



Low Outgassing Sensors & Cables

For Vacuum Testing





Low Outgassing Sensors and Cables for Space Vehicle Vacuum Testing

Exposure to the high vacuum level of a space environment induces material outgassing in ordinary accelerometers and cables. Any substance subjected to a vacuum has the potential to release trapped gasses. Contaminants from outgassing can condense onto nearby surfaces such as photo-optic devices and obscure them, rendering them useless in their final space application.

During random vibration or shock testing prior to flight, space craft payloads are often fitted with accelerometers in hard to reach mounting locations. As the space structure is built up around them, it can become impossible to remove the accelerometers after ground test, and they must fly with the structure. In some cases, the sensor becomes part of in flight vibration monitoring to telemeter back initial payload vibration data due to actual launch conditions.

Many hermetic accelerometer designs naturally have low outgassing qualities. Cables with rubberized boots or shrink tubing typically do not have low outgassing qualities. For all non-metallic materials outside of a hermetic package that may be required for an application in a vacuum environment, PCB® verifies that the material has less than or equal to 1% TML (total mass loss) and a CVCM (collected volatile condensable mass) less than or equal to 0.1%. This is verified either using NASA documentation or the materials can be sent to an outside laboratory.

Leak testing on hermetic sensors can be performed in two stages depending on the required level of hermeticity documentation.

Stage 1 – A gross bubble test is provided on all hermetic accelerometers. The test verifies $<1 \times 10^{-3}$ cc/sec flow. This is a quick bubble-out test with a heated fluid. The heated fluid causes any internal gasses to bubble out and be visible during the test. Refer to Figure 1 for a schematic of the heated bubble test.

Stage 2 – A fine helium test uses a helium bomb to pressurize the sensors, then a fine leak detector to verify $<2 \times 10^{-8}$ cc/sec flow. Refer to Figure 2 for a schematic of the Helium bomb test set up. The fine leak test is a vacuum test, where the Helium bomb is pressurized at 300 psi for a minimum of 30 minutes, then a mass spectrometer vacuum leak detector verifies $<2 \times 10^{-8}$ cc/sec.

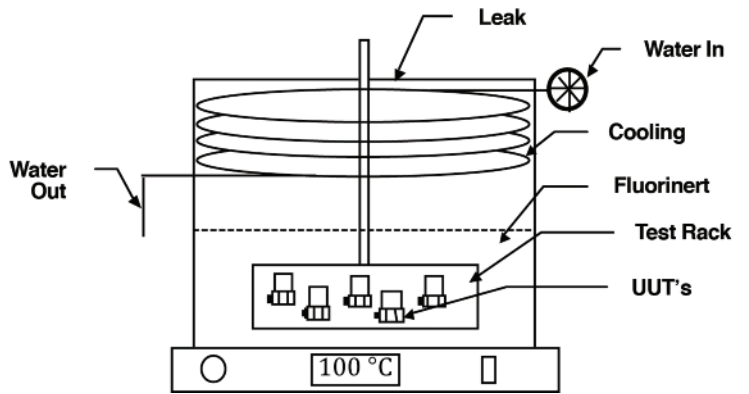


Figure 1
Heated Bubble Test Set Up

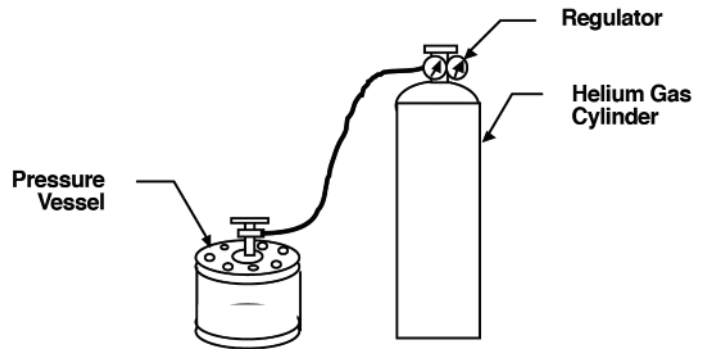


Figure 2
Helium Bomb Test Set Up

Sensors fall into four basic categories: miniature, triaxial, shock, and high-temperature. Popular models from PCB® are shown below, but are certainly not limited to the designs shown.

Accelerometers

Triaxial



356M208

- Sensitivity 5 mV/g
- Measurement Range $\pm 1,000$ g pk
- Frequency 2 to 8k Hz
- Weight 1.0 gm
- Hermetic 0.25 inch cube Titanium housing
- 5 ft integral cable
- 034M22 Low outgassing cable



356M57

- Sensitivity 10 mV/g
- Measurement Range ± 500 g pk
- Frequency 2 to 7k Hz
- Weight 4.0 gm
- 5 ft integral cable
- Hermetic 0.4 inch cube titanium housing
- 4-pin, 1/4-28 jack



354M56

- Sensitivity 10 mV/g
- Measurement Range ± 500 g pk
- Frequency 2 to 8k Hz
- Weight 5.0 gm
- Ground isolated
- 5 ft Integral cable
- Hermetic, titanium housing
- 034M22 Low outgassing cable
- 4-pin, 1/4-28 jack



356M132

- High sensitivity 500 mV/g
- Measurement Range ± 10 g pk
- Frequency 0.5 to 3k Hz
- Weight 11.8 gm
- Hermetic 0.55 inch cube titanium housing
- 4-pin, 1/4-28 jack



356M98

- High sensitivity 1 V/g
- Measurement Range ± 5 g pk
- Frequency 2 to 3k Hz
- Mass 39.0 gm
- Hermetic 0.86 inch cube titanium housing
- 4-pin, 1/4-28 jack



Mini-triaxial applications

Space craft structures are often made of thin, light-weight materials and require low mass accelerometers. Full-scale space craft random vibration responses are three-dimensional, so the combination of a triaxial, low-mass accelerometer with low outgassing properties is highly sought after. PCB® Model 356M208 meets this requirement with a low mass of one gram and low outgas materials for construction and is supplied with a low outgassing cable Model 034M22. Figure 3 shows a unit in action.

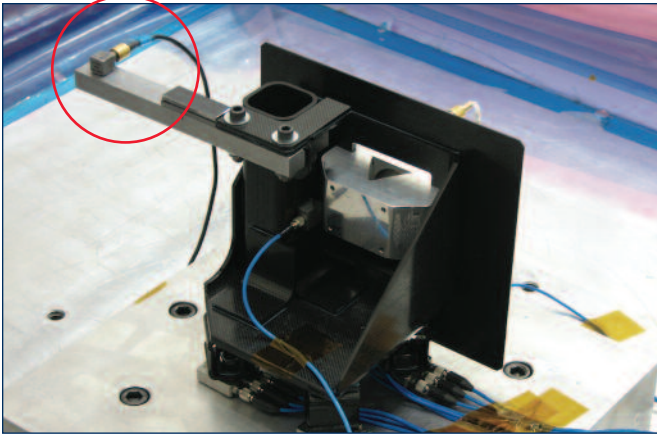


Figure 3

PCB® accelerometers & force sensors used during vibration testing of Bracket Assembly at UT State Space Dynamics Lab

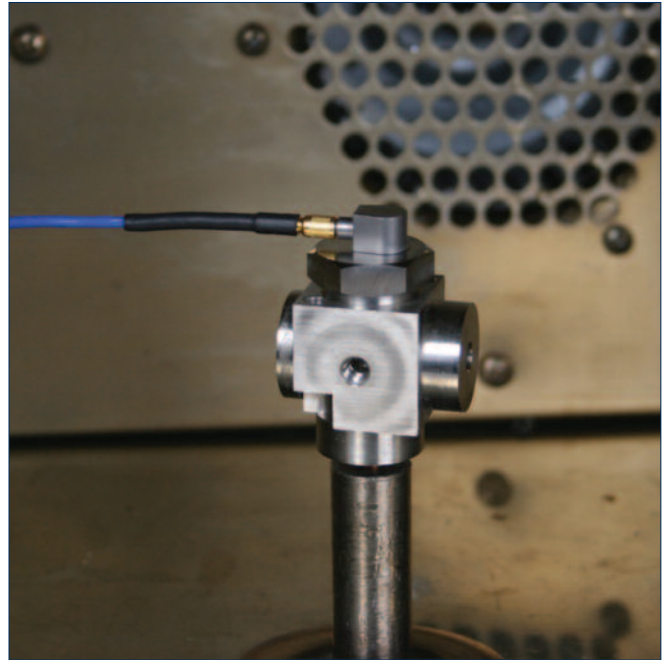


Figure 4

PCB® Model 357A07 shown in an environmental chamber

Shock applications

Separation of booster stages cause shock events that may be transmitted to the spacecraft payload. Low outgassing accelerometers such as PCB® Model 350M72 may be launched with the payload or used in vacuum chamber to simulate launch conditions.

Miniature and Hi-temp applications

Environmental stress screening is often performed in thermal vacuum chambers (see Figure 4) to verify operating characteristics at the component level rather than full-scale space craft. PCB® Model 357A07 offers a hermetic, low-mass package with a wide operating temperature range from -100 to +500 °F (-73 to +260 °C) and is supplied with a low outgassing cable.

Cables

Signal output transmission through ordinary cables offers the greatest source of outgassing contamination. There are multiple cable options from PCB® and all materials are verified for TML and CVCM. Insulation and strain relief at each connector end are the largest contributors in cable design. Some examples of cables (shown in figure 6) use materials such as Viton® and Teflon®, which are known to have low TML and CVCM values.

Summary

In any application involving a vacuum environment, the important things to consider when selecting low outgassing accelerometers and cables are; welded hermetic housings, polymers and epoxies that have been verified for TML and CVCM, and finally, leak testing services for low outgas verification of accelerometers.

Shock



350M72

- Sensitivity 0.5 mV/g
- Measurement Range ± 10,000 g pk
- Frequency 0.4 to 10k Hz
- Electrical filter 13k Hz (-3 dB)
- Mechanical filter 23k Hz
- Hermetic, titanium housing
- 10 ft Integral cable
- Cable termination 10-32 plug

350M77

- Sensitivity 0.25 mV/g
- Measurement Range ± 20,000 g pk
- Frequency 1 to 15k Hz
- Electrical filter 23k Hz, -12 dB/octave
- Hermetic, stainless steel housing
- 10-32 jack

Miniature Single Axis



352M208

- Sensitivity 10 mV/g
- Measurement Range ± 500 g pk
- Frequency 2 to 10k Hz
- Weight 0.7 gm
- 10 ft integral cable
- Hermetic, titanium housing
- 10-32 plug

352M212

- Sensitivity 10 mV/g
- Measurement Range ± 500 g pk
- Frequency 2 to 10k Hz
- Weight 0.64 gm
- 10 ft integral cable
- Hermetic, titanium housing
- 10-32 plug

High-temperature

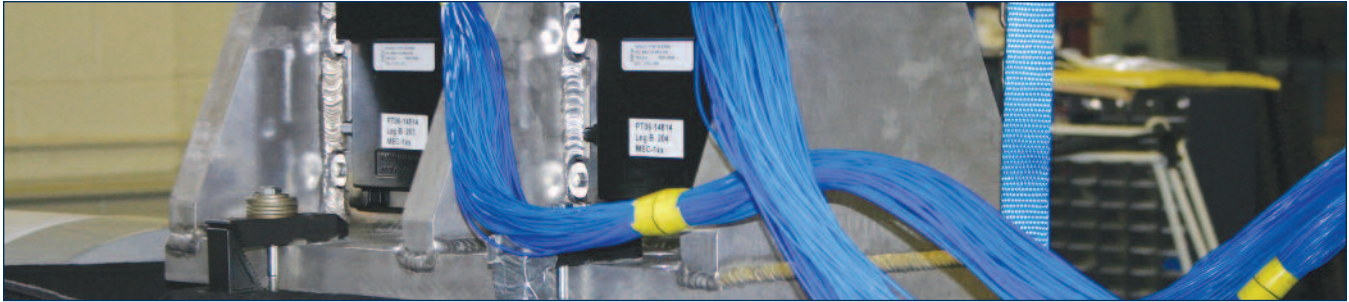


357A07

- Charge sensitivity 1.7 pC/g
- Measurement Range ± 2,000 g pk
- Frequency 15k Hz
- Weight 0.96 gm
- High temperature 500° F (260° C)
- Hermetic, titanium housing
- M3 jack

357A09

- Charge sensitivity 1.7 pC/g
- Measurement Range ± 2,000 g pk
- Frequency 10k Hz
- Weight 0.6 gm
- High temperature 350° F (177° C)
- Titanium housing
- 3-56 jack



Cables

Contact the factory for custom length cables

Cables for Single Axis Accelerometers



003M208

- Connecting cable
- Low noise coaxial, Teflon®
- 10 ft, 5-44 plug to 10-32 plug



003A10

- Connecting cable
- Low-noise, coaxial Teflon®
- 10 ft, 10-32 plug to 10-32 plug



003M269/010

- Connecting cable
- Low-noise, coaxial Teflon®
- 10 ft, 10-32 plug to BNC plug



003M252

- Low-noise coaxial, Teflon®
- 2 meter, 2-socket MS3106 to BNC plug
- For 2-pin MIL connectors



003M204

- Low-noise coaxial, Teflon®
- 5 ft, 2-socket MS3106 to pigtails
- For 2-pin MIL connectors



030A10

- Connecting cable
- Low-noise, coaxial Teflon®
- 10 ft, 3-56 plug to 10-32 plug



030B10

- Connecting cable
- Low-noise coaxial, Teflon®
- 10 ft, M3 plug to 10-32 jack



003EK010PH

- Connecting cable
- Low-noise, coaxial Teflon®
- 10 ft, 3-56 plug to 10-32 jack

Cables for Triaxial Accelerometers



034M22

- Breakout cable
- 4-conductor shielded, Teflon®
- 20 ft, 4-pin 1/4-28 plug to (3) BNC plugs



034M51

- Extension cable
- 4-conductor shielded, Teflon®
- 40 ft, 4-pin 1/4-28 plug to 4-pin 1/4-28 plug



010M128/040

- Extension cable
- 4-conductor shielded, Teflon®
- 40 ft, 4-pin 1/4-28 plug to 4-pin 1/4-28 jack



034M21

- Breakout cable
- 4-conductor shielded, Teflon®
- 20 ft, mini 4-pin 3-36 plug to (3) BNC plugs



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AD-LOW-OUTGASSING-1111

Printed in U.S.A.

Hochwertige Messtechnik und Beratung aus einer Hand



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