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AERONAUTIC DEFENSE SPACE

THERMOCOAX Space Products

Shape Memory Alloy Application

Non-Pyrotechnic Technology

New Generation Heating Solution for:

Single-one time Use Valve, Pin Puller, HDRM, Hinge

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Thermocoax Pedigree

For 15 years, THERMOCOAX has been a world leader in designing, developing and manufacturing heating systems for the space market.

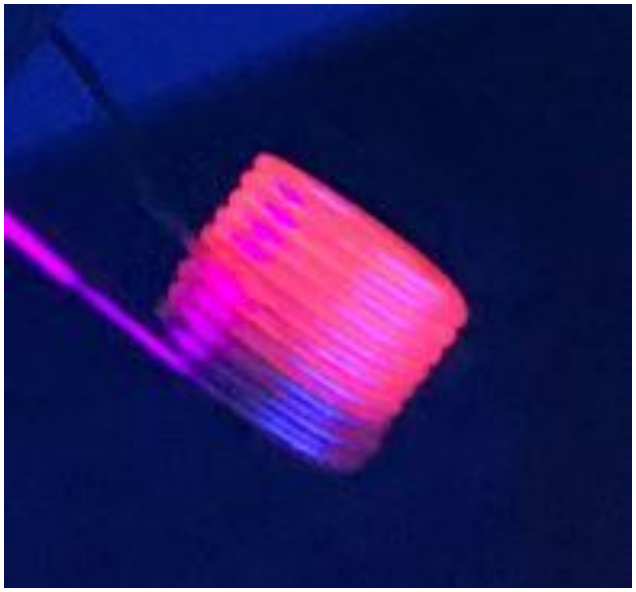
We provide solutions for:

- Ground applications:

  - ✓ R&D programs with institutes
  - ✓ Ground equipment

- Flying models:
  - ✓ Heating management system at 50 & 100 volts Satcom.
  - ✓ Catalyst bed heater for chemical propulsion
  - ✓ Heating solution for electrical thruster

- Scientific missions:
  - ✓ Heating system on Curiosity Rover
  - ✓ Heating element on ISS for MSL
  - ✓ Heating element for pyrolyser on Cassini-Huygens Titan probe



Technical Application of SMA heater

Spacecrafts require a variety of mechanisms to accomplish their mission. Their typical functions include deployment, articulation, positioning, displacement.

Pyrotechnic separation nuts, paraffin actuators and other devices can no longer fulfil satellite requirements regarding shocks wave generation and potential risk of contamination.

Non-pyrotechnic devices, using SMA technology and equipped with a heating element inside, offer smooth and slow response, cleanliness, good vibration & shock resistance.

Thermocoax address this new market with small and powerful heating elements, components already demonstrated on on-board satellite propulsion and thermal management.

A° Single One-time Use Valve:

The propulsion systems are equipped with valves, which are usually closed. To feed the thrusters, one-time single-use valves are required to achieve an open position and allow the passage of gas or liquid.

The typical technology that has been used up to now is a pyrotechnic process to eject the nut and open the fuel circuit. This technique has several drawbacks such as mechanical shocks, sealing breakage and fuel contamination.

SMA technology makes the propulsion system valve secure due to zero shock and zero risk of contamination.

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B° Non-Pyrotechnic Hold Down & Release Mechanism:

Typical application is the locking of solar arrays, antennas and instruments during launch and deployment when orbiting.

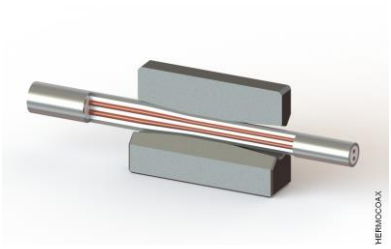
Compared to the conventional pyrotechnic system, SMA offers a weight and volume reduction and a simpler design.

In order for the SMA to function, it must be coupled with a heating element to cause a thermo-mechanic phases passage inside the actuator to create movement. The heating device must be as small as possible for integration and to reduce weight.

Based on 15 years of experience in the space industry, hermocoax designs and produces small dimensioned heating elements based on a mineral-insulated cable.
We offer wide range of temperatures from room temperature up to 1000°C, with redundancy concept.

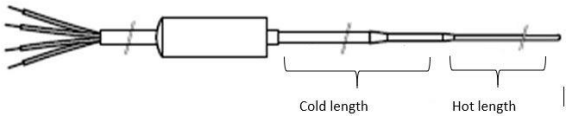
echnical Description of Heating Element

We use our best mineral-insulated cable.



The cable is fabricated with 2 resistive wires welded together at the tip to make one electrical loop and has $10^{10}\Omega$.m insulation.

To comply with space component requirements, a redundancy concept is proposed either by using 2 separate heating cables with an outer diameter of 0.5 to 1mm or by using only 1 cable with 4 wires for 2 heating loops with an outer diameter of 1.5mm.



The cable diameter is small enough to shape it and fit the SMA part.

We comply with the dielectric strength ESA standard under 500V, between wires and sheath.

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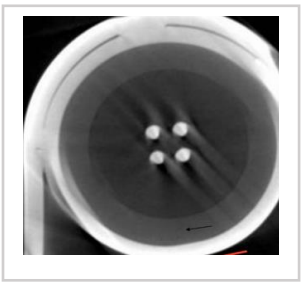
Heating Element:

- 2 redundant electrical loops
- Nominal power supply: up to 100 volts
- Example of power version already used:
  - ✓ Cable Ø1 mm 28VDC
    - 2 to 10 watts
  - ✓ Cable Ø0.5mm, 28volts:
    - 30 watts with 1 loop activated
    - 60 watts with 2 loops activated
  - ✓ Cable Ø1.5mm, 100volts:
    - 150 watts with 1 loop activated
    - 300 watts with 2 loops activated
- Temperature in operation:
  - Over 250°C adaptable to SMA criteria
- Active part exposure temperature:
  - Technology resistance max 1000 °C
  - Technology resistance min -180°C
- Heating device response time:
  - <30 second from -180 to 200°C

Mineral-Insulated Cable:

- Exposure temperature 1000°C
- Stainless steel or Inconel 600 sheath
- 2 or 4 resistive wires
- Power adaptable by:
  - Ø of the cable
  - Ø of the resistive wires
  - Alloy wire type
  - Cable length

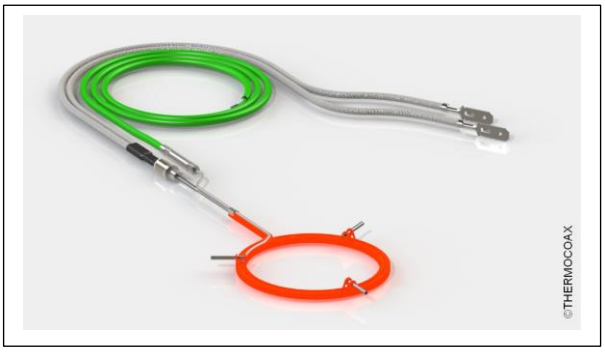


Lead Wires:

- 2 or 4 wires
- Color code for each loop
- AWG24 or 26
- Strength 1.4 kg

Acceptance Test Criteria:

- ➢ Helium leak test
- ➢ X-ray of the junction MIC/lead wires
- ➢ Lead attachment strength test
- ➢ Visual and mechanical examination
- ➢ Overvoltage
- ➢ Line resistance
- ➢ Insulation resistance under 500 volts
- ➢ Burn-in test
- ➢ Dielectric 100/300/500VAC, 60Hz/60s
- ➢ Weight
- ➢ Final manufacturing report



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Test List for Qualification Program

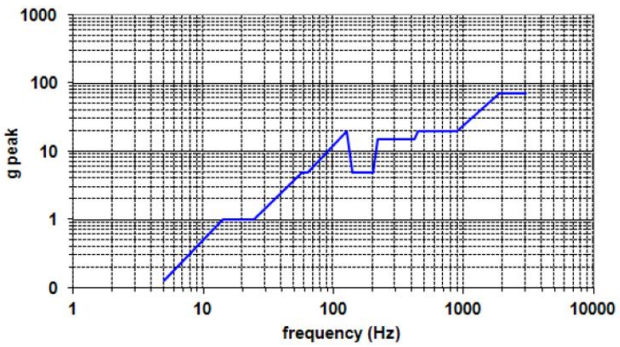
hermocoax manages and conducts the qualification test program in accordance with our customer's specification.
Our engineers write the QTP for customer approval prior to running the test.

Most of the tests (thermal, humidity, electrical, etc.) are performed in HERMOCOAX labs.

Tests requiring heavy equipment (vibration, acceleration, shocks etc.) are subcontracted to external laboratories or supported by our customers with the complete propulsion system.

-Feasible qualification test list:

- Vibration
- Acceleration
- Mechanical shock
- Pyrotechnic Shock
- Helium leak
- Burn-in
- Humidity
- Hot firing
- Electrical cycling
- Thermal cycling
- Lead attachment
- Dielectric
- Destructive physical analysis
- X-ray examination



- Packaging and Cleanness:

Packaging is designed specifically to ensure that the heating solution's excellent condition is maintained during transportation and storage:

hermocoax has been supplying the space industry for the last 15 years with:

- ✓ SMART1
- ✓ Alphabus
- ✓ Alphasat
- ✓ E3000 E3000e
- ✓ Myriad
- ✓ Pleiades
- ✓ Rover Curiosity
- ✓ EXOMARS2020
- ✓ Planet

To come:

- ✓ SSL1300
- ✓ Boeing 702 platform
- ✓ NEOSat
- ✓ Electra
- ✓ Astranis
- ✓ Astroscale

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- hermocoax is a leading player in onboard heating solutions for electrical heating systems and is proud to participate in challenging international space programs.

- HERMOCOAX focuses on high quality heating products for maximum stability and repeatability during operation. We have understood our customers' needs and have responded over the past 20 years by manufacturing spacecrafts to improve lives.

  New large constellation programs are currently in progress.
  HERMOCOAX is now ready to support the SMA market with highly reliable and efficient heating elements.