DEVELOPMENT OF SHEAR STRENGTH IN MAPLE BLOCK JOINTS MADE WITH TWO RESORCINOL GLUES AT TEMPERATURES FROM 40° TO 80° F.

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DEVELOPMENT OF SHEAR STRENGTH IN MAPLE BLOCK JOINTS MADE WITH TWO RESORCINOL GLUES AT TEMPERATURES FROM 40° TO 80° F.[1]

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Resorcinol-formaldehyde resin glues, as currently formulated, are commonly used at temperatures of 75° F. or higher. Since temperatures lower than 75° F., however, often prevail in shipyards where resorcinol resin glues may be used in ship construction, the Bureau of Ships requested the Forest Products Laboratory to determine whether resorcinol glues would cure well enough at temperatures as low as 40° F. to give joints of sufficient strength for boat assembly wood work. The results of the experiments conducted in compliance with this request are herein reported.

The experiments consisted of a study of the rate of development of block joint strength with resorcinol-formaldehyde resin glues at several temperatures. Two commercial resorcinol resin glues mixed in accordance with the manufacturer's directions were employed. They are designated as A and B in this report. Glued joints were made with hard maple blocks, 3/4 by 2-1/2 by 12 inches in size, selected for straightness of grain, freedom from defects, and specific gravity above 0.65 based on volume and weight when oven dry. The blocks were conditioned to about 12 percent moisture content, and well surfaced on a jointer just before gluing. High density maple was chosen because the development of joint strength could thus be followed to a higher strength level than on weaker wood. The glues were cured at four temperatures, 40°, 60°, 70°, and 80° F., in rooms or cabinets maintained within 2 or 3 degrees of these temperatures. The glues, blocks, and clamps were at the desired temperature when the glue was applied. To one of each pair of surfaces to be joined, 8 to 10 grams of glue was applied by brushing. The blocks were then placed together in closed assembly for 30 minutes, after which they were put under a pressure of 200 pounds per square inch in pressure-equalizing rocker-head clamps. After various periods of time under pressure at the constant temperature, the joints were removed from the clamps, cut into standard block shear specimens, and tested immediately in compression shear in a universal testing machine.

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The results of the shear tests are given in table 1. The quality of the maple used for this experiment was such as to break in shear with a strength of at least 3,000 pounds per square inch. From the table, it may be seen that strengths of this magnitude were reached in 2 days at 80° F. and in 10 days at 70° F., but were not attained in 40 days at 60° F. or in 84 days at 40° F.

From the data, it appears that the full strength of the maple would never be reached at temperatures of 40° F. and 60° F. with these glues for, after an initial period of strength development, there was little or no further gain. This was further attested by the results of a side experiment in which maple block joints cured at 40° and 60° F. for 14 days were removed from the low-temperature rooms and, still under pressure, placed in a kiln at 140° F. for 24 hours. The strengths of these joints are compared with those of similar joints without the kiln treatment in table 2. The changes in joint strength and wood failure wrought by the subsequent elevated temperature treatment are probably not significant and certainly not important. This observation leads to the conclusion that these glues had hardened in 14 days at the low temperature to a state of mediocre strength over which little further improvement could be expected with further time and higher temperature.

From the results obtained in this experiment, it may be concluded that resorcinol glues of the room-temperature-setting type used in these experiments will not produce satisfactory joints in laminated maple at temperatures of 60° F. or lower, and that 70° F. is so close to the borderline that 75° F. would appear to be a more conservative and safer limit for the minimum curing temperature at which to use glues of this type upon high density woods.

By the addition of alkali or other catalyzing agents, resorcinol glues can be made to set more quickly or at lower temperatures, but highly catalyzed resorcinol glues are not indiscriminately recommended by the glue manufacturers and were not included in this study.

Assuming that these resorcinol glues cure at the same rate on other species as on sugar maple, it would seem possible to reach a joint strength equal to the full strength of less dense woods at temperatures lower than 70° F. This was corroborated in experiments with Glue A on blocks of Sitka spruce and Douglas-fir, cured at 60° F., and it was found that, for the particular density of wood used, the full strength of the Sitka spruce was reached at this stemperature in about 50 hours and that of the Douglas-fir in about 60 hours. In this connection, however, it is important to point out that there is little information as yet on the durability of resorcinol glued joints set at temperatures below 80° F.

Table 1.--Results of shear tests on maple block joints glued with two resorcinol resin glues at temperatures from 40° to 80° F.

Curing time		Curing temperature							
		40° F.		60° F.		70° F.		80° F.	
		Glue A	Glue B	Glue A	Glue B	Glue A	Glue B	Glue A	Glue B
Hours	Days								
2								[1]228-0	[1]981-0
3						[1]572-0	[1]361-0		
4								1211-0	1010-0
6				[1]146-0	[1]366-0	957-0	592-0	2601-2	1331-0
8								2078-0	2106-14
9						1508-0	705-0		
12				390-0	614-0	1056-0	877-0	2317-23	2613-2
16								2398-2	1992-2
	1	[1]122-0	[1]210-0	1349-0	781-0	1788-0	947-0	2998-43	2727-37
	2	109-0	274-0	1953-0	1059-0	1833-0	1549-0	3055-75	3187-79
	3	553-0	578-0	1866-0	1634-0				
	4					2114-3	1551-0		
	7	672-0	723-0	2034-0	1551-0	2672-25	2525-14		
	10					3408-75	3416-64		
	14	1249-0	1380-0	1760-0	1769-0				
	40	1499-0	1418-0	1998-18	2060-0				
	84	1466-0	1409-0						

[1]In this table the first value is the average shear strength; the value after the dash is the average estimated percentage of wood failure. Each value is the average of the test results on 10 specimens.

Table 2.--Results of shear tests on maple block joints glued with two resorcinol resin glues at 40° F. and 60° F. for 14 days with and without subsequent curing at 140° F. for 24 hours

Curing conditions	Glue A	Glue B
14 days at 40° F.	[1]1249-0	[1]1380-0
14 days at 40° F. plus 24 hours at 140° F.	1541-0	1339-0
14 days at 60° F.	1760-0	1769-0
14 days at 60° F. plus 24 hours at 140° F.	2274-4	1629-2

[1]In this table the first value is the shear strength in pounds per square inch; the value after the dash is the estimated percentage of wood failure. Each value is the average for 10 specimens.