Single package testing method

Erik Tunestål

Fulmination 2023

The European Leader in Energetic Materials

▪ OUR PURPOSE

- EURENCO is a key player in the defense sector serving the sovereignty of France and Europe. We design, produce and supply innovative products and solutions with high added value in the fields of pyrotechnics and chemistry.

▪ OUR MISSION

- To design, produce and monitor, throughout their life cycle, high performance and safety products and solutions in the field of energetic materials for Defense and their derivatives for civilian applications

EURENCO
IGNITE YOUR AMBITIONS

Our market segments

Medium & Large Caliber Propellants & Propelling Charges

Warheads & Medium and Large Caliber Explosives

Small Caliber Propellants

Oil, Gas, Mining

Fuel additives

Propellants in Karlskoga

Products

Large caliber Extruded Propellants

Small Caliber Extruded Propellants

Main applications

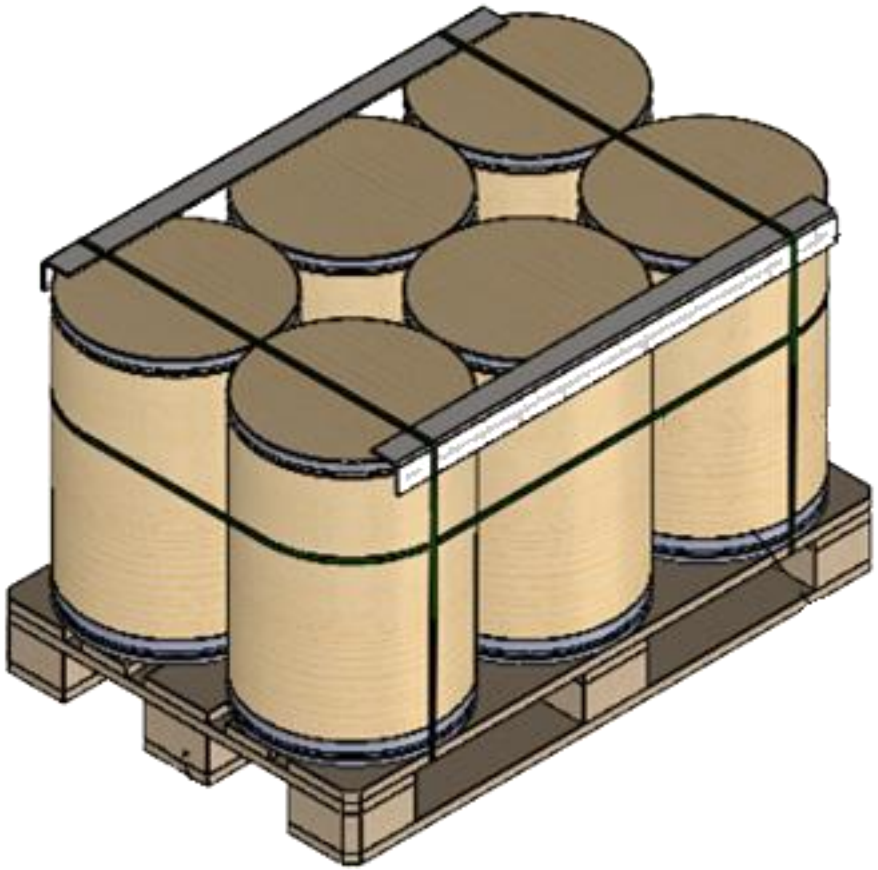
Generic process

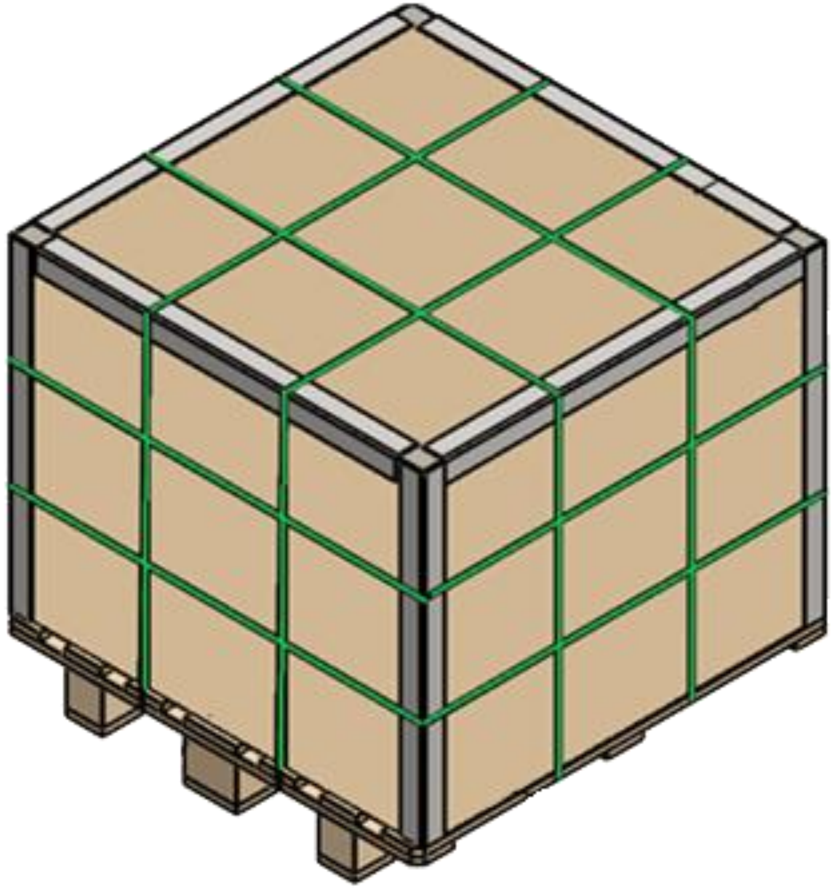
- **A propellant grain is born**
  - Sensitivity and stability tests.
- **Identify a packaging which is approved for explosives**
  - Regulates the maximum net weight to be loaded in packaging.
- **How much material can be loaded with a classification of 1.3C**
  - A single package test 6a
    - If unclear from 6a a 6b test can be performed.
- **Loop-process for all new propellant grains**
  - New dimension
  - New geometry
  - New formulation

Challenges

CHALLENGES	SOLUTIONS
01 LOGISTICS Improve logistics chain – more material per pallet – less footprint in storage - cheaper	**SOLUTION 01 — 01** New package which stacks better.
2 UN TRANSPORT UN Transport classification very thorough – many different tests	**WORST CASE — 2** Identify the most severe/important test and optimize for extensive testing
3 WIDE PORTFOLIO Wide product portfolio 350+ propellant products to be evaluated	**FIND A MODEL — 3** Find a general formula/criteria for transport evaluation.

Logistics





Decreased logistic footprint with 20% (kg/m^2)

Logistics

Not only a energetic problem…

- Identified that the supplier sent the wrong type of box

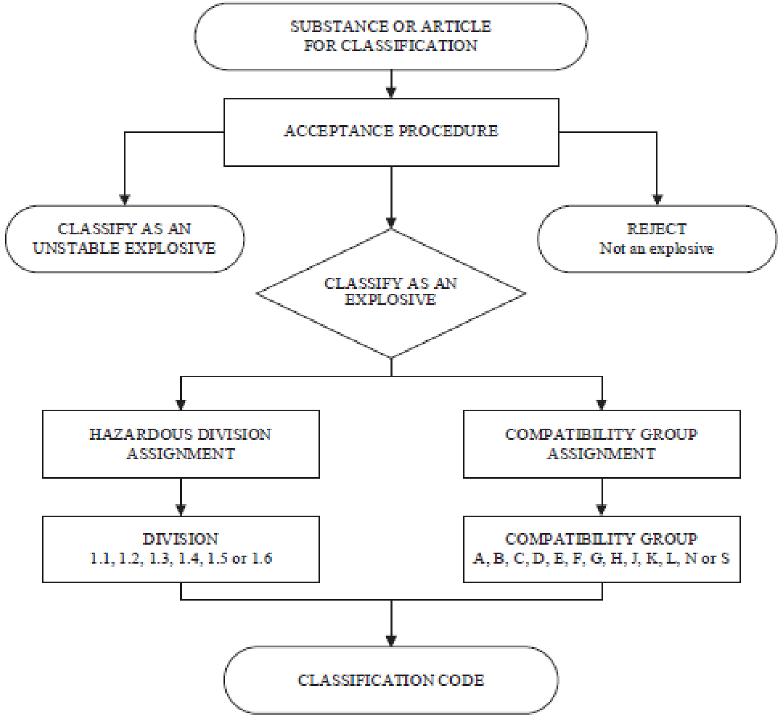
- **Challenge:**
  - **An extensive test scheme for products**
    - How can this be simplified for simliar products

Manual of Tests and Criteria

Seventh revised edition

UNITED NATIONS
New York and Geneva, 2019

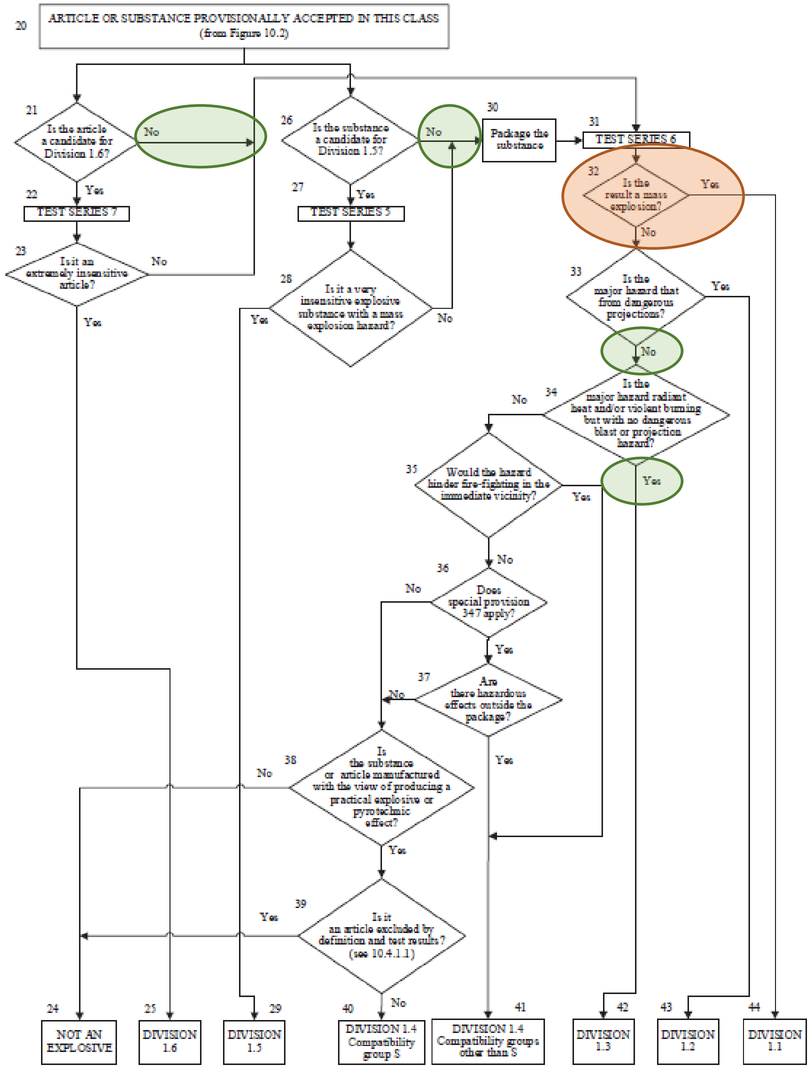
Figure 10.1: Overall scheme of the procedure for classifying a substance or article in the class of explosives



UN Transport

- **Challenge:**
  - **An extensive test scheme for products**
    - How can this be simplified for simliar products

Figure 10.3: Procedure for assignment to a division of the class of explosives



Unclassified

- **Solution:**
  - **Focus on 6 (a) Single Package test**
    - Perform 6 (c) External fire (bonfire) test on extreme

16.2 Test methods

16.2.1 The test methods currently used are listed in Table 16.1.

Table 16.1: Test methods for test series 6

Test code	Name of test	Section
6 (a)	Single package test[a]	16.4.1
6 (b)	Stack test[a]	16.5.1
6 (c)	External fire (bonfire) test[a]	16.6.1
6 (d)	Unconfined package test[a]	16.7.1

[a] *Recommended test.*

16.2.2 Test types 6 (a), 6 (b), 6 (c) and 6 (d) are normally performed in alphabetical order. However, it is not always necessary to follow this order or to conduct tests of all types.

(a) Test type 6 (a) may be waived if explosive articles are classified without packaging or when the package contains only one article, (see also section 16.2.2 (d));

(b) Test type 6 (b) may be waived if in each type 6 (a) test, (see also section 16.2.2 (d));

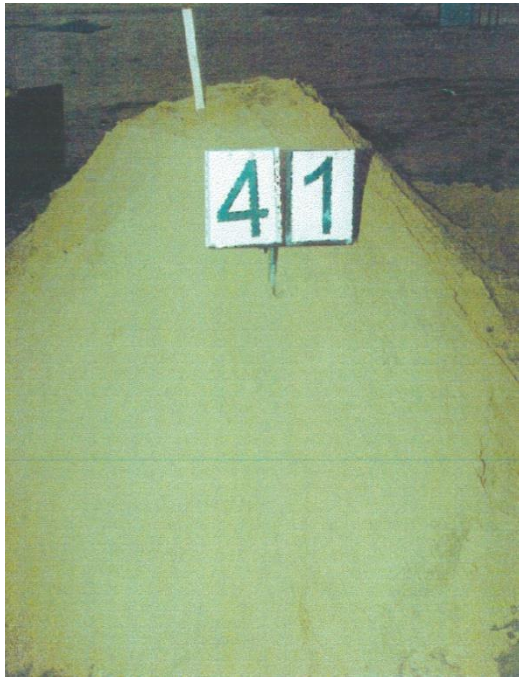
(i) The exterior of the package is undamaged by internal initiation; or

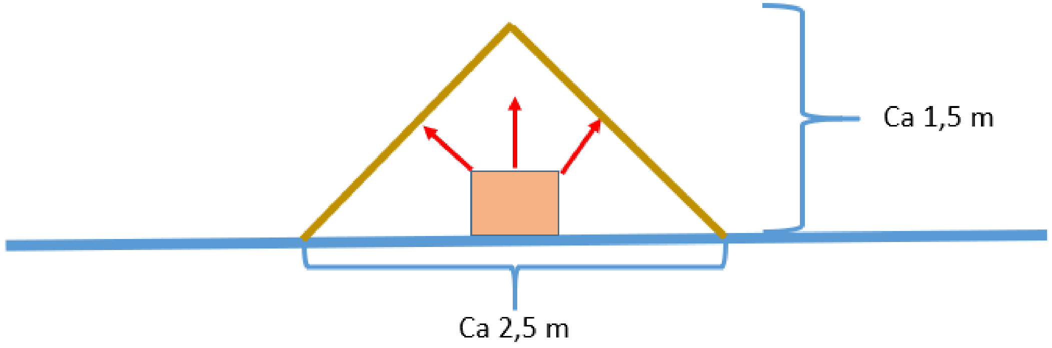
(ii) The contents of the package fail to explode, or explode so feebly as would exclude propagation of the explosive effect from one package to another in test type 6(b).

(c) Test type 6 (c) may be waived if, in a type 6 (b) test, there is practically instantaneous explosion of virtually the total contents of the stack. In such cases the product is assigned to Division 1.1;

(d) Test type 6(d) is a test used to determine whether a 1.4S classification is appropriate and is only used if special provision 347 on Chapter 3.3 of the Model Regulations applies. When testing articles to which special provision 347 applies, test type 6(d) may be performed first. If the results of test type 6(d) indicate that a 1.4S classification is appropriate, then test types 6(a) and 6(b) may be waived.

- **Challenge:**
  - Be able to perform a number of tests (6a) in a rational way – without affecting reproducibility
  - No known test method was deemed to fulfill these requirements
- **Existing test method**
  - ”Pile method” – problem with 500 mm containment in all directions

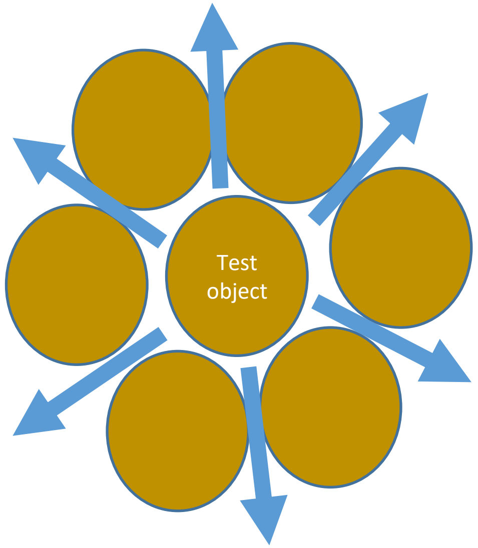




UN Transport

- **Challenge:**
  - Be able to perform a number of tests (6a) in a rational way – without affecting reproducibility
  - No known test method was deemed to fulfill these requirements

- **Existing test method**
  - Package containment
    - Functions as a blasting tin
    - Expensive and laborous with packages



UN Transport

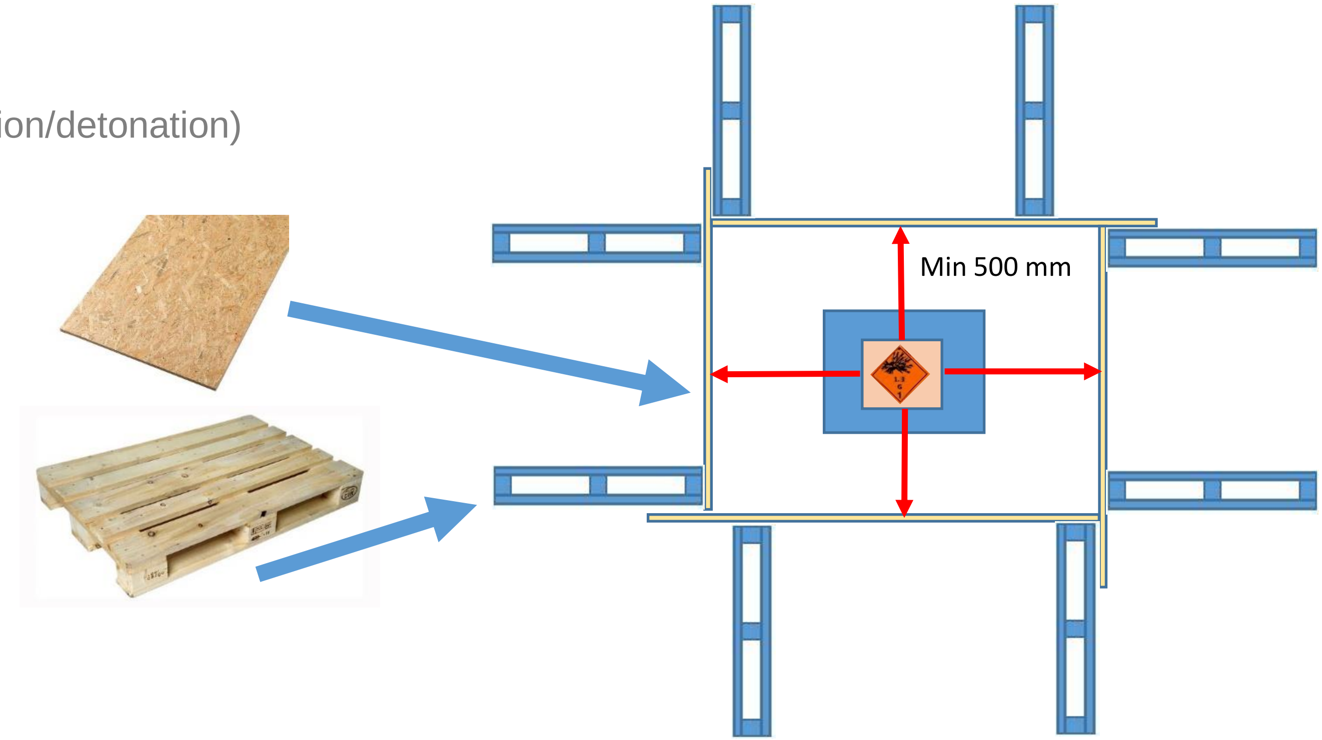
- **Challenge:**
  - **Be able to perform a number of tests (6a) in a rational way – without affecting reproducibility**
  - **No known test method was deemed to fulfill these requirements**

- **Proposal**
  - **The Safepac-method**
    - Cheap material
    - Re-usable (if no explosion/detonation)

UN Transport

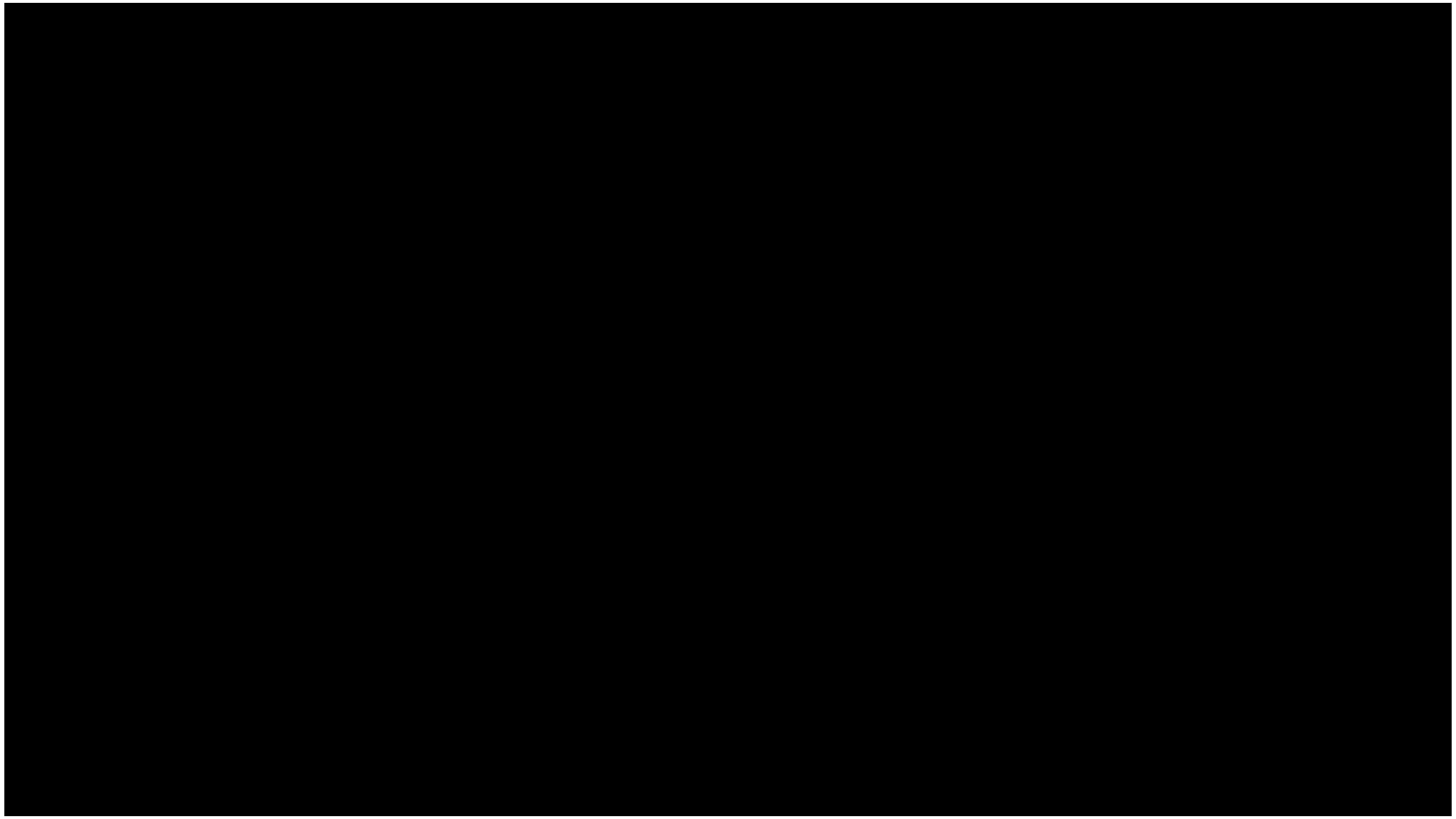
- **Challenge:**
  - **Be able to perform a number of tests (6a) in a rational way – without affecting reproducibility**
  - **No known test method was deemed to fulfill these requirements**

- **Proposal**
  - **The Safepac-method**
    - Cheap material
    - Re-usable (if no explosion/detonation)



- **Proposal**
  - **The Safepac-method**
    - Cheap material
    - Re-usable (if no explosion/detonation)
    - Easy to setup and pre-fabricate

- **Validation of test method – repeatability**



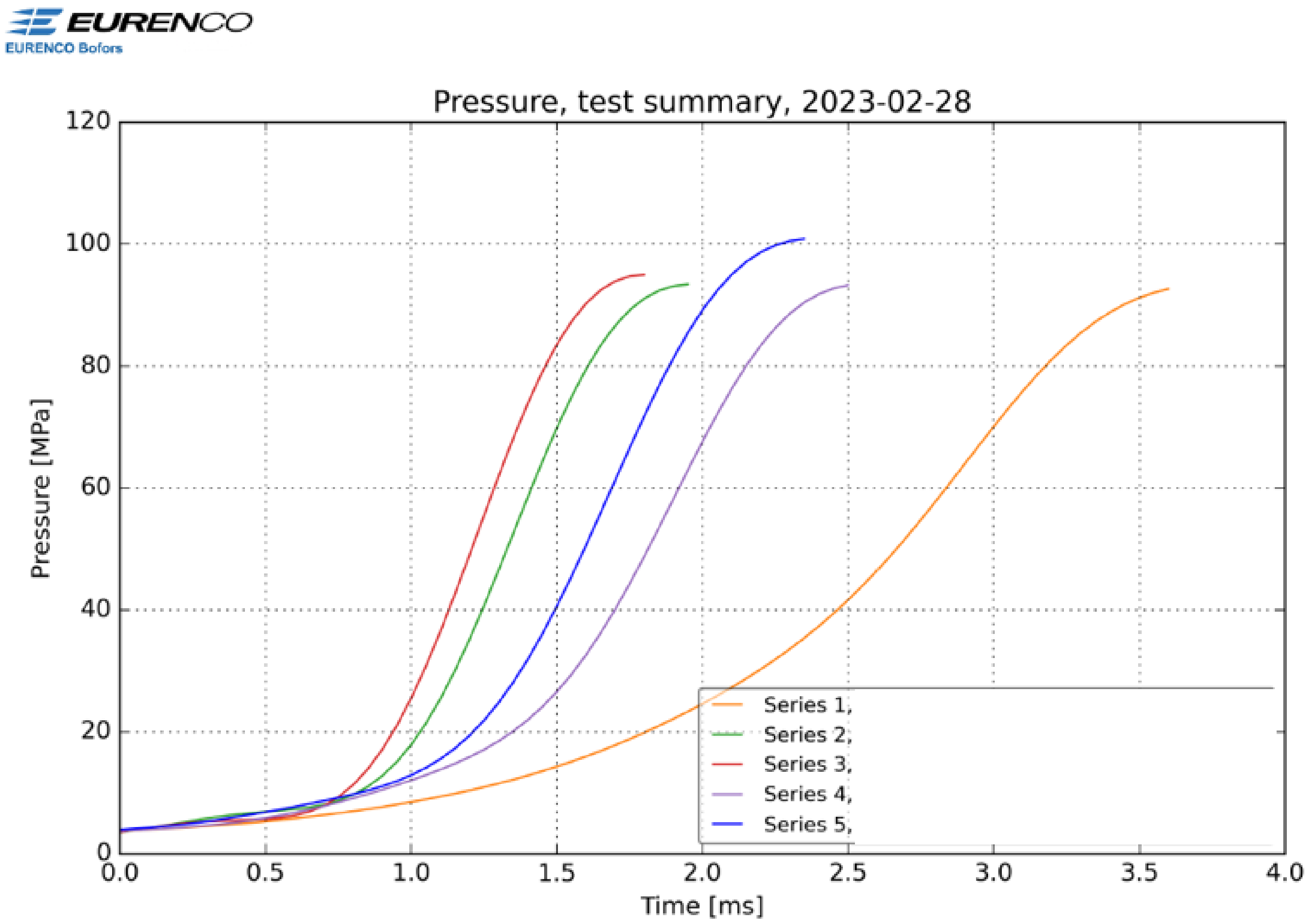
Wide Portfolio

- **A lot of testing!**
  - **More than 700 sales articles**
    - When is new testing required?
- **New packaging – requires new testing!**
- **Cost and time consuming!**
- **There must be a more efficient way!**

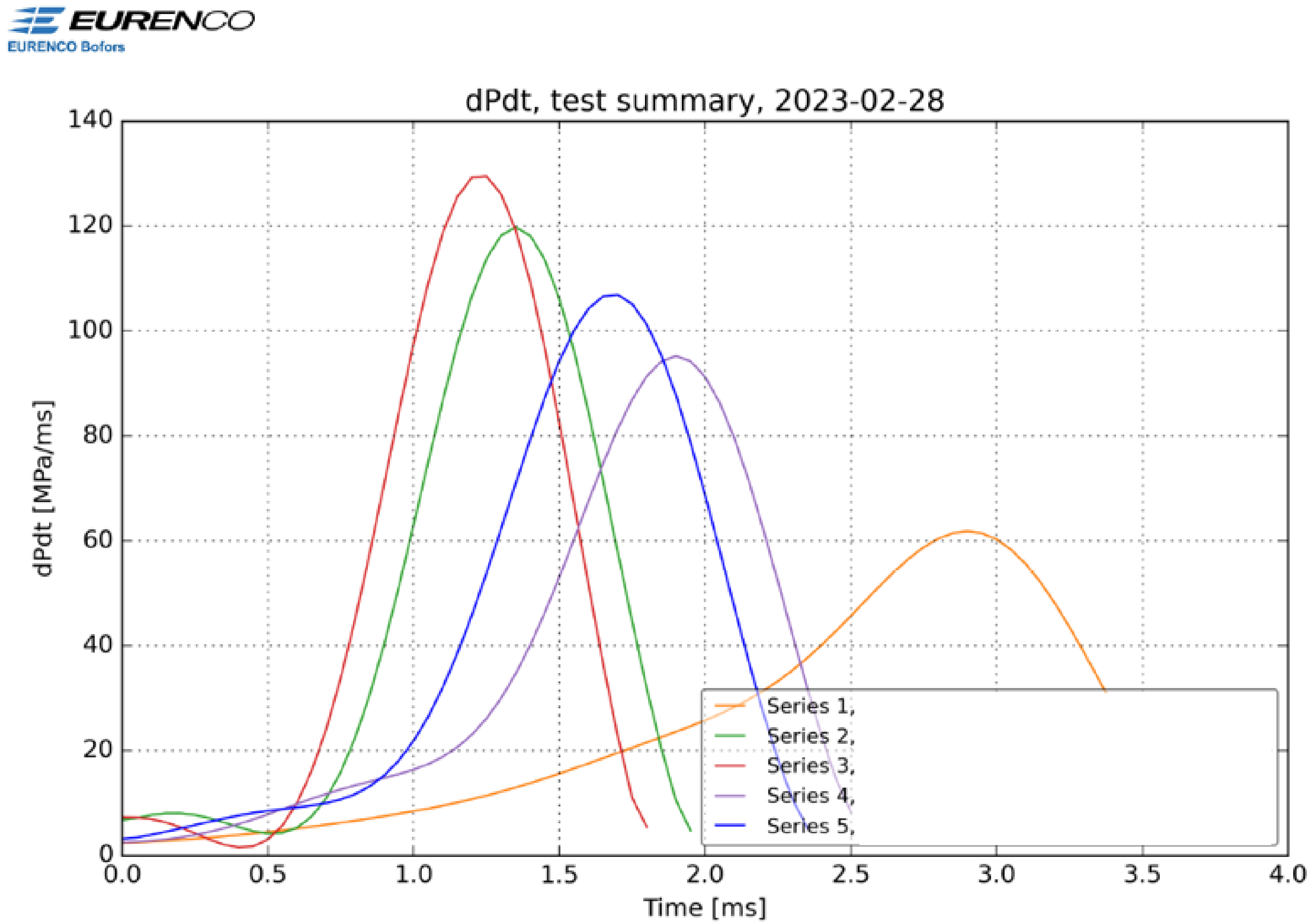
The proposal

- **Empirical model based on test data on lab scale and full scale package tests**
- **What is the effect generating a DDT**
  - **The burning of materials generates a pressure which is so high that the deflagration transitions into a detonation**
  - **The Quickness from a manometric bomb test is a measurement of the pressure increase (the derivative of the pressure-time curve.**
    - Could this be used to differentiate different propellants?

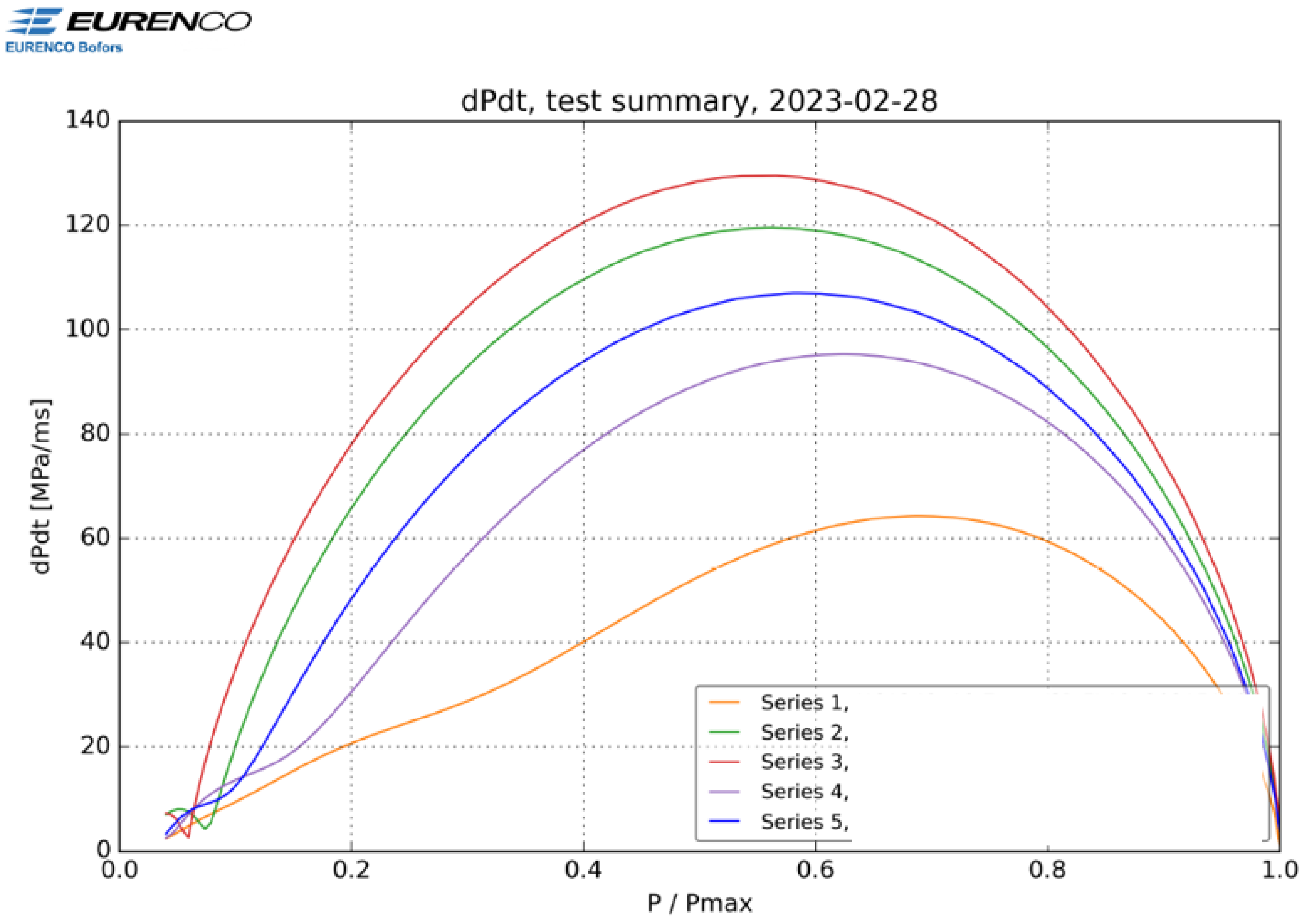
The proposal



The proposal

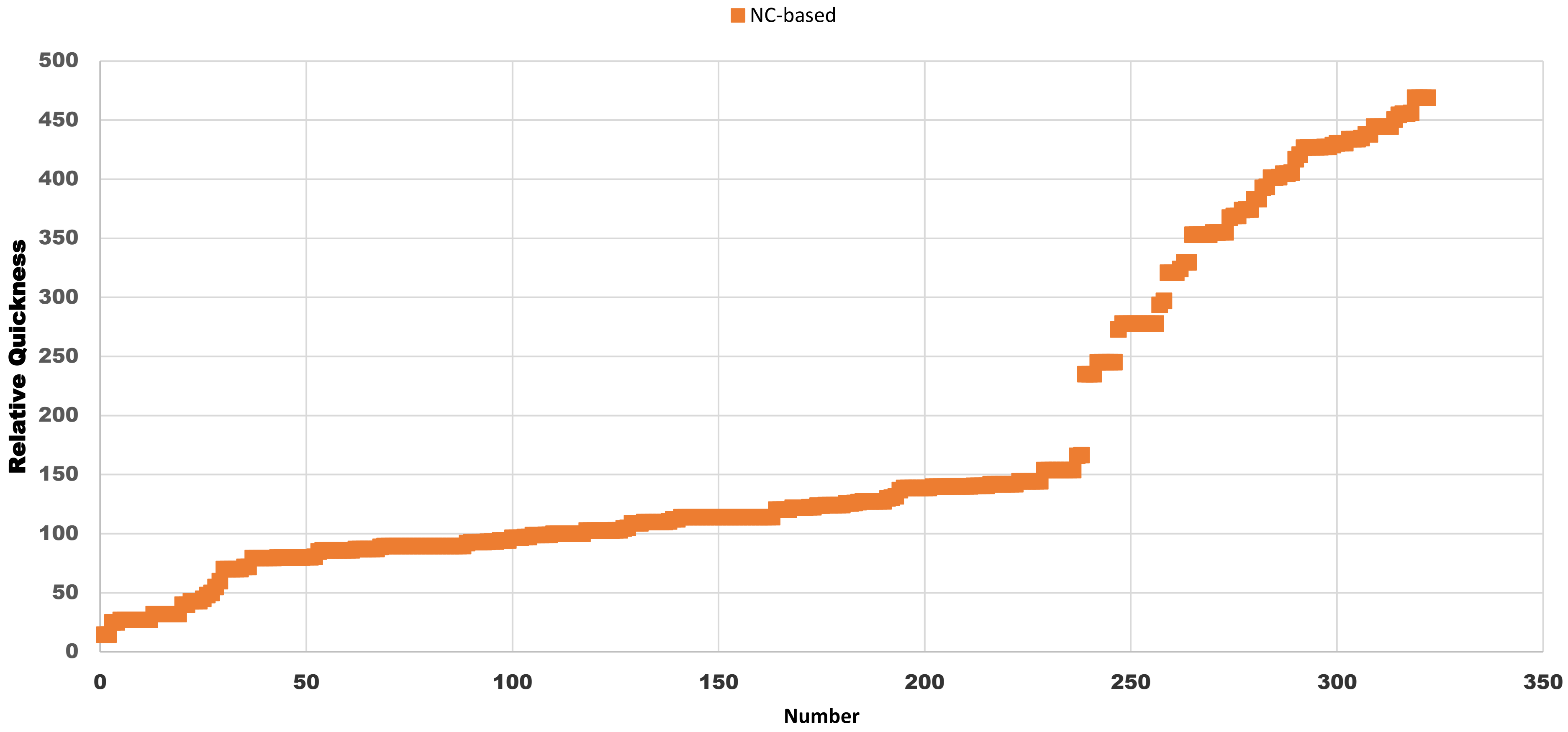


The proposal



Propellant portfolio

- **Emperical model based on RQ value for the propellant**
  - **All propellants arranged by their Quickness value compared to a set reference.**



Test results

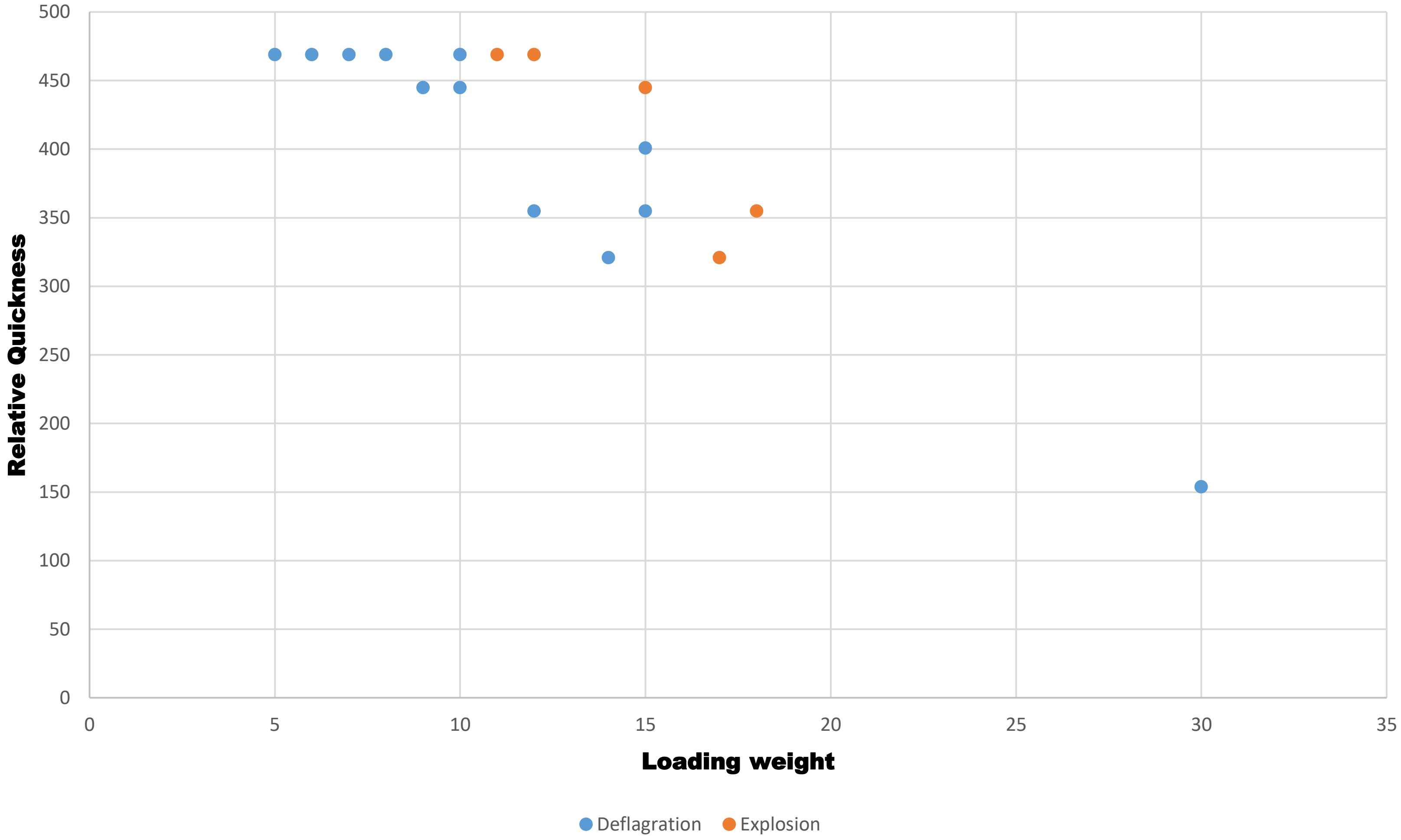
- **For lower RQ-values the package could be fully loaded and still deemed 1.3C**
  - This also includes some propellants with lower bulk density.

Test results

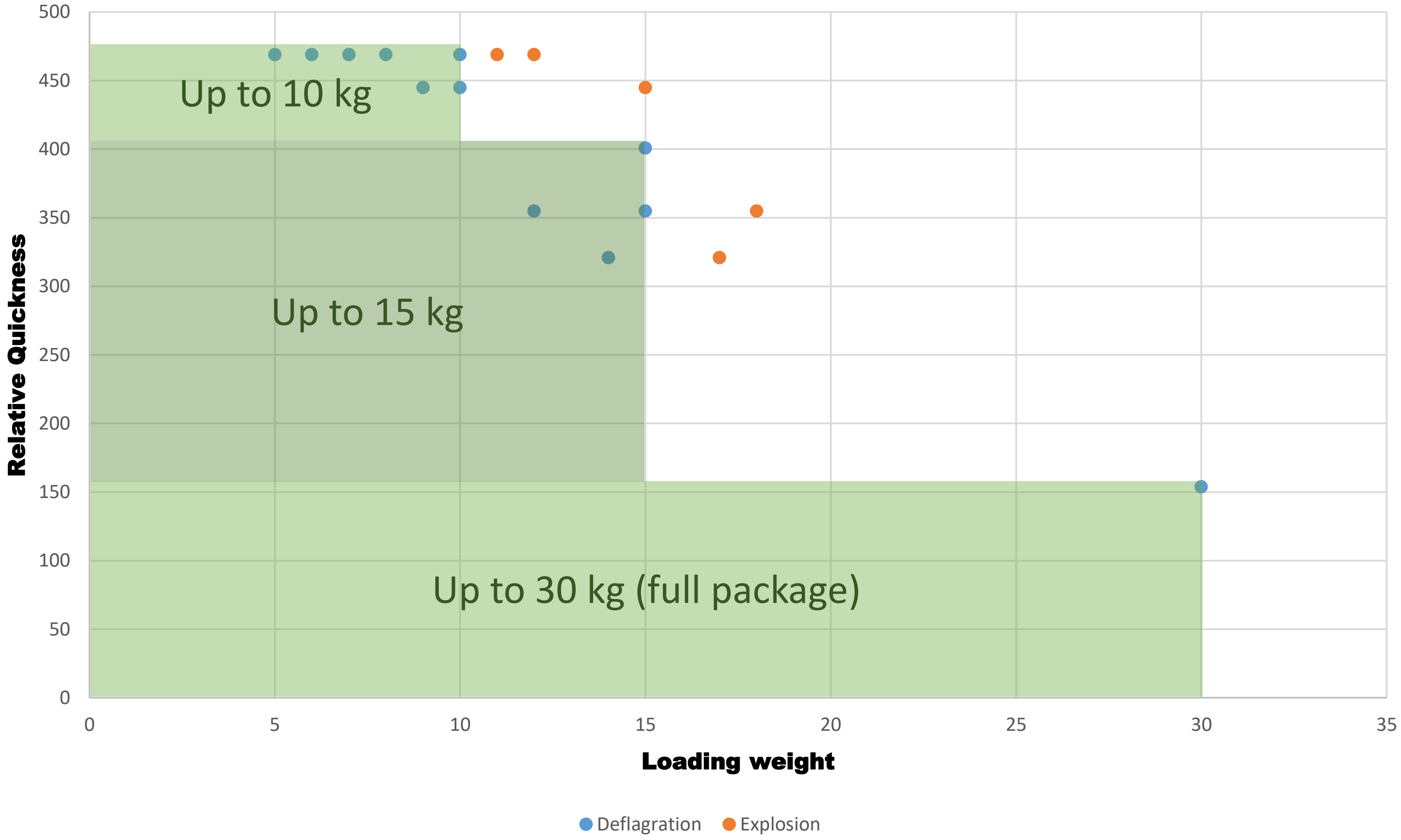
- For higher RQ-values an iteration was performed with increased loading density until a non-1.3C condition was observed.

[redacted]

Test results

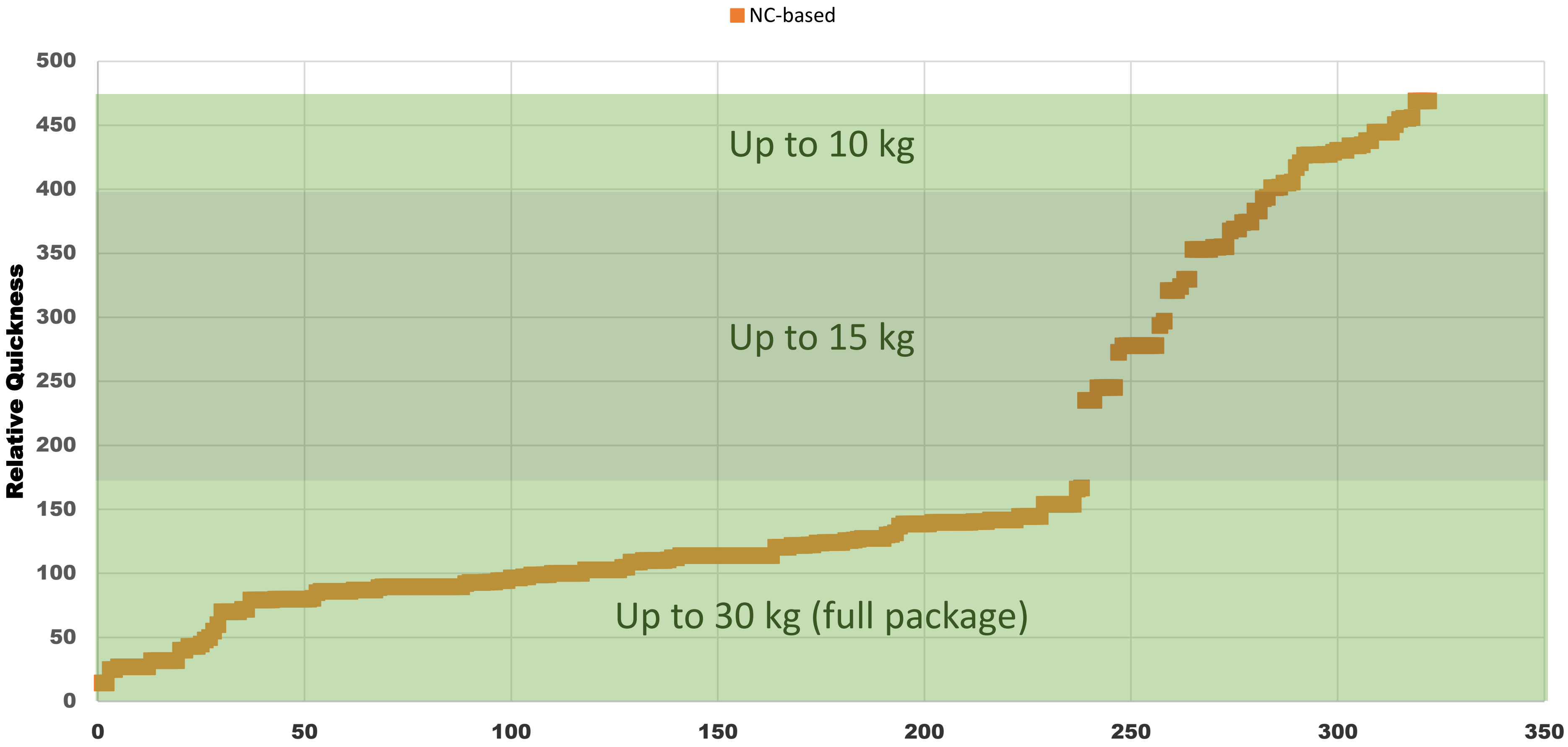


Test results



Test results

- **Emperical model based on RQ value for the propellant**
  - **All propellants arranged by their Quickness value compared to a set reference.**



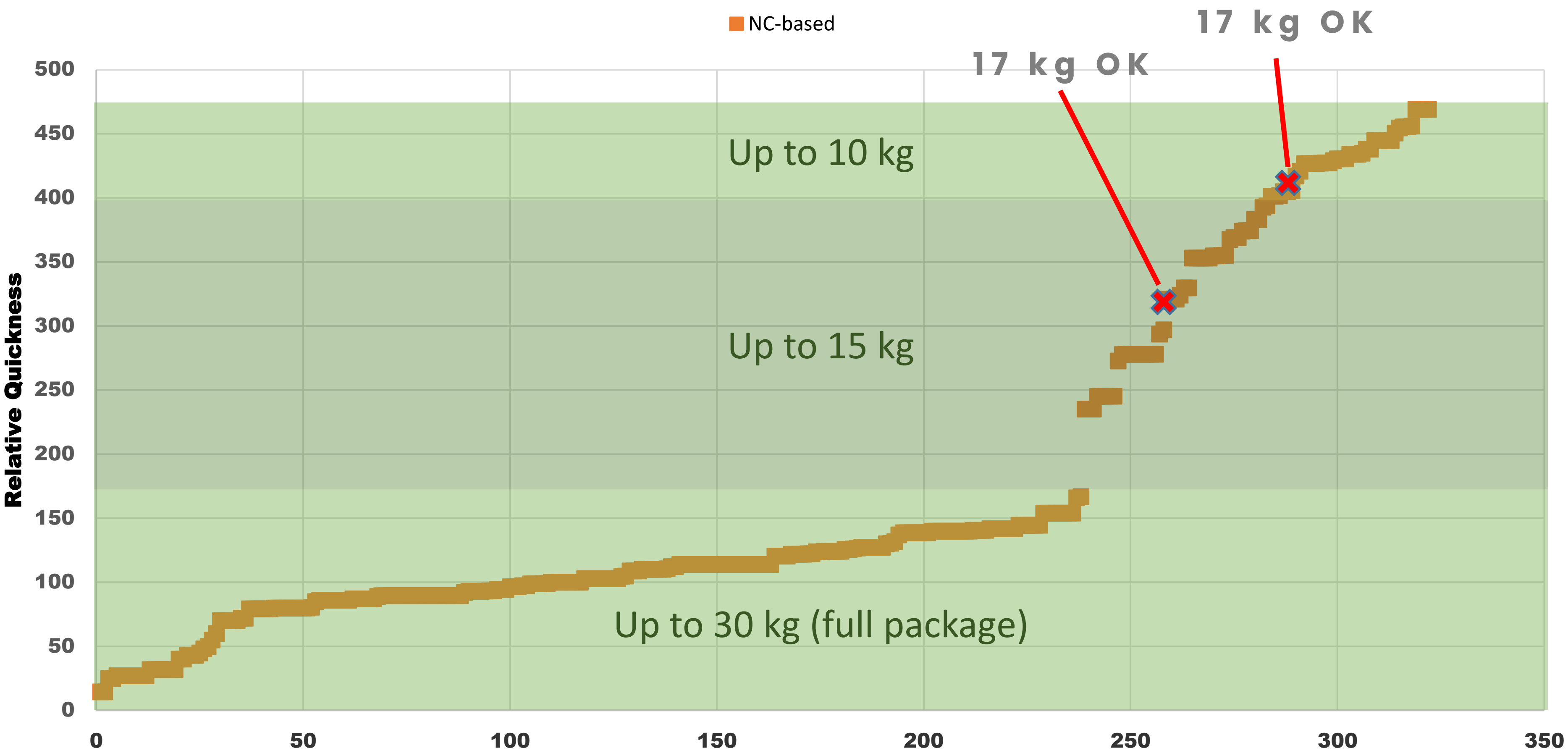
EURENCO
IGNITE YOUR AMBITIONS

Further analysis

- **Other propellant types**
  - **Propellants consists of very different formulations**
  - **During the 6(a) testing it was noticed that these behave differently**
    - The same generic model cannot be used for all ranges of propellant in Karlskoga.

[redacted]

- **Results from other propellant types**
  - High energy double base



Conclusions

- **The test method works very well**
  - Good reproducibility
  - Confinement material could be better defined (moisture content)
  - Easy setup – pre-fabrication possible
- **Methodology is confirmed**
  - Good relation between RQ-value and loading weight
  - Analogy can be used for new propellants with similar compositions
- **Future work**
  - Different propellant types with same RQ-value generate differing weight
  - Extend model to include bulk density?
- **Good co-operation**
  - Our dangerous goods consultant