NON-EXPLOSIVE RELEASE ACTUATOR DEVELOPMENT AND QUALIFICATION

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ABSTRACT

NEReA is a Non-Explosive release actuator developed internally by Sener, which has been designed to cover the following needs:

- To be refurbisheable by user with external interchangeable cartridges.
- To reduce complexity, weight and cost as far as possible, decoupling the MAIN and REDUNDANT circuits mechanically and electrically.
- To be able to allocate a threaded bolt with several sizes which can be adapted to different threads. For example, with same envelope can be adapted to M8, M10 and M12 bolts.
- Introduce in the design materials (polyimides) with high damping, wide temperature range, good electrical isolation properties and low density.

The NEReA device is based on a torsion spring and a fuse wire. The mechanism is based on a segmented nut of M8, M10 or M12 diameter which is surrounded by the coils of the torsion spring. When the spring is preloaded, the internal diameter of the torsion spring is smaller compared to the relaxed configuration, so the coils keep the three segments of the nut preloaded and so the thread maintains the bolt captured.

The fuse wire is keeping the torsion spring in place. It is burnt by means of an external voltage of 28v. Once the fuse wire disappears, the leg of the torsion spring is released and the internal diameter of the coils get increased by some millimetres. The sectors get separated from each other and so the bolt is released from the thread.

During 2018, TRL 5 has been achieved by testing of a prototype in ambient conditions. For 2019 the objective of the development is to reach a TRL 7-8 by performing a full qualification campaign which includes functional, vibration and TVAC cycling testing.

INTRODUCTION

In many aerospace mechanisms, the release devices are a key component for the successful completion of the mission. They usually have the function of fixing some part or subassembly (antennas, booms, instruments, scanners) to a structural part of the spacecraft to be released at some point of the mission.

Currently in the market, there are several options for these components, based on different technologies, each of them with strong and weak points. In the last years, the non-explosive range of devices have been widely used as they are much less aggressive to the mechanical subsystems to be released and also they are more simple to operate during AIT operations.

Prior to the trade off, the following requirements were identified as critical for the development of a non-explosive release device:

- To be as simple as possible, reducing the number of components, with no critical parts to be manufactured and assembled.
- It shall be resettable and allow refurbishment at the user premises.
- With the same body and key components it shall be valid for several different bolts sizes to reduce the number of product variations in the same family.
- Export low shock (less than 300g)
- Operate in -80°C to +100°C (operational) and withstand in temperatures from -130°C to 130°C (non-operational).
- Assure misalignment capability of 2° half cone between the interface and the bolt axis.
- High reliability with low sensitivity to preload and rod tolerances.
- To be fed with 28v and 5 amps signal.
- Equipped by 2 independent redundant circuits which should be also mechanically

independent or semi-independent.
- Release time to be lower than 100 ms
- Low weight. Less than 170 gr for a M8/M10/M12 rod device.
- Avoid or minimize the use of magnetic materials as far as possible.
- Limited envelope.
- Low cost.

TRADE-OFF

Please see below a quick summary of the different technologies existing in the market for release mechanisms:

- SMA Initiator Based devices
- SMA Rod-breakage devices
- Fuse Wire Separation Nuts
- Electromagnetic Separation Nuts
- Electromagnetic Clamps
- Paraffin Actuators

The SMA release devices are in general quite good for reducing the shock levels, as they allow preload reduction meanwhile the SMA material is actuating. However, the actuation time is not low, the power needed for the activation is higher and the actuation is very dependent on the initial temperature of the SMA material.

The electromagnetic release devices are also convenient in terms of shock, they are easily refurbisheable or even resetable. However, the electromagnetic force decreases quickly with the distance to the winding and they are quite bulky. The magnetic constraints in some missions could potentially be a limitation for these devices.

The paraffin actuators have long actuation times, in the order of 30s or higher. The power consumption associated to this time is also non-negligible and the mechanism is more suitable for pin pullers or pin actuators rather than release nuts.

Finally the selected option is based on a fuse wire. This selection is supported by the following characteristics of this mechanism, see below:

- Very low actuation time
- Low power consumption
- The fuse wire acts as switch for interrupting the current feed once it has been melted
- Low mass

Some of the existing release actuators in the market based on fuse wire have limitations:

- The release points for Main and Redundant Circuits are quite on the same place, so an issue with one circuit can easily propagate to the other one, reducing the robustness of the design
- In many cases, the refurbishment of the device shall be done by the supplier.

DESIGN CONCEPT

The key element of the NEReA (Sener Non-Explosive Release Actuator) is a segmented nut formed by three pieces which are held together by means of a torsional spring. Rotation of the spring ends is constrained through initiators, which are placed tangentially on the outer surface of the cylindrical housing. When the initiators are actuated – fuse wires are blown – the spring ends are released and the spring is free to return to its resting position. Simultaneously the spring internal diameter increases and the nut segments separates reducing preload and finally leaving the tie-rod disengaged.

This concept, based on segmented nut allows release without the need to allocate a rod coming out together with the bolt. The first product of the family has M10 thread but can be easily escalated to M8 and M12.

ENGINEERING MODEL

During 2018, an Engineering model was manufactured and assembled and submitted to several tests, all of them in ambient conditions at clean room environment.

See in fig.1 EM picture once assembled.

Figure 1. NEReA Engineering Model

This model was submitted to the following tests:

- Mass characterization
- Release tests
- Preload tests
- Wire Fuse Time

In the release test the bolt is preloaded in the NEReA and release signal is applied for checking that the segments release properly the screw. The simplicity of this test allows to perform several runs for checking reliability and robustness of the basic concept.

See in fig.2 picture of the release test.

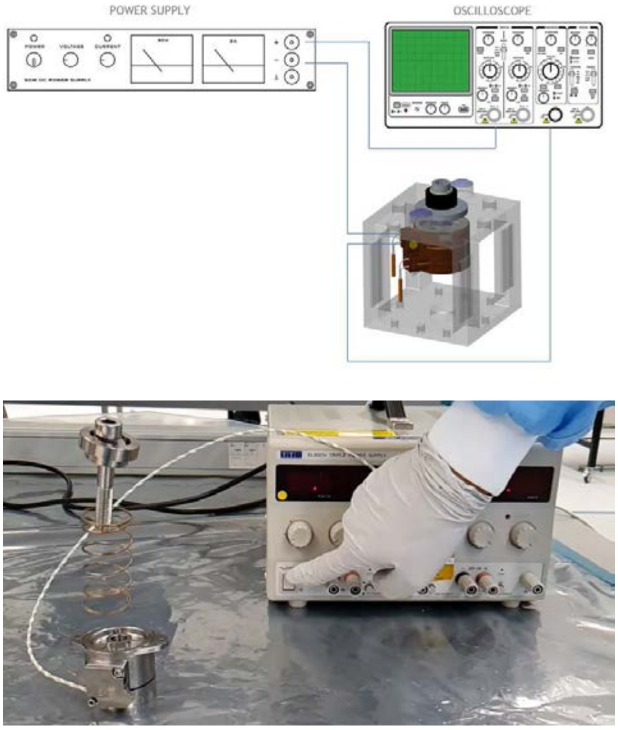

Figure 2. Release Test

For the characterization of the fuse time of the wire, oscilloscope was used to get the time frame in which the source was providing current to the fuse wire before circuit interruption. The power supply was not able to provide 5 Amps from the beginning, so the fuse time was a bit longer than expected, in the order of 40 ms.

With proper input signal, fuse time lower than 20 ms is expected.

See fig. 3 for current input vs time.

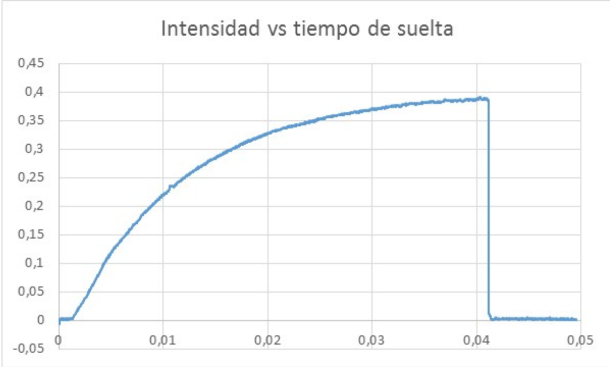

Figure 3. Current-time plot during release

For the preload test, load cell is located between the bolt head and the base of the NEReA through which the axial force is translated into the threaded segments. This load cell signal is monitored by means of dedicated acquisition system.

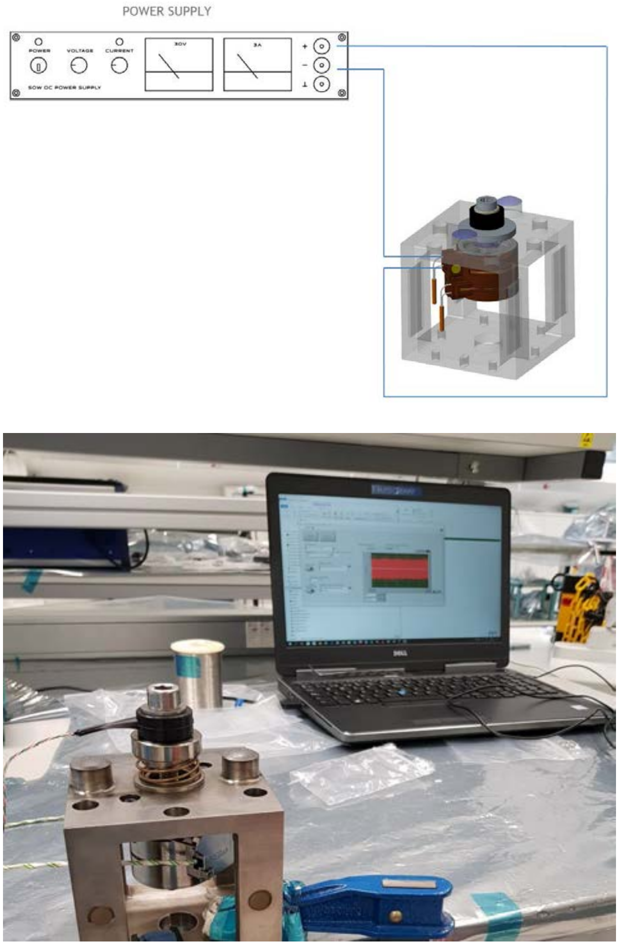

Figure 4. Preload characterization Test

QUALIFICATION MODEL

For the qualification model, some modification were implemented in the design based on the experience of the EM testing and some new ideas which were introduced in the architecture. See below:

- The housing material, which was manufactured of titanium grade 5, was replaced with peek (Polyetheretherketone) to reduce mass, improve the isolation between Main and Redundant circuits and reduce the shock levels thanks to a better damping of the material.
  This material has also a wide temperature range (up to 260º) and is easier to machine, so complex shapes can be manufactured
- The bottom cover was integrated into the housing to reduce the number of parts and the mass of the device.
- The cartridges which allocate the fuse wires have been redesigned so that they can be inserted without the need of removing the cover. The insertion is done tangentially, to simplify the tool.
- The copper terminals which support the fuse wire are located radially instead of tangentially.

See fig.5 for 3D view of the NEReA final design.

Figure 5. NEReA QM 3D view

REFURBISHEABILITY BY THE END USER

One of the driving points for the design of the NEReA is that it should be refurbisheable by the user at its premises.

For this operation Sener provides the complete cartridge to be replaced with the one that has been fired. See picture below. For this operation, the spring has to be preloaded until the final position by means of a tool. This operation can also be performed manually, with extra difficulties. This opens also the possibility to refurbishment of the NEReA without disassembly from the HDRM in which it is installed, depending on the free volume which is around the device.

See fig.6 for refurbishment process.

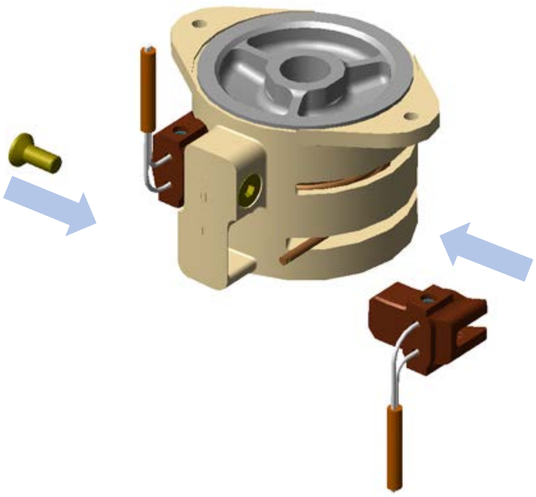

Figure 6. NEReA refurbishment process

See below table of characteristics for the NEReA, please note that with this product 3 different metrics can be covered.

	NEReA M8	**NEReA M10**	**NEReA M12**
Resistance	Less tan 2 Ohm		
Input voltage	28 V.		
Actuation current	5 A.		
Actuation time	Less tan 50 ms.		
Bolt Dimension	M8	M10	M12
Axial preload (orientative)	15000 N	30000 N	42000 N
Mass	160 gr.		
Envelope	70 mm diam		
	40 mm height.		
TRL	5 (TRL8 Q4 2019)		

Table 1. NEReA Datasheet

The NEReA QM has been already manufactured and assembled. See Fig.7.

Figure 7. NEReA QM picture

The QM is to be submitted to the following test campaign:

- Functional testing
    - Mass characterization
    - Envelope
    - Bonding
    - Isolation
    - Resistance measurement
    - Release in ambient
    - Fuse time measurement
- TVAC testing, with release in cold conditions.
- Vibration testing.

Qualification campaign is to start and be completed during second half of 2019.

Recently, Sener has been awarded with ESA contract for the development of NEReA for M20 thread under the frame of ATHENA mission. See fig.8 for 3D view.

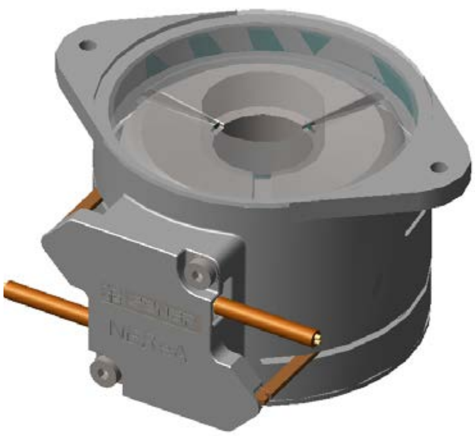

Figure 8. NEReA M20 3D view for ATHENA project

REFERENCES

None