

STRENGTH OF JOINTS IN HARD MAPLE BLOCKS, GLUED WITH CERTAIN RESIN GLUES, AFTER VARIOUS OPEN AND CLOSED ASSEMBLY PERIODS

Information Reviewed and Reaffirmed

July 1955



**This Report is One of a Series
Issued in Cooperation with the
ARMY-NAVY-CIVIL COMMITTEE
on
AIRCRAFT DESIGN CRITERIA
Under the Supervision of the
AERONAUTICAL BOARD**

No. 1542

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FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison 5, Wisconsin
In Cooperation with the University of Wisconsin**

STRENGTH OF JOINTS IN HARD MAPLE BLOCKS, GLUED WITH
CERTAIN RESIN GLUES, AFTER VARIOUS OPEN AND
CLOSED ASSEMBLY PERIODS¹

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Introduction

This report is part of an investigation being made at the Forest Products Laboratory to find suitable gluing techniques for room-temperature-setting and intermediate-temperature-setting resorcinol-, phenol-, and melamine-resin glues. Blocks of hard maple lumber were glued together with each of nine commercial resin glues allowing various periods of open and closed assembly within the range customarily required in practical gluing operations. This was done at three room temperatures. After the joints were cured and conditioned, they were tested for strength and the test data were plotted to reveal the effect of the assembly period and temperature on the joint strength.

Nine glues, designated by letters in this report, were tested. Glues A, B, and C were intermediate-temperature-setting phenol resins; glues D, E, F, and G were room-temperature-setting resorcinol resins; glue H was an intermediate-temperature-setting melamine resin catalyzed with acid to accelerate the setting; and glue I was a nearly neutral intermediate-temperature-setting melamine resin.

Procedures

Hard maple boards were conditioned in air at 80° F. and 65 percent relative humidity to approximately 12 percent moisture content and were then sawed and surfaced to blocks 3/4 by 2-1/2 by 12 inches in size. Only selected maple was used within a range of specific gravity of 0.63 to 0.69 based on oven-dry weight and volume. The blocks were glued together in stacks of six laminations.

¹This is one of a series of progress reports prepared by the Forest Products Laboratory relating to the use of wood in aircraft. Results here reported are preliminary and may be revised as additional data become available.

Both surfaces were spread with glue. The average spreading rate was about 35 pounds per 1,000 square feet of each contact surface or 70 pounds per 1,000 square feet of joint area.

Assembly temperatures of 70°, 90°, and 105° F. were used. When the assembly temperature was 90° or 105° F., the glue was maintained at about 70° F. by a water jacket around the glue pot to prolong the working life.

For the preparation of the block joints with closed assembly, the glue was applied, within 15 minutes after mixing, to the upper surface of the first lamination and to the under surface of the second lamination, and the two spread surfaces were immediately laid in contact. After a measured time interval, the glue was spread on the upper surface of the second lamination and on the under surface of the third lamination, and the two spread surfaces at once laid together. This procedure was followed until 6 laminations were assembled, using the same batch of mixed glue for the five glue lines. Pressure was then applied. Each glue line thus had a different closed assembly time, from a long period for the first glue line to a short period for the last.

For the preparation of block joints with open assembly, a similar procedure was used except that the laminations were kept separate and the glue-coated surfaces were exposed to the air until the time for application of pressure.

The closed assembly periods were usually 3, 30, 60, 90, and 120 minutes at 70° and 90° F., and 3, 15, 30, 45, and 60 minutes at 105° F. The open assembly periods were 3, 15, 30, 45, and 60 minutes at 70° and 90° F., and 3, 10, 20, 30, and 45 minutes at 105° F.

Pressure was applied to the assembly by pressure-equalizing head clamps tightened to either 50 or 200 pounds per square inch pressure with a calibrated torque wrench. Although 50 pounds per square inch is below the usually recommended pressure, the surfaces were well-fitting surfaces and there was little need for high pressure to force them together.

The clamped assembly was immediately placed in a kiln in which the temperature and relative humidity were controlled to maintain a moisture content of 10 to 12 percent. A kiln temperature of 180° F. was used for the phenol-resin glues and the neutral melamine-resin glue. The resorcinol-resin glues and acid-catalyzed melamine-resin glue were cured at 140° F. All assemblies were left in the kiln for 24 hours to cure the glue to a high degree. After removal from the kiln, the blocks were conditioned 1 to 2 weeks in air at 80° F. and 65 percent relative humidity.

Three blocks, each containing six laminations, were prepared at each assembly temperature with each pressure, and 4 step-type, block-joint specimens were cut from each block. As each lamination or step represented a different assembly time, 12 joint tests were thus provided for each combination of assembly time, assembly temperature, and pressure. Occasionally extra specimens were made when a more significant average was considered necessary. The specimens were tested by shearing to failure in a universal testing machine with the shearing head moving about 0.015 inch per minute.

Results

The average joint strength and wood failure data are presented graphically in figures 1 through 15. In table 1 are given approximately the maximum assembly periods that, as indicated by the results of this study could be employed to obtain joint strengths of 2,800 pounds per square inch or more on hard maple blocks glued together at the different glue-room temperatures using a double spread and 200 pounds per square inch pressure. With lower pressures, maximum assembly periods were often shorter, although this was by no means invariably true, as shown by the curves for 50 and 200 pounds per square inch pressure in figures 1 through 15. For single spreading somewhat shorter maximum assembly periods could probably be expected, particularly if the assembly be open. The data of table 1 and figures indicate the individual behavior of the various glues tested.

From table 1 it is seen that the three intermediate-temperature-setting phenol-resins (glues A, B, and C) performed very much alike, allowing closed assembly periods of at least 60 to 120 minutes depending on the glue room temperature. In open assembly, in which glues A and B of this type were tested, the results indicate allowable assembly periods of 40 to over 60 minutes for both glues.

The resorcinol-resin glues (D, E, F, and G) showed rather similar limitations with respect to maximum closed assembly time, but the two tested in open assembly (glues E and G) exhibited very distinct differences in the maximum allowable open assembly time at all three temperatures. Even the shortest allowable time, however, was still ample for many assembly operations.

The acid-catalyzed melamine-resin glue (glue H) when contrasted with the results for the neutral melamine-resin (glue I), showed the effect of the catalyst in shortening both the closed and open maximum allowable assembly periods.

Table 1.—Maximum assembly periods at which a joint strength of 2,800 pounds per square inch was achieved in hard maple blocks glued with several types of glues under 200 pounds per square inch gluing pressure

Glue and type	Closed assembly			Open assembly		
	at 3 assembly temperatures			at 3 assembly temperatures		
	70° F.	90° F.	105° F.	70° F.	90° F.	105° F.
	<u>Minutes</u>	<u>Minutes</u>	<u>Minutes</u>	<u>Minutes</u>	<u>Minutes</u>	<u>Minutes</u>
A, phenol ¹	120+	120+	60+	60+	60+	45+
B, phenol ¹	120+	120+	60+	60+	60+	40
C, phenol ¹	120+	120+	60+			
D, resorcinol ²	120+	120+	60+			
E, resorcinol ²	120+	110	60+	20	20	5
F, resorcinol ²	120+	100	60+			
G, resorcinol ²	120+	100	60+	60+	60+	35
H, melamine ^{1,3}	90+	90	55	60+	22	7
I, melamine ¹	120+	120+	120+	60+	60+	45+
	:	:	:	:	:	:
	:	:	:	:	:	:

¹—Intermediate-temperature-setting.

²—Room-temperature-setting.

³—Acid-catalyzed.

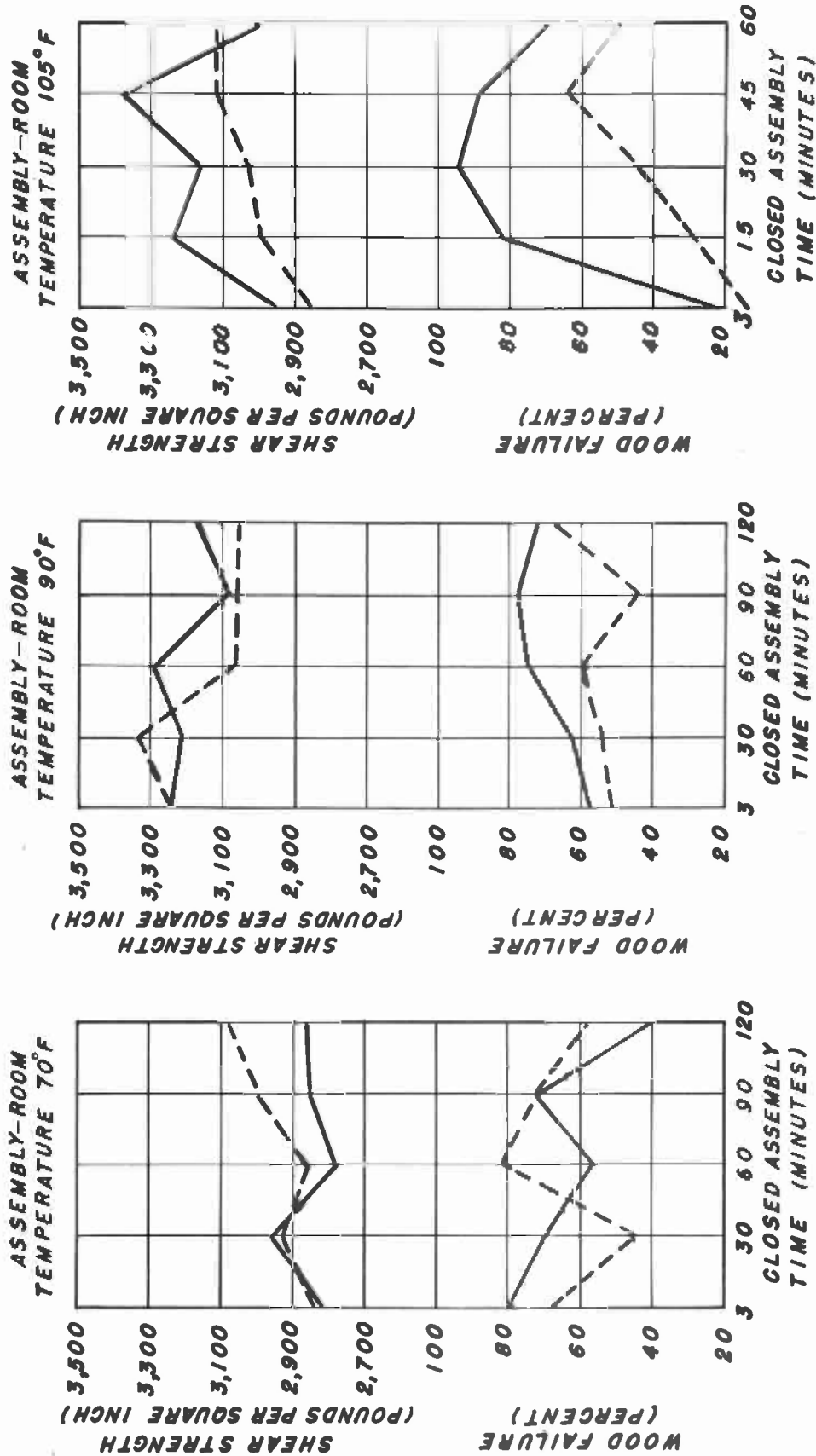


Figure 1.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue A at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

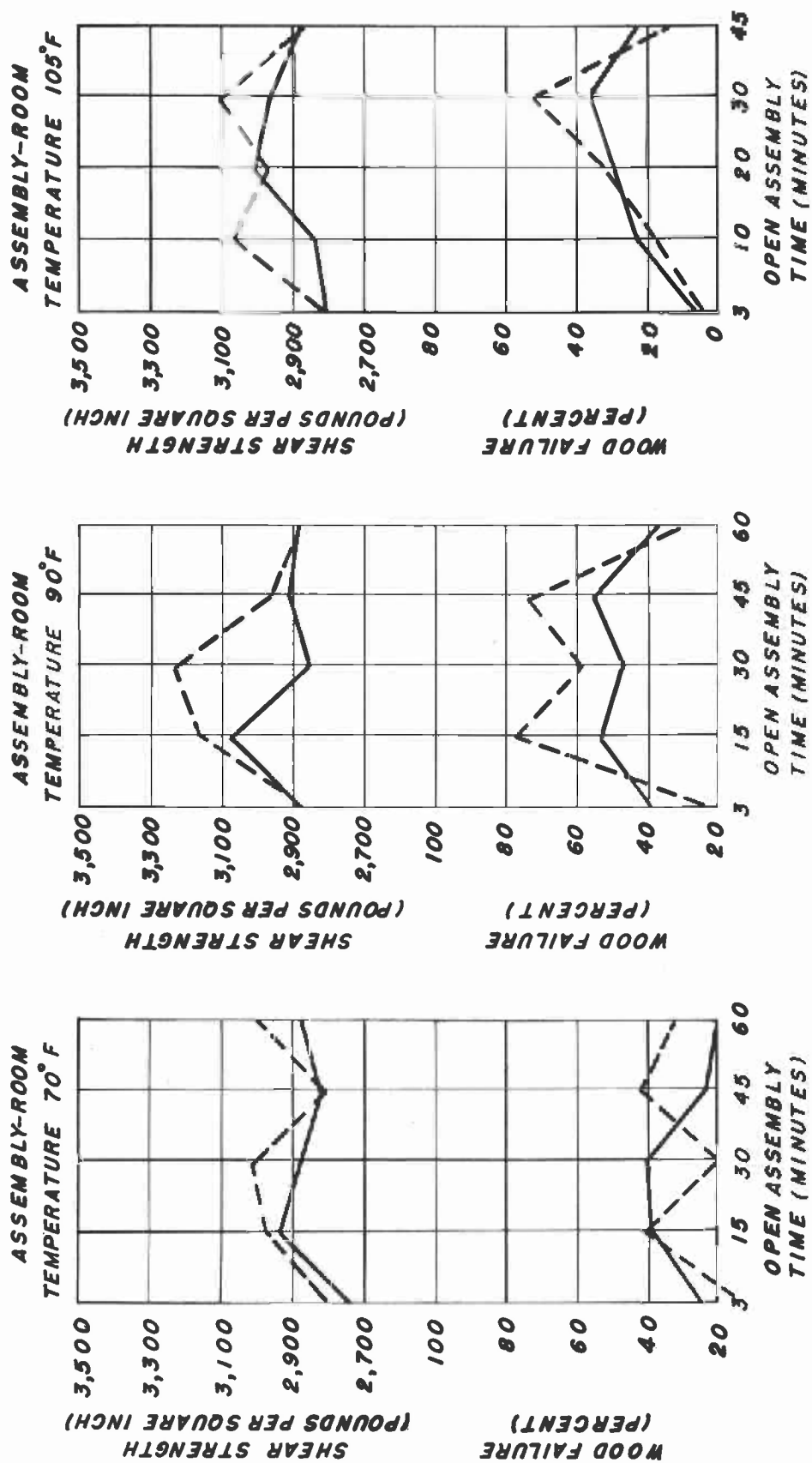


Figure 2.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue A at different open assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

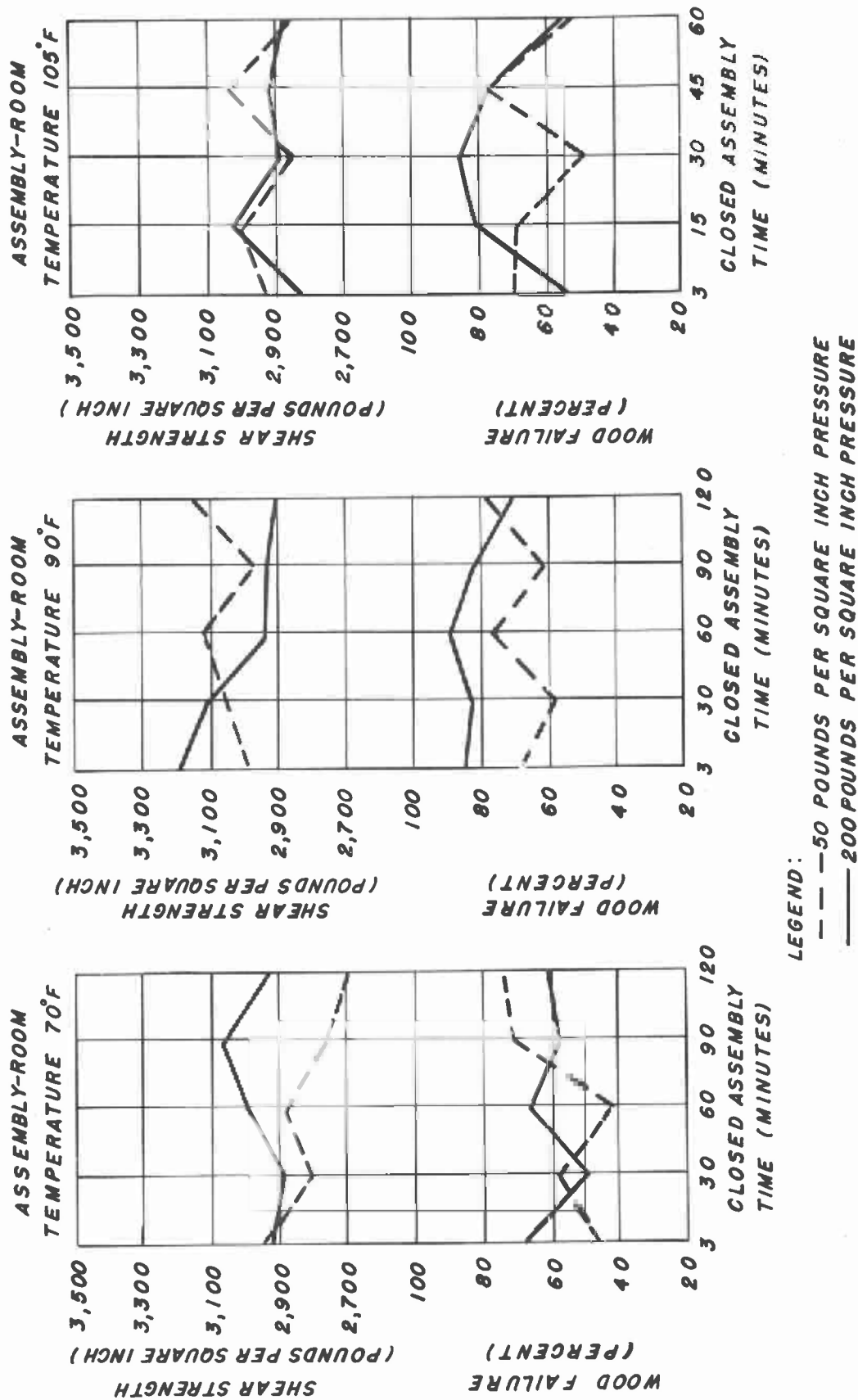


Figure 3.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue B at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

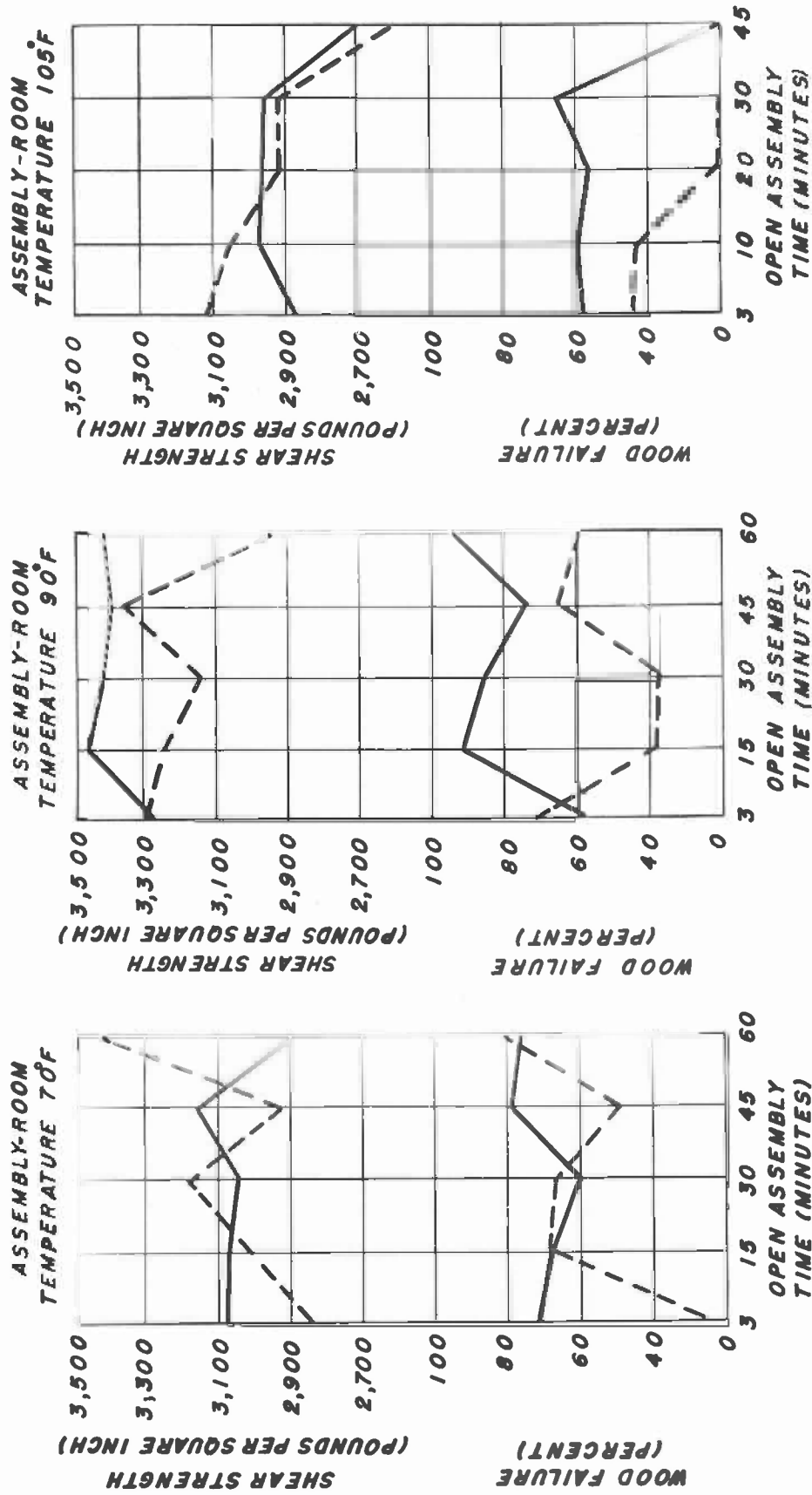


Figure 4.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue B at different open assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

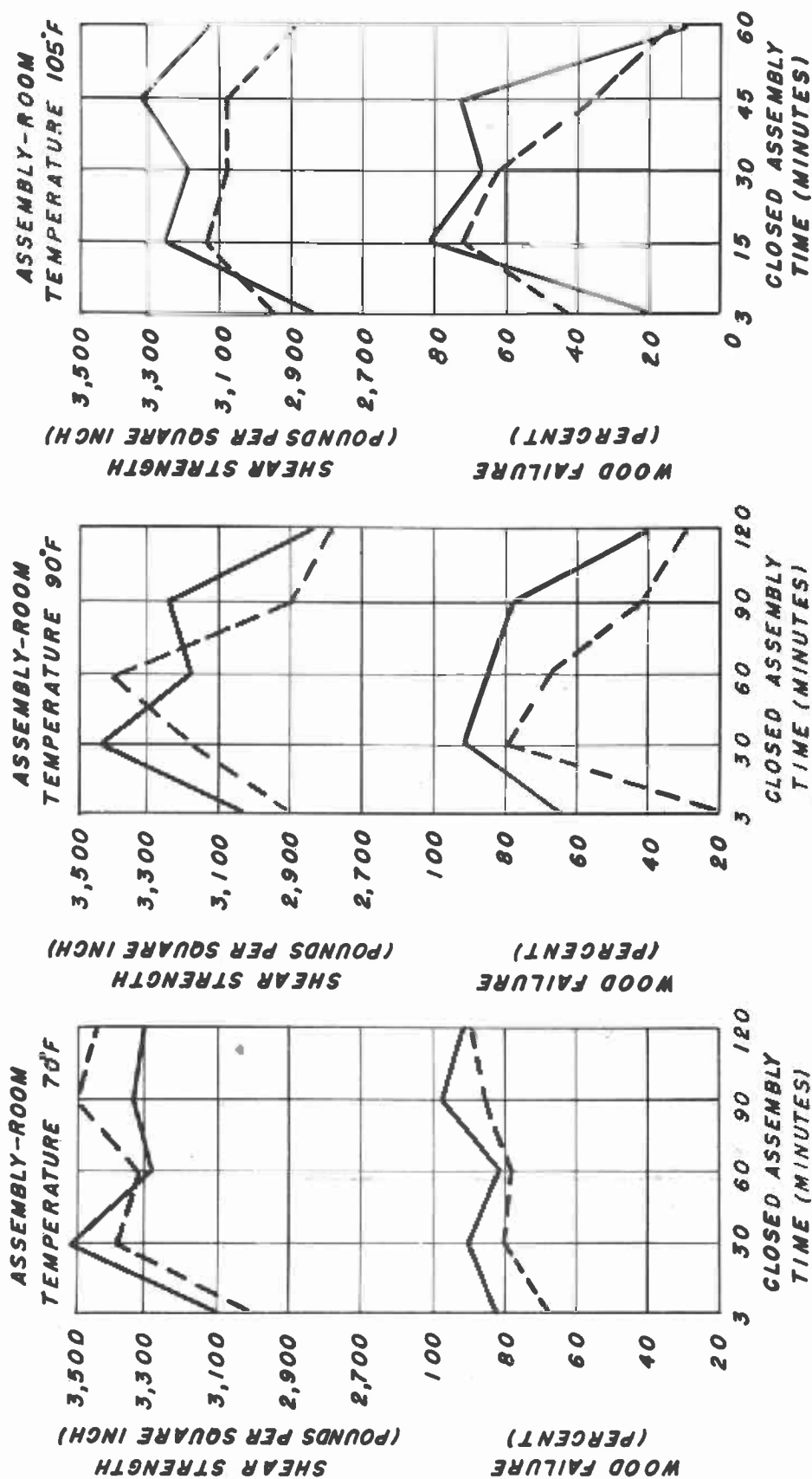


Figure 5.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue D at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

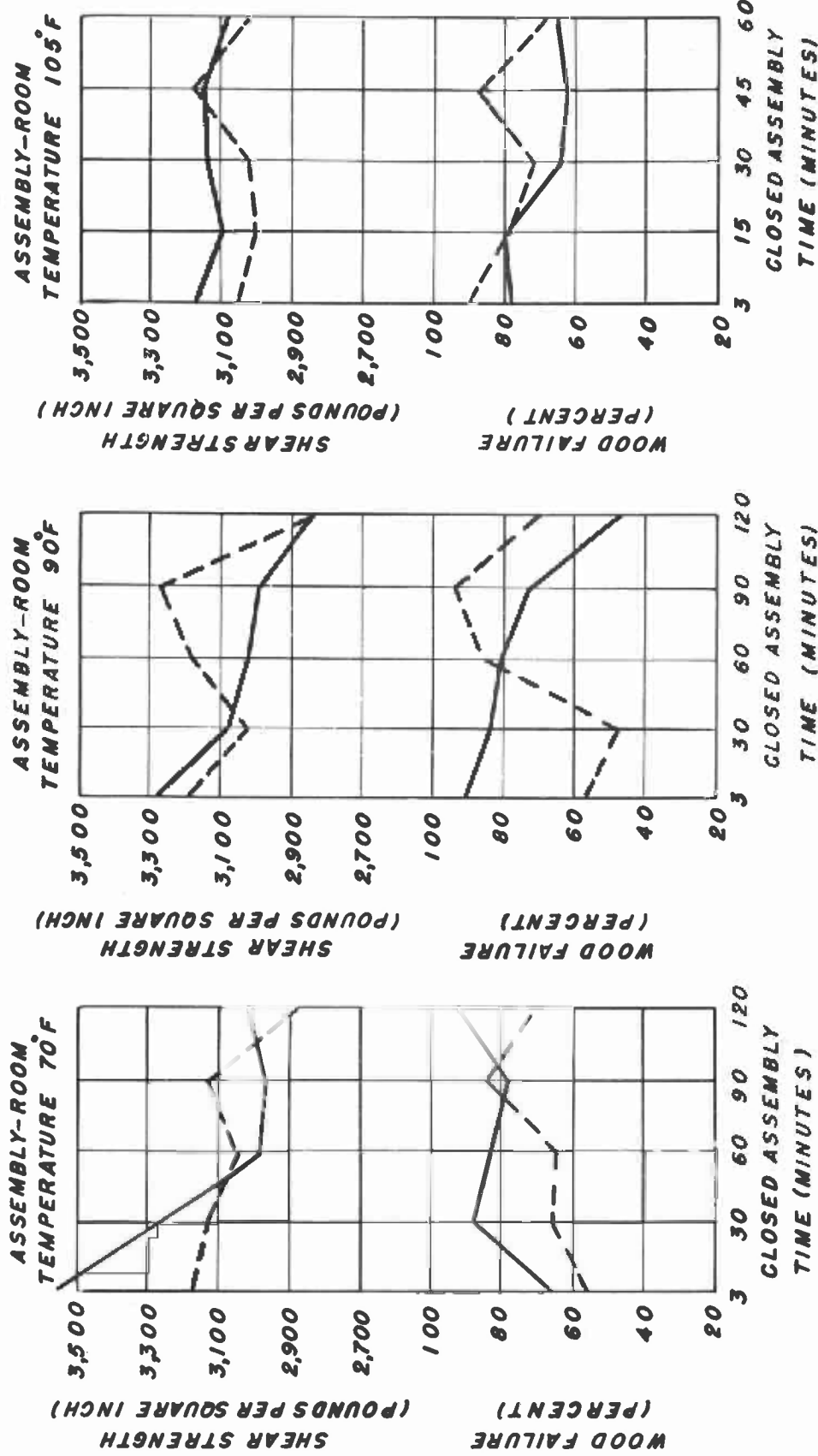


Figure 6.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue C at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

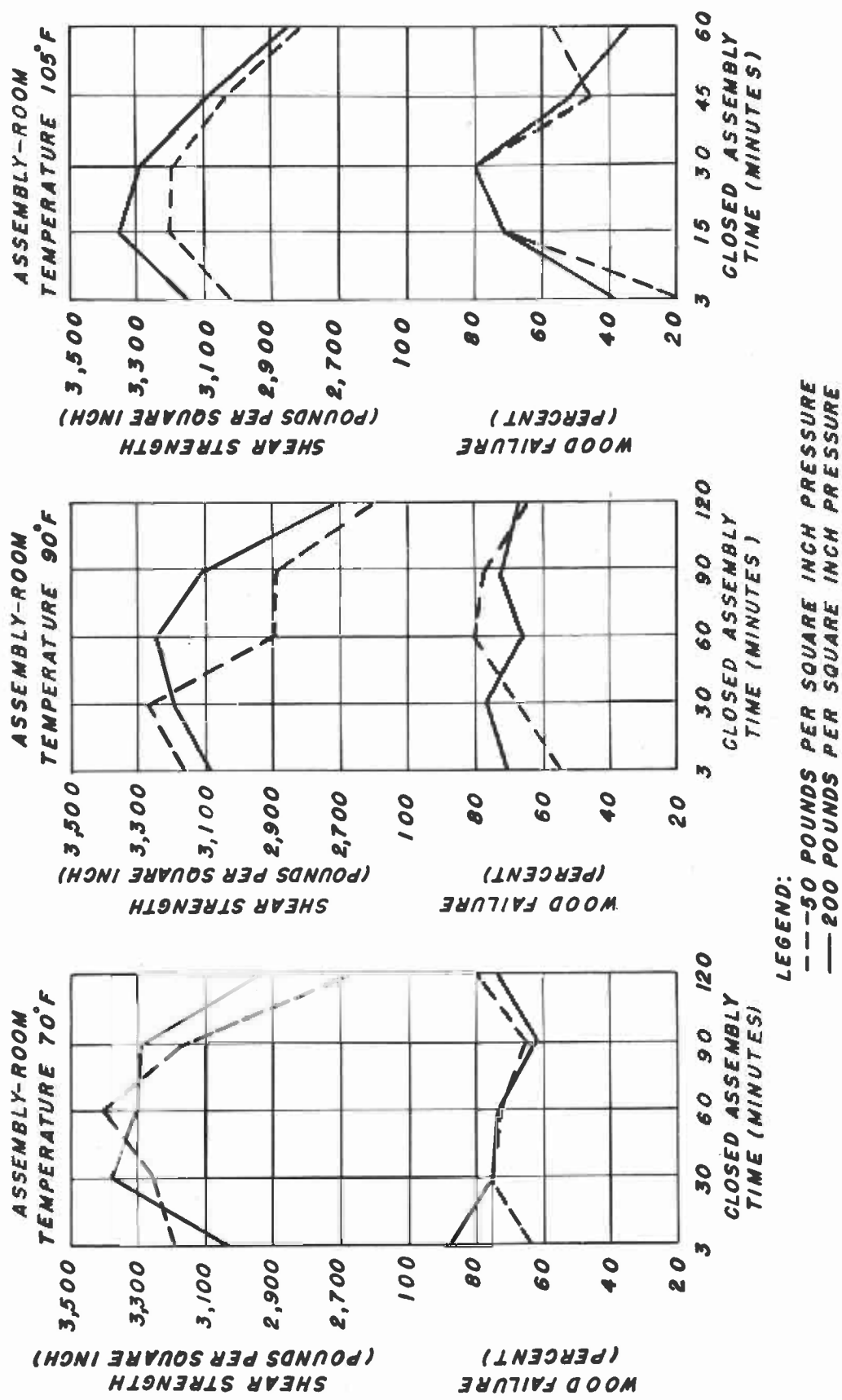


Figure 7.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue E at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

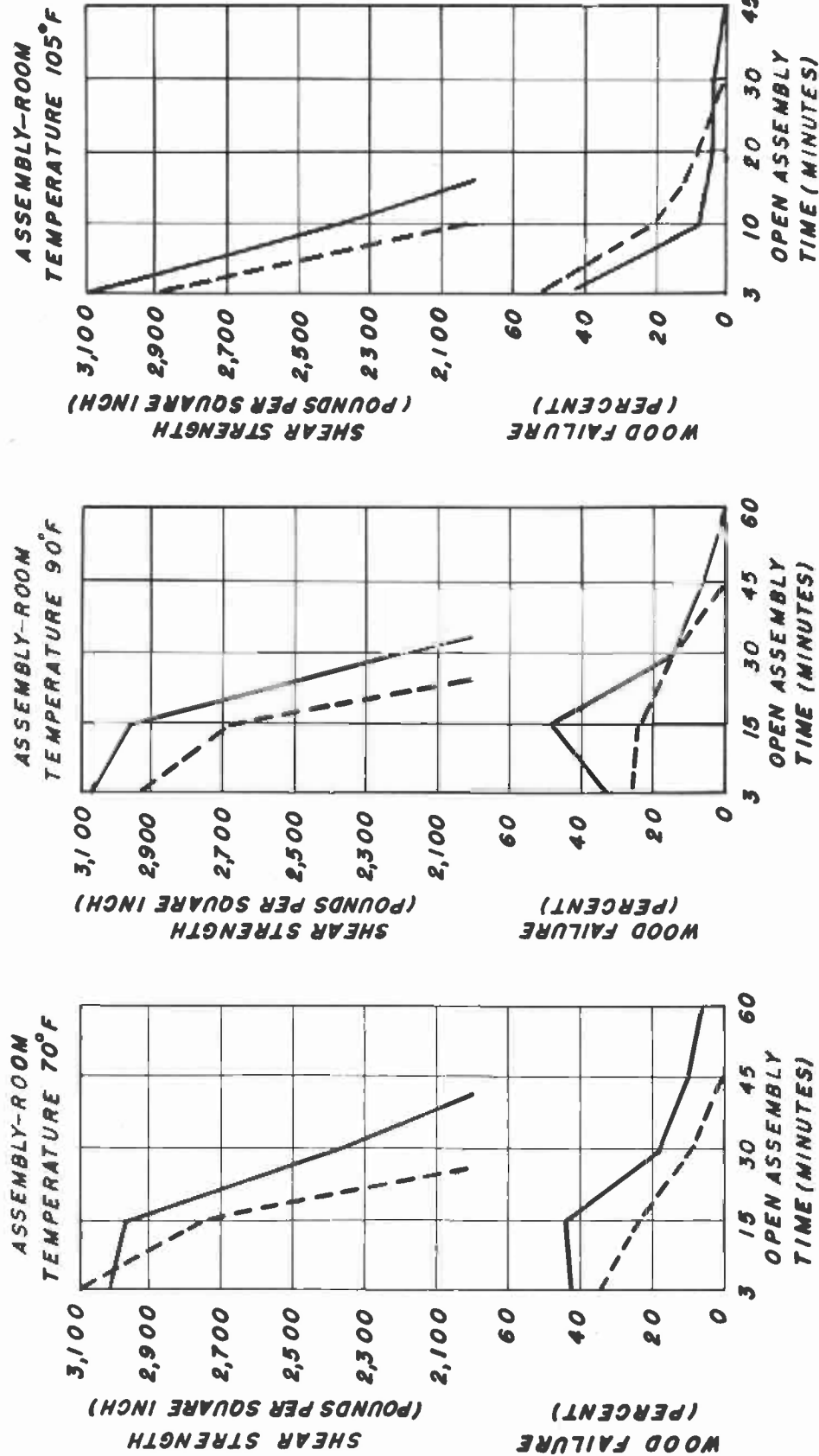


Figure 8.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue E at different open assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

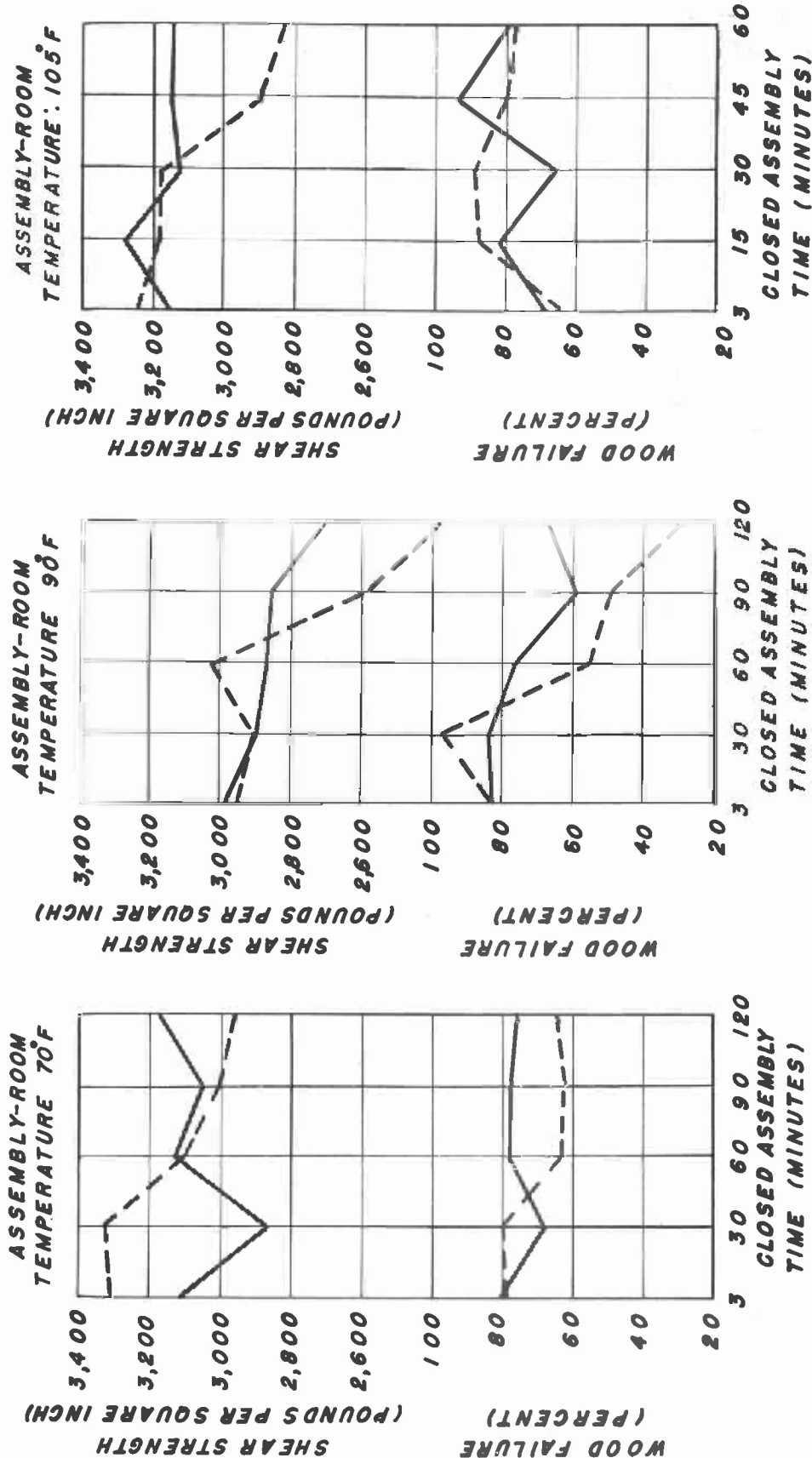


Figure 9.---Average shear strength and wood failure obtained in hard maple block joints prepared with Glue F at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

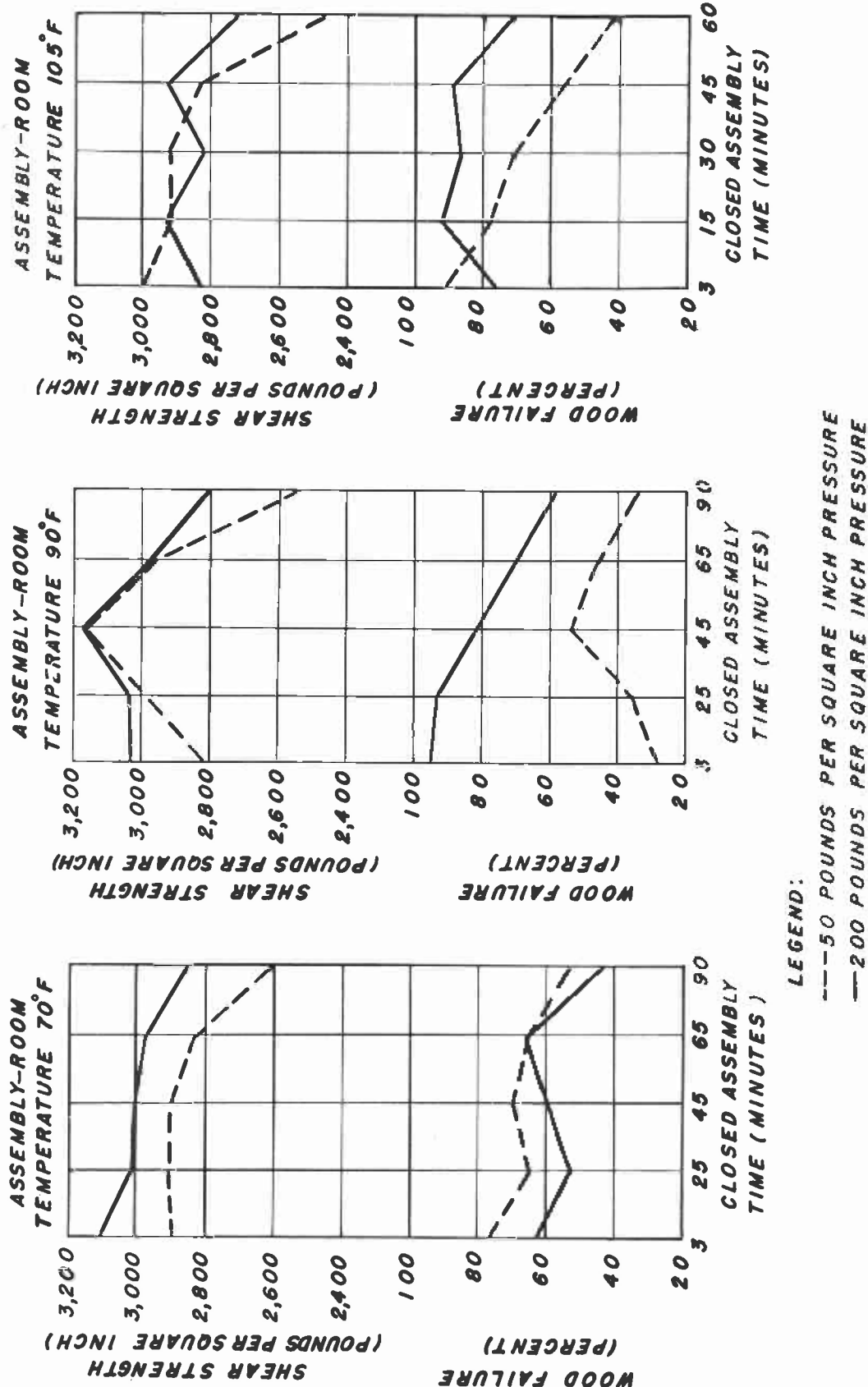


Figure 10.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue H at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

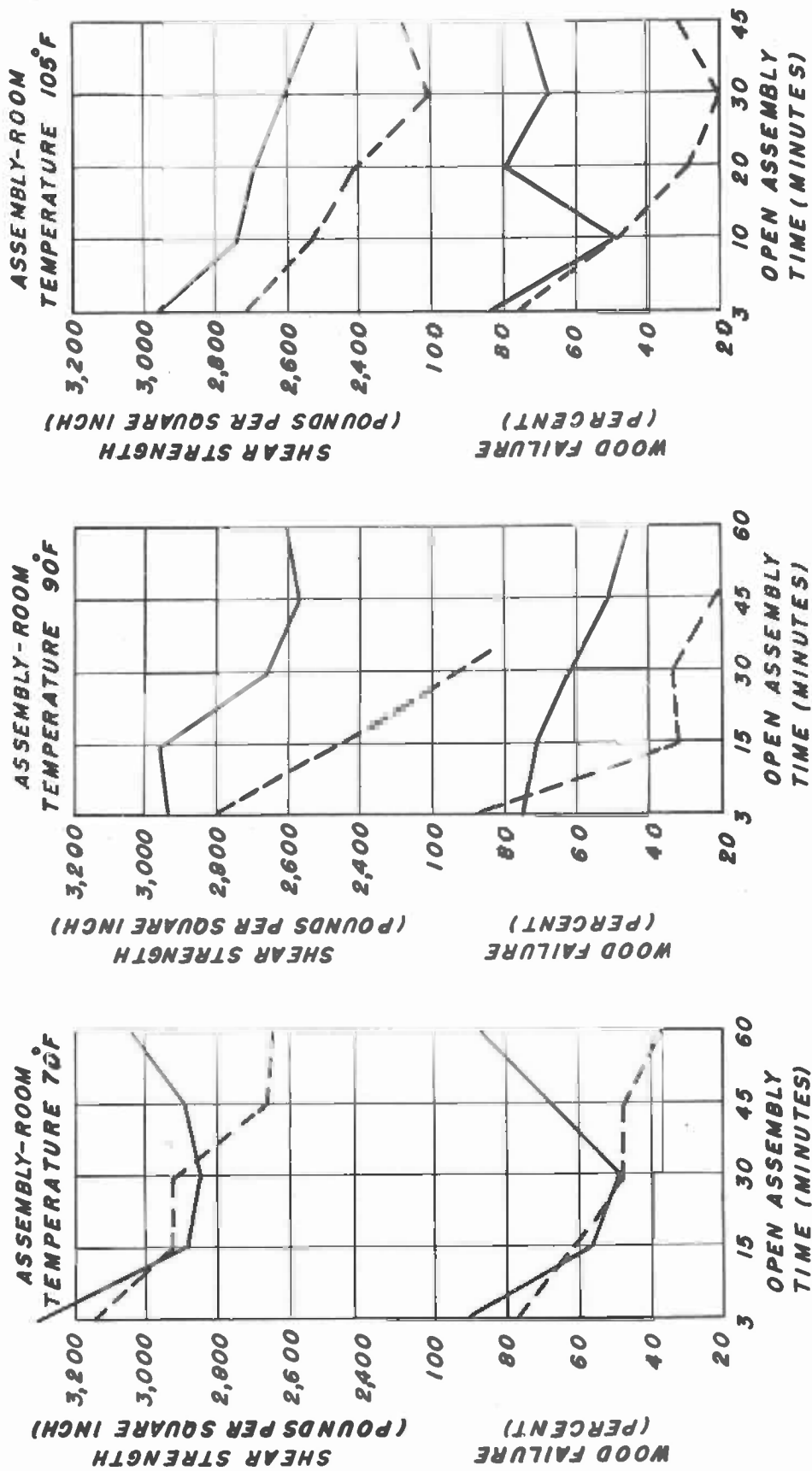


Figure 11.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue H at different open assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24

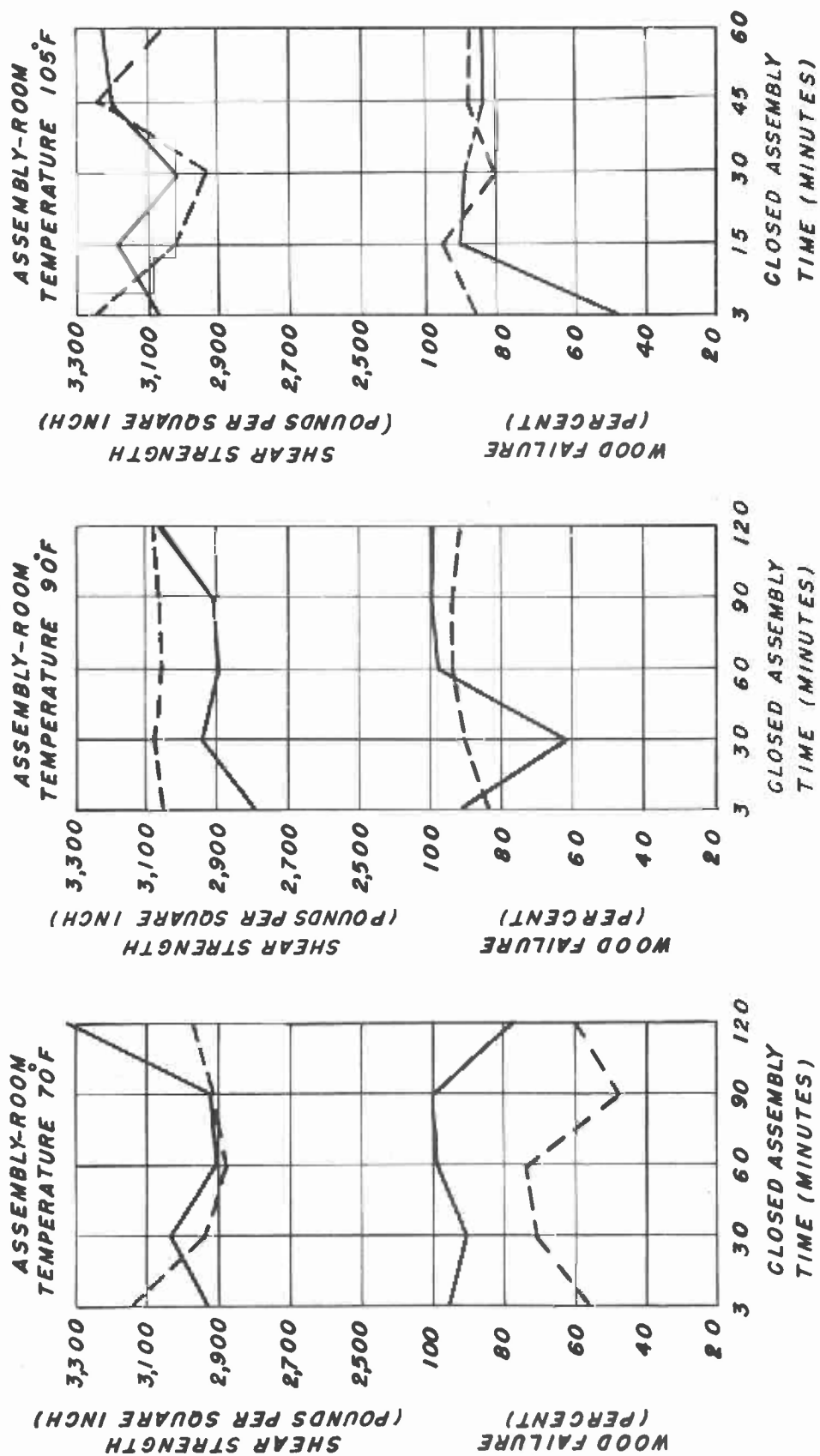


Figure 12.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue I at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

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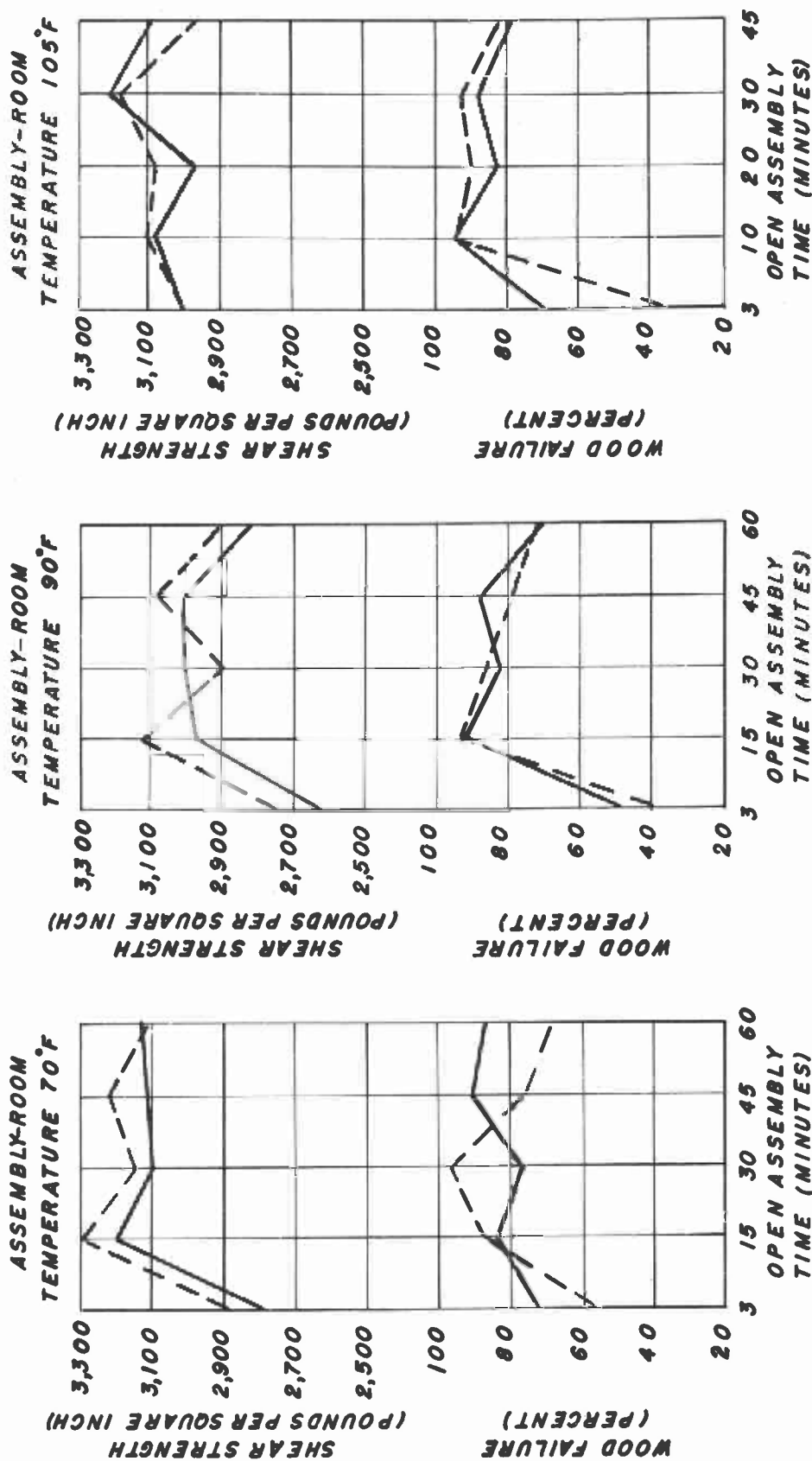


Figure 13.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue I at different open assembly times. Glue was applied to both joined surfaces. Cure was at 180° F. for 24 hours.

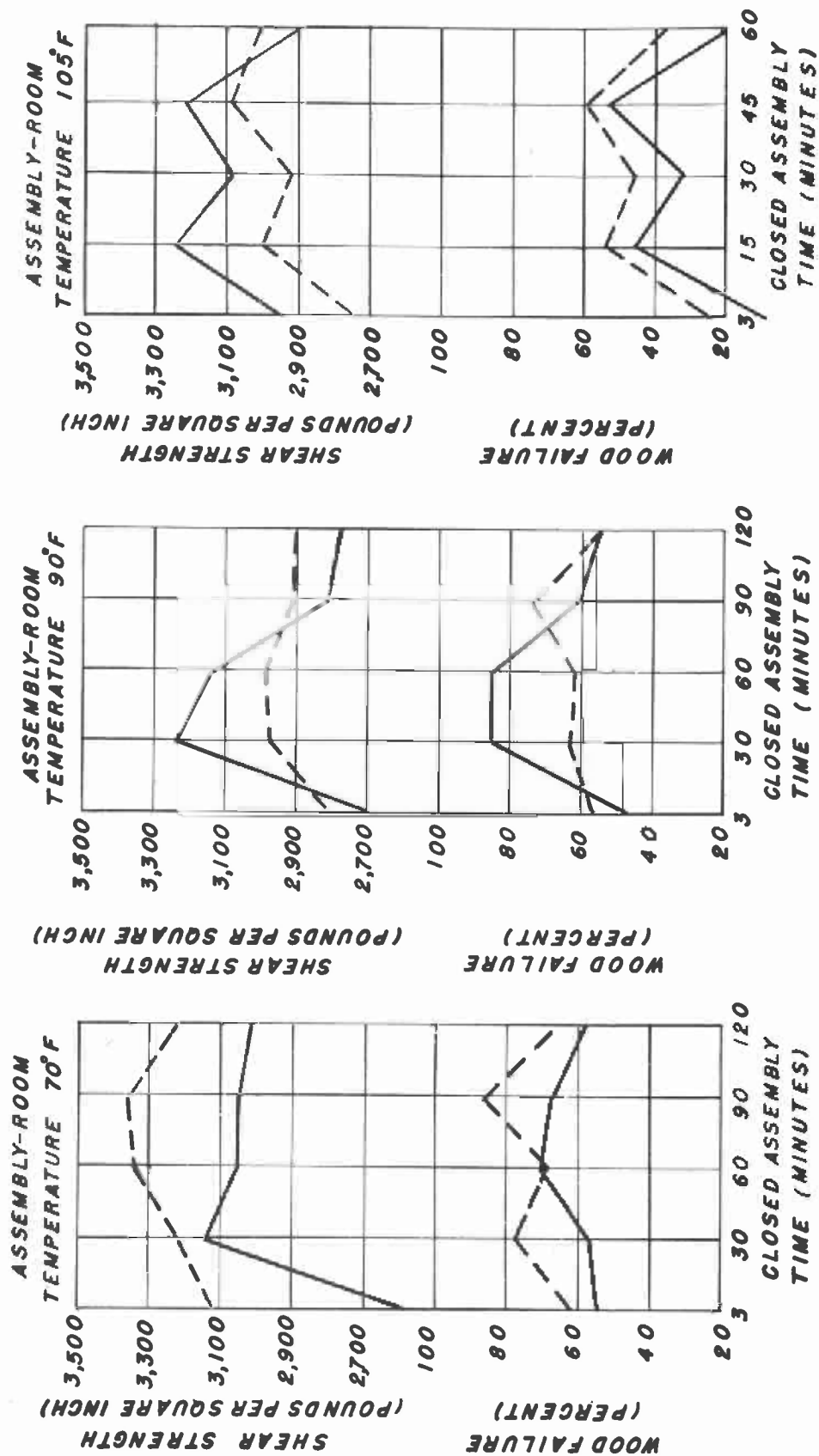


Figure 14.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue G at different closed assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.

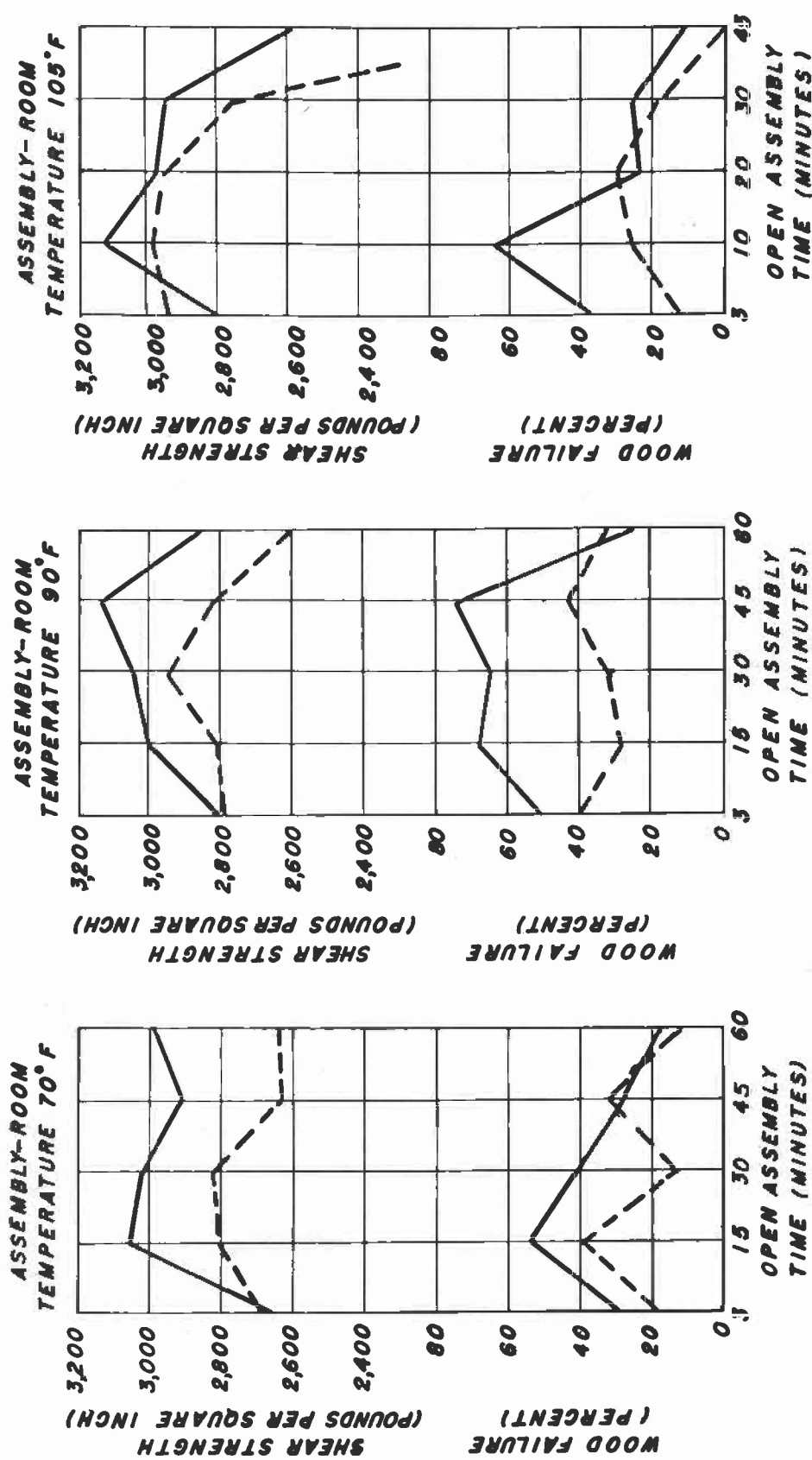


Figure 15.--Average shear strength and wood failure obtained in hard maple block joints prepared with Glue G at different open assembly times. Glue was applied to both joined surfaces. Cure was at 140° F. for 24 hours.