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MOUND BRIDGE-WIRE WELDING, TESTING AND CORROSION SEMINAR
MAY 7 and 8, 1968

M. A. Richards

Date: August 7, 1968

MONSANTO RESEARCH CORPORATION
A SUBSIDIARY OF MONSANTO COMPANY

MOUND LABORATORY
MIAMISBURG, OHIO

OPERATED FOR

UNITED STATES ATOMIC ENERGY COMMISSION
U.S. GOVERNMENT CONTRACT NO. AT-33-1-GEN-53
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A seminar was held on Bridge-wire Welding and Testing at Mound Laboratory on May 7 and 8, 1968.

An informal discussion period on the first day provided a worthwhile give-and-take on techniques of welding, different types of electrodes to eliminate sticking, use of sacrificial anodes to eliminate corrosion of the most crucial parts of the detonator and trends in testing techniques.

On the second day of the session after the presentations a tour was conducted in the B-building welding production area, DS building standards and welding development area, and the non-destructive test area.

A series of outlines and summaries follow covering the various talks which were presented. Further information pertinent to them should be directed to the originator.

At the conclusion of this report (Page 29) is a list of the members attending the conference.

At this point Mound Laboratory wishes to take the opportunity to thank those who contributed to the conference via presentation, discussion, tours or visual aids.
For the future use of low voltage fire sets a means of attaching the B. W. to give firing characteristics similar to soldered B. W. assemblies has been studied. Various welding techniques were evaluated. The shaped and slotted electrode, vibro-crimped by the use of the Sonobond ultrasonic welder, has proven to be the optimum type bonding technique for the application desired.
I. Ultrasonic Welding
   A. Systems
   B. Sonobond Ultrasonic Bonder
      1. Principles
      2. Problems
      3. Causes and solutions of problems

II. Resistance Welding (Series)
   A. Experience with materials of interest
   B. Problems
   C. Partial Solutions

III. Resistance Welding (Parallel Gap)
   A. Materials Used
   B. Limitations of Process

IV. Welding at Biorad
   A. Results to Date
   B. Future Plans
METHODS INVESTIGATED

1. Resistance Welding - Satisfactory
   a. Known Method
   b. Schedule Variations
   c. Tip Material and Configurations
   d. Problems
      Material Adaptability
      Material Deformation

2. Pulsed Arc Welding - Questionable
   a. Problems
      Porosity
      Cleanliness
      Joint Integrity
   b. Outboard Weld after Mechanical

3. Mechanical Joint
   a. Flap - Questionable
   b. Tube - Questionable
   c. Cold Weld/Stake
   d. Crimp
4. Mechanical
   a. Pulsed Arc
   b. Laser Beam
   c. Ultrasonic Bond

5. Ultrasonic Bond
   a. w/Mechanical
   b. Alone

6. Adhesives
   a. Carbon Ink
   b. Epoxy - Conductive
   c. Tape

NEW METHODS

1. Fluid Deposition
   a. Gold Plate (Gold/Copper System)
      Liquid Solution at 120°F
      Immersed for 15 min
      Current Density - 42 Ma
      Resistance Values - 20 milliohms
2. Organometallics
   a. In-process
   b. Operational in June
   c. Patent Application
   d. Vapor, Liquid, or Gel
   e. Heat - Approx. 250°C/400°C

3. Thermal Compression/Yield Point Bonding
   a. Oxide Films/Contaminants
   b. Material Deformation
ULTRASONIC'S PLASTIC ASSEMBLIES OF DETONATOR COMPONENTS

W. R. Schurman
Mound Laboratory

A. Typical Uses
1. Plastic to Plastic Welding
2. Plastic to Metal Staking or Crimping
3. Placement of Metal Inserts
4. Reactivation of Adhesives

B. Theory and Equipment
1. Ultrasonic vibration is transmitted through the plastic to the joint where friction and pressure causes plastic to soften and melt.
2. Power supply, piezoelectric or magnetostrictive transducer, horn or tip, parametric cylinder and timer.

C. Usage Consideration
1. Vibration Transmissibility of the Plastic
2. Joint Geometry
3. Assembly Rate
4. Joint Location
5. Component Size
D. Present Usage and Development at Mound

1. LASL Designed ER-245 Head Cylinder Assembly
2. Placement of Metal Electrodes into Header Blank
3. Plastic Welding of Detonator Cylinder onto Header
4. Plastic Welding of Detonator Cap onto Cylinder
LASER WELDING BRIDGE-WIRES

S. D. Sims
Biorad Corporation

The approach to laser welding of bridge-wires at Biorad has been to use the welds as the sole method of connecting the bridge-wire to the header. No crimping or other attachment methods are used.

The procedure used is a two-step process. First the wire is irradiated with a laser to form a ball on the end. This ball is then brought into contact with the substrate and irradiated again to form a weld. The actual manufacturing process being developed involves cutting a wire to a specified length and then irradiating both ends to form a dumbbell structure. The dumbbell is then placed in the proper position on the header posts and the final welds made.

The process appears to be feasible, the primary problem being associated with the tooling required for handling the dumbbells. A prototype production machine is under construction and is scheduled for delivery this summer.
Biorad, Inc. has a dual interest in laser safety:

1. As a research and development organization pursuing biomedical guidelines for the general use of the scientific and technological community.

2. As a company engaged in the design and manufacture of laser systems for specialized metal working applications.

The principal physiological hazard associated with the employment of laser beams is the potential for irreversible damage to the unprotected eye. The eye comprises an efficient optical train for focusing light energy in the visible and near-infrared region of the electromagnetic spectrum on the retina. High brightness systems - particularly lasers - can produce burns on the retina which may result in permanent diminution of vision.

The implications of viewing both direct and scattered laser radiation are discussed with particular reference to laser welding methodology. Tangential potential hazards such as the production of aerosols are reviewed. Safe operational procedures, intelligent design, and protective equipment are discussed.
The NDT laboratory has been engaged in various aspects of bridge-wire weld evaluations for approximately one year. Initial endeavors were merely use of two test methods developed by Sandia Corporation applied to various types of Mound bridge-wire assemblies.

In addition, a considerable amount of work has been done using a constant current test, originally suggested by Mike Richards. Other test methods included some work on microradiography and to a limited extent, infrared evaluation.

For your information a brief description of each of these test methods will be presented.

1. **Bridge-wire Noise Test (Slide #1)**

   This test consists of passing a DC current of approximately 300 ma through a bridge-wire assembly and measuring the AC noise signal developed across it. The theory behind this procedure is that the amount of noise generated is inversely proportional to the soundness of the bridge-wire weld.
2. **Thermal Cycle Test (Slide #2)**

This test is an adaptation of the noise test previously described with the addition of a cyclic shock of the bridge-wire using a mechanical oscillator and a source of dry nitrogen. This alternate heating and cooling of the bridge-wire and attendant shock, induces additional noise into the bridge-wire weld area which is monitored on the General Radio 1232-A Tuned Amplifier and Null Detector.

3. **Constant Current Test (Slide #3)**

This test consists of subjecting a bridge-wire assembly to a constant current of from 0.1 to 2.0 amperes DC and measuring the voltage developed across it as a function of time. A two channel strip chart recorder is utilized to plot both the voltage drop across the bridge-wire and to confirm the constancy of current through it. This test has been of some value in evaluating consistency of welds, but to date, no qualitative limits of acceptability in terms of $\Delta R$ have been established. (Slide #4)
4. **Microradiography (Slide #5)**

A technique for analysis of bridge-wire welds using a microradiography technique was developed along lines recommended by Group GMX-1 at LASL. Parameters are as follows:

- **X-ray Generator:** 150 KV Norelco, 1/2 mm Target
- **Energy:** 45 KV
- **MA:** 8
- **Time:** 18 min
- **STF Distance:** 48"
- **Film:** High Resolution Glass Plates

Slide #5 is an isodensitracer of the radiography with a 100 X magnification. The top trace shows a smooth homogeneous weld and the bottom trace shows a weld with a 0.001 inch void or gas pocket.
THERMAL CYCLE TEST

24 VDC

10 H Choke

NC Contacts

General Radio 1232-A

Tuned Amplifier & Null Detector

1,000 mfd

Ballantine AC Voltmeter
Model 320A

Source of Dry Nitrogen

Mechanical Oscillator

Transducer

SLIDE #2
CONSTANT CURRENT TEST

\[ R = \frac{E}{I} \]

\[ \Delta R \cdot \Delta E \]

\[ \text{0 - 2 Amps DC} \]

\[ \text{Constant Current Source} \]

\[ \text{Calibrated Resistor} \]

\[ \text{B/W Assy} \]

\[ \text{MV Strip Chart Recorder} \]

SLIDE #3
NON-DESTRUCTIVE TESTING AT MOUND LABORATORY

M. A. Richards
Mound Laboratory

I. Resistance Measuring Device from ESI
   A. Specifications
   B. Recording Abilities
   C. Automated Features

II. Need for more readily available NDT equipment
   A. Establish broad history
   B. Use on diverse jobs
THERMAL CYCLE DATA AND EVALUATION

W. E. Bergsten
Sandia Corporation

SL Data

ER-234 Headers

dia Data

MC-2498
SA-1394

Verification

Firing Data

ull Test Data

ry
I. Test Concept
   A. Thermal Cycling of Material
   B. Measurement of Resistance Change
   C. Dynamic measurement of the thermal properties of electrical connections

II. Test Theory
   A. Relationship of Contact Area and Heat Transfer Ability
   B. Generation of Heat
   C. Application of Cycle Thermal Load
   D. Method of Detecting Resistance Change

III. Establishing Test Setup
   A. Heating of Part
   B. Probe Size
   C. Frequency of Thermal Cycle Load
   D. Part Geometry and Thermal Characteristics
CORROSION OF DETONATOR ELECTRODE AND BRIDGE-WIRE

M. J. Savitski
Mound Laboratory

Results of accelerated corrosion tests of bridge-wire materials in appropriate solution were shown for wires with and without a thin protective coat of high-purity parent metal. Without the protective coat, pitting corrosion is observed after only a one-day exposure. With the protective coat, applied by ion vapor deposition, no corrosion is observed even after three months of exposure.

It was shown that certain similar alloy wires from two different sources can have widely different corrosion resistance even though their chemical compositions are alike in regard to the major alloying elements.

In a discussion of corrosion principles, it was emphasized that a low ratio of cathodic area to anodic area, and the choice of a bridge-wire alloy that is more cathodic than the electrodes to which it is welded, will minimize corrosion.
We, as representatives of Sigmund Cohn Corporation, suppliers of bridge-wire to your various activities, appreciate the invitation to this conference. As far as a formal presentation goes, my commentary will be limited primarily to areas which we think are open to considerable discussion and I shall attempt to give you some broad general thoughts on the materials; but as I see it, our prime purpose here in this meeting is to try to answer your questions, to stimulate some discussion, and possibly even play the part of devil's advocate. If this is accomplished, we can consider our visit a success. It is even possible that we have considerably more questions to ask you than you have to ask us.

There are normally three measurements that can be made of a piece of wire as far as physical dimensions are concerned: diameter, electrical resistance, and weight per unit length. There are also other guideline numbers, such as tensile strength, elongation, and breaking load. However, the first three mentioned are the ones in which the group here in general seems more interested. There is one that we are least in favor of;
and that is tolerances on diameter. We prefer, and think we can make a good argument for, the use of resistance and weight per unit length as quality control criteria, and we would like to return to this subject area later.

There is one other final category in physical properties, and that is the chemical composition of any given alloy or pure metal. In the case of a pure metal, state-of-the-art limitations are somewhere in the neighborhood of 99.999% purity, and when fabricating an alloy it is of course quite desirable that all the constituents of the alloy be of maximum available purity.

Of the various materials which we have been furnishing to you, three are fairly recent history and probably will be the area of greatest discussion. Gold has a long history within the Commission, and we think it is a good history, with only occasional minor problem areas. The investigation of Gold alloys such as 30% Platinum-Gold, is relatively new, as are other alloys. In fact, our investigation in this area has led us into areas in which the company has previously had little or no interest. We are in the process right now of delivering some exotic combinations. A major portion of these exotic
CORROSION STUDIES AND FABRICATION OF BRIDGE-WIRE AT SIGMUND COHN (Continued)

combinations and the choice of them was based on what we had in Cohn's attic so to speak. It has given us excuses for investigating new areas.

We certainly think there are some areas of controversy as far as, for example, corrosion resistance is concerned. During some recent conversations with representatives of the Commission the question of compatibility with PETN was brought up. PETN in the dry form gives no corrosion problem; however, in the moist condition there is corrosion. This is just a small spot example. Therefore we would like to throw the discussion open and examine all facets, ranging from dimensional tolerances, resistance, corrosion, material, weldability or lack of weldability, insulation, certainly discussions of areas of quality control, and so forth. We know what our capabilities are (or think we do); therefore where can we aid you?
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