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August 10, 1958

U. S. Army Prosthetics Research Laboratory
Walter Reed Army Medical Center
Washington 12, D. C.

FORGIVE EXPORT LAMINATE EVALUATED

**FC
BAC**

James T. Hill
Pvt. William C. Williams

Approved by: _____
Chief, Prostheses Dev. Branch

Approved by: John B. Bawley JCB
For Director

Part VII, Effect of Drying Time on Laminated Properties

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III. RESULTS

I. IMPACT

The impact tests were conducted on the properties of the laminates. A total of 12 tests were conducted on 12 samples. The results of the tests are shown in Table II. The impact resistance of the laminates was found to be directly related to the curing temperature and time. The laminates cured at 70°C showed the highest impact resistance, while those cured at 100°C showed the lowest impact resistance.

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II. P

The physical properties of the laminates were described in detail in the report. A PVA (polyvinyl alcohol) was used as the adhesive between the nylon and the steel plates. The thickness of the nylon was 24 mil. The thickness of the steel plates was 1/8 inch. The laminates were cured for 90-120 minutes depending on the curing temperature. The curing temperature was 70°C or 100°C. The curing time was 1 hour or 2 hours. The curing temperature and time were varied to determine the effect on the physical properties of the laminates. The curing temperature and time were varied to determine the effect on the physical properties of the laminates.

The laminates were tested for impact resistance, tensile strength, and compressive strength.

Sample	Curing Temperature (°C)
A	70
B*	70
C	70
D*	70
E	80
F	80
G	80
H*	80
I	100
J	100
K	100
L	100

*Samples B, D and H were disc shaped laminates of 2 inches diameter.

The impact tests were plotted in Fig. 1 and listed in Table II. It may be seen that the highest effective porosity were obtained at 70°C. The impact resistance was obtained at 100°C. The physical properties of the laminates are listed in Table II.

IMPACT

Since samples A and B (70° cure) were the only two laminates in this series, it is difficult to reach any definite conclusions concerning the effect of curing time on their properties. However, there is an indication that a maximum impact resistance may be obtained by curing between 1 and 3 hours, possibly at 2 hours. The 70°C series will be completed in the future.

Sample F (120 minute cure) in the 80°C series shows the best compressive strength. It is interesting to note that this sample also was cured for 2 hours. Almost all of our "standard" laminates have been cured under conditions similar to sample F's. Of all the samples tested, this one had the highest compressive strength. However, in the 100° series, the 1 hour sample had the more favorable compressive properties. This is probably due to the high curing temperature; the 2 hours being too long at such a high temperature.

IMPACT

Again in the 70° series, due to incomplete results, no definite conclusion can be derived. However, generally it can be stated that the best results should be obtained between 1 and 2 hours.

In the 80° series the 1 hour cure appears to have more favorable physical properties, but since the effective porosity is only half that of the 2 hour cure, the 2 hour cure again may be considered the most desirable. In the 100°C series the 1 hour cure proved to give the best result.

IMPACT

Samples A (70° x 60 minutes) and I (100° x 30 minutes) gave similar impact resistance, although they are at the extremes of porosity, sample A having a porosity of 13% and sample I with 13%. Both of these samples showed high impact resistance. Previous experiments have shown that the laminates with higher porosity give higher impact resistance. This trend was observed in these experiments.

At high porosities, the laminate is so resilient that it collapses under a relatively light load. On the other hand, a laminate will become more susceptible to an earlier craze or crack when the effective porosity is low.

IV. CONCLUSIONS

1. The compressive stress at buckle of the laminate is not significantly affected by curing temperature or curing times over the range tested. Therefore, the effective porosity should be the controlling factor to be considered when choosing curing conditions with respect to compressive properties.
2. The bearing stress at 4% elongation, like compressive stress, does not appear to be significantly affected by curing conditions over the range tested. Again, the effective porosity appears to be the controlling factor.
3. The impact resistance like bearing and compressive strength is controlled by effective porosity rather than curing conditions over the range tested. As a result of these tests we make a general conclusion that the laminates may be completely cured at a temperature of 70°C or higher after a minimum precure of 60 minutes. The best conditions for curing, taking into account effect porosity and physical properties, appear to be 70°C for 120 minutes. Longer or higher temperatures tend to cause discoloration of the laminates.

V. RECOMMENDATION

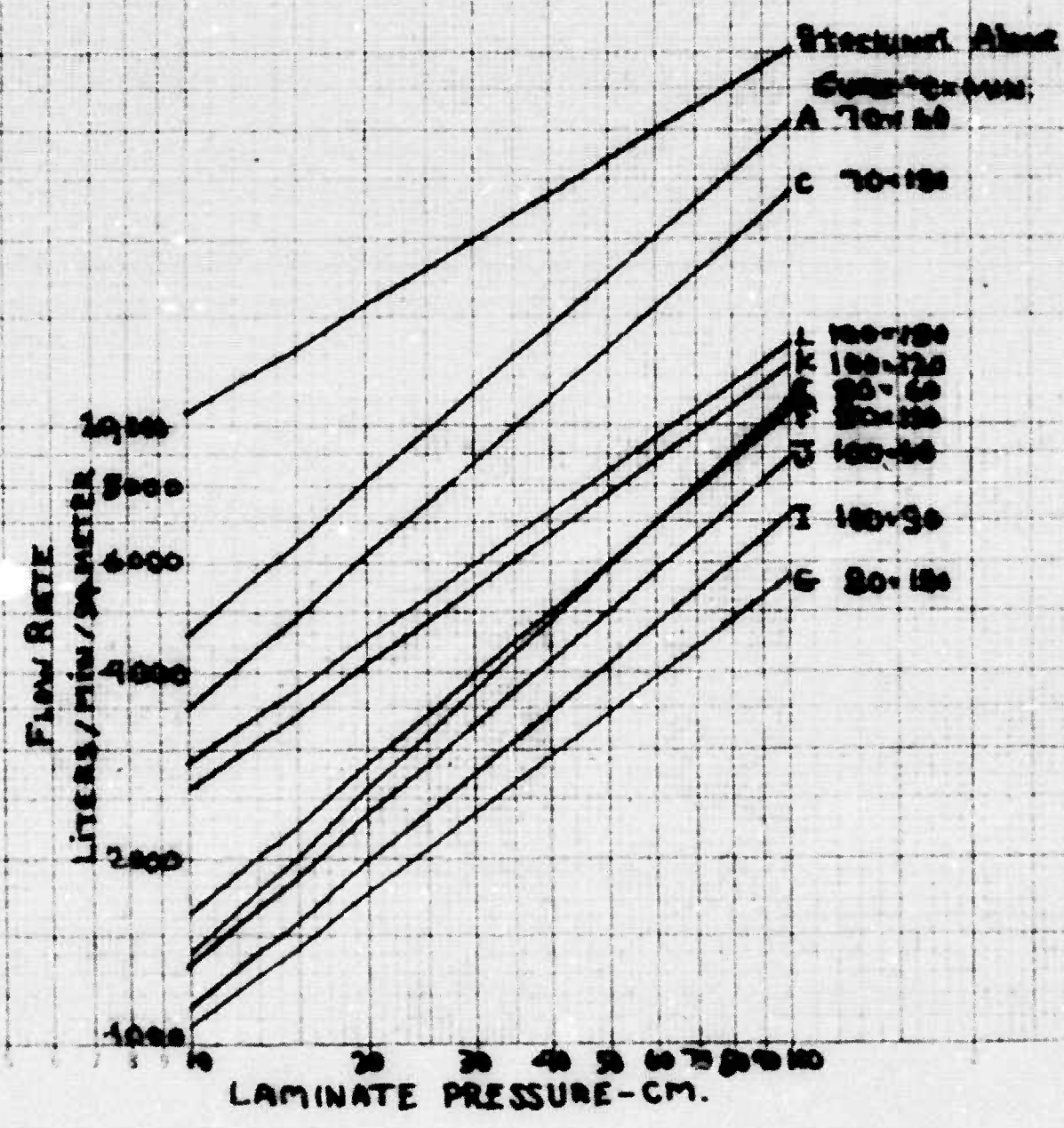
1. An addenda to the Link Shop procedure (T.R. #5840) for fabrication of porous laminated arms should be prepared. This addenda should contain a recommendation stating the use of a 70°C cure instead of the 80°C cure now in use.

TABLE II

Sample	Cure Temp (°C)	Cure Time (min.)	COMPRESSION		TENSILE		IMPACT		Effective Porosity (%)
			Stress at Buckle (psi)	Strain (in/in)	Breaking Stress (psi)	Ult. Stress (psi)	Initial Crack (in. lbs)	Collapse (in. lbs)	
A	70	60	354	.0109	1011	10,366	12	15	60.4
C	70	180	804	.013	1133	4,666	18	21	46.2
E	80	60	312	.006	1656	6,083	15	18	20.3
F	80	120	1407	.015	2153	8,230	15	21	21.2
G	80	180	1262	.013	3500	10,000	15	18	12.4
I	100	30	763	.009	2519	7,244	12	15	12.3
J	100	60	863	.004	2461	8,076	18	21	17.7
K	100	120	519	.023	2366	8,630	15	21	26.4
L	100	180	737	.0109	1111	5,105	15	18	30.4

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FIG. 1
EFFECT OF CURING CONDITIONS ON FLOW RATE



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