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HERMETICALLY SEALED MICROMINIATURE MULTISOCKET CONNECTOR*

Paul J. Konnick
Sandia National Laboratories
Albuquerque, NM 87185
(505) 844-7923

ABSTRACT

A unique hermetic microminiature multisocket connector was designed at Sandia as a means of interfacing with a sealed component package in a weapon system to ensure a controlled environment. Such a capability had not previously been available on any existing connector of comparable size and contact density. The connector is characterized by glass sealing of a high-density contact pattern, a weldable mounting flange, and by microminiature size. This glass-to-metal sealing method, using individual glass beads, requires 51 holes on 50-mil centers in the web portion of the shell.

As an alternative to the glass-to-metal method, the connector contacts and shell were redesigned for compatibility with ceramic-to-metal sealing techniques. In this potentially lower cost, higher yield method, the metal web of the shell is replaced with a ceramic web containing 51 metallized holes on 50-mil centers.

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This report

- Presents the design requirements for the hermetic microminiature multisocket connector
- Describes its physical and electrical characteristics
- Traces the testing and evaluation program as developed and evaluated by Sandia National Laboratories with the support of ITT Cannon Electric Division of Phoenix, AZ
- Describes the electrical and environmental test program performed by Bendix Corporation of Kansas City, MO

DESIGN REQUIREMENTS

Introduction

The principal design objective for this connector was to devise a hermetically sealed system (1×10^{-8} cm^3/s helium) in a high-density, multisocket connector. The inherent problems in achieving this objective stem from two sources: the physical and mechanical characteristics of the materials being joined, and the processing difficulties of glass-sealing a high-density contact pattern in a small rectangular boundary. The connectors previously studied used concentric contact patterns and

shell configurations on larger center-to-center contact spacings, or rectangular shell configurations with low-density contact patterns. Also, most sealing systems in the concentric forms incorporated a standard solid-glass web that provided a hermetic seal. Unfortunately, the existing connector envelopes were too large for the number of contacts that were required for the application. Therefore, a new high-density, hermetically sealed microminiature, multisocket connector needed to be designed and tested.

Specific Problems

The connector design was based on the following physical, electrical, and environmental criteria: the connector must be capable of

- Sealing helium in a high-density contact pattern (1×10^{-8} cm^3/s)
- Terminating 26 AWG wire in a high-density contact pattern
- Restricting the entrance of moisture
- Withstanding the thermal shock of cold water ($< 39°F$) and hot water ($> 201°F$)
- Withstanding the test voltage of 150 Vdc at ambient pressure
- Achieving long-term shelf life
- Fitting into limited space in the next assembly
- Interfacing with existing MDM series connector
- Holding a weldable flange by means of a test fixture construction
- Functioning after temperature cycling
- Functioning after sinusoidal and random vibration
- Functioning after mechanical shock (1000 g, 6 ms sawtooth)
- Functioning after acceleration of 5000 g's for 1 min
- Withstanding handling abuse

Description

The connector (Figure 1) is characterized by hermetic sealing of a high-density contact pattern without sacrificing the standard interface compatibility of Military Specification MIL-C-83513. It is designed to terminate #26 AWG stranded wire and to be installed in the next assembly by laser welding.

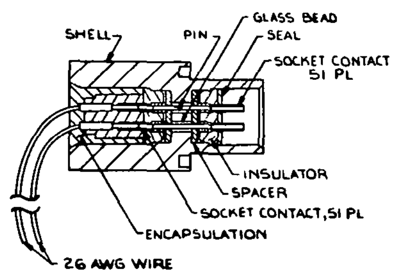

FIGURE 1. Cross-Sectional View of Multisocket Connector

Physical Characteristics

As shown in Figure 1, the connector is composed of a shell, insulator, interfacial seal, contact pins, a spacer, and socket contacts.

- The Hastelloy 'C' shell is designed to facilitate glass or ceramic sealing of the contact pins and laser welding in the next assembly. The cable end contains a cavity that secures the wire terminations with encapsulation.

- The brass socket contacts are plated with gold over nickel to ensure low resistance at the mating interface and cable terminations.
- The alloy 52 contact pins are nickel-plated to ensure a stable low-resistance joint when the socket contacts are installed.
- The glass bead hermetic seals are formed by surrounding the contact pins with glass beads in the shell (51 PL).
- The plastic spacer is used to eliminate air gaps and locates the socket contacts during the press-fit assembly operation.
- The silicone rubber interfacial seal prevents moisture from entering the electrical creepage paths and is a dielectric seal between socket contacts.

Electrical Creepage Paths

The connector was designed to provide adequate isolation of electrical circuits to withstand a rated voltage (150 Vdc) at ambient pressure. The interface creepage paths are symmetrical between the socket contact (50-mil centers) pattern and shell. In the mated condition, the interfacial seal contacts a diallyl phthalate insulator in the mating connector to form an interface dielectric seal. The internal creepage path within the connector extends from the pin to the web of the shell. The air gap between the socket contact at the cable end is also filled with encapsulation. These creepage paths are illustrated in Figure 2.

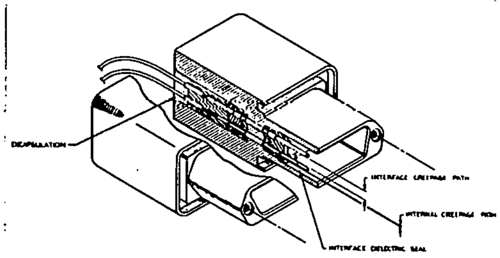

FIGURE 2. Electrical Creepage Paths

Cable Assembly Operations

The cable wires are attached to the connector by first crimping and/or soldering a male contact to each wire. Then the male contact is inserted into the socket contact at the cable end. After all wires are terminated, the shell cavity is filled with encapsulation, which also acts as a moisture seal.

DEVELOPMENT TEST AND EVALUATION PROGRAM

The development test and evaluation program for this connector consisted of (1) inspection of product to demonstrate its interchangeability with the MDM family, per MIL-C-83513; (2) insulation resistance to ensure isolation of the socket contacts to each other and the shell; (3) dielectric withstanding voltage and high-potential ground level to show low-voltage capabilities at ambient pressure; (4) helium leak rate to verify the glass sealing of the socket contacts and shell; (5) environmental tests to include temperature, sinusoidal and random vibrations, acceleration and mechanical shock to evaluate the hermetic seal, moisture seal, dielectric seal, material compatibility, cable assembly techniques, and mechanical design of the connectors; (6) mechanical strength tests to demonstrate the physical properties of the connector under extreme handling conditions. A description of each test and the results follow. Figure 3 illustrates a typical test specimen.

FIGURE 3. Cable Prepared for Electrical and Mechanical Tests

DESCRIPTIONS OF TEST PLAN

This plan covered the inspection and testing of microminiature hermetic rectangular electrical connector with polarized shells.

The following military and Department of Energy (DOE) specifications formed a part of these tests to the extent stated:

9958001-03	Instrumentation and Equipment, Steady-State Acceleration Test
9958002-03	Instrumentation and Equipment, Sinusoidal Vibration Test
9958003-4	Instrumentation and Equipment, Mechanical Shock Test
9958004-02	Instrumentation and Equipment, Complex-Vibration Test
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-C-83513	General Specification for Microminiature Rectangular Plug Electrical Connector with Polarized Shell

Testing Requirements

General--Connector dimensions, contact arrangement, materials, electrical ratings, and service conditions were as specified on the applicable product definition and acceptance specification.

Marking--Each connector was marked on the body with the manufacturer's name or trademark and part number, and Sandia National Laboratories 800,000-xxx drawing number.

Tests--All specimens were subjected to all tests as specified below. In addition, Tests 2 through 10 were performed in the mated condition and as indicated in Section 5.

1. Inspection of Product--The connector was inspected for conformance to the detail definition as described in MIL-C-83513 and the applicable Sandia definition.

2. Insulation Resistance--An insulation resistance test was applied in accordance with MIL-STD-202E, Method 302, Condition A for 1 min. The voltage was applied from each contact to all other contacts and shells tied in common. The insulation resistance was to be at least 1000 MΩ.

3. Dielectric Withstanding Voltage--A dielectric withstanding voltage test was applied in accordance with MIL-STD-202E, Method 301. A potential of 150 Vdc was applied for at least 5 s. The voltage was applied from each contact to all other contacts and shells tied in common. There was to be no evidence of flashover or insulation breakdown.

4. Helium Leak Rate--With the MDMH connectors mounted on a gasket plate to prevent leakage around the weldable mounting flange, a differential pressure of 1 atm was applied across the connector, with the lower pressure at the mating end. Using helium per 4526005 as a tracer gas the total leakage through the interior of the connector was not to exceed $1 \times 10^{-8} cm^3/s$ as determined by a helium leak detector.

5. Contact--

   a. Contact Resistance--The contact resistance on voltage drop was measured per MIL-STD-202E, Method 307. The contact resistance did not exceed 8 mΩ plus the dc resistance of the wire, if applicable.

   b. Contact Durability--The connectors were mated and unmated to a compatible mating connector 500 times. Rate of mating did not exceed 500/h. The test was performed to simulate motions encountered in service. There was to be no cracking, breaking, or loosening of parts. After the test, the connector should meet the requirements of Contact Resistance while fully mated.

   c. Mating Forces--The axial force required to fully mate the plug and receptacle did not exceed the product of number of contacts x 8 oz. The minimum withdrawal force was equal to the product of the number of contacts x 0.5 oz. The axial force was measured by applying the force uniformly at 1 lb/s.

   d. Contact Retention--The connectors were tested for contact retention by using loose pins or sockets as test probes. Pins were of 0.0215-in.-dia. steel and were inserted into the bottom of the socket contacts. Socket contacts were loose standard MDM contact-mated to the connector pin contacts. The contacts were to withstand at least a 3-lb load without evidence of damage or contact dislodging.

6. High-Potential Ground Level-For this test, a voltage of 150 Vdc from a current-limited (5 mA) power supply

was applied for at least 5 s between each contact to all other contacts and shell. (Any leakage current > 5 μA constitutes a failure.)

7. Temperature (Thermal Shock)- The connector was subjected to 10 cycles of thermal shock in accordance with the following procedures:

   a. The connector was suspended for 10 min in the approximate center of a cubic foot cold-water bath. Water temperature did not exceed 39°F. Container dimensions were not < 10 in, in any direction.

   b. Within 5 s after removal from the cold water, Step a. was repeated using hot water at a temperature of at least 201°F.

   c. Step a., then Step b. were repeated 9 times more, allowing no more than 5 s between cycles.

   d. At the end of the tenth cycle, excess moisture was removed from the connector and the connector was dried in a forced-air oven at 150°F±5°F for 15±1 min.

   e. The connector was subjected to the requirements of the Helium Leak Rate.

8. Sinusoidal Vibration--The provisions of DOE specification 9958002 applied. The connectors were subjected to the following vibrations: 10 g, a 20-2000-20-Hz cycle, sweep at 1/2 oct/min, cycle twice in each of three mutually perpendicular planes. The connectors were held together with two #2-56 screws. The connectors did not become disengaged, and there was no cracking, breaking, or loosening of parts. After the test, the connectors were subjected to the requirements of Tests 2, 3, and 4.

9. Random Vibration--The provisions of DOE specification 9958004 applied. The connectors were subjected to the following random vibration: $0.2g^2$/Hz 20-2000 Hz for 30 s in each of three mutually perpendicular planes. Attenuation outside specified bandwidth was at no less than 18 dB octave. The connectors were held together with two #2-56 screws. The contacts were wired in series with a monitoring current flowing through the circuit during vibration, and instrumentation was used to indicate any discontinuity > 1 μs. The connectors did not become disengaged, and there was no cracking, breaking, or loosening of parts. After the test, the connectors were subjected to the requirements of Tests 2, 3, and 4.

10. Acceleration--The provisions of DOE specification 9958001 applied. The connector was subjected to an acceleration of 5000 g's for 1 min. The acceleration was applied in both directions in each of three mutually perpendicular planes. The connectors were held together with two #2-56 screws. The connectors did not become disengaged, and

there was no cracking, breaking, or loosening of parts. After the test, the connectors were subjected to the requirements of Tests 2, 3, and 4.

11. Mechanical Shock--The provisions of DOE specification 9958003 applied. The connectors were subjected to mechanical shock in accordance with MIL-STD-202, Method 213, Condition I (1000 g, 6 ms, sawtooth) in each of three mutually perpendicular planes. The connectors were held together with two #2-56 screws. The connectors were not to become disengaged, and there was to be no cracking, breaking, or loosening of parts. After this test, the connectors were subjected to the requirements of Tests 2, 3, and 4.

TEST RESULTS

At this time, complete test results are not available. However, preliminary test findings demonstrate that the glass-to-metal seals withstand the environmental test requirements. Because of the limited isolation between contacts, failures of up to four contacts per connector were encountered during the electrical tests. The postmortem analysis indicates that contamination was the breakdown mechanism. Final test results will be presented during the symposium.

CONCLUSIONS

The development evaluation tests indicate that the hermetically sealed microminiature multicontact connector can fulfill a reduced level of the specified design requirements.

The tests have pointed out the need for a contamination-free assembly environment and piecepart cleaning procedures. Final conclusions will be presented during the live presentation.

BIOGRAPHY

Paul J. Konnick

Member of the Technical Staff, Sandia National Laboratories.

Mr. Konnick received his diploma of Associate in Mechanical Engineering from Pennsylvania State University in 1961, a BS in Mathematics from the University of Albuquerque in 1974, and an MS in Electrical Engineering/ Computer Science from the University of New Mexico in 1981.

In 1961, Mr. Konnick joined the Engineering Information Systems Development Department of Sandia Laboratories where he made significant contributions to the design of mechanical and electromechanical devices. In 1966, he assumed responsibilities in the Interconnections Division, where his efforts are directed toward the design and development of high-voltage coaxial and triaxial connectors and cables. In 1970 he was awarded US Patent No. 3,550,064 for Electrical Connector Plug and Connector Assembly. He then transferred to the Computer Engineering Applications Department.

After 5 years in computing, Mr. Konnick returned to the Interconnections Division, where he assumed project responsibility for connectors and cables on weapons and nonweapon systems.