smiths interconnect
bringing technology to life

C SERIES

SHOCK & VIBRATION TESTING

CONTENTS

PERFORMANCE

TEST REPORT OVERVIEW

Military air, sea, and land applications present unusually severe requirements for durability and stability to the connectors that unite their electrical systems. Extreme conditions of shock, vibration and acceleration can cause issues with electrical stability and contact degradation over time.

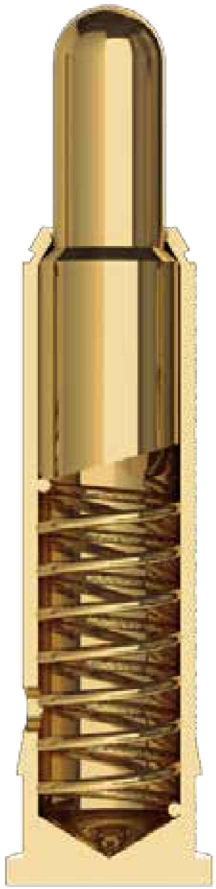
IDI's advanced C Series contacts offer exceptional compliance, modularity, and design flexibility in a wide range of applications. Electrical performance of contacts designed for power applications is assured using a proven 'bias plunger' design. To enhance the capability of the series in military applications, IDI has developed a version which uses a 'bias ball' device to guarantee electrical performance especially in terms of vibration and shock. This paper is an exploration of the contrasting capabilities of each type. To quantify this difference, the bias ball and bias plunger versions of IDI's C Series Spring Probes were rigorously tested using the full capabilities of IDI's highly regarded test laboratory.

Characteristics tested included endurance vibration and shock tests along several axes on a wide frequency range. The survivability of the contacts was examined, as well as electrical stability through static and dynamic contact resistance measurements. Extensive testing according to the ANSI/EIA-364 standard was performed to quantify the technology's performance to these standards. The results of those tests are captured in this document.

C SERIES PROBES
Featuring three primary terminations: surface mount, thru hole and solder cup

CONTACT DESCRIPTION

The samples subjected to this test plan were two versions of the IDI 2.54mm C Series Family. This series of contacts is designed for maximum application flexibility. IDI offers two mated heights, four and six millimeter; two plunger extension values, to permit easy hot-swap capability through extended grounding contacts; and three termination variants, for surface mount, thru hole and cable attachment. The probes are also offered in power, signal and ground configurations, with each having different electrical performance versus cost. The creation of the bias ball version of the contact is an extension of the capability of the power variants, and this paper contrasts bias plunger versus bias ball designs to evaluate their suitability to that task.



BIASED PLUNGER

Figure 1a

BIASED PLUNGER WITH BIAS BALL

Figure 1b

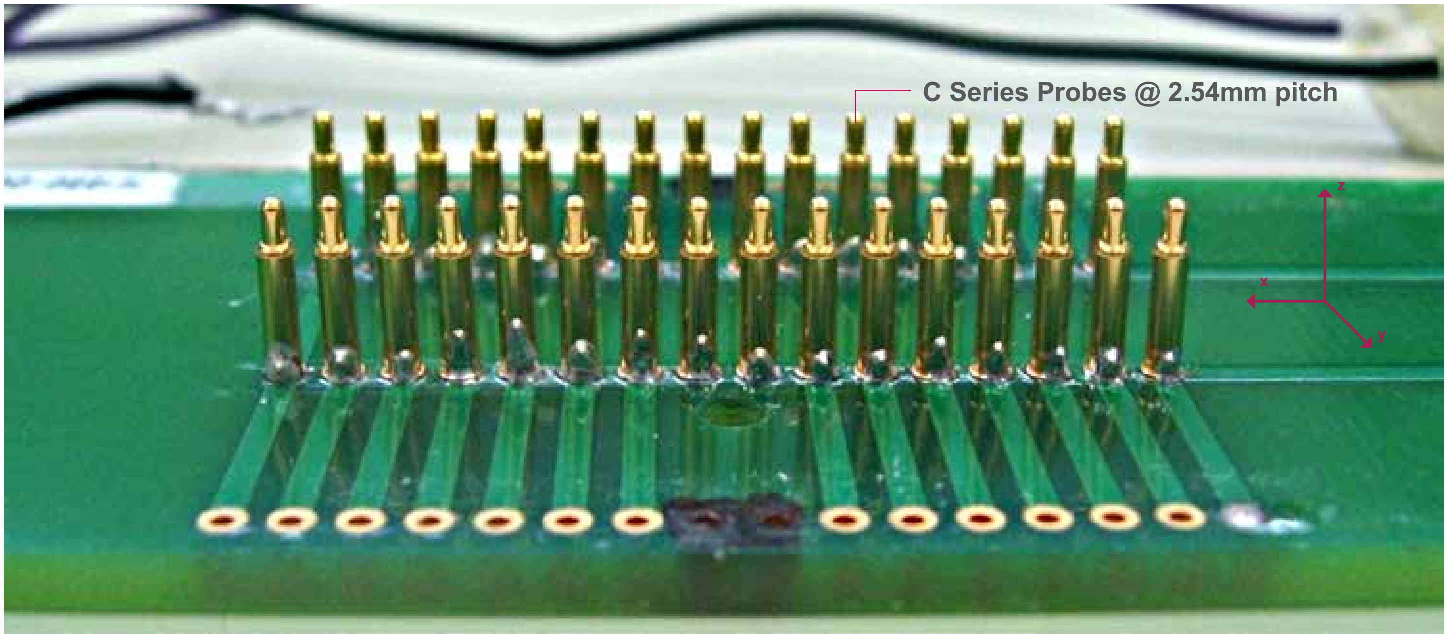
Probes are 'biased' to ensure solid contact between the probe's plunger and its barrel. If the current can easily travel between these two components, it avoids the relatively high resistance path of the spring. Non-axial force delivered to the plunger causes greater intimacy of contact between the plunger and the barrel; thus, side force is inversely proportionate to contact resistance.

While the application may be expected to deliver a degree of non-axial force, bias designs build this tendency into the inner workings of the probe. By creating an angle on the bottom of the plunger, as is the case with the bias plunger design, the spring delivers some of its force in a non-axial direction. By interposing a ball between the spring and the plunger, this tendency can be enhanced, and a backup current path is created. By contrast, space for the ball given the same overall probe length must be taken from either the spring, limiting travel or the plunger, reducing the bearing surface length that guides the plunger and forms the current path.

Each basing technique has significant merit in conditions of shock and vibration. Both greatly enhance the stability of contact resistance in these extremes, and can mechanically stabilize the position of the plunger through side force to limit the possibility of internal fretting.

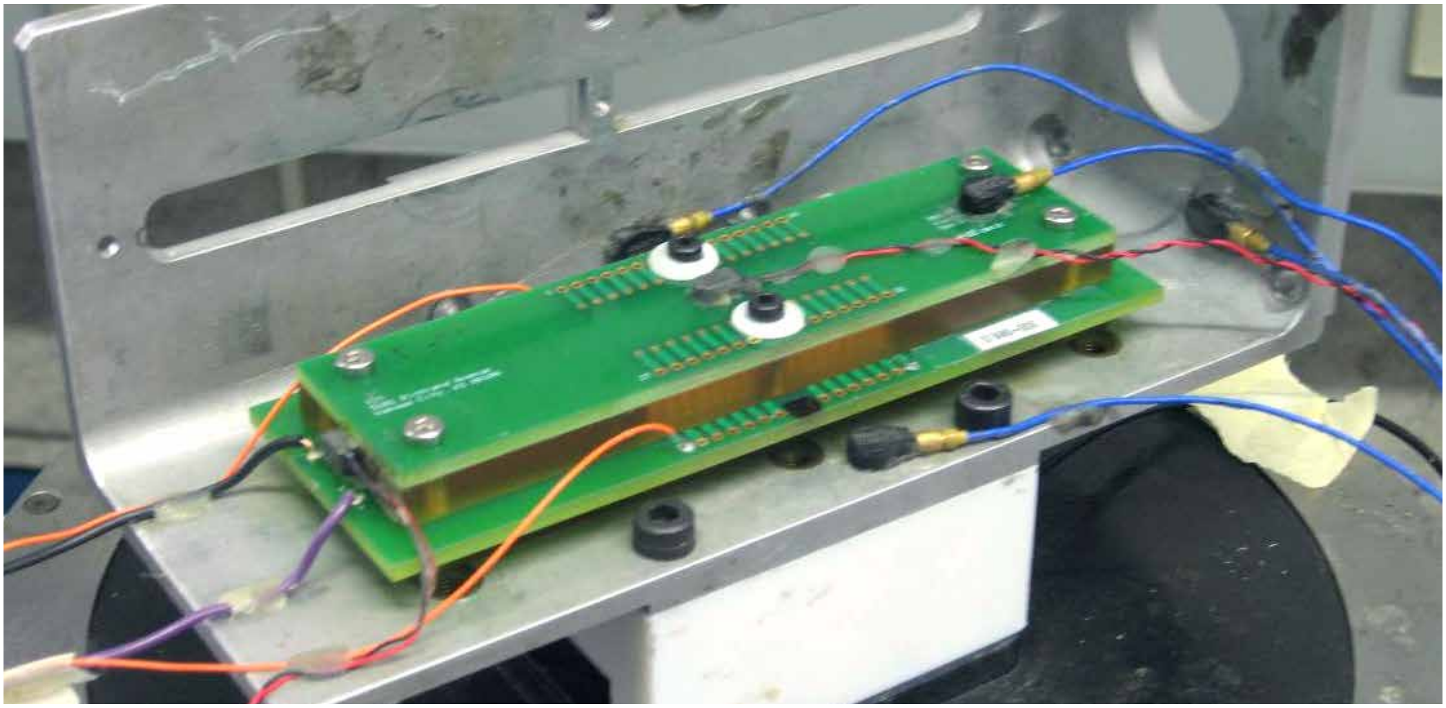
TEST SET UP DESCRIPTION

Two sets of connectors were created with two rows of sixteen contacts soldered by thru hole termination into plated through holes in a printed circuit board and connected in a series circuit. The connectors were then compressed to their nominal value onto an antagonist gold plated PCB and tested in conditions of vibration and shock at different levels across multiple frequencies.



CONTACT CONNECTOR

Figure 2a



TEST FIXTURE FOR Z-AXIS TEST

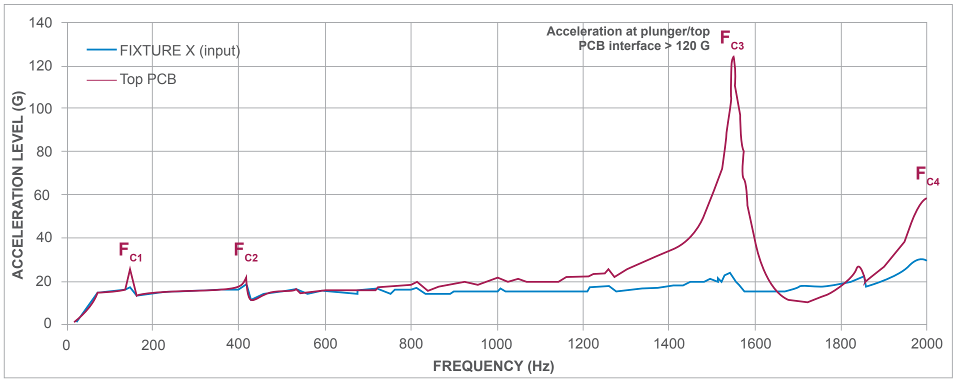
Figure 2b

NANO INTERRUPTION DETECTION

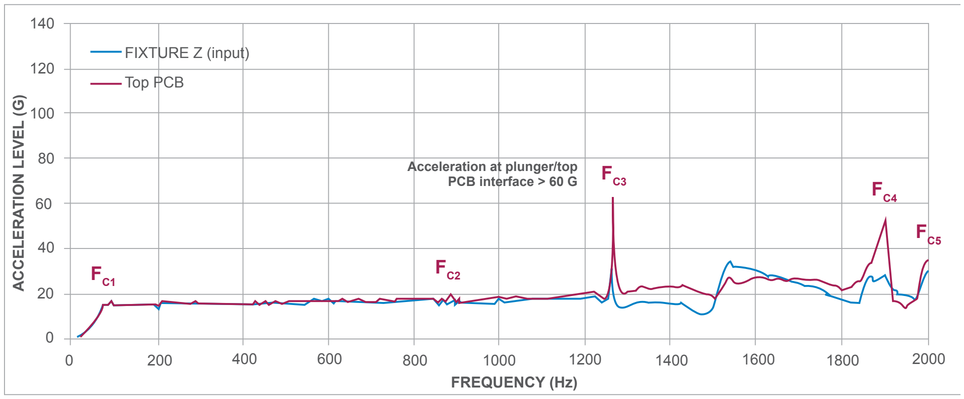
VIBRATION

Nano interruption detection was performed continuously during characterization and endurance tests at different input levels up to 15G. The total test time is more than 4 hours per axis where the frequency was sweeping from 20 to 2000Hz with 1 Oct/min change rate. The resulting frequency behavior of the system is presented below for each axis. It shows that the complete system has several resonance frequencies that correspond to the worst case scenarios in terms of vibration. Indeed the 15G input has been measured on the vibration table but, due to the resonance of the system, the acceleration measured at the interface between the spring probes and the top PCB is much higher at resonance frequencies and can reach up to 120G (X axis) and 60G (Z axis).

During this monitoring, No Nano interruption > 2ns was found clearly demonstrating that IDI C Series Probes, both bias plunger and bias ball designs, exhibit remarkable performance even in the most severe environments.



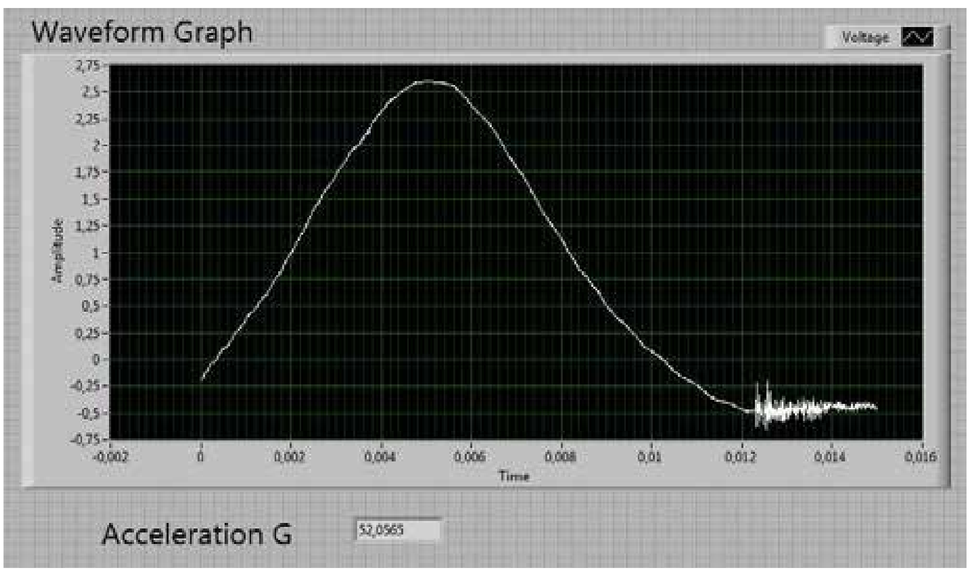
RESONANCE FREQUENCIES OF THE SYSTEM ALONG X
Graph 1



RESONANCE FREQUENCIES OF THE SYSTEM ALONG Z
Graph 2

SHOCK

In addition to the endurance vibration, the samples were submitted to shock tests for each axis at different levels up to 50G (11ms impulse as shown below). Once again, no Nano interruption >100 ns was found during the tests both for the bias plunger and bias ball designs.



SHOCK IMPULSE
Graph 3

DYNAMIC CONTACT RESISTANCE

Providing contact continuity during vibration and shock is critical for harsh environment applications but it may not be sufficient if the quality of the transmitted signal is not adequate. The contact resistance of the spring probes must therefore be kept as stable as possible to guarantee a constant and reliable contact.

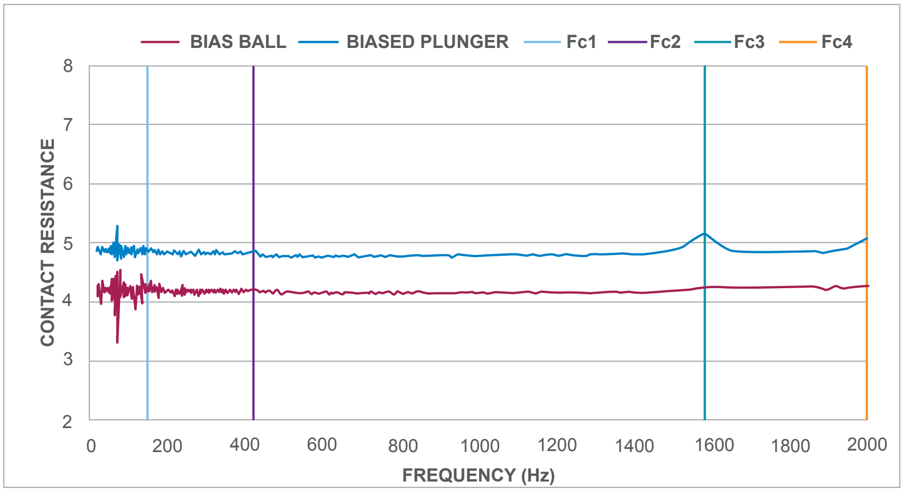
Through IDI's expertise in testing and data acquisition, a test methodology was created allowing for dynamic monitoring of the contact resistance of a single contact during vibration with an acquisition rate up to 20Hz.

This dynamic contact resistance monitoring was completed on each axis during frequency sweeping but also for each resonance frequency of the system to ensure that even at these critical frequencies the contact resistance remains stable over a long period of time. Stability is defined as >5min per resonance frequency.

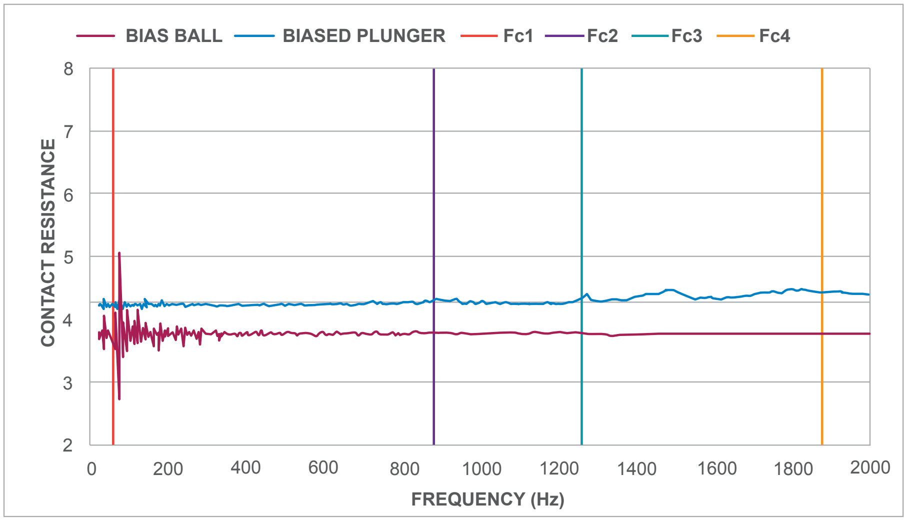
Below are the resulting illustrations of the contact resistance for both the bias plunger and bias ball designs. The resonance frequencies of the system have been reported for information. Stability of contact resistance of IDI spring probes is clearly demonstrated with the bias ball design offering superior contact resistance and an even greater stability.

NOTES

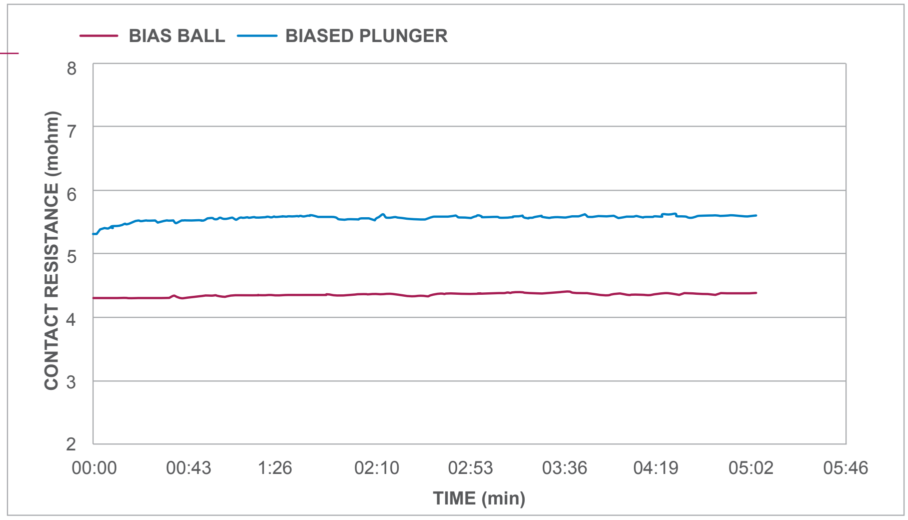
After investigation, the C_{RES} variations at low frequency are induced by test set up frequency (displacement of the accelerometers cables)



DYNAMIC CONTACT RESISTANCE DURING FREQUENCY SWEEPING: X AXIS -15G INPUT
Graph 4



DYNAMIC CONTACT RESISTANCE DURING FREQUENCY SWEEPING: Z AXIS -15G INPUT
Graph 5

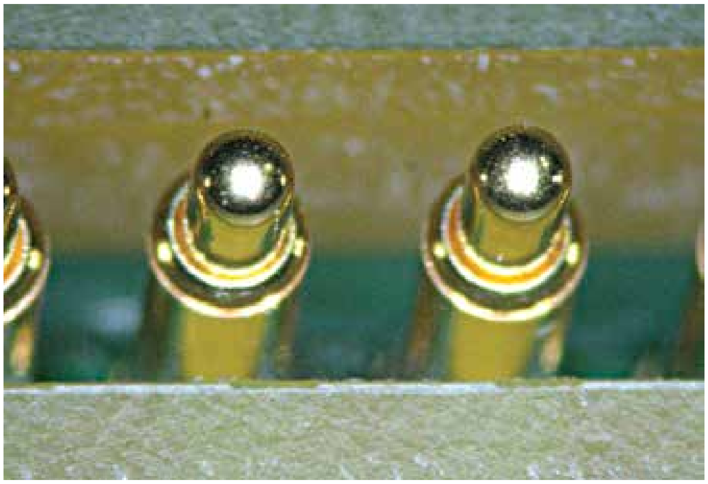


DYNAMIC CONTACT RESISTANCE AT WORST RESONANCE FREQUENCY F_c=1550Hz - X-AXIS -15G
Graph 6

VISUAL INSPECTION AFTER TEST

After the rigorous vibration and shock test sequences, accounting for a total test time of more than 10 hours, a visual inspection of the probe interface (plunger and mating PCB) was performed to ensure there was no fretting corrosion or wear concerns. Both the bias plunger and bias ball connectors illustrate excellent surface finish with minimal indentation marks as shown below:

BIAS BALL



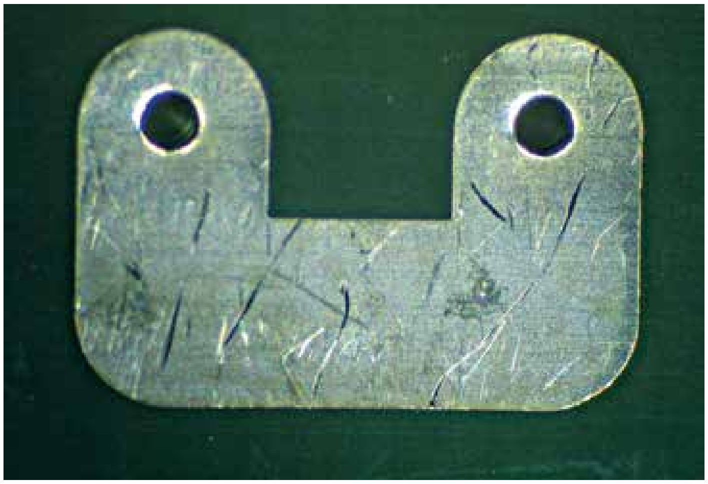
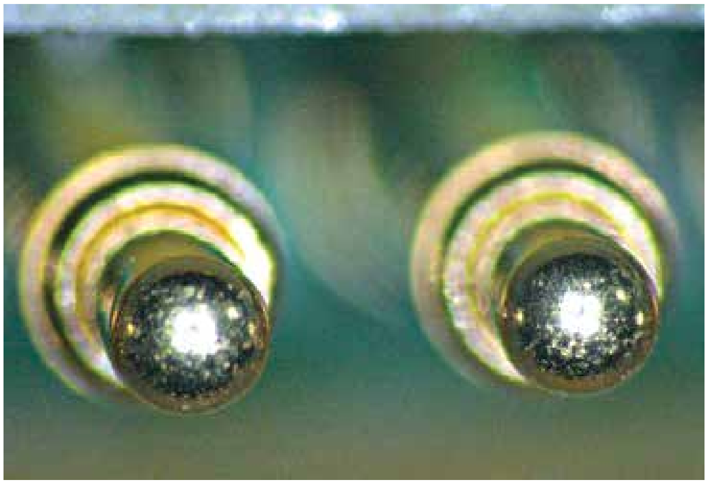


PHOTO OF CONTACT SURFACES AFTER TESTING FOR BIAS BALL CONFIGURATION
*Figures 3a and 3b**

BIAS PLUNGER



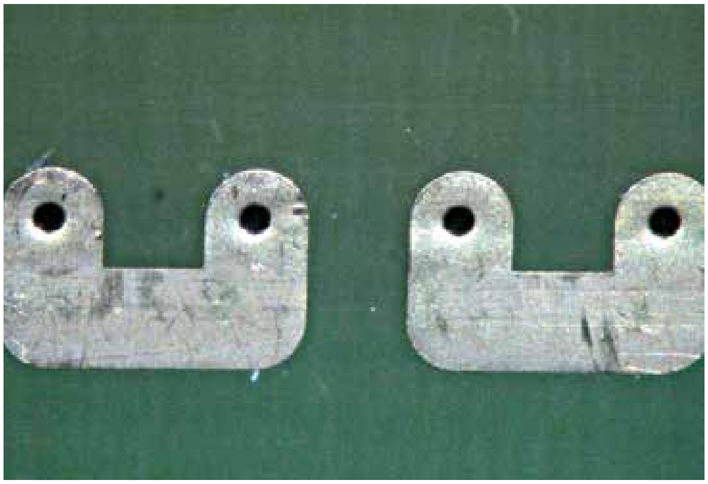


PHOTO OF CONTACT SURFACES AFTER TESTING FOR BIAS PLUNGER CONFIGURATION
*Figures 3c and 3d**

**Scratches on the pad area occur during system alignment not vibration testing.*

CONCLUSION

Thorough and exhaustive testing performed in the course of this exercise demonstrates that all C Series Spring Probes passed the vibrations tests >15G and shock tests >50G regardless of the internal biasing technology. They are therefore compliant with Mil-Aero standard requirements and can safely be used for harsh environment applications.

Looking more closely at the test results, it is revealed that the C Series Probes actually passed tests with higher acceleration levels. During the resonance frequencies testing, the 15G input resulted in levels up to 120G (Radial direction) and 60G (Axial direction) at the interface between PCB and spring probe plunger.

Comparing the different biasing techniques we can see that bias ball offers better results and C_{RES} stability than the bias plunger technology.

After more than 10 hours of vibration and shock testing, the contact surfaces of the spring probe tip and PCB are still free of any wearing or fretting corrosion with near perfect surface finish.