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2 - Introduction

The muzzle velocity is one of the most important features of any weapon.

According some legislations the muzzle velocity or the muzzle energy defines also the legal class in each rifle must inserted.

In Europe, appears to have been established 2 main standards concerning air-rifle's power: 7,5 Joule and 12 Ft-lbs. German and British references respectively.

Both standards have in common that below each ones the air-rifle's acquisitions are free.

For higher powers, a special licence is required before buying an air-rifle. By this way the FAC word (Fire Arms Certificate) became synonymous of "high-power air-rifle" around the world.

3 - Objective

The main goal of this study is the analyses of the muzzle velocity and muzzle energy variation in a "springer" air-rifle using pellets with different weights and profiles.

4 - Procedure

For data acquisition, the following procedure had been performed:

1) Evaluate electronically the weight of the pellet
2) Reset chronograph
3) Charge and cock the rifle with the evaluated pellet
4) Aim to a safe direction
5) Shoot it!
6) Note the muzzle velocity of the shot from the chronograph
7) Wait 60 sec.
8) Repeating the upper steps 10 times for each different model of selected pellets

After that, a simple statistic analyses had been performed as well as the energy calculated using the well-know kinetic energy formula:

$$E(J) = \frac{M(g).V(m/s)^2}{2000}$$

Considerations and conclusions had been made after performing all the tasks above described.

5 - Hardware

To “do the job”, the following items had been selected:

1) WEIHRAUCH HW-97K cal. 4,5mm (.177) S/N: 1642352, one of the best known “springer” air-rifle of the market. “Zero-Shot” rifle, brand new. Factory declared top muzzle velocity of 290 m/s (950 Ft/s).
2) Selected pellets:
   - A - Haendler & Natermann Diabolo Sport
   - B - Dynamit Nobel Geco
   - C - Gamo Match
   - D - Weihrauch Magnum
3) “GSC SNUG-300” high precision electronic scale
4) “Combro CB625 Mk4” Chronograph
5) Safe and soft target able to prevent pellet’s ricochet
6) Scientific-Oregon weather station
7) Personal computer with worksheet software

6 - Environmental conditions

- Atmospheric air temperature 17,5º C
- Relative humidity 60%
- Atmospheric pressure 999 mBar
- 232 m above sea-level

7 - Data and Calculus

The data and calculus above had been obtained following the described procedures:

7.1 - Haendler & Natermann Diabolo Sport

H&N Sport				
Shot	**Weight (g)**	**V0 (m/s)**	**E (J)**	**E (ft-lbs)**
1	0,53	283,3	21,27	15,69
2	0,51	284,3	20,61	15,20
3	0,54	262,6	18,62	13,73
4	0,51	290,9	21,58	15,92
5	0,53	288,1	22,00	16,22
6	0,54	283,3	21,67	15,98
7	0,50	315,0	24,81	18,30
8	0,52	287,1	21,43	15,81
9	0,50	303,0	22,95	16,93
10	0,53	282,3	21,12	15,58
Average	**0,52**	**287,99**	**21,61**	**15,94**
Standard Deviation	***0,014***	***13,034***	***1,500***	***1,106***

7.2 - Dynamit Nobel Geco

DN Geco				
Shot	**Weight (g)**	**V0 (m/s)**	**E (J)**	**E (ft-lbs)**
1	0,46	272,4	17,07	12,59
2	0,46	272,4	17,07	12,59
3	0,47	269,0	17,00	12,54
4	0,45	272,1	16,66	12,29
5	0,45	272,7	16,73	12,34
6	0,47	268,4	16,93	12,49
7	0,45	273,0	16,77	12,37
8	0,46	266,9	16,38	12,08
9	0,45	273,3	16,81	12,40
10	0,46	274,6	17,34	12,79
Average	**0,46**	**271,48**	**16,88**	**12,45**
Standard Deviation	***0,007***	***2,357***	***0,252***	***0,186***

7.3 - Gamo Match

GAMO Match				
Shot	**Weight (g)**	**V0 (m/s)**	**E (J)**	**E (ft-lbs)**
1	0,49	260,6	16,64	12,27
2	0,49	260,6	16,64	12,27
3	0,49	270,0	17,86	13,17
4	0,49	259,2	16,46	12,14
5	0,49	258,0	16,31	12,03
6	0,49	260,9	16,68	12,30
7	0,49	258,9	16,42	12,11
8	0,49	277,4	18,85	13,91
9	0,49	259,7	16,52	12,19
10	0,49	268,7	17,69	13,05
Average	**0,49**	**263,40**	**17,01**	**12,54**
Standard Deviation	***0,000***	***6,085***	***0,797***	***0,587***

7.4 - Weihrauch Magnum

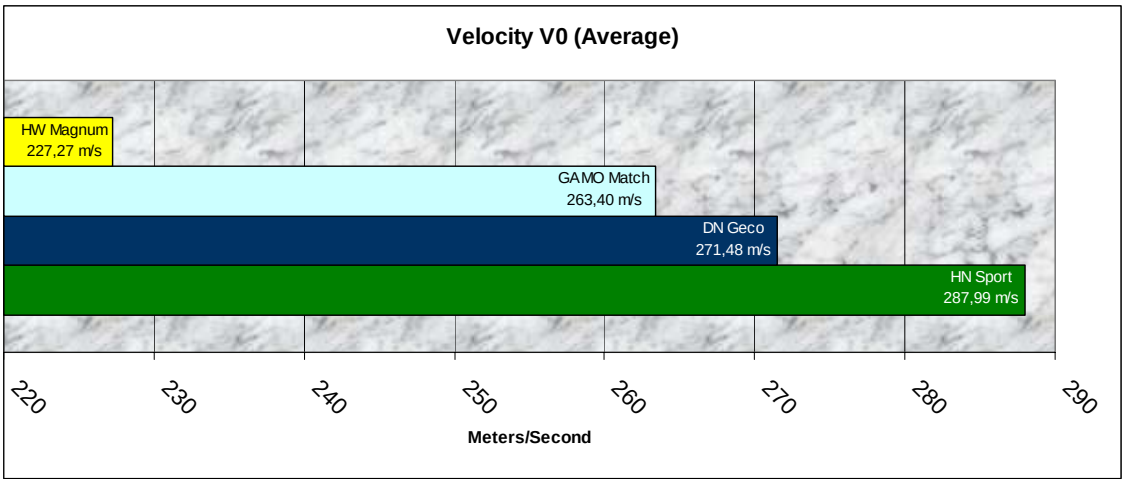
HW Magnum				
Shot	**Weight (g)**	**V0 (m/s)**	**E (J)**	**E (ft-lbs)**
1	0,68	235,0	18,78	13,85
2	0,67	242,6	19,72	14,54
3	0,67	224,9	16,94	12,50
4	0,68	217,0	16,01	11,81
5	0,67	226,2	17,14	12,64
6	0,67	226,4	17,17	12,66
7	0,67	233,7	18,30	13,49
8	0,68	212,6	15,37	11,33
9	0,67	235,7	18,61	13,73
10	0,67	218,6	16,01	11,81
Average	**0,67**	**227,27**	**17,40**	**12,84**
Standard Deviation	***0,005***	***9,003***	***1,336***	***0,986***

The environmental conditions remained constants all across the test.

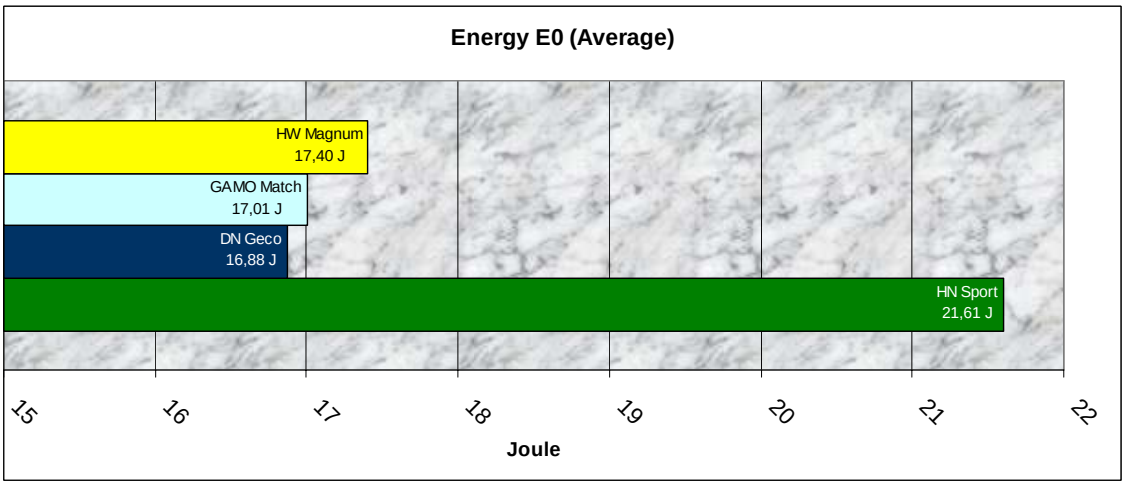
8 - Results analyses

To show clearly and compare easily the results obtained by the measures and calculations done, the following graphics had been processed:

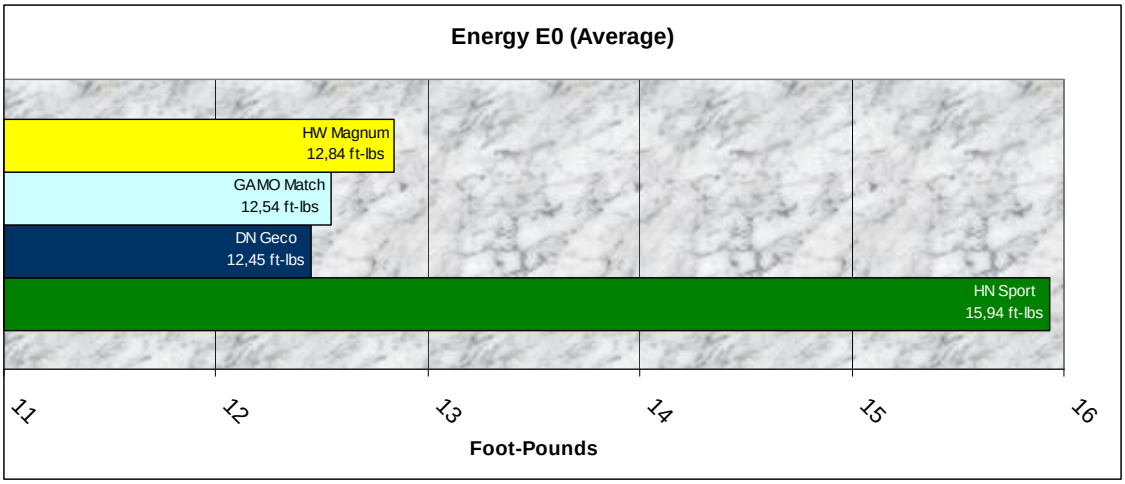
8.1 - Graph 1: Average muzzle velocity (m/s)



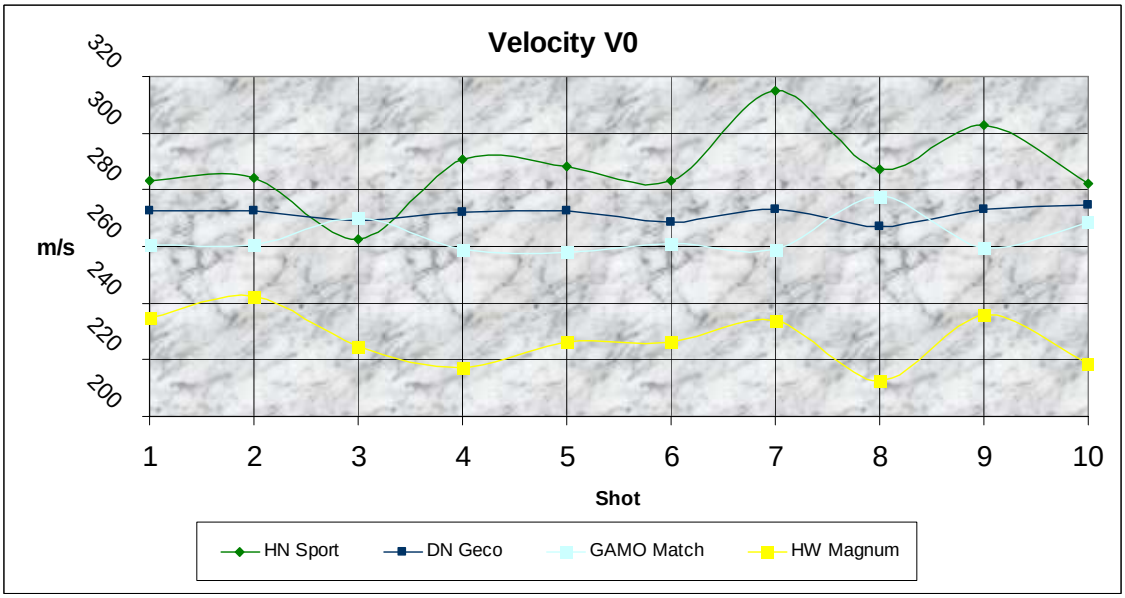
8.2 - Graph 2: Average muzzle Energy (m/s)



8.3 - Graph 3: Average muzzle Energy (ft-lbs)

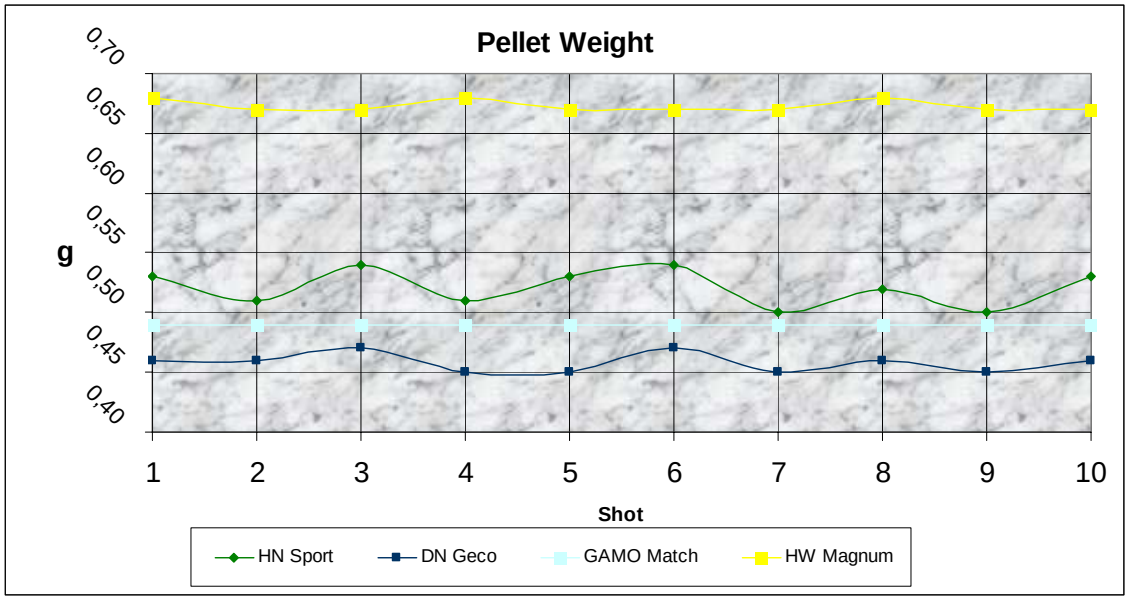


8.4 - Graph 4: Muzzle velocity (m/s) vs. shot



A mostly concerned with the pellet's characteristics graphic had been also performed.

8.5 - Graph 5: Muzzle velocity (m/s) vs. shot



9 - Conclusions

- With ALL the pellets tested, the rifle reached FAC performances. Nevertheless a factory report indicates that a “springer” air-rifle only reaches top performances after 600-800 shots.

- The factory declared top muzzle velocity of 290 m/s (950 Ft/s) was reached with H&N Diabolo Sport (287,99 m/s) from an “out-of-the-box” rifle.

- The H&N Diabolo Sport is by far-away the top-performer of all tested pellets (accuracy hadn’t be considered/tested).

- With exception of the H&N Diabolo Sport, all the tested pellets have very similar muzzle energies (Standard Deviation of only 2.57% of the muzzle velocity average!)