The

World Directory

of

Custom Bullet Makers

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Table of Contents

These sections are separate,

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Guide to Jacket Making

Corbin Software Guide

Introduction

This book is intended to serve three audiences:

☑ People looking for sources of custom bullets

☑ People who want to make and sell custom bullets

☑ Writers, editors, and firearms researchers

If you are looking for bullets that are not found in the "mass market" channel (distributed to your local sporting goods store or through mail order from the major high volume producers), this book can be used as a guide to the custom bullet makers who may help you. If you've ever asked one of the large mass producers, such as Sierra, Hornady, Winchester, Remington, Nosler, or Speer, for a small quantity of anything other than what they already produce in the millions, you probably know that mass producers simply cannot help you.

Quantities less than a million are typically not profitable to produce on the high volume equipment they use. Their markets are well defined, low margin and high volume channels. To stop the presses and make a few thousand specials is so costly that they don't even want to quote a price, and you'd be unlikely to pay it if they did. Sometimes, they may weaken and make as few as 50,000 bullets, but they usually regret it and vow never again unless the price was fairly steep (and possibly even then, since the cost of tooling up, shutting down, making all the test runs and wasting the scrap that comes off a high speed production press line until everything is tuned in might not have been covered by even a rather high unit price).

Custom bllet makers produce an existing exotic line of bullets that fills the gaps left by mass producers, but they can often customize the product to suit your needs, or even develop new bullets to match your requirements, at a far lower volume and total outlay than you'd have to pay at a mass production firm.

The price per bullet is usually higher, but the total cost of getting twenty, fifty or a couple of hundred custom bullets is far less than the minimum quantity of much cheaper bullets you'd need to buy to get the attention of a mass producer. It's usually quite affordable, in fact. Nearly anyone can come up with twenty to a hundred dollars to invest in their hobby or firearms related business interest. That might only buy a few bullets, but the total out-of-pocket cost is in the realm of possibility.

Hardly anyone wants to pay for a million bullets for their own use, even at wholesale cost. You are still talking about a very large total bill, even if each bullet only costs you a dime. The cost could be raised by refinancing your home, for instance. Big difference between that and giving up a dinner out, or a couple of nights at the movies, to satisfy the urge to know how some new bullet design might work in your gun. You'd have to be a very curious person indeed, in both senses of the word.

Custom bullet makers are here to serve you, and this book is here to show you who they are, where they can be reached, and a general idea of what they make. It lists the last reported diameters of bullets for which each bullet maker has the dies, but not the styles and weights because those can be almost unlimited even with a single set of dies. If a bullet maker isn't listed as having the diameter of bullet you want, call a few of them anyway and ask if they'd be interested in

getting the tools. Most of them would do it if you want to either buy enough bullets so they can pay for the dies (which may be a few more than you need, but certainly not in the tens of thousands or millions) or perhaps work out some other way of helping them cover the cost of the dies.

Some folks buy the tooling and then the bullet maker pays for it by manufacturing a certain quantity of bullets against the price. Dies can run anywhere from a couple of hundred dollars to a thousand dollars, depending on bullet complexity.

Others buy the tooling and find a custom bullet maker with the press and the time to use it, and pay them for material and labor to use their dies. However you want to do it, there's always a way you can have anything you want in a custom bullet so long as you don't mind paying a reasonable cost for either tooling or bullets that will cover the tooling. Custom bullet makers are usually individuals, with a few exceptions who have become big based on very successful designs and marketing.

The smaller the firm, the more likely it is that you can work out a deal to make things that are not listed in this directory as part of their existing capability. Larger outfits usually have their hands full just filling their own product design orders, even though they are far more accomodating than true mass producers. Some of the firms listed enjoy the challenge as much as the income and will take on nearly anything. Others are trying to develop a specialty line to the exclusion of completely custom work. The best way to find out is to ask them!

If you are a custom bullet maker, or think you might like to be one, this book can help you avoid choosing a company name that is already in use, point you to

the sources of copper and lead that you need to manufacture bullets, and help with other aspects of deciding what to make and how to sell it.

If you are good at reading between the lines, you probably will recognize that this book serves as a market study for the custom bullet field as well as a guide for potential clients. If you would like to be listed, all you have to do is request a listing form and fill it out, sign and return it to Corbin, and your firm will be listed in the next edition. Because we use a loose-leaf format and assemble these books in small batches, it isn't long between editions, and we can revise just the listings without having to re-write the entire book. You could be in print within a few days after submitting the information and permission to publish it.

Without the signed permission granted by the returned survey form, we cannot list you. Phoned in requests and casual notes to "put me in the book" do not give us enough legal grounds to risk invading your privacy by publishing your address and phone number, and we need clearly legible written information so that if we get your number or address incorrect, it's really our fault and not yours for scribbling something that looked like a "3" and was meant to be a "4".

A major secondary benefit of being listed here is that we also publish this information on our web site at www.corbins.com/bmakers.htm. Thousands of people every week look at this site, searching for bullet makers. It is still free, although the day may come when it isn't. Get your name in now if you have any desire to sell bullets. Free advertising is a rare thing.

If you are a writer, publisher of gun magazines, researcher in the ballistic field or just need to be aware of what is happening at the real cutting edge of bullet design, this book will point you in directions that might

otherwise not have been apparent. Very few general interest gun writers know enough about bullet swaging to even realize that it is the driving force behind the custom bullet market, and that isn't surprising: the makers of custom bullets can easily become swamped with work and decide they don't need to promote themselves very much, especially after the first couple of years.

They are as busy as they want to be, and start to become hard to locate. If you didn't catch their ads when they first were building up, you probably won't see any indication they exist. The majority of custom bullet makers are individuals who are retired, had another line of work or career that became boring or oppressive and decided life was too short not to have more fun. They are not necessarily chasing maximum income, and therefore are content with the fact that a little more effort could be applied on their part to bring in more exposure in the firearms press. If you write about them, they'll appreciate it, but it's not too likely they will seek you out if they have not done it already.

Some of these people are very interested in more exposure, especially those who are not necessarily retired and are seriously interested in supporting their family with custom bullet making, rather than just paying for their hobby and maybe supplementing their 401k checks. These people often have the most exciting bullet designs you've ever come across, certainly more interesting than the two-hundred year old designs constantly being revamped and retouted by mass producers. Some of the designs may be a little on the far side of impractical, but remember, they are capable of shifting weights and styles around the way a blackjack dealer shuffles the deck: if you could provide a little input from the practical side of the business, it

might help them fill a niche and feed the family all at the same time. You could get a warm and fuzzy feeling about doing some good for a struggling new business and at the same time help the rest of us get some new bullets to try, on top of producing a story you don't see every day in gun magazines.

If you are an editor, you might consider showing the list of bullet makers to your advertising manager. It's nice to smooth the sometimes rocky path between the editorial staff and the financial department, and custom bullet makers need to buy advertising just like anyone else. They may not be the biggest accounts, and in fact on average they tend to buy ads by the column inch rather than page, but look at how many different businesses are listed! Just tracking down and calling all these people will keep the ad guys out of your office for weeks...

If you have some regular stringers writing for the magazine, it wouldn't hurt to let the ad man send the list to these custom bullet makers so they could, in turn, send samples for testing and possible write-ups. There are only so many ways to write about the conventional jacketed or plated lead bullet. Readers might enjoy seeing what unconventional bullets can do.

Researchers, you have a vast army of allies when it comes to information about unusual bullet developments. The list of custom bullet makers is a treasure house for finding people with special experience in developing and testing bullets which stretch at the seams of one's imagination. If your purpose is to find a prototype design for some new project, or have someone build the design you have already worked out, you could not find a better place to start.

Who Are Custom Bullet Makers?

Custom bullet manufacturing is one of the fastest growing and most exciting branches of the firearms field. Around the world, thousands of individuals swage special calibers, weights and designs of bullets, far advanced from the standard mass produced offerings. The operative word here is "custom".

There are bullet makers listed in this book who can fill nearly any need for a special caliber, style, weight or design of bullet for almost any purpose. If it doesn't exist yet, a dozen or more of these craftsmen can build it for you.

The day when only conventional, standard bullets—made for everyone in general and no one in particular—were all you could get, is long gone. Mass production firms may still turn a deaf ear to requests for small lots of special sizes or weights, as well they should: they are in business to move large volumes of identical products and cannot afford to spend time making a box of fifty or even a special shipment of ten thousand bullets.

But custom bullet makers are in business to do just that. They have the tools and techniques available that let them make short runs of nearly design of bullet. Even as few as one box of ten or twenty bullets isn't too small for them to handle. They thrive on the kind of order most shooters of twenty years ago only wished they could place. Got a new idea for a bullet? Want to try it out without spending your life savings? Contact a custom bullet maker, and the product can be in your hands at a price that is far less than nearly any other alternative.

Custom bullets are not "cheap" when compared with mass produced ones. The quality of a custom bullet is, of course, up to the person who makes it, but

most custom bullet makers don't stay in business very long unless their quality is high. The average cost of a custom made bullet is in the area of $37.50 for a box of 25, or about $1.50 each. But where else in the world will you be able to get exactly the weight, caliber, and style you want, made to your order, in a single box of 25 bullets?

Some of the custom bullet makers have discovered a unique design that fills a need so well, in some special niche of the shooting field, that they specialize only in that style of bullet. You might argue that they have really become "specialty" bullet makers rather than "custom" bullet makers, and there is merit in your arguement. But regardless of what you call them, they usually offer bullets far advanced over the factory product, when used for the intended purpose.

What keeps the mass producers from simply duplicating one of these ideas, putting it on their high speed production machines and turning it out by the millions (which would bring the cost down considerably)?

The market for such advanced bullets is simply not big enough. Only a few expert shooters understand and appreciate the benefit brought by these new designs. Most average shooters are perfectly matched with average bullets: the price is right, and the performance is good enough for them. They are by definition average product buyers.

At the top of the curve there are people who understand some particular area of shooting so well that they have begun to question the usual bullet designs. They want something better, because they have experienced situations where average isn't good enough.

There are not millions of such people. But there are millions of average shooters who at one time or another see the need for something special, and want to try it. Just for a brief time, they join the ranks of the experts in toying with the cutting edge of technology, in a very special field. Some elevate their interests and actually become experts. Others are content with to go back to the average product again.

Regardless, the custom bullet maker exists to serve them as well. A good example of a "temporary expert" user might be a person who loves to shoot big game, but has never used anything other than factory or cast bullets. Then one day, he gets the opportunity to take an expensive guided hunt that may not be his to try again in this lifetime. For that brief period, he wants the best bullet available at any price. Cost is not important in this situation, comparing a twenty cent bullet to a dollar or even a two dollar bullet. Who cares, so long as it gives him the edge that might make the hunt a success?

After it is over, and the success fades to a fond memory, he'll probably go back to his old ways and not ask for more than the average bullet again. But for that moment, when the sun was glinting off the water and the record eland or Cape buffalo was barely visible in the morning haze, the custom bullet maker's finest effort was exactly what that person wanted and needed. It worked. A lesser design might have failed. A lifetime opportunity might have turned into agony tracking and losing a noble trophy. But it didn't, because the best possible design was selected, regardless of cost. The typical guided hunt might cost $5,500 today. A two-dollar bullet would be cheap insurance!

Custom bullets are also made for special guns that don't use standard diameters, lengths, or shapes. People who would like to shoot their antique firearms may need a few custom bullets, but not enough to interest one of the big ammo makers. Law enforcement and military special operations may use bullets that are tailored to a specific circumstance, such as areas where penetration of walls must be avoided (air marshalls, for instance, or guards in a building where the next room might be filled with dignitaries or scientists).

Unless there is a large enough market to sell at least a few hundred thousand bullets a year of a specific weight, shape and caliber, the only source may be the custom bullet maker. But that is nearly the same as saying the only source of air is the atmosphere, because there are hundreds of custom bullet makers willing to develop new designs, or already making something far beyond the ordinary.

Custom bullet makers, unfortunately, do not receive as much publicity as mass producers, because they are primarily one person shops and don't spend much on advertising. Since it is just a fact of life that those who pay the bills get the most editorial coverage, we should not be surprised to learn that so many custom bullet sources around the world have escaped our notice for decades.

The fact that we might not have known about them only underscores the nature of their work in narrow, special areas where they are free to do their very best in pursuit of a tightly focused idea. They may be be preceived as having "mass appeal" to the average readers of gun magazines, so they don't get front page coverage even though their product may be worthy of greater technical praise than the usual magazine cover

fare. Custom bullet makers may be forgiven for quietly chafing a bit when they see a minor modification to a seventy year old design touted as the next revolution in bullet development, especially when they have been offering the same idea for years as an afterthought to their more innovative products.

In an interesting development, the mass producers have been purchasing bullets from some of Corbin's custom bullet clients and marketing the ammunition loaded with them as a "premium" grade. Undoubtedly this is more of a mind-share market strategy than an attempt to meet the market demand.

None of the old line firms want to be seen as mass producers of standardized, old-time products. They prefer to be known as the leaders in cutting edge technology, without actually giving up the mass market. Making bullets for the average buyer is what produces high volume, competitive low margin income and pays for the high speed presses, the huge volume buys of copper and lead, and keeps the wheels of commerce turning (as they have for two hundred years, with some of these firms).

The only thing wrong with this picture is the slightly mis-focused cutting edge image: study what is really happening and you will discover that most of the innovation has been with small custom shops, not the mass market behemoths.

For over two decades, Corbin has been at the heart of custom bullet development by working on the tools, materials, and techniques that nearly all custom bullet firms put to use in making their products. Corbin develops tools in a modular way: you can pick and choose from a wide variety of features, combining a little of this and a bit of that, and in the process, develop a new bullet that no one else has put together the same way.

Custom bullet makers develop their products in several ways. Some have specific design they always wanted to try. Others know the kind of performance they want, but don't know how to get the bullet to do it. Corbin provides whatever part of the design, materials and equipment that is required, while the customer provides the goal, and builds a company based on achieving it.

Still other potential bullet makers only know they like the idea of producing custom bullets for a living, but don't know what product to make or where to market it. This is actually the easiest assignment, since there are so many niche markets unfilled as yet.

Custom bullet makers sometimes come into the field almost by accident, through a hobby interest or perhaps a need to obtain a bullet that no one else is making at the time. Then they decide to sell their bullets, and the entire firearms field is better for it.

Regardless of how a custom bullet maker gets started, the important thing is that so many of them exist. Having a large number of places to look for specialty bullets helps keep the quality up, and assures us all of being able to try a flow of new designs that might never appear in the mass market.

By making themselves commercially available, the custom bullet makers help assure us of a supply of bullets even in troubled times, when production of the mass producers might be diverted due to political decisions, or curtailed altogether as far as civilian markets are concerned. It happened during both World Wars. It could happen again. But this time, you have many other sources.

What Are Custom Bullets?

Custom bullets fall into three categories. They can be bullets that are...

☑ designed to your specifications and ideas

☑ offered with a series of optional features

☑ designed by the bullet maker to fill special needs

The most "custom" of these is the first, where you have an idea and tell the bullet maker what you want, and he develops the bullet the way you want it, including the caliber, materials, shape, weight, and special features. This kind of bullet may require some tooling investment other than what the bullet maker already owns, so there can be arrangements to help cover the cost of the tooling directly or by buying a certain minimum quantity of bullets.

The most common of the custom bullets is the second, where a bullet maker has invested in tools to build a certain caliber of bullet, and offers the variations in this caliber and shape that are easily done without buying more tooling. This keeps your cost down because there is no additional investment needed to make the variations or optional features. In theory you could buy one bullet. Some bullet makers will sell one at a time if you really want to pay the shipping on such a small order.

The least "custom" is the bullet that simply isn't available from mass producers, so the custom bullet maker worked out a design and series of weights that fills the need, as he and hopefully most of his customers perceive it. It is custom in the sense that it is made by hand in small quantities compared to the typical

mass produced bullets, to work in a limited special situation or with a firearm that is just not popular enough to justify wide distribution of bullets for it.

The custom features or differences that custom bullets can offer include:

☑ Obsolete or unusual calibers

☑ Special weights and lengths

☑ Unusual materials

☑ Interesting jacket designs

☑ Shapes not found on factory bullets

☑ Enhanced performance characteristics

☑ Variations in the center of balance versus length

☑ Multiple projectiles in one bullet

...and other differences from conventional bullets that are limited only by imagination.

The most obvious two needs in a custom bullet would be for unusual diameter and weights. Diameters that are not readily available from standard sources might include obsolete or discontinued calibers for antique firearms, hard to find foreign calibers, or any caliber that is either so new that supplies are hard to find or so limited in market size that few mass producers offer it.

Special weights can be needed in the most common calibers. There are a limited number of very popular weights in each caliber, yet nothing is wrong with trying lighter or heavier than those the factories arbitrarily decided to build. Some guns simply do not get their best performance with the standard weights. Others would recoil far less and be more pleasant to

shoot year round at targets and small game, when used with a bullet that was half the weight of a conventinal offering.

The custom bullet maker balances the length, twist rate of the rifling, and the weight of the bullet so that ultra light and extremely heavy bullets can still be shot accurately in guns not designed for them. The conventional bullet becomes longer as it is made heavier, shorter as it is made lighter. The rate of spin of a given barrel, in turns per inch, is set for the average weight of bullet intended to be fired, but really it is set for the average length of bullet.

Weight and length only march together in lock step so long as the material density remains the same. If bullets are only made from lead, and copper alloy jackets, the old ideas about spin rate and stability vary apply whether you are talking about weight or length. But change to a core material like powdered tungsten, which has 1.7 times the density of lead, and now you can make a stable bullet of exactly the same length as a conventional weight, having 70% more weight!

The spin rate is set by length of bullet, and the custom bullet maker can separate the weight from the length almost at will, by using combinations of lead and tungsten on the heavy end, and combinations of lead and polymer "bullet ball" fillers on the light end. Whereas a standard lead or jacketed bullet would become too short to be stable if you made a 50 grain .357 Magnum bullet, fill a half-inch long jacket with polymer balls and top it with a little lead nose for balance, and you have a bullet that might go 3,000 fps out of a snub nose revolver, and still hit in the black at 50 yards! (You'd need to use one of the faster burning pistol or shotgun powders, such as Unique or Bullseye, in order to get enough pressure before the bullet popped out the end of the barrel.)

On the other end of the spectrum, a custom bullet maker might assemble a jacketed rifle bullet that had a core of powdered tungsten, topped by a small cap of pure soft lead. This bullet might look exactly the same as a soft point 180 grain .30-30 WCF factory slug, but when you picked it up, you'd notice it weighed far more. A scale might prove that it actually weighed 250 grains!

Normally, a 250 grain .308 diameter bullet would be rather long, over 1.25 inches, which might not feed in the mechanism of some rifles or fit the magazine. And even if it did, guns with a 1-12 twist rate (one turn in twelve inches) probably would not stabilize such a long bullet and it would tumble in flight.

But the custom tungsten core bullet would be the same length that normally is stable in a conventional .30-30 twist rate, so you could fire it confidently. The balance of the bullet could be set exactly where it needs to be, by using a combination of lead and tungsten sections in the core.

That is, if the bullet tends to maintain its attitude (retain the launch angle) instead of following the trajectory with its nose, the weight can be shifted to the rear by using more lead in the nose. If the bullet tends to wobble and wants to turn over in flight, the weight can be shifted more to the nose by using a short piece of lead core in the base before the tungsten is put in, or by using less lead in the nose.

There are many fine old .40 caliber Winchester, Remington, Ballard, Marlin, and other brands of rifles still in good shootable condition. Nothing prevents a modern rifle from being built to shoot the .405 Winchester cartridge, for that matter. The firearms hobby has room for people who enjoy using the early cali-

bers of cartridges. Cases can be made by reforming modern cartridge cases. Powder and primers are universal. But the bullets may not exist.

Custom bullet makers can specialize in providing these sizes of bullets, either in nearly exact replication of the orginals for the history purists, or in vastly improved modern designs for those who like to show what can be done with the older designs. It is amazing just how good a .348 Winchester will perform with modern metalurgy and a well designed bullet.

From time to time, political decisions create a demand for custom bullets. This can happen when a ban on certain styles of guns is passed, and suddenly there is a big demand for that style before the rules go into effect. Often, a foreign government may release a supply of obsolete military guns to take advantage of the sudden interest, and the only problem is finding bullets that bring out the best results from the gun and cartridge.

Military surplus ammunition can have at least three problems that translate into opportunity for the bullet makers and their clients:

☑ Corrosive or hard-to-reload Berdan primers

☑ Military FJM style bullets that don't expand

☑ Deteriorated chemistry that gives erratic speed

For these reasons, a custom bullet maker might have good success offering expanding soft point bullets or high performance hollow points, in weights that function the action but offer improved performance (less recoil, more speed, better accuracy are a few points of improvement).

Custom bullets often find their best markets, however, in applications where the quantity of rounds fired is low, the peripheral costs are high, and the time spent in the activity is short. In other words, the stakes are high and the number of bullets needed are few, provided they work exactly as expected. The two best examples are:

☑ Big game hunting

☑ Personal defense

In the field of big game hunting, custom bullets dominate the market now. You can hardly flip the pages of popular gun magazines without seeing ads from several of Corbin's clients, offering high performance hunting bullets.

The specific kinds of improvements in these bullets include the usual special weights and materials (tungsten, polymer, and so forth) but one of the most noticable improvements is the use of Corbin's Core Bond flux to create a bullet where the core won't separate from the jacket, and the use of heavy walled, pure copper tubing for bullet jackets.

In the field of self defense, the market divides into the professional and home users. Civilians protecting themselves legally against break-ins and muggings (in the "right-to-carry" states) shoot very few bullets but when the need arises, it is a life and death matter. No price is too high for a bullet that will work reliably under trying circumstances. The special designs used to achieve this include the ultra-light high speed expanders, multiple projectile bullets, fragmenting designs, hydraulic or pneumatic expanding devices designed into the bullet, special cuts, slits and teeth (such as the "saber tooth" design of hollow point) for better expansion.

In the high power hunting bullet area, some custom bullet makers offer solid copper bullets, but the solid copper bullet typically has these problems compared to a lead or tungsten core:

☑ Only 3/4 the weight for the same length

☑ Less stable in the same weights

☑ Petals break off at high speed after expansion

☑ Expansion may be too limited

☑ Over-penetration can be a problem

☑ Pressure may be higher for the same weight

☑ Increased stress on the barrel

Not all designs of solid copper bullets have every problem, but all of them are lighter for the same length as a lead-filled bullet. That is just basic physics. Combining this lighter slug with a big enough hollow point to allow good expansion in solid copper can shift the center of gravity far toward the rear, requiring a faster twist to stabilize it. When fired from conventional guns, the solid copper bullet may become less stable than a well-made lead core bullet of the same weight.

For a target bullet, the problem may be overcome by using a lead plug at the tip or by eliminating the hollow point entirely. The benefit of the solid copper bullet is that there is no jacket to separate, and also no possibility of imbalance because of differences in jacket wall thickness from one side to the other. These are strong points to consider for a target bullet.

For big game hunting, the level of accuracy that is achieved by jacketed bullets with a bit of wall thickness variation is normally quite acceptable, although of course if all the other performance factors can be

achieved with the maximum possible accuracy, it is all the better. The point is, using solid copper for increased accuracy over a better performing bonded core bullet is solving a non-problem and picking up other problems that are more important.

However, custom bullet makers have among themselves generations of experience in solving bullet design and performance questions. What seems true at this point may soon become yesterday's situation; a new solution is just around every corner, with so many bullet makers trying ideas that range from the ridiculous to the ingenius, as fast as bullets can be swaged. The sheer volume of digging brings a gem into the light now and then.

What Can You Specify?

Although each bullet maker has a unique plan that determines what can be customized, in general it is possible to specify these parameters when you order custom bullets:

☑ Weight (within broad limits)

☑ Nose shape (from a specific selection)

☑ Tip design (open tip, hollow point, soft point, FJM)

☑ Jacket thickness (sometimes, up to two or three)

☑ Exact diameter (sometimes to 0.0001 inches)

☑ Construction features (such as bonding)

The easiest thing to specify is a different weight. Bullet swaging, which is the technology used to make custom bullets, is extremely versatile about weight. That is, the same investment in equipment can make hundreds or even thousands of different bullet weights simply by adjusting the depth that a punch goes into a die.

There are some designs where a change in weight means a change in tooling. Very light bullets might require different punch lengths to reach further than usual into the die, or a die with relocated "bleed" holes to extrude the surplus lead at a different column height of the core. Very heavy bullets might require a longer die to get all the materials inside. But within a vast range of weights, you can get what you want without requiring anything other than a change in settings.

Some bullet designs don't look very good if you change the weight in a certain direction without doing some other things to compensate. For example, a

bullet maker has a stock of inch long .45 caliber jackets that make a nice looking open tip 350 grain bullet, and you order a 400 grain bullet. Now those jackets might be too short to make an open tip, since the additional lead core will project beyond the jacket, making a lead nose. If you want a lead nose (soft point), this could be fine.

In order to make your 400 grain open tip bullet, the bullet maker would have to make longer jackets, or use a more dense material than lead (such as tungsten powder) in the bullet. Either way, some additional costs would be involved beyond just the 50 grains of lead. If the bullet maker builds copper tubing or drawn strip jackets himself, and the tooling was designed to allow longer jackets, there might not be any significant expense in tooling. Perhaps he might need a different punch to do the final length draw and trim step.

But if the jacket making tools are already building their maximum jacket at one inch, and your bullet requires an inch and a quarter length jacket, it might mean starting over with a different set of jacket dies, perhaps a thicker or wider supply of metal strip also.

For this reason, you might have no problem getting a heavier or lighter bullet from one bullet maker (who has the equipment for the required jacket) but another might balk unless you pay some tooling charges. Some may have no trouble at all up to a certain limit, and then you'd have to change bullet styles to get the weight (or pay for tooling to make new jackets).

Generally, though, a change in weights does not cost more than a possible new punch, from twenty to fifty dollars depending on the kind of press being used, and often not even that (depending on whether the jacket is tapered or straight inside, and where the punch contacts it at the new core height).

It is not possible to state absolutely that you can or cannot make something without new tooling, until all the factors are taken into consideration. Each time you make a change in the bullet, it affects other parameters. The bullet maker uses his experience and skill to determine what is possible on his equipment (normally, if it is Corbin equipment, he has a good source of information to rely upon). That is why dealing with a custom bullet maker is something like going to your tailor for a new suit. Your personal tastes are taken into consideration, and if you work with the materials and tools your bullet maker has available, you will get a far better deal than if you are adamant about specific features and weights which, in reality, could shift a bit and not affect anything enough to matter.

Diameter is far more important than weight, when it comes to determining performance. A few grains one way or the other really isn't significant in controlling accuracy or trajectory compared to the changes in ogive shape, base design, and diameter.

Bullet swaging dies are very diameter specific. A die set makes precisely one diameter of bullet with a given material and pressure. The pressure used to assemble the bullet can be varied a little, and the diameter of the resulting bullet may change slightly as a result. For smooth operation, the pressures are kept to a minimum that will do the job. Ejection from the dies usually is easiest at a certain combination of core seating and point forming pressures, so using pressure to control diameter is a limited option.

Materials that are used can have a far greater effect on the final diameter. Every step in making the custom bullet expands it slightly larger. Pressure is applied to the core of the bullet, through a punch. The pressure flows through the malleable lead or powdered

tungsten core or combination polymer/lead/tungsten core materials, and expands the jacket like a balloon skin.

When the pressure is released, the bullet jacket shrinks very slightly back toward original diameter. This releases the tight grip on the die walls, so the bullet can be pushed out of the die. Some materials spring back more than others. If you ask for an aluminum jacket or a steel jacket, instead of soft copper, the bullet maker may or may not be able to swage it in the same dies. But if he is able to get the new material to work correctly, it is almost guaranteed that the diameter will not be the same as it would be the material for which the die was designed.

Some bullet makers are surprised at the results when they order a set of dies for a given caliber, such as .512, and don't mention that they plan to machine some jackets out of solid Kryptonite instead of using the copper that was in turn used to develop and test the dies. OK, no one has yet done that, but there have been many instances where dies designed for tubing jacket were used with drawn strip jackets, which are much harder and spring back a different amount.

There is nothing wrong with this, provided the parts don't stick on the punches or in the dies. But the bullets will probably change diameter from .512 to .5119 or .5121 inches. Does it matter, in the real world? Probably not. Most guns have more variation than that along the length of their bores. Having a bullet that fits at one point does not guarantee it fits so precisely an inch further down. Obviously it must not matter, as records are set every year with guns that have more than .0001 inch "waviness" in the bore size.

What might matter is the reaction of the custom bullet buyer who owns a micrometer and feels the need to use it instead of firing a few groups. Testing bullets is best done in a gun rather than on a bench, because the results can be at variance with what appears to be logical evidence. Excellent groups have been fired with bullets having as much as five grains variation out of a possible 168 grain total weight (provided the weight difference is not caused by a variation that is eccentric). How does one know that a .309 bullet might not outshoot a .308 bullet in a given gun, unless tests are fired?

You can order different diameters from some bullet makers because they purchase a slightly larger than standard swage die set, as with the .309 bullet example, and then push the finished bullets through various reduction dies to give you precise parallel sided bullet diameters.

As long as the reduction doesn't exceed about .005 inches, the effect is not noticable. No significant change in accuracy is caused by reductions of .003 or less inches, even in a laboratory test situation. That is not to say that the bullet might not shoot better or less well in a given gun and load, but only that the mechanics of reduction do not significantly impact the accuracy by causing a "loose core" or "banana shape" stress change.

If you do exceed the .005 inch reduction, then the effects start to compound. The bullet may begin to curve, as the metal springs back slightly more on one side than on the other. The lead core may be left smaller while the jacket pops away from it, so that the core does not spin as fast as the jacket and the bullet is not stable.

This figure of .005 inches is empirical in nature; nothing happens suddenly at that level that is not happening at a greater rate as you reduce further. The elastic modulus of the jacket material effects the reduction allowed. One thing will nearly solve the reduction problem, however: bonding the core.

If a bullet maker bonds the jacket and core (melts the core in the jacket, in the presence of Core Bond Flux, and then lets it cool, boils it in a solution of sodium bicarbonate and water, and then seats the core as usual), drawing down the bullet cannot affect the tightness of the core and jacket. Only the curvature of the jacket wall remains as a potential problem.

The custom bullet maker, then, can offer you something no factory will: a series of bullets that are identical in every way except diameter, for the same caliber. This lets you determine for yourself, with no secondary influences, exactly what diameter of bullet shoots the best in your gun with a given load, case, and primer.

Why does this matter? It only matters if you care about accuracy. When you are attempting to put bullets into the same spot with every shot, knowing that a .3085 diameter 168 grain bullet with an 8-S ogive is the one that comes closest to perfection with your favorite load can be a comfort. You can order .3085 diameter bullets from someone who either has a precise .3085 diameter die set, or has a larger .3090 set and a reducing die.

This technique does not extend to reducing a .338 bullet for use in a .318 rifle, by the way. That is far too much. The accuracy will be absent by definition. However, you can use a .323 (standard 8mm today) and reduce it to a .318 (smaller bore German military 8mm of an earlier time). The accuracy is still acceptable.

Bullet makers can also "bump up" your existing bullet a little bit. But if you try to go too far with this, the bullets will become so tapered or shortened that they are not useful. For instance, a .308 bullet can be "bumped up" in the point forming die of a .310, .311, or even a .312 diameter die set. It would be better to make the bullet using a core seating die and apply pressure to the lead core, expanding it and the jacket together.

When you "bump up" a bullet, pressure is applied to the outside and the bullet is shortened. The internal pressure to expand it comes from this external force and does not properly shape the parallel shank section. You get more of a tapered shank, which works within reason.

Like bullet reduction, as you go beyond a small change to a larger one, the bad effects on accuracy go up rapidly until the bullet becomes unusable. But with small differences (which some wit with an engineering background once symbolized with the Greek letters "mu" and "delta" placed side by side, which reads as "micro-change") both external pressure processes work well enough to be useful.

You may draw the conclusion that custom bullet making is a process that requires getting inside the bullet to form it, before it is really a bullet, whereas the more compromising techniques all are performed on a finished bullet by trying to form it from the outside. And that would be correct.

Design parameters such as whether or not the core is bonded, where and how many cannelure grooves are placed around the shank, and whether or not a rebated boattail, cup base, soft point, hollow point, open tip, or full metal jacket is part of the design, are usually listed in the custom bullet maker's brochure and price list, but not always. If you want something

special, ask about it! Just because the bullet maker doesn't list it now, does not mean he wouldn't do it for you. Perhaps no one ever asked before.

Usually, a custom bullet maker won't be able to offer different core hardness, various jacket materials, or arbitrary jacket wall thicknesses, because these factors are designed into a given set of tools and are not easily modified without buying additional equipment.

Some bullet makers build their own jackets from tubing stock, which is commonly available only in certain mill runs of diameter and thickness. These standard diameter tubes are then reduced by drawing individual cut lengths to correct diameter for a given caliber. Not only does the material have to be available from the mills in a thickness that will develop into the desired jacket wall, but the bullet maker needs to have a fairly sophistocated set of precision tools made specifically for the dimensions.

Other bullet makers draw flat strip into complex tapered wall jackets, using high precision Corbin jacket maker kits. This kind of tooling is more versatile, starting with a specific mill thickness of strip but drawing the jacket walls to whatever thinner measurement is desired. Relatively inexpensive punches are all that must be changed, but there can be several such punches matched for a given jacket design. This means a tooling fee or minimum order size for special wall designs not "in the catalog".

The Custom Bullet Market

Custom bullets are sold in a far different way than mass produced bullets, and certainly in a different way than most cast bullets. Because the equipment for casting is relatively simple, hundreds of people make cast bullets for resale. Some of them discover the existence of equipment for swaging jacketed (or lead) bullets, and want to know "how many can I make an hour?" with swaging equipment.

This is the wrong question. The right one is, "How much profit can I make an hour with swaging?"

Unlike mass production and casting, where the profit margins are quite thin and only high volumes can bring in enough to support the business, the custom bullet market is a botique business. By that I mean that it caters to very sharply defined segments of the market, rather than attempting to generate a wide general appeal. Price is not a major factor: performance is most important to the buyers.

Swaging custom bullets means building the products that have little or no competition from mass producers. This means there is room to for a very healthy profit margin, and the customer will not go away because of it. Those who would not pay the price were never serious potential customers in the first place. It does no good to try to attract them. They will buy mass produced and cast bullets, at a very low margin. So long as there are either (1) very efficient mass production businesses or (2) people willing to work for little or nothing per hour, the high volume, low profit market will not want for lack of products.

The problem with the high volume market, for a custom bullet maker, is the low margins and tremendous amount of competition from people who may or may not have very good business ability. Although

they eventually go broke or give up, while they are spending their savings down trying to make penny bullets to beat the next fellow's price (or to compete with banks of high speed punch presses run by the major factories, some of which were originally paid for by public taxes during wartime emergencies and are long-since depreciated), they are selling bullets below what it costs to stay in business.

To compete with these people on price alone is worst than standing on the street corner and handing your money out to every passing stranger: at least you get it over with quickly that way, and can start over sooner with something that pays! In an isolated instance, where one or two morons were selling below what it cost to survive and didn't know it, you could just wait until they went broke, step in and offer a good bullet at a reasonable price. But there is an endless stream of people who think they know all about bullet casting, and want to throw themselves into the bottomless pit of unprofitable business practices based only on price competition.

There are only a few, limited things you can do to compete reasonably. You can lower your costs by investing larger amounts in machinery and supplies, shop smarter and cut transportation costs for the heavy raw materials and delivery of finished goods. You can try to offer a higher quality product. But the products are all very much the same today. With casting, a bullet is a frozen piece of lead with various kinds of lubricant applied. Other than different diameters, shapes and weights, there is little to differentiate one from another. The basic construction and design are the same. Price is one of the few things left for competitive advantage.

Swaging, on the other hand, can use materials that do not have to be melted. That opens up a vast array of new designs, any of which can by itself present a distinct marketing advantage. Relatively few people swage bullets outside of the mass production plants (where nearly all bullets are swaged, but on very expensive high speed machinery that is not at all versatile, and must be used to make millions of identical bullets to pay for the equipment).

This is because until Corbin developed the wide range of swaging tools available today, the field was barren of equipment except for (1) very cheap handgun swages sold over the counter, for making half-jacket style bullets and (2) very costly benchrest rifle swages made in miniscule quantities by craftsmen who were not primarily in that business, but did it as a sideline. There was no single source for presses, dies, supplies, chemicals, information, and consulting services. Certainly no one was available to advise individuals about the business of custom bullet making. Anyone who tried it, did it alone.

Twenty-five years ago (at this writing), the largest manufacturer of swaging equipment in the world consisted of a shop with two people, one of them part-time. Theodore Smith ran the old S.A.S. dies company in North Bend, Oregon. He invented a number of tools, including the powder trickler ("Little Dripper") that were copied and marketed widely by other firms. The S.A.S. motto was "If you want a die, we can help you!" which could almost be a mafia offer one couldn't refuse! S.A.S. stood for "Shooters' Accessory Supply".

About that time, I had just sold my first successful electronics company, Teletron Communication Electronics, Inc., and I was "between jobs", doing a little writing, some photography for the local businesses, putting together small businesses based on little elec-

tronic inventions that I'd build virtually on a kitchen table and then market for a few months to get some history, package the whole thing and sell it as a ready-made small business opportunity.

John Amber was the editor-in-chief of Gun Digest at that time. I had a number of firearms articles, even a column in one of the magazines, and John had asked me to write a story about Ted Smith and his swaging business. I had no idea such a thing was even being done, or how it worked.

When I found Ted, he was recovering from a very bad situation: he had been using gasoline as a cleaner to remove the cutting oils from his swage dies, and his big barn-like shop had wall-mounted electric heaters that sparked when their simply open-contact thermostats operated. His over-alls were saturated with oil and the gasoline vapors set him afire like a torch. His part-time helper did the best thing he could think of, which was to grab one of the big fire extinguishers off the wall and spray Ted down with it.

Unfortunately, it was an old baking soda and sulfuric acid fire extinguisher. The mixture did almost as much skin damage as the fire. Ted spend about a year in the burn ward, he told me. His face and hands were spared, but he had scars over the rest of his body. He was tough and survived it so well that one could not see any after effects in his manner or activity. But the bills had piled up during that time.

Ted's wife had really been overwhelmed with the mail that kept coming in, ordering more swage dies. Around the corner from the kitchen was a little office, and I could see the corner of a desk sticking out from under a mountain of unopened mail. As I got to know Ted better with more visits, I became more and more

intrigued by the bullet swaging idea. Obviously, I wasn't alone: those letters were full of orders with stale-dated checks!

Ted agreed to teach me how to make swage dies, and I agreed to help him get out of debt and sell the products in return. We did this for about a year, with me working for him without pay in order to learn. Then he worked for me, in essence, by filling orders while I wrote catalogs, ads, and handled the shipping, and worked on new ideas to expand the product line. It wasn't long before he was tired of it, and offered to sell the business. I bought it, and expanded the "D.R. Corbin Manufacturing Co." into a full time bullet swage equipment venture, incorporating later with my brother Richard, and my friend N. Bradford Pritchett as the other stockholders.

By the time "Corbin" had become a famous name in the field of swaging, we had seven books to explain the various aspects of the field, including Ted Smith's original "Bullet Swage Manual", kept in its manuscript text to preserve the history and viewpoint of the interesting gentleman, who passed away a few years ago. My interest in bullet swaging has only grown greater with the passing years, because of the constant discovery of new techniques and solutions to challenges that only swaging can provide.

Swaging provides a solution to the challenge of paying for a shooting hobby, for hundreds of shooters. It can do this because of a unique paradox, which I have not seen often in business: the higher the production, the less profit is made!

Of course, if all other factors were equal, this would be patently untrue. You can't sell more and make less. But the factors are locked together with logical bars of iron: when you move one, the others move in unison, and not always in the same direction.

Custom bullets are made to fill the gaps left by mass producers and bullet casters. That is, they provide answers to the botique buyers' needs. Obsolete calibers, special purpose, high performance, experimental, unusual imports, all the special situations we've mentioned in this book that make custom bullets different, are linked to a high profit margin. It must be so, because one cannot hand-build just a few of anything for the same price as millions can be stamped out.

Now, suppose you decide that instead of seeking those special markets where people are willing to pay more for small lots of unusual bullets, you want to make a copy of a factory bullet. To sell it, you have to compete with the factory price. They have machines already paid for that cost hundreds of thousands of dollars, in order to get the cost per part down to pennies.You can buy similar machinery, or you can work for nothing. Even working for nothing, the materials you buy will either have to be purchased in huge lots, to factory pricing, or they will cost you more than the finished factory product.

It does not sound feasible to compete with the high investment in marketing, production tools, and experience that the factory has built over the years, does it? So, what if you decide to raise the volume of special bullets sold, by making a unique design in a very common caliber, and lowering the price so that even if you are not exactly competitive with the factory, you are barely charging more than a standard bullet?

This is not an either/or situation: it is a sliding scale. As you charge less for the bullet, you may get more buyers. But in order to make the bullet fast enough to supply them, you have to spend more money for machinery speed. As you invest more in machinery, you have a larger overhead to pay back, perhaps a loan to

service or at least the return on your higher investment to consider. That means you need more customers, and since you are not seeking the botique crowd but are going after the average consumer of bullets with a better quality product, you may find (as most people do) that the average consumer is mostly interested in price.

Factory bullets are reasonable in cost and performance, in the standard applications that most people use. The casual deer hunter, the plinker, the average target shooter all think that factory bullets are just fine. If you want to get their business, you not only have to overcome the tremendous investment in brand loyalty and recognition that millions of dollars in advertising have created, but you have to offer some economic incentive. In other words, make the price better. Doing this brings more sales, but less profit.

To get enough profit to pay for the machinery, you may need to invest in even higher speed machinery, and that will begin to include packaging machinery too, since high volume handling has its own special problems that a low volume operation does not have to consider. Now you are heavily invested in both production and delivery, and will need more people to help you get those millions of bullets into the hands of buyers. More volume! Turn up the treadmill!

It isn't long before you are competing with the factory at some level. The point where you stop will be the point where your bullet's technical advantage and the marketing edge you can milk out of it do not influence the remaining potential clients. The ones who would have bought your bullet at ten times the price have long been adsorbed into your customer base. The ones who would buy it at a modestly profitable amount higher than standard factory bullets have bought all

they can use. Now you run into the hard wall of reality: the remaining people don't care about better performance if it costs them anything at all.

How are you going to weather the dips in sales now that you have your house and future mortgaged to pay for that high speed, low volume business? More sales by lowering the price? At what point do you give away bullets just to keep the machinery turning and your people from going away, in the hopes that the dip is only temporary and better days are around the corner?

Because there is a limited, but viable, market for specialty bullets, price elasticity is quite limited. If you gave away all the .600 Nitro bullets you could make, you'd find no takers after the first month! Obviously, there is an upper limit to what the few .600 Nitro Express gun owners will pay, too. But it isn't nearly as low as what a target shooter will pay for another 9mm clone bullet.

Most custom bullets sell in the $1.50 price range. That is far too high for most target shooters, because they use far too many bullets and there is nothing at stake except the winning or losing of a match. The best shooters win using fairly standard, but good, bullets. The worst shooters will never win no matter what bullet they use. If you offered these people a bullet that cost ten times the standard price but guaranteed that they would win any match when all else was equal (their competition using standard bullets but being no better shooters or having no better equipment otherwise), it would still be a hard sell. That is because a target shooter might fire several hundred bullets in the course of a match, and hundreds more getting prepared for it. Even if he really wanted to win badly enough to pay your price, he probably couldn't afford it.

On the other hand, if this same person were going to hunt elk in Montana, and the trip was going to cost him anywhere from five hundred to ten thousand dollars (certainly in the ballpark for guided hunts these days), he would be foolish not to buy at least a box of your bullets, if they were designed specifically to take down a trophy elk cleanly and humanely at the ranges he planned to hunt. At ten times the standard factory price, they are still nearly the cheapest part of the trip.

If this same person were licensed to carry a concealed weapon and felt the need to do so in order to protect his life, or that of his family, he would not only be foolish but would feel humiliated if he passed up the chance to use the very best self-defense bullet on the market, and his standard factory bullet failed to work. He might, in fact, feel much worse than that. Or nothing whatever, including a pulse, depending on when and how the lower cost bullet failed to perform.

Those who simply cannot obtain the bullet style, weight or caliber they want from the factory either don't shoot their guns or they pay what it costs to make the special bullets. Making the bullets faster and cheaper usually has little or no effect on the sales, other than making them less profitable.

There is a relationship between sales volume and profit margin that people without business experience sometimes overlook when they start their first business. As you increase the price, those people who were just on the edge of buying usually back off and don't buy, but those who were a little further into their economic comfort zone are not affected. So, you lose a few sales but the ones you have become more profitable.

At some point in the curve of sales volume versus profitability, a point is reached where any further loss of sales reduces the over-all profit. But until you hit

that point, you can make more money on less sales. And that is the entire point of custom bullet making as a market segment: as long as you go after the narrowly limited areas where the factories do not find it profitable to work, you will be able to operate free of any serious competition, and can make a very nice profit on your work. But as soon as you decide that the volume is too small, and rather than looking for more of these niches in the market, you turn to the playing field of the mass producers, you are headed for a real fight.

Working with people who know you are making the bullets by hand, one at a time, and doing the very best possible job on each one, means that your customers realize that your price must be high. They are willing to pay it, or they wouldn't be your customers! The biggest mistake a custom bullet maker can make is to think in terms of "bullets per hour". Always consider why you are doing it (other than the satisfaction, of course): the bottom line is "dollars per hour". Keeping that in mind makes it easier to seek new niche markets instead of lusting after the mass producers' clients.

Bullet Testing

In order to know if a certain bullet design has merit, either for production or for your personal use, it is important to know how to test it. Gun magazines publish many tests of bullets, but the circumstances under which most gun writers operate virtually precludes doing a very meaningful test.

I say this, having been a gun writer myself. Fortunately, I had other income and could do a little more than if I had to depend on the salary from writing to support my family. At that time, I had no family to support, and had other business income to buy the guns and supplies needed. Time wasn't a major problem then. Even so, the tests that I did of bullets consumed a vast amount of both time and money. The standard fees paid by magazines for articles did not leave much for the work: I figured I would make about twice as much pumping gas as doing good gun articles that involved bullet testing.

A fairly standard technique is to fire a few bullets into wet newspapers, clay, a plastic milk jug filled with water, or some other target material, and recover the bullets to photograph and measure. Anywhere from three to twenty bullets might be fired in groups of three to five shots to check the accuracy, using a favorite gun fired from whatever rest the author has found satisfactory. And that's the basis for the article.

I've read a few articles where the author fired one or two shots and pronounced judgement on the performance based on what happened at that particular speed and range when the bullet hit a stack of wet phone books. And I fully understand why this is passed off as a bullet test. If I were trying to make a living today writing gun articles, I'd probably have to do something like that in order to stay solvent.

I don't blame the writers or the magazines for not putting enough time and money into the tests to be meaningful. But I do think it wise that a person who is counting on the right bullet design, either for a business venture in making custom bullets or in using the bullet for some important purpose, should conduct a much more thorough testing before making any such decision.

Before discussing the test methods that actually provide meaningful information, I must say that regardless of what artificial target materials are used, there is a large error factor introduced in real life hunting and defense situations which cannot truely be simulated. We are forced to conduct a scientific experiment in which the simulation of reality is far more exact than the reality itself.

No matter what you use to simulate a Cape Buffalo, it probably won't charge you head on and make you take two or three more quick shots at a bobbing, weaving, and rapidly closing menace of horn and skull so thick that full metal jacket military bullets are bent and can be turned to come back at you! That Cape Buffalo has large areas of soft tissue that are similar to a big leather bag full of water, and other areas inches away that are as tough as a five-inch thick oak.

Depending on how it stands, or runs, you may only see horns and head, or you may see any angle of its body. It may be docile one moment and running as fast as it can to gore you in the next. How do you simulate all of that?

Game hunting has another target factor besides the mechanical physics of the materials: the spirit or will of the animal to continue, or give up, regardless of the severity of its wound. Sometimes it will drop like a rock with the same hit that, in another animal of the same species, would allow it to run away.

People are similar in their response to being shot: I spoke with a gentleman who was shot in the leg and only realized it when his boot filled with blood, and he could hear it squishing as he walked. I've read about people who died of non-fatal wounds, from shock and fear, and others who were so emotionally wound up that they were able to survive a fatal wound far longer than anyone would logically presume possible.

I've never been shot, fortunately, so I can't write any personal impressions about it. Speaking with experts in the forensic ballistic field and people who have survived gunshot wounds, though, has given me enough insight into the results of shootings that I would not count on any particular bullet test as being exactly indicative of what would happen.

You would think that being shot point blank in the torso with a .44 Magnum would result in immediate death, would you not? Yet, a woman in Chicago purchased a .44 Magnum for protection against muggers, was mugged while carrying it home from work in a paper bag, pulled it out and shot him point blank, and all he did was stand there looking at the tear in his arm and ribs, and then run away!

If you fired that round into a large block of clay, it would make a most impressive hole. Yet, there you have it. At least one criminal was still on his feet after being hit with one of the most powerful handgun rounds on the market. Testing has severe practical limits, no matter how well we do it. But we must do it anyway, because we can at least rule out some miserable failures, and point in at least a tentative way toward some potential successes.

Before we test anything, we need to establish a base line for what is normal. This is one of the most glaring omissions in so many articles: the writer fails to duplicate the test using a "control" bullet fired at the same

speed, range, and from the same gun into the same media. The control bullet should be one that is commonly available and familiar to most readers or users of that particular caliber. Otherwise, firing two obscure and different bullets doesn't really tell us anything.

The control bullet is used to tell us exactly what a "normal" bullet would do in the same circumstances. But because there are variations in high energy physical impacts (not to be confused with high energy physics, which deals with much lighter projectiles going much faster speeds!), a single round isn't enough. Depending on the amount of variation between rounds, a person should average the results of at least ten shots. If the ten all seem to give nearly identical results, then perhaps the next time, you could get by with five. But never just one.

In an ideal world, you could fire enough rounds both of your control bullet and your test samples to be statistically meaningful, perhaps several hundred. But the reality of the bank account steps in, and insists that five to ten shots probably won't miss that many opportunities for a very different performance. That is what we are looking for: a wildly different result than the previous few shots. If we find it, we have a problem to solve in firing enough more shots so that we can determine if that was just a strange anomoly or part of a pattern. We can't ignore it. So we rather hope it doesn't occur!

Having tested the standard bullet at exactly the same speed and range, into the same material we plan to use for our "unknown" bullet, we have a written record of the penetration depth, the diameter of the entrance cavity, the shape of the cavity, the remaining weight of the bullet and its expanded diameter, and any other factors we are interested in comparing.

Then we fire the "unknown" bullet, so that we might know it better, under circumstances duplicated to the best of our ability.

Immediately a problem is apparent: if our custom bullet is the world's lightest or heaviest for that caliber, or if it simply cannot be matched in velocity or weight with any standard mass produced bullet, what do we use as a standard? What happens if the test bullet is the only brand available, and that is why we are using it?

Creative logic has to be applied. You have to decide what the closest standard bullet would be to the one you are using, even if it is a different caliber. The thing that is different about the custom bullet is what you are testing, so that thing will not be duplicated in the control bullet. Everything else, as far as it is possible, should be.

If you are testing the world's lightest, fastest bullet in a .38 pistol, then you want to see if it penetrates, expands, holds together, gives more or less pressure with the same loads as the nearest standard bullet with which everyone reading the article or considering buying your product will have some possibility of experience. If the bullet you are testing happens to be a round nose shape, then you would probably want to get a standard round nose bullet of normal weight to compare. If it is jacketed, you'd want the control bullet to be jacketed also. But if the special bullet is full of plastic instead of lead, you don't necessarily want your control bullet to be the same construction, since that is the main factor in making the custom bullet different: you are testing whether a plastic filled, light weight bullet that can go very fast is of any benefit when it comes to firing under the same circumstances as a regular bullet of normal construction and weight, of roughly the same shape.

If the thing you are testing is the shape, then you would want to try to get as close to the weight and velocity with your control bullet as possible. You may in some circumstances have to try more than one control bullet or load it to different speeds in order to find out which factors are improved and why .

For instance, if the shape is like a football, and the penetration is twice as great as your round nose control bullet, you may want to find out if the reason is that the base drag is reduced by the other end of that curve, and thus the bullet is simply hitting at a higher rate of speed. To do that, you might have to chronograph the downrange velocity, load a conventional bullet to a higher speed and see if it penetrates the same. If it does, then the nose shape isn't the reason for the superior performance of the new design.

But if the round nose penetrates less at the same speed of impact, then the reduced base drag isn't the whole answer, and comparing the material hardness and nose shapes may reveal the answer: perhaps the new bullet is just harder and expands less, so it goes in further. Bullet testing isn't just a matter of firing one or two shots and proclaiming something about the expansion.

Once you have established how the test bullet differs in performance from the control bullet at one speed and range, you need to repeat the test at several other speeds to see how the performance may change. I usually test bullets at the lowest and highest speed that would typically be loaded in that caliber, and then compare the results. Each test uses at least five shots, since variations can start to occur at one speed that did not occur at another.

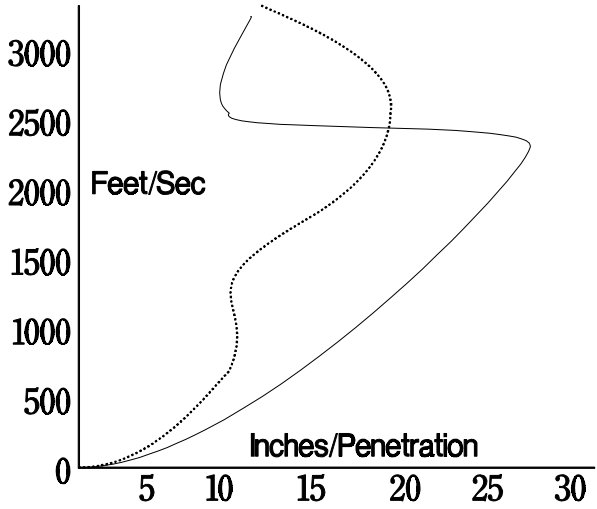
If there is a significant difference in expansion and penetration, which there usually is, then I try a speed approximately half way between them. If the penetra-

tion and expansion are linear when plotted on a chart against the speed, I figure that any other tests will probably fall close to that line, and can decide whether to shoot any more based on available time and money without a great deal of fear that I might miss something by stopping here.

But if the middle shot plots very far off the line, I need to split the difference on either side of it and fire at least five more rounds at those speeds, to see where the line moves. If it is a log curve, growing ever more sharply at one end and more slowly at the other, I've discovered something useful. If it jumps around, there are mechanisms working in that design that don't fit a conventional pattern, and probably bear further tests.

One interesting situation which comes to light with expanding bullets is a situation where the penetration in certain kinds of target materials changes in a nonlinear manner with velocity. The results at first can be puzzling but ultimately yield to logic.

Here is what happens: a given bullet may not expand at all, or only a small amount, during a series of shots where the velocity is increased from the very lowest practical values to the middle range of speeds. The jacket is maintaining the efficient shape of the bullet at these low energy levels, so it tends to penetrate in a fairly linear way with increasing speed.



Penetration versus velocity: two bullets, one expanding (dotted) and the other solid, fired to destructive impact.

As soon as a certain speed is reached, the jacket is no longer strong enough to resist being torn back, and it starts to expand more rapidly, which increases the frontal area and rapidly slows down the bullet, sometimes expanding so fast with increases in velocity that the curve becomes level or even negative.

What is happening is that the increased speed is being converted to energy sufficient to rapidly expand the bullet, and it offers more drag (friction), which retards its forward momentum, spreading the available energy over a wider area so it penetrates less, or at least doesn't seem to increase its penetration as much with each increase in speed as it did before expansion became so great.

Then suddenly the curve becomes more sharp again, and further increases cause even more penetration. This is the point where the "petals" of expanded jacket and core material are folded back or broken off, reducing the frontal area of the remaining projectile, so it now has the ability to leave bits of itself behind and bore a deeper hole with the piece that is left.

With even further increase in speed, the width of the hole can be come greater but the penetration can once again slow down or become negative, and finally level out at some maximum speed beyond which there is no futher penetration. This is the point at which the energy is so great at first impact that the bullet literally explodes, scattering itself into so many small pieces that none of them have enough kinetic energy to penetrate very far.

You can see that picking one or two velocities, in a given target material, might give you an entirely erroneous picture of what happens when you extrapolate the results to other speeds. For instance, if you happened to choose two speeds well into the negative penetration curve, you might conclude that this bullet penetrates best at slowest speed and less as you increase speed. You'd only be right for a very narrow portion of the curve, possibly for two little segments of it. Anyone choosing to load a lower or somewhat higher velocity would find just the opposite to be true.

You can see that it is important to try a fairly wide range of velocities, with a given target material. It is also important to try more than one media for the target, unless you are only comparing bullets that you know will be used in nearly identical material. For instance, dry magazines or paper may make a convenient target, and you can tell quite a bit by comparing bullets fired into it, but hollow point designs usually plug up with dry paper and act almost like solids. If

you fired the same hollow point bullet into a jug of water, it might mushroom to twice its size, and a solid might not expand at all.

Both of the bullets fired into dry materials could expand nearly the same amount. This is because hollow point designs usually depend on some kind of hydraulic effect to generate pressure that is evenly distributed in the cavity, and dry materials are often just cut and packed into the cavity on impact, which makes them part of the solid bullet rather than an expanding force.

The Oregon State Police told me that they used water to capture bullets, and that it gives them fairly close approximation to bullets recovered from human wounds (assuming of course that bone isn't hit). Firing into a water tank usually doesn't expand most conventional velocity handgun bullets, and neither do they seem to expand much after hitting someone. I can't vouch for it myself except to say that reliable forensic experts have told me it is true.

If so, then it means the idea of recovering a bullet in water to prevent any damage to it, is close to what would happen if it were used in defense. Conversely, if you design a bullet that expands well when fired into water (at a specified range of velocities, of course), it probably will do close to the same thing if called upon to defend someone against a violent criminal, assuming that the distance it has to travel is about the same as it would in a person, and it did not encounter any other significant materials along the path.

By the end of the day, we have fairly well used up a supply of whatever target material adsorbed all those hits. Some of them are quite renewable, as with water tanks having a pair of rubber sheets stretched over one end, or various kinds of book-binders' glue that has the consistence of old jello and melt in a double-

boiler (lower than 212-degrees F). You can cast this stuff in the plastic moulds that it comes in, and use it over and over, so long as you don't over heat it and cause it to "carmelize" or turn stiff and brown.

Water-soaked phone books or tightly-bundled newspapers soaked in water are fairly good test targets, also, but their density can vary with the pressure you use to pack them, the temperature and humidity, and how long they sit around waiting to soak up or dry out. I've heard of people buying a rack of ribs and shooting up perfectly good entres in an attempt to more closely simulate real game, but the game animal is alive, and its bones and muscle have not nearly the same resistance to a bullet as the meat in the butcher's case.

I'm not outlining a specific way to test or design bullets, but only trying to illustrate how you would have to think about your tests in order to make them meaningful. Always hold your assumptions at arms length. By that, I mean do not take what you think to be true as fact, but only as one of the possibilities. A blind faith in a certain kind of performance, or a given shape or bullet feature just because it appears to have worked well in a few instances, isn't proof that it will always be the best.

Maybe you are assuming, for instance, that a boattail is more accurate than a flat base bullet, when in reality you were comparing some mediocre flat base bullets, with out of tolerance jacket walls, to some very fine boattails with extremely well-drawn jackets. The only way to really find out is to try a number of experiments with different jackets, weights, loads, and calibers, and see if boattails are always more accurate than flat base bullets. They may have less drag, but that doesn't mean they are necessarily more ac-

curate. Bullets can be shot on a very flat trajectory into a big group, or they can be lobbed high into the air and drop into nearly one hole.

Another common assumption is that hollow points expand more than lead tip bullets. Sometimes the opposite is true, if the hollow point uses a fairly small tip and thick jacket, and the lead tip bullet uses a thinner jacket, or even the same jacket not closed down to such a small opening where the lead protrudes from it. The main control of expansion in jacketed bullets is the diameter of the jacket mouth at the time of impact. If two bullets are fired at the same speed into identical media, and one is nearly a cylinder while the other is closed down at the tip, it doesn't matter very much whether soft lead protrudes or not. The cylinder will expand more because it is already expanded more when it hits. The pointed bullet has further to expand just to catch up. And, generally, when you point a bullet more, the tip tends to become thicker, which resists expansion.

Another assumption is that tiny tip openings result in more accurate target bullets. A small tip may contribute to a lower drag, up to some limit, but it also causes the jacket material to be stretched further and thus any differences in hardness or thickness between one side of the jacket and the other are exaggerated, and show up at the tip. I've fired absolute cylinders into nearly one hole from a machine rest, doing just as well as a very pointed bullet, so I know that at least under some circumstances, the point shape doesn't control the accuracy.

When testing bullets, you do not need to simulate reality, because reality itself varies so much from shot to shot.The exact performance is not quite as important as a good comparison with a bullet that we all know well. The fact that our favorite 30-30 bullet hap-

pens to penetrate six inches of water-soaked phone books and makes a six-inch diameter hole while retaining eighty percent of its original weight does not translate to any particular results on the next deer we shoot.

If we know that the bullet does a pretty good job on deer, and it makes certain size holes in the phone books, that we can say that if another bullet does the same or better in the phone books, chances are good it will perform the same or better in the deer. We don't know it for a fact, but we can make a tentative assumption, or a working hypothesis, until it is proved otherwise.

Likewise, if we know that a certain standard bullet usually breaks up and damages a lot of meat at a certain speed, and we fire it at the phone books or clay or book-binders' glue, and we find that it makes a wonderful textbook example of a perfect wound cavity, without breaking up, then we know that another bullet that performs just like that in phone books might also break up when we shoot the deer.

We don't know for a fact that it will, but we have an indication. We have to decide what kind of performance would translate to reasonable results in actual use, and that isn't always easy, unless you are sure that a certain design worked more than once, and can try it in your test material to see what happens.

The concept of a control is basic to any scientific experiment. There are some people who would say that since there are so many "unknowns", it doesn't matter if we have one more, and then do their testing with one or two shots compared to... nothing! It may be true that we have a tough job in deciding what is close enough to be a valid control bullet, and exactly what kind of performance we are looking for in a target material, as opposed to performance in actual use.

But as with most things in life, if you can't get all the answers, the least you can do is get all the answers you can.

I was once called to a Federal tax court as a rebuttal witness to give "expert testimony" about bullet testing in a tax case. This was rather interesting because there were two main points the defendant had to prove in order to keep the Internal Revenue Service from collecting fines and penalties of a significant nature.

Here is the background: a custom bullet maker decided to build bullets for hunting dangerous African game, and in order to test them, he went to Africa and actually hunted the game himself. He decided to wait to advertise these bullets until he had perfected the design, based on actual experience, which would give him a very good advertising point.

But this meant spending quite a bit of money before actually selling any products, and that is where the I.R.S. disagreed with his intentions, saying he was just using the business venture as an excuse to have fun and write it off as a business expense. They claimed that he didn't have a business because he wasn't selling any bullets, and even if he did have one, it wasn't necessary to go to Africa and actually shoot Cape Buffalo in order to advertise that the bullets were designed and tested for this purpose.

He had two claims to support this action. First, he claimed that it was an ordinary, prudent business decision to invest in research and development, which meant testing and refining the product in actual use. Second, he claimed that product liability laws would require that he test the bullet in the same manner that his clients were supposed to use it.

He actually made more than one trip, because he said the first trip proved that the design he had tried in the usual test materials, and thought was working well, didn't actually perform well at all in a real hunting situation. So, he adjusted his assumptions about the design, tried different test materials for targets, changed the design, and went back next year to try again.

The I.R.S. had a good arguement because he actually had not sold any of these bullets, and therefore it would be a legal question of whether, in two years time, he could actually be said to have had a business. But he brought forth these two claims for the tax court to rule upon, and I was asked to rebut the testimony of the prosecution's expert witness, another custom bullet maker, who said that you did not need to shoot actual game in order to find out exactly what was going to happen with a given bullet design.

This other bullet maker, a famous name in the field who I will not identify, was very nice but also rather "bull headed", I thought, about his contention that wet newsprint or water-soaked magazines would tell you all you needed to know without actually shooting any game.

During a break, I had a chance to talk with him about it, but he was quite stubborn in insisting this was so. I contended that it was not, and that anyone claiming a bullet was designed to stop dangerous game animals had better test it on such an animal before making that claim in print, or the widow and survivors might sue him when it didn't quite work the same way in the Zimbabwe brush as it did in his back yard with a pile of wet phone books.

Who won? I don't know! Both sides presented their cases, the judge accepted written briefs and said he'd rule on it in the future sometime, and everyone went

home! I never found out. But the idea that product liability requires the best possible testing, in as nearly identical conditions as the expected usage, so far as it is practical to do so, should prevail.

I wouldn't advise trying to write off a couple of safaris, however, unless you had good legal and accounting advise before the event, and they said the I.R.S. wouldn't mind. In fact, I wouldn't advise anything remotely connected with law or accounting, not being a lawyer or accountant, and I disclaim any such intentions! I'm just relating what happened. You be the judge—but try to decide a little sooner, please!

This story is presented to show how important bullet testing methods can become in some situations. Another time, I was asked to do some bullet testing for a client who was trying to get permission to build a range, and the building authorities insisted that he prove the ability of his construction plan to stop bullets. The building was to be made of concrete blocks filled with cement and reinforcement steel bar (re-bar), two layers thick at the target end.

The concern was whether a .44 Magnum would penetrate this barrier. We built little sections of wall to that plan and fired many shots at it. Surprisingly, the concrete did fail at certain angles, when hit in the thin web section, but the solid concrete filler withstood several more rounds, and a double row was very tedious to penetrate. It could be done, but a person would need to concentrate his firepower on one spot for long enough to draw attention.

Of course, an adsorbent bullet trap such as the angled cut-up rubber tire bits or sloping sand shelf or even angled steel plates would protect the wall, but the building people wanted the wall alone to stop a stray round, and it would. We sent our bill for cement and blocks and some ammo and time, along with our

independent third party report and the building went forth. So far, I've not heard of anyone taking a stray slug in the alley during a match, so the tests must have been realistic enough.

Another time, we were asked to develop a bullet that would not go through a conventional frame house wall (with a 3/8-inch drywall on both sides), yet would be adequate to stop an intruder. We could not do it. Anything that was powerful enough to cause a criminal to drop in his tracks was also strong enough to blast through the gypsum boards like they didn't exist. We tried very light, fast bullets that had so much energy that they would break up on anything, and very slow heavy bullets made of powdered tungsten in a beeswax capsule or "jacket". Regardless, there was no way to guarantee the safety of anyone on the other side of the simulated room wall. Some goals are mutually exclusive. But if you find an answer, I'd be glad to hear it.

The "Holy Grail" of game bullet design is the bullet that will expand to double diameter at nearly any velocity or range and won't break up at the highest speed nor fail to expand and penetrate to vital organs at the lowest speed. In this application, speed translates to range. A hunter may not know exactly how far the trophy will be when it appears.

If it steps from behind a bush 50 feet away, he's a great tracker or maybe just lucky, but not if the bullet blows to bits on impact with the hide, and the animals runs off to die from the wound.

If it appears on the other side of the valley just before dusk, on the last day of the hunt, and it's a matter of taking a 350 yard shot or letting it go, some people are good enough (or dumb enough) to try it,

but their success will then depend on whether the well placed shot is made with a bullet that can expand even after losing a good deal of its initial velocity.

Rotational velocity, imparted to the bullet by the rifling, varies with the forward velocity. It is always so many turns per inch of travel, controlled by the barrel used, but the centrifugal force is increased as the bullet covers that inch in less time. However, the amount of energy that is released by the spin alone is not a major factor in determining what the bullet will do when it hits. The bullet stops spinning almost as soon as it expands, since the leverage of those petals projecting from the bullet exert a resistance that is greater than the rotational momentum.

After all, any given point on the jacket has the same mass that it did while the bullet was spinning through the air, but it normally pops out to nearly twice the distance from the center of rotation when it strikes, while most of the rest of the bullet stays the same distance from the center. If you think of a single line of radius as a little lever, you can see that the expanded bullet has little levers that are twice as long as the main diameter of the unexpanded portion, pulling on the thick material and trying to move it with them.

You can see the evidence of this by shooting bullets into an oil-based clay, where the tracks left by spinning are generally very short or absent. The clay doesn't tend to shrink back to original size like gelatin or elastic bookbinders' glue, so you can see the spin traces in the way the clay is pulled and twisted. There is just enough to show that it isn't a very big effect.

What this means is that you can get a fairly good idea of what happens at long ranges by loading your cartridges so that the close-range impact velocity is the same as it would be after the bullet had decelerated. You might think this would be obvious, but the

rate of spin doesn't slow down nearly as much as the rate of forward travel. A bullet that travels 2,600 feet per second, for instance, covers one inch in 0.000032 seconds (32 millionths of a second). If it is spun at a rate of one turn for every ten inches of travel, that means when it goes ten inches, a little over 32 millions times ten or 0.00032 seconds will have passed. The rate of spin, in revolutions per second, is one turn in 0.00032 seconds or dividing that fraction out, you get 3125 turns per second.

Sixty times that gives you turns per minute, a measurement we know and love because it is used more often. The bullet is spinning at 187,500 RPM. The motor on your drill press probably turns at 1725 RPM or 3250 RPM, and a high speed rotary grinder like the Moto-Tool might get up to 10,000 RPM.

But the leverage arm from the center of that bullet to the jacket is only half the caliber. On a .308 bullet, which is the diameter of nearly all .30 calibers regardless of what the manufacturer calls them, is .154 inches. That's a rather small arm with which to pry something. Centrifugal force is the energy that is achieved by spinning a certain weight (or mass, really) by a certain lever arm. The effective mass is the combined effect of each point along the lever times its effective speed.

Without delving into the math, the little spinning lever effectively generates a rather small amount of energy, and is slowed down almost instantly when it encounters resistance (actually, it slows completely when it meets matching resistance, which is supplied very soon after impact). This means that while spin does have an effect on the terminal performance of the bullet, it can be ignored for purposes of testing

big game or defense ammo, since the most likely use of the bullets will involve field variables far greater than the error introduced in the tests.

This does not mean there is no effect caused by spin, and that the results will be identical if you shoot 1000 yards or if you load so that the bullet strikes up close at the same rate it would be moving at 1000 yards. It just means that for most practical purposes, the effect isn't big enough to spend much time and effort in an attempt to simulate it.

So it can be with any number of effects: first you must determine if the factor you want to simulate is significant, or just a minor part of the performance picture. Bullet testing consumes so much time, when done correctly, that anything you can do to reduce the work without significant risk of missing something important is a good thing to do. On the other hand, three shots at a watermelon doesn't constitute much of a test!

Sources of Bullet Materials

The following pages contain the names and addresses of suppliers for primary and secondary (reclaimed) lead in ingot, powder, and wire form, and mills furnishing copper tubing, rod, and sheet (strip) as well as various alloys such as gilding metal, commercial bronze, and brass.

In most cases, the sources are primary mining, refining, or milling industries and will not sell small quantities directly to bullet makers, but they can direct you to distributors or sales outlets. Some of the world's largest raw materials producers are listed even though they do not sell the finished products. Don't be hesitant about contacting large mining or refining companies and asking them for a list of "fabricators" for the finished products you seek.

Some of the names are associate members of copper or lead industry associations, and may be end users of the materials rather than producers, but are listed because you may find them helpful in locating a near-by outlet that will sell small quantities. A purchase of at least 2,000 pounds of lead, or 500 pounds of copper tubing or strip is generally the threshold for dealing with the smelters and mills.

Another good source of information is the yellow pages of any large city telephone directory. Look under "Lead" or "Copper", "Metals", or "Manufacturers". Please bear in mind that if you cannot find a suitable supplier, you can count on Corbin for smaller quantities of standard dimensions as well as reasonable prices on larger lots of special sizes.

Lead Facts

Primary Lead. The world produces close to 6,250,000 tons of lead every year, mined in 48 countries. In the USA, Missouri provides over 90% of the lead mined, with Arizona, Colorado, Idaho, New Mexico, and Washington supplying the rest. The Doe Run company is one of the largest lead mining firms in the USA.

Secondary Lead. The largest percentage of lead is used in storage batteries. In the USA, about 78% of the lead consumed in 1988 (1,053,000 tons) went into battery manufacture. Additional uses for lead include telephone and power cable sheathing, glass coating for electronic components, leaded glass for crystal and for video display terminal screens, medical and industrial X-ray shielding, roofing, solder, moisture seals, earthquake dampers for buildings, nuclear materials containers, and industrial scrubbers for removing sulphur and sulphuric acids from exhaust gas.

Lead is also formulated with other elements to form chemicals used in corrosion-resistant paint and in ultrasonic transducers. Stable memory chips for computers based on lead compounds are being suggested as a replacement for silicon-based RAM. The common forms of scrap lead are wheel-weights, battery plates, telephone cable sheathing, lead pipe and solder, sheet lead used in radiation shielding, and nuclear medicine shields, as well as fired bullets and shotgun pellets.

Chemical Symbol:	Pb
Melting Point	327.5° C.
Boiling Point:	1740° C.
Atomic Number:	82
Atomic Weight:	207.19
Density:	.4079 lb/cu.-in. (11.35gm/cc)

Sources of Lead

The primary information source for lead suppliers in the United States is the Lead Industries Association, Incorporated, 295 Madison Avenue, New York, NY 10017. Call 212-578-4750, or send a telefax message to 212-684-7714, to obtain a current membership list, safety and health information about handling lead, and the uses and sources of lead.

Lead is the most recycled metal in the world today, with about 90 percent of the lead in use coming from secondary (recycled) sources. Lead recyclers are actually providing more new lead on the market than lead mines. Your best sources for all forms of lead (ingots, powder, and wire) will originate at a recycling plant or smelter.

Lead prices typically vary from a low of about 19 cents per pound in large quantities (tons) in pig form, to a high of over $3 per pound in specialized, extruded forms such as lead came (for stained glass assembly). You would normally want either lead wire (for bullet cores) or pre-cast cylinders to fit your lead extruder body. These range from about $0.70 to $2.50 per pound, depending on packaging, quantity, and quality (cleanliness, precision, and reliability of the source).

Straight or pure lead is typically 99.95% lead with a trace of silver. This is the best kind for bullet swaging. Harder alloys containing tin or antimony are often used for casting, and may also be swaged using sufficiently large dies to hold the extra pressure. Adding 3% antimony to lead can double the required swaging pressure, far exceeding the limits of the die walls in large calibers used in smaller presses where the die diameter is under 1.5-inches. Any lead alloy can be swaged, however, if the equipment is specially designed for the job.

ALLECO INCORPORATED
17100 FRANCIS
MELVINDALE MI 48122

ALPHA METALS, INC.
600 ROUTE 440
JERSEY CITY NJ 07304

AMES METAL PRODUCTS CO.
4323 SOUTH WESTERN BOULEVARD
CHICAGO IL 60609

ASARCO INCORPORATED
180 MAIDEN LANE
NEW YORK NY 10038

BRITANNIA REFINED METALS LT.
BOTANY ROAD
GRAVESEND KENT DA11 9BG ENGLAND

CANADA METAL COMPANY, LTD.
721 EASTERN AVENUE
TORONTO ONT M4M 1E6 CANADA

CARTERCHEM CANADA INC.
1295 AVENUE DE LORIMIER
MONTREAL QB H2K 3V9 CANADA

CHATHAM METALS, INC.
P.O. BOX 534, 101 CHURCH ST.
MATAWAN NJ 07747-0534

CROWN NOVELTY WORKS CORP.
86-15 LIBERTY AVENUE
OZONE PARK NY 11417

DELCO REMY
2401 COLUMBUS AVENUE
ANDERSON IN 46018

DIVISION LEAD LTD. PARTNERSHIP
7742 WEST 61ST PLACE
SUMMIT IL 60501 UAS

DRESSER INDUSTRIES,INC.
P.O. BOX 6504
HOUSTON TX 77265-6504

EAGLE-PICHER INDUSTRIES, INC.
P.O. BOX 550
JOPLIN MO 64802

EAST PENN MANUFACTURING CO,INC
DEKA ROAD
LYON STATION PA 19536

ETHYL CORPORATION
330 SOUTH FOUTH ST.
RICHMOND VI 23271

FEDERAL-MOGUL CORPORATION
P.O. BOX 1966
DETROIT MI 48235

FEDERATED-FRY METALS
4100 SIXTH AVENUE
ALTOONA PA 16602

GARDINER METAL COMPANY
4820 SOUTH CAMPBELL AVENUE
CHICAGO IL 60632

HAMMOND LEAD PRODUCTS, INC.
P.O. BOX 6408
HAMMOND IN 46325

HOCHSCHILD PARTINERS
250 PARK AVENUE
NEW YORK NY 10177

HORNADY MANUFACTURING CO.
P.O. BOX 1848
GRAND ISLAND NE 68802

INDIUM CORPORATION OF AMERICA
P.O. BOX 269
UTICA NY 13503

AARVAL LEAD PRODUCTS
INTERCHANGE TOWER, SUITE 875
600 SOUTH HIGHWAY 169
MINNEAPOLIS MN 55426

JOHNSON CONTROLS, INC.
5757 NORTH GREEN BAY AVENUE
MILWAUKEE WI 53201

K W BATTERY COMPANY
3555 HOWARD ST.
SKOKIE IL 60076

KENNETH LYNCH & SONS
P.O. BOX 488
WILTON CT 06897-0488

KESTER SOLDER COMPANY
515 EAST TOUHY AVENUE
DES PLAINES IL 60018-2675

LONE STAR LEAD CONSTRUCTION CO
P.O. BOX 24038
HOUSTON TX 77229

M.C. CANFIELD SONS
BOX 3100
UNION NJ 07083

MASTER METALS, INC.
2850 WEST THIRD STREET
CLEVELAND OH 44113

MAYFIELD MANUFACTURING CO.
P.O. BOX 19397
BIRMINGHAM AL 35219

METALLIC RESOURCES, INC.
P.O. BOX 177
TWINSBURG OH 44087

NEW ENGLAND LEAD BURNING CO.
P.O. BOX 607
WOBURN MA 01801

NORANDA SALES CORPORATION, LTD
ONE ADELAIDE ST, EAST STE 2700
TORONTO ONT M5C 2Z6 CANADA

O & C CORPORATION
P.O. BOX 681380
INDIANAPOLIS IN 46268

O.G. KELLEY & COMPANY
BOX 660
JOHNSON CITY TN 37601

PASMINCO METALS
GPO BOX 1291K
MELBOURNE VIC 3001 AUSTRALIA

PENOLES METALS & CHEMICALS INC
80 BROAD ST.
NEW YORK NY 10004-2203

QUENELL ENTERPRISES, INC.
5909 EAST RANDOLPH ST.
CITY OF COMMERCE CA 90040

REPUBLIC LEAD BURNING & EQUPT.
P.O. BOX 05070
CLEVELAND OH 44105

RSR CORPORATION
1111 WEST MOCKINGBIRD LANE
DALLAS TX 75247

SPORTING ARMS & AMMUNITION MFG
555 DANBURY ROAD
WILTON CT 06897

STAINED GLASS ASSN OF AMERICA
SIX S.W. SECOND STREET, #7
LEE'S SUMMIT MS 64063

SYNTHETIC PRODUCTS CO., INC.
20600 CHAGRIN BLVD. SUITE 801
SHAKER HEIGHTS OH 44122

THE DOE RUN COMPANY
11885 LACKLAND ROAD
ST. LOUIS MO 63146

THE G.A. AVRIL COMPANY
P.O. BOX 12050
CINCINNATI OH 45212

TROJAN BATTERY COMPANY
12380 CLARK STREET
SANTA FE SPRINGS CA 90670

VULCAN LEAD PRODUCTS
1400 WEST PIERCE STREET
MILWAUKEE WI 53204

Copper Facts

Copper is mined in many parts of the world, with the largest suppliers being Chile, the United States, the former USSR, Peru, Poland, Zaire and Zambia. There are more than 160 minerals known to contain copper. In the late 1990's, the annual world production was about 8 million metric tons.

Copper is used in electrical and plumbing applications, where its high resistance to corrosion and excellent electrical and thermal conductivity make it useful for wiring, pipes, condensers, radiators, and electrical components. The chemical uses include fungicides, textile dyes, timber preservatives, and as a catalyst in producing formaldehyde from methanol.

One of the largest open-pit mines in the world, the Berkeley Pit in Butte, Montana, was closed in 1982. However, an upturn in the economy starting in 1984 caused a partial reversal of the trend: by 1988, copper consumption in the U.S.A. had reached its highest point in a decade. Nearly 50% of the copper is reclaimed (recycled).

"Pure" copper generally has less than 1% of other elements, but even trace amounts can change the characteristics. Tough pitch ETP copper has a small amount of oxygen, which makes it slightly tougher but can cause it to become brittle when heated. Deoxidized copper, or silver-bearing copper, both withstand higher temperatures without becoming brittle. Copper has a tensile strength of about 32,000 psi, nearly 32 times greater than lead. The addition of small amounts of zinc, to produce a brass alloy, can increase the tensile strength to as much as 130,000 psi. Copper is made harder by mechanical work hardening (drawing, etc.).

Sources of Copper Alloys

Copper and its alloys are identified in North America by the Unified Numbering System (UNS), a five-digit number prefixed by the letter C, and managed by the American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE). There are two broad classes of copper alloys: wrought (meaning, mechanically formed by drawing or rolling, as with tubing and sheets), and cast (as with pipes and ingots).

The UNS numbers from C10000 to C79999 are wrought alloys, while numbers from C80000 to C99999 are cast. Wrought products are those formed by mechanical methods such as rolling or drawing, such as tubing and sheet metal. These are the alloys used by bullet makers.

Copper No. C11000 (formerly CDA-110) or C10800 (MIL-B-20292) is a good starting point for tubing to be used for bullet jackets, although virtually any of the drawn tubing or rolled sheet products including gilding metal (C21000) or commercial bronze (C22000) are routinely used for jacket-making.

Straight, half-hard lengths of copper tubing are more easily cut to small pieces in a lathe, but annealed (soft) coiled copper tube can be used provided that the coils are large enough so the tubing isn't permanently kinked. Sheet copper should be the "non-earing" grade (an even, annealed temper with uniform grain) to reduce waste in deep draws.

Tubing is generally purchased direct from drawing mills and specialty tubing suppliers, generally in 200 to 500 pound lots, in 12 to 20 foot lengths, with walls of 0.025 to 0.125-inch thickness. Sheet strip is generally furnished in pancake coils, from 0.5-inch to 1.5-inch in width and from 0.030 to 0.080-inch thickness, 100 pounds per coil, in 500 pound shipments.

The Copper Development Association (CDA) is the principal trade association for the copper industry in the USA. A Standards Handbook can be purchased from the CDA at a nominal cost. Their address is: Copper Development Association, Inc., 2 Greenwich Office Park, PO Box 1840, Greenwich, CT 06836, phone (203)-625-8210, fax number (203)-625-0174.

Chemical Symbol:	Cu
Density:	.321 lbs/cu.-in. (8.96 gm/cc)
Melting Point:	1083.4° C.
Boiling Point:	2567° C.
Atomic Number:	29
Atomic Weight:	63.546

A.J. OSTER COMPANY
50 SIMS AVENUE
PROVIDENCE RI 02909

ACCURATE FORGING CORPORATION
201 PINE STREET
BRISTOL CT 06010

ADMIRAL METALS SERVICENTER CO.
P.O. BOX 349
TAUNTON MA 02780

ALASKAN COPPER WORKS
P.O. BOX 3546
SEATTLE WA 98124

AMPCO METAL INCORPORATED
P.O. BOX 2004
MILWAUKEE WI 53215

ANCHOR-HARVEY COMPONENTS INC.
600 LAMM ROAD
FREEPORT IL 61032

ANSONIA COPPER & BRASS, INC.
P.O. BOX 109
ANSONIA CT 06401

BRUSH WELLMAN INC.
17876 ST. CLAIR AVENUE
CLEVELAND OH 44110

CAMDEN WIRE COMPANY, INC.
12 MASONIC AVE.
CAMDEN NY 13316

CERRO COPPER PRODUCTS CO.
P.O. BOX 66800
ST. LOUIS MO 63166

CERRO METAL PRODUCTS CO.
P.O. BOX 388
BELLEFONTE PA 16823

CHICAGO EXTRUDED METALS CO.
1601 SOUTH 54TH AVENUE
CICERO IL 60650

COULTER STEEL & FORGE CO.
P.O. BOX 8008
EMERYVILLE CA 94662

CRITERION METALS INC.
44 QUAKER LANE
WARWICK RI 02886

EAGLE BRASS CO.
R.D. #1, BOX 1377
LEESPORT PA 19533-9605

ELKHART PRODUCTS CORPORATION
P.O. BOX 1008
ELKHART IN 46515

EXTRUDED METALS
302 ASHFIELD STREET
BELDING MI 48809

HALSTEAD METAL PRODUCTS
300 N. GREENE ST., SUITE 400
GREENSBORO NC 27401

HAMILTON PRECISION METALS
P.O. BOX 3014
LANCASTER PA 17604

HANDY & HARMON
P.O. BOX 610
FAIRFIELD CT 06430

HEYCO METALS INC.
P.O. BOX 620
READING PA 19605

HOWELL METAL COMPANY
P.O. BOX 218
NEW MARKET VA 22844

HUDSON INTERNATIONAL CONDUCTOR
62 WATER STREET
OSSINING NY 10562

HUSSEY COPPER, LTD
100 WASHINGTON STREET
LEETSDALE PA 15056

INCO ALLOYS INTERNATIONAL, INC
P.O. BOX 1958
HUNTINGTON WV 25720

KEARNY SMELTING & REFINING CO.
936 HARRISON AVENUE
KEARNY NJ 07029

LITTLE FALLS ALLOYS, INC.
171-191 CALDWELL AVENUE
PATERSON NJ 07501

LUCAS-MILHAUPT, INC.
5656 S. PENNSYLVANIA AVENUE
CUDAHY WI 53110

MCINNES STEEL COMPANY
441 EAST MAIN STREET
CORRY PA 16407-0901

MODINE HEAT TRANSFER INC.
415 EAST PRAIRIE RONDE
DOWAGIAC MI 49047

MUELLER BRASS COMPANY
1925 LAPEER AVENUE
PORT HURON MI 48060

NATIONAL COPPER & SMELTING CO.
3333 STANWOOD BLVD.
HUNTSVILLE AL 35811

NEW HAVEN COPPER COMPANY
P.O. BOX 455
SEYMOUR CT 06483

NGK METALS CORPORATION
P.O. BOX 13367
READING PA 19612-3367

NIBCO INC.
P.O. BOX 1167
ELKHART IN 46515

NORTHERN WIRE & STRIP MILLS
3333 SOUTH CENTRAL AVENUE
CHICAGO IL 60650

OLIN BRASS
427 NORTH SHAMROCK STREET
EAST ALTON IL 62024-1174

OUTOKUMPU AMERICAN BRASS CO.
P.O. BOX 981
BUFFALO NY 14240

OWL WIRE & CABLE, INC.
ROUTE 5, SENECA TURNPIKE
CANASTOTA NY 13032

PHELPS DODGE BAYWAY OPERATIONS
P.O. BOX 648
ELIZABETH NJ 07207

PLUME AND ATWOOD
235 EAST MAIN STREET
THOMASTON CT 06787

PRECISION TUBE COMPANY, INC.
WISSAHICKON AVE. & CHURCH ST.
NORTH WALES PA 19454

RATHBONE PRECISION METALS, INC
241 PARK STREET
PALMER MA 01069

READING TUBE CORPORATION
P.O. BOX 14026
READING PA 19612-4026

REVERE COPPER PRODUCTS, INC.
P.O. BOX 300
ROME NY 13440

SCM METAL PRODUCTS
11000 CEDAR AVENUE
CLEVELAND OH 44106

SCOTT BRASS, INC.
1637 ELMWOOD AVENUE
CRANSTON RI 02910

SEYMOUR SPECIALTY WIRE CO.
15 FRANKLIN STREET
SEYMOUR CT 06483

SMALL TUBE PRODUCTS, INC.
P.O. BOX 1674
ALTOONA PA 16603

SOMERS THIN STRIP
P.O. BOX 270
WATERBURY CT 06720

TALCO METALS CO.
5201 UNRUH AVENUE
PHILADELPHIA PA 19135

THE DRAWN METAL TUBE CO.
P.O. BOX 370
THOMASTON CT 06787

THE ELECTRICAL MATERIALS CO.
P.O. BOX 390
NORTH EAST PA 16428

THE LINDERME TUBE COMPANY
1500 EAST 219TH STREET
CLEVELAND OH 44117

THE MILLER COMPANY
99 CENTER STREET
MERIDEN CT 06450

THE NIPPERT COMPANY
801 PITTSBURGH DRIVE
DELAWARE OH 43015

THE WILKINSON COMPANY
P.O. BOX 4558
THOUSANDS OAKS CA 91359

TROJAN TUBE CO., INC.
P.O. BOX 496
FARMINGDALE NJ 07727

ULLRICH COPPER INC.
2 MARK ROAD
KENILWORTH NJ 07033

UNIFORM TUBE INC.
200 WEST SEVENTH AVENUE
COLLEGEVILLE PA 19426

VALLEYCAST INC.
P.O. BOX 1714
APPLETON WI 54913

WALTEC AMERICAN FORGINGS INC.
P.O. BOX 35
WATERBURY CT 06725-0035

WATERBURY ROLLING MILLS, INC.
P.O. BOX 550
WATERBURY CT 06720

WELDALOY PRODUCTS COMPANY
11551 STEPHENS DRIVE
WARREN MI 48089

WOLVERINE TUBE (CANADA), INC.
P.O. BOX 420
MONTREAL QB H1BSK4 CANADA

YOUNGSTOWN WELDING & ENG. CO.
P.O. BOX 2461
YOUNGSTOWN OH 44509-0461

Custom Bullet Makers by Firm Name

AAA AMMUNITION
14717 INDUSTRIAL RD
OMAHA, NE 68144 USA
Contact: PAUL HARLOW
Phone: (402)334-3389 Fax: (402)334-0777
Bullet diameters: 224 243 308 511

ACADIAN BALLISTIC SPECIALTIES
P O BOX 61
COVINGTON, LA 70434 USA
Contact: B.J. DANTIN
Bullet diameters: 452 454 455

ACCURACY UNLIMITED
1175 BECKY DRIVE
COLORADO SPRINGS, CO 80921USA
Contact: ALLAN SHINOGLE
Phone: (719)481-8246 Fax: (719)481-0726
E-mail: SSUPRA@IX.NETCOM.COM
Lead wire offered
Bullet diameters: 451 452 500 505 545

A.J. BROWN ARMS
709 NORTH WASHINGTON STREET
BLOOMFIELD, IN 47424 USA
Contact: A.J. BROWN
Phone: (812)384-1056 Fax: (812)384-4100
E-mail: AJ-BROWN@VIADUCT.CUSTOM.NET
Lead wire offered
Bullet diameters: 224 452

ALASKA BULLET WORKS, INC.
9978 CRAZY HORSE DRIVE
JUNEAU, AK 99801 USA
Contact: MIKE MURRAY
Phone: (907)789-3834 Fax: (907)789-3433
Bullet diameters: 277 284 308 338 358 375 416 458

ALPHA MANUFACTURING
PO BOX 81072
LINCOLN, NE 68501 USA
Contact: JERRY J. FRANCK
Phone: (402)466-3193 Fax: (402)466-3193
Bullet diameters: 458 430 452 416 357

ARMFIELD CUSTOM BULLETS
4775 CAROLINE DR
SAN DIEGO, CA 92115 USA
Contact: JIM ARMFIELD
Phone: (619)582-7188 Fax: (619)287-3238
Bullet diameters: 224 243 257 264 277 284 308 338

BALLARD BUILT
P.O. BOX 1443
KINGSVILLE, TX 78364-1443 USA
Contact: DENNIS BALLARD
Phone: (512)592-3608
Bullet diameters: 430 451 475 510

BAYOU BALLISTICS
PO BOX 773
NICEVILLE, FL 32588-0773 USA
Contact: DAVE BURKHALTER
Phone: (850)678-0812 Fax: (850)678-2811
E-mail: BURKHALT@AOL.COM
Bullet diameters: 224 308 355 357 400 429 452

BAYFIELD BULLET COMPANY
PO BOX 1185
BAYFIELD, WI 54814 USA
Contact: BILL CORNELIUS
Phone: (715)779-7019
E-mail: BAYFIELDBILL@YAHOO.COM
Website: WWW.CUSTOMBULLET.COM
Bullet diameters: 416 411 377 375 348

BG ROYAL BULLETS
3499 E. Bayshore Rd. #133
Redwood City, CA 94063 USA
Contact: BRUCE OR SALLY GROUT
Phone: (650)368-5289
E-mail: BGROYAL1@AOL.COM
Bullet diameters: 257 270 284 308 338

BIG BORE BULLETS
PO BOX 872785
WASILLA, AK 99687 USA
Contact: DOUG VAN WINGERDEN
Phone: (907)373-2673 Fax: (907)373-2673
Bullet diameters: 224 308 355 357 375 429 452 458

BISON BULLETS
1727 HWY 32
BOLIVAR, MO 65613 USA
Contact: WILLIAM CASSETT
Phone: (417)326-8176
Lead wire offered
Bullet diameters: 308 312 4085

BLUE MOUNTAIN BULLETS
HCR 77 BOX 231
JOHN DAY, OR 97845 USA
Contact: JACK DEROSIER
Phone: (541)820-4594
Bullet diameters: 243 257 277 284 308 323 338 358 375 429

BOUNDARY BULLETS
HCR 60 BOX 271
BONNERS FERRY, ID 83805-9518 USA
Contact: WM LEFEBVRE
Phone: (208)267-7378
Bullet diameters: 243 284 429

BUCK-STIX— SOS PRODUCTS
PO BOX 3
NENAH, WI 54957-0003 USA
Contact: HELMUT SAKSCHEK
Phone: (414)729-9609
E-mail: BUCKSTIX@AOL.COM
Lead wire offered
Bullet diameters: 145 269 308 410 441 457

BUCKHORN BULLETS
406 W. BROADWAY STREET
GAINESVILLE, TX 76240 USA
Contact: BUCK STIENKE
Phone: (940)665-2289
Lead wire offered
Bullet diameters: 308 338 416 458 429 452 510 512

BUCKSKIN BULLET CO.
PO BOX 1893
CEDAR CITY, UT 84721 USA
Contact: J. LOWE BARTON
Phone: (801)586-3286
Bullet diameters: 45 50 54 58

BULL-X, INC.
520 N. MAIN
FARMER CITY, IL 61842 USA
Contact: ANGELIQUE DOLBERT
Phone: (800)248-3845
Fax: (309)928-2130
E-mail: BULL-X@BULL-X.COM
Website: BULL-X.COM
Bullet diameters: 313 356 357 358 401 411
427 430 452 458

CERTECH INTERNATIONAL
11514-15TH AVE N E,STE.531
SEATTLE, WA 98115 USA
Contact: MICHAEL CRAIG
Phone: (206)527-8532
Fax: (206)524-8289
E-mail: MCRA16@CYBERSPACE.COM
Bullet diameters: 204

COLORADO BONDED BULLETS
7910 BLUE GILL
FALCON, CO 80831 USA
Contact: C.H. PERDUE
Phone: (719)683-3575
Fax: (719)683-3575
E-mail: COBONDED@AOL.COM
Website: WWW.MEMBERS.AOL.COM/COBONDED
Bullet diameters: 264 284 308 358

CUSTOM BULLET SHOP DEGOL
SLANGBEEKWEG 43
ZONHOVEN, 3-3520 BELGIUM
Contact: WIM DEGOL
Phone: (321)122-9510
Fax: (321)122-9510
Jackets offered
Bullet diameters: 510 458 440 435 423 416
411 408 375 366

D K T INC.
14623 VERA DRIVE
UNION, MI 49130 USA
Contact: CHUCK RICHARDSON
Phone: (616)641-7120
Fax: (616)641-2015
E-mail: dktinc@aol.ocm
Jackets offered
Bullet diameters: 228 287 300 318 329 351 406
411 585 620

ELD ENTERPRISES
2811 N MESA DR #35
PRESCOTT VALLEY, AZ 86314 USA
Contact: ERIC DENNIS
Phone: (520)772-4085
Lead wire offered
Bullet diameters: 223 224 308 356 429 452 675 710

ELKHORN BULLETS
PO BOX 5293
CENTRAL POINT, OR 97502 USA
Contact: RALPH MCKECHNIE
Phone: (541)826-7440
Lead wire and Jackets offered
Bullet diameters: 284 308 338 348 358 375 412
416 458

E V D ROHM
37 BULAWAYO, KENRIDGE HEIGHTS
DURBANVILLE, 7550 REP. SOUTH AFRICA
Contact: E V D ROHM
Bullet diameters: 243 251

G & C BULLET CO
8835 THORNTON RD
STOCKTON, CA 95209 USA
Contact: SAM GARCIA
Phone: (209)477-6479
Fax: (209)477-2813
Lead wire offered
Bullet diameters: 311 356 357 358 401 429
452 457 575

G.T.B.
482 COMERWOOD CT
SOUTH SAN FRANCISCO, CA 94080 USA
Contact: ROBERT CAUTERUCIO
Phone: (415)583-1550
Jackets offered
Bullet diameters: 224 264 284 308

HARRIS ENTERPRISES
PO BOX 105
BLY, OR 97622 USA
Contact: STERLING HARRIS
Phone: (503)353-2625
Bullet diameters: 224 264 348

HEIDENSTROM HYLNER OG KULER
URDNGT 7 3927 HEROYA
PORNGRUNN,
NORWAY
Contact: OLAV-REIDUN HEIDENSTROM
Phone: (003)551-3356
Fax: (003)551-3356
Lead wire offered
Bullet diameters: 311 313 308 358 264 314 500

HIGH SCORE BULLET CO
PO BOX 80271
INDIANAPOLIS, IN 46280-0271 USA
Contact: MARK NOTTER
Phone: (317)783-4838
Fax: (317)783-4838
E-mail: HIGHSCOR@AOL.COM
Web Site: High Score Bullet Co
Bullet diameters: 224 243 308 355 356 357
400 429 452

J & M CUSTOM BULLETS
13021 GOPHER WOOD TRAIL
TALAHASSEE, FL 32312 USA
Contact: MICHAEL Q MCINNIS
Phone: (904)668-2751
Bullet diameters: 358 429

J. PHILLIPPI CUSTOM BULLETS
PO BOX 773
LIGONIER, PA 15658-0773 USA
Contact: JUSTIN PHILLIPPI
Phone: (412)238-9671
Fax: (412)238-2962
E-mail: JRPHIL@JUNO.COM
Bullet diameters: 224 358 430

JERICHO TOOL
BOX 70—RD 3, RTE 7
BAINBRIDGE, NY 13733 USA
Contact: BOB WILLIAMS
Phone: (607)563-8222
Fax: (207)563-8560
Lead wire offered
Bullet diameters: 429

JEWELL'S CUSTOM FIREARMS
PO BOX 733, 211 WEST 2ND AVE.
RIDDLE, OR 97469-0733 USA
Contact: JERRY JEWELL
Phone: (541)874-2926
Fax: (541)874-2526
E-mail: JEWELL@PIONEER-NET.COM
Bullet diameters: 224 308 375 458 510

KASWER CUSTOM, INC.
13 SURREY DRIVE
BROOKFIELD, CT 06804 USA
Contact: BILL KASWER
Phone: (203)775-0564
Fax: (203)775-6872
E-mail: KASWER.CUSTOM@SNET.NET
Bullet diameters: 243 308 355 357 400
410 430 451 458 730

KEITH LUCKHURST ASSOCIATES
26 YORK ROAD, GREENDALE
HARARE, ZIMBABWE
Contact: KEITH LUCKHURST
Phone: (263)449-5365
Fax: (263)449-5365
Bullet diameters: 308 366 375 284

KITZMILLER'S KUSTOM BULLETS
360 2ND AVE
GALION, OH 44833-2810 USA
Contact: MERRLIN KITZMILLER
Phone: (419)468-5219
Fax: (419)468-5219
E-mail: KITZY@MAIL.BRIGHT.NET
Bullet diameters: 172 224 243 287 308

KLA ENTERPRISES, INC.
PO BOX 2028
EATON PARK, FL 33840 USA
Contact: STEVE LEGG
Phone: (941)682-2829
Fax: (941)682-2829
Bullet diameters: 355 357 429 452

KONA RELOADS
PO BOX 1178
KEALAKEKUA, HI 96750 USA
Contact: BRIAN NAKASHIMA
Phone: (808)323-2757
Bullet diameters: 224

LIGHTNING PERFORMANCE INNOV.
RD 1 BOX 555
MOHAWK, NY 13407-1509 USA
Contact: MATTHEW PIELECHA
Phone: (315)866-8819
Fax: (800)242-5873
Lead wire and Jackets offered
Bullet diameters: 338

LYNN MCMURDO CUSTOM 50 BULLETS
BOX 404
AFTON, WY 83110 USA
Contact: LYNN MCMURDO
Phone: (307)886-5535
Fax: (307)886-9282
Bullet diameters: 510

MAD DOG MUNITIONS
2455 BENNETT VLY.RD-STE C-218
SANTA ROSA, CA 95404 USA
Contact: JOHN MADERIOUS
Phone: (707)526-5200
Fax: (707)526-9674
Bullet diameters: 577

MECO CUSTOM FIREARMS
1922 BROADWATER AVE
BILLINGS, MT 59102 USA
Contact: PAT ELLINGHOUSE
Phone: (406)652-6002
Fax: (406)652-6002
E-mail: MECO@WTP.NET
Website: WWW.LWTP.NET/MECO
Lead wire and Jackets offered
Bullet diameters: 224

MOLOC BULLETS
PO BOX 2810
TURLOCK, CA 95380-2810 USA
Contact: RICHARD NELSON
Phone: (209)632-1644
Bullet diameters: 224 268 308 312

MONTANA PRECISION SWAGING
PO BOX 4746
BUTTE, MT 59702-4746 USA
Contact: RUSSELL M. DUGDALE
Phone: (406)782-7502
Fax: (406)782-7502
Lead wire offered
Bullet diameters: 365 395 399 431 439 440
450 505 577 412

NAHAS AMMUNITION
RD 1 BOX 150
BELL VERNON, PA 15012 USA
Contact: TONY NAHAS
Phone: (412)379-7942
Lead wire and Jackets offered
Bullet diameters: 224 243 277 284 308 357 429 452

NO. AMERICAN BONDED BULLET CO.
672 WORTHAM CIRCLE
MUNDELEIN, IL 60060 USA
Contact: JOHN BOICH
Phone: (847)949-9569
Fax: (847)949-9570
Lead wire offered
Bullet diameters: 284 308 338 375 458

NORDIK PREMIER BULLET MFG.AB
BOX 133
AMMARNAS, 92075 SWEDEN
Contact: OLLE NILSSON
Phone: (460)952-60370
Fax: (460)952-60370
E-mail: OLLE_NILSSON@FC.TELESTUGAN.SE
Bullet diameters: 264 308

NORTHWEST CUSTOM PROJECTILE
PO BOX 1141
MOORHEAD, MN 56561 USA
Contact: ROBERT
Phone: (701)361-3783
E-mail: Baydog@cableONE.net
Website: www.cableONE.net/Baydog
Bullet diameters: 224 308 284 452 12ga

NORTHERN PRECISION
329 SOUTH JAMES ST.
CARTHAGE, NY 13619 USA
Contact: WILLIAM NOODY
Phone: (315)493-1711
Bullet diameters: 358 375 416 429 458

NORTHWEST PRECISION
2700 SELTICE, STE 2-200
POST FALLS, ID 83854 USA
Contact: BOB BURLEIGH
Phone: (208)777-2037
Bullet diameters: 224 308 311 355 357 452

PABLO FIERRO-CANSECO
CALLE BANOS 45-70
ALBACETE, 02005 SPAIN
Contact: PABLO FIERRO-CANSECO
Phone: (346)750-3988
E-mail: NAVARRON@CTV.ES
Jackets offered
Bullet diameters: 313 355 400 429 451

PB CUSTOM AMMUNITION
44631 NORTH HWY 60
MORRISTOWN, AZ 85342 USA
Contact: WARREN S. PHILLIPS
Phone: (520)684-0402
Bullet diameters: 312 357 429 223 355 410 451

PRECISION RIFLE MUZZLE BULLETS
BOX 12 GRO 71 RR 1
ANOLA, MB R0E 0A0 CANADA
Contact: CECIL EPP
Phone: (204)949-7949
Fax: (204)866-2269
E-mail: PRBULLET@MB.SYMPATICO.CA
Website: WWW.MTS.NET/~PRBULLET
Lead wire offered
Bullet diameters: 429 502 540

RAPTOR ARMS
2OO3 BRIARSTEM DR
HOUSTON, TX 77072 USA
Contact: MICHAEL COLLINS
Phone: (281)558-4514
Fax: (281)558-1928
Lead wire offered
Bullet diameters: 284 308 312 338 358 429 451 458

RAZORBACK BULLET WORKS
136 WILD ROSE LANE
ROCK SPRINGS, WY 82901 USA
Contact: BILL CROY
Phone: (307)382-6899 E-mail:
ABCVENTURES@WYOMING.COM
Bullet diameters: 224 257 338 375

REARDON BULLETS
12520 115TH AVENUE
CHIPPEWA FALLS, WI 54729 USA
Contact: F.C. REARDON
Phone: (715)288-6439
Bullet diameters: 406 411

RHINO BULLETS
PO BOX 787
LOCUST, NC 28097 USA
Contact: TIM CLARK
Phone: (704)753-1906
Fax: (704)753-2198
Lead wire and Jackets offered
Bullet diameters: 358 375 416 430 452

RICOCHET SPORTS
15 BLUFF AVE
TIVERTON, RI 02878 USA
Contact: DAVID REGAN
Phone: (401)624-6847
Bullet diameters: 575

ROLL YOUR OWN AMMO
7525 E. MAIN STREET
FARMINGTON, NM 87402 USA
Contact: LEE TURNER
Phone: (505)326-6401
Fax: (505)326-6401
Lead wire and Jackets offered
Bullet diameters: 510 500 452 429 401 357
355 308 284

SABERTOOTH INDUSTRIES
PO BOX 772
SANTA CLARA, CA 95052 USA
Contact: PETER GISE
Phone: (415)515-4546
Bullet diameters: 355 45

SCORPION BULLET CO.
36 GLENN ST
DOUGLAS, MA 01516 USA
Contact: TONY TOLOCZKO
Phone: (508)476-7009
Lead wire and Jackets offered
Bullet diameters: 451 452

SHELL RELOADING
1485 SOUTH LAWSON
APACHE JUNCTION, AZ 85220 USA
Contact: BOB SHELL
Phone: (602)983-7078
E-mail: REL4350@AOL.COM
Bullet diameters: 308 356 357 358 400 410
430 452

SIOUX BULLETS INC.
5201 S COUNTY RD 1063
MIDLAND, TX 79706 USA
Contact: KEITH GREENWOOD
Phone: (915)683-0957
E-mail: SIOUX@IGLOBAL.NET
Lead wire and Jackets offered
Bullet diameters: 257 264 284 308 338 357 375
452 458

SPRING PRAIRIE BULLET CO
W 1384 POTTER RD
BURLINGTON, WI 53105 USA
Contact: RANDY AMANN
Phone: (414)767-0549
Lead wire and Jackets offered
Bullet diameters: 510

STARKE BULLET CO
BOX 400 605 6TH ST. N.W.
COOPERSTOWN, ND 58425 USA
Contact: CLINTON STARKE
Phone: (888)797-3431
Fax: (701)797-3433
Bullet diameters: 224 243 308

TIMBER BEAST PRODUCTS,INC.
W 652 COUNTY HWY D
BERLIN, WI 54923 USA
Contact: WARREN GABRILSKA
Phone: (414)987-5052
Fax: (414)987-5052
E-mail: TBPWAR@AOL.COM
Bullet diameters: 224 243 308 429 452

TRUE SHOT
2101 FAIRLANE RD
YREKA, CA 96097 USA
Contact: TERRY SIMAS
Phone: (916)842-2312
Bullet diameters: 284 355 358

VILLAGE METAL WORKS
PO BOX 1358
SNOQUALMIE, WA 98065-1358 USA
Contact: FUZZY FLETCHER
Bullet diameters: 357 429 451 452

VINCENTS SHOP
210 ANTOINETTE
FAIRBANKS, AK 99701 USA
Contact: GEORGE VINCENT
Phone: (907)452-4392
Bullet diameters: 224 257 308 338 358 375
416 510

WILDCAT CUSTOM BULLETWORKS
RYNDON 165-16
ELKO, NV 89801 USA
Contact: RICHARD WOMACK
Phone: (702)753-8576
Bullet diameters: 284 308 338

WILDERNESS TRADING
RT 2 PO BOX 246
MARSHFIELD, VT 05658 USA
Contact: STEVE OR TIM
Phone: (802)426-4088
Fax: (802)426-4089
E-mail: WILDER@PLAINFIELD.BYPASS.COM
Bullet diameters: 308

WYOMING BONDED BULLETS
PO BOX 91
SHERIDAN, WY 82801 USA
Contact: ROBIN BLAKELEY
Phone: (307)674-9519
Bullet diameters: 284 358 375 308

ZERO INDEX CO.
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