Mineral or Metal	**GRAPHITE**
Description of Ore	A graphite ore containing some quartz, mica and pyrite. Graphite occurs principally in small flake form.
Assay of Ore, Approximate	Graphite 4.0%
Method or Process	Denver "Sub-A" Flotation with Denver "Sub-A" Unit Cell in grinding circuit.
Concentrates and Recovery	%Graphite / %Recovery Flot. Conc. 75.5 / 68.0 Middling Product 18.0 / 26.0
Reagents, Lbs. Per Ton	Fuel Oil 0.10 Pine Oil 0.03 Caustic Starch 0.3 Calcium Hydroxide 3.0 } to depress pyrite Mag. Sulphate 2.0 } Sodium Cyanide 0.2 }
Miscellaneous Data	pH, 7.0 and 11.0 Grind, Flotation feed—48 mesh

Mineral or Metal	**GYPSUM**
Description of Ore	A gypsum ore containing some calcium carbonate, siliceous gangue and small amounts of black sand, bonded together by clay.
Assay of Ore, Approximate	Calcium Oxide 13.0% Sulfur Trioxide 11.0% Iron 2.5% Insoluble 48.0% Gypsum 25.0%
Method or Process	Washing successively
Concentrates and Recovery	Washed Product: %Gypsum 83.0, %Recovery 91.0 (Slimes product to waste)
Reagents, Lbs. Per Ton	No reagents required. Process consists of a series of washing steps.
Miscellaneous Data	Material all minus 4 mesh

Mineral or Metal	**HUBNERITE**
Description of Ore	An ore of tungsten containing hubnerite in a siliceous gangue and appreciable amounts of pyrite, chalcopyrite, arsenopyrite and sphalerite.
Assay of Ore, Approximate	Tungsten Oxide 3.0% Copper 4.0% Zinc 0.5% Iron 5.0% Insoluble 84.0% Sulphur 1.3%
Method or Process	Denver Mineral Jig and Table Denver "Sub-A" Flotation
Concentrates and Recovery	$\%WO_3$ / %Recovery Jig & Table Conc. 66.3 / 86.0 Flotation Conc. 70.8 / 82.0 %As nil %Zn 0.07 %S 0.4 %Cu 0.05 (Middlings not included)
Reagents, Lbs. Per Ton	Soda Ash 4.0 Copper Sulphate 2.0 Z-6 Xanthate 0.5 Cresylic Acid 0.6
Miscellaneous Data	pH, 8.5 Grind, table feed—48 mesh Grind, Flotation feed—48 mesh

Mineral or Metal	**KAOLIN**
Description of Ore	An ore containing kaolin and quartz with very low iron, and being exceptionally white and of good grade.
Assay of Ore, Approximate	Silica 90.4% Alumina 7.2% Iron Oxide 0.02%
Method or Process	Grinding, washing, and some tabling.
Concentrates and Recovery	Kaolin, minus 325 mesh, 25% of heads by weight, burns very white; does not melt at 1350° C.* Sand prod.: % Heads 57%, % SiO_2 97.5, % Al_2O_3 2.5, % FeO 0.02 Table sand: % Heads 14%, % SiO_2 96.0 (*Meets market requirements)
Reagents, Lbs. Per Ton	None required. Kaolin and quartz separation accomplished by gravity methods from pulp in which kaolin is slimed; quartz remains coarse and granular.

Mineral or Metal

KYANITE

Description of Ore

Kyanite mineral with considerable quartz, some calcium and magnesium sulphates and a small amount of pyrite.

Assay of Ore, Approximate

Silica	74.0%
Alumina	21.0%
Iron	0.5%
Magnesium Oxide	0.2%
Calcium Oxide	2.0%

Method or Process

Denver "Sub-A" Flotation

Concentrates and Recovery

	% Assay SiO_2	% Assay Al_2O_3	% Recovery SiO_2	% Recovery Al_2O_3
Flot. Conc.	41.0	53.0	14.0	63.0
Rougher Tails	93.0	3.0	61.0	7.0

(Middling not included)

Reagents, Lbs. Per Ton

Soda Ash	2.0
Fuel Oil	0.6
Oleic Acid	3.0
Sodium Silicate	2.0

Miscellaneous Data

pH, 7.6
Grind, flotation feed—65 mesh

LEAD

Description

An oxidized lead ore containing a high content of iron oxide. Chief economic mineral—cerussite with small amount of anglesite.

Assay of Ore

Pb (Percent)	Fe (Percent)	Insol. (Percent)	S (Percent)
14.8	18.9	39.4	0.49

Method or Process

Denver Mineral Jig in grinding circuit followed by oxide flotation and gravity table concentration of flotation tailing.

Concentrates and Recovery

	Assays Percent Pb	Assays Percent Fe	Insol.	Recovery Percent Pb
Jig Concentrate	64.69	9.83	....	31.8
Oxide Flotation Concentrate	59.72	2.44	....	22.7
Table Concentrate	53.44	14.29	....	27.6

Reagents Lbs. Per Ton

Sodium Silicate	1.0
Annite	1.0
Yarmor F Pine Oil	0.08

Miscellaneous Data

Pulp pH, 7.4
Annite added in stages of 0.25 lbs./ton per stage. All attempts to sulphidize the lead minerals or float with Reagents 404 or 425 failed on this ore.

LEAD-COPPER-GOLD-SILVER

Description

A semi-oxidized lead-copper ore. The principal economic minerals are galena, cerussite, malachite, cuprite and chalcopyrite; gold and silver in economic amounts.

Assay of Ore

Au (Oz./Ton)	Ag (Oz./Ton)	Pb (Percent)	Cu (Percent)	Fe (Percent)	S (Percent)
0.07	2.25	2.6	2.26	1.8	0.69

Method or Process

Denver "Sub-A" Flotation with a Denver Mineral Jig in the grinding circuit. Flotation in two stages—concentrates combined.

Concentrates and Recovery

	Assays Percent Pb	Assays Percent Cu	Recovery Percent Pb	Recovery Percent Cu
1st Flotation Stage with Jig (Sulphide)	56.14	3.07	46.5	3.1
2nd Flotation Stage (Oxide)	9.44	14.62	45.6	86.0

Reagents Lbs. Per Ton

1st Flotation Stage (Sulphide)

Reagent 404	0.08
Yarmor F Pine Oil	0.06

2nd Flotation Stage (Oxide)

Denver Sulphidizer	6.0
Sodium Bicarbonate	1.0
Reagent 404	0.24
Yarmor F Pine Oil	0.04

Miscellaneous Data

Pulp pH.7.4—Sulphide Flotation
Pulp pH.8.4—Oxide Flotation

LEAD-GOLD-SILVER

Description

An oxidized lead ore containing low values in gold and silver. Principal economic minerals — cerussite, some oxidized galena.

Assay of Ore

Ag (Oz./Ton)	Au (Oz./Ton)	Pb (Percent)	Cu (Percent)	Zn (Percent)
0.69	0.01	10.4	0.12	0.65

Method or Process

Denver "Sub-A" Flotation with the Denver Mineral Jig in the grinding circuit followed by gravity table concentration.

Concentrates and Recovery

	Assays Percent Pb	Recovery Percent Pb
Jig Concentrate	50.9	45.05
Flotation Concentrate	52.3	32.93
Table Concentrate	38.0	11.33

Reagents Lbs. Per Ton

Reagent 404	0.5
Sodium Silicate	1.0
Butyl Xanthate (Z-8)	0.2

Miscellaneous Data

Pulp pH, 7.4.
Grind 0.84% plus 48 mesh.
55.67% minus 200 mesh.

LEAD-SILVER

Description
An oxidized lead-silver ore containing cerussite, anglesite, galena with associated silver minerals, and argentite.

Assay of Ore

Oz./Ton Ag	Percent Pb
13.9	1.8

Method or Process
Two-stage Denver Flotation — Denver Sulphidizer in last stage.

Concentrates and Recovery

	Assays Oz./Ton Ag	Assays % Pb	Recovery Percent Ag	Recovery Percent Pb
1st Flotation Stage (Sulphide)	277.9	19.1	75.38	53.2
2nd Flotation Stage (Oxide)	45.5	9.9	9.75	21.7

Reagents Lbs. Per Ton
1st Flotation Stage (Sulphide)
Reagent 404 ..... 0.05
Aerofloat 25 ..... 0.03
Xanthate (Z-6) 0.12
2nd Flotation Stage (Oxide)
Denver Sulphidizer 0.8
Sodium Bicarbonate 1.0
Xanthate (Z-6) 0.10

Miscellaneous Data
Pu'p pH, 7.5
Grind ..... 0.3% plus 65 mesh, 83.0% minus 200 mesh

LEAD-SILVER

Description
A lead-silver ore containing the following chief economic minerals —argentite, silver bearing cerussite and semi-oxidized galena.

Assay of Ore

Oz./Ton Ag	Percent Tot. Pb	Percent Oxide Pb	Percent Fe
24.5	1.9	1.1	1.8

Method or Process
Sulphidization Flotation with Unit Cell in grinding circuit.

Concentrates and Recovery

	Assays Oz./Ton Ag	Assays % Pb	Recovery Percent Ag	Recovery Percent Pb
Unit Cell Concentrate	645.5	24.0	65.16	34.15
Oxide Flotation Concentrate	378.4	48.4	28.73	51.37

Reagents Lbs. Per Ton
Sodium Sulphide 1.5
Amyl Xanthate (Z-5) 0.25
Yarmor F Pine Oil 0.10
Soda Ash 1.0

Miscellaneous Data
Pulp pH, 7.7
Xanthate and frothers stage added to machine. Sulphidization conditioning time 7 minutes.
Grind ..... 1.0% plus 48 mesh, 62.0% minus 200 mesh

MODERN CONCENTRATION OF MINERALS

Mineral or Metal **SILICA SAND**

Description of Ore
Quartz (Silica) Sand contaminated with particles of metallic iron.

Assay of Ore, Approximate
Head ore contained 0.12% Fe which was to be removed as completely as possible to reach glass sand specifications.

Method or Process
Denver Mineral Jig
Denver "Sub-A" Flotation

Concentrates and Recovery

	% Iron	% Weight
Jig Concentrate	0.4	3.0
Flotation Concentrate	7.8	1.0
Flotation Tailing	0.02	96.0

Reagents, Lbs. Per Ton
Aerofloat 25 ..... 0.25
Z-6 Xanthate 0.1
Hydrochloric Acid 4.8

Miscellaneous Data
pH, 4.0
Grind, none. Material as received —14 mesh.

Mineral or Metal **MANGANESE**

Description of Ore
A soft ore containing pyrolusite and wad with inclusion of silica, silicates and aluminates.

Assay of Ore, Approximate
Manganese 40%
Silica 12%
Insoluble 17%

Method or Process
Denver Mineral Jig
Denver-Wilfley Tables

Concentrates and Recovery

	% Manganese	% Recovery
Jig and Table Concentrates	52.6	62.0

% SiO_2 ..... 3.3 % Insol. 4.4
(Middling not included)

Reagents, Lbs. Per Ton
No reagents required, gravity concentration process.

Reliable Denver Ore Tests insure your mining investment.

Mineral or Metal	SILVER
Description of Ore	An ore of silver with a high content of pyrite and minor amounts of secondary copper sulphides, galena, sphalerite in a siliceous gangue.
Assay of Ore, Approximate	Gold — trace Silver — 67.7 oz/ton Lead — 2.0% Zinc — 2.7% Iron — 26.5% Insol. — 40.0% Sulphur — 9.7%
Method or Process	Denver "Sub-A" Unit Cell Denver "Sub-A" Flotation
Concentrates and Recovery	(see table below)
Reagents, Lbs. Per Ton	Lime — 6.5 Thiocarbanilide — 0.15 Minerec 194 — 0.05 Zinc Sulphate — 0.5 Sodium Cyanide — 0.1 Aerofloat 25 — 0.09 Z-5 Xanthate — 0.10
Miscellaneous Data	pH, 8.8 Grind, Unit Cell—28 mesh. Grind, Flotation—65 mesh.

Concentrates and Recovery (Silver):

	Assay oz. Ag/ton	% Recovery
Unit cell conc.	335.4	64.3
Total conc.	217.0	80.1

(Middlings not included)

Mineral or Metal	TALC
Description of Ore	An ore of talc containing also calcite, tremolite, iron, and other impurities.
Assay of Ore, Approximate	Iron Oxide — 3.0% Alumina — 7.0% Calcium Oxide — 12.0% Silica — 47.5% Magnesium Oxide — 14.0% Ignition Loss — 16.0%
Method or Process	Denver "Sub-A" Flotation
Concentrates and Recovery	Concentrate, 48% by weight: MgO — 26.8 SiO_2 — 55.2 CaO — 3.7 Al_2O_3 — 6.7 Fe_2O_3 — 1.7 Ignition Loss — 5.7
Reagents, Lbs. Per Ton	Soda Ash — 2.0 Ultrawet — 0.8
Miscellaneous Data	pH, 8.0 Grind—100 mesh. Grade of product dependent upon physical characteristics such as color, fineness, texture. Flotation concentrate acceptable.

Mineral or Metal	TIN
Description of Ore	Cassiterite in relatively coarse crystals in pegmatite composed of feldspar, quartz and muscovite mica.
Assay of Ore, Approximate	Tin — 1.7% Some heavy silicates and a trace of ilmenite.
Method or Process	Denver Mineral Jig. Denver-Wilfley Table.
Concentrates and Recovery	(see table below)
Reagents, Lbs. Per Ton	No reagents required. Process entirely gravity concentration.
Miscellaneous Data	Grind, Jig feed—10 mesh. Grind, Table feed—28 mesh.

Concentrates and Recovery (Tin):

	% Tin	% Recovery
Jig Conc.	64.7	92.5
Table Conc.	58.8	6.9

Mineral or Metal	TITANIUM
Description of Ore	A gravity plant tailing containing ilmenite in a siliceous gangue with quartz, feldspar, hornblende, garnet and mica.
Assay of Ore, Approximate	Titanium Oxide — 18%
Method or Process	Denver "Sub-A" Flotation.
Concentrates and Recovery	(see table below)
Reagents, Lbs. Per Ton	Sulphuric Acid — 10.7 Sodium Fluoride — 3.3 Oleic Acid — 2.5 Alcohol — 0.3
Miscellaneous Data	pH, 3.6 Grind, Flotation feed—65 mesh.

Concentrates and Recovery (Titanium):

Cleaned Flot.	% TiO_2	% Recovery
Concentrate	47.0	73.0
Middlings	24.0	10.0

Mineral or Metal	VERMICULITE
Description of Ore	Material containing vermiculite, mixed silicates and some feldspar.
Assay of Ore, Approximate	Recoverable vermiculite 60%
Method or Process	Agglomerate tabling.
Concentrates and Recovery	Recovery 80% of the recoverable vermiculite contained in the heads, in a concentrate containing 98.5% vermiculite, and weighing 14 lbs. per cu. ft. after exfoliation.
Reagents, Lbs. Per Ton	Sulphuric Acid 3.8 Aluminum Sulphate 4.0 Armac-S 3.0 Fuel Oil 7.0
Miscellaneous Data	Grind, Table feed—8+20 mesh.

Mineral or Metal	ZINC
Description of Ore	A gravity tailing containing sphalerite, pyrite and a small amount of zinc carbonate in a siliceous gangue with traces of galena.
Assay of Ore, Approximate	Zinc (Total) 1.1 Lead 0.1 Iron 3.3 Sulphur 3.4
Method or Process	Denver "Sub-A" Flotation.
Concentrates and Recovery	% Zn / % Recovery Cleaned Flot. Concentrate 62.9 / 83.1 Middling 22.0 / 11.7
Reagents, Lbs. Per Ton	Lime 4.5 Copper Sulphate 1.0 Z-5 Xanthate 0.09 Pine Oil 0.04
Miscellaneous Data	pH, 9.5 Grind, Flotation feed—65 mesh.

Flotation Reagent Table

Table from Colorado School of Mines. "Trends of Flotation."

cc. per min.	Lbs. per min.	Pounds Per Day											
		100%	92%	90%	27%	25%	20%	14%	12.5%	10%	5%	2.5%	1%
1	.002	3.2	2.9	2.9	.9	.8	.6	.4	.4	.3	.16	.08	.03
2	.004	6.4	5.9	5.7	1.7	1.6	1.3	.9	.8	.7	.32	.16	.07
3	.007	9.5	8.8	8.6	2.6	2.4	1.9	1.3	1.2	1.0	.48	.24	.10
4	.009	12.7	11.7	11.5	3.4	3.2	2.5	1.8	1.6	1.3	.64	.32	.13
5	.011	15.9	14.7	14.3	4.3	4.0	3.2	2.2	2.0	1.6	.80	.40	.16
6	.013	19.1	17.6	17.2	5.6	4.8	3.8	2.7	2.4	1.9	.96	.48	.19
7	.015	22.2	20.5	20.0	6.0	5.6	4.5	3.1	2.8	2.3	1.12	.56	.23
8	.018	25.4	23.4	22.9	6.9	6.4	5.1	3.6	3.2	2.6	1.28	.64	.26
9	.020	28.6	26.4	25.8	7.7	7.2	5.7	4.0	3.6	2.9	1.44	.72	.29
10	.022	31.8	29.3	28.6	8.6	7.9	6.4	4.5	3.9	3.2	1.58	.79	.32
20	.044	64	59	57	17	16	12.7	8.9	8	6.4	3.2	1.6	.64
30	.066	95	88	86	26	24	19.1	13.4	12	9.6	4.8	2.4	.96
40	.088	127	117	115	34	32	25.4	17.8	15	12.7	6.4	3.2	1.3
50	.110	159	147	143	43	40	31.8	22.3	20	15.9	8.0	4.0	1.6
60	.132	191	176	172	52	48	38.2	26.7	24	19.1	9.6	4.8	1.9
70	.154	222	205	200	60	56	44.6	31.2	28	22.3	11.2	5.6	2.2
80	.176	254	235	229	69	64	50.9	35.6	32	25.5	12.8	6.4	2.6
90	.199	286	264	258	77	72	57.3	40.0	36	28.7	14.4	7.2	2.9
100	.221	318	293	285	85	79	64	44.5	40	32	15.8	7.9	3.2

The following are useful for calculating the amount of reagent being fed to a mill circuit:

$$\text{lbs./ton} = \frac{\text{cc/min. x sp. gr. of liquid}}{\text{0.315 x short tons per 24 hrs.}} \qquad \text{lbs./ton} = \frac{\text{grams per minute}}{\text{0.315 x short tons per 24 hrs.}}$$

If weights or measures in the above formulae do not refer to 100% solutions, multiply by solution strength in percent weight.

Flotation Reagent Equivalents

10 Per Cent Solution

Tons per 24 Hrs.	75	100	125	150	175	200
CC per Min.	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton
1	0.004	0.003	0.003	0.002	0.002	0.002
2	0.008	0.006	0.005	0.004	0.004	0.003
3	0.013	0.010	0.008	0.006	0.005	0.005
4	0.017	0.013	0.010	0.008	0.007	0.006
5	0.021	0.016	0.013	0.011	0.009	0.008
6	0.025	0.019	0.015	0.013	0.011	0.010
7	0.029	0.022	0.018	0.015	0.013	0.011
8	0.034	0.025	0.020	0.017	0.015	0.013
9	0.038	0.029	0.023	0.019	0.016	0.014
10	0.042	0.032	0.025	0.021	0.018	0.016
20	0.084	0.063	0.051	0.042	0.036	0.032
30	0.126	0.095	0.076	0.063	0.054	0.047
40	0.168	0.127	0.101	0.084	0.072	0.063
50	0.210	0.159	0.127	0.105	0.091	0.079
60	0.252	0.190	0.152	0.126	0.109	0.095
70	0.294	0.222	0.177	0.147	0.127	0.111
80	0.336	0.254	0.202	0.168	0.145	0.126
90	0.378	0.285	0.228	0.189	0.163	0.142
100	0.420	0.317	0.253	0.210	0.181	0.158

100 Per Cent Solution

Tons per 24 Hrs.	75	100	125	150	175	200
CC per Min.	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton	Lbs. per Ton
1	0.042	0.032	0.025	0.021	0.018	0.016
2	0.084	0.063	0.051	0.042	0.036	0.032
3	0.126	0.095	0.076	0.063	0.054	0.047
4	0.168	0.127	0.101	0.084	0.072	0.063
5	0.210	0.159	0.127	0.105	0.091	0.079
6	0.252	0.190	0.152	0.126	0.109	0.095
7	0.294	0.222	0.177	0.147	0.127	0.111
8	0.336	0.254	0.202	0.168	0.145	0.126
9	0.378	0.285	0.228	0.189	0.163	0.142
10	0.420	0.317	0.253	0.210	0.181	0.158
20	0.840	0.634	0.506	0.420	0.362	0.317
30	1.260	0.951	0.759	0.630	0.543	0.474
40	1.680	1.268	1.012	0.840	0.724	0.634
50	2.100	1.585	1.265	1.050	0.905	0.790
60	2.520	1.902	1.518	1.260	1.086	0.948
70	2.940	2.219	1.771	1.470	1.267	1.106
80	3.360	2.536	2.024	1.680	1.448	1.264
90	3.780	2.853	2.277	1.890	1.629	1.422
100	4.200	3.174	2.530	2.100	1.810	1.585

Specific Gravity and Physical Properties of the Useful Metals

Substance	Atomic Weight	Specific Gravity	Specific Heat	Melting Point, Deg. F.	Boiling Point, Deg. F.	Cubical Expansion by Heat from 32° F. to 212° F.	Heat Conductivity, Silver = 100	Electrical Conductivity, Silver = 100	Tensile Strength, Lb. per Sq. In.	Hardness, Moh Scale
Aluminum	27.1	2.67	......	1217	3272	0.0070	48	53	18,000	3 −
Antimony	120.2	6.76	.050	1166	2624	.027 .050	4.2	3.5	1,000	3 +
Bismuth	208.0	9.82	.0301	520	2300	.0040	1.8	1.13	6,400	2 +
Brass	....	7.8 8.6	.092	1650 ±	....	.0057 .0064	15 30	23 17	9,000 40,000	3 +
Bronze	......	8.52 8.96	.086	1650 ±	....	.0051 .0057	......	......	3,500 25,000	3 +
Cadmium	112.40	8.65	.0567	609.6	1430	.0094	......	......	......	......
Cobalt	58.97	8.55	.107	2696	....	.0037	......	19.9	34,400	6
Copper	63.57	8.85	.0093	1981.4	5050	.0051	89	99.5	30,000	3
German Silver	......	8.5	.095	1850 ±	....	.0055	8	10 32	......	3 +
Gold	197.2	19.258	.032	1945.5	3992	.0044	53.2	76.7	14,000	3 −
Iridium	193.1	22.38	.032	4280 ±	....	.0020	34	30	......	6
Iron	55.84	7.9	.113	2786	4442	.0036	11 18	9.9 17	39,500 ±	4 5
Iron, Cast	......	7.22	.1298	1900 2200	....	.0033	11.9	2.8 1.4	......	6 8
Iron, Wrought	......	7.70	.1138	2700 2900	....	.0035	......	17	50,000 ±	......
Lead	207.20	11.38	.031	621.3	2900 3600	.0088	8.2	7.6	1,600 2,400	2 −
Magnesium	24.32	1.75	.025	1204	2048	.0083	37.6	35.8	20,000	2
Manganese	54.93	8.0	......	2246	3452	......	......	......	......	......
Mercury	200.6	13.58	.033	−37.97	680	.0182	1.8	1.7	......	......
Nickel	58.68	8.8	.109	2642	......	.0038	14	14.5 9.9	50,000 100,000	4 +
Osmium	190.9	22.5	.031	4890 ±	......	.0020	......	16	......	......
Palladium	106.7	12.0	.058	2822	......	.0036	17	15	50,000	5 −
Platinum	195.2	21.5	.032	3191	......	.0027	17	20 10	30,000 50,000	4 +

(Continued from previous page)

Rhodium	102.9	12.4	.058	3542		.0026	30	23		
Silver	107.88	10.51	.057	1760.9	3550	.0058	100	100	36,000	2+
Steel		7.9	.117	2550 =		.0041	6	16	50,000	4
						.0030	14	3	20,000	9
Tantalum	181.5	14.1 16.1	.036	5250		.0024		9.9		
Tin	118.7	7.35	.056	449.4	3800	.0069	15.2	11.3	5,000	2
Titanium	48.1	3.54		3260 =				13.7		
Tungsten	184.0	18.8	.033	6152				23	500,000	
Zinc	65.37	7.14	.096	786.9	1724	.0088	28.1	26	9,000 24,000	3+

—Data from GENERAL ELECTRIC CO.

International Atomic Weights—

Element	Symbol	Atomic Number	Atomic Weight	Valence	Element	Symbol	Atomic Number	Atomic Weight	Valence
ACTINIUM	Ac	89	227.0		MERCURY	Hg	80	200.61	1, 2
ALUMINUM	Al	13	26.97	3	MOLYBDENUM	Mo	42	95.95	3, 4, 6
ANTIMONY	Sb	51	121.76	3, 5	NEODYMIUM	Nd	60	144.27	3
ARGON	A	18	39.944	0	NEON	Ne	10	20.183	0
ARSENIC	As	33	74.91	3, 5	NICKEL	Ni	28	58.69	2, 3
BARIUM	Ba	56	137.36	2	NITROGEN	N	7	14.008	3, 5
BERYLLIUM	Be	4	9.02	2	OSMIUM	Os	76	190.2	2, 3, 4, 8
BISMUTH	Bi	83	209.00	3, 5	OXYGEN	O	8	16.000	2
BORON	B	5	10.82	3	PALLADIUM	Pd	46	106.7	2, 4
BROMINE	Br	35	79.916	1, 3, 5, 7	PHOSPHORUS	P	15	30.98	3, 5
CADMIUM	Cd	48	112.41	2	PLATINUM	Pt	78	195.23	2, 4
CALCIUM	Ca	20	40.08	2	POLONIUM	Po	84	210.0	
CARBON	C	6	12.01	2, 4	POTASSIUM	K	19	39.096	1
CERIUM	Ce	58	140.13	3, 4	PRASEODYMIUM	Pr	59	140.92	3
CESIUM	Cs	55	132.91	1	PROTOACTINIUM	Pa	91	231.0	
CHLORINE	Cl	17	35.457	1, 3, 5, 7	RADIUM	Ra	88	226.05	2
CHROMIUM	Cr	24	52.01	2, 3, 6	RADON	Rn	86	222.0	0
COBALT	Co	27	58.94	2, 3	RHENIUM	Re	75	186.31	
COLUMBIUM	Cb	41	92.91	3, 5	RHODIUM	Rh	45	102.91	3
COPPER	Cu	29	63.57	1, 2	RUBIDIUM	Rb	37	85.48	1
DYSPROSIUM	Dy	66	162.46	3	RUTHENIUM	Ru	44	101.7	3, 4, 6, 8
ERBIUM	Er	68	167.2	3	SAMARIUM	Sm, Sa	62	150.43	3
EUROPIUM	Eu	63	152.0	2, 3	SCANDIUM	Sc	21	45.10	3
FLUORINE	F	9	19.000	1	SELENIUM	Se	34	78.96	2, 4, 6
GADOLINIUM	Gd	64	156.9	3	SILICON	Si	14	28.06	4
GALLIUM	Ga	31	69.72	2, 3	SILVER	Ag	47	107.880	1
GERMANIUM	Ge	32	72.60	4	SODIUM	Na	11	22.997	1
GOLD	Au	79	197.2	1, 3	STRONTIUM	Sr	38	87.63	2
HAFNIUM	Hf	72	178.6	4	SULPHUR	S	16	32.06	2, 4, 6
HELIUM	He	2	4.003	0	TANTALUM	Ta	73	180.88	5
HOLMIUM	Ho	67	164.94	3	TELLURIUM	Te	52	127.61	2, 4, 6
HYDROGEN	H	1	1.0080	1	TERBIUM	Tb	65	159.2	3
INDIUM	In	49	114.76	3	THALLIUM	Tl	81	204.39	1, 3
IODINE	I	53	126.92	1, 3, 5, 7	THORIUM	Th	90	232.12	4
IRIDIUM	Ir	77	193.1	3, 4	THULIUM	Tm	69	169.4	3
IRON	Fe	26	55.85	2, 3	TIN	Sn	50	118.70	2, 4
KRYPTON	Kr	36	83.7	0	TITANIUM	Ti	22	47.90	3, 4
LANTHANUM	La	57	138.92	3	TUNGSTEN	W	74	183.92	6
LEAD	Pb	82	207.21	2, 4	URANIUM	U	92	238.07	4, 6
LITHIUM	Li	3	6.940	1	VANADIUM	V	23	50.95	3, 5
LUTECIUM	Lu	71	174.99	3	VIRGINIUM	Vi	87	224.0	1
MAGNESIUM	Mg	12	24.32	2	XENON	Xe	54	131.3	0
MANGANESE	Mn	25	54.93	2, 3, 4, 6, 7	YTTERBIUM	Yb	70	173.04	3
MASURIUM	Ma	43			YTTRIUM	Yt	39	88.92	3
					ZINC	Zn	30	65.38	2
					ZIRCONIUM	Zr	40	91.22	4

Minerals and Their Characteristics

The first step in the identification of a mineral before any chemical tests are made should be the recognition of the physical and optical properties and occurrence of the mineral. The physical properties are discussed below.

Color: The color is fairly constant in some minerals but not in all, and commonly the color is due to pigments or impurities in the minerals.

Lustre: The lustre of a mineral is its appearance in ordinary reflected light. There are seven kinds of lustre: metallic, the lustre of metals; adamantine, that of uncut diamonds; vitreous, cut diamonds, or broken glass; resinous of the yellow resins; greasy; pearly; silky. There are five degrees of intensity of lustre recognized: splendent, shining, glistening, glimmering, dull.

Specific Gravity: An important factor in identifying a mineral is the specific gravity, or weight of the mineral in air compared with the weight of an equal volume of water. Minerals can be classed as heavy and light, thereby eliminating many of the possibilities that a specimen could be due to its other physical properties. Minerals with a specific gravity of 3.5 or more are generally considered as heavy, whereas minerals with a specific gravity of 3.2 or less are considered to be light.

Streak: The streak is more nearly constant than the color. The streak is determined by crushing the mineral, or by marking unglazed porcelain, or simply by scratching the mineral with a knife and observing the color of the powder. The color of the streak may differ considerably from the color of the mineral specimen as in the case of hematite, the streak which is always red although the color of this mineral may vary from red to black.

Hardness: The resistance to abrasion, or scratching. For convenience in description hardness is often designated by a number according to a scale devised by Mohs. This scale is as follows (talc being the softest and diamond the hardest):

1. Talc	4. Fluorite	7. Quartz
2. Gypsum	5. Apatite	8. Topaz
3. Calcite	6. Orthoclase	9. Corundum
		10. Diamond

The approximate hardness can be easily determined by noting the ease or difficulty with which a mineral scratches or is scratched by one of the following:

Thumbnail	2.5	Quartz or flint	7.0
Copper or silver coin	3.0	Emery (wheel or paper)	8.0 to 9.0
Knife blade	5.5 to 6.0	Corundum paper	9.0
Window glass	5.5 to 6.0	Carborundum	9.5
File	6.5 to 7.0	Diamond	10.0

If you can scratch a mineral with a knife blade, but not with a copper or silver coin, its hardness lies between 3 and 6, etc.

Occurrence and Characteristics: Occurrence refers to the form in which it is found, other minerals with which it is associated in the deposit, and its relation to the enclosing rock. Occurrence is an extremely valuable factor in the identification of a mineral. Special Characteristics:

A. MAGNETISM. If a mineral is magnetic it may rapidly lead to the identification of the mineral. Magnetite, pyrrhotite, ilmenite, iron-platinum, and chromite may occur as a magnetic mineral.

B. SOLUBILITY. Minerals which are soluble in water may be one of the following: potash, soda, nitrates, borax, epsom salt, and halite.

C. TASTE. Soluble minerals usually have a characteristic taste.

Potash	Alkaline	Epsomite	Bitter-saline
Epsom Salt	Bitter	Nitre	Saline-cooling
Borax	Sweetish-alkaline	Sylvite	Bitter-saline
Carnalite	Bitter		

D. ODOR. Some minerals emit characteristic odors. Examples:
   Kaolinite, odor of clay, when breathed upon.
   Arsenopyrite, odor of garlic upon heating.
   Pyrite, sulfurous odor upon heating.

E. FEEL OR TOUCH. When a mineral is rubbed by the finger, it may have a characteristic feel. Examples:
   Graphite feels greasy.
   Kaolinite feels greasy.
   Meerschaum feels smooth.
   Molybdenite feels greasy.
   Talc feels greasy.

F. SOIL. Some minerals mark paper or soil the hands. Examples:
- Graphite marks paper.
- Molybdenite marks paper.
- Pyrolusite soils fingers.

COMMERCIALLY IMPORTANT ORES*

In the following table, the figures after each name of an ore indicate the percentage of the element specified which the pure mineral contains. When this is variable or is merely mechanically included, an interrogation mark takes the place of the above-mentioned figure.

Important ores are in heavy face type, less common species are in lighter type, and minerals which are only occasionally mined and treated for the element specified are in *italics*.

Each group is arranged in the order of decreasing importance.

ALUMINUM: **Bauxite** (39.2), Cryolite (12.8).

ANTIMONY: **Stibnite** (71.8).

ARSENIC: **Arsenopyrite** (46), **Smaltite** (71.8), **Cobaltite** (45.2), Niccolite (?), Enargite (19.1).

BARIUM: **Witherite** (65).

BISMUTH: **Bismuthinite** (40.6).

CHROMIUM: **Chromite** (46.2).

COBALT: **Smaltite** (?), Cobaltite (35.5), *Arsenopyrite* (?).

COPPER: **Native Copper** (95), **Chalcopyrite** (34.5), **Bornite** (55.5), **Cuprite** (88.8), Malachite (57.5), Chalcocite (79.8), Enargite (48.3), Tetrahedrite (?), Azurite (55.4), *Covellite* (66.4), *Chrysocolla* (45.2), *Atacamite* (62.4), *Tenorite* (79.9).

GOLD: **Native Gold** (99.8), **Pyrite** (?), **Sylvanite** (24.5), **Calavarite** (39.5), **Chalcopyrite** (?), Hessite (?), Petzite (25.5), Galenite (?), *Arsenopyrite* (?), *Stibnite* (?).

IRON: **Hematite** (70), **Limonite** (59.8), **Magnetite** (72.4), Siderite (48.4), Goethite (62.9), *Pyrite* (46.7).

* Handbook of Minerals, by G. Montague Butler, E.M.

COMMERCIALLY IMPORTANT ORES

LEAD: **Galena** (86.6), **Cerussite** (77.7), **Anglesite** (73.6), **Pyromorphite** (76.4), Mimetite (69.7); Vanadinite (73.2) Wulfenite (56.5), *Tetrahedrite* (?).

LITHIUM: **Amblygonite** (4.7), Spodumene (3.7).

MAGNESIUM: **Magnesite** (28.6), Dolomite (21.9).

MANGANESE: **Pyrolusite** (63.2), **Psilomelane** (?), Manganite (62.4).

MERCURY: **Cinnabar** (86.2), *Native Mercury* (99).

MOLYBDENUM: **Molybdenite** (60).

NICKEL: **Garnierite** (?), **Pyrrhotite** (?), Millerite (64.4), Niccolite (43.9), *Chalcopyrite* (?), *Arsenopyrite* (?).

PLATINUM: **Native Platinum** (86.5).

SILVER: **Galenite** (?), **Cerargyrite** (75.3), **Pyrargyrite** (59.9), **Proustite** (65.4), **Argentite** (87.1), Tetrahedrite (?), Native Silver (95), Native Gold (?). Native Copper (?), Hessite (63), Petzite (43), Stephanite (68.5), *Pyrite* (?), *Chalcopyrite* (?), *Jamesonite* (?), *Stibnite* (?), *Cerussite* (?), *Polybasite* (75.6).

STRONTIUM: **Strontianite** (56.8), Celestite (45.7).

SULPHUR: **Pyrite** (53.3), **Native Sulphur** (100), Pyrrhotite (?).

THORIUM: **Monazite** (?).

TIN: **Cassiterite** (78.6).

TITANIUM: **Rutile** (59.9).

TITANITE: (31.6), *Rutile* (59.9).

TUNGSTEN: **Wolframite** (60.7), Huebnerite (60.7), *Scheelite* (63.9).

URANIUM: **Uraninite** (?), **Carnotite** (?), Autunite (51.9), Torbernite (50.8), *Samarskite* (?).

VANADIUM: **Vanadinite** (10.8), **Carnotite** (?).

ZINC: **Sphalerite** (67), **Smithsonite** (52), **Calamine** (54.1), Zincite (80.8), *Franklinite* (?), *Willemite* (58.4).

Note: In the foregoing table, Marcasite is included under Pyrite, and Tennantite under Tetrahedrite.

Minerals and Their Characteristics

FROM DENVER EQUIPMENT CO. INDEX, VOL. I, SECOND EDITION; AMENDED BY G. M. BUTLER

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARD-NESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
ACTINOLITE	$Ca(MgFe)_3(SiO_3)_4$	No metal source	Green	Vitreous		5.0–6.0	3.0–3.2	Usually long crystals, columnar or fibrous
ALBITE	$NaAlSi_3O_8$	Al_2O_3–19.5%	White to blue	Vitreous	White	6.0–6.6	2.6–2.7	Occurs sometimes in platy masses. Otherwise like anorthite. See Anorthite
ALMANDITE	$Fe_3Al_2(SiO_4)_3$	No metal source	Red to black		White	6.5–7.5	3.1–4.3	Variety of garnet. See garnet
ALTAITE	PbTe	61.9% Pb	Tin white Yellow tinge	Metallic	Grayish Black	3.0	8.2	Associated with pyrite, galena, tetrahedrite
ALUNITE	$K_2(Al_2OH)_6(SO_4)_4$	K–9.4%. Al–19.6%	Pink-red	Vitreous Pearly	White	3.8	2.7	Associated with kaolin and pyrite
AMOSITE	$(FeCaH_2Mn)OSiO_2$	No metal source	Gray to green				2.2–2.3	Long fibered asbestos
ANALCITE	$NaAlSi_2O_6.2H_2O$	Al_2O_3–23.2%	White	Vitreous	White	5.0–5.5	2.2–2.3	Trapezohedral crystals in cavities in basic igneous rocks
ANDALUSITE	Al_2SiO_5	Al_2O_3–63.2%	White Red-green.	Vitreous		7.5	3.2	Nearly square prisms; occurs with gneiss, mica, schists
ANDRADITE	$Ca_3Fe_2(SiO_4)_3$	No metal source	Green Red-black.	Adamantine	White	6.5–7.5	3.1–4.3	Variety of garnet. See garnet
ANGLESITE	$PbSO_4$	Pb–68.3%	Yellow Green-gray.	Adamantine, Vitreous	White	2.8–3.0	6.1–6.4	Occurs in oxidation zones of lead veins
ANORTHITE	$CaAl_2Si_2O_8$	Al_2O_3–36.7%	White, Gray-red	Vitreous	White	6.0–6.5	2.7–2.8	Tabular crystals in igneous rocks, with fine longitudinal lines on the better of two perfect cleavages at 90° to each other
ANTHOPHYLLITE	$(MgFe)SiO_3$	No metal source	Gray Brown-green	Vitreous	Uncolored, Grayish	5.0	3.0–3.2	Found in crystalline schists
APATITE	$Ca_4(CaF)(PO_4)_3$	P_2O_5–42.3%	Green-blue	Vitreous	White	4.5–5.0	3.2	Usually granular or in 6-sided prisms
ARAGONITE	$CaCO_3$	CaO–56%	White	Vitreous	White	3.5–4.0	2.9	Effervesces like calcite. Powder becomes lilac or purple when boiled in 10% solution of cobalt nitrate

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARD-NESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
ARGENTITE	Ag_2S	Ag–87.1%	Black	Metallic	Shiny Black	2.0–2.5	7.2–7.4	Cuts like lead; with silver, cobalt and nickel
ARGYRODITE	$3Ag_2S.GeS_2$	Ag–73.5%	Steel gray red tinge	Metallic	Grayish Black	2.5	6.1	Occurs with sphalerite, siderite and marcasite
ARSENOPYRITE	FeAsS	Fe–34.3% As–46.0%	Steel Gray	Metallic	Gray, Black	5.5–6.0	5.9–6.3	Widely spread; yields sparks and garlic odor when struck slanting blows with steel
ATACAMITE	$Cu_2(OH)_3Cl$	Cu–59.5%	Green	Adamantine, Vitreous	Apple Green	3.0–3.5	3.8	Always of secondary origin with copper ores
AZURITE	$2CuCO_3.Cu(OH)_2$	Cu–55.0%	Blue	Vitreous, Dull	blue	3.5–4.0	3.8–3.9	Oxidized mineral that effervesces vigorously in muriatic acid of any strength and temperature
BARITE	$BaSO_4$	BaO–65.7%	White, Blue-red	Vitreous	White	2.5–3.5	4.3–4.6	Found commonly as gangue of lead-zinc ores. Platy or granular masses or either diamond-shaped or rectangular crystals
BAUXITE	$Al_2O_3.3H_2O$	Al–34.9%	White-red Brown-yellow	Dull	Like Color	1.0–3.0	2.6	Chief ore of aluminum; occurs massive. Completely soluble in salt of phosphorous bead
BENTONITE	$(CaMg)O.SiO_2(AlFe)_2O_3$	No metal source	Blue	Dull	Light Gray	1.0	2.1	The clay of montmorillonite. Swells greatly when placed in water
BERYL	$Be_3Al_2(SiO_3)_6$	Be–5% Al_2O_3–19%	White, Green-blue	Vitreous	White	7.5–8.0	2.6–2.8	Often imbedded in quartz; with mica, feldspar. Usually in 6-sided prisms with flat terminations in pegmatite. Gem varieties
BERYLLONITE	$NaBePO_4$	Be–7.1%	White-yellow	Vitreous, Brilliant	White	5.8	2.8	Found with beryl, feldspar, columbite
BIOTITE	$(HK)_2(MgFe)_2Al_2(SiO_4)_3$	No metal source	Black-Brown	Pearly, Vitreous	White	2.5–3.0	2.7–3.1	Cleaves easily into very thin, flexible and elastic plates
BISMITE	Bi_2O_3	No metal source	Straw Yellow White	Pearly	Like Color		4.4	Of secondary origin resulting from oxidation
BISMUTH	Bi	Bi–100%	Silver White	Metallic	Silver White	2.3	9.7	Native; with cobalt, nickel; brassy tarnish
BISMUTHINITE	Bi_2S_3	Bi–81.2%	Lead gray	Metallic	Like Color	2.0	6.4–6.5	Occurs in form of thin coating
BISMUTITE	$(BiO)_2CO_3.H_2O$	No metal source	Green-white	Vitreous, Dull	Greenish Gray-White	4.0	6.9–7.7	Incrusting fibrous, or earthy and pulverulent
BORAX	$Na_2B_4O_7.10H_2O$	B_2O_3–36.6% Na_2O–16.2%.	White	Vitreous, Dull	White	2.0–2.5	1.7	Refer to introduction for characteristic taste
BORNITE	Cu_3FeS_3	Cu–63.3%	Reddish	Metallic	Blackish Gray	3.0–3.5	4.9–5.4	Associated with chalcoite. Usually massive. Quickly tarnishes iridescent blue

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NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
BOURNONITE	$PbCuSbS_3$	Pb–42.5% Sb–24.7% Cu–13%	Steel gray Iron black	Metallic	Like Color	2.5–3.0	5.7–5.9	Occurs fine-grained massive; brittle
BRAUNITE	$3Mn_2O_3.MnSiO_3$	Mn–78.3%	Steel gray Brownish black	Submetallic	Like Color	6.0–6.5	4.8	Occurs in porphyry; brittle
BREITHAUPTITE	NiSb	Ni–32.5% Sb–67.5%	Copper red	Metallic	Reddish Brown	5.5	7.5	Occurs with other sulfides and silver minerals
BROCHANTITE	$CuSO_4.3Cu(OH)_2$	Cu–56.2%	Green	Vitreous	Green	3.5–4.0	3.9	Oxidized mineral. Dissolves quietly in nitric acid
BRUCITE	$MgO.H_2O$	MgO–69%	White to gray blue, green	Pearly, Vitreous	White	2.5	2.4	Associated with serpentine; secondary mineral
CALAMINE	$H_2(Zn_2O)SiO_4$	ZnO–67.5%	White, blue, green, brown	Vitreous, Dull	White	4.5–5.0	3.4–3.5	Usually in crystal coatings; sometimes in cockscomb-like aggregates. Often with smithsonite
CALAVERITE	$AuTe_2$	Au–43.6%	Bronze yellow Silver-yellow tinge	Metallic	Yellowish Gray	2.5	9.0	Similar to sylvanite, but never in crystals
CALCITE	$CaCO_3$	CaO–56%	Many colors	Vitreous	White	3.0	2.7	Massive and 6-sided pointed or prismatic crystals. Effervesces vigorously in muriatic acid of any strength or temperature
CALOMEL	HgCl	Hg–85% Cl–15%	White, yellow	Adamantine	Pale Yellow, White	1.0–2.0	6.5	Associated with cinnabar
CARNALLITE	$KMgCl_3.6H_2O$	K–14.1% Cl–38.3%	White	Shining	White	2.5	1.6	Strongly phosphorescent; taste—bitter
CARNOTITE	$K_2O.2UO_3.V_2O_5.3H_2O$ Variable	Variable	Yellow	Vitreous, Dull	Yellow	1.5	....	Powder or earth in sandstone. Often concentrated around petrified wood
CASSITERITE	SnO_2	Sn–78.8%	Brown, black, red	Adamantine	White, Light Brown	6.0–7.0	6.8–7.1	Massive or squarish crystals
CELESTITE	$SrSO_4$	Sr–47.7%	Light blue, white, red	Vitreous	White	3.0–3.5	3.9–4.0	Same as barite
CERARGYRITE	AgCl	Ag–75.3%	Pearly gray	Waxy, greasy	White to Gray	1.0–1.5	5.6	Cuts like wax; exposure changes color to violet brown
CERUSSITE	$PbCO_3$	Pb–77.5%	White, gray	Adamantine	White	3.0–3.5	6.5–6.6	Oxidized mineral. Effervesces vigorously in warm concentrated or boiling dilute muriatic acid
CERVANTITE	$2Sb_2O_4$ $Sb_2O_3.Sb_2O_5$	Sb–79.4%	Yellow reddish white	Greasy, Pearly	White	4.0–5.0	4.1–5.3	Usually associated with stibnite
CHALCANTHITE	$CuSO_4.5H_2O$	CuO–31.8%	Blue	Vitreous	White	2.5	2.1–2.3	Oxidized mineral. Tastes metallic and nauseating
CHALCEDONY	SiO_2	No metal source	Pale blue, gray White to black	Waxy	White	7.0	2.6–2.7	Smoothly rounded fracture. Semi-precious gem varieties
CHALCOCITE	Cu_2S	Cu–79.8%	Black-Gray	Metallic	Like Color	2.5–3.0	5.5–5.8	Highly polished surface where cut
CHALCOMENITE	$CuSeO_3.2H_2O$	Cu–28.1% Se–34.9%	Blue	Vitreous	Bluish White	2.5–3.0	3.8	With various selenides of silver, copper, and lead
CHALCOPYRITE	$CuFeS_2$	Cu–34.6%	Brassy yellow	Metallic	Greenish Black	3.5–4.0	4.1–4.3	Softer than pyrite; with pyrite, galena, sphalerite
CHERT	SiO_2	No metal source	White-gray	Dull	White	7.0	2.6	Impure, coarse-grained, opaque flint
CHLOANTHITE	$NiAs_2$ Variable	Ni–28.1% As–71.9%	Tin white, steel gray	Metallic	Grayish black	5.8	6.5	Granular or in crystals like pyrite. Often associated with erythrite. See erythrite
CHROMITE	$FeO.Cr_2O_3$	Cr–46.2%	Black	Vitreous	Dark Brown	5.5	4.3–4.6	Grains may look like glack glass. Often with serpentine
CHRYSOBERYL	$BeOAl_2O_3$	BeO–19.8%	Green	Vitreous	White	8.5	3.7–3.8	Usually in crystals or worn pebbles. Gem varieties
CHRYSOCOLLA	$CuOSiO_2.2H_2O$	Cu–36.2%	Blue, green	Vitreous, Dull	White	2.0–4.0	2.0–2.2	Adheres to dry tongue; important ore of copper
CHRYSOLITE	$(MgFe)_2SiO_4$	No metal source	Green	Vitreous	White or Yellowish	6.5–7.0	3.3	In granular masses, glassy grains or crystals. Gem varieties
CHRYSOTILE	$H_4Mg_3Si_2O_9$		White, greenish	Metallic	White	1.7	2.2	Best asbestos. Masses of tough, usually parallel, slender fibers
CINNABAR	HgS	Hg–86.2%	Red	Adamantine, Submetallic	Scarlet	2.0–2.5	8.0–8.2	Only important ore of mercury; tastes "chalky"
CLAUSTHALITE	PbSe	Pb–72.4%	Lead gray	Metallic	Lead Gray	2.8	8.0	Resembles granular galena
COBALTITE	CoAsS	Co–35.5%	Tin white, steel gray	Metallic	Grayish Black	5.5	6.0–6.3	Granular or in crystals like pyrite. Often with erythrite. See erythrite
COLEMANITE	$Ca_2B_6O_{11}.5H_2O$	No metal source	White, yellowish	Brilliant, Vitreous	White	4.0–4.5	2.4	Usually occurs as geodes; brittle

(Continued on next page)

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NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
COLUMBITE	$(FeMn)(CbTa)_2O_6$	Variable—Cb_2O_5 and Ta_2O_5	Iron black	Submetallic	Dark Red, Black	6.0	6.3	Brittle; nearly pure niobate
COPPER	Cu	Cu—100%	Copper red	Metallic	Copper-red	2.8	8.8	Tarnishes easily; malleable
CORUNDUM	Al_2O_3	Al—52.9%	All colors	Vitreous, Adamantine	White	9.0	3.9–4.1	In 6-sided crystals and masses that may break in three directions at nearly 90°. Gem varieties
COSALITE	$Pb_2Bi_2S_5$	Pb—41.8% Bi—42.1%	Lead gray	Metallic	Black	2.8	6.5	In quartz veins; with pyrite, sphalerite
COVELLITE	CuS	Cu—66.5%	Blue	Submetallic	Black	1.5–2.0	4.6	Platy or granular massive. Turns purple when moistened
CROCIDOLITE	$NaFe(SiO_3)_2.FeSiO_3$	No metal source	Blue to green	Silky, Dull	Like Color	4.0–5.0	3.2–3.3	Fibrous masses; like asbestos, valuable
CROCOITE	$PbCrO_4$	Pb—64.1% Cr—16.1%	Red	Adamantine	Orange Yellow	2.5	6.0	Found with quartz, galena, vanadinite
CRYOLITE	Na_3AlF_6	Al—13% F—54.4%	Snow white	Greasy to Vitreous	White	2.5	3.0	Appearance, hardness are distinctive
CUPRITE	Cu_2O	Cu—88.8%	Red	Adamantine to dull	Red	3.5–4.0	5.9–6.2	Oxidized mineral. Often in crystals—usually cubical
CYANITE (or Kyanite)	Al_2SiO_5	Al—33.3%	White, to blue or green	Vitreous, Pearly		4.0-7.0	3.6	Bladed crystals with flat cleavage surfaces that are easily scratched longitudinally but not transversely
DESCLOIZITE	$4RO.V_2O_5.H_2O$	Variable. V_2O_5	Red, brown, black	Greasy	Orange	3.5	6.0	Associated with vanadinite
DIAMOND	C	C—100%	White, gray	Adamantine, Greasy	Ash Gray	10.0	3.5	Occurs in crystals (usually rounded octahedrons) in a basic igneous rock, and in placers. Gem varieties
DIASPORE	$Al_2O_3.H_2O$	Al_2O_3—85%	Many colors	Vitreous	White	6.5–7.0	3.4	Occurs in thin scales; very brittle
DIATOMACEOUS EARTH	$SiO_2.nH_2O$		Yellow to brown	Vitreous	White to Gray	2.0	2.2	Roughens glass. Uniformly very fine texture and light in weight
DOLOMITE	$CaMg(CO_3)_2$	CaO—30.4% MgO—21.9%	White, gray, pink, yellow	Vitreous, Pearly	White	3.5–4.0	2.8–2.9	Effervesces vigorously in any condition of muriatic acid except cold dilute. Like calcite, but common in warped rhombohedrons

ENARGITE	$3Cu_2S.As_2S_5$	Cu—48.4%	Iron black	Metallic	Black	3.0	4.4	Color and streak both black; prismatic cleavage
EPIDOTE	$Ca_2(AlOH)(AlFe)_2(SiO_4)_3$	No metal source	Green	Vitreous, Dull	White	6.0–7.0	3.2–3.5	Brittle; usually granular
EPSOM SALT	$MgSO_4.7H_2O$	Mg—9.9%	White	Vitreous	White	2.3	1.7	Tastes bitter and saline; in mineral waters
ERYTHRITE	$Co_3As_2O_8.8H_2O$	Co—29.5%	Usually pink, gray	Pearly	Paler than Color	1.5–2.5	3.0	Deposits of secondary origin; with cobalt ores
FERBERITE	$FeWO_4$	W—60.6%	Brown, black, gray	Metallic		5.0–5.5	7.2–7.5	Found with other tungsten ores
FLUORITE	CaF_2	F—48.9%	All colors	Vitreous	White	4.0	3.0–3.3	Octahedral cleavage; brittle
FRANKLINITE	(ZnFeMn)O $(FeMn)_2O_3$	Variable for Zn and Mn	Iron black	Metallic	Brown to Black	5.5–6.5	5.2	Usually associated with zincite; sometimes magnetic
GALENA	PbS	Pb—86.6%	Lead gray	Metallic	Lead Gray	3.0	7.4–7.6	Very brittle; cubic cleavage
GARNET	Various	No metal source	Red, brown, yellow	Vitreous	White	6.5–7.5	3.2–4.3	Often in complete dodecahedral crystals, in schists or limestone. Gem varieties
GARNIERITE	$H_2(NiMg)SiO_4$	Variable for Ni	Green	Dull, greasy	Greenish White	2.0–4.0	2.4	Amorphous; source of nickel; with serpentine, chromite
GENTHITE	$2NiO.2MgO.3SiO_2.6H_2O$	Ni—22.6%	Green	Dull, greasy	Greenish White	2.0–4.0	2.4	Similar to garnierite
GIBBSITE	$Al(OH)_3$	Al—34.6%	White, green	Pearly		2.0–3.5	2.4	Occurs under same conditions as bauxite
GOLD	Au	Au—100%	Golden	Metallic	Golden Yellow	2.8	15.6–19.3	Malleable and sectile. Does not tarnish
GRAPHITE	C	C—100%	Black	Dull, Submetallic	Dark Gray, Iron Black	1.0–2.0	2.2	Soft; marks paper; feels greasy; often impure
GREENOCKITE	CdS	Cd—77.7%	Yellow	Adamantine	Yellow to red	3.0–3.5	5.0	Usually occurs as coating on zinc minerals
GROSSULARITE	$Ca_3Al_2(SiO_4)_3$	No metal source	White, green, yellow	Vitreous	White	6.5–7.5	3.4–3.7	Often imbedded in mica and schists, limestones. Variety of garnet. See Garnet
GYPSUM	$CaSO_4.2H_2O$	CaO—32.6%	White, red	Vitreous	White to Gray	1.5–2.0	2.3	Earthy, fibrous, scaly, and crystals with perfect cleavage in one direction

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NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
HALITE	NaCl	Na–39.4%	White	Vitreous	White	2.5	2.1–2.6	Natural table salt. Perfect cubical cleavage
HALLOYSITE	$H_4Al_2O_3.2SiO_2.H_2O$	No metal source	White, green, blue, red	Pearly, Waxy, dull		1.0–2.0	2.0–2.2	Often occurs in veins of ore as secondary product
HAUSMANNITE	Mn_3O_4	Mn–72%	Black, brown	Metallic	Brown	5.3	4.7	Associated with other manganese minerals
HEMATITE	Fe_2O_3	Fe–70%	Brown, red, black	Metallic, Dull Submetallic	Red, Brown	5.5–6.5	4.9–5.3	Becomes magnetic upon heating under reducing conditions
HESSITE	Ag_2Te	Ag–63%	Gray	Metallic	Black	2.5–3.0	8.3–8.9	With chalcopyrite, pyrite, and sphalerite
HORNEBLENDE	Variable	Variable	White, green, black	Vitreous	White	5.0–6.0	3.2	Crystals have 6-sided or diamond-shaped cross sections. Two perfect cleavages at angle of about 124°
HUEBNERITE	$MnWO_4$	Mn–18.1% W–60.7%	Brown	Submetallic	Yellowish Brown	5.0–5.5	7.2–7.5	Usually in bladed aggregates with rough, flat parting, in quartz
HYDROZINCITE	$ZnCo_3.2Zn(OH)_2$	Zn–59.5%	White, gray, yellow	Dull	White	2.0–2.5	3.6–3.8	Usually associated with other zinc ores
HYPERSTHENE	$(FeMg)SiO_3$	No metal source	Black	Pearly	Gray	5.0–6.0	3.5	Occurs in foliated or platy masses
ILMENITE	$FeTiO_3$	Ti–31.6%	Iron black	Metallic, Submetallic	Brown	5.0–6.0	4.5–5.0	Magnetic; with pyrite, horneblende, feldspars
IODYRITE	AgI	Ag–46%	Yellow, green			3.0–4.0	5.6–5.7	Usually in thin plates; rare
IRIDIUM	Variable	Alloy–100%	White	Metallic	Gray	6.7	22.7	With platinum and allied metals
IRIDOSMENE	IrOs(RhPtRu)	Alloy–100%	Tin White	Metallic	Gray	6.0–7.0	19.3–21.1	Rare metals alloy
JAMESONITE	$2PbS.Sb_2S_3$	Pb–50.8% Sb–29.5%	Gray	Metallic	Grayish Black	2.0–3.0	5.5–6.0	Usually in parallel or divergent aggregates of narrow blades. Sometimes in hair- or needle-like crystals
JEFFERISITE	Variable	Variable	Yellowish brown	Pearly	White	1.5	2.3	A mica with flexible but not elastic cleavage plates that puffs out greatly when heated

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
KAINITE	$MgSO_4.KCl.3H_2O$	KCl–30.0%	White to red	Vitreous		2.8	2.1	See Cyanite
KAOLINITE	$H_4Al_2Si_2O_9$	Al_2O_3–39.5%	White, yellow	Pearly	Same as Color	2.0–2.5	2.6	Widespread; earthy odor; clay
KERMESITE	Sb_2S_2O	Sb–75.3%	Cherry	Adamantine, Metallic	Brownish Red	1.3	4.6	Occurs with stibnite
KIESERITE	$MgSo_4.H_2O$	Mg–17.6%	White, yellow	Vitreous		3.3	2.6	Often with gypsum and carnallite
LEPIDOLITE	$KLi[Al(OHF)_2]Al(SiO_3)_3$	Small amount of Li	Red, lilac, white	Pearly	White	3.0	2.8–3.3	A mica with flexible, elastic cleavage plates. Usually in pegmatites
LEUCITE	$KAl(SiO_3)_2$	K_2O–21.5% Al_2O_3–23.5%	Gray	Vitreous, Dull	White	5.5–6.0	2.5	Complete trapezohedral crystals in igneous rock
LIMESTONES	Chiefly $CaCO_3$	Ca–40%	Variable	Dull	White	3.0	2.7	Eliminate this heading since limestone is a rock, not a mineral
LIMONITE	$2Fe_2O_3.3H_2O$	Fe–59.9%	Brown, yellow	Submetallic	Yellowish Brown	5.0–5.5	3.6–4.0	Massive, fibrous or porous; magnetic after fusing
LINNAEITE	Co_3S_4	Co–58.0%	Steel gray	Metallic	Blackish Gray	5.5	4.8–5.0	Copper red tarnish; in gneiss with chalcopyrite
LIVINGSTONITE	$HgS.2Sb_2S_3$	Hg–22.0%	Lead gray	Metallic	Red	2	4.81	Resembles stibnite; fuses easily
MAGNESITE	$MgCO_3$	Mg–28.9%	White to black	Vitreous	White	4.0–4.5	3.1	Effervesces vigorously in hot, concentrated muriatic acid
MAGNETITE	$FeO.Fe_2O_3$	Fe–72.4%	Iron black	Metallic, Submetallic	Black	5.5–6.5	5.2	Strongly magnetic; many associations
MALACHITE	$CuCO_3.Cu(OH)_2$	Cu–57.5%	Green	Silky	Green	3.5–4.0	4.0	Oxidized mineral. Effervesces vigorously in muriatic acid of any strength or temperature
MANGANITE	$Mn_2O_3.H_2O$	Mn–62.5%	Iron black, steel gray	Metallic, Submetallic	Brown	4.0	4.2–4.4	Hardness and streak are distinctive
MARBLE	Chiefly $CaCO_3$	Ca–40%	Variable	Vitreous, Earthy	White, Gray	3.0	2.7	Granular calcite. See calcite
MARCASITE	FeS_2	Fe–46.6%	Yellow	Metallic	Grayish, Brown, black	6.0–6.5	4.9	Deposited near earth's surface. Often in tabular crystals in coxcomb-like groups
MARMATITE	(ZnFe)S Variable	Zn–46.5% to 56.9%	Yellow, brown, black	Adamantine	Brownish	5.0	3.9–4.2	Closely allied with galena; common zinc ore
MELACONITE	CuO	Cu–79.9%	Black	Earthy, Metallic		3.0–4.0	6.5	

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MELILITE	$Ca_2Al_2SiO_7$		White, yellow, green, brown	Vitreous	White	5	2.9–3.1	Formed from magmas; common in Portland cement
MERCURY	Hg	Hg–100%	Tin white	Metallic			13.59	Liquid; rarely found in metallic state
METACINNABARITE	HgS	Hg–86.2%	Grayish black	Metallic	Black	3	7.7	Found in upper portions of mercury deposits
MILLERITE	NiS	Ni–64.8%	Yellow	Metallic	Greenish Black	3.0–3.5	5.3–5.7	Crusts with a radiating texture and hair- or needle-like crystals
MIMETITE	$(PbCl)Pb_4As_3O_{12}$	Pb–69.7%	Yellow to brown	Resinous	White	3.5	7.0–7.3	Often in crystals with 6 sided cross sections, which may taper
MOLYBDENITE	MoS_2	Mo–60%	Lead gray	Metallic	Greenish Gray	1.0–1.5	4.7–4.8	Feels greasy. Makes light greenish yellow mark on glazed paper
MOLYBDITE	MoO_3	Mo–66.67%	Yellow	Adamantine, Pearly		1.5	4.5	Occurs with molybdenite
MONAZITE	$(CeLaDy)PO_4.ThSiO_4$	ThO_2–9%	Yellow, brown	Resinous	White	5.0–5.5	4.9–5.3	Rounded grains; with gold, chromite, iron
MOTTRAMITE	Variable	Variable	Black, yellow	Resinous	Yellow	3	5.8	A vanadate of lead and copper
MUSCOVITE	$H_2KAl_3(SiO_4)_3$	Variable	Yellowish white	Vitreous, Pearly	White	2.0–2.5	2.8–3.0	Cleaves easily into very thin, elastic, flexible leaves
NAUMANNITE	$(Ag_2Pb)Se$	Ag–37.2%	Iron black	Metallic	Iron Black	2.5	8	Malleable; in cubic crystals; selenide of silver and lead
NEPHELITE	$NaAlSiO_4$	No metal source	White, yellow	Vitreous, Greasy	White	5.5–6.0	2.5–2.7	Widely distributed in igneous rocks; usually massive
NICCOLITE	NiAs	Ni–44.1% As–55.9%	Copper red	Metallic	Brownish Black	5.0–5.5	7.3–7.7	Often found with a green coating; brittle; compact
NITRE	KNO_3	K–38.6% N–13.9%	White	Vitreous	White	2	2.1	Tastes saline and cooling; salt petre

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
OLIVINE	$(MgFe)_2SiO_4$	No metal source	Green	Vitreous	White or Yellowish	6.5–7.0	3.3	Same as Chrysolite
OPAL	$SiO_2.nH_2O$	No metal source	All colors	Greasy, Vitreous	White	5.5–6.5	1.9–2.3	Very smooth, curving fracture
ORPIMENT	As_2S_3	As–61%	Lemon yellow	Resinous	Lemon Yellow	1.5–2.0	3.5	Usually associated with realgar; seldom valuable
ORTHOCLASE	$KAlSi_3O_8$	Al_2O_3–18.4%	Red, gray, yellow, white	Vitreous, Dull	White	6.0–6.5	2.5–2.6	Common, often pinkish igneous rock mineral with two smooth right angled cleavages
PENTLANDITE	(FeNi)S	Fe–42.0% Ni–22.0%	Yellow-bronze	Metallic	Black	3.5–4.0	4.6–5.0	Associated with pyrrhotite, millerite, chalcopyrite, etc.
PETZITE	$(AuAg)_2Te$	Au–25.4% Ag–41.7%	Gray to black	Metallic	Gray	2.5	9.1	A rare but valuable ore of gold and silver; often tarnishes
PHOSPHATE ROCK	$Ca_3(PO_4)_2$	P_2O_5–32.1%	Gray	Dull	Gray	5	3.2	Occurs in massive deposits
PLATINUM	Pt	Pt–100%	Tin white, steel white	Metallic	Shiny Gray	4.5	17.0	Sometimes magnetic; with gold and chromite
POLIANITE	MnO_2	Mn–63.2%	Steel gray, iron gray	Metallic	Black	6.3	4.9	Looks like pyrolusite, but harder and dryer; rare
POLYBASITE	$9Ag_2S.Sb_2S_3$	Ag–75.6% Sb–9.4%	Iron black	Metallic	Black	2.0–3.0	6.0–6.2	With chalcopyrite, calcite, pyrargyrite, stephanite
POWELLITE	$Ca(Mo,W)O_4$	Variable	Greenish yellow	Resinous		3.5	4.5	Often associated with scheelite
PROUSTITE	$3Ag_2S.As_2S_3$	Ag–65.5%	Scarlet	Adamantine, Dull	Scarlet	2.0–2.5	5.6	Usually associated with other silver ores
PSILOMELANE	$MnO_2.H_2O.K_2BaO$		Black	Submetallic Dull	Black, Brownish Black	5.0–6.0	3.7–4.7	Either powdery (Wad) or has smooth, curving fracture
PYRARGYRITE	$3Ag_2S.Sb_2S_3$	Ag–60% Sb–22.2%	Black, reddish	Adamantine, Metallic	Purplish Red	2.5	5.8–5.9	Often associated with argentite and proustite
PYRITE	FeS_2	Fe–46.7%	Brass yellow	Metallic	Greenish Brn.-Blk.	6.0–6.5	5.0	Often in crystals that are cubical or show prominently a form with 5-sided faces
PYROLUSITE	MnO_2	Mn–63.2%	Black, dark gray	Metallic, Dull	Black, Blu.-Blk.	1.0–2.5	4.8	Soils fingers; hardness and streak are distinctive
PYROMORPHITE	$Pb_5Cl(PO_4)_3$	Pb–76.4%	Yellow	Greasy, Adamantine	White, Yel. White	3.5–4.0	5.9–7.1	Alteration product of lead minerals. Occurs like mimetite

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PYROPE	$Mg_3Al_2(SiO_4)_3$	No metal source	Red	Vitreous, Resinous	White	6.5–7.6	3.7	Variety of garnet. See garnet
PYROPHYLLITE	$HAl(SiO_3)_2$	Al_2O_3–28.3%	White, brown	Pearly, Dull	White	1.0–2.0	2.8–2.9	Feels greasy or soapy
PYROXENE	$Ca(AlMgMnFe)(SiO_3)_2$	No metal source	Green	Vitreous, Dull	White to Green	5.0–6.0	3.3	Commonly in igneous rocks in square or 8-sided crystals
PYRRHOTITE	Fe_5S_6 to $Fe_{16}S_{17}$	Fe–61.5% Variable	Brownish yellow	Metallic	Grayish Black	3.5–4.6	4.6	Only magnetic sulphide and therefore distinctive
QUARTZ	SiO_2	Si–46.9%	Colorless, all colors	Vitreous	White	7.0	2.65–2.66	Common in 6-sided prisms with pointed terminations. Gem varieties
REALGAR	AsS	As–70.1%	Orange	Resinous	Orange	1.5–2.0	2.6	Usually associated with Orpiment; flexible
RHODOCHROSITE	$MnCo_3$	MnO–61.7%	Usually red	Vitreous, Pearly	White	3.5–4.5	3.5–3.6	Blackens on exposure. Effervesces vigorously in hot, concentrated muriatic acid
RHODONITE	$MnSiO_3$	Mn–42.0%	Brownish red	Vitreous, Dull	White	5.5–6.5	3.4–3.7	With calcite, Zincite, tetrahedrite
ROSCOELITE	$H_8K(MgFe)(AlV)_4(SiO_3)_{12}$	Variable	Brown	Pearly		Soft	2.9	Vanadium mica in which vanadium replaced aluminum
RUTILE	TiO_2	Ti–60%	Brown, red, black	Adamantine, Submetallic	Light Brown	6.0–6.5	4.2	Commonly in crystals with longitudinally grooved faces, or needle- or hair-like
SCHEELITE	$CaWO_4$	W–63.9%	White-Yellowish	Vitreous, Adamantine	White	4.5–5.0	5.9–6.1	Weight, hardness, and uneven fracture are distinctive
SENARMONTITE	Sb_2O_3	Sb–83.6%	Colorless, grayish	Vitreous, Dull	White	2	5.3	Formed by oxidation of stibnite
SERPENTINE	$H_4Mg_3Si_2O_9$	Mg–43%	Green, blackish or yellow, white	Wax-like, Silky	White	4.0	2.5–2.6	Feels smooth and sometimes slightly greasy
SIDERITE	$FeCO_3$	Fe–48.3%	Brown, gray	Vitreous, Pearly, Dull	White to Yellow	3.5–4.0	3.9	Magnetic after heating. Effervesces vigorously in hot, concentrated muriatic acid
SILVER	Ag	Ag–100%	Silver white	Metallic	Silver-White	2.8	10.5	Malleable and sectile. Tarnishes quickly

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARDNESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
SMALTITE	$CoAs_2$	Co–28.2%, As–71.8%	Tin white, steel gray	Metallic	Grayish Black	5.5–6.0	5.7–6.8	Granular or in crystals like pyrite. Often with erythite. See erythite
SMITHSONITE	$ZnO.CO_2$	Zn–52%	Green, gray, blue	Vitreous, Dull	White, grayish	5.0	4.3–4.5	Effervesces vigorously in any strength or temperature or muriatic acid except cold dilute
SODA NITRE	$NaNO_3$		White, reddish brown; colorless	Vitreous	White	1.8	2.3	Taste-cooling; incrustations in beds; massive
SPERRYLITE	$PtAs_2$	Pt–56.6% As–43.4%	Tin white	Metallic, Brilliant	Black	6.5	10.6	Found with gold-quartz, covellite, limonite
SPESSARTITE	$Mn_3Al_2(SiO_4)_3$	No metal source	Purplish, red	Vitreous		6.5–7.5	4.0–4.3	A form of garnet
SPHALERITE	ZnS	Zn–67.1%	Brown, yellow, reddish, black	Submetallic, Resinous	Light Brown, Yellow	3.5–4.0	3.9–4.1	Cleaves smoothly in six directions at angles of 60°, 90°, and 120°
SPINEL	$MgO.Al_2O_3$	Al_2O_3–71.8% MgO–28.2%	Black, gray, brown, red	Vitreous, Dull	White to Gray	8.0	3.5–4.1	Massive or in octahedral crystals. Gem varieties
SPODUMENE	$LiAl(SiO_3)_2$	Al_2O_3–27.4% Li_2O–8.4%	White, grayish	Vitreous, Dull	White	6.5–7.0	3.1–3.2	Occurs usually in platy masses or chunky crystals, sometimes huge. Gem varieties
STANNITE	$Cu_2S.FeS.SnS_2$	Sn–27.5% Cu–29.5%	Steel gray, iron black	Metallic	Blackish	4.0	4.5	Has appearance of bronze
STEPHANITE	$5Ag_2S.Sb_2S_3$	Ag–68.5%	Iron black	Metallic	Iron Black	2.0–2.5	6.2–6.3	Associated with other silver ores
STIBNITE	Sb_2S_3	Sb–71.8%	Lead gray	Metallic	Lead Gray, Black	2.0	4.5–4.6	Cleavage surfaces marked transversely with parallel lines
STRONTIANITE	$SrCO_3$	Sr–59.3%	Yellow to brown Green	Vitreous, Greasy	White to Gray	3.5–4.0	3.7	Effervesces vigorously in dilute cold, but not in concentrated cold, muriatic acid. Effervescing fragment colors alcohol flame red
SULFUR	S	S–100%	Yellow	Greasy, Adamantine	Pale Yellow	2.0	2.0	Burns with a characteristic odor
SYLVANITE	$(AuAg)Te_2$	Au–24.5% Ag–13.4%	White to steel gray	Metallic	Same as Color	1.5–2.0	7.9–8.3	Occurs often in small, bladed or prismatic crystals
SYLVITE	KCl	K–52.4%	White, yellowish red	Vitreous	White	2.0	1.98	Taste—saline; soluble; bitter
TALC	$H_2Mg_3(SiO_3)_4$	Mg–19.2% Si–29.6%	Green to white	Pearly	White	1.0–1.5	2.7–2.8	Common; feels greasy; extensive beds
TANTALITE	$FeTa_2O_6$	Variable Ta_2O_5–65.6%	Iron black	Submetallic, Greasy, Dull	Reddish Brown	6.3	5.3–7.3	Iron and manganese content variable; with columbite

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FROM DENVER EQUIPMENT CO. INDEX, VOL. I, SECOND EDITION; AMENDED BY G. M. BUTLER

NAME	FORMULA	PERCENT METAL	COLOR	LUSTRE	STREAK	HARD-NESS	SPEC. GRAV.	CHARACTERISTICS—OCCURRENCE
TENNANTITE	$Cu_8As_2S_7$ Variable	Cu–57.5% Variable	Steel gray, iron black	Metallic	Black, Reddish Brown	3.0–4.5	4.4–4.5	Occurs granular massive or in tetrahedral crystals
TENORITE	CuO	Cu–79.9%	Black	Metallic		3.0	5.8–6.3	Sublimation product in volcanic regions
TEPHROITE	Mn_2SiO_4	No metal source	Red, ash gray	Vitreous		6.5–7.0	4.0–4.1	Rarely in small crystals; like chrysolite
TETRADYMITE	$Bi_2(TeS)_3$	Variable	Pale steel gray	Metallic		1.8	7.4	Soils paper; found in gold-quartz and igneous rocks
TETRAHEDRITE	$4Cu_2S.Sb_2S_3$	Cu–52.1% Sb–24.8%	Gray to black	Metallic	Black	3.0–4.5	4.4–5.1	Like tennanite but has a darker straek—not reddish
TITANITE	$CaTiSiO_5$	TiO_2–40.8%	Brown, gray, yellow, green	Adamantine	White	5.0–5.5	3.4–3.6	Occurs in platy massive or in wedge-shaped crystals
TOPAZ	$(AlF)_2SiO_4$	No metal source	Many	Vitreous		8.0	3.4–3.6	Often in prismatic crystals with diamond-shaped cross sections and a perfect transverse cleavage. Gem varieties
TOURMALINE	$[(NaLiK)_6(MgFeCa)_3(AlCrFe)_2B_2SiO_4]$	No metal source	Black, brown, & many others.	Vitreous to Resinous	White	7.0–7.5	3.0–3.2	Usually in prismatic crystals with spherical triangular cross sections. Gem varieties
TREMOLITE	$CaMg_3(SiO_3)_4$	No metal source	White to dark gray	Silky	White	5.0–6.0	2.9–3.4	Perfect cleavages in two directions at an angle of about 124°
TRIPHYLLITE	$LiFePO_4$	Li–4.4%	Greenish gray, bluish gray	Vitreous, Resinous	White to Grayish White	4.8	3.5	A phosphate or iron, manganese and lithium
ULLMANNITE	NiSbS	Ni–27.6% Sb–57.3%	Steel gray to white	Metallic	Grayish	5.3	6.4	With galena and chalcopyrite
URANINITE	UO_3, UO_2 Variable	Radium Source	Gray, green, brown	Submetallic to Greasy	Black, Gray, Green	5.5	9.0–9.7	Of primary and secondary origin; no definite formula
UVAROVITE	$Ca_3Cr_2(SiO_4)_3$	No metal source	Green	Vitreous	White	6.5–7.5	3.5	A form of garnet
VALENTINITE	Sb_2O_3	Sb–83.5%	White	Adamantine to Pearly	White	2.5–3.0	5.6	An oxidized mineral
VANADINITE	$(PbCl)Pb_4(VO_4)_3$	Variable	Red, brown, yellow.	Resinous	White or Yellow	2.7–3.0	6.6–7.1	Like mimetite, but crystals usually very sharp and do not taper
VERMICULITE	$3MgO.(FeAl)_2O_3.3SiO_2$	Variable	Grayish	Talc-like	Uncolored	1.5	2.7	Becomes worm-like threads upon heating—exfoliates
WILLEMITE	Zn_2SiO_4	Zn–58.5%	Green, yellow, brown	Vitreous, Dull	White or Grayish	5.5	3.9–4.2	Massive to granular; valuable zinc ore
WITHERITE	$BaCO_3$	BaO–77.7%	Yellow, brown	Vitreous Pearly	White	3.4	4.4	Reacts like strontianite in muriatic acid, but effervescing fragment colors alcohol flame light yellowish green
WOLFRAMITE	$(FeMn)WO_4$	W–60.58% 60.69%	Gray, brown, black	Submetallic	Reddish-Brown	5.0–5.5	7.2–7.5	Differs from huebnerite in streak
WULFENITE	$PbMoO_4$	Pb–56.4% Mo–26.2%	Yellow, grayish	Resinous, Adamantine	White	3.0	6.8	In square crystals, usually tabular with beveled edges
ZARATITE	$NiCO_3.2Ni(OH)_2.4H_2O$	Ni–46.8%	Green	Vitreous	Light Green	3	2.6	Emerald nickel; amorphous
ZINCITE	ZnO	Zn–80.3%	Red, yellow	Sub Adamantine	Orange Yellow	4.0–4.5	5.4–5.7	Associated with other zinc ores
ZIRCON	$ZrSiO_4$	ZrO_2–67.2%	Yellow, gray	Adamantine	Colorless	7.5	4.2–4.7	In sharp crystals with square cross sections and as pebbles. Gem varieties

THE MORE COMMON URANIUM MINERALS (According to Color)

Name	Chemical Composition	Percent U_3O_8	Color	Luster	Hardness	Soecific Gravity	Characteristics—Occurrence
Pitchblende	Uranium Oxide	50–80	Black (Grayish, Greenish)	Pitch-like Earthy, Dull, or Glassy	5–6	6–9	In Veins; often with Sulphides of Cobalt, Nickel, Silver, Bismuth or Yellow Secondary Uranium Minerals. Never Brownish or Reddish.
Uraninite	Uranium Oxide	65–85	Black (Grayish, Greenish, Brownish)	Pitch-like Dull or Glassy	5–6	8–10	Small Amounts in Pegmatites and in Veins Almost Never Brownish or Reddish.
Betafite (fresh)	Uranium Columbate	15–27	Black to Greenish-Brown	Glassy to Sub-Metallic	4–5	4–5	In Pegmatites; Less Commonly, in Placers. Commonly Altered to Brown and Yellow Green.
Euxenite	Rare Earth Titanium Columbate	1–20	Black to Brown "Liver Brown"	Glassy when Fresh	5–7	4–6	Nests or Pockets in Pegmatites.
Samarskite	Rare Earth Columbate	9–18	Black to Brown "Liver Brown"	Glassy when Fresh	5–6	4–6	Similar to Euxenite.
Fergusonite (fresh)	Rare Earth Columbate	0-8	Black to Brown "Liver Brown"	Glassy	5–6	4–6	In Pegmatites; Less Commonly in Placers. Usually Externally Coated with Buff to Pinkish Clay-Like Material.
Brannerite (fresh)	Uranium Titanium Oxide	40	Jet Black (Brownish, Greenish)	Brilliant	4	4–5	In Placers. Rare; Known to Occur in the United States only in Idaho. Alters to Yellowish-Brown.
Thucholite	Hydrocarbon	2-8	Jet Black	Brilliant	3–4	2	Coal-Like; Will Burn. Sometimes Replaces Original Uraninite.
Carnotite	Potassium Uranium Vanadate	50–55	Canary Yellow	Earthy or Pearly	2–3	4+	Scattered Irregular Lenses in Sandstone Beds. Frequently Associated With Fossil Logs or Bones.

THE MORE COMMON URANIUM MINERALS (According to Color)

Name	Chemical Composition	Percent U_3O_8	Color	Luster	Hardness	Specific Gravity	Characteristics—Occurrence
Tyuyamunite	Calcium Uranium Vanadate	48–55	Greenish Yellow	Earthy or Pearly	2–3	3–4	Associated With Calcite Minerals. Similar to Carnotite.
Autunite	Calcium Uranium Phosphate	60	Lemon Yellow or Apple Green	Pearly	2–3	3	Mica-Like Crystals, Usually Small, Earthy. A Common Secondary Uranium Mineral.
Pyrochlore-Microlite	Columbium Tantalum Oxide	0-15	Pale Yellow to Colorless and Others	Glassy or Resinous	5–6	4–6	In Pegmatites, Syenites, Some Limestones. Often Associated with Lithium or Fluorine Minerals. Placers.
Uranophane	Calcium Uranium Silicate	65	Various Shades of Yellow	Pearly to Greasy	2–3	4	An Alteration Product of Gummite, Pitchblende or Other Uranium Minerals. Commonly Associated With Other Secondary Uranium Minerals.
Gummite	Variable	40-80	Yellow to Orange and Variable	Dull, Waxy, Greasy	2–5	4–6	Commonly Associated With Pitchblende. An Alteration Product of Uranium Minerals. Chiefly Uranium Oxide, Water and Lead.
Schroeck-Ingerite	Carbonate and Sulphate Containing Uranium	30	Yellow to Greenish-Yellow	Pearly	2–3	1–2	Rounded Masses Distributed in Gypsum-Bearing Sandy Clay.
Meta-Torbernite Also Torbernite	Copper Uranium Phosphate	60	Various Shades of Green	Pearly	2–3	3–4	Mica-Like Square Crystals. With Other Uranium Minerals as Coatings on Many Types of Rocks.

The above minerals cause the Geiger Counter to React and will give positive Bead Tests for Uranium.
Reference: Publication of the U. S. Atomic Energy Commission and the U. S. Geological Survey.

Frank A. Seeton, Dec. 2, 1952

BULK MATERIAL CHARACTERISTICS

MATERIAL	CLASS	Avg. Wt.	Max. Conveying Angle
ASHES, COAL, DRY, MINUS 3"	CFH 40°-45°	35-40	22°
ASHES, COAL, WET, MINUS 3"	CGHK	45-50	25°
BARITE	CFH	150-180	18°
BAUXITE, CRUSHED MINUS 3"	CFH	75-85	20°
BENTONITE, MINUS 100 MESH	AFY	50	20°
BORAX, POWDERED	AF	50	22°
CAST IRON BORINGS	BGH	130-200	20°
CEMENT, PORTLAND	AFHY 40°	90-100	20°
CEMENT, CLINKER	CFA 35°	75-80	18°
CHARCOAL	CGHS	18-25	20°
CINDERS, COAL	CFH	40-45	22°
COAL, ANTHRACITE, SIZED, 3/8" to 6"	CFS 27°	55	16°
COAL, BITUMINOUS, SLACK	CFK 37°	50	22°
COAL, BITUMINOUS, RUN OF MINE	CFKS 35°	50	18°
COFFEE, BEAN	BF	25	15°
COKE, LOOSE	CFHSL 30°	25-30	20°
COKE, PETROLEUM	CFH	25-40	20°
COKE, BREEZE, MINUS 1/4"	BFH	25-35	22°
CONCRETE, WET: 6" SLUMP	CES	150	12°
4" SLUMP	CFS	150	20°
2" SLUMP	CGS	150	24°
COPPER ORE	CFH	120-150	20°
CORAL, CRUSHED	CFH	40-45	20°
CORN, SHELLED	BFX	45	16°
COTTONSEED, DRY, DE-LINTED	BF	25	16°
CULLET, CRUSHED	CFHL	80-120	20°
CULM, MINUS 3/64", DAMP	AEKLY 45°	50	20°
DOLOMITE, CRUSHED	CFH	90-100	22°
EARTH, COMMON, LOAM, DRY	CF 30°-45°	70-80	20°
EARTH, CLAY, DRY	CF 25°-45°	100-120	20°
EARTH, MOIST	CGL 45°	80-100	22°
FELDSPAR, GROUND, MINUS 1/8"	AFH 45°	65-70	18°
FLUORSPAR	CFH	90-110	20°
FULLER'S EARTH, BURNT	AFH 35°	40	20°
FULLER'S EARTH, RAW	AFH	35-40	20°
GLASS, BATCH	CFH	90-100	20°
GRANITE, CRUSHED	CFH	95-100	20°
GRAVEL, AVERAGE, BLENDED	CFH 30°-40°	90-100	18°
GRAVEL, SHARP	CFH 40°	90-100	20°
GRAVEL, ROUND	CFH 30°	90-100	15°
GYPSUM, CALCINED	BFH	55-60	20°
GYPSUM, CRUSHED	CFH	90-100	20°

BULK MATERIAL CHARACTERISTICS

MATERIAL	CLASS	Avg. Wt.	Max. Conveying Angle
GYPSUM, POWDERED	AGH	60-80	23°
IRON ORE	AFH 35°	135-150	22°
KAOLIN CLAY, MINUS 3"	CFH	160	20°
LIGNITE, AIR DRIED	CF	45-55	20°
LIME, GROUND MINUS 1/8"	AFL 45°	60	20°
LIME, PEBBLE	CF 30°	55	18°
LIME, OVER 1/2"	CF	55	18°
LIMESTONE, AGRICULTURAL	AFHL	70	20°
LIMESTONE, CRUSHED	CFH 40°-45°	85-90	20°
MANGANESE ORE	CFH	120	21°
MARBLE, CRUSHED, OVER 1/2"	CFH	90-95	20°
MICA, GROUND, MINUS 1/8"	AF	40	20°
PHOSPHATE ROCK	CFH 40°	75-85	20°
SALT, COURSE, DRY	BFK 25°	40-45	20°
SALT, FINE, DRY	AFK 30°	70-80	22°
SAND, BANK, DAMP	AGH 35°-45°	110-120	22°
SAND, BANK, DRY	AFH 25°-35°	90-110	15°
SAND, FOUNDRY, PREPARED	AGH	90	24°
SAND, FOUNDRY, SHAKEOUT	CFH	90	20°
SAND, SILICA, DRY	AFHY 25°-35°	90-100	15°
SAND, SATURATED	AEH 15°-30°	110-130	15°
SHALE, CRUSHED	BFH 40°	85-90	20°
SLAG, FURNACE, CRUSHED	CGH	80-90	18°
SLAG, FURNACE, GRANULATED	BFH 25°	60-65	22°
SLATE, CRUSHED, MINUS 1/2"	BFH 30°	80-90	20°
SLATE, GROUND, MINUS 1/8"	AFHY 45°	80	20°
SODA ASH, LIGHT	AFHY 32°	25-35	20°
SODA ASH, HEAVY	BFH 37°	55-65	20°
STONE, CRUSHED	CFHL	85-90	20°
STONE, SCREENINGS	BFH	85-90	18°
STONE, DUST	AFHY	75-85	20°
SULPHUR, CRUSHED, MINUS 1/2"	BGX 35°	50-65	20°
SULPHUR, LUMPY, MINUS 3"	CGX 40°	80-85	20°
SULPHUR, POWDERED	AGXY 45°	50-60	22°
TRAPROCK, CRUSHED	CFHL	105-110	20°
VERMICULITE ORE	CF	80	20°
WHEAT	BFX 23°	45-48	16°
WOOD CHIPS	CGL 22°	15-25	25°

CLASSIFICATION OF MATERIAL

Size Characteristics
- A - Fine, under 1/8"
- B - Granular, 1/8" to 1/2"
- C - Lumpy, over 1/2"

Miscellaneous Characteristics
- H - Abrasive
- K - Corrosive
- L - Interlocks or mats
- S - Degradable, affecting use or quality
- X - Contains explosive dust
- Y - Powdery, may be wind-swept
- 35° - Angle of Repose

Flow Characteristics
- E - Slurry, fluid quality
- F - Free flowing, easily shaped
- G - Sluggish, not readily shaped

Example: Gravel, round - CFH 30°
- C - Lumpy, over 1/2"
- F - Free flowing, easily shaped
- H - Abrasive
- 30° - Angle of repose

Common and Technical Names

COMMON NAME	TECHNICAL NAME
AGATIZED WOOD	AGATE
ALUM STONE	ALUNITE
AMBER MICA	PHLOGOPITE
ANTIMONY GLANCE	STIBNITE
AQUA FORTIS	NITRIC ACID
AQUA REGIA	NITRIC AND HYDRO-CHLORIC ACIDS
ARGENTINE	LABRADORITE
ARSENICAL NICKEL	NICCOLITE
ASPHALT	ASPHALTUM
BARYTA	BARIUM OXIDE
BARYTES	BARIUM SULPHATE
BEESWAX MINERAL	OZOCERITE
BELL METAL ORE	STANNITE
BITUMEN	ASPHALTUM
BLACK HEMATITE	PSILOMELANE
BLACK JACK	SPHALERITE
BLACK LEAD	GRAPHITE
BLACK MICA	BIOTITE
BLACK OXIDE OF MANGANESE	PYROLUSITE
BLENDE	SPHALERITE
BLUE CARBONATE OF COPPER	AZURITE
BLUE COPPER	COVELLITE AND OTHERS
BLUE IRON EARTH	VIVIANITE
BLUE STONE	COPPER SULPHATE
BLUE VITRIOL	COPPER SULPHATE
BORAX	SODIUM BORATE
BRIMSTONE	SULPHUR
BRITTLE SILVER	STEPHANITE
BROWN HEMITITE	BRUCITE
BUTTER OF ANTIMONY	ANTIMONIOUS CHLORIDE
CALAMINE ELECTRIC	CALAMINE
CALC-SPAR	CALCITE
CALOMEL	MERCUROUS CHLORIDE
CAPILLARY PYRITE	MILLERITE
CHALK	CALCIUM CARBONATE
CHINA CLAY	KAOLINITE
CHROME IRON ORE	CHROMITE
COBALT GLANCE	COBALTITE
COMMON SALT	HALITE
COPALITE	AMBER
COPPERAS	IRON SULPHATE
COPPER GLANCE	CHALCOCITE
COPPER NICKEL	NICCOLITE
COPPER PYRITE	CHALCOPYRITE
CORDIERITE	IOLITE
CORROSIVE SUBLIMATE	MERCURIC CHLORIDE
CREAM OF TARTAR	POTASSIUM BITARTRATE
DARK RUBY SILVER	PYRARGYRITE
DESMINE	STILBITE
DICHROITE	IOLITE

COMMON NAME	TECHNICAL NAME
ELECTRIC CALAMINE	CALAMINE
EPSOM SALTS	MAGNESIUM SULPHATE
FEATHER ORE	JAMESONITE
FIBROLITE	SILLIMANITE
FLUORSPAR	FLUORITE
FOOL'S GOLD	CHALCOPYRITE, PYRITE
FOWLER'S SOLUTION	POTASSIUM ARSENITE
GALENA	GALENITE
GENTHITE	GARNIERITE
GLAUBER'S SALTS	SODIUM SULPHATE
GRAY ANTIMONY	STIBNITE
GRAY COPPER	TETRAHEDRITE, TENNANTITE
GREEN CARBONATE OF COPPER	MALACHITE
GREEN VITRIOL	IRON SULPHATE
GYPSUM	CALCIUM SULPHATE
HARTSHORN	AMMONIA WATER
HEAVY SPAR	BARITE
HEMATITE BLACK	PSILOMELANE
HEMATITE BROWN	LIMONITE
HORN SILVER	CERARGYRITE, SILVER CHLORIDE
HORSEFLESH ORE	BORNITE, CHALCOPYRITE
HYPO	SODIUM HYPOSULPHITE
IDOCRASE	VESUVIANITE
INDIGO COPPER	COVELLITE
IRON PYRITES	PYRITE, MARCASITE
ISINGLASS	MUSCOVITE
JACK	SPHALERITE
KAOLIN	KAOLINITE
KYANITE	CYANITE
LAUGHING GAS	NITROUS OXIDE
LEUCOPYRITE	LOLLINGITE
LIGHT RUBY SILVER	PROUSTITE
LIME	CALCIUM OXIDE
LIME FELDSPAR	ANORTHITE
LIME WATER	CALCIUM HYDRATE
LITHARGE	LEAD OXIDE
LITHIA MICA	LEPIDOLITE
LIVER OF SULPHUR	POTASSIUM SULPHIDE
LUNAR CAUSTIC	SILVER NITRATE
MAGNESIA	MAGNESIUM OXIDE
MAGNESIUM LIMESTONE	DOLOMITE
MAGNESIUM MICA	BIOTITE
MAGNETIC IRON ORE	MAGNETITE
MAGNETIC PYRITES	PYRRHOTITE
MANGANESE BLENDE	ALABANDITE
MANGANESE GLANCE	ALABANDITE
MARMATITE	FERRIFEROUS SPHALERITE
MEERSCHAUM	MAGNESIUM SILICATE
MENACCANITE	ILMENITE

MERCURY BLENDE	CINNABAR
MICA	MUSCOVITE
MINE VERMILION	CINNABAR
MISPICKLE	ARSENOPYRITE
MOLLY	MOLYBDENITE
MOSAIC GOLD	TIN BISULPHIDE
MUNDIC	PYRRHOTITE
NEEDLE ZEOLITE	NATROLITE
NEPHELINE	NEPHELITE
NICKEL ARSENITE	NICCOLITE
NIGRINE	RUTILE
NITER	SODIUM NITRATE
NITER CAKE	SODIUM BISULPHATE
NOUMEITE	GARNIERITE
OIL OF VITRIOL	SULPHURIC ACID
OLIVINE	CHRYSOLITE
PEACOCK ORE	BORNITE, CHALCOPYRITE
PENCIL STONE	PYROPHYLLITE
PERICLINE	ALBITE
PITCH BLENDE	URANINITE
PLUMBAGO	GRAPHITE
POTASH FELDSPAR	ORTHOCLASE, MICROCLINE
POTASH MICA	MUSCOVITE
PRUSSIAN BLUE	FERRIC-FERROCYANIDE
PRUSSIC ACID	HYDROCYANIC ACID
PURPLE COPPER ORE	BORNITE
PYRO	PYROGALLIC ACID
QUICKSILVER	MERCURY
RED IRON ORE	HEMATITE
RED LEAD	LEAD OXIDE
RED OCHRE	HEMATITE
RED OXIDE OF COPPER	CUPRITE
RED PRECIPITATE	RED MERCURIC OXIDE
RED SILVER	PROUSTITE
RED ZINC ORE	ZINCITE
RIPIDOLITE	CHLORITE
ROCHELLE SALTS	POTASSIUM AND SODIUM TARTRATE
ROCK SALT	HALITE
RUBY COPPER	CUPRITE
RUBY JACK	SPHALERITE
RUBY SILVER DARK	PYRARGYRITE
RUBY SILVER LIGHT	PROUSTITE
SAL AMMONIAC	AMMONIUM CHLORIDE
SAL SODA	SODIUM CARBONATE, CRYSTAL
SAL VOLATILE	AMMONIUM BICARBONATE
SALT CAKE	SODIUM SULPHATE
SALT, COMMON	SODIUM CHLORIDE
SALTPETER	POTASSIUM NITRATE
SCAPOLITE	WERNERITE
SCHORL	TOURMALINE
SILVER GLANCE	ARGENTITE
SODA ASH	SODIUM CARBONATE
SODA FELDSPAR	ALBITE
SPATHIC ORE	SIDERITE
SPECULAR IRON	HEMATITE
SPIRITS OF SALT	HYDROCHLORIC ACID
SUGAR OF LEAD	LEAD ACETATE
TARTAR EMETIC	ANTIMONY AND POTASSIUM TARTRATE
TINKAL	BORAX
TIN PYRITE	STANNITE
TITANIC IRON ORE	ILMENITE
TUNGSTEN	WOLFRAMITE, HUEBNERITE
VARIEGATED COPPER	BORNITE
VERDIGRIS	COPPER ACETATE
VERMILION	CINNABAR
VINEGAR	ACETIC ACID
WATER GLASS	SODIUM SILICATE
WHITE IRON	PYRITE, MARCASITE
WHITE LEAD	LEAD CARBONATE
WHITE LEAD ORE	CERUSSITE
WHITE MICA	MUSCOVITE
WHITE PRECIPITATE	AMMONIUM MERCURIC CHLORIDE
WHITE VITRIOL	ZINC SULPHATE
WHITE ZINC	ZINC OXIDE
YELLOW JACK	SPHALERITE
ZINC	SPHALERITE
ZINC BLENDE	SPHALERITE
ZINC BLOOM	HYDROZINCITE
ZINC SPINEL	GAHNITE

ENGINEERING DATA TABLES AND FORMULAE

CREDITS: For information in this section we wish to thank all companies who have cooperated in supplying various data. Some sources are unknown due to assembly of information over long periods of time. In addition to Denver Equipment Company publications credit goes to Wright Engineers, Ltd., Vancouver, B. C., The General Engineering Company (Canada), Ltd., Toronto, Allis-Chalmers Manufacturing Company, Milwaukee, Dorr Company, Inc., New York City, Stephens-Adamson, Link-Belt, Crane Co., Barber Green, Century Electric Co., Pit and Quarry Handbook, Paper and Pulp Mill Catalogs, Anthracite Mining Manual, various U. S. Government publications as well as various trade publications and industrial bulletins.

Denver Equipment Company,
Denver, Colorado, U.S.A.

Formulas for Milling Calculations

Courtesy of the Dow Chemical Company

The control of a milling operation is a problem in imponderables: from the moment that the ore drops into the mill scoop the process becomes continuous, and continuity ceases only when the products finally come to rest at the concentrate bins and on the tailing dams. Material in process often cannot be weighed without a disturbance of continuity; consequently, mill control must depend upon the sampling of material in flux. From these samples the essential information is derived by means of analyses for metal content, particle size distribution, and content of water or other ingredient in the ore pulp.

With such information at hand performance is calculated by the use of formulas and tabulations. Some of these are given here for convenient reference.

Pulp Densities

Pulp densities indicate by means of a tabulation (see p. 324) the percentages of solids (or liquid-to-solid ratio) in a sample of pulp. This figure is valuable in two ways—directly, because for each unit process and operation in milling the optimum pulp density must be established and maintained, and indirectly, because certain important tonnage calculations are based on pulp density.

Definitions and notation follow:

Let P = percentage solids by weight,
D = dilution, or ratio of weight of liquid to weight of solid,
S = specific gravity of solid,
W = weight of one liter of pulp in grams,
w = weight of dry ore (grams) in one liter of pulp,
K = the solids constant,

Assume the specific gravity of the water in the pulp to be unity.

$$\text{By definition } K = \frac{S-1}{S} \tag{1}$$

$$\text{then } W = 1000 + wK \tag{2}$$

$$w = \frac{W-1000}{K} \tag{3}$$

$$P = \frac{W-1000}{WK} \times 100 \tag{4}$$

$$W = \frac{100000}{100-PK} \tag{5}$$

$$\text{and } D = \frac{100-P}{P} \tag{6}$$

$$\text{or } P = \frac{100}{D+1} \tag{7}$$

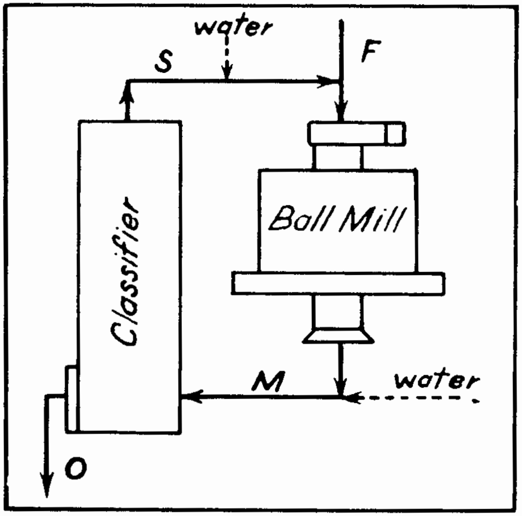
Formula (5) is used in making tabulations for mill use.

As used in these formulas the specific gravity of the ore is obtained simply by weighing a liter of mill pulp, then drying and weighing the ore. With these two weights formula (2) may be used to obtain K, and then formula (1) to convert to S, the specific gravity. A volumetric flask of one liter capacity provides the necessary accuracy. In laboratory work the ore should be ground wet to make a suitable pulp. This method does not give the true specific gravity of the ore, but an "apparent" specific gravity which is more suitable for the intended purposes.

Calculation of Circulating Load in a Classifier

A mechanical classifier often receives its feed from a ball mill and produces (1) finished material which overflows to the next operation and (2) sand which returns to the mill for further size-reduction. The term "circulating load" is defined as the tonnage of sand that returns to the ball mill, and the "circulating load ratio" is the ratio of circulating load to the tonnage of original feed to the ball mill. Since the feed to the classifier, the overflow of the classifier, and the sand usually are associated with different proportions of water to solid, the calculation of circulating load ratio can be based on a pulp density formula.

The adjoining diagram represents the usual classifier-mill setup, in which we may let



F = tonnage of ore to mill
O = tonnage of ore in overflow
S = tonnage of sand
M = tonnage of ore in mill discharge

and Ds, Do, and Dm are the liquid-to-solid ratios of the sand, overflow, and classifier feed at the points where they leave or enter the classifier.

$$\text{Then circulating load ratio} = \frac{Do - Dm}{Dm - Ds} \qquad (8)$$

$$\text{And circulating load tonnage} = F\,\frac{Do - Dm}{Dm - Ds} \qquad (9)$$

Example: A mill in closed circuit with a classifier receives 300 dry tons of crude ore per day, and the percentages of solid are respectively 25, 50, and 84% in the classifier overflow, feed to classifier, and sand, equivalent to L:S ratios of 3.0, 1.0, and 0.190. Then the circulating load ratio equals

$$\frac{3-1.00}{1.000-.190} \text{ or } 2.47 \text{ (or } 247\%)$$

and the circulating tonnage is 2.47 × 300 or 741 tons.

A more accurate basis for calculation of tonnage in a grinding circuit is the screen analysis. Samples of the mill discharge, return sand, and the classifier overflow are screen sized, and the cumulative percentages are calculated on several meshes.

Let d = cumulative percentage on any mesh in the mill discharge,
o = cumulative percentage on same mesh in the classifier overflow,
s = cumulative percentage on same mesh in the classifier sand.

The percentages through the finest screen may be used in place of the cumulative oversizes.

$$\text{Circulating load ratio} = \frac{d-o}{s-d} \qquad (10)$$

Example: Screen analyses on the three samples are as follows:

Mesh	Mill discharge %	Mill discharge % Cum.	Classifier overflow %	Classifier overflow % Cum.	Classifier sand %	Classifier sand % Cum.
+ 48	42.3		1.2		55.7	
+ 65	15.3	57.6	6.6	7.8	18.2	73.9
+100	9.5	67.1	9.4	17.2	9.6	83.5
+150	5.7	72.8	10.2	27.4	4.2	87.7
+200	6.1	78.9	12.4	39.8	4.1	91.8
—200	21.1		60.2		8.2	

$$\text{Applying the formula to } +65\text{, ratio } \frac{57.6 - 7.8}{73.9 - 57.6} \quad 3.05$$

$$\text{Applying the formula to } +150\text{, ratio } \frac{72.8 - 27.4}{87.7 - 72.8} \quad 3.05$$

$$\text{Applying the formula to } -200\text{, ratio} = \frac{21.1 - 60.2}{8.2 - 21.1} \quad 3.03$$

Average 3.04. If daily feed tonnage to the mill is 200 tons, the tonnage of sand is then 608 tons.

Calculation of Classifier Efficiency

The efficiency of a classifier, also determined by means of screen analyses, has been defined as the ratio, expressed as percentage, of the weight of classified material in the overflow to the weight of classifiable material in the feed. Overflow having the same sizing test as the feed is not considered classified material.

Let f = percentage of material in the classifier feed finer than the mesh of separation,
o = percentage of material in the overflow finer than the mesh of separation,
F = tonnage of feed to classifier,
O = tonnage of classifier overflow.

$$\text{Then efficiency, } E = 10000 \frac{O}{F} \times \frac{o-f}{f(100-f)} \qquad (11)$$

Screen Efficiency

The simplest and yet the most accurate formula for the efficiency of a screen, disregarding the quality of the product, is

E = 100 minus % true undersize in the coarse product (12)

Measurement of Tonnage by Pulp Dilution or Addition of a Chemical Substance

When no other method is available an approximation of the tonnage in a pulp stream or in a batch of pulp can be quickly obtained by one of these methods. In the dilution method water is added to a stream of pulp at a known rate, or to a batch of pulp in known quantity, and the specific gravity of the pulp ascertained before and after dilution.

$$T = \frac{Q}{D_2 - D_1} \qquad (13)$$

Where T = tons of ore per hour
and Q = tons of added water per hour
or T = tons of ore (for batch determinations)
and Q = tons of added water.

In both cases D_1 and D_2 are dilutions (tons of water per ton of ore) before and after addition of water. These are found from the specific gravities of the pulp, by formulas (4) and (6) or directly by the use of the tabulation on pages 324-327 of Pulp Density Tables.

In the chemical method a strong solution of known concentration of common salt, zinc sulphate, or other easily measured chemical is added to the flowing pulp at a known rate, or to a batch of pulp in known quantity. The degree of dilution of this standard solution by pulp water is ascertained by chemical analysis of solution from a filtered sample, and the tonnage of ore is then calculated from the percentage solid. This method is impractical for most purposes, but occasionally an exceptional circumstance makes its employment advantageous. It has also been suggested as a rapid and accurate method of determining concentrate moistures, but in this application the expense is prohibitive, since ordinary chemicals of reasonable cost are found to react quickly with the concentrate itself.

Concentration and Recovery Formulas

These are used to compute the production of concentrate in a mill or in a particular circuit. The formulas are based on assays of samples, and the results of the calculations are generally accurate—as accurate as the sampling, assaying, and crude ore (or other) tonnage on which they depend.

Two-Product Formulas

The simplest case is that in which two products only, viz., concentrate and tailing, are made from a given feed. If F, C, and T are tonnages of feed concentrate, and tailing respectively; f, c, and t are the assays of the important metal; K, the ratio of concentration (tons of feed to make one ton of concentrate); and R, the recovery of the assayed metal; then—

$$C = F \frac{f-t}{c-t} \text{ or } \frac{F}{K} \qquad (14), (15)$$

$$K = \frac{c-t}{f-t} \text{ or } \frac{F}{C} \qquad (16), (17)$$

$$R = \frac{100c}{Kf} \qquad (18)$$

$$R = \frac{100c\,(f-t)}{f\,(c-t)} \qquad (19)$$

Example: From a 6.5% lead ore, milled at the rate of 300 tons per day, is produced a concentrate assaying 72.5% lead, and a tailing with 0.5% lead.

By formula (16) $K = \frac{72.5-0.5}{6.5-0.5} = 12$

(15) $C = \frac{F}{K} = 25$ tons

or (14) $C = 300 \times \frac{6.5-0.5}{72.5-0.5} = 25$ tons

(18) $R = \frac{100 \times 72.5}{12 \times 6.5} = 92.9\%$ of the lead

or (19) $R = \frac{100 \times 72.5\,(6.5-0.5)}{6.5\,(72.5-0.5)} = 92.9\%$ of the lead.

Three-Product Formulas

When a feed containing, say, metal "l" and metal "z," is divided into three products, e.g., a concentrate rich in metal "l," another concentrate rich in metal "z," and a tailing reasonably low in both "l" and "z," several formulas in terms of assays of these two metals and tonnage of feed can be used to obtain the ratio of concentration, the weights of the three products, and the recoveries of "l" and "z" in their concentrates. For simplification in the following notation. we shall consider a lead-zinc ore from which a lead concentrate and a zinc concentrate are produced:

Notation	Weight	Lead assay	Zinc assay
Feed	F	l_1	z_1
Lead concentrate	L	l_2	z_2
Zinc concentrate	Z	l_3	z_3
Tailing	T	l_4	z_4

R_l and R_z are the recoveries of lead and zinc, respectively, in the corresponding concentrates, and K_l and K_z the ratios of concentration of the two concentrates. Then

$$L = F \frac{(l_1-l_4)(z_3-z_4)-(z_1-z_4)(l_3-l_4)}{(l_2-l_4)(z_3-z_4)-(z_2-z_4)(l_3-l_4)} \qquad (20)$$

$$Z = F \frac{(l_2-l_4)(z_1-z_4)-(l_1-l_4)(z_2-z_4)}{(l_2-l_4)(z_3-z_4)-(z_2-z_4)(l_3-l_4)} \qquad (21)$$

$$R_l = \frac{Ll_2}{Fl_1} \times 100 \qquad (22)$$

$$R_z = \frac{Zz_3}{Fz_1} \times 100 \qquad (23)$$

$$K_l = \frac{F}{L} \qquad (24)$$

$$K_z = \frac{F}{Z} \qquad (25)$$

There are other forms of the above formulas that are equally useful, but the ones shown above satisfy most requirements.

Example:

	Tons	Assays % Lead	Assays % Zinc
Feed	600 (F)	6.2 (l_1)	8.2 (z_1)
Lead concentrate	L	71.8 (l_2)	6.4 (z_2)
Zinc concentrate	Z	1.4 (l_3)	57.8 (z_3)
Tailing	T	0.3 (l_4)	0.8 (z_4)

Then, by (20) $L = 600 \dfrac{(5.9 \times 57.0) - (7.4 \times 1.1)}{(71.5 \times 57.0) - (5.6 \times 1.1)} = 48.4$ tons

by (21) $Z = 600 \dfrac{(71.5 \times 7.4) - (5.9 \times 5.6)}{(71.5 \times 57.0) - (5.6 \times 1.1)} = 73.1$ tons

by (22) $R_l = \dfrac{48.4 \times 71.8}{600 \times 6.2} \times 100 = 93.4\%$

by (23) $R_z = \dfrac{73.1 \times 57.8}{600 \times 8.2} \times 100 = 85.9\%$

by (24) $K_l = \dfrac{600}{48.4} = 12.4$

by (25) $K_z = \dfrac{600}{73.1} = 8.2$

The advantages of using the three-product formulas (20-25) instead of the two-product formulas (14-19), are four-fold—(a) simplicity, (b) fewer samples involved, (c) intermediate tailing does not have to be kept free of circulating material, (d) greater accuracy if application is fully understood.

In further regard to (d) the three-product formulas have certain limitations. Of the three products involved, two must be concentrates of different metals. Consider the following examples (same as foregoing, with silver assays added):

	Assays Oz. Ag.	% Lead	% Zinc
Crude ore	8.0	6.2	8.2
Lead concentrate	80.0	71.8	6.4
Zinc concentrate	2.75	1.4	57.8
Tailing	1.52	0.3	0.8

In this example the formula will give reliable results when lead and zinc assays or silver and zinc assays, but not if silver and lead assays, are used, the reason being that there is no concentration of lead or silver in the second concentrate. Nor is the formula dependable in a milling operation, for example, which yields only a table lead concentrate containing silver, lead, and zinc, and a flotation concentrate only slightly different in grade, for in this case there is no metal which has been rejected in one product and concentrated in a second. This is not to suggest that the formulas will not give reliable results in such cases, but that the results are not dependable—in certain cases one or more tonnages may come out with negative sign, or a recovery may exceed 100%.

Reagent Consumption

Formulas for calculating reagent consumption:
Liquid reagents:

$$\text{Lbs. per ton} = \frac{\text{ml per min} \times \text{sp gr liquid} \times \%\ \text{strength}}{31.7 \times \text{tons per 24 hrs}} \quad (26)$$

$$\text{Solid reagents: Lbs. per ton} = \frac{\text{g per min}}{.317 \times \text{tons per 24 hrs}} \quad (27)$$

Example:
400 ton daily rate, 200 ml per min of 5% xanthate solution

$$\text{Lbs. per ton} = \frac{200 \times 1 \times 5}{31.7 \times 400} = .079$$

Pulp Density Tables

Easy to Use...Simplify Calculations

The Deco Pulp Density Tables were compiled to eliminate the many complicated calculations which were required when using other pulp density tables. The total tank volume required for each twenty-four hour period of treatment is obtained in one computation. The table gives a figure, in cubic feet, which includes the volume of a ton of solids plus the necessary volume of water to make a pulp of the particular specific gravity desired. Multiply this figure by the number of dry tons of feed per twenty-four hours. Then simply adjust this figure to the required treatment time, such as 16, 30, 36, 72 hours. See examples which follow.

How to Obtain the Specific Gravity of Dry Solids

To obtain the per cent solids in a pulp, from the specific gravity of that pulp, the specific gravity of the dry solids in the pulp must be known. The following is a simplified procedure for obtaining this figure.

Place a weighed amount, say 200 grams, of dry solids in a dry graduate. Add to this graduate a measured volume of water, say 500 cubic centimeters (or milliliters). Measure the increase in volume caused by the dry solids displacing some of the water. Assume the new volume is 550 c.c. The displacement, then, is 50 c.c. (550–500). Divide the weight of the dry solids (200 gr.) by the difference in volume (50 c.c.). The result, 4.00, is the specific gravity of the dry solids.

Calculations for Capacities of Agitators

Example 1.

It is desired to give 48 hours of contact on 100 tons per 24 hours of 2.7 specific gravity ore in a pulp of 40% solids (1:1.5). What size agitators will be needed?

Total volume equals 59.85 (from Deco Pulp Density tables, page 326).

Tons feed equal 100.

59.85 time 100 equals 5,985 cu. ft. (total volume 24 hour agitation).

Therefore, 5,985 times 2 equals 11,970 cu. ft. (Total volume 48 hours agitation).

We find that 15′ 4½″x16′ 1″ Denver Bolted Steel Tank has an available capacity of 2,860 cu. ft.; therefore, four of these will handle the job.

Or we find that four 15′x16′ Denver Welded Steel Tanks would give this approximate capacity or four 16′x16′ Wood Tanks would be suitable for this application.

Example 2.

It is desired to condition 420 tons of 2.9 gravity ore for 25 minutes in a pulp of 30% solids (1:2.33) What size conditioner will be required?

Conditioning factor equals 0.0594.

Number of minutes equals 25.

0.0594 times 25 equals 1.485.

Number of tons equals 420.

1.485 times 420 equals 623.7 (0.0594 times 25 times 420 equals 623.7).

This time we find that 9′2-⅝″x10′ 0″ Denver Bolted Steel Tank gives an available capacity of 634 cu. ft.—sufficient for the problem.

Or a 9′x10′ welded steel tank or a 10′x10′ wood tank.

Mathematically inclined users of these tables will undoubtedly be interested in a description of the methods used in calculating them. Although the tables cover a much wider range than is usual, it might be that some special application would call for an extension of the figures in some direction, thus the following information would be helpful.

Total Volume:

What is the total volume of a ton of dry solids with a specific gravity of 2.6 in a pulp containing 25% solids?

Solution:

1 ton of solids of 2.6 specific gravity comprises 12.31 cubic feet. 1 ton of water comprises 32.0 cubic feet. With 25% solids in the pulp there will be one ton of solids plus 3 tons of water. Therefore, the total volume figure will be 12.31 plus 3 times 32 or 108.31 cubic feet.

Conditioning Factor:

The conditioning factor is the total volume divided by 1440, the number of minutes in 24 hours. Thus it gives a figure for use in conditioning problems where contact time is always a matter of minutes instead of hours.

PULP DENSITY TABLES

Specific Gravity, given as weight in grams, of 1 liter of pulp. **Total Volume,** (in cubic feet) is the volume of 1 ton of solids + necessary volume of water to make a pulp of sp. gr. shown. **Conditioning Factor**—Volume, in cubic feet, necessary to give 1 minute contact on 1 ton per 24 hours.

Specific Gravity Cubic feet per ton		1.4 22.86			1.8 17.78			2.2 14.55			2.5 12.80			2.6 12.31		
% Solids	Solids to Solution	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor
5	1:19.00	1015	630.86	.4381	1013	625.78	.4346	1028	622.55	.4323	1031	620.80	.4311	1032	620.31	.4308
6	1:15.67	1017	524.30	.3641	1027	519.22	.3606	1034	515.99	.3583	1037	514.24	.3571	1036	513.75	.3568
7	1:13.29	1020	448.14	.3112	1032	443.06	.3077	1040	439.83	.3054	1043	438.08	.3042	1045	437.59	.3039
8	1:11.50	1023	390.86	.2714	1037	385.78	.2679	1046	382.55	.2657	1050	380.80	.2644	1052	380.31	.2641
9	1:10.11	1026	346.38	.2405	1042	341.30	.2370	1052	338.07	.2348	1057	336.32	.2336	1059	335.83	.2332
10	1: 9.00	1029	310.86	.2159	1047	305.78	.2123	1058	302.55	.2101	1064	300.80	.2089	1065	300.31	.2085
11	1: 8.09	1032	281.74	.1957	1051	276.66	.1921	1064	273.43	.1899	1070	271.68	.1887	1073	271.19	.1883
12	1: 7.33	1036	257.42	.1788	1056	252.34	.1752	1070	249.11	.1730	1078	247.36	.1718	1080	246.87	.1714
13	1: 6.69	1039	236.94	.1645	1061	231.86	.1610	1076	228.63	.1588	1085	226.88	.1576	1087	226.39	.1572
14	1: 6.14	1042	219.34	.1523	1066	214.26	.1488	1083	211.03	.1465	1092	209.28	.1453	1094	208.79	.1450
15	1: 5.67	1045	204.30	.1419	1071	199.22	.1383	1089	195.99	.1361	1099	194.24	.1349	1102	193.75	.1345
16	1: 5.25	1048	190.86	.1325	1076	185.78	.1290	1096	182.55	.1268	1106	180.80	.1256	1109	180.31	.1252
17	1: 4.88	1051	179.02	.1243	1082	173.94	.1208	1102	170.71	.1185	1114	168.96	.1173	1117	168.47	.1170
18	1: 4.56	1054	168.78	.1172	1087	163.70	.1137	1109	160.47	.1114	1121	158.72	.1102	1125	158.23	.1099
19	1: 4.26	1057	159.18	.1105	1092	154.10	.1070	1116	150.87	.1048	1129	149.12	.1036	1133	148.63	.1032
20	1: 4.00	1061	150.86	.1048	1098	145.78	.1012	1122	142.55	.0990	1136	140.80	.0978	1140	140.31	.0974
21	1: 3.76	1064	143.18	.0994	1103	138.10	.0959	1129	134.87	.0937	1144	133.12	.0924	1148	132.63	.0921
22	1: 3.55	1066	136.46	.0948	1108	131.38	.0912	1136	128.15	.0890	1152	126.40	.0878	1157	125.91	.0874
23	1: 3.35	1070	130.06	.0903	1114	124.98	.0868	1143	121.75	.0845	1160	120.00	.0833	1165	119.51	.0830
24	1: 3.17	1074	124.30	.0863	1119	119.22	.0828	1151	115.99	.0805	1168	114.24	.0793	1173	113.75	.0790
25	1: 3.00	1077	118.86	.0825	1125	113.78	.0790	1158	110.55	.0768	1176	108.80	.0756	1182	108.31	.0752
26	1: 2.85	1080	114.06	.0792	1131	108.98	.0757	1165	105.75	.0734	1185	104.00	.0722	1190	103.51	.0719
27	1: 2.70	1084	109.26	.0759	1136	104.18	.0723	1173	100.95	.0701	1193	99.20	.0689	1199	98.71	.0685
28	1: 2.57	1087	105.10	.0730	1143	100.02	.0695	1180	96.79	.0672	1202	95.04	.0660	1209	94.55	.0657
29	1: 2.45	1090	101.26	.0703	1148	96.18	.0668	1188	92.95	.0645	1211	91.20	.0633	1217	90.71	.0630
30	1: 2.33	1094	97.42	.0677	1154	92.34	.0641	1196	89.11	.0618	1220	87.36	.0607	1226	86.87	.0603
31	1: 2.23	1097	94.22	.0654	1160	89.14	.0619	1204	85.91	.0597	1229	84.16	.0584	1236	83.67	.0581
32	1: 2.13	1101	91.02	.0632	1166	85.94	.0597	1211	82.71	.0574	1238	80.96	.0562	1245	80.47	.0559
33	1: 2.03	1104	87.82	.0610	1172	82.74	.0575	1220	79.51	.0552	1247	77.76	.0540	1255	77.27	.0536
34	1: 1.94	1108	84.94	.0590	1178	79.86	.0555	1228	76.63	.0532	1256	74.88	.0520	1264	74.39	.0517

Continued on page 676

PULP DENSITY TABLES continued from preceding page

35	1 : 1.86	1111	82.38	.0572	1184	77.30	.0537	1236	74.07	.0514	1266	72.32	.0502	1274	71.83	.0499
36	1 : 1.78	1115	79.82	.0554	1190	74.74	.0519	1244	71.51	.0497	1276	69.76	.0484	1284	69.27	.0481
37	1 : 1.70	1118	77.26	.0537	1197	72.18	0501	1253	68.95	.0479	1285	67.20	.0467	1295	66.71	.0463
38	1 : 1.63	1122	75.02	.0521	1203	69.94	.0486	1261	66.71	.0463	1295	64.96	.0451	1305	64.47	.0448
39	1 : 1.56	1125	72.78	.0505	1210	67.70	.0470	1270	64.47	.0448	1305	62.72	.0436	1316	62.23	.0432
40	1 : 1.50	1129	70.86	.0492	1216	65.78	.0457	1279	62.55	.0434	1316	60.80	.0422	1326	60.31	.0419
41	1 : 1.44	1133	68.94	.0479	1223	63.86	.0443	1288	60.63	.0421	1326	58.88	.0409	1337	58.39	.0405
42	1 : 1.38	1136	67.02	.0465	1230	61.94	.0430	1297	58.71	.0408	1337	56.96	.0396	1348	56.47	.0392
43	1 : 1.33	1140	65.42	.0454	1236	60.34	.0419	1306	57.11	.0397	1348	55.36	.0384	1359	54.87	.0381
44	1 : 1.27	1144	63.50	.0441	1243	58.42	.0406	1316	55.19	.0383	1358	53.44	.0371	1372	52.95	.0368
45	1 : 1.22	1148	61.90	.0430	1250	56.82	.0395	1325	53.59	.0372	1370	51.84	.0360	1383	51.35	.0357
46	1 : 1.17	1151	60.30	.0419	1257	55.22	.0383	1335	51.99	.0361	1381	50.24	.0349	1395	49.75	.0345
47	1 : 1.13	1155	59.02	.0410	1264	53.94	.0375	1345	50.71	.0352	1393	48.96	.0340	1407	48.47	.0337
48	1 : 1.08	1159	57.42	.0399	1271	52.34	.0363	1355	49.11	.0341	1405	47.36	.0329	1419	46.87	.0325
49	1 : 1.04	1163	56.14	.0390	1278	51.06	.0355	1365	47.83	.0332	1416	46.08	.0320	1431	45.59	.0317
50	1 : 1.00	1167	54.86	.0381	1286	49.78	.0346	1375	46.55	.0323	1429	44.80	.0311	1444	44.31	.0308
52	1 : 0.92	1174	52.30	.0363	1301	47.22	.0328	1396	43.99	.0305	1454	42.24	.0293	1471	41.75	.0290
54	1 : 0.85	1182	50.06	.0348	1316	44.98	.0312	1418	41.75	.0290	1479	40.00	.0278	1498	39.51	.0274
56	1 : 0.79	1190	48.14	.0334	1331	43.06	.0299	1440	39.83	.0277	1506	38.08	.0264	1526	37.59	.0261
58	1 : 0.72	1199	45.90	.0319	1347	40.82	.0283	1463	37.59	.0261	1534	35.84	.0249	1555	35.35	.0245
60	1 : 0.67	1207	44.30	.0308	1364	39.22	.0272	1486	35.99	.0250	1563	34.24	.0238	1585	33.75	.0234
62	1 : 0.61	1215	42.38	.0294	1380	37.30	.0259	1511	34.07	.0237	1592	32.32	.0224	1617	31.83	.0221
64	1 : 0.56	1224	40.78	.0283	1398	35.70	.0248	1536	32.47	.0225	1623	30.72	.0213	1650	30.23	.0210
66	1 : 0.52	1232	39.50	.0274	1415	34.42	.0239	1563	31.19	.0217	1656	29.44	.0204	1684	28.95	.0201
68	1 : 0.47	1241	37.90	.0263	1433	32.82	.0228	1590	29.59	.0205	1689	27.84	.0193	1719	27.35	.0190
70	1 : 0.43	1250	36.62	.0254	1452	31.54	.0219	1618	28.31	.0197	1724	26.56	.0184	1757	26.07	.0181
72	1 : 0.39	1296	35.34	.0245	1471	30.26	.0210	1647	27.03	.0188	1761	25.28	.0176	1796	24.79	.0172
74	1 : 0.35	1306	34.06	.0237	1490	28.98	.0201	1677	25.75	.0179	1799	24.00	.0167	1836	23.51	.0163
76	1 : 0.32	1316	33.10	.0230	1510	28.02	.0195	1708	24.79	.0172	1838	23.04	.0160	1879	22.55	.0156
78	1 : 0.28	1326	31.82	.0221	1531	26.74	.0186	1740	23.51	.0163	1879	21.76	.0151	1923	21.27	.0148
80	1 : 0.25	1336	30.86	.0214	1552	25.78	.0179	1774	22.55	.0157	1923	20.80	.0144	1970	20.31	.0141
82	1 : 0.22	1346	29.[illegible]0	.0208	1573	24.82	.0172	1809	21.59	.0150	1969	19.84	.0138	2019	19.35	.0134
84	1 : 0.19	1357	28.94	.0201	1596	23.86	.0166	1846	20.63	.0143	2016	18.88	.0131	2070	18.39	.0128
86	1 : 0.16	1367	27.98	.0194	1619	22.90	.0159	1884	19.67	.0137	2066	17.92	.0124	2124	17.43	.0121
88	1 : 0.14	1378	27.34	.0190	1642	22.26	.0155	1923	19.03	.0132	2118	17.28	.0120	2181	16.79	.0117
90	1 : 0.11	1389	26.38	.0183	1666	21.30	.0148	1964	18.07	.0125	2174	16.32	.0113	2241	15.83	.0110

DENVER CONDITIONER AND AGITATOR CAPACITY

Tank Size Feet Dia. X Depth	Available Capacity Steel Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	Available Capacity Wood Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	DENVER CONDITIONER OR AGITATOR—CAPACITY IN DRY TONS PER 24 HOURS. Tables Below Are Based on Steel Tank Capacities with Average Ore of 2.6 Sp. Gr.											
					10-Minute Contact			30-Minute Contact			60-Minute Contact			12-Hour Contact		
					Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution		
					1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
4'x4'	30.7	12.6	31.5	10.7	129	74	53	43	25	18	....	....	....	....	....	....
5'x5'	77.5	19.6	64.5	17.3	252	145	103	84	48	34	....	....	....	....	....	....
6'x6'	139.0	28.3	117.0	25.5	453	259	185	150	86	62	....	....	....	....	....	....
8'x8'	350.0	50.3	306.5	46.5	1138	653	465	379	218	155	189	109	78	....	....	....
10'x10'	682.0	78.0	630.0	74.0	2214	1272	907	738	424	302	369	212	151	31	18	13
12'x12'	1217.0	113.0	1133.0	108.0	3951	2270	1618	1317	757	539	659	378	270	55	32	23
These figures are the reciprocal of the time in Minutes X Conditioner Factor. This figure X Available Capacity will give tons per 24 hours for any tank. ➡					3.2467	1.8656	1.3297	1.0822	.6218	.4432	.5411	.3109	.2216	.0451	.0259	.0185

PULP DENSITY TABLES

Specific Gravity, given as weight in grams, of 1 liter of pulp. **Total Volume**, (in cubic feet) is the volume of 1 ton of solids +necessary volume of water to make a pulp of sp. gr. shown. **Conditioning Factor**—Volume, in cubic feet, necessary to give 1 minute contact on 1 ton per 24 hours.

Specific Gravity Cubic feet per ton		2.7 11.85			2.8 11.43			2.9 11.03			3.0 10.67			3.2 10.00		
% Solids	Solids to Solution	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor
5	1 :19.00	1033	619.85	.4305	1033	619.43	.4302	1034	619.03	.4298	1034	618.67	.4296	1036	618.00	.4292
6	1 :15.67	1039	513.29	.3505	1040	512.87	3562	1041	512.47	3559	1042	512.11	.3556	1043	511.44	.3552
7	1 :13.29	1046	437.13	.3036	1047	436.71	3032	1048	436.31	.3029	1049	435.95	.3027	1051	435.28	3023
8	1 :11.50	1053	379.85	.2638	1054	379.43	.2635	1055	379.03	2632	1056	378.67	.2630	1058	378.00	.2625
9	1 :10.11	1060	335.37	.2329	1061	334.95	.2326	1063	334.55	2323	1064	334.19	.2321	1066	333.52	.2316
10	1 : 9.00	1067	299.85	.2082	1069	299.43	.2079	1070	299.03	2077	1071	298.67	.2074	1074	298.00	.2069
11	1 : 8.09	1074	270.73	.1880	1076	270.31	.1877	1078	269.91	1874	1078	269.55	.1872	1082	268.88	.1867
12	1 : 7.33	1082	246.41	.1711	1084	245.99	1708	1085	245.59	1705	1087	245.23	.1703	1090	244.56	1698
13	1 : 6.69	1089	225.93	.1569	1091	225.51	.1566	1093	225.11	1563	1095	224.75	.1561	1098	224.08	.1556
14	1 : 6.14	1097	208.33	.1447	1099	207.91	1444	1101	207.51	.1441	1103	207.15	.1439	1107	206.48	.1434

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PULP DENSITY TABLES continued from preceding page

15	1 : 5.67	1104	193.29	.1342	1107	192.87	.1339	1109	192.47	.1337	1111	192.11	.1334	1115	191.44	.1329
16	1 : 5.25	1112	179.85	.1249	1115	179.43	.1246	1117	179.03	.1243	1119	178.67	.1241	1124	178.00	.1236
17	1 : 4.88	1119	168.01	.1167	1123	167.59	.1164	1125	167.19	.1161	1128	166.83	.1159	1132	166.16	.1154
18	1 : 4.56	1128	157.77	.1096	1131	157.35	.1093	1134	156.95	.1090	1136	156.59	.1087	1141	155.92	.1083
19	1 : 4.26	1136	148.17	.1029	1139	147.75	.1026	1142	147.35	.1023	1145	146.99	.1021	1150	146.32	.1016
20	1 : 4.00	1144	139.85	.0971	1148	139.43	.0968	1151	139.03	.0965	1154	138.67	.0963	1159	138.00	.0958
21	1 : 3.76	1152	132.17	.0918	1156	131.75	.0915	1160	131.35	.0912	1163	130.99	.0910	1169	130.32	.0906
22	1 : 3.55	1161	125.45	.0871	1165	125.03	.0868	1168	124.64	.0865	1172	124.27	.0863	1178	123.60	.0858
23	1 : 3.35	1169	119.05	.0827	1174	118.63	.0824	1177	118.23	.0821	1181	117.87	.0818	1188	117.20	.0814
24	1 : 3.17	1178	113.29	.0787	1182	112.87	.0784	1187	112.47	.0781	1190	112.11	.0779	1198	111.44	.0774
25	1 : 3.00	1187	107.85	.0749	1191	107.43	.0746	1196	107.03	.0743	1200	106.67	.0741	1208	106.00	.0736
26	1 : 2.85	1196	103.05	.0716	1201	102.63	.0713	1205	102.23	.0710	1210	101.87	.0707	1218	101.20	.0703
27	1 : 2.70	1205	98.25	.0682	1210	97.83	.0679	1215	97.43	.0677	1220	97.07	.0674	1228	96.40	.0669
28	1 : 2.57	1214	94.09	.0653	1220	93.67	.0650	1225	93.27	.0648	1230	92.91	.0645	1238	92.24	.0641
29	1 : 2.45	1223	90.25	.0627	1229	89.83	.0624	1235	89.43	.0621	1240	89.07	.0619	1249	88.40	.0614
30	1 : 2.33	1233	86.41	.0600	1239	85.99	.0597	1245	85.59	.0594	1250	85.23	.0592	1260	84.56	.0587
31	1 : 2.23	1243	83.48	.0580	1249	83.06	.0577	1255	82.66	.0574	1261	82.03	.0570	1271	81.63	.0567
32	1 : 2.13	1252	80.01	.0556	1259	79.59	.0553	1265	79.19	.0550	1271	78.83	.0547	1282	78.16	.0543
33	1 : 2.03	1262	76.81	.0533	1269	76.39	.0530	1276	75.99	.0528	1282	75.63	.0525	1293	74.96	.0520
34	1 : 1.94	1272	73.93	.0513	1280	73.51	.0510	1287	73.11	.0508	1293	72.75	.0505	1305	72.08	.0500
35	1 : 1.86	1283	71.73	.0496	1290	70.95	.0493	1298	70.55	.0490	1304	70.19	.0487	1317	69.52	.0483
36	1 : 1.78	1293	68.81	.0478	1301	68.39	.0475	1309	67.99	.0472	1316	67.63	.0470	1329	66.96	.0465
37	1 : 1.70	1303	66.25	.0460	1312	65.83	.0457	1320	65.43	.0454	1328	65.07	.0452	1341	64.40	.0447
38	1 : 1.63	1315	64.01	.0445	1323	63.59	.0442	1332	63.19	.0439	1340	62.83	.0436	1354	62.16	.0432
39	1 : 1.56	1325	61.77	.0429	1335	61.35	.0426	1343	60.95	.0423	1351	60.59	.0421	1366	59.92	.0416
40	1 : 1.50	1337	59.85	.0416	1346	59.43	.0413	1355	59.03	.0410	1363	58.67	.0407	1379	58.00	.0403
41	1 : 1.44	1348	57.93	.0402	1358	57.51	.0399	1367	57.11	.0397	1376	56.75	.0394	1392	56.08	.0389
42	1 : 1.38	1360	56.01	.0389	1370	55.59	.0386	1380	55.19	.0383	1389	54.83	.0381	1406	54.16	.0376
43	1 : 1.33	1371	54.41	.0378	1382	53.99	.0375	1392	53.59	.0372	1402	53.23	.0370	1420	52.56	.0365
44	1 : 1.27	1383	52.49	.0365	1394	52.07	.0362	1405	51.67	.0359	1415	51.31	.0356	1434	50.64	.0352
45	1 : 1.22	1395	50.89	.0353	1407	50.47	.0350	1418	50.07	.0348	1429	49.71	.0345	1448	49.04	.0341
46	1 : 1.17	1408	49.29	.0342	1420	48.87	.0339	1431	48.47	.0337	1443	48.11	.0334	1463	47.44	.0329
47	1 : 1.13	1420	48.01	.0333	1433	47.59	.0330	1445	47.19	.0328	1457	46.83	.0325	1477	46.16	.0321
48	1 : 1.08	1433	46.41	.0322	1446	45.99	.0319	1459	45.59	.0317	1471	45.23	.0314	1493	44.56	.0309
49	1 : 1.04	1446	45.13	.0313	1460	44.71	.0310	1473	44.31	.0308	1485	43.95	.0305	1508	43.28	.0301

PULP DENSITY TABLES

50	1 : 1.00	1459	43.85	.0305	1474	43.43	.0302	1487	43.03	.0299	1500	42.67	.0296	1524	42.00	.0292
52	1 : 0.92	1487	41.29	.0287	1502	40.87	.0284	1517	40.47	.0281	1531	40.11	.0279	1556	39.44	.0274
54	1 : 0.85	1515	39.05	.0271	1532	38.63	.0268	1548	38.23	.0265	1563	37.87	.0263	1590	37.20	.0258
56	1 : 0.79	1545	37.13	.0258	1563	36.71	.0255	1580	36.31	.0252	1596	35.95	.0250	1626	35.28	.0245
58	1 : 0.72	1575	34.89	.0242	1595	34.47	.0239	1613	34.07	.0237	1631	33.71	.0234	1663	33.04	.0229
60	1 : 0.67	1607	33.29	.0231	1628	32.87	.0228	1648	32.47	.0225	1667	32.11	.0223	1702	31.44	.0218
62	1 : 0.61	1640	31.37	.0218	1663	30.95	.0215	1684	30.55	.0212	1705	30.19	.0210	1743	29.52	.0205
64	1 : 0.56	1675	29.77	.0207	1699	29.35	.0204	1722	28.95	.0201	1745	28.59	.0199	1786	27.92	.0194
66	1 : 0.52	1711	28.49	.0198	1737	28.07	.0195	1762	27.67	.0192	1786	27.31	.0190	1831	26.64	.0185
68	1 : 0.47	1749	26.89	.0187	1777	26.47	.0184	1803	26.07	.0181	1830	25.71	.0179	1878	25.04	.0174
70	1 : 0.43	1788	25.61	.0178	1818	25.19	.0175	1847	24.79	.0172	1875	24.43	.0170	1928	23.76	.0165
72	1 : 0.39	1829	24.33	.0169	1862	23.91	.0166	1893	23.51	.0163	1923	23.15	.0161	1980	22.48	.0156
74	1 : 0.35	1872	23.05	.0160	1920	22.63	.0157	1941	22.23	.0154	1974	21.87	.0152	2036	21.20	.0147
76	1 : 0.32	1917	22.09	.0153	1955	21.67	.0150	1992	21.27	.0148	2027	20.91	.0145	2094	20.24	.0141
78	1 : 0.28	1965	20.81	.0145	2006	20.39	.0142	2045	19.99	.0138	2083	19.63	.0136	2156	18.96	.0132
80	1 : 0.25	2015	19.85	.0138	2059	19.43	.0135	2101	19.03	.0132	2143	18.67	.0130	2222	18.00	.0125
82	1 : 0.22	2067	18.89	.0131	2114	18.47	.0128	2160	18.07	.0125	2206	17.71	.0123	2293	17.04	.0118
84	1 : 0.19	2123	17.93	.0125	2174	17.51	.0122	2192	17.11	.0119	2273	16.75	.0116	2367	16.08	.0112
86	1 : 0.16	2181	16.97	.0118	2237	16.55	.0115	2257	16.15	.0112	2344	15.79	.0110	2447	15.12	.0105
88	1 : 0.14	2243	16.33	.0113	2302	15.91	.0110	2326	15.51	.0107	2419	15.15	.0105	2532	14.48	.0101
90	1 : 0.11	2308	15.37	.0107	2373	14.95	.0104	2399	14.55	.0101	2500	14.19	.0099	2623	13.52	.0094

Tank Size Feet Dia. X Depth	Available Capacity Steel Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	Available Capacity Wood Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	DENVER CONDITIONER OR AGITATOR—CAPACITY IN DRY TONS PER 24 HOURS. Tables Below Are Based on Steel Tank Capacities with Average Ore of 2.6 Sp. Gr.														
					60-Minute Contact			12-Hour Contact			24-Hour Contact			48-Hour Contact			60-Hour Contact		
					Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution		
					1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
14'x14'	1950.0	154.0	1811.0	148.0	1055	606	432	88	51	36	44	25	18	....	....	....	....	....	....
16'x14'	2560.0	201.0	2300.0	189.0	1385	796	567	115	66	47	58	33	24	....	....	....	....	....	....
18'x16'	3725	254	3430	243	2016	1158	825	168	97	69	84	48	34	42	24	17	34	19	14
20'x16'	4625	314	4280	302	2503	1438	1025	209	120	86	104	60	43	52	30	21	42	24	17
22'x16'	5615	380	5190	367	3038	1746	1244	253	145	104	126	73	52	63	36	26	51	29	21
These figures are the reciprocal of the time in Minutes X Conditioner Factor. This figure X Available Capacity will give tons per 24 hours for any tank. ➡					.5411	.3109	.2216	.0451	.0259	.0185	.0225	.01295	.00923	.01127	.0065	.00461	.00901	.00518	.00269

PULP DENSITY TABLES

Specific Gravity, given as weight in grams, of 1 liter of pulp. **Total Volume**, (in cubic feet) is the volume of 1 ton of solids + necessary volume of water to make a pulp of sp. gr. shown. **Conditioning Factor**—Volume, in cubic feet, necessary to give 1 minute contact on 1 ton per 24 hours.

Specific Gravity Cubic feet per ton		3.4 9.41			3.8 8.42			4.2 7.62			4.6 6.96			5.0 6.40		
% Solids	Solids to Solution	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor	Specific Gravity	Total Volume	Cond. Factor
5	1:19.00	1037	617.41	.4288	1038	616.42	.4280	1040	615.62	.4275	1041	614.96	.4270	1042	614.40	.4267
6	1:15.67	1044	510.85	.3547	1046	509.86	.3541	1048	509.06	.3535	1049	508.40	.3531	1050	507.84	.3527
7	1:13.29	1052	434.69	.3019	1054	433.70	.3012	1056	432.90	.3006	1058	432.24	.3002	1059	431.68	.2998
8	1:11.50	1060	377.41	.2621	1063	376.42	.2614	1065	375.62	.2608	1067	374.96	.2604	1068	374.40	.2600
9	1:10.11	1068	332.93	.2312	1071	331.94	.2305	1074	331.14	.2300	1076	330.48	.2295	1078	329.92	.2291
10	1:9.00	1076	297.41	.2065	1080	296.42	.2058	1082	295.62	.2053	1085	294.96	.2048	1087	294.40	.2044
11	1:8.09	1084	268.29	.1863	1088	267.30	.1856	1091	266.50	.1851	1094	265.84	.1846	1096	265.28	.1842
12	1:7.33	1093	243.97	.1694	1097	247.98	.1687	1101	242.18	.1682	1104	241.52	.1677	1106	240.96	.1673
13	1:6.69	1101	223.49	.1552	1106	222.50	.1545	1110	221.70	.1540	1113	221.04	.1535	1116	220.48	.1531
14	1:6.14	1110	205.89	.1430	1115	204.90	.1423	1119	204.10	.1417	1123	203.44	.1413	1126	202.88	.1409
15	1:5.67	1118	190.85	.1325	1124	189.86	.1318	1129	189.06	.1313	1133	188.40	.1308	1136	187.84	.1304
16	1:5.25	1127	177.41	.1232	1134	176.42	.1225	1139	175.62	.1220	1143	174.96	.1215	1147	174.40	.1211
17	1:4.88	1136	165.57	.1150	1143	164.58	.1143	1149	163.78	.1137	1153	163.12	.1133	1157	162.56	.1129
18	1:4.56	1146	155.33	.1079	1153	154.34	.1072	1159	153.54	.1066	1164	152.88	.1062	1168	152.32	.1058
19	1:4.26	1155	145.73	.1012	1163	144.74	.1005	1169	143.94	.1000	1175	143.28	.0995	1179	142.72	.0991
20	1:4.00	1164	137.41	.0954	1173	136.42	.0947	1180	135.62	.0942	1186	134.96	.0937	1190	134.40	.0933
21	1:3.76	1174	129.73	.0901	1183	128.74	.0894	1190	127.94	.0888	1197	127.28	.0884	1202	126.72	.0880
22	1:3.55	1184	123.01	.0854	1193	122.02	.0847	1201	121.22	.0842	1208	120.56	.0837	1214	120.00	.0833
23	1:3.35	1194	116.61	.0810	1204	115.62	.0803	1212	114.82	.0797	1220	114.16	.0793	1225	113.60	.0789
24	1:3.17	1204	110.85	.0770	1215	109.86	.0763	1224	109.06	.0757	1231	108.40	.0753	1238	107.84	.0749
25	1:3.00	1214	105.41	.0732	1226	104.42	.0725	1235	103.62	.0720	1243	102.96	.0715	1250	102.40	.0711
26	1:2.85	1225	100.61	.0699	1237	99.62	.0692	1247	98.82	.0686	1255	98.16	.0682	1263	97.60	.0678
27	1:2.70	1235	95.81	.0665	1248	94.82	.0658	1259	94.02	.0652	1268	93.36	.0648	1279	92.80	.0644
28	1:2.57	1246	91.65	.0636	1260	90.66	.0630	1271	89.86	.0624	1281	89.20	.0619	1289	88.64	.0616
29	1:2.45	1257	87.81	.0610	1272	86.82	.0603	1284	86.02	.0597	1294	85.36	.0593	1302	84.80	.0589
30	1:2.33	1269	83.97	.0583	1284	82.98	.0576	1296	82.18	.0571	1307	81.52	.0566	1316	80.96	.0562
31	1:2.23	1280	80.77	.0561	1296	79.78	.0554	1309	78.98	.0548	1320	78.32	.0544	1330	77.76	.0540
32	1:2.13	1292	77.57	.0539	1309	76.58	.0532	1322	75.78	.0526	1334	75.12	.0522	1344	74.56	.0518
33	1:2.03	1304	74.37	.0516	1321	73.38	.0510	1336	72.58	.0504	1348	71.92	.0499	1359	71.36	.0496
34	1:1.94	1316	71.49	.0496	1334	70.50	.0490	1350	69.70	.0484	1363	69.04	.0479	1374	68.48	.0476

PULP DENSITY TABLES

(Continued from previous page)

35	1:1.86	1328	68.93	.0479	1348	67.94	.0472	1364	67.14	.0466	1377	66.48	.0462	1389	65.92	.0458
36	1:1.78	1341	66.37	.0461	1361	65.38	.0454	1378	64.58	.0448	1392	63.92	.0444	1404	63.36	.0440
37	1:1.70	1354	63.81	.0443	1375	62.82	.0436	1393	62.02	.0431	1408	61.36	.0426	1420	60.80	.0422
38	1:1.63	1367	61.57	.0428	1389	60.58	.0421	1408	59.78	.0415	1423	59.12	.0411	1437	58.56	.0407
39	1:1.56	1380	59.33	.0412	1403	58.34	.0405	1423	57.54	.0400	1439	56.88	.0395	1453	56.32	.0391
40	1:1.50	1393	57.41	.0399	1418	56.42	.0392	1438	55.62	.0386	1456	54.96	.0382	1471	54.40	.0378
41	1:1.44	1407	55.49	.0385	1433	54.50	.0378	1454	53.70	.0373	1472	53.04	.0368	1488	52.48	.0364
42	1:1.38	1421	53.57	.0372	1448	52.58	.0365	1471	51.78	.0360	1490	51.12	.0355	1506	50.56	.0351
43	1:1.33	1436	51.97	.0361	1464	50.98	.0354	1487	50.18	.0348	1507	49.52	.0344	1524	48.96	.0340
44	1:1.27	1451	50.05	.0348	1480	49.06	.0341	1504	48.26	.0335	1525	47.60	.0330	1543	47.04	.0327
45	1:1.22	1466	48.45	.0336	1496	47.46	.0330	1522	46.66	.0324	1544	46.00	.0319	1563	45.44	.0316
46	1:1.17	1481	46.85	.0325	1513	45.86	.0318	1540	45.06	.0313	1563	44.40	.0308	1582	43.84	.0304
47	1:1.13	1496	45.57	.0316	1530	44.58	.0310	1558	43.78	.0304	1582	43.12	.0299	1603	42.56	.0296
48	1:1.08	1512	43.97	.0305	1547	42.98	.0298	1577	42.18	.0293	1602	41.52	.0288	1623	40.96	.0284
49	1:1.04	1529	42.69	.0296	1565	41.70	.0290	1596	40.90	.0284	1622	40.24	.0279	1645	39.68	.0276
50	1:1.00	1545	41.41	.0288	1583	40.42	.0281	1615	39.62	.0275	1643	38.96	.0271	1667	38.40	.0267
52	1:0.92	1580	38.85	.0270	1621	37.86	.0263	1656	37.06	.0257	1686	36.40	.0253	1712	35.84	.0249
54	1:0.85	1616	36.61	.0254	1661	35.62	.0247	1699	34.82	.0242	1732	34.16	.0237	1761	33.60	.0233
56	1:0.79	1654	34.69	.0241	1703	33.70	.0234	1744	32.90	.0228	1780	32.24	.0224	1812	31.68	.0220
58	1:0.72	1693	32.45	.0225	1746	31.46	.0218	1792	30.66	.0213	1831	30.00	.0208	1866	29.44	.0204
60	1:0.67	1735	30.85	.0214	1792	29.86	.0207	1842	29.06	.0202	1885	28.40	.0197	1923	27.84	.0193
62	1:0.61	1778	28.93	.0201	1841	27.94	.0194	1895	27.14	.0188	1943	26.48	.0184	1984	25.92	.0180
64	1:0.56	1824	27.33	.0190	1892	26.34	.0183	1952	25.54	.0177	2003	24.88	.0173	2049	24.32	.0169
66	1:0.52	1872	26.05	.0181	1947	25.06	.0174	2011	24.26	.0168	2068	23.60	.0164	2119	23.04	.0160
68	1:0.47	1923	24.45	.0170	2004	23.46	.0163	2075	22.66	.0157	2138	22.00	.0153	2193	21.44	.0149
70	1:0.43	1977	23.17	.0161	2065	22.18	.0154	2143	21.38	.0148	2212	20.72	.0144	2273	20.16	.0140
72	1:0.39	2034	21.89	.0152	2130	20.90	.0145	2215	20.10	.0140	2291	19.44	.0135	2358	18.88	.0131
74	1:0.35	2094	20.61	.0143	2199	19.62	.0136	2293	18.82	.0131	2376	18.16	.0126	2451	17.60	.0122
76	1:0.32	2157	19.65	.0136	2273	18.66	.0130	2376	17.86	.0124	2468	17.20	.0119	2551	16.64	.0116
78	1:0.28	2225	18.37	.0128	2352	17.38	.0121	2465	16.58	.0115	2567	15.92	.0111	2660	15.36	.0107
80	1:0.25	2297	17.41	.0121	2436	16.42	.0114	2561	15.62	.0108	2674	14.96	.0104	2777	14.40	.0100
82	1:0.22	2374	16.45	.0114	2527	15.46	.0107	2665	14.66	.0102	2791	14.00	.0097	2907	13.44	.0093
84	1:0.19	2457	15.49	.0108	2624	14.50	.0101	2778	13.70	.0095	2919	13.04	.0091	3049	12.48	.0087
86	1:0.16	2545	14.53	.0101	2730	13.54	.0094	2901	12.74	.0088	3058	12.08	.0084	3205	11.52	.0080
88	1:0.14	2640	13.89	.0096	2844	12.90	.0090	3035	12.10	.0084	3212	11.44	.0079	3378	10.88	.0076
90	1:0.11	2742	12.93	.0090	2969	11.94	.0083	3182	11.14	.0077	3382	10.48	.0073	3571	9.92	.0069

DENVER CONDITIONER AND AGITATOR

Tank Size Feet Dia. X Depth	Available Capacity Steel Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	Available Capacity Wood Tank Cu. Ft.	Additional Capacity Per Foot of Depth Cu. Ft.	DENVER CONDITIONER OR AGITATOR—CAPACITY IN DRY TONS PER 24 HOURS Tables Below Are Based on Steel Tank Capacities with Average Ore of 2.6 Sp. Gr.														
					60-Minute Contact			12-Hour Contact			24-Hour Contact			48-Hour Contact			60-Hour Contact		
					Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution			Ratio Solids to Solution		
					1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
24'x16'	6700	452	6230	438	3625	2083	1485	302	174	124	151	87	62	76	43	31	60	35	25
26'x20'	9880	531	9280	515	5346	3072	2189	446	256	183	222	128	91	111	64	46	89	51	36
28'x20'	11520	616	10850	598	....	....	....	520	298	213	259	149	106	130	74	53	104	60	43
30'x20'	13280	707	12550	688	....	....	....	599	344	246	299	172	123	150	86	61	120	69	49
35'x20'	18180	962	17240	940	....	....	....	820	471	336	409	235	168	205	117	84	164	94	67
These figures are the reciprocal of the time in Minutes X Conditioner Factor. This figure X Available Capacity will give tons per 24 hours for any tank. ➡					.5411	.3109	.2216	.0451	.0259	.0185	.0225	.01295	.00923	.01127	.0065	00461	.00901	.00518	.00269

We have often been referred to as the "Diagnosticians of the ore dressing industry." Perhaps we can help you with your mineral recovery problems. Please let us try.

PULP DENSITY TABLES

	SPECIFIC GRAVITY 1.35, CUBIC FT PER TON 23.70			SPECIFIC GRAVITY 1.45, CUBIC FT PER TON 22.07		
Percent Solids	**Spec. Grav.**	**Total Volume**	**Cond. Factor**	**Spec. Grav.**	**Total Volume**	**Cond. Factor**
5	1013	631.70	.4387	1016	630.07	.4375
6	1016	525.14	.3647	1019	523.51	.3635
7	1018	448.98	.3118	1022	497.35	.3107
8	1021	391.70	.2720	1025	390.07	.2709
9	1024	347.22	.2411	1028	345.59	.2400
10	1027	311.70	.2165	1031	310.07	.2153
11	1030	282.58	.1962	1034	280.95	.1951
12	1032	258.26	.1793	1038	256.63	.1782
13	1035	237.78	.1651	1042	236.15	.1640
14	1038	220.18	.1529	1045	218.55	.1518
15	1041	205.14	.1425	1049	203.51	.1413
16	1043	191.70	.1331	1052	190.07	.1320
17	1046	179.86	.1249	1055	178.23	.1259
18	1049	169.62	.1108	1059	167.99	.1167
19	1052	160.02	.1111	1062	158.39	.1100
20	1055	151.70	.1053	1066	150.07	.1042
21	1057	144.02	.1000	1070	142.39	.0989
22	1060	137.30	.0953	1073	135.67	.0942
23	1063	130.90	.0909	1076	129.27	.0898
24	1066	125.14	.0869	1080	123.51	.0858
25	1069	119.70	.0831	1084	118.07	.0820
26	1072	114.90	.0798	1087	113.27	.0787
27	1075	110.10	.0765	1091	108.47	.0753
28	1078	105.94	.0736	1095	104.31	.0724
29	1081	102.10	.0709	1098	100.47	.0698
30	1085	98.26	.0682	1102	96.63	.0671
31	1088	95.06	.0660	1106	93.43	.0649
32	1091	91.86	.0638	1110	90.23	.0627
33	1094	88.66	.0616	1114	87.03	.0604
34	1096	85.78	.0595	1118	84.15	.0584
35	1100	83.22	.0578	1122	81.59	.0567
36	1103	80.66	.0560	1126	79.03	.0549
37	1106	78.10	.0542	1129	76.47	.0531
38	1110	75.86	.0527	1133	74.23	.0515
39	1113	73.62	.0511	1137	71.99	.0500
40	1116	71.70	.0498	1141	70.07	.0487
41	1119	69.78	.0485	1145	68.15	.0473
42	1122	67.86	.0471	1149	66.23	.0460
43	1125	66.26	.0460	1153	64.63	.0449
44	1129	64.34	.0447	1157	62.71	.0435
45	1133	62.74	.0436	1162	61.11	.0424
46	1136	61.14	.0425	1165	59.51	.0413
47	1139	59.86	.0416	1170	58.23	.0404
48	1142	58.26	.0405	1174	56.63	.0393
49	1145	56.98	.0396	1179	55.35	.0384
50	1149	55.70	.0387	1183	54.07	.0375
52	1155	53.14	.0369	1192	51.51	.0358
54	1163	50.90	.0353	1201	49.27	.0342
56	1170	48.98	.0340	1210	47.35	.0329
58	1176	46.74	.0325	1218	45.11	.0313
60	1185	45.14	.0313	1228	43.51	.0302
62	1192	43.22	.0300	1237	41.59	.0289
64	1199	41.62	.0289	1247	39.99	.0278
66	1206	40.34	.0280	1257	38.71	.0269
68	1214	38.74	.0269	1267	37.11	.0258

SPECIFIC GRAVITY	1.50			1.55		
CUBIC FT PER TON	21.33			20.65		
Percent Solids	Spec. Grav.	Total Volume	Cond. Factor	Spec. Grav.	Total Volume	Cond. Factor
5	1017	629.33	.4329	1018	628.65	.4368
6	1020	522.77	.3630	1021	522.09	.3626
7	1024	446.61	.3101	1025	445.93	.3097
8	1028	389.33	.2704	1029	388.65	.2699
9	1031	344.85	.2395	1033	344.17	.2390
10	1034	309.33	.2148	1036	308.65	.2143
11	1037	280.21	.1946	1040	279.53	.1941
12	1041	255.89	.1777	1044	255.21	.1772
13	1045	235.41	.1635	1048	234.73	.1630
14	1049	217.81	.1513	1052	217.13	.1508
15	1053	202.77	.1408	1056	202.09	.1403
16	1056	189.33	.1315	1060	188.65	.1310
17	1060	177.49	.1233	1064	176.81	.1228
18	1064	167.25	.1161	1068	166.57	.1157
19	1068	157.65	.1095	1072	156.97	.1090
20	1072	149.33	.1037	1077	148.65	.1032
21	1076	141.65	.0984	1081	140.97	.0979
22	1079	134.93	.0937	1085	134.25	.0932
23	1083	128.53	.0893	1089	127.85	.0888
24	1087	122.77	.0653	1093	122.09	.0848
25	1091	117.33	.0815	1098	116.65	.0810
26	1095	112.53	.0781	1102	111.85	.0777
27	1099	107.73	.0748	1106	107.05	.0743
28	1103	103.57	.0719	1110	102.89	.0715
29	1107	99.73	.0693	1114	99.05	.0688
30	1111	95.89	.0666	1119	95.21	.0661
31	1115	92.69	.0644	1123	92.01	.0639
32	1120	89.49	.0621	1128	88.81	.0617
33	1124	86.29	.0599	1133	85.61	.0595
34	1129	83.41	.0579	1138	82.73	.0575
35	1133	80.85	.0561	1142	80.17	.0557
36	1137	78.29	.0544	1147	77.61	.0539
37	1141	75.73	.0526	1151	75.05	.0521
38	1145	73.49	.0510	1156	72.81	.0506
39	1149	71.25	.0495	1160	70.57	.0490
40	1153	69.33	.0481	1165	68.65	.0477
41	1158	67.41	.0468	1170	66.73	.0463
42	1162	65.49	.0455	1175	64.81	.0450
43	1167	63.89	.0444	1180	63.21	.0439
44	1171	61.97	.0430	1185	61.29	.0426
45	1176	60.37	.0419	1190	59.69	.0415
46	1180	58.77	.0408	1194	58.09	.0403
47	1185	57.49	.0399	1199	56.81	.0395
48	1190	55.89	.0388	1205	55.21	.0388
49	1195	54.61	.0379	1210	53.93	.0375
50	1200	53.33	.0370	1215	52.65	.0366
52	1210	50.77	.0353	1226	50.09	.0348
54	1220	48.53	.0337	1237	47.85	.0332
56	1230	46.61	.0324	1248	45.93	.0319
58	1240	44.37	.0308	1259	43.69	.0303
60	1250	42.77	.0297	1270	42.09	.0292
62	1260	40.85	.0284	1282	40.17	.0279
64	1271	39.25	.0273	1294	38.57	.0268
66	1282	37.97	.0264	1306	37.29	.0259
68	1293	36.37	.0253	1318	35.69	.0248

1.60			1.65			1.70		
20.00			19.39			18.82		
Spec. Grav.	Total Volume	Cond. Factor	Spec. Grav.	Total Volume	Cond. Factor	Spec. Grav.	Total Volume	Cond. Factor
1019	629.00	.4361	1020	627.39	.4357	1021	626.82	.4352
1022	521.44	.3621	1024	520.83	.3617	1025	520.26	.3613
1026	445.28	.3092	1028	444.67	.3088	1030	444.10	.3084
1030	388.00	.2694	1032	387.39	.2690	1034	386.82	.2686
1034	343.52	.2386	1036	342.91	.2381	1038	342.34	.2377
1038	308.00	.2138	1041	307.39	.2135	1043	306.82	.2131
1042	278.88	.1937	1045	278.27	.1932	1047	277.70	.1928
1046	254.56	.1768	1049	253.95	.1764	1052	253.38	.1760
1050	234.08	.1625	1054	233.47	.1621	1057	232.90	.1617
1054	216.48	.1503	1058	215.87	.1499	1062	215.30	.1495
1059	201.44	.1399	1063	200.83	.1409	1067	200.26	.1391
1063	188.00	.1306	1067	187.39	.1301	1072	186.82	.1297
1067	176.16	.1223	1071	175.55	.1219	1076	174.98	.1215
1072	165.92	.1152	1076	165.31	.1148	1080	164.74	.1144
1076	156.32	.1086	1081	155.71	.1081	1084	155.14	.1077
1081	148.00	.1028	1086	147.39	.1024	1089	146.82	.1020
1085	140.32	.0974	1090	139.71	.0970	1094	139.14	.0966
1090	133.60	.0928	1095	132.99	.0924	1099	132.42	.0920
1094	127.20	.0883	1099	126.59	.0879	1104	126.02	.0875
1099	121.44	.0843	1104	120.83	.0839	1109	120.26	.0835
1104	116.00	.0806	1109	115.39	.0801	1115	114.82	.0797
1108	111.20	.0772	1114	110.59	.0768	1121	110.02	.0764
1112	106.40	.0739	1119	105.79	.0735	1126	105.22	.0731
1117	102.24	.0710	1124	101.63	.0706	1131	101.26	.0703
1121	98.40	.0683	1129	97.79	.0679	1136	97.22	.0675
1126	94.56	.0657	1134	93.95	.0652	1142	93.38	.0648
1131	91.36	.0634	1139	90.75	.0630	1147	90.18	.0626
1136	88.16	.0612	1144	87.55	.0608	1152	86.98	.0604
1141	84.96	.0590	1149	84.35	.0586	1157	83.78	.0582
1146	82.08	.0570	1154	81.47	.0566	1162	80.90	.0562
1151	79.52	.0592	1160	78.91	.0548	1168	78.34	.0544
1156	76.96	.0534	1165	76.35	.0530	1174	75.78	.0526
1161	74.40	.0517	1171	73.79	.0512	1180	73.22	.0508
1166	72.16	.0501	1176	71.55	.0497	1186	70.98	.0493
1171	69.92	.0486	1182	69.31	.0481	1192	68.74	.0477
1176	68.00	.0472	1188	67.39	.0468	1198	66.82	.0464
1181	66.08	.0459	1193	65.47	.0455	1203	64.90	.0451
1187	64.16	.0446	1198	63.55	.0441	1209	62.98	.0437
1192	62.56	.0434	1203	61.95	.0430	1215	61.38	.0426
1198	60.64	.0421	1209	60.03	.0417	1221	59.46	.0413
1203	59.04	.0410	1215	58.43	.0406	1227	57.86	.0402
1208	57.44	.0399	1221	56.83	.0395	1233	56.26	.0391
1213	56.16	.0390	1227	55.55	.0386	1239	54.98	.0382
1219	54.56	.0379	1233	53.95	.0375	1246	53.38	.0371
1224	53.28	.0370	1239	52.67	.0366	1252	52.10	.0362
1230	52.00	.0361	1245	51.39	.0357	1259	50.87	.0353
1242	49.44	.0343	1257	48.83	.0339	1272	48.26	.0335
1254	47.20	.0328	1270	46.59	.0324	1286	46.02	.0320
1266	45.28	.0314	1283	44.67	.0310	1300	44.10	.0306
1278	43.04	.0299	1296	42.43	.0295	1310	41.86	.0291
1290	41.44	.0288	1309	40.83	.0284	1328	40.26	.0280
1303	39.52	.0274	1323	38.91	.0270	1343	38.34	.0266
1316	37.92	.0263	1337	37.31	.0259	1358	36.74	.0255
1329	36.64	.0254	1351	36.03	.0250	1373	35.46	.0246
1342	35.04	.0243	1366	34.43	.0239	1388	33.86	.0235

PULP DENSITY TABLES

Percent Solids	Spec. Grav. (S.G. 1.75; 18.29 cu ft per ton)	Total Volume (S.G. 1.75; 18.29 cu ft per ton)	Cond. Factor (S.G. 1.75; 18.29 cu ft per ton)	Spec. Grav. (S.G. 1.85; 17.30 cu ft per ton)	Total Volume (S.G. 1.85; 17.30 cu ft per ton)	Cond. Factor (S.G. 1.85; 17.30 cu ft per ton)	Percent Solids
5	1022	626.29	.4349	1023	625.30	.4342	5
6	1026	519.73	.3609	1028	518.74	.3602	6
7	1031	443.57	.3080	1033	442.58	.3073	7
8	1036	386.29	.2683	1038	385.30	.2676	8
9	1040	341.81	.2375	1043	340.82	.2367	9
10	1045	306.29	.2127	1048	305.30	.2120	10
11	1049	277.17	.1925	1053	276.18	.1918	11
12	1054	252.85	.1756	1058	251.86	.1749	12
13	1059	232.37	.1614	1063	231.38	.1607	13
14	1064	214.77	.1491	1068	213.78	.1482	14
15	1069	199.73	.1387	1074	198.74	.1380	15
16	1074	186.29	.1294	1079	185.30	.1287	16
17	1079	174.45	.1211	1084	173.46	.1205	17
18	1084	164.21	.1140	1090	163.22	.1133	18
19	1088	154.61	.1074	1095	153.62	.1067	19
20	1094	146.29	.1016	1101	145.30	.1009	20
21	1099	138.61	.0963	1106	137.62	.0956	21
22	1103	131.89	.0916	1112	130.90	.0909	22
23	1109	125.49	.0871	1118	124.50	.0865	23
24	1114	119.73	.0831	1124	118.74	.0825	24
25	1120	114.29	.0793	1130	113.30	.0787	25
26	1126	109.49	.0760	1136	108.50	.0753	26
27	1131	104.69	.0727	1142	103.70	.0720	27
28	1137	100.53	.0698	1148	99.54	.0691	28
29	1142	96.69	.0671	1154	95.70	.0665	29
30	1148	92.85	.0642	1160	91.86	.0638	30
31	1154	89.65	.0623	1166	88.06	.0616	31
32	1159	86.45	.0600	1172	85.46	.0593	32
33	1165	83.25	.0578	1179	82.26	.0574	33
34	1170	80.37	.0558	1185	79.38	.0551	34
35	1176	77.81	.0540	1192	76.82	.0533	35
36	1182	75.25	.0523	1198	74.26	.0516	36
37	1189	72.69	.0505	1205	71.70	.0499	37
38	1195	70.45	.0489	1211	69.46	.0482	38
39	1201	68.21	.0474	1218	67.22	.0467	39
40	1208	66.29	.0460	1225	65.30	.0453	40
41	1213	64.37	.0447	1232	63.38	.0440	41
42	1220	62.45	.0434	1239	61.46	.0427	42
43	1226	60.85	.0423	1246	59.86	.0416	43
44	1232	58.93	.0409	1253	57.94	.0402	44
45	1238	57.33	.0398	1261	56.34	.0391	45
46	1245	55.73	.0387	1268	54.74	.0380	46
47	1252	54.45	.0378	1276	53.46	.0371	47
48	1259	52.85	.0367	1283	51.86	.0360	48
49	1265	51.57	.0358	1291	50.58	.0351	49
50	1272	50.29	.0349	1299	49.30	.0342	50
52	1287	47.73	.0331	1315	46.74	.0325	52
54	1301	45.49	.0316	1331	44.50	.0309	54
56	1316	43.57	.0303	1348	42.58	.0296	56
58	1331	41.33	.0287	1364	40.34	.0280	58
60	1346	39.73	.0276	1381	38.74	.0269	60
62	1362	37.80	.0263	1399	36.82	.0256	62
64	1378	36.21	.0251	1418	35.22	.0245	64
66	1394	34.93	.0243	1437	33.94	.0236	66
68	1411	33.33	.0231	1456	32.34	.0225	68

SPECIFIC GRAVITY OF PULPS

Number of U.S. Gallons Per Minute equivalent to 1 ton of dry solids per 24 hours in pulps of various water-solid ratios.

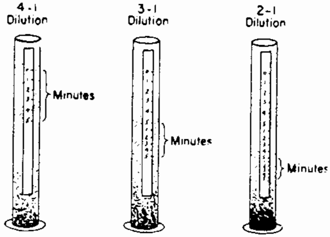
WATER-SOLID RATIO: % Solids by Weight	WATER-SOLID RATIO: Ratio Solids To Solution		Specific Gravity of the Dry Solids in the Pulp: 1.4	2.2	2.6	2.7	2.8	2.9	3.0	3.2	3.4	3.8	4.2	5.0
5	1 : 19.00	Sp. Gr. of Pulp	1.02	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.01
		U.S. G. P. M.	**3.28**	**3.24**	**3.23**	**3.22**	**3.22**	**3.22**	**3.22**	**3.21**	**3.21**	**3.21**	**3.20**	**3.19**
10	1 : 9.00	Sp. Gr. of Pulp	1.03	1.06	1.07	1.07	1.07	1.07	1.07	1.07	1.08	1.08	1.08	1.09
		U.S. G. P. M.	**1.62**	**1.57**	**1.56**	**1.56**	**1.56**	**1.56**	**1.55**	**1.55**	**1.55**	**1.54**	**1.54**	**1.53**
15	1 : 5.67	Sp. Gr. of Pulp	1.05	1.09	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.14
		U.S. G. P. M.	**1.06**	**1.02**	**1.01**	**1.01**	**1.00**	**1.00**	**1.00**	**1.00**	**0.99**	**0.99**	**0.98**	**0.98**
20	1 : 4.00	Sp. Gr. of Pulp	1.06	1.12	1.14	1.14	1.15	1.15	1.15	1.16	1.16	1.17	1.18	1.19
		U.S. G. P. M.	**0.78**	**0.74**	**0.73**	**0.73**	**0.73**	**0.72**	**0.72**	**0.72**	**0.71**	**0.71**	**0.71**	**0.70**
25	1 : 3.00	Sp. Gr. of Pulp	1.08	1.16	1.18	1.19	1.19	1.20	1.20	1.21	1.21	1.23	1.24	1.25
		U.S. G. P. M.	**0.62**	**0.57**	**0.56**	**0.56**	**0.56**	**0.56**	**0.55**	**0.55**	**0.55**	**0.54**	**0.54**	**0.53**
30	1 : 2.33	Sp. Gr. of Pulp	1.09	1.20	1.23	1.23	1.24	1.25	1.25	1.26	1.27	1.28	1.30	1.32
		U.S. G. P. M.	**0.51**	**0.46**	**0.45**	**0.45**	**0.45**	**0.45**	**0.44**	**0.44**	**0.44**	**0.43**	**0.43**	**0.42**
35	1 : 1.86	Sp. Gr. of Pulp	1.11	1.24	1.27	1.28	1.29	1.30	1.30	1.32	1.33	1.35	1.36	1.39
		U.S. G. P. M.	**0.43**	**0.39**	**0.37**	**0.37**	**0.37**	**0.37**	**0.37**	**0.36**	**0.36**	**0.35**	**0.35**	**0.34**
40	1 : 1.50	Sp. Gr. of Pulp	1.13	1.28	1.33	1.34	1.35	1.36	1.36	1.38	1.39	1.42	1.44	1.47
		U.S. G. P. M.	**0.37**	**0.33**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**	**0.30**	**0.30**	**0.29**	**0.29**	**0.28**
45	1 : 1.22	Sp. Gr. of Pulp	1.15	1.33	1.38	1.40	1.41	1.42	1.43	1.45	1.47	1.50	1.52	1.56
		U.S. G. P. M.	**0.32**	**0.28**	**0.27**	**0.26**	**0.26**	**0.26**	**0.26**	**0.26**	**0.25**	**0.25**	**0.24**	**0.24**
50	1 : 1.00	Sp. Gr. of Pulp	1.17	1.38	1.44	1.46	1.47	1.49	1.50	1.52	1.55	1.58	1.62	1.67
		U.S. G. P. M.	**0.29**	**0.24**	**0.23**	**0.23**	**0.23**	**0.22**	**0.22**	**0.22**	**0.22**	**0.21**	**0.21**	**0.20**
55	1 0.82	Sp. Gr. of Pulp	1.19	1.43	1.51	1.53	1.55	1.57	1.58	1.61	1.63	1.68	1.73	1.79
		U.S. G. P. M.	**0.26**	**0.21**	**0.20**	**0.20**	**0.19**	**0.19**	**0.19**	**0.19**	**0.19**	**0.18**	**0.18**	**0.17**
60	1 : 0.67	Sp. Gr. of Pulp	1.21	1.49	1.59	1.61	1.63	1.65	1.67	1.70	1.74	1.79	1.84	1.92
		U.S. G. P. M.	**0.23**	**0.19**	**0.15**	**0.17**	**0.17**	**0.17**	**0.17**	**0.16**	**0.16**	**0.16**	**0.15**	**0.14**
65	1 : 0.54	Sp. Gr. of Pulp	1.23	1.55	1.67	1.70	1.72	1.74	1.76	1.81	1.85	1.92	1.99	2.08
		U.S. G. P. M.	**0.21**	**0.17**	**0.15**	**0.15**	**0.15**	**0.35**	**0.15**	**0.14**	**0.14**	**0.13**	**0.13**	**0.12**
70	1 : 0.43	Sp. Gr. of Pulp	1.25	1.62	1.76	1.79	1.82	1.85	1.88	1.93	1.98	2.07	2.14	2.27
		U.S. G. P. M.	**0.19**	**0.15**	**0.14**	**0.13**	**0.13**	**0.13**	**0.13**	**0.12**	**0.12**	**0.12**	**0.11**	**0.10**

Determining Thickener Capacities

The thickener capacity required to handle a pre-determined tonnage of a certain pulp, by overflowing a clear solution and obtaining the desired pulp density of thickener discharge, depends upon the settling rate of that particular pulp. The settling rate of any pulp is easily determined by simple laboratory tests such as outlined below:

Laboratory Test Method

Place a measured quantity of pulp at a known density in a beaker or glass cylinder. Fix a narrow strip of paper on one side of the container. Mix pulp thoroughly. Draw a line on the paper at the top of the pulp and mark "0" minutes. For five minutes, at one-minute intervals, mark the point to which the solids have settled. This determines the free settling rate of the solids at the initial density.



Usually readings should be taken at three different densities of the pulp corresponding approximately to densities which will exist in the various zones in the thickener.

Decant sufficient clear water or solution to establish a pulp with intermediate density. For instance, if initial pulp density was 4:1, water to solids, the removal of one-fourth of the water would establish a density of 3:1. Mix thoroughly. Repeat readings of settlement as above.

Then decant again to obtain a pulp at the third density. The pulp just tested was at 3:1 dilution, so decanting one-third of the water will give 2:1 dilution. water to solids. Mix thoroughly. Repeat settling measurements at one-minute intervals for five minutes.

The settling rate per minute should be uniform during the testing at each dilution, until compression is reached. at which time the amount of settling will decrease during each succeeding minute. Measure the settling marks in

inches, thus determining the settling rate in inches per minute for each pulp density, and convert this to feet per hour.

Determining Final Density

Final density is then determined Thoroughly mix the pulp remaining after the test at 2:1 dilution and allow to settle for 19 hours. Mark the position of settled pulp and let stand for a few hours to see if final density was reached. If pulp continues to settle, mark its position at hourly intervals until settling stops. Decant off all clear water or solution. Then determine moisture content of pulp by weighing and drying.

Calculating Thickener Area

Thickener area required is then calculated by applying above determined data in the following formula:

$$A = \frac{1.333\ (F-D)}{R}$$

A = Thickener area in square feet per ton of dry solids thickened in 24 hours.

F = Initial density (Parts Water to Solids by weight).

D = Final density to which pulp will settle or density at which you want to discharge pulp from thickener.*

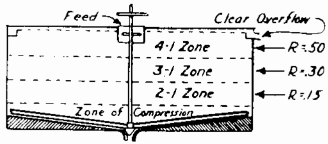
R = Settling rate in feet per hour.

*Usually it is desired to discharge pulp from the thickener at its final density as shown in the above test. However, if you want to discharge pulp more diluted than the actual final density, the density desired should be used in above formula rather than the final density to which the pulp will settle.

Calculations of indicated thickener area from each of the three settling rates obtained in tests will indicate any change in settling rate in the different zones of the thickener, and the largest area obtained from the three calculations should be used.

Assume the following data was obtained from the above tests:

At 4:1 dilution R = 0.50 feet per hour
At 3:1 dilution R = 0.30 feet per hour
At 2:1 dilution R = 0.15 feet per hour
Final density D = 1:1



Applying this data to above formula. you obtain:

$$A = \frac{1.33\ (4-1)}{.50} = 7.98$$

$$A = \frac{1.33\ (3-1)}{.30} = 8.86$$

$$A = \frac{1.33\ (2-1)}{15} = 8.87$$

Factor of Safety

Normally a 25 per cent factor of safety is allowed in determining the thickener area size. Thus, in the above case, 8.87 (largest of three figures) plus 25 per cent factor of safety, equals 11.09 square feet area required per ton of dry solids fed to the thickener per 24 hours.

If the pulp reached its final density during the 19 hour test, a standard depth thickener is considered adequate. However, if additional time was required to reach final density, the thickener volume would have to be large enough to retain the pulp for this extra time.

Standard thickener depths are as follows:

Thickener Diameter	Standard Thickener Depth
5′ to 7′	4′
8′ to 11′	6′
12′ to 25′	8′
26′ to 40′	10′

Storage Capacity

Another factor to be considered is the storage capacity desired in a thickener. For example, it may be necessary to shut a filter down for repairs and at the same time keep the balance of the mill in operation. In this case the thickener will act as a storage reservoir. Where storage capacity in a thickener is of importance such as in many of the non-metallic flotation plants, a larger factor of safety should be applied in calculating the area. Greater depth should not be used unless the lift of the thickener mechanism can also be increased.

Duplicating Thickener Action

Many times a pulp standing without agitation will not settle to as low a final density as when aided by movement of thickener rakes in actual operation. The DECO Test Laboratory developed a miniature thickener mechanism which is used in determining final density under actual operating conditions.

LIQUID-SOLID RELATIONSHIPS

Specific Gravity—Specific Volume

Practically all metals occur as minerals in the earth's crust. One of the most important characteristics of minerals is the relative weight, usually measured as specific gravity.

The specific gravity of a solid or liquid is the ratio of its weight to the weight of an equal volume of water under standard conditions. Density is any weight/volume relationship, including specific gravity. The specific gravity of water is 1.000 at 4° C.

WATER at maximum density, 4° C., 39° F.

1 cu. ft. weighs 62.4283 lbs. = 28.317 kilogram. 1 cu. in. = 0.578 oz.
1 cu. centimeter (cc) weighs 1 gram.
1 ton equals 32.04 cu. ft. under above conditions.
1 ton equals 32.2 cu. ft. at 90° F.

The above value will be reduced by impurities always present in ordinary tap water, so that a value of 32 cu. ft. per ton (32 C.F.P.T.) may be used in ordinary mill calculations.

Sea water contains in solution about 3.44% soluble salts (of which 2.5 is common salt), weighs 64.176 lbs. per cubic foot, average 31.13 C.F.P.T. and 1.028 specific gravity. The concentrated waters in Great Salt Lake and the Dead Sea contain about 22.4% soluble salts, weigh 73.5 lbs. per cubic foot, average 27.2 C.F.P.T., and 1.17 specific gravity.

The reciprocal of specific gravity is specific volume. A more convenient form of specific volume for use in mill calculations is cubic-feet-per-ton (C.F.P.T.);

$$\text{specific gravity} = \frac{32}{\text{C.F.P.T.}} \qquad \text{C.F.P.T.} = \frac{32}{\text{Sp. G.}}$$

Determination of specific gravity and CFPT: Solids; weigh up 32 grams of dry solids in small enough pieces to pour into a 50 cc. glass graduate; fill the latter to a definite mark, 25 cc. or 30 cc.; pour in the solids; the rise in cc. is C.F.P.T., and $\frac{32}{\text{C.F.P.T.}}$ is the specific gravity. For more accurate work use 320 grams and a 500 cc. graduate, and divide rise by 10 for C.F.P.T.

This method may be used for pulps, except for the sticking of solids to the side of the graduate; the usual method is with a sp. g. flask. Fill the flask to the mark, weigh it, deduct the empty weight of flask, and divide the net weight in grams by the volume in cc., which gives sp. g.

The following relations exist between the constituents of a mixture which contains no voids, such as a pulp, or a rock.

$$aF_a + bF_b = (a + b)\,F_c, \text{ by weight}$$
$$AG_a + BG_b = (A + B)\,G_c, \text{ by volume}$$

where a and b are fractional parts (usually totalling 100%) by weight; A and B are fractional parts by volume; F_a, F_b and F_c are C.F.P.T. of the two substances and their combinations; G_a, G_b and G_c are specific gravities of the two substances and their combination.

Pulps and Circulating Loads

The following formulæ, derived from the fundamentals, are useful in pulp calculations:

$$\text{S, percent solids in pulp} = 100\,\frac{32 - F_p}{32 - F_s} = 100\,\frac{G_p - 1}{G_s - 1} \times \frac{G_s}{G_p}$$

$$100 - \text{S, percent water in pulp} = 100\,\frac{F_p - F_s}{32 - F_s} = 100\,\frac{G \;\; - G_p}{(G_s - 1)\,G_p}$$

$$\text{Cubic feet pulp per ton dry solids} = F_p\,\frac{32 - F_s}{32 - F_p} = 32\,\frac{(G_s - 1)}{(G_p - 1)\,G_s}$$

F and G refer to C.F.P.T. and sp. g.; subscripts $_p$ and $_s$ to pulps and solids. Similar formulæ applied to moisture values are useful for calculations on circulating loads from classifiers, and for thickeners, particularly for operations:

F, S, and Q are dry tons of feed, sands and overflow.
f, s and q are percent of moisture in feed, sands and overflow.

$$F = S + Q;\ \frac{F}{100 - f} = \frac{Q}{100 - q} + \frac{S}{100 - s}$$

$$S = F\frac{100 - s}{100 - f} \times \frac{q - f}{q - s}$$

$$Q = F\frac{100 - q}{100 - f} \times \frac{f - s}{q - s}$$

$$F = Q\frac{100 - f}{100 - q} \times \frac{q - s}{f - s} = S\frac{100 - f}{100 - s} \times \frac{q - s}{q - f}$$

Five quantities must be known to find the other.

The following method of calculating the circulating load in closed circuited grinding is from F. C. Bond, A.I.M.E., Mining & Metallurgy, November 1937:

$$L = \frac{M - DF}{D - S} = \frac{PF - C - DF}{D - S}$$

Where L is dry tons per hour of classifier returned Sand.
F is dry tons per hour of new feed to mill.
D is dilution (parts liquid to 1 part solids) mill Discharge.
S is dilution (parts liquid to 1 part solids) classifier Sand.
P is dilution (parts liquid to 1 part solids) classifier Overflow.
C is tons per hour, new water added to classifier.
M is tons per hour, new water added to mill feed, including moisture in ore.

The circulating load relationship is expressed also by the following:

$$Q = \frac{100T}{100 - P}$$

Where Q is total dry tons per hour or day through the grinding unit.
T is total dry tons per hour or day, initial feed, and overflow.
P is returned sands in percent of Q.

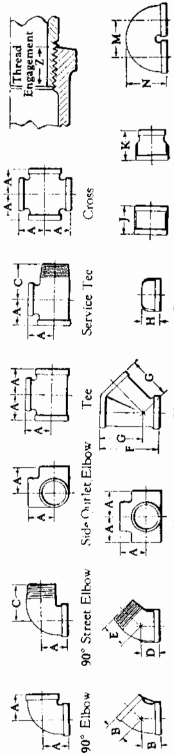
NUMBER OF U.S. GALLONS OF PULP PER MINUTE
Required to Deliver 100 Tons (2000 lbs. per ton) of Dry Solids in 24 Hours

Specific Gravity of Solids in Pulp	Percent Water by Weight in Pulp															
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
2.5	9.70	10.90	12.23	13.96	15.69	17.95	21.94	23.40	27.13	31.78	38.03	45.75	56.92	73.68	100.54	157.47
2.6	9.44	10.64	11.97	13.69	15.42	17.68	21.67	23.14	26.86	31.65	37.77	45.48	56.65	73.41	100.28	157.20
2.7	9.17	10.37	11.70	13.43	15.16	17.42	21.41	22.87	26.60	31.38	37.50	45.22	56.39	73.15	100.01	156.94
2.8	9.04	10.10	11.57	13.16	15.02	17.15	21.28	22.74	26.46	31.12	37.24	44.95	56.25	72.88	99.88	156.80
2.9	8.77	9.97	11.30	13.03	14.89	17.02	21.01	22.47	26.20	30.98	37.10	44.82	55.99	72.75	99.75	156.67
3.0	8.64	9.70	11.17	12.76	14.76	16.75	20.88	22.34	26.06	30.72	36.84	44.55	55.72	72.61	99.48	156.40
3.1	8.37	9.57	10.90	12.63	14.49	16.62	20.61	22.21	25.80	30.59	36.70	44.42	55.59	72.35	99.35	156.14
3.2	8.24	9.31	10.77	12.50	14.23	16.49	20.48	21.94	25.66	30.32	36.57	44.28	55.46	72.21	99.21	156.00
3.3	8.11	9.17	10.64	12.36	14.09	16.35	20.34	21.81	25.53	30.19	36.44	44.02	55.32	72.08	98.95	155.87

Formula; $U.S.G.P.M. = T \times .1675 \left(\frac{W}{R} + \frac{1}{SpGr}\right)$

T = Tons of dry solids delivered by pulp in 24 hours.
SpGr = Specific Gravity of the dry solids.
W = % by Wt. of water in the pulp.
R = % by Wt. of dry solids in the pulp.

Standard Malleable Iron Fittings
Dimensions, in Inches



Size	A	B	C	D	E	F	G	H	J	K	Z
1/8	11/16	1/2	1	11/16	13/16			9/16	15/16		1/4
1/4	13/16	3/4	1 3/16	5/8	15/16			5/8	1 1/16	1	3/8
3/8	15/16	13/16	1 7/16	11/16	1 1/16	2 1/8	1 7/16	3/4	1 3/16	1 1/8	3/8
1/2	1 1/8	7/8	1 5/8	13/16	1 3/16	2 7/16	1 11/16	7/8	1 5/16	1 1/4	1/2
3/4	1 5/16	1	1 7/8	15/16	1 5/16	2 13/16	2 1/16	1 1/16	1 1/2	1 7/16	9/16
1	1 1/2	1 1/8	2 1/8	1 1/16	1 1/2	3 3/8	2 7/16	1 3/16	1 11/16	1 11/16	11/16
1 1/4	1 3/4	1 5/16	2 7/16	1 1/4	1 11/16	4 1/16	2 15/16	1 1/4	1 15/16	2 1/16	11/16
1 1/2	1 15/16	1 7/16	2 11/16	1 3/8	1 7/8	4 1/2	3 5/16	1 5/16	2 1/8	2 5/16	11/16
2	2 1/4	1 11/16	3 1/4	1 11/16	2 1/4	5 7/16	4	1 7/16	2 1/2	2 13/16	3/4
2 1/2	2 11/16	1 15/16	3 13/16	1 7/8	2 9/16	6 1/4	4 11/16	1 5/8	2 7/8	3 1/4	15/16
3	3 1/8	2 3/16	4 1/2	2 1/8	3	7 1/4	5 9/16	1 3/4	3 3/16	3 11/16	1
3 1/2	3 7/16	2 3/8	5 1/8	2 3/8	3 3/8			1 15/16	3 7/16	4	1 1/16
4	3 3/4	2 5/8	5 11/16	2 1/2	3 3/4	8 7/8	6 15/16	2 1/16	3 11/16	4 3/8	1 1/8
5	4 1/2	3 1/16	6 7/8					2 5/16	4 1/4	3 7/8	1 1/4
6	5 1/8	3 7/16	8					2 9/16	4 3/4	4 3/8	1 5/16

Return Bends								
Size	M	N	Size	M	N	Size	M	N
Close Pattern			Open Pattern			Wide Pattern		
1/2	1	1 3/4	1/2	1 1/2	1 7/8	3/8	1 1/2	1 5/8
3/4	1 1/4	2 3/16	3/4	2	2 1/4	3/4	4	3 3/16
1	1 1/2	2 1/2	1	2 1/2	2 5/8	3/4	6	4 1/2
1 1/4	1 3/4	2 13/16	1 1/4	3	3 3/16	1	6	4 1/2
1 1/2	2 3/16	3 3/16	1 1/2	3 1/2	3 5/8	1 1/4	6	4 3/4
2	2 5/8	3 7/8	2	4	4 3/8	1 1/2	6	5
Medium Pattern			2 1/2	4 1/2	4 15/16	2	5	4 3/4
1/2	1 1/4	1 5/8	3	5	5 9/16	2	6	5 5/16
3/4	1 1/2	1 15/16	4	6	6 11/16	3	7 1/2	6 13/16
1	1 7/8	2 1/4				3	8	6 13/16
1 1/4	2 1/4	2 13/16				6	12	11 1/16
1 1/2	2 1/2	3 3/16						
2	3	3 7/8						

Please contact Denver Equipment for current process for any and all of your mill requirements. All we ask is the opportunity to work with you and we will gladly supply current prices and delivery information upon request.

Ratio of Concentration by Assay

In calculating the Ratio of Concentration (R) of one mineral operations, the following formula has been found very useful. Assays of heads, concentrate, and tailing are required.

Explanation of Symbols	Assay
Heads	H
Tailing	T
Concentrate	C
Ratio of Concentration	R

Formula

$$R = \frac{C - T}{H - T}$$

Mill Water Requirements

Tons Ore Fed per 24 Hrs.	Dilutions 3 : 1 Tons Water per 24 Hrs.	3 : 1 Gals. Water per Min.	4 : 1 Tons Water per 24 Hrs.	4 : 1 Gals. Water per Min.	5 : 1 Tons Water per 24 Hrs.	5 : 1 Gals. Water per Min.	6 : 1 Tons Water per 24 Hrs.	6 : 1 Gals. Water per Min.
10	30	5.0	40	6.7	50	8.3	60	10.0
15	45	7.5	60	10.0	75	12.5	90	15.0
20	60	10.0	80	13.3	100	16.6	120	20.0
25	75	12.5	100	16.6	125	20.8	150	25.0
35	105	17.5	140	23.3	175	29.3	210	35.0
50	150	25.0	200	33.3	250	41.7	300	50.0
65	195	32.5	260	43.3	325	54.2	390	65.0
100	300	50.0	400	66.7	500	83.4	600	100.0
125	375	62.5	500	83.4	625	104.0	750	125.0
150	450	75.0	600	100.0	750	125.0	900	150.0
200	600	100.0	800	133.3	1000	166.6	1200	200.0
300	900	150.0	1200	200.0	1500	250.0	1800	300.0
500	1500	250.0	2000	333.3	2500	417.0	3000	500.0

Machines	Water to Ore Ratios	Machines	Water to Ore Ratios
Harz Type Jigs	3:1 to 5:1	Stamps—Gravity	3:1 to 6:1
Flotation Machines (Oxidized Ore)	2:1 to 3:1	Ball and Rod Mills	1:1 to 1:4
Flotation Machines (Sulphide Ore)	3:1 to 5:1	Hydraulic Classifiers	3:1 to 10:1
Cyanide Slime Agitators	1:1 to 2:1	Screens	1:1 to 3:1
Thickener Discharge	1:1 to 2:1	Concentrating Tables	2:1 to 5:1
Filter Discharge	1:20 to 1:5	Denver Mineral Jigs	1:1 to 2:1

Average Cyanide Circuits	1 to 3 Tons Water : Ton Ore.
Average Flotation Circuits	3 to 5 Tons Water : Ton Ore.
Average Table Circuits	5 to 7 Tons Water : Ton Ore.
Average Jig and Table Circuits	6 to 10 Tons Water : Ton Ore.
Average Table and Amalgam.	8 to 12 Tons Water : Ton Ore.

1 Gallon Water = 8.33 pounds = 3.785 Liters.
1 Ton Water = 240 gallons = 908.49 Liters.
1 Cubic Foot = 7.48 gallons.
G.P.M. = Tons of Water per 24 Hrs. x 0.16643.

Resistance to Crushing for Various Materials

Approximate values in pounds per square inch

Material	Resistance to Crushing in Lbs. per Sq. In.	Material	Resistance to Crushing in Lbs. per Sq. In.
Brick:			
Soft burned	3000-6000	Granite	9700-34000
Hard burned	4500-6500	Limestone	6000-25000
Vitrified	8500-25000	Marble	7600-20700
Brownstone	7300-23600	Sandstone	2400-29300
Concrete	800-3800	Tufa	7700-11600

DRYING ORES AND CONCENTRATES

Heat and Coal

To Drive off Moisture (theoretical) per Ton (2,000 lbs.) of Dry Material
(Condensed from Ruggles-Coles Eng. Co., Cat. No. 16)

Moisture, %	Water, lbs.	At 100% Efficiency Total B.T.U.	At 100% Efficiency Coal, lbs.	Moisture, %	Water, lbs.	At 100% Efficiency Total B.T.U.	At 100% Efficiency Coal, lbs.
1	20	86,200	7.2	25	667	809,550	67.5
2	41	109,680	9.2	30	857	1,021,970	85
4	83	156,530	13.1	35	1,077	1,267,930	106
6	128	207,940	17.7	40	1,333	1,554,130	130
8	174	258,370	21.5	50	2,000	2,299,840	193
10	222	312,040	26.0	60	3,000	3,417,840	285
12	273	369,050	30.8	70	4,667	5,280,430	440
14	325	427,190	35.6	80	8,000	9,007,840	756
16	381	489,800	40.8	85	13,333	12,734,090	1,060
18	439	554,640	46.2	90	18,000	20,188,000	1,680
20	500	622,840	52	95	38,000	42,548,000	3,550

Total B.T.U. include 63,840 B.T.U. to raise temperature of material from 60° F. to 212° F. at which point evaporation takes place (at sea level); specific heat of material taken as 0.21.

Coal assumed to have 12,000 B.T.U. per lb. as used and is for 100% efficiency as specified. Table of coal added to original data by The General Engineering Company.

ROTARY DRYERS have efficiencies of 50% to 70%; coal consumption may be determined from the above table by subtracting pounds of coal corresponding to percent moisture in the dried product from the pounds of coal to percent moisture in the feed, and dividing by the efficiency expressed decimally.

Capacity 250 to 660 lbs. water evaporated per sq. ft. of section per 24 hours.

Rabble Dryers are frequently used for drying concentrates; generally have a cast iron bottom, heated on the under side; the material being dried is moved along, counter to the flow of the heating gases, by rabbles; evaporated moisture usually goes direct into the room.

Capacity: 50 to 75 pounds of water evaporated per 24 hours, per sq. ft.

Power: 3 to 10 H.P. hours per ton of water evaporated.

Fuel efficiency: About 50% at maximum rating; may go down to 30% on reduced load.

The usual practice on flotation concentrates is to remove by drying about half to three-fourths of the moisture in the filter cake, which runs from 8% to 30%.

DENVER EQUIPMENT COMPANY CONTINUOUS PILOT PLANT TESTING EQUIPMENT

Name of Machine	50 to 150 Size Designation	50 to 150 HP Motor	50 to 150 Ship. Wt. Pounds	200 to 500 Size Designation	200 to 500 HP Motor	200 to 500 Ship. Wt. Pounds	1500 to 2500 Size Designation	1500 to 2500 HP Motor	1500 to 2500 Ship. Wt. Pounds
Coarse Ore Bin	5 ton	—	950	10 ton	—	1350	25 ton	—	2300
Denver Belt Ore Feeder	9"	¼	550	12"	½	900	18"	1	1400
Denver Jaw Crusher	5"x6"	5	1130	5"x6"	5	1130	8"x10"	10	3120
Denver Bucket Elevator	6"	1½	2200	6"	1½	2300	6"	1½	2400
Denver-Dillon Screen, Double Deck	12"x24"	½	275	12"x24"	½	275	18"x36"	½	400
Denver Crushing Rolls	10"x6"	1½	1530	10"x6"	1½	1530	12"x12"	3	2350
Denver Ore Sampler, Snyder	27"	½	425	27"	½	425	42"	1	625
Fine Ore Bin	5 ton	—	950	10 ton	—	1350	25 ton	—	2300
Denver Fine Ore Feeder, Belt	9"	¼	550	12"	½	900	18"	1	1400
or Belt-Hopper	6"x18"	¼	365	6"x18"	¼	365	9"x54"	½	550
Denver Ball Mill	12"x12"	1	1000	16"x16"	1½	1850	30"x36"	7½	5000
Denver Cross-Flow Classifier	6"	¼	400	9"	¼	575	12"	½	950
Denver Hydro-Classifier with Diaphragm Pumps	30"	¼	400	30"	¼	400	48"	¼	650
Denver Mineral Jig	1 M	1/6	120	4"x6"	1/6	200	8"x12"	½	500
Denver Unit Flotation Cell	No. 5	¼	260	No. 7	½	500	No. 8	¾	700
Denver Conditioner	12"x18"	¼	200	18"x24"	½	360	24"x36"	½	560
Denver Flotation Machine (1), 6 Cell	No. 5	¼	260	No. 7	½	500	No. 8	¾	700
Denver Concentrate Thickener with Diaphragm Pumps	3'	¼	600	4'	½	850	6'	1	1600
Denver Concentrate Filter (2), Drum	18"x6"	1½	910	18"x12"	1½	910	3'x2'	3¾	3010
or Pan	3'x3'	1	845	4'x4'	1½	1000			
Denver Wet Reagent Feeder	Portable	1/20	130	Portable	1/20	130	Portable	1/20	130
Denver Dry Reagent Feeder, Cone	6"	¼	130	6"	¼	130	12"	¼	175
or Belt	6"x6'	¼	460	6"x6'	¼	460	6"x6'	¼	460
Denver Vertical Sand Pump	¾"	1	380	1"	2	445	1"	2	445
Denver Cyanide Agitators (3)	30"x30"	¼	500	36"x36"	¼	660	6'x8'	1	1400
Denver Cyanide Thickeners with Diaphragm Pumps	4'	½	850	6'	1	1600	14'x4'	2	3000
Denver Cyanide Filter (2)	3'x1'	2¾	1695	3'x2'	3¾	3010	4'x4'	7½	6200
Denver Precipitation Equipment	No. 1	2	1200	No. 1	2	1200	No. 2	2¼	5000
Denver Pulp Sampler	Lab. 8"	1/12	50	Lab. 8"	1/12	50	No. 1	¼	200
Denver-Wilfley Laboratory Table	13 B	¼	410	13 B	¼	410	12	1	1650

(1) Multiple banks to be used depending on problem (2) Includes necessary vacuum equipment (3) At least two preferably three. Includes steel tank. Sizes shown in this table are for estimating only. Exact requirements will depend on many factors including grindability of ore, fineness required, flotation time and densities, settling and filtering characteristics. For your particular needs consult our Engineering Department for recommendations.

Following is a list of instruments and small equipment necessary in producing the desired data from the testing operation:

	H.P.	Wt.
1. Denver Pulp Density Scale		7
2. Denver Shaker Screen	1/6	140
3. Set Tyler Standard Screen Sieves		23
4. Electric pH Meter		20
5. Binocular Microscope		10
6. Mineralight		10
7. Jones Sample Splitter		70
8. Platform Scale—500 lbs. capacity		180
9. Laboratory Pan Balance		10
10. Reagent solution tanks, carboys, and pails		500
11. Vanning plaques		1
12. Hand pulp samplers		4
13. Sample pans and pails		50
14. Volumetric measuring cylinders		10

Information and Data on Concrete

THE FIRST consideration in building any structure is the allowable bearing pressure between the footings and the soil upon which the foundation rests. The center of pressure on a foundation should always pass through the center of the footing and the allowable bearing pressure between the footings and the soil for tall structures should naturally be less than for low structures. Also foundations subject to shock should be figured with less unit pressures than foundations for stationary loads in order to allow for possible disarrangement of soil due to vibration. Water is always dangerous in soils, as it directly affects the amount of allowable pressure that the strata can support. The following table can be considered good practice in figuring foundation loads quickly:

Kind of Material	Bearing Power in Tons per Square Feet
ROCK, HARDEST, in thick layers on native bed	200
ROCK, HARD, equal to best ashlar masonry	25–30
ROCK, HARD, equal to best brick masonry	15–20
ROCK, SOFT, equal to poor brick masonry	5–10
CLAY ON THICK BEDS, always dry	4–6
CLAY ON THICK BEDS, moderately dry	2–4
CLAY, SOFT	1–2
GRAVEL AND COARSE SAND, well cemented	8–10
SAND, compact and well cemented	4–6
SAND, clean dry	2–4
SAND, QUICK, alluvial soils, etc	0 5–1

However, if more accurate determinations are desired, in addition to this table, direct experiment aided by careful examination will enable one to determine with accuracy its supporting power. Standard practice in present day foundations is to use Portland cement mixed with sand and aggregate to the proper consistency. The cement is usually shipped in sacks which contain approximately one cubic foot of material, as this is the handy and economical way to purchase such supplies. A barrel of cement contains 4 sacks.

As cement readily absorbs moisture and deteriorates with age, care should be taken to store it in a cool, dry place until ready for use. Care must also be taken to make certain the materials used for concrete work are clean and suitable for the purpose at hand. This is particularly true of the sand. A quick method of determining the dirt or unsuitable matter in sand is to rub it between the palms of the hands and if a discoloration shows, it is well to make further tests by sedimentation. This can easily be done by putting a small amount of sand in a bottle or glass jar and an equal amount of water added to the material. This is well shaken and allowed to set for one hour. If the water shows a muddy discoloration or has a one-eighth line of sediment showing on top of the bulk of the sand, it indicates this material is not suitable for concrete unless thoroughly washed. In choosing sand—it is always well to have a mixture where both coarse and fine grades can be obtained from the bank run, and as free from mica as possible.

The proportion of aggregate to the cement is largely determined by the purpose for which the concrete is to be used. In the following table when proportions are expressed in parts, the cement is assumed to be one full sack equal to one cubic foot, as in the proportion of 1:3:5. It is thus indicated . . . one bag of cement to 3 cu. ft. of sand to 5 cu. ft. of stone or aggregate.

The following proportions by Taylor and Thompson in their book on concrete may be taken as suitable for fair average practice:

Rich Mixture—1:1½:3 is suitable for columns, and other structural parts which are subjected to high stresses, or which require water tightness.

Standard Mixture—1:2:3½ and 1:2:4 are known as standard mixtures for reinforced concrete floors, beams and columns, arches, reinforced engine or machine foundations subject to vibrations, tanks, sewers, conduits, and other water tight work, also for plain and reinforced concrete pavement.

Medium Mixture—1:2½:5 is suitable for ordinary machine foundations, retaining walls, abutments, piers, foundation walls, building walls, ordinary floors, sidewalks, and sewers with heavy walls. Generally used where reinforcing is not required.

Lean Mixture—1:3:6 suitable for unimportant work in masses, for heavy walls, large foundations supporting a stationary load, and as backing for stone masonry; also suitable for concrete base for many types of pavements, such as asphalt, brick or wood block.

Particular care must be taken to keep the proper water-cement ratio, since a slight extra amount of water will be more detrimental to strength than a corresponding variation in the other conditions incident to the making of concrete.

Our desire is to make you "Happier, Healthier and Wealthier."

The quantities of materials in a concrete mixture can be accurately determined by making use of the fact that the volume of concrete produced is equal to the sum of the absolute volume of the cement, plus the absolute volume of the aggregate, plus the volume of water.

This can best be illustrated by an example. Suppose the concrete batch is to consist of one sack of cement (94 lbs.), 2.2 cu. ft. of dry fine aggregate weighing 110 lbs. per cu. ft. and 3.6 cu. ft. of dry coarse aggregate weighing 100 lbs. per cu. ft. and is to be mixed with a water-cement ratio of 7 gal. per sack. The apparent specific gravity of the cement is usually about 3.1 and of the more common aggregate 2.65.

Cement 1 cu. ft. @ $\frac{94}{3.1 \times 62.5} = .49$ cu. ft. absolute volume.

Fine Aggregate 2.2 cu. ft. @ $\frac{110}{2.65 \times 62.5} = 1.46$ cu. ft. absolute volume.

Coarse Aggregate 3.6 cu. ft. @ $\frac{100}{2.65 \times 62.5} = 2.18$ cu. ft. absolute volume.

Volume Water $\frac{7.0}{7.5} = .93$ cu. ft. absolute volume.

Total volume concrete produced .... 5.06 cu. ft.

Thus one sack of cement produces 5.06 cu. ft. neglecting absorption and losses in manipulation.

The cement required for 1 cu. yd. of concrete is $\frac{27}{5.06} = 5.34$ sacks. The quantities of fine and coarse aggregate required are therefore $\frac{5.34 \times 2.2}{27} = .42$ cu. yd. fine and $\frac{5.34 \times 3.6}{27} = .71$ cu. yd. coarse. For unusual material such as blast furnace slag, and light weight aggregate, the exact specific gravities hould be used.

The Portland Cement Association maintains offices in all the larger cities and will be glad to go into any problem.

Brickwork

Brick vary in size and quality. A cubic foot of wall requires 17 brick 8½"x4⅛"x2½" and 20 brick 8¼"x4"x2¼", based on mortar joints not over ⅜" thick. In calculating the number of brick, small openings are counted solid, while large openings (75 sq. ft. or over in area) should be subtracted.

Firebrick average 9"x4½"x2½", weigh about 7 lbs. per brick; 1,000 firebrick require 800 lbs. of fireclay mortar.

1—3 LIME MORTAR	1—3 CEMENT MORTAR
1000 brick 175 lbs. lump lime 3/5 ton or 4/9 yard of sand	1000 brick 1-1/4 barrels or 5 sacks cement (500 lbs.) 3/5 ton or 4/9 yard of sand

All we ask is a chance to help you and the opportunity to work with you on your equipment needs.

Capacities of Belt Conveyors

Belt Width in Inches	Max. Size of Pieces in Inches	Max. Belt Speed in Feet per Minute	Capacity at Belt Speed of 100 Feet Per Minute: Flat Rollers			Troughed Rollers 15°			Troughed Rollers 20°		
			Cubic Feet per Hour	Tons per Hour W = 50	Tons per Hour W = 100	Cubic Feet per Hour	Tons per Hour W = 50	Tons per Hour W = 100	Cubic Feet per Hour	Tons per Hour W = 50	Tons per Hour W = 100
12	2	250	216	5.45	10.9	390	9.5	19	...	.....	...
14	3	300	294	7.4	14.8	530	13.	26	...	.....	...
16	4	300	384	9.6	19.2	690	17.	34	...	.....	...
18	5	350	486	12.2	24.4	870	22.	44	970	24.5	49
20	6	350	600	15.0	30.0	...	....	..	1200	30.0	60
22	7	400	726	18.1	36.2	...	....	..	1450	36.5	73
24	8	400	864	21.6	43.2	...	....	..	1730	43.	86
30	12	450	1350	33.8	67.6	...	...	..	2700	67.5	135
36	14	500	1944	48.6	97.2	...	...	.	3900	97.5	195
42	18	550	2646	66.2	132.4	...	...	..	5300	13.2	264
48	20	600	3456	86.4	172.8	...	....	..	6900	17.25	345

Belt Conveyor Data

Belt Width in Inches	Usual Ply	Head Pulley Diameter, Inches	Tail Pulley Diameter, Inches	Spacing of Carrying Rollers: Material 50 Lbs. Cu. Ft.	Material 75 Lbs. Cu. Ft.	Material 100 Lbs. Cu. Ft.	Spacing Return Rollers
12	4	16–18	12	5'-0"	5'-0"	5'-0"	12'-0"
14	4–5	18–20	12–14	5'-0"	5'-0"	5'-0"	12'-0"
16	4–5	18–20	12–14	5'-0"	5'-0"	5'-0"	12'-0"
18	4–5	18–24	12–18	5'-0"	4'-9"	4'-6"	12'-0"
20	4–5	20–24	14–20	4'-9"	4'-6"	4'-6"	12'-0"
22	5–6	24–30	16–20	4'-6"	4'-6"	4'-3"	12'-0"
24	5–6	24–30	16–24	4'-6"	4'-6"	4'-3"	10'-0"
30	5–8	30–42	18–30	4'-0"	4'-0"	3'-6"	10'-0"
36	6–8	36–42	20–36	3'-9"	3'-9"	3'-6"	10'-0"
42	6–8	36–54	24–42	3'-6"	3'-6"	3'-3"	8'-0"
48	6–10	48–60	30–42	3'-6"	3'-3"	3'-0"	8'-0"

Diesel Power Plants

The Diesel engines shown below are medium weight, medium speed, 4 cycle, full Diesel engines; the 10, 20, and 30 horsepower are hand cranked, the 40 and 60 are electric start, the 80, 120, and the 160 can be electric, air, or gasoline engine start. The fuel consumption of these engines will run approximately 0.5 pound per brake horsepower per hour at full load, and they operate approximately 1000 rated horsepower hours on one gallon of lubricating oil. The weights and dimensions are approximately correct.

Sea Level Rating in H.P.	No. of Cylinders	Dimensions			R.P.M.	Wt., Lbs.
		Length with Clutch	w.	h.		
10	1	2′7″	28″	4′0″	1200	1050
20	2	4′3″	28″	4′0″	1200	1350
30	3	4′10″	28″	4′0″	1200	1650
40	4	5′6″	28″	4′0″	1200	2750
60	6	6′8″	28″	4′0″	1200	3250
80	4	6′0″	36″	4′3″	1200	3600
120	6	7′4″	36″	4′3″	1200	4900
160	8	8′7″	36″	4′3″	1200	6200

The engines shown below are two cycle, heavy duty, low speed engines, with a very conservative rating and designed for continuous, full load operation. The fuel consumption will run, at full load, approximately 0.4 pounds per brake horsepower per hour and the lubricating oil life is about 3000 rated horsepower hours per gallon. These engines are started with compressed air.

Sea Level Rating in H.P.	No. of Cylinders	Dimensions			R.P.M.	Wt., Lbs.
		Length with Clutch	w.	h.		
60	1	12′3″	8′	8′6″	360	13000
75	1	13′1″	8′	9′4″	300	17000
120	2	15′2″	8′	8′6″	360	19000
150	2	16′5″	8′	9′4″	300	26000
180	3	18′2″	8′	8′6″	360	27000
225	3	19′2″	8′	9′4″	300	36000
300	4	24′3″	8′	9′4″	300	48000

The Diesel Engine Mfg. Association derate Diesel engines at high altitudes as follows: 10% at 3200′, 20% at 5700′, 30% at 8000′, 40% at 10800′, and 50% at 14000′. The fuel consumption increases slightly at the higher altitudes, approximately 10% at 8000′.

Approximate B.T.U.'s in various fuels:

Lignite	12,160
Sub-Bituminous	13,030
Bituminous	15,560
Anthracite	14,070
Fuel Oil	18,000

1 pound Fuel Oil = 1 pound Coal.

Gasoline Power Plants

The Gasoline Power Plants listed below include: Engine, radiator and fan, fuel tank, bell housing and clutch, angle sills, oil filter, oil type air cleaner, carburetor, and magneto. Engines can be furnished with any or all attachments.

*Sea Level Rating in H.P.	No. of Cylinders	Dimensions			R.P.M. Low Governed	Weight, Pounds
		l.	w.	h.		
19.0	4	48¼″	23¾″	39¾″	1400	735
27.5	4	60⅜″	28″	50″	800	1600
34.0	4	61½″	35⅜″	51¾″	950	1675
44.0	4	66⅜″	37¾″	59⅛″	850	2145
36.0	6	72¼″	33⅜″	54¾″	1000	2055
38.0	6	72¼″	33⅜″	54¾″	1000	2055
84.0	6	82¼″	46¾″	57⅛″	1400	3370
107.0	6	82¼″	46¾″	57⅛″	1400	3370

*This horse power is for continuous operation and is figured for derated load. Deduct 3% for each 1000 feet in altitude for intermittent load. Deduct 3% for each 1000 feet in altitude over 3000 feet for continuous load.

POWER PLANT FUELS—CALCULATED PERFORMANCE Oil vs. Coal vs. Wood

Feed Water at 100° F.; Steam at 100 Lbs. Per Sq. In.

Fuels	B.T.U. per Pound of Fuel As Fired	B.T.U. per Pound of Steam at 100 lb.	Pounds of Steam Evap. per Pound Fuel Theor.	Fuel Theor. B.T.U. Ratios	Small Fire-Tube Hand Fired	Medium Fire-Tube Hand Fired	Medium Fire-Tube Stoker Fired	Large Water Tube Stoker Fired
					Boiler Efficiencies			
					50%	60%	70%	80%
					Actual Pounds of Steam Delivered per Pound of Fuel			
Fuel Oil	18000	1120.8	16.90	100	.....	10.18	11.82	13.50
Good Coal	14000	1120.8	12.45	73.5	.....	7.47	8.73	9.98
Medium Coal	12000	1120.8	10.65	63	.....	6.40	7.45	8.50
Poor Coal	10000	1120.8	8.90	52.6	4.45	5.34	6.25	7.11
Lignite	7000	1120.8	6.22	39.5	3.11	3.72	4.35	.....
Wood, Fresh Cut and Wet, Direct Fired Under Steam Boilers	3000 Wet	1120.8	2.68	15.8	1.31	1.34	.....	.....
Used in Gas Producers		2 to 2.3 Pounds Wood per H.P. Hour. Approx. ⅓ to ¼ that used under Boiler for same H.P.						

For other steam pressures, results will be proportional to B.T.U.:—25 lb., 1101 B.T.U.; 50 lb., 1110 B.T.U.; 100 lb., 1120.8 B.T.U.; 150 lb., 1127 B.T.U.; 200 lb., 1131 B.T.U.; 300 lb., 1137 B.T.U.; 500 lb., 1140 B.T.U.; all for saturated steam and feed water at 100° F.

RATIO OF CONCENTRATION AND RECOVERY

Let H, C, T be weights or percent weights of Heads, Concentrates and Tails.

$$H = C + T$$

Let h, c, t, be assay values, percent metal, etc.

$$Hh = Cc + Tt$$

The following formulæ derived from the above, are used when the three prime assays are available:

Ratio concentration, $R = \frac{H}{C} = \frac{c - t}{h - t}$

Recovery and Extraction %, $E = 100\frac{Cc}{Hh} = 100\frac{c}{Rh} = 100\frac{c(h - t)}{h(c - t)}$

Two Metal Formulæ, as arranged by R. Gilman Brown, A.I.M.M.E.:

DIFFERENCES ASSAY VALUES ÷ 100

$P - Tp = .030 - .004 = .026 = a$
$Cz - Tz = .134 - .015 = .119 = b$
$Z - Tz = .072 - .015 = .057 = c$
$Cp - Tp = .566 - .004 = .562 = d$
$Bp - Tp = .061 - .004 = .057 = e$
$Bz - Tz = .519 - .015 = .504 = f$

ASSAYS

	%. Pb		%. Zn		Oz. Au	Oz. Ag
Ore	P	3.0	Z	7.2	G	S
Lead conc.	Cp	56.6	Cz	13.4	Cg	Cs
Zinc conc.	Bp	6.1	Bz	51.9	Bg	Bs
Tailing	Tp	.4	Tz	1.5	Tg	Ts

FORMULÆ:

$$\text{Tons Pb Conct.} = \frac{100\,(a \times f) - 100\,(c \times e)}{(f \times d) - (e \times b)} \text{ per 100 tons ore.}$$

$$\text{Tons Zn Conct.} = \frac{100\,(c \times d) - 100\,(a \times b)}{(f \times d) - (e \times b)} \text{ per 100 tons ore.}$$

CALCULATION:

$$\text{Tons Pb Conct.} = \frac{100\,(0.026 \times 0.504) - 100\,(0.057 \times 0.057)}{(0.504 \times 0.562) - (0.057 \times 0.119)} = \frac{0.9855}{0.276465} = 3.56 \text{ tons/100}$$

$$\text{Tons Zn Conct.} = \frac{100\,(0.057 \times 0.562) - 100\,(0.026 \times 0.119)}{(0.504 \times 0.562) - (0.057 \times 0.119)} = \frac{2.894}{0.276465} = 10.46 \text{ tons/100}$$

BALANCE SHEET:

100 tons ore 3% Pb, 7.2% Zn			Tons Pb	Tons Zn
3.56 tons Pb Conct.	56.6% Pb	13.4% Zn	2.01496 (g)	0.47704
10.46 tons Zn Conct.	6.1% Pb	51.9% Zn	0.63806	5.42874 (g)
14.02 tons both				
85.98 tons tailing	0.4% Pb	1.5% Zn	0.34392	1.28976
			2.9969 (h)	7.195 (h)

Recovery $R = \frac{g}{h}$ — 67.2% Pb in Pb conc. — 75.4% Zn in Zn conc.

Ratio concentration $\frac{100\,Cp}{P \times R} = \frac{5660}{3 \times 67.2} = 28.1$ — $\frac{100\,Bz}{Z \times R} = \frac{5190}{7.2 \times 75.4} = 9.56$

All we ask is a chance to help you and the opportunity to work with you on your equipment needs.

BALL CHARGES FOR DENVER BALL MILLS

BALL CHARGE IN POUNDS FOR

Denver Ball Mill Size Dia. x Lgth.	*Total Ball Charge Lbs.	Coarse Grinding, Size of Balls 2"	3"	4"	5"	Fine Grinding, Size of Balls 1"	1½"	2"	3"
3'x 2'	1600	500	500	600	...	500	500	600	...
3'x 3'	2500	800	800	900	...	800	800	900	...
3'x 4'	3400	1100	1100	1200	...	1100	1100	1200	...
3'x 5'	4300	1400	1400	1500	...	1400	1400	1500	...
3'x 6'	5200	1700	1700	1800	...	1700	1700	1800	...
3'x 8'	7000	2300	2300	2400	...	2300	2300	2400	...
3'x 9'	7900	2600	2600	2700	...	2600	2600	2700	...
4'x 3'	4300	1400	1400	1500	...	...	1400	1400	1500
4'x 4'	5900	1900	2000	2000	...	...	1900	2000	2000
4'x 5'	7500	2500	2500	2500	...	...	2500	2500	2500
4'x 6'	9100	3000	3000	3100	...	...	3000	3000	3100
4'x 8'	12300	4100	4100	4100	...	...	4100	4100	4100
4'x10'	15600	5200	5200	5200	...	...	5200	5200	5200
5'x 3'	6700	...	2200	2200	2300	...	2200	2200	2300
5'x 4'	9200	...	3000	3100	3100	...	3000	3100	3100
5'x 5'	11700	...	3900	3900	3900	...	3900	3900	3900
5'x 6'	14300	...	4700	4800	4800	...	4700	4700	4900
5'x 8'	19300	...	6400	6400	6500	...	6400	6400	6500
5'x10'	24300	...	8100	8100	8100	...	8100	8100	8100
5'x12'	29300	...	9700	9800	9800	...	9700	9800	9800
6'x 4'	13100	...	4300	4400	4400	...	4300	4400	4400
6'x 5'	16800	...	5600	5600	5600	...	5600	5600	5600
6'x 6'	20500	...	6800	6800	6900	...	6800	6800	6900
6'x 8'	28000	...	9300	9300	9400	...	9300	9300	9400
6'x10'	35500	...	11800	11800	11900	...	11800	11800	11900
6'x12'	43000	...	14300	14300	14400	...	14300	14300	14400

*Based on 50 percent of mill volume and weight of balls 256 lbs. per cu. ft.

Denver Ore Tests are made on an "actual cost" basis. This brings the world's finest laboratory equipment and skilled technicians to your service at a very low cost.

BALL-MILL CAPACITY CALCULATIONS, ETC.

Base: Soft ores ground from —½" to all pass 28 mesh in mills of the dimensions as listed below.

Per J. M. Callow, London, Aug. 1st, 1938

Nominal Sizes of Mill Inside Liners	40% of Section Area	Tons of Balls	H.P. per Ton of Balls	H.P. Required to Run	Capacities Soft Ores Crushed from ½ to 28 Mesh		Grinding Co-efficients					
								Grindability				
					Ton/-Day	H.P.	Sizes Ground to	Soft	Easy	Med.	Hard	Very Hard
3' x 3' 2'8" x 3' 2'6" x 3'	2.82 2.25 1.96	1.00 .86 .75	7.37	7.37 6.35 5.52	53 46 40	7.27	-28 Mesh =35% -200 =.023"	1.	.842	.707	.595	.50
4' x 4' 3'8" x 4' 3'6" x 4'	5.02 4.24 3.85	2.57 2.19 1.97	8.75	22.50 19.15 17.25	175 148 134	7.75	-35 Mesh =40% -200 =.016"	.705	.594	.50	.42	.352
5' x 5' 4'8" x 5' 4'6" x 5'	7.85 6.84 6.35	5.02 4.36 4.07	9.72	48.8 42.3 39.6	404 349 327	8.25	-48 Mesh =50% -200 =.0116"	.505	.425	.357	.30	.252
6' x 6' 5'8" x 6' 5'6" x 6'	11.30 10.10 9.50	8.70 7.76 7.31	10.55	91.7 81.8 77.8	800 712 670	8.70	-65 Mesh =65% -200 =.0082"	.352	.296	.249	.209	.176
7' x 7' 6'8" x 7' 6'6" x 7'	15.40 14.0 13.25	13.80 12.53 11.87	11.20	155. 140. 133.	1420 1288 1220	9.20	-100 Mesh =80% -200 =.0058"	.248	.208	.175	.147	.124
8' x 8' 7'8" x 8' 7'6" x 8'	20.10 18.5 17.6	20.5 18.9 18.0	11.75	241. 222. 211	2330 2150 2040	9.67	-150 Mesh =90% -200 =.0041"	.176	.148	.125	.105	.088
9' x 9' 8'8" x 9' 8'6" x 9'	25.4 23.6 22.7	29.2 27.2 26.1	12.40	362. 338. 323.	3680 3430 3280	10.15	-200 Mesh =100%-200 =.0029"	.125	.105	.088	.074	.062

ASSUMPTIONS:—

Ball Loads = 40% of inside-liner volume × 256 lbs. per cubic foot.
Speed = 70% of critical. Ton = 2000 lbs. Feed = all pass ½ inch.

CAPACITIES ARE ASSUMED TO VARY AS:—

(a) The 2.5 power of the different mill diameters.
(b) Approximately as their lengths.
(c) Proportional to the reciprocals of the apertures ground through.
(d) In accordance with the following "Grindability Factors": Soft 1.00; Easy .842; Medium .707; Hard .505, Very Hard .50.

For installed motor H.P. add 10–20% to the "H.P. to Run" given herein depending on the H.P. and type of motor used.

EXAMPLE: Required capacity 8' x 6' mill grinding "medium ore" to 80% -200?

ANSWER: The 8' x 8' "base-mill" = 2330T/D to -28 mesh "soft ore." Grinding co-efficient medium ore to minus 100 mesh = 0.175.

Calculations as follows:—

Capacity 8' x 6' mill medium ore to − 100 = 2330 x ¾ x .175 = 306.T/D
Capacity 8' x 6' mill medium ore to − 150 = 2330 x ¾ x .125 = 219.T/D
Capacity 7'8" x 6' mill medium ore to − 150 = 2150 x ¾ x .125 = 202.T/D
Capacity 7'6" x 6' mill medium ore to − 170 = 2040 x ¾ x .106 = 162.T/D

Slide Rule Calculations. SKL. 315.

Formula for H.P. See Coghill et al Milling Methods AIMME 1934.

$$\text{Kw.-Hrs./Ton} = \frac{\text{H.P.} \times 18}{\text{Tons, 24 Hrs.}}$$

WEIGHT OF STEEL BALLS

1" diameter	Each 2½ oz.	Approx.
1⅜" diameter	" 6¼ oz.	"
1½" diameter	" 8 oz.	"
1¾" diameter	" 13 oz.	"
2" diameter	" 19¼ oz.	"
2½" diameter	" 2½ lbs.	"
3" diameter	" 4¼ lbs.	"
4" diameter	" 10 lbs.	"
5" diameter	" 20 lbs.	"

SCREEN DATA

EQUIVALENT ROUND AND SQUARE OPENINGS

Tyler Std. Mesh	Square Hole		Round Hole		Equiv. Rd. Hole Frac. of Inch	U. S. Standard Square	Inches Equiv. Rd.
	Inches	m.m.	Inches	m.m.			
	2.750	69.8	3.250	82.60	3 1/4		
	1.875	47.7	2.412	61.30	2 7/16		
	1.375	34.9	1.562	39.70	1 9/16		
	.688	17.5	.812	20.62	13/16		
	.438	11.1	.563	14.31	9/16		
	.250	6.35	.315	8.00	5/16		
5	.1563	3.970	.1875	4.765	3/16		
	.0994	2.525	.1250	3.175	1/8		
8	.0929	2.362	.1171	2.975	7.5/64	.0938	.118
	.0869	2.207	.1093	2.778	7/64		
	.0781	1.985	.0938	2.381	3/32		
10	.0650	1.651	.0819	2.080	5.2/64	.0795	.100
	.0621	1.579	.0781	1.954	5/64		
12	.0551	1.397	.0693	1.760			
	.0497	1.263	.0625	1.588	1/16		
14	.0464	1.168	.0579	1.470		.0557	.0700
16	.0390	0.991	.0491	1.247		.0472	.0592
	.0373	0.947	.0469	1.191	3/64		
18						.0395	.0497
20	.0328	0.833	.0413	1.050		.0336	.0422
24	.0276	0.701	.0347	.882			
25						.0281	.0353
	.0248	0.630	.0312	.794	1/32		
28	.0234	0.589	.0292	.742			
30						.0233	.0293
32	.0195	0.495	.0245	.622			
35	.0164	0.417	.0207	.526		.0198	.0249
40						.0166	.0209
42	.0138	0.351	.0174	.444			
	.0124	0.307	.0156	.397	1/64		
48	.0116	0.295	.0146	.372			
60	.0097	0.246	.0122	.310		.0099	.0124
65	.0082	0.208	.0103	.263			
80	.0069	0.175					
100	.0058	.1470				.0059	.0074
115	.0049	.1240					
150	.0041	.1040					

COMPARISON OF TESTING SCREENS

Tyler Standard: Mesh	Tyler Standard: Aperture in.	Tyler Standard: Aperture mm.	Tyler Standard: Mesh Double Tyler Series	U.S. Bureau of Stand.: Mesh	U.S. Bureau of Stand.: Aperture in.	U.S. Bureau of Stand.: Aperture mm.	U.S. Bureau of Stand.: Tolerance ± %	British Standard: Mesh	British Standard: Aperture in.	British Standard: Aperture mm.	British Standard: Tolerance ± %	I.M.M. Screens: Mesh	I.M.M. Screens: Aperture in.	I.M.M. Screens: Aperture mm.
	.312	7.925	2½	2½	.315	8.00	3							
3	.263	6.680		3	.265	6.73	3							
	.221	5.613	3½	3½	.223	5.66	3							
4	.185	4.699		4	.187	4.76	3							
	.156	3.962	5	5	.157	4.00	3							
6	.131	3.327		6	.132	3.36	3	5	.1320	3.35	3			
	.110	2.794	7	7	.111	2.83	3	6	.1107	2.81	3			
8	.093	2.362		8	.0937	2.38	3	7	.0949	2.41	3	5	.100	2.54
	.078	1.981	9	10	.0787	2.00	3	8	.0810	2.06	3			
10	.065	1.651		12	.0661	1.68	3	10	.0660	1.67	3	8	.063	1.574
	.055	1.397	12	14	.0555	1.41	3	12	.0553	1.40	3			
												10	.050	1.270
14	.046	1.168		16	.0469	1.19	3	14	.0474	1.20	3			
												12	.0416	1.056
	.039	.991	16	18	.0394	1.00	3	16	.0395	1.00	3			
20	.0328	.833		20	.0331	.84	5	18	.0336	.85	5			
												16	.0312	.792
	.0276	.701	24	25	.0280	.71	5	22	.0275	.70	5			
												20	.025	.635
28	.0232	.589		30	.0232	.59	5	25	.0236	.60	5			
	.0195	.495	32	35	.0197	.50	5	30	.0197	.50	5	25	.020	.508
35	.0164	.417		40	.0165	.42	5	36	.0166	.421	5	30	.0166	.421
	.0138	.351	42	45	.0138	.35	5	44	.0139	.353	6	35	.0142	.361
												40	.0125	.317
48	.0116	.295		50	.0117	.297	6	52	.0116	.295	6			
	.0097	.246	60	60	.0098	.250	6	60	.0099	.252	6	50	.01	.254
65	.0082	.208		70	.0083	.210	6	72	.0083	.211	6	60	.0083	.211
	.0069	.175	80	80	.0070	.177	6	85	.0070	.177	6	70	.0071	.180
100	.0058	.147		100	.0059	.149	6	100	.0060	.152	6	80	.0062	.157
												90	.0055	.139
	.0049	.124	115	120	.0049	.125	8	120	.0049	.125	8	100	.0050	.127
150	.0041	.104		140	.0041	.105	8	150	.0041	.105	8	120	.0042	.107
	.0035	.088	170	170	.0035	.088	8	170	.0035	.089	8	150	.0033	.084
200	.0029	.074		200	.0029	.074	8	200	.0030	.076	8			
	.0024	.061	250	230	.0024	.062	8	240	.0026	.066	8	200	.0025	.063
270	.0021	.053		270	.0021	.053	8	300	.0021	.053	8			
	.0017	.043	325	325	.0017	.044	8							
400	.0015	.037												

NOTES ON TABLE

(1) The base of the Tyler series is the 200 mesh screen with aperture equal to .0029 inches or .074 mm. The ratio between apertures of consecutive screens is the square root of 2. For closer sizing a series of intermediate screens are available, the ratio between apertures of consecutive screens in the Double Tyler series being the fourth root of 2. Owing to manufacturing difficulties, no Tyler screens finer than 400 mesh are available. Tyler screens coarser than 2½ mesh are available but are not numbered.

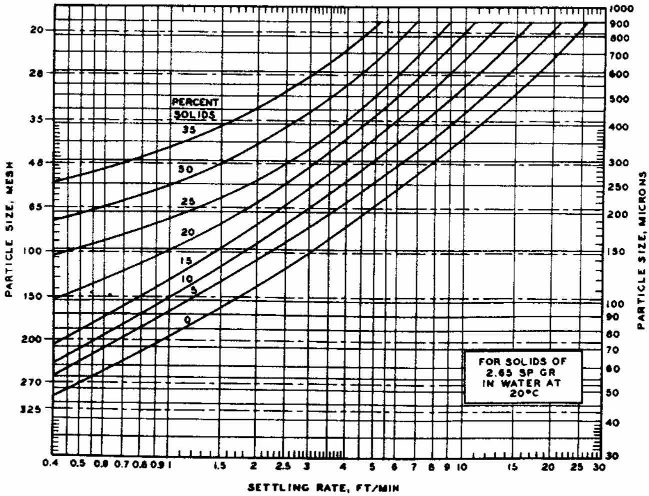
(2) The base of the U.S. Bureau of Standards series is the 18-mesh screen with 1.00 mm. aperture. The ratio between apertures of consecutive screens is the fourth root of 2.

(3) The ratio between apertures of consecutive British Standard screens is only approximately equal to the fourth root of two because wire diameters are limited to those occurring in the S.W.G. series.

(4) In I.M.M. screens, wire diameter equals aperture and aperture in inches equals one divided by twice the mesh number.

(5) Adapted by D.C.G. from presentation in ***Chem. Eng. & Mining Review***, June 10, 1940. Original source: Ore Dressing Laboratory of University of Melbourne.

SETTLING RATE VS PARTICLE SIZE AT VARIOUS PERCENTS SOLIDS



STANDARD ANTHRACITE SPECIFICATIONS

Approved and Adopted by The Anthracite Committee — Effective July 28, 1947

Size Coal	Test Mesh—Round		Oversize	Undersize		Maximum Impurities		
	Thru	Over	Max.	Max.	Min.	Slate*	Bone*	Ash**
Broken	4-3/8"	3 1/4"-3"		15%	7-1/2%	1-1/2%	2%	or 11%
Egg	3-1/4" - 3"	2 7/16"	5%	15%	7-1/2%	1-1/2%	2%	or 11%
Stove	2-7/16"	1 5/8"	7-1/2%	15%	7-1/2%	2%	3%	or 11%
Nut	1-5/8"	13/16"	7-1/2%	15%	7-1/2%	3%	4%	or 11%
Pea	13/16"	9/16"	10%	15%	7-1/2%	4%	5%	or 12%
Buckwheat	9/16"	5/16"	10%	15%	7-1/2%			13%
Rice	5/16"	3/16"	10%	17%	7-1/2%			13%
Barley	3/16"	3/32"	10%	20%	10%			15%
No. 4	3/32"	3/64"	20%	30%	10%			15%
No. 5	3/64"		30%	No Limit				16%

*When slate content in Broken to Nut inclusive is less than above standards, bone content may be increased by one and one-half times the decrease in the slate content under the allowable limits, but slate content specified above shall not be exceeded in any event.

**Ash determinations are on a dry basis.

A tolerance of 1% is allowed on the maximum percentage of undersize and the maximum percentage of ash content. The maximum percentage of undersize is applicable only to anthracite as it is produced at the preparation plant. "Slate" is defined as any material which has less than 40% of fixed carbon. "Bone" is defined as any material which has 40% or more, but less than 75% of fixed carbon.

VIBRATORY SCREENS

35° to 45° inclination

Tons thru screen per square foot screening area per 24 hours, wet or dry.

MESH	¾″	½″	¼″	6	8	10	14	20	28	35	48	100
AVE.	75	50	30	17	15	13	10	7	5	4	3	1
MAX	120	90	50	30	20	17	14	12	9	7	5	2

Average ores carrying up to 10% moisture can be screened to 10 mesh without previous drying; beyond that, the screening should be wet, with 3 to 3½ ratio of water to ore.

CHUTES AND BINS

Slope Angles for Various Materials

Slopes Given in Inches (Vertical) per Foot (Horizontal)

MATERIAL	Repose On Itself		Starting — Bright Steel		for Sliding Wood		Concrete	
	Angle	Slope	Angle	Slope	Angle	Slope	Angle	Slope
Limestone Gangue	..	..	20	4¼	..	..	..	..
Sandstone Gangue	..	..	22½	5	..	..	..	..
Quartzite	..	..	35	8½	..	..	..	..
Iron Ore	35	8½	22	5	..	..	..	..
Crushed Rock, Sized	37-45	9-12	20-40	4-10	30-45	7-12	40-45	10-12
Gravel	37-45	9-12	25-30	5½-7	40	10	40	10
Sand & Gravel	26	6	..	..	..	..	..	..
Sand, Dry	34	8	18	4	30	7	40	10
Sand, Moist	60	21	40	10	45	12	45	12
Sand, Tailings, Wet	33	7½	..	..	..	..	..	..
Earth & Clay, Dry	29	6½	..	..	..	..	..	..
Earth & Clay, Moist	45	12	..	..	..	..	..	..
Earth & Clay, Mud	17	3½	..	..	..	..	..	..
Cement, Dry	40	10	..	..	..	..	..	..
Cement, Clinker	33	7½	..	..	..	..	..	..
Ashes	30-45	7-12	31	7	40	10	40	10
Shale	..	..	21	4½	..	..	..	..
Coal-Anthracite, Sized	27	6	17	3½	..	..	..	..
Coal-Bituminous, Sized	35	8½	22-24	5-5½	35	8½	35	8½
Coal-Slack & R-O-M	35-45	8½-12	26	6	..	..	..	..
Coal-Dust	16	3½	21	4½	..	..	..	..

After starting sliding angle is 2°–3° less.

In practice, sliding angles are 5°–10° more than above.

Capacity of chutes is determined largely by the opening to the chute.

In gates and other openings or restricted spaces in which pieces of rock are intermittently passing, the width should be at least 3 to 4 times the diameter of the largest pieces, to prevent arching, and in the running chute probably at least 6 times, to prevent arching and reduce side friction. Velocities in the case of round pebbles will tend to approach those of free fall unler gravity, while sliding masses have the free fall velocities materially reduced by friction on the bottom.

Spiral chutes of steel, for which slopes have been determined for packages, sacks, and bulk materials, deliver vertically with minimum breakage.

Per Cent Voids in Crushed Materials

	% Voids	Lbs. Cu. Ft.		% Voids	Lbs. Cu. Ft.
SAND			Volcanic Ash		
Quartz, Washed, 30 mesh	40·0	90	Loose	74	...
Moulders	solid	136	Compact	68	...
Moulders Rammed	31·6	93	Rammed	65	...
Dry Sand, Loose	38–45	90–106			
SOILS			SPHERES		
Surface Organic			Piled in Cubes	47·75	...
Loose	59	...	Piled in Pyramids	46·0	...
Compact	49	...			
Rammed	44	...	ZINC DUST	solid	427
Coarse Subsoil			120 mesh	47·5	224
Loose	55	...	100 mesh	44	239
Compact	49	...			
Rammed	46	...	ZINC SHAVINGS		
Fine Subsoil			Coarse	96·5	14
Loose	54	...	Fine	98	6–7
Compact	45	...			
Rammed	43	...			

CENTRIFUGAL FORCE IN MILLS, TROMMELS, ELEVATORS, ETC.

Centrifugal force combined with gravity plays an important part in the operation of cylinder mills, trommels, elevators and other moderate speed horizontal axis machines.

$$C = \frac{Wv^2}{Gr} = 1.227\ Wrn^2 = .0000284\ WRN^2 \text{ pounds, where}$$

C = Centrifugal force, or pull on radius arm in pounds

W = Weight of body in pounds

v = Velocity in feet per second

n = Revolutions per Second; N = Revolutions per minute

r = Radius in Feet; R = Radius in inches, from center of rotation

When C = W $N^2R = 35000$ approx.

The neutral Point where centrifugal force C equals the weight W is **directly above** the center of rotation, and at a distance found by the above formula, $N^2R = 35000$, or from following table.

N—RPM	10	12	14	16	18	20	22	24	28	32	36	40	44	48
R—Inches	350	240	180	137	108	87	72	61	44½	34	27	22	18	15¼

The force at any point in the rotating mass is the weight at that point times the ratio of its distance from the neutral point—to R; the direction of the force is the line from the neutral point to it. Lines of equal force, corresponding to points of equal pressure in an open tank, are circles drawn about the neutral point as a center.

Pressures

Air Pressure				Water Column, 62.428 Lb./Cu. Ft.		Mercury Column, Sp. Gr. 13.596	
Atmosphere	Lb./Sq. In.	Lb./Sq. Ft.	Kilometers cm^2	Meters	Feet	Milli-meters	Inches
1	14.969	2116.35	1.0332	10.332	33.90	760	29.92
.06804	1	144	.07031	.70307	2.3066	51.7116	2.03588
.0004725	.006944	1	.0004882	.004882	.01602	.35911	.014140
.96778	14.2234	2048.1	1	10	32.8083	735.514	28.9572
.09678	1.42234	204.817	.10	1	3.28083	73.5514	2.89572
.0295	.43353	62.4288	.03048	.3048	1	22.4185	.88262
.001316	.01934	2.78468	.00136	.0136	.04461	1	.03937
.03342	.49119	70.7310	.03453	.34534	1.13299	25.4001	1

1 oz. water gauge = 1.73 inches. 1 lb. water gauge = 28.68 inches.

Weights

Short Ton	Metric Tonne	Long Ton	Pounds Average	Ounces Average	Ounces Troy	Kilo-meters	Grams
1	.90719	.89286	2000	32000	29166.67	907.184	
1.1023	1	.98421	2204.62	35273.9	32150.8	1000	
1.1200	1.01605	1	2240	35840	32666.7	1016.05	
.0005	.0004536	.000446	1	16	14.5830	.45359	453.592
			.0625	1	.9115	.028349	28.3494
			.0686	1.0971	1	.031104	31.1035
.0011032	.001	.009842	2.2046	35.2735	32.15	1	1000.0
			.002204	.03527	.03215	.001	1

LAUNDERS

Launders should have high enough velocities to prevent particles from settling, or if they fall to the bottom, to keep them rolling and sliding. The depth of water should not be much over the diameter of the largest rolling particles.

SLOPES FOR LAUNDERS, INCHES PER FOOT

MAX. SIZE PARTICLE	PERCENT SOLIDS [IN WATER]					DRY		Moist Sand
	1-2	10-15	20-25	30-50	60-80	Broken	Round	
2″	.	3	4	5	6	12-10	8-6	
½″	2	2½	3	4	5	14-12	10-8	16″
20 Mesh	1	1	1½	2	3	16-14	12-10	18
50 Mesh	½	¾	1	1½	2	......	......	20
200 Mesh	¼	½	⅝	1	1¼	......	......	..
Slime Tails	7/16	¼	⅜	..	..	......	......	..
Sand Tails		⅜	⅝			......	......	..

For concentrates and heavy gangues slopes should be increased 25—100%.

WATER IN LAUNDERS:—While it is claimed that the quantity of water flowing with ore in a launder does not definitely follow Kutters formula, etc., the following data for the flow of water in a rectangular wooden launder will assist in calculating quantities of ore and water. Actual quantities in mill launders is probably between 50% and 75% of the quantities given below.

STORED ENERGY IN FLYWHEEL

Feet-Pounds energy stored in flywheel = E = ½ (Wv^2/g)

In which E = feet-pounds stored energy

W = weight of flywheel in pounds

v = velocity of radius of gyration in feet per second

g = acceleration due to gravity (32.2 feet per second)

Torque-H.P. Formula

$$\text{Torque} = \frac{\text{H.P.} \times 5250}{\text{r.p.m.}}$$

Centrifugal Force

F = centrifugal force in pounds

W = weight of revolving body in pounds

r = distance from the axis of motion to the center of gravity of the body in feet

g = acceleration due to gravity (32.2 feet per second)

N = number of revolutions per minute

v = velocity in feet per second

$$F = \frac{W v^2}{gr} = 0.00034\ Wr\ N^2$$

Capacities of Troughing Belt Conveyors Tons per Hour

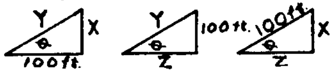
Material Weighing 100 Pounds per Cubic Foot

Width of Belt Inches	SPEED OF BELT IN FEET PER MINUTE										
	100	150	200	250	300	350	400	450	500	550	600
12	22	34	46	58	68	80	92	102	112	124	134
14	30	45	60	75	90	105	120	135	150	165	180
16	40	60	80	100	120	140	160	180	200	220	240
18	50	75	100	125	150	175	200	225	250	275	300
20	62	92	125	154	186	218	248	280	310	342	372
24	90	135	180	225	270	315	360	405	450	495	540
30	144	216	290	363	435	507	580	653	720	790	860
36	210	315	420	525	630	735	840	945	1050	1150	1260
42	290	435	580	725	870	1015	1160	1305	1450	1595	1740
48	380	570	760	950	1140	1330	1520	1710	1900	2090	2280
54	490	735	980	1225	1470	1715	1960	2205	2450	2695	2940
60	600	900	1200	1500	1800	2100	2400	2700	3000	3300	3600

Note. Above capacities are based on the assumption that material will be fed to conveyor uniformly and continuously. If loading is intermittent the conveyor should be designed for the maximum rate of loading likely to occur.

For flat belts not troughed, use one-half of the above capacities.

ESTIMATING CONVEYOR SLOPE, LENGTH, HEIGHT



Degree θ	% Rise	x (ft.)	y (ft.)	y (ft.)	z (ft.)	x (ft.)	z (ft.)
1°	1.7%	1.7	100.0	5729.9	5729.0	1.7	100.0
2°	3.5%	3.5	100.1	2865.4	2863.6	3.5	99.9
3°	5.2%	5.2	100.1	1910.7	1908.1	5.2	99.9
4°	7.0%	7.0	100.2	1433.6	1430.1	7.0	99.8
5°	8.7%	8.7	100.4	1147.4	1143.0	8.7	99.6
6°	10.5%	10.5	100.6	956.7	951.4	10.5	99.5
7°	12.3%	12.3	100.8	820.6	814.4	12.2	99.3
8°	14.1%	14.1	101.0	718.5	711.5	13.9	99.0
9°	15.8%	15.8	101.2	639.2	631.4	15.6	98.8
10°	17.6%	17.6	101.5	575.9	567.1	17.4	98.5
11°	19.4%	19.4	101.9	524.1	514.5	19.1	98.2
12°	21.3%	21.3	102.2	481.0	470.5	20.8	97.8
13°	23.1%	23.1	102.6	444.5	433.2	22.5	97.4
14°	24.9%	24.9	103.1	413.4	401.1	24.2	97.0
15°	26.8%	26.8	103.5	386.4	373.2	25.9	96.6
16°	28.7%	28.7	104.0	362.8	348.7	27.6	96.1
17°	30.6%	30.6	104.6	342.0	327.1	29.2	95.6
18°	32.5%	32.5	105.2	323.6	307.8	30.9	95.1
19°	34.4%	34.4	105.8	307.2	290.4	32.6	94.6
20°	36.4%	36.4	106.4	292.4	274.8	34.2	94.0
21°	38.4%	38.4	107.1	279.0	260.5	35.8	93.4
25°	46.6%	46.6	110.3	236.6	214.4	42.3	90.6
30°	57.7%	57.7	115.5	200.0	173.2	50.0	86.6
35°	70.0%	70.0	122.1	174.3	142.8	57.4	81.9
40°	83.9%	83.9	130.5	155.6	119.2	64.3	76.6
45°	100.0%	100.0	141.4	141.4	100.0	70.7	70.7
50°	119.2%	119.2	155.6	130.5	83.9	76.6	64.3
55°	142.8%	142.8	174.3	122.1	70.0	81.9	57.4
60°	173.2%	173.2	200.0	115.5	57.7	86.6	50.0
65°	214.4%	214.4	236.6	110.3	46.6	90.6	42.3
70°	274.8%	274.8	292.4	106.4	36.4	94.0	34.2
75°	373.2%	373.2	386.4	103.5	20.8	96.6	25.9
80°	567.1%	567.1	575.9	101.5	17.6	98.5	17.4
85°	1143.0%	1143.0	1147.4	100.4	8.7	99.6	8.7

MAXIMUM ANGLE OF INCLINATION FOR VARIOUS MATERIALS

(Angles greater than 20° should be carefully scrutinized.)

Material	Maximum Angle degrees
Alumina, sized or briquette	10°
Ashes, wet	38°
Ashes, dry	27°
Bauxite, ground dried	23°
Bauxite, mine run	17°
Cement, Clinker	20°
Cement, Portland	28°
Cinders	23°
Clay, dry in lump loose	21°
Clay, ground	22°
Clay, gray, granular	20°
Coal, Bituminous Slake	20°
Coal, Run-of-mine	18°
Coke, crushed and screened	17°
Coke, Breeze	20°
Coke, run of oven	18°
Concrete—wet	15°
Earth, loose	20°
Feldspar, crushed	17°
Gravel, sharp	27°
Gravel, round	15°
Gravel, from bank	18°
Gravel, screened and washed	12°
Gypsum	33°
Gypsum, regular lumps	15°
Gypsum, ground	27°
Iron ore, Limonite	28°
Iron ore, soft	21°
Kaolin, green crusher	19°
Kaolin, pulverized	32°
Lime, burned pebble (sized)	15°
Lime, burned pulverized	17°
Lime, fine	29°
Limestone, pulverized	34°
Limestone, mixed sized	21°
Limestone, coarse sized	12°
Mica, ground	23°
Molybdenite ore, powdered	25°
Manganese	24°
Ore, crushed	20°
Phosphate, Florida	14°
Phosphate, pulverized	28°
Sand, damp	20°
Sand, dry	15°
Slag, furnace granulated	13°
Stone, crushed	18°
Shale	26°

Definitions of Common Engineering Terms

Work is the overcoming of resistance through a certain space.

The **Foot Pound** is the unit of work and is equal to the amount of work done in overcoming a pressure or weight equal to one pound through a distance of one foot.

Power is the rate at which work is done.

The Horsepower is the unit rate of doing work.

1 H. P. = { 33,000 ft. lbs. per minute
550 ft. lbs. per second
2,545 B. t. u. per hour
42.42 B. t. u. per minute
746 Watts (watts = volts × amperes)

The **Horsepower-Hour** is a measure of work done.

1 horsepower-hour equals 60 × 33,000 or 1,980,000 ft. lbs. or 2,545 B. t. u.

Energy is the capacity for doing work.

Velocity is the rate of motion or speed of a body at any instant.

Resistance is that which opposes an acting force and is equal and opposite to force.

Force is anything that tends to change the state of a body with respect to rest or motion.

The **Pound Avoirdupois** is the unit of force in American engineering practice. It is the force which would give to a pound of matter an acceleration of 32.1740 feet per second, or the force with which gravity attracts a pound of matter at 45° latitude at sea level.

Inertia is that property of a body by virtue of which it tends to continue in a state of rest or motion, in which it may be placed, until acted upon by some force.

The **British Thermal Unit** (B. t. u.) is the quantitative measure of heat and has ordinarily been defined as the amount of heat necessary to raise the temperature of one pound of water at a definite temperature one degree Fahrenheit (F.). The "mean B. t. u." adopted as standard is 1/180 of the heat required to raise one pound of pure water from 32 to 212 degrees Fahrenheit (from the ice point to the steam point), both at standard atmospheric pressure (14.7 pounds per square inch absolute). It is approximately equal to the heat required to raise the water from 63 to 64 degrees Fahrenheit.

The **Large-Calorie** (kilogram-calorie) is the heat required to raise the temperature of one kilogram of water from 14.5 degrees to 15.5 degrees Centigrade (C.), or 1/100 of the heat required to raise one kilogram of water from 0 degrees Centigrade to 100 degrees Centigrade.

The **Pound-Calorie** (lb.-cal.) is the heat required to raise the temperature of one pound of water one degree Centigrade.

1 B. t. u. = 778 ft. lbs.

1 Kg.-Cal. = 2.2046 × 9/5 = 3.968 B. t. u.

2545 B. t. u. per hour = 1 h. p.

Saturated Steam is steam in the condition in which it is generated from water with which it is in contact, or whose temperature is that due to its pressure. At the ordinary atmospheric pressure of 14.7 pounds per square inch, its temperature is 212 degrees Fahrenheit. As the pressure is increased its temperature and that of the water in its presence increases.

Superheated Steam is steam heated to a temperature above that of saturated steam at a corresponding pressure. Heat may be added to steam not in contact with water, resulting in an increase of temperature and pressure if the volume be kept constant, or an increase in temperature and volume if the pressure remain constant.

Dry Steam contains no moisture, and may be either saturated or superheated.

Wet Steam contains intermingled moisture, mist, or spray. Water introduced into superheated steam will evaporate until the steam becomes saturated; that is, until its temperature is lowered to that due to its pressure. Water at a lower temperature than that of saturated steam into which it is introducted will condense some of it, thus lowering both the temperature and the pressure of the rest until the temperature again equals that due to its pressure.

The **Quality of Steam** is the percentage of weight of steam in a mixture of steam and water. Thus, if in a mixture of 100 pounds of steam and water there is ¾ of a pound of water, the quality of the steam will be 99.25 per cent.

Absolute and Gauge Pressures—Steam gauges indicate the pressure above atmospheric pressure. As the atmospheric pressure changes according to the altitude and barometric variations, calculations involving the properties of steam are based on absolute pressures, which are equal to the gauge pressure plus the atmospheric pressure. The latter is usually assumed to be 14.7 pounds per square inch at sea level, but for other levels it must be determined by barometer readings.

The heat necessary to raise one pound of water from 32 degrees to the temperature of the boiling point is called the **"Heat of the Liquid."**

The **Total Heat of Steam** is the heat necessary to change one pound of water at 32 degrees into one pound of steam at the temperature of the boiling point.

The heat necessary to convert one pound of water at the temperature of the boiling point into steam at the same temperature is called the **"Latent Heat."**

The **Calorific Power or Heating Value** of a fuel is the total amount of heat developed by the complete combustion of a unit weight of fuel.

Boyle's Law—The volume of a given mass of gas varies inversely as the pressure, provided the temperature remains constant.

Charles' Law—Under a constant pressure, the volume of a given mass of gas is proportional to its absolute temperature.

One Boiler Horsepower is equal to an evaporation of 34.5 pounds of water per hour from and at 212 degrees Fahrenheit into dry and saturated steam.

The **Volt** (analogous to head or pressure in hydraulics) is the unit of electromotive force. It is the force required to send one ampere of current through one ohm of resistance.

The **Ohm** (analogous to the loss of head due to the flow of water in a pipe) is the unit of resistance. It is the resistance offered to the passage of one ampere when impelled by one volt and may be defined as the resistance of a column or thread of mercury the mass of which is 14.4521 grams and which has a uniform cross section, and a length of 106.3 plus or minus centimeters at 0 degrees Centigrade. This column is practically 106.3 centimeters long and one square millimeter in cross section. Ten feet of No. 30 copper wire has a resistance of 1.033 ohms.

The **Ampere** (analogous to the rate of water through a pipe in gallons per second) is the unit of current. It is the current which one volt can send through a resistance of one ohm. Such a current will deposit 0.001118 gram of silver per second from a solution of silver nitrate or 0.00032959 gram of copper per second from a solution of copper sulphate. The milliampere, or thousandth part of an ampere, is used as a unit for the measurement of small currents.

The **Coulomb** is the unit of quantity. It is the quantity of electricity transferred by a current of one ampere in one second.

The **Farad** is the unit of capacity and is the capacity of a condenser charged to a potential of one volt by one coulomb of electricity.

The **Joule** is the unit of work. It is the work done by one watt in one second.

The **Watt** is the unit of electrical energy and is the product of ampere and volt—one ampere of current flowing under a pressure of one volt gives one watt of energy.

746 watts equal 1 horsepower.

1 kilowatt equals 1.3410 horsepower.

PAINTING

Paints are for protective purposes and are used to assist lighting. The labor cost is about double that of the paint cost. Normal spreading rates are as follows:

SQUARE FEET PER GALLON

	On Wood	On Metal	On Concrete
Priming Coat	300–400	500–700	150–250
Second and Third Coats	400–600	700–800	300–400
Spray Painting, First Coat	275–350		
Second and Third Coats	500		

First coat of spray painting equal to 2 coats brush painting.
Spray painting, cold water white, etc.—1 lb covers 25 sq. ft.

Your comments and suggestions are always welcome. Please write to us.

Contents of Round Tanks

in U. S. gallons for each foot in depth

Diameter Feet	Diameter Inches	Gallons One Foot in Depth	Diameter Feet	Diameter Inches	Gallons One Foot in Depth	Diameter Feet	Diameter Inches	Gallons One Foot in Depth
1	0	5.9	6	9	267.7	14	6	1235.3
1	3	9.2	7	0	287.9	15	0	1321.9
1	6	13.2	7	3	308.8	15	6	1411.5
1	9	18.0	7	6	330.5	16	0	1504.1
2	0	23.5	7	9	352.9	16	6	1599.5
2	3	29.7	8	0	376.0	17	0	1697.8
2	6	36.7	8	3	399.9	17	6	1799.3
2	9	44.4	8	6	424.5	18	0	1903.6
3	0	52.9	8	9	449.8	18	6	2010.8
3	3	62.0	9	0	475.9	19	0	2120.9
3	6	72.0	9	3	502.7	19	6	2234.0
3	9	82.6	9	6	530.2	20	0	2350.1
4	0	94.0	9	9	558.5	21	0	2591.0
4	3	106.1	10	0	587.5	22	0	2843.6
4	6	119.0	10	6	647.7	23	0	3108.0
4	9	132.6	11	0	710.9	24	0	3384.1
5	0	146.9	11	6	777.0	25	0	3672.0
5	3	161.9	12	0	846.0	26	0	3971.6
5	6	177.7	12	6	918.0	27	0	4283.0
5	9	194.2	13	0	992.9	28	0	4606.2
6	0	211.5	13	6	1070.8	29	0	4941.0
6	3	229.5	14	0	1151.5	30	0	5287.7
6	6	248.2						

YEAR BY YEAR GROWTH OF $100 A MONTH COMPOUNDED QUARTERLY AT VARIOUS RATES

	3%	4%	5%	6%
After 1 Year:	$ 1,217	$ 1,222	$ 1,228	$ 1,233
" 2 "	2,470	2,494	2,518	2,542
" 3 "	3,762	3,816	3,874	3,932
" 4 "	5,092	5,195	5,299	5,407
" 5 "	6,463	6,628	6,797	6,972
" 6 "	7,876	8,119	8,371	8,633
" 7 "	9,332	9,671	10,035	10,396
" 8 "	10,831	11,286	11,764	12,268
" 9 "	12,377	12,966	13,591	14,254
" 10 "	13,969	14,715	15,511	16,362
" 11 "	15,609	16,534	17,529	18,599
" 12 "	17,299	18,428	19,650	20,974
" 13 "	19,041	20,408	21,879	23,494
" 14 "	20,835	22,449	24,221	26,169
" 15 "	22,685	24,583	26,683	29,009
" 16 "	24,589	26,803	29,270	32,022
" 17 "	26,551	29,113	31,989	35,221
" 18 "	28,573	31,518	34,847	38,615
" 19 "	30,657	34,020	37,850	42,218
" 20 "	32,804	36,623	41,006	46,042

COURTESY OF DORR CO.

Conversion Tables

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Acres	43,560	Square feet
"	4047	Square meters
"	1.562×10^{-3}	Square miles
"	4840	Square yards
Acre-feet	43,560	Cubic feet
" "	325,851	Gallons
" "	1233.49	Cubic meters
Atmospheres	76.0	Cms. of mercury
"	29.92	Inches of mercury
"	33.90	Feet of water
"	10,333	Kgs./sq. meter
"	14.70	Lbs./sq. inch
"	1.058	Tons/sq. ft.
Barrels–oil	42	Gallons–oil
" –cement	376	Pounds–cement
Bags or sacks–cement	94	Pounds–cement
Board-feet	144 sq. in. x 1 in.	Cubic inches
British Thermal Units	0.2520	Kilogram-calories
" " "	777.5	Foot-lbs.
" " "	3.927×10^{-4}	Horse-power-hrs.
" " "	107.5	Kilogram-meters
" " "	2.928×10^{-4}	Kilowatt-hrs.
B.T.U./min.	12.96	Foot-lbs./sec.
" / "	0.02356	Horse-power
" / "	0.01757	Kilowatts
" / "	17.57	Watts
Centares (Centiares)	1	Square meters
Centigrams	0.01	Grams
Centiliters	0.01	Liters
Centimeters	0.3937	Inches
"	0.01	Meters
"	10.	Millimeters
Centimtrs. of mercury	0.01316	Atmospheres
" " "	0.4461	Feet of water
" " "	136.0	Kgs./sq. meter
" " "	27.85	Lbs./sq. ft.
" " "	0.1934	Lbs./sq. inch

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Centimeters/second	1.969	Feet/min.
" / "	0.03281	Feet/sec.
Centimeters/second	0.036	Kilometers/hr.
" / "	0.6	Meters/min.
" / "	0.02237	Miles/hr.
" / "	3.728x10^{-4}	Miles/min.
Cms./sec./sec.	0.03281	Feet/sec./sec.
Cubic centimeters	3.531x10^{-5}	Cubic feet
" "	6.102x10^{-2}	Cubic inches
" "	10^{-6}	Cubic meters
" "	1.308x10^{-6}	Cubic yards
" "	2.642x10^{-4}	Gallons
" "	10^{-3}	Liters
" "	2.113x10^{-3}	Pints (liq.)
" "	1.057x10^{-3}	Quarts (liq.)
Cubic feet	2.832x10^{4}	Cubic cms.
" "	1728	Cubic inches
" "	0.02832	Cubic meters
" "	0.03704	Cubic yards
" "	7.48052	Gallons
" "	28.32	Liters
" "	59.84	Pints (liq.)
" "	29.92	Quarts (liq.)
Cubic feet/minute	472.0	Cubic cms./sec.
" " / "	0.1247	Gallons/sec.
" " / "	0.4720	Liters/sec.
" " / "	62.43	Pounds of water/min.
Cubic feet/second	0.646317	Million gals./day
" " / "	448.831	Gallons/min.
Cubic inches	16.39	Cubic centimeters
" "	5.787x10^{-4}	Cubic feet
" "	1.639x10^{-5}	Cubic meters
" "	2.143x10^{-5}	Cubic yards
" "	4.329x10^{-3}	Gallons
" "	1.639x10^{-2}	Liters
" "	0.03463	Pints (liq.)
" "	0.01732	Quarts (liq.)

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Cubic meters	10^{6}	Cubic centimeters
" "	35.31	Cubic feet
" "	61.023	Cubic inches
" "	1.308	Cubic yards
" "	264.2	Gallons
Cubic meters	10^{3}	Liters
" "	2113	Pints (liq.)
" "	1057	Quarts (liq.)
Cubic yards	7.646x10^{5}	Cubic centimeters
" "	27	Cubic feet
" "	46,656	Cubic inches
" "	0.7646	Cubic meters
" "	202.0	Gallons
" "	764.6	Liters
" "	1616	Pints (liq.)
" "	807.9	Quarts (liq.)
Cubic yards/min.	0.45	Cubic feet/sec.
" " / "	3.367	Gallons/sec.
" " / "	12.74	Liters/sec.
Decigrams	0.1	Grams
Deciliters	0.1	Liters
Decimeters	0.1	Meters
Degrees (angle)	60	Minutes
" "	0.01745	Radians
" "	3600	Seconds
Degrees/sec.	0.01745	Radians/sec.
" / "	0.1667	Revolutions/min.
" / "	0.002778	Revolutions/sec.
Dekagrams	10	Grams
Dekaliters	10	Liters
Dekameters	10	Meters
Drams	27.34375	Grains
"	0.0625	Ounces
"	1.771845	Grams
Fathoms	6	Feet
Feet	30.48	Centimeters
"	12	Inches
"	0.3048	Meters
"	1/3	Yards

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Feet of water	0.02950	Atmospheres
" " "	0.8826	Inches of mercury
" " "	304.8	Kgs./sq.meter
" " "	62.43	Lbs./sq.ft.
" " "	0.4335	Lbs./sq.inch
Feet/min.	0.5080	Centimeters/sec.
" / "	0.01667	Feet/sec.
" / "	0.01829	Kilometers/hr.
" / "	0.3048	Meters/min.
" / "	0.01136	Miles/hr.
Feet/sec.	30.48	Centimeters/sec.
" / "	1.097	Kilometers/hr.
" / "	0.5921	Knots
" / "	18.29	Meters/min.
" / "	0.6818	Miles/hr.
" / "	0.01136	Miles/min.
Feet/sec./sec	30.48	Cms./sec./sec.
" / " / "	0.3048	Meters/sec./sec.
Foot-pounds	1.286×10^{-3}	British Thermal Units
" "	5.050×10^{-7}	Horse-power-hrs.
" "	3.241×10^{-4}	Kilogram-calories
" "	0.1383	Kilogram-meters
" "	3.766×10^{-7}	Kilowatt-hrs.
Foot-pounds/min.	1.286×10^{-3}	B. T. Units/min.
" " / "	0.01667	Foot-pounds/sec.
" " / "	3.030×10^{-5}	Horse-power
" " / "	3.241×10^{-4}	Kg.-calories/min.
" " / "	2.260×10^{-5}	Kilowatts
Foot-pounds/sec.	7.717×10^{-2}	B. T. Units/min.
" " / "	1.818×10^{-3}	Horse-power
" " / "	1.945×10^{-2}	Kg.-calories/min.
" " / "	1.356×10^{-3}	Kilowatts
Gallons	3785	Cubic centimeters
"	0.1337	Cubic feet
"	231	Cubic inches
"	3.785×10^{-3}	Cubic meters
"	4.951×10^{-3}	Cubic yards
"	3.785	Liters
"	8.	Pints (liq.)
"	4.	Quarts (liq.)

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Gallons, Imperial	1.20095	U.S. gallons
" U.S.	0.83267	Imperial gallons
Gallons water	8.3453	Pounds of water
Gallons/min.	2.228×10^{-3}	Cubic feet/sec.
" / "	0.06308	Liters/sec.
" / "	8.0208	Cu. ft./hr.
" / "	8.0208 / Area (sq. ft.)	Overflow rate (ft./hr.)
Gallons water/min.	6.0086	Tons water/24 hrs.
Grains (troy)	1.	Grains (avoir.)
" "	0.06480	Grams
" "	0.04167	Pennyweights (troy)
" "	2.0833×10^{-3}	Ounces (troy)
Grains/U.S. gal.	17.118	Parts/million
" /U.S. gal.	142.86	Lbs./million gal.
" /Imp. gal.	14.254	Parts/million
Grams	980.7	Dynes
"	15.43	Grains
"	10^{-3}	Kilograms
"	10^{3}	Milligrams
"	0.03527	Ounces
"	0.03215	Ounces (troy)
"	2.205×10^{-3}	Pounds
Grams/cm.	5.600×10^{-3}	Pounds/inch
Grams/cu. cm.	62.43	Pounds/cubic foot
" / " "	0.03613	Pounds/cubic inch
Grams/liter	58.417	Grains/gal.
" / "	8.345	Pounds/1000 gals.
" / "	0.062427	Pounds/cubic foot
" / "	1000	Parts/million
Hectares	2.471	Acres
"	1.076×10^{5}	Square feet
Hectograms	100	Grams
Hectoliters	100	Liters
Hectometers	100	Meters
Hectowatts	100	Watts

Multiply	*By*	*To Obtain*
Horse-power	42.44	B.T. Units/min.
" "	33,000	Foot-lbs./min.
" "	550	Foot-lbs./sec.
" "	1.014	Horse-power (metric)
" "	10.70	Kg.-calories/min.
" "	0.7457	Kilowatts
" "	745.7	Watts
Horse-power (boiler)	33,479	B.T.U./hr.
" " "	9.803	Kilowatts
Horse-power-hours	2547	British Thermal Units
" " "	1.98×10^{6}	Foot-lbs.
" " "	641.7	Kilogram-calories
" " "	2.737×10^{5}	Kilogram-meters
" " "	0.7457	Kilowatt-hours
Inches	2.540	Centimeters
Inches of mercury	0.03342	Atmospheres
" " "	1.133	Feet of water
" " "	345.3	Kgs./sq. meter
" " "	70.73	Lbs./sq. ft.
" " "	0.4912	Lbs./sq. inch
Inches of water	0.002458	Atmospheres
" " "	0.07355	Inches of mercury
" " "	25.40	Kgs./sq. meter
" " "	0.5781	Ounces/sq. inch
" " "	5.202	Lbs./sq. foot
" " "	0.03613	Lbs./sq. inch
Kilograms	980,665	Dynes
"	2.205	Lbs.
"	1.102×10^{-3}	Tons (short)
"	10^{3}	Grams
Kilograms-calories	3.968	British Thermal Unit
" "	3086	Foot-pounds
" "	1.558×10^{-3}	Horse-power-hours
" "	1.162×10^{-3}	Kilowatt-hours
Kilogram-calories/min.	51.43	Foot-pounds/sec.
" " / "	0.09351	Horse-power
" " / "	0.06972	Kilowatts
Kgs./meter	0.6720	Lbs./foot

May We Please Work With You On All Your Equipment Needs?

Multiply	*By*	*To Obtain*
Kgs./sq. meter	9.678×10^{-5}	Atmospheres
" / " "	3.281×10^{-3}	Feet of water
" / " "	2.896×10^{-3}	Inches of mercury
" / " "	0.2048	Lbs./sq. foot
" / " "	1.422×10^{-3}	Lbs./sq. inch
Kgs./sq. millimeter	10^{6}	Kgs./sq. meter
Kiloliters	10^{3}	Liters
Kilometers	10^{5}	Centimeters
"	3281	Feet
"	10^{3}	Meters
"	0.6214	Miles
"	1094	Yards
Kilometers/hr.	27.78	Centimeters/sec.
" / "	54.68	Feet/min.
" / "	0.9113	Feet/sec.
" / "	0.5396	Knots
" / "	16.67	Meters/min.
" / "	0.6214	Miles/hr.
Kms./hr./sec.	27.78	Cms./sec./sec.
" / " / "	0.9113	Ft./sec./sec.
" / " / "	0.2778	Meters/sec./sec.
Kilowatts	56.92	B.T. Units/min.
"	4.425×10^{4}	Foot-lbs./min.
"	737.6	Foot-lbs./sec.
"	1.341	Horse-power
"	14.34	Kg.-calories/min.
"	10^{3}	Watts
Kilowatt-hours	3415	British Thermal Units
" "	2.655×10^{6}	Foot-lbs.
" "	1.341	Horse-power-hrs.
" "	860.5	Kilogram-calories
" "	3.671×10^{5}	Kilogram-meters
Liters	10^{3}	Cubic centimeters
"	0.03531	Cubic feet
"	61.02	Cubic inches
"	10^{-3}	Cubic meters
"	1.308×10^{-3}	Cubic yards
"	0.2642	Gallons
"	2.113	Pints (liq.)
"	1.057	Quarts (liq.)

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Liters/min	5.886×10^{-4}	Cubic ft.-sec.
“ / “	4.403×10^{-3}	Gals.-/sec.
Lumber Width (in.) x Thickness (in.) / 12	Length (ft)	Board Feet
Meters	100	Centimeters
“	3.281	Feet
“	39.37	Inches
“	10^{-3}	Kilometers
“	10^{3}	Millimeters
“	1.094	Yards
Meters/min	1.667	Centimeters/sec.
“ / “	3.281	Feet/min.
“ / “	0.05468	Feet/sec.
“ / “	0.06	Kilometers/hr.
“ / “	0.03728	Miles/hr.
Meters/sec	196.8	Feet/min.
“ / “	3.281	Feet/sec.
“ / “	3.6	Kilometers/hr.
“ / “	0.06	Kilometers/min.
“ / “	2.237	Miles/hr.
“ / “	0.03728	Miles/min.
Microns	10^{-6}	Meters
Miles	1.609×10^{5}	Centimeters
“	5280	Feet
“	1.609	Kilometers
“	1760	Yards
Miles/hr	44.70	Centimeters/sec.
“ / “	88	Feet/min.
“ / “	1.467	Feet/sec.
“ / “	1.609	Kilometers/hr.
“ / “	0.8684	Knots
“ / “	26.82	Meters/min.
Miles/min	2682	Centimeters/sec.
“ / “	88	Feet/sec.
“ / “	1.609	Kilometers/min.
“ / “	60	Miles/hr.
Milliers	10^{3}	Kilograms
Milligrams	10^{-3}	Grams
Milliliters	10^{-3}	Liters

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Millimeters	0.1	Centimeters
“	0.03937	Inches
Milligrams/liter	1	Parts/million
Million gals./day	1.54723	Cubic ft./sec.
Miner's inches	1.5	Cubic ft./min.
Minutes (angle)	2.909×10^{-4}	Radians
Ounces	16	Drams
“	437.5	Grains
“	0.0625	Pounds
“	28.349527	Grams
“	0.9115	Ounces (troy)
“	2.790×10^{-5}	Tons (long)
“	2.835×10^{-5}	Tons (metric)
Ounces, troy	480	Grains
“ “	20	Pennyweights (troy)
“ “	0.08333	Pounds (troy)
“ “	31.103481	Grams
“ “	1.09714	Ounces, avoir.
Ounces (fluid)	1.805	Cubic inches
“ “	0.02957	Liters
Ounces/sq. inch	0.0625	Lbs./sq. inch
Overflow rate (ft./hr.)	0.12468 x area (sq. ft.)	Gals./min.
1 / Overflow rate (ft./hr.)	8.0208	Sq. ft./gal./min.
Parts/million	0.0584	Grains/U.S. gal.
“ / “	0.07016	Grains/Imp. gal.
“ / “	8.345	Lbs./million gal.
Pennyweights (troy)	24	Grains
“ “	1.55517	Grams
“ “	0.05	Ounces (troy)
“ “	4.1667×10^{-3}	Pounds (troy)
Pounds	16	Ounces
“	256	Drams
“	7000	Grains
“	0.0005	Tons (short)
“	453.5924	Grams
“	1.21528	Pounds (troy)
“	14.5833	Ounces (troy)

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Pounnds (troy)	5760	Grains
" "	240	Pennyweights (troy)
" "	12	Ounces (troy)
" "	373.24177	Grams
" "	0.822857	Pounds (avoir.)
" "	13.1657	Ounces (avoir.)
" "	3.6735×10^{-4}	Tons (long)
" "	4.1143×10^{-4}	Tons (short)
" "	3.7324×10^{-4}	Tons (metric)
Pounds of water	0.01602	Cubic feet
" " "	27.68	Cubic inches
" " "	0.1198	Gallons
Pounds of water/min.	2.670×10^{-4}	Cubic ft./sec.
Pounds/cubic foot	0.01602	Grams/cubic cm.
" / " "	16.02	Kgs./cubic meter
" / " "	5.787×10^{-4}	Lbs./cubic inch
Pounds/cubic inch	27.68	Grams/cubic cm.
" / " "	2.768×10^{4}	Kgs./cubic meter
" / " "	1728	Lbs./cubic foot
Pounds/foot	1.488	Kgs./meter
Pounds/inch	178.6	Grams/cm.
Pounds/sq. foot	0.01602	Feet of water
" / " "	4.883	Kgs./sq. meter
" / " "	6.945×10^{-3}	Pounds/sq. inch
Pounds/sq. inch	0.06804	Atmospheres
" / " "	2.307	Feet of water
" / " "	2.036	Inches of mercury
" / " "	703.1	Kgs./sq. meter
Quadrants (angle)	90	Degrees
" "	5400	Minutes
" "	1.571	Radians
Quarts (dry)	67.20	Cubic inches
Quarts (liq.)	57.75	Cubic inches
Quintal, Argentine	101.28	Pounds
" Brazil	129.54	Pounds
" Castile, Peru	101.43	Pounds
" Chile	101.41	Pounds
" Mexico	101.47	Pounds
" Metric	220.46	Pounds

What can we do to help you?

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Quires	25	Sheets
Radians	57.30	Degrees
"	3438	Minutes
"	0.637	Quadrants
Radians/sec.	57.30	Degrees/sec.
" / "	0.1592	Revolutions/sec.
" / "	9.549	Revolutions/min.
Radians/sec./sec.	573.0	Revolutions/min/min.
" / " / "	0.1592	Revolutions/sec./sec.
Reams	500	Sheets
Revolutions	360	Degrees
"	4	Quadrants
"	6.283	Radians
Revolutions/min	6	Degrees/sec.
" / "	0.1047	Radians/sec.
" / "	0.01667	Revolutions/sec.
Revolutions/min./min.	1.745×10^{-3}	Rads./sec./sec.
" / " / "	2.778×10^{-4}	Revs./sec./sec.
Revolutions/sec.	360	Degrees/sec.
" / "	6.283	Radians/sec.
" / "	60	Revolutions/min.
Revolutions/sec./sec	6.283	Radians/sec./sec.
" / " / "	3600	Revolutions/min/min.
Seconds (angle)	4.848×10^{-6}	Radians
Square centimeters	1.076×10^{-3}	Square feet
" "	0.1550	Square inches
" "	10^{-4}	Square meters
" "	100	Square millimeters
Square feet	2.296×10^{-5}	Acres
" "	929.0	Square centimeters
" "	144	Square inches
" "	0.09290	Square meters
" "	3.587×10^{-8}	Square miles
" "	1/9	Square yards
$\frac{1}{\text{Sq. ft./gal./min.}}$	8.0208	Overflow rate (ft./hr.)

May We Please Work With You On All Your Equipment Needs?

CONVERSION FACTORS

Multiply	*By*	*To Obtain*
Square inches	6.452	Square centimeters
" "	6.944×10^{-3}	Square feet
" "	645.2	Square millimeters
Square kilometers	247.1	Acres
" "	10.76×10^{6}	Square feet
" "	10^{6}	Square meters
" "	0.3861	Square miles
" "	1.196×10^{6}	Square yards
Square meters	2.471×10^{-4}	Acres
" "	10.76	Square feet
" "	3.861×10^{-7}	Square miles
" "	1.196	Square yards
Square miles	640	Acres
" "	27.88×10^{6}	Square feet
" "	2.590	Square kilometers
" "	3.098×10^{6}	Square yards
Square millimeters	0.01	Square centimeters
" "	1.550×10^{-3}	Square inches
Square yards	2.066×10^{-4}	Acres
" "	9	Square feet
" "	0.8361	Square meters
" "	3.228×10^{-7}	Square miles
Temp. (°C.) + 273	1	Abs. temp. (°C.)
" " + 17.78	1.8	Temp. (°F.)
" (°F.) + 460	1	Abs. temp. (°F.)
" " − 32	5/9	Temp. (°C.)
Tons (long)	1016	Kilograms
" "	2240	Pounds
" "	1.12000	Tons (short)
Tons (metric)	10^{3}	Kilograms
" "	2205	Pounds
Tons (short)	2000	Pounds
" "	32000	Ounces
" "	907.18486	Kilograms

Multiply	*By*	*To Obtain*
Tons (short)	2430.56	Pounds (troy)
" "	0.89287	Tons (long)
" "	29166.66	Ounces (troy)
" "	0.90718	Tons (metric)
$\frac{1}{\text{Tons dry solids/24 hrs.}}$	Area (sq. ft.)	Sq.ft./ton/24 hrs.
Tons of water/24 hrs.	83.333	Pounds water/hour
" " " / "	0.16643	Gallons/min.
" " " / "	1.3349	Cu. ft./hr.
Watts	0.05692	B. T. Units/min.
"	44.26	Foot-pounds/min.
"	0.7376	Foot-pounds/sec.
"	1.341×10^{-3}	Horse-power
"	0.01434	Kg.-calories/min.
"	10^{-3}	Kilowatts
Watt-hours	3.415	British Thermal Units
"	2655	Foot-pounds
"	1.341×10^{-3}	Horse-power-hours
"	0.8605	Kilogram-calories
"	367.1	Kilogram-meters
"	10^{-3}	Kilowatt-hours
Yards	91.44	Centimeters
"	3	Feet
"	36	Inches
"	0.9144	Meters

COURTESY OF DORR CO.

Decimal Equivalents

1/64	.015625	17/64	.265625	33/64	.515625	49/64	.765625
1/32	.03125	9/32	.28125	17/32	.53125	25/32	.78125
3/64	.046875	19/64	.296875	35/64	.546875	51/64	.796875
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.078125	21/64	.328125	37/64	.578125	53/64	.828125
3/32	.09375	11/32	.34375	19/32	.59375	27/32	.84375
7/64	.109375	23/64	.359375	39/64	.609375	55/64	.859375
1/8	.1250	3/8	.3750	5/8	.6250	7/8	.8750
9/64	.140625	25/64	.390625	41/64	.640625	57/64	.890625
5/32	.15625	13/32	.40625	21/32	.65625	29/32	.90625
11/64	.171875	27/64	.421875	43/64	.671875	59/64	.921875
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.203125	29/64	.453125	45/64	.703125	61/64	.953125
7/32	.21875	15/32	.46875	23/32	.71875	31/32	.96875
15/64	.234375	31/64	.484375	47/64	.734375	63/64	.984375
1/4	.2500	1/2	.5000	3/4	.7500	1	1.0000

Multiply	*By*	*To Obtain*

CONVERSION TABLE

Horse-Power to Kilowatts

H.P.	Kw	H.P.	Kw	H.P.	Kw	H.P.	Kw
1	.746	79	58.93	157	117.12	235	175.31
2	1.49	80	59.68	158	117.87	236	176.06
3	2.24	81	60.43	159	118.61	237	176.80
4	2.98	82	61.17	160	119.36	238	177.55
5	3.73	83	61.92	161	120.11	239	178.29
6	4.48	84	62.66	162	120.85	240	179.04
7	5.22	85	63.41	163	121.60	241	179.79
8	5.97	86	64.16	164	122.34	242	180.53
9	6.71	87	64.90	165	123.08	243	181.28
10	7.46	88	65.65	166	123.84	244	182.02
11	8.20	89	66.39	167	124.58	245	182.77
12	8.95	90	67.14	168	125.33	246	183.52
13	9.70	91	67.89	169	126.07	247	184.26
14	10.44	92	68.63	170	126.82	248	185.01
15	11.19	93	69.38	171	127.57	249	185.75
16	11.94	94	70.12	172	128.31	250	186.50
17	12.68	95	70.87	173	129.06	255	189.23
18	13.43	96	71.62	174	129.80	260	193.96
19	14.17	97	72.36	175	130.55	265	197.69
20	14.92	98	73.11	176	131.30	270	201.42
21	15.67	99	73.85	177	132.04	275	205.15
22	16.41	100	74.60	178	132.79	280	208.88
23	17.16	101	75.35	179	133.53	285	212.61
24	17.90	102	76.09	180	134.28	290	216.34
25	18.65	103	76.84	181	135.03	295	220.07
26	19.40	104	77.58	182	135.77	300	223.80
27	20.14	105	78.33	183	136.52	305	227.53
28	20.89	106	79.08	184	137.26	310	231.26
29	21.63	107	79.82	185	138.01	315	234.99
30	22.38	108	80.57	186	138.76	320	238.72
31	23.126	109	81.31	187	139.50	325	242.45
32	23.87	110	82.06	188	140.25	330	246.18
33	24.62	111	82.81	189	140.99	335	249.91
34	25.36	112	83.55	190	141.74	340	253.64
35	26.11	113	84.30	191	142.49	345	257.37
36	26.86	114	85.04	192	143.23	350	261.10
37	27.60	115	85.79	193	143.98	355	264.83
38	28.35	116	86.54	194	144.72	360	268.56
39	29.09	117	87.28	195	145.47	365	272.29
40	29.84	118	88.03	196	146.22	370	276.0
41	30.59	119	88.77	197	146.96	375	279.7
42	31.32	120	89.52	198	147.71	380	283.4
43	32.08	121	90.27	199	148.45	385	287.2
44	32.82	122	91.01	200	149.20	390	290.9
45	33.57	123	91.76	201	149.95	395	294.6
46	34.32	124	92.50	202	150.69	400	298.4
47	35.06	125	93.25	203	151.44	405	302.1
48	35.81	126	94.00	204	152.18	410	305.8
49	36.55	127	94.74	205	152.93	415	309.5
50	37.30	128	95.49	206	153.68	420	313.3

CONVERSION TABLE

Horse-Power to Kilowatts

H.P.	Kw	H.P.	Kw	H.P.	Kw	H.P.	Kw
51	38.07	129	96.23	207	154.42	425	317.0
52	38.79	130	96.98	208	155.17	430	320.7
53	39.54	131	97.73	209	155.91	435	324.5
54	40.28	132	98.47	210	156.66	440	328.2
55	41.03	133	99.22	211	157.41	445	331.9
56	41.78	134	99.96	212	158.15	450	335.7
57	42.52	135	100.71	213	158.90	460	343.1
58	43.27	136	101.46	214	159.64	470	350.6
59	44.01	137	102.20	215	160.39	480	358.0
60	44.76	138	102.95	216	161.14	490	365.5
61	45.51	139	103.69	217	161.88	500	373.0
62	46.25	140	104.44	218	162.63	510	380.4
63	47.00	141	105.19	219	163.37	520	387.9
64	47.74	142	105.93	220	164.12	530	395.3
65	48.49	143	106.68	221	164.87	540	402.8
66	49.24	144	107.42	222	165.61	550	410.3
67	49.98	145	108.17	223	166.36	575	428.9
68	50.73	146	108.92	224	167.10	600	447.6
69	51.47	147	109.66	225	167.85	625	466.2
70	52.22	148	110.41	226	168.60	650	484.9
71	52.97	149	111.15	227	169.34	675	503.5
72	53.71	150	111.90	228	170.09	700	522.2
73	54.46	151	112.65	229	170.83	750	559.5
74	55.20	152	113.39	230	171.58	800	596.8
75	55.95	153	114.14	231	172.33	850	634.1
76	56.70	154	114.88	232	173.07	900	671.4
77	57.44	155	115.63	233	173.82	950	708.7
78	58.19	156	116.38	234	174.56	1000	746.0

Areas and Volumes

Circumference of circle	=3.1416×diameter
Diameter of circle	=0.3183×circumference
Side of a square of equal area	=0.8862×diameter
Diameter of a circle of equal area	=1.1284×side of square
Area of a circle	=0.7854×square of the diameter
Diameter of a circle	=1.1284×square root of the area
Surface area of a sphere	=3.1416×square of the diameter
Volume of a sphere	=0.5236×cube of diameter
Volume of cylinder or prism	=area of base×height
Volume of cone or pyramid	=⅓×area of base×height
Volume of the frustrum of a cone or pyramid	=⅓×height×(area of upper base+area of lower base+ √ area of upper base×area of lower base)

Doubling the diameter of a pipe increases its volume four times; generalizing, increasing the diameter "n" times increases the volume "n^2" or "n×n" times.

Comparison of Temperature Scales

Centigrade Scale (C.)

The freezing point of water is zero °. The boiling point of water is 100° Centigrade at sea level. The intervening space is divided into 100 equal degrees.

Fahrenheit Scale (F.)

The freezing point of water is 32° F. The boiling point of water is 212° F., at sea level. The intervening space is divided into 180 equal degrees and the same graduation is extended above and below. Below zero ° a minus sign is prefixed.

Reaumur Scale (R.)

The freezing point of water is zero ° R. The boiling point of water is 80° R., at sea level. The intervening space is divided into 80 equal degrees.

To convert Centigrade degrees into degrees of Fahrenheit, multiply by 9, divide the product by 5 and add 32.

To convert Fahrenheit degrees into degrees of Centigrade, subtract 32, multiply by 5 and divide by 9.

To convert Reaumur degrees into degrees of Fahrenheit, multiply by 9, divide by 4 and add 32.

To convert Fahrenheit degrees into degrees of Reaumur, subtract 32, multiply by 4 and divide by 9.

To convert Reaumur degrees into degrees of Centigrade, multiply by 5 and divide by 4.

To convert Centigrade degrees into degrees of Reaumur, multiply by 4 and divide by 5.

Centigrade	Fahrenheit
1930	3506
1910	3470
1890	3434
1870	3398
1850	3362
1830	3326
1740	3164
1720	3128
1705	3101
1685	3065
1670	3038
1650	3002
1635	2975
1620	2948
1600	2912
1590	2894
1575	2867
1560	2840
1550	2822
1540	2804
1530	2786
1510	2750
1490	2714
1470	2678
1450	2642
1430	2606
1410	2570
1390	2534
1370	2498
1350	2462
1330	2426
1310	2390
1290	2354
1270	2318
1250	2282
1230	2246
1210	2210
1190	2174
1170	2138
1150	2102
1130	2066
1110	2030
1090	1994
1070	1958
1050	1922
1030	1886
1010	1850
990	1814
970	1778
950	1742
920	1688
890	1634
860	1580
830	1526
800	1472
770	1418
740	1364
710	1310
680	1256
650	1202
620	1148
590	1094
580	1076
570	1058
560	1040
550	1022
540	1004
530	986
520	968
510	950

Centigrade	Fahrenheit
500	932
490	914
480	896
470	878
460	860
450	842
440	824
430	806
420	788
410	770
400	752
390	734
380	716
370	698
360	680
350	662
340	644
330	626
320	608
310	590
300	572
290	554
280	536
270	518
260	500
250	482
240	464
230	446
220	428
210	410
200	392
195	383
190	374
185	365
180	356
175	347
170	338
165	329
160	320
155	311
150	302
145	293
140	284
135	275
130	266
125	257
120	248
115	239
110	230
105	221
100	212
99	210.2
98	208.4
97	206.6
96	204.6
95	203
94	201.2
93	199.4
92	197.6
91	195.8
90	194
89	192.2
88	190.4
87	188.6
86	186.8
85	185
84	183.2
83	181 4
82	179.6
81	177.8

Centigrade	Fahrenheit
80	176
79	174.2
78	172.4
77	170.6
76	168.8
75	167
74	165.2
73	163.4
72	161.6
71	159.8
70	158
69	156.2
68	154.4
67	152.6
66	150.8
65	149
64	147.2
63	145.4
62	143.6
61	141.8
60	140
59	138.2
58	136.4
57	134.6
56	132.8
55	131
54	129.2
53	127.4
52	125.6
51	123.8
50	122
49	120.2
48	118.4
47	116.6
46	114.8
45	113
44	111.2
43	109.4
42	107.6
41	105.8
40	104
39	102.2
38	100.4
37	98.6
36	96.8
35	95
34	93.2
33	91.4
32	89.6
31	87.8
30	86
29	84.2
28	82.4
27	80.6
26	78.8

Centigrade	Fahrenheit
25	77
24	75.2
23	73.4
22	71.6
21	69.8
20	68
19	66.2
18	64.4
17	62.6
16	60.8
15	59
14	57.2
13	55.4
12	53.6
11	51.8
10	50
9	48.2
8	46.4
7	44.6
6	42.8
5	41
4	39.2
3	37.4
2	35.6
1	33.8
0	32
-1	30.2
-2	28.4
-3	26.6
-4	24.8
-5	23
-6	21.2
-7	19.4
-8	17.6
-9	15.8
-10	14
-11	12.2
-12	10.4
-13	8.6
-14	6.8
-15	5
-16	3.2
-17	1.4
-18	-0.4
-19	-2.2
-20	-4.0
-21	-5.8
-22	-7.6
-23	-9.4
-24	-11.2
-25	-13.0
-26	-14.8
-27	-16.6
-28	-18.4
-29	-20.2

ESTIMATING TEMPERATURES ROUGHLY BY APPEARANCE

Color	Centigrade Degrees	Fahrenheit Degrees
Just glowing in the dark	525	977
Dark Red	700	1252
Cherry Red	908	1666
Bright Cherry Red	1000	1832
Orange	1150	2102
White	1300	2372
Dazzling White	1500	2732

Conversion Tables

Indian Weights and Measures

Fixed by Government Regulations in 1883

1 Tola	Weight of 1 Rupee	
5 Tolas	1 Chittack	2 2/35 ozs.
16 Chittacks	1 Seer	2 2/35 lbs.
40 Seers	1 Maund	82 2/7 lbs.

British-Indian Conversion Table

To convert Seers to Pounds Av.	Multiply by 72/35
To convert Maunds to Cwts.	Multiply by 36/49
To convert Tons to Maunds	Multiply by 27⅕

Indian Land Measure

5 Square yards	1 Chatak
16 Chataks	1 Cottah
20 Cottahs	1 Bigha = 1600 sq. yards
3 1/40 Bighas	1 Acre

Avoirdupois Weight—British and Metric

British Units	Metric Equiv.	Metric Units	British Equiv.
1 grain	64.7989 mg.	1 mg.	.0154 gr.
1 grain	6.4798 cg.	1 cg.	.1543 gr.
1 grain	.0647 g.	1 g.	15.4323 gr.
1 ounce	28.3495 g.	1 g.	.0352 oz.
1 ounce	.0283 kg.	1 kg.	35.2739 oz.
1 pound	.4535 kg.	1 kg.	2.2046 lb.
1 cwt.	50.80 kg.	1 kg.	.01968 cwt.
1 ton	1.0160 tonne	1 tonne	.9842 ton

Avoirdupois Weight—U. S. Standard

16 Drams	1 Ounce (437.5 grs.)
16 Ounces	1 Pound (lb.)
14 Pounds	1 Stone
28 Pounds	1 Quarter
112 Pounds	1 Hundredweight (cwt.)
20 Hundredwts.	1 Ton

Air Pressure to Operate Lifts

GENERAL DATA

Lift, Ft.	Submergence, Ft.	*Theoretical Gauge Pressure in Pounds per Square Inch to Elevate Fluid of Specific Gravity					
		1.0	1.1	1.2	1.3	1.4	1.5
5′	7.5′	3.2	3.6	3.9	4.2	4.5	4.9
10′	15.0′	6.5	7.1	7.8	8.4	9.1	9.7
15′	22.5′	9.7	10.7	11.6	12.6	13.6	14.5
20′	30.0′	13.0	14.3	15.6	16.9	18.2	19.5
25′	37.5′	16.2	17.8	19.4	21.0	22.7	24.3
30′	45.0′	19.5	21.4	23.4	25.3	27.3	29.2
35′	52.5′	22.7	25.0	27.2	29.5	31.8	34.0
40′	60.0′	26.0	28.6	31.2	33.8	36.4	39.0
45′	67.5′	29.2	32.1	35.0	38.0	40.9	43.8
50′	75.0′	32.5	35.7	39.0	42.2	45.5	48.7
5′	10.0′	4.3	4.7	5.2	5.6	6.0	6.5
10′	20.0′	8.7	9.6	10.4	11.3	12.2	13.0
15′	30.0′	13.0	14.3	15.6	16.9	18.2	19.5
20′	40.0′	17.3	19.0	20.8	22.5	24.2	25.9
25′	50.0′	21.6	23.8	25.9	28.1	30.2	32.4
30′	60.0′	26.0	28.6	31.2	33.8	36.4	39.0
35′	70.0′	30.3	33.3	36.4	39.4	42.4	45.4
40′	80.0′	34.6	38.0	31.5	45.0	48.4	51.9
45′	90.0′	39.0	42.9	46.8	50.7	54.6	58.5
50′	100.0′	43.3	47.6	52.0	56.3	60.6	64.9

*An increase in pressure of from 10 to 20% over the figures given will be necessary in practice.

Horsepower Required to Compress Air

APPROXIMATE MOTOR HORSEPOWER REQUIRED TO COMPRESS 100 CU. FT. OF FREE AIR DELIVERED AT THE PRESSURES SHOWN

Altitude	Atmospheric Pressure Pounds	Blowers Motor Horsepower			Compressors Motor Horsepower		
		5 Lbs.	10 Lbs.	20 Lbs.	60 Lbs.	80 Lbs.	100 Lbs.
0	14.69	1.4	3.6	12.6	16.3	19.5	22.1
1000	14.16	1.4	3.6	12.5	16.1	19.2	21.7
2000	13.66	1.3	3.5	12.3	15.9	18.9	21.3
3000	13.16	1.3	3.5	12.2	15.7	18.6	20.9
4000	12.68	1.3	3.5	12.1	15.4	18.2	20.6
5000	12.22	1.3	3.5	12.0	15.2	17.9	20.3
6000	11.77	1.3	3.5	11.9	15.0	17.6	20.0
7000	11.33	1.2	3.4	11.7	14.7	17.3	19.6
8000	10.91	1.2	3.4	11.6	14.5	17.1	19.3
9000	10.50	1.2	3.4	11.5	14.3	16.8	18.9
10000	10.10	1.2	3.4	11.3	14.1	16.5	18.6
11000	9.71	1.2	3.4	11.1	13.6	15.9	17.9
12000	9.34	1.1	3.3	10.9	13.1	15.2	17.2
13000	8.97	1.1	3.3	10.7	12.6	14.5	16.5
14000	8.62	1.1	3.3	10.5	12.1	13.8	15.8
15000	8.28	1.0	3.3	10.2	11.6	13.1	15.1

Initial temperature of air taken as 60° F.
Horsepower showo will vary with type and kind of blower or compressor

WATER PRESSURE LOSSES BY FRICTION IN WOOD PIPES

Head in feet of water lost per 1,000 feet of pipe at various rates of flow.

Rate of Flow, feet per second	Pipe Size, inches						
	4	6	8	12	16	20	30
	Head in Feet Lost per 1,000 Feet						
1	.97	.63	.43	.26	.18	.11	.09
1.5	2.3	1.3	.97	.61	.41	.22	.16
2	4.2	2.4	1.6	1.1	.73	.45	.29
2.5	6.5	3.8	2.6	1.7	1.2	.83	.47
3	9.4	5.5	3.9	2.5	1.6	1.1	.66
3.5	12.6	7.4	5.5	3.4	2.3	1.6	.89
4	16.0	9.5	7.2	4.4	3.0	2.1	1.1
4.5	19.7	12.1	9.2	5.5	3.8	2.7	1.4
5	23.6	15.1	11.3	6.7	4.7	3.3	1.8
5.5	27.5	18.1	13.5	8.1	5.6	4.0	2.2
6	....	21.4	16.0	9.7	6.7	4.8	2.7
6.5	....	25.1	18.7	11.5	7.7	5.6	3.2
7	....	....	21.5	13.3	8.8	6.5	3.7
7.5	....	....	24.4	15.3	10.2	7.3	4.2
8	....	....	27.3	17.2	11.6	8.3	4.7
8.5	....	....	....	19.3	13.1	9.3	5.2
9	....	....	....	21.5	14.6	10.2	5.7
9.5	....	....	....	22.8	16.1	11.2	6.3
10	....	....	....	....	17.6	12.2	6.8

Average Capacity of Air-Lifts

Diam. of Lift Pipe	Gallons per Minute	Cu. Ft. per Minute	Tons of Pulp per 24 Hours with Pulp of Specific Gravity					
			1.0	1.1	1.2	1.3	1.4	1.5
2"	45	6	270	297	324	351	378	405
2½"	75	10	450	495	540	585	630	675
3"	10.5	14	630	693	756	819	882	945
3½"	15	20	900	990	1080	1170	1260	1350
4"	18.75	25	1125	1237	1350	1462	1575	1637
5"	30	40	1800	2980	2160	2340	2520	2700
6"	42	56	2520	2772	3024	3276	3528	3780

—By A. W. Allen, Engineering and Mining Journal.

Barometric Pressure

Altitude (Feet)	Pressure (Lb. Sq. In.)	Barometer (In. Hg)	Air Wt.	Boil'g Point (Water, °F)
0	14.72	29.92	100.0	212.0
1,000	14.17	28.81	96.3	210.1
2,000	13.64	27.72	92.6	208.2
3,000	13.13	26.70	89.2	206.3
4,000	12.64	25.70	85.9	204.4
5,000	12.17	24.76	82.8	202.6
6,000	11.71	23.81	79.6	200.7
7,000	11.27	22.92	76.7	198.9
8,000	10.85	22.08	73.8	197.1
9,000	10.45	21.26	71.0	195.0
10,000	10.06	20.47	68.4	193.1
11,000	9.69	19.71	65.8	191.2
12,000	9.33	18.98	63.4	189.3

AIR PIPE FRICTION

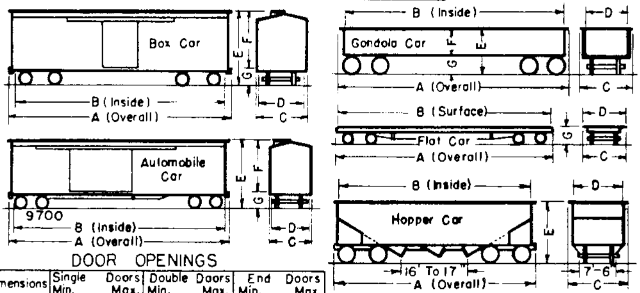
Velocity f.p.m.	Velocity Pressure, Inches w.g.	Pipe Diameters								
		6"	8"	10"	12"	14"	16"	20"	24"	28"
		Air friction per 100 ft. of pipe, inches Water Gauge								
1000	0.06	0.33	0.25	0.20	0.16	0.14	0.12	0.10	0.08	0.07
2000	0.25	1.3	0.98	0.78	0.65	0.55	0.49	0.39	0.32	0.28
2500	0.40	2.1	1.54	1.22	1.05	0.88	0.77	0.61	0.51	0.44
3000	0.55	2.9	2.2	1.76	1.45	1.25	1.1	0.88	0.72	0.63
3500	0.77	4.0	3.0	2.4	2.0	1.7	1.5	1.2	1.0	0.85
4000	1.0	5.2	3.9	3.1	2.6	2.2	1.95	1.55	1.3	1.1
5000	1.55	8.0	6.0	4.8	4.0	3.4	3.0	2.4	2.0	1.7
		Quantity c.f.m. (varies as velocities)								
1000		200	342	567	800	1067	1400	2000	2833	4167
3000		600	1025	1700	2400	3200	4200	6000	8500	12500
5000		1000	1700	2800	4000	5300	6000	10000	14200	20800

w.g., water gauge; f.p.m., feet per minute; c.f.m., cubic feet per minute.

ALTITUDE EFFECTS

Altitude Above Sea Level	Barometric Pressure				Approx. Boiling Point Water °F.	Relative Volumetric Efficiency Density
	Mercury Column		Water Column feet	Pounds per Sq. In.		
	MM	Inches				
0	762	30.00	34.0	14.72	212	1.000
1000	733	28.85	32.7	14.17	210	0.965
2000	707	27.82	31.5	13.64	208	0.93
3000	681	26.82	30.3	13.13	206	0.895
4000	657	25.85	29.2	12.64	204	0.86
5000	631	24.92	28.1	12.17	202	0.83
6000	610	24.00	27.0	11.71	201	0.80
7000	587	23.1	26.0	11.27	199	0.77
8000	562	22.17	25.0	10.85	197	0.74
9000	540	21.3	24.1	10.45	195	0.71
10000	517	20.34	23.2	10.06	193	0.68
11000	503	19.8	22.4	9.69	191	0.66
12000	485	19.1	21.6	9.33	190	0.635
13000	464	18.3	20.8	8.98	188	0.61
14000	447	17.6	20.0	8.64	186	0.59
15000	432	17.0	19.3	8.32	184	0.57
20000	349	13.75	15.6	6.75	175	0.458
30000	226	8.88	10.08	4.36	157	0.277
40000	140.8	5.54	6.29	2.72	138	0.1499
50000	87.4	3.44	3.91	1.69	120	0.068

FREIGHT CAR DIMENSIONS



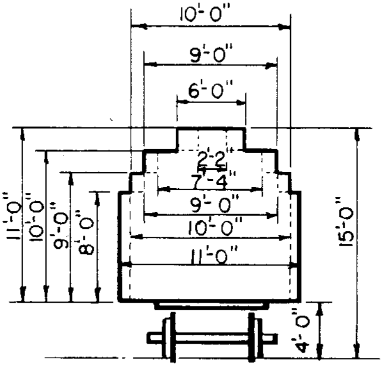
DOOR OPENINGS

Dimensions	Single Doors Min.	Single Doors Max.	Double Doors Min.	Double Doors Max.	End Doors Min.	End Doors Max.
Width	5'-6"	6'-1"	7'-9"	15'-0"	8'-6"	9'-4"
Height	7'-8"	10'-6"	8'-0"	9'-11"	8'-6"	10'-1"

CAR DIMENSIONS

Type of Car	A Length Over Strikers Avg	B Inside Length Min.	B Inside Length Max.	C Overall Width Avg.	D Inside Width Min.	D Inside Width Max.	E Overall Height Avg.	F Inside Height Min.	F Inside Height Max.	G Floor Height Avg.	Level Full Capacity Avg. Cu. Ft.	Tare Weight Avg. Lbs.
Flat	53'-0"	36'-0"	60'-0"	10'-3"	8'-6"	10'-6"	......	......	......	3'-11"	......	48,700
Gondola	43'-0"	33'-6"	65'-0"	10'-4"	7'-6"	9'-6"	8'-7"	4'-8" Avg.		3'-11"	1775	42,800
Hopper	35'-10"	34'-10" Avg.		10'-5"	10'-3" Avg.		10'-8"	....	....	.....	2328	30,000
Box	41'-9"	40'-0"	50'-0"	10'-8"	8'-5"	9'-4"	14'-1"	7'-9"	10'-6"	3'-8"	3468	48,200
Automobile	52'-3"	50'-6" Avg.		10'-8"	9'-2" Avg.		15'-1"	10'-4" Avg.		3'-7"	4798	53,300

SHIPPING CLEARANCES ON STD. GAUGE FLAT CARS



Full lines indicate clearances on standard gauge flat cars to all points of United States, **Canada and Mexico** with exceptions noted below. Lengths may go up to **46'-6" for** these widths and heights. For shipments requiring greater clearances full information should be obtained. Blocking etc. must be included when estimating required clearances. Dotted lines indicate clearances on certain railroads passing thru the following cities.

Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Montreal, New York, Philadelphia, Pittsburgh, St. Louis, Washington D.C., Mackinaw Mich.

For shipments over railroads passing through these cities, when more clearance is required that is indicated above, complete information should be obtained.

TRIGONOMETRIC FUNCTIONS

Every triangle has six parts—three angles and three sides. When any three of these parts are known, provided one of them is a side, the other parts may be determined.

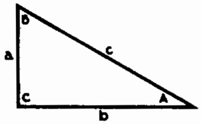
The sum of the three angles of a triangle is equal to 180 degrees. The complement of an angle, or arc, is the remainder after subtracting the angle, or arc, from 90 degrees. In general, if any arc is represented by A, its complement is (90°—A). Hence the complement of an arc that exceeds 90 degrees is negative.

In all right triangles having the same acute angles, the sides have the same ratio to each other. These ratios have received special names as follows: if A is one of the acute angles, a is the opposite side, b the adjacent side, and c the hypotenuse.

The sine (sin) of the angle A is the quotient of the opposite side divided by the hypotenuse. $\text{Sin } A = \frac{a}{c}$.

The tangent (tan) of the angle A is the quotient of the opposite side divided by the adjacent side.

$\text{Tan } A = \frac{a}{b}$.



The secant (sec) of the angle A is the quotient of the hypotenuse divided by the adjacent side. $\text{Sec } A = \frac{c}{b}$.

The cosine (cos), cotangent (cot) and cosecant (cosec) of an angle are respectively the sine, tangent, and secant of the complement of that angle. The terms sine, cosine, etc., are called trigonometrical functions.

Inter-relationship of functions.

$$\text{Sin}^2 A + \text{Cos}^2 A = 1$$

$$\text{Sin } A = \sqrt{1 - \text{Cos}^2 A} \qquad \text{Cos } A = \sqrt{1 - \text{Sin}^2 A}$$

$$\text{Tan } A = \frac{\text{Sin } A}{\text{Cos } A} = \frac{1}{\text{Cot } A} \qquad \text{Cot } A = \frac{\text{Cos } A}{\text{Sin } A} = \frac{1}{\text{Tan } A}$$

$$\text{Sec } A = \frac{1}{\text{Cos } A} \qquad \text{Cosec } A = \frac{1}{\text{Sin } A}$$

With the aid of the above formulas, and the tables below, the function of any angle may be found.

Our desire is to make you "Happier, Healthier and Wealthier."

Degrees	Natural Sines			
	0′	20′	40′	60′
0	0.0000	0.0058	0.0116	0.0175
1	0.0175	0.0233	0.0291	0.0349
2	0.0349	0.0407	0.0465	0.0523
3	0.0523	0.0581	0.0640	0.0698
4	0.0698	0.0756	0.0814	0.0872
5	0.0872	0.0930	0.0987	0.1045
6	0.1045	0.1103	0.1161	0.1219
7	0.1219	0.1276	0.1334	0.1392
8	0.1392	0.1449	0.1507	0.1564
9	0.1564	0.1622	0.1679	0.1736
10	0.1736	0.1794	0.1851	0.1908
11	0.1908	0.1965	0.2022	0.2079
12	0.2079	0.2136	0.2193	0.2250
13	0.2250	0.2306	0.2363	0.2419
14	0.2419	0.2476	0.2532	0.2588
15	0.2588	0.2644	0.2700	0.2756
16	0.2756	0.2812	0.2868	0.2924
17	0.2924	0.2979	0.3035	0.3090
18	0.3090	0.3145	0.3201	0.3256
19	0.3256	0.3311	0.3365	0.3420
20	0.3420	0.3475	0.3529	0.3584
21	0.3584	0.3638	0.3692	0.3746
22	0.3746	0.3800	0.3854	0.3907
23	0.3907	0.3961	0.4014	0.4067
24	0.4067	0.4120	0.4173	0.4226
25	0.4226	0.4279	0.4331	0.4384
26	0.4384	0.4436	0.4488	0.4540
27	0.4540	0.4592	0.4643	0.4695
28	0.4695	0.4746	0.4797	0.4848
29	0.4848	0.4899	0.4950	0.5000
30	0.5000	0.5050	0.5100	0.5150
31	0.5150	0.5200	0.5250	0.5299
32	0.5299	0.5348	0.5398	0.5446
33	0.5446	0.5495	0.5544	0.5592
34	0.5592	0.5640	0.5688	0.5736
35	0.5736	0.5783	0.5831	0.5878
36	0.5878	0.5925	0.5972	0.6018
37	0.6018	0.6065	0.6111	0.6157
38	0.6157	0.6202	0.6248	0.6293
39	0.6293	0.6338	0.6383	0.6428
40	0.6428	0.6472	0.6517	0.6561
41	0.6561	0.6604	0.6648	0.6691
42	0.6691	0.6734	0.6777	0.6820
43	0.6820	0.6862	0.6905	0.6947
44	0.6947	0.6988	0.7030	0.7071
	60′	40′	20′	0′
	Natural Cosines			

Natural Cosines			
0′	20′	40′	60′
1.0000	0.9999	0.9999	0.9998
0.9998	0.9997	0.9996	0.9994
0.9994	0.9992	0.9989	0.9986
0.9986	0.9983	0.9980	0.9976
0.9976	0.9971	0.9967	0.9962
0.9962	0.9957	0.9951	0.9945
0.9945	0.9939	0.9932	0.9925
0.9925	0.9918	0.9911	0.9903
0.9903	0.9894	0.9886	0.9877
0.9877	0.9868	0.9858	0.9848
0.9848	0.9838	0.9827	0.9816
0.9816	0.9805	0.9793	0.9781
0.9781	0.9769	0.9757	0.9744
0.9744	0.9730	0.9717	0.9703
0.9703	0.9689	0.9674	0.9659
0.9659	0.9644	0.9628	0.9613
0.9613	0.9596	0.9580	0.9563
0.9563	0.9546	0.9528	0.9511
0.9511	0.9492	0.9474	0.9455
0.9455	0.9436	0.9417	0.9397
0.9397	0.9377	0.9357	0.9336
0.9336	0.9315	0.9293	0.9272
0.9272	0.9250	0.9228	0.9205
0.9205	0.9182	0.9159	0.9135
0.9135	0.9112	0.9088	0.9063
0.9063	0.9038	0.9013	0.8988
0.8988	0.8962	0.8936	0.8910
0.8910	0.8884	0.8857	0.8829
0.8829	0.8802	0.8774	0.8746
0.8746	0.8718	0.8689	0.8660
0.8660	0.8631	0.8601	0.8572
0.8572	0.8542	0.8511	0.8480
0.8480	0.8450	0.8418	0.8387
0.8387	0.8355	0.8323	0.8290
0.8290	0.8258	0.8225	0.8192
0.8192	0.8158	0.8124	0.8090
0.8090	0.8056	0.8021	0.7986
0.7986	0.7951	0.7916	0.7880
0.7880	0.7844	0.7808	0.7771
0.7771	0.7735	0.7698	0.7660
0.7660	0.7623	0.7585	0.7547
0.7547	0.7509	0.7470	0.7431
0.7431	0.7392	0.7353	0.7314
0.7314	0.7274	0.7234	0.7193
0.7193	0.7153	0.7112	0.7071
60′	40′	20′	0′
Natural Sines			

Natural Tangents			
0′	20′	40′	60′
0.0000	0.0058	0.0116	0.0175
0.0175	0.0233	0.0291	0.0349
0.0349	0.0407	0.0466	0.0524
0.0524	0.0582	0.0641	0.0699
0.0699	0.0758	0.0816	0.0875
0.0875	0.0934	0.0992	0.1051
0.1051	0.1110	0.1169	0.1228
0.1228	0.1287	0.1346	0.1405
0.1405	0.1465	0.1524	0.1584
0.1584	0.1644	0.1703	0.1763
0.1763	0.1823	0.1884	0.1944
0.1944	0.2004	0.2065	0.2126
0.2126	0.2186	0.2247	0.2309
0.2309	0.2370	0.2432	0.2493
0.2493	0.2555	0.2617	0.2679
0.2679	0.2742	0.2805	0.2867
0.2867	0.2931	0.2994	0.3057
0.3057	0.3121	0.3185	0.3249
0.3249	0.3314	0.3378	0.3443
0.3443	0.3508	0.3574	0.3640
0.3640	0.3706	0.3772	0.3839
0.3839	0.3906	0.3973	0.4040
0.4040	0.4108	0.4176	0.4245
0.4245	0.4314	0.4383	0.4452
0.4452	0.4522	0.4592	0.4663
0.4663	0.4734	0.4806	0.4877
0.4877	0.4950	0.5022	0.5095
0.5095	0.5169	0.5243	0.5317
0.5317	0.5392	0.5467	0.5543
0.5543	0.5619	0.5696	0.5774
0.5774	0.5851	0.5930	0.6009
0.6009	0.6088	0.6168	0.6249
0.6249	0.6330	0.6412	0.6494
0.6494	0.6577	0.6661	0.6745
0.6745	0.6830	0.6916	0.7002
0.7002	0.7089	0.7177	0.7265
0.7265	0.7355	0.7445	0.7536
0.7536	0.7627	0.7720	0.7813
0.7813	0.7907	0.8002	0.8098
0.8098	0.8195	0.8292	0.8391
0.8391	0.8491	0.8591	0.8693
0.8693	0.8796	0.8899	0.9004
0.9004	0.9110	0.9217	0.9325
0.9325	0.9435	0.9545	0.9657
0.9657	0.9770	0.9884	1.0000
60′	40′	20′	0′
Natural Cotangents			

Cotangents

0′	20′	40′	60′	Degrees
∞	171.88540	85.93979	57.28996	89
57.28996	42.96408	34.36777	28.63625	88
28.63625	24.54176	21.47040	19.08114	87
19.08114	17.16934	15.60478	14.30067	86
14.30067	13.19688	12.25051	11.43005	85
11.43005	10.71191	10.07803	9.51436	84
9.51436	9.00983	8.55555	8.14435	83
8.14435	7.77035	7.42871	7.11537	82
7.11537	6.82694	6.56055	6.31375	81
6.31375	6.08444	5.87080	5.67128	80
5.67128	5.48451	5.30928	5.14455	79
5.14455	4.98940	4.84300	4.70463	78
4.70463	4.57363	4.44942	4.33148	77
4.33148	4.21933	4.11256	4.01078	76
4.01078	3.91364	3.82083	3.73205	75
3.73205	3.64705	3.56557	3.48741	74
3.48741	3.41236	3.34023	3.27085	73
3.27085	3.20406	3.13972	3.07768	72
3.07768	3.01783	2.96004	2.90421	71
2.90421	2.85023	2.79802	2.74748	70
2.74748	2.69853	2.65109	2.60509	69
2.60509	2.56046	2.51715	2.47509	68
2.47509	2.43422	2.39449	2.35585	67
2.35585	2.31826	2.28167	2.24604	66
2.24604	2.21132	2.17749	2.14451	65
2.14451	2.11233	2.08094	2.05030	64
2.05030	2.02039	1.99116	1.96261	63
1.96261	1.93470	1.90741	1.88073	62
1.88073	1.85462	1.82907	1.80405	61
1.80405	1.77955	1.75556	1.73205	60
1.73205	1.70901	1.68643	1.66428	59
1.66428	1.64256	1.62125	1.60033	58
1.60033	1.57981	1.55966	1.53987	57
1.53987	1.52043	1.50133	1.48256	56
1.48256	1.46411	1.44598	1.42815	55
1.42815	1.41061	1.39336	1.37638	54
1.37638	1.35968	1.34323	1.32704	53
1.32704	1.31110	1.29541	1.27994	52
1.27994	1.26471	1.24969	1.23490	51
1.23490	1.22031	1.20593	1.19175	50
1.19175	1.17777	1.16398	1.15037	49
1.15037	1.13694	1.12369	1.11061	48
1.11061	1.09770	1.08496	1.07237	47
1.07237	1.05994	1.04766	1.03553	46
1.03553	1.02355	1.01170	1.00000	45
60′	40′	20′	0′	

Tangents

N	0	1	2	3	4	5	6	7	8	9	Proportional Parts 1	2	3	4	5
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4
N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5

N	0	1	2	3	4	5	6	7	8	9	Proportional Parts 1	2	3	4	5
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3
70	8451	8457	8463	8470	8476	8482	8488	8491	8500	8506	1	1	2	2	3
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2
N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5

Areas and Circumferences of Circles

Diam., In.	Area, Sq. In.	Circum., In.	Diam., In.	Area, Sq. In.	Circum., In.	Diam., In.	Area, Sq. In.	Circum., In.	Diam., In.	Area, Sq. In.	Circum., In.
1/16	.0031	.1963	8½	56.7451	26.7036	21½	363.051	67.5444	50	1963.50	157.080
1/8	.0123	.3927	5/8	58.4264	27.0963	3/4	371.543	68.3298	51	2042.83	160.222
1/4	.0491	.7854	3/4	60.1322	27.4890	22	380.134	69.1152	52	2123.72	163.363
3/8	.1104	1.1781	7/8	61.8625	27.8817	1/4	388.822	69.9006	53	2206.19	166.505
1/2	.1963	1.5708	9	63.6174	28.2744	1/2	397.609	70.6860	54	2290.23	169.646
5/8	.3068	1.9635	1/8	65.3968	28.6671	3/4	406.494	71.4714	55	2375.83	172.788
3/4	.4418	2.3562	1/4	67.2008	29.0598	23	415.477	72.2568	56	2463.01	175.930
7/8	.6013	2.7489	3/8	69.0293	29.4525	1/4	424.558	73.0422	57	2551.76	179.071
1	.7854	3.1416	1/2	70.8823	29.8452	1/2	433.737	73.8276	58	2642.09	182.213
1/8	.9940	3.5343	5/8	72.7599	30.2379	3/4	443.015	74.6130	59	2733.98	185.354
1/4	1.2272	3.9270	3/4	74.6621	30.6306	24	452.390	75.3984	60	2827.44	188.496
3/8	1.4849	4.3197	7/8	76.5889	31.0233	1/2	471.436	76.9692	61	2922.47	191.638
1/2	1.7671	4.7124	10	78.540	31.4160	25	490.875	78.5400	62	3019.08	194.779
5/8	2.0739	5.1051	1/8	80.516	31.8087	1/2	510.706	80.1108	63	3117.25	197.921
3/4	2.4053	5.4978	1/4	82.516	32.2014	26	530.930	81.6816	64	3217.00	201.062
7/8	2.7612	5.8905	3/8	84.541	32.5941	1/2	551.547	83.2524			
2	3.1416	6.2832	1/2	86.590	32.9868	27	572.557	84.8232			
1/8	3.5466	6.6759	5/8	88.664	33.3795	1/2	593.959	86.3940			
1/4	3.9761	7.0686	3/4	90.763	33.7722						

Areas and Circumferences of Circles

Diam., In.	Area, Sq. In.	Circum., In.
⅜	4.4301	7.4613
½	4.9087	7.8540
⅝	5.4119	8.2467
¾	5.9396	8.6394
⅞	6.4918	9.0321
3	7.0686	9.4248
⅛	7.6699	9.8175
¼	8.2958	10.2102
⅜	8.9462	10.6029
½	9.6211	10.9956
⅝	10.3206	11.3883
¾	11.0447	11.7810
⅞	11.7933	12.1737
4	12.5664	12.5664
⅛	13.3641	12.9591
¼	14.1863	13.3518
⅜	15.0330	13.7445
½	15.9043	14.1372
⅝	16.8002	14.5299
¾	17.7206	14.9226
⅞	18.6655	15.3153

Diam., In.	Area, Sq. In.	Circum., In.
⅞	92.886	34.1649
11	95.033	34.5576
⅛	97.205	34.9503
¼	99.402	35.3430
⅜	101.623	35.7357
½	103.869	36.1284
⅝	106.139	36.5211
¾	108.434	36.9138
⅞	110.754	37.3065
12	113.098	37.6992
¼	117.859	38.4846
½	122.719	39.2700
¾	127.677	40.0554
13	132.733	40.8408
¼	137.887	41.6262
½	143.139	42.4116
¾	148.490	43.1970
14	153.938	43.9824
¼	159.485	44.7678
½	165.130	45.5532

Diam., In.	Area, Sq. In.	Circum., In.
28	615.754	87.9648
½	637.941	89.5356
29	660.521	91.1064
½	683.494	92.6772
30	706.860	94.248
½	730.618	95.819
31	754.769	97.390
½	779.313	98.960
32	804.250	100.531
½	829.579	102.102
33	855.301	103.673
½	881.415	105.244
34	907.922	106.814
½	934.822	108.385
35	962.115	109.956
½	989.800	111.527
36	1017.878	113.098
½	1046.349	114.668

Diam., In.	Area, Sq. In.	Circum., In.
65	3318.31	204.204
66	3421.20	207.346
67	3525.66	210.487
68	3631.69	213.629
69	3739.29	216.770
70	3848.46	219.912
71	3959.20	223.054
72	4071.51	226.195
73	4185.40	229.337
74	4300.85	232.478
75	4417.87	235.620
76	4536.47	238.762
77	4656.64	241.903
78	4778.37	245.045
79	4901.68	248.186

5	19.6350	15.7080
⅛	20.6290	16.1007
¼	21.6476	16.4934
⅜	22.6907	16.8861
½	23.7583	17.2788
⅝	24.8505	17.6715
¾	25.9673	18.0642
⅞	27.1086	18.4569
6	28.2744	18.8496
⅛	29.4648	19.2423
¼	30.6797	19.6350
⅜	31.9191	20.0277
½	33.1831	20.4204
⅝	34.4717	20.8131
¾	35.7848	21.2058
⅞	37.1224	21.5985
7	38.4846	21.9912
⅛	39.8713	22.3839
¼	41.2826	22.7766
⅜	42.7184	23.1693
½	44.1787	23.5620
⅝	45.6636	23.9547
¾	47.1731	24.3474
⅞	48.7071	24.7401
8	50.2656	25.1328
⅛	51.8487	25.5255
¼	53.4563	25.9182
⅜	55.0884	26.3109

¾	170.874	46.3386
15	176.715	47.1240
¼	182.655	47.9094
½	188.692	48.6948
¾	194.828	49.4802
16	201.062	50.2656
¼	207.395	51.0510
½	213.825	51.8364
¾	220.354	52.6218
17	226.981	53.4072
¼	233.706	54.1926
½	240.529	54.9780
¾	247.450	55.7634
18	254.470	56.5488
¼	261.587	57.3342
½	268.803	58.1196
¾	276.117	58.9050
19	283.529	59.6904
¼	291.040	60.4758
½	298.648	61.2612
¾	306.355	62.0466
20	314.160	62.8320
¼	322.063	63.6174
½	330.064	64.4028
¾	338.164	65.1882
21	346.361	65.9736
¼	354.657	66.7590

37	1075.213	116.239
½	1104.469	117.810
38	1134.118	119.381
½	1164.159	120.952
39	1194.593	122.522
½	1225.420	124.093
40	1256.64	125.664
½	1288.25	127.235
41	1320.26	128.806
½	1352.66	130.376
42	1385.45	131.947
½	1418.63	133.518
43	1452.20	135.089
½	1486.17	136.660
44	1520.53	138.230
½	1555.29	139.801
45	1590.43	141.372
½	1625.97	142.943
46	1661.91	144.514
½	1698.23	146.084
47	1734.95	147.655
½	1772.06	149.226
48	1809.56	150.797
49	1885.75	153.938

80	5026.56	251.328
81	5153.01	254.470
82	5281.03	257.611
83	5410.62	260.753
84	5541.78	263.894
85	5674.51	267.036
86	5808.82	270.178
87	5944.69	273.319
88	6082.14	276.461
89	6221.15	279.602
90	6361.74	282.744
91	6503.90	285.886
92	6647.63	289.027
93	6792.92	292.169
94	6939.79	295.310
95	7088.24	298.452
96	7238.25	301.594
97	7389.83	304.735
98	7542.98	307.877
99	7697.71	311.018
100	7854.00	314.160

CONVERSION TABLE—Basis 1 in.=25.400 mm. (Temperature 20° C)

MILLIMETERS INTO INCHES

mm.	0	1	2	3	4	5	6	7	8	9	mm.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
0		.03937	.07874	.11811	.15748	.19685	.23622	.27559	.31496	.35433	0
10	0.39370	.43307	.47244	.51181	.55118	.59055	.62992	.66929	.70866	.74803	10
20	0.78740	.82677	.86614	.90551	.94488	.98425	1.02362	1.06299	1.10236	1.14173	20
30	1.18110	1.22047	1.25984	1.29921	1.33858	1.37795	1.41732	1.45669	1.49606	1.53543	30
40	1.57480	1.61417	1.65354	1.69291	1.73228	1.77165	1.81102	1.85039	1.88976	1.92913	40
50	1.96850	2.00787	2.04724	2.08661	2.12598	2.16535	2.20472	2.24409	2.28346	2.32283	50
60	2.36220	2.40157	2.44094	2.48031	2.51968	2.55905	2.59842	2.63779	2.67716	2.71653	60
70	2.75590	2.79527	2.83464	2.87401	2.91338	2.95275	2.99212	3.03149	3.07086	3.11023	70
80	3.14960	3.18897	3.22834	3.26771	3.30708	3.34645	3.38582	3.42519	3.46456	3.50393	80
90	3.54330	3.58267	3.62204	3.66141	3.70078	3.74015	3.77952	3.81889	3.85826	3.89763	90
100	3.93700	3.97637	4.01574	4.05511	4.09448	4.13385	4.17322	4.21259	4.25196	4.29133	100

INCHES INTO MILLIMETERS

in.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	in.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
0		2.54	5.08	7.62	10.16	12.70	15.24	17.78	20.32	22.86	0
1	25.40	27.94	30.48	33.02	35.56	38.10	40.64	43.18	45.72	48.26	1
2	50.80	53.34	55.88	58.42	60.96	63.50	66.04	68.58	71.12	73.66	2
3	76.20	78.74	81.28	83.82	86.36	88.90	91.44	93.98	96.52	99.06	3
4	101.60	104.14	106.68	109.22	111.76	114.30	116.84	119.38	121.92	124.46	4
5	127.00	129.54	132.08	134.62	137.16	139.70	142.24	144.78	147.32	149.86	5
6	152.40	154.94	157.48	160.02	162.56	165.10	167.64	170.18	172.72	175.26	6
7	177.80	180.34	182.88	185.42	187.96	190.50	193.04	195.58	198.12	200.66	7
8	203.20	205.74	208.28	210.82	213.36	215.90	218.44	220.98	223.52	226.06	8
9	228.60	231.14	233.68	236.22	238.76	241.30	243.84	246.38	248.92	251.46	9
10	254.00	256.54	259.08	261.62	264.16	266.70	269.24	271.78	274.32	276.86	10

FRACTIONAL INCHES INTO MILLIMETERS

Inches		0	1	2	3	4	5	6	7	8	9	10	11	12
		mm.	25.400	50.800	76.200	101.600	127.000	152.400	177.800	203.200	228.600	254.000	279.400	304.800
1/64	.015625	0.397	25.797	51.197	76.597	101.997	127.397	152.797	178.197	203.597	228.997	254.397	279.797	305.197
1/32	.03125	0.794	26.194	51.594	76.994	102.394	127.794	153.194	178.594	203.994	229.394	254.794	280.194	305.594
1/16	.0625	1.588	26.988	52.388	77.788	103.188	128.588	153.988	179.388	204.788	230.188	255.588	280.988	306.388
3/32	.09375	2.381	27.781	53.181	78.581	103.981	129.381	154.781	180.181	205.581	230.981	256.381	281.781	307.181
1/8	.125	3.175	28.575	53.975	79.375	104.775	130.175	155.575	180.975	206.375	231.775	257.175	282.575	307.975
5/32	.15625	3.969	29.369	54.769	80.169	105.569	130.969	156.369	181.769	207.169	232.569	257.969	283.369	308.769
3/16	.1875	4.763	30.163	55.563	80.963	106.363	131.763	157.163	182.563	207.963	233.363	258.763	284.163	309.563
7/32	.21875	5.556	30.956	56.356	81.756	107.156	132.556	157.956	183.356	208.756	234.156	259.556	284.956	310.356
1/4	.25	6.350	31.750	57.150	82.550	107.950	133.350	158.750	184.150	209.550	234.950	260.350	285.750	311.150
9/32	.28125	7.144	32.544	57.944	83.344	108.744	134.144	159.544	184.944	210.344	235.744	261.144	286.544	311.944
5/16	.3125	7.938	33.338	58.738	84.138	109.538	134.938	160.338	185.738	211.138	236.538	261.938	287.338	312.738
11/32	.34375	8.731	34.131	59.531	84.931	110.331	135.731	161.131	186.531	211.931	237.331	262.731	288.131	313.531
3/8	.375	9.525	34.925	60.325	85.725	111.125	136.525	161.925	187.325	212.725	238.125	263.525	288.925	314.325
13/32	.40625	10.319	35.719	61.119	86.519	111.919	137.319	162.719	188.119	213.519	238.919	264.319	289.719	315.119
7/16	.4375	11.113	36.513	61.913	87.313	112.713	138.113	163.513	188.913	214.313	239.713	265.113	290.513	315.913
15/32	.46875	11.906	37.306	62.706	88.106	113.506	138.906	164.306	189.706	215.106	240.506	265.906	291.306	316.706
1/2	.50	12.700	38.100	63.500	88.900	114.300	139.700	165.100	190.500	215.900	241.300	266.700	292.100	317.500
17/32	.53125	13.494	38.894	64.294	89.694	115.094	140.494	165.894	191.294	216.694	242.094	267.494	292.894	318.294
9/16	.5625	14.288	39.688	65.088	90.488	115.888	141.288	166.688	192.088	217.488	242.888	268.288	293.688	319.088
19/32	.59375	15.081	40.481	65.881	91.281	116.681	142.081	167.481	192.881	218.281	243.681	269.081	294.481	319.881
5/8	.625	15.875	41.275	66.675	92.075	117.475	142.875	168.275	193.675	219.075	244.475	269.875	295.275	320.675
21/32	.65625	16.669	42.069	67.469	92.869	118.269	143.669	169.069	194.469	219.869	245.269	270 669	296.069	321.469
11/16	.6875	17.463	42.863	68.263	93.663	119.063	144.463	169.863	195.263	220.663	246.063	271 463	296.863	322.263
23/32	.71875	18.256	43.656	69.056	94.456	119.856	145.256	170.656	196.056	221.456	246.856	272.256	297.656	323.056
3/4	.75	19.050	44.450	69.850	95.250	120.650	146.050	171.450	196.850	222.250	247.650	273.050	298.450	323.850
25/32	.78125	19.844	45.244	70.644	96.044	121.444	146.844	172.244	197.644	223.044	248.444	273.844	299.244	324.644
13/16	.8125	20.638	46.038	71.438	96.838	122.238	147.638	173.038	198.438	223.838	249.238	274.638	300.038	325.438
27/32	.84375	21.431	46.831	72.231	97.631	123.031	148.431	173.831	199.231	224.631	250.031	275.431	300.831	326.231
7/8	.875	22.225	47.625	73.025	98.425	123.825	149.225	174.625	200.025	225.425	250.825	276.225	301.625	327.025
29/32	.90625	23.019	48.419	73.819	99.219	124.619	150.019	175.419	200.819	226.219	251.619	277.019	302.419	327.819
15/16	.9375	23.813	49.213	74.613	100.013	125.413	150.813	176.213	201.613	227.013	252.413	277.813	303.213	328.613
31/32	.96875	24.606	50.006	75.406	100.506	126.206	151.606	177.006	202.406	227.806	253.206	278.606	304.006	329.406

—Data courtesy SKF Industries, Inc.

Length of Wire Rope Splices

Size of Rope	Length of Splice	Size of Rope	Length of Splice
1/2 inch	Not less than 20 feet	1 inch	Not less than 40 feet
5/8 inch	Not less than 25 feet	1 1/8 inch	Not less than 45 feet
3/4 inch	Not less than 30 feet	1 1/4 inch	Not less than 50 feet
7/8 inch	Not less than 35 feet	1 3/8 inch	Not less than 55 feet
		1 1/2 inch	Not less than 60 feet

May We Please Work With You On All Your Equipment Needs?

Decimals of a Foot for Each 1/32 of an Inch

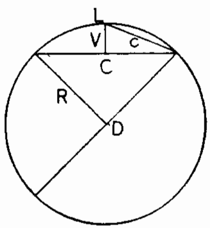
Inches	0	1	2	3	4	5	6	7	8	9	10	11
0	0.0	0.0833	0.1667	0.2500	0.3333	0.4167	0.5000	0.5833	0.6667	0.7500	0.8333	0.9167
1/32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
3/32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245
1/8	.0104	.0937	.1771	.2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271
5/32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
7/32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
9/32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
11/32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453
3/8	.0312	.1146	.1979	.2812	.3646	.4479	.5312	.6146	.6979	.7812	.8646	.9479
13/32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
15/32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
17/32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
19/32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
21/32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
23/32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792
25/32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
27/32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870
7/8	.0729	.1562	.2396	.3229	.4062	.4896	.5729	.6562	.7396	.8229	.9062	.9896
29/32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948
31/32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974
1	......	......	......	......	......	......	......	......	......	......	......	1.0000

Areas and Volumes

Plane Surfaces

CIRCLES

Let R = radius, D = diameter, L = length of arc, V = Rise, or height of arc, C = chord of the arc, c = chord of ½ the arc



500-517

Fig. 500-517.

$$L = \frac{8c - C}{3} \text{ very nearly}$$

$$C = 2\sqrt{c^2 - V^2} = 2\sqrt{(D-V) \times V}$$

$$c = \sqrt{D \times V} = \frac{3L + C}{8}$$

$$D = \frac{c^2}{V} = \frac{C^2}{4V} + V \qquad V = \frac{c^2}{D}$$

Area of a circle $= \pi R^2 = 3.1416 R^2$

Area of sector of circle = Arc of sector × ½ radius = ½ L R

SPHERES: Area of Sphere = 4 × Area of a great circle = πD^2

Volume of Sphere = Area × one third radius = $\frac{\pi D^3}{6}$

AREAS AND VOLUMES (continued from preceding page)

ELLIPSE: Area = $\frac{1}{4}\pi AB$, A and B being length and breadth respectively.

TRIANGLES: Area = $\frac{1}{2}$ Base × altitude

$= \sqrt{S(S-A)(S-B)(S-C)}$ $S = \frac{1}{2}$ Sum of 3 sides, **A, B and C.**

TRAPEZIUM: Area = Sum of area of its 2 triangles.

TRAPEZOID: Area = $\frac{1}{2}$ sum of parallel sides × perpendicular height.

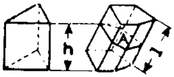
PARALLELOGRAM: Area = Base × perpendicular height.

REGULAR POLYGON: Area = $\frac{1}{2}$ Sum of Sides × Inside radius.

Lateral Surfaces (S) and Volumes (V) of Miscellaneous Solids

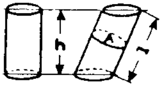
Parallelopiped.

S = [perimeter, P, perpendicular to sides × lateral length, l] = Pl
V = [area of base, B, × perpendicular height, h] = Bh
V = [area of section, A, perpendicular to sides × lateral length, l] = Al



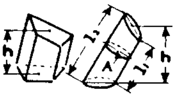
Prism, Right or Oblique, Regular or Irregular.

S = [perimeter, P, perpendicular to sides × latera length, l] = Pl
V = [area of base, B, × perpendicular height, h] = Bh
V = [area of section, A, perpendicular to sides × lateral length, l] = Al



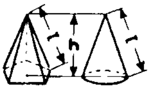
Cylinder, Right or Oblique, Circular or Elliptical.

S = [perimeter of base, P, × perpendicular height, h] = Ph
S = [perimeter, P_1, perpendicular to sides × lateral length, l] = $P_1 l$
V = [area of base, B, × perpendicular height, h] = Bh
V = [area of section, A, perpendicular to sides × lateral length, l] = Al



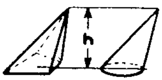
Frustum of Any Prism or Cylinder.

V = [area of base, B, × perpendicular distance, h, from base to center of gravity of opposite face] = Bh
For cylinder: $V = \frac{1}{2}A(l_1 + l_2)$



Pyramid or Cone, Right and Regular

S = [perimeter of base, P, × $\frac{1}{2}$ slant height, l] = $\frac{1}{2}$ Pl
V = [area of base, B, × $\frac{1}{3}$ perpendicular height, h] = $\frac{1}{3}$ Bh

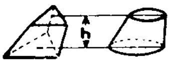


Pyramid or Cone, Right or Oblique, Regular or Irreg.

V = [area of base, B, × $\frac{1}{3}$ perpendicular height, h] = $\frac{1}{3}$ Bh
V = [$\frac{1}{3}$ volume of prism or cylinder of same base and perpendicular height]

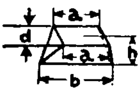
Frustum of Pyramid or Cone, Right and Regular, Parallel Ends.

S = [(sum of perimeter of base, P, and top, p) × $\frac{1}{2}$ slant height, l] = $\frac{1}{2}l(P + p)$
V = [(sum of areas of base, B, and top, b, + square root of their products) × $\frac{1}{3}$ perpendicular height, h]
= $\frac{1}{3}h(B + b + \sqrt{Bb})$



Frustum of Any Pyramid or Cone, Parallel Ends.

V = [(sum of areas of base, B, and top, b, + square root of their products) × $\frac{1}{3}$ perpendicular height, h]
= $\frac{1}{3}h(B + b + \sqrt{Bb})$

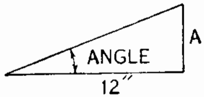


Wedge, Parallelogram Face

V = [$\frac{1}{6}$ (sum of three edges, a b a, × perpendicular height, h, × perpendicular width, d)] = $\frac{1}{6}dh(2a + b)$

("Kent" and "Carnegie")

Table of Bevels



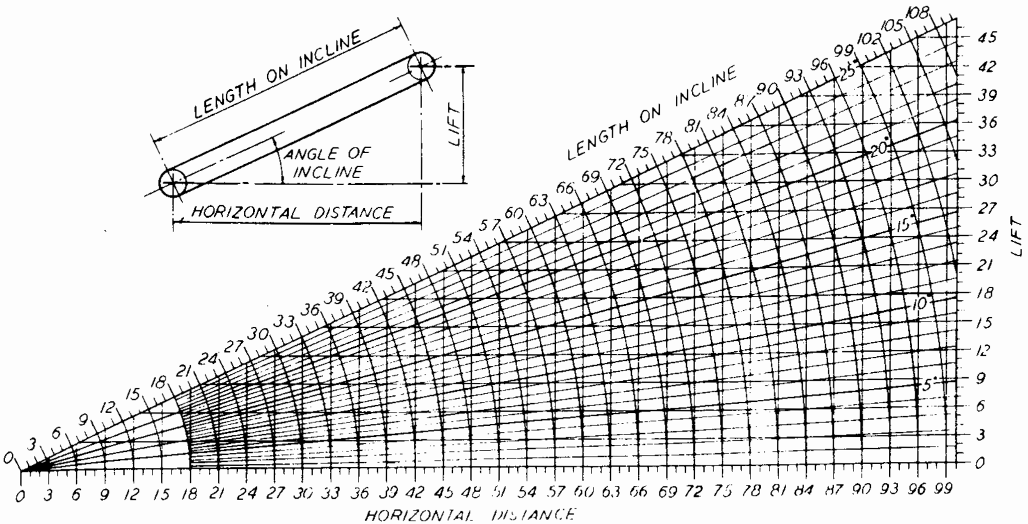
A Height, Inches	0″ Angle Deg.	0″ Angle Min.	1″ Angle Deg.	1″ Angle Min.	2″ Angle Deg.	2″ Angle Min.	3″ Angle Deg.	3″ Angle Min.	4″ Angle Deg.	4″ Angle Min.	5″ Angle Deg.	5″ Angle Min.	6″ Angle Deg.	6″ Angle Min.	7″ Angle Deg.	7″ Angle Min.	8″ Angle Deg.	8″ Angle Min.	9″ Angle Deg.	9″ Angle Min.	10″ Angle Deg.	10″ Angle Min.	11″ Angle Deg.	11″ Angle Min.
0	...	...	4	45	9	28	14	03	18	26	22	37	26	34	30	15	33	42	36	52	39	48	42	31
1/32	0	09	4	55	9	37	14	11	18	35	22	45	26	41	30	22	33	48	36	58	39	54	42	36
1/16	0	18	5	04	9	45	14	19	18	43	22	53	26	49	30	29	33	54	37	04	39	59	42	40
3/32	0	27	5	12	9	54	14	28	18	50	23	00	26	55	30	35	34	00	37	10	40	05	42	45
1/8	0	36	5	20	10	02	14	36	18	59	23	08	27	02	30	42	34	07	37	15	40	10	42	50
5/32	0	45	5	31	10	12	14	45	19	07	23	15	27	10	30	49	34	13	37	20	40	15	42	55
3/16	0	54	5	39	10	20	14	53	19	15	23	23	27	17	30	56	34	18	37	26	40	20	43	00
7/32	1	02	5	48	10	29	15	01	19	23	23	30	27	24	31	02	34	24	37	32	40	25	43	05
1/4	1	11	5	57	10	38	15	09	19	30	23	38	27	30	31	09	34	30	37	38	40	30	43	10
9/32	1	20	6	06	10	46	15	18	19	38	23	46	27	38	31	15	34	37	37	43	40	35	43	14
5/16	1	30	6	15	10	55	15	26	19	46	23	53	27	45	31	22	34	43	37	49	40	40	43	19
11/32	1	38	6	24	11	04	15	34	19	54	24	00	27	52	31	28	34	49	37	55	40	46	43	24
3/8	1	47	6	32	11	12	15	42	20	02	24	08	27	58	31	35	34	55	38	00	40	51	43	28
13/32	1	57	6	41	11	20	15	51	20	10	24	16	28	06	31	41	35	00	38	05	40	56	43	33
7/16	2	06	6	50	11	29	16	00	20	18	24	23	28	13	31	48	35	07	38	11	41	01	43	38
15/32	2	15	6	59	11	38	16	08	20	26	24	30	28	20	31	54	35	13	38	16	41	06	43	42
1/2	2	24	7	08	11	46	16	16	20	34	24	38	28	27	32	00	35	19	38	22	41	11	43	47
17/32	2	33	7	16	11	55	16	24	20	41	24	45	28	34	32	07	35	25	38	27	41	16	43	51
9/16	2	41	7	25	12	03	16	32	20	49	24	53	28	41	32	14	35	31	38	33	41	21	43	56
19/32	2	50	7	34	12	12	16	40	20	57	25	00	28	48	32	20	35	36	38	39	41	26	44	01
5/8	2	59	7	43	12	20	16	49	21	05	25	08	28	55	32	26	35	42	38	44	41	31	44	06
21/32	3	08	7	52	12	30	16	57	21	12	25	15	29	02	32	32	35	48	38	50	41	37	44	10
11/16	3	17	8	00	12	38	17	05	21	20	25	22	29	08	32	38	35	55	38	55	41	41	44	15
23/32	3	26	8	09	12	46	17	13	21	28	25	29	29	15	32	45	36	00	39	00	41	46	44	20
3/4	3	35	8	18	12	55	17	21	21	35	25	37	29	22	32	51	36	06	39	06	41	51	44	24
25/32	3	44	8	27	13	04	17	30	21	44	25	44	29	28	32	58	36	12	39	11	41	56	44	29
13/16	3	52	8	35	13	12	17	38	21	52	25	51	29	35	33	04	36	17	39	16	42	01	44	33
27/32	4	01	8	44	13	20	17	46	21	59	25	58	29	42	33	10	36	24	39	21	42	06	44	38
7/8	4	10	8	53	13	29	17	54	22	07	26	05	29	48	33	17	36	30	39	27	42	11	44	42
29/32	4	20	9	02	13	37	18	02	22	15	26	13	29	55	33	23	36	35	39	32	42	16	44	47
15/16	4	28	9	11	13	45	18	10	22	22	26	20	30	02	33	29	36	40	39	38	42	21	44	51
31/32	4	37	9	20	13	54	18	18	22	30	26	27	30	09	33	35	36	46	39	43	42	26	44	56

Decimal Equivalents of Fractions

1/64	.015625	13/64	.203125	25/64	.390625	37/64	.578125	49/64	.765625	61/64	.953125
1/32	.03125	7/32	.21875	13/32	.40625	19/32	.59375	25/32	.78125	31/32	.96875
3/64	.046875	15/64	.234375	27/64	.421875	39/64	.609375	51/64	.796875	63/64	.984375
1/16	**.0625**	**1/4**	**.25**	**7/16**	**.4375**	**5/8**	**.625**	**13/16**	**.8125**		
5/64	.078125	17/64	.265625	29/64	.453125	41/64	.640625	53/64	.828125		
3/32	.09375	9/32	.28125	15/32	.46875	21/32	.65625	27/32	.84375		
7/64	.109375	19/64	.296875	31/64	.484375	43/64	.671875	55/64	.859375		
1/8	**.125**	**5/16**	**.3125**	**1/2**	**.5**	**11/16**	**.6875**	**7/8**	**.875**		
9/64	.140625	21/64	.328125	33/64	.515625	45/64	.703125	57/64	.890625		
5/32	.15625	11/32	.34375	17/32	.53125	23/32	.71875	29/32	.90625		
11/64	.171875	23/64	.359375	35/64	.546875	47/64	.734375	59/64	.921875		
3/16	**.1875**	**3/8**	**.375**	**9/16**	**.5625**	**3/4**	**.75**	**15/16**	**.9375**		

INCLINED CONVEYORS

This chart consists of triangles representing horizontal, vertical, and inclined distances. Any one unknown distance can be determined when the other two are known. For distances greater than the limits of the chart, divide the given dimensions by a figure to bring within the range of the chart. Multiply the result by the same figure to restore the proportions. Example: Conveyor 180 ft. horizontal distance, 48 ft. lift. Divide by 2, giving 90 ft. and 24 ft. The intersection of a vertical line from the 90 ft. HORIZONTAL DISTANCE with a horizontal line from the 24 ft. LIFT would occur at a point (on the 15° line) corresponding to a radius length of 93 ft. (approx.). Multiplying by 2, the actual incline length is 186 ft. The angle is 15° in both cases.



Materials Tested in DECO Laboratory

Alunite
Anglesite
Antimony
Apatite
Argentite
Arsenic
Arsenopyrite
Asbestos
Barite
Bauxite
Bentonite
Beryl
Biotite
Bismuth
Bituminous Sands
Borax
Bornite
Brucite
Calcite
Carnallite
Cassiterite
Celestite
Cement
Cerargyrite
Cerussite

Chalcocite
Chalcopyrite
Chrome
Chromite
Chrysocolla
Cinnabar
Clay
Coal
Cobalt
Cobaltite
Copper
Corundum
Cryolite
Cuprite
Cyanite
Diamond
Diatomaceous Earth
Dolomite
Enargite
Epsom Salt
Feldspar
Ferberite
Fluorite
Fluorspar
Franklinite

Galena
Garnet
Gibbsite
Gold
Grains
Graphite
Gypsum
Halite
Hematite
Horneblende
Hubnerite
Ilmenite
Industrial Wastes
Iron
Jamesonite
Kyanite
Lead
Lepidolite
Leucite
Limestones
Limonite
Livingstonite
Magnesite
Magnetite
Malachite

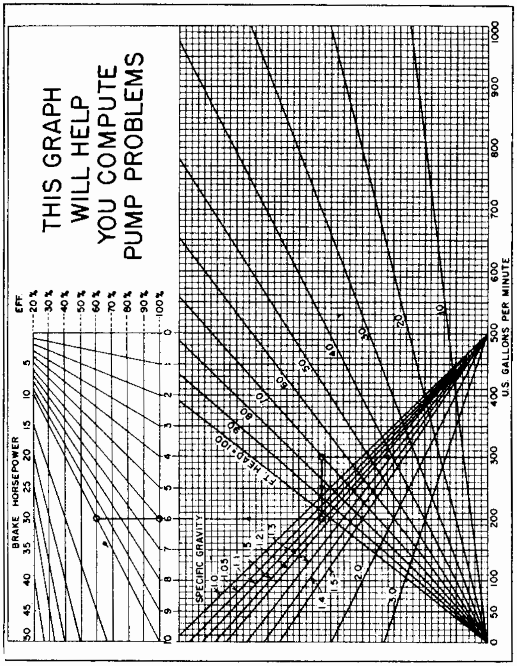
Manganese
Manganite
Marmatite
Mercury
Mica
Microlite
Molybdenum
Monazite
Muscovite
Nepheline Syenite
Niccolite
Nickel
Nitre
Olivine
Orpiment
Orthoclase
Pentlandite
Phosphate
Platinum
Potash
Powellite
Proustite
Psilomelane
Pyrargyrite

Pyrite
Pyrolusite
Pyromorphite
Pyrophyllite
Pyroxene
Pyrrhotite
Quartz
Quicksilver
Realgar
Rhodochrosite
Rubber
Rutile
Salt
Scheelite
Sericite
Siderite
Silica Sand
Sillimanite
Silver
Smaltite
Smithsonite
Soda Nitre
Sperrylite
Sphalerite
Spodumene

Stannite
Stibnite
Strontianite
Sulphur
Sylvanite
Sylvite
Talc
Tantalite
Tennantite
Tetrahedrite
Tin
Titanite
Titanium
Topaz
Tungsten
Uraninite
Vanadinite
Vermiculite
Willemite
Witherite
Wolframite
Zinc
Zincite
Zircon

And various industrial products.

PUMP CHART



(See typical problem on page 772)

Denver Equipment Company publishes DECO TREFOIL, an exchange of helpful engineering information designed to improve milling. DECO TREFOIL is published every other month. If you are connected with mining and do not receive DECO TREFOIL please write to us.

Continued from preceding page

OUR FRIEND, Christian W. Matthews, Denver, Colo., has submitted the above chart for calculating the typical problems faced by mine, mill and smelter engineers. It makes easy work of the following equation:

$$HP. = \frac{GPM \times 8.33 \times ft.\ head \times spec.\ gravity}{33{,}000 \times efficiency}$$

Example: A pump is delivering 300 gpm of 1.15-gravity pulp through 70 ft. of head. The pump is 60% efficient. Find brake horsepower which must be supplied to the pump for these operating conditions.

Solution: Follow heavy "example" line from 300 gpm (bottom) up to 70-ft. head line. Then go horizontally (or right if gravity line is on right) to the intersection with specific-gravity line. Next go vertically to intersection with 60%-efficiency line (top left) and read the horsepower directly. Output of pump (6 hp.) is given on the 100%-efficiency line; input (10 hp.) is given on true-efficiency line.

Note: If GPM is 10 times as great, calculate for one-tenth that GPM and then multiply HP. by 10 to get answer. That is also true for foot of head.

May We Please Work With You On All Your Equipment Needs?

Properties of Water

Boiling Point at Different Elevations			Weight and Heat Content at Various Temperatures		
Alt. Above Sea Level in Feet	Barometer Reading in Inches	Boiling Point Degrees F.	Temp. in Degrees F.	Weight per Cu. Ft. in Lbs.	B.T.U. per Lb.
15,221	16.79	184	32	62.42	0.
14,649	17.16	185	35	62.42	3.02
14,075	17.54	186	40	62.42	8.05
13,498	17.93	187	45	62.42	13.07
12,934	18.32	188	50	62.41	18.08
12,367	18.72	189	55	62.39	23.08
11,799	19.13	190	60	62.37	28.08
11,243	19.54	191	65	62.34	33.07
10,685	19.69	192	70	62.31	38.06
10,127	20.39	193	75	62.28	43.05
9,579	20.82	194	80	62.23	48.03
9,031	21.26	195	85	62.18	53.02
8,481	21.71	196	90	62.13	58.00
7,932	22.17	197	95	62.08	62.99
7,381	22.64	198	100	62.02	67.97
6,843	23.11	199	105	61.96	72.95
6,304	23.59	200	110	61.89	77.94
5,764	24.08	201	115	61.82	82.92
5,225	24.58	202	120	61.74	87.91
4,697	25.08	203	125	61.65	92.90
4,169	25.59	204	130	61.56	97.89
3,642	26.11	205	135	61.47	102.88
3,115	26.64	206	140	61.37	107.87
2,589	27.18	207	145	61.28	112.86
2,063	27.73	208	150	61.18	117.86
1,809	28.00	208.5	155	61.08	122.86
1,539	28.29	209	160	60.98	127.86
1,290	28.56	209.5	165	60.87	132.86
1,025	28.85	210	170	60.77	137.87
754	29.15	210.5	175	60.66	142.87
512	29.42	211	180	60.55	147.88
255	29.71	211.5	185	60.44	152.89
0—Sea Level	30.00	212	190	60.32	157.91
−261 Below S.L.	30.30	212.5	195	60.20	162.92
−511 Below S.L.	30.59	213	200	60.07	167.94
			205	59.95	172.96
			210	59.82	177.99
			212	59.76	180.00

Blackmer Pump Co.

Tons Water per 24 Hours—12" Wide 1" Deep

Slope, Inches per Foot	¼	½	¾	1	1½	2	2½	3	4	5	6
Velocity F. P. S.	16	23	28	32	39	45	51	56	64	72	78
Tons Water 24 Hrs.	3600	5200	6300	7200	8500	10200	11500	12600	14400	16200	17500
Gallons P. Min.	600	870	1050	1200	1420	1700	1920	2100	2400	2700	2920

Velocity is practically constant for all depths; quantity proportional to depth x width.

Units of Measurement and Useful Data—Water

One cubic inch weighs .0361 pounds.

One cubic foot equals 62.4245 pounds at 39 degrees F., equals 7.48 gallons U. S. or 6.2321 gallons imperial.

One pound equals 27.7 cubic inches.

One gallon U. S. equals 8.33 pounds; equals 231 cubic inches; equals .13368 cubic feet.

One imperial gallon equals 10 pounds at 62 degrees F., equals 277.274 cubic inches, equals .16046 cubic feet.

To convert imperial gallons to U. S. gallons, multiply by the factor 1.2.

To convert U. S. gallons into imperial gallons, multiply by .8333.

One acre-inch is the quantity of water required to cover one acre of area a depth of one inch, equals 3,630 cubic feet, equals 27,152 gallons.

One acre-foot equals 12 acre-inches, equals 43,560 cubic feet, equals 325,829 gallons.

One cubic foot per second (second-foot) equals 448.8 gallons per minute.

A flow of one second-foot will produce one acre-inch in about an hour.

One pound per square inch pressure is equivalent to the pressure of a column of water 2.31 feet in height.

A column of water one foot in height produces a pressure of .433 pounds per square inch.

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch at sea level, and with a perfect vacuum it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high.

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

To determine the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144 and divide the product by the area of the pipe in inches.

To find the theoretical velocity due to any head, multiply the square root of the head in feet by 8.02.

Table for Converting Feet Head of Water into Pressure per Square Inch

Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch
1	.43	55	23.82	190	82.29
2	.87	60	25.99	200	86.62
3	1.30	65	28.15	225	97.45
4	1.73	70	30.32	250	108.27
5	2.17	75	32.48	275	119.10
6	2.60	80	34.65	300	129.93
7	3.03	85	36.81	325	140.75
8	3.40	90	38.98	350	151.58
9	3.90	95	41.14	375	162.41
10	4.33	100	43.31	400	173.24
15	6.50	110	47.64	500	216.55
20	8.66	120	51.97	600	259.85
25	10.83	130	56.30	700	303.16
30	12.99	140	60.63	800	346.47
35	15.16	150	64.96	900	389.78
40	17.32	160	69.29	1000	433.09
45	19.49	170	73.63	——	——
50	21.65	180	77.96	——	——

Table for Converting Pressure per Square Inch into Feet Head of Water

Pounds per Square Inch	Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch	Feet Head
1	2.31	55	126.99	180	415.61
2	4.62	60	138.54	190	438.90
3	6.93	65	150.08	200	461.78
4	9.24	70	161.63	225	519.51
5	11.54	75	173.17	250	577.24
6	13.85	80	184.72	275	643.03
7	16.16	85	196.26	300	692.69
8	18.47	90	207.81	325	750.41
9	20.78	95	219.35	350	808.13
10	23.09	100	230.90	375	865.89
15	34.63	110	253.98	400	922.58
20	46.18	120	277.07	500	1154.48
25	57.72	125	288.62	——	——
30	69.27	130	300.16	——	——
35	80.81	140	323.25	——	——
40	92.36	150	346.34	——	——
45	103.90	160	369.43	——	——
50	115.45	170	392.52	——	——

Quantity of Water in One Foot of Pipe in Cubic Feet and in U. S. Gallons

Dia. of Pipe in Inches	Cu. Ft. of Water in 1 Foot of Pipe	U. S. Gals. in 1 Foot of Pipe
½	0.0014	0.0102
¾	0.0031	0.0230
1	0.0055	0.0408
2	0.0218	0.1632
3	0.0491	0.3672
4	0.0873	0.6528
5	0.1364	1.020
6	0.1963	1.469
8	0.3491	2.611
10	0.5454	4.080
12	0.7854	5.875
14	1.069	7.997
16	1.396	10.44
18	1.767	13.22
20	2.182	16.32
22	2.640	19.75
24	3.142	23.50
26	3.687	27.58
28	4.276	31.99
30	4.909	36.72
32	5.585	41.78
34	6.305	47.16
36	7.069	52.88
38	7.876	58.92
40	8.727	65.28
42	9.621	71.97
44	10.559	78.99
46	11.541	86.33
48	12.566	94.00
50	13.635	102.00
52	14.748	110.3
54	15.904	119.0
56	17.104	128.0
58	18.348	137.3
60	19.635	146.9
62	20.966	156.8
64	22.340	167.1
66	23.76	177.7
68	25.22	188.7
70	26.73	200.0
72	28.27	211.5
74	29.87	223.4
76	31.50	235.6
78	33.18	248.2
80	34.91	261.1
82	36.67	274.3
84	38.48	287.9
86	40.34	301.7
88	42.24	316.0
90	44.18	330.5
92	46.16	345.3
94	48.19	360.5
96	50.27	376.0
98	52.38	391.8
100	54.54	408.0
102	56.75	424.5
104	58.99	441.2
106	61.28	458.4
108	63.62	475.9
110	66.00	493.7
112	68.42	511.8
114	70.88	530.2
116	73.39	549.0
118	75.94	568.0
120	78.54	587.5

Conversion of Water Discharges to Various Units

To convert N units of—	To M units of—	Multiply N by—
Cubic feet per second	Gallons per minute	448.83
	Gallons per hour	26930.
	Gallons per day	646317.
	Acre-feet per day	1.9835
	Miner's inches	40.
Cubic feet per minute	Gallons per hour	448.83
Cubic feet per hour	Gallons per day	179.53
Cubic feet per day	Gallons per minute	.005195
	Gallons per hour	.31169
Gallons per second	Cubic feet per hour	481.25
	Acre-feet per day	.26515
Gallons per minute	Cubic feet per second	.002228
	Cubic feet per hour	8.0208
	Acre-feet per day	.004419
	Miner's inches	.08912
Miner's inches	Cubic feet per second	.025
	Cubic feet per minute	1.5
	Gallons per minute	11.22
1,000,000 gallons per day	Cubic feet per second	1.547
	Gallons per minute	694.4
	Miner's inches	61.88
Acre-feet per day	Cubic feet per second	.5042
	Gallons per minute	226.3
	Miner's inches	20.17

To determine the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144 and divide the product by the velocity in feet per minute.

A Miner's Inch is a measure for flow of water, and is the quantity of water that will flow in one minute through an opening one inch square in a plank 2 inches thick under a head of 6½ inches to the center of the orifice. This is equivalent, approximately to 1.2 cubic feet, or 9 gallons per minute. This measure is not the same for all states, as some use a different head.

Gallons and Cubic Feet

United States Gallons in a Given Number of Cubic Feet

(1 cubic foot = 7.480519 U. S. gallons; 1 gallon = 231 cubic inches = 0.13368056 cubic foot.)

Cu. ft	Gallons	Cubic feet	Gallons	Cubic Feet	Gallons
0.1	0.75	50	374.0	8,000	59,844.2
0.2	1.50	60	448.8	9,000	67,324.7
0.3	2.24	70	523.6	10,000	74,805.2
0.4	2.99	80	598.4	20,000	149,610.4
0.5	3.74	90	673.2	30,000	224,415.6
0.6	4.49	100	748.1	40,000	299,220.8
0.7	5.24	200	1,496.1	50,000	374,025.9
0.8	5.98	300	2,244.2	60,000	448,831.1
0.9	6.73	400	2,992.2	70,000	523,636.3
1	7.48	500	3,740.3	80,000	598,441.5
2	14.96	600	4,488.3	90,000	673,246.7
3	22.44	700	5,236.4	100,000	748,051.9
4	29.92	800	5,984.4	200,000	1,496,103.8
5	37.40	900	6,732.5	300,000	2,244,155.7
6	44.88	1000	7,480.5	400,000	2,992,207.6
7	52.36	2000	14,961.0	500,000	3,740,259.5
8	59.84	3000	22,441.6	600,000	4,488,311.4
9	67.32	4000	29,922.1	700,000	5,236,363.3
10	74.81	5000	37,402.6	800,000	5,984,415.2
20	149.6	6000	44,883.1	900,000	6,732,467.1
30	224.4	7000	52,363.6	1,000,000	7,480,519.0
40	299.2				

Cubic Feet in a Given Number of Gallons

Gallons	Cubic feet	Gallons	Cubic feet	Gallons	Cubic feet
1	.134	1,000	133.681	1,000,000	133,680.6
2	.267	2,000	267.361	2,000,000	267,361.1
3	.401	3,000	401.042	3,000,000	401,041.7
4	.535	4,000	534.722	4,000,000	534,722.2
5	.668	5,000	668.403	5,000,000	668,402.8
6	.802	6,000	802.083	6,000,000	802,083.4
7	.936	7,000	935.764	7,000,000	935,763.9
8	1.069	8,000	1,069.444	8,000,000	1,069,444.5
9	1.203	9,000	1,203.125	9,000,000	1,203,125.0
10	1.337	10,000	1,336.806	10,000,000	1,336,805.6

Table of Theoretical Horsepower to Lift Water to Different Heights

Gallons per Minute	Height in Feet																		
	5	10	15	20	25	30	35	40	45	50	60	75	90	100	125	150	175	200	250
5	006	012	.019	025	031	037	044	05	06	.06	.07	09	11	12	16	19	22	25	31
10	012	025	037	050	062	075	087	10	11	12	.15	19	.22	25	31	37	44	50	.62
15	019	037	056	075	064	112	131	15	17	19	22	28	34	37	47	.56	66	75	.94
20	025	050	075	100	125	150	175	20	22	25	30	37	45	50	62	.75	87	1.00	1.25
25	031	062	093	125	156	187	219	25	28	31	37	47	56	62	78	94	1.09	1.25	1.56
30	037	075	112	150	187	225	262	30	34	37	45	56	67	75	94	1.12	1.31	1.50	1.87
35	043	087	131	175	219	262	306	35	39	44	52	66	79	87	1.08	1.31	1.53	1.75	2.19
40	050	100	150	200	250	300	350	40	45	50	60	75	.90	1.00	1.25	1.50	1.75	2.00	2.50
45	.056	112	168	225	281	337	394	45	51	56	67	84	1.01	1.12	1.41	1.69	1.97	2.25	2.81
50	062	.125	187	250	312	375	437	50	56	62	75	94	1.12	1.25	1.56	1.87	2.19	2.50	3.12
60	075	150	225	300	375	450	525	60	67	75	90	1.12	1.35	1.50	1.87	2.25	2.26	3.00	3.75
75	093	187	281	375	469	562	656	75	84	94	1.12	1.40	1.69	1.87	2.34	2.81	3.28	3.75	4.69
90	112	225	337	450	562	675	787	90	1.01	1.12	1.35	1.68	2.02	2.25	2.81	3.37	3.94	4.50	5.62
100	125	250	375	500	625	750	875	1.00	1.12	1.25	1.50	1.87	2.25	2.50	3.12	3.75	4.37	5.00	6.25
125	156	312	469	625	781	937	1.094	1.25	1.41	1.56	1.87	2.34	2.81	3.12	3.91	4.69	5.47	6.25	7.81
150	187	375	562	750	937	1.125	1.312	1.50	1.69	1.87	2.25	2.81	3.37	3.75	4.69	5.62	6.56	7.50	9.3[illegible]
175	219	437	656	875	1.093	1.312	1.531	1.75	1.97	2.19	2.62	3.28	3.94	4.37	5.47	6.56	7.66	8.75	10.94
200	250	500	750	1.000	1.250	1.500	1.750	2.00	2.25	2.50	3.00	3.75	4.50	5.00	6.25	7.50	8.75	10.00	12.50
250	312	625	937	1.250	1.562	1.875	2.187	2.50	2.81	3.12	3.75	4.69	5.62	6.25	7.81	9.37	10.94	12.50	15.72
300	375	750	1.125	1.500	1.875	2.250	2.625	3.00	3.37	3.75	4.50	5.62	6.75	7.50	9.37	11.25	13.12	15.00	18.75
350	437	.875	1.312	1.750	2.187	2.625	3.062	3.50	3.94	4.37	5.25	6.56	7.87	8.75	10.94	13.12	15.31	17.50	21.87
400	500	1.000	1.500	2.000	2.500	3.000	3.500	4.00	4.50	5.00	6.00	7.50	9.00	10.00	12.50	15.00	17.50	20.00	25.00
500	.625	1.250	1.875	2.500	3.125	3.750	4.375	5.00	5.62	6.25	7.50	9.37	11.25	12.50	15.62	18.75	21.87	25.00	31.25

Horsepower theoretically required for pumping water equals the gallons per minute multiplied by the head in feet, and divided by 4,000. For power recommended, divide by 2,000 instead of 4,000.

Theoretical Discharge of Nozzles in U. S.

Gallons Per Minute

Head		Velocity of Discharge Feet per Second	Diameter of Nozzle in Inches												
Lbs.	Feet		1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4	94.5	120	148	179
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5	116.	147	181	219
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102.	134.	169	209	253
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114.	149.	189	234	283
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125.	164.	207	256	309
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135.	177.	224	277	334
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106.	145.	189	239	296	357
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113.	153.	200.	253	313	379
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119.	162.	211.	267	330	399
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125.	169.	221.	280	346	418
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130.	177.	231.	293	362	438
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136.	184.	241.	305	376	455
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141.	191.	250.	317	391	473
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101.	146.	198.	259.	327	404	489
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104.	150.	205.	267.	338	418	505
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108.	155.	211.	276.	349	431	521
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111.	160.	217.	284.	359	443	536
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114.	164.	223.	292.	369	456	551
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117.	168.	229.	299.	378	467	565
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120.	172.	234.	306.	388	479	579
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122.	176.	240.	314.	397	490	593
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125	180.	245.	320.	406	501	606
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128.	184.	251.	327.	414	512	619
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130.	188.	256.	334.	423	522	632
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133.	192.	261.	341.	432	533	645
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136.	195.	266.	347.	439	543	656
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138.	199.	271.	354.	448	553	668
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140.	202.	275.	360.	455	562	680
150	346.4	149.5	1.43	5.72	12.9	22.9	51.8	91.5	143.	206.	280.	366.	463	572	692
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154.	222.	302.	395.	500	618	747
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106.	165.	238.	323.	423.	535	660	799
250	577.4	193.0	1.85	7.39	16.6	29.6	66.5	118.	185.	266.	362.	473.	598	739	894
300	692.8	211.2	2.02	8.08	18.2	32.4	72.8	129.	202.	291.	396.	517.	655	808	977

Head		Velocity of Discharge Feet per Second	Diameter of Nozzle in Inches												
Lbs.	Feet		1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5	5 1/2	6
10	23.1	38.6	213	289	378	479	591	714	851	1158	1510	1915	2365	2855	3405
15	34.6	47.25	260	354	463	585	723	874	1041	1418	1850	2345	2890	3490	4165
20	46.2	54.55	301	409	535	676	835	1009	1203	1638	2135	2710	3340	4040	4810
25	57.7	61.0	336	458	598	756	934	1128	1345	1830	2385	3025	3730	4510	5380
30	69.3	66.85	368	501	655	828	1023	1236	1473	2005	2615	3315	4090	4940	5895
35	80.8	72.2	398	541	708	895	1106	1335	1591	2168	2825	3580	4415	5340	6370
40	92.4	77.2	425	578	756	957	1182	1428	1701	2315	3020	3830	4725	5710	6810
45	103.9	81.8	451	613	801	1015	1252	1512	1802	2455	3200	4055	5000	6050	7210
50	115.5	86.25	475	647	845	1070	1320	1595	1900	2590	3375	4275	5280	6380	7600
55	127.0	90.4	498	678	886	1121	1385	1671	1991	2710	3540	4480	5530	6690	7970
60	138.6	94.5	521	708	926	1172	1447	1748	2085	2835	3700	4685	5790	6980	8330
65	150.1	98.3	542	737	964	1220	1506	1819	2165	2950	3850	4875	6020	7270	8670
70	161.7	102.1	563	765	1001	1267	1565	1888	2250	3065	4000	5060	6250	7560	9000
75	173.2	105.7	582	792	1037	1310	1619	1955	2330	3170	4135	5240	6475	7820	9320
80	184.8	109.1	602	818	1070	1354	1672	2020	2405	3280	4270	5410	6690	8080	9630
85	196.3	112.5	620	844	1103	1395	1723	2080	2480	3375	4400	5575	6890	8320	9920
90	207.9	115.8	638	868	1136	1436	1773	2140	2550	3475	4530	5740	7090	8560	10210
95	219.4	119.0	656	892	1168	1476	1824	2200	2625	3570	4655	5900	7290	8800	10500
100	230.9	122.0	672	915	1196	1512	1870	2255	2690	3660	4775	6050	7470	9030	10770
105	242.4	125.0	689	937	1226	1550	1916	2312	2755	3750	4890	6200	7650	9250	11020
110	254.0	128.0	705	960	1255	1588	1961	2366	2820	3840	5010	6350	7840	9470	11300
115	265.5	130.9	720	980	1282	1621	2005	2420	2885	3930	5120	6490	8010	9680	11550
120	277.1	133.7	736	1002	1310	1659	2050	2470	2945	4015	5225	6630	8180	9900	11800
125	288.6	136.4	751	1022	1338	1690	2090	2520	3005	4090	5340	6760	8350	10100	12030
130	300.2	139.1	767	1043	1365	1726	2132	2575	3070	4175	5450	6900	8530	10300	12290
135	311.7	141.8	780	1063	1390	1759	2173	2620	3125	4250	5550	7030	8680	10400	12510
140	323.3	144.3	795	1082	1415	1790	2212	2670	3180	4330	5650	7160	8850	10600	12730
145	334.8	146.9	809	1100	1440	1820	2250	2715	3235	4410	5740	7280	8990	10880	12960
150	346.4	149.5	824	1120	1466	1853	2290	2760	3295	4485	5850	7410	9150	11070	13200
175	404.1	161.4	890	1210	1582	2000	2473	2985	3560	4840	6310	8000	9890	11940	14250
200	461.9	172.6	950	1294	1691	2140	2645	3190	3800	5175	6750	8550	10580	12770	15220
250	577.4	193.0	1063	1447	1891	2392	2955	3570	4250	5795	7550	9570	11820	14290	17020
300	692.8	211.2	1163	1582	2070	2615	3235	3900	4650	6330	8260	10480	12940	15620	18610

Note:—The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94% of the figures given in the tables.

NUMBER OF U.S. GALLONS OF PULP PER MINUTE

Required to Deliver 100 Tons (2000 lbs. per ton) of Dry Solids in 24 Hours

Specific Gravity of Solids in Pulp	Percent Water by Weight in Pulp															
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
2.5	9.70	10.90	12.23	13.96	15.69	17.95	21.94	23.40	27.13	31.78	38.03	45.75	56.92	73.68	100.54	157.47
2.6	9.44	10.64	11.97	13.69	15.42	17.68	21.67	23.14	26.86	31.65	37.77	45.48	56.65	73.41	100.28	157.20
2.7	9.17	10.37	11.70	13.43	15.16	17.42	21.41	22.87	26.60	31.38	37.50	45.22	56.39	73.15	100.01	156.94
2.8	9.04	10.10	11.57	13.16	15.02	17.15	21.28	22.74	26.46	31.12	37.24	44.95	56.25	72.88	99.88	156.80
2.9	8.77	9.97	11.30	13.03	14.89	17.02	21.01	22.47	26.20	30.98	37.10	44.82	55.99	72.75	99.75	156.67
3.0	8.64	9.70	11.17	12.76	14.76	16.75	20.88	22.34	26.06	30.72	36.84	44.55	55.72	72.61	99.48	156.40
3.1	8.37	9.57	10.90	12.63	14.49	16.62	20.61	22.21	25.80	30.59	36.70	44.42	55.59	72.35	99.35	156.14
3.2	8.24	9.31	10.77	12.50	14.23	16.49	20.48	21.94	25.66	30.32	36.57	44.28	55.46	72.21	99.21	156.00
3.3	8.11	9.17	10.64	12.36	14.09	16.35	20.34	21.81	25.53	30.19	36.44	44.02	55.32	72.08	98.95	155.87

Formula; $U.S.G.P.M. = T \times .1675 \left(\frac{W}{R} + \frac{1}{SpGr}\right)$

T = Tons of dry solids delivered by pulp in 24 hours.
SpGr = Specific Gravity of the dry solids.
W = % by Wt. of water in the pulp.
R = % by Wt. of dry solids in the pulp.

Mill design and Flowsheet design are also services of Denver Equipment Co. Write for details how these services might help you.

FRICTION OF WATER IN PIPES

Loss of head in feet due to friction per 100 feet of 15 year old ordinary cast iron or steel pipe. These figures are for clear cold water.
Vel.—Velocity in feet per second. Fric.—Friction loss or head in feet.

Flow In U.S. Gal. per Min	1½ Inch Pipe		2 Inch Pipe		2½ Inch Pipe		3 Inch Pipe		4 Inch Pipe		5 Inch Pipe		6 Inch Pipe		8 Inch Pipe		10 Inch Pipe		12 Inch Pipe	
	Vel.	Fric	Vel.	Fric.	Vel	Fric.	Vel	Fric.	Vel.	Fric.	Vel	Fric.	Vel	Fric.	Vel	Fric.	Vel	Fric.	Vel	Fric.
25	3.9	**7.8**	2.6	**2.7**	1.6	**0.9**	1.1	**0.4**												
50	7.9	**28.4**	5.1	**9.9**	3.3	**3.3**	2.3	**1.4**	1.3	**0.3**										
75	11.8	**60.0**	7.7	**20.9**	5.0	**7.1**	3.4	**3.1**	1.9	**0.7**										
100			10.2	**15.8**	6.5	**12.0**	4.5	**5.0**	2.6	**1.2**	1.6	**0.4**								
125			12.8	**54.0**	8.2	**18.2**	5.7	**7.6**	3.2	**1.9**	2.0	**0.6**								
150			15.3	**76.0**	9.8	**25.5**	6.8	**10.5**	3.8	**2.6**	2.5	**0.9**	1.7	**0.1**						
175					11.3	**33.8**	7.9	**14.0**	4.5	**3.4**	2.9	**1.2**	2.0	**0.5**						
200					13.1	**43.1**	9.1	**17.8**	5.1	**4.4**	3.3	**1.5**	2.3	**0.6**						
250					16.5	**66.0**	11.3	**27.2**	6.4	**6.7**	4.1	**2.2**	2.8	**0.9**	1.6	**0.2**				
300							13.6	**38.0**	7.7	**9.3**	4.9	**3.1**	3.4	**1.3**	1.9	**0.3**				
350									8.9	**12.3**	5.7	**4.2**	4.0	**1.8**	2.2	**0.4**				
400									10.2	**16.0**	6.5	**5.4**	4.5	**2.2**	2.6	**0.5**				
450									11.5	**19.8**	7.4	**6.7**	5.1	**2.7**	2.9	**0.7**	1.8	**0.2**		
500									12.8	**24.0**	8.2	**8.1**	5.6	**1.3**	3.2	**0.8**	2.0	**0.3**	1.4	**0.1**
600											9.8	**11.3**	6.7	**4.7**	3.8	**1.1**	2.5	**0.4**	1.7	**0.2**
700											11.4	**15.1**	7.8	**6.2**	4.5	**1.5**	2.9	**0.5**	2.0	**0.2**
800													9.1	**8.0**	5.1	**2.0**	3.3	**0.7**	2.3	**0.3**
900													10.3	**10.1**	5.8	**2.5**	3.7	**0.8**	2.6	**0.3**
1000													11.3	**12.0**	6.4	**3.0**	4.1	**1.0**	2.8	**0.4**
1500															9.6	**6.3**	6.1	**2.1**	4.2	**0.9**
2000															12.7	**10.7**	8.1	**3.7**	5.6	**1.4**
2500																	10.1	**5.3**	7.0	**2.3**

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FRICTION OF WATER IN 90° ELBOWS

Equivalent Number of Feet Straight Pipe

Size of elbow, inches	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12	14	15	16	20
Friction equivalent feet straight pipe	5	6	6	8	8	8	11	15	16	10	18	24	30	40	54	55	55	70

When pipe is slightly rough add 15 per cent. to friction head indicated in margin. When pipe is very rough add 30 per cent. to friction head indicated in margin.

Capacity of Pipes: A pipe one yard long holds as many pounds of water as the square of its diameter, in inches. Thus, a 6-inch pipe holds 36 pounds of water in each yard of length.

BAROMETRIC PRESSURE AT DIFFERENT ALTITUDES

With equivalent head of water and the vertical suction lift of pumps.

Altitude, Feet	Barometric Pressure, Pounds per Square Inch	Equivalent Head of Water, Feet	Practical Suction Lift of Pump, Feet
Sea Level	14.70	33.95	25
1,320	14.02	32.38	24
2,640	13.33	30.79	23
3,960	12.68	29.24	21
5,280	12.02	27.76	20
6,600	11.42	26.38	19
7,920	10.88	25.13	18
10,560	9.88	22.82	17

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Resistance of Valves and Fittings to the Flow of Fluids

Tabular values indicate equivalent length of straight pipe in feet, having same resistance as fitting. Values given are for steam, air, or gas.

For water and non-viscous liquids, multiply tabular values by the factor given in the last column. Values given are for screwed fittings. For flanged items, multiply tabular values as follows: gate valves by 0.80; globe valves by 0.96; angle valves by 0.90; elbows, tees, and bends by 0.75.

Pipe Size Inches	Gate Valve	Globe Valve	Angle Valve	90° Elbow	45° Elbow	Close Return Bend	Tee-Straight Through	Tee-Through Side Outlet	Multiplying Factor for Water and Non-Viscous Liquids
½	0.4	10	5	0.9	0.6	2.2	0.7	2.2	1.07
¾	0.5	15	7	1.3	0.9	3.4	1.1	3.4	1.08
1	0.7	20	10	1.8	1.2	4.4	1.5	4.4	1.09
1¼	0.9	25	12	2.2	1.5	5.5	1.8	5.5	1.10
1½	1.1	30	15	2.7	1.8	6.7	2.2	6.7	1.11
2	1.5	40	20	3.6	2.5	9.0	3.0	9.0	1.13
2½	1.8	50	25	4.4	3.0	11.0	3.7	11.0	1.14
3	2.2	60	30	5.3	3.7	13.5	4.4	13.5	1.15
3½	2.5	70	35	6.2	4.3	15.5	5.1	15.5	1.16
4	3.0	80	40	7.0	5.0	18.0	6.0	18.0	1.17
5	3.6	100	50	9.0	6.2	22.5	7.4	22.5	1.19
6	4.4	120	60	10.5	7.5	27.0	9.0	27.0	1.20
8	6.0	160	80	14.0	10.0	36.0	12.0	36.0	1.21
10	7.5	200	100	18.0	12.5	45.0	15.0	45.0	1.22
12	9.0	240	120	21.5	15.0	56.0	18.0	56.0	1.22

Walworth Company

We have often been referred to as the "Diagnosticians of the ore dressing industry." Perhaps we can help you with your mineral recovery problems. Please let us try.

FLOW OF WATER THROUGH SCHEDULE 40 STEEL PIPE

(Adapted from Crane's Technical Paper No. M-409)

Pressure Drop per 1000 feet of Schedule 40 Steel Pipe, in Pounds per Square Inch

Pipe Diameter	1"		1¼"		2"		3"		4"		6"		8"		10"	
Discharge, G.P.M. (U.S.)	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop	Velocity, feet per Second	Pressure Drop
2	0.74	1.70	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4	1.49	5.94	0.63	0.74	....	....	....	....	....	....	....	....	....	....	....	....
6	2.24	12.25	0.95	1.53	0.57	0.46	....	....	....	....	....	....	....	....	....	....
8	2.98	21.1	1.26	2.63	0.76	0.75	....	....	....	....	....	....	....	....	....	....
10	3.72	30.8	1.57	3.86	0.96	1.14	....	....	....	....	....	....	....	....	....	....
20	7.44	110.5	3.15	13.5	1.91	3.86	0.87	0.59	....	....	....	....	....	....	....	....
30	....	....	4.72	29.1	2.87	8.04	1.30	1.21	....	....	....	....	....	....	....	....
40	....	....	6.30	47.8	3.82	13.7	1.74	2.06	1.01	0.53	....	....	....	....	....	....
50	....	....	7.87	74.7	4.78	20.6	2.17	3.10	1.26	0.80	....	....	....	....	....	....
70	....	....	....	....	6.69	38.6	3.04	6.84	1.76	1.50	....	....	....	....	....	....
100	....	....	....	....	9.56	75.1	4.34	11.4	2.52	2.81	1.11	0.39	....	....	....	....
150	....	....	....	....	....	....	6.51	23.5	3.78	6.02	1.67	0.78	....	....	....	....
200	....	....	....	....	....	....	8.68	39.7	5.04	10.2	2.22	1.32	....	....	....	....
250	....	....	....	....	....	....	10.85	61.9	6.30	15.9	2.78	2.05	1.60	0.55	....	....
300	....	....	....	....	....	....	13.02	84.7	7.56	21.8	3.33	2.80	1.92	0.75	....	....
400	....	....	....	....	....	....	....	....	10.08	36.7	4.44	4.72	2.56	1.27	....	....
500	....	....	....	....	....	....	....	....	12.59	57.3	5.55	7.39	3.20	1.87	2.04	0.63
750	....	....	....	....	....	....	....	....	....	....	8.32	15.7	4.81	4.21	3.05	1.35
1,000	....	....	....	....	....	....	....	....	....	....	11.10	26.3	6.41	7.08	4.07	2.40
1,300	....	....	....	....	....	....	....	....	....	....	14.43	44.4	8.33	11.3	5.29	3.83
1,500	....	....	....	....	....	....	....	....	....	....	16.65	55.5	9.62	15.0	6.10	5.11
1,800	....	....	....	....	....	....	....	....	....	....	19.98	79.8	11.54	21.6	7.32	6.91
2,000	....	....	....	....	....	....	....	....	....	....	22.20	98.5	12.83	25.0	8.13	8.54

Equation of Pipes

It is frequently desired to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the squares of their diameters; thus one 4-inch pipe will deliver the same volume as four 2-inch pipes. With the same head however, the velocity is less in the smaller pipe, and the volume delivered varies about as the square root of the fifth power. This table is calculated on this basis. The figures opposite the intersection of any two sizes is the number of the smaller-sized pipes required to equal one of the larger; thus one 4-inch equals 5.7 two-inch.

Dia. in.	1	2	3	4	5	6	7	8	10	12	14	16	18	20	24	30	36
2	5.7	1.															
3	15.6	2.8	1.														
4	32.	5.7	2.1	1.													
5	55.9	9.9	3.6	1.7	1.												
6	88.2	15.6	5.7	2.8	1.6	1.											
7	130.	22.9	8.3	4.1	2.3	1.5	1.										
8	181.	32.	11.7	5.7	3.2	2.1	1.4	1.									
10	316.	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.								
11	401.	70.9	25.	12.5	7.2	4.6	3.1	2.2	1.3								
12	499.	88.2	32.	15.6	8.9	5.7	3.8	2.8	1.6	1.							
13	609.	108.	39.1	19.	10.9	7.1	4.7	3.4	1.9	1.2							
14	733.	130.	47.	22.9	13.1	8.3	5.7	4.1	2.3	1.5	1.						
15	787.	154.	55.9	27.2	15.6	9.9	6.7	4.8	2.8	1.7	1.2						
16		181.	65.7	32.	18.3	11.7	7.9	5.7	3.2	2.1	1.4	1.					
17		211.	76.4	37.2	21.3	13.5	9.2	6.6	3.8	2.4	1.6	1.2					
18		243.	88.2	43.	24.6	15.6	10.6	7.6	4.3	2.8	1.9	1.3	1.				
19		278.	101.	49.1	28.1	17.8	12.1	8.7	4.8	3.2	2.1	1.5	1.1				
20		316.	115.	55.9	32.	20.3	13.8	9.9	5.7	3.6	2.4	1.7	1.3	1.			
22		401.	146.	70.9	40.6	25.7	17.5	12.5	7.2	4.6	3.1	2.2	1.7	1.3			
24		499.	181.	88.2	50.5	32.	21.8	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1.		
30								27.2	15.6	10.0	6.7	4.8	3.6	2.8	1.75	1.0	
36									24.6	15.6	10.6	7.6	5.7	4.3	2.76	1.6	1.0

—American Pipe Manual (Fifth Edition) American Cast Iron Pipe Co.

Square Feet of Radiating Surface for Various Lengths of Pipe, Per Lineal Foot

(On all lengths over one foot, figures are given to nearest tenth.)

Length of Pipe in ft.	SIZE OF PIPE, IN INCHES										
	¾	1	1¼	1½	2	2½	3	3½	4	5	6
1	.275	.346	.434	.494	.622	.753	.916	1.047	1.175	1.455	1.739
2	.5	.7	.9	1.0	1.2	1.5	1.8	2.1	2.4	2.9	3.5
3	.8	1.0	1.3	1.5	1.9	2.3	2.7	3.1	3.5	4.4	5.2
4	1.1	1.4	1.7	2.0	2.5	3.0	3.6	4.2	4.7	5.8	7.0
5	1.4	1.7	2.2	2.4	3.1	3.8	4.6	5.2	5.8	7.3	7.7
6	1.6	2.1	2.6	2.9	3.7	4.5	5.5	6.3	7.0	8.7	10.5
7	1.9	2.4	3.0	3.4	4.4	5.3	6.4	7.3	8.2	10.2	12.1
8	2.2	2.8	3.5	3.9	5.0	6.0	7.3	8.4	9.4	11.6	13.9
9	2.5	3.1	3.9	4.4	5.6	6.8	8.2	9.4	10.6	13.1	15.7
10	2.7	3.5	4.3	4.9	6.2	7.5	9.1	10.5	11.8	14.6	17.4
11	3.0	3.8	4.8	5.4	6.8	8.3	10.0	11.5	12.9	16.0	19.1
12	3.3	4.1	5.2	5.9	7.5	9.0	11.0	12.6	14.1	17.4	20.9
13	3.6	4.5	5.6	6.4	8.1	9.8	11.9	13.6	15.3	18.9	22.6
14	3.8	4.8	6.1	6.9	8.7	10.5	12.8	14.7	16.5	20.3	24.3
15	4.1	5.2	6.5	7.4	9.3	11.3	13.7	15.7	17.6	21.8	26.1
16	4.4	5.5	6.9	7.9	10.0	12.0	14.6	16.7	18.8	23.2	27.8
17	4.7	5.9	7.4	8.4	10.6	12.8	15.5	17.8	20.0	24.7	29.5
18	5.0	6.2	7.8	8.9	11.2	13.5	16.5	18.8	21.2	26.2	31.3
19	5.2	6.6	8.3	9.4	11.8	14.3	17.4	19.9	22.3	27.6	33.1
20	5.5	6.9	8.7	9.9	12.5	15.0	18.3	20.9	23.5	29.1	34.8
25	6.9	8.6	10.9	12.3	15.6	18.8	22.9	26.2	29.3	36.3	43.5
30	8.3	10.4	13.0	14.8	18.7	22.5	27.5	31.4	35.3	43.6	52.1
35	9.6	12.1	15.2	17.3	21.8	26.3	32.0	36.6	41.1	50.9	60.8
40	11.0	13.8	17.4	19.8	24.9	30.1	36.6	41.9	47.0	58.2	69.5
45	12.4	15.6	19.5	22.2	28.0	33.8	41.2	47.1	52.9	65.5	78.2
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	52.3	58.7	72.7	87.0
55	15.2	19.0	23.9	27.1	34.3	41.3	50.4	57.6	64.6	80.1	95.6
60	16.6	20.8	26.0	29.6	37.3	45.2	55.0	62.8	70.5	87.3	104.3
65	18.0	22.6	28.2	32.1	40.5	48.8	59.5	68.0	76.4	94.5	112.9
70	19.4	24.2	30.4	34.6	43.5	52.7	64.1	73.3	82.3	101.9	121.7
75	20.7	26.0	32.6	37.1	46.6	56.5	68.7	78.5	88.1	109.1	130.4
80	22.0	27.7	34.7	39.6	49.8	60.2	73.3	83.8	94.0	116.4	139.1
85	23.4	29.4	36.9	42.0	53.4	63.9	77.8	89.0	99.9	123.7	147.9
90	24.8	31.1	39.1	44.5	56.0	67.8	82.4	94.2	105.8	130.9	156.5
95	26.2	32.9	41.2	46.9	59.6	71.5	87.2	99.5	111.6	138.2	165.2
100	27.5	34.6	43.4	49.4	62.2	75.3	91.6	104.7	117.5	145.5	173.9

—Ehret Magnesia Mfg. Co.

Calculating Horsepower and Torque and Designing Shafting

To design a shaft upon which a gear is mounted to transmit a given horsepower either the speed must be known on the twisting moment or torque must be specified.

Let F. P. M. equal speed of pitch line of gear in feet per minute.

Let R. P. M. equal revolutions of gear per minute.

$$\text{F. P. M.} = \frac{(\text{Pitch Diameter})'' \times 3.1416 \times \text{R.P.M.}}{12}$$

$$= (\text{Pitch Diameter})'' \times .262 \times \text{R.P.M.}$$

$$\text{H. P.} = \frac{\text{Load on Teeth (lbs.)} \times \text{F.P.M.}}{33000}$$

$$\text{Load on Teeth} = \frac{\text{H. P.} \times 33000 \text{ lbs.}}{\text{F. P. M.}}$$

$$\text{Load on Teeth} = \frac{\text{Torque (inch lbs.)}}{(\text{Pitch Radius})}$$

$$\text{H. P.} = \frac{\text{Torque (inch lbs.)} \times \text{R.P.M.}}{63000}$$

$$\text{Torque} = \frac{\text{H.P.} \times 63000 \text{ inch lbs.}}{\text{R.P.M.}}$$

Horsepower of Head Shafts

$$D = \sqrt[3]{\frac{100 \times H}{R}} \qquad H = \frac{D3 \times R}{100}$$

H = Horsepower. D = Diameter of shaft. R = Revolutions per minute

Diameter of Shaft in Inches	Number of Revolutions per Minute							
	25	50	100	200	300	400	500	600
1 7/16	.85	1.7	3.4	6.8	10.2	3.6	17.	20.4
1 11/16	1.35	2.7	5.4	10.8	16.2	21.6	27.	32.4
1 15/16	2	4.	8.	16.	24.	32.	40.	48.
2 3/16	2.8	5.7	11.4	22.8	34.2	45.6	57.	68.4
2 7/16	3.9	7.8	15.6	31.2	46.8	62.4	78.	93.6
2 11/16	5.2	10.5	21.	42.	63.	84.	105.	126.
2 15/16	6.7	13.5	27.	54.	81.	108.	135.	162.
3 3/16	8.5	17.	34.	68.	102.	136.	170.	204.
3 7/16	10.7	21.5	43.	86.	129.	172.	215.	258.
3 15/16	16.	32.	64.	128.	192.	256.	320.	384.
4 7/16	22.7	45.5	91.	182.	273.	364.	455.	546.
4 15/16	31.2	62.5	125.	250.	375.	500.	625.	750.
5 7/16	41.	83.1	166.3	332.6	499.	655.	831.	998.
5 15/16	54.	108.	216.	432.	648.	864.	1080.	1296.
6½	68.6	137.2	274.4	548.8	823.2	1097.6	1372.	1646.4
7	85.75	171.5	343.	686.	1029.	1372.	1715.	2058.
7½	105.4	210.8	421.6	843.2	1264.8	1686.2	2108.	2529.6
8	128.	256.	512.	1024.	1536.	2048.	2560.	3072.
9	182.35	364.5	729.	1458.	2187.	2916.	3645.	4374.
10	250.	500.	1000.	2000.	3000.	4000.	5000.	6000.

Amount of Babbitt for Bearings

Showing pounds of babbitt metal required per inch of length of bearing liner, exclusive of metal contained in anchoring grooves.

Inside Diam. of Bearing	Inside Circum. of Bearing	Total Thickness of Liner 1/8"	3/16"	1/4"	3/8"	1/2"
		Weight of Metal, Lbs.				
3	9.425	0.442	0.676	0.918	1.43	1.98
3 1/8	9.818	0.459	0.702	0.954	1.48	2.05
3 1/4	10.210	0.477	0.728	0.990	1.54	2.12
3 3/8	10.603	0.495	0.755	1.026	1.58	2.19
3 1/2	10.996	0.513	0.781	1.060	1.65	2.26
3 5/8	11.388	0.530	0.808	1.096	1.70	2.33
3 3/4	11.781	0.548	0.834	1.130	1.75	2.41
3 7/8	12.174	0.566	0.862	1.167	1.80	2.48
4	12.566	0.583	0.887	1.201	1.86	2.55
4 1/8	12.959	0.601	0.915	1.237	1.91	2.62
4 1/4	13.352	0.618	0.941	1.274	1.96	2.69
4 3/8	13.744	0.636	0.968	1.307	2.02	2.76
4 1/2	14.137	0.654	0.995	1.343	2.07	2.83
4 5/8	14.530	0.671	1.020	1.380	2.12	2.90
4 3/4	14.923	0.689	1.048	1.415	2.17	2.97
4 7/8	15.315	0.707	1.074	1.450	2.23	3.04
5	15.708	0.724	1.093	1.484	2.28	3.11
5 1/8	16.101	0.742	1.128	1.520	2.33	3.18
5 1/4	16.493	0.760	1.154	1.556	2.39	3.25
5 3/8	16.886	0.777	1.180	1.590	2.44	3.33
5 1/2	17.279	0.795	1.207	1.625	2.49	3.40
5 5/8	17.671	0.813	1.233	1.660	2.55	3.47
5 3/4	18.064	0.830	1.260	1.697	2.60	3.54
5 7/8	18.457	0.848	1.286	1.730	2.65	3.60
6	18.850	0.866	1.313	1.767	2.71	3.67
6 1/8	19.242	0.884	1.339	1.800	2.76	3.74
6 1/4	19.635	0.901	1.366	1.840	2.81	3.82
6 3/8	20.028	0.919	1.392	1.873	2.86	3.89
6 1/2	20.420	0.937	1.420	1.910	2.92	3.96

Inside Diam. of Bearing	Inside Circum. of Bearing	Total Thickness of Liner 1/8"	3/16"	1/4"	3/8"	1/2"
		Weight of Metal, Lbs.				
6 5/8	20.813	0.955	1.444	1.943	2.97	4.03
6 3/4	21.206	0.973	1.474	1.980	3.02	4.10
6 7/8	21.598	0.990	1.499	2.015	3.07	4.18
7	21.991	1.008	1.523	2.050	3.13	4.25
7 1/8	22.384	1.026	1.550	2.085	3.18	4.32
7 1/4	22.776	1.043	1.578	2.120	3.23	4.38
7 3/8	23.169	1.060	1.605	2.155	3.29	4.45
7 1/2	23.562	1.078	1.630	2.192	3.34	4.52
7 5/8	23.955	1.095	1.658	2.230	3.39	4.59
7 3/4	24.347	1.113	1.684	2.260	3.45	4.67
7 7/8	24.740	1.130	1.710	2.300	3.50	4.74
8	25.133	1.148	1.737	2.340	3.55	4.81
8 1/8	25.525	1.166	1.763	2.370	3.60	4.88
8 1/4	25.918	1.184	1.790	2.410	3.65	4.95
8 3/8	26.311	1.202	1.814	2.440	3.71	5.02
8 1/2	26.704	1.220	1.844	2.475	3.76	5.09
8 5/8	27.096	1.237	1.868	2.510	3.82	5.16
8 3/4	27.489	1.255	1.896	2.545	3.87	5.23
8 7/8	27.882	1.272	1.920	2.580	3.92	5.30
9	28.274	1.290	1.950	2.620	3.98	5.37
9 1/8	28.667	1.307	1.975	2.650	4.03	5.44
9 1/4	29.060	1.324	2.000	2.690	4.08	5.52
9 3/8	29.452	1.343	2.030	2.720	4.13	5.59
9 1/2	29.845	1.362	2.050	2.760	4.18	5.66
9 5/8	30.238	1.379	2.080	2.790	4.22	5.73
9 3/4	30.631	1.396	2.110	2.830	4.28	5.80
9 7/8	31.023	1.414	2.130	2.865	4.35	5.87
10	31.416	1.432	2.160	2.900	4.40	5.94

We have often been referred to as the "Diagnosticians of the ore dressing industry." Perhaps we can help you with your mineral recovery problems. Please let us try.

Compound Interest Table

Amount of $1 principal after given number of years and at given rates per cent.

Years	2%	3%	4%	5%	6%
1	1.020	1.030	1.040	1.050	1.060
2	1.040	1.061	1.082	1.103	1.124
3	1.061	1.093	1.125	1.158	1.191
4	1.082	1.126	1.170	1.216	1.262
5	1.104	1.159	1.217	1.276	1.338
6	1.126	1.194	1.265	1.340	1.419
7	1.149	1.230	1.316	1.407	1.504
8	1.172	1.267	1.369	1.478	1.594
9	1.195	1.305	1.423	1.551	1.690
10	1.219	1.344	1.480	1.629	1.791
11	1.243	1.384	1.540	1.710	1.898
12	1.268	1.426	1.601	1.796	2.012
13	1.294	1.469	1.665	1.886	2.133
14	1.320	1.513	1.732	1.980	2.261
15	1.346	1.558	1.801	2.079	2.397
16	1.373	1.605	1.873	2.183	2.540
17	1.400	1.653	1.948	2.292	2.693
18	1.428	1.702	2.026	2.407	2.853
19	1.457	1.754	2.107	2.527	3.026
20	1.486	1.806	2.191	2.653	3.207
25	1.641	2.094	2.666	3.386	4.292
30	1.811	2.427	3.243	4.322	5.744
35	2.000	2.814	3.946	5.516	7.686
40	2.208	3.262	4.801	7.040	10.286
45	2.438	3.782	5.841	8.985	13.765
50	2.692	4.384	7.107	11.467	18.420
55	2.971	5.082	8.646	14.635	24.650
60	3.281	5.891	10.519	18.679	32.988
65	3.622	6.830	12.798	23.839	44.145
70	3.999	7.917	15.571	30.426	59.077
75	4.415	9.178	18.945	38.832	79.058
80	4.875	10.640	23.049	49.561	105.798
85	5.382	12.335	28.043	63.254	141.582
90	5.943	14.300	34.119	80.730	189.469
95	6.561	16.578	41.511	103.035	253.553
100	7.244	19.218	50.504	131.501	339.312
105	7.998	22.279	61.447	167.833	454.077
110	8.831	25.828	74.759	214.202	607.659
115	9.750	29.942	90.956	273.382	813.186
120	10.765	34.711	110.663	348.912	1,088.228

Complete Milling Equipment From Testing . . . To Feeder . . . To Dryer.

For exact quotations and complete specifications contact any one of our offices.

Use of Coins as Weights

(Approximate values for United States coins.)

One 50c piece = 12.5 grams = 200 grains (avoir.)

One 25c piece = 6.25 grams = 100 grains (avoir.)

One 10c piece = 2.5 grams = 40 grains (avoir.)

One 5c piece = 5 grams = 80 grains (avoir.)

One 1c piece = 3.1 grams = 50 grains (avoir.)

One 10c piece + two 50c pieces = 27.5 grams = 440 grains or approximately one ounce; i.e. 437.5 grains.

Combustion Data

In Terms of Pounds per Pound of Fuel

	Molecular Symbol	Theoretically Required Pounds		Products of Combustion Pounds				
		O_2	Air	CO_2	H_2O	N_2	CO	SO_2
Carbon (to CO_2)	C	2.667	11.52	3.667	......	8.85	......	......
Carbon (to CO)	C	1.333	5.76	......	......	4.43	2.333	......
Carbon Monoxide	CO	0.572	2.46	1.57	......	1.89	......	......
Sulphur	S	1.000	4.32	......	......	3.32	......	2.00
Hydrogen	H_2	8.000	34.56	......	9.00	26.56	......	......
Methane	CH_4	4.000	17.28	2.75	2.25	13.28	......	......
Acetylene	C_2H_2	3.077	13.29	3.39	0.69	10.21	......	......
Ethylene	C_2H_4	3.429	14.81	3.14	1.29	11.38	......	......
Ethane	C_2H_6	3.733	16.13	2.93	1.80	12.40	......	......
Hydrogen Sulphide	H_2S	1.412	6.10	......	0.53	4.69	......	1.88

Safe Bearing Power of Soils

(Ira O. Baker)

Kind of Material	Bearing Power in Tons per Square Foot	
	Minimum	Maximum
Rock—the hardest—in thick layers, in native bed	200	...
Rock equal to best ashlar masonry	25	30
Rock equal to best brick masonry	15	20
Rock equal to poor brick masonry	5	10
Clay in thick beds, always dry	4	6
Clay in thick beds, moderately dry	2	4
Clay, soft	1	2
Gravel and coarse sand, well cemented	8	10
Sand, compact, and well cemented	4	6
Sand, clean, dry	2	4
Quicksand, alluvial soils, etc	0.5	1

Linear Coefficients of Thermal Expansion

Common Metals

The coefficient given is the increase in length per unit length (measured at 0° C.) per degree Centigrade

Metal	Temp. °C	Coefficient	Observer
Aluminum, Commercial	20-100	.0000240	Hidnert, 1925
Brass, Wire	0-100	.0000193	Smeaton
Brass, Commercial 64.81% Copper	25-100	.0000190	Hidnert, 1921
Copper, Electrolytic	25-100	.0000168	Hidnert, 1921
Duralumin, Cast	20-100	.0000236	Hidnert, 1925
German Silver	0-100	.00001836	Pfaff
Glass, soft		.0000085	Schott
Gold	16-100	.0000143	Gruneisen, 1910
Gun Metal		.0000183	National Physical Laboratory
Iron, Wrought	− 18 to + 100	.00001140	Andrews
Steel, 1.2% Carbon	0-100	.0000105	Le Chatelier, 1899
Lead	18-100	.00002940	Gruneisen, 1910
Monel Metal	25-100	.0000137-.0000145	Souder and Hidnert
Nickel	16-250	.00001397	Holborn and Day 1901
Silver	20	.0000188	Voigt, 1893
Tin	18-100	.00002692	Gruneisen, 1910
Zinc	10-100	.00002628	Thiesen, 1895

Stainless Steel

Allegheny Metal 18-8 (18% Chromium, 8% Nickel)	20-100	.0000173	Allegheny Ludlum Steel Corporation
Allegheny Metal 25-12 (25% Chromium, 12% Nickel)	20-100	.0000162	
Allegheny 12 (12% Chromium)	20-100	.0000104	
Allegheny 17 (17% Chromium)	0-600	.0000107-.0000121	

Joseph T. Ryerson & Son, Inc., Alloy Steel Reference Book

Our desire is to make you "Happier, Healthier and Wealthier."

Weight of Steel Plates

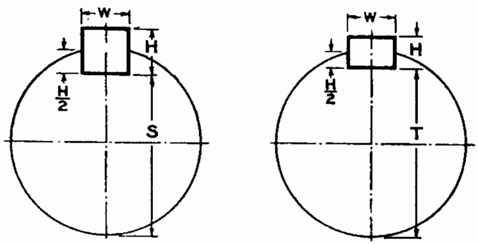
Size	Wt., Lbs. per Sq. Ft.	Size	Wt., Lbs. per Sq. Ft.
12-Gauge	4.90	3/16-inch	7.65
1/8-Inch	5.10	1/4-Inch	10.20
10-Gauge	5.75	5/16-Inch	12.75
8-Gauge	6.37	3/8-Inch	15.30

Shafting Weights

Size in Inches	Weight per Ft., Lbs.	Size in Inches	Weight per Ft., Lbs.	Size in Inches	Weight per Ft., Lbs.
5/8	1.04	1-15/16	10.02	3-11/16	36.31
3/4	1.50	2-3/16	12.78	3-15/16	41.40
7/8	2.05	2-7/16	15.87	4-7/16	52.58
1	2.67	2-11/16	19.29	4-15/16	65.10
1-3/16	3.77	2-15/16	23.04	5-7/16	78.95
1-7/16	5.52	3-3/16	27.13	5-15/16	94.14
1-11/16	7.60	3-7/16	31.55		

A. S. A. Standard Keys

and Standard Keyseats



Recover Your Mineral As Soon And As Coarse As Possible.

*DIMENSIONS OF SQUARE AND FLAT PLAIN PARALLEL STOCK KEYS IN INCHES

Shaft Diameter	Square Key W x H	Flat Key W x H	* † Tolerance on W and H (—)	Bottom of Key-seat to Opposite Side of Shaft	
				Square Key S	Flat Key T
1/2	1/8x1/8	1/8x3/32	0.0020	0.430	0.445
9/16	1/8x1/8	1/8x3/32	0.0020	0.493	0.509
5/8	3/16x3/16	3/16x1/8	0.0020	0.517	0.548
11/16	3/16x3/16	3/16x1/8	0.0020	0.581	0.612
3/4	3/16x3/16	3/16x1/8	0.0020	0.644	0.676
13/16	3/16x3/16	3/16x1/8	0.0020	0.708	0.739
7/8	3/16x3/16	3/16x1/8	0.0020	0.771	0.802
15/16	1/4x1/4	1/4x3/16	0.0020	0.796	0.827
1	1/4x1/4	1/4x3/16	0.0020	0.859	0.890
1-1/16	1/4x1/4	1/4x3/16	0.0020	0.923	0.954
1-1/8	1/4x1/4	1/4x3/16	0.0020	0.986	1.017
1-3/16	1/4x1/4	1/4x3/16	0.0020	1.049	1.081
1-1/4	1/4x1/4	1/4x3/16	0.0020	1.112	1.144
1-5/16	5/16x5/16	5/16x1/4	0.0020	1.137	1.169
1-3/8	5/16x5/16	5/16x1/4	0.0020	1.201	1.232
1-7/16	3/8x3/8	3/8x1/4	0.0020	1.225	1.288
1-1/2	3/8x3/8	3/8x1/4	0.0020	1.289	1.351
1-9/16	3/8x3/8	3/8x1/4	0.0020	1.352	1.415
1-5/8	3/8x3/8	3/8x1/4	0.0020	1.416	1.478
1-11/16	3/8x3/8	3/8x1/4	0.0020	1.479	1.542
1-3/4	3/8x3/8	3/8x1/4	0.0020	1.542	1.605
1-13/16	1/2x1/2	1/2x3/8	0.0025	1.527	1.590
1-7/8	1/2x1/2	1/2x3/8	0.0025	1.591	1.654
1-15/16	1/2x1/2	1/2x3/8	0.0025	1.655	1.717
2	1/2x1/2	1/2x3/8	0.0025	1.718	1.781
2-1/16	1/2x1/2	1/2x3/8	0.0025	1.782	1.843
2-1/8	1/2x1/2	1/2x3/8	0.0025	1.845	1.908
2-3/16	1/2x1/2	1/2x3/8	0.0025	1.909	1.971
2-1/4	1/2x1/2	1/2x3/8	0.0025	1.972	2.034
2-5/16	5/8x5/8	5/8x7/16	0.0025	1.957	2.051
2-3/8	5/8x5/8	5/8x7/16	0.0025	2.021	2.114
2-7/16	5/8x5/8	5/8x7/16	0.0025	2.084	2.178
2-1/2	5/8x5/8	5/8x7/16	0.0025	2.148	2.242
2-5/8	5/8x5/8	5/8x7/16	0.0025	2.275	2.368
2-3/4	5/8x5/8	5/8x7/16	0.0025	2.402	2.495
2-7/8	3/4x3/4	3/4x1/2	0.0025	2.450	2.575
2-15/16	3/4x3/4	3/4x1/2	0.0025	2.514	2.639
3	3/4x3/4	3/4x1/2	0.0025	2.577	2.702
3-1/8	3/4x3/4	3/4x1/2	0.0025	2.704	2.829
3-1/4	3/4x3/4	3/4x1/2	0.0025	2.831	2.956
3-3/8	7/8x7/8	7/8x5/8	0.0030	2.880	3.005
3-7/16	7/8x7/8	7/8x5/8	0.0030	2.944	3.069
3-1/2	7/8x7/8	7/8x5/8	0.0030	3.007	3.132
3-5/8	7/8x7/8	7/8x5/8	0.0030	3.140	3.259
3-3/4	7/8x7/8	7/8x5/8	0.0030	3.261	3.386
3-7/8	1x1	1x3/4	0.0030	3.309	3.434
3-15/16	1x1	1x3/4	0.0030	3.373	3.498

*Note: Stock keys are applicable to the general run of work and the tolerances have been set accordingly. It is understood that these keys are to be cut from cold-finished stock and are to be used without machining. They are not intended to cover the finer applications where a closer fit may be required.

†Note: These tolerances are **negative** and represent the maximum allowable variation **below** the exact nominal size. For example, the standard stock square key for a 2-inch shaft has a maximum size of 0.500x0.500 inch and a minimum size of 0.4975x0.4975 inch.

HORSEPOWER CALCULATED FROM LOAD-MECHANICS DATA

1. Constant Speed
   A. *Rotational*

$$H.P. = \frac{\text{Torque (Pounds-Feet)} \times \text{Speed (r.p.m.)}}{5250}$$

   B. *Prony-brake Horsepower*

$$H.P. = \frac{2 \times 3.1416 \times \text{Pounds Applied at 1-foot Radius} \times \text{r.p.m.}}{33{,}000}$$

   C. *Linear*

$$H.P. = \frac{\text{Force (Pounds)} \times \text{Feet per Minute Velocity}}{33{,}000}$$

2. Acceleration from 0 to Full Speed
   A. *Rotational*

$$H.P. = \frac{\text{Inertia } (WR^2) \times \text{r.p.m.}^2}{1.62 \times 10^6 t \text{ (in seconds to come up to speed)}}$$

   B. *Linear*

$$H.P. = \frac{\text{Inertia (W)} \times \text{f.p.m.}^2}{6.38 \times 10^7 t \text{ (in seconds to come up to speed)}}$$

Horsepower Calculations for Specific Applications (Approximate)

Pumping Water

$$H.P. = \frac{\text{Gallons per Minute} \times \text{Total Dynamic Head in Feet}}{3960 \times \text{Pump Efficiency}}$$

Moving Air

$$H.P. = \frac{\text{Volume (c.f.m.)} \times \text{Pressure (Pounds per Square Foot)}}{33{,}000 \times \text{Efficiency}}$$

or

$$= \frac{5.2 \times \text{Volume (c.f.m.)} \times \text{Head (Inches of Water)}}{33{,}000 \times \text{Efficiency}}$$

Compressing Gases

$$H.P. = \frac{PLAN}{33{,}000 \times 0.90}$$ For one working stroke per revolution (Single-acting)

P = Means effective pressure in cylinders (pounds per square inch)
L = Length of stroke in feet
A = Area of piston in square inches
N = Number of revolutions per minute

For Hoisting and Moving Cranes (Approximate)

$$\text{*H.P. of Hoist Motor} = \frac{\text{Load in Tons} \times \text{Lifting Speed (f.p.m.)}}{11}$$

H.P. of Trolley or Bridge Motor =

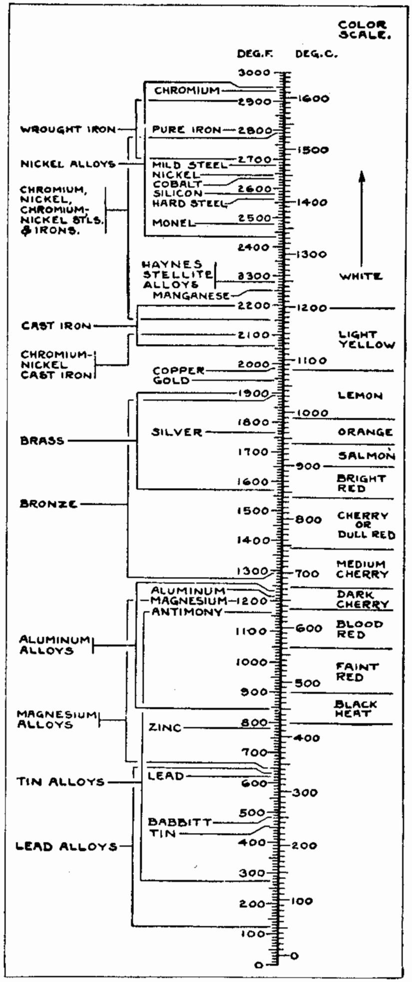
(1) (For bronze-bushed bearings) $\frac{WS}{132} \times \frac{(d)}{(D)}$

(2) (For roller bearings) $\frac{WS\left\{30 \times \left(\frac{S}{20}\right)\right\}}{33{,}000}$

W = Total weight in tons
S = Travel speed (f.p.m.)
d = Diameter of axle, inches
D = Diameter of wheel, inches

*Assuming overall efficiency of 66%

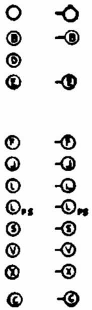
Melting Points of Metals and Alloys of Practical Importance



Electrical Wiring Symbols

General Outlets

Symbol (Ceiling, Wall) — Description



- Outlet.
- Blanked Outlet.
- Drop Cord.
- Electrical Outlet—for Use Only When Circle Used Alone Might Be Confused with Columns, plumbing symbols, Etc.
- Fan Outlet.
- Junction Box.
- Lamp Holder.
- Lamp Holder with Pull Switch.
- Pull Switch.
- Outlet for Vapor Discharge Lamp.
- Exit Light Outlet.
- Clock Outlet (Specify Voltage).

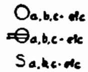
Convenience Outlets

- Duplex Convenience Outlet.
- Convenience Outlet Other Than Duplex. 1=Single, 3=Triplex, Etc.
- Weatherproof Convenience Outlet.
- Range Outlet.
- Switch and Convenience Outlet.
- Radio and Convenience Outlet.
- Special Purpose Outlet (Desc. in Spec.)
- Floor Outlet.

Switch Outlets

S	Single Pole Switch.
S_2	Double Pole Switch.
S_3	Three Way Switch.
S_4	Four Way Switch.
S_D	Automatic Door Switch.
S_E	Electrolier Switch.
S_K	Key Operated Switch.
S_P	Switch and Pilot Lamp.
S_{CB}	Circuit Breaker.
S_{WCB}	Weatherproof Circuit Breaker.
S_{MC}	Momentary Contact Switch.
S_{RC}	Remote Control Switch.
S_{WP}	Weatherproof Switch.
S_F	Fused Switch.
S_{WF}	Weatherproof Fused Switch.

Special Outlets



Any Standard Symbol As Given Above with the Addition of a Lower Case Subscript Letter May Be Used to Designate Some Special Variation of Standard Equipment of Particular Interest In a Specific Set of Architectural Plans.

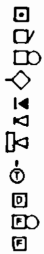
When Used They Must Be Listed In the Key of Symbols On Each Drawing and If Necessary Further Described In the Specifications.

Panels, Circuits and Miscellaneous

Symbol — Description

- Lighting Panel.
- Power Panel.
- Branch Circuit—Concealed in Ceiling or Wall.
- Branch Circuit—Concealed in Floor.
- Branch Circuit Exposed.
- Home Run to Panel Board. Indicate Number of Circuits by Number of Arrows.
  Note: Any Circuit without Further Designation Indicates a Two-Wire Circuit. For a Greater Number of Wires Indicate As Follows: (3 Wires), (4 Wires), Etc.
- Feeders. Note: Use Heavy Lines and Designate by Number Corresponding to Listing in Feeder Schedule.
- Underfloor Duct & Junction Box—Triple System. Note: For Double or Single Systems Eliminate One or Two Lines. This Symbol Is Equally Adaptable to Auxiliary System Layouts.
- Generator.
- Motor.
- Instrument.
- Power (Or Draw to Scale) Transformer.
- Controller.
- Isolating Switch.

Auxiliary Systems



- Push Button.
- Buzzer.
- Bell.
- Annunciator.
- Outside Telephone.
- Interconnecting Telephone.
- Telephone Switchboard.
- Bell-Ringing Transformer.
- Electric Door Opener.
- Fire Alarm Bell.
- Fire Alarm Station.

City Fire Alarm Station.
Fire Alarm Central Station.
Automatic Fire Alarm Device.
Watchman's Station.
Watchman,s Central Station.
Horn.
Nurse's Signal Plug.
Maid's Signal Plug.
Radio Outlet.
Signal Central Station.
Interconnection Box.
Battery.
Auxiliary System Circuits.

Note: Any Line without Further Designation Indicates a 2-Wire Circuit. For a Greater Number of Wires Designate with Numerals in Manner Similar to — - — 12-No. 18W-¾"-C., or Designated by Number Corresponding to Listing in Schedule.

Special Auxiliary Outlets.
Sub-Script Letters Refer to Notes on Plans or Detailed Description in Specifications.

Motor Characteristics

Direct-Current Motors

Direct-current motors are divided into three classes, designated according to the method of connecting the armature and field windings as shunt-series and compound-wound.

Alternating-current motors are divided into two general classes, induction and synchronous, while Induction motors are of two types, designated according to the type of rotor winding as the Squirrel-cage type and as the wound-rotor or slip-ring, type.

Shunt-Wound D.C Motors

This type of motor runs at practically constant speed, regardless of the load. It is the type most generally used in commerical practice and is usually recommended where starting conditions are not unusually severe.

Speed of shunt-wound motors may be regulated in two ways, first, by inserting resistance in series with the armature, thus decreasing the speed; and second, by inserting resistance in the field circuit, thereby increasing the speed. In the former case, the speed will vary with each change in load; in the latter, the speed is practically constant for any setting of the controller. The latter is most generally used for adjustable-speed service, as in the case of machine tools.

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Series-Wound D-C Motors

This type of motor speed varies automatically with the load, increasing as the load decreases. Use of series motors is generally limited to cases where a heavy power demand is necessary to bring the machine up to speed, as in the case of certain elevator and hoist installations, for streetcars, etc. Series-wound motors should never be used where the motor can be started without load, since they will race to a dangerous degree.

Compound-Wound D-C Motors

A combination of the shunt-wound and series-wound types combines the characteristics of both. Characteristics may be varied by varying the combination of the two windings.

Generally used where severe starting conditions are met and constant speed is required at the same time.

Squirrel-Cage Induction Motors

The most simple and reliable of all electric motors. Essentially a constant speed machine, which is adaptable for uses under all but the most severe starting conditions. Requires little attention as there are no commutator or slip rings, yet operates with good efficiency.

Wound-Rotor (Slip-Ring) Induction Motors

Used for constant-speed service requiring a heavier starting torque than is obtainable with the squirrel-cage type. Because of its lower starting current, this type is frequently used instead of the squirrel-cage type in the larger sizes.

Wound-rotor motors are also used for varying-speed service. Speed varies with this load, so that they should not be used where constant speed at each adjustment is required, as for machine tools.

Single-Phase Induction Motors

This motor is used, mostly in small sizes, where polyphase current is not available. Characteristics are not as good as the polyphase motor and for sizes larger than 10 hp., the line disturbance is likely to be objectionable. Are commonly used for light starting and for running loads up to ⅓ hp. Capacitor and repulsion types provide greater torque and are built in sizes up to 10 hp.

Synchronous Motors

Run at a constant speed fixed by frequency of the system.

Require direct current for excitation and have low starting torque. For large motor-generator sets, frequency changers, air compressors, and similar apparatus which permits starting under a light load, for which they are generally used.

Are used with considerable advantage, particularly on large power systems, because of their inherent ability to improve the power factor of the system.

Full-Load Currents of Motors

Direct Current Motors

1947 N.E.C. Table 21

Hp.	115V.	230V.	550V.	Hp.	115V.	230V.	550V.
½	4.6	2.3	...	25	184.0	92.0	38.0
¾	6.6	3.3	1.4	30	220.0	110.0	46.0
1	8.6	4.3	1.8	40	292.0	146.0	61.0
1½	12.6	6.3	2.6	50	360.0	180.0	75.0
2	16.4	8.2	3.4	60	430.0	215.0	90.0
3	24.0	12.0	5.0	75	536.0	268.0	111.0
5	40.0	20.0	8.3	100	.....	355.0	148.0
7½	58.0	29.0	12.0	125	.....	443.0	148.0
10	76.0	38.0	16.0	150	.....	534.0	220.0
15	112.0	56.0	23.0	200	.....	712.0	295.0
20	148.0	74.0	31.0			.....	.....

These values for full-load current are average for all speeds.

*Single Phase, A.C. Motors

1947 N.E.C. Table 22

Hp.	115V.	230V.	440V.	Hp.	115V.	230V.	440V.
⅙	3.2	1.6	...	2	24.0	12.0	....
¼	4.6	2.3	...	3	34.0	17.0	....
½	7.4	3.7	...	5	56.0	28.0	....
¾	10.2	5.1	...	7½	80.0	40.0	21.0
1	13.0	6.5	...	10	100.0	50.0	26.0
1½	18.4	9.2	...		....	....	....

For full-load currents of 208 and 200-volt motors, increase corresponding 230-volt motor full-load current by 10 and 15 per cent, respectively.

*Two-Phase, A.C. Motors—4 Wire

1947 N.E.C. Table 23

	Induction Type — Squirrel-Cage and Wound Rotor — Amperes					Synchronous Type — †Unity Power Factor — Amperes			
Hp.	110V.	220V.	440V.	550V.	2300V.	220V.	440V.	550V.	2300V.
½	4.0	2.0	1.0	.8	....				....
¾	4.8	2.4	1.2	1.0					....
1	6.4	3.2	1.6	1.3					....
1½	8.8	4.4	2.2	1.8					....
2	11.2	5.6	2.8	2.2					....
3	....	8.0	4.0	3.2					....
5	....	13.0	7.0	6.0					....
7½	....	19.0	9.0	8.0					....
10	....	24.0	12.0	10.0					....
15	....	34.0	17.0	14.0					....
20	....	45.0	23.0	18.0					....
25	....	55.0	28.0	22.0	6.0	47.0	24.0	19.0	4.7
30	....	67.0	34.0	27.0	7.5	56.0	29.0	23.0	5.7
40	....	88.0	44.0	35.0	9.0	75.0	37.0	31.0	7.0
50	....	108.0	54.0	43.0	11.0	94.0	47.0	38.0	9.0
60	....	129.0	65.0	52.0	13.0	111.0	56.0	44.0	11.0
75	....	158.0	79.0	63.0	16.0	140.0	70.0	57.0	13.0
100	....	212.0	106.0	85.0	21.0	182.0	93.0	74.0	17.0
125	....	268.0	134.0	108.0	26.0	228.0	114.0	93.0	22.0
150	....	311.0	155.0	124.0	31.0	.....	137.0	110.0	26.0
200	....	415.0	208.0	166.0	41.0	.....	182.0	145.0	35.0

*Three-Phase, A.C. Motors

1947 N.E.C. Table 24

½	4.0	2.0	1.0	.8					
¾	5.6	2.8	1.4	1.1					
1	7.0	3.5	1.8	1.4					
1½	10.0	5.0	2.5	2.0					
2	13.0	6.5	3.3	2.6					
3	....	9.0	4.5	4.0					
5	....	15.0	7.5	6.0					
7½	....	22.0	11.0	9.0					
10	....	27.0	14.0	11.0					
15	....	40.0	20.0	16.0					
20	....	52.0	26.0	21.0					
25	....	64.0	32.0	26.0	7.0	54.0	27.0	22.0	5.4
30	....	78.0	39.0	31.0	8.5	65.0	33.0	26.0	6.5
40	....	104.0	52.0	41.0	10.5	86.0	43.0	35.0	8.0
50	....	125.0	63.0	50.0	13.0	108.0	54.0	44.0	10.0
60	....	150.0	75.0	60.0	16.0	128.0	64.0	51.0	12.0
75	....	185.0	93.0	74.0	19.0	161.0	81.0	65.0	15.0
100	....	246.0	123.0	98.0	25.0	211.0	106.0	85.0	20.0
125	....	310.0	155.0	124.0	31.0	264.0	132.0	106.0	25.0
150	....	360.0	180.0	144.0	37.0	.....	158.0	127.0	30.0
200	....	480.0	240.0	192.0	49.0	.....	210.0	168.0	40.0

For full-load currents of 208 and 200-volt motors, increase the corresponding 220-volt motor full-load current by 6 and 10 per cent respectively.

*Currents are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for sepecially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.

†For 90 and 80 per cent power factor, the above figures should be multiplied by 1.1 and 1.25 respectively.

Current in common conductor of 2-Phase, 3-wire system will be 1.41 times value given.

Electrical Conductors

The above sizes are those commonly used throughout the electrical industry, mills, mines, etc. Sizes are selected for a given motor or piece of electrical equipment, from the Name Plate Rating on the equipment to which lines are connected.

The above table, standard throughout the world, gives the sizes of conductors which will carry the current as listed without undue heating. A SAFE WIRE FROM A FIRE STANDPOINT.

For any electrical installation the necessity of considering the most economical size wire should be given much study. The most economical conductor to use is one in which the annual cost of energy loss is equal to the interest and depreciation charges on the conductor—copper or aluminum.

To calculate the proper sized wire it is necessary to know (1) Amount of power, (2) Cost of power, (3) Hours of operation, (4) Cost of conductor in cents per pound, (5) Interest and depreciation charges.

Example: A continuous operation, such as a mill, smelter or other industrial plant using power twenty-four hours per day, 8,760 hours per year, with a power cost of .0125 cents per kilowatt hour, 20% interest and depreciation charges, with copper conductor costing $.25 per pound, use 2,750 circular mills per ampere of current. Aluminum conductors costing $.25 per pound, use 6,400 circular mills per ampere of current. Where the load factor is low, power costs are greater, hence with an operation on an eight-hour-per-day basis, approximately the same wire sizes are required.

Notes: The circular mills of conductor per ampere and the cost of conductor per pound, are fixed. Voltage has nothing to do with the problem. The wire or cable has to have suitable insulation for the location and service where used. Insulation of conductor, wire supports, conduit, and building that supports the wire are not a part of the electrical circuit. There are no electrical losses in these. *The wire conductor itself is the only part that carries the current, the only part in which losses occur.* It is common to find wires carrying so much current that the losses per year will often equal the cost of the conductors many times over.

Size of Conduits for the Installation of Wires and Cables

Table 1.—Two-wire and Three-wire Systems

Size of Conductor	Number of Conductors in One Conduit							
	2	3	5	6	1	7	8	9
	Minimum Size of Conduit, Inches							
14	½	½	¾	¾	1	1	1	1
12	½	¾	¾	¾	1	1	1	1¼
10	¾	¾	1	1	1¼	1¼	1¼	1¼
8	¾	1	1	1	1½	1¼	1¼	1¼
6	1	1¼	1¼	1½	2	2	2	2
5	1¼	1¼	1¼	1½	2	2	2	2
4	1¼	1¼	1½	2	2	2	2	2½
3	1¼	1¼	1½	2	2	2	2½	2½
2	1¼	1½	1½	2	2½	2½	2½	2½
1	1½	1½	2	2	2½	2½	3	3
0	1½	2	2	2½	3	3	3	3
00	2	2	2½	2½	3	3	3	3½
000	2	2	2½	3	3	3	3½	3½
0000	2	2½	3	3	3	3½	3½	4
200000	2	2½	2½	3	3½	3½	3½	4
225000	2½	2½	3	3	3½	3½	4	4
250000	2½	2½	3	3	3½	3½	4	4½
300000	2½	3	3	3½	4	4	4½	4½
350000	2½	3	3½	3½	4	4½	4½	5
400000	3	3	3½	4	4½	4½	5	5
450000	3	3	3½	4	4½	4½	5	6
500000	3	3	3½	4	5	5	5	6
550000	3	3½	4	4½	5	5	6	6
600000	3	3½	4	4½	5	6	6	6
650000	3½	3½	4	4½	5	6	6	6
700000	3½	3½	4½	5	6	6	6	
750000	3½	3½	4½	5	6	6	6	
800000	3½	4	4½	5	6	6	6	
850000	3½	4	4½	5	6	6		
900000	3½	4	4½	5	6	6		
950000	4	4	5	6	6	6		
1000000	4	4	5	6				
1100000	4	4½	6	6				
1200000	4½	4½	6	6				
1250000	4½	4½	6	6				
1300000	4½	5	6	6				
1400000	4½	5	6					
1500000	4½	5	6					
1600000	5	5	6					
1700000	5	5	6					
1750000	5	5	6					
1800000	5	6	6					
1900000	5	6						
2000000	5	6						

For sizes not greater than No. 10 B. & S. gauge, one more conductor than permitted by the above table may be installed in the specified conduit, provided the conduit is not longer than 30 feet, and has not more than the equivalent of two quarter bends from outlet to outlet, the bends at the outlets not being counted.

Symptoms and Causes of Motor Troubles and How to Remedy Them

Trouble Symptoms	Probable Causes	Tests and the Remedy
[A]—Motor Will Not Start Its Load		
Determine by inspection.	1. No voltage at the motor terminals. 2. Low line voltage. 3. Fuses blown (See E). 4. Poor contacts or connections. 5. Brushes not set properly. 6. Motor connected to the wrong power circuit (See K). 7. Motor terminals not properly connected to the power circuit. 8. Service lines or transformer, or both, too small. 9. Motor overloaded. 10. Shorted, grounded or open windings (See J, K and L). 11. Worn bearings allowing the rotating part to drop down on the stationary field.	1. See if lights on the same circuit burn or connect test lamp across motor terminals with motor switch closed. 2. Check voltage. If abnormal voltage drop in service lines, rewire circuit with larger wire. 3. Check size and condition of fuses. 4. Examine and tighten all loose connections. 5. See that brushes seat well on the commutator and are free to move in their holders. Check the brush setting. 6. Check nameplate data. 7. Check motor line connections. 8. Check transformer. (Also see No. 2 above.) 9. Check speed. An overload usually causes the speed to drop below nameplate marking. 10. See J, K and L. 11. Inspect bearings for tightness and lubrication.
[B]—Motor Seems Too Weak—Runs Slow		
Determine by inspection.	1. Low voltage at motor terminals. 2. Motor overloaded. 3. Poor contacts or connections. 4. Motor connected to the wrong power circuits. 5. Motor improperly connected to circuit. 6. Motor windings damaged (See J, K and L).	1. See A-2. 2. Remove load. If motor operates at rated speed check bearings for tightness and lubrication. 3. Check all contacts at main switch or auxiliary switches used to operate motor. Clean commutator and make sure that the brushes are free in holders. 4. See A-6. 5. See A-7. 6. See J, K and L.

[C]—Motor Runs Too Fast		
Check speed.	1. High voltage. 2. Motor connected to wrong circuit. 3. Motor terminals improperly connected to circuit. 4. Frequency too high (a. c. motors only). 5. Motor windings damaged (See J, K and L).	1. Check voltage on line. 2. See A-6. 3. See A-7. 4. Determine frequency stamped on motor nameplate and check with power source. 5. If d.c. motor test for open shunt field circuit. 6. See J, K and L.
[D]—Motor Runs Too Hot		
Determine by thermometer reading. SYMPTOMS: Distinct odor of burning insulation.	1. Motor overloaded during starting and running period. 2. Line voltage too high. 3. Line voltage too low. 4. Belt too tight or coupling or gear out of line 5. Insufficient lubrication. 6. Faulty commutation (See F). 7. Motor windings damaged. 8. One fuse blown in two- or three-phase motor circuit allowing motor to operate on one phase (single phase).	1. Remove load, run motor idle. Give it a general inspection. Apply load gradually and note characteristics. Inspect for localized heating. 2. See C-1. 3. See A-2. 4. Adjust belt, gear or coupling. 5. See I. 6. See F-2. 7. See J, K and L. 8. If trouble not eliminated check windings for defects (See J, K and L).
[E]—Motor Fuses Blow		
Determine by inspection. SYMPTOMS: (a) Motor stops. (b) Motor gets hot. (c) Motor refuses to start.	1. Motor overloaded. 2. Fuse too small. 3. Motor connected to wrong power circuit. 4. Motor improperly connected to circuit. 5. Damaged motor windings.	1. See D-1. 2. Check fuse information sent with the motor. 3. See A-6. 4. See A-7. 5. See J, K and L.

Symptoms and Causes of Motor Troubles and How to Remedy Them

Trouble Symptoms	Probable Causes	Tests and the Remedy
[F]—Faulty Commutation		
SYMPTOMS: (a) Excessive flashing. (b) Blackened commutator. (c) Brushes wear rapidly.	1. Protruding mica or rough commutator. 2. Dirt or oil on commutator. 3. Brushes stuck in holders. 4. Wrong brush position. 5. Weak springs. 6. Overloaded motor. 7. Motor windings damaged.	1. Remove armature and have a thin cut taken off the commutator with sharp lathe tool. 2. Clean commutator with a soft rag. 3. Make sure brushes ride easily in their holders. 4. See A-5. 5. Replace springs. 6. See A-9. 7. See J, K and L.
[G]—Excessive Brush Wear		
Determine by inspection. One set of brushes should function satisfactorily for at least 2,500 running hours.	1. Excessive sparking or flashing at the brushes. 2. Wrong quality brush. 3. Rough commutator or high mica between the commutator bars. 4. Overloads.	1. Inspect condition of commutator, also brush spring tension. 2. Replace brushes to insure proper commutation. 3. If mica segments protrude take a thin lathe cut from commutator. Polish with No. 00 sandpaper. Use no oil. 4. See A-9, and D-1.

[H]—Motor Is Noisy

Determine by inspection.	1. Worn bearings (See I). 2. Rough commutator or high mica between bars. 3. Unbalanced armature. 4. Brushes fit too loosely in the holder. 5. Armature out of center. 6. Insufficient end play. 7. Excessive end play. 8. Air gap not uniform. 9. Loose accessories such as condulet box, guards, etc. 10. Motor mounted on foundation that is not solid or that vibrates when motor is running. 11. Bearings not properly assembled. 12. Motor out of alignment (coupling or gear drive only).	1. See I. 2. See F-1. 3. Return complete motor to factory for correction or replace with spare armature. 4. Replace brushes. 5. Ship motor to factory for correction. 6. Oil thoroughly. 7. If end play exceeds 0.010 in. on ball bearings or 1/32 in. on sleeve bearings tighten adjusting nuts. 8. Replace the bearings. 9. See that end covers, guards, etc., are tight. 10. Make sure that motor is properly fastened to its foundation. 11. Make sure that adjusting nuts are tight. If ball bearings (1) remove dust caps (2) tap races to see if properly seated. 12. Loosen motor foot bolts and re-align with driven machine.
[I]—Worn Bearings		
Determine by inspection. SYMPTOMS: Excessive noise. Excessive vibration. Rotor striking field.	1. Insufficient lubrication. 2. Wrong kind of lubrication. 3. Belt too tight. 4. Coupling or gear out of line. 5. Excessive end play.	1. and 2. Replace bearings and lubricate thoroughly. 3. See that belt is just tight enough to prevent slipping during starting and running periods. 4. See H-12. 5. See H-7.

[J]—Grounded Field or Armature

Grounded field—Determine by using series lamp or magneto test from motor leads to frame. Grounded armature—Test from shaft to commutator. SYMPTOMS: Loss of power. Slow speed.	1. Copper dust. 2. Oil or dirt on brush-holder parts where coils enter the slots in the field. 3. Defective insulation. 4. Mechanical damage to insulation in handling. 5. Over-heating sufficient to char the insulation. 6. Damaged winding.	1. Remove all oil, dust or dirt from the motor. 2. Look for bare wires near end cover bolts, end of the slots, or where leads are soldered. 3. Wipe commutator with dry rag. 4. Clean mica between commutator bars. 5. On Type RA, single-phase motors, if segments touch the commutator the armature will be grounded. 6. If the windings are making direct contact with the frame reinsulate thoroughly.

[K]—Short-Circuited Field or Armature

Armature short-circuited in a. c. motor. The shorted coil will center under the stator coil and become excessively hot. If d. c. motor, it will operate at speeds below normal for all loads and the shorted coil will get very hot.	1. Solder between commutator bars where armature leads are connected. 2. Damaged winding.	Regardless of cause proceed as follows: 1. Inspect the soldering of the commutator leads to see that solder does not touch any two commutator bars at the same time. 2. If windings have been damaged and two bare wires are touching each other, reinsulate with varnished cloth or tape. 3. If trouble is not removed by (1) and (2) return the motor direct to the factory for repairs.

[L]—Open-Circuited Field or Armature

SYMPTOMS: 1. Burnt mica between bars nearest open circuit. 2. Excessive sparking around commutator. 3. Refusal to start at certain portions of the armature. 4. Failure to start generally accompanied by a humming sound when motor line switch is thrown on.	1. Broken wires. 2. Defective soldering. 3. Damaged winding. 4. Lead wires disconnected. 5. Commutator leads loose.	1. Examine line fuses to make sure they have not blown. This is especially important with two or three-phase motors. 2. See that the motor is properly connected to the line. 3. If a broken wire is apparent make the repair and reinsulate the splice with friction tape. 4. Check point where motor leads connect to the winding. 5. Resolder any loose commutator leads. If open circuit cannot be located return to factory for repair.

[M]—Improper Current Supply

SYMPTOMS: 1. Motor overheats. 2. Motor is noisy. 3. Refuses to start. 4. Line fuses blow.		Replace the motor with one built for operation on the local power circuit.

[N]—Worn Brushes		
SYMPTOMS: 1. Motor refuses to start. 2. Motor not up to normal speed.	1. Overload. 2. Natural wear. 3. Rough commutator.	1. See A-9. 2. Replace with new brushes. Fit the new brushes to the curvature of the commutator. 3. Polish the commutator with sandpaper (never use emery paper) or take small cut off in a Lathe.

[C]—Motor Too Small		
Determine wattage input under load. SYMPTOMS: 1. Will not come up to speed under load. 2. Excessive or continuous sparking.		1. Check speed when testing for wattage input. 2. Relieve part of the load or use a larger motor.

[P]—Sticking Brushes		
SYMPTOMS: 1. Motor turns but will not always start. 2. Excessive flashing at the commutator.	1. Presence of dirt or foreign matter in brush holder. 2. Rings or slots on brushes. 3. Brush tension spring incorrectly applied.	Press down on brushes. If motor starts remove brushes, clean out holders and sand with No. 00 sandpaper. Also sand the commutator.

[Q]—Brushes Not Making Contact		
SYMPTOMS: 1. Loss of power. 2. Excessive sparking. 3. Refusal to start.	1. Brush spring tension weak. 2. Brush spring not in proper position. 3. Brushes not properly sanded.	1. and 2. Correct brush spring position or replace with new springs. 3. Sand the brush until it conforms to the commutator curvature.

Courtesy of Master Electric Company, Dayton, Ohio, and Industrial Engineering.

TOTAL DROP IN VOLTAGE IN LONG TRANSMISSIONS

3 Phase—60 Cycle. AC at 85% PF

Volts per ampere, per 1000 feet Transmission. For Reactance and Resistance combined

From 80 to 90% power factor, voltage drop may be assumed to vary inversely as power factor.

B. & S. Gauge	Size In Circular Mills.	At 0.15 React. Volts		At 0.20 React. Volts		At 0.25 React. Volts	
		Spacing, Inches	Voltage Drop	Spacing, Inches	Voltage Drop	Spacing, Inches	Voltage Drop
6	26250	1.7	0.40	4.5	.42	15	.44
4	41740	2.0	0.26	6	.27	18	.29
2	66370	2.5	0.18	8	.19	24	.21
1	83690	3	.15	9	.16	27	.18
0	105500	3.3	.13	10	.14	30	.16
00	133100	3.6	.11	11	.125	33	.15
000	167800	4.0	.10	12	.115	36	.13
0000	211600	4.5	.09	14	.100	42	.115
	250000	5.0	.08	16	.090	48	.110
	300000	5.5	.075	17	.085	51	.105
	350000	6.0	.068	18	.082	54	.100
	400000	6.5	.064	20	.077	60	.098
	500000	7.2	.060	22	.075	66	.090
	600000	8.0	.056	24	.071	72	.087

Power-Factor Improvement

The figures below × kilowatt input = kv-a. required to improve from one power-factor to another.

Original Power-factor %	DESIRED POWER-FACTOR 100%	95%	90%	85%	80%
20	4.899	4.570	4.415	4.279	4.149
21	4.656	4.327	4.171	4.036	3.906
22	4.433	4.104	3.949	3.813	3.683
23	4.231	3.902	3.747	3.611	3.481
24	4.045	3.716	3.561	3.425	3.295
25	3.873	3.544	3.389	3.253	3.123
26	3.714	3.385	3.229	3.094	2.964
27	3.566	3.238	3.082	2.946	2.816
28	3.429	3.100	2.944	2.809	2.679
29	3.300	2.971	2.816	2.680	2.550
30	3.180	2.851	2.696	2.560	2.430
31	3.067	2.738	2.583	2.447	2.317
32	2.961	2.632	2.476	2.341	2.211
33	2.861	2.532	2.376	2.241	2.111
34	2.766	2.437	2.282	2.146	2.016
35	2.676	2.347	2.192	2.056	1.926
36	2.592	2.263	2.107	1.972	1.842
37	2.511	2.182	2.027	1.891	1.761
38	2.434	2.105	1.950	1.814	1.684
39	2.361	2.032	1.877	1.741	1.611
40	2.291	1.963	1.807	1.671	1.541
41	2.225	1.896	1.740	1.605	1.475
42	2.161	1.832	1.676	1.541	1.410
43	2.100	1.771	1.615	1.480	1.349
44	2.041	1.712	1.557	1.421	1.291
45	1.985	1.656	1.501	1.365	1.235
46	1.930	1.602	1.446	1.310	1.180

Original Power-factor %	DESIRED POWER-FACTOR 100%	95%	90%	85%	80%
47	1.877	1.548	1.392	1.257	1.128
48	1.828	1.499	1.343	1.208	1.077
49	1.779	1.450	1.295	1.159	1.029
50	1.732	1.403	1.248	1.112	.982
51	1.687	1.358	1.202	1.067	.936
52	1.643	1.314	1.158	1.023	.892
53	1.600	1.271	1.116	.980	.850
54	1.559	1.230	1.074	.939	.808
55	1.518	1.189	1.034	.898	.768
56	1.497	1.150	.995	.859	.729
57	1.442	1.113	.957	.822	.691
58	1.405	1.076	.920	.785	.654
59	1.368	1.040	.884	.748	.618
60	1.333	1.004	.849	.713	.583
61	1.299	.970	.815	.679	.549
62	1.266	.937	.781	.646	.515
63	1.233	.904	.748	.613	.482
64	1.201	.872	.716	.581	.450
65	1.169	.840	.685	.549	.419
66	1.138	.810	.654	.518	.388
67	1.108	.779	.624	.488	.358
68	1.078	.750	.594	.458	.328
69	1.049	.720	.565	.429	.298
70	1.020	.691	.536	.400	.270
71	.992	.663	.507	.372	.241
72	.964	.635	.480	.344	.214
73	.936	.608	.452	.316	.186

Original Power-factor %	DESIRED POWER-FACTOR 100%	95%	90%	85%	80%
74	.909	.580	.425	.289	.158
75	.882	.553	.398	.262	.132
76	.855	.527	.371	.235	.105
77	.829	.500	.344	.209	.078
78	.802	.474	.318	.182	.052
79	.776	.447	.292	.156	.026
80	.750	.421	.266	.130	
81	.724	.395	.240	.104	
82	.698	.369	.214	.078	
83	.672	.343	.188	.052	
84	.646	.317	.162	.026	
85	.620	.291	.136		
86	.593	.265	.109		
87	.567	.238	.082		
88	.540	.211	.056		
89	.512	.183	.028		
90	.484	.155			
91	.456	.127			
92	.426	.097			
93	.395	.066			
94	.363	.034			
95	.329				
96	.292				
97	.251				
98	.203				
99	.142				
100					

Example—Total kw. input of plant from wattmeter reading 100 kw. at a power-factor of 60 per cent. The kv-a. of the capacitor necessary to raise the power-factor to 80 per cent is found by multiplying the 100 kw. by the factor found in the table which is 0.58. 100 kw. × 0.58 = 58 kv-a. in capacitor capacity. The nearest standard size, of course, is 60 kv-a. and this should be recommended.

General Electric Co.

FORMULAS FOR DETERMINING KW, KVA, REACTIVE KVA, HP AND AMPERES

DESIRED DATA	ALTERNATING CURRENT: SINGLE PHASE	TWO-PHASE* FOUR WIRE	THREE PHASE	DIRECT CURRENT
KILOWATTS	$\frac{\text{Volts} \times \text{amps} \times \text{P.F.}}{1000}$	$\frac{2 \times \text{volts} \times \text{amps} \times \text{P.F.}}{1000}$	$\frac{1.73 \times \text{volts} \times \text{amps} \times \text{P.F.}}{1000}$	$\frac{\text{Volts} \times \text{amps}}{1000}$
KVA	$\frac{\text{Volts} \times \text{amps}}{1000}$	$\frac{2 \times \text{volts} \times \text{amps}}{1000}$	$\frac{1.73 \times \text{volts} \times \text{amps}}{1000}$	
REACTIVE KVA	$\frac{\text{Volts} \times \text{amps} \times \sqrt{1 - \text{P.F.}^2}}{1000}$	$\frac{2 \times \text{volts} \times \text{amps} \times \sqrt{1 - \text{P.F.}^2}}{1000}$	$\frac{1.73 \times \text{volts} \times \text{amps} \times \sqrt{1 - \text{P.F.}^2}}{1000}$	
HORSE POWER (Output)	$\frac{\text{Volts} \times \text{amps} \times \text{Eff.} \times \text{P.F.}}{746 \times 100}$	$\frac{2 \times \text{volts} \times \text{amps} \times \text{Eff.} \times \text{P.F.}}{746 \times 100}$	$\frac{1.73 \times \text{volts} \times \text{amps} \times \text{Eff.} \times \text{P.F.}}{746 \times 100}$	$\frac{\text{Volts} \times \text{amps} \times \text{Eff.}}{746 \times 100}$
AMPERES (When Horse power is known)	$\frac{\text{Hp} \times 746 \times 100}{\text{Volts} \times \text{Eff.} \times \text{P.F.}}$	$\frac{\text{Hp} \times 746 \times 100}{2 \times \text{volts} \times \text{Eff.} \times \text{P.F.}}$	$\frac{\text{Hp} \times 746 \times 100}{1.73 \times \text{volts} \times \text{Eff.} \times \text{P.F.}}$	$\frac{\text{Hp} \times 746 \times 100}{\text{Volts} \times \text{Eff.}}$
AMPERES (When Kilowatts are known)	$\frac{\text{Kilowatts} \times 1000}{\text{Volts} \times \text{P.F.}}$	$\frac{\text{Kilowatts} \times 1000}{2 \times \text{volts} \times \text{P.F.}}$	$\frac{\text{Kilowatts} \times 1000}{1.73 \times \text{volts} \times \text{P.F.}}$	$\frac{\text{Kilowatts} \times 1000}{\text{Volts}}$
AMPERES (When kva is known)	$\frac{\text{Kva} \times 1000}{\text{Volts}}$	$\frac{\text{Kva} \times 1000}{2 \times \text{volts}}$	$\frac{\text{Kva} \times 1000}{1.73 \times \text{volts}}$	

*In 3-Wire, 2-Phase circuits the current in the common conductor is 1.41 times that in either other conductor.

(Eff.) Efficiency in the above formulas is expressed in percent—such as 95(%).

(P.F.) Power factor in the above formulas is expressed as a decimal—such as 0.85

ALTERNATING CURRENT MOTOR SPEEDS

Cycles		Number of poles 2	4	6	8	10	12	14	16
		Speeds, r.p.m.							
60	Synchronous	3600	1800	1200	900	720	600	514	450
	Running	3500	1745	1160	870	700	580	500	435
50	Synchronous	3000	1500	1000	750	600	500	430	375
	Running	2920	1450	970	730	580	485	417	365
25	Synchronous	1500	750	500	375	300	250	214	187
	Running	1460	725	485	365	290	243	208	182

Running speeds are approximate and vary according to H.P. and frame size.

AVERAGE MOTORS—AC AND DC

Percent Rated horsepower	Horsepower 200 150	100 75	50	30 20	15 7½	5 3	2 1	½ ¼
	N, Efficiency							
100	.91	.90	.89	.88	.87	.85	.83	.79
50	.88	.87	.85	.84	.82	.79	.77	.72
25	.81	.80	.77	.75	.73	.70	.67	.60
	PF, Power Factor							
100	.92	.91	.90	.89	.87	.86	.80	.75
50	.87	.85	.83	.81	.79	.77	.60	.65
25	.77	.75	.73	.70	.67	.64	.48	.40

$$\text{Kw. Input: } \frac{\text{H.P.} \times .746}{N}$$

Spacing for Line Shaft Bearings

Shaft Size In.	MAXIMUM DISTANCE BETWEEN BEARINGS — Transmitting Power Without Any Pulleys, Gears or Other Bending Strains: 1 to 250 R.P.M.	251 to 400 R.P.M.	Carrying Pulleys, Gears, etc. and Subject to Usual Bending Strains: 1 to 250 R.P.M.	251 to 400 R.P.M.
1 7/16	9'0"	8'0"	7'0"	6'6"
1 15/16	10'0"	9'0"	7'6"	7'0"
2 7/16	11'0"	10'0"	8'0"	7'6"
2 15/16	12'0"	11'0"	8'6"	8'0"
3 7/16	13'0"	12'0"	9'0"	8'6"
3 15/16	14'0"	13'0"	9'6"	9'0"
4 7/16	15'0"	14'0"	10'0"	9'6"
4 15/16	16'0"	14'6"	10'0"	9'6"
5 7/16	17'0"	15'0"	10'6"	10'0"
5 15/16	18'0"	15'6"	10'6"	10'0"

TABLE OF SHILLINGS AND PENCE

Expressed as the Decimal Equivalent of a Pound Sterling

s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound
		4- 0	.20000	8- 0	.40000	12- 0	.60000	16- 0	.80000
0- 1	.00417	4- 1	.20417	8- 1	.40417	12- 1	.60417	16- 1	.80417
0- 2	.00833	4- 2	.20833	8- 2	.40833	12- 2	.60833	16- 2	.80833
0- 3	.01250	4- 3	.21250	8- 3	.41250	12- 3	.61250	16- 3	.81250
0- 4	.01667	4- 4	.21667	8- 4	.41667	12- 4	.61667	16- 4	.81667
0- 5	.02083	4- 5	.22083	8- 5	.42083	12- 5	.62083	16- 5	.82083
0- 6	.02500	4- 6	.22500	8- 6	.42500	12- 6	.62500	16- 6	.82500
0- 7	.02917	4- 7	.22917	8- 7	.42917	12- 7	.62917	16- 7	.82917
0- 8	.03333	4- 8	.23333	8- 8	.43333	12- 8	.63333	16- 8	.83333
0- 9	.03750	4- 9	.23750	8- 9	.43750	12- 9	.63750	16- 9	.83750
0-10	.04167	4-10	.24167	8-10	.44167	12-10	.64167	16-10	.84167
0-11	.04583	4-11	.24583	8-11	.44583	12-11	.64583	16-11	.84583
1- 0	.05000	5- 0	.25000	9- 0	.45000	13- 0	.65000	17- 0	.85000
1- 1	.05417	5- 1	.25417	9- 1	.45417	13- 1	.65417	17- 1	.85417
1- 2	.05833	5- 2	.25833	9- 2	.45833	13- 2	.65833	17- 2	.85833
1- 3	.06250	5- 3	.26250	9- 3	.46250	13- 3	.66250	17- 3	.86250
1- 4	.06667	5- 4	.26667	9- 4	.46667	13- 4	.66667	17- 4	.86667
1- 5	.07083	5- 5	.27083	9- 5	.47083	13- 5	.67083	17- 5	.87083
1- 6	.07500	5- 6	.27500	9- 6	.47500	13- 6	.67500	17- 6	.87500
1- 7	.07917	5- 7	.27917	9- 7	.47917	13- 7	.67917	17- 7	.87917
1- 8	.08333	5- 8	.28333	9- 8	.48333	13- 8	.68333	17- 8	.88333
1- 9	.08750	5- 9	.28750	9- 9	.48750	13- 9	.68750	17- 9	.88750
1-10	.09167	5-10	.29167	9-10	.49167	13-10	.69167	17-10	.89167
1-11	.09583	5-11	.29583	9-11	.49583	13-11	.69583	17-11	.89583
2- 0	.10000	6- 0	.30000	10- 0	.50000	14- 0	.70000	18- 0	.90000
2- 1	.10417	6- 1	.30417	10- 1	.50417	14- 1	.70417	18- 1	.90417
2- 2	.10833	6- 2	.30833	10- 2	.50833	14- 2	.70833	18- 2	.90833
2- 3	.11250	6- 3	.31250	10- 3	.51250	14- 3	.71250	18- 3	.91250
2- 4	.11667	6- 4	.31667	10- 4	.51667	14- 4	.71667	18- 4	.91667
2- 5	.12083	6- 5	.32083	10- 5	.52083	14- 5	.72083	18- 5	.92083
2- 6	.12500	6- 6	.32500	10- 6	.52500	14- 6	.72500	18- 6	.92500
2- 7	.12917	6- 7	.32917	10- 7	.52917	14- 7	.72917	18- 7	.92917
2- 8	.13333	6- 8	.33333	10- 8	.53333	14- 8	.73333	18- 8	.93333
2- 9	.13750	6- 9	.33750	10- 9	.53750	14- 9	.73750	18- 9	.93750
2-10	.14167	6-10	.34167	10-10	.54167	14-10	.74167	18-10	.94167
2-11	.14583	6-11	.34583	10-11	.54583	14-11	.74583	18-11	.94583
3- 0	.15000	7- 0	.35000	11- 0	.55000	15- 0	.75000	19- 0	.95000
3- 1	.15417	7- 1	.35417	11- 1	.55417	15- 1	.75417	19- 1	.95417
3- 2	.15833	7- 2	.35833	11- 2	.55833	15- 2	.75833	19- 2	.95833
3- 3	.16250	7- 3	.36250	11- 3	.56250	15- 3	.76250	19- 3	.96250
3- 4	.16667	7- 4	.36667	11- 4	.56667	15- 4	.76667	19- 4	.96667
3- 5	.17083	7- 5	.37083	11- 5	.57083	15- 5	.77083	19- 5	.97083
3- 6	.17500	7- 6	.37500	11- 6	.57500	15- 6	.77500	19- 6	.97500
3- 7	.17917	7- 7	.37917	11- 7	.57917	15- 7	.77917	19- 7	.97917
3- 8	.18333	7- 8	.38333	11- 8	.58333	15- 8	.78333	19- 8	.98333
3- 9	.18750	7- 9	.38750	11- 9	.58750	15- 9	.78750	19- 9	.98750
3-10	.19167	7-10	.39167	11-10	.59167	15-10	.79167	19-10	.99167
3-11	.19583	7-11	.39583	11-11	.59583	15-11	.79583	19-11	.99583

SOME USES OF TABLE

4 tons 6 cwt. 3 qrs. 11 lbs. at £3 5s. 9d. per ton = £14 5s. 6d.
4.3424 x 3.2875 = £14.27564 .27564 = 5s. 6d.
CONVERT £14 5s. 6d. to U. S. money. Exchange rate $4.8665. 14.275 x 4.8665 = $69.47.

PHONE, WIRE, OR WRITE YOUR ORDER TODAY

ALTERNATING CURRENT MOTOR SPEEDS

Cycles		Number of poles							
		2	4	6	8	10	12	14	16
		Speeds, r.p.m.							
60	Synchronous	3600	1800	1200	900	720	600	514	450
	Running	3500	1745	1160	870	700	580	500	435
50	Synchronous	3000	1500	1000	750	600	500	430	375
	Running	2920	1450	970	730	580	485	417	365
25	Synchronous	1500	750	500	375	300	250	214	187
	Running	1460	725	485	365	290	243	208	182

Running speeds are approximate and vary according to H.P. and frame size.

AVERAGE MOTORS—AC AND DC

	Horsepower							
Percent Rated horsepower	200 150	100 75	50	30 20	15 7½	5 3	2 1	½ ¼
	N, Efficiency							
100	.91	.90	.89	.88	.87	.85	.83	.79
50	.88	.87	.85	.84	.82	.79	.77	.72
25	.81	.80	.77	.75	.73	.70	.67	.60
	PF, Power Factor							
100	.92	.91	.90	.89	.87	.86	.80	.75
50	.87	.85	.83	.81	.79	.77	.60	.65
25	.77	.75	.73	.70	.67	.64	.48	.40

$$\text{Kw. Input:} \ \frac{\text{H.P.} \times .746}{N}$$

Spacing for Line Shaft Bearings

Shaft Size In.	MAXIMUM DISTANCE BETWEEN BEARINGS			
	Transmitting Power Without Any Pulleys, Gears or Other Bending Strains		Carrying Pulleys, Gears, etc. and Subject to Usual Bending Strains	
	1 to 250 R.P.M.	251 to 400 R.P.M.	1 to 250 R.P.M.	251 to 400 R.P.M.
1 7/16	9'0"	8'0"	7'0"	6'6"
1 15/16	10'0"	9'0"	7'6"	7'0"
2 7/16	11'0"	10'0"	8'0"	7'6"
2 15/16	12'0"	11'0"	8'6"	8'0"
3 7/16	13'0"	12'0"	9'0"	8'6"
3 15/16	14'0"	13'0"	9'6"	9'0"
4 7/16	15'0"	14'0"	10'0"	9'6"
4 15/16	16'0"	14'6"	10'0"	9'6"
5 7/16	17'0"	15'0"	10'6"	10'0"
5 15/16	18'0"	15'6"	10'6"	10'0"

TABLE OF SHILLINGS AND PENCE

Expressed as the Decimal Equivalent of a Pound Sterling

s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound	s d	Decimal of Pound
		4- 0	.20000	8- 0	.40000	12- 0	.60000	16- 0	.80000
0- 1	.00417	4- 1	.20417	8- 1	.40417	12- 1	.60417	16- 1	.80417
0- 2	.00833	4- 2	.20833	8- 2	.40833	12- 2	.60833	16- 2	.80833
0- 3	.01250	4- 3	.21250	8- 3	.41250	12- 3	.61250	16- 3	.81250
0- 4	.01667	4- 4	.21667	8- 4	.41667	12- 4	.61667	16- 4	.81667
0- 5	.02083	4- 5	.22083	8- 5	.42083	12- 5	.62083	16- 5	.82083
0- 6	.02500	4- 6	.22500	8- 6	.42500	12- 6	.62500	16- 6	.82500
0- 7	.02917	4- 7	.22917	8- 7	.42917	12- 7	.62917	16- 7	.82917
0- 8	.03333	4- 8	.23333	8- 8	.43333	12- 8	.63333	16- 8	.83333
0- 9	.03750	4- 9	.23750	8- 9	.43750	12- 9	.63750	16- 9	.83750
0-10	.04167	4-10	.24167	8-10	.44167	12-10	.64167	16-10	.84167
0-11	.04583	4-11	.24583	8-11	.44583	12-11	.64583	16-11	.84583
1- 0	.05000	5- 0	.25000	9- 0	.45000	13- 0	.65000	17- 0	.85000
1- 1	.05417	5- 1	.25417	9- 1	.45417	13- 1	.65417	17- 1	.85417
1- 2	.05833	5- 2	.25833	9- 2	.45833	13- 2	.65833	17- 2	.85833
1- 3	.06250	5- 3	.26250	9- 3	.46250	13- 3	.66250	17- 3	.86250
1- 4	.06667	5- 4	.26667	9- 4	.46667	13- 4	.66667	17- 4	.86667
1- 5	.07083	5- 5	.27083	9- 5	.47083	13- 5	.67083	17- 5	.87083
1- 6	.07500	5- 6	.27500	9- 6	.47500	13- 6	.67500	17- 6	.87500
1- 7	.07917	5- 7	.27917	9- 7	.47917	13- 7	.67917	17- 7	.87917
1- 8	.08333	5- 8	.28333	9- 8	.48333	13- 8	.68333	17- 8	.88333
1- 9	.08750	5- 9	.28750	9- 9	.48750	13- 9	.68750	17- 9	.88750
1-10	.09167	5-10	.29167	9-10	.49167	13-10	.69167	17-10	.89167
1-11	.09583	5-11	.29583	9-11	.49583	13-11	.69583	17-11	.89583
2- 0	.10000	6- 0	.30000	10- 0	.50000	14- 0	.70000	18- 0	.90000
2- 1	.10417	6- 1	.30417	10- 1	.50417	14- 1	.70417	18- 1	.90417
2- 2	.10833	6- 2	.30833	10- 2	.50833	14- 2	.70833	18- 2	.90833
2- 3	.11250	6- 3	.31250	10- 3	.51250	14- 3	.71250	18- 3	.91250
2- 4	.11667	6- 4	.31667	10- 4	.51667	14- 4	.71667	18- 4	.91667
2- 5	.12083	6- 5	.32083	10- 5	.52083	14- 5	.72083	18- 5	.92083
2- 6	.12500	6- 6	.32500	10- 6	.52500	14- 6	.72500	18- 6	.92500
2- 7	.12917	6- 7	.32917	10- 7	.52917	14- 7	.72917	18- 7	.92917
2- 8	.13333	6- 8	.33333	10- 8	.53333	14- 8	.73333	18- 8	.93333
2- 9	.13750	6- 9	.33750	10- 9	.53750	14- 9	.73750	18- 9	.93750
2-10	.14167	6-10	.34167	10-10	.54167	14-10	.74167	18-10	.94167
2-11	.14583	6-11	.34583	10-11	.54583	14-11	.74583	18-11	.94583
3- 0	.15000	7- 0	.35000	11- 0	.55000	15- 0	.75000	19- 0	.95000
3- 1	.15417	7- 1	.35417	11- 1	.55417	15- 1	.75417	19- 1	.95417
3- 2	.15833	7- 2	.35833	11- 2	.55833	15- 2	.75833	19- 2	.95833
3- 3	.16250	7- 3	.36250	11- 3	.56250	15- 3	.76250	19- 3	.96250
3- 4	.16667	7- 4	.36667	11- 4	.56667	15- 4	.76667	19- 4	.96667
3- 5	.17083	7- 5	.37083	11- 5	.57083	15- 5	.77083	19- 5	.97083
3- 6	.17500	7- 6	.37500	11- 6	.57500	15- 6	.77500	19- 6	.97500
3- 7	.17917	7- 7	.37917	11- 7	.57917	15- 7	.77917	19- 7	.97917
3- 8	.18333	7- 8	.38333	11- 8	.58333	15- 8	.78333	19- 8	.98333
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PHONE, WIRE, OR WRITE YOUR ORDER TODAY

OPERATIONAL COST—INDUCTION MOTORS

Horse Power	Wattage At Full Load In KW	@ 1c KWH Per 24 Hours	@ 1c KWH Per 360 Days*	@ 1½c KWH Per 24 Hours	@ 1½c KWH Per 360 Days*	@ 2c KWH Per 24 Hours	@ 2c KWH Per 360 Days*	@ 2½c KWH Per 24 Hours	@ 2½c KWH Per 360 Days*	@ 3c KWH Per 24 Hours	@ 3c KWH Per 360 Days*	HP
1	1.0	$ .24	$ 87	$ .36	$ 130	$ .48	$ 174	$ .60	$ 218	$ .72	$ 260	1
2	1.9	.46	166	.69	249	.92	332	1.15	415	1.38	498	2
3	2.8	.67	241	1.01	361	1.34	482	1.67	603	2.02	722	3
5	4.3	1.03	370	1.55	555	2.06	740	2.58	925	3.10	1110	5
7½	6.7	1.61	580	2.42	870	3.21	1160	4.02	1450	4.84	1740	7½
10	8.8	2.21	795	3.32	1190	4.42	1590	5.52	1990	6.64	2380	10
15	13.5	3.24	1167	4.86	1750	6.48	2334	8.10	2920	9.72	3500	15
20	17.5	4.20	1510	6.30	2240	8.40	3020	10.50	3770	12.60	4480	20
25	21.5	5.16	1860	7.75	2790	10.32	3720	12.90	4650	15.50	5580	25
30	25.4	6.10	2200	9.15	3300	12.20	4400	15.25	5500	18.30	6600	30
50	41.1	9.80	3530	14.70	5300	19.60	7060	24.50	8820	29.40	10600	50
75	63	15.10	5430	22.60	8150	30.20	10860	37.80	13600	45.30	16300	75
100	83	19.90	7160	29.80	10700	39.80	14320	49.80	17900	59.60	21400	100
150	124	29.80	10700	44.70	16100	59.60	21400	74.50	26700	89.40	32200	150
200	163	39.10	14100	58.60	21200	78.20	28200	97.70	35200	117.30	42400	200

Note: The above figures are based on Normal Starting Torque, Open Frame, 1000 R. P. M., Induction Motors, operating at full load on 220 volts, 3 phase, 60 cycle current.

Power cost to an average "large industrial user" is 1c to 1½c per KWH.

Diesel power, when fuel is 15c and operating costs are normal, will run about 2c per KWH.

* The 360 days year are 24 hour days.

The cost of electric power at various rates is shown below for one Kilowatt per hour per day and one Kilowatt per hour per year of 365 days.

Cost/KWH	Per Day	Per Year
.75c	$0.18	$ 65.70
1.00c	0.24	87.60
1.25c	0.30	109.50
1.50c	0.36	131.40
1.75c	0.42	153.30
2.00c	0.48	175.20
2.50c	0.60	219.80
3.00c	0.72	262.80
4.00c	0.96	350.40
5.00c	1.20	438.00

COST PER HORSE-POWER DAY AT THE RATES PER KILOWATT-HOUR SHOWN @ 80% POWER FACTOR

HP	¾c/ KWH	1c/ KWH	1½c/ KWH	2c/ KWH	2½c/ KWH	3c/ KWH	4c/ KWH	5c/ KWH
1	0.17	0.22	0.34	0.45	0.56	0.67	0.88	1.12
2	0.34	0.45	0.67	0.89	1.12	1.34	1.78	2.24
3	0.50	0.67	1.01	1.34	1.68	1.96	2.66	3.36
4	0.67	0.89	1.34	1.78	2.23	2.68	3.56	4.47
5	0.84	1.12	1.68	2.24	2.80	3.36	4.47	5.59
10	1.68	2.24	3.36	4.47	2.24	6.71	8.94	11.18
15	2.52	3.36	5.04	6.71	8.40	10.07	13.42	16.77
25	4.20	6.60	8.40	11.18	15.00	17.78	22.37	27.95
50	8.39	11.18	16.78	22.37	27.95	33.55	44.74	55.92
100	16.78	22.37	33.55	44.74	55.92	67.10	89.47	111.84
200	33.55	44.74	67.10	89.47	111.84	134.21	178.94	223.68
500	83.88	111.84	167.76	223.68	279.60	335.62	447.36	559.20

Coals of the United States

(Ash-Free Analysis)

TYPE OF COAL	Per Cent. Fixed Carbon	Per Cent. Volatile Matter	Per Cent. Moisture	B. T. U. Per Pound
Anthracite	92 to 96	1 to 5	3.2	14440
Semi-Anthracite	83.8	10.2	6.0	14880
High-rank Semi-Bitum	83.4	11.6	5.0	15360
Low-rank Semi-Bitum	75.0	22.0	3.0	15480
High-rank Bituminous	64.6	32.2	3.2	15160
Medium-rank Bitum.	54.2	40.8	5.0	13880
Low-rank Bituminous	47.0	41.4	11.6	12880
Sub-Bituminous	42.4	34.2	23.4	9720
Lignite	37.8	18.8	43.4	7400

OPERATIONAL COST—INDUCTION MOTORS

Horse Power	Wattage At Full Load In KW	@1c KWH Per 24 Hours	@1c KWH Per 360 Days*	@1½c KWH Per 24 Hours	@1½c KWH Per 360 Days*	@2c KWH Per 24 Hours	@2c KWH Per 360 Days*	@2½c KWH Per 24 Hours	@2½c KWH Per 360 Days*	@3c KWH Per 24 Hours	@3c KWH Per 360 Days*	HP
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20	17.5	4.20	1510	6.30	2240	8.40	3020	10.50	3770	12.60	4480	20
25	21.5	5.16	1860	7.75	2790	10.32	3720	12.90	4650	15.50	5580	25
30	25.4	6.10	2200	9.15	3300	12.20	4400	15.25	5500	18.30	6600	30
50	41.1	9.80	3530	14.70	5300	19.60	7060	24.50	8820	29.40	10600	50
75	63	15.10	5430	22.60	8150	30.20	10860	37.80	13600	45.30	16300	75
100	83	19.90	7160	29.80	10700	39.80	14320	49.80	17900	59.60	21400	100
150	124	29.80	10700	44.70	16100	59.60	21400	74.50	26700	89.40	32200	150
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The cost of electric power at various rates is shown below for one Kilowatt per hour per day and one Kilowatt per hour per year of 365 days.

Cost/KWH	Per Day	Per Year
.75c	$0.18	$ 65.70
1.00c	0.24	87.60
1.25c	0.30	109.50
1.50c	0.36	131.40
1.75c	0.42	153.30
2.00c	0.48	175.20
2.50c	0.60	219.80
3.00c	0.72	262.80
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2	0.34	0.45	0.67	0.89	1.12	1.34	1.78	2.24
3	0.50	0.67	1.01	1.34	1.68	1.96	2.66	3.36
4	0.67	0.89	1.34	1.78	2.23	2.68	3.56	4.47
5	0.84	1.12	1.68	2.24	2.80	3.36	4.47	5.59
10	1.68	2.24	3.36	4.47	2.24	6.71	8.94	11.18
15	2.52	3.36	5.04	6.71	8.40	10.07	13.42	16.77
25	4.20	6.60	8.40	11.18	15.00	17.78	22.37	27.95
50	8.39	11.18	16.78	22.37	27.95	33.55	44.74	55.92
100	16.78	22.37	33.55	44.74	55.92	67.10	89.47	111.84
200	33.55	44.74	67.10	89.47	111.84	134.21	178.94	223.68
500	83.88	111.84	167.76	223.68	279.60	335.62	447.36	559.20

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TYPE OF COAL	Per Cent. Fixed Carbon	Per Cent. Volatile Matter	Per Cent. Moisture	B. T. U. Per Pound
Anthracite	92 to 96	1 to 5	3.2	14440
Semi-Anthracite	83.8	10.2	6.0	14880
High-rank Semi-Bitum	83.4	11.6	5.0	15360
Low-rank Semi-Bitum	75.0	22.0	3.0	15480
High-rank Bituminous	64.6	32.2	3.2	15160
Medium-rank Bitum	54.2	40.8	5.0	13880
Low-rank Bituminous	47.0	41.4	11.6	12880
Sub-Bituminous	42.4	34.2	23.4	9720
Lignite	37.8	18.8	43.4	7400

TANK, DENVER BOLTED STEEL

Water Solution Ore Storage, Agitator and Conditioner Tanks

*Thickener Tanks, so marked.

Dia.	Height	Rings	Bot.	Gauge of Steel 1	2	3	Rim Angle In Inches	Capacity Cu. Ft.	Gals.	Net Wt.	List Price	Export Crated Wt.	Displacement	Export Crated Price
7'-8"	8'-0½"	1	14	14	--	--	2x2x¼"	370	2765	1050	254.00	1300	50	294.00
*7'-8"	6'-0"	1	12	12	--	--	2x2x¼"	4x6	launder	1380	353.00	1655	50	407.00
7'-8"	10'-0"	1	14	14	--	--	2x2x¼"	462	3456	1220	303.00	1525	60	350.00
*9'-2⅝"	6'-0"	1	12	12	--	--	2x2x¼"	4x6	launder	1675	436.00	2060	60	502.00
9'-2⅝"	8'-0½"	1	14	14	--	--	2x2x¼"	538	4025	1315	315.00	1645	60	364.00
9'-2⅝"	10'-0"	1	14	14	--	--	2x2x¼"	672	5030	1500	366.00	1875	75	422.00
9'-2⅝"	12'-0"	2	12	12	14	--	2x2x¼"	806	6036	2250	483.00	2800	90	558.00
*12'-3"	8'-0"	1	12	12	--	--	2¼"x2¼"x3/16"	6x6	launder	2820	728.99	3400	80	837.00
12'-3"	10'-0"	1	12	12	--	--	2¼"x2¼"x3/16"	1179	8820	2875	621.00	3500	95	718.00
12'-3"	12'-0"	2	12	12	12	--	3x3x¼"	1414	10584	3260	710.00	4000	110	820.00
12'-3"	16'-1"	2	12	12	12	--	3x3x¼"	1886	14112	3770	828.00	4600	140	958.00
*15'-4¾"	8'-0"	1	10	10	--	--	3x3x¼"	6x9	launder	4600	1045.00	5660	130	1201.00
15'-4½"	12'-0"	2	12	12	14	--	2x2x3/16"	2218	16584	4300	881.00	5400	160	1017.00
15'-4¾"	12'-0"	2	10	10	12	--	3x3x¼"	2218	16584	5500	1063.00	6800	165	1230.00
15'-4¾"	16'-1"	2	12	21	14	--	2x2x3/16"	2957	22112	5050	1031.00	6300	175	1190.00
15'-4¾"	16'-1"	2	7	7	7	--	2x2x3/16"	2957	22112	9080	1891.00	10900	185	2185.00
15'-4¾"	20'-0"	3	12	12	12	14	2x2x3/16"	3696	27640	6270	1330.00	7800	205	1538.00
15'-4¾"	20'-0"	3	7	7	7	7	3x3x¼"	3696	27640	10630	2194.00	12740	215	2535.00
*21'-6¾"	8'-0"	1	10	10	--	--	3x3x¼"	8x9	launder	7050	1590.00	8760	190	1828.00
*21'-6¾"	8'-0"	1	7	7	--	--	3x5x5/16"	8-10	launder	9350	2015.00	11160	190	2318.00
21'-6"	16'-1"	2	12	12	14	--	2x2x3/16"	5808	43456	7400	1596.00	8250	210	1845.00
21'-6"	16'-1"	2	7	7	7	--	3x5x5/16"	5808	43456	13600	3811.00	16320	220	3248.00
21'-6"	20'-0"	3	12	12	12	14	2x2x3/16"	7260	54320	9400	1992.00	11750	265	2301.00
21'-6"	20'-0"	3	7	7	7	7	3x5x5/16"	7260	54320	16100	3227.00	19320	280	3729.00
21'-6"	24'-1½"	3	10	10	12	12	2x2x3/16"	8770	65618	12250	2466.00	15300	310	2850.00
21'-6"	24'-1½"	3	7	7	7	10	3x3x¼"	8770	65618	16900	3288.00	20280	330	3801.00
21'-6"	24'-1½"	3	3	3	7	7	3x5x5/16"	8770	65618	22000	4287.00	26380	340	4942.00
*26'-1¾"	10'-0"	1	10	10	--	--	3x5x¼"	8x10	launder	11200	2229.00	13980	265	2564.00
*26'-1¾"	10'-0"	1	7	7	--	--	3x5x5/16"	8x10	launder	14050	2723.00	17080	275	3132.00
26'-1"	16'-1"	2	10	10	10	--	3x3x¼"	8592	64272	13500	2523.00	16500	335	2915.00
26'-1"	16'-1"	2	7	7	7	--	3x5x5/16"	8592	64272	17830	3196.00	21400	345	3693.00
26'-1"	20'-0"	3	10	10	12	12	2½x2½x3/16"	10740	80340	14550	2636.00	18000	380	3046.00
26'-1"	24'-1½"	3	10	10	12	12	3x3x¼"	12973	97051	16300	3057.00	20400	425	3533.00
26'-1"	24'-1½"	3	7	7	7	10	3x3x¼"	12973	97051	22300	4012.00	26760	440	4636.00
26'-1"	24'-1½"	3	3	3	7	7	3x5x5/16"	12973	97051	28800	5308.00	34600	450	6117.00
*29'-8½"	10'-0"	1	10	10	--	--	3x3x¼"	10x12	launder	13250	2702.00	16400	290	3107.00
*29'-8½"	10'-0"	1	7	7	--	--	3x5x5/16"	10x12	launder	17050	3309.00	20700	300	3805.00
*29'-8½"	10'-0"	1	3	3	--	--	3x5x5/16"	10x12	launder	23450	5076.00	28530	320	5838.00
29'-8½"	16'-1"	2	10	10	10	--	3x3x¼"	11120	83200	16700	3133.00	20300	415	3620.00
29'-8½"	16'-1"	2	7	7	7	--	3x5x5/16"	11120	83200	21850	3931.00	26300	430	4541.00
29'-8½"	20'-0"	3	7	7	7	7	3x3x¼"	13900	104000	25300	4451.00	30300	490	5144.00
29'-8½"	20'-0"	3	3	3	7	7	3x5x5/16"	13900	104000	31200	5754.00	38000	500	6631.00
29'-8½"	24'-1½"	3	7	7	7	10	3x3x¼"	16791	125632	27100	4888.00	32600	530	5647.00
29'-8½"	24'-1½"	3	3	3	7	7	3x5x5/16"	16791	125632	35000	6463.00	42700	550	7448.00
*38'-7½"	10'-0"	1	7	7	--	--	3x5x5/16"	10x12	launder	24600	4897.00	30000	450	5633.00
*38'-7½"	10'-0"	1	3	3	--	--	3½x6x⅜"	10x12	launder	35020	8065.00	42660	470	9257.00
*38'-7½"	16'-1"	2	10	10	12	--	3x5x5/16"	18784	140512	22600	4067.00	27600	800	4699.00
38'-7½"	16'-1"	2	7	7	7	--	3½x6x⅜"	18784	140512	31200	5635.00	37440	840	6512.00
38'-7½"	24'-1½"	3	3	3	7	7	3½"x6x⅜"	28363	212173	49200	9108.00	60000	1000	10496.00
*54'-11½"	12'-0"	2	7	7	10	--	3½x6x⅜"	10x12	launder	39200	8922.00	47000	850	10260.00
54'-11½"	12'-0"	2	3	3	3	--	3½x6x⅜"	10x12	launder	62700	14277.00	75260	860	16586.00
54'-11½"	16'-1"	2	3	3	7	--	3½x6x⅜"	38000	284240	64500	11958.00	77000	1300	13779.00
54'-11½"	24'-1½"	3	7	7	7	10	3½x6x⅜"	57380	429202	63100	11457.00	75700	1600	13238.00
54'-11½"	24'-1½"	3	3	3	7	7	3½x6x⅜"	57380	429202	81600	15144.00	97900	1700	17451.00

Single and double tray thickener tanks are available, write for prices. Additional sizes and gauges of Denver Bolted steel tanks are available on special quotation. Above list prices are F.O.B. Denver and the export prices are F.O.B. Denver and the export prices are F.O.B. New Orleans on 45000 lbs., otherwise F.O.B. Factory.

COMPARISON OF SINGLE AND TWO STAGE GRINDING CIRCUIT

Single Stage Crushing, Single Stage Grinding: HP Installed	HP Actual	Weight	Approx. Cost	Item	Single Stage Crushing, Two Stage Grinding: HP Installed	HP Actual	Weight	Approx. Cost
50 Tons 24 Hours—Medium Ore—65 Mesh Grind								
1½	1	1650	$ 1110	A Denver Ore Feeder	1½	1	1650	$ 1110
10	9	3156	1741	B 8"x10" Denver Jaw Crusher	10	9	3156	1741
2	1½	1525	1332	C 14" Denver Conveyor	2	1½	1525	1332
1	⅝	1470	799	F—16"x6' Denver Belt Feeder	1	⅝	1470	799
30	28	18620	6426	G1—4'x5' Denver Ball Mill				
				G2—3'x4' Denver Ball Mill	15	12	8082	2967
2	1	4248	2562	H—24"x16' Denver Classifier	2	1	4248	2562
				J 3'x5' Denver Rod Mill	15	14	8782	3623
46½	41⅛	30669#	$13970	TOTALS	46½	39⅛	28913#	$14164
100 Tons 24 Hours—Medium Ore—65 Mesh Grind								
Closed Circuit Crushing (1½" Product)					Open Circuit Crushing (¾" Product)			
2	1	8858	3299	A—24"x10' Apron Ore Feeder	2	1	8858	3299
20	15	6390	2846	B—10"x16" Denver Jaw Crusher	20	15	6390	2846
3	2½	4076	2966	C—(two)—16" Conveyors	3	2	4076	2778
¾	½	711	712	D—2'x4' Denver-Dillon Screen	¾	½	711	712
25	20	10051	7690	E1—24" Secondary Cone Crusher				
				E2—18" Secondary Cone Crusher	20	16	4142	4439
1	¾	1603	861	F—16"x10" Adj. Stroke Feeder	1	¾	1603	861
60	57	32451	10668	G1—5'x6' Denver Ball Mill				
				G2—4'x4½' Denver Ball Mill	25	20	16702	5808
3	2	6483	3375	H—30"x18' Denver Spiral Classifier	3	2	6483	3375
				J—4'x6' Denver Rod Mill	40	34	21485	7237
114¾	98½	70623#	$32417	TOTALS	114¾	91¼	70450#	$31355
200 Tons/24 Hours—Medium Ore—65 Mesh Grind								
Closed Circuit Crushing					Open Circuit Crushing			
3	1	10208	$ 3776	A—30"x10' Denver Apron Ore Feeder	3	1	10208	$ 3776
25	20	7987	4100	B—10"x20" Denver Jaw Crusher	25	20	7987	4100
6	4	4166	3574	C—18" Denver Conveyors (two)	6	4	4166	3383
2	1½	1408	1304	D—3'x6' Denver-Dillon Vib. Screen	2	1½	1408	1304
50	40	16714	11236	E1—28" Secondary Cone Crusher				
				E2—24" Secondary Cone Crusher	25	20	10051	7690
1½	1	1800	1143	F—24"x10' Denver Belt Feeder	1½	1	1800	1143
150	125	55902	24729	G1—6'x8' Denver Ball Mill				
				G2—5'x4' Denver Ball Mill	50	42	23033	7953
5	3	12668	5752	H—42"x21'8" Denver Classifier	5	3	12668	5752
				J—5'x8' Denver Rod Mill	75	67	36651	12922
242½	195½	110853#	$55614	TOTALS	192½	159½	107972#	$48023
350 Tons 24 Hours—Medium Ore—65 Mesh Grind								
3	2	11608	$ 4705	A—36"x10' Apron Ore Feeder	3	2	11608	$ 4705
40	35	12535	7597	B—11"x30" Denver Jaw Crusher	40	35	12535	7597
6	5	4666	3800	C—(two) 20" Conveyors	6	5	4666	3576
3	2½	2533	1966	D—4'x8' Denver-Dillon Screen	3	2½	2533	1966
75	60	23530	15997	E1—3' Secondary Cone Crusher				
				E2—28" Secondary Cone Crusher	50	40	16714	11236
2	1½	2118	1554	F—30"x10' Adj. Stroke Feeder	2	1½	2118	1554
200	170	79976	30359	G1—7'x6' Ball Mill				
				G2—5'x5' Denver Ball Mill	50	48	26935	9195
10	7	24620	10555	H—60"x30' Denver Classifier	10	7	24620	10555
				J—5'x10' Denver Rod Mill	100	94	42434	15848
339	283	161586#	$76533	TOTALS	264	235	144163#	$66232

Continued on page 824

COMPARISON OF SINGLE AND TWO STAGE GRINDING CIRCUIT

Closed Circuit Crushing (1½" Product) Single Stage Grinding HP Installed	HP Actual	Weight	Approx. Cost	Item	Open Circuit Crushing (¾" Product) Two Stage Grinding HP Installed	HP Actual	Weight	Approx. Cost
550 Tons/24 Hours—Medium Ore—65 Mesh Grind								
7.5	5	28368	$11244	A—48"x20' Apron Ore Feeder	7.5	5	28368	$11244
60	48	21189	10241	B—15"x36" Denver Jaw Crusher	60	48	21189	10241
10	7	7486	5992	C—(two) 24" Conveyors	10	7	7486	4728
5	3½	3800	2858	D—5'x10' Denver-Dillon Screen	5	3½	3800	2858
150	120	47008	26848	E1—4' Secondary Cone Crusher				
				E2—3' Secondary Cone Crusher	75	60	23530	15997
3	2½	2448	1856	F—36"x12' Adj. Stroke Feeder	3	2¼	2448	1836
300	250	134200	45373	G1—8'x7' Ball Mill				
				G2—6'x6' Denver Ball Mill	125	105	47707	21317
10	7½	39500	13662	H—72"x38' Simplex Classifier	10	7½	39500	13662
				J—6'x8' Denver Rod Mill	150	130	55532	24573
545½	443½	283999#	$118054	TOTALS	445½	368¼	229580#	$106636

ALL WEIGHTS AND PRICES ARE FOR MOTOR V-BELT DRIVEN TYPE AND ARE ALL FOB DENVER DOMESTIC PRICES

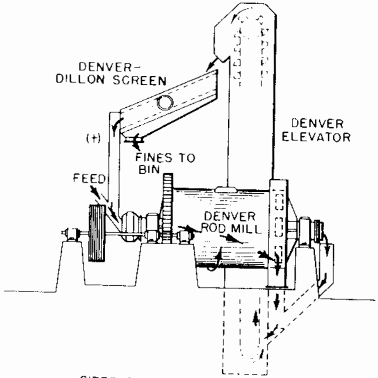
SWITCHES (Manual Type)

(Motor starting—Single phase, general purpose enclosure 60 cycle, 115V)

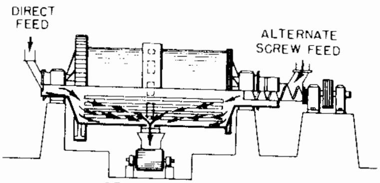
Horsepower	Approximate Shipping Weight—Lbs.	Approx. Price F.O.B. Factory
1/20-1	2	$ 6
Three Phase 60 220/440V		
½-2	5	16
3 -5	6	20
(Magnetic motor starting switches with separate push button stop-start stations 220V)		
½-2	8	32
3 -5	8	37
7½-15	20	65
20 -30	50	105
40 -50	100	230
60 -100	100	465
125 -200	650	1,345
(for 440V)		
½-2	8	32
3 -7½	8	37
10 -25	20	65
30 -50	50	105
60 -100	100	228
125 -200	100	463
Switches, general purpose enclosure (drum control type)		
30	275	340
40	305	370
50	315	375
60	320	385
75	330	390
100	395	425
125	465	630
150	475	640
200	560	685

Bulletins or other descriptive material giving details and specifications as well as up-to-date prices will be sent on request.

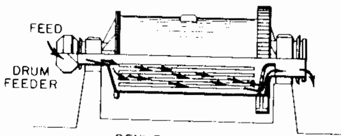
DRY GRINDING FLOWSHEETS



SIZED GRINDING BY DENVER
ROD-MILL WITH DENVER
VIBRATING SCREEN
PERIPHERAL DISCHARGE

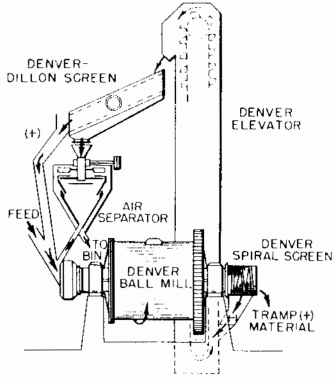


DENVER ROD-MILL
DOUBLE FEED-PERIPHERAL DISCHARGE
ALL RUGGED STEEL CONSTRUCTION

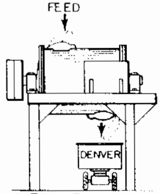


DENVER ROD-MILL
GRATE DISCHARGE TYPE

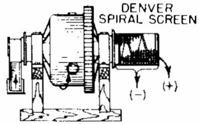
DRY GRINDING FLOWSHEETS



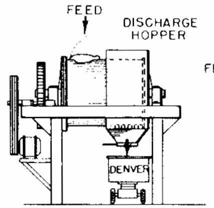
FINE GRINDING WITH DENVER
BALL MILL & AIR SEPARATOR
AND DENVER VIBRATING SCREEN



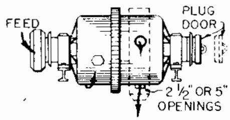
BATCH DENVER MILL
TIGHT & LOOSE DIRECT
PULLEY DRIVE



DENVER 30"x18" MILL
REVERSIBLE SCOOP FEEDER
SCREEN DISCHARGE
GEAR DRIVE
3 ONLY 2 1/2" OR 5" OPENINGS
IN CAST DRUM



BATCH DENVER MILL
GEAR DRIVE-CONTINUOUS
OR INTERMITTENT DISCHARGE
DRY OR WET GRINDING



DENVER 30"x36" MILL
DRUM FEEDER-PERIPHERAL
OR TRUNNION DISCHARGE
DRY OR WET GRINDING
WITH OR WITHOUT LINERS

1954 4-DOOR SEDANS – What You Get For Your Money

MAKE	SPECIFICATIONS							COST OF ACCESSORIES†					
	Price*	Wheel-base	Length	Weight	Max. hp at rpm	Compr. Ratio	Engine Type	Over-drive	Auto. Trans.	Power Steer.	Power Brakes	Radio	Heater
CHEVROLET													
150 series	$1680	115	196.4	3210	125/4000‡	7.5-1	OHV-S6	...	$178.00	$134.50	$37.70	$61.25	$40.50
210 series	1771	115	196.4	3230	125/4000‡	7.5-1	OHV-S6	...	178.00	134.50	37.70	61.25	40.50
Bel Air	1884	115	196.4	3255	125/4000‡	7.5-1	OHV-S6	...	178.00	134.50	37.70	61.25	40.50
PONTIAC													
Chieftain 6 Special	2026	122	202.6	3391	118/3800‡	7.7-1‡	L-S6	...	178.35	134.40	35.50	79.91	80.82
Chieftain 6 Deluxe	2130	122	202.6	3406	118/3800‡	7.7-1‡	L-S6	...	178.35	134.40	35.50	79.91	80.82
Chieftain 8 Special	2101	122	202.6	3451	127/3800‡	7.7-1‡	L-S8	...	178.35	134.40	35.50	79.91	80.82
Chieftain 8 Deluxe	2205	122	202.6	3466	127/3800‡	7.7-1‡	L-S8	...	178.35	134.40	35.50	79.91	80.82
Star Chief Deluxe	2301	124	213.6	3536	127/3800‡	7.7-1‡	L-S8	...	178.35	134.40	35.50	79.91	80.82
Star Chief Custom	2394	124	213.6	3536	127/3800‡	7.7-1‡	L-S8	...	178.35	134.40	35.50	79.91	80.82
OLDSMOBILE													
88 series	2337	122	205.2	3692	170/4000	8.2-1	OHV-V8	...	178.35	134.40	39.80	100.82	79.58
Super 88 series	2476	122	205.2	3734	185/4000	8.2-1	OHV-V8	...	178.35	134.40	39.80	100.82	79.58
98 series	2805	126	214.2	3846	185/4000	8.2-1	OHV-V8	...	178.35	134.40	39.80	100.82	79.58
BUICK													
Special	2265	122	206.3	3714	143/4200	7.2-1	OHV-V8	...	192.50	134.40	49.50	92.50	81.70
Century	2520	122	206.3	3786	195/4100	8.0-1	OHV-V8	...	192.50	134.40	49.50	92.50	81.70
Super	2711	127	216.8	4105	177/4100	8.0-1	OHV-V8	...	192.50	134.40	49.50	92.50	81.70
Roadmaster	3269	127	216.8	4250	200/4100	8.5-1	OHV-V8	...	standard	standard	49.50	92.50	81.70
CADILLAC													
Series 62	3932	129	216.4	NA	230/4400	8.2-1	OHV-V8	...	standard	standard	47.70	131.95	128.85
Fleetwood 60	4683	133	227.4	NA	230/4400	8.2-1	OHV-V8	...	standard	standard	47.70	131.95	128.85
PLYMOUTH													
Plaza series	1765	114	193.5	3004	100/3600	7.1-1	L-S6	97.55	145.80	134.40	...	82.50	56.25
Savoy series	1872	114	193.5	3036	100/3600	7.1-1	L-S6	97.55	145.80	134.40	...	82.50	56.25
Belvedere series	1953	114	193.5	3050	100/3600	7.1-1	L-S6	97.55	145.80	134.40	...	82.50	56.25
DODGE													
Meadowbrook 6	1999	119	205.5	3195	110/3600	7.2-1	L-S6	97.55	130.10	...	...	82.50	78.25
Meadowbrook V-8	2150	119	205.5	3390	140/4400	7.1-1	OHV-V8	97.55	130.10	...	...	82.50	78.25
Coronet 6	2111	119	205.5	3235	110/3600	7.2-1	L-S6	97.55	189.00	134.40	...	82.50	78.25
Coronet V-8	2219	119	205.5	3405	150/4400	7.5-1	OHV-V8	97.55	189.00	134.40	...	82.50	78.25
Royal V-8	2347	119	205.5	3425	150/4400	7.5-1	OHV-V8	97.55	189.00	134.40	...	82.50	78.25
DESOTO													
Powermaster 6	2385	125.5	214.5	3590	116/3600	7.0-1	L-S6	97.75	189.00	139.75	36.55	101.00	78.25
Fire Dome 8	2673	125.5	214.5	3750	170/4400	7.5-1	OHV-V8	97.75	189.00	139.75	36.55	101.00	78.25
CHRYSLER													
Windsor Deluxe	2532	125.5	215.6	3655	119/3600	7.0-1	L-S6	...	184.00	139.75	36.55	101.00	78.25
New Yorker	3193	125.5	215.6	3970	195/4400	7.5-1	OHV-V8	...	standard	139.75	standard	101.00	78.25
New Yorker Deluxe	3398	125.5	215.6	4065	235/4400	7.5-1	OHV-V8	...	standard	139.75	standard	101.00	78.25
Custom Imperial	4224	133.3	223.7	4355	235/4400	7.5-1	OHV-V8	...	standard	139.75	standard	101.00	78.25
FORD													
Mainline 6	1700	115.5	198	3155	115/3900	7.2-1	OHV-S6	102.00	184.00	134.40	40.00	81.30	71.44
Mainline V-8	1776	115.5	198	3250	130/4200	7.2-1	OHV-V8	102.00	184.00	134.40	40.00	81.30	71.44
Customline 6	1793	115.5	198	3175	115/3900	7.2-1	OHV-S6	102.00	184.00	134.40	40.00	81.30	71.44
Customline V-8	1869	115.5	198	3270	130/4200	7.2-1	OHV-V8	102.00	184.00	134.40	40.00	81.30	71.44
Crestline 6	1898	115.5	198	3185	115/3900	7.2-1	OHV-S6	102.00	184.00	134.40	40.00	81.30	71.44
Crestline V-8	1974	115.5	198	3280	130/4200	7.2-1	OHV-V8	102.00	184.00	134.40	40.00	81.30	71.44
MERCURY													
Custom	2295	118	206.2	3480	161/4400	7.5-1	OHV-V8	102.00	189.77	130.00	37.47	98.57	67.20
Monterey	2350	118	206.2	3515	161/4400	7.5-1	OHV-V8	102.00	189.77	130.00	37.47	98.57	67.20
LINCOLN													
Lincoln	3522	123	214.8	4190	205/4200	8-1	OHV-V8	...	standard	145.00	40.00	121.60	112.53
Capri	3711	123	214.8	4245	205/4200	8-1	OHV-V8	...	standard	145.00	40.00	121.60	112.53

HUDSON													
Jet	1858	105	180.6	2675	104/4000§	7.5-1**	L-S6	102.46	178.03			81.81	72.72
Super Jet	1954	105	180.6	2725	104/4000§	7.5-1**	L-S6	102.46	178.03			81.81	72.72
Jet Liner	2056	105	180.6	2760	104/4000§	7.5-1**	L-S6	102.46	178.03			81.81	72.72
Wasp	2256	119.8	201.5	3440	126/4400§	7.0-1	L-S6	110.77	178.03	177.38	42.80	99.82	74.39
Super Wasp	2465	119.8	202.9	3525	140/4000§	7.0-1	L-S6	110.77	178.03	177.38	42.80	99.82	74.39
Hornet	2768	123.8	208.8	3620	160/3800§	7.5-1	L-S6	110.77	178.03	177.38	42.80	99.82	74.39
KAISER													
Kaiser Special	NA	118.5	213.8	3210	118/3650	7.3-1	L-S6	98.79	165.00	NA		83.50	51.50
Manhattan	NA	118.5	215.6	3275	140/3900	7.3-1	L-S6††	98.79	165.00	NA		33.50	51.50
NASH													
Rambler Super	1795	108	193.3	2605	90/3800	7.3-1	L-S5	103.50	178.85		39.25	NA	NA
Ramblem Custom	1965	108	193.3	2665	90/3800	7.3-1	L-S6	103.50	178.85		39.25	NA	NA
Statesman Super	2158	114.2	202.2	3045	110/4000	8.5-1	L-S6	103.50	178.85	139.50	39.25	89.60	77.45
Statesman Custom	2332	114.2	202.2	3070	110/4000	8.5-1	L-S6	103.50	178.85	139.50	39.25	89.60	77.45
Ambassador Super	2412	121.2	209.2	3430	130/3700	7.6-1	OVH-S6	112.25	178.85	149.50	32.25	89.60	77.45
Ambassador Custom	2595	121.2	209.2	3480	130/3700	7.6-1	OVH-S6	112.25	178.85	149.50	32.25	89.60	77.45
PACKARD													
Clipper Deluxe	2695	122	215.7	3795	165/3600	8.0-1	L-58	110.00	199.00	177.50	43.00	102.00	79.50
Clipper Super	2815	122	215.7	3830	165/3600	8.0-1	L-58	110.00	199.00	177.50	43.00	102.00	79.50
Cavalier	3344	127	216.7	4090	185/4000	8.0-1	L-58	110.00	199.00	177.50	43.00	102.00	79.50
Patrician	3890	127	216.7	4190	212/4000	8.7-1	L-58		standard	177.50	43.00	102.00	79.50
STUDEBAKER													
Champion Custom	1801	116.5	198.6	2770	85/4000	7.5-1	L-S6	105.35	216.11	177.38		63.84	65.92
Champion Deluxe	1918	116.5	198.6	2770	85/4000	7.5-1	L-S6	105.35	216.11	177.38		63.84	65.92
Champion Regal	2026	116.5	198.6	2770	85/4000	7.5-1	L-S6	105.35	216.11	177.38		63.84	65.92
Commander Deluxe	2179	116.5	198.6	3120	120/4000	7.5-1	OHV-V8	118.25	226.50	177.38		63.84	65.92
Commander Regal	2287	116.5	198.6	3120	120/4000	7.5-1	OHV-V8	118.25	226.50	177.38		63.84	65.92
Land Cruiser	2438	120.5	202.6	3230	120/4000	7.5-1	OHV-V8	118.25	226.50	177.38		63.84	65.92
WILLYS													
Lark	NA	108	180.8	2661	90/4200	7.6-1	F-S6	80.00	NA	NA		74.25	62.81
Ace	NA	108	180.8	2778	115/3650	7.3-1	F-S6	80.00	NA	NA		74.25	62.81

* Factory delivered price including federal excise tax, delivery and handling charges exclusive of state and local taxes and all optional equipment. † Suggested delivered price. ‡ Lower with standard transmission. § Higher with optional twin carburetors. ** Higher with optional aluminum head. †† Supercharger standard.

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