Excalibur
PAINT & COATINGS, LTD.

CALCULATIONS and FORMULAS GUIDE for PAINTS and COATINGS

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HOW TO SPECIFY BLASTING

Your coating supplier will always designate the degree of surface preparation required for his materials. The three basic standards used to describe surface preparation are: Steel Structure Painting Council (SSPC) "Surface Preparation Specifications", the National Association of Corrosion Engineers Standards (N.A.C.E.) and the Swedish Pictoral Standards. Their basic definitions are:

SSPC	NACE	SWEDISH*	DESCRIPTION
SP 1, Solvent Cleaning	N/A	N/A	Removal of oil, grease, dirt, soil and contaminants by cleaning with solvent, vapor, alkali, emulsion or steam.
SP 2, hand Tool Cleaning	N/A	St 2	Removal of loose rust, loose mill scale and loose paint by hand chipping, scraping, sanding and wire brushing.
SP 3, Power Tool Cleaning	N/A	St 3	Removal of loose rust, loose mill scale and loose paint by power tool chipping, descaling, sanding, wire brushing and grinding.
SP 5, White Metal Blast Cleaning	1	Sa 3	Removal of all visible rust, mill scale, paint and foreign matter by blast cleaning.
SP 6, Commercial Blast Cleaning	3	Sa 2	Blast cleaning until at least two thirds of each square inch is free of all visible residues.
SP 7, Brush-Off Blast Cleaning	4	Sa 1	Blast cleaning of all except tightly adhered residues of mill scale, rust and coatings.
SP 8, Pickling			Complete removal of rust and mill scale by acid pickling, duplex pickling or electrolytic pickling.
SP 10, Near White Blast Cleaning	2	Sa 2½	Blast cleaning until at least 95% of each square inch is free of all visible rust, mill scale, paint and foreign matter.
SP 11-87T, Power Tool Cleaning to Bare Metal	N/A	N/A	Removal of all visible rust, mill scale, paint and foreign matter using power tools and producing a minimum profile of 1 mil.

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ABRASIVE / PROFILE COMPARATIVE CHART

The following chart should be used only for approximating the abrasive size required to obtain a specified anchor pattern. The standard metal used to obtain these results was hot rolled steel with tightly adhering mill scale. The resulting depth of anchor pattern will vary with the method used for measuring depths as well as any one of numerous other variables (type and hardness of steel, thickness of mill scale, degree of cleaning specified, etc.) This information can be used for centrifugal wheel as well as pressure blasting. Pressure blasting should be done using 90-100 psi nozzle pressure. The depth of anchor pattern used in this chart is an average and not a minumum of maximum depth obtainable. Consult local abrasive suppliers for specific technical data.

1 Mil Profile
30/60 Mesh Silica Sand
G-80 Steel Grit
S-110 Steel Shot*
80 Mesh Garnet
100 Aluminum Oxide
Clemtex #4
Black Beauty 3060

1.5 Mil Profile
16/35 Mesh Silica Sand
G-50 Steel Grit
S-170 Steel Shot*
36 Mesh Garnet
50 Grit Aluminum Oxide
Clemtex #3
Black Beauty 3060

2 Mil Profile
16/35 Mesh Silica Sand
G-40 Steel Grit
S-230 Steel Shot*
36 Mesh Garnet
36 Grit Aluminum Oxide
Clemtex #3
Black Beauty 2040

2.5 Mil Profile
8/35 Mesh Silica Sand
G-40 Steel Grit
S-280 Steel Shot*
16 Mesh Garnet
24 Grit Aluminum Oxide
Clemtex #2
Black Beauty 2040

3 Mil Profile
8/20 Mesh Silica Sand
G-25 Steel Grit
S-330 or 390 Steel Shot*
16 Mesh Garnet
16 Grit Aluminum Oxide
Clemtex #2
Black Beauty 1240

*Steel shot alone will not give a good angular pattern and should be used in combination with steel grit for best results.

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REDUCTION IN SOLIDS CONTENT BY ADDING THINNER

(THINNER ADDED)

Original Solids Content of Material Before Adding Thinner	%	2%	5%	7%	10%	12%	15%	17%	20%	25%	30%	35%	Solids Content After Thinner
	100	98	95	93	91	89	87	85	83	80	77	74	
	95	93	90	89	86	85	83	81	79	76	73	70	
	90	88	86	84	82	80	78	77	75	72	69	67	
	85	83	81	79	77	76	74	73	71	68	65	63	
	80	78	76	75	73	71	70	68	67	64	62	59	
	75	74	71	70	68	67	65	64	63	60	58	56	
	70	69	67	65	64	63	61	60	59	56	54	52	
	65	64	62	61	59	58	57	56	54	52	50	48	
	60	59	57	56	55	54	52	51	50	48	46	44	
	55	54	52	51	50	49	48	47	46	44	42	41	
	50	49	48	47	46	45	44	43	42	40	39	37	
	45	44	43	42	41	40	39	38	37	36	35	33	
	40	39	38	37	36	36	35	34	33	32	31	30	
	35	34	33	32	31	31	30	30	29	28	27	26	
	30	29	29	28	27	27	26	26	25	24	23	22	
	25	24	24	23	23	22	22	21	21	20	19	19	

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VOLUME OF THINNER REQUIRED

TO THIN PERCENTAGE SHOWN

1 Gallon Kit

%	Oz.	Liter
2	2.6	0.08
5	6.5	0.19
7	9.0	0.27
10	12.8	0.38
12	15.4	0.46
15	19.2	0.57
17	21.8	0.64
20	25.6	0.76
25	32.0	0.95
30	38.4	1.14
35	44.8	1.32

5 Gallon Kit

%	Oz.	Liter
2	13.0	0.40
5	32.5	0.95
7	45.0	1.35
10	64.0	1.90
12	77.0	2.30
15	96.0	2.85
17	109.0	3.20
20	128.0	3.80
25	160.0	4.75
30	192.0	5.70
35	224.0	6.60

5 Liter Kit

%	Liter	Oz.
2	0.10	3.5
5	0.25	8.5
7	0.35	12.0
10	0.50	17.0
12	0.60	20.5
15	0.75	25.5
17	0.85	29.0
20	1.00	34.0
25	1.25	42.5
30	1.50	50.5
35	1.75	59.0

20 Liter Kit

%	Liter	Oz.
2	0.4	14.0
5	1.0	34.0
7	1.4	48.0
10	2.0	68.0
12	2.4	82.0
15	3.0	102.0
17	3.4	116.0
20	4.0	136.0
25	5.0	170.0
30	6.0	202.0
35	7.0	236.0

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WET FILM THICKNESS REQUIREMENTS

Required Dry Film Thickness (Mils)

Solids Content of Material After Thinning	%	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	100	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
	95	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5	11.6	12.6	13.7	14.7	15.8	16.8	17.9
	90	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10.0	11.1	12.2	13.3	14.4	15.6	16.7	17.8	18.9
	85	2.4	3.5	4.7	5.9	7.1	8.2	9.4	10.6	11.8	12.9	14.1	15.3	16.5	17.7	18.8	20.9
	80	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.7	15.0	16.3	17.5	18.8	20.0	21.3
	75	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.6	16.0	17.3	18.7	20.0	21.3	22.7
	70	2.9	4.3	5.7	7.1	8.6	10.0	11.4	12.9	14.3	15.7	17.1	18.6	20.0	21.4	22.9	24.3
	65	3.1	4.6	6.2	7.7	9.2	10.8	12.3	13.9	15.4	16.9	18.5					
	60	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3						
	55	3.6	5.5	7.3	9.1	10.9	12.7	14.6	16.4	18.2							
	50	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0								
	45	4.4	6.7	8.9	11.1	13.3	15.6	17.8									
	40	5.0	7.5	10.0	12.5	15.0	17.5										
	35	5.7	8.6	11.4	14.3	17.1											
	30	6.7	10.0	13.3	16.7												
	25	8.0	12.0	16.0													

Wet Film Thickenss Required

Example:

Matl. = 70% Solids

DFT = 6 mils
Wet Film = 8.6 mils

Note: Dry film thicknesses are minimum. No allowance is made for evaporation of solvents during application.

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THEORETICAL COVERAGE IN SQUARE FEET PER U.S. GALLON

Required Dry Film Thickness Per Coat (Mils)

Solids Content by Volume	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Theoretical Coverage Per Gallon
	100	1604	802	535	401	321	267	229	201	178	160	146	135	123	115	107	100	
	95	1524	762	511	381	305	254	218	191	169	152	139	127	117	109	102	95	
	90	1444	722	481	361	289	241	206	181	160	144	131	120	111	104	96	90	
	85	1363	682	455	341	273	227	195	170	152	136	124	114	105	98	91	85	
	80	1283	642	428	321	257	214	183	160	143	128	117	107	98	92	86	80	
	75	1203	602	401	301	241	201	172	150	134	120	109	100	92	86	80	75	
	70	1123	561	374	281	225	187	160	140	125	112	102	94	86	80	75	70	
	65	1043	521	348	261	209	174	149	130	116	104	95	87	80	75	70	65	
	60	962	481	321	241	193	160	138	120	107	96	88	80	74	69	64	60	
	55	882	441	294	221	176	147	126	110	98	88	80	74	68	63	59	55	
	50	802	401	267	201	160	134	115	100	89	80	73	67	62	58	54	50	
	45	772	361	241	181	144	120	103	90	80	72	66	60	55	52	48	45	
	40	642	321	214	160	128	107	92	80	71	64	58	54	49	46	43	40	
	35	561	281	187	140	112	94	80	70	62	56	51	47	43	40	37	35	
	30	481	241	160	120	96	80	69	60	54	48	44	40	37	35	32	30	
	25	401	201	134	100	80	67	57	50	45	40	37	33	31	29	27	25	

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COATING COVERAGE CALCULATIONS

Theoretical Coverage
(on smooth surface)

$$ft^2 / U.S.\ gal = \frac{\%\ SBV/100 \times 1604}{dft\ (mils)}$$

$$m^2 / 1 = \frac{\%\ SBV/100 \times 1000}{dft\ (micronsn)}$$

Practical Coverage = Theoretical Coverage - $\frac{\text{Theoretical Coverage} \times \%\ \text{Loss}}{100}$

Consumption = $\frac{\text{Area } (ft^2 \text{ or } m^2)}{\text{Practical Coverage (gallons or liters)}}$

Film Thickness

Wet to Dry: $\frac{wft \times \%\ SBV}{100}$

Dry to Wet: $\frac{dft \times 100}{\%\ SBV}$

% Solids by Volume and wet film thickness adjustments due to thinning

$$W = \frac{X}{1 + Y}$$

$$A = \frac{Z}{W}$$

A = adjusted WFT required for thinned material
W = adjusted % solids by volume due to thinning
X = original materials % solids by volume
Y = % thinner added
Z = required dry film thickness

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ABRASIVE CONSUMPTION PER HOUR
and
AIR CONSUMPTION IN CUBIC FEET PER MINUTE

Pressure at Nozzle						
Orifice Size	**60 PSI**	**70 PSI**	**80 PSI**	**90 PSI**	**100 PSI**	
3/16"	30	33	38	41	45	Air (CFM)
(5mm)	171	196	216	238	264	Sand (lb/hr)
	7	7.5	8.5	9.5	10	H.P.*
1/4"	54	61	68	74	81	Air
(6mm)	312	354	408	448	494	Sand
	12	13.5	15	16.5	18	H.P.
5/16"	89	101	113	126	137	Air
(8mm)	534	604	672	740	812	Sand
	20	22.5	25.5	28	30.5	H.P.
3/8"	126	143	161	173	196	Air
(10mm)	764	864	960	1052	1152	Sand
	28	32	36	38.5	44	H.P.
7/16"	170	194	217	240	254	Air
(11mm)	1032	1176	1312	1448	1584	Sand
	38	43.5	48.5	53.5	56.5	H.P.
1/2"	224	252	280	309	338	Air
(13mm)	1336	1512	1680	1856	2024	Sand
	50	56	62.5	69	75	H.P.
5/8"	356	404	452	504	548	Air
(16mm)	2140	2422	2690	2973	3250	Sand
	80	90	100	112	122	H.P.
3/4"	504	572	644	692	784	Air
(19mm)	3056	3456	3840	4208	4608	Sand
	112	127	143	154	175	H.P.

*Electric motor horsepower required to product indicated C.F.M.

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EXAMPLES OF ABRASIVE CLEANING RATES[1]

Abrasive	Abrasive Consumption	Production Rate	Comments
Silica Sand 16 / 40 Mesh	2.6 lbs. / sq. ft.	275 ft² / hr.	1½ mil profile dusty
Crushed Flint 12 / 30 Mesh	3.6 lbs. / sq. ft.	161 ft² / hr.	3 mils
Staurolite 50 / 100 Mesh	3.1 lbs. / sq. ft.	291 ft² / hr.	1½ mil profile smooth surface
Coal Slag 16 / 40 Mesh	3.2 lbs. / sq. ft.	230 ft² / hr.	2½ mil profile
Copper Slag 16 / 40 Mesh	3.1 lbs. / sq. ft.	262 ft² / hr.	2 mil profile
*Garnet 36 Grit	*3.6 lbs. / sq. ft.	213 ft² / hr.	1½ mil profile very little dust
*Aluminum Oxide 36 Grit	*3.1 lbs. / sq. ft.	275 ft² / hr.	1½ mil profile very little dust
*G-40 Steel Grit	*5.5 lbs. / sq. ft.	184 ft² / hr.	2½ mil profile no dust

*These abrasives are normally reused

[1]Newly fabricated steel using a 3/8" I.D. orifice nozzle and 100 psi to a SSPC-SP 10 near white condition.

EXAMPLES OF CLEANING PRODUCTION RATES[1]

	Method	Production Rate	Abrasive Used
1.	SSPC-SP 1	500 ft² / hour	1 gal / hour
2.	SSPC-SP 2	250-300 ft² / hour	4 units / day
3.	SSPC-SP 3	100 ft² / hour	2 units / day
4.	SSPC-SP 5	1000 ft² [1]	10,000 lbs.
5.	SSPC-SP 6	2500 ft² [1]	8,000 lbs.
6.	SSPC-SP 7	5200 ft² [1]	7,000 lbs.
7.	SSPC-SP 10	1500 ft² [1]	12,500 lbs.

[1]Per a 3 person crew day on lightly rusted steel, using 30 / 40 mesh medium hardness abrasive, 3/8" orifice nozzle at 80 psi.

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PRESSURE LOSS IN HOSE

Lubrication Only at Tool - No Line Lubricator

Hose Length and Inside Diameter	cfm Free Air	Line Pressure - psig						
		60	80	100	120	150	200	300
50 Feet	60	3.1	2.4	2.0				
	80	5.3	4.2	3.5	2.9	2.4	1.8	1.2
	100	8.1	6.4	5.2	4.5	3.6	2.8	1.9
	120		9.0	7.4	6.3	5.1	3.9	2.7
	140		12.0	9.9	8.4	6.9	5.3	3.6
	160			12.7	10.8	8.9	6.8	4.6
3/4"	180				13.6	11.1	8.5	5.8
	200				16.6	13.5	10.5	7.1
	220					16.2	12.4	8.4
50 Feet	120	2.7	2.1					
	150	4.1	3.2	2.7	2.3			
	180	5.8	4.6	3.8	3.2	2.6	2.0	1.3
	210	7.7	6.1	4.0	4.3	3.5	2.7	1.8
	240		7.9	6.5	5.5	4.5	3.4	2.3
	270		9.8	8.1	6.9	5.6	4.3	2.9
	300		12.0	9.9	8.4	6.9	5.3	3.6
	330			11.8	10.0	8.2	6.3	4.3
1"	360			13.9	11.9	9.7	7.4	5.0
	390				13.8	11.3	8.7	5.9
	420				15.9	13.0	10.0	6.8
	450					14.8	11.4	7.7
50 Feet	200	2.4						
	250	3.7	2.9	2.4	2.0			
	300	5.2	4.1	3.4	2.9	2.3	1.8	1.2
	350	7.0	5.5	4.5	3.8	3.1	2.4	1.6
	400	8.9	7.0	5.8	4.9	4.0	3.1	2.1
	450		8.8	7.3	6.2	5.0	3.9	2.6
	500		10.8	8.9	7.6	6.2	4.7	3.2
	550			10.7	9.1	7.4	5.7	3.9
	600			12.6	10.7	8.7	5.7	4.6
1¼"	650			14.6	12.4	10.2	7.8	5.3
	700				14.3	11.7	9.0	6.1
	750					13.3	10.2	6.9
	800					15.0	11.5	7.8
50 Feet	300	2.1						
	400	3.7	2.9	2.4	2.0			
	500	5.6	4.4	3.7	3.1	2.5	1.9	1.3
	600	8.0	6.3	5.2	4.4	3.6	2.8	1.9
	700		8.5	7.0	5.9	4.9	3.7	2.5
	800		10.9	9.0	7.7	6.3	4.8	3.2
	900			11.2	9.5	7.8	6.0	4.1
	1000			13.6	11.6	9.5	7.3	4.9
1½"	1100				14.0	11.4	8.8	6.0
	1200					13.6	10.4	7.1
	1300					15.8	12.1	8.3

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PRESSURE LOSS IN HOSE - cont.

Lubrication Only at Tool - No Line Lubricator

Hose Length and Inside Diameter	cfm Free Air	Line Pressure - psig						
		60	80	100	120	150	200	300
50 Feet 2"	600	1.9						
	800	3.2	2.5	2.1				
	1000	5.0	3.9	3.2	2.7	2.2	1.7	1.1
	1200	7.0	5.5	4.5	3.8	3.1	2.4	1.6
	1400	9.3	7.4	6.1	5.2	4.2	3.2	2.2
	1600		9.6	7.9	6.7	5.5	4.2	2.8
	1800		12.1	9.9	8.4	6.9	5.3	3.6
	2000			12.2	10.4	8.5	6.5	4.4
	2200			14.6	12.5	10.2	7.8	5.3
	2400				14.7	12.0	9.2	6.3
	2600					14.1	10.8	7.3
	2800					16.2	12.4	8.5
50 Feet 2½"	1000	1.7						
	1500	3.7	2.9	2.4	2.0			
	2000	6.5	5.1	4.2	3.6	2.9	2.2	1.5
	2500	10.0	7.9	6.5	5.5	4.5	3.4	2.3
	3000		11.2	9.3	7.9	6.4	4.9	3.3
	3500			12.4	10.6	8.7	6.6	4.5
	4000				13.7	11.2	8.6	5.8
	4500					14.0	10.7	7.3
50 Feet 3"	2000	2.5	2.0					
	2500	3.9	3.0	2.5	2.1			
	3000	5.5	4.4	3.6	3.1	2.5	1.9	1.3
	3500	7.5	5.9	4.9	4.1	3.4	2.6	1.7
	4000	9.8	7.6	6.3	5.3	4.4	3.3	2.3
	4500		9.6	7.9	6.7	5.5	4.2	2.8
	5000		11.7	9.6	8.2	6.7	5.1	3.5
	5500			11.5	9.8	8.0	6.1	4.2
	6000			13.6	11.5	9.4	7.2	4.9
	6500				13.5	11.0	8.4	5.7
	7000				15.6	12.7	9.8	6.6
	7500					14.5	11.1	7.6
25 Feet 4"	5000	1.9						
	6000	2.7	2.1	1.7				
	7000	3.6	2.8	2.3	2.0		1.2	
	8000	4.7	3.7	3.0	2.6	2.1	1.6	
	9000	5.9	4.6	3.8	3.2	2.6	2.0	
	10000	7.2	5.7	4.7	4.0	3.2	2.5	
	11000	8.7	6.8	5.6	4.8	3.9	3.0	
	12000		8.1	6.7	5.7	4.6	3.5	
	13000		9.4	7.8	6.6	5.4	4.1	
	14000			9.0	7.6	6.2	4.8	
	15000				8.7	7.1	5.4	
	16000				9.8	8.0	6.2	
	17000					9.1	6.9	

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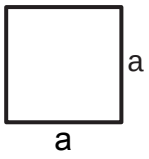
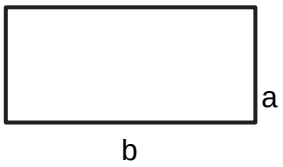
COMMONLY USED FORMULAS for CALCULATING SURFACE AREA



Squares and Rectangles

The areas of a square and of a rectangle are obtained by multiplying the length of one side by the length of the other, *i.e.*

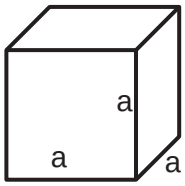
square = a x a



rectangle = a x b

Cubes

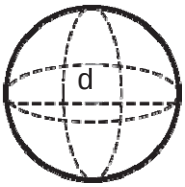
A cube has 6 sides that are all identical squares. To calculate the total surface area, multiply 6 by the square of the length (a) of one of the sides *i.e*.



6 x a x a

Spheres

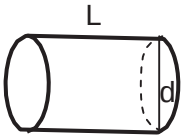
The surface area of a sphere is 3.1416 multiplied by the square of the diameter *i.e.*



3.1416 x d x d

Pipes

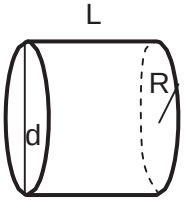
The surface area of a pipe is 3.1416 multiplied by the diameter (d) and by the length (L) *i.e*.



3.1415 x d x L

Cylindrical Tanks

The surface area consists of the cylindric shell plus the top and bottom area *i.e.*



3.1416 x d x L + 2 x (3.1416 x R x R)

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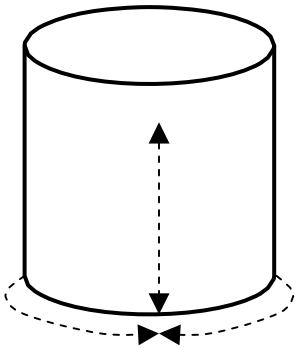
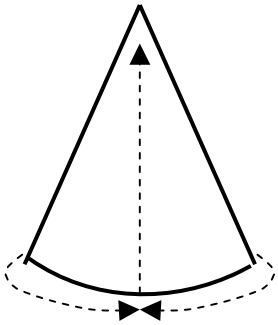
ESTIMATING SQUARE FOOTAGE IN VARIOUS SHAPES



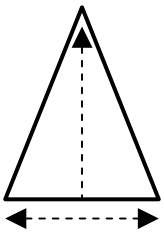
Cylinder

a. Determine area of both ends of cylinder (circles) by multiplying 3.1416 times the radius (in feet) squared.
b. Determine area of side of cylinder by multiplying circumference (in feet) times height (in feet).
c. Add square feet of both ends to square feet of side for total square feet of cylinder.



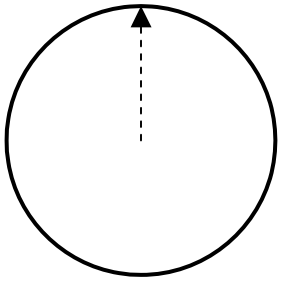
Cone

a. Determine area of base by multiplying 3.1416 times the radius (in feet) squared.
b. Determine the area of the side of the cone by multiplying circumference of base (in feet) times one-half of the slant height (in feet).
c. Add the square foot area of the base to the square foot area of the cone side for total square foot area.



Triangle

Multiply the base measurement (in feet) times one-half the altitude (in feet).



Circle

To determine the square footage of the area of a circle, multiply 3.1416 times the radius (in feet) squared.

Circumference

To determine the circumference of a circle, multiply 3.1416 times the diameter (twice the radius).

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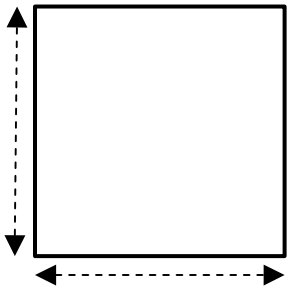

Square or Rectangle
Multiply the base measure (in feet) times the height (in feet).

Estimating Square Footage from Tonnage

Many times structures will have unusual shapes or be too difficult to accurately measure. In such instances, if the tonnage and thickness of the steel can be determined, fairly accurate estimates of area can be determined from the table below.

Thickness of Steel (inches)	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	1-1/2	2
Square Foot Area Per Ton	800	533	400	320	267	200	160	133	114	100	67	50