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Presentation of CAEPE test facilities and validation by testing of a MURAT approach

INTRODUCTION

French MOD initiated activities in the field of IM munitions in the early nineties in parallel with the development and commissioning of the first French nuclear aircraft carrier. CAEPE - at that time only dedicated to SRM ground testing - was chosen to become the official expert for the IM activities and the implementation of the MURAT doctrine.

The first needs were in term of evaluation of new technologies or innovative concepts to improve missile and ammunitions safety. : intumescent coating, cutting cord with thermal sensor, internal percussion cap ...

It was then necessary to validate the ability to apply these technical solutions to operational equipments such as motors or military heads.

MURAT APPROCH & SECURISATION

French MURAT (MUnition à Risques ATtenués) doctrine

MURAT ammunition that meets all the requirement in term of performances, readiness or logistic footprint, but for which the probabilities of a unexpected initiation or collateral damage in case of accidental reaction have been reduced to a minimum. The delay of apparition of dangerous phenomena is also taken into consideration. The evaluation and qualification of an ammunition cover all the phases of its operational life (storage, preparation, operational use ...). However the application of specific protection may lead to assign different labels according to the phase of its life (ammunition in container or not for example).

MURAT label requires applying 9 different kinds of test:

- Electric and Electromagnetic aggressions
- High height drop
- Fast cook-off
- Slow cook-off
- Bullet impact
- Sympathetic reaction
- Light and heavy fragments impacts
- Shaped charge jet

STANAG rules are applied to carry out these tests.
 Test results are sorted through AOP 39 instructions.

Matrix of MURAT “stars”

Risk/level of reaction	No reaction	V	IV	III	II	I
Electric	☆☆☆					
Drop	☆☆☆					
Fast cook-off	☆☆☆	☆☆☆	☆			
Slow cook-off	☆☆☆	☆☆☆	☆	☆		
Bullet impact	☆☆☆	☆☆☆	☆	☆		
Sympathetic reaction	☆☆☆	☆☆☆	☆☆☆	☆		
Light fragment impact	☆☆☆	☆☆☆	☆☆	☆☆	☆	☆
Heavy fragment impact	☆☆☆	☆☆☆	☆☆☆	☆☆	☆	☆
Shaped charge jet	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆	☆

☆☆☆ MURAT *** ☆☆ MURAT ** ☆ MURAT *

Aircraft-Carrier Securisation

Securisation implies a systematic study of the ammunition subsystem.

- Condition of use: peacetime/malevolence/hostile aggression
- Ship situation: naval base/deepwater
- Ammunition configuration : store room/preparation room/ship desk
- Kind of aggression
- Kind of reaction: combustion/explosion/propulsion/detonation

Comparison of the MURAT and securisation approaches

According to the MURAT doctrine, the whole field of dangerous situations is described by some generic aggressions. On the contrary, securisation implies the assessment of the aggressions that could occur.

To get a MURAT label, the whole set of aggression is applied during the qualification test to the ammunition even if some of these aggressions won't never be met during the operational life. Under the securisation concept, only the aggressions likely to be met under every corresponding phases of the operational life are applied.

CAEPE TEST FACILITIES

CAEPE (Centre d’Achèvement et d’Essais de Propulseurs et Engins) is a DGA (French Defense Procurement Agency) test center near BORDEAUX that operates in the realm of solid propellant rockets for strategic and tactical missiles.

CAEPE not only operates for the DGA but also for a number of companies such as MBDA, ROXEL, SME, PROTAC, GIAT, CNES, SAFRAN, and EADS.

The center brings together expertise and ground testing methods for the DGA in the area of anaerobic propulsion for strategic and tactical missiles.

Hence, CAEPE is able to ground test SRM developing up to 250 tons of thrust, replicate altitude conditions up to 70 km and test the security of the pyrotechnical systems containing 10 tonnes of explosives (hazard division 1.1) or 30 tonnes of propellant (hazard division 1.3).

All missiles in service in the French armed forces have been tested or assessed by CAEPE.

CAEPE can perform security tests on the following systems : complete missiles, missiles in container, tactical missile SRM, explosives, bombs, missile warheads, decoys, tracers



CAEPE operates 3 safety zones that are free from any obstacles over 200m x 200m. Each one is equipped with underground instrumentation and able to accommodate up to 135 measurements.

CAEPE can perform the complete set of standard safety tests:

DROP TEST



A new drop test tower has been recently built which allows dropping from up to 12 m for a test article weighing up to 2.2 tonnes. The cage surrounding the drop test improves the safety conditions of test.

SLOW COOK-OFF



SYMPATHETIC REACTION



SHAPED CHARGE JET



LIQUID FUEL FIRE



FRAGMENT IMPACT



BULLET IMPACT



For the qualification of some ammunitions for use on the nuclear A/C, CAEPE has developed and performed some specific test configurations such as propellant fire (2000°) or torching.



Propellant fire

CAEPE has also some numeric tools to accompany its testing activities. Following soft wares are widely used :

- CRONOS (assessment of danger zone)
- FLUENT 6 (CFD)
- QUICKFIELD
- LS DYNA 2D
- ...

Type of measurement

Validation of aggressions:

- Meteorological measurement : Temperature, hygrometry, wind velocity, pressure
- Liquid fuel fire temperature
- Slow cook-off temperature
- Bullet velocity

Assessment of the level of reaction:

- Aerial overpressure
- Heat flux
- High speed video
- Microphone
- ...

Scenario of reaction:

- thrust measurement
- combustion pressure
- datation
- ...

IM SOLUTIONS VALIDATED TROUGH TESTS

The test article is representative of a motor with a composite charge. Its dimensions are:

Length = 2 m

Diameter = 227 mm

Propellant weight = 100 kg

Two slow cook-off tests have been performed: one on the basic configuration and the other on a modified configuration meant to improve its insensitivity. Two modification had been applied

- local weakening of the structure (slot)
- addition of a double-base propellant to the initial igniter composition.

Tests results

Modified motor configuration: reaction temperature was 130°C. The motor casing was torn along the slot. The nozzle had broken down in several pieces recovered closed to the test article. The igniter was recovered: flakes had functioned but initiator was intact. A complete combustion of propellant was observed. The level of aerial pressure measured was 50mbars at 15m.



It was a type III Reaction

Basic configuration motor: reaction temperature was 192°C. The test article and corresponding tooling were utterly destroyed. No significant parts were found in the test area (100m radius). Some nozzle parts recovered within a 150 m radius area. A complete combustion of propellant was observed. The level of aerial pressure measured was 50mbars at 15m.



It was a type I Reaction

Conclusion: thanks to the fittings described hereupon and applied to this motor, a gain of two levels of insensitivity was observed with respect to the slow cook-off test.