TECHNICAL NOTE NUMBER 236

FOREST PRODUCTS LABORATORY UNITED STATES FOREST SERVICE

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NAIL-HOLDING POWER OF AMERICAN WOODS

The Forest Products Laboratory has made tests, incorporated in the table accompanying this note, on the resistance of 51 species of wood to direct withdrawal of nails. Resistance to direct withdrawal or nail-holding power is vital to innumerable uses of wood, and in construction where the joints may be the weakest parts—such as boxes and crates—holding power may decide the choice of a species. Factors influencing the magnitude of resistance to direct withdrawal include the species and density of the wood, changes in the moisture condition of the wood, area of contact between the wood and nail, the surface condition of the nail and the shape and form of the nail, including the head, shank, and point.

The value for any species in the table appended to this note represents the average load required to pull one 7d cement-coated nail, immediately after the nail had been driven into the wood to a depth of 1¼ inches. It should be noted that cement-coated nails are much higher in their immediate resistance to withdrawal than plain nails. All tests were made in a uniform manner on 2 by 2 by 6 inch specimens (end, radial, and tangential grain), four or more per tree tested for each species, and six nails to the specimen. The differences in moisture content noted in the table proved to be sufficiently slight to exert little influence on nail holding. Change in moisture content subsequent to driving of nails is of far greater significance, constituting a major cause of loss of holding power with any type of nail or wood.

Although the table indicates that the dense, heavy woods are higher in nail-holding power than the lighter ones, this does not mean that the lighter spe-

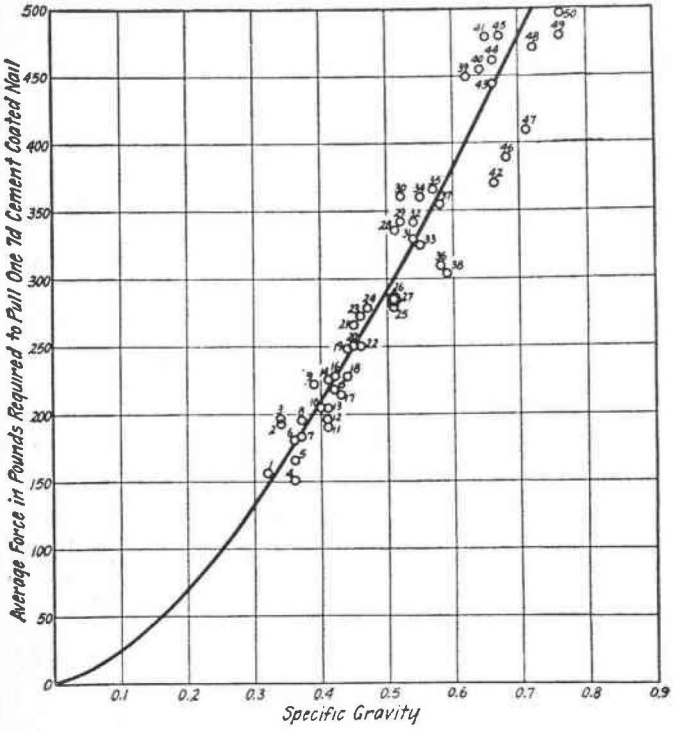
NAIL-HOLDING POWER OF VARIOUS SPECIES OF WOOD

(7d cement-coated nails driven to a depth of one and one-quarter inches and pulled at once)

Common and botanical name of species—	Place of growth of material tested	Number of trees	Moisture content *per cent*	Specific gravity based on vol. and wt. of oven-dry wood	Average holding power for one nail when driven into		
					End surface *pounds*	Radial surface (edge-grain) *pounds*	Tangential surface (flat-grain) *pounds*
Ash, white (*Fraxinus americana*)	Ark.	5	8.9	0.64	385	455	452
Aspen (*Populus tremuloides*)	Colo. **N. Mex, Wis.**		**5.3**	**.39**	**117**	**187**	**201**
Aspen, largetooth (*Populus grandidentata*)	Wis.	5	6.5	.41	157	202	207
Basswood (*Tilia glabra*)	Pa.	5	6.5	.41	138	199	194
Beech (*Fagus grandifolia*)	Ind.	5	8.4	.67	358	495	460
Birch, yellow (*Betula lutea*)	Wis.	5	8.6	.66	331	473	451
Cedar, western red (*Thuja plicata*)	Mont., Wash.	10	7.6	.34	118	192	202
Cedar, northern white (*Thuja occidentalis*)	Wis.	5	9.3	.32	103	153	160
Chestnut (*Castanea dentata*)	Md., Tenn.	10	9.2	.45	172	258	273
Cottonwood, black (*Populus trichocarpa*)	Wash.	5	5.9	.37	122	194	196
Cottonwood, eastern (*Populus deltoides*)	.....	.....	6.8	.34	143	189	197
Cypress, southern (*Taxodium distichum*)	La., Mo.	10	8.3	.47	144	266	291
Douglas fir (*Pseudotsuga taxifolia*)	Oreg., Wash.	28	6.3	.51	183	273	296
Elm, American (*Ulmus americana*)	Pa.	5	8.2	.54	236	344	339
Fir, California red (*Abies magnifica*)	Calif.	3	9.0	.37	100	177	189
Fir, silver (*Abies amabilis*)	Wash.	5	4.9	.40	86	201	207
Fir, white (*Abies concolor*)	Calif.	8	8.0	.41	104	176	203
Fir, lowland white (*Abies grandis*)	Idaho.	5	5.3	.36	60	150	182
Gum, red (*Liquidambar styraciflua*)	Ark.	.....	8.3	.51	192	292	278
Gum, tupelo (*Nyssa aquatica*)	La., Mo.	6	9.3	.52	233	376	345
Hemlock, eastern (*Tsuga canadensis*)	Tenn., Wis.	28	8.9	.42	127	225	230
Hemlock, western (*Tsuga heterophylla*)	Wash.	9	6.7	.46	149	266	277
Hop-hornbeam (*Ostrya virginiana*)	Wis.	3	6.5	.76	457	513	480
[redacted] (*Larix occidentalis*)	Idaho.	5	4.4	.58	180	299	319
[redacted] *Robinia pseudoacacia*)	Tenn.	3	4.1	.71	404	461	345

cies are disqualified for uses requiring high holding power. As a rule the less dense species do not split so readily as do the dense ones, thus offering an opportunity for increasing the diameter, length, and number of nails to compensate in whole or in part for the lesser holding power.

A curve based on the tests recorded in the table has been made a part of this note. To estimate the holding power of species not tested, follow the specific gravity line corresponding most closely to the specific gravity of the wood in question to the point where it intersects the curve. Read to the left for the corresponding holding power.



KEY

1. Cedar, northern white
2. Cottonwood, eastern
3. Cedar, western red
4. Aspen
5. Fir, lowland white
6. Spruce, Engelmann
7. Fir, California red
8. Cottonwood, black
9. Pine, northern white
10. Fir, silver
11. Fir, white
12. Basswood
13. Aspen, largetooth
14. Spruce, red
15. Poplar, yellow
16. Hemlock, eastern
17. Spruce, white
18. Pine, western yellow
19. Pine, lodgepole
20. Pine, western white
21. Chestnut
22. Pine, jack
23. Hemlock, western
24. Cypress, southern
25. Pine, Norway
26. Douglas fir
27. Gum, red
28. Maple, silver
29. Magnolia, cucumber
30. Gum, tupelo
31. Pine, pitch
32. Elm, American
33. Pine, mountain
34. Sycamore
35. Pine, pond
36. Larch, western
37. Pine, shortleaf
38. Pine, loblolly
39. Maple, black
40. Ash, white
41. Maple, sugar
42. Pine, longleaf
43. Oak, red
44. Birch, red
45. Beech
46. Pine, slash
47. Locust, black
48. Oak, white
49. Locust, honey
50. Hop-hornbeam

–Relation of specific gravity (based on weight and volume of oven-dry wood) of wood to nail holding power. 7d cement coated nails driven 1¼ inches depth into the side grain of thoroughly seasoned wood and pulled at once.

Locust, honey (*Gleditsia triacanthos*)	Ind.	1	6.5	.76	431	508	449
Magnolia, cucumber (*Magnolia acuminata*)	Tenn.	5	5.1	.52	233	350	335
Maple, black (*Acer nigrum*)	Ind.	1	9.8	.62	357	480	415
Maple, silver (*Acer saccharinum*)	Wis.	5	6.8	.51	280	333	338
Maple, sugar (*Acer saccharum*)	Ind.	4	9.2	.65	396	497	459
Oak, red (*Quercus borealis*)	Ark., Tenn., N.H.	22	8.4	.66	312	466	422
Oak, white (*Quercus alba*)	Ark., La.	10	8.6	.72	320	496	444
Pine, jack (*Pinus banksiana*)	Wis.	5	7.6	.46	161	228	272
Pine, loblolly (*Pinus taeda*)	Fla.	10	8.0	.59	179	271	335
Pine, lodgepole (*Pinus contorta*)	Colo., Idaho	8	6.3	.44	141	244	252
Pine, longleaf (*Pinus palustris*)	Fla., La., Miss.	34	7.7	.64	244	362	376
Pine, mountain (*Pinus pungens*)	Tenn.	5	7.1	.55	209	318	330
Pine, Norway (*Pinus resinosa*)	Wis.	5	7.4	.51	165	273	282
Pine, pitch (*Pinus rigida*)	Tenn.	5	7.7	.54	235	325	330
Pine, pond (*Pinus rigida serotina*)	Fla.	5	7.5	.57	211	348	384
Pine, shortleaf (*Pinus echinata*)	La.	6	7.2	.58	235	331	377
Pine, slash (*Pinus caribea*)	Fla.	5	7.6	.68	290	356	420
Pine, northern white (*Pinus strobus*)	Wis.	5	7.7	.39	136	220	225
Pine, western white (*Pinus monticola*)	Mont.	5	8.2	.45	134	255	246
Pine, western yellow (*Pinus ponderosa*)	Calif., Oreg.	7	6.6	.44	122	224	233
Poplar, yellow (*Liriodendron tulipifera*)	Tenn.	5	7.3	.42	162	212	223
Spruce, Engelmann (*Picea engelmannii*)	Colo.	5	9.4	.36	136	177	184
Spruce, red (*Picea rubra*)	Tenn.	5	10.7	.41	148	229	221
Spruce, white (*Picea glauca*)	Wis.	5	7.6	.43	146	209	218
Sycamore (*Platanus occidentalis*)	Tenn.	5	7.0	.55	270	369	349
Redwood (*Sequoia sempervirens*)	**Calif.**	**11**	**6.0***	**.42**	**106**	**221**	**226**

The nail-holding properties of wood are in general closely related to the specific gravity or density of the material but species characteristics may, however, account for variations, of as much as 25 per cent in these relations. Since in any species there is variation in specific gravity (one-half of the material falling within about 8 per cent of the average specific gravity) the nail-holding properties of individual pieces may vary considerably from the averages presented (one-half of the material falling within about 12 per cent of the average nail-holding value for the species). Hence it is possible to select material of any species that is relatively high in nail-holding properties and is better than the average.

*Approximate