ARQUIMEA Ingeniería s.l.
Parque Científico de Leganés Tecnológico – VE
C\ Margarita Salas, 16
28916, Leganés
Madrid, SPAIN

RESETTABLE SMA HOLD DOWN AND RELEASE ACTUATOR FOR GENERAL USE IN SATELLITE SYSTEMS (REACT)

Arquimea Ingeniería, S.L.U.	Developer
Arquimea Ingeniería, S.L.U.	Inventor
Thales Alenia Space France	Customer

Introduction

The main objectives of the project were to develop and qualify a hold down and release actuator for space applications with higher temperature capability. The products available in the market are limited in their operating temperatures, avoiding their use in missions where this requirement is more restrictive.

The Innovation

Arquimea suggests a new HDRA (REACT) base on a novel SMA material (SMARQ) with increased temperature performance capabilities able to overcome the current temperature limitations of similar devices. REACT can work in the range of temperatures of -60ºC to 120ºC with a minimum preload of 100N. Other important advantages of the proposed technology are its lightweight, high force to weight ratio and low volume, which makes it especially attractive in space applications.

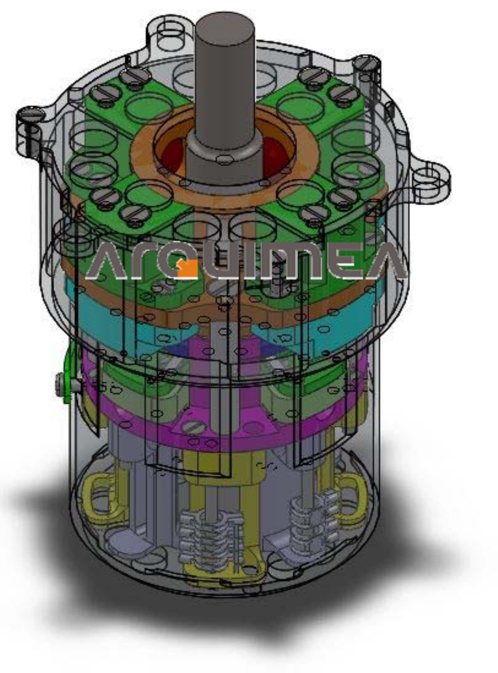

Figure 1: 3D-CAD model of the REACT (housing is in transparent for visualization of the internal structure).

Results of the GSTP activity

The technical work done during the GSPT activity can be divided in two main blocks: design and analysis of the mechanism as well as qualification of built models in space like environment.

Design and Analysis of REACT

The REACT design of Figure 1 is based on spheres which support the rod at the initial position, which represent the mechanical interface of the actuator for the preload application. When SMA actuates, a crown rotates allowing the spheres displacement, and then rod moves to the actuated position.

Projections of the base with thru-holes allow the REACT integration to the space system by using commercial screws. A feature on the bottom face of the rod does not allow the undesired rotation of rod during installation. Thus, the rod should be pushed downwards and fitted in the proper hole of the structure. The reset is planned to be done by using a commercial screwdriver for locating the mechanism in the initial position.

A monitoring system is required in order to check the successful operation of REACT. This system consists in a switch which is open circuit when the actuator is unactuated and closed circuit when it is actuated.

Finite element analysis (FEA) has been carried out in order to check the feasibility of the design as well as the components and assembly resistance. The worse operating scenario has been simulated during the FEA, such as applying the maximum preload during extended time. A factor of margin (FOM) of 1.25 has been assumed for input forces and factors of safety FOS of 1.25 for yield stress and 1.5 for ultimate stress have been assumed for the FEA results. Similar analyses have been developed for verification of non self actuation of the device and mechanism jamming during operation.

The mechanical design of REACT ensures the alignment of components and compactness of the design. Mechanical parts have been designed as made of aluminium alloy. Coating of solid lubricant is applied on moving part surfaces in order to reduce friction. Moreover, hard anodizing is applied in order to improve the tribological characteristics of the mechanism reducing wear and adhesion.

Qualification Campaign on Built Models

A qualification test campaign for REACT has been performed in order to check the effectiveness of the proposed mechanism for space applications. Five units have been used for qualification, which allow getting some statistics for the test results. The performed tests have been: pre-test; visual inspection; physical and electrical measurements; operation validation; sine vibration; random vibration; inputted SRS shock; SRS shock generated; thermal-vacuum actuation; thermal-vacuum cycling; lifetime, creep and post-test.

Figure 2 shows the test campaign that has been developed for the QMs and Figure 3 shows a qualification model used for the test campaign.

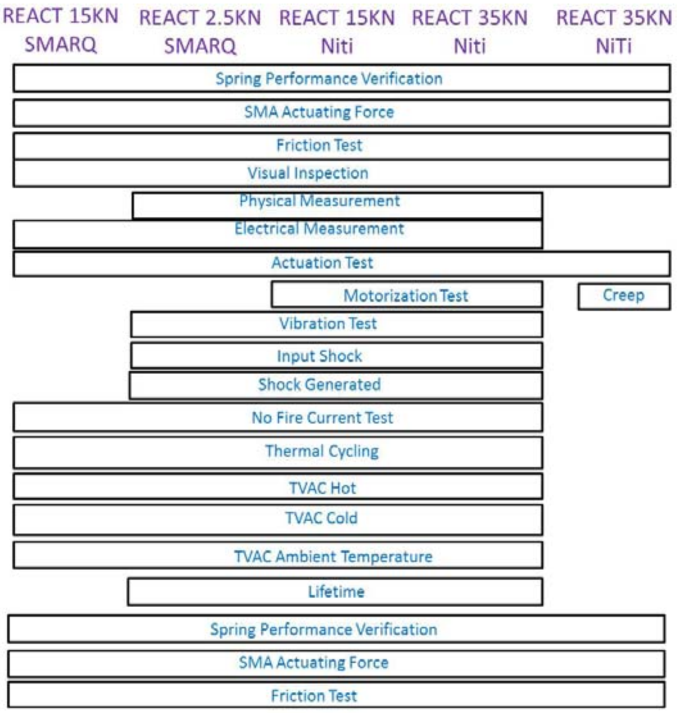

Figure 2: QM test sequence.

Figure 3: Qualification Model.

Springs performance verification, friction measurement and pull force measurement of the SMA actuator have been performed before and after test campaign in order to check degradations. The results of pre and post tests have presented similar values. Any degradation has been recognized in the reset spring and SMA actuator.

A general inspection of the REACTs has been carried out at the beginning of the test campaign in order to check the good external appearance, robustness and compactness of the device. The models have presented suitable physical characteristics, such like compact design with a robust mechanical structure.

Electrical parameters, such as resistance, dielectric, grounding and insulation, have been checked in order to verify the compatibility of this electro-mechanical device with the available electrical interfaces.

The successfulness of the QM operation has been validated by verifying the operation under the application of the maximum preload. Moreover, the effectiveness of the motorization computations has been checked by actuating the device with one initiator.

Sine and random vibrations have been applied to REACT by using the setup of Figure 4. Non self actuations during the test development and any damage in the mechanical structure have been recognized. The device worked properly after the application of these external dynamic forces.

Thermal vacuum tests have consisted in actuation at maximum (120ºC), ambient (23ºC) and minimum (-120ºC) actuating temperatures under vacuum conditions as well as cycling of 8 cycles between these temperatures. Successful actuations have been performed at -60, +23 and +120 ºC. The successful actuations have been verified by using a proper MGSE, as shown in Figure 5.

Figure 4: Setup for the vibration tests.

Figure 5: Setup for the thermal-vacuum tests.

Table 1: Performance of REACT.

Requirement	Value
Actuator Type	Non-Explosive
Preload	2.5 KN /15 KN / 35KN
Mass	94 g / 192 g / 412 g
Envelop	64 Ø x 29 L / 52 Ø x 58.2 L / 78 Ø x 78.5 L
Mechanical Interface	M3 / M6 / M10
Misalignment	± 2.4º
Elongation	0.5 / 1.5 mm
Working Pressure	1.33·10-4 Pa
Working Temperature	- 60ºC to 70 / 120ºC
Storage Temperature	- 20ºC to 60ºC
Electrical interfaces	Pyro
Actuation Time max [s]	< 10 s
Lifetime	10 cycles
Low Shock	Yes
Fully resettable	Yes (manual operation)
Redundancy	Redundant Actuation required.
Other	ITAR Free (based on European components and processes)

Similar, REACT has withstood 8 cycles of vacuum from -120 to +120ºC without suffering damages. Actuations have been performed before and after thermal-vacuum cycling with results similar to the operation validation.

Finally, the device has performed more than 50 cycles of actuations and more than 2 months without lose preload, which demonstrate the mechanism reliability. The results of the qualification test campaign have demonstrated the capabilities of the proposed device to be used as space mechanisms. Table 1 summarizes the performance obtained with REACT during the test campaign.

Contact

Arquimea Ingeniería, S.L.
Nestor Nava
nnava@arquimea.com.