JOURNAL OF APPLIED POLYMER SCIENCE VOL. II, ISSUE NO. 6, PAGES 337-339 (1959)

A Loss in Curing Test for Tire Cords

S. L. Reegen* and J. Sabo

High Polymer Laboratory, Industrial Rayon Corporation, Cleveland, Ohio

1. INTRODUCTION

In the high temperature curing of tires by the Bag-O-Matic process[1] it is considered important to determine the ability of the tire cord to withstand the curing conditions without serious loss of tensile strength. This has been done by a plunger test,[2] in which the energy required to break an inflated tire with a plunger of $^5/_8$-in. or $1^1/_4$-in. diameter is measured. These values, together with the residual tensile strength of cords removed from the cured tires,[3] give data that are indicative of the effect of the curing conditions on the tire cord.

It would be of great aid in tire cord development work to have a laboratory method for comparing the resistance to curing of experimental cords. This test could be carried out on limited cord samples and would eliminate the lengthy and costly task of tire building, curing; and testing—at least until the results of the preliminary laboratory test prove promising. A method has been developed that involves embedding cord samples into a pad of rubber stock and curing the pad, in a mold, in a press at various temperatures.

This method was used in an effort to determine the cause of cord tensile losses during curing of nylon.

2. EXPERIMENTAL

The curing press used for these tests has 20-in. × 20-in. platens which are heated by steam. The dimensions of the steel mold, shown in Figure 1, are 15 × 4 × 0.045 in. The curing pads, 15 × 4 in., were made with seven lengths of cord (cut to 15 in. to fit the length of the mold) sandwiched between two strips of 0.025-in. rubber stock; the cords were placed $^1/_2$ in. apart onto the rubber under 20 g. tension. The tensioning was carried out by clamping one end of the cord and laying it down onto the rubber and then over a bench edge with a weight attached to the other end of the cord. It was necessary to allow the tension to be applied before allowing the cord to be gripped in the rubber stock. The samples were either bare or dipped cords. After the pad was placed into the mold, curing was allowed to take place in the press under 2000 psi pressure on a 16-in. rim that was applied to the mold. During curing, rubber flash was forced out through the end of the mold. Four curing temperatures were used in the test procedure, the time of heating decreasing with increasing temperature. The time-temperature combinations shown in Table I were used.

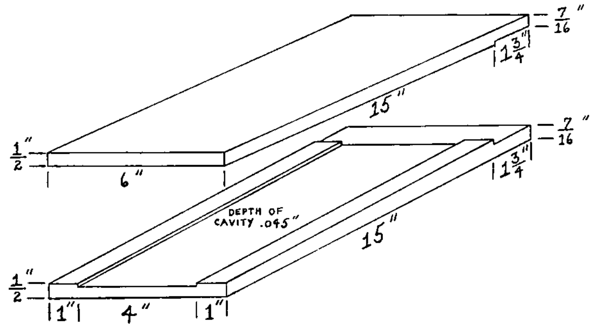

Fig. 1. Mold and top plate.

TABLE I

Temperature, °F.	Time, min.
300	35
320	28
340	21
360	15

With the rubber stock used in these tests, the above heating times gave satisfactory cures. Variations in stock compounding might make necessary some changes in the time-temperature combinations.[4,5] The platen temperatures were measured by a gauge in the steam line, while the temperature of the pads was obtained by insertion of a thermocouple in the pad in a position between two cords.

* Present address: Research Laboratories, General Motors Corporation, Warren, Michigan.

When the cure was completed, the mold was withdrawn from the press immediately upon release of the pressure. The top plate and the cured pad were taken from the mold within 5–8 sec. after removal from the press. Upon cooling to room temperature, the pads were cut into seven rubber-cord strips, each containing one cord. The breaking tensile strengths were obtained for these samples and compared with those for the uncured cord.

An advantage is gained by testing the cords while they are embedded in rubber rather than first attempting to strip the rubber from the cords. It was determined that more variable and lower tensile data were usually obtained with stripped cords. Thus, for dipped nylon cords, cured at 320°F., a significant difference was detected. This is shown in Table II.

TABLE II
Cured Tensiles of Nylon 66, Type 300 Cords Cured at 320°F. for 21 Min. Samples Embedded in Rubber and Stripped from Rubber

Samples		Cured tensile strengths, lb.
Nylon No. 1, embedded in rubber		29.2
Nylon No. 2, embedded in rubber		28.8
Nylon No. 3, embedded in rubber		29.1
Nylon No. 4, embedded in rubber		28.9
	Average	*29.0*
Nylon No. 1, after stripping rubber		28.1
Nylon No. 2, after stripping rubber		27.7
Nylon No. 3, after stripping rubber		26.3
Nylon No. 4, after stripping rubber		28.0
	Average	*27.5*

The lower and the more variable tensiles for the stripped samples appear to be due to the breaking of filaments which occurs in removing the rubber from the cords. This is found to be more significant with dipped cord samples than with bare cords because the rubber adheres more firmly to dipped cords.

3. RESULTS

Data were obtained on both bare and dipped nylon 66 cords. Figure 2 shows plots of cured tensiles vs. temperature for representative samples of bare cords conditioned at 75°F. and 55% R.H. The cords were nylon 66, type 300, 1890 denier; the construction of these cords was 12Z × 12S.

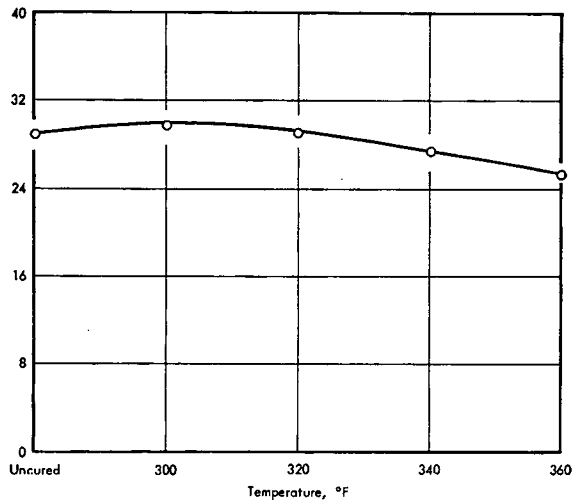

Fig. 2. Effect of curing on nylon 66 cords. Ordinate: Tensile strength, pounds

Figure 2 shows that nylon cords increase slightly in tensile strength after curing at 300°F.; maintain their original tensile after curing at 320°F. and suffer a slight loss after curing at 340°F. and 360°F. All cured tensile strength measurements were made on a Scott IP-4 tester within 1 hr. after the curing test.

Effect of Temperature of Pad Ejection

An important variable in the curing results was found to be the temperature at which the pads are ejected from the mold. It was determined that, at curing temperatures where a cord tends to lose tensile, the loss can be reduced or eliminated if the pad ejection is carried out at lower temperature; for example, by allowing the mold to cool in air. Therefore, it was necessary to carry out this procedure during a definite time interval. Periods of 5–8 sec. were found satisfactory. The manipulation can be carried out without difficulty, and the 3-sec. range makes no measurable difference in temperature.

TABLE III
Cured Tensile Strengths of Nylon 66, Type 300 Bare Cord; Cured at 340°F. Effect of Ejection Temperature

Pad ejection temperature, °F.	Tensile strength, lb.
340	27.5
330	27.6
320	28.3
310	28.9
300	29.1
290	29.0

Figure 2 shows a tensile loss occurs when a bare nylon cord is tested at 340°F. by the above procedure. The effect of pad ejection temperature on cured tensiles is shown in Table III.

It is apparent that the curing loss can be eliminated when the pad ejection is carried out at 310°F. or lower. Ejection at lower temperatures also causes a reduction in cord shrinkage: shrinkage is 4.7% at 340°F. and 1.0% at 310°F.

4. DISCUSSION

The data in Figure 2 show that a tensile strength loss occurs when nylon 66 tire cord (type 300) is cured at 340 or 360°F. Table III shows that this tensile strength loss can be eliminated by ejecting the cured pad from the mold after cooling to 310°F. This indicates that the tensile loss does not occur during the curing cycle, but at the time of ejecting the pad from the mold. A further test was carried out which showed that bare nylon cords suffer no tensile loss when heated in a nitrogen atmosphere for 21 min. at 340°F.; shrinkages of 5–9% were obtained when tensions were varied from 100 g. to 20 g. It is suggested that the difference between heating the samples in air and heating in a pad is the ability of the cords to lose moisture while being heated in air. In the pad the moisture is trapped as steam in contact with the cords. To test whether moisture does play a role in the curing loss, a sample of nylon 66 cord was dried (in vacuum over Drierite) to a moisture content of 0.5% as analyzed by Karl Fischer reagent prior to the curing test at 340°F. This sample showed no tensile strength loss while the control, which contained 3.0% moisture, showed a tensile loss of 1.4 lb.

From the foregoing, it is concluded that shrinkage of the cord, in the presence of moisture, causes the tensile strength loss in the curing test. If the shrinkage is eliminated (by ejecting the pad at a lower temperature) or the moisture removed (by predrying the cord sample), the tensile strength loss can be effectively eliminated.

This tensile strength loss is not reversible. Tests have shown it cannot be recovered after curing by exhaustive drying, stretching, or by a combination of both.

References

1. Sonderquist, L. E., in *Lectures From a Course in Basic Rubber Technology*, DiMaggio, A. J., ed., Villanova University, Villanova, Pa., 1955, Paper No. X-C.

2. Military Specifications for Tires, Pneumatic, For Military Ground Vehicles, MIL-T-12459 (Ord.), January 29, 1953, Methods 4.5.1 to 4.5.1.3.

3. *Ibid.*, Methods 4.5.2–4.5.2.2.

4. Jure, A. E., in *Synthetic Rubber*, Whitby, G. S., ed., Wiley, New York, 1954, Chapter 12, p. 425.

5. Sperberg, L. R., in *Proc. Rubber Technol. Conf., 3rd Conf. London*, Messenger, T. H., ed., 1954, Paper No. 73, p. 528.

Synopsis

A laboratory method for determining the effect of curing conditions on the tensile strength of tire cords has been developed which makes use of rubber-cord pads cured in a mold. The tensile strengths of the cured cords embedded in rubber are measured after removal from the mold. The method is suitable for nylon cords, either bare or dipped. It has been determined that tensile strength losses during curing of nylon are caused by shrinkage of the cords in the presence of moisture.

Résumé

Une méthode de laboratoire en vue de déterminer l'effet des conditions de traitement sur les tensions de cordes de pneus a été mise au point; elle utilise du matériel traité dans un moule. Les tensions des cordes du matériau sont enrobés dans le caoutchouc et sont mesurées après enlèvement du moule. La méthode est adaptable aux cordes de nylon, soit nues soit traités. On a déterminé que les pertes de tension en cours de traitement du nylon sont causés par plissement des cordes par suite de l'humidité.

Zusammenfassung

Eine Laboratoriumsmethode zur Bestimmung des Einflusses der Vulkanisationsbedingungen auf die Festigkeit von Reifencord wurde entwickelt. Es werden dabei Kautschuk-Cordkörper benützt, die in einer Form vulkanisiert wurden. Die Festigkeit der in Kautschuk eingebetteten Cords nach der Vulkanisation wurde nach der Entfernung aus der Form gemessen. Das Verfahren ist für ungetauchte und getauchte Nyloncords geeignet. Es wurde gefunden, dass Festigkeitsverluste während der Vulkanisation bei Nylon durch Schrumpfung des Cords in Gegenwart von Feuchtigkeit verursacht werden.

Received July 10, 1959