left-hand side of Eq. 7 should approach infinity. This can occur only if the maximum peak area is y_0/cP (maximum $A = y_0/cP$).

Let A_M denote the peak area for a maximum cure sample, and for convenience, let a new constant $B = (n - 1)\, k_0/cP^{1-n}$. Substituting the above terms into Eq. 7 gives the following:

$$(A_M - A)^{1-n} - (A_M - A_0)^{1-n} = Bte^{-E/RT} . \quad (8)$$

The form of Eq. 8 is compatible with the observed PGC phenol peak area. A computer solution of Eq. 8, utilizing curve fitting techniques, resulted in the curves shown in Fig. 6. The PGC data can be expected to include some variance due to sample, procedure, and instrument effects. A normal distribution of these variances was assumed; hence the values of A_0, A_m, n, B, and E were sought which minimized the sum of the squares of their absolute differences between model and test data. The best set of values obtained by the curve fitting is given in Table 1.

The calculated values of peak area and the deviations from the experimental values are given in Table 2.

The literature value for the activation energy for methylene bridge formation is 13.7 Kcal/g mole. (5) With cross-linking, there would be multiple bond formation, thereby increasing the activation energy. Also, hexa reacts with phenolic resin to form aromatic amines which again would influence the activation energy. Thus, a value of 19.9 Kcal/g mole for the activation energy is quite reasonable.

INDEX OF CURE - An index of cure can be defined which reduces the time/temperature curing conditions to a single parameter. It is defined as:

$$I_c = \frac{A - A_0}{A_M - A_0} \times 100 . \quad (9)$$

This equation is based on the assumption that samples with the same phenol peak area have a similar "state of cure." Calculated values of the index of cure are given in Table 3 for this oil-modified, phenolic resin system. For example, it appears that a sample cured for 4 hr at 350 F has a similar state of cure to one cured for 1 hr at 400 F. Preliminary comparisons between the values of cure index and FAST wear (total weight loss) and friction indicate a strong qualitative agreement for this resin system. This will be illustrated in a later section.

Table 3 - Index of Cure

	Time, hr				
	1	2	4	8	16
Temperature, F					
250	0.5	1	2	4	8
287	2.0	3.5	7	13	23.5
350	11	20	33	50	66.5
400	31	47.5	64.5	78.5	88

FUNCTIONAL RESPONSES TO CURE CONDITION CHANGES

CURE TIME AND TEMPERATURE EFFECTS - The FAST machine test procedure used was able to show significant changes in the friction and wear behavior due to the varying cure conditions studied.

Fig. 8 shows the sample weight loss during the FAST test plotted versus cure time, with cure temperature as parameter. The effect of cure temperature on total sample wear increases nonlinearly with temperature in the same manner as the PGC response described previously. The cure time effect on wear is also similar to the PGC response; that is, the effect is greatest for the low cure times and rapidly diminishes above the 4 hr cure time. The solid curves shown represent the best fit to the data of an equation of the same form as was used to generate the PGC peak areas from the mathematical model of the cure kinetics.

Fig. 9 shows four of the friction traces from the FAST machine and illustrates the type of friction differences found. There was generally a slight overall increase in friction level with increasing cure, especially at the higher test disc temperatures (> 500 F). A rational interpretation can be made of the friction variations during the beginning of the test. Variations which occur during the first three minutes of the test may be disregarded due to seating and surface conditioning effects. The variations during the remainder of the test can be attributed to the cure variations. Beyond 20 or 30 minutes, the cure effects diminish as the materials approach the same state of cure due to the heat generated at the friction interface.

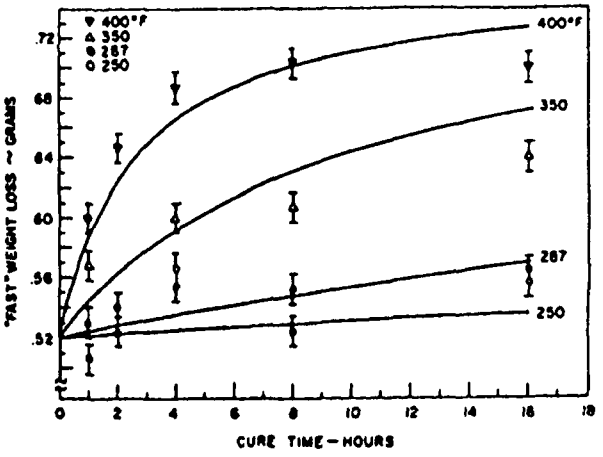

Fig. 8 - Variation in FAST wear with cure conditions

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