
63/64	0.984375	25.003

AREA AND CIRCUMFERENCE OF CIRCLES (INCHES)

Dia.	Area	Cir.	Dia.	Area	Cir.	Dia.	Area	Cir.	Dia.	Area	Cir.
⅛	0.0123	0.3926	10	78.54	31.41	30	706.86	94.24	65	3,318.3	204.2
¼	0.0491	0.7854	10½	86.59	32.98	31	754.76	97.38	66	3,421.2	207.3
⅜	0.1104	1.178	11	95.03	34.55	32	804.24	100.5	67	3,525.6	210.4
½	0.1963	1.57	11½	103.86	36.12	33	855.3	103.6	68	3,631.6	213.6
⅝	0.3067	1.963	12	113.09	37.69	34	907.92	106.8	69	3,739.2	216.7
¾	0.4417	2.356	12½	122.71	39.27	35	962.11	109.9	70	3,848.4	219.9
⅞	0.6013	2.748	13	132.73	40.84	36	1,017.8	113	71	3,959.2	223
1	0.7854	3.141	13½	143.13	42.41	37	1,075.2	116.2	72	4,071.5	226.1
1⅛	0.9940	3.534	14	153.93	43.98	38	1,134.1	119.3	73	4,185.3	229.3
1¼	1.227	3.927	14½	165.13	45.55	39	1,194.5	122.5	74	4,300.8	232.4
1⅜	1.484	4.319	14	176.71	47.12	40	1,256.6	125.6	75	4,417.8	235.6
1½	1.767	4.712	15½	188.69	48.69	41	1,320.2	128.8	76	4,536.4	238.7
1⅝	2.073	5.105	16	201.06	50.26	42	1,385.4	131.9	77	4,656	241.9
1¾	2.405	5.497	16½	213.82	51.83	43	1,452.2	135	78	4,778.3	245
1⅞	2.761	5.89	17	226.98	53.4	44	1,520.5	138.2	79	4,901.6	248.1
2	3.141	6.283	17½	240.52	54.97	45	1,590.4	141.3	80	5,026.5	251.3
2¼	3.976	7.068	18	254.46	56.46	46	1,661.9	144.5	81	5,153	254.4
2½	4.908	7.854	18½	268.8	58.11	47	1,734.9	147.6	82	5,281	257.6
2¾	5.939	8.639	19	283.52	59.69	48	1,809.5	150.7	83	5,410.6	260.7
3	7.068	9.424	19½	298.64	61.26	49	1,885.7	153.9	84	5,541.7	263.8
3¼	8.295	10.21	20	314.16	62.83	50	1,963.5	157	85	5,674.5	257
3½	9.621	10.99	20½	330.06	64.4	51	2,042.8	160.2	86	5,808.8	270.1
3¾	11.044	11.78	21	346.36	65.97	52	2,123.7	163.3	87	5,944.6	272.3
4	12.566	12.56	21½	363.05	67.54	53	2,206.1	166.5	88	6,082.1	276.4
4½	15.904	14.13	22	380.13	69.11	54	2,290.2	169.6	89	6,221.1	279.6
5	19.635	15.7	22½	397.6	70.68	55	2,375.8	172.7	90	6,361.7	282.7
5½	23.758	17.27	23	415.47	72.25	56	2,463	175.9	91	6,503.8	285.8
6	28.274	18.84	23½	433.73	73.82	57	2,551.7	179	92	6,647.6	289
6½	33.183	20.42	24	452.39	75.39	58	2,642	182.2	93	6,792.9	292.1
7	38.484	21.99	24½	471.43	76.96	59	2,733.9	185.3	94	6,939.7	295.3
7½	44.178	23.56	25	490.87	78.54	60	2,827.4	188.4	95	7,088.2	298.4
8	50.265	25.13	26	530.93	81.68	61	2,922.4	191.6	96	7,238.2	301.5
8½	56.745	26.7	27	572.55	84.82	62	3,019	194.7	97	7,389.8	304.7
9	63.617	28.27	28	615.75	87.96	63	3,117.2	197.9	98	7,542.9	307.8
9½	70.882	29.84	29	660.52	91.1	64	3,216.9	201	99	7,697.7	311

TRIGONOMETRIC FUNCTIONS

Angle	Sin	Cos	Tan
0	0	1	0
1	0.017	0.999	0.017
2	0.035	0.999	0.035
3	0.052	0.999	0.052
4	0.07	0.998	0.07
5	0.087	0.996	0.087
6	0.105	0.995	0.105
7	0.112	0.993	0.123
8	0.139	0.99	0.141
9	0.156	0.988	0.158
10	0.174	0.985	0.176
11	0.191	0.982	0.194
12	0.208	0.978	0.213
13	0.225	0.974	0.231
14	0.242	0.97	0.249
15	0.259	0.966	0.268
16	0.276	0.961	0.287
17	0.292	0.956	0.306
18	0.309	0.951	0.325
19	0.326	0.946	0.344
20	0.342	0.94	0.364
21	0.358	0.934	0.384
22	0.375	0.927	0.404
23	0.391	0.921	0.424
24	0.407	0.914	0.445
25	0.423	0.906	0.466
26	0.438	0.898	0.488
27	0.454	0.891	0.51
28	0.469	0.883	0.532
29	0.485	0.875	0.554
30	0.5	0.866	0.577
31	0.515	0.857	0.601
32	0.53	0.848	0.625
33	0.545	0.839	0.649
34	0.559	0.829	0.675
35	0.574	0.819	0.7
36	0.588	0.809	0.727
37	0.602	0.799	0.754
38	0.616	0.788	0.781
39	0.629	0.777	0.81
40	0.643	0.766	0.839
41	0.656	0.755	0.869
42	0.669	0.743	0.9
43	0.682	0.731	0.933
44	0.695	0.719	0.966
45	0.707	0.707	1

Angle	Sin	Cos	Tan
46	0.719	0.695	1.04
47	0.731	0.682	1.07
48	0.743	0.699	1.11
49	0.755	0.656	1.15
50	0.766	0.643	1.19
51	0.777	0.629	1.23
52	0.788	0.616	1.28
53	0.799	0.602	1.33
54	0.809	0.588	1.38
55	0.819	0.574	1.43
56	0.829	0.559	1.48
57	0.839	0.545	1.54
58	0.848	0.53	1.6
59	0.857	0.515	1.66
60	0.866	0.5	1.73
61	0.875	0.485	1.8
62	0.883	0.469	1.88
63	0.891	0.454	1.96
64	0.898	0.438	2.05
65	0.906	0.423	2.14
66	0.914	0.407	2.25
67	0.921	0.391	2.36
68	0.927	0.375	2.48
69	0.934	0.358	2.61
70	0.94	0.342	2.75
71	0.946	0.326	2.9
72	0.951	0.309	3.08
73	0.956	0.292	3.27
74	0.961	0.276	3.49
75	0.966	0.259	3.73
76	0.97	0.242	4.01
77	0.974	0.225	4.33
78	0.978	0.208	4.7
79	0.982	0.191	5.14
80	0.985	0.174	5.67
81	0.988	0.156	6.31
82	0.99	0.139	7.12
83	0.993	0.122	8.14
84	0.995	0.105	9.51
85	0.996	0.087	11.43
86	0.998	0.07	14.3
87	0.999	0.035	19.08
88	0.999	0.035	28.64
89	0.999	0.017	57.28
90	1	0	Infinity

THEORETICAL WEIGHTS OF STEEL PLATES

Size (in)	Wt. per sq. ft. (lb)	Size (in)	Wt. per sq. ft. (lb)	Size (in)	Wt. per sq. ft. (lb)
3/16	7.65	9/16	22.95	1 1/4	51
1/4	10.2	5/8	25.5	1 3/8	56.1
5/16	12.75	3/4	30.6	1 1/2	61.2
3/8	15.30	7/8	35.70	1 5/8	66.3
7/16	17.85	1	40.8	1 3/4	71.4
1/2	20.4	1 1/8	45.9	2	81.6

STANDARD STEEL SHEET GAUGES & WEIGHTS

Size (in)	Wt. per sq. ft. (lb)	Size (in)	Wt. per sq. ft. (lb)	Size (in)	Wt. per sq. ft. (lb)
1		11.25	16	0.0598	2.5
2		10.625	17	0.0538	2.25
3	0.2391	10	18	0.0478	2
4	0.2242	9.375	19	0.0418	1.75
5	0.2092	8.75	20	0.0359	1.5
6	0.1943	8.125	21	0.0329	1.375
7	0.1793	7.5	22	0.0299	1.25
8	0.1644	6.875	23	0.0269	1.125
9	0.1494	6.25	24	0.0239	1
10	0.1345	5.625	25	0.0209	0.875
11	0.1196	5	26	0.0179	0.75
12	0.1046	4.375	27	0.0164	0.6875
13	0.0897	3.75	28	0.0149	0.625
14	0.0747	3.125	29	0.0135	0.5625
15	0.0673	2.812	30	0.012	0.5

NOTE: (1/4" Thick and Heavier Are Called Plates.)

To avoid errors, specify decimal part of one inch or mention gauge number and the name of the gauge. Orders for a definite gauge weight or gauge thickness will be subject to standard gauge weight or gauge thickness tolerance, applying equally plus and minus form the ordered gauge weight or gauge thickness.

U.S. Standard Gauge—Iron and steel sheets. Note: U.S. Standard Gauge was established by act of Congress in 1893, in which weights per square foot were indicated by gauge number. The weight, not thickness, is determining factor when the material is ordered to this gauge.

APPROXIMATE WEIGHTS PER LINEAL FOOT IN POUNDS OF STANDARD STEEL BARS

Dia. (in)	Rd.	Hex.	Sq.
1/16	0.101	0.012	0.013
3/32	0.023	0.026	0.03
1/8	0.042	0.046	0.053
5/32	0.065	0.072	0.083
3/16	0.094	0.104	0.12
7/32	0.128	0.141	0.163
1/4	0.167	0.184	0.212
9/32	0.211	0.233	0.269
5/16	0.261	0.288	0.332
11/32	0.316	0.348	0.402
3/8	0.376	0.414	0.478
13/32	0.441	0.486	0.561
7/16	0.511	0.564	0.651
15/32	0.587	0.647	0.747
1/2	0.667	0.736	0.85
17/32	0.754	0.831	0.96
9/16	0.845	0.932	1.08
19/32	0.941	1.03	1.2
5/8	1.04	1.15	1.33
21/32	1.15	1.27	1.46
11/16	1.26	1.39	1.61
23/32	1.38	1.52	1.76
3/4	1.5	1.66	1.91
25/32	1.63	1.8	2.08
13/16	1.76	1.94	2.24

Dia. (in)	Rd.	Hex.	Sq.
27/32	0.19	2.1	2.42
7/8	2.04	2.25	2.6
29/32	2.19	2.42	2.79
15/16	2.35	2.59	2.99
31/32	2.51	2.7	3.19
1	2.67	2.95	3.4
1 1/16	3.01	3.32	3.84
1 1/8	3.38	3.37	4.3
1 3/16	3.77	4.15	4.8
1 1/4	4.17	4.6	5.31
1 5/16	4.6	5.07	5.86
1 3/8	5.05	5.57	6.43
1 7/16	5.52	6.09	7.03
1 1/2	6.01	6.63	7.65
1 5/8	7.05	7.78	8.98
1 3/4	8.18	9.02	10.41
1 7/8	9.39	10.36	11.95
2	10.68	11.78	13.6
2 1/8	12.06	13.3	15.35
2 1/4	13.52	14.91	17.21
2 3/8	15.06	16.61	19.18
2 1/2	16.69	18.4	21.25
2 3/4	20.2	22.27	25.71
3	24.03	26.5	30.6

WEIGHTS OF FLAT BARS AND PLATES

To find weight per foot of flat steel, multiply width in inches by figure listed below:

Thickness	Thickness	Thickness
1/16″ 0.2125	7/8″ 2.975	1 3/4″ 5.950
1 1/8″ 0.4250	15/16″ 3.188	1 13/16″ 6.163
3/16″ 0.6375	1″ 3.400	1 7/8″ 6.375
1/4″ 0.8500	1 1/16″ 3.613	1 15/16″ 6.588
5/16″ 1.0600	1 1/8″ 3.825	2″ 6.800
3/8″ 1.2750	1 3/16″ 4.038	2 1/8″ 7.225
7/16″ 1.4880	1 1/4″ 4.250	2 1/4″ 7.650
1/2″ 1.7000	1 15/16″ 4.463	2 3/8″ 8.075
9/16″ 1.9130	1 3/8″ 4.675	2 1/2″ 8.500
5/8″ 2.1250	1 7/16″ 4.888	2 5/8″ 8.925
11/16″ 2.3380	1 1/2″ 5.100	2 3/4″ 9.350
3/4″ 2.5500	1 9/16″ 5.313	2 7/8″ 9.775
13/16″ 2.7630	1 5/8″ 5.525	3″ 10.200
.... 1 11/16″	5.738	

APPROXIMATE WEIGHT OF VARIOUS METALS

To find weight of various metals, multiply contents in cubic inches by the number shown; result will be approximate weight in pounds.

Iron 0.27777	Brass 0.31120	Tin 0.26562
Steel 0.28332	Lead 0.41015	Aluminum. 0.09375
Copper. . . . 0.32118	Zinc. 0.25318	

STEEL WIRE GAUGE DATA

Ga. No.	Birmingham Wire Guage or Stubs Guage		Brown & Sharpe or American Wire	Steel Wire Gauge (washburn & Moren)
	Thickness (in)	*Wt. per Sq. Ft.		
3	0.259	10.567	0.2294	0.2437
4	0.238	9.71	0.2043	0.2253
5	0.22	8.976	0.1819	0.207
6	0.203	8.282	0.162	0.192
7	0.18	7.344	0.1443	0.177
8	0.165	6.732	0.1285	0.162
9	0.148	6.038	0.1144	0.1483
10	0.134	5.467	0.1019	0.135
11	0.12	4.896	0.0907	0.1205
12	0.109	4.447	0.0808	0.1055
13	0.095	3.876	0.072	0.0915
14	0.083	3.386	0.0641	0.08
15	0.072	2.938	0.0571	0.072
16	0.065	2.652	0.0508	0.0625
17	0.058	2.366	0.0453	0.054
18	0.049	1.999	0.0403	0.0475
19	0.042	1.714	0.0359	0.041
20	0.035	1.428	0.032	0.0348
21	0.032	1.306	0.0285	0.0317
22	0.028	1.142	0.0253	0.0286
23	0.025	1.02	0.0226	0.0258
24	0.022	0.898	0.0201	0.023
25	0.020	0.816	0.0179	0.0204
26	0.018	0.734	0.0159	0.0181
27	0.016	0.653	0.0142	0.0173
28	0.014	0.571	0.0126	0.0162
29	0.013	0.53	0.0113	0.015
30	0.012	0.49	0.01	0.014

NOTE: Birmingham or Stubs Gauge—Cold rolled strip, round edge flat wire, cold roll spring steel, seamless steel and stainless tubing and boiler tubes.

*B.W. Gauge weights per sq. ft. are theoretical and based on steel weight of 40.8 lbs. per sq. ft. of 1” thickness; weight of hot rolled strip is predicted by using this factor.

Steel Wire Gauge—(Washburn & Moen Gauge)—Round steel wire in black annealed, bright basic, galvanized, tinned and copper coated.

ROCKWELL-BRINELL CONVERSION TABLE

Birnell Numbers 10mm ball 3000 kg Load	Rockwell C Scale Brale Penetrator 150 kg load	Birnell Numbers 10mm ball 3000 kg Load	Rockwell C Scale Brale Penetrator 150 kg load
690	65	393	42
673	64	382	41
658	63	372	40
645	62	362	39
628	61	352	38
614	60	342	37
600	59	333	36
587	58	322	35
573	57	313	34
560	56	305	33
547	55	296	32
534	54	290	31
522	53	283	30
509	52	276	29
496	51	272	28
484	50	265	27
472	49	260	26
460	48	255	25
448	47	248	24
437	46	245	23
426	45	240	22
415	44	235	21
404	43	230	20

AMERICAN STANDARD COARSE AND FINE THREAD SERIES

Size	Threads per inch	
	Coarse NC	Fine NF
0		80
1	64	72
2	56	64
3	48	56
4	40	48
5	40	44
6	32	40
8	32	36
10	24	32
12	24	28
¼	20	28
5⁄16	18	24
⅜	16	24
7⁄16	14	20
½	13	20

Size	Threads per inch	
	Coarse NC	Fine NF
9⁄16	12	18
⅝	11	18
¾	10	16
⅞	9	14
1	8	14
1⅛	7	12
1¼	7	
1⅜	6	
1½	6	12
1¾	5	
2	4½	
2¼	4½	
2½	4	
2¾	4	
3	4	
Over 3		

SPEED RATIOS

Speed ratios and groups from which speed change selection can be made.

$$\text{Ratio of transmission} = \frac{\text{Revolutions per minute of faster shaft}}{\text{Revolutions per minute of slower shaft}}$$

Number of Teeth in Driven Gear & Sprocket	Number of Teeth in Driver Dear & Sprocket							
	17	19	21	23	25	27	30	33
19	1.12	1	0.91	0.83	0.76	0.7	0.64	0.58
21	1.23	1.1	1	0.91	0.84	0.78	0.7	0.65
23	1.35	1.21	1.1	1	0.92	0.85	0.78	0.7
25	1.47	1.32	1.19	1.09	1	0.93	0.83	0.76
27	1.59	1.42	1.28	1.17	1.08	1	0.9	0.82
30	1.77	1.58	1.43	1.3	1.2	1.11	1	0.91
33	1.94	1.74	1.57	1.43	1.32	1.22	1.19	1
36	2.12	1.89	1.71	1.56	1.44	1.33	1.2	1.09
40	2.35	2.1	1.9	1.74	1.6	1.48	1.33	1.21
45	2.65	2.37	2.14	1.96	1.8	1.67	1.5	1.36
50	2.94	2.63	2.38	2.18	2	1.85	1.67	1.52
55	3.24	2.89	2.62	2.39	2.2	2.04	1.83	1.67
60	3.53	3.16	2.86	2.61	2.4	2.22	2	1.82
68	4	3.58	3.24	2.96	2.72	2.52	2.27	
75	4.41	3.95	3.57	3.26	3	2.78		
84	4.94	4.42	4	3.65	3.36			
90	5.3	4.74	4.28	3.91				
102	6	5.37	4.86					
	Number of Teeth in Driver Dear & Sprocket							
	36	40	45	50	55	60	68	75
19	0.53	0.48	0.42	0.38	0.35	0.32	0.28	0.25
21	0.58	0.53	0.47	0.42	0.38	0.35	0.31	0.28
23	0.64	0.58	0.51	0.46	0.42	0.38	0.34	0.31
25	0.7	0.63	0.56	0.5	0.46	0.42	0.37	0.33
27	0.75	0.68	0.6	0.54	0.49	0.45	0.4	0.36
30	0.83	0.75	0.67	0.6	0.55	0.5	0.44	
33	0.92	0.83	0.73	0.66	0.6	0.55		
36	1	0.9	0.8	0.72	0.65			
40	1.11	1	0.89	0.8				
45	1.25	1.13	1					
50	1.3	1.25						
55	1.53							

GENERAL INFORMATION ON CHAINS

The chain drive has three elements: the driver sprocket, the driven sprocket, and the endless chain that transmits power from the first to the second. The distance from center to center of adjacent chain pins is the chain pitch and also the sprocket pitch.

$$\text{Chain speed, f.p.m.} = \frac{\text{No. of teeth in sprocket x chain pitch (in.) x r.p.m.}}{12}$$

$$\text{H.P. of drive} = \frac{\text{Chain speed in f.p.m. x pull in pounds}}{33{,}000}$$

Chain speed, except for high speed RC and silent chains, should not exceed 500 ft. per min. Working load should be held under 1/6 the ultimate strength for speeds up to 200 f.p.m., 1/10 where speed is between 200 and 300 f.p.m., and less if speed exceeds 300 f.p.m.

CONVERSION OF THERMOMETER SCALE

Centigrade — Fahrenheit

°C = 5/9 (°F -32)   °F = 9/5 °C + 32

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-80	-112	1	33.8	31	87.8	61	141.8	91	195.8
-70	-94	2	35.6	32	89.6	62	143.6	92	197.6
-60	-76	3	37.4	33	91.4	63	145.4	93	199.4
-50	-58	4	39.2	34	93.2	64	147.2	94	201.2
-45	-49.1	5	41	35	95	65	149	95	203
-40	-40	6	42.8	36	96.8	66	150.8	96	204.8
-35	-31	7	44.6	37	98.6	67	152.6	97	206.6
-30	-22	8	46.4	38	100.4	68	154.4	98	208.4
-25	-13	9	48.2	39	102.2	69	156.2	99	210.2
-20	-4	10	50	40	104	70	158	100	212
-19	-2.2	11	51.8	41	105.8	71	159.8	105	221
-18	-0.4	12	53.6	42	107.6	72	161.6	110	230
-17	1.4	13	55.4	43	109.4	73	163.4	115	239
-16	3.2	14	57.2	44	111.2	74	165.2	120	248
-15	5	15	59	45	113	75	167	130	266
-14	6.8	16	60.8	46	114.8	76	168.8	140	284
-13	8.6	17	62.6	47	116	77	170.6	150	302
-12	10.4	18	64.4	48	118.4	78	172.4	160	320
-11	12.2	19	66.2	49	120.2	79	174.2	170	338
-10	14	20	68	50	122	80	176	180	356
-9	15.8	21	69.8	51	123.8	81	177.8	190	374
-8	17.6	22	71.6	52	125.6	82	179.6	200	392
-7	19.4	23	73.4	53	127.4	83	181.4	250	482
-6	21.2	24	75.2	54	129.2	84	183.2	300	572
-5	23	25	77	55	131	85	185	350	662
-4	24.8	26	78.8	56	132.8	86	186.8	400	752
-3	26.6	27	80.6	57	134.6	87	188.6	500	932
-2	28.4	28	82.4	58	136.4	88	190.4	600	1,112
-1	30.2	29	84.2	59	138.2	89	192.2	700	1,292
0	32	30	86	60	140	90	194	800	1,472
								900	1,652
								1,000	1,832

MISCELLANEOUS USEFUL INFORMATION

To find capacity in U.S. gallons of rectangular tanks, multiply length by width by depth (all in inches) and divide result by 231.

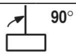
To find number of U.S. gallons in pipe or cylinder, divide cubic contents in inches by 231.

Doubling the diameter of a pipe increases its capacity four times.

To find pressure in pounds per square inch of column of water, multiply height of column in feet by .434; to find height of column of water when pressure in pounds per square inch is known, multiply pressure in pounds by 2.309 (2.309 Feet Water exerts pressure on one pound per square inch.)

APPROX. SAFE LOAD FOR CHAINS AND WIRE ROPES UNDER DIFFERENT LOADING CONDITIONS

Alloy Sling Chain ASTM A-391 Approx. Working Load Limits

Alloy Chain Size		Single Leg		Double Leg					
		 90°		 60°		 45°		 30°	
in	mm	lb	kg	lb	kg	lb	kg	lb	kg
¼	6.35	3,250	1,474	5,660	2,563	4,600	2,086	3,250	1,474
⅜	9.52	6,600	2,994	11,400	5,171	9,300	4,218	6,600	2,994
½	12.7	11,250	5,103	19,500	8,845	15,900	7,212	11,250	5,103
⅝	15.9	16,500	7,484	28,600	12,973	23,300	10,559	16,500	7,484
¾	19	23,000	10,433	39,800	18,053	32,500	14,742	23,000	10,433
⅞	22.2	28,750	13,041	49,800	22,589	40,700	18,461	28,750	13,041
1	25.4	38,750	17,577	67,100	30,436	54,800	24,857	38,750	17,577
1¼	31.7	57,500	26,082	99,600	45,178	81,300	36,878	57,500	26,082

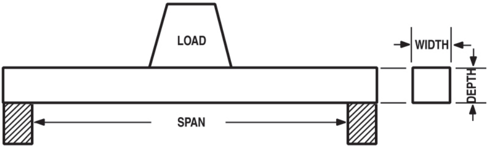
The above Working Load Limits are based upon using chain having a working load equal to that shown in column for single leg. - Courtesy of The Crosby Group

WIRE ROPE

Single-Part Rope Body Size		Rated Capacity (Approx.)							
		1 Sling Vertical		2 Legs 60°		2 Legs 45°		2 Legs 30°	
				 60°		 45°		 30°	
Inch	mm	Tons*	mt	Tons*	mt	Tons*	mt	Tons*	mt
½	12.7	1.8	1.6	3.2	2.9	2.6	2.4	1.8	1.6
9⁄16	14.3	2.3	2.1	4	3.6	3.2	2.9	2.3	2.1
⅝	15.9	2.8	2.5	4.8	4.4	4	3.6	2.8	2.5
¾	19	3.9	3.5	6.8	6.2	5.5	5	3.9	3.5
⅞	22.2	5.1	4.6	8.9	8.1	7.3	6.6	5.1	4.6
1	25.4	6.7	6.1	11	10	9.4	8.5	6.7	6.1
1⅛	28.6	8.4	7.6	14	12.7	12	10.9	8.4	7.6
1¼	31.7	10	9.1	18	16.3	15	13.6	10	9.1
1⅜	34.9	12	10.9	21	19	17	15.4	12	10.9
1½	38.1	15	13.6	25	22.7	21	19	15	13.6
1⅝	41.3	17	15.4	30	27.2	24	21.8	17	15.4
1¾	44.4	20	18.1	34	30.8	28	25.4	20	18.1
1⅞	47.6	22	20	39	35.4	34	30.8	22	20
2	50.8	26	23.6	44	40	36	32.6	26	23.6

*Ton = 2,000 lbs. - Courtesy Macwhyte Company

AVERAGE SAFE CONCENTRATED LOADS ON WOODEN BEAMS—AVERAGE CONDITIONS



Span		Beam Dimension				Load	
		Width		Depth			
ft	m	in	mm	in	mm	lb	kg
4	1.219	6	152	6	152	2,100	952.6
		8	203	8	203	4,970	2,254
		8	203	10	254	7,765	3,522
6	1.829	6	152	6	152	1,398	634.1
		6	152	8	203	2,490	1,129
		8	203	8	203	3,320	1,506
		8	203	10	254	5,184	2,351
		10	254	10	254	6,480	2,939
		10	254	12	305	9,330	4,232
		12	305	12	305	11,197	5,097
8	2.438	6	152	6	152	1,050	476.3
		6	152	8	203	1,866	846.4
		8	203	8	203	2,488	1,128
		8	203	10	254	3,888	1,763
		10	254	10	254	4,860	2,204
		10	254	12	305	7,000	3,175
		12	305	12	305	8,400	3,810

Under ideal conditions the load can be increased 1/3

Concentrated Load = ½ of uniformly distributed load.

TONS OF MATERIAL REQUIRED PER MILE FOR VARIOUS WIDTHS AND POUNDS PER SQUARE YARD

lb per sq.	Width (ft)													
yd	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60
1	0.3	0.6	.9	1.2	1.5	1.8	2.1	2.3	2.6	2.9	5.9	8.8	11.7	14.7	17.6
2	0.6	1.2	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.9	11.7	17.6	23.5	29.3	35.2
3	0.9	1.8	2.6	3.5	4.4	5.3	6.2	7	7.9	8.8	17.6	26.4	35.2	44	52.8
4	1.2	2.3	3.5	4.7	5.9	7	8.2	9.4	10.6	11.7	23.5	35.2	46.9	58.7	70.4
5	1.5	2.9	4.4	5.9	7.3	8.8	10.3	11.7	13.2	14.7	29.3	44	58.7	73.3	88
6	1.8	3.5	5.3	7	8.8	10.6	12.3	14.1	15.8	17.6	35.2	52.8	70.4	88	105.6
7	2.1	4.1	6.2	8.2	10.3	12.3	14.4	16.4	18.5	20.5	41.1	61.5	82.1	102.7	123.2
8	2.3	4.7	7	9.4	11.7	14.1	16.4	18.8	21.1	23.5	46.9	70.4	93.9	117.3	140.8
9	2.6	5.3	7.9	10.6	13.2	15.8	18.5	21.1	23.8	26.4	52.8	79.2	105.6	132	158.4
10	2.9	5.9	8.8	11.7	14.7	17.6	20.5	23.5	26.4	29.3	58.7	88	117.3	146.7	176
20	5.9	11.7	17.6	23.5	29.3	35.2	41.1	46.9	52.8	58.7	117.3	176	234.7	293.3	352
30	8.8	17.6	26.4	35.2	44	52.8	61.6	70.4	79.2	88	176	264	352	440	527.9
40	11.7	23.5	35.2	46.9	58.7	70.4	82.1	93.9	105.6	117.3	234.7	352	469.3	586.7	704
50	14.7	29.3	44	58.7	73.3	88	102.7	117.3	132	146.7	293.3	440	586.7	733.3	880
60	17.6	35.2	52.8	70.4	88	105.6	123.2	140.8	158.4	176	352	528	704	880	1,056
70	20.5	41.1	61.6	82.1	102.7	123.2	143.7	164.3	184.8	205.3	410.7	616	821.3	1,026.7	1,232
80	23.5	46.9	70.4	93.9	117.3	140.8	164.3	187.7	211.2	234.7	469.3	704	938.7	1,173.3	1,408
90	26.4	52.8	79.2	105.6	132	158.4	184.8	211.2	237.6	264	528	792	1,056	1,320	1,584
100	29.3	58.7	88	117.3	146.7	176	205.3	234.7	264	293.3	586.7	880	1,173.3	1,466.7	1,760
200	58.7	117.3	176	234.7	293.3	352	410.7	469.3	528	586.7	1,173.3	1,760	2,346.7	2,933.3	3,520
300	88	176	264	352	440	528	616	704	792	880	1,760	2,640	3,520	4,400	5,280
400	117.3	234.7	352	469.3	586.7	704	821.3	938.7	1,056	1,173.3	2,346.7	3,520	4,693.3	5,866.7	7,040
500	146.7	293.3	440	586.7	733.3	880	1,026.7	1,173.3	1,320	1,466.7	2,933.3	4,400	5,866.7	7,333.3	8,800
600	176	352	528	704	880	1,056	1,232	1,408	1,584	1,760	3,520	5,280	7,040	8,800	10,560
700	205.3	410.7	616	821.3	1,026.7	1,232	1,437.3	1,642.7	1,848	2,053.3	4,106.7	6,160	8,213.3	10,266.7	12,320
800	234.7	469.3	704	938.7	1,173.3	1,408	1,642.7	1,877.3	2,112	2,346.7	4,693.3	7,040	9,386.7	11,733.3	14,080
900	264	528	792	1,056	1,320	1,584	1,848	2,112	2,376	2,640	5,280	7,920	10,560	13,200	15,840
1,000	293.3	586.7	880	1,173.3	1,466.7	1,760	2,053.3	2,346.7	2,640	2,933.3	5,866.7	8,800	11,733.3	14,666.7	17,600

NOTE: Formula used for calculation is as follows:

$$w = \left(\frac{W}{3}\right)\left(\frac{5280}{3}\right)\left(\frac{R}{2000}\right) = 0.2933\ RW$$

Where w = Weight of material in tons per mile
R = Rate of application in lbs. per sq. yd.
W = Width of application in feet

Data From The Asphalt Institute

APPROXIMATE CUBIC YARDS OF AGGREGATE REQUIRED FOR ONE MILE OF ROAD AT VARIOUS WIDTHS AND LOOSE DEPTHS—*(See Note)*

Width of Road (ft)	sq. yd. Per Mile	Loose Depth (in)									
		1	2	3	4	5	6	7	8	9	10
1	587	16	33	49	65	81	98	114	130	147	163
8	4,693	130	261	391	521	652	782	913	1,043	1,173	1,304
9	5,280	147	293	440	587	733	880	1,027	1,173	1,320	1,467
10	5,867	163	326	489	652	815	978	1,141	1,304	1,467	1,630
12	7,040	196	391	587	782	978	1,173	1,369	1,565	1,760	1,956
14	8,213	228	456	685	912	1,141	1,369	1,597	1,825	2,054	2,282
15	8,800	244	489	733	977	1,222	1,467	1,711	1,955	2,200	2,445
16	9,387	261	521	782	1,042	1,304	1,564	1,827	2,086	2,347	2,608
18	10,560	293	587	880	1,173	1,467	1,760	2,053	2,347	2,641	2,933
20	11,733	326	652	978	1,304	1,630	1,956	2,281	2,607	2,933	3,259
22	12,907	358	717	1,076	1,434	1,793	2,152	2,510	2,868	3,228	3,586
24	14,080	391	782	1,173	1,564	1,956	2,347	2,738	3,128	3,521	3,912
26	15,253	424	847	1,271	1,694	2,119	2,543	2,966	3,388	3,815	4,238
28	16,427	456	913	1,369	1,824	2,282	2,738	3,194	3,684	4,108	4,564
30	17,600	489	879	1,467	1,956	2,444	2,933	3,422	3,911	4,440	4,889
40	23,467	652	1,304	1,956	2,607	3,259	3,911	4,563	5,215	5,867	6,519

NOTE: 16.30 cubic yards—1″ deep, 1′ wide and 1 mile long. To obtain the amount of material required for depth after compaction, increase the above figures 15% to 30% depending on the type and gradation of material.

APPROXIMATE WEIGHT IN POUNDS PER SQUARE YARD OF AGGREGATES OF VARYING DENSITIES AT VARIOUS DEPTHS

Density (lb per cu. yd)	Depth (in)										
	1	2	3	4	5	6	7	8	9	10	12
1,500	41.7	83.3	125	166.7	208.3	250	291.7	333.3	375	416.6	500
1,600	44.4	88.9	133.3	177.8	222.2	266.7	311	355.5	400	444.4	533.3
1,700	47.2	94.5	141.6	188.9	236.1	283.3	330.4	377.8	425	472.2	566.7
1,800	50	100	150	200	250	300	350	400	450	500	600
1,900	52.8	105.5	158.3	211.1	263.9	316.7	369.4	422.2	475	527.8	633.3
2,000	55.6	111.1	166.7	222.2	277.8	333.3	388.9	444.4	500	555.6	666.7
2,100	58.3	116.7	175	233.3	291.7	350	408.3	466.7	525.5	583.4	733.3
2,200	61.1	122.2	183.3	244.4	305.6	366.7	427.8	488.9	550	611.1	733.3
2,300	63.9	127.8	191.7	255.5	319.5	383.3	447.2	511.1	575	638.9	766.6
2,400	66.7	133.3	200	266.7	333.3	400	466.7	533.3	600	666.7	800
2,500	69.4	138.9	208.3	277.8	347.2	416.7	486.1	555.5	625	694.4	833.3
2,600	72.2	144.4	216.7	288.9	361.1	433.3	505.6	577.8	650	722.2	866.7
2,700	75	150	225	300	375	450	525	600	675	750	900
2,800	77.8	155.5	233.3	311.1	388.9	466.7	544.4	622.2	700	777.8	933.3
2,900	80.6	161.1	241.7	322.2	402.8	483.3	563.9	644.4	725	805.6	966.7
3,000	83.3	166.7	250	333.3	416.7	500	563.3	666.7	750	833.3	1,000
3,100	86.1	172.2	258.3	344.4	430.6	516.7	602.8	688.9	775	861.2	1,033.3
3,200	88.9	177.8	266.7	355.5	444.5	533.3	622.2	711.1	800	888.9	1,066.7
3,300	91.7	183.3	275	366.7	458.3	550	641.7	733.3	825	944.4	1,133.3
3,400	94.4	188.9	283.3	377.8	472.2	566.7	661.1	755.5	850	944.4	1,133.3
3,500	97.2	194.4	291.7	388.9	486.1	583.3	680.6	777.8	875	972.2	1,166.7
3,600	100	200	300	400	500	600	700	800	900	1,000	1,200
3,700	102.8	205.5	308.3	411.1	513.9	626.7	719.4	822.2	925	1,027.8	1,233.3

APPROXIMATE CUBIC YARDS OF CONCRETE IN SLABS OF VARIOUS AREAS AND THICKNESS

Area (Sq. Ft.)	Thickness of Slabs (in)										
	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
10	0.03	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.15	0.17	0.19
20	0.06	0.09	0.12	0.16	0.19	0.22	0.25	0.28	0.31	0.34	0.37
30	0.09	0.14	0.19	0.23	0.28	0.33	0.37	0.42	0.46	0.41	0.56
40	0.12	0.19	0.25	0.31	0.37	0.43	0.5	0.56	0.62	0.68	0.74
50	0.15	0.23	0.31	0.39	0.46	0.54	0.62	0.7	0.77	0.85	0.93
60	0.19	0.28	0.37	0.46	0.56	0.65	0.74	0.83	0.93	1.02	1.11
70	0.22	0.32	0.43	0.54	0.65	0.76	0.87	0.97	1.08	1.19	1.3
80	0.25	0.37	0.49	0.62	0.74	0.87	1	1.11	1.24	1.36	1.67
90	0.28	0.42	0.56	0.7	0.84	0.97	1.11	1.25	1.39	1.53	1.67
100	0.31	0.46	0.62	0.78	0.93	1.08	1.24	1.39	1.55	1.7	1.85
200	0.62	0.93	1.23	1.54	1.85	2.16	2.47	2.78	3.09	3.4	3.7
300	0.93	1.39	1.85	2.32	2.78	3.24	3.7	4.17	4.63	5.1	5.56
400	1.23	1.83	2.47	3.1	3.7	4.32	4.94	5.56	6.17	6.79	7.41
500	1.54	2.32	3.09	3.86	4.63	5.4	6.17	7	7.72	8.49	9.26
600	1.85	2.78	3.7	4.63	5.56	6.48	7.41	8.33	9.26	10.19	11.11
700	2.16	3.24	4.32	5.4	6.48	7.56	8.64	9.72	10.8	11.88	12.96
800	2.47	3.7	4.94	6.2	7.41	8.64	9.88	11.11	12.35	13.58	14.82
900	2.78	4.17	5.56	6.95	8.33	9.72	11.11	12.5	13.89	15.28	16.67
1,000	3.09	4.63	6.17	7.72	9.26	10.8	12.35	13.89	15.43	16.98	18.52

NOTE: This table may be used to estimate the cubic content of slabs of greater thickness and area than those shown. Examples: To find the cubic content of a slab of 1000 sq. ft. area and 8″ thickness, add the figures given under 6″ and 2″ for 1,000 sq. ft. To find the cubic content of a slab 6″ thickness and 1,500 sq. ft. area, add the figures given for 1,000 and 500 sq. ft. under 6″ thickness.

DEFINITIONS AND TERMS

Admixtures—Substances, not normally a part of paving materials or mixtures, added to them to modify their properties

Agglomeration—Gathering into a ball or mass

Aggregates—In the case of materials for construction, essentially inert materials which when bound together into a conglomerated mass by a matrix form asphalt, concrete, mortar or plaster; crushed rock or gravel screened to size for use on road surfaces

Ballast—Broken stone or gravel used in stabilizing a road bed or making concrete

Bank Gravel—Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, or combinations thereof; gravelly clay, gravelly sand, clayey gravel, and sandy gravel, indicate the varying proportions of the materials in the mixture

Base—Foundation for pavement

Beneficiation—Improvement of the chemical or physical properties of a material or intermediate product by the removal of undesirable components or impurities

Binder Course—The course, in sheet asphalt and bituminous concrete pavements, placed between base and surface courses

Binder Soil—Material consisting primarily of fine soil particles (fine sand, silt, true clay and colloids); good binding properties; commonly referred to as clay binder

Bleeding—Upward migration of bituminous material, resulting in film of bitumen on surface

Blow-up—Localized buckling or shattering of rigid pavement caused by excessive longitudinal pressure

Bog—Wet spongy ground, sometimes filled with decayed vegetable matter

Boulders—Detrital material greater than about 8” in diameter

Construction Joint—Vertical or notched plane of separation in pavement

Contraction Joint—Joint of either full depth or weakened-plane type, designed to establish position of any crack caused by contraction, while providing no space for expansion of pavement beyond original length

Corrugations—Regular transverse undulation in surface of pavement consisting of alternate valleys and crests

Cracks—Approximately vertical cleavage due to natural causes or traffic action

Crazing—Pattern cracking extending only through surface layer, a result of more drying shrinkage in surface than interior of plastic concrete

"D" Lines—Disintegration characterized by successive formation of series of fine cracks at rather close intervals paralleling edges, joints and cracks, and usually curving across slab corners. Initial cracks forming very close to slab edge and additional cracks progressively developing, ordinarily filled with calcareous deposit

Dense and Open Graded Aggregates—Dense applies to graded mineral aggregate containing sufficient dust or mineral filler to reduce all void spaces in compacted aggregate to exceedingly small diameters approximating size of voids in filler itself, may be either coarse or fine graded; open applies to graded mineral aggregate containing no mineral filler or so little that void spaces in compacted aggregate are relatively large

Dewater—To remove water by pumping, drainage, evaporation, or a dewatering screw

Disintegration—Deterioration into small fragments from any cause

Distortion—Any deviation of pavement surface from original shape

Expansion Joint—Joint permitting pavement to expand in length

Faulting—Differential vertical displacement of slabs adjacent to joint or crack

Flume—An open conduit of wood, concrete or metal

Gradation—Sieve analysis of aggregates, a general term to describe the aggregate composition of a mix

Gradation Aggregates—Percentages of aggregate in question which fall into specified size limits; purpose of grading aggregates is to have balanced gradation of aggregate so that voids between sizes are progressively filled with smaller particles until voids are negligible. Resulting mix reaches highest mechanical stability without binder

Granites—Crystalline, even-grained rocks consisting essentially of feldspar and quartz with smaller amounts of mica and other ferro-magnesian minerals

Gravel—Granular, pebbly material (usually coarser than 1/4″ in diameter) resulting from natural disintegration of rock; usually found intermixed with fine sands and clay; can be identified as bank, river or pea gravel; rounded character of some imparted by stream action

Gravity—The force that tends to pull bodies towards the center of mass, to give bodies weight

Grit—A coarse sand formed mostly of angular quartz grains

Gumbo—Soil of finely divided clays of varying capillarity

Hollows—Deficiencies in certain fractions of a pitrun gravel

Igneous—Natural rock composed of solidified molten material

Lime Rock—Natural material essentially calcium carbonate with varying percentages of silica; hardens upon exposure to elements; some varieties provide excellent road material

Limestone—Natural rock of sedimentary origin composed principally of calcium carbonate or calcium and magnesium carbonates in either its original chemical or fragmental, or recrystallized form

Loam—Soil that breaks up easily, usually consisting of sand, clay and organic material

Loess—An unstratified deposit of yellow-brown loam

Manufactured Sand—Not natural occurring sand, -⅜″ material made by crushing +⅜″ material

Mesh—The number of openings per lineal inch in wire screen

Metamorphic Rock—Pre-existing rock altered to such an extent as to be classed separately. One of the three basic rock formations, including igneous and sedimentary

Micron—A unit of length; one thousandth of a millimeter

Mineral Dust or Filler—Very finely divided mineral product, great bulk of which will pass No. 200 sieve. Pulverized limestone is most commonly manufactured filler; other stone dust, silica, hydrated lime and certain natural deposits of finely divided mineral matter are also used

Muck—Moist or wet decaying vegetable matter or peat

Natural Cement—Product obtained by finely pulverizing calcined argillaceous limestone, to which not to exceed 5 percent of nondeleterious materials may be added subsequent to calcination. Temperature of calcination shall be no higher than necessary to drive off carbonic acid gas

Ore—Any material containing valuable metallic matter that is mined or worked

Outcropping—A stratum of rock or other material that breaks surface of ground

Overburden—Soil mantle, waste, or similar matter found directly above deposit of rock or sand-gravel

Paving Aggregate—Vary greatly as to grade, quality, type, and composition; general types suitable for bituminous construction can be classified as: crushed stone, gravel, sand, slag, shell, mineral dust

Pebbles—Rock fragments of small or moderate size which have been more or less rounded by erosional processes

Pitrun—Natural gravel deposits; may contain some sand, clay or silt

Portland Cement—Product obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates to which no additions have been made subsequent to calcination other than water or untreated calcium sulfate, except that additions not to exceed 1 percent of other materials may be interground with clinker at option of manufacturer, provided such materials have been shown to be not harmful

Riprap—Riprap as used for facing dams, canals, and waterways is normally a coarse, grade material; typical general specifications would call for a minimum 160 lb./ft^3 (2563 kg/m^3) stone, free of cracks and seams with no sand, clay, dirt, etc

Sand—Standard classification of soil or granular material passing the ⅜″ (9.52mm) sieve and almost entirely passing the No. 4 (4.76mm) sieve and predominantly retained on the No. 200 (74 micron) sieve

Sand Clay (Road Surface)—Surface of sand and clay mixture in which the two materials have been blended so their opposite qualities tend to maintain a condition of stability under varying moisture content

Sand, Manufactured—Not natural occurring sand, -⅜″ material made by crushing +⅜″ material

Sandstone—Essentially rounded grains of quartz, with or without interstitial cementing materials, with the larger grains tending to be more perfectly rounded than the smaller ones; the fracture takes place usually in the cement, leaving the grains outstanding

Scalp Rock—Rock passed over a screen and rejected—waste rock

Screenings—Broken rock, including dust, or size that will pass through 1/2″ to 3/4″ screen, depending upon character of stone

Sedimentary—Rocks formed by the deposit of sediment

Settling Rock—An enlargement to permit the settlement of debris carried in suspension, usually provided with means of ejecting the material collected

Shale—Material composed essentially of silica and alumina with a thinly laminated structure imparted by natural stratification of extremely fine sediments together with pressure

Shell Aggregate—Applies to oyster, clam shells, etc., used for road surfacing material; shells are crushed to size but generally must be blended with other fine sands to produce specification gradation

Sieve—Test screens with square openings.

Slag—By-product of blast furnace; usually makes good paving material, can be crushed into most any gradation; most are quite porous

Slates—Rocks, normally clayey in composition, in which pressure has produced very perfect cleavage; readily split into thin, smooth, tough plates

Slope Angle—The angle with the horizontal, at which a particular material will stand indefinitely without movement

Specific Gravity—The ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of a gas-free distilled water at the same temperature

Stone—Any natural rock deposit or formation of igneous, sedimentary and/or metamorphic origin, either in original or altered form

Stone-Sand—Refers to product (usually less than 1/2" in diameter) produced by crushing of rock; usually highly processed, should not be confused with screenings

Stratum—A sheet-like mass of sedimentary rock or earth of one kind, usually in layers between bed of other kinds

Sub-grade—Native foundation that is placed road material or artificial foundation, in case latter is provided

Sub-soil—Bed or earth immediately beneath surface soil

Tailings—Stones which, after going through crusher, do not pass through the largest openings on the screen

Top-soil (Road Surface)—A variety of surfacing used principally in southeastern states, being stripping of certain top-soils containing natural sand-clay mixture. When placed on road surface, wetted and puddled under traffic, it develops considerable stability

Trap—Includes dark-colored, fine-grained, dense igneous rocks composed of ferro-magnesian minerals, basic feldspars, and little or no quartz; ordinary commercial variety is basalt, diabase, or gabbro

Viscosity—Measure of the ability of a liquid or solid to resist flow; a liquid with high viscosity will resist flow more readily than a liquid with low viscosity

Voids—Spaces between grains of sand, gravel or soil that are occupied by water or air or both

Weir—A structure for diverting or measuring the flow of water

NOTES:

1

2

3

4

5

6

Kolberg-Pioneer, Inc.
700 West 21st Street
Yankton, SD 57078 USA
800.542.9311 605.665.9311
F 605.665.8858

Johnson Crushers International, Inc.
86470 Franklin Boulevard
Eugene, OR 97405 USA
800.314.4656 541.736.1400
F 541.736.1424

Astec Mobile Screens
2704 West LeFevre Road
Sterling, IL 61081 USA
800.545.2125 815.626.6374
F 815.626.6430

www.kpijci.com

Rev. 1/20