IX. PRELIMINARY OBSERVATIONS ON THE EFFECT OF SEATING DEPTH ON MAXIMUM CHAMBER PRESSURE IN THE .30-06 CARTRIDGE

(R. Sinderman, K. Jacob and L. E. Brownell)

A. Reasons for Tests

There was no intent to investigate the effect of seating depth in these preliminary studies. However, the investigation of reported crusher gage values versus pressures determined by strain gage measurements for various loads for the .30-06 cartridge inadvertently introduced the problem of seating depth. One experimental loading involved a charge of 53 grains of IMR 4064 powder used with the 150 gr. Remington SPCL

---

*Receiver No. 614677, U.S. Springfield Armory was used in high-pressure tests.

bullet seated to an overall case length of 3.27 inches to give a reported[4] crusher value of 44,360 psi.* The 220 gr. Remington SPCL bullets used as a standard of reference were round-nosed and for this reason the first firings of the 150 gr. Remington SPCL bullets also used a round-nosed (30-30 type) bullet. The seating depth required to give an overall cartridge length of 3.27 inches gave only about 1/8 of an inch of bullet seat within the case. Firing these rounds produced unexpectedly high pressures in excess of 70,000 psi absolute pressure.

An attempt was made to investigate the unusually high pressures obtained. Remington produces three different 150 gr. SPCL bullets designed for three different seating depths and we first thought that the wrong bullet was being used. The pointed version of the SPCL bullet gives a more reasonable depth of bullet seat in the case for an overall length of 3.27 inches listed by NRA.* Therefore firings loaded with IMR 4064 powder with various seating depths were made with the 150 gr. SPCL (RN) Remington bullet. However, high pressures were still observed over a range of seating depths as shown in Table II and Figure 19. Substituting the pointed SPCL bullet for the round-nosed bullet failed to give a crusher value less than 54,000 psi at any seating depth.

The Du Pont handloading tables for center-fire rifle[1] report that 52.0 gr. of 4064 powder give a crusher value of 49,700 psi. An additional charge of 1.0 grains would be expected to raise the pressure possibly 3,000 to 5,000 psi. Other loading sources such as The Speer Handbook[12] and P. O. Ackley[13] indicate that 53 grains of 4064 powder and a 150 gr. bullet is approximately maximum for the 30-06 cartridge. The pressure reported by NRA for this load appears to be low.

To compare the observations on seating depth with data obtained on IMR 3031 powder and the 220 gr. Remington SPCL bullet a second series of preliminary tests were made as described in Table III and shown in Figure 20.

B. Discussion

Two opposing factors influencing the chamber pressure are believed to be involved if bullets are seated at various depths with a given charge of powder. One effect is that of change in the volume of

*This material is reprinted from THE AMERICAN RIFLEMAN, official journal of the National Rifle Association of America, 1600 Rhode Island Avenue, N.W., Washington 6, D.C. THE AMERICAN RIFLEMAN goes monthly to the more than one-half of a million NRA members. Membership is available to citizens of good repute.

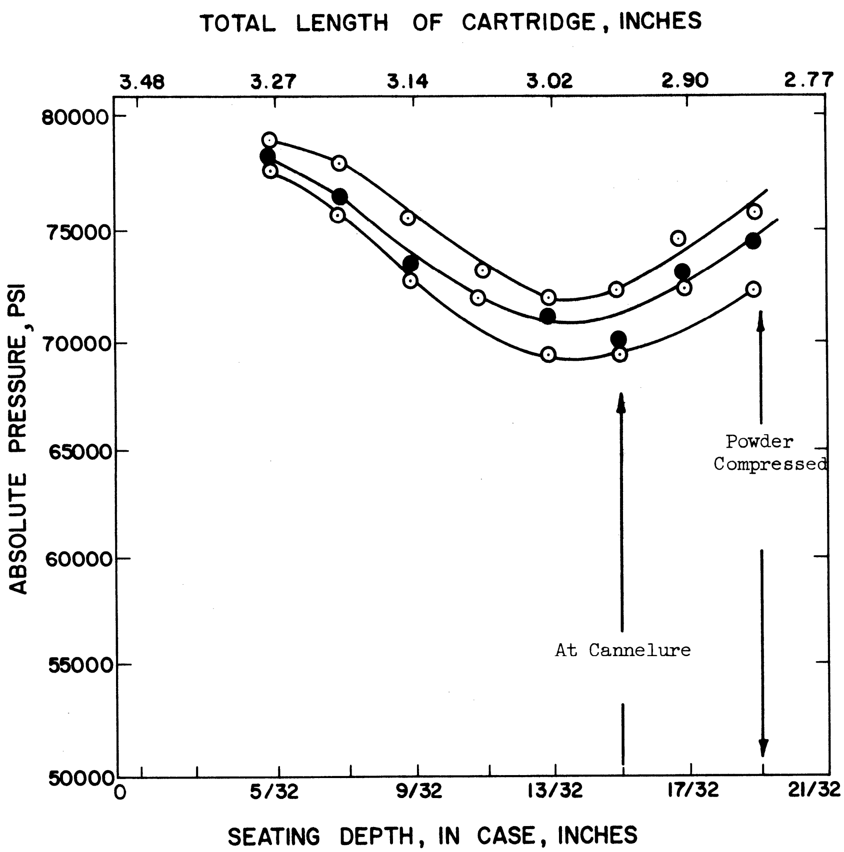

Fig. 19. Effect of Seating Depth on Maximum Chamber Pressure for 150 gr. Rem.SPCL (RN) Bullet and 53.0 gr. IMR 4064 Powder.

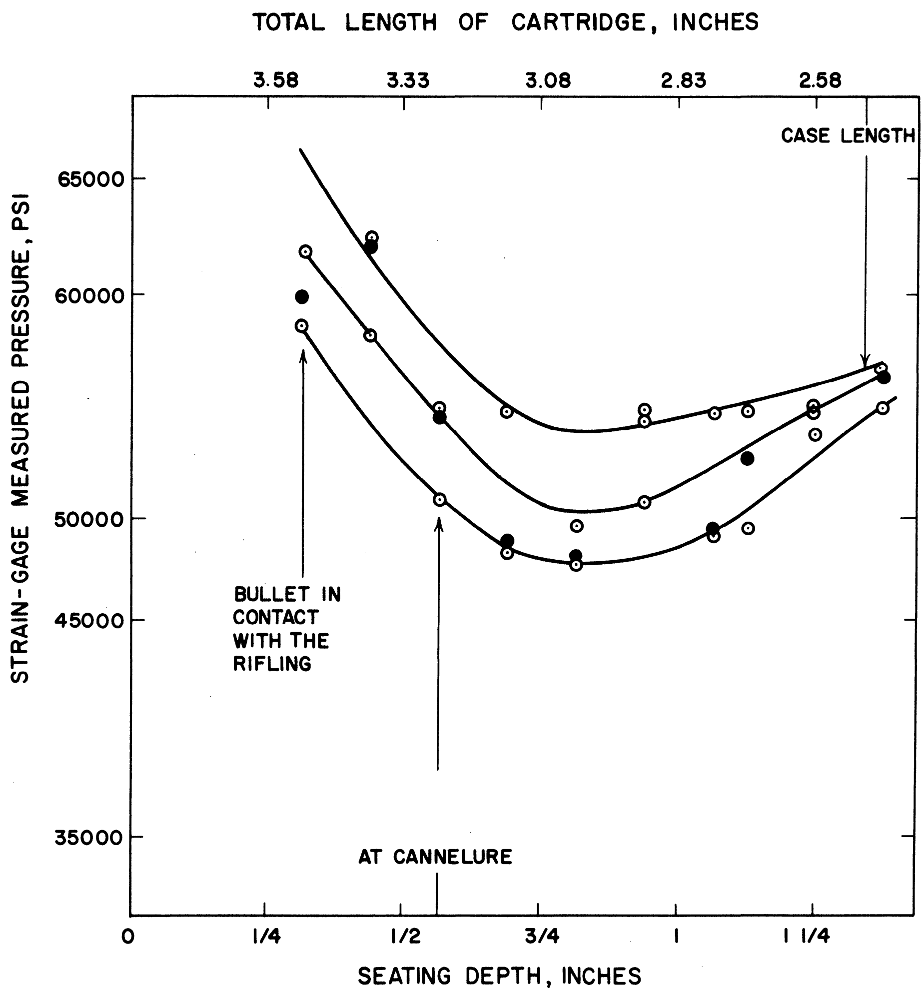

Fig. 20. Effect of Bullet Seating Depth on Maximum Chamber Pressure for 220 gr. Rem. SPCL Bullet and 38 gr. IMR 3031.

TABLE II

Preliminary Data on Seating Depth for 150 Gr. Rem. SPCL Bullet in 30-06 Cartridge and 53 Gr. IMR 4064 (RN Bullet)

Total Cartridge Length (In)	Seating Depth from Cannelure (In)	Absolute Pressure P_{max}, (psi.)	Deviation from Median (%)	Total Cartridge Length (In)	Seating Depth from Cannelure (In)	Absolute Pressure P_{max}, (psi.)	Deviation from Median (%)
3.27	5/16" out (5/32" in case)	77,500 78,000 78,700	-0.3 0.0 +0.3	3.02	1/16" out (13/32" in case)	71,400 71,000 68,500	+0.0 0.0 -1.5
3.21	4/16" out (7/32" in case)	76,000 78,500 76,100	0.0 +1.2 -0.0	2.96	At Cannelure (15/32" in case)	70,000 69,500 69,500	+0.2 0.0 -0.0
3.14	3/16" out (9/32 in case)	73,000 73,500 75,500	-0.3 0.0 +1.8	2.90	1/16" in (17/32" in case)	74,500 71,000 71,000	+2.2 0.0 -0.0
3.08	2/16" out (11/32 in case)	73,500 72,500 73,500	0.0 -0.7 +0.0	2.84	1/8" in (19/32" in case)	75,300 73,300 71,200	+1.4 0.0 -1.4

TABLE III

Preliminary Data for Seating Depth Firings Using 30-06 Cartridge Loaded with 38 Gr. 3031, 220 Gr. Rem. SPCL Bullets and Rem. Cases

Total Cartridge Length (In)	Seating Depth from Cannelure (In)	Absolute Pressure P_{max}, (psi.)	Deviation from Median (%)	Total Cartridge Length (In)	Seating Depth from Cannelure (In)	Absolute Pressure P_{max}, (Psi.)	Deviation from Median (%)
2.47	13/16" in (22/16 in case)	56,200 55,500 55,100	+0.4 0.0 -0.4	3.01	4/16" in (13/16" in case)	49,000 48,100 47,200	+1.3 0.0 -1.3
2.59	11/16" in (20/16" in case)	53,300 54,000 54,600	-0.6 0.0 +0.6	3.14	2/16" in (11/16" in case)	48,400 48,400 54,400	0.0 0.0 7.2
2.65	10/16" in (19/16" in case)	53,800 53,800 53,800	+0.0 0.0 -0.0	3.26	At Cannelure 0" in (9/16" in case)	50,400 52,400 54,400	-2.1 0.0 +2.1
2.71	9/16" in (18/16" in case)	52,200 53,300 54,400	-2.1 0.0 +2.1	3.38	1/8" out (7/16" in case)	58,100 62,200 62,200	-3.5 0.0 0.0
2.77	8/16" in (17/16" in case)	49,000 49,000 54,400	0.0 0.0 5.3	3.50	1/4" out (5/16" in case)	59,500 61,600 58,400	0.0 0.0 0.8
2.89	6/16" in (15/16" in case)	50,400 54,400 54,000	-3.7 +2.0 0.0				

the case to the bullet base. Boyle's Law for gases states that if the temperature is not varied the pressure of a confined gas times its volume remains a constant. Or, stated as an equation:

$$P \times V = C$$

where

P = gas pressure, psi,

V = volume of confined gas, cu. in. and

C = is a constant which depends on the mass of the gas, (grains), the temperature of the gas, and the average molecular weight of the gases produced by burning of the powder.

For a given type of powder, the temperature of the powder gas versus fraction of powder charge burned and the average molecular weight of the gases may be considered to be fairly constant. Therefore, the mass of the gas will be determined mainly by the weight of powder burned. If a given per cent of the charge is burned the larger charge will produce a greater pressure; i.e., if a charge of 40 grs. of a certain powder is used, one would expect to get a larger number for the constant than if 30 grs. of the same powder were used. Also, if one were to increase the temperature of the confined gas, the product of the pressure and volume would increase (according to Charles' Law) thereby increasing the constant, C .

The second effect is termed gas leakage. In most rifles the bullet is allowed to travel some distance before engaging the rifling of the barrel. This distance is termed "free-travel distance". Some gas will leak past the bullet after the rise in chamber pressure expands the neck of the cartridge case but before the bullet starts to move. In other words, some of the gases produced by the burning powder actually enter the barrel before the bullet during the period of the "free-travel" of the bullet and before it is forced tightly into the rifling. High-speed photography has been used to record this phenomenon and show that a small portion of the powder gases actually come out of the muzzle before the bullet. The egress of initial volume of gas is followed by the bullet and then by the major volume of powder gas.

The data on the series of firings for the 150 gr. Remington SPCL bullets loaded with a charge of 53 gr. of IMR 4064 powder are shown in Table II. Because of the larger volume of this larger charge it was impossible to seat the bullet more than 3/16 inch into the case from the cannelure. Also, because of the shorter length of the bullet it was impossible to seat the bullet out far enough to engage the rifling. However, the two opposing effects were still observed as shown in Figure 19. The chamber pressure reached a minimum value when the bullet was seated out 1/16 inch from the cannelure; but if the bullet was seated 5/16 inch out or 3/16 inch in from the cannelure a higher maximum pressure was produced. This indicates that the minimum value for maximum chamber pressure can be expected to be different for different powder charges and bullet weights.

A difference of about 6,250 psi was observed between the minimum and maximum values of absolute maximum chamber pressure.

In the second series of tests a 220 gr. Remington SPCL bullet was used with a charge of 38 grs. of IMR 3031 powder. The charge of 38 grs. of IMR 3031 produces a moderate pressure when the bullet is seated at the cannelure. The effects on pressure of the extremes of seating the bullet: (1) out to the rifling, and (2) in to the point of powder compression were not known, therefore, a reduced load seemed advisable. The reduced charge of 38 grains also permitted seating the bullet completely into the case without causing the powder grains to be excessively compressed or to be partially broken.

Bullets were seated over a range from 1/4 inch out from the cannelure to 13/16 inch from the cannelure. Seating the bullets out 1/4 inch actually engaged the 220 gr. Remington SPCL bullets with the rifling when the bolt was closed. This seals the barrel so as to produce a minimum of gas leakage past the bullet. Consequently, essentially all of the gases produced by the burning of the powder contributed to increase of the pressure in the chamber. This tends to produce a higher maximum chamber pressure in spite of the slightly larger case volume produced by seating 1/4 inch out from the cannelure.

At the other extreme of seating the bullets were pushed into the case 13/16 inch past the cannelure. The bullet at this seating must travel about 1-1/16 inches of "free-travel" before engaging the rifling. An increase in pressure again was noted. This is a result of Boyle's Law effect. When the bullet is seated into such an extreme the case volume is reduced to such an extent that the pressure increases in spite of the greater leakage of gas.

Intermediate seating depths produced intermediate pressures as shown in Figures 19 and 20. Figure 20 for IMR 3031 powder and 220 Remington SPCL bullets indicate that the pressure reaches a maximum at the smallest seating depth of 1/4 inch with the bullet in contact with the rifling. As the seating depth of the bullet is increased pressure decreases due to the gas leakage past the bullet into the rifle barrel. Boyle's Law would predict that the pressure would rise because of the decrease in volume, but apparently this is overshadowed by the gas leakage past the bullet. The chamber pressure appears to reach a minimum value at a seating depth of about 1/4 inch in from the cannelure. This corresponds to a total bullet seating depth of 13/16 inch. At greater seating depths the pressure rises again. This rise in maximum chamber pressure, as stated previously, is believed to be due to the predominence of Boyle's Law effect. Though considerable gas is leaking past the bullet, gas leakage is now overshadowed by the large decrease in the case volume to the base of the bullet. This decrease in case volume increases the maximum pressure rapidly as shown by Figure 20. The maximum pressure is over 5,000 psi greater than the minimum value produced with the bullet seated 1/4 inch in from the cannelure. On the other hand the maximum pressure increases about 10,000 psi above this minimum when the bullet is seated out so that it engages the rifling. Thus, some danger of excessive pressure is involved if seating depths are used which differ appreciably from those used in loadings known to be safe.

X. THE PRESSURE "HORN"

A. Reproducibility of Replicate Firings

Measurements made with the strain gage and oscilloscope equipment indicate a good reproducibility of the absolute maximum chamber pressures if the powder charge is sufficient to produce a crusher value of about 50,000 psi or more. This is indicated by the data for P_{max} in Tables II and III. In Table II the absolute pressure for each selected seating depth seldom varied more than 400 psi. However, the absolute pressures ranged from 68,500 to 78,700 depending upon the seating depth. The variation for each seating depth corresponds to a pressure deviation of about 1 per cent in most cases. All but 2 of 22 firings have pressure variations less than 1.8 per cent and the maximum observed was 2.2 per cent.

As the maximum pressure is decreased the spread in value of P_{max} for replicate firings begins to increase as is indicated by Table III where the absolute pressure values range from 47,200 psi to 62,200 psi.

sure