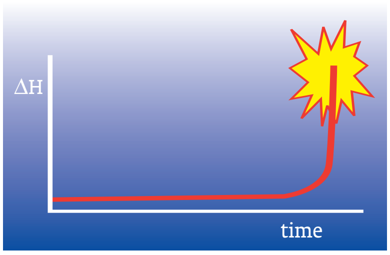
Heat Flow Calorimeter

Stability research of gun propellants by TNO



TNO is assigned by the Netherlands MoD to perform the surveillance of gun propellants used by the Netherlands Forces. For nearly 30 years we are performing this task with a Heat Flow Calorimeter. For the MoD we have developed a testing methodology and each new propellant is measured immediately after purchase and at regular intervals. From the heat production a safe period is calculated. This technique and methodology are accepted by NATO and laid down in STANAG 4582. At the moment we perform the surveillance of about 1400 different propellants and we perform about 500 tests each year.

Specifications

Measuring principle	: Peltier elements
Temperature range	: 50 till 200 °C
Sample vessels	: 15 – 30 – 70 – 500 cm^3
Vessel material	: Stainless steel, with bursting disk

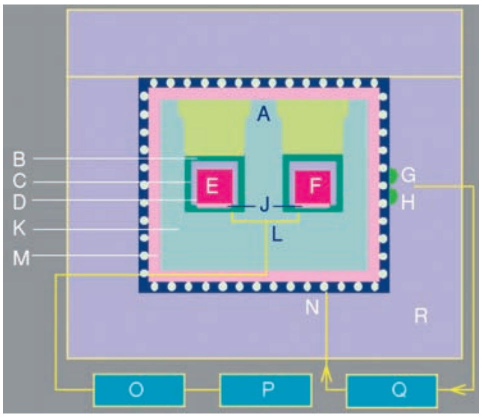
As TNO we would like to emphasise that the HFC technique is not only limited to gun-propellants. Also pyrotechnics or other energetic materials can be measured in the equipment. According to the NATO guidelines (STANAG 4582), this technique is also useful for lifetime prediction of gun propellants and compatibility research.

Stability research is necessary to prevent run-away reactions (explosions) especially on nitro-cellulose based gun propellants because they are:

- intrinsic unstable;
- inhomogeneous materials.

From the resulting HFC curve a safe diameter is calculated. This safe diameter is a parameter for safe storage of ammunition. In formula;

$$D_{344} = -\frac{2.7\cdot\lambda}{2} + \sqrt{\frac{(2.7\cdot\lambda)^2}{4} + \frac{4\cdot RT_a^2\cdot\delta_c\cdot\lambda\cdot\exp\left(\frac{E_a}{R}\left(\frac{1}{T_a}-\frac{1}{T_m}\right)\right)}{\rho_b\cdot E_a\cdot Q_{max}}}$$



Conclusion

The TNO-HFC is applicable in a broad range of energetic materials, especially for the stability research and surveillance applications on gun propellants. The range of four sample vessels covers the whole range of (inhomogeneous) propellant grains.
The HFC technique measures the overall heat generation, so the real ageing processes in the gun propellant instead of only measuring the stabiliser depletion by HPLC.

Advantages of TNO-HFC

- Robustness
- Very useful for surveillance programs
- Low costs in case of problems / explosion
- Easy to repair by (in-house) technician
- Each channel at own preset temperature
- Large vessels, no grinding necessary
- Measuring grains in its original form as “Ammunition like”
- Re-usable vessels
- Pressure build-up allowed, as in closed ammunition
- Measurement under different atmospheres
- Simultaneous measurement of heat generation and pressure (special edition)

Sample vessels

Volume : 15 ml
(intermediate is 30 ml)
Applicable for ball powder and small grains

Volume : 70 ml
Applicable for 7 and 18 holes grains {comparable to volume of STANAG tube}

Volume : 530 ml
Applicable for tubular and stick propellants

TNO Defence, Security and Safety

‘TNO Defence, Security and Safety’ is the title under which TNO operates as a strategic partner for the Dutch Ministry of Defence and makes innovative contributions to enhancing the security of the Netherlands both at home and abroad. We also use our accumulated knowledge for foreign governments and for defence-related industries.

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