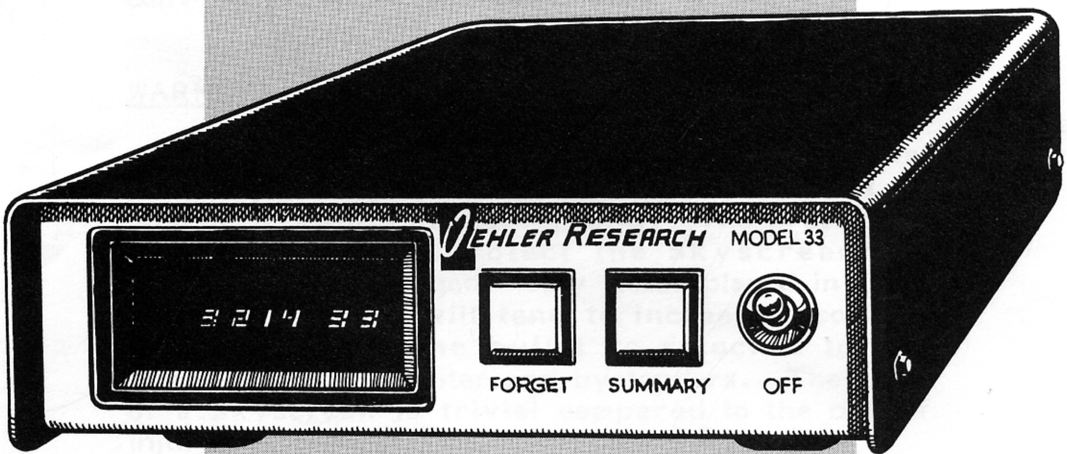
Model 33
Chronotach



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The Model 33 Chronotach is very simple to use. All you have to do is mount the skyscreens ten feet apart, plug in the cables, switch the unit on, fire over the screens, and read the velocity.

If you feel that you can effectively use your new chronograph from reading the above, go ahead with our best wishes for good luck. The rest of this book just contains a discussion on how the system works and how to set up the system for more convenience and better reliability.

WARNING

As with any other shooting activity, normal precautions such as eye and ear protection must be observed while chronographing. The practice of placing armor to protect the Skyscreens is especially discouraged. Any armor placed in front of the Skyscreens will tend to increase ricochets and may cause the bullet to ricochet in the direction of the shooter and bystanders. The price of a Skyscreen is trivial compared to the cost of injury.

WARRANTY

This chronograph system is warranted to be free of defects in materials and workmanship for a period of three years from the date of purchase. Any unit failing to operate properly during this period will be repaired free of charge if it is returned (shipping charges prepaid) to Oehler Research. The warranty does not apply to batteries or damage caused by accident, abuse, neglect or tampering. If you call us at 512/327-6900 or 800/531-5125 before you return your unit, we can often "repair" it by phone.

MUZZLE BLAST IS EVIL !!

Keep the Model 33 away from direct muzzle blast, or you will likely get some strange velocity readings! Keep the Model 33 back at your shoulder.

HOW IT WORKS

In the Model 33, time is measured by counting the ticks of an electronic clock. The clock ticks at the rate of one million pulses per second. As a bullet passes over the first skyscreen, a signal is sent to the chronotach telling it to start counting the pulses. When the bullet passes over the second skyscreen, a signal is sent telling the chronotach to stop counting the pulses and to then display the time or convert the distance and time to velocity for the display. The Model 33 not only computes velocity from time and distance, but it automatically examines the data from each valid round recorded and computes the essential velocity statistics of a test lot.

SKYSCREENS

The electric eyes of the skyscreens continually look at a thin slice of the sky or the light diffuser. As a bullet enters the field of view, the amount of light received changes momentarily. The eyes convert this tiny change in light to an electrical signal which ultimately controls the start or stop. The circuits of the skyscreen system respond only to very rapid changes in light. They will not respond to casually waving your hand over the screens.

The skyscreens are typically mounted at a spacing of between 3 and 10 feet, although the Model 33 can compute velocities with any screen spacing from 1 to 99 feet in increments of one foot. The spacing should be at least one foot for each 1000 feet of expected velocity. For example, a spacing of four feet will take care of velocities up to 4000 feet per second. If the system is to be used primarily for high velocity measurements, we urge use of a 9' or 10' spacing because accuracy is effectively doubled over that obtained with a 4' or 5' spacing. A system with a closer spacing is more convenient, but each individual can choose between accuracy and convenience.

The exact method of mounting depends on your individual shooting situation. The critical points are that the screens are spaced at a distance that can be expressed exactly in feet, that the units are located so that the bullet passes directly above the "eyes", that each unit has an unobstructed view of the sky overhead, and that the mounting is "square" so that the imaginary beams extending above the screens are not tilted with respect to each other. (A spacing error of 1/8" out of 10' will cause an error of 1 fps for each 1000 fps velocity. This error is doubled with the 5' spacing.)

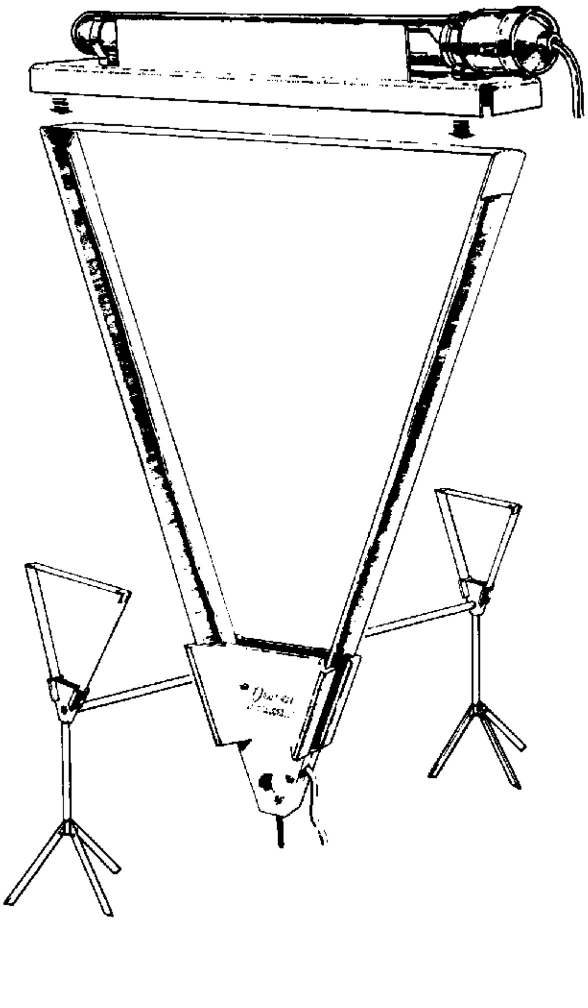
SKYSCREEN II MOUNTING

Skyscreen II units can be mounted on any convenient rail. We have seen and heard about everything from a length of 2x4 nailed to stakes in the ground to elaborately machined and anodized aluminum structures. Our favorite mounting is to use a section of 3/4" thin-wall (EMT) electrical conduit, and to invest in a pair of photographer's light stands (such as the Smith-Victor S2).

You will need a section of conduit at least 1 1/2" longer than your desired screen spacing. If you want to use a 10' spacing, you will need two pieces, each approximately 61" long and joined with a "set-screw" type conduit coupling. We usually replace one of the set-screws with a 10-24 thumbscrew or a longer screw bent to form an "L" handle. Place the screws on top for minimum sag, and you may still have to slide a piece of broomstick or dowel inside the joint as a stiffener.

Drill a 1/4" hole through the conduit approximately 3" from each end and place a 1/4"-20 x 3" bolt through each hole.

Skyscreen III Detectors



Secure the bolt with a nut leaving a 2" threaded tail sticking down. One tail fits inside the center post of each light stand and mounts the rail to the stands.

With the conduit rail mounted on the stands, fasten the Skyscreen II units to the rail with C-clamps as you measure the desired spacing and square things up. Recheck the measurement of the screen spacing (we usually just measure from the front face of the start screen to the front face of the stop screen.) Mark the mounting holes, drill 3/32" pilot holes into the conduit, and attach the skyscreens with #6 sheet-metal screws. We leave our skyscreens attached to the rail for storage. It is convenient if you mount a pair of cleats under the rail near each skyscreen so that you have a place to wrap the cables. If you are using the optional glint shields, they simply mount over the skyscreens using the same mounting holes.

SKYSCREEN III MOUNTING

With the deluxe Skyscreen III system, your screen setup is very simple. The mounting rail supplied with the system is cut for a 4' screen spacing. This spacing is adequate for normal use at velocities up to 4,000 fps. If you want to use a longer spacing, uset a piece of 1/2" EMT (thin-wall electrical conduit) exactly 3/4" longer than your desired screen spacing. If you want to use a 10' spacing, use two shorter sections of conduit joined with a "set-screw" type coupling. We suggest replacing one of the set-screws with a thumbscrew or a longer 10-24 screw bent to form an "L" handle.

Slip the Skyscreen III units over the conduit and secure with the threaded studs so that the skyscreens are flush with the ends of the conduit. The exposed portions of the threaded studs will slip into the hollow center posts of the light stands.

Place the metal slats of each light diffuser into the "claws" molded into the sides of the skyscreen cases. The concave or hollow sides of the metal slats go to the outside. Incidentally, if your buddy happens to shoot a slat, you can improvise a replacement from a scrap venetian blind slat.

The lenses of the Skyscreen III are made of plastic and should be kept relatively clean. Treat them as you would treat any optics, and clean only by wiping lightly with a dampened soft cloth. If you remove the light diffuser slats before cleaning, you can easily wipe the lens from end-to-end.

METRIC VELOCITIES

If you want readout in metric units, the screen spacing should be set so that it can be measured exactly in meters. One meter is convenient for shotshells, handguns, and velocities up to 1,000 meters per second, two meters is a good compromise, and three meters will give slightly increased accuracy.

DISTANCE SETTING AND BATTERIES

Remove the cover of the Model 33 by removing the two screws on each side. The distance switch is at the center of the electronic circuit board and is usually set at 10 when the unit is shipped. The distance shows in little windows as you view the switch from the rear of the unit. It can be readily changed by rotating the switch elements using the knurled grip showing just above the numbers. Set the numbers to your spacing in feet, 04 for 4', 05 for 5', 10 for 10', etc. If working in metric units, set the distance switch to your spacing in meters and the velocity readout will be in meters per second. If you want time instead of velocity, set the distance to 00 and read microseconds.

Install six size "D" alkaline flashlight batteries. Ordinary zinc-carbon batteries will usually work only for a few hours. Install three batteries in each tube. The positive tips of the batteries fit into the red insulating washers on the battery holders. Note that the battery holders are bent so that a significant effort is required to get the batteries into the holders. This pressure on the ends of the batteries is essential for operation in the presence of muzzle blast.

Replace the cover and turn the unit on. If the total battery voltage drops below 6.6 volts, the decimal point in the lower right corner of the display will appear. This is a positive indication that the batteries are low or that you have one battery reversed. If you see no digits displayed when the unit is turned on, the batteries are probably completely dead.

The display should read 0 00. If you push the summary button before shooting, the display will read 65535 LO, 0 HI, 1 ES, 0 A, 0 Sd, 0 00, ... Now's a good time to start the habit of turning the unit off when not in use.

ACTUAL CHRONOGRAPHING

After the agony of mounting the skyscreens for the first time, actual chronographing is very simple. The lack of proper mountings and the improper alignment will not only lead to the frustration of missed velocities, but will often lead to bullet holes through the skyscreens. If the Skyscreen II units are aligned so that they are 3 to 5 inches below the boresight line between the gun and the downrange target, any shot that is close to hitting the target will not hit the skyscreens. On the other hand, if you try to aim "just above" the units without reference to a downrange target, odds are that you will hit the skyscreens. This is especially true if your buddy is shooting. Skyscreen III units are easier to use because you just have to aim through the center of the window formed by the light diffuser.

We have found it most convenient to align the Skyscreen II system by first sandbagging a bolt action rifle so that it is aimed at a convenient down-range target. Remove the bolt and "boresight" back to the gun from the skyscreens. Holding your head so that your eye is on the boresight line, adjust the position and height of the light stand nearest the first Skyscreen II unit so that the unit is approximately 4 inches below your line of sight. Repeat with the stop skyscreen. You can verify the alignment by placing a 1"x5" piece of cardboard in each Skyscreen II slot to serve as aiming posts, and boresighting in the conventional manner from breech to target. After you have aligned your skyscreens, you can fire by aiming only at the down-range target. You can change guns (bolt actions, autos, lever actions, scoped or iron sights, or even handguns) just so long as you don't disturb the position of your fore-end rest and shoot at the same down-range target.

Alignment of the Skyscreen III units is similar but less critical. Just adjust the height and position of the light stands so the the boresight line passes through the approximate center of the window formed by the light diffuser and its supports. If the light stands provided are too tall for your particular bench and range, you may have to remove the adjustment collar and perform a small "hacksaw" surgery.

Connect the cables from the skyscreens to the input jacks of the Model 33. The screen nearest the muzzle is connected to the start input. Make sure that the plugs are pushed all the way into the jacks. Place the Model 33 near the shooter and away from the muzzle blast! The distance from muzzle to the first screen is typically 8 to 10 feet, but this distance is not critical. It's better to have a shorter distance from muzzle to first screen than to have your Model 33 sitting directly under or beside the muzzle.

Turn the Model 33 on. The unit will immediately display 0 for velocity and 00 for round number. Shoot over the screens. The display will immediately show the velocity at the left side of the window with round number 01 at the right side. Six-tenths of a second later the system is reset and ready for you to fire the next round even though the velocity display remains.

If the velocity displayed after a shot is obviously not representative of the ammunition you are testing, it can be excluded from the summary. All you have to do is push the FORGET button. Pushing the forget button will cause the velocity display to go back to zero and the round number will go back to the number of the last valid round fired. The function of the forget button is to eliminate the flagrantly bad readings; just because a velocity is 10% lower than you had hoped for is no excuse to forget it. Any round fired that results in a velocity display will be included in the statistical summary unless you push the forget button at the time the velocity is displayed. Any time "Error" is displayed, the computer resets itself automatically and the result of the error is not included in the summary. It is not necessary to "FORGET" an error before you fire another shot or start a summary.

STATISTICAL SUMMARY

After you have fired a test lot of ammo (up to 255 rounds), the Model 33 can display a summary. The summary is started by pushing the SUMMARY button. You can request a summary at any time. The first number displayed is the lowest velocity encountered in the test and is be identified by "LO" in the display. Push the button again and the highest velocity is displayed with "HI". Push the button again to display the velocity range or extreme spread denoted by "ES". Push the button again to display the average velocity with an "A". Push the button again to display the standard deviation denoted by "Sd".

If you push the button one more time, the display will show a velocity of zero and the number of valid rounds included in the summary. (The round number display is only two digits, so you must keep track of the hundreds digit yourself.) At this point in the summary you can either fire more rounds for a composite summary or cycle through the summary display again. The system will not recognize signals from the skyscreens during the display of the summary until you reach the point where round number and zero velocity are displayed. Turning the unit off will clear all the statistical information and it will be ready for a new lot when you turn it back on.

If you are firing large lots of ammo (say 20 rounds or more), we suggest that you stop and record the summary at intervals during the test. This is merely a precaution that if the test is interrupted, you will at least have the statistical information available from the earlier part of the test.

IN CASE OF TROUBLE

If the display does not change when a shot is fired, it is an indication that no start signal was received. Possible causes are the bullet passing too far above the skyscreen, the bullet passing too far to one side of a vertical line through the skyscreen, the skyscreen not having an unobstructed view of the sky overhead, or having too little light for proper skyscreen operation. It is also possible that the skyscreen or Model 33 is not operating properly, but we hate to admit that. Skyscreens typically work better on cloudy or hazy days because they then see more light than from a perfectly clear blue sky. The closer you shoot above the skyscreens the better they will work and the more likely you are to hit them. The suggested four inches above the top of the Skyscreen II units is a compromise between performance and the chances of damage to the skyscreens.

If "Error" is displayed, it means that no stop signal was received within 0.065 second after a start signal was received. Possible causes are having the cables from the skyscreens reversed, or the same comments as above, but applying to the stop skyscreen. If you observe error readings before you shoot, it is likely that they are caused by static electricity. Skyscreens are sensitive to the same electrical noises which cause static on an AM radio. Typical causes are nearby high-voltage power lines, large appliances with electrical motors or solenoids turning on or off, or even radar transmitters and electric fences.

If an obviously incorrect velocity is displayed the most common cause is muzzle blast. Keep the Model 33 away from the muzzle blast or shield it from the blast! If your velocity is less than the speed of sound (approximately 1140 feet per second), see the section on subsonic velocities.

A simple test of chronograph system operation is to set up the chronograph system and shoot with an air rifle. Velocities will typically range from approximately 250 fps for a kid's BB gun to over 600 fps for the adult versions. The BB is both small and short, and the velocities can be lower than the M33 system is designed for, so you may have to fire approximately 1 inch over the Skyscreen II units. With Skyscreen III detectors, you should be able to fire through the center of the "window".

If you still have problems or questions with the operation of your system, please call us at 512/327-6900 or toll-free at 800/531-5125. A call will normally get you back in operation a lot faster than will a letter.

GLINTS

If you look up at a bullet illuminated by a light from the side, you can see a small "glint" of light reflected from the ogive. Under certain conditions, this reflected light can cause the bullet to appear as a momentary bright spot over the skyscreen instead of the expected dark spot silhouetted against the sky. The skyscreen circuits are made to recognize either the light spot or a dark shadow as the tip of the bullet. Under certain conditions of sun angle, ogive shape, sky brightness, and reflectivity of the bullet, it is possible that the reflected light will be approximately equal to the shadow. When the glint and the shadow are equal, it is possible for them to cancel and the skyscreen sees no change in light as the bullet passes over.

The glint phenomenon occurs primarily under clear skies. There is a second factor making operation under clear skies more difficult. The amount of light from a clear sky is typically one-fourth the light reflected from a cloudy or hazy sky. While skyscreens adapt to work with this lower light level, they work better with more light. A solution is to use an "artificial cloud" above the bullet. We normally use frosted plastic drafting film, but have heard of others improvising with thin white cloth.

The optional glint shields can be fastened to the top of each Skyscreen II. The shield is a piece of folded sheet metal about 7" high, 5" wide, and 4" deep. Front and back are open to shoot through, and the top has a 5" x 1/2" slot covered with frosted plastic aligned to match the field of view of the skyscreen. This glint shield eliminates most of the problems caused by the glints, but it is still possible for quartering sunlight to come in from the sides. It may be necessary to tape on cardboard extensions to completely shade the bullet as it passes over the light slot. Frankly, the glint shields are a nuisance to carry and set up. They have only one redeeming advantage -- they seem to work when everything else fails.

If you make your own glint shields, the object of the game is to shade the bullet from direct light as it passes over the light slot, but still leave a hole in the top so that the skyscreen can see the bullet silhouetted against the sky. It works best if you cover the hole with a light diffusing material which receives direct sunlight. The light diffusing material also allows you to chronograph with the sun directly overhead. Without the diffusing material, the sun can shine into the "eye" and temporarily blind the skyscreen.

The newer Skyscreen III units incorporate the light diffuser directly into their design and no further additions are normally required. The only possible exceptions are where you are shooting over snow or light sand and the reflected light from the ground surface is almost as bright as the sky.

SUBSONIC VELOCITIES

With velocities below the speed of sound, the muzzle blast wave will reach the screen before the bullet. This muzzle blast wave is just like a lens traveling through the air at the speed of sound, and the resulting light diffraction can trigger the skyscreens. (The speed of sound ranges from 1075 fps at 20°F to approximately 1180 fps at 120°F.) At times this sound wave may trigger the skyscreens before the bullet passes over them. Premature triggering of the first screen will cause the system to indicate abnormally low velocities, for example 650 fps instead of an expected 850 fps for a .45 ACP. Premature triggering of both screens will give a velocity reading corresponding to the speed of sound, or 1140 fps at room temperature.

If the blast effect is observed, the solution is to install a blast baffle approximately halfway between the muzzle and the first screen. This baffle need be no more complicated than a large piece of heavy cardboard or plywood with a small hole in the center to shoot through. The larger the shield and the smaller the hole the better.

ARROWS

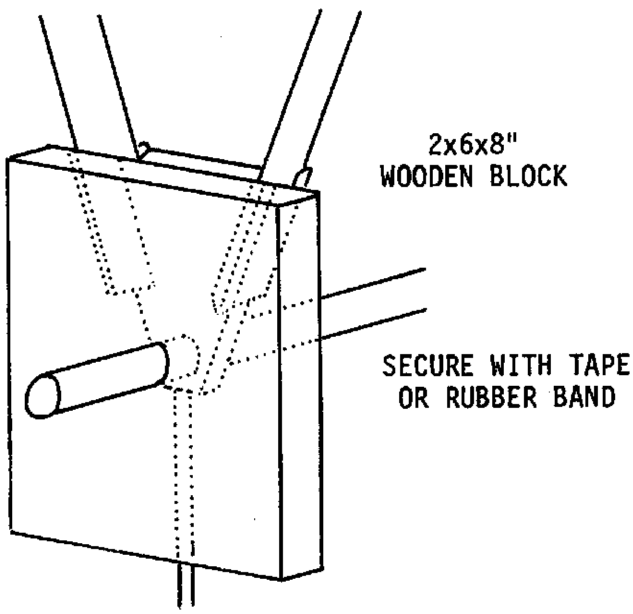
If you use the Skyscreen II system with slow projectiles such as arrows, we suggest a spacing of 1 foot between screens and placing first screen so that the tip of the arrow passes over it soon after the arrow leaves the string. Remember that you need to fire closer above the skyscreens and that your arrows should have a blunt point. You should be able to chronograph down to approximately to approximately 160 fps, but system operation will be marginal at these velocity levels.

The Skyscreen III system is much better adapted for use with arrows. You should be able to shoot through the center of the "window" and use a screen spacing of 2' or even the standard screen spacing of 4'. Note however that you should still use target or blunt points for best results.

SHOTSHELLS

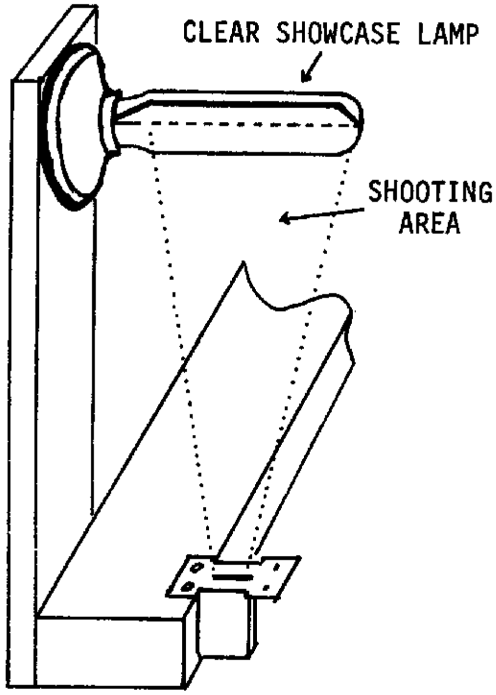
The system can be used to chronograph shotshells. It will measure the velocity of the front pellets in the shot column, and the velocities are typically 2% to 5% higher than reported factory measured velocities. For shotshells, use a screen spacing of 3' with the first screen placed 3' from the muzzle. It's wise to protect the skyscreens from damage caused by stray shot and wads by placing a block of soft wood in front of each skyscreen unit. If you are using the Skyscreen III setup with the 4' piece of 1/2" conduit, cut two pieces of 2"x6" lumber approximately 8" long. Drill a 3/4" hole in the center of each piece. If you set your skyscreens at a spacing of 3', you will have excess conduit on which to mount the wooden shields. Secure the shields to the skyscreens with tape or a heavy rubber band. If you are using the Skyscreen II units, you can do the same except that you must drill a 1" hole approximately 1" from the edge of two 6" pieces of 2"x6". Mount the blocks so that they hang down from the conduit and shield the skyscreens.

Wear goggles while shooting!



MUZZLE VELOCITY FROM INSTRUMENTAL VELOCITY

The velocity measured by the chronograph is the average velocity of the bullet as it passes between the two screens and is considered to be the velocity at the midpoint of the screens. For a typical setup the first screen is 10 feet from the muzzle and the screens are 10 feet apart. This places the midpoint of the screens 15 feet from the muzzle. The amount of velocity lost in traveling that first 15 feet can be added to the indicated velocity to get muzzle velocity. The easiest way to find the velocity lost in 15 feet is to look at the ballistics tables provided by ammo or bullet manufacturers and find the velocity lost in the first 100 yards for your bullet at your approximate velocity level. Divide this velocity loss by 20 to find the loss in 15 feet.



SKYSCREEN II USED INDOORS

INDOOR SHOOTING

To use the skyscreens indoors, you must provide a substitute for the sky. The simplest solution is a pair of our optional lamps set directly on top of the Skyscreen III units. Note that as shipped, the bulb is not centered over the window in the lamp frame. Remove the socket and bulb from the mounting clips and reinstall with the socket at the other end of the frame. The replacement lamp is know as a "40T8 (Inside Frost)" and we suggest that you get them locally to avoid possible damage in shipping.

If you are not using Skyscreen III units and our lamps, mount a long filament lamp approximately 18 inches above each Skyscreen II. ("Slim-Jim" or "Showcase" lamp bulbs, either 25 or 40 watt rating are the most available.) Use either surface mounted sockets or table lamp sockets with 1/8" pipe nipples to mount the bulbs above the screens. The lamps must be at the same spacing as the screens and positioned so that they are directly above each screen. An extra board placed across the front of the bulb will shield it from muzzle blast. The bullet must pass through the skinny triangle defined by the bulb filament at the top and the light slot at the bottom. Make sure that the filament support of each lamp is <u>not</u> between the filament and the skyscreen. Do <u>not</u> attempt to use fluorescent lamps.

WOUNDED SKYSCREENS

Considering the value of your time and ours, it is not feasible to repair wounded skyscreens. It costs more to repair a skyscreen than to make a new one. Naturally we will repair or replace at no charge any <u>defective</u> skyscreen returned to us under the warranty. Bullet holes void the warranty! Screens can also be damaged by separating gas checks and by "Accelerator" sabots.

LOAD DEVELOPMENT

In the process of developing our own loads and in hundreds of discussions with users of our equipment, we've formed our own pet system of load development. We don't claim it to be original, but include it here because we don't remember seeing it in print.

Anyone serious enough about handloading to invest in a Model 33 is no novice. You've read all the books and articles that say "select a bullet suitable for your intended use, consult several loading manuals to determine an appropriate powder and "maximum" charge weight, start at 5 to 10% below maximum charge weight, watch for pressure signs, and work up until you find the magic load." This is all good advice, but there is a lot left out between the time you start to "work up" and the time you find that "magic load".

For your chronograph data to be of full value, you must maintain records. Years from now you will wish for more complete records, but it's hard to sustain the habit. One secret is to keep the records simple. We've been working for years to refine our own record keeping system and will include sample pages with our chronographs as soon as we are satisfied with the form. As a minimum you must record the load, gun, approximate temperature, average velocity, and the group size and velocity standard deviation of each group tested.

We normally use 5-shot groups, but admit to 3-shot groups for preliminary testing with "unpleasant" guns. Further, after watching bench-rest shooters we tend to do most of our developmental loading at the range. That way we can quickly abandon a load that looks horrible without having to shoot the rest of the lot, and we have something to do while the barrel is cooling between groups. Our powder charges are "thrown" from a reliable powder measure with a proven repeatable "click" type setting. Obviously we have tested and frequently retest our powder measure against scales, we religiously check the powder level in each case, and we stay well away from maximum loads. We also work only with strong bolt action rifles.

There are several considerations for the selection of powder. These include the suggestions in the manuals, suggestions from magazines and other shooters as to what has worked well for them, your own experience, and what you have available. There are no iron-clad rules, but what has worked well for others is probably worth trying first.

Having made your powder and charge selection, fire your groups working up in charge weight. You should note the increase in velocity as the charge weight increases. If the velocity begins to approach published maximum velocities, shows little increase for increased charge, or if the standard deviation becomes high, double check for pressure signs. You can't get velocity without pressure!

Ideally you would hope to see group size and standard deviation come down together, stay small over a range of several charge weights, and then start to increase as you approach maximum pressures and velocities. Mother nature is seldom so kind! Record the groups and standard deviations anyway. Examine the data you've collected. Hopefully it will show areas in which the the groups and standard deviations tend to be smaller.

Pay no more attention to an isolated standard deviation that appears to be exceptionally large or small than you would pay to an isolated group that is exceptionally large or small. If a large standard deviation is backed by a large group, you have good reason to abandon that particular load until you've at least checked some others. If the standard deviation is large and the group is reasonable, consider it to be a warning flag. If the standard deviation is small and the group is small or even reasonable, consider it to be a good omen to be validated by further testing.

Unless you've hit on the load that satisfies all your requirements, you will want to repeat the test sequence with alternate powders. Once you've found a powder and charge that appears appropriate, you are ready to change other parameters.
Note: Beware of selections which give good performance only over a very narrow range of charge weights. You may have made a selection that is suitable only over a narrow temperature range.

Change only one parameter at a time. Observe the velocities as you shoot. Any drastic changes in velocity means that you may want to recheck the selected charge with your new components or suspend testing with that particular component. When you find a change that improves the performance, hold on to it as you vary other components. When you finally reach an acceptable load, it is a good idea to go back and try charge weights slightly higher and lower.

One further hint -- the powder lot number is an essential bit of data. If you start a new lot of powder and your pet load goes sour, first try adjusting the charge weight for the new lot until you get approximately the same velocity as you recorded for the old lot.

VELOCITY DECISIONS

The purpose of this section is not to turn every shooter into a statistician. Statistics is an exact science, but not in the sense that an average velocity of 2964 fps observed on a few sample rounds means that the average velocity of the entire lot of ammunition is 2964 feet per second. Statistics simply lets you know how close your estimate of 2964 is to the average velocity you would get if you could fire a few hundred more rounds of ammo from the same lot before the barrel wears out or other conditions change.

The shooter testing the velocity of ammo is primarily interested in answering two questions. What is the average velocity of the ammunition? Is load A more uniform than load B?

The idea of average velocity is well understood. The average velocity you read from the Model 33 is indeed the average velocity of the rounds you fired, but is only an estimate of the average velocity you would get if you chronograph more "identical" ammunition. How good is the estimate? The more rounds you test and the more uniform the ammunition, the better your estimate. Before you know how much confidence to place in the average velocity you have just measured, you must know how uniform the velocities are.

The "standard deviation" is commonly accepted as the best measure or indicator of uniformity. It has been seldom used because it is troublesome to compute. The Oehler Model 33 computes the standard deviation automatically. You don't have to know how to compute the standard deviation in order to use it; you simply regard it as a measure of uniformity.

If you don't want to bother with statistics, you should still record the standard deviations observed from your ammo. You will soon develop a feel for the numbers. Our own very crude guidelines are listed below.

less than 5 fps -- probably luck
5 - 12 fps -- uniform ammo
13 - 30 fps -- marginal
above 30 fps -- improve it

Assume now that you have the average velocity and the standard deviation from your velocity tests. Just how good is the test average for the purpose of predicting the average velocity of more rounds loaded and fired under the same conditions? Assume that in a ten-round test you observed an average velocity of 2900 fps and a standard deviation of 10 fps. A statistician would say that with 90% confidence, the true average of the entire lot will fall within 6 fps of the average you observed in the test. Loosely translated, it means that the statistician would give 9 to 1 odds that if you fired the balance of the lot, the final average would be between 2894 and 2906 fps.

These 90% confidence numbers are listed in Table 1 for various values of standard deviation and number of rounds fired. When you fire a test and get the average velocity with the standard deviation, you can immediately establish the confidence interval for the average velocity. Just enter Table 1 at the standard deviation and go across until you are reading under the number of rounds in your test. The confidence interval number you read from the table tells you that you have 9 to 1 odds that the true average velocity of the entire lot will fall at least that close to the average velocity you measured. The true average can be either above or below the test average by up to the amount shown.

You can also use the values from Table 1 as an approximation to determine if the difference between two average velocities is significant. Each of the average velocities will have a confidence interval number determined by its standard deviation and its number of rounds. If the difference between the two average velocities exceeds the larger of the confidence intervals, then you are roughly 90% confident that the true average velocities of the two lots are different.

The shooter also wants to answer the question, "Is load A more uniform than load B?" While a few rounds are sufficient to establish a good estimate of the average velocity, more rounds are required to establish a valid measure of uniformity. Although standard deviation is a much better measure of uniformity than is extreme spread, three-round tests for uniformity are practically useless and five-round tests are marginal. From Table 2 you can see that if a three-round test showed load A to have a standard deviation of 10 fps, a three-round test of load B would have to show a standard deviation of at least 44 fps before you could say with 95% confidence that load A was the most uniform. If load A showed the 10 fps standard deviation on a five-round test, load B would have to show a standard deviation of only 25 fps on a five-round test until you could say with 95% confidence that load A was the most uniform.
Note: Even though you may not have 95% confidence, if the standard deviation from load B is any higher than the standard deviation of load A, you have a better than even money bet that load A is the most uniform.

Table 2 shows the value of standard deviation for load B that must be exceeded before you can say with 95% confidence that load A is indeed more uniform than load B. Enter the table on the row determined by the standard deviation of load A and read the critical value for load B standard deviation in the column under the number of rounds used to test each load.

TABLE 1. For the observed standard deviation you have 90% confidence that the actual average will fall at least this close to the observed sample average.

STANDARD DEVIATION	NUMBER OF ROUNDS 3	5	10	20	50	100
2	4	2	1	1	1	1
3	5	3	2	1	1	1
4	7	4	3	2	1	1
5	9	5	3	2	1	1
6	10	6	4	3	2	1
7	12	7	4	3	2	1
8	13	8	5	3	2	1
9	15	9	5	4	2	2
10	17	10	6	4	3	2
12	20	11	7	5	3	2
14	24	13	8	6	4	3
16	27	15	9	6	4	3
18	30	17	10	7	4	3
20	34	19	12	8	5	3
25	42	24	14	10	6	4
30	51	29	17	12	7	5
35	59	33	20	14	8	6
40	67	38	23	15	10	7
45	76	43	26	17	11	8
50	84	48	29	19	12	9
60	101	57	35	23	14	10
70	118	67	41	27	17	12
80	135	76	46	31	19	13
90	152	86	52	35	21	15
100	169	95	58	39	24	17

TABLE 2. The standard deviation of load B must exceed the value shown in the table for 95% confidence that load A is the most uniform.

STANDARD DEVIATION LOAD A	NUMBER OF ROUNDS 3	5	10	20	50	100
2	9	5	4	3	3	2
3	13	8	6	4	4	4
4	17	10	7	6	5	5
5	22	13	9	8	7	6
6	26	15	11	9	8	7
7	31	18	12	10	9	8
8	35	20	14	12	10	10
9	39	23	16	13	11	11
10	44	25	18	15	13	12
12	52	30	21	18	15	14
14	61	35	25	21	18	17
16	70	40	28	24	20	19
18	78	46	32	26	23	22
20	87	51	36	29	25	24
25	109	63	44	37	32	30
30	131	76	53	44	38	36
35	153	89	62	51	44	38
40	174	101	71	59	51	48
45	196	114	80	66	57	54
50	218	126	89	74	64	60
60	262	152	107	88	76	72
70	305	177	125	103	89	84
80	349	202	142	118	102	96
90	392	228	160	132	114	108
100	436	253	178	147	127	120