



**WMIA**<sup>®</sup>

Woodworking Machinery Industry Association

2013 WOODWORKING TECHNOLOGY

# SHOP GUIDE



Brought to you by WMIA and:





## WMIA SHOP GUIDE DISCLAIMER

The following guide has been prepared based upon information received from a variety of sources which WMIA believes to be reliable. However, WMIA cannot guarantee the accuracy of the information contained therein. The user is advised to verify the information before proceeding with its application. WMIA will not accept any responsibility for damages resulting from the misapplication of the information contained in this shop guide.

# WMIA Shop Guide

---

## Table Of Contents

### Section 1

Conversion Tables .....	3
Useful Conversions .....	4
Geometric Areas and Volumes .....	6
Inches to Millimeters .....	7
Millimeters to Inches .....	8
Threads.....	11

### Section 2

Machine Service/Installation Information.....	13
Approximate Motor Full-Load Current Rating.....	14
Electrical Formulas .....	15
Electrical Systems .....	17
Hydraulics and Pneumatics .....	23
Hydraulic and Pneumatic Systems.....	29
Compressed Air Systems.....	33
Dust Collection and Extraction.....	35

### Section 3

Glossary of Terms.....	39
------------------------	----

© 2013 Woodworking Machinery Industry Association





# WMIA Shop Guide

---

## Conversion Tables

# SECTION 1



# Useful Conversions

**TO CONVERT.....MULTIPLY BY.....TO OBTAIN**

Acres.....	43,400.....	sq. ft.
acres.....	4,047.....	sq. meters
atmospheres.....	1.0333.....	kgs./sq.cm.
atmospheres.....	14.7.....	pounds/sq.in.
<b>Bars.....</b>	<b>0.9869.....</b>	<b>atmospheres</b>
bars.....	14.5.....	pounds/sq.in.
btu.....	778.16.....	foot-pounds
btu.....	1,055.....	joules
btu.....	0.252.....	kilogram-calories
btu/hr.....	0.0003929.....	horsepower
btu/hr.....	0.2931.....	watts
btu/min.....	0.02356.....	horsepower
btu/min.....	0.01757.....	kilowatts
<b>Centimeters.....</b>	<b>0.0321.....</b>	<b>feet</b>
centimeters.....	0.3937.....	inches
cubic centimeters.....	0.06102.....	cubic in.
cubic feet.....	0.02832.....	cu. meters
cubic feet.....	7.48052.....	gallons (u.s. liquid)
cubic feet.....	28.32.....	liters
cubic feet/min.....	0.4719.....	liters/sec.
cubic feet/sec.....	448.831.....	gallons/min.
cubic inches.....	0.0005787.....	cu. ft.
cubic inches.....	0.00001639.....	cu. meters
cubic inches.....	0.004329.....	gallons
cubic inches.....	0.01693.....	liters
cubic meters.....	35.31.....	cu. ft.
cubic meters.....	61.024.....	cu. inches
cubic meters.....	264.2.....	gallons (u.s. liquid)
cubic meters.....	1,000.....	liters
<b>Fathoms.....</b>	<b>1.8288.....</b>	<b>meters</b>
feet.....	0.3048.....	meters
feet.....	304.8.....	millimeters
feet/min.....	0.3048.....	meters/min.
feet/sec.....	18.288.....	meters/min.
foot-candle.....	10.764.....	lumen/sq. meter
foot-candle.....	10.764.....	lux
foot-pounds.....	0.1383.....	kg.-meter
<b>Gallons.....</b>	<b>0.1337.....</b>	<b>cu. Feet</b>
gallons.....	0.003785.....	cu. Meters
gallons.....	3.785.....	liters
grams.....	0.03215.....	ounces (troy)
grams.....	0.002205.....	pounds
grams/liter.....	0.062427.....	pounds/cu.ft.
<b>Horsepower (metric).....</b>	<b>0.9863.....</b>	<b>horsepower</b>
horsepower.....	0.7457.....	kilowatts
<b>Inches.....</b>	<b>25.4.....</b>	<b>millimeters</b>
inches of mercury.....	1.133.....	feet of water
in. of water (at 40C.).....	0.07355.....	inches of mercury
in. of water (at 40C.).....	0.00254.....	kgs./sq. cm.
in of water (at 40C.).....	5.204.....	pounds/sq. ft.
<b>Joules.....</b>	<b>0.7376.....</b>	<b>foot-ounds</b>
joules.....	0.1020.....	kg.-meters
<b>Kilograms.....</b>	<b>2.2046.....</b>	<b>pounds</b>
kilograms/cu. meter.....	0.06243.....	pounds/cu. ft.
kilograms/sq. cm.....	0.9678.....	atmospheres



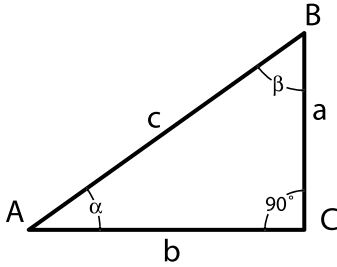


# Useful Conversions

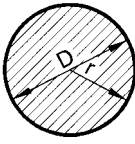
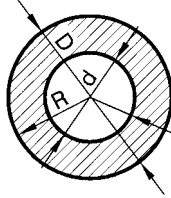
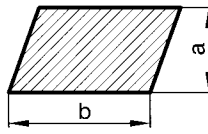
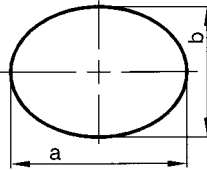
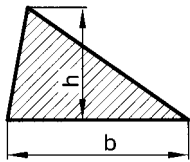
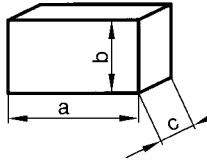
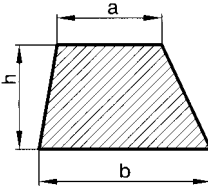
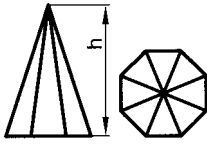
TO CONVERT.....	MULTIPLY BY.....	TO OBTAIN
kilograms/sq. cm .....	32.81 .....	feet of water
kilograms/sq. cm .....	28.96 .....	inches of mercury
kilograms/sq. cm .....	14.22 .....	pounds/sq. in.
kilogram-meters .....	7.233 .....	foot-pounds
kilometers .....	3,281 .....	feet
kilometers .....	0.6214 .....	miles (statute)
kilometers/hr.....	0.6214 .....	miles/hr.
kilowatts .....	1.341 .....	horsepower
Liters .....	0.03531 .....	cu. ft.
liters.....	0.001 .....	cu. meters
liters.....	0.2642 .....	gallons (u.s. liquid)
Meters .....	3.281 .....	feet
meters .....	39.37 .....	inches
meters .....	1.094 .....	yards
meters/min .....	1.667 .....	cms./sec.
meters/min .....	3.281 .....	feet/min.
meters/min .....	0.05468 .....	feet/sec.
meters/sec .....	3.281 .....	feet/sec.
meters/sec./sec.....	3.281 .....	ft./sec./sec.
meter-kilograms .....	7.233 .....	pound-feet
miles (statute).....	1.6093 .....	kilometers
miles/hr .....	1.6093 .....	kms./hr.
millimeters .....	0.003281 .....	feet
millimeters .....	0.03937 .....	inches
Ohms .....	0.000001 .....	megohms
ohms .....	1,000,000 .....	microhms
ounces .....	0.0625 .....	pounds
Pints (liquid) .....	0.125 .....	gallons
pints (liquid) .....	0.4732 .....	liters
pounds.....	453.59 .....	grams
pounds-feet .....	0.1383 .....	meter-kgs.
pounds/sq. in. ....	27.684 .....	in. of water
pounds/sq. in. ....	0.06894 .....	bar
Radians .....	57.296 .....	degrees
radians .....	3,438 .....	minutes
reams .....	500 .....	sheets
revolutions/min .....	0.1047 .....	radians/sec.
Square centimeters .....	0.0001 .....	sq. meters
square feet .....	144 .....	sq. inches
square feet .....	0.0929 .....	sq. meters
square feet .....	0.0000003587 .....	sq. miles
square inches .....	0.006944 .....	sq. ft.
square inches .....	645.2 .....	sq. millimeters
square meters .....	10,000 .....	q. cms.
square meters .....	10.76 .....	sq. ft.
square meters .....	1.196 .....	sq. yards
square yards .....	0.0002066 .....	acres
Temperature °F .....	5/9 after subtracting 32 .....	temp. °C
temperature °C .....	1.8 then add 32 .....	temp. °F
tons (metric) .....	1,000 .....	kilograms
tons (metric) .....	2,205 .....	pounds
Watts .....	3.4129 .....	btu/hr.
watts.....	0.001341 .....	horsepower
watts.....	0.00136 .....	horsepower (metric)
Yards.....	0.9144 .....	meters



## Geometric Areas and Volumes



- (1)  $a^2 + b^2 = c^2$ ,      (2)  $\alpha + \beta = 90^\circ$ ,  
 (3)  $\sin \alpha = \frac{a}{c} = \cos \beta$     (4)  $\cos \alpha = \frac{b}{c} = \sin \beta$ ,  
 (5)  $\tan \alpha = \frac{a}{b} = \cot \beta$ ,    (6)  $\cot \alpha = \frac{b}{a} = \tan \beta$ .

 <p><b>Circle</b>          A = area          C = circumference  <math>A = \pi r^2 = \frac{\pi D^2}{4}</math>  <math>C = 2\pi r = \pi D</math></p>	 <p><b>Circle Ring</b>          A = area          C = circumference  <math>A = \pi (R^2 - r^2)</math>  <math>= 0.7854 (D^2 - d^2)</math></p>
 <p><b>Parallelogram</b>          A = area  <math>C = ab</math>          Note that dimension <i>a</i> is measured at right angles to line <i>b</i>.</p>	 <p><b>Ellipse</b>  <i>a</i> = major axis  <i>b</i> = minor axis  <math>A = \frac{\pi ab}{4}</math></p>
 <p><b>Triangle</b>          A = area  <math>A = \frac{bh}{2}</math></p>	 <p><b>Square Prism</b>          V = volume          A = area of surface  <math>V = abc</math>  <math>A = 2ab + 2ac + 2bc</math></p>
 <p><b>Trapezoid</b>          A = area  <math>A = \frac{(a+b)h}{2}</math></p>	 <p><b>Pyramid</b>          V = volume  <math>V = \frac{1}{3}h \times \text{area of base.}</math></p>





## From Inches to Millimeters

inch	decimal	mm	inch	decimal	mm
0	0	0	1/2	0.5	12.7
1/64	0.015625	0.396875	33/64	0.515625	13.096875
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.190625	35/64	0.546875	13.890625
1/16	0.0625	1.5875	9/16	0.5625	14.2875
5/64	0.078125	1.984375	37/64	0.578125	14.684375
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.778125	39/64	0.609375	15.478125
1/8	0.125	3.175	5/8	0.625	15.875
9/64	0.140625	3.571875	41/64	0.640625	16.271875
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.365625	43/64	0.671875	17.065625
3/16	0.1875	4.7625	11/16	0.6875	17.4625
13/64	0.203125	5.159375	45/64	0.703125	17.859375
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.953125	47/64	0.734375	18.653125
1/4	0.25	6.35	3/4	0.75	19.05
17/64	0.265625	6.746875	49/64	0.765625	19.446875
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.540625	51/64	0.796875	20.240625
5/16	0.3125	7.9375	13/16	0.8125	20.6375
21/64	0.328125	8.334375	53/64	0.828125	21.034375
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.128125	55/64	0.859375	21.828125
3/8	0.375	9.525	7/8	0.875	22.225
25/64	0.390625	9.921875	57/64	0.890625	22.621875
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.715625	59/64	0.921875	23.415625
7/16	0.4375	11.1125	15/16	0.9375	23.8125
29/64	0.453125	11.509375	61/64	0.953125	24.209375
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.303125	63/64	0.984375	25.003125



## From Millimeters to Inches

mm	inch	mm	inch	mm	inch
0.1	0.00394	26	1.02362	160	6.29921
0.2	0.00787	27	1.06299	170	6.69291
0.3	0.01181	28	1.10236	180	7.08661
0.4	0.01575	29	1.14173	190	7.48031
0.5	0.01969	30	1.18110	200	7.87402
0.6	0.02362	31	1.22047	210	8.26772
0.7	0.02756	32	1.25984	220	8.66142
0.8	0.03150	33	1.29921	230	9.05512
0.9	0.03543	34	1.33858	240	9.44882
1	0.03937	35	1.37795	250	9.84252
2	0.07874	36	1.41732	260	10.23622
3	0.11811	37	1.45669	270	10.62992
4	0.15748	38	1.49606	280	11.02362
5	0.19685	39	1.53543	290	11.41732
6	0.23622	40	1.57480	300	11.81102
7	0.27559	41	1.61417	310	12.20472
8	0.31496	42	1.65354	320	12.59843
9	0.35433	43	1.69291	330	12.99213
10	0.39370	44	1.73228	340	13.38583
11	0.43307	45	1.77165	350	13.77953
12	0.47244	46	1.81102	360	14.17323
13	0.51181	47	1.85039	370	14.56693
14	0.55118	48	1.88976	380	14.96063
15	0.59055	49	1.92913	390	15.35433
16	0.62992	50	1.96850	400	15.74803
17	0.66929	60	2.36220	410	16.14173
18	0.70866	70	2.75591	420	16.53543
19	0.74803	80	3.14961	430	16.92913
20	0.78740	90	3.54331	440	17.32283
21	0.82677	100	3.93701	450	17.71654
22	0.86614	110	4.33071	460	18.11024
23	0.90551	120	4.72441	470	18.50394
24	0.94488	130	5.11811	480	18.89764
25	0.98425	140	5.51181	490	19.29134





# Wood Cutting Tool Normal Operating Standards

## Rim Speed (V): in ft./sec.

Materials	TCT Cutters	TCT Saw Blades
Softwood — along grain	190–250	230–310
Softwood — across grain	160–260	230–290
Hardwoods	180–240	220–280
Chipboards	200–260	220–280
Laminated boards	180–240	200–260
Plastic materials	140–200	160–240
Light metals	80–140	160–200

## Tooth/Knife Progression (Sz):

### Circular (TCT) Saw Blades:

Softwood — along grain	0.008 > 0.035"
Softwood — across grain	0.004 > 0.008"
Hardwoods	0.003 > 0.006"
Chipboards	0.004 > 0.010"
Laminated boards	0.002 > 0.006"
Plastic materials	0.003 > 0.008"
Light metals	0.001 > 0.004"

### Shaper/Moulder/Tenoner ( TCT )Cutters:

Fine Chip	0.010 > 0.025"
Medium Chip	0.025 > 0.065"
Coarse Chip	0.065 > 0.130"

## Router Tool Operating Standards:

**RPM (N) ranges from 14,000 to 24,000**

**Tool diameters range from 1/8" to 3"**

**Tooth/Knife Progress varies by tool diameter;**

1/8" to 3/8"	0.0015" to 0.003"
3/8" to 3/4"	0.003" to 0.007"
3/4" to 1-1/4"	0.008" to 0.012"
1-1/4" to 2"	0.012" to 0.016"
Over 2"	0.016" to 0.020"

## Drill and Boring Bits

### RPM—Ranges:

Large diameter drills	500 > 1500
Medium diameter drills	1500 > 2500
Small diameter drills	2500 > 8000

### Feed Rates—progress per revolution:

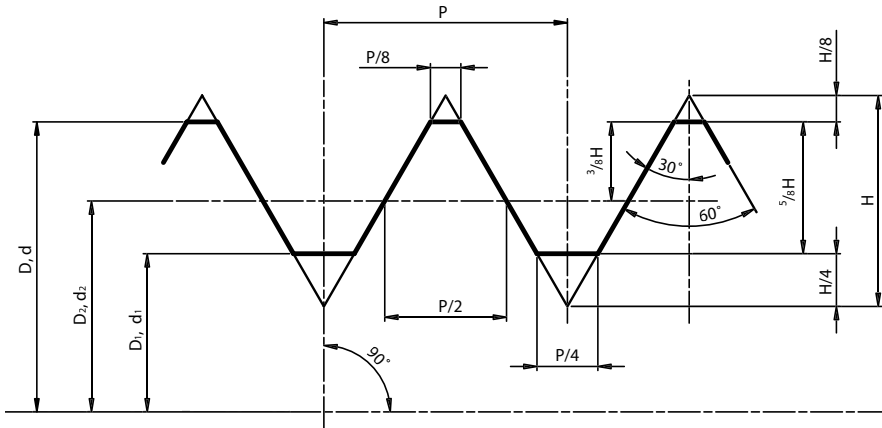
Large diameter drills	0.008" > 0.015"
Small diameter drills	0.001" > 0.007"



## Decimal Equivalents (Letter Size Drills)

Letter	Size of Drill in Inches	Letter	Size of Drill in Inches
A	.234	N	.302
B	.238	O	.316
C	.242	P	.323
D	.246	Q	.332
E	.250	R	.339
F	.257	S	.348
G	.261	T	.358
H	.266	U	.368
I	.272	V	.377
J	.277	W	.386
K	.281	X	.397
L	.290	Y	.404
M	.295	Z	.413

## ISO General Purpose Metric Screw Thread BASIC PROFILE



P = pitch  
 D = major diameter of internal thread  
 d = major diameter of external thread  
 D1 = minor diameter of internal thread

d1 = minor diameter of external thread  
 D2 = pitch diameter of internal thread  
 d2 = pitch diameter of external thread  
 H = height of fundamental triangle





## ISO Metric Threads (Regular Pitch)

In accordance with the ISO International Standard, a regular pitch metric thread is designated by the letter **M** followed by the nominal diameter (major diameter) in mm. Example: **M 8**

Most commonly used sizes (all dimensions are in millimeters)

Bolt Threads				Nominal Size		Nut Threads			
Major Diameter		Pitch Diameter		1st Choice Progression		Pitch Diameter		Minor Diameter	
max	min	max	min	Designation	Pitch	max	min	max	min
1.000	0.933	0.838	0.785	<b>M 1</b>	0.25	0.894	0.838	0.785	0.729
1.200	1.133	1.038	0.985	<b>M 1,2</b>	0.25	1.094	1.038	0.985	0.929
1.581	1.496	1.354	1.291	<b>M 1,6</b>	0.35	1.458	1.373	1.321	1.221
1.981	1.886	1.721	1.654	<b>M 2</b>	0.40	1.830	1.740	1.679	1.567
2.480	2.380	2.188	2.117	<b>M 2,5</b>	0.45	2.303	2.208	2.138	2.013
2.980	2.874	2.655	2.580	<b>M 3</b>	0.50	2.775	2.675	2.599	2.459
3.978	3.838	3.523	3.433	<b>M 4</b>	0.70	3.663	3.545	3.422	3.242
4.976	4.826	4.456	4.361	<b>M 5</b>	0.80	4.605	4.480	4.334	4.134
5.974	5.794	5.324	5.212	<b>M 6</b>	1.00	5.500	5.350	5.153	4.917
7.972	7.760	7.160	7.042	<b>M 8</b>	1.25	7.348	7.188	6.912	6.647
9.968	9.732	8.994	8.862	<b>M 10</b>	1.50	9.206	9.026	8.676	8.376
11.966	11.701	10.829	10.679	<b>M 12</b>	1.75	11.063	10.863	10.441	10.106
15.962	15.682	14.663	14.503	<b>M 16</b>	2.00	14.913	14.701	14.210	13.835
19.958	19.623	18.334	18.164	<b>M 20</b>	2.50	18.600	18.376	17.744	17.294
23.952	23.577	22.003	21.803	<b>M 24</b>	3.00	22.316	22.051	21.252	20.752
29.947	29.522	27.674	27.462	<b>M 30</b>	3.50	28.007	27.727	26.771	26.211
35.940	35.465	33.342	33.118	<b>M 36</b>	4.00	33.702	33.402	32.270	31.670

## ISO Metric Threads (Fine Pitch)

In accordance with the ISO International Standard, a fine pitch metric thread is designated by the letter **M** followed by the nominal diameter (major diameter) in mm and by the pitch in mm, separated by the sign **x**. Example: **M 8 x 1**

Most commonly used sizes (all dimensions are in millimeters)

Bolt Threads				Nominal Size		Nut Threads			
Major Diameter		Pitch Diameter		1st Choice Progression		Pitch Diameter		Minor Diameter	
max	min	max	min	Designation	Pitch	max	min	max	min
7.974	7.794	7.324	7.212	<b>M 8 x 1</b>	1.00	7.500	7.350	7.153	6.917
9.972	9.760	9.160	9.042	<b>M 10 x 1,25</b>	1.25	9.348	9.188	8.912	8.647
11.972	11.760	11.160	11.028	<b>M 12 x 1,25</b>	1.25	11.368	11.188	10.912	10.647
15.968	15.732	14.994	14.854	<b>M 16 x 1,5</b>	1.50	15.216	15.026	14.676	14.376
19.968	19.732	18.994	18.854	<b>M 20 x 1,5</b>	1.50	19.216	19.026	18.676	18.375
23.962	23.682	22.663	22.493	<b>M 24 x 2</b>	2.00	22.925	22.701	22.210	21.835
29.962	29.682	28.663	28.493	<b>M 30 x 2</b>	2.00	28.925	28.701	28.210	27.835
35.952	35.577	34.003	33.803	<b>M 36 x 3</b>	3.00	34.316	34.051	33.252	32.752



# ISO Metric Threads

Approximate Imperial Dimensions of Metric Threads (Regular Pitch)

Nominal Size		Approx. Inches Dimensions				
1st Choice Progression		Threads per Inch count	Major Diameter		Minor Diameter	
Designation	Pitch		max	min	max	min
<b>M 3</b>	0.50	50.8	0.117	0.113	0.102	0.097
<b>M 4</b>	0.70	36.3	0.157	0.151	0.135	0.128
<b>M 5</b>	0.80	31.8	0.196	0.190	0.171	0.163
<b>M 6</b>	1.00	25.4	0.235	0.228	0.203	0.194
<b>M 8</b>	1.25	20.3	0.314	0.306	0.272	0.262
<b>M 10</b>	1.50	16.9	0.392	0.383	0.342	0.330
<b>M 12</b>	1.75	14.5	0.471	0.461	0.411	0.398
<b>M 16</b>	2.00	12.7	0.628	0.617	0.559	0.545
<b>M 20</b>	2.50	10.2	0.786	0.773	0.699	0.681
<b>M 24</b>	3.00	8.5	0.943	0.928	0.837	0.817
<b>M 30</b>	3.50	7.3	1.179	1.162	1.054	1.032
<b>M 36</b>	4.00	6.4	1.415	1.396	1.270	1.247

Approximate Imperial Dimensions of Metric Threads (Fine Pitch)

Nominal Size		Approx. Inches Dimensions				
1st Choice Progression		Threads per Inch count	Major Diameter		Minor Diameter	
Designation	Pitch		max	min	max	min
<b>M 8 x 1</b>	1.00	25.4	0.314	0.307	0.282	0.272
<b>M 10 x 1,25</b>	1.25	20.3	0.393	0.384	0.351	0.340
<b>M 12 x 1,25</b>	1.25	20.3	0.471	0.463	0.430	0.419
<b>M 16 x 1,5</b>	1.50	16.9	0.629	0.619	0.578	0.566
<b>M 20 x 1,5</b>	1.50	16.9	0.786	0.777	0.735	0.723
<b>M 24 x 2</b>	2.00	12.7	0.943	0.932	0.874	0.860
<b>M 30 x 2</b>	2.00	12.7	1.180	1.169	1.111	1.096
<b>M 36 x 3</b>	3.00	8.5	1.415	1.401	1.309	1.289

Recommended Tightening Torques for Class 8.8 Bolts and Nuts (Regular Pitch)

Nominal Size		Tightening Torques				
1st Choice Progression		Wrench Opening	Black Untreated		Zinc Plated	
Designation	Pitch		Nm	ft lb.	Nm	ft lb.
<b>M 3</b>	0.50	5.5	1.37	1.01	1.28	0.94
<b>M 4</b>	0.70	7.0	3.1	2.29	2.9	2.14
<b>M 5</b>	0.80	8.0	6.15	4.54	5.75	4.24
<b>M 6</b>	1.00	10.0	10.5	7.7	9.9	7.3
<b>M 8</b>	1.25	13.0	26.0	19.0	24.0	17.7
<b>M 10</b>	1.50	17.0	51.0	37.0	48.0	35.0
<b>M 12</b>	1.75	19.0	89.0	65.0	83.0	61.0
<b>M 16</b>	2.00	24.0	215.0	158.0	200.0	147.0
<b>M 20</b>	2.50	30.0	420.0	309.0	390.0	287.0
<b>M 24</b>	3.00	36.0	725.0	534.0	675.0	497.0
<b>M 30</b>	3.50	46.0	1450.0	1069.0	1350.0	995.0
<b>M 36</b>	4.00	55.0	2530.0	1865.0	2360.0	1740.0

Recommended Tightening Torques for Class 8.8 Bolts and Nuts (Fine Pitch)

Nominal Size		Tightening Torques				
1st Choice Progression		Wrench Opening	Black Untreated		Zinc Plated	
Designation	Pitch		Nm	ft lb.	Nm	ft lb.
<b>M 8 x 1</b>	1.00	13	27	19	25	18
<b>M 10 x 1,25</b>	1.25	17	52	38	49	36
<b>M 12 x 1,25</b>	1.25	19	95	70	88	64
<b>M 16 x 1,5</b>	1.50	24	225	165	210	154
<b>M 20 x 1,5</b>	1.50	30	460	339	425	313
<b>M 24 x 2</b>	2.00	36	780	575	720	531





# WMIA Shop Guide

## Machine Service/ Installation Information

# SECTION 2



# Approximate Motor Full-Load Current Rating

Ampères

**Three Phase Induction Motors**  
60 cycles  
full load current

HP	RPM	230V	460V	575V
1/4	1800	.96	.48	.38
1/3	1800	1.16	.58	.47
1/2	1800	1.68	.84	.67
3/4	1800	2.33	1.17	.93
1	3600	2.75	1.38	1.10
	1800	3.05	1.53	1.22
1-1/2	3600	4.17	2.09	1.67
	1800	4.28	2.14	1.71
2	3600	5.56	2.78	2.22
	1800	5.76	2.88	2.30
3	3600	7.87	3.94	3.14
	1800	8.29	4.14	3.32
5	3600	12.7	6.34	5.08
	1800	13.2	6.60	5.28
7-1/2	3600	19.2	9.6	7.68
	1800	19.3	9.7	7.72
10	3600	24.5	12.3	9.8
	1800	25.2	12.6	10.1
15	3600	36.7	18.4	14.7
	1800	50.5	25.3	20.2
25	3600	59.2	29.6	23.6
	1800	62.7	31.3	25.0
30	1800	72.8	36.4	29.2
	1200	77.1	38.6	30.8
40	1800	98	49.0	39.2
	1200	99	49.5	39.6
50	1800	121	60.5	48.4
	1200	122	61.0	48.8
60	1800	143	71.5	57.2
	1200	148	74.0	59.2
75	1800	178	89.0	71.2
	1200	181	90.5	72.4
100	1800	233	116	93.2
	1200	239	120	95.6
125	1800	289	144	115
	1200	298	149	119
150	1800	346	173	138
	1200	350	175	140
200	1800	460	230	184
	1200	466	233	186
250	1800	572	286	229
	1200	580	290	232
300	1800	685	343	274
	1200	696	348	278

**Single Phase Induction Motors**  
60 cycles  
full load current

HP	RPM	115V	230V
1/8	3600	2.52	1.26
	1800	2.80	1.40
1/6	3600	2.88	1.44
	1800	3.20	1.60
1/4	3600	4.00	2.00
	1800	4.60	2.30
1/3	3600	4.70	2.35
	1800	5.20	2.60
1/2	3600	6.50	3.25
	1800	7.40	3.70
3/4	3600	9.05	4.52
	1800	10.20	5.10
1	3600	11.70	5.85
	1800	13.00	6.50
1-1/2	3600	17.80	8.90
	1800	18.40	9.20
2	3600	23.00	11.50
	1800	24.00	12.00
3	3600	32.30	16.15
	1800	34.00	17.00
5	3600	54.00	27.00
	1800	56.00	28.00
7-1/2	3600	79.20	39.60
	1800	80.00	40.00
10	3600	97.50	48.75
	1800	100.00	50.00



# Electrical Formulas

Amperes, Horsepower, Kilowatts and KVA

To find Kilowatts	Single phase $\frac{I \times E \times PF}{1000}$	Three phase $\frac{I \times E \times 1.73 \times PF}{1000}$	Direct current $\frac{I \times E}{1000}$
KVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$	–
Horsepower	$\frac{I \times E \times \% \text{ Eff} \times PF}{746}$	$\frac{I \times E \times 1.73 \times \% \text{ Eff} \times PF}{746}$	$\frac{I \times E \times \% \text{ Eff}}{746}$
Amperes when Horsepower is known	$\frac{HP \times 746}{E \times \% \text{ Eff} \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \% \text{ Eff} \times PF}$	$\frac{HP \times 746}{E \times \% \text{ Eff}}$
Amperes when Kilowatts is known	$\frac{kW \times 1000}{E \times PF}$	$\frac{kW \times 1000}{1.73 \times E \times PF}$	$\frac{kW \times 1000}{E}$
Amperes when KVA is known	$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$	
E=Volts	I = Amperes	% Eff = Per cent efficiency	PF = Power factor

Amperage = $\frac{\text{Wattage (W)}}{\text{Voltage (V)}}$	Amperage (AMP) x Resistance (Ω) = Voltage
--	---

## Average efficiency and power factor values of motors:

When the actual efficiencies and power factors of the motors to be controlled are not known, the following approximations may be used.

Efficiencies:

- DC motors, 35 horsepower and less .....80% to 85%
- DC motors, above 35 horsepower .....85% to 90%
- Synchronous motors (at 100% Power factor) .....92% to 95%

“Apparent” efficiencies (= Efficiency x Power factor):

- Three phase induction motors, 25 horsepower and less .....70%
  - Three phase induction motors, above 25 horsepower .....80%
- These figures may be decreased slightly for single phase induction motors.

## Variations of Ohm’s Law

**Volts**

Volts = Amperes X Ohms

$$\text{Volts} = \frac{\text{Watts}}{\text{Amperes}}$$

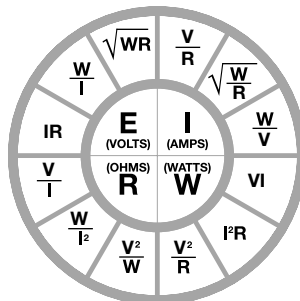
$$\text{Volts} = \sqrt{\text{Watts} \times \text{Ohms}}$$

**Ohms**

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$\text{Ohms} = \frac{\text{Watts}}{\text{Amperes}^2}$$

$$\text{Ohms} = \frac{\text{Volts}^2}{\text{Watts}}$$



**Amperes**

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Amperes} = \sqrt{\frac{\text{Watts}}{\text{Ohms}}}$$

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

**Watts**

$$\text{Watts} = \frac{\text{Volts}^2}{\text{Ohms}}$$

$$\text{Watts} = \text{Amperes}^2 \times \text{Ohms}$$

$$\text{Watts} = \text{Volts} \times \text{Amperes}$$

**Wattage varies directly as ratio of voltages squared**

$$W_2 = W_1 \times \left(\frac{V_2}{V_1}\right)^2$$

$$3 \text{ Phase Amperes} = \frac{\text{Total Watts}}{\text{Volts} \times 1.7321}$$



## Useful Motor Formulas

### **Nominal Input Power**

The nominal power of an electric motor is that given to the shaft at nominal voltage and frequency in continuous duty (S1). The unit of power is kW or HP and they are related as follows:

$$1 \text{ HP} = 0.736 \text{ kW (at 50Hz)}$$

$$1 \text{ HP} = 0.746 \text{ kW (at 60Hz)}$$

### **Continuous Duty S1**

Constant load running with life at least sufficient to reach the thermic equilibrium. Running with a continuous overload is not scheduled in the specifications. With correct voltage and frequency an overload capacity of 106% (min.) of the nominal torque for 2 minutes is permitted. If the overload is higher then the time must be reduced proportionally.

### **Voltage and Supply Frequency**

CEI 2-3 and IEC 34-1 specifications allow a nominal voltage change of  $\pm 5\%$  and a max. temperature rise of  $10^\circ\text{C}$  higher than the permissible values of the different insulation classes.

The motors wound at 50 Hz for a certain voltage, can be used without modifications at 60 Hz but the characteristics will change in accordance with the example in the table below.

		<i>Voltage</i>	<i>Power</i>	<i>Power</i>	<i>Current</i>	<i>RPM</i>
At	50 Hz	380 V	11 kW	15 HP	23 A	1450
Conversion ratios		–	1.15	1.15	1.0	1.20
At	60 Hz	440 V	12.7 kW	17.3 HP	23 A	1740











Note: A motor wound for use at 60 Hz cannot be used at 50 Hz. The current increase can damage the motor and become a fire hazard.







## International Schematics (Electric/Electronic Systems)

NR NO NO NO	SYMBOL SYMBOL SIMBOLO SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
1		F	FUSE	FUSIBILE	SCHMELZSICHERUNG	FUSIBLE	FUSIBLE
2		L	INDUCTANCE (COIL)	INDUTTANZA (BOBINA)	INDUKTIVITÄT (SPULE)	INDUCTIVIDAD (BOBINA)	INDUCTANCE (BOBINE)
3		L	INDUCTANCE WITH IRON CORE	INDUTTANZA CON NUCLEO IN FERRO	INDUKTIVITÄT MIT EISENKERN	INDUCTIVIDAD CON NUCLEO DE HIERRO	INDUCTANCE A NOYAU DE FER
4		F	BIMETAL TRIGGER	RELÈ TERMICO TRIFASE	BIMETALLAUSLOSER	DISPARADOR DE BIMETAL	DECLENCHEUR BIMETALLIQUE
5		F	AUTOMATIC CIRCUIT-BREAKER	INTERRUTTORE AUTOMATICO MAGNETOTERMICO UNIPOLARE	SICHERUNGS- AUTOMAT	FUSIBLE AUTOMATICO	COUPE-CIRCUIT AUTOMATIQUE
6		O	MOTOR PROTECTING SWITCH WITH BIMETAL AND INSTANTANEOUS TRIGGER	INTERRUTTORE AUTOMATICO MAGNETOTERMICO TRIPOLARE (SALVAMOTRE)	MOTORSCHUTZ- SCHALTER MIT BIMETALL- UND SCHNELLAUSLOSER	DISYUNTOR PROTECTOR DEL MOTOR CON DISPARADOR DE BIMETALY DE ACCION INSTANTANEA	DISJONCTEUR DE PROTECTION DE MOTEUR INCL. DECLENCHEUR BIMETALLIQUE E A ACTION INSTANTANEE
7		M	DC-MOTOR	MOTORE IN CORRENTE CONTINUA	GLEICHSTROM- MOTOR	MOTOR DE CORRIENTE CONTINUA	MOTEUR A COURANT CONTINU
8		M	THREE-PHASE CURRENT MOTOR	MOTORE ASINCRONO TRIFASE	DREHSTROMMOTOR	MOTOR DE CORRIENTE TRIFASICA	MOTEUR TRIPHASE
9		G	3-POLE GENERATOR	GENERATORE TRIFASE	GENERATOR 3-POLIG	GENERADOR DE 3 POLOS	GENERATEUR A 3 POLES
10		M	SINGLE-PHASE MOTOR	MOTORE MONOFASE	EINPHASENMOTOR	MOTOR MONOFASICO	MOTEUR MONOPHASE





## International Schematics (Electric/Electronic Systems)

NR NO NO	SYMBOL SYMBOL SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
11		M	THREE-PHASE MOTOR (STAR-DELTA)	MOTORE TRIFASE (STELLA TRIANGOLO)	DREIPHASENMOTOR (STERN-DREIECK)	MOTOR TRIFASICO (ESTRELLA-TRIANGULO)	MOTEUR TRIPHASE (ETOILE-TRIANGLE)
12		M	THREE-PHASE GENERATOR (STAR DELTA)	GENERATORE TRIFASE (STELLA TRIANGOLO)	DREIPHASEN-GENERATOR (STERN-DREIECK)	GENERADOR TRIFASICO (ESTRELLA-TRIANGULO)	GENERATEUR TRIPHASE (ETOILE-TRIANGLE)
13		T	THREE-PHASE TRANSFORMER	TRASFORMATORE TRIFASE	DREHSTROMTRANSFORMATOR	TRANSFORMADOR DE CORRIENTE TRIFASICA	TRANSFORMATEUR TRIPHASE
14		K	POWER CONTACTOR	CONTATTORE DI POTENZA	LEISTUNGSSCHOTZ	CONTACTOR DE POTENCIA	CONTACTEUR DE PUISSANCE
15		X	PRIMARY CURRENT TERMINAL BLOCK	MORSETTIERA (PRINCIPALE)	HAUPTSTROM REIHENKLEMME	CORRIENTE PRINCIPAL BORNE EN SERIE	COURANT PRINCIPAL BARRETTE A BORNES
16		X	CONTROL CURRENT TERMINAL BLOCK	MORSETTO (DI SEGNALE)	STEUERSTROM REIHENKLEMME	CORRIENTE DE MANDO BORNE EN SERIE	COURANT DE COMMANDE BARRETTE A BORNES
17		X	CONTROL CURRENT TERMINAL BLOCK (FOR OPERATING PANEL)	MORSETTO (DI SEGNALE) PER PANNELLO OPERATORE	STEUERSTROM REIHENKLEMME (FUR BEDIENFELD)	CORRIENTE DE MANDO BORNE EN SERIE (PARA PANEL DE MANDO)	COURANTE DE COMMANDE BARRETTE A BORNES (POUR PANNELAU DE COMMANDE)
18		X	CONTROL CURRENT TERMINAL BLOCK (CORRESPONDING)	MORSETTO (CORRISPONDENTE)	STEUERSTROM REIHENKLEMME (KORRESPONDIEREND)	CORRIENTE DE MANDO BORNE EN SERIE (CORRESPONDIENDO)	COURANT DE COMMANDE BARRETTE A BORNES (CORRESPONDANTE)
19		X	CONTROL CURRENT TERMINAL	MORSETTO TERMINALE	STEUERSTROM STUTZPUNKIKLEMME	CORRIENTE DE MANDO BORNE DE SOPORTE	COURANT DE COMMANDE BORNE DE POINT DE REPRISE
20		O (S)	REVERSING SWITCH	INTERRUTTORE D'INVERSIONE	WENDESCHALTER	INTERRUPTOR INVERSOR	COMBINA TEUR D'INVERSION





## International Schematics (Electric/Electronic Systems)

NR NO NO NO	SYMBOL SYMBOL SYMBOLE SYMBOLE		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
21		0	DISCONNECTOR	SEZIONATORE TRIFASE	TRENNSCHALTER	SECCIONADOR	INTERRUPTEUR SEPARATEUR
22		0	STAR-DELTA SWITCH WITH POSITION "0"	COMMUTATORE STELLA-TRIANGOLO CON POSIZIONE DI ZERO	STERN-DREIECK-SCHALTER MIT 0-STELLUNG	INTERRUPTOR DE ESTRELLA-TRIANGULO CON POSICION "0"	COMMUTEUR ETIOLE-TRIANGLE AVEC POSITION ZERO
23			CONTROL TRANSFORMER	TRASFORMATORE DI COMANDO	STEUERTRANSFORMATOR	TRANSFORMADOR DE MANDO	TRANSFORMATEUR DE COMMANDE
24		T	THREE-PHASE CURRENT AUTOTRANSFORMER Y-CONNECTION	AUTOTRASFORMATORE TRIFASE A STELLA	DREHSTROMSPARTRANSFORMATOR Y-SCHALTUNG	AUTOTRANSFORMADOR DE CORRIENTE TRIFASICA CONEXION EN Y	AUTOTRANSFORMATEUR TRIPHASE MONTAGE EN Y
25		Y	MAGNETIC CLUTCH WITH RC ELEMENT	FRIZIONE ELETTRO-MAGNETICA CON ELEMENTO RC	MAGNETKUPPLUNG MIT RC-GLIED	ACOPLAMIENTO MAGNETICO CON MODULO RC	PRISE MAGNETIQUE INCL. MODULE RC
26			MAGNETIC BRAKE WITH RC ELEMENT	FRENO ELETTRO-MAGNETICO CON ELEMENTO RC	MAGNETBREMSE MIT RC-GLIED	FRENO MAGNETICO CON MODULO RC	FREIN MAGNETIQUE INCL. MODULE RC
27			PLUGS AND SOCKETS 4-FOLD	CONNETTORE QUADRIPOLARE	STECKVERBINDUNG 4-FACH	UNION ENCHUFABLE CUADRIPLO	CONNECTEUR QUADRUPLE
28		S (K)	NORMALLY CLOSED CONTACT	CONTATTO NORMALMENTE CHIUSO (NC)	OFFNER	CONTACTO DE REPOSO	CONTACT DE REPOS
29		S (K)	NORMALLY OPEN CONTACT	CONTATTO NORMALMENTE APERTO (NA)	SCHLIESSER	CONTACTO DE TRABAJO	CONTACT DE TRAVAIL
30		S (K)	DELAYED CONTACT (ADJUSTABLE)	CONTATTO TEMPORIZZATO (REGOLABILE)	KONTAKTVERZÖGERUNG (EINSTELLBAR)	RETARDO DE CONTACTO (ADJUSTABLE)	TEMPORISATION DE CONTACT (REGLABLE)









## International Schematics (Electric/Electronic Systems)

NR NO NO	SYMBOL SYMBOL SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
31		F	BIMETAL RELAY (AUXILIARY CONTACT)	CONTATTO AUSILIARIO DI RELE TERMICO	BIMETALLRELAIS (HILFSKONTAKT)	RELE DE BIMETAL (CONTACT AUXILIAIRE)	RELAIS THERMIQUE (CONTACT AUXILIAIRE)
32		A	CHANGEOVER CONTACT	COMMUTATORE	UMSCHALTER	CONMUTADOR	INVERSEUR
33		A	NORMALLY CLOSED CONTACT, LAGGING	CONTATTO NORMALMENTE CHIUSO RITARDATO	OFFNER, NACHEILENO	CONTACTO DE REPOSO, RETARDADO	CONTACT DE REPOS EN RETARD
34		A	NORMALLY OPEN CONTACT, LEADING	CONTATTO NORMALMENTE APERTO ANTICIPATO	SCHLIESSER, VOREILENO	CONTACTO DE TRABAJO ADELANTADO	CONTACT DE TRAVAIL EN AVANCE
35		Y	SOLENOID VALVE WITH RC ELEMENT OR SUPPRESSOR DIODE	ELETTRIVALVOLA CON MODULO RC O DIODO SOPPRESSORE DI INSERZIONE	MAGNETVENTIL MIT RC-GLIED ODER LOSCHDIODE	VALVULA MAGNETICA CON MODULO RC O DIODO SUPRESOR	ELECTROVANNE INCL. MODULE RC OU DIODE D'EXTINCTION
36		K	ON-DELAY RELAY, ELECTRO- MECHANICAL WITH RC ELEMENT	RELÈ ELETTRO- MECCANICO RITARDATO CON MODULO RC	ZEITRELAIS ELECTROMECHANISCH ANZUGVERZOGERT MIT RC-GLIED	RELE TEMPORIZADOR ELECTRO- MECANICO, DE CIERRE RETARDADO CON MODULO RC	RELAIS DE TEMPORISATION ELECTRO- MECANIQUE A ACTIONNEMENT RETARDE INCL. MODUL RC
37		R	POTENTIOMETER	POTENZIOMETRO	POTENTIOMETER	POTENCIO-METRO	POTENTIOMETRE
38		P	COUNTING MECHANISM	CONTATORE (SIMBOLO GENERALE)	ZAEHLWERK	MECANISIMO CONTADOR	COMPTEUR
39		H	HORN	TROMBA	HUPE	BOCINA	AVERTISSEUR
40		H	LAMP	LAMPADA	LAMPE	LAMPARA	LAMPE





## International Schematics (Electric/Electronic Systems)

NR NO NO NO	SYMBOL SYMBOL SYMBOLE SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
41		H	GLOW LAMP	LAMPADA FLUORESCENTE	GLIMMLAMPE	LAMPARA DE EFLUVIOS	LAMPE AU NEON
42		K	ON-DELAY RELAY	RELE RITARDATO IN ECCITAZIONE	ZEITRELAIS ANZUGVERZOEGT	RELE TEMPORIZADOR DE CIERRE TETARDADO	RELAIS DE TEMPORISATION A ACTIONNEMENT RETARDE
43		K	OFF-DELAY RELAY	RELE RITARDATO IN DISECCITAZIONE	ZEITRELAIS, ABFALLVERZOEGT	RELE TEMPORIZADOR DE APERTURE RETARDADA	RELAIS DE TEMPORISATION A RETOMBEE RETARDE
44		K	ON-DELAY AND OFF-DELAY RELAY	RELE RITARDATO IN ECCITAZIONE E IN DISECCITAZIONE	ZEITRELAIS, ANZUG- UND ABFALLVERZOEGT	RELE TEMPORIZADOR DE CIERRE Y APERTURA RETARDADOS	RELAIS DE TEMPORISATION A ACTIONNEMENT ET RETOMBEE RETARDES
45		K	LATCHING RELAY	RELE CON AUTORITENUTA	SELBSTHALTE- RELAIS	RELE ENGANCHADOR	RELAIS AUTO- ENTRETIEN
46		K	DRIVE WITH AC MOTOR	AZIONAMENTO PER MOTORE AC	ANTRIEB MIT WECHSELSTROM- MOTOR	ACCIONAMIENT POR MOTOR DE CORRIENTE ALTERNIA	EINTRAINEMENT PAR MOTEUR A COURANT ALTERNATIF
47		F	UNDER- AND OVERVOLTAGE RELAY	RELE DI MASSIMA E MINIMA TENSIONE	SPANNUNG- SWACHTER	RELE DE CONTROL DE TENSION	RELAIS DE PROTECTION VOLTMETRIQUE
48		H	FLUORESCENT LAMP	TUBO FLUORESCENTE	LEUCHSTOFFROHRE	TUBO FLUORESCENTE	TUBE FLUORESCENT
49		S	DECADE SWITCH	COMMUTATORE DECADICO	DEKADENSCHALTER	INTERRUPTOR DECADICO	COMMUTEUR DECADIQUE
50		S	LIGHT SWITCH	FOTOCPELLULA	LICHTTASTER	PULSADOR DE FIBRO-OPTICA	COMMUTEUR D'ECLAIRAGE
51		S	IND./CAP. PROXIMITY SWITCH	INTERUTTORE DI PROSSIMITA INDUTTIVO O CAPACITIVO	IND./KAP. NAHERUNGS- SCHALTER	INTERRUPTOR DE PROXIMIDAD IND./CAP.	COMMUTEUR INDUCTIF/ CAPACITIF





## International Schematics (Electric/Electronic Systems)

NR NO NO	SYMBOL SYMBOL SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
52		S	LIGHT-EMITTING DIODE (TRANSMITTER)	FOTODIODO (TRASMETTITORE)	LEUCHTDIODE (SENDER)	DIODO LUMINOSO (EMISOR)	DIODE LUMINESCENTE (EMETTEUR)
53		S	LIGHT BARRIER (RECEIVER)	BARRIERA FOTOELETTRICA (RICEVITORE)	LICHTSCHRANKE (EMPFANGER)	BARRERA DE LUZ (RECEPTOR)	BARRAGE PHOTOELECTRIQUE (RECEPTEUR)
54		B	ENCODER	ENCODER	DREHGEBER	TRANSMISOR ROTATIVO	ENCODEUR
55		S	SWITCH MECH.	INTERRUTTORE MECCANICO	SCHALTER MECH.	INTERRUPTOR MEC.	COMMUTEUR MEC.
56		S	SWITCH WITH AUTOMATIC DISCONNECTION MECH.	INTERRUTTORE CON SGANCIO AUTOMATICO MECCANICO	SCHALTER MIT ZWANGSTRENNER MECH.	INTERRUPTOR CON DESCONECTOR AUTOMATICO	COMMUTEUR INCL. INTERRUPTEUR-SEPARATEUR COMMANDE MEC.
57		S	REED CONTACT	CONTATTO REED	REED-KONTAKT	CONTACTO TIPO REED	CONTACT REED
58		S	SWITCH WITHOUT LATCHING	PULSANTE NORMALMENTE APERTO	TASTER OHNE RASTUNG	PULSADOR SIN TRINQUETE	BOUTON-POUSSOIR CRANTAGE
59		S	SWITCH WITH LATCHING	PULSANTE PERMANENTE NORMALMENTE APERTO	TASTER MIT RASTUNG	PULSADOR CON TRINQUETE	BOUTON-POUSSOIR AVEC CRANTAGE
60		S	SWITCH MECHANICALLY CONNECTED	PULSANTE AD AZIONE MECCANICA	TASTER, MECH. VERBUNDEN	PULSADOR, UNIDO MECANICAMENTE	BOUTON-POUSSOIR A RACCOINDEMENT MEC.
61		S	CABLE-OPERATED SWITCH WITH LATCHING	CONTATTO COMANDATO A CAVO CON AUTORITENUTA	SEILZUGSCHALTER MIT RASTUNG	INTERRUPTOR DEL SISTEMA DE CABLE DE TRACCION CON TRINQUETE	COMMUTEUR A CABLE AVEC CRANTAGE
62		U	RECTIFIER CIRCUIT	RADDRIZZATORE	GLEICHRICHTER-SCHALTUNG	CIRCUITO RECTIFICADOR	MONTAGE EN REDRESSEUR





# Hydraulic and Pneumatic Valves & Cylinders

## Flow Control Valves

The flow control valve combines a needle valve and a check valve parallel to each other in one housing. This allows for free flow in one direction, and metered flow in the other. Metered flow is indicated by an arrow on the side of the housing. Flow control valves are used to control the speed of a cylinder or air motor. The valves are mounted so that the arrow is pointing away from the cylinder or motor, so that it is metering flow on the exhaust.

## Shuttle Valve

The shuttle valve is a 3-way valve, which accepts either or both of two inputs and provides one output. If a tee were used in place of the shuttle valve, the air pressure from the right inlet port could escape through the left port and through the exhaust of another valve.

## Quick Exhaust Valve

The quick exhaust valve is a 3-way valve that provides quick release of exhaust air in a cylinder. The valve is used to achieve maximum cylinder speeds in double acting cylinders by reducing the restriction of the exhaust air.

## Directional Control Valves

3-Way, 2-Position directional control valve contains three working ports, provides two flow paths, and has two operating positions. This type of valve is used on single acting cylinders or air system that require that the equipment not be under pressure when not energized. The valve can be set up in two configurations; normally passing and normally non-passing.

- Normally passing – In the valves normal position, port 1 (generally the inlet port) is open or flows to port 2 (generally the working port), and port 3 (generally the exhaust port) is blocked. When the valve is shifted to the second position, port 1 is now blocked, and port 2 is open or exhausts to port 3.
- Normally non-passing – Port 1 is blocked, and port 2 is open or exhausting to port 3. When the valve is shifted to the second position, port 1 is open or flows to port 2, and port 3 is blocked.

Some 3-Way, 2-Position valves can be used for both normally passing and non-passing.

4-Way Direction control valve contains either four or five working ports (depending on the design), provides four flow paths, and is available in either 2 or 3 positions.

- A 4-Way, 2-Position valve works as follows:

In the normal position of the valve, port 1 is open or flows to port 2, port 3 is blocked, and port 4 is open or exhaust to port 5. When the valve is shifted to the second position, port 1 is now open or flows to port 4, port 5 is blocked, and port 2 is open or exhausts to port 3.





A 4-Way, 3-Position valve works the same way except it has a center neutral position where the inlet port 1 is blocked, and the two working ports 2 and 4 can be set up into two configurations of all ports blocked or cylinder port open. All ports blocked configuration means that in the neutral position all ports are blocked and the valve will not pass any air. In the cylinder ports open configuration, ports 2 and 4 are open or exhaust to ports 3 and 5.

The valves can be shifted by four types of actuators: manual, mechanical, pilot, or solenoid.

Manual actuators are any device, which is controlled directly by the operator, and come in a wide range of styles from hand lever, push button, and foot.

Mechanical actuator is any actuating device triggered by another mechanical drive, such as a roller cam or limit arm.

Pilot actuator receives a pneumatic signal from another valve to shift the spool in the valve. These valves are normally used as a power valve receiving their signals from smaller limit valves.

Solenoid valves receive an electrical current to the solenoid to shift the spool. Solenoid valves are available in two types: direct acting and solenoid pilot or pilot operated.

On direct acting solenoid valves the solenoid is mechanically connected to the main valve spool. When the solenoid coil is energized the spool is shifted due to mechanical connection.

Solenoid pilot operated valves, the solenoid is attached to a small pilot valve which when energized sends a pilot signal to end of the main spool shifting the spool. The advantages of the pilot valve are that it reduces the chance of solenoid burn-out if the valve spool should stick, and reduces the size of the valve since only a small solenoid is needed to open up the pilot port. Pilot operated valves do require a minimum inlet pressure so that the valve can shift.

2-Position valves can either have manual actuator to shift the valve into both position or returned to the original position by some sort of spring force. A 3-Position valve is the same with the neutral position being the center position.

Valve body configurations come in two types; body ported or manifold:

Body ported valves have threaded ports in the body of the valve to which plumbing connections are made.

Manifold mounting is a method of mounting several valves side-by-side using a common air supply.

## Cylinders

Single acting cylinders are any cylinder which uses air on only one stroke, and uses some other means, usually a spring, to move the piston on the other stroke or back to its original position.

Double acting cylinders are cylinders designed to use air to extend and retract the piston.

Bore is the inside diameter of the cylinder.

Stroke is the length that the piston rod travels.

Force is the mechanical pressure that the piston can develop. Force can be calculated by:

$$\text{Force} = \text{Area} \times \text{PSI.}$$







# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO	SYMBOL SYMBOL SYMBOLE SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
1			Flowline Junction	Giunzione	Abzweigung	Union	Jonction des conduites
2			Non-connecting flowline crossing	Incrocio di linee senza giunzione	Kreuzung ohne Anschluss	Cruze de linea sin coneccion	Croisement de conduites non-connectées*
3			Flexible flowline	Linea flessibile	bewegliche Schlauchverbindung	Linea flexible	Conduite flexible
4			Continuous air bleed	Sfiato continuo	durchgehender Luftablass	Desahogo continuo de aire	Échappement continu
5			Temporary air bleed	Sfiato temporaneo	voruebergehender Luftablass	Desahogo temporal de aire	Échappement temporaire
6			Test port	Collegamento strumentazione di prova	Testanschluss	Coneccion de prueba	Port de test
7			Quick release coupling	Manicotto rapido	Schnellschluss Kupplung	Acoplamiento con conectores rapidos	Union raccord rapide
8			Quick release coupling with non-return check valves	Manicotto rapido con valvola di ritegno	Schnellschluss Kupplung ohne Rueckschlagventil	Acoplamiento con conectores rapidos y valvula de no regreso	Union raccord rapide à clapet
9			Push button actuator	Attuatore a pressione	Taster Druckbetaetigung	Actuador de presión	Commande musculaire par bouton poussoir
10			Pull button actuator	Attuatore a tiro	Taster Ziehbetaetigung	Actuador de jalo	Commande musculaire par bouton à tirer





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO	SYMBOL SYMBOLE SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
11			Push-Pull button actuator	Attuatore a tiro e a pressione	Taster mit Druck- und Zieh-betaetigung	Actuador de presión-jalo	Commande musculaire par bouton pousser-tirer
12			Lever actuator	Attuatore a leva	Taster mit Hebelbetaetigung	Actuador a palanca	Commande musculaire par levier
13			Foot pedal actuator	Attuatore a pedale	Taster mit Fussdruck-betaetigung	Actuador a pedal	Commande musculaire par pédale
14			Foot treadle actuator	Attuatore a scarpetta	Taster mit geneigter Fuss-druckbetaetigung	Actuador a suela	Commande musculaire pour pédale 3 positions
15			Plunger actuator	Attuatore a pistone	Stossbetaetigung	Actuador a embolo	Commande mécanique par poussoir
16			Spring return	Ritorno a molla	Rueckfeder	Regreso con resorte	Commande mécanique par ressort
17			Plunge roller actuator	Attuatore a pistone con contatto a ruota	Stossbetaetigung mit Betaetigungsrad	Actuador con embolo a rodillo	Commande mécanique par galet
18			Roller arm plunge actuator	Attuatore a pistone con contatto a ruota disassato	Stossbetaetigung mit Hebelarm	Actuador con embolo a rodillo de brazo	Commande mécanique par galet escamotable
19			Single acting electric solenoid actuator	Bobina di comando ad un solo effetto	Elektrisch gesteuertes Einwegventil	Actuador con accion a simple bobina electrica	Commande électrique par électro-aimant
20			Double acting electric solenoid actuator	Bobina di comando a doppio effetto	Pneumatisch gesteuerte Betaetigung	Actuador con accion a doble bobina electrica	Commande électrique à deux bobines





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO NO	SYMBOL SYMBOLE SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
21			Pneumatic pilot operated actuator	Attuatore a comando pneumatico	Pneumatisch gesteuerte Betaetigung	Actuador a comando pneumatico	Commande pneumatique à pilote externe
22			Hydraulic pilot operated actuator	Attuatore a comando idraulico	Hydraulisch gesteuerte Betaetigung	Actuador a comando hidraulico	Commande hydraulique à pilote externe
23			Hydraulic pump	Pompa idraulica	Hydraulik Pumpe	Bomba hidraulica	Pompe hydraulique
24			Air Compressor	Compressore d'aria	Kompressor	Compresor de aire	Compresseur
25			Pneumatic motor with two directions of rotation	Motore pneumatico bidirezionale	Pneumatik Motor mit rechts und linkslauf	Motor pneumatico bidireccional	Moteur pneumatique bidirectionnel
26			Pneumatic semi-rotary actuator	Attuatore pneumatico a semirotazione	Pneumatische Umlauf Betaetigung	Actuador pneumatico de semirotacion	Moteur pneumatique oscillant
27			Hydraulic variable speed drive unit	Motovariatore idraulico	Motovariatore idraulico	Motovariador hidraulico	Unité de vitesse variable hydraulique
28			Pressure compensated variable displacement hydraulic pump	Pompa a portata variabile con regolatore di pressione	Hydraulische Verdraengungs-pumpe mit Druckausgleich	Bomba de flujo variable con compensacion de presion	Pompe à débit variable à pression compensée
29			Single acting cylinder	Cilindro ad un solo effetto	Einwege Zylinder	Cilindro de una sola accion	Vérin simple action
30			Single acting cylinder with spring return	Cilindro ad un solo effetto con ritorno a molla	Einwege Zylinder mit Federrueck-fuehrung	Cilindro de una sola accion con regreso a resorte	Vérin simple action à retour par ressort'





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO	SYMBOL SYMBOLE SIMBOLO	ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
31		Double acting cylinder with double-ended piston rod	Cilindro a doppio effetto con stelo passante	Zweiwege Zylinder mit Federrueckfuehrung	Cilindro a doble accion con doble barra de piston	"Vérin double action avec double tige"
32		Double acting hydraulic cylinder with single-ended piston rod, Adjustable cushions at both sides, and piston area ratio 2:1	Cilindro a doppio effetto a camere regolabili. Rapporto aree pistone 2:1	Zweiwege Hydraulikzylinder mit einseitiger Kolbenstange und verstellbaren Daempfern. Kolbenbereich Verhaeltnis 2:1	Cilindro hidraulico a doble accion con sensilla barra de piston con colchone regulable al final de ambos lados. Relacion del area del piston 2:1	Cylindre hydraulique double action avec 1 tige, amortissement ajustable des 2 cotés et surface de piston à ratio 2:1
33		Pneumatic-hydraulic actuator	Attuatore idropneumatico	Pneumatische und hydraulische Betaetigung	Actuador hidro-neumático	Commande oléo-pneumatique
34		Pressure intensifier, transformer For two types of fluid	Moltiplicatore di pressione idropneumatico	Druckwandler fuer zwei verschiedene Fluessigkeiten	Amplificador de presión. Para dos tipos de fluidos	Intensificateur de pression, transformateur pour 2 types de fluides
35		Accumulator, gas loaded	Accumulatore a gas	Speicher-behaelter mit Gas gefuellt	Acumulador a gas	Accumulateur chargé en gaz
36		Air receiver	Compensatore	Luftbehaelter	Receptor de aire	Capteur d'air
37		Hydraulic source of energy	Fonte di energia idraulica	Hydraulischer Energieanschluss	Fuente de energia hidraulica	Alimentation hydraulique
38		Pneumatic source of energy	Fonte di energia pneumatica	Pneumatischer Energieanschluss	Fuente de energia neumatica	Alimentation pneumatique
39		Electric motor	Motore elettrico	Elektromotor	Motor electrico	Moteur électrique
40		Directional control valve 2/2 2 ports 2 positions normally closed	Valvola di distribuzione a 2 uscite e 2 posizioni, normalmente chiusa	Zweiwege Ventil mit drei Anschluessen	Valvula de control de direccion 2/2. 2 puertos 2 posiciones normalmente cerradas	Distributeur 2/2, 2 orifices, 2 positions, fermé au repos"





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO	SYMBOL SYMBOLE SIMBOLO	ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
41		Directional control valve 3/2 with three ports, two positions	Valvola di distribuzione a 3 uscite e 2 posizioni	Zweiwege Ventil mit fuerf Anschluessen	Valvula de control de direccion 3/2 con tres puertos y dos posiciones	Distributeur 3/2 3 orifices, 2 positions
42		Directional control valve 5/2 with five ports, two positions	Valvola di distribuzione a 5 uscite e 2 posizioni	Zweiwege Ventil mit sieben Anschluessen	Valvula de control de direccion 5/2 con 5 puertos y 2 posiciones	Distributeur 5/2 5 orifices, 2 positions
43		Directional control valve 4/3 with four ports, three positions, closed center	Valvola di distribuzione a 4 uscite e 3 posizioni, a posizione centrale chiusa	Zweiwege Ventil mit sieben Anschluessen und geschlossenem Zentrum	Valvula de control de direccion 4/3 con 4 puertos y 3 posiciones, cerrada al centro	Distributeur 4/3 4 orifices 3 positions, centre ouvert
44		Directional control valve 4/3 with four ports, three positions, open center	Valvola di distribuzione a 4 uscite e 3 posizioni, a posizione centrale aperta	Zweiwege Ventil mit sieben Anschluessen und geoeffnetem Zentrum	Valvula de control de direccion 4/3 con 4 puertos y 3 posiciones, abierta al centro	Distributeur 4/3 4 orifices 3 positions, centre ouvert
45		Non-return check valve	Valvola di non ritorno	Rueckschlagventil	Valvula de no regreso	Clapet anti-retour
46		Spring-loaded non-return valve	Valvola di non ritorno caricata a molla	Rueckschlagventil mit Feder-verstaerkung	Valvula de no regreso con resorte	Clapet anti-retour à ressort
47		Non-return valve, pilot controlled	Valvola di non ritorno pilotata	Steuerbares Rueckschlagventil	Valvula de no regreso controlada	Clapet anti-retour piloté
48		Shuttle valve	Valvola a navetta	Pendelventil	Valvula de regilite	Sélecteur de circuit (OU)
49		Priority shuttle valve	Valvola a navetta a precedenza	Hauptpendelventil	Valvula de regilite con prioridad	Sélecteur de circuit prioritaire (ou exclusif)
50		Quick-exhaust valve	Valvola di scarico rapido	Ventil mit Schnellaeser	Valvula de desahogo rapido	Purge rapide





# Hydraulic and Pneumatic Systems

(International Schematics)







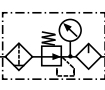



NR NO NO	SYMBOL SYMBOL SYMBOLE SIMBOLO	ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
51		Single-stage pressure relief valve	Valvola di sicurezza ad un solo effetto	Einseitiges Druckabbau Ventil	Valvula de seguridad a fase sencilla	Valve de séquence
52		Single-stage pressure relief sequence valve	Valvola di sicurezza sequenziale ad un solo effetto	Einseitiges Druckabbau Ventil mit Mehrbereich	Valvula de seguridad secuencial a fase sencilla	Valve de séquence pilotée
53		Pressure regulator	Regolatore di pressione	Druckregler	Regulador de presión	Régulateur de pression
54		Pressure reducing valve with relief to atmosphere	Regolatore di pressione con scarico in atmosfera	Druckregler mit Auspuff	Valvula reductora de presión con desahogo a la atmosfera	Régulateur de pression à échappement à l'air libre
55		Adjustable restrictor valve	Valvola di regolazione	Einstellbarer Druckbegrenzer	Valvula de regulación	Étrangleur variable
56		Gate-valve	Valvola di intercettazione	Zugangsventil	Valvula de puerta	Robinet d'arrêt
57		One-way restrictor valve	Valvola di regolazione monodirezionale	Einwege einstellbarer Druckbegrenzer	Valvula de regulacion monodireccional	Étrangleur variable et clapet
58		Vented reservoir	Serbatoio aperto	Belueftetes Reservoir	Deposito ventilado	Réservoir ventilé
59		Local drain or return	Punto di drenaggio o di ritorno	Ablass oder Rueckfuehrung	Punto de desagüe o de retorno	Retour au réservoir
60		Sealed reservoir	Serbatoio in pressione	Abgedichtetes Reservoir	Deposito sellado	Réservoir scellé





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO	SYMBOL SYMBOL SIMBOLE SIMBOLO	ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
61		Filter	Filtro	Filter	Filtro	Fitre
62		Separator drain valve Manually drained	Separatore con drenaggio manuale	Fluessigkeits- abscheider mit manuellem Ablass	Separador con drenaje manual	Séparateur avec purgeur manuel des condensats
63		Separator drain valve Automatically drained	Separatore con drenaggio automatico	Fluessigkeits- abscheider mit automatischem Ablass	Separador con drenaje automático	Séparateur avec purgeur auomatique des condensats
64		Filter with separator Manually drained	Filtro separatore con drenaggio manuale	Filter mit Abscheider und manuellem Ablass	Filtro separador con drenaje manual	Fitre séparateur avec purgeur manuel des condensats
65		Air dryer	Deumidificatore	Lufttrockner	Secador de aire	Déshydrateur d'air
66		Lubricator	Lubrificatore	Schmierung	Lubricador	Lubrificateur
67		Conditioning unit consisting of filter with separator, pressure regulator, pressure gauge, lubricator	Gruppo di regolazione, filtraggio, e separazione	Formeinheit bestehend aus Filter mit Abscheider, Druckregler, Manometer und Schmierung	Unidad condicionadora consistente en Filtro sperador, regulador de presion, medidor de presion, lubricador	Unité de conditionnement comprenant fitreur, séparateur, régulateur de pression, manomètre, lubrificateur
68		Pressure indicator	Indicatore di pressione in linea	Druckanzeige	Indicador de presion	Voyant pneumatique
69		Pressure gauge	Manometro	Manometer	Manometro	Manomètre
70		Liquid level measuring instrument	Indicatore di livello	Fuellstand- anzeige	Indicador de nivel	Instrument de mesure de niveau liquide





# Hydraulic and Pneumatic Systems

(International Schematics)

NR NO NO NO	SYMBOL SYMBOL SYMBOLE SIMBOLO		ENGLISH	ITALIAN	GERMAN	SPANISH	FRENCH
71			Thermometer	Termometro	Temperatur- anzeige	Termometro	Thermomètre
72			Flow indicator	Indicatore di portata	Ablaufsanzeige	Indicador de flujo	Témoins de débit
73			Flow meter	Misuratore di portata	Ablauf- bemessung	Medidor de flujo	Débimètre
74			Pressure switch	Pressostato	Druckschalter	Presostato	Capteur de pression
75			Analog transducer	Trasduttore analogico	Analogwandler	Convertidor analogico	Transducteur analogique
76			Pneumatic Silencer	Silenziatore	Luftdruck Schalldaempfer	Silenciador neumático	Silencieux pneumatique







# Compressed Air System

## Economics

Delivering compressed air to a manufacturing facility is an expensive operation. Delivery requires costly equipment that consumes significant amounts of electricity and needs frequent maintenance. In spite of this, many facilities have no idea how much their compressed air systems cost on an annual basis, or how much money they could save by improving the performance of these systems.

Electricity costs are by far the largest expense of owning and operating a compressed air system. The annual cost of electricity to operate a 100 HP compressor is between \$15,000 - \$30,000 depending on the hours of operation. Added to this are annual maintenance costs, which can be 10% or more of the initial cost of the system.

Due to the relatively low initial cost of the compressor when compared to lifetime electricity expenses, users should utilize life-cycle cost analysis when making decisions about compressed air systems. In addition, a highly efficient compressed air system is not merely a system with an energy-efficient motor or efficient compressor design. Overall system efficiency is the key to maximum cost savings. Too often users are only concerned with initial cost and accept the lowest bid on a compressed air system, ignoring system efficiency.

Thorough analysis and design will be required to obtain an efficient system. Many compressed air system users neglect these areas, thinking they are saving money, but end up spending much more in energy and maintenance costs.

This Fact Sheet presents a simple calculation to estimate annual electricity costs.

$$(\text{Motor full-load brake horsepower}) \times (0.746 \text{ Kw/HP}) \times (1.11 \text{ efficiency factor}) \times (\text{Annual hours of operation}) \times (\$/\text{KWH electricity cost}) = \text{Annual Electricity Cost}$$

For example:

Motor full-load = 20 bhp

Annual hours of operation = 2,000 Hrs (single shift continuous operation)

Hourly Cost of Electricity = (\$0.047 / KwH)

Peak Load Electricity Charge = \$8.10 / Kw / Month

20 Hp x 0.746 Kw / Hp x 1.11 Efficiency Factor x 2000 Hours x \$0.047 / KwH . . . . .	\$1,557
20 Hp x 0.746 Kw / Hp x \$8.10 / Kw x 12 months . . . . .	\$1,450
Total Annual Electricity Cost . . . . .	\$3,007





# Compressed Air Data

## Conversion Factors: US Standards to Metric

### Air flow:

Cubic Meters per hour (m <sup>3</sup> /hr)	Cubic Feet per minute (cfm)	multiply by 0.5885
Cubic Meters per minute (m <sup>3</sup> /min)	Cubic Feet per minute (cfm)	multiply by 35.31
Liters per minute (lt/min)	Cubic Feet per minute (cfm)	multiply by 0.03531

### Pressure:

PSI (pounds per square inch)	Bar	multiply by 0.0689
Bar	PSI (pounds per square inch)	multiply by 14.5

### Volume:

Liter	Gallons US	multiply by .2642
Gallons US	Liter	multiply by 3.79

### Power:

Horsepower	KW	multiply by .0746
KW	HP	multiply by 1.341

**Time to fill a tank is:** (Reservoir Capacity/Compressor Output) x (Final Pressure required + 14.5/Starting Pressure + 14.05)

i.e. 32 Cu Ft receiver, 20 cfm compressor 100 psi final receiver pressure:

$$\text{Time} = (32/20) \times (100 + 14.05 / 0 + 14.05) = 12.63 \text{ mins} = 12 \text{ mins and } 38 \text{ secs}$$

### Pipe sizes and pressure drop

100 psi (7 Bar) base pressure with 100 foot (about 30 meters) of galvanized pipe with up to 10% pressure drop in 1/2", and up to 5% pressure drop in other sizes to 2"

1/2" good for up to 50 cfm, 1.4m<sup>3</sup>/min

3/4" good for up to 80 cfm, 2.3m<sup>3</sup>/min

1" good for up to 150 cfm, 4.2m<sup>3</sup>/min

1 1/4" good for up to 300 cfm, 8.5m<sup>3</sup>/min

1 1/2" good for up to 450 cfm, 12.7m<sup>3</sup>/min

2 good for up to 900 cfm, 25.5m<sup>3</sup>/min

These are only 'rule of thumb' figures; and elbows, joints and quality of the pipe itself will affect flow and pressure drop.





## Dust Collection and Extraction

Efficient dust collection is achieved when using outlets and ducting with a round cross section, and an air velocity at the center of the duct comprised between 30 and 35  $\text{ms}^{-1}$  (98 to 115 fps). At these velocities the airflow has the ability to remove wood dust and large wood particles even if the airflow works against gravity.

In practical life the air velocity is measured using an indirect method: the measure of the static pressure at the center of the outlet or at the center of the duct. The relationship between the two is expressed by means of complex mathematical formulas that are normally developed through lab testing. We therefore suggest the use of charts, in metric or imperial units. Given the diameter (in inches or in millimeters) of an outlet or a duct, the chart provides the values of the necessary airflow and its relevant static pressure.

A simple formula to accurately calculate the dust collection requirements for each outlet is the following:

In metric units:  $D \times D / 40 =$  liters per second (where D is in mm)

In imperial units:  $D \times D \times 36 =$  CFM (where D is in inches)

An excellent rule-of-thumb for the static pressure is that the value for the static pressure almost always equals the value of the diameter of the outlet.

Example:

A machine has 3 outlets with a diameter of 4.5" and 1 outlet with a diameter of 5.75": How much dust collection is required?

Each 4.5" outlet will require:  $4.5 \times 4.5 \times 36 = 729$  CFM

The 5.75" outlet will require:  $5.75 \times 5.75 \times 36 = 1190$  CFM

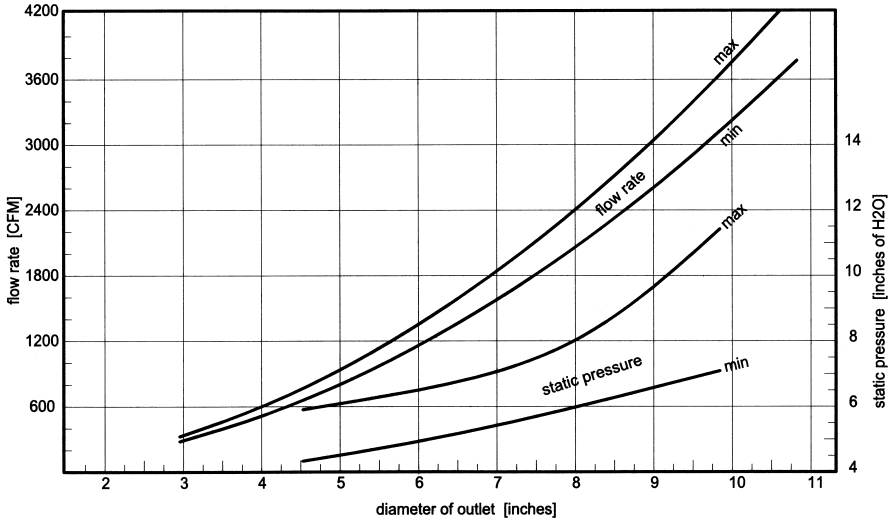
The total dust collection requirement is:  $729 + 729 + 1190 = 2648$  CFM

The static pressures measured at each outlet shall be 4.5 inches of  $\text{H}_2\text{O}$  for the 4.5" outlets, and 5.75 inches of  $\text{H}_2\text{O}$  for the 5.75" outlet.

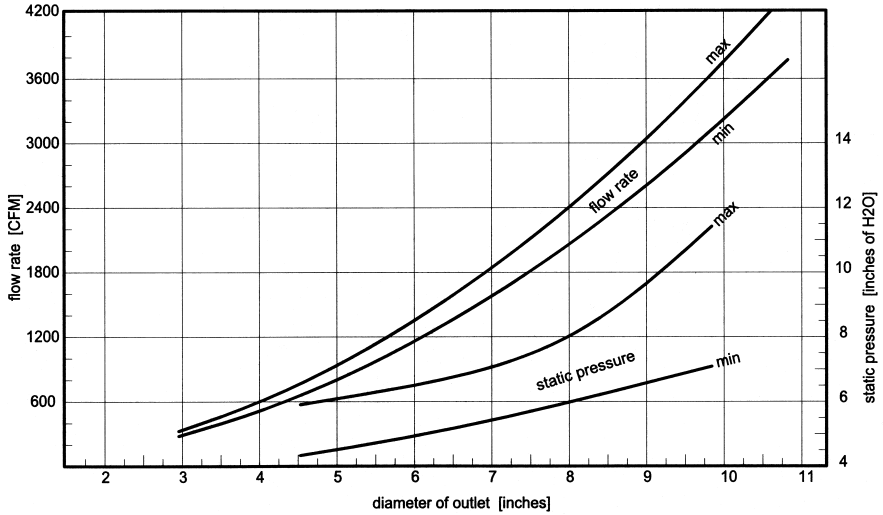
Once the dust collection is in place, ask your installer to double check the efficiency of the system by measuring the value of the static pressure at each outlet. When it falls within the limits of the charts, the system is efficiently removing dust and other wood particles.



DUST COLLECTION CHART FOR ROUND OUTLETS (IMPERIAL UNITS)



DUST COLLECTION CHART FOR ROUND OUTLETS (IMPERIAL UNITS)





## Understanding the Measurement of Actual Air Flow in Dust Collection Pipes and Ducts

The mass of air (Q) that is being moved by the fans through a dust collection pipe can be accurately measured when the temperature (T), the pressure (P), the velocity (V), the cross section area (S) of the pipe, the content of humidity and the composition of the air are known.

In practical applications, as with dust collection systems, the temperature and pressure are considered to be constant, and the humidity to be irrelevant, introducing in this way a negligible error in the calculation of the air flow, which is therefore expressed by the following formula:

$$Q(\text{cu.ft/sec})=V(\text{ft/sec})\leftrightarrow S(\text{sq.ft})$$

Or, since the air flow Q is usually measured in cu.ft/min, and the ducts diameter in inches (with the cross section area S in sq.inch):

$$Q(\text{cu.ft/min})=0.42\leftrightarrow V(\text{ft/sec})\leftrightarrow S(\text{sq.inches})$$

Assuming that a tract of pipe is made of a constant diameter (same cross section), the measurement of Q becomes as simple as measuring V, i.e. the velocity of the air in the pipe.

A good practical system to measure the velocity is based on the measurement of the dynamic Pressure (Pd) by means of a pressure gauge. The velocity V is calculated by the following formula:

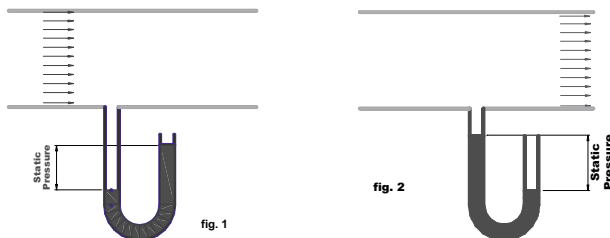
$$V(\text{ft/sec})=265\leftrightarrow d\leftrightarrow \sqrt{Pd(\text{inchH2O})}$$

Where d is the density (lbs/cu.ft) of the air at normal conditions (at sea level and at 60°F the density is typically 0.08072 lbs/cu.ft). The dynamic Pressure is measured in inches of water (inch H2O). The above formula is therefore valid for moderate elevation above the sea level. With the increase of the elevation the air becomes thinner (lower density). To achieve an efficient extraction capacity a dust collection system placed at high elevations must develop a larger dynamic Pressure Pd.

The dynamic Pressure is measured as the difference between the total Pressure Pt and the static Pressure Ps:

$$Pd(\text{inchH2O}) = Pt(\text{inchH2O}) - Ps(\text{inchH2O})$$

Figure 1 shows the measurement of the static Pressure Ps in a pipe duct under pressure (fan pressurized) and Figure 2 shows the measurement of the static Pressure in an aspirated pipe duct (by a fan extractor).





The air moving in a pipe duct also contains an energy due to the mass (of air) moving at a high velocity. Figure 3 shows how the total Pressure  $P_t$  measures in an aspirated pipe duct and in a pressurized pipe duct.

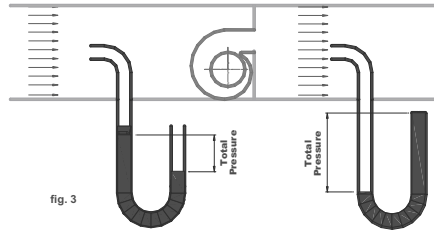


fig. 3

Since the dynamic Pressure is the difference between the total Pressure and the static Pressure, Fig. 4 shows how in practice the static Pressure  $P_s$  is “subtracted” from the total Pressure  $P_t$  in the two cases of an aspirated pipe duct and a pressurized pipe duct.

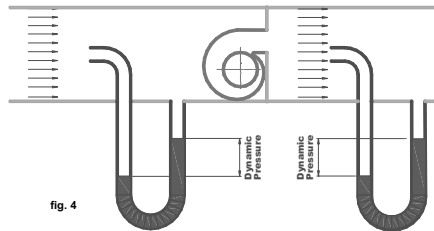


fig. 4

In real applications the flow of the air is not uniform and it is higher at the center of the duct and minimal at the wall of the duct. Joints, curves, and bends in the ducting also introduce turbulences that are detrimental to the achievement of good sustained dynamic Pressure. This is the reason why installers of good dust extraction systems place so much care in avoiding sudden changes of shapes and build joints and bends that do not disrupt the air flow. Measurements of the pressure in dust extraction ducts shall always be taken in a portion of the duct where the flow is as uniform and as undisturbed as possible, i.e. away from areas of possible turbulence. The measurement of the dynamic Pressure ( $P_d$ ) shall be taken at the center of the duct, while the measurement of the static Pressure ( $P_s$ ) shall be taken at the wall of the duct.





# WMIA Shop Guide

---

## Glossary of Terms

# SECTION 3



# Glossary of Terms

**ABRASIVE MATERIAL:** A mineral substance coating on a sanding belt that abrades or sands the board by removing material.

**ACTUAL YIELD:** The actual amount that is produced.

**ADHESIVE:** A substance capable of holding materials together by surface attachment. The term is used to cover the bonding of sheet material and is synonymous with glue. The term “binder” is used for materials concerned in the manufacture of particleboard.

**AIR DRIED:** Dried by exposure to air in a yard or shed, without artificial heat.

**AIR REVERSAL:** Changing the airflow to flow in the opposite direction through a load of drying lumber or products.

**ALLOWABLE UNIT STRESS:** The value of a strength property normally published for design use. Allowable unit stresses are identified with grade descriptions and standards, reflect the anisotropic structure of wood, and anticipate certain end uses.

**ANEMOMETER:** An instrument for measuring air velocity.

**ANISOTROPIC:** Not isotropic; that is, not having the same properties in all directions.

**ANNUAL LAYERS (RINGS):** The layers of wood grown by a tree during a single growing season; in the temperate zone, annual layers of many species are readily distinguished because of differences in the cells formed during the early and late parts of the season.

**ARMOIRE:** A large cupboard, for storing clothes. Probably an adaptation of the aumbry, or armor, used in early English times for the storing of arms and armor.

**ASSEMBLY TIME:** The minimum and maximum time allowed after glue spreading before pressure must be applied to form a satisfactory wood-glue bond.

**BACKER:** A non-decorative laminate used on the back of composite panel constructions to protect the substrate from changes in humidity and to balance the panel construction.

**BAFFLE:** In forced air or kiln drying, a canvas, metal, or wood barrier used for deflecting, checking, or otherwise directing the flow of air.

**BALANCED CONSTRUCTION:** A composite panel construction that will not warp when subjected to uniformly distributed moisture changes.

**BANDSAW:** A band of steel with teeth on one edge (single cutting) or both edges (double cutting), running on a set of large wheels. Used for longitudinal cutting of wood. See also twin and quad bandsaws.

**BARKER or DEBARKER:** A machine for removing bark either mechanically or by high-pressure water jets.

**BARK POCKETS:** Small patches of bark that have become partially or wholly enclosed by the growth of a tree.

**BARRIER or BASE COAT:** An initial coating applied to protect plastics from being attacked by the solvents in subplastics from being attacked by the solvents in subsequently applied finishing materials. Also called base coat.

**BEAM:** A structural member that supports a load applied transversely to it. See also timbers, rectangular.

**BENT WOOD:** Curved wood formed by steaming or boiling, or by special finishing, and then bending to a form.

**BEVEL ANGLE:** The angle of the knife face in relation to the lathe knife.

**BIRDS-EYE FIGURE:** Figure produced on flat-sawn or rotary-cut surfaces by small, conical depressions of the fibers, which form numerous rounded areas of the grain remotely resembling small eyes. Generally limited to hard maples.

**BLEED-THROUGH:** The exudation of colored wood extractives or of coating materials through a paint film.

**BLENDING:** The application of binder and additives to particles in the manufacture of particleboard.

**BLISTER SPOT:** Spot or area where veneer does not adhere and bulges like a blister. (In Veneer & Plywood terms) Produced by rotary or half-round cutting through uneven contour of annual rings to give the effect of blisters.

**BLISTERING:** The formation of bubbles or pimples on the surface of finished work. Caused by exposure to excessive heat, by grease or other volatile material under the finish, by moisture in the wood or by the too frequent application of coats. Anything which causes a gas or vapor to form under the film may cause blistering.

**BLOOMING:** The formation of crystals on the surface of treated wood by exudation and evaporation of the solvent in preservative solutions.

**BLUE STAIN:** A bluish or grayish discoloration of the sapwood caused by the growth of certain dark-colored fungi on the surface and in the interior of the wood, made possible by the same conditions that favor the growth of other fungi.

**BOARD:** Lumber that is less than 38 mm (2 in.) thick and wider than 38 mm (2 in.).

**BOARD FOOT:** A standard unit of measurement for logs, usually expressed in multiples of a thousand (MBM). Represents the equivalent number of 1-foot-wide, 1-foot-long, and 1-inch-thick units that can be sawn from a log.

**BOLT:** A short section of wood, as cut for shingles, shakes, rough dimension stock, stakes, pallet and crating material, and rotary-cut veneer.

**BOLSTER:** A piece of wood, generally a nominal 4 in. in cross section, placed between stickered packages of lumber or other wood products to provide space for the entry and exit of the forks of a lift truck.

**BOUND WATER:** Water contained within the cell walls of wood and held by hygroscopic forces.

**BOW:** The distortion of lumber along the face of a piece from end to end, measured at the point of greatest deviation from a straight line.

**BOXED HEART:** The term used when the pith falls entirely within the outer faces of a piece of wood anywhere in its length. Also called boxed pith.

**BOX SHOOK:** Veneer cut primarily for use as box sides, bottoms, and other box parts.

**BRASH WOOD:** Wood with low resistance to shock and with a tendency to sudden and complete breakage across the grain without splintering.

**BROWN ROT:** A condition caused by fungi that decompose the cellulose and associated carbohydrates in wood rather than the lignin. The result is a brown, friable residue. Sometimes called brown cubical rot because of the formation of cracks caused by shrinkage.

**BROWN STAIN:** See stain.

**BUFFER COAT:** A coat of finishing material applied over another dried film to protect it from the solvent action of the succeeding coats.

**BULL EDGER:** A combination circular gang resaw and edger used to break down small cants as well as for edging.

**BURL FIGURE:** Swirled figure produced by cutting through burls, which are hard, woody outgrowths on trees.

**BUTT JOINT:** An end joint formed by abutting the squared ends of two pieces of wood.

**CALIPER:** An instrument for measuring diameters or thickness. Also used as the term describing board thickness.

**CALORIFIC VALUE:** The potential heat-production value of a wood source. Depends on the cellulose-lignin ratio, the percentage of extractives, and the moisture content.

**CAMBIUM:** A thin layer of tissue between the bark and wood that repeatedly subdivides to form new wood and bark cells.





**CANT:** A log that has been slabbed on one or more sides by the headrig for subsequent breakdown into lumber by other machines. See also flitch.

**CANTER:** A machine that produces a cant.

**CANTING:** A sawing method that is a combination of two other sawing methods, sawing around and live sawing. The most common sawing pattern used for softwoods. See also sawing around and live sawing.

**CAPILLARY FORCES:** The forces of liquid adhesion and cohesion combined with surface tension by which a liquid moves through a cellular structure. Also called 'capillary action.'

**CARBIDE TIPPED:** Machining tools that are surfaced or tipped with a carbide material.

**CASEGOODS:** Finished furniture that serves to store with drawers, i.e. dressers shelves, armoires.

**CASE HARDENING:** The condition that occurs when a finishing material dries hard on top and remains more or less soft and mushy underneath instead of drying thoroughly throughout the film. Sometimes caused by relative humidity of the atmosphere being too low. Case hardening may result in checking, cracking and alligatoring when the underneath portion of the film finally becomes hard.

**CELL:** A general term for the structural units of plant tissue, including wood fibers, vessel members, and other elements of diverse structure and function.

**CELLULOSE:** The carbohydrate that is the principal constituent of wood and forms the framework of the wood cells.

**CENTER:** Inner layer whose grain direction runs parallel to that of the outer plies.

**CHATTER:** A wavy condition across the width of a panel caused by sanding. These markings are parallel to one another between 1/4 and 1/2 inch apart and perpendicular to the sander grit markings. Sometimes they can be felt but always can be seen.

**CHECKS:** Lengthwise separations of wood that usually extend across the annual layers and commonly result from stresses set up in wood during drying.

**CHIP LOAD:** Bite per tooth, or the amount of material removed by each cutting tooth as it goes through the material being cut.

**CHIP OUT:** Along the top or bottom face edges, the fines or flakes are removed or torn out of the surface.

**CHIPPING:** The condition which obtains when a dried film of finishing material separates from the underneath surface in the form of flakes or chips. Usually caused by insufficient elasticity or improper adhesion to the base material.

**CHIPS:** Uniform pieces of thin wood, about five eighths of an inch wide and an inch long.

**CHIPPER CANTER:** A headrig machine that reduces barked logs directly to chips and cants without producing sawdust.

**CHUCK:** Device used to secure each end of the peeler block to the lathe spindles.

**CIRCULAR SAW:** A circular metal plate with teeth on the circumference that rotates on a drive shaft.

**CLADDING:** See siding.

**CLIMB CUTTING:** Machining with the cutting tool rotating in the same direction as the material being cut is traveling.

**CLIPPER, VENEER:** A plywood machine used to cut the veneer ribbons or sheets into specified widths.

**CAD:** Abbreviation for Computer Aided Design. The use of computer hardware and software to assist in designing machine parts, buildings etc.

**CNC:** Abbreviation for Computer Numerical Control.

**COLD PRESS:** A press using time and pressure to assist the adhesive in bonding the panel plies without the aid of externally applied heat.

**COLLAPSE:** The flattening of single cells or rows of cells in the heartwood during the drying or pressure treatment of wood. The

wood surface is often characterized by a caved-in or corrugated appearance.

**COMPOSITES:** Built-up, bonded products consisting wholly of natural wood, or in combination with metals, plastics, etc.

**COMPOSITE PANEL:** A panel constructed with softwood veneer outerplies permanently bonded to a reconstituted wood core.

**COMPRESSION FAILURE:** Deformation of wood fibers resulting from excessive compression along the grain either in direct end compression (as sustained by columns) or in bending (as on the upper side of a beam under load). It may develop in standing trees as a result of bending by wind or snow or internal longitudinal stresses developed in growth; it may also result from stresses imposed after the tree is cut. In surfaced lumber, compression failures may appear as fine wrinkles across the face of the piece.

**COMPRESSION WOOD:** Abnormal wood formed on the lower side of branches and inclined stems of softwood trees. Compression wood is identified by its relatively wide annual layers and dark reddish color. Compared with normal wood, it shrinks excessively lengthwise. See also reaction wood.

**CONDITIONING:** The use of humidity in a dry kiln to produce a uniform distribution (equalization) of moisture in timber and to reduce drying stresses.

**CONIFER:** See softwoods.

**CONTINUOUS BELT ROLL LAMINATING SYSTEMS:** The continuous belt laminating system is a more involved and sophisticated equipment arrangement, where panels of particleboard, MDF, hardboard, etc., are fed into the line continuously end to end. The overlays are applied from rolls, either for single or double sided lamination, onto the adhesive coated substrate prior to bonding. Depending on the adhesive system used, the process may be completed (bonding) by using either hot or cold calender rolls. For the latest state of the art methods, a hot press is desired.

After the bonding takes place, the boards are separated, trimmed, and stacked.

**CONTINUOUS LAMINATES:** The typical construction of a continuous laminate is a melamine-impregnated, alpha cellulose overlay plus a decorative surface paper, superimposed over one or more phenolic or melamine resin impregnated papers. The laminate is formed on a continuous, double belt press at pressures of 125 to 750 psi and at temperatures between 275 and 300 degrees F.

The thickness, which is determined by the number of layers of Kraft papers and the resulting amount of resin absorbed, is normally in the 1/32" range. When the sheet is pressed, a steel caul plate or a paper release sheet is used to create a surface finish ranging from high gloss smooth, to fully textured. Continuous laminates can be rolled, but only into large diameter rolls.

**CONTOUR EDGEBANDING:** Is the process by which a decorative laminate is attached to a core stock in such a way as to meet the requirements of the above definition of edgebanding as well as the additional requirement that any two adjacent edges meet along a curved corner rather than a square corner. This is primarily accomplished with hot melt adhesives, but water based adhesives are also used.

**CONVENTIONAL POSTFORMING:** This is the process where a laminated surface is formed to a shaped substrate material. It is one of three ways of putting a soft, round edge on a panel. The other two ways are softforming or profiling. There are two types of machines used for conventional postforming, both of which require that the substrate material be preshaped and have the laminate already applied, with the necessary overhang.

The first is a stationary machine where a heated bar follows the preshaped core and is used with either contact adhesives or PVAC. PVAC is generally preferred since thermal reactivation is not a problem. Stationary machines can use a variety of surface materials and are easy to set up and operate.

Throughfeed postforming is used where higher production rates are required and includes the following stations: sizing of laminate, glue application by either roller or spray nozzle, activation zone utilizing quartz lamps and hot air blowers, forming zone, and trimming.





**COOPERAGE:** Containers, such as barrels and kegs, consisting of two round head pieces and a body composed of staves held together with hoops.

**CORE:** The center layer in a composition (multi-layered) board panel.

**CORE BOARD:** A solid or discontinuous middle layer or ply used in panel-type glued structures (such as furniture panels and solid-or hollow-core doors). In furniture manufacture, also known as 'furniture board' or 'industrial board.'

**CORE GAP:** Spaces in the cross-bands of plywood in which the veneers do not butt tightly together.

**CORE STOCKS:** Because almost all core stocks are wood or wood by-products, the variables affecting adhesion to wood veneers and solid wood banding apply here also. Problems encountered can be even more severe due to the larger mass of the core stock compared to the mass of the laminates.

The two most important factors affected by the larger mass are core stock temperature and moisture content. Other factors affecting adhesion that are unique to a specific type of core stock are noted below

**CROOK:** The distortion of lumber from a straight line along the edges from end to end of a piece, measured at the point of greatest deviation from a straight line.

**CROSS-BAND:** In plywood, a layer of veneer whose grain direction is at right angles to that of the face plies; also, to place layers of wood with their grains at right angles in order to minimize shrinking and swelling.

**CROSS CUT OPTIMIZING:** Maximizing the efficiency in yield in the cross cut operation.

**CROSS-CUTTING:** Sawing wood across the grain to expose an end called a cross-section or transverse section. See also transverse.

**CROSS GRAIN:** Wood in which the fibers are not aligned parallel to the axis of the piece. See also diagonal grain and spiral grain.

**CUBICAL ROT:** See brown rot.

**CUBIC RECOVERY:** The percentage of the cubic volume of plywood expressed as a percentage of the total cubic volume of log used.

**CUBIC YIELD:** The cubic volume of plywood produced expressed as a percentage of the total cubic volume of the log less the peeler core.

**CULLS:** High-defect peelable logs that do not meet the requirements of Peeler and Sawmill grade rules but are suitable for rotary cutting.

**CUNIT:** A unit of measurement which equals 100 cubic metre.

**CUP:** A form of board warp in which there is a deviation from a straight line across the width.

**CUPPING:** Distortion of a board whereby the faces become concave or convex across the grain or width. This condition usually occurs in drying.

**CURE:** The change in properties of an adhesive by chemical reaction which results in the development of maximum strength of the adhesive. Generally accomplished by the action of heat or a catalyst, with or without pressure.

**CURLY GRAIN:** Wavelike undulations in the orientation of wood cells that cause light to be reflected at different angles from the surface and result in a pleasing effect of alternating light and dark bands.

**CURTAIN COATING:** A method of glue application in which the veneer passes through a curtain of adhesive.

**DADO:** A rectangular groove cut into the side of a piece of wood to receive another at right angles to it.

**DECAY:** The decomposition of wood substance by fungi. The destruction is readily recognized because the wood has become punky, soft and spongy; stringy, ring-shaked, pitted, or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

**DECIDUOUS:** See hardwoods.

**DECKING:** Lumber used for pallets, roofs, and walls - usually tongued and grooved.

**DECORATIVE FOILS:** Cellulose papers weighing between 40 and 140 grams per square meter untreated. The papers may be impregnated with melamine thermosetting resins, or left untreated.

Treating may add 20 to 40 grams of weight or more, depending on the basis weight of the paper. Decorative foils require an adhesive for lamination.

These papers are generally referred to as "finished foils" in Europe. In the United States they have been called melamine papers, intermediate weight foils, and impregnated foils. They are all of intermediate weight, but so are most of the saturated papers. And, "foils" are not all finished, nor are they all impregnated. Impregnation, or lack thereof, and the percentage of resin used, have a direct effect on the internal bond strength of the paper, as well as the porosity, cutting qualities, and machinability.

**DEFLECTION:** Downward bending of a board between supports when a load is applied such as a shelf or floor panel. Usually measured in inches and is greater in the center of the span.

**DEGRADE:** A reduction in the quality of wood due to defects that result from seasoning.

**DELAMINATION:** The separation of layers in a laminate through failure within the adhesive or at the bond between the adhesive and the lamination.

**DENATURANT:** A material added to another substance to alter its effectiveness for certain purposes. Denaturant alcohol is ethyl alcohol containing small quantities of other materials which render it unfit for beverage purposes. Most alcohol denaturants are poisonous.

**DENSITY:** As usually applied to wood of normal cellular form, density is the mass of wood substance enclosed within the boundary surfaces of a wood- plus-voids complex having unit volume. It is variously expressed as kilograms per cubic metre or pounds per cubic foot at a specified moisture content.

**DENSITY:** The weight of a panel as measured in pounds per cubic foot.

**DEPRESSION, WET-BULB:** The difference between the dry-bulb and wet-bulb temperature.

**DEW POINT:** The temperature at which steam or water vapor begins to condense.

**DIAGONAL GRAIN:** Wood in which the annual layers are at an angle with the axis of a piece as a result of sawing at an angle to the fiber direction. A form of cross grain.

**DIAMONDING:** A form of warp in which the cross section assumes a diamond shape.

**DIFFUSE-POROUS WOOD:** Wood from certain hardwood species whose pores are nearly uniform in size and distributed evenly through the annual layer (e.g., birch and maple). Annual layers are sometimes difficult to identify.

**DIFFUSION:** Spontaneous movement of heat, dissolved material, moisture, or gas through a body or space. Movement is from high points to low points of temperature, concentration, or partial pressure.

**DIMENSIONAL STABILIZATION:** Special treatment of wood to reduce swelling and shrinking caused by changes in its moisture content that accompany changes in relative humidity.

**DIMENSION LUMBER:** Lumber with a thickness of 38 mm (2 in.) up to, but not including, 114 mm (5 in.) and a width of 38 mm (2 in.) or more.

**DIMPLED GRAIN:** A distinctive figure produced on flat-sawn or rotary-cut surfaces of certain softwoods, notably lodgepole pine, by small, conical depressions of the fibers.

**DIRECT FIRED:** A method of heating a dry kiln where the hot gases produce by burning gas, oil, or wood waste are discharged directly into the kiln atmosphere.

**DIRECT POSTFORMING:** Direct postforming is a new concept which involves the same processes of conventional postforming, with the primary difference being that the substrate is preshaped on the same machine, leaving only the laminate to be wrapped. The machine can also include a gluing area for the insertion of an MDF strip or, depending on the quality of the core, can go directly to the glue application where the processes would be the same as conventional postforming. This equipment requires fewer processing stations than conventional postforming machines.





**DIRECTION OF GRAIN:** As applied to plastic laminates. A sanded grit pattern which can be seen on the laminate back and is usually parallel with a printed wood grain pattern.

**DOGS:** Steel, teelike projections usually attached to the knee of a heading carriage to hold the log firmly in position on the carriage headblock.

**DRESSED LUMBER:** Lumber that has been dressed by a planing machine for purposes of attaining smoothness of surface and uniformity of size.

**DRY-BULB TEMPERATURE:** The temperature of air as indicated by a standard thermometer.

**DRYING (SEASONING):** Removing moisture from green wood to improve its serviceability and utility. See also air dried and kiln, dried.

**DRYOUT:** Glue line failure caused by exceeding the maximum assembly time (q.v.).

**DRY FILM BONDING ADHESIVE:** Dry film bonding adhesives are non-tacky elastomeric materials coated on a release liner and sold in roll form. The film adhesive is bonded to the edge backing material with low temperature heat and pressure. The adhesive backed material is then heat-bonded at a higher temperature and thermoset to the application surface.

**DRY ROT:** A condition caused by the attack of a specific fungus, *Merulius lacrymans* or *Poria incrassata*, in which the fungus is capable of transferring water to 'dry' wood, resulting in brown rot. Sometimes erroneously applied to all decay.

**DURABILITY:** A general term for permanence or resistance to deterioration. Frequently used to refer to the degree of resistance of a species of wood to attack by wood-destroying fungi under conditions that favor such attack.

**EARLYWOOD:** The portion of the annual layer that is formed during the early part of the growing season. It is usually less dense and weaker mechanically than latewood.

**EASED EDGE:** Slightly rounded surfacing on pieces of lumber to remove sharp corners. Lumber 4 in or less in thickness is frequently shipped with eased edges unless otherwise specified. Lumber of 1 in and 2 in thicknesses may be rounded to a radius of no more than 1/16 in and 1/8 in, respectively.

**EDGE FOILERS:** These are single or double sided machines that typically shape, sand, and foil to a straight or profiled edge. The foil is transferred by heated silicone wheels using pressure to match the desired edge profile. Medium density fiberboard is the most common substrate used in edge foiling. The number of foiling stations, or heated silicone wheels, is determined by the complexity of the profile and production requirements.

**EDGE-GLUED:** Where two pieces of wood are joined edge to edge by gluing.

**EDGE GRAIN:** Lumber in which the annual layers form an angle of 45-90° with the wide surface of the piece. Also referred to as 'quarter sawn' or 'vertical grain.'

**EDGE PILING:** In air drying, stacking of wood products on edge, e.g., 2 by 4's, so that the broad face of the item is vertical; usually done to restrain crook. In kiln drying, stacking of lumber on edge for drying in kilns with vertical air circulation.

**EDGER:** A machine used to produce two parallel sides (wide face) by removing the rounded edges of a board (wane). Lumber is edged to specified width (softwoods) and to random width (hardwoods).

**EDGE BANDERS:** Edgebanders apply a variety of types of edging materials to the edges of panels. Types of edgebanding materials include HPL, PVC, Melamine, Polyester, and solid wood and wood veneers.

Types of edgebanders include single and double sided machines, hot air, PVC, contour, straight line and soffforming variations. Edgebanders can be manual or automatic. They can apply edgings with or without coated adhesives. Many larger edgebanders have front end tenoning capabilities for sizing and shaping.

**EDGEBANDING:** Is defined as the process by which a decorative laminate is attached to the surface that is adjacent to and at a 90° angle from the largest flat area of a given core stock. This is

primarily accomplished with hot melt adhesives, but water based adhesives are also used.

**ELECTRONIC BURNER:** An engraving machine energized by electric means.

**ELECTROSTATIC SPRAYING:** A process which uses electrostatic charges to attract an atomized chemical coating to its target. It increases the efficiency of the coating operation by the reduction of overspray.

**EMPTY-CELL PROCESS:** Any process for impregnating wood with preservatives in which air in the wood is maintained at or above atmospheric pressure before injection of the preservatives under pressure. After the pressure is released, a vacuum is drawn to drive out a portion of the preservatives from the wood cell cavities.

**ENCASED KNOT:** See knots.

**END JOINT:** The place where two pieces are joined end to end, commonly by scarf-jointing or finger-jointing.

**END MATCHED:** Another name for butt matched. Adjacent sheets from a flitch are laid so the ends of the sheets are matched.

**EPOXY ADHESIVES:** A two-component thermosetting adhesive typically used for laminating medium and heavy gauge vinyls, where a firm destruct bond is desired. Epoxy adhesives are generally binned 1:1 (resin to hardener) by volume and are roll-coated to either the backside of the vinyl web or to the board surface. Wet lamination is followed by stack curing the panels from one to three days at temperatures above 50° F. Solvent containing epoxies typically have better initial green strength (wet tack) than the newer 100% solids systems.

**EQUALIZATION & CONDITIONING:** In kiln drying, the process of increasing the equilibrium moisture content condition in the final stages of drying lumber and other mill products to (1) reduce the moisture content range between boards, (2) flatten the moisture content gradient within boards, and (3) relieve drying stresses. Usually equalization and conditioning are two separate stages in final kiln drying.

**EQUILIBRIUM MOISTURE CONTENT:** The moisture content at which wood neither gains nor loses moisture when surrounded by air at a given relative humidity and temperature.

**ESSENTIAL OILS:** Pleasant smelling oils prepared by passing steam through foliage and finely divided twigs of several conifer species (mainly cedars, Douglas-fir, and western hemlock).

**EXTRACTIVES:** Substances in wood, not an integral part of the cellular structure, that can be removed by solution in hot or cold water, ether, benzene, or other solvents that do not react chemically with wood components.

**FACE CHECKS:** Small longitudinal splits or separations visible on the surface of wood.

**FACE VENEER:** The outside piece of woods used in the construction of plywood. Its grain is usually at right angles to the grain of adjacent plies.

**FBM:** Foot Board Measure. One board foot is equal to a piece of wood one inch thick by 12 inches wide by 12 inches long.

**FEED RATE:** The rate in which material passes a cutting tool, measured in feet per minute (fpm).

**FIBERBOARD:** A broad, generic term inclusive of sheet materials of widely varying densities manufactured of refined or partially refined wood (or other vegetable) fibers. Bonding agents and other materials may be added to increase strength or resistance to moisture, fire, or decay.

**FIBER SATURATION POINT:** The stage in the drying or wetting of wood at which the cell walls are saturated and the cell cavities are free from water. It is usually taken as approximately 25-30% moisture content, based on oven-dry weight.

**FIBER, WOOD:** Long, thin, cylindrical wood cells, tapered and closed at both ends. Also a general term of convenience for any long, narrow cellular tissue.

**FIDDLEBACK FIGURE:** Figure produced by a type of fine wavy grain wood. Wood with such figure is traditionally used for the backs of violins.

**FIGURE:** Any characteristic pattern produced in a wood surface by annual growth rings, rays, knots, deviations from regular grain such as interlocked and wavy grain, and irregular coloration.



**FILLER:** A finishing material, usually containing considerable quantities of pigment, use to build up or fill depressions and imperfections in the surface.

**FINE GRAIN:** A nontechnical term variously used to describe wood with narrow, inconspicuous annual layers or with relatively small or uniform cell diameters.

**FINGER JOINT:** An end joint made up of several meshing fingers of wood bonded together with adhesive. Fingers may be sloped or cut parallel to either the face or the edge of the piece.

**FINISH:** Wood products such as doors, stairs, and other fine work required to complete a building, especially the interior.

**FINISHES:** Coatings of paint, varnish, lacquer, wax, and so on applied to wood surfaces to protect and enhance their durability or appearance.

**FINITE ELEMENT METHOD:** A method used in wood engineering for detailed stress analysis and precise calculations of deflections.

**FIRE ENDURANCE:** A measure of the time during which a material or assembly continues to withstand fire or to give protection from fire under specified conditions of test and performance.

**FISH EYE:** A small globular cavity which appears as a fault in translucent or transparent plastic.

**FLAT GRAIN:** The figure produced when lumber is sawn approximately tangent to the annual layers. Lumber is considered flat-grained when the annual layers make an angle of less than 45° with the surface of the piece. (Also referred to as 'flat sawn' or 'plain sawn'.)

**FLAT LAMINATING:** Is defined as the process by which a decorative laminate is attached to the largest flat area of a given core stock. This is usually accomplished through the use of epoxy, solvent or water based adhesives.

**FLAT PILE:** In air drying and kiln drying, stacking of stock so that the broad face of the item is horizontal. In kiln drying, the stickered loads are level.

**FLAT SAWN:** Another term for flat grain.

**FLAT GRAIN:** Veneer cut so that the growth rings meet the face over at least half the width at an angle of less than 45 degrees. Also called plain cut, flat sawn, slash grain.

**FLITCH:** A portion of a log sawn on two or more sides, frequently with wane on one or both edges, and intended for further conversion into lumber. See also cant.

**FOILS:** Cellulose papers weighing between 40 and 140 grams per square meter untreated. The papers may be impregnated with melamine thermoplastic resins or left untreated.

**FORMALDEHYDE:** A reactive organic compound, CH<sub>2</sub>O.

**FREE WATER:** Moisture that is contained in cell cavities and intercellular spaces and is held by capillary forces only.

**FULL-CELL PROCESS:** Any process for impregnating wood with preservatives or chemicals in which a vacuum is drawn to remove air from the wood before admitting the preservative. This process favors heavy absorption and retention of preservative in the treated portions.

**FUNGI:** A lower form of chlorophyll-less nonvascular plant life. Wood-inhabiting fungi use constituents of wood as food and also require moisture, oxygen, and suitable temperatures in order to develop.

**GRAIN:** In its restrictive meaning, grain designates the direction of alignment of wood elements that determines a plane of cleavage. This term is also used in a variety of ways to describe the size, arrangement, appearance, or other qualities of wood fibers. (See also cross grain, curly grain, diagonal grain, edge grain, fine grain, flat grain, interlocked grain, open grain, spiral grain, straight grain, texture, figure.)

**GRAIN RAISING:** The objectionable roughness of wood caused by the swelling and stiffening of the short, broken fibers on the surface.

**GRAIN RAISING GREEN:** Used in referring to freshly sawn or undried wood. Wood that has become completely wet after immersion in water is not considered green but may be said to be in the 'green condition.'

**GRIT SIZE:** Refers to coarseness of an abrasive material on a sanding belt. The lower the grit label, the coarser the abrasive material.

**GROWTH-RING FIGURE:** See figure.

**GUM:** A comprehensive term for nonvolatile, viscous plant exudates which either dissolve or swell in contact with water. Many substances referred to as gums, such as pine and spruce gum, are actually oleoresins.

**GYMNOSPERM:** A term signifying plants bearing exposed seeds, usually borne in cones. See also softwoods.

**GYPSUMBOARD:** A panel material formed of gypsum plaster faced on both sides by a sheet of structural paper.

**HARDBOARD:** A generic term for a panel manufactured primarily from interfelted wood fibers consolidated under heat and pressure in a hot press. The density of hardboard ranges from 55 to 75 pounds per cubic foot. The inter-fiber bond is primarily achieved through the action of the lignin mechanism. Other materials may be added during manufacture to improve certain properties such as stiffness, hardness, finishing properties, resistance to abrasion and moisture, as well as to increase strength, durability and utility. Hardboard is manufactured as either smooth-two-sides (S2S), or smooth-one-side (S1S) depending on the particular manufacturing process.

**HARDNESS:** A measure of resistance to indentation of the board surface and is related to board density. Value stated in pounds (lbs).

**HARDWOODS:** Generally one of the botanical groups of trees that have broad leaves in contrast to the conifers or softwoods. The wood produced by these trees contains pores. The term has no reference to the actual hardness of the wood.

**HEADRIG:** The first machine in a sawmill to start the breakdown of logs into lumber products.

**HEADSAW:** The principal saw in a sawmill used for the breakdown of logs by cutting parallel to the grain.

**HEART CHECK:** A radial shake originating from the heart or central portion of a log. Also called 'heart shake' and 'rift crack.'

**HEART SHAKE:** See heart check.

**HEARTWOOD:** The inner core of a woody stem, where the cells no longer participate in the life processes of the tree. Usually contains extractive materials that give it a darker color and greater decay resistance than the outer enveloping layer (sapwood).

**HEAT REACTIVE ADHESIVE ROLL LAMINATING EQUIPMENT:** Heat reactive equipment uses decorative overlays that have a dry adhesive already applied to the back of the overlay. The laminating machine contains heated rollers which activate the adhesive, roll the overlay onto the substrate, and apply pressure while the bond is created. Bond and cure are rapid. No ovens are required for curing.

**HEAT SEAL ADHESIVES:** These newer systems are dry coatings on the back of flexible laminates. They are heat sealed to panels by rollers or quick presses at low temperatures and pressures. They are applied and dried by the laminate producer using water or solvent based polymers. Heat seal adhesives differ from hot melts in chemistry, so they do not reflow on heating and do not change with age. They adhere to most surfaces and form very tough bonds.

**HEAT TRANSFER FOILS:** Heat transfer foils involve the transfer of a complete coating system from a carrier film to a substrate by means of heat and pressure. When transferred, the coating system is complete, providing both a decorative effect and a protective layer to provide specified end use properties.

The foils are gravure printed in reverse sequence on a mylar film. That is, the release coat is printed first, followed by the pattern of a wood grain print, the ground coat, and finally the adhesive.

**HEMICELLULOSE:** Noncellulosic polysaccharides of the cell wall that are easily decomposed by dilute acid, yielding several different simple sugars.

**HIGH PRESSURE LAMINATES:** Decorative laminated plastic sheets which consist of papers, fabrics or other core materials that have been laminated at pressures normally between 1,000 and 1,400 psi, using thermosetting condensation resins as binders.

A typical sheet of general purpose HPL is made from a sandwich of melamine-impregnated, alpha cellulose overlay and decorative





surface papers, superimposed over phenolic resin-impregnated Kraft papers. The sandwich is pressed at temperatures exceeding 265 degrees F, at pressures as high as 1,200 pounds psi.

The thickness, which is determined by the number of layers of Kraft papers and the resulting amount of resin absorbed, can range up to 3/8". When the sheet is pressed, a steel caul plate or a paper release sheet is used to create a surface finish ranging from high gloss smooth to fully textured or embossed. HPL is made in a multitude of solid colors and printed patterns.

**HIGH TEMPERATURE DRYING:** In kiln drying wood, use of dry-bulb temperatures of 212 degrees F or more.

**HOLOCELLULOSE:** The total carbohydrate fraction of wood - that is, cellulose plus hemicellulose.

**HONEYCOMBING:** A term used to describe advanced white rot; also checks, often not visible on the surface, that occur in the interior of a piece of wood, usually along the wood rays during seasoning.

**HOT MELT ADHESIVES:** An adhesive which is a 100% solids thermoplastic and is applied molten to form a bond upon cooling. Hot melts differ from conventional liquid adhesives because they set by cooling rather than by absorption or evaporation. In practice, papers are precoated with hot melt by the manufacturer and the adhesive is later reactivated by heat on the laminating line.

**HOT PLATEN PRESS:** Hot platen presses are equipped with internally heated single-opening or multi-opening, with either flat or molded press platens. The pressing time and temperature are determined by the adhesive and the chemical or heat reactions, as well as by the thickness of the laminating materials. Depending on the grade of automation, the process can be charged and discharged either manually or automatically.

A glue spreader is usually used to apply common adhesives to the board prior to lamination. The adhesives used are, urea formaldehyde, PVA, PVAC, and phenolic resins.

**HOT PRESS:** A major piece of plywood plant equipment which, through heat and pressure bonds the assembled veneer plies and adhesive into a panel.

**HPL:** High pressure laminate. A sheet material formed from multiple layers of kraft paper saturated with phenolic resin; a decorative layer of paper saturated with melamine resin; and a very thin top sheet of paper heavily saturated with a melamine resin. Fused together in the hot press under high temperature and pressure to produce a stiff plastic sheet.

**HUMIDIFICATION:** The process of adding moisture to the finished board.

**HUMIDITY, ABSOLUTE:** The weight of water vapor per unit volume of space.

**HUMIDITY, RELATIVE:** Ratio of the amount of water vapor present in the air to that which the air would hold at saturation at the same temperature. It is usually considered on the basis of the weight of the vapor, but for accuracy it should be considered on the basis of vapor pressures.

**HYDROGENATION:** Treatment of wood with hydrogen and suitable catalysis at high temperature and pressure to produce a gas or oils.

**HYDROLYSIS:** Conversion of the polysaccharides in wood or other cellulosic materials into sugars by treatment (hydrolysis) of wood with acids.

**HYGROMETER:** An instrument for measuring relative humidity, often consisting of dry-bulb and wet-bulb thermometers.

**HYPHAE:** Threadlike strands of fungi.

**IMPACT RESISTANCE:** Ability of a material to withstand sharp blows or violent contact.

**INSULATION VALUE:** Ability of a material to resist heat flow. Stated as R or thermal resistance value.

**INTERGROWN KNOT:** See knots.

**INTERLOCKED GRAIN:** A cross grain condition in which the direction of slope of the fibers alternates periodically between left-hand and right-hand spiral arrangements.

**INTERNAL BOND STRENGTH:** An overall measure of the board's integrity illustrating how well the core materials bonded together. Tested by applying tension perpendicular to the panel surface. Value stated in pounds per square inch (psi).

**ISOCYANATE ADHESIVES:** Based on polymethylene polyphenyl isocyanate and methylene bisphenyl diisocyanate (MDI).

**ISOTROPIC:** Having identical properties in all directions.

**ISO 9000:** A series of internationally recognized quality system standards that specify the requirements of a quality system, not it's product or service.

**JOINER TRADES:** Woodworking or furniture making skilled trades.

**JOINERY:** The skill or trade of a joinery. A joiner is a skilled woodworker or furniture maker.

**JOINT:** The line between the edges or ends of two adjacent sheets of veneer or strips of lumber core in the same plane.

**JOINT EDGE:** Joint running parallel to the grain of the wood.

**JOINT, OPEN:** Joint in which two adjacent pieces of veneer do not fit together closely.

**JOIST:** One of a series of parallel beams used to support floor and ceiling loads and supported in turn by larger beams, girders, or bearing walls.

**JUVENILE WOOD:** The innermost layers of wood adjacent to the pith, formed during the juvenile years of the tree's growth. Certain features, such as cell structure and size, differ from those typical of mature wood.

**KERF:** The narrow slot cut by a saw as it advances through wood, or the thickness of wood removed as sawdust by a saw.

**KILN:** A chamber having controlled air flow, temperature, and relative humidity used for drying lumber, veneer, and other wood products.

- compartment kiln A dry kiln in which the total charge of lumber is dried as a single unit. At any given time, the temperature and relative humidity are uniform throughout the kiln.

- progressive kiln A dry kiln in which the total charge of lumber is not dried as a single unit but as several units, such as kiln truckloads, that move progressively through the kiln. The temperature is lower and the relative humidity higher at the entering end (green end) than at the discharge end (dry end).

**KILN CHARGED:** In kiln drying, the total amount of lumber or wood items to be dried in a dry kiln.

**KILN DRIED:** Wood dried in a kiln to not more than 19% moisture content.

**KILN LEAKAGE:** The undesirable loss of heat and vapor from a kiln through and around doors and ventilators or through cracks in the walls and roof.

**KILN RUN:** The term applied to the drying of a single charge of lumber or other wood product.

**KILN SAMPLE:** A length cut from a sample board and placed in the kiln charge so that it may be removed for examination.

**KILN SCHEDULE:** In kiln drying, the prescribed schedule of dry-bulb and wet-bulb temperatures used in drying a kiln charge of lumber or other wood products.

**KNIFE ANGLE:** The angle between the knife face and a horizontal plane while peeling the block at various diameters. Also called slope angle.

**KNOTS:** Those portions of a branch or limb that have been surrounded by subsequent growth of the stem. The shape of a knot as it appears on a cut surface depends on the plane of the cut relative to the long axis of the knot.

- encased knot - A knot whose annual layers are not intergrown (i. e., not continuous) with those of the surrounding wood.

- intergrown knot - A knot whose annual layers are intergrown (i. e., continuous) with those of the surrounding wood.

- loose knot - A knot that is not held firmly in place or position and that cannot be relied upon to remain in place.





- pin knot - A knot of not more than 13 mm (1/2 in.) diameter.
- sound knot - A knot showing no indication of unsound wood. It may be red or black.
- spike knot - A knot sawn approximately parallel to its long axis so that the exposed section is definitely elongated.

**LAM:** Abbreviation for Labour and Material i.e. LAM bar code OR Abbreviation for Laminated as in glulam or lam-stock

**LAMELA:** A thin layer.

**LAMINATE:** (n) A product made by bonding together two or more layers of material. (v) To unite layers of material with adhesive.

**LAMINATED VINYL:** A lamination of two materials, generally vinyl to vinyl, although ABS and paper backers may be used. The lamination produces edgebanding rigid enough for automatic edgebanders.

The carrier is generally a rigid PVC .010" to .030" thick, and may be clear or in color. The surface is a printed or solid color lamination grade vinyl, usually reverse printed, and .002" to .008" thick. End users often supply their own vinyl for exact color match. The sandwich construction is then slit and is suitable for straight-line or sofform applications, depending on the backer used.

**LAMINATED WOOD:** An assembly made by bonding layers of veneer or lumber with an adhesive so that the grain of all laminations is essentially parallel.

**LAMINATOR:** A machine used to glue together or laminate pieces of materials such as lumber or plywood.

**LAP:** A condition where the veneers used are so misplaced that one piece overlaps the other and does not make a smooth joint.

**LATHE:** A machine for holding pieces of wood and turning them against a cutting or shaping tool.

**LATHE, ROTARY:** A piece of equipment in which a peeler block is rotated while a carriage equipped with a full-length veneer knife advances a predetermined distance with each rotation of the peeler block. The result is a continuous veneer ribbon of uniform thickness.

**LATEWOOD:** The portion of the annual layer that is formed during the latter part of the growing season after the earlywood formation has ceased.

**LIGNIN:** The thin, cementing layer between wood cells, located principally in the secondary wall and the middle lamella. Lignin is the second most abundant constituent of wood. Chemically it is an irregular polymer of substituted propylphenol groups, and thus no simple chemical formula can be written for it.

**LIMIT STATES DESIGN:** A structural design procedure for proportioning to a structure a measured degree of safety against the occurrence of undesirable conditions or limit states in which the structure ceases to fulfill the function(s) for which it is intended. Those exceeding the load capacity, fracture, and so on are called 'ultimate limit states.' Those which restrict the use or affect the appearance, such as minor distress, vibration, cracking, and deformation, are called 'serviceability limit states.'

**LINE BORED:** A manufacturing operation that results in straight line drilled holes.

**LINEAR EXPANSION:** A measure of growth along length and width of the board when exposed to conditions from low to high humidity stated in percent (%).

**LINERBOARD:** A paperboard used as a facing material in corrugated and solid fiber shipping containers. Linerboard is usually classified according to furnish, as for example, kraft linerboard.

**LINEAR OPTIMIZATION:** A method of finding the optimum solution to a problem with constraints and many internal decisions using the techniques of linear programming.

**LIQUID ADHESIVE ROLL LAMINATING EQUIPMENT:** The roll laminating equipment consists of one (sometimes two or three) heated roll combining stations, where continuous rolls of paper or vinyl film are laminated to the substrates. The liquid adhesive is applied to the board, to the web, or both, prior to the combining of the film and substrate.

The lamination and bond are created as paper or vinyl film is pulled

from an unwind stand, and married with the substrate as they meet and pass through the rotary roll combining station. After lamination is complete, the panels are separated and stacked.

The equipment arrangement can be for a single top lamination or top and bottom lamination.

**LIVE SAWING:** Sawing through and through without turning the log or by turning it only once - that is, sawing with a bandmill headrig or with a circular headrig.

**LONGITUDINAL:** Generally, parallel to the direction of the wood fibers.

**LONGITUDINAL SHEAR STRENGTH:** The capacity of a body to resist longitudinal shearing stresses.

**LOW BASIS WEIGHT PAPERS:** Low basis weight papers have sometimes been referred to as "micro-papers" or "rice papers."

Low basis weight papers range in weight from 23 to 30 grams and are sometimes preimpregnated with resin. Acrylic, polyester, and other resins can be added during the paper making process to improve the internal bond strength of the paper. The paper is then printed and generally coated with polyurethane, urea, polyester, acrylic or melamine resins, or a combination thereof.

Low basis weight papers are usually divided into two categories, standard or industrial. Standard grade papers contain a lower amount of resin in the base paper, and offer an economical laminate for use on low wear surfaces, such as wall paneling. Industrial grade papers have a higher resin content and have greater internal bond strength.

**LOW PRESSURE PRESS:** This system earned its name from the distinction between high pressure laminates, pressed separately with pressures between 700-1400 PSI, and low pressure lamination at 430 PSI. Low pressure lamination is a process whereby the resin saturated films are pressed straight onto the substrate (particleboard or MDF) with 430 PSI and a lower temperature, generally around 390 degrees Fahrenheit. In this fashion, the overlay is "thermofused" directly to the core.

The resin is the bonding material, and liquefies under pressure and heat. The surface structure of the final product is set by the caul plates, which are fixed to the hot press platens. The most common resins are melamine and polyester. Phenolic resin surface films are mainly used for concrete forming boards in the construction industry.

**LOW TEMPERATURE KILN:** Forced air drying in a moderately tight building equipped to produce air movement through the loads and recirculate the air over heat and/or humidity sources, with dry-and wet-bulb controls to maintain small to moderate wet-bulb depressions in the temperature ranges between 85 degrees and 120 degree F.

**LPI:** Low pressure laminate. A preprinted or solid color decorative paper that has been saturated with a resin. Under heat and pressure, it bonds to a board surface without need for additional adhesive.

**LUMBER:** The product of saw and planing mills that is not further manufactured beyond sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching.

**LUMBER GRADER:** A person who grades lumber into appropriate grades.

**LUMEN:** The cavity within a wood cell.

**MACHINE DIRECTION:** The panel orientation that corresponds with the direction that the product moved through the machine that manufactured or machined it. Also referred to as the parallel direction.

**MACHINE STRESS RATED (MSR):** Lumber that has been evaluated by means of nondestructive machine stress-rating equipment.

**MARGO:** That portion of the membrane of bordered pits that supports the torus; that is, the membrane exclusive of the torus.

**MATCHED LUMBER:** Lumber that is edge-dressed and shaped to form a tongued and grooved or similar joint when pieces are laid side by side.

**MEAMINE:** Low pressure laminate, or more often called melamine laminate, is very similar to HPL. Because the resin is not allowed to fully saturate the plies of paper and low pressure instead of high pressure is used to react the resin, melamine laminate is lower in density and much more porous than HPL, making it much easier to bond. The surface durability of melamine is closer to PVC rather than HPL, but allows more detail for more realistic print patterns.





**MEDIUM DENSITY FIBERBOARD:** A panel product manufactured from wood fibers combined with a synthetic resin or other suitable binder, and bonded under heat and pressure to a density of between 31 and 55 pounds per cubic foot. Because of its homogeneous construction, medium density fiberboard (MDF) features an extremely smooth face and a tight, machineable core. MDF is favored by laminators using thin foil laminates and/or requiring unfilled machined edges. MDF is available up to 2' thick and nearly any panel size transportable.

**MELAMINE:** The resin is introduced into the paper during an impregnating operation. After the paper is impregnated it is partially cured ("B" stage) using curing ovens. The melamine resin is fully cured at 300-400 psi and 300-400 degrees F during hot press lamination. The "B" staged paper has a definite shelf life that varies with temperature and humidity.

**MEMBRANE PRESS:** Membrane press technology, formerly known as the vacuum press system, is used for the lamination of molded (three-dimensionally shaped) substrates with veneers, vinyls, and other materials. The adhesives are applied either to the core or to the laminating materials. The pressing process is performed with a silicone or rubber membrane which forms the laminating material under pressure and heat over the molded substrate. In a membrane press, heat is applied to both top and bottom, pressure is applied to the top only, and a vacuum is drawn from the bottom. The pressure used to complete the laminating process is in the range of 105 pounds per square inch.

The adhesives used for veneers are primarily PVA and urea formaldehyde. Vinyls are usually bonded with water based polyurethane, which is dried after application and reactivated with heat during the pressing process.

**MENISCUS:** The curved upper surface of a liquid in a tube or container. Wood cells serve as containers for liquid water. The surface of the water in the cell is concave, owing to the effect of surface tension.

**METALLIC EDGE-BANDING:** Polished or brushed metals, or metallic transfer foils laminated to a backer in a master log. The material can be slit to virtually any width. This decorative edgebanding may also be used as an inlay. The material may come with a pressure sensitive adhesive backing, or may be applied with a contact cement. A protective surface coating is removed after application.

**MICROFIBRIL:** A threadlike component of the cell wall structure composed of chain molecules of cellulose extending through regions of parallel order known as crystallites and through regions of disorder known as amorphous regions. Microfibrils are the smallest natural units of cell wall structure that can be distinguished with an electron microscope.

**MIDDLE LAMELLA:** The lignin-rich layer that cements adjoining cells together. This layer is dissolved in the chemical pulping processes which separate wood into pulp fibers.

**MILDEW:** Surface growths of fungi, usually dark gray in color, growing on the exterior wood of buildings.

**MILLWORK:** Planed and patterned lumber for finish work in building, including items such as sashes, doors, cornices, panel work, and other items of interior or exterior trim. Does not include flooring, ceilings, or siding.

**MILLWRIGHT:** A person who design, builds, or sets up mills or machinery for mills.

**MINEARL STAIN:** See stain.

**MODULUS OF ELASTICITY:** A measure of the stiffness of wood.

**MODULUS OF ELASTICITY (MOE):** A measure of the board's resistance to deflection or sagging when loaded as a simple beam. Value stated in pounds per square inch (psi).

**MODULUS OF RUPTURE (MOR):** An index of the maximum breaking strength of the board when loaded as a simple beam. Value stated in pounds per square inch (psi).

**MOISTURE CONTENT:** The amount of water contained in wood, usually expressed as a percentage of the weight of the oven-dry wood.

**MOLD:** Superficial, usually colored growth of fungi on damp wood; also referred to as mildew.

**MORTISED:** A hole in one piece of wood cut to receive the projection on another piece.

**MOULDER:** A machine that shapes into finished dimensions the face and edged surfaces.

**MSF:** Abbreviation for thousand square feet.

**MSR:** Abbreviation for Mechanically Stress Rated as in lumber.

**NAVAL STORES:** Oils, resins, tars, and pitch extracted from pine and fir trees. Historically, the term was derived to describe those products when they were used in the construction of wooden sailing vessels.

**NOSE BAR:** A beveled bar mounted parallel with the tip of the lathe knife and designed to compress the veneer block into the cutting edge of the lathe knife.

**OLEORESIN:** A solution of resin in an essential oil that occurs in or exudes from many plants, especially softwoods.

**OPACITY:** As applied to a filled board surface. Complete coverage of filler that masks the board surface.

**OPEN GRAIN:** Common classification for woods with large pores, such as oak, ash, and walnut.

**OPTIMIZING:** Making the most of or the most efficient. i.e. optimizing saw.

**OVEN DRY:** A term applied to wood dried to constant weight in an oven maintained at temperatures of from 214 degrees to 221 degrees F.

**OVERLAY:** A thin layer of paper, plastic, film, metal foil, or other material bonded to one or both faces of panel products, or to lumber, to provide a protective or decorative face or a base for painting.

**PACKAGED-LOADED KILN:** A trackless compartment kiln for drying packages of stickered lumber or other wood products. The dryer usually has large doors that can be opened so that the kiln charge can be placed in or removed from the dryer by forklift trucks. It is usually a forced-air circulation kiln with fans mounted overhead or at the side.

**PALLET:** A horizontal platform device used as a base for assembling, storing, handling, and transporting materials and products as a unit load.

**PALLETIZED:** Storing and/or shipping items on a pallet.

**PARALLEL LAMINATED VENEERS:** Used as a substitute for solid sawn timbers formerly made from old growth trees.

**PARAMETRIC LINKING:** A design method whereby the design details such as the geometry and the location of arcs and lines are linked to the outside dimensions of the part. This allows the design to be easily scaled to match the part dimensions when ever they are changed.

**PARENCHYMA:** Short cells having simple pits and functioning primarily in the metabolism and storage of plant food materials. They remain alive longer than the tracheids, fibers, and vessel segments, sometimes for many years. Two kinds of parenchyma cells are recognized: those in vertical strands, known more specifically as axial parenchyma, and those in horizontal series in the rays, known as ray parenchyma.

**PARTICLEBOARD:** A panel manufactured from wood particles or combinations of wood particles and fibers, bonded together with synthetic resins under heat and pressure. Particleboard is more dimensionally stable and machineable than many other cellulosic substrates and offers a smooth surface that bonds readily with nearly all laminating adhesives. While particleboard is available in many different grades and densities, industrial grades are typically specified for laminating applications. Particleboard is available up to 2' thick and nearly any panel size transportable.

**PHENOL FORMALDEHYDE (PF):** A water resistant thermosetting resin system commonly used to bond softwood plywood, oriented strand board (OSB), and exterior particleboard (ANSI A208.1 Type 2).

**PHENOLIC RESINS:** Synthetic petrochemical-based adhesives used in the manufacture of hot-pressed plywood.

**PHLOEM:** Inner bark tissue, characterized by the presence of sieve tubes and serving for the transport of foodstuffs.





**PILE:** In air drying, stacking lumber layer by layer, separated by stickers or kiln sticking, on a supporting foundation (hand stacked). Also, stickered unit packages by lift truck or crane, one above the other on a foundation and separated by bolsters.

- Box pile - A method of flat stacking random length lumber for air drying or kiln drying. Full-length boards are placed in the outer edges of each layer and shorter boards in between are alternated lengthwise to produce square-end piles, unit packages, or kiln truckloads.

- Machine-stacked pile - Unit packages of stickered lumber or other wood products stacked by mechanical means onto a pile foundation and one above another to build a pile of packages.

- Random-length pile - Stacking lumber of various lengths in the same pile or package. The pile or package is usually square at one end with the long length at the other end unsupported by stickers.

- Self-stickered pile - Stacking in which the stock is used as stickers to separate the layers. In crib stacking, the boards are in contact at the tree corners. In level or sloped stacking of softwood boards and dimensions, stock is used for stickers and the pile width is the same as the length. Hardwood dimension stock and railroad ties are often self stickered.

**PIN KNOT:** See knots.

**PIT:** A discontinuity in the secondary cell wall normally found in adjacent pairs of cells forming a pathway for liquid movement between neighboring cells. The two halves of a pit pair are normally separated by a membrane consisting of the middle lamella and adjacent primary cell walls. Sometimes the central portion of the membrane is thickened to form a torus.

**PIT ASPIRATION:** The displacement of the torus of a bordered pit pair against one of the pit borders closing the pit aperture.

**PIT PAIR:** Two complementary pits of adjacent cells.

**PITCH POCKET:** An opening extending parallel to the annual layers that contains, or has contained, either solid or liquid pitch.

**PITCH STREAKS:** A local accumulation of resin in the form of a streak, occurring in certain softwoods.

**PITH:** The small core of soft primary tissue occurring near the center of a tree stein, branch, and sometimes, root.

**PITH FLECKS:** Flecks on planed lumber caused by insects boring in the cambium layer, producing wound tissue with brownish contents.

**PLAIN SAWN:** See flat grain.

**PLANNER-MATCHER:** A surfacing machine for lumber. Profiler heads can be inserted to create side-matching pieces of wood – that is, tongue and groove or shiplap. See also matched lumber.

**PLANK:** A piece of square-cut timber, generally more than 25 mm (1 in.) thick and 140 mm (6 in.) wide or greater, and of any length.

**PLENUM CHAMBER:** The space between the lumber stack and kiln wall for air circulation on the pressure side of a fan or blower in which the air is maintained under pressure.

**PLATFORM FRAME SYSTEM:** A framing system in which floor joists of the upper stories rest on the top plates of the story below (or on the foundation wall), and bearing walls and partitions rest on the subfloor of each story.

**PLUGS:** Sound wood of various shapes, used to replace defective portions of veneers. Also, synthetic plugs used to fill openings and provide a solid surface.

**PLY:** A single veneer laminate in a glued plywood panel.

**PLYWOOD:** Plywood differs from the other core stocks in that periodically along its edge, large gaps occur within the plies. This requires large amounts of hot melt adhesive at random moments for gap filling.

In addition, when plywood is panel sized, the saw blade has a tendency to raise the two exterior plies above the interior plies on certain types of plywood. Thus, the edge to be bonded looks more like a trough, requiring even larger amounts of hot melt adhesive.

**PNEUMATIC:** Relating to air, wind or gas.

**POCKET ROT:** Advanced decay that appears in the form of a hole or pocket.

**POLYESTER:** The resin is introduced into the paper during an impregnating operation. After the paper is impregnated it is dried in a drying oven. Polyester resin is fully cured at 175-200 psi and 275-350 degrees F during hot press lamination. The dried paper has a definite shelf life that varies with temperature and humidity.

The melamine sheet is widely used in Europe and is generally referred to as “low pressure laminate.” In North America, the more common term for both melamine and polyester laminated panels is Permalam.

Permalam is a registered trademark of the American Laminators Association (ALA). It is the term that may be used by ALA members to describe a decorative thermoset panel produced by hot press laminating polyester or melamine resin impregnated, self-bonding (minimum 50% resin content) paper to any cellulosic substrate.

**POLYESTER LAMINATES:** Decorative papers, often matching popular high pressure laminates, are impregnated with polyester resin and laminated to a variety of backers. Typically produced in light and heavy weight versions, either can be preglued for heat bar or hot air application. The heavy weight version is excellent for straight-line, contour, and softform automatic edgebanding applications. Produced in logs, polyester edgebanding can be slit to any width. Surface finish options include textured, satin, wood grain, ticked, and stainable, oversprayable versions.

**POLYURETHANE DISPERSIONS:** Polyurethane dispersions (PUD's) are aqueous dispersions of fully reacted urethane polymers containing hydrophilic anionic, cationic, or nonionic groups noted for their high performance properties, excellent adhesion, chemical resistance, outstanding toughness, and low temperature flexibility.

PUD's are used for the membrane pressing of vinyl films and veneer to a MDF core. PUD's can be used in conjunction with a hardener for higher heat resistance if required. The hardener level is usually 5% by weight and should be added with very good agitation.

PUD's are typically spray applied to the MDF at a coat weight of 2-4 wet mils, and then air dried before mating with the vinyl film or veneer in the membrane press. Typical membrane press temperatures are 70-90° C, with cycle times of 20-120 seconds.

**PORES:** See vessels.

**POSTIMPREGNATED:** Papers that are treated after they have been manufactured with a resin system such as melamine or urea formaldehyde, usually with acrylic, which allows the sheet to remain flexible even after the resins are fully cured. In postimpregnated papers, the paper fibers are encapsulated with resin, and the voids and air spaces in the paper are filled with resin. The papers may be top coated and may have hot melt adhesives applied at the point of manufacture.

**PRECISION PREDRYER:** A type of low temperature dryer. Stickered loads or unit packages of lumber or other wood products are placed in a large building provided with fans, heating system, and vents such that air of a given temperature and humidity can be circulated through the lumber.

**PREFINISHED PANEL:** Panels having factory- applied decorative or protective coatings.

**PREIMPREGNATED:** Papers that are treated during the paper making process with a resin system such as melamine or urea formaldehyde, usually with acrylic, which allows the sheet to remain flexible after the resins are fully cured. The resin is applied through a size press and calendered, either on the paper machine or later. The calendering provides a good printable surface and one that takes coating easily. These papers can be chemically embossed and may be available with preapplied hot melt adhesives.

**PRESERVATIVE:** Any substance that, for a reasonable length of time, is effective in preventing the development and action of wood-rotting fungi, borers of various kinds, and harmful insects that deteriorate wood.

**PRESS DRYING:** A veneer drying method in which single green veneer sheets are placed between press platens under predetermined heat, pressure, and time; the resulting dry veneer is flat and uniformly dried to a desired moisture content.







**PRESSURE PROCESS:** Any process of treating wood in a closed container whereby the preservative or fire retardant is forced into the wood under pressures greater than 1 atmosphere (101 kPa). Pressure is generally preceded or followed by vacuum, as in the vacuum-pressure and empty-cell processes; or the applications of pressure and vacuum may alternate, as in the full-cell and alternating processes.

**PRESSURE SENSITIVE ADHESIVES:** Pressure sensitive adhesives are viscoelastic materials coated on a release liner and sold in roll or sheet form. The adhesive is sticky to the touch and can be applied to most surfaces with light roll down pressure. Pressure sensitive adhesives bond through intermolecular forces of attraction between like or unlike surface, which resist their separation.

The highest performing, longest aging adhesives are usually cross linked high molecular weight acrylic materials. Pressure sensitive adhesive backed veneers or other substrates are easy to apply and eliminate the need for liquid adhesives.

**PRIMER:** That coat of material that is applied directly over the uncoated surface.

**PROFILE DENSITY:** Variation of density of a panel from face to core.

**PROFILE WRAPPERS:** Profile wrap machines apply an overlay to a preformed substrate, typically in lineal molding ("stick") form. A preshaped molding, in a variety of substrates, including but not limited to, solid wood, MDF, particleboard, extruded plastics, and various metals, is fed into the machine in stick form. A flexible overlay of paper, vinyl, wood, veneer, or metallic is concurrently fed into the machine and applied through pressure rollers to the surface of the molding.

Profile wrappers are generally Hot Melt or PVA adhesive systems. Profile wrapped parts can be cut to size with finished ends or left in fixed length sticks form.

**PROFILE WRAPPING:** Is the process by which a decorative laminate is attached to a core stock that does not have a single surface that can be considered the largest flat area and to which the laminate is attached to the core stock over an arc greater than 135°. This is primarily accomplished through the use of water based or hot melt adhesives.

**PROGRAM:** A high-achievement or top level wood technology program.

**PROJECTED YIELD:** The amount of yield that is predicted and is usually based on research and statistical data.

**PSF:** Pounds per square foot. Measure of loads distributed over a square foot of board surface.

**PSI:** Pounds per square inch. Measure of loads distributed over a square inch of board surface.

**PSYCHROMETER:** An instrument with both wet-bulb and dry-bulb thermometers for determining the amount of water vapor in the atmosphere.

**PVC:** An extruded or calendered thermoplastic edgbanding made of polyvinyl chloride, used to match vinyl, paper, paint or high pressure laminates. Calendered PVC is manufactured in wide logs and slit to size, while extruded is manufactured to exact width. PVC offers unlimited color and pattern availability, a wide range of widths (to 3.5"), thicknesses (.016 to .187), surface textures, and gloss levels. The printed surfaces as well as the solid colors are generally top coated with a UV cured resin for protection.

PVC is mainly used for straight-line and contour automatic edgbanding applications. Thicker versions are available pregled for hot air applications. PVC is not recommended for softform applications.

**PVC LAMINATE:** This is a thermoplastic material which will melt or deform if too much hot melt is applied to the core stock. This is usually very noticeable in a softforming operation. PVC varies in thickness ranging from 0.010 inch up to 0.125 inch, which changes its heat sink (ability to absorb heat) characteristics. PVC does not absorb water nor does it expand with an increase in ambient temperature. It, in fact, becomes more elastic at elevated temperatures, thus decreasing the strain on the bond line. All PVC must be primed (usually with a solvent-based adhesive) before a standard EVA-based hot melt edgbanding adhesive may be used.

PVC primers are not suitable for use on other types of laminates nor should primers be used on PVC that are designed for other laminates. A few hot melt polyamide adhesives are suitable for unprimed PVC, but are not economically feasible. Please note that not all hot melt polyamide adhesives are suitable for unprimed PVC.

**PYROLYSIS:** Chemical decomposition of wood by the action of heat; that is, burning of wood.

**RADIAL:** Coincident with a radius from the axis of the tree or log to the circumference. A radial section is a lengthwise section in a plane that passes through the center line of the tree stem.

**RAFTER:** One of a series of parallel structural members of a roof designed to support roof loads. The rafters of a flat roof are sometimes called roof joists.

**RAISED GRAIN:** A roughened condition of the surface of dressed lumber in which the hard latewood is raised above the softer earlywood but not torn loose from it.

**RAT TAILING:** A defect in a dried film caused by a bubble or a small piece of dirt, flowing downward on a vertical surface in such a way as to leave a thinner film of finishing material above it, due to the material having lost its flowing power, and somewhat resembling a rat tail.

**RATE OF RECOVERY:** The rate at which something is recovered in a unit of time.

**RAYS, WOOD:** Ribbon like strands of tissue extending radially within a tree and varying in height from a few cells in some species to several centimeters in oak. The rays serve primarily to store food and transport it horizontally through the tree.

**REACTION WOOD:** Wood with abnormal structure and properties formed in parts of leaning or crooked stems and in branches. In hardwoods it is called "tension wood"; in softwoods, "compression wood."

**RECONSTITUTED WOOD:** Wood in forms ranging from logos to coarse residues are first reduced to small fragments and then put back together again by special manufacturing processes into panel products of relatively large sizes and various thickness such as particleboard, medium density fiberboard and hardboard.

**RECONSTITUTED WOOD STRIPS:** A man-made veneer generally manufactured in Europe. Light colored woods are cut, dyed, and reformed into flitches before being re-sliced into sheets that approximate flat cut or quartered veneer. This produces a consistent, custom colored, and grained wood veneer. These veneers can be processed into fleece or paper backed strips or coils for straight-line, contour, or softform automatic edgbanding applications. The back can also be coated with hot melt adhesive or PVA.

**RECORDER CONTROLLER:** An instrument that continuously records dry- and wet-bulb temperatures of circulated air and regulators these temperatures in a dryer or kiln by activating automatic heat and steam spray valves.

**RELATIVE DENSITY:** Formerly called specific gravity. As applied to wood, the ratio of the oven-dry weight of a sample to the weight of a volume of water equal to the volume of the sample at a specified moisture content (green, air-dry, or oven-dry).

**RELATIVE HUMIDITY:** Ratio of the amount of water vapor present in the air to the amount that the air would hold at saturation at the same temperature. It is usually considered on the basis of the weight of the vapor but, for accuracy, should be considered on the basis of vapor pressures.

**RELAXATION:** Reduction of stress with time on a wood member maintained under constant deflection.

**RESIDUALS:** Wood by-products of the primary peeling process; includes pulp chips, hog fuel, and peeler cores.

**RESAW:** A sawing machine used to break down cants into lumber, for recovering lumber from slabs, and for upgrading lumber by ripping off defective portions.

**RESIN:** A comprehensive term for secretions of certain trees, or of insects feeding on them, that are oxidation or polymerization products of the terpenes, consisting of mixtures of aromatic acids and esters insoluble in water but soluble in ether, alcohol, and other organic solvents. These secretions often exude from wounds and are obtained commercially by tapping or by extraction with solvents. The term is



also applied to synthetic organic products related to the natural resins.

**RESIN DUCTS:** Intercellular canals or passages that contain and transmit resinous materials. They may extend vertically parallel to the axis of the tree or at right angles to the axis and parallel to the rays.

**RESISTIVITY:** The resistance of a cubic centimetre of material, such as wood, to the direct-current flow of electricity between opposite faces.

**RIBBON STRIPE:** A form of figure produced on the surface of wood because of the presence of interlocked grain.

**RIFT CRACK:** See heart check.

**RIFT SLICED, RIFT SAWN ALSO TERMED COMB-GRAIN:** Refers to method of producing veneer by slicing or sawing at an angle of approximately 45 degrees with the annual rings to bring out certain figures produced by the medullary rays, which are especially conspicuous in oak.

**RING-POROUS:** Used in referring to a group of hardwoods in which the annual growth layers consist of a more or less continuous zone of large earlywood pores that changes relatively abruptly to a denser latewood zone having smaller pores and an abundance of fibrous tissue (e. g., oak and ash).

**RING SHAKE:** A separation along the grain that occurs most commonly between adjoining annual layers. See also shake.

**RIP SAW:** A saw that cuts along the lengthwise edge of lumber.

**RIPPING:** Cutting lengthwise, parallel to the grain.

**ROLLER BAR:** A rotating round bar mounted parallel with the tip of the lathe knife; designed to compress the veneer block into the cutting edge of the lathe knife.

**ROTARY CUT VENEER:** Veneer cut in a lathe that rotates a log or bolt against a knife set in such a manner as to peel off a continuous thin sheet. Also, a method of cutting veneers from a log. The log is steamed in a vat to soften the wood, the bark is removed and the whole log is mounted in a large lathe and turned against a long, sharp knife. As the log revolves the veneer is peeled off in long sheets. It also refers to manner of cutting veneer by which the entire log is centered in a lathe and turned against a broad cutting knife, which is set into the log at a slight angle.

**ROUGH LUMBER:** Lumber that has been sawn, edged, and trimmed but not dressed (planed).

**ROUGH SAND:** Area of a sanded panel that was not sanded with the finish sanding heads. The surface will appear and feel rough.

**RPM:** Revolution per minute. The turning speed of a motor or cutting tool.

**SAP:** Fluid contents of the living wood cells.

**SAP STAIN:** See stain.

**SAPWOOD:** The wood located near the outside of the tree stem containing the tissues actively involved in the transport of sap. It is generally lighter in color than heartwood and has lower natural resistance to decay.

**SASH GANG SAW:** A sash or frame holding a battery of parallel saws that move up and down on the end of a connecting rod attached to a heavy crank shaft.

**SATURATED PAPERS:** Decorative surface papers generally weighing between 60 and 130 grams per square meter. These papers are saturated with reactive resins and partially cured at the point of manufacture. Final curing is done at the time of hot press lamination when the resins form a hard crosslinked thermoset material. The paper formation is similar to the sheet used for high pressure laminates. These products are self-bonding; that is, the resin in the paper flows into the surface of the board during lamination, creating a permanent bond. Thus, no adhesives are required.

Two different resin systems may be used to impregnate saturated papers for lamination:

**SATURATED PAPERS:** Decorative surface papers generally weighing between 60 and 130 grams per square meter. These papers are saturated with melamine or polyester resins and partially cured at the point of manufacture. Final curing is done at the time of hot press lamination.

**SAWING AROUND:** Breaking down a log by turning it on the carriage of a headsaw to obtain the best yield of lumber from the clear outer portion of the log.

**SAWN VENEER:** Veneer produced by sawing.

**SAWYER:** A person whose work is sawing timber.

**SCALER:** A person who scales or measures the volume of timber or lumber.

**SCARF JOINT:** An end joint formed by joining with glue the ends of two pieces that have been tapered or beveled, usually to a feather edge, to form a slope of the same length and inclination in both pieces.

**SCRAG SAW:** Two or more pairs of saws, one pair to a drive shaft, or two or more pairs of saws, each saw on an individual drive shaft, all sawing different lines. Saws may be fixed or adjustable to different settings.

**SCREWHOLDING:** A measure of the force required to withdraw a screw directly from the face or edge of a board stated in pounds (lbs).

**SEALERS:** Undercoating materials for sealing a surface in preparation for painting, varnishing, or application of final finish.

**SEASONING:** See drying.

**SECOND GROWTH:** Trees that replace the original virgin stand of timber.

**SEMICHEMICAL PULP:** Pulp obtained by mild treatment of wood chips by any of the chemical pulping processes, which remove only part of the lignin from the wood chips, followed by mechanical treatment to complete the separation of individual cellulose fibers.

**SET:** A permanent or semipermanent deformation in wood caused by internal stresses.

**SETWORKS:** The mechanism on an edger, on a log carriage, or on twin and quad bandsaws for regulating the thickness of the wood being cut.

**SHAKE:** A rupture or separation along the grain. The term is most commonly applied to 'ring shakes,' which develop tangentially either within a given annual layer or at the boundary between two layers.

**SHAKES:** In construction, a type of shingle usually hand cleft from a bolt and used for roofing or weatherboarding.

**SHEAR:** The displacement of woody tissues following fracture as a result of shearing stresses which cause the fibers to slide relative to one another.

**SHEAR, LONGITUDINAL:** Shearing stress that tends to cause the fibers to slide over each other lengthwise.

**SHEAR STRENGTH:** The capacity of a body to resist shearing stresses.

**SHEATHING:** The structural covering, usually of boards, building fiberboards, waferboard, or plywood, placed over exterior studding or rafters of a structure.

**SHIM STOCK:** Thin strips of wood used to level off irregularities under a hardwood floor.

**SHINGLES:** Thin, rectangular pieces of wood, sawn along the grain and tapering in thickness, used like tiles for roofing and weatherboarding.

**SHRINKAGE:** Contraction caused by drying wood below the fiber saturation point; it is greater in the wide face of flat-grain than in edge-grain lumber, and minimal in the longitudinal direction.

**SIDING (CLADDING):** The finish covering of the outside wall of a frame building, whether made of horizontal weatherboards, vertical boards with battens, shingles, or other material.

**SINKER:** A log which sinks in water.

**SINKER STOCK:** Green lumber or other green sawmill products that will not float in water. Sinker stock may be sawn from sinker logs that were water-logged during ponding or from freshly cut logs containing wetwood. The green moisture content is abnormally high, and the lumber tends to dry slowly and is prone to develop checks and honeycomb.

**SLAB:** The exterior portion of a log removed in sawing lumber.

**SLICED VENEER:** Veneer that is sliced off a log, bolt, or flitch with a knife.





**SOFT ROT:** A special type of decay developing under very wet conditions in the outer wood layers, caused by certain fungi that destroy the cellulose in the secondary cell walls; as a result the wood becomes soft. The decayed wood is similar in appearance to brown rot.

**SOFTFORMING:** Is the process by which a decorative laminate is attached to the surface that is adjacent to and is at any angle or combination of angles other than 90° from the largest flat area of a given core stock. This is primarily accomplished through the use of hot melt and water based adhesives.

**SOFTFORMING EDGE BANDERS:** Single and double sided softforming edgebanders are capable of applying either a flat or shaped edge, such as an Ogee. Most softformers have sizing and shaping stations which mill the edge prior to the application of the edgeband. Softform edgebanders can be either PVA or Hot Melt systems.

**SOFTWOODS:** Generally, one of the botanical groups of trees that in most cases have needlelike or scalelike leaves (the conifers); also the wood produced by such trees. The wood does not contain pores. The term has no reference to the actual hardness of the wood.

**SOLID WOOD:** Solid wood core stocks contain a myriad of variables that affect adhesion. Depending on the type of wood used, large variations in porosity and internal strength of the wood will be seen.

In addition, these same factors will be seen in a given piece of core stock when individual characteristics of side grain, end grain and face grain are examined.

Solid wood core stocks are very often finger-jointed, which requires additional finishing steps. This greatly increases the probability of resination to occur.

**SOLID WOOD BANDS:** Solid wood banding is almost identical to wood veneers in the types of adhesion problems encountered, but generally are more severe due to additional variables. The adhesive surface of the wood banding is, for a variety of reasons, more likely to be run through a variety of prefinishing operations such as sanding or moulding. This drastically increases the chances for resination to occur.

Solid wood banding also is capable of acting as a much greater heat sink, hence, the actual temperature of the banding is important. If the temperature of the banding drops below 65° F, the hot melt adhesive will be heat sunk too quickly to obtain good penetration into the wood. Incorrect moisture content causes a much larger dimensional change, which significantly increases the forces for delamination.

**SOLVENT BORNE ADHESIVES:** An adhesive containing polymeric materials dissolved in volatile organic solvents to which a small percentage of crosslinker is added to obtain certain desired performance properties; i.e., higher heat resistance. This type of adhesive is typically used on a "hot line" laminator where it is applied in two coats to the board surface, dried, and then heat activated prior to a hot roll laminating station. Good coatability, non-grain raising on particleboard, high heat resistance, and excellent bond strengths when laminating 2 mil reverse print and 4 mil solid vinyl films, are characteristic of this adhesive.

**SORTER:** - Sorter, Drop - A mechanical lumber-sorting device that sorts lumber for thickness, width, and length by dropping them into separate compartments accordingly.

- Sorter, Edge - A mechanical lumber-sorting device consisting of grooves or slots in which the lumber is placed on edge. Lines of live rolls, arranged under the slots, carry the lumber to the desired bin or compartment.

- Sorter, Tray - A mechanical lumber-sorting device consisting of a series of trays one above the other into which the lumber is ejected by either mechanical or electrical signaling devices.

**SPALT:** The pie-shaped portion of a shingle bolt that remains after processing.

**SPECIFIC GRAVITY:** See relative density.

**SPECIFIC HEAT:** The heat in joules required to raise the temperature of one gram of wood 1°c.

**SPIKE GRID:** A type of wood connector with teeth projecting from both surfaces that cut into the wood members as they are drawn together.

**SPIKE KNOT:** See knots.

**SPIRAL GRAIN:** Wood in which the fibers take a spiral course about the stem of a tree. The spiral may extend toward the right or left around the tree stem. Spiral grain is a form of cross grain.

**SPLINTS:** Trim from the edges of shingles and shakes.

**SPLITS:** Separations along the grain extending through a piece. Commonly caused by stresses set up in the wood during drying.

**SPOROPORE:** The fruiting body of a fungus; a conk.

**SPRAY BOOTH:** A booth or area where finishing sprays such as primers, sealers or other finishes are applied so as to contain the sprays.

**SPRAY LINE:** A plain pipe of varying sizes and lengths that is drilled with holes of various sizes and spacing through which steam is injected into the kiln.

**SPRINGBACK:** Tendency of a pressed particleboard panel to return to its original uncompressed state.

**SPRINGWOOD:** See earlywood.

**SQUARE EDGE:** Free from wane and without eased edges.

**SQUARENESS:** Right angles at the corners or equal diagonals from corner to corner.

**STAIN:** A discoloration in wood that may be caused by such diverse agents as microorganisms, sunlight, metals, chemicals, and chemical interaction. The term also applies to materials used to impart color to wood.

- Blue Stain - A bluish or grayish discoloration of the sapwood caused by the growth of certain dark-colored fungi on the surface and in the interior of the wood. Blue stain is made possible by the same conditions that favor the growth of other fungi.

- Brown Stain - A dark brown discoloration of the sapwood of some pine logs that occurs during storage. Sometimes called 'coffee-brown stain,' it is caused by a fungus.

- Chemical Brown Stain - A brownish discoloration that may occur during the seasoning of certain softwoods, apparently caused by the concentration and oxidation of extractive chemicals.

- Hemlock Brown Stain - See chemical brown stain.

- Mineral Stain - An olive to greenish-black or brown discoloration of undetermined cause in hardwoods.

- Sap Stain - See blue stain.

- Sticker Stain - A brown or blue stain that develops on lumber during seasoning where the stickers contact the boards.

**STAR SHAKE:** A number of heart shakes more or less in the form of a star.

**STARVED GLULINES:** A condition caused by an insufficient adhesive spread to adhere two materials together as in a laminated panel construction.

**STEM:** The principal axis of a tree, capable of producing sawlogs, veneer logs, large poles, or pulpwood.

**STICKERS:** Narrow wood strips used to separate the layers of lumber in a pile and thus improve air circulation.

**STRAIGHT GRAIN:** Wood in which the fibers are aligned parallel to the axis of the piece.

**STRANDWOOD:** A board made of long, narrow slices of softwood (mostly poplar) bonded together in one direction in the horizontal plane, forming the middle layer, or core, in composite plywood.

**STRENGTH:** The limit of ability of a member to sustain stress. Also, in a specific mode of test, the maximum stress sustained by a member loaded to failure.

**STRENGTH RATIO:** The hypothetical ratio of the strength of a structural member to that which it would have if it contained no strength-reducing characteristics (knots, cross grain, shake, etc.).

**STRESS GRADES:** Lumber grades having assigned working stress and modulus of elasticity values in accordance with accepted principles of strength grading.



**STRESS, WORKING:** See allowable unit stress.

**STRUCTURAL TIMBERS:** Pieces of wood of relatively large size, the strength of which is the controlling element in their selection and use. Examples are trestle timbers (caps, posts, sills, bracing, bridge ties, guardrails); car timbers (car framing, including upper framing; car sills); framing for building (posts, sills, girders); ship timber (ship timbers, ship decking); and cross-arms for poles. See also timbers.

**STUMP FIGURE:** Figure produced by irregular grain in wood from the stump or base of a tree.

**SUBSTRATE:** A material that provides the surface on which an adhesive is spread for any purpose, such as laminating or coating.

**SUBSTRATE VARIABLES THAT AFFECT BOND PERFORMANCE:** As in any assembly operation, unique characteristics, introduced by the substrates affect the quality and durability of the bond as much as selecting the proper adhesive or making the correct machine adjustments. It is essential to have a working knowledge of all of the variables that affect adhesive performance.

The substrates can be broken down into and core stocks. Comments on each of the major members of each category are as follows:

**SUMMERWOOD:** See latewood.

**SURFACE FOILING EQUIPMENT:** This equipment takes a heat transfer foil (hot stamping foil) and transfers it to the surface of a smooth substrate. The foil is transferred from the carrier film through heat and pressure. Because the foil is so thin, it is very important that the surface be extremely clean of all dust particles.

There are three additional types of foiling machines that can cover board surfaces as well as their edges.

- Bluff cut (overhead) machines: specialized machines to shape, sand, and foil crosscuts used in drawer fronts, doors, and panels.
- Random foilers: foils serpentine, oval, and round tops either by use of a pattern (template) or by means of computer control.
- Molding foilers: transfers a heat transfer foil to moldings, such as picture frame stock. Shaped silicone wheels in various numbers apply the foil to the molding.

**SWELL:** Thickness increase in a panel which can occur from excessive moisture pick up or wetting.

**TALL OIL:** An oily material liberated from soap skimmings from sulfate pulping liquor. Used chiefly in the paint and lacquer industry.

**TANGENTIAL:** Strictly, coincident with a tangent at the circumference of a tree or log, or parallel to such a tangent. In practice, however, it often means roughly coincident with an annual layer. A tangential section is a longitudinal section through a tree or limb perpendicular to a radius. Flatgrain lumber is sawn tangentially.

**TENONER:** A production machine used.

**TENSILE STRENGTH:** The greatest longitudinal stress a material can resist without tearing apart. Value in pounds per square inch (psi).

**TENSION WOOD:** Reaction wood formed on the upper side of branches and inclined stems of hardwood trees. Tension wood is characterized anatomically by lack of cell-wall lignification and often by the presence of gelatinous fibers. It has excessive longitudinal shrinkage, and sawn surfaces usually have projecting fibers. Planed surfaces often are torn or have raised grain.

**TEXTURE:** Refers to the size of the cellular components of wood; may also describe their relative uniformity in size. See also grain.

**THERMAL CONDUCTIVITY:** A measure of the rate of heat flow through a material subjected to a temperature gradient, or the number of watts passing between the faces of a piece of wood 1 m<sup>2</sup> in area and 1 mm thick per 1°c temperature difference between the faces.

**THERMAL DIFFUSIVITY:** The ratio of the thermal conductivity to the product of density and specific heat. A measure of how quickly a material can absorb heat from its surroundings.

**THERMOFORMED OVERLAY FILMS:** Calendered or extruded solid color rigid vinyl films in single-ply or two-ply construction. Gauges range from .010" to .030" and film may be printed in wood grain or

decorative patterns. Films may be embossed and may be coated with scuff and stain resistant coatings. Primers to promote adhesion are available. Films are designed for thermoforming with heat and pressure in the bladder press or vacuum forming process. Decorative effects can be achieved with two-ply films when a router is used to expose a different color in the bottom ply film. Films may also be flat laminated or miterfolded.

**THERMOPLASTIC:** Resins or adhesives that harden at room temperature and resoften upon exposure to heat.

**THERMOSETTING:** Resins or adhesives that cure at room temperature or in the hot press by chemical reaction to form rigid bonds that are not resoftened by exposure to heat.

**THINBOARD:** A particleboard made in thickness up to 6 mm (1 in.) on a continuous rotary drum press. Differs from particleboard only by the pressing technique used in its manufacture.

**TIMBERS, RECTANGULAR:** Wood products (beams) 114 m (~ in.) thick or more with the width more than 38 mm (2 in.) greater than the thickness.

**TIMBERS, SQUARE:** Wood products (posts and timbers) 114 mm X 114 mm (5 in. x - in.) and larger with the width not more than 38 mm (z in.) greater than the thickness.

**TORUS:** Central thickened portion of a pit membrane of bordered pits.

**TRACHEID:** An elongated cell with bordered pits and imperforate ends. Tracheids constitute the principal part of the cellular structure of softwoods. Tracheids are frequently referred to as fibers and are present in many hardwoods.

**TRANSVERSE:** Direction in wood perpendicular to that of the fibers. A transverse section is one that is cut across the grain at right angles to the fiber direction.

**TRIMMER:** A battery of adjustable saws for trimming lumber to specific lengths or for removing defects.

**TWIN & QUAD BANDSAWS:** A twin bandsaw is an adjustable, double bandsaw headrig making two cuts simultaneously. A quad bandsaw makes four cuts simultaneously.

**TWIST:** Distortion caused by the turning or winding of the edges of a board so that the four corners of any face are no longer in the same plane.

**TYLOSES:** Ingrowths of parenchyma cells into the lumen of a vessel (or sometimes a fiber) occurring generally in the heartwood of certain hardwoods.

**TYLOSIDS:** Structures in resin ducts resembling tyloses in hardwoods.

**UNBALANCED CONSTRUCTION:** When individual components or layers of a laminate do not respond equally to changes in moisture thus causing warp.

**UNDERCURE:** Incomplete cure of a chemical-setting adhesive, producing bonds of low strength.

**UNDERLAYMENT:** A panel product used to provide an appropriate surface for a finished floor (tile, carpet, hardwood). It may also include the complete subfloor.

**UNIMPREGNATED:** These are essentially untreated papers, although a small amount of resin (2%-3%) is generally added during manufacturing. The papers may be delivered with a varnish top coat, or may be top coated after lamination.

**UREA FORMALDEHYDE (UF):** Interior thermosetting resin system (Type 1, ANSI A208.1) commonly used in the manufacture of particleboard.

**VACUUM PRESS:** Vacuum presses are used for the lamination of molded (three-dimensionally shaped) substrates with vinyls, and other materials. At the present time, they cannot be used for form veneers. The adhesives are applied either to the core or to the laminating materials. The pressing process uses a silicone or rubber membrane which forms the laminating material under pressure and heat over the molded substrate.

In a vacuum press, heat is applied only to the top of the press, while a vacuum is drawn from the bottom. Since only atmospheric pressure





is involved, the laminating process operates in the range of 26 pounds per square inch at sea level.

Vinyls are usually bonded with water based polyurethane, which is dried after application and reactivated with heat during the pressing process.

**VAPOR PRESSURE GRADIENT:** A gradation in water vapor pressure established between the interior of wood and its surface during drying.

**VENT:** In kiln drying, an opening in the kiln roof or wall that can be opened and closed to control the wet-bulb temperature within the kiln.

**VENEER:** A thin layer or sheet of wood. See also rotary-cut, sawn, and sliced veneer.

**VERTICAL GRAIN:** See edge grain.

**VESSELS:** Tubelike structures in porous woods (hardwoods only) made up of longitudinal series of relatively short, large-diameter cells having more or less open ends. Open vessels exposed on the surfaces of a piece of wood are known as pores.

**VINYL FILM:** Film made of polyvinyl chloride used for decorative surfacing and may be either clear or solid color. If it is clear, it is printed on the reverse side to protect the print. If it is a solid color, the printing is on the top.

**VISUAL LUMBER GRADES:** Assessment of lumber grades by the eye of a grader.

**WATER BORNE ADHESIVES:** Water based adhesives include both thermosetting urea formaldehyde systems as well as formulated synthetic latex (usually vinyl acetate) types. These products are generally used for paper laminating where the adhesive is applied to the web and/or board surface and tacks up through one or more heated rolls that combine paper to board. Water based vinyl acetate/ethylene (VAE) copolymer adhesives are often used for laminating 2 and 4 mil vinyl films to various board surfaces on similar types of wet laminating equipment.

**WET BULB TEMPERATURE:** Temperature of the wet bulb thermometer in a relative humidity measurement. Compared with the dry bulb temperature to determine RH.

**WOOD VENEERS:** Real wood veneers that are flat cut, rift cut, quarter cut, etc. from a variety of hardwood species, domestic and imported. The veneers are sliced from 1/25" to 1/50" thin and are available plain, paper, or fleece backed in varying degrees of flexibility. The backers provide stability and strength to the veneer, and minimize splintering, cracking, and checking. The veneers may be finger or butt jointed to produce continuous coil edgebanding. Veneer edging products are suitable for straight-line, contour, and sofform automatic applications, as well as preglued for hot air or heat bar machines.

**XYLEM:** The wood portion of the tree stem, branches, and roots. It lies between the pith and the cambium.







**Woodworking Machinery  
Industry Association**  
27 Main St.  
Suite 1  
New Milford, CT 06776  
Phone: 860-350-9642  
Fax: 860-354-0677  
Email: [info@wmia.org](mailto:info@wmia.org)  
Web: [www.wmia.org](http://www.wmia.org)

