Firing Cycle

Fred Bohl – April 2006 – Preliminary Report

CAUTION – DISCLAIMER

The suggestions and recommendations herein are the opinions of the author based upon his own experience and supported by the experience of others with whom he has done testing and research. However, the author claims no special knowledge or expertise and assumes no responsibility for the consequences of anyone using these suggestions or recommendations.

The author's experience and that of the others with whom he has done testing and research is almost entirely in target (from the bench) and Benchrest competitive shooting.

The author has no affiliation with any of the suppliers of the brands listed. Nor does the author receive any remuneration from the suppliers or dealers thereof for suggesting or recommending their products.

PURPOSE

More consistent firing cycle time means more precise shooting. Reducing the firing cycle time reduces the potential for movement off the point of aim.

LIMITATIONS

The following discussion will be limited in scope to precision shooting. More specifically to serious target shooting and/or Benchrest shooting wherein results are measured via group size. We will assume the firearms to be bolt action rifles that are: custom, semi-custom, modified commercial, or purpose built commercial as opposed to "off-the-shelf" quality.

DEFINITIONS

For the purpose of this discussion, the firing cycle will be defined as beginning when the shooter has decided to fire and ending when the bullet base passes the crown of the muzzle. This includes these intervals:

1. Reaction Time – decision to fire to start of trigger actuation
2. Trigger Actuation – start of trigger motion to sear release
3. Lock Time – sear release to firing pin strike on primer
4. Barrel Time – firing pin strike to bullet base passing crown

Time intervals will be stated in milliseconds and abbreviated as msec (1.5 msec for example). One millisecond is one one-thousandth of a second (0.001 sec).

REACTION TIME

Results – Preliminary research and verification testing show a range of 150 to 250 msec with the shortest times typical of subjects in their late twenties and longer times for both younger and older subjects.

Comments – The test protocol included a practice/training run of 20 sets of 5 trials followed by one hour rest then 10 sets of 5 trials for data. All subjects showed slight reduction (5 to 10 msec) in total time over the 150 trials. The subjects also showed initial spreads of 10 to 20 msec in initial practice trials with steady improvement. All data trials showed initial spreads of less than 2 msec in trials and all last trials were under 1 msec spreads with a minimum spread of 0.5 msec (note that the test resolution is believed to be 0.1 msec). *Practice helps!*

Caution – The test protocol used a simulator not live fire and correlation of absolute values to live fire time is not yet proven but is believed to be very close.

TRIGGER ACTUATION

Results – Preliminary research and verification testing show a range of 2 to 16 msec directly proportional to trigger actuation energy. Also, a minimum of 1 to 2 msec seems required that is proportional to age but independent of trigger pull below a 3 to 4 ounce trigger pull force setting.

Comments – There appears to be a minimum detectable pull force (about 1.5 ounce) and a minimum detectable creep (about 0.008 inch). Setups below these values all were perceived as near identical by the participants.

Caution – The test protocols used showed limited correlation shooter to shooter on the same trigger set up limiting timing resolution confidence to 0.1 msec.

LOCK TIME

Results – Preliminary research and verification tests showed two distributions: a range of 2.2 to 4 msec for purpose built commercial actions and 1.0 to 1.8 msec for custom, semi-custom and modified commercial actions using low mass firing pins and special firing pin springs (typically David Tubb's SpeedLock Systems).

Comments – The faster group also showed much better repeatability in lock time. The purpose built commercial action group was not only generally less repeatable, but three specimens showed occasional large variances. Subsequent analysis found potential problems with part fit and finish – one firing pin too large a diameter for bolt bore when cocked and two with rough shoulders on firing pins leaving scratches in the bolt bore.

BARREL TIME

Results – Preliminary research and verification testing show a range of 0.9 to 1.3 msec with the shortest times for highest muzzle velocities and shortest barrels.

Comments – This interval is included only to show relative magnitude within the firing cycle. This interval is the domain of the reloader and already the subject of many volumes and worthy of its own extensive study. These data were collected via live fire using an acoustic sensor coupled to the barrel to detect the firing pin strike to bullet exit interval.

SUMMARY FIRING CYCLE TIMES

	Time (in milliseconds)	Percent of Total
Reaction Time	150.0 to 250.0	97.47 to 92.15
Trigger Actuation	2.0 to 16.0	1.30 to 5.89
Lock Time	1.0 to 4.0	0.65 to 1.47
Barrel Time	0.9 to 1.3	0.58 to 0.48
Total	153.9 to 271.3	100

ADDITIONAL OBSERVATIONS

Apparatus – The simulator used attached to the participating shooters own rifle of choice so that the shooter was already comfortable and practiced with it thus limiting the learning/practice necessary to obtain good data. The simulator was also equipped with a sensor to record barrel motion during the measurement interval. Because of variation in rifle and front/rear rest geometry, barrel motion data is only relative rather than absolute.

Results – The Trigger Actuation interval showed the largest magnitude and most frequent barrel motion (mostly horizontal) and was generally proportional to actuation time for both magnitude and frequency. Lock Time was next in barrel motion (mostly vertical) but somewhat erratic with peaks at firing pin release and just before primer strike [note that there was typically two to three times as much barrel motion for the purpose built commercial actions versus the custom, semi-custom and modified commercial actions using low mass firing pins and special firing pin springs]. The least barrel motion occurred during the Reaction Time interval (mostly vertical) and was very low in both magnitude and frequency.

Comments – In all three cases, a net offset from original point of aim was typical but no correlation to actual live fire results is possible. The consensus of the shooters was that the shortest times yield the least offset and would probably result in smaller groups and more accurate shot placement.