

# FINISHERS HANDBOOK

For Platers, Anodizers, and Electronics



**Conversion Factors**

**Temperature Conversion**

**Tank Make Up and Additions**

**Capacity of Round & Rectangular Tanks**

**Temperature of Saturated Steam**

**Water Quality**

**Electrochemical Equivalents**

**Thickness of Electrodeposits**

**Coating Weights**

**Cathode Efficiencies**

**Metals for Metal Finishing Fixtures**

**Metal Conductivity**

**Common Chemical Names**

**Acid Conversion Table**

**Concentration Conversion**

**Chemical Components**

## Table of Conversion Factors

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Amperes/sq.ft.,	0.108	amperes/sq. dm.
Ampere hours,	3600	coulombs
Amperes/sq. dm.,	9.29	amperes/sq. ft.
Angstrom units,	$1 \times 10^{-4}$	microns
Centimeters	0.394	inches
Centimeters	393.7	mils
Centimeters	0.0328	feet
Cubic centimeters	$3.53 \times 10^{-5}$	cubic feet
Cubic centimeters	0.061	cubic inches
Cubic centimeters	$2.64 \times 10^{-4}$	gallons
Cubic centimeters	0.0338	ounces (fluid)
Cubic feet	28317	cubic centimeters
Cubic feet	1728	cubic inches
Cubic feet	7.48	gallons
Cubic feet of water 60°F	62.37	pounds
Cubic inches	16.39	cubic centimeters
Faradays	$9.65 \times 10^{-4}$	coulombs
Faraday/second	96500	amperes
Feet	30.48	centimeters
Feet	12	inches
Feet	0.3048	meters

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Gallons	4	quarts (liquid)
Gallons	3785.4	cubic centimeters
Gallons (U.S.)	231	cubic inches
Gallons (U.S.)	3.785	liters
Gallons (U.S.)	128	ounces (fluid)
Gallons (U.S.)	8	pints
Gallons (U.S.)	8.34	pounds (av.) of H <sub>2</sub> O at 62°F.
Gallons (U.S.)	1.2	gallons (British)
Grains	0.0648	grams
Grains	0.0023	ounces (avoir.)
Grains	0.0021	ounces (troy)
Grains	0.0417	pennyweights (troy)
Grams	15.43	grains
Grams	1000	milligrams
Grams	0.0353	ounces (avoir.)
Grams	0.0321	ounces (troy)
Grams	0.643	pennyweights
Grams/liter	0.122	ounces/gallon (troy)
Grams/liter	0.134	ounces/gallon (avoir.)
Grams/liter	1000	parts per million
Grams/liter	2.44	pennyweights/gallon

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Inches	2.54	centimeters
Inches	1000	mils
Kilograms	1000	grams
Kilograms	2.205	pounds (avoir.)
Kilograms	2.679	pounds (troy)
Liters	1000	milliliters
Liters	0.264	gallons
Meters	100	centimeters
Meters	39.37	inches
Microns	$3.9 \times 10^{-5}$	inches
Milligrams	0.001	grams
Milliliters	1.000027	cubic centimeters
Mils	0.001	inches
Mils	25.4	microns
Ounces (avoir.)	437.5	grains
Ounces (avoir.)	28.35	grams
Ounces (avoir.)	0.911	ounces (troy)
Ounces (avoir.)	18.23	pennyweights
Ounces (avoir.)	0.076	pounds (troy)
Ounces/gallon (avoir.)	7.5	grams/liter
Ounces (troy)	480	grains
Ounces (troy)	31.1	grams
Ounces (troy)	1.097	ounces (avoir.)
Ounces (troy)	20	pennyweights
Ounces/gallon (troy)	8.2	grams/liter

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Ounces (fluid)	29.57	cubic centimeters
Ounces/gallon (fluid)	7.7	cc./liter
Pennyweights	24	grains
Pennyweights	1.56	grams
Pennyweights/gallon	0.41	grams/liter
Pints	16	ounces (fluid)
Pounds (avoir.)	453.6	grams
Pounds (avoir.)	16	ounces (avoir.)
Pounds (avoir.)	14.58	ounces (troy)
Pounds (avoir.)	1.215	pounds (troy)
Pounds (troy)	373.24	grams
Pounds (troy)	12	ounces (troy)
Pounds (troy)	0.823	pounds (avoir.)
Quarts (liquid)	946.4	cubic centimeters
Quarts (liquid)	2	pints
Square feet	929.23	square centimeters
Square feet	144	square inches
Square inches	6.45	square centimeters

# Temperature Conversions

Fahrenheit to Centigrade - Centigrade to Fahrenheit

**Formulae:**

C. to F. =  $(^{\circ}\text{C.} \times 9/5) + 32 = ^{\circ}\text{F.}$  | F. to C. =  $(^{\circ}\text{F.} - 32) \times 5/9 = ^{\circ}\text{C.}$

The table below can be used to convert °F. to °C. and vice versa. Locate the temperature to be converted (either F. or C.) in the center column (bold face). The number to the left gives corresponding °C.; to the right corresponding °F.

°C	<b>Converted</b>	°F	°C	<b>Converted</b>	°F	°C	<b>Converted</b>	°F
-128.9	<b>-200</b>	-328.0	-0.6	<b>31</b>	87.8	21.7	<b>71</b>	159.8
-73.3	<b>-100</b>	-148.0	0.0	<b>32</b>	89.6	22.2	<b>72</b>	161.6
-62.2	<b>-80</b>	-112.0	0.6	<b>33</b>	91.4	22.8	<b>73</b>	163.4
-51.1	<b>-60</b>	-76.0	1.1	<b>34</b>	93.2	23.3	<b>74</b>	165.2
-45.6	<b>-50</b>	-58.0	1.7	<b>35</b>	95.0	23.9	<b>75</b>	167.0
-40.0	<b>-40</b>	-40.0	2.2	<b>36</b>	96.8	24.4	<b>76</b>	168.8
-34.4	<b>-30</b>	-22.0	2.8	<b>37</b>	98.6	25.0	<b>77</b>	170.6
-28.9	<b>-20</b>	-4.0	3.3	<b>38</b>	100.4	25.6	<b>78</b>	172.4
-23.3	<b>-10</b>	14.0	3.9	<b>39</b>	102.2	26.1	<b>79</b>	174.2
-17.8	<b>0</b>	32.0	4.4	<b>40</b>	104.0	26.7	<b>80</b>	176.0
-17.2	<b>1</b>	33.8	5.0	<b>41</b>	105.8	27.2	<b>81</b>	177.8
-16.7	<b>2</b>	35.6	5.6	<b>42</b>	107.6	27.8	<b>82</b>	179.6
-16.1	<b>3</b>	37.4	6.1	<b>43</b>	109.4	28.3	<b>83</b>	181.4
-15.6	<b>4</b>	39.2	6.7	<b>44</b>	111.2	28.9	<b>84</b>	183.2
-15.0	<b>5</b>	41.0	7.2	<b>45</b>	113.0	29.4	<b>85</b>	185.0
-14.4	<b>6</b>	42.8	7.8	<b>46</b>	114.8	30.0	<b>86</b>	186.8
-13.9	<b>7</b>	44.6	8.3	<b>47</b>	116.6	30.6	<b>87</b>	188.6
-13.3	<b>8</b>	46.4	8.9	<b>48</b>	118.4	31.1	<b>88</b>	190.4
-12.8	<b>9</b>	48.2	9.4	<b>49</b>	120.2	31.7	<b>89</b>	192.2
-12.2	<b>10</b>	50.0	10.0	<b>50</b>	122.0	32.2	<b>90</b>	194.0
-11.7	<b>11</b>	51.8	10.6	<b>51</b>	123.8	32.8	<b>91</b>	195.8
-11.1	<b>12</b>	53.6	11.1	<b>52</b>	125.6	33.3	<b>92</b>	197.6
-10.6	<b>13</b>	55.4	11.7	<b>53</b>	127.4	33.9	<b>93</b>	199.4
-10.0	<b>14</b>	57.2	12.2	<b>54</b>	129.2	34.4	<b>94</b>	201.2
-9.4	<b>15</b>	59.0	12.8	<b>55</b>	131.0	35.0	<b>95</b>	203.0
-8.9	<b>16</b>	60.8	13.3	<b>56</b>	132.8	35.6	<b>96</b>	204.8
-8.3	<b>17</b>	62.6	13.9	<b>57</b>	134.6	36.1	<b>97</b>	206.6
-7.8	<b>18</b>	64.4	14.4	<b>58</b>	136.4	36.7	<b>98</b>	208.4
-7.2	<b>19</b>	66.2	15.0	<b>59</b>	138.2	37.2	<b>99</b>	210.2
-6.7	<b>20</b>	68.0	15.6	<b>60</b>	140.0	37.8	<b>100</b>	212.0
-6.1	<b>21</b>	69.8	16.1	<b>61</b>	141.8	48.9	<b>120</b>	248.0
-5.6	<b>22</b>	71.6	16.7	<b>62</b>	143.6	60.0	<b>140</b>	284.0
-5.0	<b>23</b>	73.4	17.2	<b>63</b>	145.4	71.1	<b>160</b>	320.0
-4.4	<b>24</b>	75.2	17.8	<b>64</b>	147.2	93.3	<b>200</b>	392.0
-3.9	<b>25</b>	77.0	18.3	<b>65</b>	149.0	100.0	<b>212</b>	413.6
-3.3	<b>26</b>	78.8	18.9	<b>66</b>	150.8	115.6	<b>240</b>	464.0
-2.8	<b>27</b>	80.6	19.4	<b>67</b>	152.6	137.8	<b>280</b>	536.0
-2.2	<b>28</b>	82.4	20.0	<b>68</b>	154.4	160.0	<b>320</b>	608.0
-1.7	<b>29</b>	84.2	20.6	<b>69</b>	156.2	182.2	<b>360</b>	680.0
-1.1	<b>30</b>	86.0	21.1	<b>70</b>	158.0	204.4	<b>400</b>	752.0

## TABLE OF TANK MAKEUP AND ADDITIONS FOR DRY AND LIQUID MATERIALS

Addition of 4 oz./gal. to 600 gallon tank read 4 oz./gal. in left column and under 600 find 150 lbs.

$$\frac{\text{Oz. Per Gal.} \times \text{Tank Vol.}}{16} = \text{Pounds To Add}$$

### DRY PRODUCTS

### TANK SIZE - GALLONS

OZ./GAL.	100	200	300	400	500	600	700	800	900	1000
.5	3.13	6.25	9.38	12.50	15.63	18.75	21.88	25.00	28.13	31.25
1.0	6.25	12.50	18.75	25.00	31.25	37.50	43.75	50.00	56.75	62.50
2.0	12.50	25.00	37.50	50.00	62.50	75.00	87.50	100.00	112.50	125.00
3.0	18.75	37.50	56.25	75.00	93.75	112.50	131.25	150.00	168.75	187.50
4.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	250.00
5.0	31.25	62.50	93.75	125.00	156.25	187.50	218.75	250.00	281.25	312.50
6.0	37.50	75.00	112.50	150.00	187.50	225.00	262.50	300.00	337.50	375.00
7.0	43.75	87.50	131.25	175.00	218.75	262.50	306.25	350.00	393.75	437.50
8.0	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
9.0	56.25	112.50	168.75	225.00	281.25	337.50	393.75	450.00	506.25	562.50

Addition of 0.3% by volume to 600 gallon tank read .3 in left column and under 600 find 1.8 gallons..

$$\text{Rectangular tank Capacity} = \frac{L \times W \times H}{231} \text{ (Gal.)}$$

### LIQUID PRODUCTS

### TANK SIZE - GALLONS

% By VOLUME	100	200	300	400	500	600	700	800	900	1000
.1	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
.2	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0
.3	.3	.6	.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
.4	.4	.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
.5	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
2.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
3.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0
4.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0
5.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0

## CAPACITY OF ROUND TANKS

Basis: Inside Measure, 1 cubic foot = 7.481 gallons • Table Gives Gallons Per Foot of Height

Diameter	gal/ft*
1'-0"	5.88
1'-3"	9.18
1'-6"	13.22
1'-9"	17.99
2'-0"	23.50
2'-3"	29.75
2'-6"	36.72
2'-9"	44.43
3'-0"	52.88
3'-6"	71.98
4'-0"	94.01
4'-6"	118.98
5'	146.89
6'	211.52
7'	287.90
8'	376.04
9'	475.92
10'	587.56
11'	710.94
12'	846.08
15'	1322.00
20'	2350.23
25'	3672.23
30'	5288.01



## CAPACITY OF RECTANGULAR TANKS

Basis: Inside Measure, 1 cubic foot = 7.481 gallons (U.S.) • Table Gives Gallons Per Foot of Depth

Length	1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"
1'-0"	7.48	11.22	14.96	18.70	22.44	29.92	37.41	44.89	52.37	59.85	67.33	74.81
1'-3"	9.35	14.03	18.70	23.38	28.05	37.41	46.76	56.11	65.46	74.81	84.16	93.51
1'-6"	11.22	16.83	22.44	28.05	33.66	44.89	56.11	67.33	78.55	89.77	100.99	112.22
1'-9"	13.09	19.64	26.18	32.73	39.28	52.37	65.46	78.55	91.64	104.73	117.83	130.92
2'-0"	14.96	22.44	29.92	37.41	44.89	59.85	74.81	89.77	104.73	119.70	134.66	149.62
2'-3"	16.83	25.25	33.66	42.08	50.50	67.33	84.16	100.99	117.83	134.66	151.49	168.32
2'-6"	18.70	28.05	37.41	46.76	56.11	74.81	93.51	112.22	130.92	149.62	168.32	187.03
2'-9"	20.57	30.86	41.15	51.43	61.72	82.29	102.86	123.44	144.01	164.58	185.15	205.73
3'-0"	22.44	33.66	44.89	56.11	67.33	89.77	112.22	134.66	157.10	179.54	201.99	224.43
3'-6"	26.18	39.28	52.37	65.46	78.55	104.73	130.92	157.10	183.28	209.47	235.65	261.84
4'-0"	29.92	44.89	59.85	74.81	89.77	119.70	149.62	179.54	209.47	239.39	269.32	299.24
4'-6"	33.66	50.50	67.33	84.16	100.99	134.66	168.32	201.99	235.65	269.32	302.98	336.65
5'-0"	37.41	56.11	74.81	93.51	112.22	149.62	187.03	224.43	261.84	299.24	336.65	374.05
6'-0"	44.89	67.33	89.77	112.22	134.66	179.54	224.43	269.32	314.20	359.09	403.97	448.86

## TEMPERATURE OF SATURATED STEAM

This table gives the gage pressure of saturated steam in pounds per square inch corresponding to the stated temperature.

Zero gage pressure is equal to 14.70 pounds per square inch absolute.

°F	PSI
212	0.00
214	0.59
216	1.31
218	1.84
220	2.49
222	3.17
224	3.86
226	4.58
228	5.32
230	6.08
232	6.87
234	7.68
236	8.52
238	9.38
240	10.27
242	11.19
244	12.13
246	13.10
248	14.10
250	15.13
252	16.19
254	17.28
256	18.40
258	19.55
260	20.73
262	21.95
264	23.20
266	24.49
268	25.81
270	27.16
Continued on next page	

272	28.56
274	29.99
276	31.45
278	32.96
280	34.51
282	36.09
284	37.72
286	39.39
288	41.10
290	42.86
292	44.66
294	46.51
296	48.39
298	50.33
300	52.32

## WATER QUALITY

Specific Conductance micromhos/cm*	Specific resistance megohm-cm*	As Ion	Parts Per Million As CaCO <sub>3</sub>	As NaCL**	Gr./Gal. as CaCO <sub>3</sub>
.055	18.240	none	none	none	none
.056	18.000	.036	.028	.022	.002
.063	16.000	.041	.031	.025	.002
.071	14.000	.046	.036	.029	.002
.083	12.000	.054	.042	.033	.002
.100	10.000	.065	.050	.040	.003
.125	8.000	.081	.063	.050	.004
.167	6.000	.108	.083	.067	.005
.250	4.000	.163	.125	.100	.007
.500	2.000	.325	.250	.200	.015
1.000	1.000	.650	.500	.400	.029
1.250	.800	.813	.625	.500	.037
1.667	.600	1.083	.833	.667	.049
2.500	.400	1.625	1.250	1.000	.073
5.000	.200	3.250	2.500	2.000	.146
10.000	.100	6.500	5.000	4.000	.292
20.000	.050	13.000	10.000	8.000	.585
40.000	.025	26.000	20.000	16.000	1.170
80.000	.0125	52.000	40.000	32.000	2.340
158.730	.0063	103.175	79.635	63.492	4.641
312.500	.0032	203.125	156.250	125.000	9.137
625.000	.0016	406.250	312.500	250.000	18.273
1,250.000	.0008	812.500	625.000	500.000	36.550
2,500.000	.0004	1,625.000	1,250.000	1,000.000	73.099
Continued on next page					

5,000.000	.0002	3,250.000	2,500.000	2,000.000	146.199
10,000.000	.0001	6,500.000	5,000.000	4,000.000	292.398

**\* At 25°C**

**\*\* At 25°C, given specific conductance values included in this table.**

1 psi = 2.307 head feet of water	Calcium (ppm) x .04990 = Calcium (Meq/Liter)
1 psi = .07031 kg/cm <sup>2</sup>	Magnesium (ppm) x .08226 = Magnesium (Meq/Liter)
	Potassium (ppm) x .02557 = Potassium (Meq/Liter)
1 grain per gal. = 17.1 ppm (CaCO <sub>3</sub> )	Sodium (ppm) x .04350 = Sodium (Meq/Liter)

## ELECTROCHEMICAL EQUIVALENTS

Calculated on Basis of 100% Cathode Efficiency

METAL	SYMBOL	VALENCE	ATOMIC WEIGHT	SPECIFIC GRAVITY	THICKNESS in INCHES of 1 oz./sq.ft.	GRAMS DEPOSITED PER AMP. HR.	AMP. HR. PER SQ. FT. TO DEPOSIT 0.001
ANTIMONY	Sb	3	121.76	6.68	.00180	1.514	10.4
CADMIUM	Cd	2	112.41	8.65	.00139	2.0968	9.73
CHROMIUM	Cr	6	52.01	7.1	.00169	0.3233	51.8
COBALT (OUS)	Co	2	58.94	8.9	.00135	1.100	19.0
COPPER (OUS)	Cu	1	63.57	8.93	.00134	2.371	8.89
COPPER (IC)	Cu	2	63.57	8.93	.00134	1.186	17.8
GOLD (OUS)	Au	1	197.2	19.3	.00068*	7.356	6.2
GOLD (IC)	Au	3	197.2	19.3	.00068*	2.450	18.6
HYDROGEN	H	1	1.0078	0.0899 g./l.	---	0.0376	---
INDIUM	In	3	114.76	7.31	.00182*	1.427	12.0
IRON (OUS)	Fe	2	55.84	7.87	.00153	1.042	17.9
LEAD	Pb	2	207.22	11.35	.00106	3.865	6.9
NICKEL	Ni	2	58.69	8.90	.00135	1.095	19.0
OXYGEN	O	2	16.00	1.429g./l.(0°c)	---	0.2985	---
PALLADIUM	PD	2	106.7	11.40	.00116*	1.990	13.5
PLATINUM	Pt	4	195.23	21.45	.00062*	1.821	27.8
RHODIUM	Rh	3	102.91	12.5	.00106*	1.280	22.9
SILVER	Ag	1	107.88	10.5	.00126*	4.025	6.2
TIN (OUS)	Sn	2	118.70	7.3 (tetragonal)	.00164	2.214	7.8
TIN (IC)	Sn	4	118.70	7.3 (tetragonal)	.00164	1.107	15.6
ZINC	Zn	2	65.38	7.14	.00168	1.182	14.3

**\* These figures are for 1 troy ounce per square foot**

### THICKNESS OF ELECTRODEPOSITS (Inches)

Thickness in Inches	.0001	.0002	.0004	.0006	.0008	.001
<b>At 10 Amperes per Square Foot</b>						
Cadmium	:06	:12	:24	:35	:46.7	:58
Copper (acid)	:10 1/2	:21 1/2	:43 1/2	1:05 1/2	1:25	1:49
Copper (cyanide)	:05 1/3	:10 1/2	:21	:31	:42	:53
Tin (Stannate)	:12	:23 1/2	:47	1:10	1:34	2:00
Zinc	:08	:16 1/2	:33	:50	1:06	1:28
Nickel	:12	:24	:48	1:12	1:36	2:00

Thickness in Inches	.0001	.0002	.0004	.0006	.0008	.001
<b>At 20 Amperes per Square Foot</b>						
Cadmium	:03	:06	:12	:17 1/2	:23 1/8	:29
Copper (acid)	:05 1/3	:10 3/4	:22	:32 1/2	:43	:54 1/2
Copper (cyanide)	:02 1/2	:05 1/3	:10 1/2	:17	:23	:27
Tin (Stannate)	:06	:12	:23 1/2	:35 1/4	:47	:59
Zinc	:04	:08 1/4	:16 1/2	:25	:33	:44
Nickel	:06 2/3	:12	:24	:36	:48	:59

Thickness in Inches	.0001	.0002	.0004	.0006	.0008	.001
<b>At 30 Amperes per Square Foot</b>						
Cadmium	:02	:04	:08	:12	:16	:19
Copper (acid)	:03 1/2	:07 1/3	:14 1/2	:22	:28	:36
Copper (cyanide)	:01 2/3	:03 1/2	:07 1/2	:10 1/2	:14	:18
Tin (Stannate)	:04	:08	:16	:23 1/2	:31 1/4	:39
Zinc	:02 3/4	:05 1/3	:10 2/3	:16 1/2	:22	:28
Nickel	:04	:08	:16	:24	:32	:40

Continued on next page

Thickness in Inches	.0001	.0002	.0004	.0006	.0008	.001
<b>At 40 Amperes per Square Foot</b>						
Cadmium	:01 1/4	:03	:06	:08 3/4	:12	:15
Copper (acid)	:02 2/3	:05 1/2	:11 2/3	:16 1/3	:22	:27
Copper (cyanide)	:01 1/3	:02 1/2	:05 1/3	:08	:10 1/2	:13
Tin (Stannate)	:03	:06	:12	:18	:23 1/2	:29 1/4
Zinc	:02	:04	:08 1/4	:12 1/2	:16 1/2	:22
Nickel	:03	:06	:12	:18	:24	:29

Add 10% to time figures for commercial use; above are obtained under ideal Conditions

Figures denote time in hours and minutes to deposit required thickness at given current densities

Cadmium based on 100% cathode efficiency

Copper (acid) based on 97% cathode efficiency

Copper (cyanide) based on 100% cathode efficiency

Tin (stannate) based on 80% cathode efficiency

Nickel based on 95% cathode efficiency



## COATING WEIGHTS FOR ONE-MIL THICK DEPOSITS

This table gives the gage pressure of saturated steam in pounds per square inch corresponding to the stated temperature.

Zero gage pressure is equal to 14.70 pounds per square inch absolute.

<b>METAL</b>	<b>oz./sq. ft.</b>	<b>mg/sq. in.</b>	<b>mg/sq. cm.</b>
Aluminum	0.225	44.7	6.9
Antimony	0.557	111	17.0
Arsenic	0.475	94.3	14.5
Bismuth	0.816	162	24.9
Cadmium	0.72	143	22.0
Chromium	0.591	117	18.0
Cobalt	0.74	147	22.6
Copper	0.74	147	22.6
Gallium	0.491	97.5	15.0
Germanium	0.445	88.3	13.6
Gold	1.61	320	49.2
Indium	0.608	121	18.6
Iridium	1.869	368	57.0
Iron	0.66	130	20.1
Lead	0.94	185	28.7
Manganese	0.598	118	18.2
Nickel	0.742	146	22.6
Palladium	0.998	196	30.4
Platinum	1.78	350	54.3
Rhodium	1.04	205	31.8
Rhenium	1.71	336	52.2
Selenium	0.400	78.7	12.2
Silver	0.875	172	26.7
Tellurium	0.520	102	15.9
Thallium	0.986	194	30.1
Tin	0.61	120	18.6
Zinc	0.59	116	18.0

## AVERAGE CATHODE CURRENT EFFICIENCIES OF COMMON PLATING SOLUTIONS

NOTE: Some of these figures are very approximate. Cathode efficiency depends very much on the plating conditions actually used. However, the figures below serve as a starting point for estimating metal yields from tables of plating times or electrochemical equivalents which are based on cathode efficiencies of 100%.

<b>METAL</b>	<b>Type of Bath</b>	<b>Usual Cathode Efficiency Percent</b>
Cadmium	Cyanide	88 - 95
Chromium	Chromic acid-Sulfate	12 - 16
Copper	Acid Sulfate	97 - 100
Copper	Cyanide	30 - 95
Copper	Rochelle-Cyanide	40 - 70
Cobalt	Acid Sulfate	95 - 98
Gold	Cyanide	70 - 90
Indium	Cyanide	30 - 50
Iridium	Fluoborate	30 - 50
Indium	Acid Sulfate	70 - 80
Iron	Acid Chloride	90 - 98
Iron	Acid Sulfate	95 - 98
Lead	Fluoborate	100
Lead	Fluosilicate	100
Nickel	Acid Sulfate	94 - 98
Silver	Cyanide	100
Tin	Acid Sulfate	90 - 95
Tin	Stannate	70 - 90
Rhodium	Acid Phosphate	10 - 18
Rhodium	Acid Sulfate	10 - 18
Zinc	Acid Sulfate	99
Zinc	Cyanide	85 - 90

## METALS FOR METAL-FINISHING FIXTURES

PROCESS	FRAME MATERIAL	CONTACT MATERIAL	ANODE MATERIAL
NICKEL-CHROME PLATING	COPPER	STAINLESS STEEL	PLATINIZED TITANIUM/LEAD/STEEL
HARD CHROME PLATING	COPPER	PHOSPHOR BRONZE	LEAD
CADMIUM PLATING	COPPER/STEEL	STAINLESS STEEL	CADMIUM STEEL
ZINC PLATING	COPPER/STEEL	MONEL	ZINC/STEEL
NICKEL PLATING	COPPER	STAINLESS STEEL	NICKEL/PLATINIZED TITANIUM
SILVER PLATING	STEEL	STAINLESS STEEL/STEEL	STAINLESS STEEL/SILVER
GOLD PLATING	COPPER/STEEL	STAINLESS STEEL	PLATINIZED TITANIUM
COPPER PLATING	COPPER/STEEL	PHOSPHOR BRONZE/MONEL	COPPER/STEEL
ANODIZING	ALUMINUM/TITANIUM	ALUMINUM/TITANIUM	ALUMINUM/TITANIUM
PAINTING	STEEL	STEEL/SPRING STEEL/MAGNETS/STAINLESS STEEL	----
HEAT TREATING	INCONEL/NIKROME/HASTOLOY	INCONEL/NIKROME/HASTOLOY	----
ELECTROPOLISHING	COPPER	TITANIUM	STAINLESS STEEL
ELECTROLESS PLATING	STAINLESS STEEL	STAINLESS STEEL	----

Compliments of ARC - [associatedrack.com](http://associatedrack.com)

## METAL CONDUCTIVITY (AMPERES)

SIZE	COPPER	ALUMINUM	BRASS	STEEL	PHOS. BRONZE	STAINLESS STEEL	TITANIUM
1x1	1000	600	250	120	180	23	31
1/2 x 1	500	300	125	60	90	12	16
3/8 x 1	375	225	94	45	68	9	12
1/4 x 1	250	150	63	30	45	6	8
1/4 x 3/4	187	112	47	22	33	4.5	6
1/2 x 1/2	250	150	63	30	45	6	8
1/4 x 1/2	125	75	31	15	22	3	4
3/8 x 3/8	140	84	35	17	27	4	5
1/2 ø	200	120	50	24	36	5	6
1/4 ø	50	30	13	6	9	1	1.5
3/16 ø	28	16	7	3.5	5	.6	.8
5/32 ø	20	12	5	2.5	3.7	.5	.6
1/8 ø	12	7	3	1.5	2.2	.3	.4
3/32 ø	7	4	1.7	.8	1.2	.2	.2
1/16 ø	3	1.8	.7	.4	.5	.1	.1

Compliments of ARC - [associatedrack.com](http://associatedrack.com)

## COMMONLY USED NAMES FOR CHEMICALS

COMMONLY USED NAMES	Chemical Name or Compound	COMMONLY USED NAMES	Chemical Name or Compound
<b>Alum</b>	Potassium aluminum sulfate, $K_2Al_2(SO_4)_4 \cdot 24H_2O$ (varies)	<b>Gypsum</b>	Calcium sulfate, $CaSO_4 \cdot 2H_2O$
<b>"Aloxite" Alumina "Alundum"</b>	Aluminum oxide, $Al_2O_3$	<b>Hypo</b>	Sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$
<b>Aqua fortis</b>	Nitric acid	<b>Lime</b>	Calcium oxide, $CaO$
<b>Aqua regia</b>	Nitric acid - 1 part + Hydrochloric acid - 3 parts	<b>Litharge</b>	Lead monoxide, $PbO$
<b>Baking soda</b>	Sodium bicarbonate, $NaHCO_3$	<b>Liver of sulfur</b>	Potassium polysulfide, $K_2S_x$
<b>Bleaching powder</b>	Calcium hypochlorite, $CaOCl_2$	<b>Marble</b>	Calcium carbonate, $CaCO_3$
<b>Blue dip</b>	Solution of mercury salt	<b>Metso</b>	Sodium metasilicate, $Na_2SiO_3 \cdot 5H_2O$
<b>Blue stone Blue vitriol</b>	Copper sulfate, $CuSO_4 \cdot 5H_2O$	<b>Milk of lime</b>	Calcium hydroxide, $Ca(OH)_2$
<b>Boracic acid</b>	Boric acid	<b>Muriatic acid</b>	Hydrochloric acid, $HCl$
<b>Borax</b>	Sodium tetraborate, $Na_2B_4O_7 \cdot 10H_2O$	<b>Oil of vitriol</b>	Acid sulfuric, $H_2SO_4$
<b>Butter of antimony</b>	Antimony trichloride, $SbCl_3$	<b>Peral ash</b>	Potassium carbonate, $K_2CO_3$
<b>Calcite</b>	Calcium carbonate, $CaCO_3$	<b>Plaster of Paris</b>	Calcium sulfate, $2CaSO_4 \cdot H_2O$
<b>Calomel</b>	Mercurous chloride, $Hg_2Cl_2$	<b>Quick lime</b>	Calcium oxide, $CaO$
Continued on next page			

<b>"Carborundum"</b>	Silicon carbide, SiC	<b>Quicksilver</b>	Mercury
<b>Caustic potash</b>	Potassium hydroxide, KOH	<b>Rochelle salt</b>	Sodium potassium tartrate, NaK(C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ) · 4H <sub>2</sub> O
<b>Caustic soda</b>	Sodium hydroxide, NaOH	<b>Rouge .</b>	Iron oxide, Fe <sub>2</sub> O <sub>3</sub>
<b>Chalk</b>	Calcium carbonate, CaCO <sub>3</sub>	<b>Sal ammoniac</b>	Ammonium chloride, NH <sub>4</sub> Cl
<b>Chevereul salt</b>	Cupro cupricsulfite, Cu <sub>2</sub> SO <sub>3</sub> - CuSO <sub>4</sub> - 2H <sub>2</sub> O	<b>Single nickel salt</b>	Nickel sulfate, NiSO <sub>4</sub> · 6H <sub>2</sub> O or NiSO <sub>4</sub> · 7H <sub>2</sub> O
<b>Chloride of lime</b>	Calcium hypochlorite CaOCl <sub>2</sub>	<b>Slaked lime</b>	Calcium hydroxide, Ca(OH) <sub>2</sub>
<b>Common salt</b>	Sodium chloride, NaCl	<b>Soda ash</b>	Sodium carbonate, Na <sub>2</sub> CO <sub>3</sub>
<b>Copperas</b>	Ferrous sulfate, FeSO <sub>4</sub> · 7H <sub>2</sub> O	<b>Sour water</b>	Dilute sulfuric acid
<b>Cream of tartar</b>	Potassium acid tartrate, KH(C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> )	<b>Sugar of lead</b>	Lead acetate, Pb(CH <sub>3</sub> COO) <sub>2</sub>
<b>Double nickel salt</b>	Nickel ammonium sulfate NiSO <sub>4</sub> (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> · 6H <sub>2</sub> O	<b>TSP</b>	Trisodium phosphate, Na <sub>3</sub> PO <sub>4</sub>
<b>Emery</b>	Aluminum oxide, Al <sub>2</sub> O <sub>3</sub>	<b>Washing soda</b>	Sodium carbonate, Na <sub>2</sub> CO <sub>3</sub> · 10H <sub>2</sub> O
<b>Epsom salt</b>	Magnesium sulfate, MgSO <sub>4</sub> · 7H <sub>2</sub> O	<b>Water glass</b>	Sodium silicate solution
<b>Flowers of sulfur</b>	Sulfur, S	<b>Wood's metal</b>	Low melting temperature Alloy, e.g., 4 pts Bi, 2 pts Ph, 1 pt Sn, 1 pt Cd
<b>Fluorspar</b>	Calcium fluoride, CaF <sub>2</sub> ,	<b>Vienna lime</b>	Calcium carbonate CaCO <sub>3</sub>
<b>Glauber's salt</b>	Sodium sulfate, Na <sub>2</sub> SO <sub>4</sub> · 10H <sub>2</sub> O		

**CONVERSION TABLE  
SPECIFIC GRAVITY,  
DEGREES BAUME, POUNDS PER CUBIC FOOT**

$$^{\circ}\text{Bé.} = 145 - \frac{145}{\text{sp.gr.}} \text{ (heavier than H}_2\text{O)}; \text{ } ^{\circ}\text{Bé.} = \frac{140}{\text{sp.gr.}} - 130 \text{ (lighter than H}_2\text{O)}$$

Sp. gr. 60°/60°	°Bé	Lb. per gal. at 60°F wt. in air	Lb. per cu. ft. at 60°F wt. in air
1.000	10.00	8.3283	62.300
1.005	0.72	8.3700	62.612
1.010	1.44	8.4117	62.924
1.015	2.14	8.4534	63.236
1.020	2.84	8.4950	63.547
1.025	3.54	8.5367	63.859
1.030	4.22	8.5784	64.171
1.035	4.90	8.6201	64.483
1.040	5.58	8.6618	64.795
1.045	6.24	8.7035	65.107
1.050	6.91	8.7452	65.419
1.055	7.56	8.7869	65.731
1.060	8.21	8.8286	66.042
1.065	8.85	8.8703	66.354
1.070	9.49	8.9120	66.666
1.075	10.12	8.9537	66.978
1.080	10.74	8.9954	67.290
1.085	11.36	9.0371	67.602
1.090	11.97	9.0787	67.914
1.095	12.58	9.1204	68.226
1.100	13.18	9.1621	68.537
1.105	13.78	9.2038	68.849
1.110	14.37	9.2455	69.161
1.115	14.96	9.2872	69.473

Sp. gr. 60°/60°	°Bé	Lb. per gal. at 60°F wt. in air	Lb. per cu. ft. at 60°F wt. in air
1.455	45.34	12.1223	90.681
1.460	45.68	12.1640	90.993
1.465	46.02	12.2057	91.305
1.470	46.36	12.2473	91.616
1.475	46.69	12.2890	91.928
1.480	47.03	12.3307	92.240
1.485	47.36	12.3724	92.552
1.490	47.68	12.4141	92.864
1.495	48.01	12.4558	93.176
1.500	48.33	12.4975	93.488
1.505	48.65	12.5392	93.800
1.510	48.97	12.5809	94.112
1.515	49.29	12.6226	94.424
1.520	49.61	12.6643	94.735
1.525	49.92	12.7060	95.047
1.530	50.23	12.7477	95.359
1.535	50.54	12.7894	95.671
1.540	50.84	12.8310	95.983
1.545	51.15	12.8727	96.295
1.550	51.45	12.9144	96.606
1.555	51.75	12.9561	96.918
1.560	52.05	12.9978	97.230
1.565	52.35	13.0395	97.542
1.570	52.64	13.0812	97.854

1.120	15.54	9.3289	60.785
1.125	16.11	9.3706	70.097
1.130	16.68	9.4123	70.409
1.135	17.25	9.4540	70.721
1.140	17.81	9.4957	71.032
1.145	18.36	9.5374	71.344
1.150	18.91	9.5790	71.656
1.155	19.46	9.6207	71.968
1.160	20.00	9.6624	72.280
1.165	20.54	9.7041	72.592
1.170	21.07	9.7458	72.904
1.175	21.60	9.7875	73.216
1.180	22.12	9.8292	73.528
1.185	22.64	9.8709	73.840
1.190	23.15	9.9126	74.151
1.195	23.66	9.9543	74.463
1.200	24.17	9.9960	74.775
1.205	24.67	10.0377	75.087
1.210	25.17	10.0793	75.399
1.215	25.66	10.1210	75.711
1.220	26.15	10.1627	76.022
1.225	26.63	10.2044	76.334

1.575	52.94	13.1229	98.166
1.580	53.23	13.1646	98.478
1.585	53.52	13.2063	98.790
1.590	53.81	13.2480	99.102
1.595	54.09	13.2897	99.414
1.600	54.38	13.3313	99.725
1.605	54.66	13.3730	100.037
1.610	54.94	13.4147	100.349
1.615	55.22	13.4564	100.661
1.620	55.49	13.4981	100.973
1.625	55.77	13.5398	101.285
1.630	56.04	13.5815	101.597
1.635	56.32	13.6232	101.909
1.640	56.59	13.6649	102.220
1.645	56.85	13.7066	102.532
1.650	57.12	13.7483	102.844
1.655	57.39	13.7900	103.156
1.660	57.65	13.8317	103.468
1.665	57.91	13.8734	103.780
1.670	58.17	13.9150	104.092
1.675	58.43	13.9567	104.404



Sp. gr. 60°/60°	°Bé	Lb. per gal. at 60°F wt. in air	Lb. per cu. ft. at 60°F wt. in air
1.230	27.11	10.2461	76.646
1.235	27.59	10.2878	76.958
1.240	28.06	10.3295	77.270
1.245	28.53	10.3712	77.582
1.250	29.00	10.4129	77.894
1.255	29.46	10.4546	78.206
1.260	29.92	10.4963	78.518
1.265	30.38	10.5380	78.830
1.270	30.83	10.5797	79.141
1.275	31.27	10.6214	79.453
1.280	31.72	10.6630	79.765
1.285	32.16	10.7047	80.077
1.290	32.60	10.7464	80.389
1.295	33.03	10.7881	80.701
1.300	33.46	10.8298	81.013
1.305	33.89	10.8715	81.325
1.310	34.31	10.9132	81.636
1.315	34.73	10.9549	81.948
1.320	35.15	10.9966	82.260
1.325	35.57	11.0383	82.572
1.330	35.98	11.0800	82.884
1.335	36.39	11.1217	83.196
1.340	36.79	11.1634	83.508
1.345	37.19	11.2051	83.820
1.350	37.59	11.2467	84.131
1.355	37.99	11.2884	84.443
1.360	38.38	11.3301	84.755

Sp. gr. 60°/60°	°Bé	Lb. per gal. at 60°F wt. in air	Lb. per cu. ft. at 60°F wt. in air
1.680	58.69	13.9984	104.715
1.685	58.95	14.0401	105.027
1.690	59.20	14.0818	105.339
1.695	59.45	14.1235	105.651
1.700	59.71	14.1652	105.963
1.705	59.96	14.2069	106.275
1.710	60.20	14.2486	106.587
1.715	60.45	14.2903	196.899
1.720	60.70	14.3320	107.210
1.725	60.94	14.3737	107.522
1.730	61.18	14.4153	107.834
1.735	61.34	14.4570	108.146
1.740	61.67	14.4987	108.458
1.745	61.91	14.5404	108.770
1.750	62.14	14.5821	109.082
1.755	62.38	14.6238	109.394
1.760	62.61	14.6655	109.705
1.765	62.85	14.7072	110.017
1.770	63.08	14.7489	110.329
1.775	63.31	14.7906	110.641
1.780	63.54	14.8323	110.953
1.785	63.77	14.8740	111.265
1.790	63.99	14.9157	111.577
1.795	64.22	14.9574	111.889
1.800	64.44	14.9990	112.200
1.805	64.67	15.0407	112.512
1.810	64.89	15.0824	112.824

1.365	38.77	11.3718	85.067
1.370	39.16	11.4135	85.379
1.375	39.55	11.4552	85.691
1.380	39.93	11.4969	86.003
1.385	40.31	11.5386	86.315
1.390	40.68	11.5803	86.626
1.395	41.06	11.6220	86.938
1.400	41.43	11.6637	87.250
1.405	41.80	11.7054	87.562
1.410	42.16	11.7471	87.874
1.415	42.53	11.7888	88.186
1.420	42.89	11.8304	88.498
1.425	43.25	11.8721	88.810
1.430	43.60	11.9138	89.121
1.435	43.95	11.9555	89.433
1.440	44.31	11.9972	89.745
1.445	44.65	12.0389	90.057
1.450	45.00	12.0806	90.369

1.815	65.11	15.1241	113.136
1.820	65.33	15.1658	113.448
1.825	65.55	15.2075	113.760
1.830	65.77	15.2492	114.072
1.835	65.98	15.2909	114.384
1.840	66.20	15.3326	114.696
1.845	66.41	15.3743	115.007
1.850	66.62	15.4160	115.318
1.855	66.83	15.4577	115.630
1.860	67.04	15.4993	115.943
1.865	67.25	15.5410	116.255
1.870	67.46	15.5827	116.567
1.875	67.67	15.6244	116.879
1.880	67.87	15.6661	117.191
1.885	68.08	15.7078	117.503
1.890	68.28	15.7495	117.814
1.895	68.48	15.7912	118.126
1.900	68.68	15.8329	118.438

Compliments of ARC - [associatedrack.com](http://associatedrack.com)

## CONCENTRATION OF REAGENTS

	HYDROCHLORIC ACID	NITRIC ACID	SULFURIC ACID	PHOSPHORIC ACID	FORMIC ACID	ACETIC ACID	AMMONIUM HYDROXIDE
Specific Gravity	1.18	1.41	1.84	1.69	1.20	1.06	0.90
Average % Acid or Base present in Concentrated Reagent	37.3%	70.0%	96.5%	85.0%	90.0%	99.7%	29.0%
Weight of Acid or Base (gms) in Solution per Liter of Reagent (average)	442	989	1772	1436	1084	1053	535
Molecular Weight	36.47	63.02	98.08	98.00	46.03	60.05	35.05
Normality of Concentrated Reagent	12	16	36	44	24	17	15
No. of ml. Reagent to Prepare One Liter 1 N Solution	83	64	28	23	42	58	66

Compliments of ARC - [associatedrack.com](http://associatedrack.com)

## COMPONENT PARTS IN PERCENT BY WEIGHT OF SALTS COMMONLY USED IN ELECTROPLATING

The following table indicates the percentages of the metal, sulfate, chloride, etc., in the commercial grades of the various chemicals most commonly used in electroplating solutions. The quantity of a chemical to be added to produce the desired increase in metal content, chloride content, etc., per gallon can be readily calculated from this table.

Ammonium Bifluoride, $\text{NH}_4\text{HF}_2$		
	$\text{NH}_4$	31.6%
Ammonium Chloride, $\text{NH}_4\text{Cl}$		
	$\text{NH}_4$	33.7%
	Cl	66.3%
Antimony Trichloride, $\text{SbCl}_3$		
	Sb	53.4%
	Cl	46.6%
Arsenic Trioxide, $\text{As}_2\text{O}_3$		
	As	75.7%
	O	24.3%

Cadmium Cyanide, $\text{Cd}(\text{CN})_2$		
	Cd	68.4%
	CN	31.6%
Cadmium, Oxide, $\text{CdO}$		
	Cd	87.5%
	O	12.5%
Cadmium Sulfate, $\text{CdSO}_4$		
	Cd	54.0%
	$\text{SO}_4$	46.0%
Chromic Acid, $\text{CrO}_3$		
	Cr	52.0%
Cobalt Sulfate, $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$		
	Co	20.9%
	$\text{SO}_4$	30.0%

Copper Carbonate, Basic $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$ , (Approximate)		
	Cu	53.5%
	$\text{CO}_3$	34.8%
Copper Cyanide, $\text{CuCN}$		
	Cu	70.9%
	CN	29.1%
Copper Fluoborate*, $\text{Cu(BF}_4)_2$		
	Cu	26.8%
Copper Pyrophosphate, $\text{Cu}_2\text{P}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$		
	Cu	35.8%
	$\text{P}_2\text{O}_7$	48.9%
Copper Sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$		
	Cu	25.4%
	$\text{SO}_4$	38.4%
Gold Chloride, $\text{AuCl}_3 \cdot 2\text{H}_2\text{O}$		
	Au	58.0%
	Cl	31.4%
Gold Potassium Cyanide, $\text{KAu(CN)}_2$		
	Gold	68.3%

Indium Chloride, $\text{InCl}_3$		
	In	51.9%
Indium Sulfate, $\text{In}_2(\text{SO}_4)_3$		
	In	66.5%
Iron Chloride, Anhyd., $\text{FeCl}_3$		
	Fe	34.4%
Iron Chloride, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$		
	Fe	20.7%
Iron (ous) Chloride, $\text{FeCl}_2 \cdot 2\text{H}_2\text{O}$		
	Fe	38.6%
Iron Sulfate, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$		
	Fe	21.7%
	$\text{SO}_4$	34.5%
Lead Fluoborate*, $\text{Pb}(\text{BF}_4)_2$		
	Pb	54.3%
Lead Sulfamate, $\text{Pb}(\text{SO}_3 \cdot \text{NH}_2)_2$		
	Pb	51.9%

Nickel Ammonium Sulfate (Double Nickel Salts) $\text{NiSO}_4(\text{NH}_4)_2 \cdot \text{SO}_4 \cdot 6\text{H}_2\text{O}$		
	Ni	14.8%
	$\text{SO}_4$	48.6%
	$\text{NH}_4$	9.1%
Nickel Carbonate, $2\text{NiCO}_3 \cdot 3\text{Ni}(\text{OH})_2 \cdot 4\text{H}_2\text{O}$		
	Ni	50.0%
	$\text{CO}_3$	10.2%
Nickel Chloride, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$		
	Ni	24.5%
	Cl	29.6%
Nickel Cyanide, $\text{Ni}(\text{CN})_2 \cdot 4\text{H}_2\text{O}$		
	Ni	32.1%
	CN	28.5%
Nickel Fluoborate*, $\text{Ni}(\text{BF}_4)_2$ ,		