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**STRENGTH MEASUREMENTS ON
TRANSISTOR HEADER LEAD WELDS**

Technological Spinoff Report

March 1973

Bendix Corporation
Kansas City, Missouri

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March 1973

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STRENGTH MEASUREMENTS ON TRANSISTOR HEADER LEAD WELDS

Tensile, shear, and peel strength measurements were performed on the common lead welds of TO-5 and TO-46 coin type transistor headers. Fixturing was designed and fabricated to perform these measurements.

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SUMMARY

Tensile, shear, and peel strength measurements were performed on the common lead welds of TO-5 and TO-46 coin-type transistor headers. Product representative of material presently available from transistor manufacturers was evaluated to develop a test which could be used for destructive lot sample acceptance criteria.

The test results showed that a peel test performed by pulling the header lead parallel to the surface of the header base was sensitive to variations in the quality of the weld, and therefore could be used as an acceptance test on incoming transistor lots. The peel test was found superior to both tensile and shear tests as a lot sample acceptance test.

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DISCUSSION

SCOPE AND PURPOSE

A test was required to assess the quality of welds bonding common leads to the base of coin-type transistor headers. A sample destructive test was needed as an acceptance test on incoming transistor lots. Ideally, this test could also be used by the header manufacturer as an in-process monitor of the welding operation.

ACTIVITY

Description of Test Sample

The test samples were selected from lots of TO-5 and TO-46 packaged transistors. Both TO-5 and TO-46 coin-type header common leads are butt-welded to the base of each header. Before welding, a nail head is formed on the end of the lead which is welded to the header. Figure 1 is a cross-sectional view of the typical butt-welded lead on a transistor coin header.

Figure 1. Cross-Section of Butt Welded Lead on TO-5 or TO-46 Coin Header

Figure 2. Test Fixture with Lead Weld Shear Adapter

Description of Test Fixturing and Test Method

The lester used to perform these tests is shown in Figure 2. At both ends of the base plate, force gages are mounted on movable slides. Only one gage was used during these tests. The holding and clamping fixture, used to secure the device under test, is mounted in the center of the base plate. The channeled blocks on both sides of the holding fixture are guides for the tools which are attached to the arms of the force gages.

For the tensile test the device to be tested was held stationary while the common lead was clamped in the jaws of a tool attached to the arm of the force gage. The lead was pulled in an axial direction perpendicular to the base of the header. Figure 3 shows a close-up of the tensile test adapter with a device undergoing test.

For the shear test the device under test was held stationary while the shearing ram pushed against the nail head of the lead. The direction of the shear force was parallel to the base of the header. Figure 4 shows a close-up of a transistor lead weld undergoing the shear test.

For the peel test the angle of peel was arbitrarily selected as 90 degrees (1.6 radians). While the header of the device was held stationary the lead was pulled at an angle of 90 degrees with respect to the axial direction of the lead. Figure 5 shows a close-up of a transistor lead undergoing the 90-degree peel test.

Figure 3. Tension Test Adapter and Transistor Under Test

Figure 4. Shear Test Adapter and Transistor Under Test

Figure 5. Peel Test Adapter and Transistor Under Test

Comparison of Tensile, Shear, and Peel Tests

To compare the sensitivity of the tensile, shear, and peel tests to the quality of the lead weld a sample of 150 units was selected from a transistor lot with a history of lead-weld failures. The sample represented material from a lot of the YJ0000 transistor manufactured by Company A. The results of these tests are summarized in Table 1.

The tensile test data shows that on all 50 devices the leads failed before the weld did. The exact opposite was true for the shear test. For the 90-degree peel test there was a 35 to 15 split between weld and lead failures respectively. The shear and peel data is characterized by relatively large standard deviations and ranges compared to the tensile data. This data suggested that the shear and the peel tests were superior to the tensile test in detecting variations in the quality of the welds.

During shear and peel testing the majority of the welds failed before the leads, this indicates that the welds on this lot of material were questionable.

Shear Test Results

To further characterize the shear test, samples were taken from five different lots of XJ0000 transistors, also manufactured by Company A. A total of 48 devices were subjected to the collector lead shear test. The results of these tests are summarized in Table 2.

The data in Table 2 suggests that the shear strengths of this material are similar to those of the Table 1 samples. The difference in the failure modes observed between the Table 1 samples (50 of 50 welds failed) and the Table 2 samples (5 of 48 welds failed) shows, however, that the quality of the welds of the Table 2 samples are superior to those of the Table 1 samples. During the testing of the Table 2 samples, it was noted that the shearing ram had a tendency to ride up on the lead and in some cases the lead was sheared above the nail head. This pointed out that the shearing ram needed to be more restrained from moving upward to obtain consistent shear strength data. The problem is complicated by the various irregular shapes of the nail heads which are typical of these headers.

Peel Test Results

To characterize the peel strength of lead welds on various lots of transistors, 90-degree peel tests were performed on samples from 19 different transistor lots. These samples represented material from three different transistor

Table 1. Summary of Tension, Shear, and Peel Tests on TO-46 Headers

	Collector Lead Stress Mode		
	Tension	Shear	Peel
Sample Quantity	50	50	50
Mean, Pound Force (Newtons)	28.0 (124.5)	26.2 (116.5)	11.7 (52.0)
Standard Deviation in Pound Force (Newtons)	0.9 (4.0)	5.5 (24.5)	4.9 (21.8)
Range in Pound Force (Newtons)	5.0 (22.1)	21.5 (95.6)	15.1 (67.2)
Failure Mode Quantities			
Weld	0	50	35
Lead	50	0	15
<p>The 150 test samples were YJ0000's (TO-46) coin headers.</p> <p>The 15 units that had lead failure mode during peel testing all had peel strengths exceeding 16 pounds.</p>			

Table 2. Collector Lead Shear Test Results on TO-5 Headers

Test Group XJ0000*	Sample Quantity	Shear Force, Pound-Force (Newtons)					Failure Mode Quantities	
		Mean	Standard Deviation	Minimum	Maximum	Range	Weld	Lead
1	10	21.6 (96.1)	5.3 (23.6)	15.5 (68.9)	33.0 (146.8)	17.5 (77.8)	1	19
2	8	24.5 (109.0)	7.1 (31.6)	14.0 (62.3)	33.0 (146.8)	19.0 (84.5)	0	8
3	10	28.6 (127.2)	6.1 (27.1)	19.0 (84.5)	36.0 (160.1)	17.0 (75.6)	2	8
4	10	25.2 (112.1)	4.9 (21.8)	17.0 (75.6)	31.0 (137.9)	14.0 (62.3)	0	10
5	10	26.2 (116.5)	4.6 (20.5)	19.0 (84.5)	33.0 (146.8)	14.0 (62.3)	2	8
* Vendor was Company A.								

vendors, called Companies A, B, and C. The test results were separated into three groups. The first group included samples from the same five lots of XJ0000 transistors which were sampled for the shear tests summarized in Table 2. The results of these peel tests are summarized in Table 3. The data shows very consistent results from lot-to-lot and much improved mean peel strengths and standard deviations compared to the peel test results shown in Table 1. These results show that the quality of the lead weld and the processes used to control the quality were much better on the Table 3 devices than the Table 1 units.

The second and third groups of devices subjected to the peel test were from various lots of TO-5 and TO-46 packaged transistors. The test results of Tables 4 and 5 show that there is a wide variation in peel strength within a single lot of transistors and from lot-to-lot. There were no significant differences between the results on the TO-5 headers and on the TO-46 headers. In those cases where the lead failure was the predominant failure mode, the mean peel strengths were larger and the variations smaller than those cases where the weld failure was the predominant failure mode.

ACCOMPLISHMENTS

The strength characteristics of lead welds on coin-type TO-5 and TO-46 transistor headers were determined. Test results showed the following.

- On good quality welds the lead will fail before the weld does.
- The 90-degree peel test and the shear test are more sensitive to variations in the quality of the welds than the tensile test.
- A wide variation in the quality of the welds exists within a single lot of transistors and from lot-to-lot.
- The peel test is superior to the shear test as a sample lot acceptance criteria because of the simplified tooling requirements.

Table 3. Collector Lead Peel Test Results on XJ0000 TO-5 Headers

Test Group XJ0000	Vendor	Sample Quantity	Peel Force, Pound-Force (Newtons)					Failure Mode Quantities	
			Mean	Standard Deviation	Minimum	Maximum	Range	Weld	Lead
1	A	12	16.4 (72.9)	1.0 (4.4)	14.7 (65.4)	17.8 (79.2)	3.1 (13.8)	0	12
2	A	10	16.1 (71.6)	0.8 (3.6)	14.5 (64.5)	17.3 (77.0)	2.8 (12.5)	0	10
3	A	9	16.3 (72.5)	1.0 (4.4)	15.0 (66.7)	17.8 (79.2)	2.8 (12.5)	0	9
4	A	10	16.9 (75.2)	0.6 (2.7)	16.0 (71.2)	17.8 (79.2)	1.8 (8.0)	0	10
5	A	10	16.8 (74.7)	0.7 (3.1)	16.0 (71.2)	18.0 (80.1)	2.0 (8.9)	0	10

Table 4. Collector Lead Peel Test Results on TO-5 Headers

Test Group	Vendor	Quantity	Peel Force, Pound-Force (Newtons)					Failure Mode Quantities	
			Mean	Standard Deviation	Minimum	Maximum	Range	Weld	Lead
1. ZJ0000	A	13	10.0 (44.5)	2.7 (12.0)	7.5 (33.4)	16.0 (71.2)	8.5 (37.8)	13	0
2. ZJ1111	B	13	14.6 (64.9)	1.4 (6.2)	10.0 (44.5)	15.0 (66.7)	5.0 (22.2)	1	12
3. XJ0000	A	29	9.7 (43.1)	3.9 (17.3)	4.0 (17.8)	17.0 (75.6)	13.0 (57.8)	23	6
4. XJ0000	A	30	14.6 (64.9)	3.9 (17.3)	4.0 (17.8)	18.0 (80.1)	14.0 (62.3)	14	16
5. ZJ2222	C	24	11.1 (49.4)	3.2 (14.2)	2.6 (11.6)	17.9 (79.6)	15.3 (68.1)	18	6
6. ZJ0000	A	26	11.8 (52.5)	4.0 (17.8)	7.4 (39.2)	18.6 (82.7)	11.2 (49.8)	22	4
7. ZJ0000	A	24	9.6 (42.7)	2.8 (12.5)	7.0 (31.1)	18.8 (83.6)	11.8 (52.5)	22	2

Table 5. Collector Lead Peel Test Results on TO-46 Headers

Test Group	Vendor	Sample Quantity	Peel Force, Pound-Force (Newtons)					Failure Mode Quantities	
			Mean	Standard Deviation	Minimum	Maximum	Range	Weld	Lead
1. ZJ3333	B	28	12.8 (56.9)	3.0 (13.3)	7.0 (31.1)	16.5 (73.4)	9.5 (42.3)	15	13
2. ZJ4444	B	25	14.1 (62.7)	1.4 (6.2)	10.0 (44.5)	15.8 (70.3)	5.8 (25.8)	0	25
3. YJ0000	A	20	11.0 (48.9)	1.7 (7.6)	7.2 (32.1)	14.1 (62.7)	6.9 (30.7)	20	0
4. YJ1111	A	32	11.3 (50.3)	2.3 (10.2)	6.6 (29.4)	16.4 (72.9)	9.8 (43.6)	27	5
5. YJ1111	A	30	11.0 (48.9)	4.6 (20.5)	4.4 (19.6)	19.8 (88.1)	15.4 (68.5)	28	2
6. YJ1111	A	25	11.2 (49.8)	3.1 (13.8)	6.4 (28.5)	16.6 (73.8)	10.2 (45.4)	21	4
7. YJ1111	A	15	11.6 (51.6)	3.3 (14.7)	6.1 (27.1)	15.6 (69.4)	9.5 (42.6)	10	5