For isochoric combustion processes, the following parameters (amongst others) can be calculated:

- isochoric heat of combustion Q_v (kJ kg^{-1})
- total pressure in closed systems (bar)
- composition of the combustion products
- specific energy: $F = n\,RT_c$ (J kg^{-1}),

  T_c = isochoric combustion temperature.

Since as far back as even World War II, it has been common knowledge that the erosion of gun barrels leads to two main types of problems:

(i) financial: due to barrel replacement costs over the lifespan of the weapon system

and

(ii) reduced operational effectiveness: due to inconsistent gun performance and availability.

(i) mechanical action,
(ii) heat transfer effects and
(iii) changes in chemical composition.

$$Fe + CO_2 \rightarrow FeO + CO \quad (1)$$

$$3Fe + 2CO \rightarrow Fe_3C + CO_2 \quad (2)$$

$$4Fe + CO \rightarrow FeO + Fe_3C \quad (3)$$

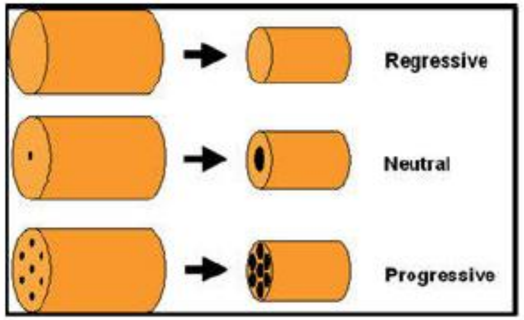
$$5Fe + CO_2 \rightarrow 2\,FeO + Fe_3C \quad (4)$$

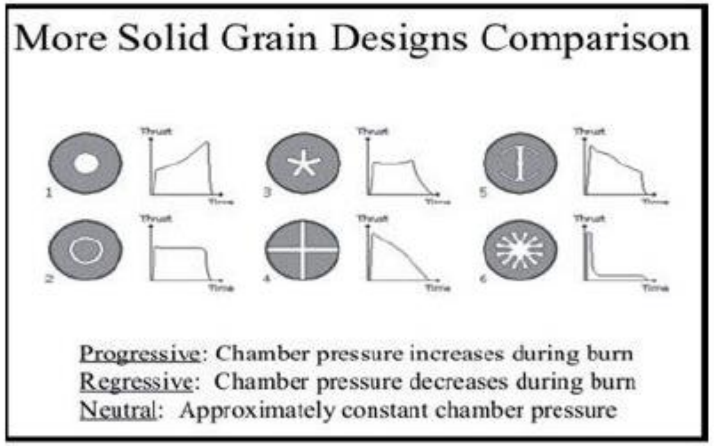
$$CO_2 > CO > H_2O > H_2 > O > N_2$$

The formation of iron nitride (mostly ε-Fe_3N at the surface and Fe_4N in lower layers) as a consequence of nitrogen gas being present in the combustion gases has been established, and it is generally accepted that in contrast to CO_2, CO, H_2O and H_2, nitrogen gas a lowering effect on gun barrel wear. Consequently, it has been proposed that combustion gases which possess a high-nitrogen content could, in fact, contribute to the re-nitridation of the gun barrel and thereby increase the service lifetime by a significant amount (up to a factor of four).

The most common equation of state for interior ballistics is that of Nobel-Abel:

$$p\,(v - b_{\mathrm{E}}) = n\,RT$$





More Solid Grain Designs Comparison

Progressive: Chamber pressure increases during burn
Regressive: Chamber pressure decreases during burn
Neutral: Approximately constant chamber pressure

Fig. 4.4b: Solid grain design (top two figures) and actual grains of manufactured HNP (see Tab. 4.11a) with the following parameters: l = 0.055 inches, outer diam = 0.06 inches, inner diam = 0.03 inches, web = 0.016 inches.

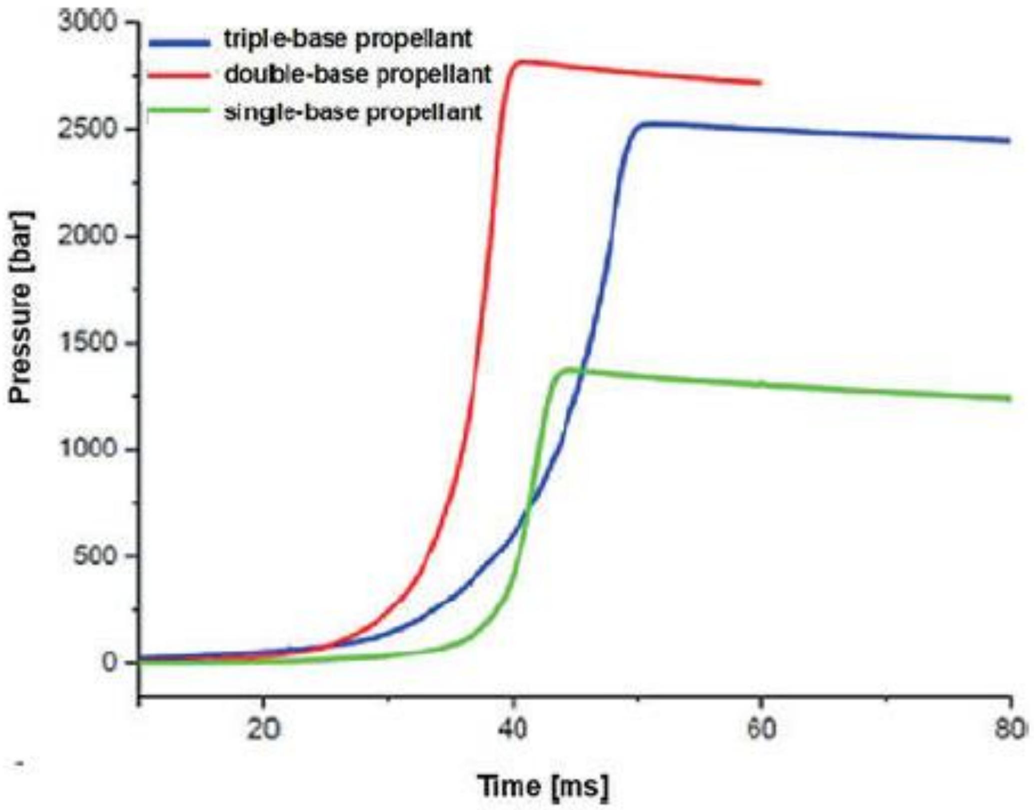


Fig. 4.4d: Pressure-time function of single-, double- and triple-base propellants using the same amounts of powder.

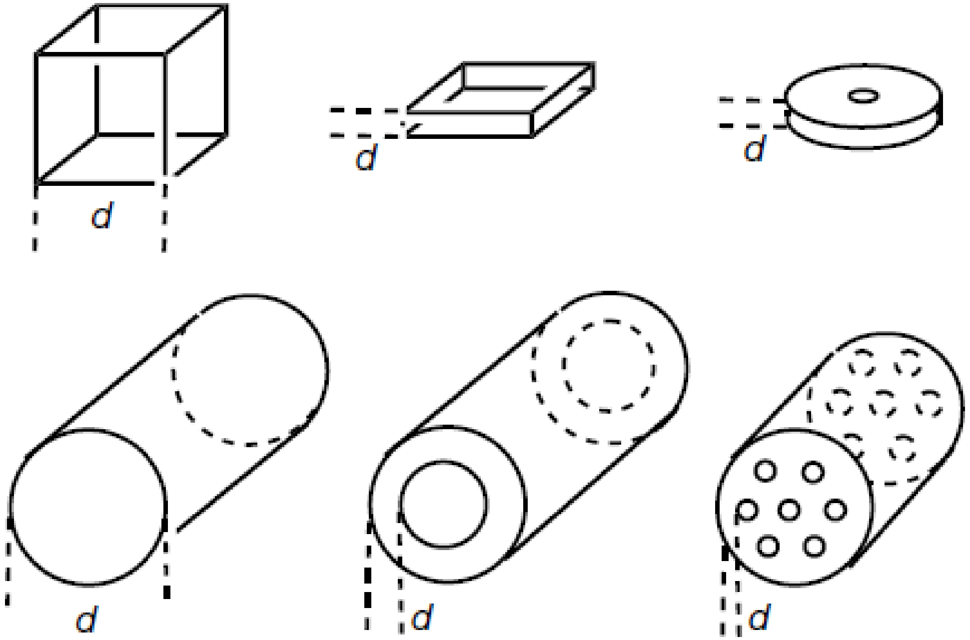


Fig. 4.4e: Smallest distance *d* in different powder geometries.

Here, β depends on the resulting pressure pulse and the powder dimensions (Eq. 3):

$$\beta = \frac{1}{I} \cdot \frac{d}{2} \tag{3}$$

I: pressure pulse, *d:* powder dimensions

Since the dependency of the powder geometry cannot be seen directly from the pressure-time curve, the dependency of the vivacity versus the powder turnover is considered. The vivacity is defined according to Eq. (4):

$$L = \frac{dp}{dt} \cdot \frac{1}{p} \cdot \frac{1}{p_m} \tag{4}$$

L: vivacity, *p:* pressure at the time t, *t:* time and p_m: maximum pressure

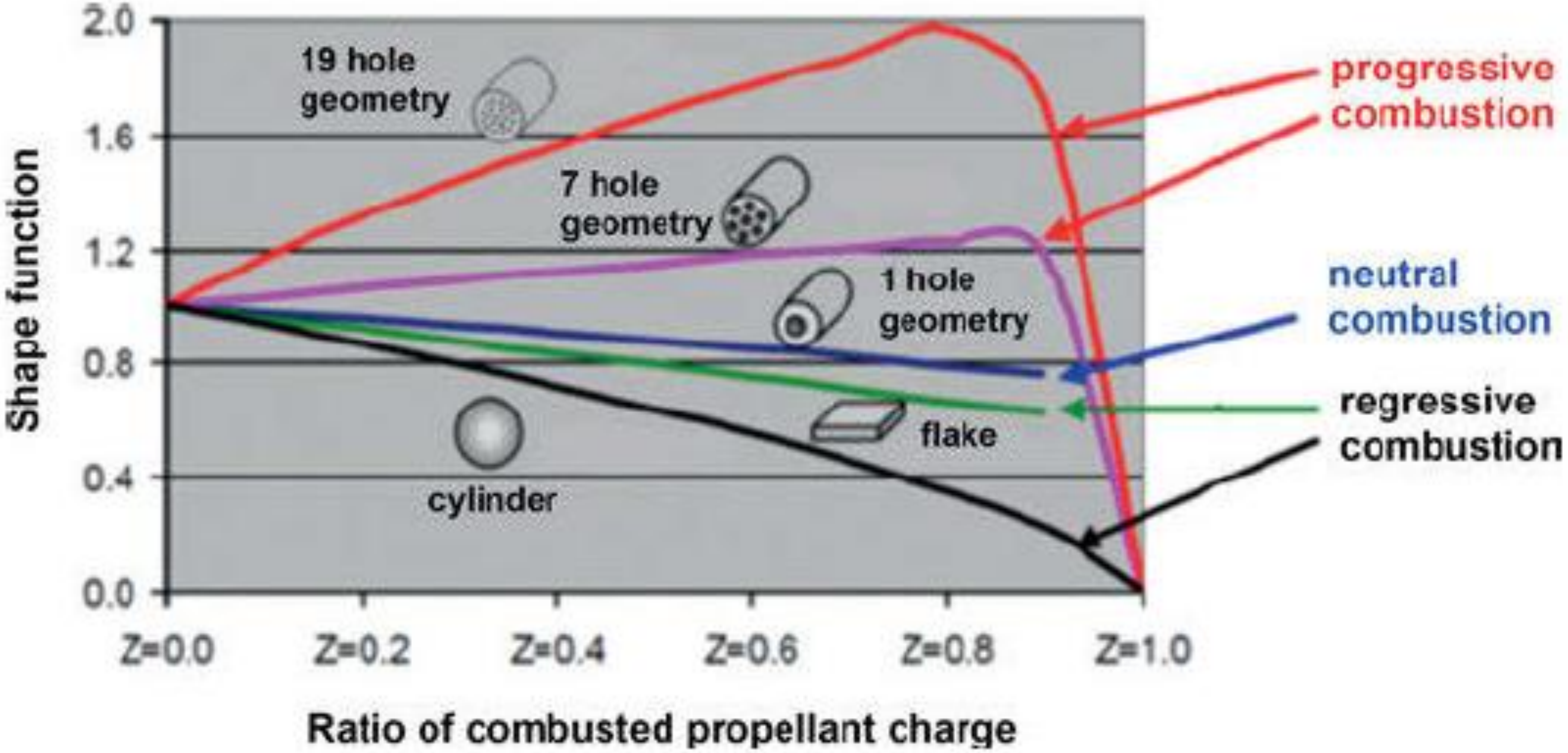


Fig. 4.4f: Schematic presentation of the vivacity of different propellant charge geometries.

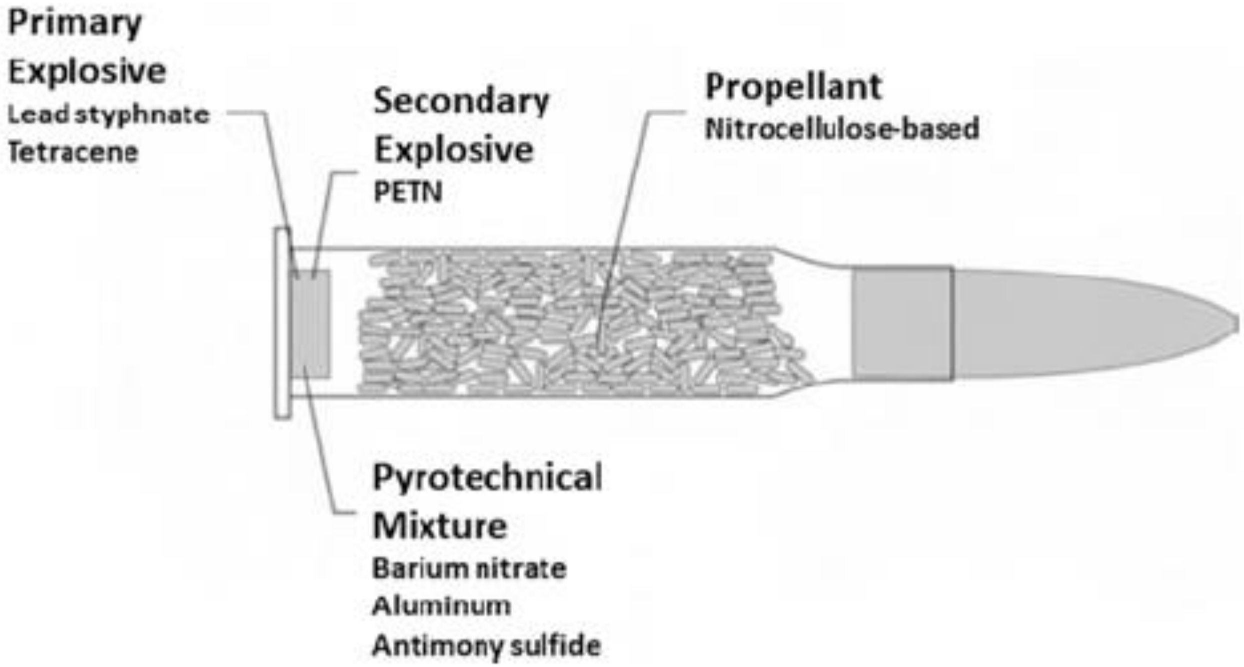


Fig. 4.4g: Typical design of a cartrdge and projectile used in light weapons, e.g. .5 cartridge (12.7 × 99 mm NATO).