Welcome

Thanks for joining us at a higher level of ballistic research and testing. With the Model 43 Personal Ballistics Lab you can measure what has in the past been speculation and opinion. You are now literally the director of a ballistics laboratory and have the obligation for responsible decisions regarding pressure and safety.

In the last thirty years I've had hundreds of conversations with experienced ballisticians and shooters. Each contributed experience and knowledge to influence this manual. I learned that velocity may indicate performance, but you must measure chamber pressure for safety. You measure chamber pressure to make sure that you stay far away from trouble, not to see how closely you can approach disaster. It takes no skill to get higher-than-factory velocities if you ignore pressures. The wise shooter seeks adequate and uniform velocities with pressures not exceeding factory levels.

Richard Larson wrote the computer program in its original DOS form, and has spent the last year rewriting it in Windows. Ken Gallia wrote the program hidden in the Model 43. My thanks to both.

Our handloader chronograph and industrial equipment manuals have evolved over twenty-five years. Users have seen and read so much about chronographs that they often don't need a manual. The Model 43 is different. With so much new material to cover regarding chamber pressure, exterior ballistics, target data and computer operation, we may leave out something. If you can't find the answers, please give us a call.

Ken Oehler

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Revision History:

06 Jan 93 - Page 33 - Use paper towel instead of gauze sponge.

01 Feb 93 - Page 32 - Specify location for mounting on shotgun.

02 Feb 93 - Page 34 - Extended shelf life for M-Bond 200.

08 Apr 93 - Appendix B-2 - Added limits for shotshell pressures.

23 Feb 94 - Page 33 - Encourage direct buy from Measurements.

01 Jun 94 - Page 22 - Removed reference to Appendix C.

16 Jun 94 - Page 3 - Revise relative pressure section.

01 Jul 94 - Page 32 - Urge sanding for long term use.

14 Nov 95 - Page 6 - Add paragraph on powder position.

06 Jun 96 - Reflect 1.08 software.

14 Oct 97 - Reflect 1.09 software. New battery charger.

CHAPTER 1

Background Information

Why This Chapter ?

The Model 43 Personal Ballistics Laboratory marks the beginning of a new era in ballistics. For the first time, the computer age will have a real impact on shooters by making measurements of pressure available along with muzzle velocities, downrange velocities, times of flight, and measured ballistic coefficients. Most of what we guessed at before can now be measured and recorded. Because this era of personal ballistics is just beginning we felt it necessary to include at least an introductory chapter. The book hasn't been written yet.

Along with the bits of historical fact and scientific background, we want to communicate a philosophy or attitude. For years we've shot with our faces stuck within a few inches of pressure bombs, and we have played in ignorance. Much of what we think we have learned about pressure has been half-truth at best. For obvious personal safety and liability reasons you must use your own good judgement in applying and telling others what you observe and measure.

Before we think ourselves experts, consider the recent quote from a senior ballistic engineer at a major ammo company.

"I'm not nearly as sure about a lot of this pressure stuff as I was 10 or 15 years ago."

Pressure Measurements

Beginning with the first firearms, shooters have had two big questions. What happens at the target? Did firing the shot damage the gun? Shooters have studied downrange results for centuries. They have plotted trajectories by observing impact points at various ranges, and they have been able to see the effects of the bullet by examining the targets. Recently chronographs and exterior ballistics programs have become commonplace, and most shooters can better understand exterior ballistics.

Shooters have a good idea of what happens in front of the gun, but they have no idea of what is going on inside the gun. If nothing breaks, it's OK; if the cartridge case can't be reloaded, it's borderline; if the gun blows up the load was a little hot. This is completely unacceptable from the viewpoint of personal safety. The wiser shooters try to "read" the indications of excess pressure by paying particular attention to the condition of the cartridge case after a shot is fired. What they don't realize is that even many of the fired cases of *proof ammo* would be considered to be reloadable by common standards for pressure signs. Proof ammunition is that test ammo specially loaded to generate distinctly higher pressures than will ever be generated by factory ammo. Each new gun is tested with one round. Shooters claim concern about pressure, but they often don't give pressure the respect it deserves. They have had no equivalent to a chronograph to help them.

The first practical pressure gauge for measuring the pressure inside a gun was invented by Sir Alfred Nobel in the 1860s. This gauge is commonly know as a "crusher gauge". To make a crusher gauge, drill a hole through the barrel into the chamber, fit the hole with a sliding piston, and let the sliding piston crush a small piece of lead against an anvil when the shot is fired. The higher the pressure, the more the lead cylinder is deformed by the piston. The crusher gauge is calibrated by using pure lead cylinders of specified height and diameter. Some cylinders from each lot are subjected to static compression tests. These tests yield a chart that shows the deformed height versus the applied force or pressure equivalent. After a shot is fired and the deformed crusher is measured, this chart is used to translate the height of the crusher to the pressure of the shot.

_Over a century later, the lead crusher gauge remains a reasonable way to measure peak pressures that fall in the black powder and shotgun ranges. Readings made with lead crushers correspond remarkably well with readings made with modern transducers. There are slight differences, and the measurements made with the lead crushers are tagged with the units of LUP (Lead Units of Pressure) instead of PSI. For most practical purposes and hand-loader decisions you need not worry about the differences between the two.

With the advent of modern cartridges and smokeless powders, pressures went higher. At higher pressures the lead cylinders deformed too much and the lead was replaced by cylinders of pure copper. The higher pressures occur faster, and they are harder to measure. During the last twenty years piezoelectric transducers have replaced copper crushers in most chamber pressure measurements. With two different methods to measure chamber pressure, users had two sets of pressure readings, and the readings did not agree. Pressure readings that had been accepted as the exact gospel truth for decades became suspect. Copper crusher readings had been assumed to represent peak pounds per square inch for many generations, but now there was another system also measuring peak pounds per square inch. Copper crusher readings and *peak* PSI readings from transducers are *not* interchangeable. Regardless of conversion charts or graphs you may have seen which pretend to offer a conversion between CUP readings and transducer *peak* PSI, there is no easy conversion. Commercial and military ballisticians have fired hundreds of thousands of rounds seeking an easy correlation. They haven't found it yet, and they won't. As a result, readings taken with copper crushers are now tagged with the designation CUP for Copper Units of Pressure and the PSI designation is reserved for readings taken with transducers.

It's possible to predict CUP readings from transducer data, but you must use the <u>total transducer pressure-time curve</u> and not just its <u>peak</u> value. The prediction of CUP values from transducer data is available only with the Oehler System 82.

Ideally, chamber pressure readings should be absolute. We are all spoiled and accustomed to absolute measurements of common items. If you buy a pound of powder you expect to get an amount that weighs exactly the same as a pound of butter from the grocery store or a pound of nails from the hardware store. Within close tolerances you will be right. All three of the items mentioned can be taken to a scale and weighed; you can repeat the comparison by weighing each item on a second scale. You can even "calibrate" the scales; it's simple to use a check weight.

Chamber pressure readings are more complicated than weighing a brick of butter. You can weigh and measure a loaded cartridge all you want to, you can fire dozens of loaded cartridges from the same lot in tightly specified pressure guns under controlled conditions, you can plead with the gods and IRS, but you still can't tell how much pressure the load will generate when fired in your gun.

You may read that the pressure of a certain load is 56,000 psi. You must not assume that the 56,000 psi is an absolute number. If the number is quoted for factory ammo you know that similar ammo was tested in accordance with ANSI/SAAMI standards and that there is little chance that the pressure of the ammo fired under ANSI/SAAMI specified conditions will exceed the 56,000 psi. The 56,000 psi number by itself does not tell you the pressure that will be generated when you fire the ammo in your gun. The pressure generated by the round depends greatly on the gun in which it is fired and the test conditions. Individual chamber and barrel tolerances are critical. Even if you use three "identical" rifles with consecutive serial numbers, I'll wager that you will get three different average velocities and average pressures. The pressure numbers so casually mentioned with great authority are not absolute; they are approximate and they are only relative!

The ANSI/SAAMI test procedures used by the major US gun and ammo makers have evolved over many decades of gun and ammo testing. The ultimate purpose of these procedures is to assure that all the ammunition loaded by the ammo makers will function **safely** in all guns which have been produced in accordance with the same family of specifications. The ANSI/SAAMI specifications define a system of measurement techniques and very specific test procedures, tight specifications for test barrels, and cooperative assessment procedures in which samples of large lots of selected uniform ammunition are fired under ideal conditions in many different labs. What you don't find in the ANSI procedures is any claim that the pressure numbers are absolute even under laboratory conditions, and you certainly won't find any claims that the quoted pressure values are directly applicable to any individual gun.

Relative Pressures

The pressures measured in your gun with the Model 43 apply only to your gun. You can use the pressure numbers to compare different ammo fired in the same gun with the same strain gage. The M43 readings correspond closely to pressures in hundreds of pounds per square inch. Pressures in your sporting gun will normally be lower than pressures of the same ammo fired in a standard test barrel because the test barrel is intentionally made tighter than sporting barrels. Just as some barrels shoot and some won't, the same ammo builds different pressures in different barrels.

We've already discussed the unresolved differences between copper units of pressure and transducer *peak* PSI. Separate standards and procedures have been established for crusher and transducer measurements, and either can be acceptable. The British have long had their way of measuring pressure, but translating to American units is more than simply translating tons per square inch to pounds per square inch. Similarly the members of the CIP (the organization of European proof houses) have their own procedures and standards. Their results will not directly translate to either the American or British results. Proponents of each of the standards may claim that theirs is the final word, but the fact remains that there is no real translation between them. Each can be used to make valid comparisons *within one system*, and none is accepted by all others as being the gospel truth. In other words, each standard is really relative. You can make valid comparisons between numbers gathered using any one standard, but you are asking for trouble if you try to make translations between systems or compare results gathered using different standards.

There is one common denominator linking common pressure measurement standards. You must use a special breech or you must drill a hole in the barrel at the chamber to mount a transducer or install a piston for a crusher. Many systems also require a hole to be drilled in the brass cartridge case. The Model 43 uses your gun and it does not require any holes be drilled. The Model 43 *estimates* the pressure by observing how much the chamber stretches. The Model 43 not intended to replace standard ANSI/SAAMI procedures and equipment. It is intended for use by individuals to estimate actual chamber pressure in sporting guns. The Model 43 will closely estimate pressure *in your gun*. Nothing else will.

Pressure Limits

If you are working within one of the established pressure measurement standards you have the advantage of others' experience using the same system. Pressure limits will have been established based on that experience. With the Model 43 you don't have the luxury of a large base of experience. You are all by yourself when you mount a strain gage on your own gun. To establish upper pressure limits in your gun, we suggest that you test several samples of fresh factory ammo of at least two different brands at room temperature. Use the overall average peak pressure reading from the factory ammo as your maximum working average pressure level. We strongly suggest that you not work with hand-loads above this pressure level. Even if you work within these prudent limits, don't ignore any of the classic pressure signs. If you see signs of pressure, back off regardless of the instrument readings.

If factory ammo is not available for your gun, you must develop your own working limits. Use what you already know about reading signs of excessive pressures. Hard opening bolts, expanded primer pockets, measured case head expansion, shiny ejector hole spots, and other classic indicators of high pressures are still valid. Any of these signs is an indication of high pressure, but it also indicates an actual *failure* of the brass case. The case may not have ruptured and sprayed your face with molten brass, but it has been pushed beyond its elastic limit. Proof ammunition (loaded at pressure levels at least 30 percent over maximum working levels) will often not show any of these pressure signs. If you reach the pressure levels where you see any of the classic pressure signs, set your maximum working pressure at no more than *80 percent* of the level at which you observed the pressure signs. To set it higher will subject your gun to the equivalent of repeated proof loads.

Reference Ammo

Reference ammo is widely used within the ammunition industry. It is typically a uniform and large lot of a common production ammo that is designated as reference ammo only after its pressure and velocity have been properly assessed at several different test facilities *using ANSI/SAAMI approved equipment and procedures.* The aggregate value of both pressure and velocity, as determined by the many tests, is assumed as the standard. Reference ammo is then fired in each individual test barrel to determine the correction factor which must be applied to tests using that particular barrel. Reference ammo is not proof ammo. The pressure and velocity of reference ammo normally falls within the range of that allowed for production ammo. The pressure of proof ammo is normally at least 30% greater than that expected from any production ammo.

When hearing about the Model 43 and our claims of only relative pressure readings, some potential users want to use reference ammo to calibrate their system. ***The assessed pressure and velocity of the reference ammo is valid only when the reference ammo is fired in test barrels meeting all ANSI/SAAMI specs, using ANSI/SAAMI procedures and instruments.***

The value of reference ammo is not simply the ammo itself, but in its controlled use within the framework of the ANSI/SAAMI specs. Firing reference ammo in your sporter as a calibration for the Model 43 is only marginally better than using readily available commercial ammo. _What can be more important to you is the use of your own *private reference* ammo. After you have installed a strain gage on your gun and have tested a few lots of ammo, select several boxes of one uniform lot to be your own *private reference* ammo. Save this ammo with its firing records for future use whenever you question the performance of your system. If you then fire a few more rounds of your *private reference* ammo, and the results are consistent with earlier results, you will have renewed confidence in your measurement. If the ammo gives results that are inconsistent with earlier data, you know that there's a problem.

Strain Gages

We don't know why strain gage manufacturers spell it gage instead of gauge, but they do.

Strain gages are simple in principle. Basically a strain gage is a piece of thin electrical wire glued to the surface of a part. Pulling on the part makes it stretch and this stretch is passed on to the electrical wire. As the wire is stretched, its electrical resistance increases. This change in resistance is tiny, normally measured in terms of parts per million, but sensitive amplifiers can be used to observe it.

An actual strain gage used with the Model 43 is more than just a little piece of wire. Instead of wire the electrical path is a zigzag path etched from constantan foil. The zigzag form is used so that a longer wire can be put into a small package. The longer the wire, the more sensitive is the gage. The tiny zigzag circuit is encapsulated in clear polyimide to protect it, and the circuit is connected to larger copper-coated tabs where lead wires can be attached.

The chamber pressure in a gun causes the chamber or barrel to stretch. (Strain gage users call it strain instead of stretch, but it means the same.) If we glue a strain gage over the chamber area we can measure the stretch when a shot is fired. Assuming that the chamber is a simple steel cylinder and that there are no "end effects", we can measure the inside and outside diameters of the cylinder and estimate the pressure required to produce the stretch or strain we observed. Note that we did not drill a hole into the chamber to gain direct access to the pressure we want to measure.

We are using an indirect observation to get only an estimate of the actual pressure. It is an ***estimate*** *and we won't let you forget it.*

The approximations used in the Model 43 are best for long straight-walled cases fired in actions with short barrel shanks and untapered barrels. Threading a barrel into a receiver stiffens one end of the chamber, and tapering the case to a bottle-neck stiffens the other end. Both cause the estimates of chamber pressure to be low. Using an octagon barrel or revolver cylinder will also cause pressure estimates to be low. Your estimates of the chamber pressure will usually be low compared to values you might read about, but your values are valid for comparing different loads fired in your gun.

CAUTION

Stay alert for the classic indications of excess pressure (head expansion, expanded primer pockets, difficult extraction, or other evidence of yielding brass). Do not push your loads to approach the published pressures if you see <u>any</u> indications of excess pressure. If your readings ever approach what is reported as "maximum product average", you may be approaching the pressure of proof ammunition.

BACK OFF!

Factory Pressure Limits

In books or magazines you may see reference to the working pressure, maximum product average pressure, or other terms gleaned from ANSI/SAAMI standards. While the numbers quoted may be correct, they can be misleading if you don't abide by all the fine print included in the actual standards. The fine print defines the procedures and equipment which must be used to measure the pressures and it defines the required statistical analysis. Unless you are prepared to spend the price of a new luxury automobile on test equipment, and are willing to follow ANSI/SAAMI procedures exactly, you cannot use their numbers to justify increasing the pressures of your handloads. See Appendix B for a tabulation of maximum pressure limits.

Offset

The term *offset* has just come into the pressure measurement vocabulary with the widespread use of the conformal piezoelectric transducer. The conformal transducer is commonly used at the ammunition factories for pressure measurements. The conformal transducer is mounted in a test barrel with the sensitive face of the transducer actually forming a portion of the chamber wall. When the cartridge is fired, the case expands to push on the chamber wall. The case must contain a significant pressure before it stretches enough to press against the chamber wall. The pressure required to expand the case and push it against the conformal transducer is called the offset and is added to the measured pressure as a correction. In industrial applications this offset correction is measured with hydraulic pressure for each lot of cases.

The offset phenomenon holds for strain gage measurements just as it does for the conformal transducers. A minimum level of pressure must be reached before the case starts to press against the chamber wall. We have chosen a default value of 7,000 psi to represent the offset and urge that you use this value for all work with brass cartridge cases. This value is not exact, but we consider it to be representative. For muzzle loaders the offset is zero because there is no cartridge case to expand. For shotshells a value of 500 psi is suggested. There is a place for you to insert the offset value in the test setup of the Model 43 and this offset value is automatically added to the raw pressure curves recorded by the Model 43.

References

For more information, we suggest that you read the sections *Chamber Pressures in Handloading* and *Measurements of Chamber Pressure* by William C. Davis, Jr., contained in the NRA ***Handloading*** book, 1981.

Factors Affecting Pressure Measurements

We all think we know what influences chamber pressure. Bullet weight and diameter, seating depth and freebore, powder weight, type and lot, case capacity, ambient temperature and primers are known to influence the pressure. Now consider the extra items that influence the *measurement* of pressure. The following list was taken directly from the ANSI/SAAMI standards, and the standards refer to the list as the *principal* items in each category which may cause difficulties.

INSTRUMENTATION

1. *Condition of test barrel (whether minimum or maximum bore, chamber size and headspace, amount of erosion at throat and bore.).*
2. *Fit of transducer in barrel.*
3. *Location of transducer in barrel.*
4. *Tightness of barrel mounting.*
5. *Shape, size and protrusion of firing-pin beyond breech face.*
6. *Force of firing-pin blow.*
7. *Characteristics of transducer.*
8. *Quality of transducer.*
9. *Quality of Read-Out System.*

AMMUNITION

1. *Condition of cartridge.*
2. *Position of powder in case.*
3. *Temperature of ammunition.*

PROCEDURE

1. *Failure to properly mount pressure barrel in Universal Receiver or other test action to assure minimum headspace.*
2. *Failure to rotate cartridge and close breech carefully to assure proper powder positioning.*
3. *Failure to fire warming shots.*
4. *Overheating barrel by excessive rate of fire.*
5. *Failure to clean bore and control metal fouling.*
6. *Failure to protect transducer against contamination, such as oil or water.*
7. *Transducer calibration.*
8. *Read-Out System calibration.*
9.

The preceding list applies to measurement of chamber pressure using conformal transducers in test barrels under laboratory conditions. They worry about problems most shooters have never considered. Note that the list doesn't begin to address differences between different measuring systems. And we thought 56,000 psi was an absolute and reproducible number!

Powder Position

Any cartridge containing less than a settled full case of powder may produce *drastic* differences in pressure depending on powder position. The industry standard requires that powder be gently positioned near the primer end by using the following procedure:

1. Ammo is placed in a loading block with primer down.

2. Grasp test cartridge between thumb and forefinger, lift from block, pause, rotate cartridge slowly in a vertical plane until the primer is up, pause, and rotate until the primer is again down.

3. Seat the cartridge gently into a horizontal chamber keeping the primer end as low as possible.

This procedure is commonly called the "SAAMI Twist" and is followed religiously. Typically, powder positioned at the primer end will give higher pressures and velocities, but exceptions have been noted.

Ballistic Coefficient

With the proliferation of exterior ballistics programs for personal computers, you now see a lot of discussion about ballistic coefficients. You can make the idea of BC very complicated or keep it simple. We like the simple version.

Years ago the commercial firearms and ammo people decided on a standard model to describe the exterior ballistic performance of sporting ammo. They chose a drag function named **G1** to represent typical performance of a sporting bullet. While "G1 drag function" sounds impressive, it's only a table showing how fast the standard projectile is losing velocity versus the momentary velocity of the projectile. If a tested bullet loses velocity twice as fast as does the standard bullet, it has a BC of 1/2 or 0.500. If the tested bullet loses velocity three times as fast as does the standard bullet, it has a BC of 1/3 or 0.333. If the tested bullet loses velocity at the same rate as the standard bullet, it has a BC of 1/1 or 1.000. If the tested bullet retains its velocity better than the standard bullet it has a BC of greater than 1.000.

To measure BC you must know both how fast your bullet is going and how fast the bullet is losing velocity. Suppose that your bullet starts at 2500 fps and loses 312 fps in 100 yards. The standard bullet loses only 84 fps starting at the same velocity under the same atmospheric conditions. The BC of your bullet is approximately 84/312 or 0.269.

BC computations are complicated because ballisticians don't just talk about a standard bullet. They also assume the bullet is flying in a standard atmosphere (pressure, temperature, and humidity). When you measure how fast your bullet is losing velocity at your local conditions, you must correct the readings to estimate how much it would lose under the standard conditions. This gets very messy and is best left to the computer program. Your responsibility is to tell the computer the exact atmospheric conditions at the time of the test, and to make sure all test distances are exactly what you tell the computer.

The definition and computation of BC hinges around one critical measurement -- the velocity lost. If you measure velocity lost to an accuracy of 5%, your ballistic coefficient will have an accuracy of approximately 5%. As an example, assume that you have a velocity loss of 200 fps representing a typical big-game bullet traveling 100 yards. To measure the velocity loss with 5% accuracy requires an error of less than 10 fps out of 200 fps. Using chronographs at both the muzzle and at 100 yards, you have an error budget of only 5 fps at each chronograph. That's an accuracy requirement of 0.17% at 3000 fps! It can be done, but it takes good equipment and a careful operator.

You will find that making reliable ballistic coefficient measurements is approximately ten to twenty times more difficult than making routine velocity measurements. What is an insignificant error in technique or recording conditions for normal velocity measurements can destroy the integrity of your measurement of ballistic coefficients. If you doubt it, just measure the ballistic coefficients from the same box of bullets with three setups on three different days.

You will sometimes see mention of BC varying with velocity. Don't worry, your bullet is not changing as it flies thru the air. It's just a mathematical trick. Measuring a BC at a particular velocity forces the theoretical drag to fit the observed drag at that velocity. Just because you've forced the measured and theoretical drag curves to fit at one velocity doesn't mean that they will fit at other velocities. If BCs measured at two velocity levels differ significantly, it means that the G1 drag function doesn't fit your bullet exactly. Even though the G1 drag function doesn't fit each bullet perfectly, it is the common standard and it is the only way we can make meaningful comparisons. Sometimes we hammer a square peg into a round hole and admit that we only get a tight fit at the corners. Though we may have different BCs over a velocity range, it's usually adequate to use an average BC. Don't worry about the third decimal place of the BC number; it's like quibbling if an estimated range is 391 or 392 yards.

An unexpected can of worms is opened as shooters begin to use the Model 43 to measure ballistic coefficients. If ballistic coefficients are measured over short ranges (less than 100 yards), the observed ballistic coefficients will probably be significantly lower than published values. Some of this loss can be attributed to the fact that at short ranges the bullet may not be fully stabilized and the yaw causes extra aerodynamic drag and a lower ballistic coefficient. The apparent ballistic coefficient for the same bullet will be higher if measured after the bullet is fully stabilized.

Even with a perfectly stabilized bullet, the observed ballistic coefficient may be different at different velocities because the G1 drag function doesn't fit every bullet fired with every load. While exterior ballistics programs may compute exterior ballistics precisely in accordance with the G1 drag table, the G1 drag table may not fit your bullet.

This doesn't mean that the G1 drag table should be abandoned. No other table fits all bullets either. You should use as long a distance as possible in measuring ballistic coefficient. Measuring hunting rifle bullet ballistic coefficients over a range of 300 yards is reasonable if you expect to use the rifle at that distance. Measuring the ballistic coefficients of long-range match bullets over 600 yards is reasonable if you expect to shoot that range. By measuring the ballistic coefficients over a long range, the BC is forced to fit over that range, and it will probably fit well over twice that range. On the other hand, if you measure ballistic coefficients over only 50 yards and then try to extrapolate out to 1000 yards, you can expect huge errors.

Don't let anyone tell you that ballistic coefficients aren't important. With a 200 yard zero, a significant change in ballistic coefficient may change the impact point only slightly at 400 yards. But, the same change in ballistic coefficient can change 400-yard energy and wind deflection significantly.

Acoustic Target

Oehler has been making acoustic targets for measuring the apparent impact points of supersonic bullets since 1982. These systems are used extensively by the military and major defense contractors.

The principle of the acoustic target is simple. Any supersonic projectile carries with it a Mach cone or "sonic boom." Three (or more) microphones detect the time at which the Mach cone arrives at the target. Given the location of each microphone, the speed of sound in air, and assuming that the bullet travels perpendicular to the target, it is possible to compute the apparent path of the bullet.

The Model 43 records the initial velocity of the bullet with a set of skyscreens and it also records the time required for the bullet to travel from the muzzle screens to the target. Knowing the *exact* distances involved we can compute the remaining velocity at the target and the ballistic coefficient.

Accuracy of the acoustic target is best with higher velocities (typically over 1800 fps). At higher velocities the Mach cone is sharp and skinny; this allows good accuracy in computing the target impact coordinates. We observe typical accuracies for the three-microphone system to be in the order of 0.3% of the side of the microphone triangle. For example, if each side is 30 inches, the coordinates are typically accurate to 0.1 inches. If each side is 60 inches, the coordinates are typically accurate to 0.2 inches. At lower velocities (say 1200 fps) the system still works, but accuracy is reduced.

A major benefit of the acoustic target is in the measurement of ballistic coefficients. The shooting window at the target is huge when compared to a set of skyscreens. Part of the price you pay for the big window, however, is that you must measure distances from muzzle screens to the target with high accuracy. It's desirable to measure these distances to within a tenth of a foot.

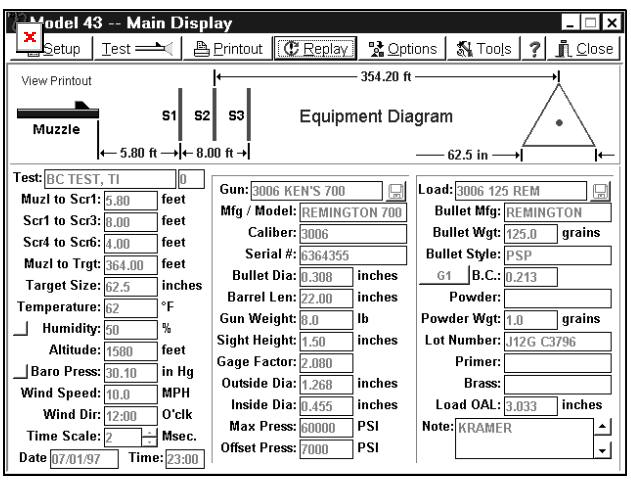
CHAPTER 2

Quick Tour Instructions

The best way to learn this system is to install the program in your computer and play along as you read these instructions. Replay some of the tests we've already fired, print them out, and then pretend you're setting up and firing tests of your own. You won't break anything.

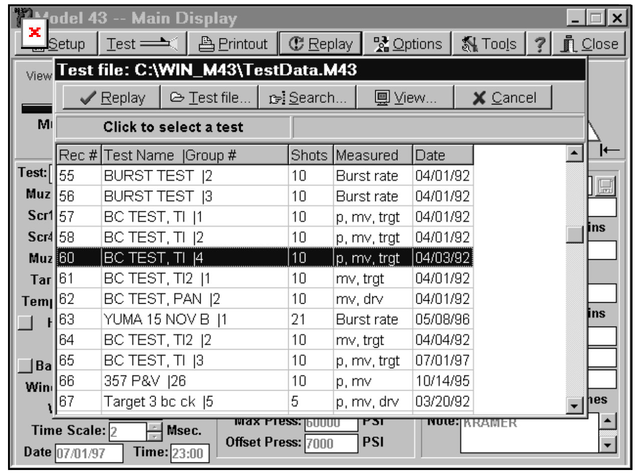
Make a working copy of the PBL disk and store the original. Operating from Windows 95, Windows 98 or Windows NT, exit from all other applications and run setup.exe from your program diskette.

The PBL program will start with a title window over the main display. Just hit the OK button to remove the title window.



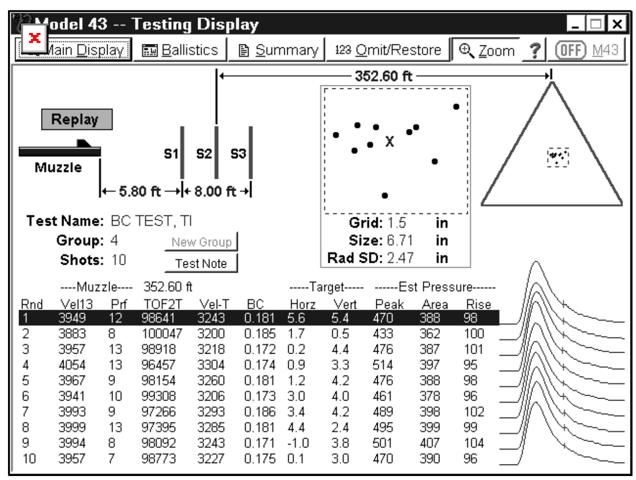
Main Display

The main display shows the test set-up and conditions, the description of the gun and description of the tested load. From the main display you can select the Replay action with the pushbutton.



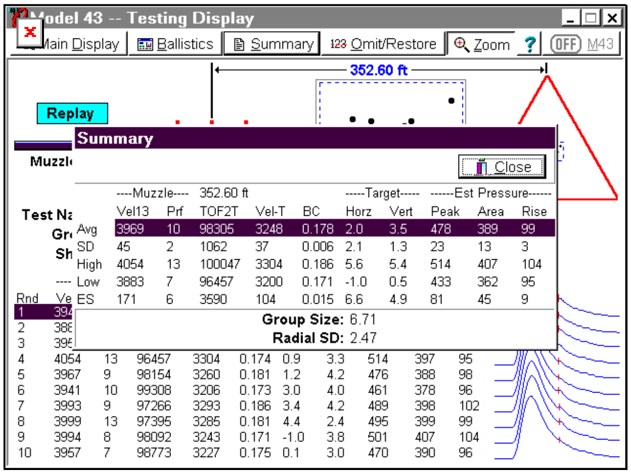
Replay Test List

Here is a list of the previously fired tests. Highlight the test your want to see and initiate the replay of that test with either a double-click on the selected test or a click on the Replay button.



Replay Test Display

This is the test screen that you would have seen at the completion of the firing. You can see the schematic of the test setup, the group on the target, the numeric value of each test parameter of each shot, and each pressure curve. Hitting the Summary pushbutton will display the statistical summary of all parameters.



Replay Summary

Here is the statistical summary of all parameters just as if you had requested the summary at the end of the test. You can close the summary window and play with the other buttons on the testing display. Ballistics shows an abbreviated ballistic table based on the actual results of the test, Omit/Restore allows you to selectively remove or restore individual shots of the test, Zoom toggles the zoomed display of the group on the target, and Main Display returns you to the main menu.

To print a previously fired test, follow a similar procedure. You just hit the Printout button instead of the replay button while you are in the Main Display window. Select the test to be printed with a double-click, push the Printout button, a Preview button is selected by default, and an OK will show the preview on your screen. If you really want the report printed on paper, select the Printer pushbutton instead of the Preview button.

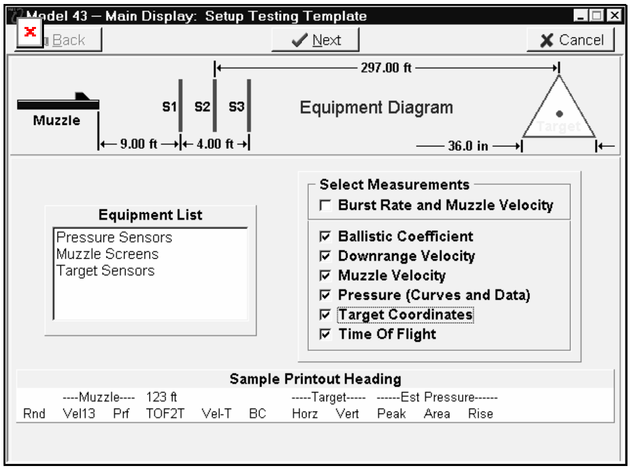
Now that you've replayed some of our tests, and printed copies of our reports, it's time to do your own test. Start from the Main Display window using the Setup pushbutton. The setup pushbutton will pull down a list of very confusing terms.

If you haven't used the Windows F1 or help key before, start now. Hit F1 and read the imbedded instructions! Remember the F1 key and use it any time you have selected a window or item and need some help.

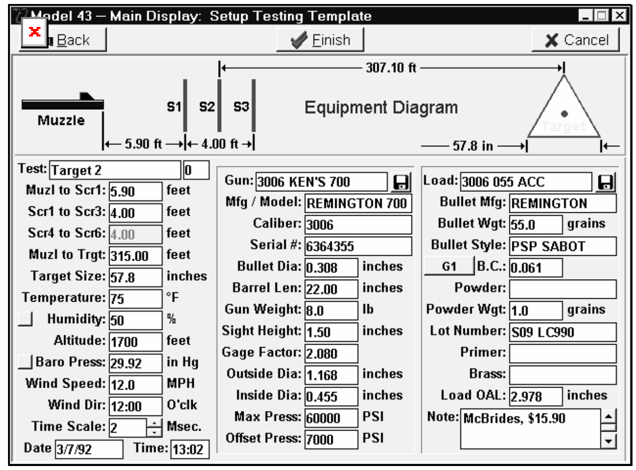
In the M43 program, we refer to the description of a test as a template. A test template is the complete description of a test *excluding* the actual firing data. The template describes what parameters are to be tested (pressure, muzzle velocity, ...), what test equipment is used and how it is arranged (screen spacing, pressure scale factor, …), environment (temperature, wind, barometric pressure, …), gun description, and load description. *You must have a test template prior to each test. You must either continue using an existing test template or you must make a new template.*

When you are testing, each test will probably be very much like the previous one. You might change powder charge between tests, or the temperature may change, or you might grab a different gun, but chances are you won't change the whole setup. The program works just like that.

From the Setup pull-down list, choose the Edit current test template option. This will bring up the Setup Testing Template window.



Setup Testing Window



Main Display – Parameter Entry

In this window you pick the measurements you wish to make during the test. In the Select Measurements box you can click on the different parameters turn the measurements off or on. The equipment list, equipment diagram, and printout heading boxes will follow your choices of desired measurements. After you have selected the desired measurements, exit with the Next pushbutton. If you've just completed a test and only want to make a minor change, you can hit Next without changing the existing selections.

You will now see a Main Display window, but the parameter boxes are now open for editing.

We check and change the parameters from top-to-bottom, left-to-right. The tab key naturally moves you this way. Remember, any time a particular box is selected, you can get help with that box by hitting the F1 key.

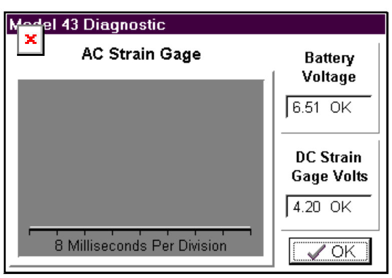
After you have completed the gun column, make sure that your click on the little diskette button and Save your gun in the Gun File. Next time you want to test with that gun, use the same button and Load the gun information. We find it convenient to start all gun names with the initial numbers of their caliber designation. That way they are easier to find in the list.

As with the guns, we always assign load names starting with the initial numbers of their caliber designation. We usually enter bullet weight as the second item of the load name, and we don't bother with entering decimal points, hyphens, mms, or grains. After a load is entered, use the diskette button and Save it. It's a lot easier to use the diskette button to retrieve a similar load and change the powder weight than it is to enter a new load from scratch.

Much of the information entered for gun and load is not critical for testing, but it is critical for test documentation. You don't appreciate it now, but you will bless it months and years from now when you review your recorded data.

After completing the entry of data into the boxes of the parameter entry screen, finish the process with the Finish pushbutton. This will typically bring up a box warning you that the test name already exists. Here you have the choice of either overwriting an existing test template (appropriate if you are making a correction or addition) or assigning a new test name. Note that this will not change the template or data from a previously fired test. As each test is fired and recorded, it saves the active template in effect at the time of the test.

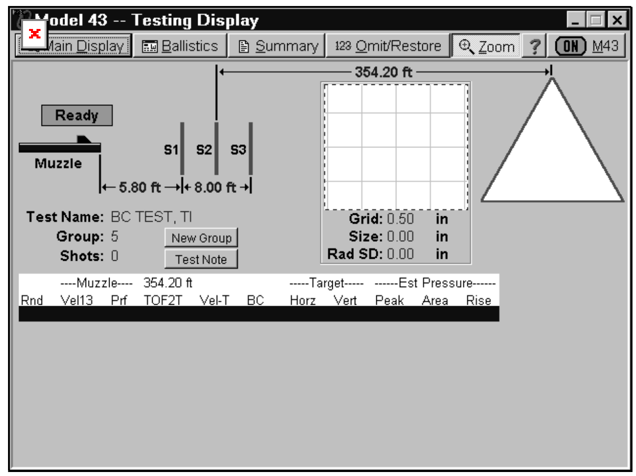
After the template is successfully saved, you will be returned to the Main Display window. Push the Test pushbutton to start the test. This will bring up a window for initializing the Model 43. With the M43 connected to the serial port of your PC, turn on the M43 and click OK. If the initialization does not finish, you will be prompted to retry. Increment the comm port number between each retry until communications are established. Note that it is critical to turn the M43 off and on as prompted to establish the proper handshaking.



Model 43 Diagnostic

After the M43 is initialized, the diagnostic window is displayed. It always shows the condition of the M43 battery. If the strain gage is used, you will see the dc voltage of the strain gage along with a note if the gage circuit is either open (broken wire, bad connector, or not plugged in) or shorted. The little green window provides oscilloscope snapshots of the strain gage signal. Ideally, you see a relatively smooth light line near the baseline of the display. If you see four characteristic humps along the line, it is an indication that you are picking up stray power-line signals. If you see the humps, attach a ground wire from the gun barrel to earth ground.

Leaving the diagnostic window shows the testing display.



Model 43 Testing Display

The testing display is your window for actual shooting. You see the graphic picture of your test setup along with the picture of the target frame and you group. Pay attention to the green ready light in the upper left of the screen. If the light shows steady green and Ready, the system is ready for you to shoot; if it's red or flashing, there are false triggers coming into either the strain gage or skyscreen circuits.

Fire the first shot and you should see the parameter value appear in each column along with the pressure curve and a bullet hole in the target. If the data is partially obscured by dashes, it has been automatically Omited by the program because some critical value was missing or was inconsistent. If you double-click on the round in question, you get a help window explaining what the program found wrong with that shot. This help window will include the raw times from each screen and microphone to give further diagnostic clues.

Clicking the Omit/Restore button will toggle the omit function. This allows you to override the machine and save test shots for which the data may be incomplete.

We use a special logic on the Omit function. If the last shot is shown as omitted on the display, the next shot will erase and overwrite it. This allows you to cleanly forget those shots obviously caused by a false trigger or other such goof. Any other shot can be omitted (removed from the summary), but it will not be erased. You can’t remove all evidence of a shot just because you later decide that you don’t like it. The data may be trying to tell you something even if you don’t recognize it now.

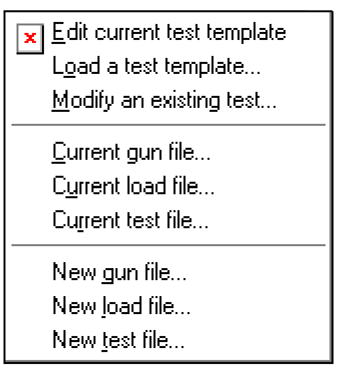
CHAPTER 3

Main Display

This chapter provides more details on setting up a test. ***If any entry or choice is not clear to you, click the cursor on the desired button or window, and press F1 for help.*** For those who don't really believe in Windows, some old-fashioned printed instructions are included. If you haven't had the quick tour described in Chapter 2, we strongly suggest that you take it now. Again, it will help if your have your M43 program running as you read these explanations.

The Main Display widow is the center of the M43 software. Everything seems to start and end at this window. You leave this window by pushing one of the buttons at the top, and you'll end up back at this window.

The Setup button will bring up a list of options.



Setup Options

The Edit current test template option simply lets you define what you want to measure, how your equipment is set up, the environmental conditions, gun information, and load information. You must go through this option prior to any test *except* when you are firing another group with the same gun and ammo under exactly the same conditions.

The Load a test template option allows you to load any previously defined template. You can add new groups to an earlier test, or you can load an earlier similar test to form the basis for editing. If you have planned and entered your test templates before going to the range, you can load them from here just before you shoot and just have to enter the temperature, wind, etc.

The Modify an existing test is a dangerous option. It allows you to correct a previously fired test if for example you remeasure the distance from gun to target on a ballistic coefficient test. Upon subsequent replay or printing, the test results will reflect the changes you make. You can edit test conditions, fill in extra blanks about the load, or make similar corrections; you can also demolish the validity of a test if you put in the wrong numbers. To maintain the integrity of your recorded data, any replay or print subsequent to a modification will include an "edit" flag in place of the date.

The Current gun file, Current load file, and Current test file options allow you to search for these files. Surprise; these files contain the information on guns, loads, and tests. As a matter of habit, we use m43 as the suffix for all of these files, and reflect the type of file in the prefix name. For instance, we would use Gundata.m43, GunRifles.m43, GunGage.M43 or similar names for gun files.

The New gun file, New load file, and New test file options allow you to create the new files for any of the three functions. If you do a lot of tests, you will probably want to start segregating different types of guns into different test data files.

The Test pushbutton starts an actual firing test. It will establish handshaking between the PC and the M43. If handshaking cannot be established, the most common causes are serial cable not properly connected, wrong comm port selected in the PC, M43 not turned off and on at the right time in the sequence, or dead battery in the M43. After communications are established, you will see the diagnostic screen. This screen shows the M43 battery condition and strain gage diagnostic information. By the time you get to the actual test screen, there isn't much to do except shoot when the light is green.

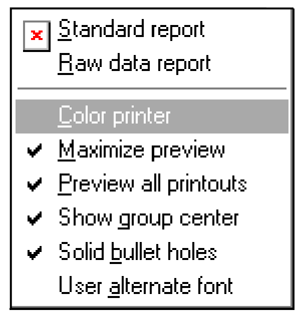
The Printout button of the main display is used to print or to view the results of previously fired tests. Select the test your want to print or view from the list. Hint: *The right mouse button will easily take you back to the last test you selected. You often want to go there*. After one or more tests are selected for printing, hitting the PrintOut button will bring up the Report Setup screen. It will default to showing a preview of the printed report on the screen. *If you want a real printed copy of the report, hit the printer icon at the top of the preview screen. If you don't hit the printer icon now, you'll have to go through the select process again and select the Printer pushbutton instead of the default Preview button*.

The Replay button of the main display is similar in function to the printout button. It allows you to select from a test list and shows the screen of the actual test results with summary and ballistics available. It will not however show you the test setup, gun, and load information. For that, you must go through the printout procedure.

Under the Options button of the main display, you can change several appearance items.

Options

The Color options affect the display of the testing screen used during actual shooting. Printout options affect the content and appearance of the printed reports. The Comm options let you test the connection between the PC and the M43. The Set Report Title option allows you to put your own report title across the tops of all printed reports.



Printout Options

Under the printout options you can make several significant selections. Selection of Raw data report will cause a printout of the raw times from each skyscreen and microphone. This report is useful if velocities or target don't work properly and you want to fax Oehler the raw information to look at. Checking the Color printer option allows jazzed up printouts from a color printer. Checking the Maximize preview just spreads the report preview over the entire screen. Checking Preview all printouts makes the machine very religious about making you look at a screen before it wastes a sheet of paper on a printout. Checking Show group center will put an X at the group center. Solid bullet holes normally look like a real target; unchecking it will show circles instead of holes so you can see individual shots in the one-hole group. Checking User alternate font may help older printers.

Tools Options

Under the Tools pushbutton of the main display, there are several useful options. The Copy test(s) allows you to quickly reorganize your tests and put them into different test files. The Delete function allows your to delete or scrap tests, guns, loads, or test templates. The Export option allows you to export your test data to either the Ballistic Explorer or to a generic database. The Import ver 1.x tests allows you to import your old DOS M43 test data into the Windows version.

The Close button gets your out of the program.

The Equipment Diagram of the main display gives you a picture of the test equipment used for the displayed template. It can be alternated with the Sample Printout Heading display.

Why all those little boxes?

For adequate documentation of each test, you should fill in all the little boxes of the main display. Some boxes are essential to the measurements, and some are simply desired for documentation. Just fill them all in; we guarantee that you won't have too much data a year from now.

Test:

Name the test with a unique name. Tests can be alpha-numerically sorted on all lists, so choose the first few characters carefully. This will determine the test order and grouping on all displayed lists. The box to the right of the test name is the group number of all those tests performed with this same template.

Muzl to Scr1: feet

Enter the distance in feet from the muzzle of your gun to the first skyscreen (the start screen). This distance should be measured and maintained within 0.1 ft if you use the Acoustic Target to measure ballistic coefficients, or if you are measuring pressure. (This distance is used to locate the muzzle mark on the pressure curve.)

Scr1 to Scr3: feet

Enter the distance between the start and stop muzzle skyscreens. The standard distance is 4 feet although you may want to use 6 or 8 feet for ballistic coefficient measurements.

Scr4 to Scr6: feet

Enter the distance between the start and stop downrange screens. The standard distance is 4 feet.

If the choice shows -N/A-, and you want to use downrange screens, go back to Select Measurements and select downrange velocity.

Muzl to Trgt: feet

Enter data here only when the Acoustic Target is used. This distance should be measured to within a few tenths of a foot if the Ballistic Coefficient is to be valid. If you guess this distance, don't be surprised at ridiculous ballistic coefficients and downrange velocity numbers. We find it most convenient to record the distance measured from the front of the shooting bench to the permanent target mounting face, and adjust this distance to obtain the distance from muzzle to microphone.

Target Size: inches

Enter data here only when the Acoustic Target is used. Enter the size of the target in inches. Measure across the base of the triangular target from the center of one black microphone to the center of the other. This dimension is typically 2.5 inches longer than the plastic support rails.

Temperature: F

Enter the current temperature in degrees Fahrenheit. Temperature affects air density and the speed of sound, both of which are essential to accurate ballistics calculations. If you are making ballistic coefficient measurements, the temperature should be updated at each test to an accuracy of 2 degrees or better.

Humidity: %

Enter the relative-humidity percentage. Humidity affects air density and the speed of sound, both of which are essential to accurate ballistics calculations. If you don't know humidity, push the button to the left of the box and the computer will ask you for the wet bulb temperature and will then calculate relative humidity. Humidity has only a slight effect on ballistic calculations.

Altitude: feet

Enter the altitude at the firing range in feet above sea level. An accuracy of 100 feet is normally sufficient for ballistic coefficient calculations.

Baro Press: in Hg

Enter the current reported barometric pressure in inches of mercury. If you do not know the current pressure, use the standard value of 29.92.

Reported pressures are corrected to sea level. The program corrects the reported pressure to the actual pressure at your altitude. If you know the raw pressure, hit the button to the left of the box and the program will then accept the raw pressure.

Wind Speed: MPH

Enter the estimated wind speed in MPH if known. This value has only a slight effect on calculations.

Wind Dir: O'clk

Enter the wind direction based on a clock face relative to the target. The target is 12:00 o'clock. A wind blowing directly from your right is from 3:00 o'clock.

Time Scale

The time scale for the overall length of the pressure curve is normally set at 2 milliseconds for handguns and rifles. It is typically set at 4 milliseconds for blackpowder and shotguns. If the time scale is too short, the muzzle mark will be off the picture and you cannot get area under the pressure curve.

Date: Time:

The program automatically picks up the time and date from the computer. If the displayed time and date are not correct, you must reset your computer's clock.

Entering Gun Data

Most gun data is entered only one time for any gun, but it can be edited. Learn to use the little load and store icon located immediately to the right of the gun name box. It will save much time.

The various entries in the gun file are.

Gun Name:

Enter the name of your gun. We find it most convenient to use the headstamp caliber numbers as the initial characters. That way it's easier to find guns in a list.

Mfg/Model:, Caliber:, Serial #:

These entries are optional.

Bullet Dia: inches

This diameter is used to scale the area under the pressure curve.

Barrel Length: inches

Barrel length is required if you are measuring pressures.

Sight Height: inches

Measure from the middle of the bore to the middle of an optical sight or to the top of the front blade of an iron sight. This value is used for the bullet path calculation. Sights mounted below the barrel have a negative height.

Gage Factor:

This entry is required for the pressure measurements. Each package of strain gages is marked with the gage factor by the manufacturer. It is typically 2.08.

Outside Dia: inches

This entry is required for pressure measurements. Enter the outside diameter of the barrel (over the chamber) at the point where the strain gage is attached. For octagonal barrels use the measurement across the flats. For a revolver cylinder use the chamber diameter plus twice the minimum chamber wall thickness.

Inside Dia: inches

This entry is required for pressure measurements. Enter the inside diameter of the chamber at the point just under where the strain gage is attached.

You can determine the chamber diameter by measuring the outside diameter of a fired cartridge case at the point corresponding to the strain gage location.

Maximum PSI:

This is the maximum pressure expected. Enter 50,000 PSI as 50000, not as 50K or 50,000. This value is used to set the height of the pressure curve picture. Space is already allowed for 25% over-range. If you observe pressure curves with an absolutely flat top, you have set this value too low.

Offset PSI:

This is the pressure required to expand the cartridge case to the chamber wall. Use the default value of 7000 psi for metallic cartridges unless you are certain of a better value. Use zero for muzzle-loaders and 500 psi for plastic shotshells.

Entering Load Data

Many times load data will be reused. Again, it will be to your advantage to learn how to save and store loads in the load file.

Load Name:

As with guns, we prefer to start load name with the numerals of the headstamp designation, followed by any required alpha character, a space and the bullet weight in grains. This grouping makes it easier to find loads in the list.

Bullet Mfg:

This is optional.

Bullet Wgt: Gr

Bullet weight in grains is required to calculate the bullet energy, power factor and recoil.

Bullet Style:

This is optional.

BC:

(Drag function/Ballistic coefficient) The button to the left of B.C. can be used to select the drag function used. Use the G1 function unless you thoroughly understand drag functions and have good reason to use another. (See Appendix A) The actual number entered in the box is the ballistic coefficient of your bullet. This ballistic coefficient is used to compute the standard atmosphere ballistics and is used to locate the muzzle mark on the pressure curve. If in doubt, enter a B.C. of 0.200. ***Do not use a B.C. of zero****.*

NOTE: If you measure the actual BC, using either downrange skyscreens or the acoustic target, the load BC value is automatically updated.

Powder:

This is optional.

Powder Wgt: Grains

You must enter powder weight for recoil calculations.

Lot Number:

This is optional, but almost as important for your records as powder type and weight.

Primer:

This is optional.

Brass:

This is optional.

Load OAL: inches

The overall length of the loaded round is optional.

Note:

You can add a short note about this load.

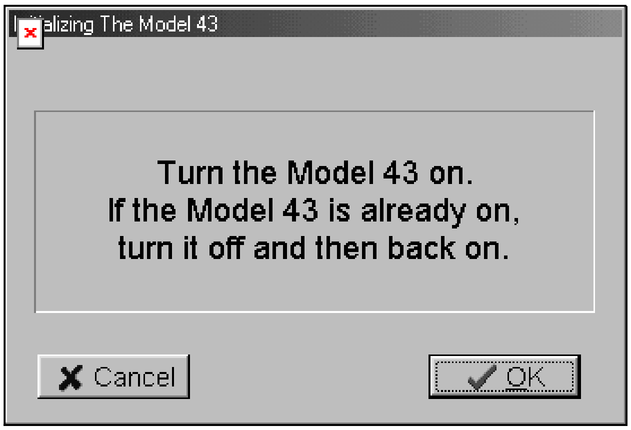
Explore the Setup Screen

Take some time to enter gun information and load information on a few guns and loads. Save the gun and load information and then load it back.

CHAPTER 5

Testing Display

You get to the Testing Display by hitting the Test pushbutton of the Main Display. You will always go through the Initializing Model 43 window if required to initialize the Model 43.



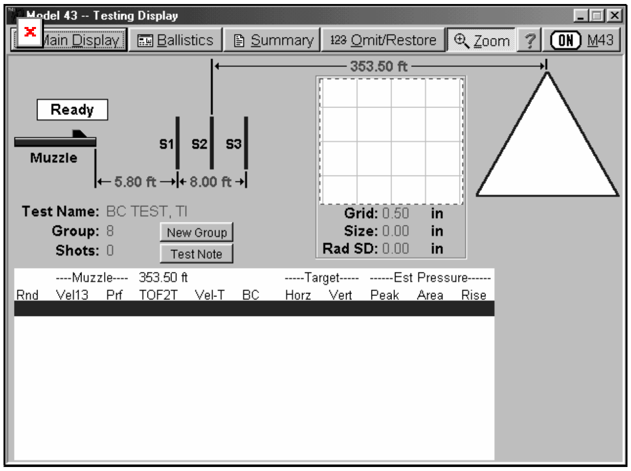
Initializing Screen

At this point, the PC establishes communication with the M43 and downloads the program for the M43. Switch the M43 off and on as prompted on the screen. You may have to change the comm port number to be used by the PC to get communications established. If handshaking cannot be established, the most common causes are serial cable not properly connected, wrong comm port selected in the PC, M43 not turned off and on at the right time in the sequence, or dead battery in the M43. After communications are established, you will see the diagnostic screen. This screen shows the M43 battery condition and strain gage diagnostic information. The diagnostic screen shows the battery voltage of the Model 43 unit. Adjacent to the battery voltage a note of OVERCHARGED, LOW, or OK will appear. If the battery shows low, it should be recharged. If it shows overcharged, the charger should be disconnected.

If pressures are being measured, the diagnostic screen will indicate the voltage across the strain gage. If the voltage across the strain gage is too low, a note of SHORTED will appear to indicate that there is probably a short circuit in the strain gage wires. If the voltage across the strain gage is too high, a note of OPEN will appear to indicate that there is probably a break or open circuit in the strain gage wires.

At the bottom of the window is a picture of the pressure signal. This signal is normally flat with very small noise peaks. The noise peaks are normally less than half the height of a capital letter on the screen. Noise interference from power lines is typically indicated by either four or eight "haystacks" along the pressure signals. If there is excessive noise, make sure the gun is grounded to earth ground. Experiment to find the best place to attach the ground wire to earth ground. Incidentally, a gear-type hose clamp used in combination with an aluminum foil pad is an ideal way to attach a ground wire to a barrel. Noise from power lines is often minimized if you operate both your computer and the Model 43 from batteries only instead of recharging during operation.

Exiting the diagnostic screen brings up the Testing Display.



Testing Display

Ballistics

After you fire at least one shot you can get a ballistics chart showing bullet path, 10-mph wind deflection, velocity, energy and power factor. This ballistic chart is calculated for standard atmospheric conditions. Zeroed range can be adjusted. The chart extends to 250 yards if the muzzle velocity is less than 2,000 fps and to 500 yards for higher muzzle velocities.

Summary

After you fire at least one shot, you can get a statistical summary of all the measurements shown on the test.

New group

After you fire at least one shot, you can start a new group. The data from all shots is cleared from the screen and the group number increments as soon as you hit [N]. Use [N] to start a new group only if you have no comments to add to your existing group and you have no changes to make regarding conditions, gun, or load. If you hit [N] and then exit to the setup screen, the setup screen will have the group number of the new group.

Omit/Restore

This button will omit the highlighted shot from the summary. It will not erase the shot. It the <u>*last*</u> *shot in an active group is omitted, it will be overwritten by any subsequent shot. If you hit this button when an omitted round is highlighted, the round will be restored. This restore function can be used to retain data of a shot for which the system detected a partial malfunction and you wish to retain the data. For example, you may wish to retain pressure and muzzle velocity data on a shot that was not scored properly on the acoustic target.*

You can omit any shot you don't like. We urge that you omit only those for which the measurement is questionable. For example, omit shots where a large proof number indicates a questionable velocity or where definite abnormal readings are shown. Values shown as dashed lines are automatically omitted. Omitted shots are not used in any calculations that appear in the Ballistics and Summary screens.

Exit

To exit from the Testing screen, press [E]. You are returned to the setup screen.

Under the pushbuttons of the testing screen is a diagram of the test setup. The example shows the muzzle skyscreens (S1 S2 S3) and the triangle represents the acoustic target. Distances are shown in feet.

If downrange skyscreens are used instead of the acoustic target, they will be shown as screens (S4 S5 S6).

Over the muzzle is a box with the word Ready. This indicates that the system is ready for you to fire a real or simulated shot. After each shot, wait for Ready to reappear before you fire again.

The Test name and Group are displayed. If you have loaded an old template, the program will automatically select the lowest unused group number. If you fire one or more shots a new data file is saved using the new group number. If you exit the testing screen without firing a shot, the group is not saved.

Measurement Channels

The column headings shown on the testing screen are those you previewed on the Setup screen. They may include:

RND

The round number of the shot within the test group.

VEL13

The velocity measured from screen #1 to screen #3. It is commonly called the instrumental velocity.

PRF

The velocity proof number. It is computed by subtracting VEL13 from VEL12. Ideally this number is both small and consistent. If the number is large (say more than 5 fps) but consistent, it normally indicates an error in screen spacing or a bent screen mounting rail. A consistently negative number, for example, indicates that screen#2 is too close to screen#3.

TOF25

The time-of-flight measured in microseconds from screen#2 to screen#5.

The distance shown above the TOF25 heading is computed from VEL13, VEL46, and TOF25. We can compute the distance more accurately than most shooters can measure it at the range, and it's much easier.

VEL46

The downrange velocity measured between screen#4 and screen#6.

PRF

Another velocity proof number computed by subtracting VEL46 from VEL45.

TOF2T

The time-of-fight measured in microseconds from screen #2 to the acoustic target. This time is corrected to compensate for the delay in the bullet's sound hitting the microphone as the bullet passes by the microphone.

VEL-T

The velocity at the target. It is computed from the distance to the target, VEL13, the assumed drag function, and the time-of-flight to the target. The distance to the target is very critical to the calculation of this velocity and the ballistic coefficient. Measure the distance to target carefully, to within a few tenths of a foot, or you will get meaningless answers.

BC

The ballistic coefficient calculated from your data and is corrected to standard atmospheric conditions. You must take special care to measure and update air temperature to get accurate values of BC. Altitude, barometric pressure, and humidity are also considered, but are less critical.

HORIZ

The horizontal impact point of the bullet measured in inches with respect to the center of the acoustic target triangle. Positive numbers are right and negative numbers are left.

VERT

The vertical impact point of the bullet measured in inches with respect to the center of the acoustic target triangle. Positive numbers are high and negative numbers are low.

PEAK

The observed peak pressure. Remember that this is an estimated relative value relative only to the gun in which the ammo was tested. It may bear no relation to published pressure numbers. This observed pressure is valid only for the test gun..

AREA

The area under the pressure curve measured from estimated ignition to the bullet exit mark. This area is proportional to impulse and bullet momentum (power factor) if there is no friction or other losses in the bore. We have scaled the area so that you can compare it to power factor.

RISE

The time in microseconds from the 25% point to the 75% point of the pressure curve. It is an indication of the powder burning rate in your load.

Pressure Curves

The pressure curves provide information on both the pressure and the instrumentation. You want to see relatively smooth curves without excessive peaks or noise. If you see extra peaks or humps on the pressure curve, fire some ammunition which has proven stable in the past.

Acoustic Target

The large triangle in the upper corner of the screen represents the acoustic target. As you shoot, a small square within the triangle shows the location of your group within the triangle.

The grid square adjacent to the triangle shows a zoomed view of your group. The grid squares start at 0.5 inch with your first square and will increase as required to show all the shots in your group. The group size (extreme spread in inches) and the group radial standard deviation are shown below the grid.

The measured data from the shot is written below the column headings, and the pressure curve is plotted to the right of the data. Note that a small mark is placed on the pressure curve corresponding to the point in time at which the bullet left the muzzle.

If the system did not recognize proper input signals for any measurement channel, that measurement will be shown as dashes, --- . Highlight the shot and double-click to get the computer's guess of what went wrong on that shot. If a shot record contains dashes instead of data, the shot will be automatically omitted. It can be restored and included with the group data by hitting the Omit/Restore button before the next shot is fired.

Ballistics Table

You can fire up to 10 shots in a string, but you can bring up the **b**allistics table at any time after the first shot.

Zero Range:

The distance at which the gun is zeroed. This distance can be adjusted up and down. Bullet path will change as you adjust the zero range.

The distance headings include the actual muzzle, the instrumental distance (midpoint of screen#1 and screen#3), and six downrange yardages. The downrange yardages extend to 500 yards for muzzle velocities in excess of 2000 fps and extend to 250 yards for velocities less than 2000 fps.

BULLET PATH

Path is the distance (in inches) the bullet is above or below the line of sight. The bullet path automatically adjusts as you change zero range.

10 MPH WIND

This is the amount of bullet drift (in inches) caused by a 10 mph crosswind.

VELOCITY

The remaining velocity at the indicated distance. Velocity at the instrumental distance is the average VEL13 shown on the testing screen. Muzzle velocity is the instrumental velocity corrected back to the muzzle.

ENERGY

The bullet energy measured in foot-pounds.

POWER FACTOR

This number is the bullet momentum expressed in "power-factor" units. (Bullet weight in grains multiplied by velocity in fps and divided by 1000)

Statistical Summary

After you have fired at least one shot, you can bring up a **S**ummary.

The line items in the summary are:

AV

Average is the average or mean value of the valid shots.

SD

The standard deviation of the valid shots.

HI

The highest value among the valid shots.

LO

The lowest value among the valid shots.

ES

The extreme spread or the range between the highest and lowest values for the group.

Burst Rate and Muzzle Velocity

If burst rate and muzzle velocity are the selected measurements, you must answer two extra questions. You are asked the maximum expected rate in rounds per minute and the minimum expected velocity in feet per second. Spacing between Screen#1 and Screen#3 must be at least two feet.

At the testing screen you are instructed to fire the burst. After the burst is fired, signal the computer by pressing any key. Your data will then be displayed.

The following heading is repeated three times across the screen:

RND TIME VEL13 PRF RATE

RND
: *The number of the round fired. If you fire more than 30 rounds the system will show only the first 30 rounds.*

TIME
: *The elapsed time of each round from the beginning of the burst. If this time exceeds 999 seconds it recycles.*

VEL13
: *The velocity of each round measured between screen#1 and screen#3.*

PRF
: *This is the velocity proof number of VEL12 minus VEL13.*

RATE
: *This rate in rounds-per-minute is calculated based on the time between each round. You can compute the average rates for portions of the burst by using the differences in times and the number of shots between the times.*

In the burst rate mode you can still access the ballistics and statistics. In the statistical summary, the average rate of fire is computed as the average of all the individual rates of fire.

CHAPTER 6

Strain Gage Mounting

WARNING ! ! !

If you do a proper job of mounting the strain gage to the barrel, you will probably deface, abrade, scratch, mar, deblue, rust and otherwise mess up the gun. Strain gages should be mounted on "working" guns only. The user must assume total responsibility for any real or cosmetic damage to the gun.

Where to Mount the Strain Gage

The strain gage must be mounted over the chamber area to measure the stretch or strain caused by the pressure inside. It is easy on some guns (typically break-open actions), difficult on some guns (most bolt actions), and impossible on others. For instance, you cannot practically glue the strain gage to the barrel inside an automatic pistol. With short cases such as the PPC there is actually very little chamber extending ahead of the receiver ring of a bolt action.

If there is no interference from action or stock you should mount the strain gage over the "middle" of the case body. This works fine with a Contender or other break-open action where you have a straight barrel, no barrel threads, and often a long straight case. With a Contender it is convenient to remove the rear sight to expose the part of the barrel over the case body. If you are shooting ballistic coefficients and want to leave the sights or scope on, there's barely enough room to mount the strain gage at the 2 o'clock position.

For shotguns mount the strain gage 1 inch from the breech.

With a bolt action rifle you must chamber an empty case, insert a cleaning rod until it bottoms out, and then mark the cleaning rod at the muzzle with a piece of tape. Remove case and cleaning rod and then hold the case alongside the chamber with its location determined by the marked cleaning rod. Estimate the desired gage mounting area to be halfway between the receiver and the case shoulder.

A strain gage is ruined when it is removed. You are encouraged to leave the strain gage mounted on the gun for future tests. If the strain gage is to remain a permanent part of the gun you may want to sacrifice a little mounting convenience in order to hide the gage. The only place to hide a gage on a bolt action rifle is under the stock, just forward of the recoil lug. The stock must be recessed so that there is room for the gage. The gage is roughly 0.30 x 0.60 inch in area and roughly 0.03 inch thick. Wires attached to the strain gage can be unsoldered after testing if they interfere with the gun's use, or they can be coiled and taped to the side of the stock if you are only using the gun at the range for testing. It's relatively easy to resolder the wires when the gage is to be used again.

For a strain gage to work properly it must be attached solidly. For the adhesives to bond properly, the metal must be clean. By clean, we do not mean drill sergeant clean with a microscopic film of oil and a very thin coating of silicone to prevent rust. We mean dry clean without a trace of oil or silicone. To get the best glue bond, the barrel must be sanded down to the bare steel and etched. The strain gage people will swear that you must strip the metal raw.

To avoid marring the gun, we sometimes omit the sanding step. This works sometimes, for a while. If you plan to use the gage on that gun for a long term, you should sand. This is a significant argument for mounting the gage in a location that will be hidden.

Plan Ahead

Before you glue on the strain gage, decide where you want the wires to go after they leave the gage. Locate and orient the gage to fit. On revolver cylinders there must be sufficient clearance between the cylinder and the top-strap to have room for the gage and the glue. Mount the gage so that the active zigzag portion is centered over the thinnest part of a chamber wall and so that the solder pads and wire will not have to pass under the top-strap before a shot is fired.

On octagonal barrels mount the gage so that the active zigzag portion is centered on a flat.

With any mounting the gage must be oriented so that it tends to wrap around the barrel or cylinder. Do not mount the gage so that the long axis of the gage follows the axis of the barrel or chamber.

WARNING ! ! !

Several of the chemicals used in mounting the strain gages are toxic. Please read and heed the specific hazard labels included or attached to the various products.

Most of the chemicals included with the strain gage starter kit are products of Measurements Group, Inc., PO Box 27777, Raleigh, NC 27611. Telephone 919-365-3800. They are the manufacturers of the recommended CEA-06-250UW-350 strain gages. You can buy from them at the same prices we must pay.

How to Mount the Strain Gage

Step 1 --
Degrease the area of the barrel within two inches of the gage mounting location. First wipe the area with a paper towel pad wet with degreaser. Repeat with another wet paper towel. Spray area with degreaser and allow to dry without wiping.

1-1-1 Trichloroethane is the active ingredient in the degreaser. It's available in bulk at a lower per unit price, but the convenience of the pressurized can is worth the extra cost. The pressurized can cannot be shipped by air.

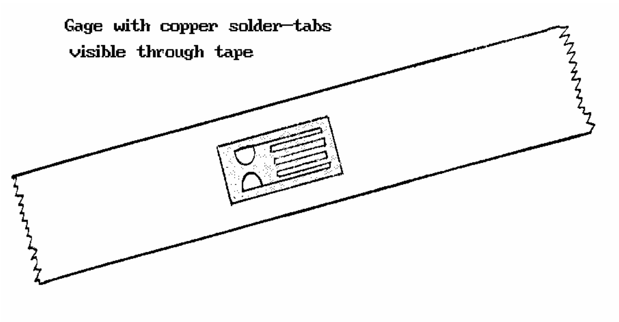
Step 2 --
Repeatedly apply M-Prep Conditioner A with cotton-tipped applicators until a clean tip is not discolored. Dry area with paper towel. Wipe out from the center of the area with a fresh portion of towel after each stroke. Don't drag contaminants into the clean area. Repeat application of conditioner and dry with a gauze pad. Never allow any solution to dry on the surface because it will leave a film and reduce the chance of a good bond.

M-Prep Conditioner A is mildly acidic and will often remove or discolor the blue.

Cotton gauze pads are hard to find. The best substitute is a sheet of Bounty brand paper towel. Fold each sheet twice to make a four-layer pad, and use each pad for only one wipe.

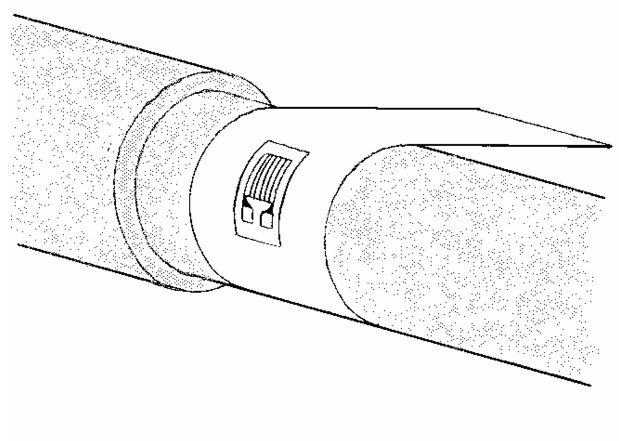
Step 3 --
Apply M-Prep Neutralizer 5A with a saturated cotton-tipped applicator and scrub. With a single slow wiping motion of a gauze pad, carefully dry the surface. Do not wipe back and forth as this may redeposit contaminants.

Step 4 --
Using tweezers take a gage from its mylar envelope and place it bonding side down on a chemically clean smooth surface. (The bonding side is the dull side; the connector side has brighter copper solder pads.) The inside of the plastic gage box is a convenient clean surface. Don't handle the gage with your greasy fingers! Stick a 5-inch piece of Micro-Measurements PCT-2A cellophane tape to the connector (bright copper) side of the gage. The long axis of the gage should run along the long axis of the tape and the gage should be roughly centered on the tape. You now have a nice tape "handle" on the gage.



Strain Gage on Cellophane Tape

Step 5 --
Position the gage/tape assembly so that the gage is at the desired location and firmly press down one end of the tape. If the location is not right, lift the tape and repeat until you have it at the right place. (A special tape is included in the kit because its mastic [sticky stuff] sticks to the cellophane better than the mastic sticks to the barrel. This prevents contaminating the mounting area with mastic pulled from the tape.)



Locate Strain Gage on Barrel

Step 6 --
Lift one end of the tape assembly until the gage is approximately 1/2 inch from the barrel. This leaves the bonding surface of the gage exposed.

Apply Catalyst to Exposed Gage

Step 7 --
Apply M-Bond 200 catalyst to the bonding surface of the gage. Very little catalyst is needed. Lift the brush-cap out of the catalyst bottle and wipe the brush approximately 10 strokes against the lip of the bottle to wring out most of the catalyst. Set the brush down on the gage and swab the surface. Do not lift and stroke the brush in painting style, but cover the gage using circular strokes. Move the brush to the adjacent tape before lifting it from the surface. Allow the catalyst to dry at least one minute.

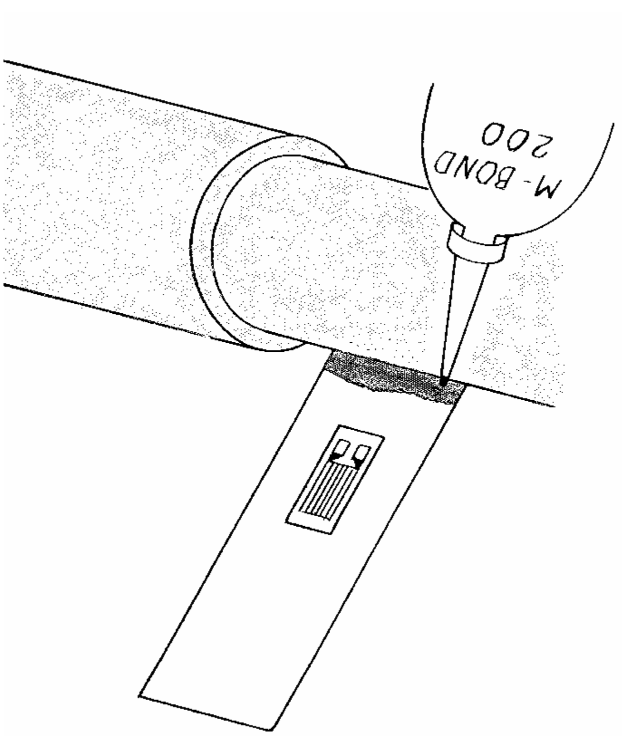
M-Bond Storage

The M-Bond 200 adhesive is always labeled with an early *use by* date. This date can sometimes be extended if the adhesive is stored in a refrigerator or freezer. Store in a sealed plastic bag; allow to reach room temperature before opening.

_CAUTION

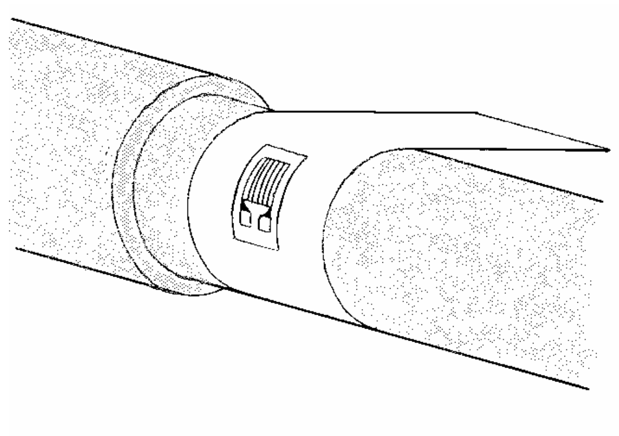
M-Bond 200 is from the super-glue family. Use care not to glue your fingers together or to anything else!

The next three steps must be completed in the sequence shown within three to five seconds after the adhesive is applied. Learn the steps and plan your work before you start.



Apply Adhesive Next to Gage

Step 8 --
Hold the free end of the tape perpendicular to the barrel surface and so that the end of the gage is approximately 1/2 inch from the barrel. Apply two drops of M-Bond 200 adhesive to the inside corner where the tape meets the barrel. This adhesive application should be 3/8 inch from the gage and the gage installation area. This insures that the initial polymerization of the adhesive will not cause unevenness in the gage glueline.



Rub Gage Onto Mounting Area

Step 9 --
Immediately rotate the tape to an approximate 30 degree angle so that the gage is bridged over the installation area. While holding the tape snug, slowly and *firmly* make a single wiping stroke over the outside of gage/tape assembly with a gauze pad. Use a firm pressure to give a very thin uniform layer of adhesive.

Step 10 --
Immediately after the wipe-out of the adhesive, apply firm thumb pressure to the gage. *Use the gauze pad or you will glue your thumb to the barrel.* Hold this pressure for at least one minute. If the temperature is below 70 degrees F or if the humidity is below 30%, hold the pressure for two minutes.

Step 11 --
Wait at least two more minutes before removing the tape. Remove the tape by pulling it back directly over itself to form the largest possible angle at the junction with the barrel. Peel the tape slowly and steadily to avoid lifting the gage.

Stainless Steel Barrels

The preceding procedure works well with ordinary steel barrels. We have sometimes encountered difficulty getting a reliable bond to stainless barrels and revolver cylinders with the M-Bond 200 adhesive and the outlined procedure. To bond to stainless, the manufacturer of the gages and adhesives suggests a "hot, wet, acid abrade". Translated, this means

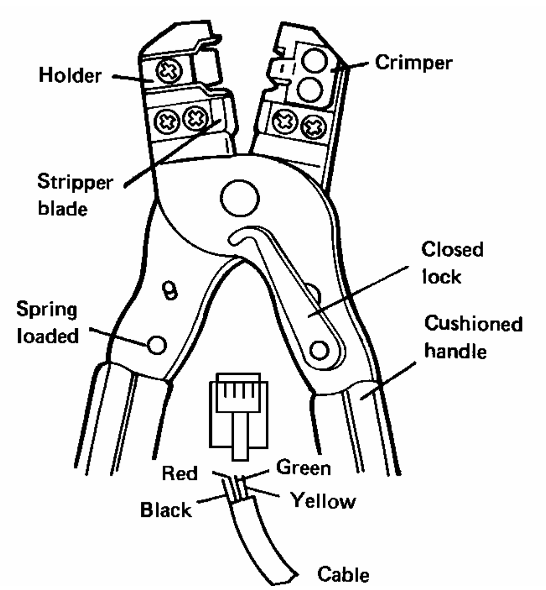
1. Heat the barrel (in the oven or with a hairdryer) until it is as warm as you can comfortably handle.
2. Use the M-Prep Conditioner A (a mild acid) with the sandpaper to abrade the gage mounting area.
3. Dry the area with a paper towel pad.
4. Repeat the above three steps and go to *Step 3* of the regular mounting procedure.

The object of this exercise is to remove all traces of oil and mold release from the area, and to leave enough "tooth" on the mounting area for the adhesive to bond.

Installing Modular Connectors

The modular connectors used by the phone company look like pieces of plastic junk, but they are usually reliable. Compared to other multi-conductor connectors they are easy to install. A modular connector installation tool is included with the strain gage starter kit.

To install a connector, first cut a piece of modular cable to 4 feet. Make sure the end is cut square, not diagonally. Shears or a sharp knife on a cutting block work fine. Strip approximately 1/4 inch of outer jacket from the end of the wire to expose the four (black, red, green, yellow) conductors. To strip, insert the cable end between the stripper blades of the connector tool. (There's a stop at the correct depth.) Close the tool to cut the outer jacket and pull the cable squarely away from the tool to remove the outer jacket. Check for damaged insulation on the inner conductors and trim any exposed copper ends.



Connector Installation Tool

Hold the cable in your left hand and one of the little modular plugs in your right. Hold the cable with the black wire next to your belly and hold the plug with the tab dangling down. Insert the wires into the plug as far as they will go. Using the cable as a pusher, insert the plug into the connector tool holder so that the plug is against the stop and the gold contacts face up to the crimper. Be sure that the cable is pushed all the way into the plug. Squeeze the tool handles firmly to set the gold contacts. Each gold contact should be pressed approximately 0.020 inch below the plastic knuckles

We always put on all connectors just as described above. Cables made for *telephone* use will have one connector inverted. If you cut such a cable in half, it will work fine for wiring to a strain gage. A cable made for telephone use will not work for wiring to the downrange amplifier unit because the wires are crossed.

Soldering Lead Wires

The lead wires to the strain gage must be attached *after* the gage has been bonded to the gun. If the wires are soldered to the gage before bonding to the gun, the gage will not conform to the gun and the glue line will be thicker and weaker.

Four-conductor modular phone wire is used to connect to the gage. Use a piece of modular phone wire approximately 3 or 4 feet long with a modular plug installed on one end. Strip approximately 4 inches of the outer jacket from the end of the phone wire to expose the 4 inner conductors. Clip off the yellow wire near the outer jacket.

Plug in the furnished 25-watt soldering iron and allow it to heat until it will readily melt the thin rosin-core solder provided.

Strip approximately 1 inch of insulation from each of the wires. Twist the exposed copper wire neatly at the exposed ends. Tin each exposed end.

To tin each wire, first clean the tip of the soldering iron with a crumpled piece of paper towel to remove the blackened flux and excess solder. Place the soldering iron on your workbench with the tip pointing toward you. Hold the twisted bare wire to the shiny side of the soldering iron tip. As the copper wire is heated, touch the end of the solder to the wire starting near the insulation. As the solder melts and wicks into the twisted copper wire, slide the wire across the soldering iron to leave any excess solder at the end of the wire. Use the wire stripper to trim the **red** and **green** wires leaving 1/10 inch of tinned wire protruding beyond the insulation.

Apply solder to the tabs of the strain gage. If the solder tabs are not clean and bright copper, clean them gently with a rubber pencil eraser. Clean the tip of the soldering iron with a crumpled piece of paper towel. Press the tip of the soldering iron to the solder tab and hold if for two or three seconds. Apply the end of the rosin-core solder wire to the junction of the iron and the copper tab. The tab should be hot enough to melt the solder; a small bit of molten solder will form a heat bridge to transfer heat from the iron to the pad. Don't melt the solder on the iron and then transport it to the copper tab. Tin each solder tab to cover it with solder, leaving a rounded mound approximately 0.020 inch high.

If you get too much solder on the tab, remove it with the "solder wick" material included in the kit. The solder wick is a braid of fine copper wire treated with flux. Place the solder wick on the top of the glob of excess solder and apply heat to the wick with a clean soldering iron. The wick will soak up molten solder. Use fresh portions of the wick as required. Reapply fresh solder to the tab.

After the wires and the gage are tinned, attach the **red** and **green** wires to the gage. (It makes no difference which wire is attached to which terminal.) Route the wires to away from the end of the strain gage. Hold the tinned end of a wire flat against a tinned solder pad and press the wire into the solder using the clean tip of the hot soldering iron. Don't let the wire move until the solder solidifies. The solder must form a solid smooth joint. If the joint looks frosty, reheat the solder and try it again. If that doesn't work, wick away the old solder and apply fresh.

Attach the **black** wire to the the gun for an electrical ground. The tinned wire can be wedged under a convenient screw head or it can be held to the gun with several *tight* turns of electrical tape. If you use electrical tape, first wrap the tinned end of the wire back around the insulation so that contact between tinned wire and the gun metal is concentrated. Tape cable to gun for strain relief. _**Practice !**

If you have no experience soldering delicate electronic parts don't worry. You will soon develop the right touch. It is difficult to apply too much heat using the soldering iron provided. If a soldered joint doesn't look smooth and shiny, you can take it apart using the solder-wick provided and try it again.

Protecting Strain Gage

The strain gage needs protection from moisture, oil, and physical damage. The most convenient protection is a thin coat of epoxy.

Mix a small batch of the Devcon 5-Minute Epoxy using a wooden toothpick as the mixer stick. With a fresh toothpick paint and flow a thin layer of epoxy over the gage, including the edges. If the wires are intended to remain permanently attached to the gage, flow epoxy over the soldered connections and the first 1/4 inch of wire adjacent to the gage. If the wires are not glued down, they will frequently break at the point where the unsupported wire enters the solder joint.

If you intend to unsolder and resolder the wires between test sessions, *do not* place epoxy over the wires or solder joint. Paint epoxy over only the zigzag end of the gage. Use electrical tape to provide strain relief to the wires during use. If a wire does fatigue and break at the solder joint, clean up the solder pad using the "solder wick" and apply a small touch of fresh solder. Strip, tin, and reattach the wire just as you attached it the first time.

If you have attached the gage to a revolver cylinder, there will probably be no room for the epoxy coat between the cylinder and the strap. You'll just have to reattach the wires after they break off.

If you are burying the gage under the barrel, place a thin epoxy paint coat only over the zigzag end of the gage. Don't bother to relieve a channel to get the wires out of the stock, but just mash the wires between the barrel and the stock. It may not be good bedding practice, but it won't change the pressure reading.

Strain Gage Startup Kit

In the strain gage startup kit we have attempted to provide most of the accessory items you will need to start using strain gages. This includes

Package of 5 strain gages.

CSM Degreaser in aerosol can.
(Omitted from air shipments.)

M-Prep Conditioner A, a mild acid.

M-Prep Neutralizer 5a, a mild base.

M-Bond 200 Adhesive kit including catalyst and generic instructions.

Special PCT-2A cellophane tape.

Tweezer for handling strain gages.

Devcon 5-Minute Epoxy.

Gauze pads or *Bounty* paper towels.

Cotton-tipped applicators.

Electrical tape.

Wire cutter / stripper.

Soldering iron.

Rosin core solder.

Solder wick.

Modular connector installation tool.

Modular plugs (10 each).

Modular cable (30 feet).

Toothpicks and paper pad for epoxy mixing.

CHAPTER 7

Setting Up at the Range

Connecting the Model 43 and the PC

Only one cable is required to connect the Model 43 and your PC. Use a standard 9-wire extension cable with male DB-9 connector on one end and female DB-9 connector on the other end. One end of the cable goes to a RS-232 serial port of your computer. The other end goes to the COMPUTER RS-232 connector on the back of the Model 43.

The internal battery (lead-acid gel cell) of the Model 43 is recharged through the connector labeled 9 VDC. Use the plug-in adapter supplied with standard 120 vac power. The battery of the Model 43 can be recharged overnight with the unit turned off. (The switch handle is down for off, just like a light switch.) Continued overcharging may reduce battery life. An indicated battery voltage of 6 volts is sufficient for operation. A fully charged battery in the Model 43 is typically good for at least 12 hours of testing.

Strain Gage

After you have the strain gage mounted on a gun, connecting it to the Model 43 is simple. Just plug the modular cable from the strain gage into the jack labeled STRAIN GAGE.

Muzzle Skyscreens

Mount the muzzle skyscreens on the rail provided. The rail includes dimples to hold three skyscreens at precise spacings. When you tighten the 1/4"-20 mounting screw of each skyscreen into its dimple, the screen spacing is exact. There is no right/left or front/back to a Skyscreen III.

Mount one skyscreen with a thumbscrew set into the dimple at the middle of the rail. This screen will be referred to as Screen#2. Mount a skyscreen on each end of the rail. Use a 3" threaded stud with attached wing-nut as the mounting screw for each. The long portion of each stud slips into the hollow center post of a stand. (If you are using a tripod to hold the rail, use thumbscrews on the end skyscreens.) Tighten each thumbscrew and stud firmly by hand.

Mount a diffuser over each skyscreen. To do this, slip a black side-rail into your skyscreen, hook one end of an orange diffuser into the standing side-rail, hook a second side-rail onto the diffuser, and then slip the last end into the skyscreen.

It is convenient to "bundle" the cables from the skyscreens. Gather all three cables together near where the cable exits from the start sky-screen. Place a wrap of electrical tape around the cables at this point. Repeat the tape wrap every foot until you get to the other end. The shortest cable end is obviously from the STOP screen; plug it in first. Plug the middle length cable into the MID jack. Finally plug the longest end into the START jack. *Make sure the plugs are pushed all the way into the jacks.* If you can see a band of metal between the plug body and the jack, plug it in farther. Even if you remove the skyscreens from the rail, just coil the bundled cables "lasso" fashion and you'll have little trouble with tangles.

You can use a longer screen spacing for improved accuracy. Use half-inch EMT (thin-wall electrical conduit) cut an inch longer than the desired screen spacing. If you choose a longer screen spacing, we suggest that the maximum length of the rail be limited to the length that you can conveniently transport to the range in one piece. Regardless of the length of the rail, the proof screen mounts midway between the two primary screens.

We discourage the use of two-piece rails. They usually sag at the coupling, and the uncertain sag cancels the benefits of the longer spacing.

Place the assembled skyscreens approximately eight to ten feet in front of the muzzle. The triangular light diffusers should form a triangle-within-a-triangle sight picture as you look down the barrel at the target from your normal shooting position.

To align the skyscreens, sandbag a bolt action rifle aimed at your down-range target. Remove the bolt, and boresight back to the gun from the skyscreens. While boresighting, adjust the first skyscreen until you look through the center of the window. Repeat with the stop skyscreen. Verify the alignment by looking at the target from your normal shooting position.

After the skyscreens are aligned, just shoot at the down-range target. You can change guns (bolt actions, autos, lever actions, scopes or iron sights, or even handguns); just use the same fore-end rest and shoot at the same target.

Carefully measure the distance between the muzzle and the first skyscreen. If you don't tell the Model 43 the correct distance, the muzzle mark on the pressure curves will be at the wrong spot and your ballistic coefficients will be wrong.

Do not place armor plate in front of the skyscreens. Shooting next to armor placed near the muzzle is hazardous and downright foolish. It is far better to blow a hole in a soft skyscreen than to deflect a round or to bounce it back in your face.

Downrange Skyscreens

The downrange skyscreens are mounted to a rail in the same way as the muzzle skyscreens. Instead of plugging directly into the Model 43, the downrange skyscreens plug into a small downrange amplifier box that is connected to the Model 43 via a modular cable. If you are using the downrange skyscreens to measure ballistic coefficient, the downrange velocity is equally as important as the muzzle velocity.

For the accurate measurement of ballistic coefficient, we suggest that the screen mountings be calibrated. To calibrate the downrange screens, place them immediately downrange from the muzzle skyscreens and shoot through both sets of skyscreens. The indicated velocity loss between the two sets of skyscreens should be within two to five fps of that predicted from the estimated ballistic coefficient, the velocity, and the distance between the midpoints of the two sets of screens. The expected velocity loss for a distance of 10 feet is given in the table below for selected velocities and ballistic coefficients.

Velocity loss in 10 feet

Velocity (fps)	C=.10	C=.15	C=.20	C=.30	C=.40
3500	36	24	18	12	9
3000	33	22	17	11	8
2500	29	20	15	10	7
2000	25	17	13	9	6
1500	20	13	10	7	5
1200	13	8	6	4	3
1000	6	4	3	2	2
800	4	2	2	1	1

If the two sets of skyscreens do not indicate the appropriate velocity loss, adjust the spacing of the downrange screens. If the velocity loss indicated by the system is too great, move the downrange START and STOP skyscreens slightly closer together on the mounting rail. After the two sets of skyscreens show the proper velocity loss, move the downrange screens to their downrange position without disturbing their spacing on the rail.

The modular cable used to connect the downrange amplifier to the Model 43 is supplied on a reel. Carry the reel downrange, fasten the cable to the downrange amplifier and tie it to a peg or other strain relief point, and unroll the cable as you walk back to the firing point. Connect the other end of the cable to the Model 43 unit at the jack labeled DOWNRANGE. When you break down your setup, you can roll the cable on the spool as you walk downrange to retrieve the skyscreens, but you can't reel in cable while you are carrying skyscreens. When unrolling and rolling the cable back on the spool, pretend that the cable is a steel tape that does not want to be twisted.

Acoustic Target

The acoustic target is shipped as a set of three microphones mounted on three triangular metal corners. You must supply the three plastic side pieces to join the metal corners. The side pieces are plain 1/2 inch Schedule 40 PVC pipe cut to length. *Don't use metal pipe.*

The accuracy of the target system is influenced by your choice of target size. If you make the target larger, it will be easier to hit, but will have less accuracy. You can make the target more accurate by making it smaller, but you are more likely to hit it with a stray shot. For typical hunting rifles we suggest making each piece of pipe 60 inches long. The target size, measured from center of microphone to center of microphone, is typically 2.5 inches larger than the length of the pipes. For the 60 inch side pieces, the target size would be entered in the setup as 62.5 inches. With this target size we see typical accuracy of 0.2 inches. The maximum suggested size is 90 inches.

For .22 and .17 caliber rifles we suggest making each pipe 40 inches long. The target size is entered as 42.5 inches.

The actual microphone element is the small black cylinder tucked under the white nylon washer. The microphone element is ceramic and is quite fragile. The washer provides mechanical protection while still letting the Mach cone sound wave hit the microphone directly. Leave the mics attached to the corner plates; do not try to disassemble. Be careful.

Make the target triangle by loosening the wingnuts on the metal corners. Insert the ends of the plastic pipe into the pockets formed between the two aluminum plates at each corner. Insert the pipe deep enough to contact the folded microphone mounting tab at each corner and tighten the wing nuts.

The modular cable used to connect the downrange amplifier to the Model 43 is supplied on a reel. Carry the reel downrange, fasten the cable to the downrange amplifier and tie it to a peg or other strain relief point, and unroll the cable as you walk back to the firing point. Connect the other end of the cable to the Model 43 unit at the jack labeled DOWNRANGE. When you break down your setup, you can roll the cable on the spool as you walk downrange to retrieve the acoustic target, but you can't reel in cable while you are carrying the target back to the bench. When unrolling and rolling the cable back on the spool, pretend that the cable is a steel tape that doesn't like to be twisted.

The system will normally work at ranges up to 200 yards with ordinary modular cable. The system can be made to work at over 1000 yards if you use a downrange cable consisting of three twisted pairs of #22 copper wire or heavier. (For the extended range, we typically use short modular jumpers at the M43 and at the target. We wire the heavier cable with a female modular receptacle at each end. One wire of each pair goes to the "black" wire of the modular jumper, and the remaining wires of the pairs go to red, green, and yellow wires of the jumper.

The target triangle is mounted downrange with the microphone heads pointing toward the gun. Choose one corner to be the top and slide the cable from that microphone down the pipe to the lower left corner. You can also slide the cable from the lower right microphone through the bottom pipe just to make a neat looking picture.

Mount the target triangle against your target frame. We hook the top corner of our target triangle on a large nail at the top of our target frame, and secure the side pieces to the target frame with a couple of rubber bungee cords. The bottom bar of the target triangle should be approximately level and square to the path of the bullet. If the microphones shift (even fore and aft) as you fire a group, the apparent impact points will also shift and the target system looses accuracy.

Connect the cables from the microphones to the inputs of the downrange amplifier box. The jacks are labeled START, MIDDLE, and STOP, and also have a diagram indicating that the LEFT microphone is plugged into the START jack, the TOP microphone is plugged into the MIDDLE jack, and the RIGHT microphone is plugged into the STOP jack. The modular cable to the Model 43 plugs into the modular jack of the downrange amplifier.

You can use either downrange skyscreens or the acoustic target, but you cannot use both.

CHAPTER 8

Miscellaneous Topics

Skyscreens

We've shipped Skyscreen III units with Oehler chronographs since 1984. Thousands of shooters have been pleased. The Skyscreen III was the first handloader skyscreen to use lenses, and the units have been refined to near perfection. We improved the shielding of the cable so you'll see fewer false triggers from static electricity and electrical interference. We reinforced the rugged single-bolt mounting system so you can't pop the mounting bolt from the case.

For years other manufacturers ridiculed our use of diffusers; now our most vocal critics advocate diffusers and sell their imitations. We've gone a step farther and have improved ours for better performance. The new diffuser's special blaze orange material gives the highest sensitivity with early and late light. The translucent material tames the brightest noonday sun while the wider roof and lens hoods protect the lens from glare.

The diffuser won't flutter in the wind and it easily absorbs the muzzle blast of the biggest guns. The new parts will withstand practically any abuse except a direct bullet hit. Still, the side rails flex to protect your skyscreens if your mounting rail takes a tumble.

All parts, including the skyscreen cases, are molded of tough General Electric Lexan polycarbonate. There's no metal to rust or kink, and there's no glue to fail. Our diffusers survive abuse that turns other diffusers into twisted scrap.

Orange Diffusers Can't Make Light

The orange diffusers shade the lenses from noonday sun and make diffuse light from direct light. If you are shooting in fog, with heavy overcast, or in the shade, then no direct light strikes the diffuser. What little light is available is already diffused, and the diffuser can't make it any brighter. If the orange diffusers don't cast a shadow leave them off. You can still use the black side-rails as aiming guides.

Proof Channel ^{tm}

Professional users have long recognized the convenience of skyscreens. These same users have also recognized limitations in the reliability of skyscreens. With skyscreens you are at the mercy of the light conditions existing at the range. Skyscreens work well under most conditions, but under certain rare light conditions there will be errors. If you haven't yet found these conditions, you will. Errors are seldom, and users will forgive the system *if* the Model 43 indicates those shots that may contain errors. If the numbers in the *Proof Channel* columns, labeled PRF, are unusually large or erratic you know to look for problems in the velocity measurement.

A large number in the *Proof Channel* can be caused by inaccurate screen spacing (more than 0.2 inch error in mounting distance, or a bent rail), shooting a small bullet too high in the screen window, shooting near the sides of the window instead of centered, muzzle blast ahead of a subsonic bullet, inadequate light, abnormally bright bullets, or the "glints" caused by excessive light reflecting from the bottom halves of the bullets.

The *Proof Channel* is actually a second chronograph. On a standard chronograph with two skyscreens, the first screen (Start) detects the bullet as it enters the skyscreens. The second screen (Stop) detects the bullet as it leave the skyscreens. The chronograph calculates the elapsed time between the signals from the Start and Stop screens, and reads out the velocity in feet-per-second.

The *Proof Channel* adds a middle screen (MID) and a second electronic channel. The bullet's velocity is measured twice by each set of three Skyscreens IIIs, once by the first two screens (the proof velocity) and once by the first and third screens (primary velocity).

If you set your screen spacing accurately, the proof velocities should be very near the primary velocities and the PRF numbers will be small. If there's a significant difference between primary and proof velocities, the PRF numbers will be large. If you do a sloppy job setting screen spacings, expect larger differences on each shot.

For example, if you move the mid screen just a quarter inch from the exact midpoint, you will see abnormally large difference between the primary and proof velocities as indicated by a large PRF number. The *Proof Channel* shows the importance of accurate and adequate screen spacing. The reading of the PRF channel is comparable in size to typical errors in your velocity measurements. Both the muzzle and downrange skyscreens in the Model 43 incorporate the *Proof Channel*.

Glints

If you look at a bullet illuminated by a light from the side, you can see a small "glint" of light reflected from the ogive. 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 patented Oehler skyscreens recognize either the light spot or a dark shadow caused by the bullet. Under certain conditions, the reflected light is approximately equal to the shadow. When the glint and shadow are approximately equal, they cancel and skyscreen performance is erratic. These difficult conditions are usually detected by the *Proof Channel*. You must change the conditions or simply wait for a better day.

The glint phenomenon occurs primarily under clear skies. Unless the sun is shining directly on the orange diffusers, the amount of light from a clear sky is typically one-fourth the light from a cloudy or hazy sky. Skyscreens will adapt to this lower light level just as does a camera with automatic exposure control, but they work better with more light. The diffuser makes an "artificial cloud" above the bullet and converts the direct light from the sun to the diffuse light needed by the skyscreens.

Glint problems also show up when shooting over snow or light sand. The bottom of the bullet is illuminated by light reflected from the ground, and the bullet appears to be almost as bright as the sky.

The only positive solution for the glints is to shade the bullet from light as it passes through the skyscreen window. Only if no light strikes the bottom half of the bullet are you absolutely sure that there are no glints.

Skyscreens want to see a dark bullet silhouetted against the bright background formed by an illuminated diffuser. If there's not enough light on the diffuser, or if the bullet is bright, you can expect problems. The beautifully polished Nosler bullets are often difficult to chronograph. It is sometimes effective to blacken the ogive with a black felt-tip marker.

Subsonic Velocities

With velocities below the speed of sound, the muzzle blast wave reaches the screen before the bullet. This muzzle blast wave is like a lens traveling through the air at the speed of sound. The resulting light diffraction can trigger the skyscreens. (The speed of sound is approximately 1060 plus the air temperature in degrees Fahrenheit, or 1130 fps at room temperature.)

Premature triggering of only the start screen will cause the primary velocities to be abnormally low and the PRF number to be way negative. Premature triggering of both start and middle screens will cause the primary velocity to read abnormally low and the PRF to be large and positive. Premature triggering of all three screens (a rare case) will cause the primary velocity to read near the speed of sound and the PRF to be small.

Subsonic blast problems can occasionally be cured by moving the skyscreens farther from the muzzle or by slightly changing the shooting direction.

The only sure solution is to install a blast baffle midway between muzzle and first screen. This baffle should be a piece of plywood with a small hole or vertical slot to shoot through. We use a piece of plywood, 2x4 feet, standing on end and leaning on a single hinged leg. Cut a vertical inch-wide shooting slot from bench level to the top of the shield. Place the baffle about halfway between the muzzle and the first skyscreen. **Do not use a metal plate!**

Personal Reference Ammo

You can quickly check the operation of the chronograph portion of the system with an airgun. Velocities will range from approximately 225 fps for a kid's BB gun, to approximately 600 fps for adult match air rifles, up to over 1000 fps for some adult sporter air rifles. BBs and pellets are small, short, and slow. They provide a severe test of skyscreen sensitivity, so you must shoot through the lower half of the skyscreen window. If your system works with an airgun, but fails with larger guns, you can suspect problems related to muzzle blast or flash.

Use one of your guns equipped with a strain gage, along with ammo that has given consistent test readings in the past, as a reference for pressure testing. If the Model 43 continues to give good results with the proven gun and ammo while results with another gun are inconsistent, there is likely a problem with the new strain gage mounting or an error in the gun input information.

Bows

The Model 43 with Skyscreen III detectors works well for archery. Make sure that the screens are far enough away that the arrow leaves the string before the point gets to the first screen. Blunt points work best, followed by round points and then target points. Needle-like field points and broad-heads can give erratic results. The skyscreens need to see an abrupt change in light. Because arrows are slower than bullets, you must help the skyscreens by using a flatter nose. Don't expect the ballistic coefficients to make any sense for archery.

Shotguns

The system can be used for shotshells. It reliably measures the velocity of the front pellets in the shot string. These velocities are typically 2% to 5% higher than factory-measured velocities. The factory systems, also made by Oehler, use inductance sensing coils to measure the velocity of the large clump of shot at the back end of the shot column. The first screen should be placed three or four feet from the muzzle. You will get the most consistent and accurate results if you use the most open choke available. Again, don't expect the regular ballistic coefficients to make any sense.

Shooting Indoors

To use skyscreens indoors, you must provide a substitute for the daylight. Use a reflector-type incandescent lamp shining down on the top of the diffuser of each skyscreen. You must use incandescent lamps; fluorescent lamps will not work! Mount the lamps just high enough to uniformly illuminate the diffuser. Common utility reflectors with 100 watt bulbs work fine. The 150 watt PAR outdoor reflector lamps with their heavy glass envelopes will better resist muzzle blast.

Using the Skyscreen III units indoors with lamps will work most of the time. Adding lamps to our skyscreen-type system will not give you all the advantages of our laboratory systems. Our laboratory systems cost more, and they perform better.

Brackets and display-case type bulbs are available from Oehler to set up Skyscreen IIIs for indoor use. With this arrangement, the bulbs mount right on top of the diffusers.

Uniformity

Assuming that you've measured the velocities and pressures, what do you do with the numbers? The first thing most shooters want to talk about is the average velocity for a given load. Doing a lot of shooting just to measure the average velocity is often a waste of time. If you're using a conservative load picked from the "middle" of the reloading tables you're not going to change the average velocity significantly. It doesn't matter how often you measure the velocities; you still won't turn a .30-30 into a .308, a .308 into a .30-06, or a .30-06 into a .300 Magnum. You can choose a load that gives reduced velocity, but it's very unlikely that you will find a magic load that gives higher velocities without violating pressure restrictions.

Few shooters can tell even a 5% difference in average velocity. For example, consider that you have a .308 and a .30-06 loaded with the same 150 grain bullet at typical velocities of 2800 and 2950 fps. The velocity of the .308 is a full 5% lower than the .30-06. Zero both guns at 200 yards and then fire groups at 100 yards to see the effect of the velocity difference. According to the computer, the .308 will strike 1.98 inches high and the .30-06 will strike 1.69 inches high. Even if both rifles are capable of minute-of-angle groups, few shooters can reliably tell the quarter inch difference in group centers between the .308 and the .30-06. The '06 still has a 10% advantage in energy. You knew that before you started if you looked at the relative sizes of the cases.

Consider again a 150 fps velocity difference, but from a slightly different viewpoint. Imagine having ten rounds of '06 ammo, with half having a velocity of 2950 fps and half having a velocity of 2800 fps. Even if both loads group inside an inch when fired separately, I'll bet that a group of "half-and-half" won't come anywhere close to an inch group. You will see a much larger difference in the group than just the quarter-inch difference in drop. The larger difference is caused by minute changes in exactly where the gun muzzle was pointed at the instant the bullet left. You can't keep the muzzle from whipping as the bullet goes down the bore, but you can try to make it whip the same on each shot. If you keep the same velocity on each shot you are a long way toward having the gun behave the same on each shot.

To hit the target and to shoot the smallest groups, your ammunition must be uniform. Every shooter knows that you get small groups by doing things exactly the same, shot after shot. Match shooters spend years developing a consistent hold and trigger squeeze; meticulous handloaders spend hours weighing charges and uniforming cases. It's all based on the accepted fact that everything must be uniform to get the smallest group. Note that we didn't say that uniform velocity guarantees small groups; it doesn't. You can have perfectly uniform velocities with bad bullets and you will still get horrible groups, but you won't find your best groups with erratic velocities.

Use velocity and pressure uniformity as an indicator of ammo consistency. You don't use velocity and pressure because they're sacred, but because they are one of the few things you can actually measure. Uniformity is best described by a number called "standard deviation" which is automatically computed by most modern chronographs. If you don't know or understand the exact meaning of standard deviation, don't worry about it. I don't understand the chemistry and thermodynamics of powder ignition and burning, but I'm perfectly willing to accept the fact that adding more powder increases both pressure and velocity. Think of standard deviation as a measure of uniformity; smaller numbers mean the velocity and pressure are more uniform. If your chronograph doesn't calculate standard deviation for you, just use the velocity range (difference between fastest and slowest shots in a group) as a measure of uniformity.

When you work up a load for any gun, consider the standard deviation of velocity and pressure along with the group sizes. Note that you should *consider* standard deviation; don't *worship* standard deviation. You can look for that magical moment when you find a load giving both small groups and small standard deviations, but don't expect many gifts from heaven. When you find a load that gives either small groups or small standard deviations, assume that the small numbers are good omens of better things to be found nearby. You may be close to something good, so keep looking. A small standard deviation often may mean only that you have good ignition and uniform charges of an appropriate powder. A small standard deviation doesn't mean a thing regarding bullet quality, barrel bedding, barrel quality, or your own bench testing techniques. You may be luckier, but I usually find many loads giving mediocre groups and mediocre standard deviations, and only find a few loads with the prized good groups. Remember, the ammo is only one of many variables that affect group size, and velocity uniformity is primarily a function of the ammo. If you are trying to make decisions regarding the ammo, it makes sense to consider the uniformity of velocity and pressure along with the groups.

We may have overstated the argument against worshiping what John Wootters once called "the handloader's god, Feepersecun". Average velocity is important because you must have enough bullet energy or momentum to do the job at the target. (If you have to push a load to reach a barely acceptable velocity, you might admit to using a larger case.) Average velocity is also important because many individual guns tend to have their own preferred velocity levels for best accuracy. Suppose you have a pet accuracy load for a given gun and deplete your proven lot of the powder. You will often get the best accuracy from the new powder lot if you adjust the charge to bring back the same average velocity you recorded with the old powder lot. With the two exceptions we just noted, we usually don't assign a lot of weight to average velocity during our own load development.

With the emphasis placed on measuring velocity *uniformity*, the chronograph must be accurate. You may see 0.5% quoted as being wonderful and adequate chronograph accuracy. The 0.5% accuracy is adequate if you are talking about average velocity. An error of 0.5% at 3000 fps translates into only 15 fps, and we already discussed that you're hard-pressed to detect a difference of 150 fps with actual shooting tests. The 15 fps error is truly small compared to the *average* velocity of 3000 fps. Now consider that the range of velocity measurements for a good load may vary no more than 10 to 30 fps from the average velocity, and realize that the quoted 0.5% accuracy applies *only to average velocities measured under ideal conditions*. That means that you're likely to see more than 15 fps error on individual shots. If you're trying to measure uniformity, and all the readings are within 25 fps of the average, even a 15 fps error looks huge. Ideally, your chronograph should show consistency in the order of 0.1% or 3 fps out of 3000 fps on *each shot* before you really rely on the uniformity measurements. If your chronograph can't demonstrate consistency to near the 0.1% level on each shot, it's not helping your load development nearly as much as it could. This degree of consistency is also very important for ballistic coefficient measurements.

It's not easy to get a chronograph capable of 0.1% consistency in actual use. To put the accuracy numbers into perspective, lets look at them in terms of distance. For years before Oehler Research introduced the use of lenses in handloader skyscreens, we advocated a screen spacing of ten feet. An error of one eighth inch in ten feet amounts to an error of 0.1%. All you who know how to use a steel tape will say it's no problem to hold an eighth inch tolerance over ten feet. I agree, *if* you can lay the tape directly on top of the board you are measuring. You don't shoot the bullet right along the top of the skyscreens because you get nicks and bullet holes; you shoot several inches away from the skyscreens. Now, keep your tape several inches away from the board and measure the length to within an eighth of an inch. That's what skyscreens are expected to do, even when the board is whizzing by at 3000 fps!

APPENDIX A

Drag Functions

The Drag Functions

The drag functions (G1, G5, G6, GL, Gs, and RA-4) are based on different styles of bullets. These drag functions are derived from the corresponding SAAMI tables and are used with permission. The G1 function is the default in the PBL program and is universally used in most applications.

The following drag functions are available in the M43 program:

G1	Standard table for all sporting bullets
G5	Low base drag (boat-tail) bullets
G6	Flat base, sharp nose bullets
G7	VLD bullets
GL	Exposed lead nose & hollow point bullets
Gs	Spherical bullets
RA-4	Standard for rimfire bullets

If you are thoroughly familiar with the various drag functions and want to be able to use other drag functions to calculate ballistic coefficients and do standard atmosphere ballistics, you can enable the other drag tables. During test setup, hit the drag function pushbutton as you are entering the bullet data. Change the drag function to any one desired.

Now that you know how to choose alternate drag functions, we again urge you to stick with the G1 drag function!

APPENDIX B

Handloading Limits

The Model 43 gives a very good estimate of the pressure generated in the test gun. Readings from the Model 43 usually correlate closely with pressure readings made with conformal or other piezoelectric transducer systems and may be used for comparison purposes. The readings from the Model 43 may not correspond to copper crusher pressure readings. For guidance we have listed maximum average transducer pressures for several cartridges. These listed maximums were extracted from industry guidelines for commercial ammunition *fired in tight test barrels under the conditions specified in the ANSI standards.* Although the industry guidelines allow some loads in excess of 60,000 psi, we show 60,000 psi as an upper limit. *In our judgement, no handload should ever exceed 60,000 psi when fired in any sporting gun.* Experienced shooters who have seen the catastrophic damage caused by excessive pressure often prefer a limit of 50,000 psi for their personal loads.

WARNING !

The pressure limits shown in this appendix must be regarded as absolute maximums and the limits must be approached with caution. If any of the classic indications of excess pressure (head expansion, expanded primer pockets, difficult extraction, or other evidence of yielding brass) are observed prior to reaching the indicated level, the maximum should be set at 80% of the pressure at which the indications of excess pressure were first observed. Note that loads which generate moderate pressure levels in one gun may generate excessive pressures in another gun.

All maximum average pressures shown assume testing of 10-shot samples.

The user is totally responsible for establishing the maximum working pressures for the user's own purposes. Oehler Research disclaims all responsibility.

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Rifle Cartridge	Maximum Average PSI(M43)
22-250 Rem	600
222 Rem	500
223 Rem	550
243 Win	600
6mm Rem	600
25-06 Rem	600
257 Rob	540
257 Rob +P	580
264 Win Mag	600
270 Win	600
280 Rem	600
284 Win	560
7mm Mauser (7x57)	510
7mm Rem Mag	600
7mm Wby Mag	600
7mm-08 Rem	600
7-30 Waters	450
30 Carbine	400
30-06 Sprg	600
30-30 Win	420
300 Sav	470
300 Wby Mag	600
300 Win Mag	600
7.62x39	450
303 Brit	490
35 Rem	335
308 Win	600
32 Win Spl	420
338 Win Mag	600
375 H&H Mag	600
416 Rem Mag	600
44 Rem Mag	360
444 Marlin	420
45-70 Govt	280

Pistol Cartridge	Maximum Average PSI(M43)
9mm Luger	350
9mm Luger +P	385
10mm Auto	375
25 Auto	250
32 Auto	205
32 S&W Long	150
357 Magnum	350
357 Rem Max	400
38 Auto	265
38 Special	170
38 Special +P	185
38 Super Auto +P	365
380 Auto	215
40 S&W	350
41 Rem Magnum	360
44 Rem Magnum	360
44 S&W Spl	155
45 Auto	210
45 Auto +P	230
45 Colt	140

Shotshell	Maximum Average PSI(M43)
10 Gauge	110
12 Gauge 2-3/4"	115
12 Gauge 3"	115
12 Gauge 3-1/2"	140
16 Gauge	115
20 Gauge	120
28 Gauge	125
410 Bore 2-1/2"	125
410 Bore 3"	135

APPENDIX C

Standards for PSI(M43)

There are no existing standards for chamber pressure measurements in common sporting guns. Industry pressure test standards are written around the use of special test barrels mounted in universal receivers under laboratory conditions. At Oehler Research we have found strain gages to be a reasonable way to *estimate* chamber pressures in sporting arms. The purpose of this appendix is to outline the assumptions we have used and to indicate limits on the proper application of the strain gages.

Chamber pressures are estimated by measuring the strain [stretch] in the barrel wall. For purposes of the Model 43, we have assumed that the chamber is part of a long cylindrical body. For reasonable estimates of chamber pressure all of the following conditions must be met.

> For bottle-neck cases, the strain gage must be mounted outside the chamber at the point midway between the case head and the case shoulder. For straight cases, the strain gage must be mounted outside the chamber at the point midway between the case head and the bullet base.
>
> If the barrel is threaded or pressed into a receiver, the distance from the receiver to the cartridge shoulder or bullet base must be at least twice the thickness of the barrel wall measured in this area. The strain gage must be mounted midway between the receiver and the cartridge shoulder.
>
> The thickness of the barrel wall should be no more than 1.2 times the diameter of the case body. (If the case is small and the barrel is thick, you don't get enough strain estimate pressure reliably.)

If the strain gage cannot be mounted within the above requirements, the pressure estimates from the Model 43 are subject to question.

The chamber does not begin to strain until the cartridge case expands to push on the chamber walls. Even after the case touches the walls, the case still contains some of the pressure and reduces the pressure actually applied to the chamber walls. For the purposes of the Model 43, this offset pressure is *assumed* to be 7,000 psi for all center-fire metallic cartridges. This offset pressure is further *assumed* to be 500 psi for shotshells, and is zero for muzzle loaders.

For center-fire metallic cartridges, the effective inside diameter of the cartridge/chamber combination is assumed to be 0.025 inch less than the inside diameter entered at the setup screen. This correction is automatically applied if and only if the offset pressure is entered as 1000 psi or greater. This correction is not applied to shotguns or muzzle-loaders where the offset is less than 1000 psi.

A modulus of elasticity for all tested chambers and barrels is assumed to be 30,000,000 and Poisson's Ratio is assumed to be 0.30.

The preferred designation of the pressure estimates obtained with the Model 43 is **PSI(M43)**. For example, the phrase "... the estimated pressure was 47600 PSI(M43)" implies that a Model 43 was used to estimate pressure, that the strain gage mounting location met the restrictions outlined above, and that the estimated chamber pressure is 47,600 psi.

APPENDIX D

Correcting Data

Sooner or later you will have a test record in which you have entered the wrong distances, temperature, load information, or other data. You will want to salvage and correct the data for the actual conditions. It can be done but you should leave clear tracks of the edit in the notes section. The corrections entered will apply only to the one group.

Begin the correction process from the Setup pushbutton of the Main Display. From the menu, select Modify an existing test. Load the desired test and make any desired modification.

After you return to the Main Display, we urge you to Replay the test you just modified, and make notes describing the nature of the correction.

The corrected group has now been saved. Replay it for a quick look at the corrected data, or use Printout for a corrected copy of the test. The procedure makes accurate corrections for small errors in distances and conditions. You cannot change the size or shape of the pressure curves. You cannot add or delete measurement channels.

You can also use the correction procedure as a tutorial. Change the distance to the acoustic target by a few feet and observe the dramatic change in ballistic coefficients.