CERTAIN PROPERTIES OF PAPREG AFFECTED BY CALENDERING PRESSURE ON MITSCHERLICH BASE PAPER

July 1943

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Issued in Cooperation with the
ARMY AIR FORCES
and the
BUREAU OF AERONAUTICS
Under the Supervision of the
AERONAUTICAL BOARD

No. 1389

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

No. 1389

CERTAIN PROPERTIES OF PAPREG AFFECTED BY CALENDERING PRESSURE ON MITSCHERLICH BASE PAPER[1]

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Introduction

Preliminary tests previously reported in Forest Products Laboratory Mimeograph 1395, "High-strength Laminated Paper Plastics for Aircraft," indicated that certain properties of papreg were definitely influenced by calendering the base paper. The purpose of this report is to present more comprehensive data showing the effects of using Mitscherlich base paper produced under various degrees of calendering pressure on certain properties of papreg. Variations in calendering pressure during paper making produce changes in the density, thickness, porosity, and many other physical properties of paper.

The results reported herein were obtained by a direct correlation between calendering pressure, a process variable, and the properties of the plastic rather than by determining changes produced in the paper and their effects on the properties of papreg.

Preparation of Paper and Papreg

The preparation of papreg for this investigation included the production of several base papers under four calendering pressures and uniformly impregnating and laminating those papers into papreg.

Papermaking.--All paper machine runs for this series were made from the same furnish using commercial Mitscherlich sulfite pulp and all variables except calendering pressure were held as constant as possible throughout the series. The calender stack consisted of a single vertical bank of seven chilled-iron rolls, the bottom roll being the driven roll. The effective

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[1]This mimeograph is one of a series of progress reports prepared by the Forest Products Laboratory to further the Nation's war effort. Results here reported are preliminary and may be revised as additional data become available.

nip pressure was increased, by applying pressure to two pneumatic cylinders, through a lever system having a mechanical advantage of 12.4 (fig. 1). The gage readings of the calender pressure system were used for convenience and simplicity in reporting results. Pressures used were 0, 25, 50, and 75 pounds.

Impregnating, laminating, and testing.--Bakelite resin No. BV-16303 was used for impregnation of the base papers for this series. The resin content of the treated paper was held at 36 percent and the volatile content at 4.5 percent. Test panels were parallel laminated at both 75 and 250 pounds per square inch for 12 minutes at 325° F. Test specimens were prepared, conditioned, and tested according to procedures set forth in "Proposed Federal Specification for Organic Plastics; General Specification (Methods of Physical Tests)," July 7, 1942. Tests included tension, compression, bending, specific gravity and water absorption. All strength tests were made parallel to grain.

Discussion of Results

The physical properties of the four papers produced under the papermaking conditions described were determined (table 1). Data showing the effect on some of the properties of papreg made from these papers are given in table 2. Curves showing trends of these properties are presented in figures 2 through 6.

Earlier in this report it was pointed out that variations in calendering pressure produce several basic changes in sheet properties. Variations in any one paper property often counterbalance or outweigh the effect of another property in a consideration of the resultant papreg properties. For example, increased calender pressure produces paper of higher density which specifically would produce higher strength plastic. At the same time, however, the resin absorbency characteristic of the paper is affected adversely, making it more difficult to impregnate. This difficulty may outweigh the advantages of increased density. The extent to which each of these changes influence the properties of papreg depends to a large extent on the type of fiber and processing used for the papermaking furnish. It is evident, therefore, that the effect of variations in calendering pressure will be different for each type of paper and the trends will not necessarily be the same for paper made from different pulps or processed under different conditions. It is also recognized that supercalendering may produce an entirely different effect from the ordinary machine calendering referred to in this report.

Specific gravity.--The specific gravity of papreg molded at 75 pounds per square inch increased from 1.34 to 1.40 when papers processed with increasing calendering pressure from 0 to 75 pounds were laminated. At 250 pounds per square inch molding pressure, however, the specific gravity was increased from 1.40 to only 1.41 with increased calendering pressure (fig. 2). These results show that by using a base paper subjected to high calendering pressure, papreg can be molded at 75 pounds per square inch having a specific gravity equal to that of papreg made of uncalendered paper and molded at 250 pounds per square inch.

Total water absorption.--Increasing the calendering pressure of Mitscherlich base papers from 0 to 25 pounds gage pressure reduced the total water absorption of papreg made from them from about 4.7 percent to about 4 percent for both high and low laminating pressures. Additional calendering pressure, however, resulted in little further change in water resistance of the papreg (fig. 3).

Edgewise compressive strength.--The maximum edgewise compressive strength of papreg molded at 75 pounds per square inch increased from about 20,500 to nearly 23,000 pounds per square inch when papers processed in a range of increasing calendering pressure from 0 to 50 pounds were used. There was a slight decrease when a higher calendering pressure was used. However, the values for this property decreased from about 23,300 to 21,700 pounds per square inch in papreg molded at 250 pounds per square inch as the calendering pressure applied to the base papers was increased from 0 to 75 pounds (fig. 4). It appears, therefore, that an advantage in compressive strength can be obtained in papreg molded at low pressure (75 pounds per square inch) by the application of some calendering to Mitscherlich sulfite type base papers. This did not appear to be true for papreg molded at 250 pounds per square inch for then the use of an uncalendered paper yielded the highest compressive strength.

Ultimate tensile strength.--The ultimate tensile strength of papreg molded at 75 pounds per square inch increased from about 34,800 to about 37,200 pounds per square inch when the calendering pressure on the base papers was increased from 0 to 25 pounds; the values decreased slightly when papers calendered at higher pressures were used. Papreg molded at 250 pounds per square inch exhibited a loss in tensile strength as the calendering pressure on the base papers was increased over the range used (fig. 5). As in the case of the compressive strength, therefore, it appears that improvement in tensile strength of papreg molded at low pressure (75 pounds per square inch) can be obtained by some calendering of the base paper, but that in papreg molded at 250 pounds per square inch a loss may be expected to follow an increase in calendering pressure.

Static bending strength.--The modulus of rupture of papreg molded at 75 pounds per square inch was not appreciably affected by increased calendering pressure applied to base paper. However, a trend toward lower bending strength of papreg molded at 250 pounds per square inch resulted from an increase in calendering pressure (fig. 6).

Moduli of elasticity.--The moduli of elasticity in tension, bending and compression of papreg material were affected but little by the use of Mitscherlich sulfite papers having a range in the degree of calendering. The over-all change in this property due to changes in calendering pressure within the limits covered did not appreciably exceed the experimental error involved in making and testing the plastic.

Conclusions

Results obtained under the conditions described in this report show that certain properties of papreg are affected by changes in pressure in calendering Mitscherlich sulfite base papers used for lamination. The effects in general appeared to be greater in papreg molded at 75 than at 250 pounds per square inch.

As the calendering gage pressure was increased in 25 pound steps from 0 to 75 pounds, the following conclusions were apparent from the data obtained:

1. The specific gravity of papreg molded at 75 pounds per square inch from paper made at calendering gage pressures of 25 to 75 pounds was considerably increased over that obtained from uncalendered paper. At 250 pounds per square inch molding pressure, however, the increase in specific gravity was not appreciable.

2. The total water absorption of papreg decreased slightly in the low range of calendering pressure, as compared to uncalendered paper, and remained virtually unchanged at higher calendering pressures.

3. The maximum edgewise compressive strength of papreg molded at 75 pounds per square inch increased with an increase in calendering pressure; it passed through a maximum at about 50 pounds calendering pressure and decreased slightly at higher pressure. Papreg molded at 250 pounds per square inch, however, decreased in compressive strength as calendering pressure was increased through the range used.

4. The ultimate tensile strength of papreg molded at 75 pounds per square inch increased when calendering pressure was increased from 0 to 25 pounds and decreased slightly with higher pressures, but at 250 pounds per square inch molding pressure, tensile strength of papreg decreased with increasing calendering pressure.

5. The modulus of rupture of papreg molded at 75 pounds per square inch was unaffected through the range of pressures used, but at 250 pounds per square inch molding pressure some strength loss in this property occurred at the higher calendering pressures.

6. No appreciable change occurred in the moduli of elasticity in tension, bending, and compression of papreg over the range of calendering pressures used.

Table 1.--Properties of four papers produced under variations in calendering pressure

Machine run	Calendering gage pressure	Physical properties				
		Ream weight 25 x 40/500	Thickness	Porosity	Density	Average tensile strength
No.	Lb.	Lb.	Mils.	Sec. per 100 cc.	Gm. per cc.	Lb. per sq. in.
2066	0	30.8	2.66	10	0.64	7,820
2067	25	32.6	2.23	12	.81	9,190
2068	50	31.3	2.02	11	.86	7,850
2069	75	28.8	1.80	9	.88	7,895

Table 2.--Effects of calendering pressure applied to paper as reflected in papreg properties

Papreg number	Calendering gage pressure	Properties of papreg[1]							
		Tension		Compression edgewise		Static bending		Specific gravity	Total water absorption 24 hrs.
		Ultimate	Modulus of elasticity	Maximum	Modulus of elasticity	Modulus of rupture	Modulus of elasticity		
	Lb.	Lb. per sq.in.	1,000 lb.per sq.in.	Lb.per sq.in.	1,000 lb.per sq.in.	Lb.per sq.in.	1,000 lb.per sq.in.		Percent
Parallel Laminated at 75 Pounds Per Square Inch									
2066-1A	0	34830	3040	20540	2830	36070	2841	1.34	4.7
2067-1A	25	37260	3038	22530	2765	35860	2809	1.38	3.7
2068-1A	50	36500	3204	22960	2880	35380	2994	1.39	3.9
2069-1A	75	35610	3175	21620	2969	36060	3031	1.40	4.0
Parallel Laminated at 250 Pounds Per Square Inch									
2066-1	0	39790	3215	23340	3178	37410	2980	1.40	4.7
2067-1	25	38020	3136	22080	2926	37820	2894	1.41	3.9
2068-1	50	35880	3329	22740	2956	36780	2932	1.41	4.0
2069-1	75	36040	3228	21700	3048	35140	3068	1.41	4.0

[1] Laminates cured for 12 minutes at 325° F. Strength tests made parallel to fiber direction (grain).

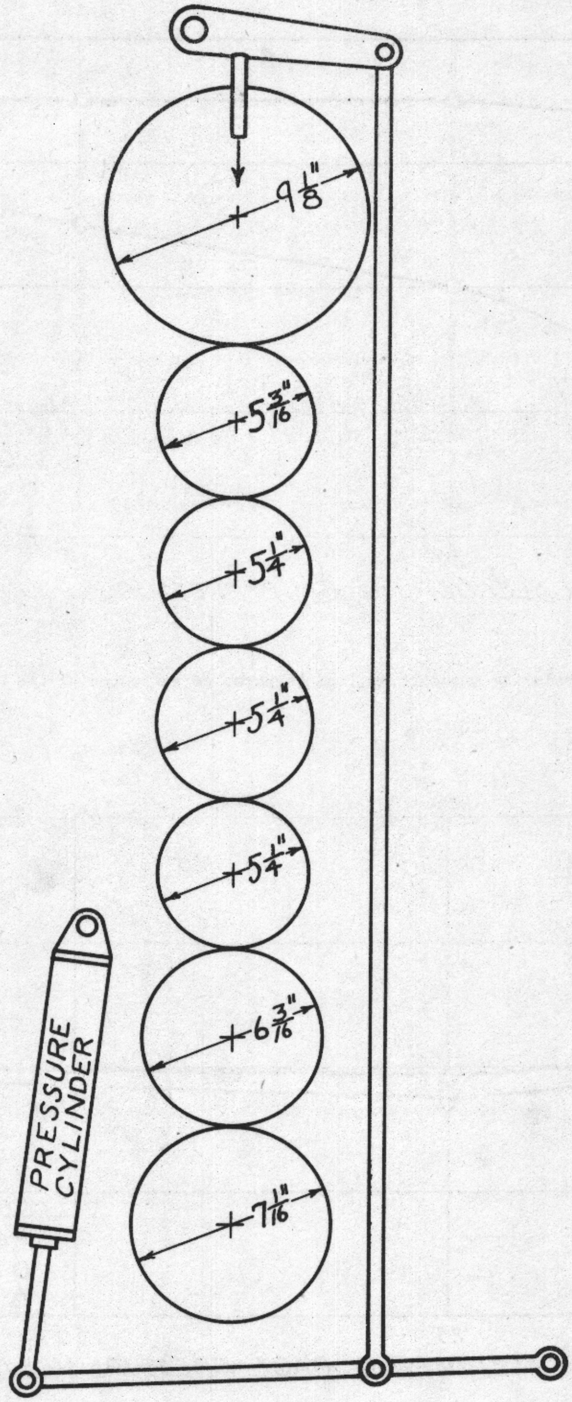

Figure 1.--U. S. Forest Products Laboratory experimental calender stack showing loading system.

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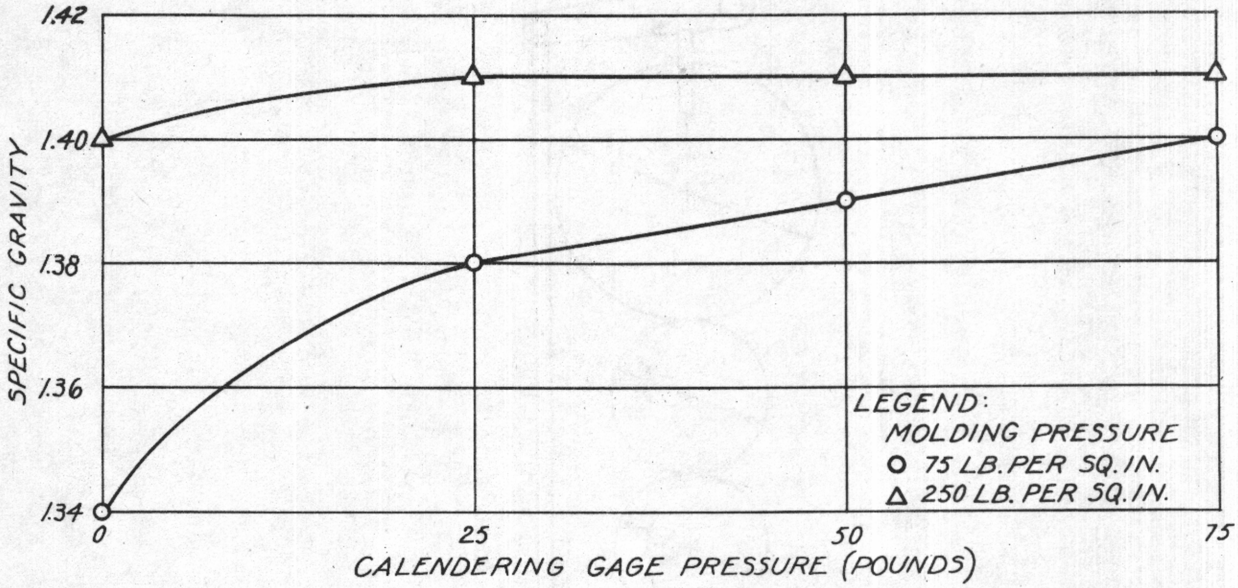

Figure 2.--Effect of calendering pressure applied to paper as reflected on the specific gravity of papreg.

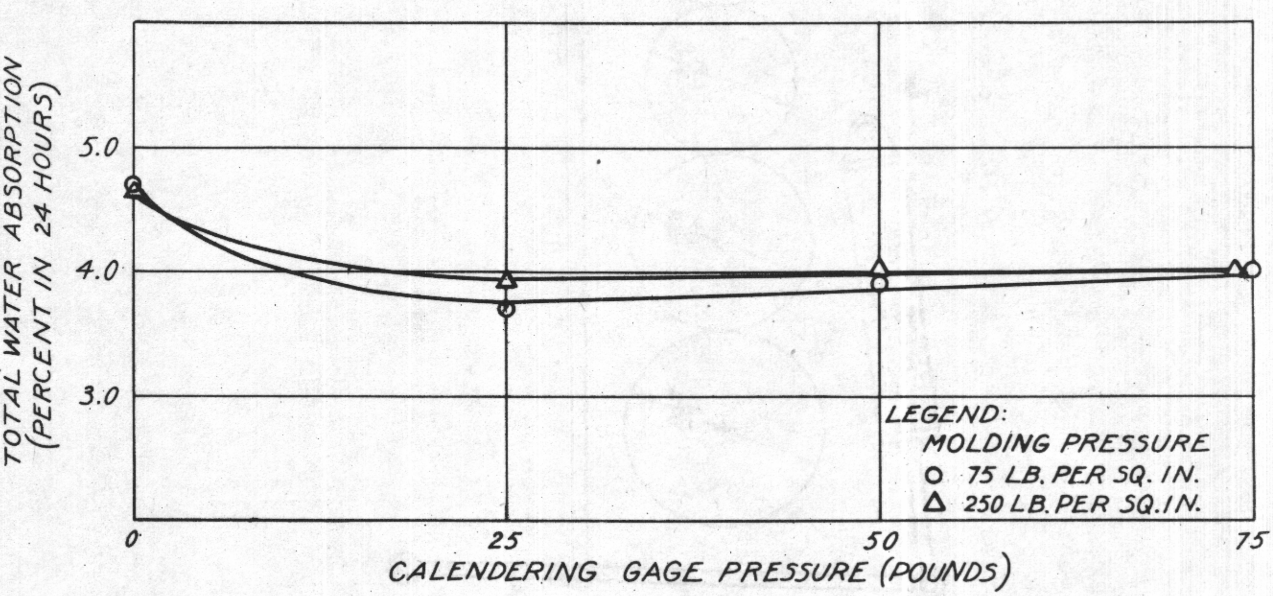

Figure 3.--Effect of calendering pressure applied to paper as reflected in total water absorption of papreg.

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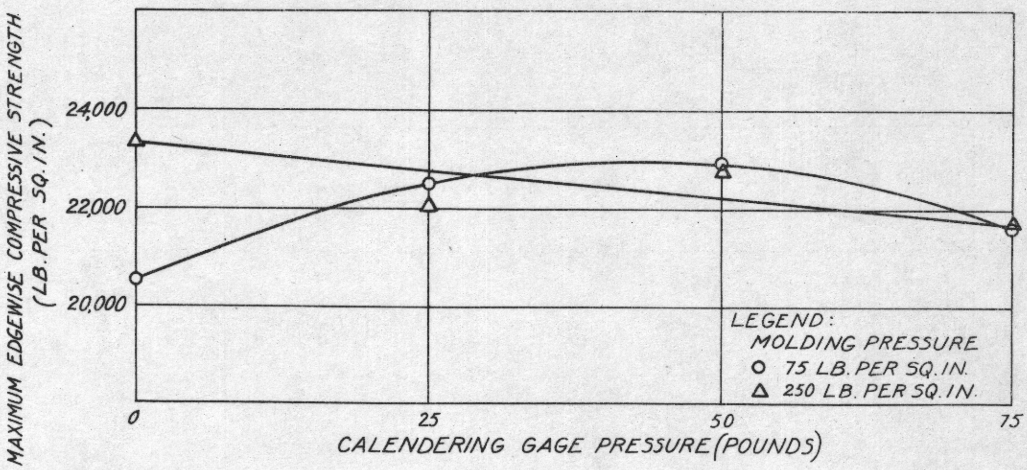

Figure 4.--Effect of calendering pressure applied to paper as reflected in the maximum edgewise compressive strength of papreg.

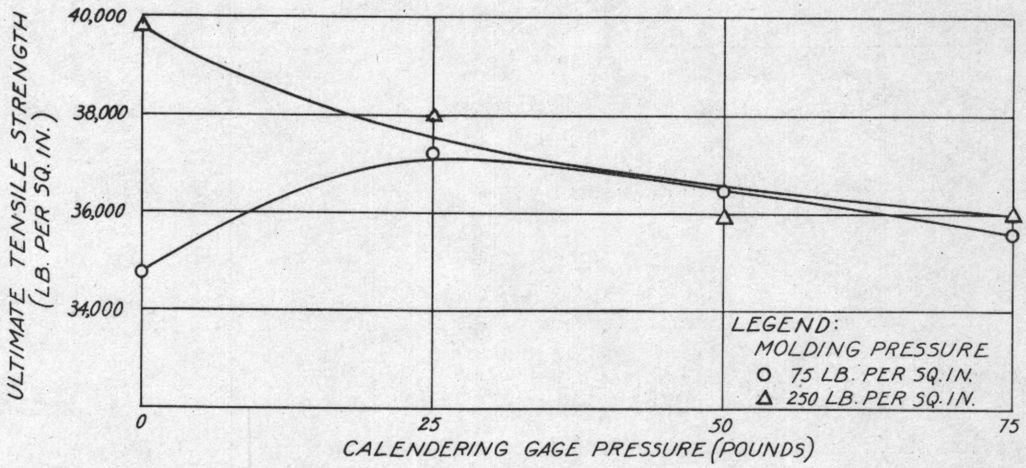

Figure 5.--Effect of calendering pressure applied to paper as reflected in the ultimate tensile strength of papreg.

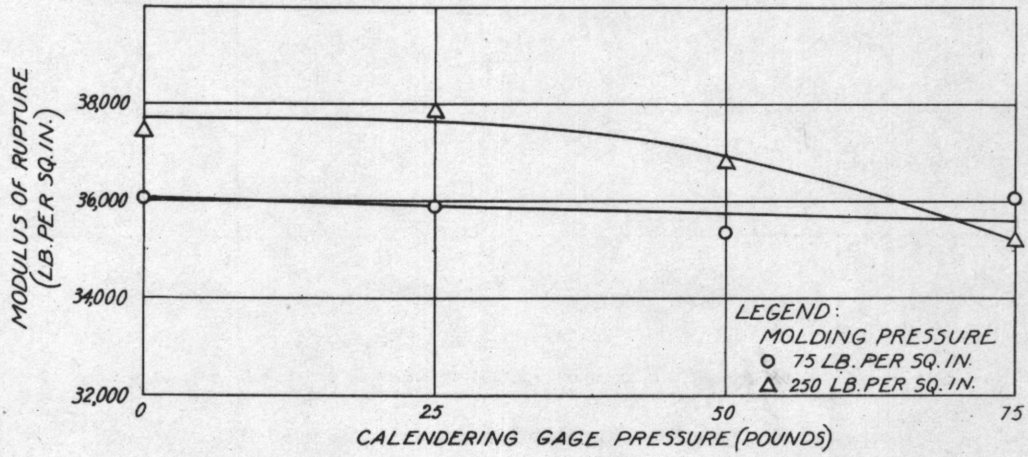

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Figure 6.--Effect of calendering pressure applied to paper as reflected in the modulus of rupture of papreg.