

Rapid Screening Device - RSD™ Technical Application Note 211 Stability of Propellants — Effect of Aging



Introduction

High energy materials are an area of study for the RSD where rapid quality-control style analyses may be required. One area of importance is effect of aging and the stability of propellant grains.

The ability of the RSD to evaluate more than one sample at a time is attractive because in a 2-sample configuration an aged and fresh sample may be compared. And of course with the RSD able to take up to 6 samples simultaneously it would be possible to simultaneously compare the fresh sample with samples aged under various regimes.

Also the ability of the RSD to use very low cost disposable sample holders of any size, the technique is attractive and can be simply applied to grains of any size. Testing of 10's of samples a day and simple data analysis allows for very rapid screening.

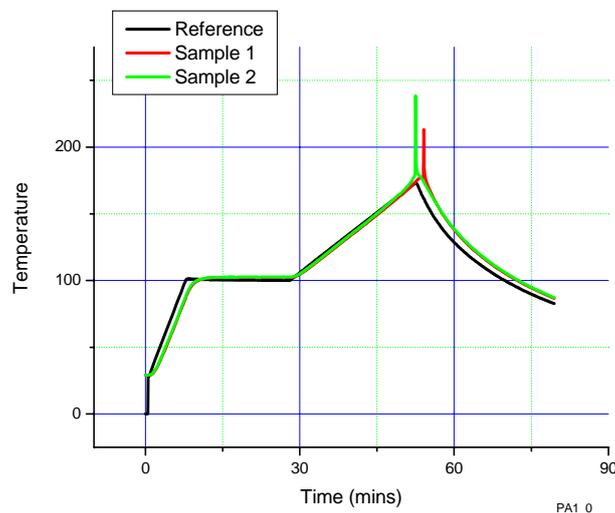
For simplicity the test reported here is of two samples.

Experimental

Two samples, one fresh and one aged of the same propellant were contained in similar tube sample holders. The exothermic reaction was expected above 150°C and therefore the program was to heat rapidly to 100°C (at 10°C/min) to hold isothermal for 20 minutes and then to heat at 3°C/min until sample ignition. This program results in a test time of more than 1 hour. Clearly it would be possible to shorten this considerably. The thermal program was controlled by a thermocouple in the air near to the samples.

Results

The test proceeded according to the program and above 150°C exothermic reaction commenced. This accelerated with temperature until ignition occurred. The associated temperature rise triggered end of test and cooling was switched on automatically.



Temperature and Pressure data plotted against Time

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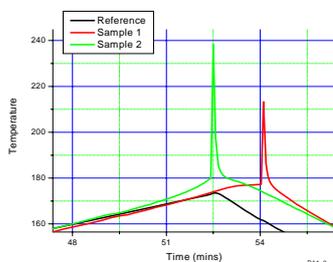
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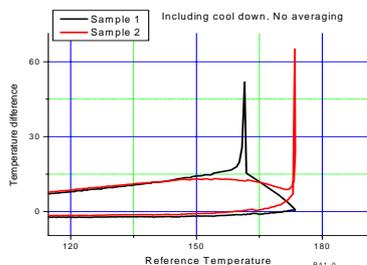
Discussion and Conclusions

The graph shown overleaf illustrates raw data from the RSD but while showing the ignition little else is discernable. The temperature and pressure data together indicate simply the melting and the decomposition. In this pure sample there is no indication of other reactions. Below the two graphs are zoom plots of the temperature against time data.

A zoom of the data before the ignition is very revealing. The fresh sample (Sample 1) follows the reference temperature whilst the aged sample (Sample 2) shows exothermic deviation and ignition prior to ignition of the fresh sample. There is a clear difference in stability.

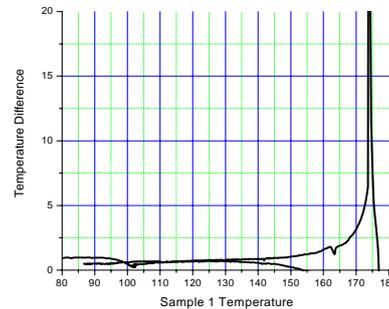


A better representation of this is obtained by plotting the data against temperature. This is shown below.

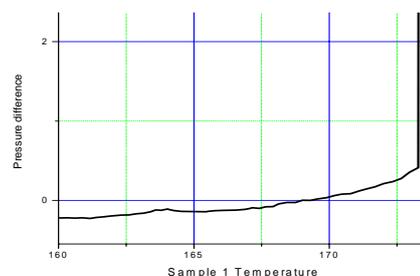


Consider the lower lines in the plots (these represent heating—the upper lines are from cooling). The aged sample deviates from the fresh sample at 160°C

Now taking the temperature difference between fresh and aged samples the graph below shows deviation from nearer 150°C.



The pressure data is also available from all tests. Here the pressure difference between fresh and aged samples is plotted against temperature of reference. Differential pressure rise is seen from 160°C



In conclusion it has been shown that there is a difference in stability between the fresh and aged sample—aging has lowered the stability of the propellant. The RSD has shown the difference in this stability in both temperature and pressure responses. In achieving this information the very high sensitivity of the RSD is seen to be essential as differences between samples are small.

If there is a necessity it would be possible to evaluate a batch of up to 6 samples with turn-round time of approximately 1 hour. In addition, re-usable sample holders have been developed for this work. This was necessary as the samples are typically hard brittle mini-cylinders and the thermocouple must be in contact with the sample. These holders are simple inserts that are of various appropriate diameters. The simple inserts are very cheap, making the running cost insignificant.

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