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Standard Guide for Ultrasonic C-Scan Bond Evaluation of Brazed or Welded Electrical Contact Assemblies[1]

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INTRODUCTION

This guidance document is the result of an investigation by the ASTM Committee B04.04 Task Force on Ultrasonic Bond Testing of Electrical Contacts. Although ultrasonic interrogation is widely employed as a non-destructive evaluation method, its application to the testing of electrical contact bonds requires specific techniques.[2,3] The desire to study the variation of technique and its effect upon test results was responsible for a round-robin test program. The program was conducted in two phases in an attempt to standardize practices which would improve testing agreement. This study provided analysis and suggestions for reducing the variability of test results. The decision of the committee was to publish a summary of this information to serve as guidelines for writing specifications that will incorporate practices.

1. Scope

1.1 This guide describes ultrasonic testing procedures that can be used for evaluating the bond quality of electrical contact assemblies manufactured by brazing or welding.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

E214 Practice for Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves (Withdrawn 2007)[5]

E500 Standard Definitions of Terms Relating to Ultrasonic Testing (Withdrawn 1990)[5]

E1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves

2.2 *American Society for Nondestructive Testing Standard (ASNT):*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing [6]

3. Summary of Guide

3.1 *Pulse-echo Technique*—The pulse-echo technique is employed as an ultrasonic testing method which displays reflected energy pulses. A Piezoelectric transducer (typically

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[2] Buckley, R. I., Commey, R. R., Jr., and Popat, P. V., "Nondestructive Ultrasonic Inspection of Braze Bonds in High Current Electrical Contact Assemblies," Proceedings of the Holm Conference on Electrical Contacts, 1971, pp. 63–71.

[3] Jost, E., and Fontaine, G., "Ultrasonic In-line Inspection Technique for Contact Materials," Proceedings of the Holm Conference on Electrical Contacts, 1979, pp. 209–213.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[5] The last approved version of this historical standard is referenced on www.astm.org.

[6] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

15–25 M Hz frequency with 0.5- to 1.5-in. (12.7- to 38.1-mm) focal length in water) converts the original electrical pulse into a mechanical sound wave and then also acts as a receiver of the reflected mechanical energy, converting it back into useful electrical energy. The electrical instrumentation used with the transducer generates, receives, amplifies, and displays the controlled electrical pulses. (See Practices E214 and E1001.)

3.2 *C-Scan*—The amplified electrical signals as received from the transducer are gated for time/distance and establish the depth of analysis. When the transducer (coupled through a water medium) is made to traverse in the X-Y directions, the gated electrical signals are then used to describe a two-dimensional plan view of defects in the interior of the tested object(s). This plan view of defect information at a given depth of analysis (that is, the brazed or welded layer within the contact assembly) is called a C-scan. (See Terminology E500.)

3.3 *Data Presentation:*

3.3.1 The gated C-scan signals are used to drive an X-Y plotter/printer that provides a permanent record of the defect plane being examined.

3.3.2 The sensitivity of the instrument (alarm levels) is adjusted with the printer circuit by a technician to provide an accurate resolution level for the true characterization of defects.

3.3.3 The calibrated C-scan printed display can then be used to evaluate the bonded area (or unbonded area shapes) of an array of contacts under examination.

4. Significance and Use

4.1 This guide is recommended to be used in preparing specifications for the non-destructive evaluation of brazed or welded electrical contact bonded area.[7] The recommended procedures are meant to improve the reproducibility of test data among various laboratories. Specific differences among equipment models and technician skills do exist which will limit absolute correlation. This guide provides an indication of the degree of variability which has been observed as realistic among industry participants.

4.2 Ultrasonic testing alone does not insure an understanding of bonded integrity. Other attributes (that is, strength) may require correlation with destructive test methods.

5. Procedure

5.1 *Fabricated Standards*—Standards must be produced from good previously C-scanned parts from the same process and dimensions as the parts to be examined. Each standard should contain three flat-bottomed holes: 0.015-, 0.031-, 0.062-in. (0.381-, 0.787-, 1.575-mm) diameter. The centerline spacing of adjacent holes should equal the diameter of the next larger hole. Require a flat end mill for finish cut and control depth from 0.000 to 0.005 in. (0.000 to 0.127 mm) into the actual brazed or welded layer.

5.2 *System Calibration*—The ultrasonic transducer, electrical instrumentation and display printer should be capable of accurate reproduction of the standard. Include this standard in every array of tested parts as an indication of system performance.

5.3 *Standard Parts*—Often it is necessary to obtain matched, focused transducers to achieve interlaboratory correlation of system resolution on fabricated standard sets. Nevertheless, display sensitivity differences can exist which are best resolved by the use of actual parts as standards. The vendor and user select an array of parts with various degrees of bond interface defects and these parts are shared to demonstrate reproducibility during each set-up.

5.4 *Scan Traverse Parallelism*—The tank bottom or support plane for the parts under investigation must be parallel (0.005 in. (0.127 mm) maximum deviation) with the plane of the X-Y rails of the scanner. The transducer and CRT display may be used to measure this variation directly and then accomplish verification by varying the location of standards over the full traverse of the C-scan area.

5.5 *Print Quality*—In addition to electrical system calibrations, it has been observed that printer performance can significantly affect the accuracy of a C-scan display. Direct particular care towards stylus parameters and thermal paper characteristics.

5.6 *Metallographic Examination*—Verification of the ultrasonic C-scan evaluation must be conducted by destructive metallographic examination of selected contact assemblies. Scanning at various instrument sensitivities and then cutting and peeling or mounting of contacts can provide good understanding and correlation of results for the technician.

5.7 *Operator Training*—Qualify the skill level of ultrasonic technicians according to the guidelines of the American Society for Nondestructive Testing. (See SNT-TC-1A.) Competence in metallographic examination and the use of area estimating templates is also required.

6. Precision and Bias

6.1 *Precision*—The expected closeness of agreement is based on tests performed during 1980–1982 by a number of experienced industry laboratories (see Table 1 and Table 2). These laboratories were all given the same parts, standards, and guidelines and involved various equipment that can be considered standard in the industry.

6.1.1 Table 1 provides reproducibility data from six different laboratories which examined the same seven brazed contacts taken from seven different lots and two of the standards used during this study.

6.1.2 Table 2 provides repeatability data from the same six laboratories which subsequently examined the same two contact assemblies taken from two of the original seven lots and the same two original standards.

6.1.3 This data shows much better relative correlation among laboratories in regard to grading the specimens in terms of unbonded area than in correlation of absolute values for unbonded area.

[7] Janitzki, A. S., and Schaefer, B., "The Influence of the Quality of Brazing on the Erosion of Contacts," Proceedings of the 9th International Conference on Electrical Contact, 1978, pp. 389–394.

TABLE 1 First Round Robin Test Results for Brazed and Welded Electrical Contact Assemblies

Lot/Sample Number	Total Contact Area (in.^{2})	Unbonded Area (in.^{2})[A] by Laboratory Number						Mean	Range
		1	2	3	4	5	6		
Brazed									
1/9	0.345	0.036	0.036	0.024	0.024	0.036	0.030	0.031	0.012
2/24	0.097	0.008	0.016	0.016	0.012	0.008	0.024	0.014	0.016
3/19	0.091	0.010	0.010	0.010	0.000	0.010	0.020	0.010	0.020
4/4	0.309	0.039	0.026	0.104	0.052	0.104	0.156	0.080	0.130
5/34	0.309	0.039	0.013	0.091	0.078	0.078	0.039	0.056	0.078
6/20	0.309	0.156	0.208	0.182	0.182	0.260	0.260	0.208	0.104
Percussion welded									
7/6	0.309	0.156	0.234	0.234	0.290	0.286	0.286	0.248	0.134
Resolution of Fabricated Standards with Flat Bottomed Hole 0.015 In. Diameter									
2/STD.		0.016	0.022	0.070	0.070	0.010	0.025	0.036	0.060
5/STD.		0.016	0.000	0.070	0.070	0.020	...	0.035	0.070

[A] 1 in.^{2} = 645 mm^2.

TABLE 2 Second Round-Robin Test Results for Brazed Electrical Contact Assemblies

Lot/Sample Number	Total Contact Area (in.^{2})	Unbonded Area (in.^{2})[A] by Laboratory Number						Mean	Range
		1	2	3	4	5	6		
Brazed									
2/25	0.097	0.006	...	0.006	0.012	0.004	0.016	0.009	0.010
5/34	0.309	0.020	...	0.039	0.078	0.020	0.026	0.037	0.058
Resolution of Fabricated Standards with Flat Bottomed Hole 0.015 In. Diameter									
2/STD.		0.020	...	0.070	0.070	0.020	0.030	0.042	0.052
5/STD.		0.024	...	0.070	0.070	...	0.070	0.059	0.046

[A] 1 in.^{2} = 645 mm^2.

6.2 *Bias*—Since there is no accepted standard or reference material suitable for determining the systematic error for this test method of measuring bonded area, no statement on bias can be made.

7. Keywords

7.1 bond evaluation; braze evaluation; C-scan; contact assemblies; electrical contacts; ultrasonic C-scan; unltrasonic testing