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THE BEGGS MMD
TEST FOR
DETERMINING THE
SHELF LIFE OF
FILM ADHESIVE

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ABSTRACT

Development of the device and technique to determine whether the shelf life of a film adhesive has expired is discussed. The new test method will supersede the procedure originally described in the material specification for the FM 123-5 film adhesive produced by Bloomingdale Department of the American Cyanamid Co.

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SUMMARY

The procedure currently used to determine whether the shelf life of FM 123-5 adhesive (Bloomington Department of American Cyanamid Co.) has expired is given in Material Specification 2180935. However, the results obtained when this test is performed are unreliable as indicators of the performance the adhesive might have under production conditions. The Beggs MMD Test was developed at Bendix Kansas City to satisfy the need for a simple, realistic test which could be related to production applications.

Before the Beggs MMD Test was finalized, a number of factors affecting the reliability of the test results were evaluated. As a result, modifications were made to the three-piece metal device used for extrusion of adhesive specimens. Evaluations were then made with the device to determine the effects of various cure conditions on the percent of flow of the adhesive. While the test was directed toward the FM 123-5 film adhesive, it could be used, if properly modified, with other materials.

No future work is planned at this time for this project.

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DISCUSSION

SCOPE AND PURPOSE

The purpose of this project was to develop a simple test for determining whether the shelf life of the Bloomingdale FM 123-5 film adhesive had expired or could be extended.

PRIOR WORK

There was no work on this project prior to that reported here.

ACTIVITY

The ability of an adhesive to satisfactorily flow onto and wet the adherends determines how well the surfaces are bonded. Since the ability of the adhesive to wet the part surfaces decreases as the adhesive ages, the time at which the adhesive resin fails to flow adequately must be determined.

The method for determining the shelf-life of film adhesives at Bendix Kansas City is given in Material Specification 2180935. This method entails making lap shear specimens and noting whether the shear strength exceeds 2500 psi. However, these lap shear specimens are bonded under a pressure of 25 to 50 psi and are unrealistic as indicators of the shear strength of production parts bonded at pressures as low as 2 psi. Consequently, a shipment (lot) of adhesive which has passed the shelf life test might prove unsatisfactory on the production line.

Work on this project to develop a simple, realistic test of the shelf life of the film adhesive was directed toward Bloomingdale's FM 123-5. Such a test was developed and identified as the Beggs MMD test. The device used for this test employs three metal pieces (Figure 1). The upper part is a stainless steel weight which is vented to permit relief of the air pressure which would otherwise be trapped in the center plug. The center plug is an aluminum cylinder 1.129 inches in diameter with a 0.073-inch extrusion hole through its center. The bottom part, an aluminum nest with a recess 1.14 inches in diameter and 0.10 inch deep, accommodates the center plug and the adhesive samples. The total weight of the top and center pieces is 944 (± 1) grams.

Use of the Beggs MMD Tester involves subjecting one square inch of the film adhesive to a pressure of 2 psi at 200°F so that the adhesive is extruded into the small hole in the center plug. The percentage of adhesive thus extruded is a measure of the usefulness of the material.

Figure 1. Beggs MMD Tester

Under the influence of heat and pressure, the adhesive resin softens and flows up the hole in the center plug. The degree of flow depends upon the state of cure of the adhesive. At the end of the cure cycle, the tester assembly is removed from the oven and allowed to cool. A small diameter rod and an arbor press are then used to force the extruded resin out of the center plug.

Cured adhesive discs and extruded resin are cut apart and weighed separately. If the extrusion weight is less than 3 percent of the total weight of extrusion plus adhesive, based on the average of 5 specimens, the adhesive is of questionable quality and is rejected.

By the test procedure described above, the flow values of fresh samples of adhesive were found to be between 8 and 11 percent. By contrast, old samples, including some that gave unsatisfactory bonds on production units, had flow values of less than 2 percent. The limited correlation data obtained thus far indicates that an adhesive having a flow value of less than 3 percent will not provide a satisfactory bond.

To compare the results of the Beggs MMD Test with the lap shear test, samples of FM 123-5 adhesive were artificially aged at 120°F. Lap shear specimens were prepared by bonding aluminum strips 1-inch wide under a pressure of 25 psi and curing the specimens at 200°F for 2 hours. The results are shown in Table 1.

Table 1. Comparison of Beggs MMD Test Results With Lap Shear Test Results

Test Condition	Average Shear Strength (psi) for 5 Specimens	Flow As Determined by Beggs MMD Test (Percent)
Fresh (control) sample	3176	8.9
24 hours at 120°F	4036	2.0
4 days at 120°F	724	0

While the results of the lap shear test actually showed an increase between the first and second samples, the ability of the adhesive to flow--as determined by the Beggs MMD Test--actually decreased. If the second sample had been evaluated for its shelf life, the lap shear test would have found it acceptable, while the same specimen would have been rejected by the Beggs MMD Test.

The shelf life of the FM 123-5 adhesive stored at room temperature is shown in Figure 2. Samples of the adhesive stored at approximately 75°F were tested for flow at 2- or 3-day intervals. As shown by the figure, the test lot of the material could have been stored without refrigeration for about 3 weeks before its flow would have decreased to a questionable level.

Before the Beggs MMD Test was finalized, a number of parameters were evaluated. Work on the test began by putting pressure on the adhesive specimen with a weight and lever device. This device was abandoned in favor of dead weights, which proved more reliable. Since production assemblies were known to apply pressures on the order of 5 psi and sometimes as low as 2 psi, both pressures were tested. At 5 psi the average percent of flow was 10.4 percent for 8 specimens; at 2 psi the average percent of flow was 9 percent for 4 specimens. Although the 5-psi load gave the higher flow reading, the 2-psi load was selected as the standard since it was easier to handle and since the time required for exposure of the adhesive to oven temperature was reduced with the smaller heat sink action of the lighter weight. Subsequent tests confirmed the 2-psi load to be adequate.

The center plug of the three-piece test device was originally made of Teflon to preclude problems with separating the cured adhesive from the fixture. However, the differential thermal expansion between the Teflon and aluminum nest prohibited the use of Teflon. The center plug was then made of aluminum and both it and the nest were treated with Garan 225 mold release. No sticking problems were encountered with this treatment.

The first tests were made with a single disc of adhesive. Additional tests were made before it was determined that four discs provided the optimum test condition (Table 2).

While the difference between the use of 3 or 4 discs was small, it was felt that the use of 4 discs gave a more representative sampling.

Figure 2. Flow Properties of FM 123-5 Adhesive Stored at Room Temperature

Table 2. Determining the Optimum Number of Adhesive Discs

Number of Adhesive Discs	Flow (Percent)	
	Test 1	Test 2
1	5.7	6.9
2	10.5	8.6
3	10.6	9.1
4	10.7	9.4
5	9.2	9.3

The original hole size in the center plug was 0.040 inch. Because of the difficulties encountered in driving the extrusion from such a small hole and the frictional interference with the resin flow, hole sizes of 0.070 and 0.073 inch were subsequently tried. The percent of flow through the 0.070-inch hole was 9.7 percent (average for 3 specimens). The percent of flow through the 0.073-inch hole was 10.7 percent (average of 5 specimens). A hole size of 0.073 inch was selected as standard for this test.

A number of cure cycles can be used with the FM 123-5 adhesive. Table 3 presents the results of tests performed to determine the influence that different cure times and temperatures might have on the flow rate of the adhesive.

Flow rates did not vary appreciably among the various cure cycles. The sample cured at 200°F for 1.5 hours was taken as a standard since it closely resembled some production cycles. This cycle requires that the stainless steel weight be preheated to assure complete cure of the adhesive. The cure time was extended to 2 hours when the weight was not heated prior to cure.

ACCOMPLISHMENTS

A simple and realistic test was developed for determining whether the shelf life of film adhesive is expired. While the test was specifically developed for FM 123-5 adhesive, it could be used with other materials if it were appropriately modified.

Table 3. Effects of Various Cure Conditions on Percent of Flow of Film Adhesive

Temperature (°F)	Time (Hours)	Pressure (psi)	Average Flow From Five Samples (Percent)
160	4	2	8.7
160	16	2	8.3
200	1.5	2	8.9
300	0.33	2	8.8
160	4	5	10.3
200	1.5	5	10.4
300	0.33	5	10.2

FUTURE WORK

No further work is planned at this time.