LTC Gun Propellants for Use in Machine Gun Ammunition

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ABSTRACT

The ammunition now has to be safe in each climate zone especially abroad when carrying out UN missions. For use in a combat aircraft for example the ammunition should have a high cook off stability in order not to undergo a self ignition reaction of the propellant while lying in the hot gun barrel. On the other hand there is still the demand on a high ballistic performance at a low barrel erosion. Accordingly, conventional single and multi base propellants border on their limits.

A new type of propellant solves the problem. Based on RDX, a nitrocellulose binder and a three component energetic plasticizer, this gun propellant disposes of a high ignition temperature of about 210 °C and a significantly improved chemical stability compared with conventional gun propellants. Beside a high force constant at a comparable low adiabatic flame temperature and a low molecular mass of the reaction gases, what in sum is of value in terms of barrel erosion, the novel gun propellant has a further outstanding property: The burning rate hardly depends on the propellant temperature which means that the temperature coefficient in Vieilles burning law is low. That is why we call that propellant a **L**ow **T**emperature **C**oefficient (LTC) propellant.

Because the burning rate does not depend much on the propellant temperature the maximum gas pressure in the gun does not as well. Therefore the maximum permissible gas pressure can be exploited to full advantage what can be used to increase the muzzle velocity.

In the meantime the LTC gun propellant has been investigated successfully in the medium caliber range. The results of that propellant type will be given and be discussed.

INTRODUCTION

The scenarios for use of gun ammunition have changed. Therefore the ammunition now has to be safe in each climate zone especially abroad when carrying out UN missions. For use in a combat aircraft for example the ammunition should have a high cook off stability in order not to undergo a self ignition reaction of the gun propellant while lying in the hot gun barrel. On the other hand there is still the demand on a high ballistic performance at a low barrel erosion. Accordingly, conventional single and multi base gun propellants border on their limits.

A new type of propellant solves the problem [1], [2]. Based on a cristalline explosive, a nitrocellulose binder and a three component energetic plasticizer this gun propellant disposes of a high ignition temperature of about 210°C and a significantly improved chemical stability compared with conventional gun propellants. Beside a high force constant at a comparable low adiabatic flame temperature and a low molecular mass of the reaction gases, what in sum is of value in terms of barrel erosion, the novel gun propellant has a further outstanding property: The burning rate hardly depends on the propellant temperature which means that the temperature coefficient in Vieilles burning law is low. That is why we call that gun propellant a **L**ow **T**emperature **C**oefficient (LTC) propellant. Because the burning rate does not depend much on the propellant temperature the maximum gas pressure in the gun does not as well. Therefore the maximum permissible gas pressure can be exploited to full advantage what can be used to increase the muzzle velocity.

FORMULATION AND PROCESSING TECHNOLOGY

The novel LTC gun propellants consist of a cristalline explosive, a binder and a special plasticizer. Depending on the formulation, the performance data vary on a large scale allowing a wide application in machine gun, tank gun or artillery ammunition [3]. The special feature of these propellants is a high specific energy at a comparatively low adiabatic flame temperature (Table 1). This turns out to be particularly valuable with respect to barrel erosion.

TABLE 1: Performance Data of LTC Propellants

Formulation	Impetus (J/g)	T_f (K)	M* (g/mol)
A	1080	2540	19.4
B	1180	2910	20.8
C	1300	3390	21.6

For processing the LTC propellants the batch technology is used. Based on a batch-mixer and a rampress the propellant strands are pressed through dies.

The improved technology is the continuous process with the co-rotating twin-screw extruder (Fig 1).

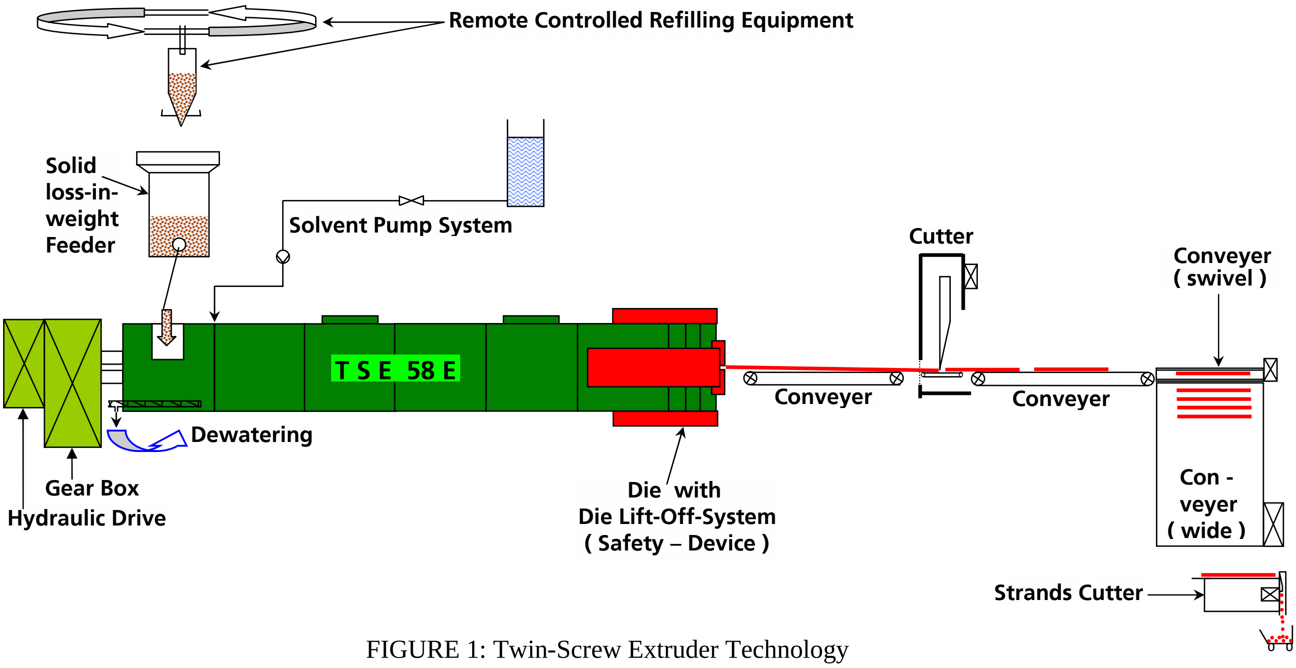

FIGURE 1: Twin-Screw Extruder Technology

CHEMICAL & PHYSICAL CHARACTERISTICS

The safety features of the LTC gun propellants are improved compared to those of the conventional nitrocellulose propellants. The ignition temperature, ranging from about 210 °C to 240 °C, is appreciable higher than that of the nitrocellulose propellants (Table 2). This high ignition temperature has an extremely positive effect on the cook-off temperature of the cartridge.

The chemical stability is also significantly improved in comparison with conventional propellants. The long term stability test at 90 °C after 18 days shows a loss of weight of only 0.80 to 1.10 %. After 30 days the loss of weight ranges between 1.30 and 1.65 %. The required value after 18 days is of the order of 3 % at the most.

The vacuum stability test at 90 °C proved a gas production of about 1.06 ml only.

TABLE 2: Safety data

Loss of weight after 18 days	1.10 %
Loss of weight after 30 days	1.65 %
Sensitivity to friction	160 N
Sensitivity to impact	4 J
Ignition temperature	210 °C

Investigations of M30, JA 2, several single base propellants and a CAB bounded nitramine propellant in the Accelerating Rate Calorimeter (ARC) show a high ignition temperature and accelerating rate for different LTC propellants (Fig 2 and Fig 3).

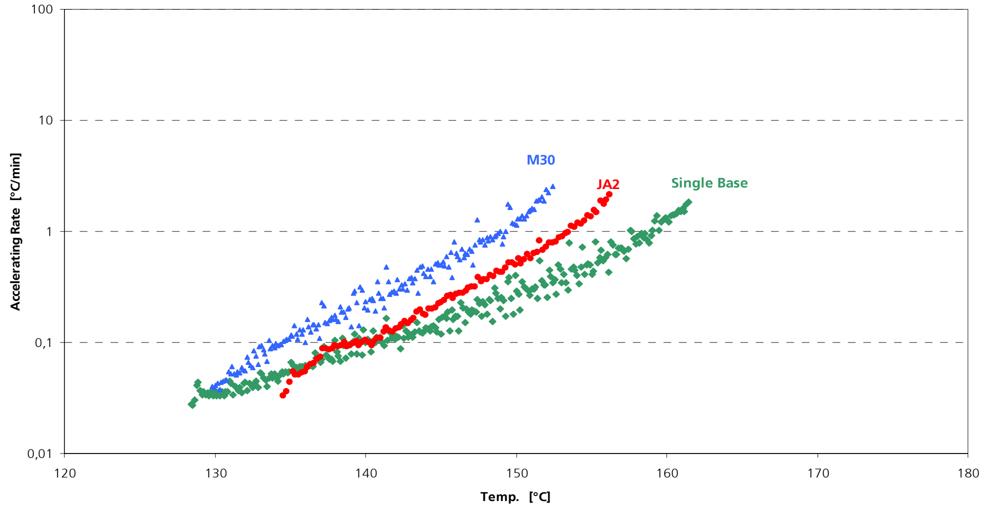

FIGURE 2: ARC measurements

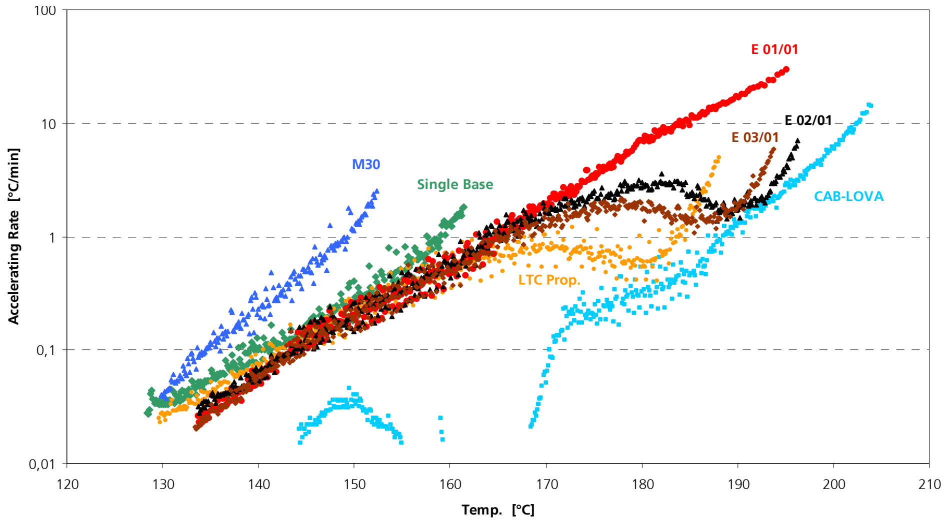

FIGURE 3: ARC measurements

In order to estimate the cook-off temperature of the propellant a special test set up was applied. The test propellant, filled in a steel cartridge case, was heated up by means of heating strips until the propellant ignition occurred. A thermocouple at the outer wall of the cartridge gave the temperature at any point of time.

We found a significantly higher reaction temperature and a longer period of time until the reaction entered for the new LTC propellants compared with conventional single and multibase propellants (Table 3).

TABLE 3: cook-off test results

propellant	temperature	time of period
single base	136 °C	83 s
triple base	150 °C	145 s
LTC 1	185 °C	205 s
LTC 2	204 °C	176 s

INTERIOR BALLISTIC CHARACTERISTICS

Closed vessel firing tests at different temperatures and varying loading densities were carried out in order to examine the combustion behaviour. The dynamic vivacity and the linear burning rate were determined from the measured values. This went to prove the particular temperature behaviour of the novel gun propellants whereupon the linear burning rate did not increase with temperature any longer but, depending on the formulation, remained or even decreased from a treshold temperature on (Fig 5).

For an estimation of the erosivity of the LTC gun propellants closed vessel tests were carried out and the mass loss of a nozzel because of the hot gas flow were measured. We found a dramatically reduced mass loss in comparison with conventional single and multibase propellants especially when compared to those of a similar energy level (Fig 6).

The LTC gun propellants were tested in the calibre 40mm x 365, 35mm x 228 and 27mm x 145. This revealed the high performance of these novel propellants (Fig 7).

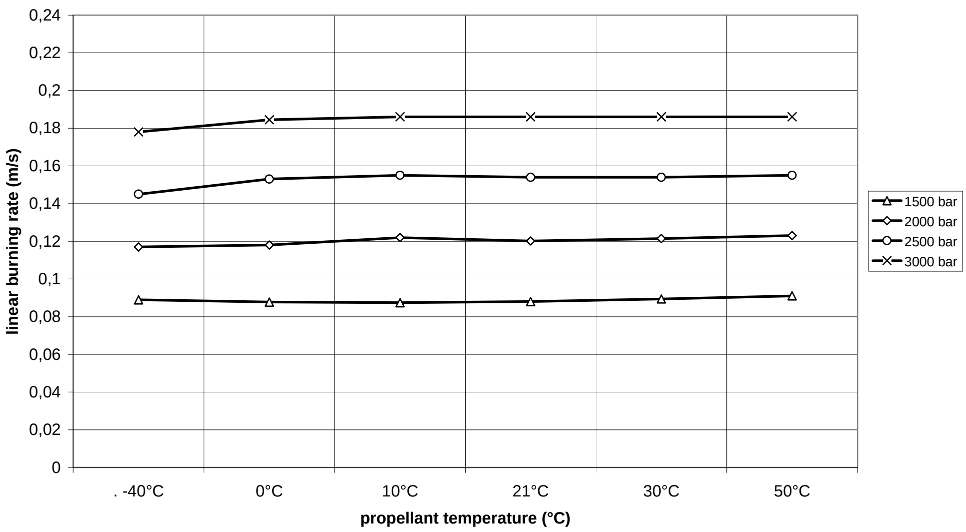

FIGURE 5: Linear burning rate of a LTC propellant at different pressures

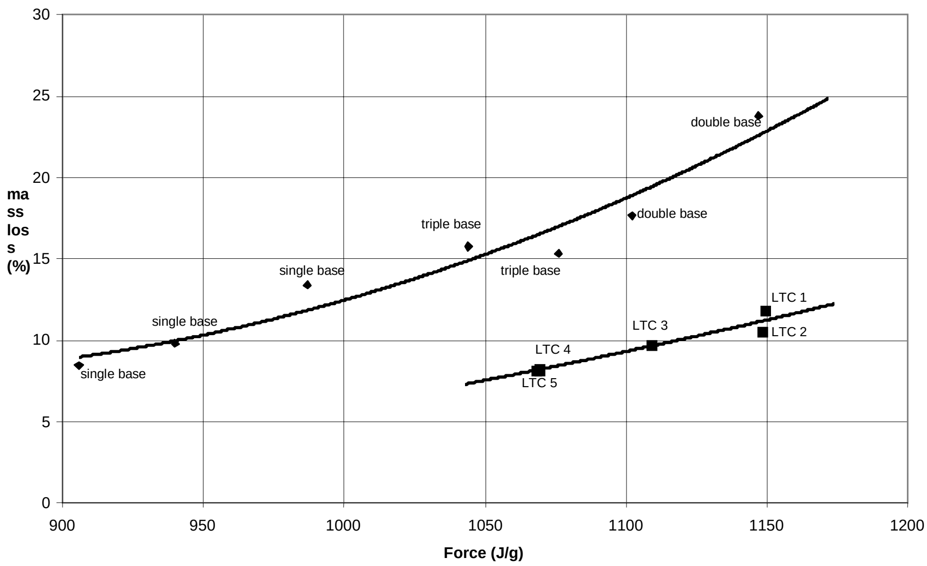

FIGURE 6: Erosivity of LTC propellants

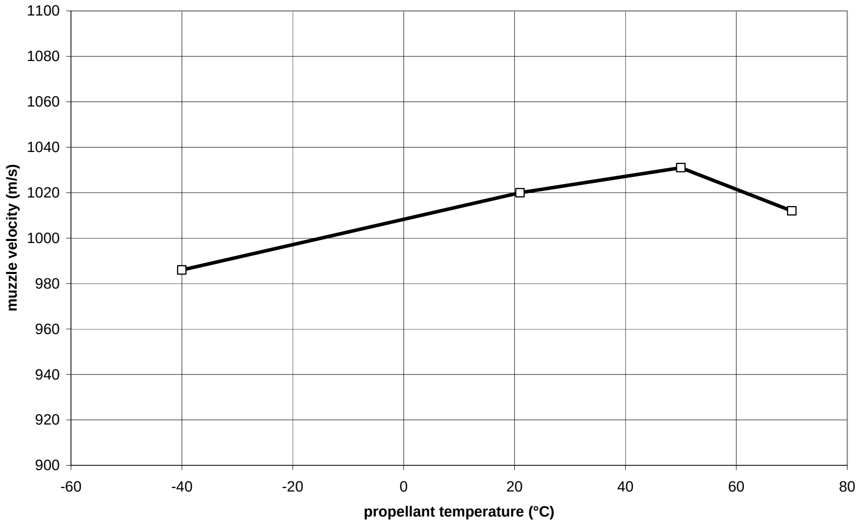

FIGURE 7: gun firing test in calibre 27mm x 145

SUMMARY

The application of a novel plasticizer enables a whole family of propellants to be produced. It is possible to adjust the specific energy of the propellants within a wide range, and, at the same time, the respective flame temperature is considerably lower than what we are used to in case of conventional propellants. On that account new propellants are less erosive than comparable ones. Due to the fact that the ignition temperature of the novel propellants amounts to more than 200 °C, they are well suited for cartridges requiring a high cook-off temperature. That's why these propellants are usable in machine gun ammunition, in tank gun ammunition and in artillery ammunition as well.
Besides their high energy density, which alone can be profitably used for an increase in performance, it is their particular temperature behaviour which produces another, by far more important increase in performance, since the permissible maximum pressure can now be utilized to full advantage.

REFERENCES

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