Prediction of the failures of the electronic components submitted to severe vibratory environments

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Contents

- Introduction
- Magnetical components
- Relays GP250
- Relays K41R
- Structural parts of electronic units are not sensitive to pyroshocks

- Electronic designs use some sensitive components
  - Relays
  - Magnetic components
  - …

- ETCA pyroshock tests facilities can be used to perform components characteristics studies and determine mechanical limits (and/or electrical abnormal behaviours) of sensitive components
Magnetic components used by ETCA often have a magnetical circuit made of « ferrite »

This material have good electrical properties but is « fragile »

Interest to know the mechanical limits of this type of components (used in many ETCA equipments)
History

- Some degradations were observed by ETCA during hybrids qualification on two sizes of RMs: RM10 & RM12

- Failures can sometimes be observed → The component keeps its electrical properties

- No problem observed during a qualification in using a RM7
**Description of the test set-up**

- Substrates (alumina) with standard dimensions (97 x 75 x 0.635 [mm])
- Substrates glued with TK7755
- RM glued on substrates with ME 7155
Pyroshock test set-up

Aluminium base plate
Aluminium mounting plate
Accelerometers
**Test sequence**

- **Successive shocks** in increasing amplitude
- **Visual inspection** between each shocks

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<th>Distance between fixation point [mm]</th>
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Analysis (Based only on out of plane shock level)

**RM12**

![Graph showing acceleration vs. frequency for RM12](image)

**RM10**

![Graph showing acceleration vs. frequency for RM10](image)
Analysis (Based only on out of plane shock level)

Zone de rupture des RM’s 6, 7 & 8

Analysis (Based only on out of plane shock level)
Analysis (Based only on out of plane shock level)

Zone de rupture des RM’s 4 & 5

![Graph showing frequency vs. acceleration for magnetic components (RM)](image)
Comparison with History (Based only on out of plane shock level)

**RM12 - caractérisation technologique et héritage - confrontation**

Shock performed for a qualification (broken RM)

Limits found during RMs pyroshocks test campaign

→ Good adequation between determined technological limits and history

**Zone de rupture des RM’s 6, 7 & 8**

Limits found during RMs pyroshocks test campaign

Shocks performed for equipments qualification without damage of RMs

→ Good adequation between determined technological limits and history
Same methodology has been followed for RM5 and RM7 reported on a PCB.

Accelerometers

(1 RM7 reported with winding)
Results

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<td>2 cm de corde explosif</td>
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<td>Acc_S18 décollé</td>
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<td>60 cm</td>
<td>Casse RM5.2 + Casse RM4.1</td>
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SRC’s – Accéléromètre S19 suivant Z₂
3 events can appear during a pyroshock:

- **Micro-switch**
  - A3, A1
  - A3, A1
  - A3, A1

- **Provisional-switch**
  - A3, A1
  - A3, A1
  - A3, A1

- **Permanent-switch**
  - A3, A1
  - A3, A1
  - A3, A1
• C.A.D. model of the fixing device of the relays on the test setup

Configuration 1

Configuration 2

Configuration 3
Test setup

Configuration 1
Test fixture
Aluminium mounting plate

Configuration 2
Pneumatic piston

Configuration 3
Steel base plate
RELAYS GP250

Electrical configuration without current

Electrical configuration with current

Two electrical configurations

Contacteurs

Resistors

Relay 1

Relay 2

Relay 3

Relay 4
Results Without current – Configuration 1

Measured Voltage
Pneumatic piston (8 bars)

Electrical dysfunctions can be identified from the evolution of the voltage measured on the connections of the relay during the shock.

Measured Voltage
Pyrotechnic shock (25 cm)
With current, It’s more difficult to identify the electrical dysfunctions from the evolution of the voltage measured on the connections of the relay.
Permanent-switch of relay GP250 (with and without current)
Permanent-switch of relay GP250 (with current)

Accelerations measured on the mounting plate
• C.A.D. model of the fixing device of the relays on the test setup
Limits of GP250 in regards of pyroshocks for the ETCA unit

Relays are sensitive to acceleration peaks.
Asymptotic SRS

\[
\log (SRS_{\text{asymp}}(f)) = \begin{cases} 
\alpha \log \left(\frac{f}{f_c}\right) + \log A & \text{si } f \leq f_c \\
\log A & \text{si } f > f_c 
\end{cases}
\]
Relation between chatters and asymptotic amplitude of the Shock Response Spectrum (SRS) - Configuration 1

Minimum level leading to an electrical dysfunction is approximately 1200 g

Parameter \( \lambda \) = number of times that the measured voltage moves away of 2% more than the reference voltage (5V) during the shock (80 ms)
- Schematic working

- 3 events can appear during a pyroshock

- Micro-switch

- Provisional-switch

- Permanent-switch
Test set-up

- Mechanical dummy of the ETCA equipment
- Control accelerometers
- Measurement accelerometers
- Relays K41-R
Limits of K41R in regards of pyroshocks for the ETCA unit

Limits comportementales K41-R (Axe Z)

- MIN µ-o
- MAX µ-o
- µ-f
- MIN Basc
- MAX Basc
- RIEN
- S4
ETCA pyroshock test facilities are used to determine the limits of sensitive components in regards of pyroshocks.

Test set-up have been used to know the limits of mechanical robustness of magnetic components, reported on substrate and PCB.

Test set-up have been developed to determine the limits of different types of relays.

All the results are used as reference for new design of electronic units, as well as the qualification status of ETCA products.
CONTACTS

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