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In order to determine the energy in the bolt plug the following information is required:

- Weight/Mass of part
- Velocity of part

The weight was measured on a precision scale as 155.1 Grains. This can be converted to mass units by converting grains to pounds and then using the equation $W = mg$ where W is weight in lbs., m is mass in lbs.-sec.²/ft. and g is acceleration due to gravity in ft./sec.²:

$$155.1 \text{ Grains} * (1 \text{ lb./7000 Grains}) / (32.174 \text{ ft./sec.}^2) = .0006887 \text{ lb.-sec.}^2/\text{ft.}$$

The average velocity is determined from the distance traveled divided by the time required to travel this distance. A string was used to determine the distance from the original location of the part on the rifle to the hole in the first sheet of paper. This distance was measured to be 19.75 inches. The time required to travel this distance was taken from the high speed movie and was determined to be .040 sec.

The calculated average velocity of the bolt plug was:

$$V_{\text{avg.}} = \Delta S / \Delta t = 19.75 \text{ in.} / .040 \text{ sec.} = 494 \text{ in./sec. or } 41.15 \text{ ft./sec.}$$

From this data the calculated kinetic energy could be determined by the equation:

$$K.E. = \frac{1}{2} * \text{Mass} * \text{Velocity} * \text{Velocity} = \frac{1}{2} * m * V^2$$

$$K.E. = \frac{1}{2} * (.0006887 \text{ lb.-sec.}^2/\text{ft.}) * (41.15 \text{ ft./sec.}) * (41.15 \text{ ft./sec.}) = .58 \text{ lb.-ft.}$$

For comparison purposes this same kinetic energy level can be obtained by dropping the same bolt plug piece a distance of 26.3 ft. or dropping a 1 lb. weight a distance of .584 ft. (7 inches). This was calculated using the relationship between kinetic energy and potential energy assuming no loss in velocity due to air resistance.

For comparison purposes a table was generated listing kinetic energy levels of other common projectiles.

Description	Kinetic Energy (lb.-ft.)
Bolt Plug from obstructed bore test	.58
BB fired from a Daisy Red Ryder (at the muzzle)	1.00
50-Grain paintball fired at 300 ft./sec.	10.40
150 Grain .30-06 caliber bullet (at the muzzle)	2820.00

In conclusion the calculated bolt plug kinetic energy is approximately 1/2 (50 %) of a BB fired from a BB gun, 1/20th (5 %) of a paintball fired at maximum allowable velocity and 1/4862 (.02 %) of a 150 grain .30-06 caliber bullet at the muzzle.

Jan. '01 Trial & Pilot Test - Remington M710 Centerfire Rifle;
R & D Technical Center Project No. 241039; T1.W 0300
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