Chronograph Accuracy

The reason why so many of us use chronographs is indeed varied.

1. Amateur Load Development – getting a rough "idea" as to what velocity we are getting from out factory or hand loads so that we can basically say to out mates what our bullets are doing.

2. Sporting Load Development – obtaining a reasonable velocity reading to give us an indication if we are under loading or overloading our cartridges for barrel and case preservation.

3. Competition Load Development – For "F" Class or "Benchrest" Load development. Those brethren require an accurate reading for standard deviation (SD) and extreme spread (ES) so that group sizes are not affected by differences in load velocities and *Sin wave(1)* barrel effect at distance.

4. Long Range Hunting / Practical Rifle Shooters – These guys require the best reading possible for the velocity reading of their projectiles for the data input into the computer programs they use for the required accurate output of the trajectories required. These guys require the best possible reading because the software they use uses both the "Ballistic Coefficient" and the "Projectile Velocity"

Old School Technology

Nothing substitutes the feedback of seeing and recording the fall of shot at various ranges with your bullet/rifle. This data is true and factual and no one can argue with it. This style of trajectory mapping[1] has been with us for the last 200 years and has been used with great results both in the civilian and military arenas to great effect.

This style of trajectory mapping will never go away as it is still required to "Confirm Data" with any of today's scientific computer calibration equipment. However this data differs from day to day, altitude, shot angle, station pressure, shot direction and latitude (shot location). Shot data books over a number of years with accurate data interpretation/interpolation can achieve precise results and rewarding outcomes. Who nowadays has the time to do this? Not many.

Accuracy in Chronographs

Shooters covering points 1 and 2 need not worry so much. Shooters in points 3 and especially 4 require the best possible results from measuring the velocity of projectiles.

[1] Trajectory mapping is comparison of the computer simulated trajectory with the actual flight path of the projectile in real time. The computer trajectory path can be "bent" by changing the muzzle velocity or G_1 Ballistic Coefficient or both. A successfully mapped trajectory matches the computer model in changing atmospheric conditions.

Chronograph accuracy is sold to us by companies on good faith. These companies are telling us that their equipment is "right on" and trusting. They are acting on good faith and are also explaining to us in their small printed manuals that there is a certain degree of accuracy. This accuracy is primarily based on two things:

Figure 1. Oehler 35P Chronograph without IR screens attached.

a. The precision of the shadow reading devices (Light sensors) utilising precision timing equipment to record the time between two or more given points.

b. The available light travelling though to the light sensors to enable a velocity reading.

We can class chronographs into two areas, ones that use available sunlight (daylight models) and others that use their own emitted infra red (IR) light with IR sensors (Infra red models). Daylight chronographs do work and have worked for years. However they have their own limitations as well as the technical limitations of the user. Common causes(2) of problems with daylight chronographs are;

1. <u>Low light</u>

There must be sufficient light for the sensors to read a "Shadow" of the projectile passing over. Angled sunlight or low light intensity can cause false, incorrect or no readings at all.

2. <u>Lens Flare</u>

Angled sunlight entering the sensor slots can cause lens flare preventing the chronograph from reading the projectile shadow.

3. <u>Ground Reflection</u>

Chronographs positioned over light sand, limestone or snow may give false, incorrect or no readings. The light reflected from the ground can illuminate the underside of the passing projectiles causing insufficient shadows for the chronograph to work properly.

Sunlight

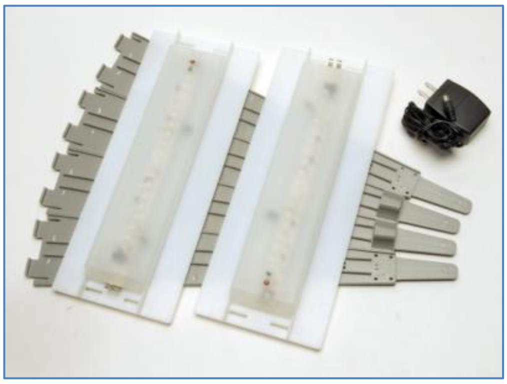

Figure 2. CED Millennium Chronograph IR Screens

Any chronograph that relies on sunlight to achieve a velocity reading is governed by the amount of sunlight that is received by the unit. Since sunlight is an electromagnetic radiation[2] (EMR) source of Visible, Infrared (IR) and Ultraviolet light (UV, among others, that changes with atmosphere concentration and density as well as it's angle (time of day). Variables in its power and composition exist thus affecting the read out of these chronographs. To put it simply, if your chronograph relies on sunlight, expect variable results from day to day and sorry to say hour to hour. The read-outs can vary up to 30fps when a cloud simply

[2] Electromagnetic radiation consists of radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. Light we can see called visible light has a shorter wave length than infrared light and a longer wave length than ultraviolet light.

covers the sun. You may also experience sporadic readouts before 10am and after 3pm.

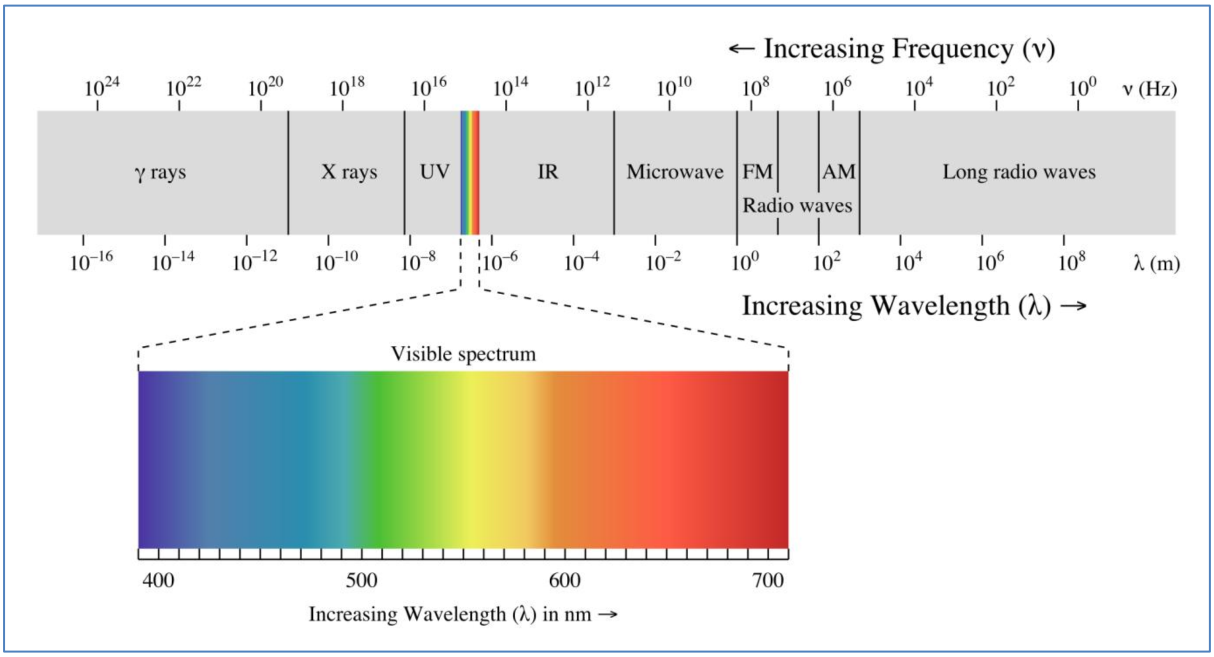

Figure 3. Electromagnetic spectrum with visible light breakdown highlighted.

To alleviate this error in chronographs read-outs, some manufacturers have introduced IR sky screens and local IR sources/receivers to combat these ever changing light emissions from the sun.

Infra-Red Sources

If you require the most accurate chronograph for your trajectory mapping then you are advised to consider a unit that “Emits” an IR light source directly into its own readers for constant and precise readings no matter what sunlight there is, especially if readings are to be taken indoors. Most chronographs in the market have the option of aftermarket IR sky screens. These alleviate most of the problems associated with their use in sunlight as previously mentioned, but do come at an additional cost. In these cases the original daylight configuration has to be purchase first.

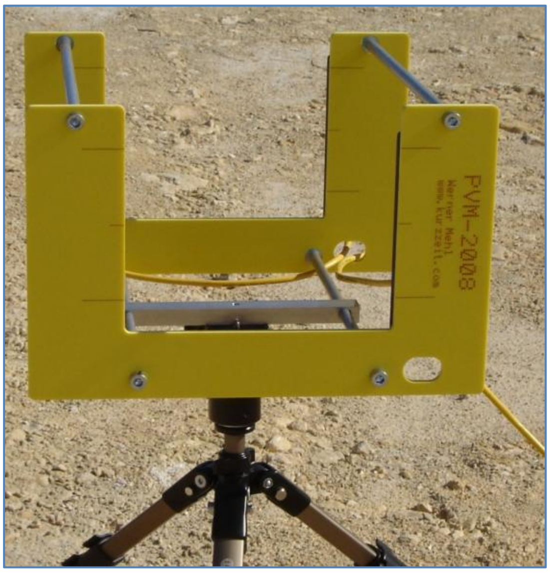

Figure 4. Kurzzeit PVM21 Chronograph with IR screens

The key to consistency and accuracy with any chronograph is having it’s own IR emission source. Better still, having this built in from the beginning. IR emission and detection in a chronograph means that reliance on available sunlight is no longer an issue. Most of these systems can be used in low light and even complete darkness, making indoor use possible.

Even though IR chronographs are far more dependable, user error can still disappoint unless certain precautions are taken to ensure set-up and use as per manufacturer’s instructions.   Some of these user errors can be;

1. Screen alignment to the user

The front and the rear screens have a set distance between them and the timing equipment has been calibrated exactly for this distance. The projectile must travel through these sensors at close to or exactly 90 degrees. If the projectile travels through these sensors at any angle less than this, the distance travelled is now less than the calibrated distance and accurate readings will suffer. Some chronographs will have a feature where they don't read at all if outside a set angle. Low quality unstable tripods are the common cause for this.

2. Screen positioning

Screens placed in the incorrect slots or areas on the chronograph are a common cause for incorrect or no readings. Oehler 35P and CED Millennium models have words indicating the positions of the screens such as "Start and Stop" etc. If these are placed in the wrong positions or the leads are placed into the wrong jacks, they will not work at all. If the screen of the Kurzzeit PVM21 with the Company name on it is fixed at the rear an error 15 message will be displayed and the chronograph will not work.

3. Too close to the sensors

Both visible light and heat exits the muzzle of a firearm with the projectile. If the first chronograph sensor is flooded with a flash of light or heat "bloom" the velocity readings may be incorrect, produce an error or no reading at all. Manufacturers recommend a minimum distance to avoid this potential error, usually being around 10ft. Form experience the more distance in front the better. Dust from the muzzle blast can even affect the readings. Keeping the distance to 8m and beyond has proven successful to avoid these factors. Remember to calculate the velocity loss from the chronograph back to the muzzle using the manufacturers G_1 Ballistic Coefficient (BC) and online ballistics programs.

Long Range Hunting

Those of us engaged in making long range first round hits require unquestionable accuracy in chronograph readings. We need a constant, accurately measured IR light source in our chronographs. If the G_1 BC is questionable and let's face it, this always is, unless it comes from Bryan Litz's data (Book: Applied Ballistics for Long Range Shooting), then we need to get our velocity readings bang on for accurate trajectory mapping using ballistic software. This is a case of what comes first, "The chicken or the egg". If our BC and our muzzle velocities are questionable, what do we rely on? Software producers such as Lex Talus Corporation owned and run by Blaine Fields an ex US Marine Sniper and Aeroballistics Engineer, only recommend accurate measuring equipment for long range ballistic software work. He clearly states this in his website(3).

With bending computer trajectories to suit what is happening in the real world by adjusting either the velocity or the BC, more often than not success is experienced when the true velocity is known and the adjustments are made to the BC, as the BC of the same projectile can change[3] in barrels of different twist rates. Since hitting targets at long range is all about error reduction or elimination, reducing the error of velocity is far easier than reverse engineering BC's trust me.

Cost Saving

The high end accurate chronographs are more expensive, but so is wasting ammunition, time, petrol and range fees on ones that aren't. Let's put this into perspective. If you have a cheap one and use

[3] The G_1Ballistic Coefficient changes along with velocity change. The average BC is used to calculate the total bullet projectile drop over distance. This average changes with varying projectile rigidity when spun through different rifle twist rates.

this data in a portable ballistics program for long range shooting. Your readings may be more than 60 fps out. If it takes 2 months of trial and error to realise that the $250 chronograph you bought not giving correct readings, then this can be the bill at the end;

1. Cost of ammunition (100 rounds)	=	$300
2. Cost of fuel to and from range	=	$70
3. Changing projectiles and powder	=	$150
4. Wasted time ($25 - $100/hr)	=	$?

Sometimes buying once and crying once may be the way to go.

Points to help you

1. Try and get a unit with its own IR source from the beginning.
2. Position the unit no closer than 8m from the muzzle despite what the manual suggests.
3. Use a quality, stable tripod to mount the unit.
4. Avoid dust or smoke at or near the sensors.
5. Fire test rounds before taking accurate measurements.
6. If using daylight models, try and measure velocities between the hours of 10am and 2pm on a grassy surface.

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References

1. Vaughn HR. Barrel Vibration. *Rifle Accuracy Facts*. Manchester, Connecticut: Precision Shooting; 1998. p. 69-74.
2. Ristow J. *Recreational Software Inc*. [Web site] Show Low, Arizona: Recreational Software Inc; 2011 [cited 2011 September 6th]; Available from: http://www.shootingsoftware.com/CEDMQA.htm.
3. Fields B. *Recommended Chronographs*. [Web Site] San Jose, California: Blaine Fields; 2011 [cited 2011 June 10th]; Available from: http://www.precisionworkbench.com/support.html.