RELOADING

FROM FIRST PRINCIPLES TO PRECISION

MARK ELLIS

1967SPUD

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From First Principles to Precision

A practical handbook for the modern reloader

Mark Ellis

1967Spud Reloading Supplies

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A Note on Changing Information

Reloading data, component specifications, legislation and technical standards change over time. The reader should always check current information from the relevant manufacturer, recognised standards body or competent authority before relying on a safety-critical value or requirement.

Important Safety Notice

Metallic-cartridge reloading involves primers, propellants and ammunition capable of producing high pressure. Incorrect component identification, unsuitable data, poor loading practice or inappropriate ammunition can cause firearm damage, serious injury or death.

This book explains principles, methods and practical reloading judgement. It is not a substitute for current pressure-tested load data. Where a powder charge, cartridge dimension, component specification or other safety-critical value is required, use current published information appropriate to the exact components and cartridge being loaded.

Do not treat a load used by another shooter, an old notebook entry, internet discussion or remembered combination as verified loading data. Begin with current data from reputable component manufacturers or recognised published sources and follow their stated procedures and limits.

Component substitutions can alter pressure and performance. A change of powder, primer, projectile, case, seating arrangement or other significant variable should be treated as a change to the load and assessed accordingly.

The handloader is responsible for confirming that components, dimensions, ammunition and procedures are suitable for the firearm and intended use, and for complying with the laws and regulations that apply where the work is carried out.

If anything during loading or firing appears abnormal, stop and establish the cause before continuing.

About This Book

Reloading is often presented as a sequence of operations. I prefer to start one step earlier: understand what each operation changes, decide whether it has a useful purpose for the ammunition being made, and then perform it consistently.

The chapters follow the practical loading process from components and case preparation through sizing, priming, powder charging, projectile seating and load development, before moving into specialist and precision techniques. The later chapters bring those operations back together as a complete working method.

The aim is not to persuade every reloader to perform every possible operation. It is to give the reader enough understanding to make sensible decisions, recognise useful measurements, preserve good results and avoid complexity that adds work without improving the ammunition.

The 1967Spud Reloading Timeline used later in the book brings that approach together as a practical working sequence developed through reloading, competition and workshop experience.

About the Author

Mark Ellis is the author of the 1967Spud reloading methodology and founder of 1967Spud Reloading Supplies. His approach has been shaped by many years at the loading bench, working with shooters and reloading equipment, and competing with ammunition prepared for specific rifles and purposes.

The book is written from that practical perspective: measure before assuming, value consistency over unnecessary complexity, and give every operation a clear reason for being there.

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There is a point familiar to many people who have been shooting for a while. You begin by buying ammunition, using it and, if it performs reasonably well, buying some more. Then sooner or later you start asking questions.

Why did that group open up?

Why does one type of ammunition perform noticeably better than another?

Why does one combination seem to suit a particular firearm while another does not?

And, perhaps most importantly, could I make ammunition that is better suited to what I actually want to do?

That is often where reloading begins.

There are plenty of practical reasons for loading your own ammunition. Cost is usually one of the first mentioned, although whether reloading genuinely saves money is a more complicated question than it initially appears. Availability can be equally important, particularly with less common cartridges or when commercial ammunition is difficult to obtain consistently. For many people there is also a great deal of satisfaction in producing their own ammunition.

For me, though, the real attraction has always been control.

Reloading allows us to control far more of what we are using. We can choose the case, primer, powder and projectile. We can decide how the brass is prepared, how consistently the powder is dispensed and how the projectile is seated. We can keep batches of cases together, record their history and gradually learn which combinations work well for a particular firearm and purpose.

None of those things guarantees accuracy or good performance. Shooting has a habit of reminding us of that occasionally.

What they do give us is the opportunity to remove variables.

And removing unnecessary variables is at the heart of making consistent ammunition.

There is another important difference between commercial ammunition and ammunition we load ourselves.

Commercial ammunition has to be fairly generic. The manufacturer has no idea which individual rifle or firearm a box will eventually be used in, so the ammunition has to function safely and reliably across a very large number of suitable firearms, with all the normal variations in chambers, barrels, magazines and actions that go with them.

When we reload, we are doing something quite different.

We know the firearm the ammunition is intended for. We can choose components that suit it, size the brass appropriately, establish a sensible seating arrangement and develop the load around the particular barrel, chamber and intended use.

That doesn't mean every handload will automatically outperform good factory ammunition. It means we have the opportunity to produce ammunition specifically suited to our own firearm rather than ammunition necessarily designed to work across thousands of them.

Done properly, that ability to tailor the ammunition is one of the biggest advantages of reloading. We are not simply trying to make another version of a factory cartridge. We are trying to get the best practical performance we can from the firearm and ammunition working together.

It is tempting to think of reloading as little more than a manufacturing process. Put an empty case into a press, perform a series of operations and eventually a loaded cartridge appears at the other end.

Mechanically, that is more or less what happens.

In practice, good reloading is much more about measurement, observation and consistency.

A fired cartridge case carries a surprising amount of information. It has expanded during firing. Its dimensions may have altered slightly. The neck has expanded and contracted, and the brass itself has been worked by both firing and resizing.

Instead of treating that case as nothing more than an empty container, a reloader begins to look at what it can tell us.

The same thing happens elsewhere.

We start noticing variations in projectile length. We learn why measuring a loaded round from its tip can sometimes be misleading. We begin measuring from more useful reference points. We discover that apparently small differences in sizing, neck tension or seating depth can sometimes affect the way ammunition performs.

This is where reloading starts to become particularly interesting.

The objective is no longer simply to produce a cartridge that will fire. Commercial ammunition already does that very well.

The objective becomes producing ammunition appropriate to the firearm, the cartridge and the job it is being asked to do, while making each round as consistent as reasonably practical.

Shooters sometimes search for a single component, tool or technique that will suddenly transform their ammunition.

There certainly are combinations that work better than others. A particular projectile may perform especially well. One powder may give more useful velocity or better consistency than another. Changes in case preparation or seating can sometimes make a noticeable difference.

But there is rarely one clever trick that produces good ammunition on its own.

Good results usually come from doing a collection of fairly ordinary things consistently.

Cases prepared in the same manner.

Primers seated properly.

Powder charges measured carefully.

Projectiles seated consistently.

Measurements taken from sensible reference points.

Good records.

And, most importantly, a repeatable process from one batch to the next.

That may not sound particularly exciting, but it is one of the main ideas running through this book.

You do not need to carry out every possible preparation operation simply because somebody else does it. Nor do you need the most expensive version of every tool available.

You need to understand what each operation is intended to achieve.

Once you understand that, you can decide whether it is useful for the ammunition you are making.

Different types of shooting place different demands on ammunition. A person loading relatively small quantities for occasional sporting use may have very different priorities from somebody producing large quantities for regular practice or competition. The level of preparation worthwhile in one situation may add very little in another.

There is no single loading routine that is ideal for everybody.

There are, however, sound principles that apply across almost all forms of reloading.

Start With What the Ammunition Has to Do

One of the easiest mistakes when beginning reloading is to become fascinated by components before thinking properly about what the finished ammunition is actually required to do.

That should come first.

The firearm, chamber, barrel where applicable, feeding system, cartridge dimensions and intended use can all influence the ammunition we sensibly produce.

A projectile that looks ideal on paper may not be appropriate for a particular barrel or intended use. A cartridge may fall within published dimensions yet still cause problems with a particular magazine or feeding system. Brass resized more than necessary may function perfectly well, but repeated excessive working can shorten its useful life.

The more we understand about the equipment and purpose involved, the more intelligently we can make decisions about the ammunition.

That doesn't mean measuring everything simply because it can be measured.

It means concentrating on measurements that are useful.

We will return to that distinction repeatedly throughout this book.

Reloading and Safety

There is another reason for understanding the process rather than simply following a sequence of instructions: safety.

Reloading deals with components which, when assembled and fired, generate considerable pressure. Mistakes therefore have the potential to be much more serious than simply producing poor accuracy.

That is why published load data matters.

It is why component changes matter.

It is why identifying powders and primers correctly matters.

And it is why relying entirely on memory is a poor habit.

Published data from reputable sources should always form the basis of load development. Loads should be approached methodically, paying attention to anything unusual and avoiding unnecessary changes to several variables at once.

A combination that has worked elsewhere is not automatically suitable in every firearm.

Neither should an unverified load found on the internet, written on an old box or remembered from many years ago be treated as reliable load data.

The loading bench is not a particularly good place for guesswork.

Good habits make reloading considerably safer: clearly identifying components, keeping powders in their correct containers, maintaining useful records and avoiding distractions during critical operations.

Most of it is common sense.

The problem with common sense is that it becomes easier to overlook after an operation has been repeated hundreds of times.

Experience does not make somebody immune from mistakes. Familiarity can occasionally make us less careful rather than more careful.

A disciplined routine is therefore useful regardless of how long somebody has been reloading.

Availability and Continuity

Another very practical reason people begin reloading is availability.

If you use one of the most common cartridges, commercial ammunition is usually relatively easy to find. Even then, the exact load you prefer may not always be available when you want it.

A particular brand, projectile type or projectile weight may become difficult to obtain. Popular lines can sell through quickly when demand is high, and supply can vary considerably from one period to another.

This becomes much more noticeable with slightly less common cartridges.

Some commercial ammunition may only be produced in a handful of configurations. Other loads may be manufactured only occasionally or imported into the UK in relatively small quantities. In some cases ammunition technically exists, but finding a dependable supply of it is another matter entirely.

That can leave a shooter in an awkward position.

You may find a commercial load that performs particularly well, buy a few boxes and then discover that nobody has any more when you next need it. The available alternative may use a different projectile, a different weight or simply not perform in the same way.

Demand can create similar problems with otherwise common ammunition. If a particular line becomes popular, your first choice may simply not be on the shelf when you need it.

You then end up choosing ammunition according to availability rather than because it is the ammunition you actually wanted.

Reloading can reduce that dependence considerably.

Provided suitable components remain available, you are no longer tied to one particular commercial load staying in stock. You can produce ammunition around a known combination and, where appropriate, buy components in quantities that allow greater continuity between batches.

For somebody using a less common cartridge, that can be every bit as important as cost or performance.

In some cases, it may be the main reason for reloading in the first place.

Do You Need Expensive Equipment?

No.

At least, not to begin with.

It is perfectly possible to produce very good ammunition with relatively straightforward equipment. A sound press, suitable dies, reliable measuring equipment and a sensible collection of preparation tools will take a new reloader a very long way.

As experience grows, additional equipment can make particular operations quicker, easier or more repeatable.

That is when it becomes worth buying.

Purchasing every specialist tool before understanding what it does usually results in an expensive loading bench and surprisingly little additional knowledge.

Equipment can also become something of a distraction.

Reloaders can spend enormous amounts of time debating which press, die, scale or measuring tool is best while giving rather less thought to the process actually being performed with it.

Good equipment certainly helps.

But an expensive tool used badly is still being used badly.

Understanding comes first.

Does Reloading Save Money?

This deserves a realistic answer.

Reloading can reduce the cost of ammunition, particularly where cases can be reused many times or commercial ammunition is expensive.

But saving money is certainly not guaranteed.

Once somebody becomes interested in reloading, the definition of “essential equipment” has a remarkable tendency to expand.

A basic loading setup becomes a better powder measure. Then perhaps a better scale. A case trimmer. More measuring equipment. Another set of dies. Eventually perhaps more specialised equipment for preparation or testing.

Before long, the original idea of saving a little money on ammunition can result in a room full of reloading equipment.

That doesn't mean reloading is poor value.

It simply means that cost is rarely the only reason people continue doing it.

For many of us, producing the ammunition becomes part of shooting itself rather than simply a cheaper way of supplying it.

Write Things Down

If there is one habit worth developing from the very first batch of ammunition, it is keeping records.

Write things down.

Record the components used, powder charge, cartridge measurements, case history and anything else that may be useful later.

If ammunition is tested over a chronograph, record the results.

If a batch performs exceptionally well, record that.

If it performs terribly, record that too.

Poor results can be surprisingly useful several months later when you are about to repeat exactly the same experiment because you have forgotten doing it the first time.

Good records turn individual shooting sessions into accumulated knowledge.

Without them, development can easily become a circle.

With them, it becomes a process.

How Far Do You Need to Take It?

Reloading can be as simple or as involved as you choose to make it.

At one end, reliable ammunition can be produced safely with a fairly small number of straightforward operations.

At the other, reloaders may sort brass, turn case necks, measure capacity, prepare projectiles, anneal cases according to carefully controlled routines and record almost every measurable part of the process.

Neither approach is automatically right or wrong.

The important question is whether an operation serves a useful purpose.

If it improves safety, reliability, consistency or our understanding of the ammunition, then it may be worthwhile.

If we are doing it only because somebody else says that serious reloaders ought to do it, it is probably worth understanding the operation properly before adding it to the routine.

That is the approach I want to take throughout this book.

We will begin with the basic process and the equipment used to carry it out. From there we can look more closely at cases, sizing, primers, powder, projectiles, seating and measurement.

As the book progresses, we can move from the basic process into detailed case preparation, component selection, load development, pistol and cast-projectile loading, black powder and the more specialised techniques used in precision and competition ammunition.

Those subjects will be dealt with when they become relevant rather than assuming from the beginning that everybody reading this book shoots in the same way.

You certainly will not need to use every technique covered in the chapters ahead.

But understanding what those techniques do — and why somebody might choose to use them — makes us better informed reloaders.

But if you understand what those techniques actually do, what they change and why somebody might choose to use them, you can make your own decisions about whether they deserve a place at your loading bench.

And that, ultimately, is the point.

Chapter 2 — Understanding the Reloading Process

Before getting into individual tools, measurements and specialist techniques, it helps to understand the reloading process as a whole.

Reloading can look complicated when you first see a well-equipped bench. There may be presses, trays of cases, measuring tools, scales, dies, shell holders, gauges and a collection of small tools that all seem to have very specific jobs.

Most of them do. But the basic process is actually quite straightforward.

A fired cartridge case is inspected and prepared. It is sized as required. A primer is fitted. Powder is added. A projectile is seated. The finished cartridge is then checked to make sure it is suitable for use.

Everything else is really a refinement of those basic stages.

Some people will carry out only the operations needed for safe and reliable ammunition. Others will go much further, adding case sorting, trimming, annealing, neck turning, weighing, measuring and other steps intended to improve consistency.

The important thing at the beginning is not to learn every possible technique.

It is to understand what is happening to the case, what each operation changes and why we are doing it.

What Happens to a Fired Case?

A common misconception among new reloaders is that a fired case somehow returns to exactly the same condition it was in when new.

It doesn't. When a cartridge is fired, pressure forces the brass outward against the chamber. The case changes shape and then springs back sufficiently to allow extraction.

How much it changes depends on a number of things, including the cartridge, chamber, pressure, brass and firearm.

When we later size that case, we deliberately change its dimensions again so that it can be reused safely and reliably in the firearm for which we are preparing it.

That doesn't necessarily mean returning it to exactly the dimensions of a brand-new case.

The amount of sizing required is something we will cover properly later. For now, the important point is that every time brass is fired and resized, it is being worked.

Understanding that helps explain why case preparation matters and why brass eventually wears out.

A Reload Belongs to the Firearm

It also introduces an important principle that will run throughout this book: I treat reloaded ammunition as belonging to the particular firearm for which it has been developed.

I want to make this clear from the beginning because it is an assumption I don't think is worth making.

I don't take reloaded ammunition developed for one firearm and simply assume it will be suitable for another.

Two firearms can have exactly the same cartridge designation marked on them and still not behave identically with the same reload.

Chambers can vary. Throat dimensions and freebore can vary. Barrels are not identical. The relationship between the projectile and the rifling may be different. Brass fired in one chamber may also have quite different dimensions from brass fired in another.

Most importantly, pressure behaviour cannot simply be assumed to be identical.

If I develop a load for a particular firearm, that is the firearm I regard that load as belonging to.

If I want to use the same cartridge and components in another firearm, I treat that as a separate load-development exercise rather than assuming the first load can simply be transferred across.

That is also why I believe good records should identify the firearm as well as the components.

We are not merely writing down a recipe consisting of a case, primer, powder charge and projectile. We are recording a combination that has been developed and tested for a particular firearm.

We will come back to this when we discuss load development in detail, but it is worth establishing the principle now.

A Brief Word About Pressure

Pressure is one of the subjects every reloader needs to understand.

We do not need to turn this chapter into a lesson in internal ballistics because pressure is dealt with properly in Chapter 5. But it would be wrong to describe the reloading process without mentioning it here.

Inspection Comes First

Before doing anything else, fired cases should be inspected.

This sounds obvious, but it is one of those simple habits that becomes increasingly important as the number of reloads grows.

You are looking for anything that suggests the case should not be used again.

That might include visible cracks, splits around the neck, unusual marks, damaged rims, badly distorted case mouths or signs that the brass has been excessively worked.

Some problems are immediately obvious. Others become easier to recognise once you know what normal fired brass from that particular firearm looks like.

The important habit is to look.

Do not assume that because a case survived its last firing it must automatically be suitable for another.

Cases are consumable items.

Good brass may last for many firings when treated sensibly, but every case has a finite life.

Cleaning and Depriming

Cases do not have to be polished until they look new before they can be reloaded.

They do, however, need to be clean enough that dirt and residue do not interfere with inspection, preparation or the loading equipment.

There are several ways to clean brass.

Some reloaders use dry media. Others use wet tumbling. Some prefer ultrasonic cleaning, while lightly used cases may need nothing more complicated than a simpler cleaning method.

Each system has advantages and disadvantages, which we will look at later.

The important thing is not appearance. A shiny case is pleasant to look at, but cleanliness and condition matter more than polish.

The spent primer must also be removed at some point.

In my normal process, I deprime first and then clean the cases. That exposes the primer pocket and flash hole before the cleaning stage and keeps the sequence consistent from batch to batch.

Personally, I like the brass to be clearly organised before I move into the main loading stages.

Case Preparation and the Order of Work

Reloading is full of operations where understanding the purpose is more useful than following somebody else's routine without knowing why they do it that way.

There is one part of the process where I have a definite personal preference.

I like to carry out my case preparation before the main sizing operation.

That includes trimming cases to my chosen length where trimming is required, along with whatever other preparation work I have decided is appropriate for that batch.

I prefer to have the brass prepared, organised and ready before I move on to sizing.

That is simply the way I like to work. It should not be taken to mean that everybody must follow exactly the same sequence. Many reloaders trim after sizing, and there are reasons for doing so depending on the cartridge, equipment and process being used.

We will come back to this properly in the case-preparation chapters because the order of trimming, sizing, annealing and the other operations deserves considerably more explanation than it needs here.

For the moment, remember that when I describe my own normal loading routine, case preparation comes first and sizing follows it.

The Basic Working Sequence

At its simplest, the way I tend to think about the process is:

Inspect the fired brass.

Deprime the fired cases, then clean them.

Carry out the case preparation required for that batch.

Trim to my chosen length where trimming is needed.

Chamfer and deburr the case mouths where necessary.

Complete any other case-preparation work I have decided is worthwhile.

Size the cases.

Check the important dimensions after sizing.

Prime.

Charge with powder.

Seat the projectiles.

Crimp where the ammunition requires it.

Inspect and measure the finished cartridges.

Record what has been loaded, including the firearm for which that load has been developed.

That is the basic framework. It can become far more detailed, but it does not need to become confusing.

Later in the book we will bring all of these operations together into the complete 1967Spud Reloading Timeline. For now, this simple sequence is enough to understand where each of the chapters ahead fits into the overall process.

It is worth repeating that not everybody performs every operation in exactly the same order.

Someone else may resize before trimming.

Other reloaders may combine depriming with sizing or clean at a different point in their process.

Annealing may appear at a different point depending on the process being used.

Some operations may not be required at all.

That is fine.

I will explain my own preferred method throughout the book because that is the process I actually use, but where other methods are common or have a good reason behind them, we will cover those as well.

The important thing is not to turn one person's workflow into a rule without understanding why it was arranged that way.

There is one distinction I won't treat simply as a matter of personal workflow, however: a developed reload belongs with the firearm for which it was developed.

If I change firearm, I treat the load development separately.

Work in Batches

Reloading becomes easier to manage when cases are handled in batches.

Rather than taking one fired case all the way through to a completed cartridge before beginning the next, most people process a group through one operation at a time.

Inspect a batch.

Prepare the batch.

Size the batch.

Prime the batch.

Charge the batch.

Seat the projectiles.

This makes the process more efficient and, more importantly, makes it easier to maintain consistency.

It can also make mistakes easier to spot because your attention is concentrated on one operation at a time.

There are exceptions, particularly with progressive loading equipment where several operations may take place during each cycle of the press, but the same underlying principles still apply.

Organisation matters.

Keep Components and Records Together

Good organisation extends beyond the cases themselves.

If ammunition is being loaded as one batch, it is sensible to know exactly which components went into it.

That means knowing which cases were used, which primer, which powder and which projectile.

It also means knowing which firearm the load belongs to.

Where consistency is especially important, people may go further and keep brass from the same manufacturer or production lot together.

The level of control needed depends on the intended use.

But there is a considerable difference between knowing exactly what went into a box of ammunition and thinking you probably remember.

That is why record keeping becomes part of the loading process rather than something added afterwards.

Learn the Ordinary Process First

New reloaders often discover advanced techniques long before they have mastered the ordinary process.

It is easy to read about neck turning, annealing, projectile pointing, case-capacity sorting and very precise measurement and assume that all of these things need to be done immediately.

They do not. Learn the basic process first.

Learn to set dies correctly.

Learn how fired brass behaves.

Learn how to measure consistently.

Learn what normal operation feels like.

And learn to recognise when something does not look, feel or behave normally.

Once those foundations are solid, the more advanced operations become much easier to understand because you know what problem they are intended to solve.

Adding complexity without understanding simply creates more opportunities to make mistakes.

A Routine Should Help You Notice What Is Different

A good loading routine should become familiar.

The tools have their places.

Components are clearly identified.

Measurements are recorded.

Cases move through the process in an organised way.

Critical operations are carried out without unnecessary distractions.

That doesn't mean reloading should become so mechanical that you stop thinking.

Quite the opposite. A good routine takes care of the ordinary things so your attention is available when something unusual appears.

A case feels different during an operation.

A primer does not seat normally.

A powder charge looks wrong.

A projectile requires noticeably more or less force to seat.

Something behaves differently when the ammunition is tested.

Those are the moments when you stop and find out why.

Do not simply force something and carry on.

Do not assume something unusual is acceptable because the previous batch was fine.

And particularly where there is any concern about pressure, do not guess.

Find the reason.

With the overall process understood, we can start looking at the individual parts of it properly.

From there we will move into cases and case preparation in much greater detail.

We will also return to pressure, how loads are developed safely and why apparently small changes can sometimes matter.

Some readers will eventually want only a straightforward and dependable loading routine. Others will want to explore much more specialised preparation and measurement.

Both approaches begin in exactly the same place.

Understand the process. Understand what each operation changes. Know which firearm the ammunition has been developed for. And only then decide how far you need to take it.

Chapter 3 — The Reloading Bench and Equipment

Once the basic reloading process makes sense, the next thing we need is somewhere to do it and the equipment to do it with.

This is also where reloading can become expensive remarkably quickly.

Open almost any catalogue and you will find several ways of carrying out what is essentially the same operation. There are simple presses and very sophisticated presses, basic dies and highly adjustable dies, beam scales and electronic laboratory-style scales, hand trimmers and powered case-preparation centres.

Figure 3.1 — *Representative sizing dies from different manufacturers. External design varies, but each is intended to control specific case dimensions.*

Most of them have a purpose.

The difficulty for somebody starting out is knowing which differences actually matter.

I have always thought it is better to understand the job first and buy the equipment second. There is little point spending a considerable amount of money on a specialist tool if you do not yet understand what it is supposed to improve.

At the same time, I'm not going to pretend that all equipment is equal. Better equipment can make some operations easier, quicker and more repeatable. There are tools I would happily spend more money on because I know exactly what advantage they give me.

The important thing is knowing the difference.

This chapter is therefore not intended as a shopping list. It is an explanation of the equipment you are likely to encounter, what it does, where the different designs have advantages and where spending more money may — or may not — make sense.

The Bench

Figure 3.2 — *A real working reloading bench. The aim is an organised, repeatable working area rather than a display bench.*

The first piece of reloading equipment is not really reloading equipment at all.

It is the bench.

A good bench needs to be solid. Some operations put a surprising amount of leverage through a press, and a lightweight table that moves every time the handle is operated soon becomes frustrating.

It doesn't have to be enormous.

As a rough guide, something around 1200 to 1800 mm (approximately 47 to 71 inches) wide and 600 to 750 mm (approximately 24 to 30 inches) deep gives a very useful working area. A height somewhere around 850 to 950 mm (approximately 33 to 37 inches) works well for many people, although this is very much a matter of whether you prefer to work standing, sitting or somewhere between the two.

Those are suggestions rather than dimensions that must be followed.

If space allows, I would generally choose more width before making the bench excessively deep. There is little advantage in having a worktop so deep that everything at the back is difficult to reach.

What matters is having enough room for the press and the equipment being used while retaining a clear area in which to work.

Figure 3.3 — *A case correctly located in the shell holder on a conventional loading press before entering the die.*

Press mounting deserves some thought.

A press generates leverage, particularly during some sizing and case-forming operations. Mounting it to a thin unsupported section of worktop is asking the bench to flex.

If possible, mount the press close to a strong part of the bench structure or reinforce the area underneath it.

The bench itself should not rock.

You should not have to hold it still with one foot while sizing a case.

Wall fixing can help where appropriate, although obviously the construction of the room and bench determines what is practical.

There are also removable press-mounting systems available. These can be extremely useful where bench space is limited or where several presses and tools share the same working position.

The important thing is rigidity.

When you operate the press, you want the press mechanism to move — not the bench.

Choose Somewhere You Can Concentrate

Where you put the bench matters.

Reloading involves several operations where distraction is unwelcome, and powder charging is an obvious example.

If possible, I would choose somewhere you can work without constantly being interrupted.

That doesn't mean reloading needs to be carried out in complete silence behind a locked door. It simply means recognising that having people continually walking past, talking to you or asking questions while you are halfway through a batch makes mistakes more likely.

I would rather have a modest bench somewhere quiet than a magnificent loading room in the busiest part of the house or workshop.

Once I start a critical operation, I like to finish it without having to remember where I had got to after an interruption.

Organisation helps here too.

A clear bench makes it easier to see what has been done and what still needs doing.

Older loading benches could operate almost entirely without electricity.

Modern ones often cannot.

Electronic scales, powder dispensers, case-preparation centres, annealing machines, ultrasonic cleaners, tumblers and lighting may all require power.

It is worth thinking about sockets before fixing the bench permanently in place.

A pair of sockets hidden behind a heavy bench soon becomes inconvenient.

Ideally, there should be enough conveniently positioned outlets that equipment can be used without creating a mass of extension leads and cables across the working surface.

Cables should not run where they can be snagged by a press handle or where they interfere with trays of cases and components.

The electrical side of a loading bench does not need to be elaborate.

It just needs to have been thought about.

The scale deserves particular attention because its environment can influence its behaviour.

Sensitive scales do not like draughts.

An open window, a nearby door, a fan or an air vent can create enough movement to make a sensitive electronic scale wander.

The more sensitive the scale, the more obvious this can become.

I therefore would not position my main powder scale directly beside a window or somewhere people are constantly walking past it.

Give it a solid, level surface away from obvious vibration and moving air.

Windows can cause another problem: direct sunlight.

Apart from glare, sunlight can warm one part of the bench and change the local temperature. Sensitive electronic equipment generally behaves better in a reasonably stable environment.

The same applies to radiators and heaters.

You do not need a laboratory.

You just want to remove avoidable influences.

Good lighting is essential.

You need to be able to inspect cases, see primers properly, look into charged cases and notice small defects.

I would always rather have too much useful light than struggle in a dark corner.

But there is another side to lighting that is less obvious.

Some sensitive electronic scales can be affected by their electrical environment. Certain fluorescent fittings, LED drivers and other electrical equipment may introduce interference that can contribute to an unstable reading.

This doesn't mean that LED lights cannot be used above a reloading bench. In most installations there will be no problem at all.

It simply means that if a sensitive scale suddenly begins drifting or behaving strangely, nearby electrical equipment is one of the things worth considering.

Switch the light or nearby device off and see whether anything changes.

It costs nothing to check.

This is also one reason I like the scale to have its own permanent position rather than being dragged around the bench every time I use it.

The Press

The press is usually the most obvious piece of equipment on a reloading bench.

Its basic job is simple.

It provides mechanical leverage and accurately brings the cartridge case and die together.

How manufacturers achieve that varies considerably.

There are several main types worth understanding.

Single-Stage Presses

The conventional single-stage press is probably the simplest place to begin, but it certainly is not only beginner's equipment.

For bottleneck rifle-type cases, and particularly where the emphasis is on accuracy and close control of each operation rather than producing large quantities quickly, I generally prefer a single-stage press.

Only one operation is taking place at a time.

That means you can concentrate on exactly what the case is doing, feel the resistance through the handle and inspect the result before moving on.

There is also relatively little mechanically going on.

A good single-stage press has comparatively few moving parts, which is one of its attractions. There are fewer pivots, indexing mechanisms and moving assemblies in which wear can gradually develop.

That simplicity matters over time.

A well-made single-stage press can remain tight and consistent for a very long time, and there are fewer places where additional play or slop can develop as the press wears.

For somebody loading bottleneck cartridges and wanting to concentrate on accuracy rather than production rate, a good single-stage press would normally be my first choice.

That doesn't mean it cannot load pistol or straight-walled ammunition.

It certainly can.

It is simply slower when large quantities are required.

Traditional presses are often broadly described by the shape of their frame.

An O-frame surrounds the working area and tends to offer considerable rigidity.

A C-frame is open at the front, which can provide easier access to the case.

There are excellent presses of both types.

Frame design, material, linkage, ram alignment and general construction all influence how a press feels in use.

For ordinary reloading, either design can work perfectly well.

Where heavy case forming or demanding sizing operations are anticipated, however, press strength and rigidity become more important.

Coaxial Presses

A coaxial press approaches the job differently.

Rather than relying on a conventional screw-in shell holder arrangement, many coaxial systems allow the case and die to align themselves to some degree during the operation.

The best-known designs use opposing jaws to hold the case head and a floating arrangement for the die.

They are particularly popular with reloaders interested in precision ammunition because they are convenient to use and can provide excellent alignment.

Die changes can also be extremely quick.

They are not automatically more accurate simply because they are coaxial.

Technique, dies, components and the rest of the process still matter.

But they are a very good example of spending more money for a genuinely different way of carrying out the operation rather than simply buying a more expensive version of the same thing.

Turret Presses

A turret press allows several dies to remain installed in a rotating head.

Instead of removing and resetting dies between operations, the appropriate die can be rotated into position.

This can be very convenient, particularly when several dies are being used in sequence.

Turret presses tend to make more sense when production rate becomes more important, and they are particularly common with pistol ammunition and smaller cartridges.

For higher-volume work, this can be a real advantage.

The trade-off is that the mechanism is more complicated than a conventional single-stage press.

There are more moving parts, more pivots and more interfaces.

Over time, particularly with very heavy use, wear can develop in those components and additional movement or slop may appear.

That doesn't mean a turret press is inaccurate.

A good one, properly maintained, can produce excellent ammunition.

It simply means there is more mechanically going on than with a basic single-stage press.

Progressive Presses

Progressive presses take the idea of increased production much further.

Several operations take place during each cycle, with cases moving from station to station.

Once properly set up, they can produce ammunition at a rate that would be impractical on a conventional single-stage press.

This is where they really come into their own.

They are particularly well suited to pistol cartridges and smaller rifle cartridges up to around the .223 Remington class, where a shooter may want to produce large quantities efficiently.

The advantage is obvious.

Speed.

The compromise is mechanical complexity.

Progressive presses contain more moving parts, indexing mechanisms, shell plates, linkages and other components than a single-stage press.

With enough use, these components can wear.

Depending on the design, maintenance and level of use, that wear can gradually introduce extra movement or slop into the system.

Again, that does not mean a progressive press cannot produce good ammunition.

It certainly can.

But if my priority were maximum control and consistency with bottleneck ammunition, I would generally favour a good single-stage press.

If my priority were producing larger quantities of pistol ammunition or something like .223 Remington, then a turret or progressive press may make considerably more sense.

The important thing is matching the press to the job.

Arbor Presses

An arbor press is another design encountered particularly in more specialised precision loading.

Rather than using conventional threaded dies mounted in a large reloading press, an arbor press commonly works with hand dies.

The operator can often feel the seating operation particularly well, which is one reason these systems have remained popular in some forms of precision and benchrest shooting.

They are not necessarily something a new reloader needs.

But they demonstrate an important point.

There is more than one good way of carrying out many reloading operations.

The best equipment depends on the job.

Price alone does not tell us very much.

What I Look For in a Press

I look for rigidity, smooth operation, good alignment, sensible leverage and a design that suits the work I intend to do.

Access around the case matters.

Spent-primer handling matters more than you might expect.

Ease of die changing can matter if you load several cartridges.

Available opening and ram travel matter with longer cartridges.

The ability to accept the dies and accessories you want to use obviously matters as well.

A huge heavy press may be excellent for case forming but unnecessary for somebody loading small quantities of relatively straightforward ammunition.

A compact press may be perfectly adequate for that job.

Buy the press for the work.

Dies

If the press supplies the movement and leverage, the dies do most of the actual work.

There are many different die designs, and we will return to several of them when we discuss sizing and seating properly.

For now, it is useful to understand the main families.

A conventional die set will usually provide the basic operations required to size the case and seat the projectile.

Depending on the cartridge and manufacturer, additional dies may perform expanding, crimping or other functions.

More specialised sets divide these operations even further.

Sizing dies deserve a little more explanation because the terminology can become confusing very quickly.

The simplest place to start is with a conventional full-length sizing die.

A standard full-length die sizes the case body, controls the shoulder position and sizes the neck as part of the same operation.

For most general bottleneck-cartridge reloading, a good conventional full-length die is perfectly capable of producing excellent ammunition.

It is also the type of sizing I personally prefer.

I like the case to be brought back to controlled dimensions each time rather than relying on neck-only sizing and allowing the rest of the fired case to remain largely unchanged.

We will get into the reasons properly later, but one of the main problems I have with neck-only sizing is that repeated firings can eventually result in cases becoming increasingly tight to chamber.

That is something I don't particularly want in either sporting or target ammunition.

In the field I want reliable chambering.

On the range I don't want to disturb a shooting position by fighting a tight bolt.

For that reason, neck-only dies are not my first choice.

That doesn't mean they have no use at all. They have been used successfully for many years and some reloaders still prefer them for particular applications.

My own method, however, favours controlled full-length sizing.

Bushing Dies

Bushing dies are slightly different because they give the reloader more control over how much the case neck is sized.

An interchangeable bushing sits in the die and determines the outside diameter to which the neck is reduced.

This is particularly useful in more precision-oriented loading because different brass, neck-wall thicknesses and preparation methods can require different amounts of sizing.

Importantly, bushing dies are not all neck-sizing dies.

You can have a full-length bushing die, which sizes the body and controls the shoulder while using an interchangeable bushing to control the neck.

You can also have a neck-only bushing die, which primarily sizes the neck.

Personally, if I want the additional control offered by a bushing system, I much prefer the full-length bushing version.

It gives me the benefits of controlled full-length sizing while also allowing me to choose how much the neck is reduced.

That can reduce unnecessary working of the neck and gives much more control over the neck-sizing stage, particularly where neck tension is being managed as part of a precision loading process.

There is considerably more to this than simply choosing a smaller or larger bushing.

Neck-wall thickness matters.

Whether an expander or mandrel is used afterwards matters.

The amount of neck tension we actually want matters.

And the relationship between the bushing, brass and finished ammunition needs to be understood rather than guessed.

We will cover all of that properly in the later sizing and neck-tension chapters.

For the moment, the distinction is straightforward.

A standard full-length die is a very good general-purpose choice.

A full-length bushing die adds more control over the neck and is particularly useful where greater precision and control of neck tension are wanted.

A neck-only die, whether conventional or bushing style, sizes only part of the case and is not my preferred method for routine loading because of the chambering and consistency issues that can develop over repeated firings.

The seating die places the projectile into the case.

Basic seating dies can do this extremely well.

More sophisticated designs may incorporate close-fitting sleeves, finer adjustment and micrometer-style seating controls.

The advantage of a micrometer seater is not that the word micrometer somehow makes the ammunition more accurate.

The real advantage is adjustment and repeatability.

If you want to change seating depth by a known amount and later return to a previous setting, a well-designed micrometer adjustment can make that considerably easier.

That is a useful feature when you actually need it.

Some dies apply a crimp as part of the seating operation.

Others perform crimping separately.

Some ammunition benefits from or requires a crimp.

Other ammunition does not.

I don't add an operation simply because the equipment allows me to.

There should be a reason.

We will deal with crimping properly later.

Shell Holders

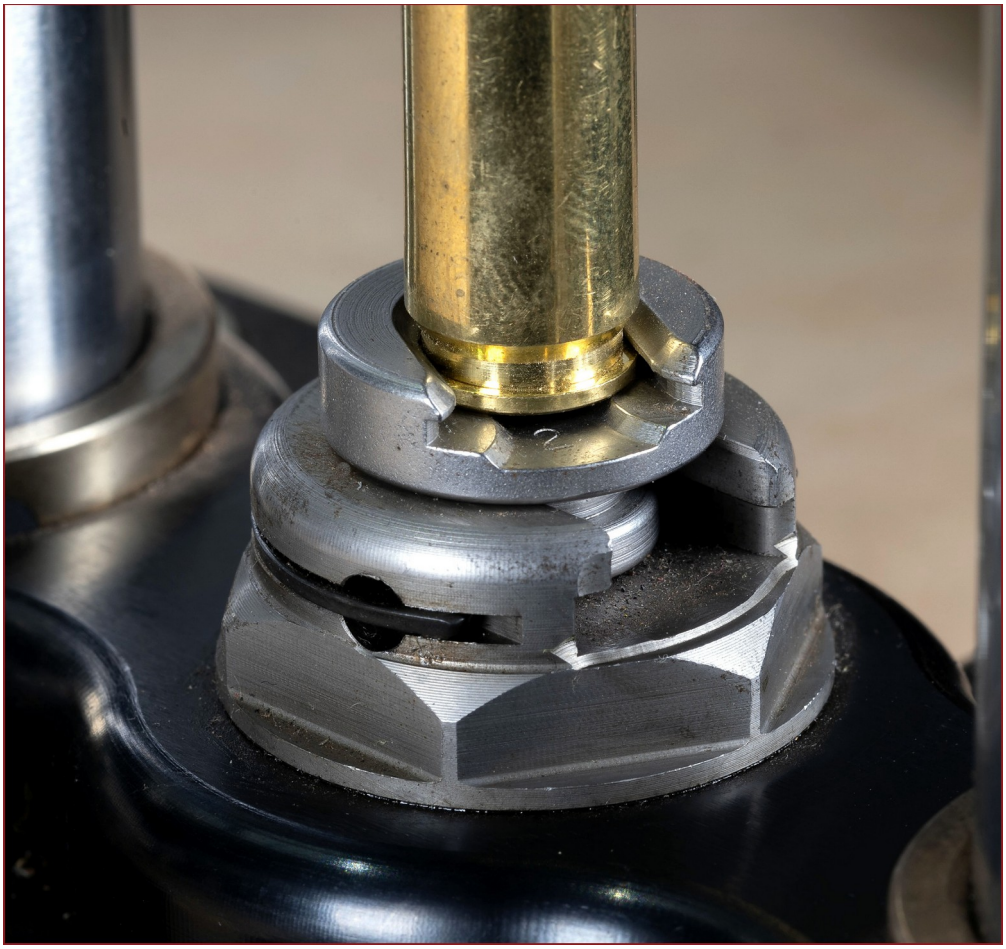


Figure 3.4 — *Close view of a case rim correctly captured by the shell holder, which itself fits onto the press ram.*

Most conventional presses use a shell holder to support the case head.

The correct shell holder must match the case.

It sounds simple, but shell-holder compatibility between manufacturers and cartridges can become confusing, particularly as the number of die sets on the bench grows.

Some cartridges share the same case-head dimensions and therefore use the same shell holder.

Others do not.

Always identify the correct one rather than choosing something because it appears to fit.

Competition Shell Holders

Competition shell-holder sets take the idea further.

Instead of one fixed relationship between the case and die, a set contains shell holders with controlled differences in height.

This allows the effective sizing relationship to be altered in small, repeatable increments without continually changing the die itself.

They can be extremely useful when controlling shoulder movement.

They are also a good example of a tool that makes little sense until you understand the measurement it is helping you control.

We will return to them when we deal with shoulder bump and sizing.

Case Lubrication

Many sizing operations require lubrication.

The lubricant reduces friction between the case and die.

Use too little and a case can become stuck.

Use far too much, particularly where it should not be, and you can create other problems.

Lubricants come as waxes, sprays, liquids and pads.

They can all work.

Application matters at least as much as brand.

When we reach sizing, we will look at lubrication in much greater detail.

Measuring Equipment

Reloading without measuring equipment is largely guesswork.

A decent set of callipers should be regarded as basic equipment.

They allow us to measure case length, cartridge length and many other dimensions.

Digital and dial callipers are both perfectly usable.

Consistency of technique is more important than the display.

As the process becomes more advanced, comparators, micrometers and specialised gauges allow us to measure from more useful reference points.

We can measure shoulder position.

We can measure from a projectile's ogive.

We can measure neck-wall thickness.

We can look at runout and concentricity.

But again, measure because the information is useful.

Do not measure something simply because somebody sells a gauge for it.

The Powder Scale

The powder scale is one of the pieces of equipment where I would be particularly careful about quality.

There are beam scales, ordinary electronic scales and increasingly sophisticated electronic weighing systems.

All can work.

A beam scale is mechanically simple and does not care about electrical interference.

Electronic scales are quick and convenient.

Higher-end systems can provide considerably greater resolution and faster settling.

But there is an important distinction between resolution and accuracy.

A scale displaying another decimal place does not automatically mean the number on the screen is more accurate.

Calibration matters.

Repeatability matters.

Stability matters.

And the environment matters.

An electronic scale should be calibrated according to the manufacturer's instructions.

I also like the idea of using known check weights.

Calibration tells the scale what a known reference is.

A check weight gives us a quick independent way of confirming that the scale is behaving as expected.

It is a simple habit.

If a scale suddenly gives an unexpected result, I would rather discover that with a check weight than with a powder charge.

Some electronic scales benefit from being switched on and allowed to stabilise before use.

The manufacturer's instructions should be followed here because designs vary considerably.

Electronic scales can also drift.

Temperature, electrical conditions, air movement and the electronics themselves can all contribute.

If the zero is moving, investigate it.

Do not repeatedly press tare and pretend nothing is happening.

A sensitive measuring instrument is only useful if you have confidence in its reading.

Powder Measures

A powder measure dispenses powder by volume.

For suitable powders and applications, a good measure can be remarkably consistent and very fast.

Different powder shapes meter differently.

Fine spherical powders tend to behave differently from long extruded kernels, for example.

Some reloaders throw a finished charge directly.

Others throw slightly under and then bring the charge to the required weight.

Both approaches have their place.

Electronic dispensers combine weighing and dispensing.

Set the desired charge and the machine dispenses powder until that weight is reached.

They can make loading very convenient, particularly when every charge is being individually weighed.

Higher-end systems can be extremely fast and precise.

But they still depend on the scale being correct.

Automation does not remove the need to pay attention.

It simply changes which part of the process the machine performs for you.

Priming Tools

Primers can be seated on the press or with a separate hand or bench-mounted tool.

All three approaches can work very well.

Hand priming tools are popular because they give good feedback and are portable.

Bench tools provide leverage and can be very consistent.

Press-mounted systems are convenient because the equipment is already there.

What matters is proper primer seating.

Later we will look at primer seating depth, feel and consistency in more detail.

Trimming and Case-Preparation Equipment

Because I personally carry out my case preparation, including trimming, before the main sizing operation, the trimmer is an important part of my bench.

There are very simple hand trimmers and sophisticated powered systems.

Some locate from the case head.

Others reference a shoulder or use pilots, collets or dedicated case holders.

The more sophisticated systems can process cases very quickly.

But the purpose remains the same.

Control case length.

Repeatability matters more to me than speed until the quantity of brass makes speed important.

Once I have trimmed a case, I want the case mouth properly finished.

The inside is chamfered.

The outside is deburred.

The internal chamfer also provides a lead-in that helps the projectile begin seating cleanly.

This can be done with a simple hand tool.

Powered tools and case-preparation centres make the same job considerably faster when processing larger quantities.

The goal is not to cut a dramatic bevel into the case.

It is to leave a clean, consistent mouth that performs the job required of it.

A powered case-preparation centre can combine several operations in one machine.

Depending on the design, this might include trimming, chamfering, deburring, primer-pocket cleaning and other preparation tasks.

They are particularly useful when processing larger batches.

For a person preparing twenty cases occasionally, a collection of hand tools may be entirely adequate.

For somebody preparing hundreds of cases regularly, powered equipment can save a considerable amount of time.

That is a recurring theme with reloading equipment.

Sometimes you are paying for greater precision.

Sometimes you are paying for greater control.

And sometimes you are simply paying to do the same job much faster.

All three can be legitimate reasons.

Cleaning Equipment

Brass can be cleaned in several ways.

Dry tumblers, wet tumblers and ultrasonic cleaners are probably the most common powered approaches.

Each produces a somewhat different result.

Wet tumbling can produce extremely clean, bright brass.

Ultrasonic cleaning can reach areas that media may not.

Dry tumbling is straightforward and has been used successfully for many years.

The important thing is not how shiny the brass looks in a photograph.

It is whether the brass is clean enough to inspect and process properly.

We will compare the methods in detail in the case-preparation section.

Loading Blocks

A loading block is one of the cheapest tools on the bench and one of the most useful.

It keeps cases upright, organised and visible.

That becomes particularly important when charging with powder.

A consistent system of moving cases from one position to another makes it easier to see where you are in the process.

This is not glamorous equipment.

It is useful equipment.

There is a difference.

Published Data Is Part of the Equipment

A reloading manual is equipment as far as I am concerned.

Without reliable data, all the expensive machinery on the bench is largely irrelevant.

Printed manuals remain extremely useful, as does current published data from reputable powder and component manufacturers.

Always check that the data actually applies to the cartridge and components you are working with.

And remember the principle from Chapter 2:

A developed reload belongs to the firearm for which it was developed.

Somebody else's load is not automatically your load data.

If I Were Starting Again

If I were starting again, I wouldn't try to build the finished loading room on day one.

I would build it in stages.

I would want a solid bench, a good single-stage press, suitable dies and shell holder, decent callipers, a trustworthy powder scale, a sensible method of dispensing powder, a priming tool, case lubrication where required, a case trimmer, chamfer and deburring tools, loading blocks and reliable published data.

That is enough to learn properly.

I would rather spend the available budget on good examples of those basic tools than spread the money across twenty specialist gadgets.

Once experience grows, I would start adding equipment that solves actual inconveniences.

Perhaps a better powder dispenser.

A powered case-preparation system.

Comparator tools for more useful measurements.

A better seating die.

A convenient method of changing dies or presses.

Possibly a second press so one can remain set up for a particular operation.

At this stage the bench begins to reflect the person using it.

That is exactly how it should be.

If the direction of shooting eventually requires greater control, the equipment may become considerably more specialised.

Higher-resolution scales.

Precision powder dispensing.

Full-length bushing or other specialist sizing dies.

Micrometer seating dies.

Mandrels.

Annealing equipment.

Neck-turning tools.

Comparators and gauges.

Concentricity equipment.

More sophisticated trimmers.

Possibly arbor or coaxial presses.

None of these makes somebody a better reloader simply by being present.

Their value comes from allowing a knowledgeable reloader to control or measure something more precisely.

That distinction matters.

Reloading equipment has a habit of accumulating.

That is normal.

Your first press may still be on the bench twenty years later.

Another tool may be replaced within a year because you discover a different system suits you better.

Something you thought was essential may eventually live permanently in a drawer.

Experience changes what you value.

That is why I would resist the temptation to buy the complete dream setup before loading the first cartridge.

Start with equipment that allows you to perform the basic process properly.

Learn what you like.

Learn what irritates you.

Learn which measurements become important to you.

Then spend money.

You will usually spend it much more wisely.

The best loading bench is not the one with the most equipment on it.

It is the one where the equipment has a reason for being there.

Some tools improve precision.

Some improve repeatability.

Some save time.

Some make a difficult operation easier.

And some simply provide another way of doing something you could already do perfectly well.

There is nothing wrong with enjoying good equipment. Reloading tools are part of the interest for many of us.

But equipment should support understanding rather than replace it.

Know what you are trying to achieve first.

Then choose the tool that helps you achieve it.

We now have somewhere sensible to work, we understand the main types of equipment and we have a much better idea of what actually needs to be on the bench.

The next step is to look at what we are putting together.

We will look at what each one does, why apparently similar components are not necessarily interchangeable and why changing even one part of a developed load deserves thought.

After that, we can start taking each part of the process apart properly.

That is where the detail really begins.

Chapter 4 — Understanding Components: Cases, Primers, Propellant and Projectiles

A loaded cartridge looks like a fairly simple object.

There is a case, a primer, some propellant and a projectile.

Four components.

It would be easy to assume that if each component is the correct general type and fits together, the combination should work. Reloading is not quite that simple.

Each of those four components has its own characteristics, and they work together as a system. Change one and you may change the behaviour of the finished ammunition.

That doesn't mean we should be frightened of changing components. Experimenting with different combinations is part of load development. What matters is recognising when a change is significant enough that we should go back and establish the load properly rather than assuming everything will remain the same.

We will devote much more space to cases, primers, propellants and projectiles later in the book. For now, I want to introduce what each component actually contributes and, perhaps more importantly, some of the differences that are not immediately obvious when you first start reloading.

For the metallic ammunition we are discussing, the four basic components are:

The case — holds everything together and provides part of the seal within the chamber when the cartridge is fired.

The primer — provides the initial ignition.

The propellant — burns to produce the gas that generates pressure and drives the projectile.

The projectile — the part that leaves the barrel and does whatever job we selected it to do.

It is tempting to think of these as four separate choices.

In reality, they interact.

The volume available inside the case affects the conditions in which the propellant burns.

The primer influences ignition.

The propellant has to be suitable for the cartridge and projectile combination.

The projectile's weight, construction and seating position can all influence how the load behaves.

This is why a load should be thought of as a **combination**, rather than simply a powder charge.

The Cartridge Case

The case is the component we spend most of our time working on because, unlike the primer, propellant and projectile, it can normally be used again.

A case does considerably more than simply hold the other components together.

It positions the primer.

It contains the propellant.

Its neck holds the projectile.

It provides the external dimensions that allow the cartridge to fit the chamber.

When fired, the brass expands against the chamber wall and helps contain and seal the rapidly developing gas pressure.

After firing, it contracts sufficiently for the case to be extracted.

That expansion and contraction is one of the reasons brass works so well as a cartridge-case material.

It is also one of the reasons the case gradually changes as it is repeatedly fired and reloaded.

One of the first lessons worth learning is that two cases carrying the same cartridge designation are not necessarily identical.

Different manufacturers use different tooling and manufacturing processes.

Case-wall thickness can vary.

Neck-wall thickness can vary.

The construction around the case head can vary.

The amount of brass used can vary.

Consequently, **internal case capacity can vary**.

That matters.

Imagine two cases with identical external dimensions. One has thicker walls and therefore less internal volume.

The outside may look much the same.

The space available inside is not.

That is one reason I don't casually change case manufacturer in an established load and assume everything else can remain exactly as it was.

We will eventually look at measuring case capacity, including the common method of using water capacity, because it gives us another useful way of comparing cases.

At this stage, just remember:

Same cartridge designation does not necessarily mean identical case.

Keep Brass in Sensible Batches

Because brass varies, I like to know what I am loading.

At the very least, keeping cases from the same manufacturer together makes sense.

For more carefully controlled ammunition, I may also keep cases from the same production lot together and maintain them as a batch throughout their life.

That means they are fired together, prepared together and their history remains known.

This becomes increasingly valuable as the level of precision increases.

For straightforward ammunition, sorting every case into tiny groups may achieve very little.

For precision ammunition, maintaining a consistent batch can remove another variable.

As with so much in reloading, the amount of work should reflect what you are trying to achieve.

Boxer and Berdan Priming

Not every cartridge case uses the same primer arrangement.

The two systems you are most likely to hear about are **Boxer** and **Berdan** priming.

Boxer-primed cases have a central flash hole in the case and the anvil is incorporated into the primer itself.

This is the system most reloaders in the UK will normally want to work with.

It is straightforward to deprime using conventional reloading equipment and is supported by the normal range of reloading tools.

Berdan-primed cases use a different arrangement, with the anvil formed as part of the case and normally more than one flash hole.

Berdan cases can be reloaded with the appropriate equipment and components, but they are considerably less convenient for the ordinary reloader.

If I am collecting or buying brass specifically for reloading, **Boxer priming is what I normally want**.

We will look at primer pockets and flash holes in considerably more detail later.

Cases are consumable components.

They do not last forever.

Every firing and preparation cycle changes the brass to some extent.

Some cases may survive many firings.

Others may have considerably shorter lives.

Cartridge design, chamber dimensions, pressure, sizing method, brass quality and preparation all play a part.

That is why inspection is important.

A valuable case is still cheaper than damaging equipment or creating a dangerous situation by trying to get one more firing from brass that should have been retired.

We will have a complete chapter on recognising case problems later.

The Primer

The primer is physically one of the smallest components in the cartridge, but its job is extremely important.

When struck by the firing mechanism, the primer produces the ignition that starts the propellant burning.

That sounds simple.

But primers are not all the same.

There are different physical sizes, different intended applications and differences in the way primers produce their ignition.

That means primer choice is part of the load.

It is not merely a question of finding something that fits the hole.

The common categories include **small and large rifle primers** and **small and large pistol primers**.

Within those categories there are further variations.

There are standard primers.

There are magnum primers.

Some manufacturers offer primers intended specifically for match or competition use.

There are also primers designed around particular applications.

One thing I want to establish early is that primer names should be taken seriously.

A primer that physically fits a primer pocket is not automatically the correct primer for that application.

Use the primer type specified by reliable data unless you have a sound reason and appropriate data for doing otherwise.

Primer Intensity

Primer intensity is a subject I think deserves considerably more attention than it sometimes receives.

Two primers of the same nominal size are not necessarily identical in the way they ignite the propellant.

The strength, duration and characteristics of the primer flame can vary between types and manufacturers.

That can influence ignition and potentially the behaviour of the load.

This becomes particularly relevant with certain propellants, larger powder columns and cartridges where consistent ignition is important.

Magnum primers are one obvious example.

The word *magnum* does not mean that fitting one automatically improves ammunition.

It means the primer has been designed to provide ignition characteristics suited to particular applications.

There will be a dedicated discussion of primer intensity later because it deserves more than a couple of paragraphs.

For now, remember that **changing the primer is changing the load**.

There is another practical consideration that has become increasingly obvious over the years.

Availability.

There is little benefit in developing a wonderful load around a particular primer if you cannot obtain enough of them to keep shooting it.

That doesn't mean we should choose components solely according to what happens to be sitting on a shelf today.

But availability is worth considering when establishing ammunition you intend to use regularly.

If I have the choice between two equally suitable components and one is readily obtainable while the other appears once every eighteen months, that will influence my decision.

The best component on paper is not always the most practical component to build a long-term load around.

Propellant

Propellant is often simply called powder.

It is worth understanding that we are dealing with a carefully formulated propellant rather than just something that burns.

Different propellants have different characteristics.

They burn at different rates.

They have different bulk densities.

Their physical form varies.

They may respond differently to temperature and pressure.

They are designed to operate within particular types of cartridge and application.

This leads to one of the most important points in the whole chapter:

Propellants are not casually interchangeable.

If published data specifies one powder, you cannot simply substitute another because it looks similar or has a similar name.

Smokeless Propellant and Black Powder

There is an important distinction to make before going any further.

The smokeless propellants normally encountered in modern metallic cartridge reloading should not simply be treated as though they are the same thing as black powder.

Black powder and smokeless powder are both covered by explosives legislation, but they are not treated identically. In Great Britain, black powder requires the appropriate explosives certificate, while smokeless powder does not; storage, transfer and security requirements can still apply to both.

That difference matters.

Black powder requires its own appropriate storage arrangements and should never simply be treated as another tub of reloading powder because both products can be used to propel a projectile.

There are also legal requirements surrounding the acquisition, possession and storage of propellants and explosives. Those requirements can depend on the material and quantities involved and can change over time.

Rather than trying to reduce an important subject to a couple of sentences here, we will deal with it properly in the next chapter.

For the moment, the important point is straightforward:

Do not assume black powder and modern smokeless propellant can be handled or stored in exactly the same way.

Know what material you have and follow the appropriate requirements for it.

Burn Rate

You will often hear powders described as faster or slower burning.

This is a useful way of broadly comparing propellants, although real behaviour inside a cartridge is more complicated than a simple list from fastest to slowest.

Different cartridges and projectile weights require different propellant characteristics.

A powder suited to a small cartridge may be completely inappropriate for a much larger one.

Likewise, two powders that sit reasonably close together on a burn-rate chart are not automatically interchangeable charge for charge.

A burn-rate chart is useful reference information.

It is **not load data**.

That distinction is important.

Propellants also come in different physical forms.

You will encounter spherical or ball powders, flake powders and extruded or tubular powders in various shapes and sizes.

This affects more than appearance.

It can influence how well the powder flows through a measure and how consistently a volumetric dispenser throws a charge.

Long extruded kernels, for example, may behave quite differently through a conventional powder measure from a fine spherical powder.

This is one reason some combinations lend themselves particularly well to volumetric dispensing while others are more commonly weighed individually.

We will explore that properly when we get to powder charging.

Never Create Mystery Powder

One simple habit can prevent a surprisingly serious mistake.

When I am loading, I like to know exactly which powder I am using.

I don't want several open powder containers surrounding the loading area.

Keep the powder in its original, correctly labelled container.

Take out what you need for the loading operation.

If powder is left in a measure or dispenser after a loading session, do not rely on memory to identify it later.

Never create mystery powder.

A container of unidentified propellant is not something to put aside until you remember what it was.

If its identity is uncertain, it cannot sensibly be treated as usable reloading propellant.

Availability matters here as well.

Propellant availability can change.

Products can disappear from the market, import arrangements change and certain powders can become difficult to obtain.

This is worth thinking about when establishing a long-term load.

If several suitable propellants are available, there is some value in choosing one that has a realistic prospect of remaining obtainable.

That doesn't mean buying whatever is most common regardless of suitability.

Suitability comes first.

Availability is part of the practical decision afterwards.

The Projectile

The projectile is perhaps the component people find easiest to become interested in because the differences are immediately visible.

Different weights.

Different shapes.

Different tips.

Flat bases and boat-tails.

Hollow points.

Polymer tips.

Different jacket designs.

And increasingly specialised designs for particular forms of shooting.

The first thing to understand is that projectile choice should begin with **what the ammunition is expected to do**.

A projectile designed for one purpose is not automatically a good choice for another.

A projectile must obviously be of the correct diameter for the cartridge and barrel.

The name of the cartridge does not always tell you the actual projectile diameter as clearly as you might expect.

Cartridge naming has developed over a very long period and is full of historical conventions.

Never choose a projectile simply because the number printed on its box appears to resemble the calibre designation on the rifle.

Check the actual specification.

This is particularly important with older cartridges and historical naming conventions, where the number in a cartridge name may not directly state the actual projectile diameter.

Projectile Weight

Within a particular diameter, projectiles are normally available in a range of weights.

Weight affects several things.

It influences the propellant data that should be used.

It can influence velocity.

It affects recoil and external ballistic performance.

And it interacts with barrel twist rate.

A heavier projectile is often longer, although construction and material also matter.

That length is important because the barrel must provide enough rotational stability.

Projectile selection, stability and twist rate are dealt with together in Chapter 23.

For now, do not assume that because a projectile has the correct diameter it is automatically suitable for your barrel.

Projectile Shape

Projectile shape has a considerable influence on how it behaves in flight.

The nose profile, ogive, boat-tail, bearing surface and meplat all contribute in different ways.

A flat-base projectile has a very different rear profile from a boat-tail.

A short conventional hunting projectile may look completely different from a long, high-BC target projectile of the same diameter.

Those differences affect more than appearance.

They can affect seating, cartridge length, stability and external ballistic performance.

The ogive is the curved portion of the projectile leading towards the nose.

It becomes particularly important to reloaders because measuring from the projectile tip is not always the most repeatable way of assessing seating.

Projectile tips can vary.

Polymer tips can introduce their own dimensional variations.

Open-tip designs can vary at the meplat.

A comparator allows us to measure from a point on the ogive instead, giving us a more useful reference for many seating measurements.

We will cover **base-to-ogive measurement** properly later.

For now, I simply want the terminology to be familiar when we reach it.

The meplat is the very front of the projectile.

On some projectiles it is effectively a small flat or open area at the tip.

Variations in meplat shape and size can influence aerodynamic consistency, which is why some precision shooters trim and point projectiles.

That is well beyond what most ammunition needs.

But for certain forms of competition shooting, those small details can matter.

We will deal with meplat trimming and projectile pointing in their own section rather than pretending everybody needs to start altering perfectly good projectiles.

The bearing surface is broadly the portion of the projectile that engages with the barrel.

Its length and design are part of the projectile's overall geometry.

Two projectiles of the same nominal weight and diameter can have quite different shapes and bearing surfaces.

This is another reason why changing from one projectile to another of the same weight does not necessarily mean you have changed nothing important.

Same weight does not mean same projectile.

Ballistic Coefficient

Ballistic coefficient, or BC, is a measure used to describe how effectively a projectile retains velocity against aerodynamic drag.

Higher-BC projectiles generally retain velocity better and are affected less by wind at longer ranges than otherwise comparable lower-BC designs.

But BC is not the only thing that matters.

A projectile must still suit the cartridge, barrel, intended velocity and job it is being asked to perform.

There is little point selecting a spectacularly high-BC projectile if it cannot be stabilised properly by the barrel or cannot be used sensibly within the dimensional limitations of the firearm.

G1, G7 and ballistic coefficient are covered in more detail in Chapter 23.

Intended Use Matters

This is where I want to keep the discussion fairly general.

We have not yet reached the chapters dealing specifically with hunting, target shooting, competition disciplines or particular cartridges.

At this stage, the principle is enough.

Choose the projectile for the job.

The requirements for one type of shooting may be quite different from another.

Some applications place great importance on terminal performance.

Others place much more emphasis on consistency and external ballistics.

Some need reliable feeding from a magazine.

Others allow cartridges to be loaded individually.

The intended use should guide the component choice rather than the other way around.

Component Lots

Components can vary between manufacturing lots.

How significant that variation is depends on the component and manufacturer, but it is another reason I like to know what I am using.

Where practical, I keep components from the same lot together.

That is particularly useful for ammunition where consistency matters.

It also makes record keeping much more meaningful.

If something changes unexpectedly, knowing that a new component lot was introduced gives you somewhere sensible to begin looking.

For ordinary ammunition, recording every possible number may feel excessive.

For carefully developed precision ammunition, lot information can be extremely useful.

Changing a Component Changes the Load

This brings us to one of the most important principles in this chapter.

Changing a component changes the load.

Change the case and internal capacity may change.

Change the primer and ignition characteristics may change.

Change the powder and you have made a fundamental change to the load.

Change the projectile and weight, geometry, bearing surface or seating arrangement may change.

Not every component change will produce a dramatic result.

But you should never assume that it cannot.

That's why I prefer to treat meaningful component changes as a reason to return to reliable data and reassess the load rather than simply substituting the new component and carrying on.

Reloading discussions have always been full of questions about which primer is best, which brass is best, which powder is best and which projectile is best.

There usually isn't one universal answer.

Best for what?

A component that is ideal for one cartridge, firearm and type of shooting may offer no advantage at all in another.

Availability, cost and the quantity of ammunition being produced matter as well.

My approach is much simpler.

Don't choose a component because somebody says it is the best. Choose it because you understand what you need it to do.

That becomes easier with experience.

It is also one of the reasons we are taking the time in this book to understand the individual components before trying to optimise them.

Components Work as a System

A good reload is not four individually impressive components thrown together.

It is a combination that works.

Excellent brass cannot compensate for an unsuitable propellant.

A very expensive projectile cannot make an inappropriate load sensible.

The most consistent primer available is of little value if it is wrong for the application.

Likewise, relatively ordinary components can sometimes produce extremely good ammunition when they are well matched and loaded consistently.

That is the lesson I want to carry forward.

Understand each component.

Understand what changing it might affect.

Keep sensible records.

And judge the finished combination by what it actually does rather than by the reputation or price of the individual pieces.

We now understand the basic reloading process, the equipment on the bench and the four components that make up the cartridge.

Before we start working through case preparation in detail, there is one subject that needs to sit between the introduction and the practical work.

Safety and pressure.

We touched on pressure in Chapter 2 because it was too important to ignore.

In the next chapter we can deal with it properly.

We will look at safe working habits, published data, how pressure develops, why maximum loads are not targets, why apparently small changes can matter, what warning signs can and cannot tell us, and when the correct decision is simply to stop.

We will also look properly at **propellant storage**, including the important differences between smokeless propellant and black powder and the current UK requirements that apply to them.

Once those foundations are in place, we can move into the detailed case and case-preparation chapters with a much better understanding of why we are doing what we are doing.

Chapter 5 — Safety, Pressure and Good Working Practice

Reloading is a very safe activity when it is approached properly.

That doesn't mean it is an activity where mistakes can simply be shrugged off.

We are dealing with primers, propellants and cartridges which generate considerable pressure when fired. The equipment on the loading bench gives us a great deal of control over what goes into that cartridge, but with that control comes responsibility.

Most reloading safety is not complicated. It comes down to using reliable information, identifying components correctly, keeping the loading area organised, avoiding distractions and being prepared to stop when something does not seem right.

The dangerous mistakes are often surprisingly ordinary ones: the wrong powder, the wrong charge, an incorrectly identified component, a load transferred from one firearm to another without being developed again, or a significant component change treated as though nothing has changed.

The safest reloader is not necessarily the person with the most experience. It is the person who keeps paying attention.

There is more load information available today than ever before. Some of it is excellent. Some of it is not.

Powder manufacturers, projectile manufacturers and reputable loading manuals publish tested data produced under controlled conditions. That is where I start.

An internet forum, social-media group or conversation at the range can be useful for discussing ideas, but I would never regard somebody else’s favourite load as a replacement for published data.

There is an important difference between “This combination has worked well for me” and “This is safe in your firearm.” Nobody can sensibly make the second statement simply because the first one is true.

A reload is developed for the firearm in which it will be used. Another firearm bearing the same cartridge designation does not automatically make that load transferable.

Published loading data usually provides a range within which development can take place. The lower end is not there merely for inexperienced reloaders. It gives us somewhere sensible to begin assessing how the combination behaves.

Likewise, the upper figure should not be treated as a target that must eventually be reached. If the ammunition performs exactly as required below the published maximum, there is no rule saying we have somehow failed to finish developing it.

> **KEY PRINCIPLE**
> *Maximum is a limit in the published test conditions. It is not a prize.*

What Pressure Actually Means

When the primer initiates the propellant, gas production causes pressure inside the cartridge and chamber to rise very rapidly. That pressure acts in all directions. It pushes the projectile forward, but it also forces the brass against the chamber walls and places considerable loads on the firearm itself.

The pressure does not remain constant. It rises rapidly, reaches a peak and then falls as the projectile moves along the barrel and the available volume increases.

The exact pressure curve depends on the complete combination. Powder type matters. Projectile weight and construction matter. Case capacity matters. Primer choice can matter. Seating arrangement can matter. The chamber and barrel matter.

Putting Pressure Into Perspective

It is difficult to appreciate chamber pressure until you attach some numbers to it.

Many modern centrefire rifle cartridges have published maximum average pressures around 50,000 to 65,000 psi under SAAMI standards. SAAMI Z299.4-2025, the current published centrefire rifle standard at the time of this revision, lists .223 Remington at 55,000 psi and .308 Winchester at 62,000 psi, while a number of modern cartridges are standardised at 65,000 psi. These are commercial ammunition standards, not handloading charge recommendations.

To put those numbers into more familiar terms, 55,000 psi is about 3,790 bar, 60,000 psi about 4,140 bar and 65,000 psi about 4,480 bar.

That is an enormous pressure being generated only a short distance from the shooter's face. The firearm, chamber and cartridge case are designed to contain it when the ammunition is operating within the conditions for which they were designed.

It is also worth remembering that SAAMI and C.I.P. figures come from their own standardised test methods. They should not be treated as a home pressure gauge or used to reverse-engineer a powder charge. For handloading, the information that matters is current published data for the cartridge and components being used.

This is another reason why judging pressure purely by looking at a primer is inadequate. A cartridge can already be operating at tens of thousands of pounds per square inch without giving us a simple visual number on the fired case.

Proof Pressure Is Not Extra Headroom

Firearms are proof tested above normal service pressure. That is deliberately a higher-pressure test intended to demonstrate the integrity of the firearm; it is not additional operating headroom for the reloader.

A firearm having passed proof does not give us permission to develop ammunition above the appropriate service limits. Proof is a safety test, not a load-development target.

Pressure Limits Are Not Performance Targets

One habit I would encourage any new reloader to avoid is chasing pressure. The objective is not to find the point where things become unsafe and then move back a tiny amount. The objective is to find a safe, reliable and useful load.

For some purposes velocity is important. That still does not make more velocity automatically better. There comes a point where adding more propellant may provide very little useful gain while increasing pressure, recoil, wear or variation.

The chronograph is a measuring tool. It should not become a scoreboard.

Be Careful With “Pressure Signs”

Figure 5.1 — *A deprimed case head showing visible marks around the primer-pocket/head area. Such marks are observations to investigate, not a stand-alone pressure measurement.*

Reloaders often talk about “reading pressure signs”. There is some useful information in fired cases and in the behaviour of the firearm, but I think the phrase can create false confidence.

A flattened primer, for example, does not provide us with a calibrated pressure reading. Primer appearance can be affected by the primer itself, the firing pin, firing-pin aperture, headspace relationship and other factors. Likewise, one apparently normal primer does not prove that a load is safely within specification.

Other things may attract attention: extraction or bolt lift may become noticeably different, case heads may show unusual marks, primer pockets may change, or velocity may depart unexpectedly from what previous development suggested.

Learn what normal behaviour looks and feels like in the firearm for which the load is being developed. If something changes unexpectedly, stop and investigate.

A cartridge that suddenly becomes noticeably harder to extract deserves attention. There can be more than one reason for difficult extraction, and not every cause is excessive pressure, but continuing to fire

ammunition while telling yourself that a stiff bolt or difficult extraction is probably nothing is not a sensible approach.

Stop. Examine the fired case. Review the load. Check the components. Consider what has changed.

A new powder lot? Different cases? A different primer? Different projectile? Changed seating depth? Different ambient conditions? A mistake in the loading process? Do not try to make the evidence fit the answer you wanted.

A chronograph does more than tell us how fast the projectile is travelling. During development, velocity provides another piece of information about how the load is behaving.

If increasing charges have been producing a fairly predictable progression and one step suddenly produces an unexpected change, that deserves attention.

The chronograph is not a pressure-testing instrument and cannot directly tell you chamber pressure. But unexpected velocity behaviour is still information.

Component Changes Matter

A common mistake is to change something that appears insignificant and assume the established load is therefore unchanged.

Change the case manufacturer and internal capacity may change. Change the primer and ignition characteristics may change. Change the projectile, even for one of the same nominal weight, and its bearing surface or seating geometry may be different. Change seating depth and you have altered the physical arrangement inside the cartridge. Change the powder and you have unquestionably changed the load.

Where the change is significant, return to reliable data and work back into the load rather than assuming yesterday’s result guarantees today’s.

Do not substitute one propellant for another by keeping the same charge weight.

Two powders can look similar, have similar names or sit beside each other on a burn-rate chart. None of those things makes them interchangeable.

A burn-rate chart is useful for understanding the broad relationship between powders. It is not a conversion table. If you change powder, use appropriate published data for the new powder.

When charging ammunition, I want one clearly identified powder in use. I don't want several open tubs of propellant around the scale.

Keep powder in its appropriate original, correctly labelled container except for the quantity actually being used. If a powder measure contains propellant at the end of a session, deal with it before walking away. Do not leave it until next week and expect to remember what it was.

Unidentified powder has no sensible place on a loading bench.

Smokeless Propellant and Black Powder

We briefly introduced this distinction in the previous chapter. It is worth making it clearer here.

In Great Britain, the Explosives Regulations 2014 use the term “shooters’ powder” in their storage provisions, and HSE guidance includes both black powder and smokeless powder within that term. Their acquisition and keeping requirements are not identical: black powder requires the appropriate explosives certificate, while smokeless powder is among the explosives that do not require an explosives certificate. Other transfer, storage and security requirements can still apply.

That is one reason I would never tell somebody simply to treat black powder as another type of smokeless reloading propellant. They are different materials and need to be understood as such.

Northern Ireland has separate arrangements, and regulations can change. This book should therefore never be used instead of checking the current official requirements for where you live.

Under the current Great Britain Explosives Regulations, shooters' powder may be stored without a storage licence up to 10 kg net mass under regulation 7(2)(a)(i), subject to the other applicable requirements and to the separate limits that apply when different categories of explosives are combined.

That doesn't mean ten kilograms can simply be placed anywhere because it falls below a licensing threshold. Safe storage still matters, and anyone keeping shooters' powder should follow the current HSE guidance and any conditions applying to their circumstances.

For the ordinary reloader, keeping propellant in its appropriate original container, away from ignition sources and unnecessary heat, and using storage arrangements that follow current official guidance is the sensible approach.

Propellant storage should be kept away from ignition sources and unnecessary heat. That includes open flames and smoking, but sensible thinking goes further.

Do not choose a storage location beside a boiler, heater or other obvious heat source. The purpose of storage arrangements is not simply to prevent somebody taking the powder; they also need to consider what happens if there is a fire.

Primers are small energetic devices. A tray of primers deserves considerably more respect than its size might suggest.

Keep them in their proper packaging until needed. Keep unnecessary quantities away from the immediate working area. Do not pour different primer types together. Do not force a primer that does not want to seat.

SAFETY WHEN PRIMING

Wear safety glasses whenever you are priming cases.
Primers contain an impact-sensitive compound and should always be handled with care. When hand priming, keep the priming tool and case pointed away from your face and body. With tray- or tube-fed systems, avoid positioning your face directly over the primer supply or feed mechanism.
Use smooth, controlled pressure when seating a primer. If one suddenly feels unusually tight, starts crooked or does not feed correctly, stop and find the cause rather than trying to force it into place.
Always follow the instructions supplied with your particular priming tool.

Smoking and reloading have no business being carried out together. The same applies to open flames.

The loading area should not be used for grinding, welding or other work that produces sparks while propellants and primers are present. Finish one job properly before beginning another.

We mentioned distractions when we designed the loading bench in Chapter 3. They become particularly important during powder charging.

If I am interrupted halfway through charging a tray of cases, I don't guess where I had reached. I establish it again.

A few minutes saved by carrying on from memory is worth very little compared with the time required to pull apart a batch of ammunition because you are no longer certain what you did.

A good routine makes errors easier to notice. Empty cases may start on one side of the bench and move to another position as they are processed. A charged case should have an obvious place. A finished cartridge should not be mixed back in with ammunition that still requires an operation.

The exact arrangement is personal. What matters is that it makes the state of the work obvious. If you have to ask yourself whether a particular case contains powder, your system has already failed.

Visually Check Charged Cases

Where the cartridge and process allow it, looking into the charged cases before projectile seating is a very useful habit.

You are not trying to judge an exact charge weight by eye. You are checking that the tray looks sensible. Is every intended case charged? Does one case appear significantly different from the others? Is something obviously wrong?

A visual check is not a substitute for accurate weighing or dispensing. It is another layer of checking.

Some cartridge and powder combinations occupy only a relatively small part of the available case volume. That can make a missing charge or other serious charging error less obvious from a casual glance. Other combinations fill much more of the case.

The lesson is to understand the particular combination you are loading and arrange the charging routine accordingly. Never rely solely on case fill to tell you that the correct charge is present.

Everybody has days when concentration is poor. You are tired. You are in a hurry. The telephone keeps ringing. Something else is occupying your mind.

That may be a good evening to clean cases or organise equipment. It may not be a good evening to weigh fifty powder charges. There is no requirement to finish ammunition simply because you started intending to.

Reloading requires judgment, measurement and concentration. Alcohol, recreational drugs and anything else that materially impairs those things do not belong in the loading process.

If you would not trust yourself to make an important measurement accurately, do not load ammunition.

A box containing ammunition should tell you what is in it. At minimum, I want enough information to identify the cartridge, the load and the firearm for which it was developed.

For developed ammunition I normally want considerably more than that in the associated record: projectile, powder, charge, primer, brass, seating information, date or batch, and anything else relevant to reproducing the result.

The label on the box and the detailed loading record do slightly different jobs. Both help ensure that six months later we are dealing with known ammunition rather than something we think we remember loading.

There will eventually be a box or cartridge that makes you think, “I’m fairly sure I know what this is.” Fairly sure is not enough.

If the identity or load of ammunition is genuinely uncertain, do not fire it simply because dismantling it feels wasteful. A bullet puller is a normal reloading tool partly because mistakes and changes of mind happen.

There is no embarrassment in dismantling ammunition. There is considerably more sense in doing that than firing something you do not trust.

Reloading equipment gives us leverage. That is useful. It also means it is possible to apply a surprising amount of force to something that is trying to tell us there is a problem.

A case suddenly requires far more force than normal. A primer does not want to seat. A projectile feels wrong during seating. A cartridge will not chamber normally.

Stop. Leverage is not a troubleshooting method. When an operation that is normally smooth suddenly becomes difficult, find out why before applying more force.

Safety and record keeping are closely connected. If I change a component, I want to know. If a new batch behaves differently, I want to be able to compare it with the previous one. If a case lot has been fired several times, I want some idea of its history.

A good record turns a suspicion into something we can investigate. Without the record, we often end up guessing. The loading bench is not a particularly good place for guesswork.

Learn What Normal Looks Like

One of the useful things experience gives us is familiarity. You learn how your equipment normally feels. You know roughly how a primer normally seats. You recognise how your brass normally looks after firing. You know what sort of velocity a developed load normally produces.

That familiarity is useful provided we do not let it turn into complacency. The purpose of knowing what normal looks like is to recognise abnormal behaviour sooner, not to dismiss it.

There will be many detailed safety points throughout the rest of this book, but there is one rule that covers an enormous number of situations.

When in doubt, stop.

Do not force the press. Do not guess at the powder. Do not assume the primer is correct. Do not fire the cartridge just to see what happens. Do not transfer an established reload into another firearm and expect identical pressure behaviour. Do not continue adding powder simply because you have not yet reached the published maximum.

Find out what is going on first. That is not excessive caution. It is good reloading.

We now have the foundations in place. We know why we reload. We understand the overall process. We have looked at the equipment on the bench. We understand the basic components. And we have established the safety principles that should sit behind everything that follows.

Now we can start working through the process properly.

We will look at how cases are made, what happens to brass during firing, why cases from different manufacturers can behave differently, how the main areas of a case are named and what the fired case can tell us before we begin preparing it for another loading.

Black powder and modern smokeless powder must not be treated as interchangeable versions of the same thing. They have different characteristics and loading practices, and data intended for one is not a basis for substituting the other. The later black-powder chapters will deal with those methods separately. For the modern smokeless-loading sequence here, I stay within appropriate published data for the exact type of propellant being used.

Chapter 6 — Understanding Cartridge Brass

The cartridge case is the component we handle more than any other during the reloading process.

The primer is used once, the propellant is used once and the projectile is used once. The case, however, may be fired, cleaned, inspected, prepared, sized, loaded and fired again many times before it is finally retired.

That is why brass deserves so much attention.

It is not simply a container for the other components. It is a working part of the ammunition, and it changes every time the cartridge is fired.

Understanding what the brass is doing makes almost every later stage of reloading easier to understand. Sizing makes more sense, case trimming makes more sense, annealing makes more sense and neck tension makes more sense. Perhaps most importantly, case inspection starts to become something more useful than simply looking for obvious damage.

A metallic cartridge case performs several jobs at once.

It holds the primer, contains the propellant, grips the projectile at the neck and provides the external dimensions that allow the loaded cartridge to fit the chamber.

When the cartridge is fired, the brass expands against the chamber and helps form a gas seal. After the pressure drops, the case contracts slightly so that it can be extracted.

That ability to expand and spring back is one of the reasons cartridge brass works so well.

The case is therefore not a rigid object. It changes shape under pressure, and once you start thinking about it that way, many of the things we do during case preparation become easier to understand.

Most modern reloadable metallic cartridge cases are made from cartridge brass.

The exact alloy can vary slightly depending on the manufacturer and application, but brass has a very useful combination of properties. It is strong enough to withstand repeated handling and firing, ductile enough to expand without immediately splitting, elastic enough to spring back slightly after pressure falls and workable enough to be resized repeatedly within sensible limits.

Those characteristics are ideal for a cartridge case.

The case needs to expand enough to seal in the chamber, but it also needs to relax enough to allow extraction. Then, during reloading, we deliberately reshape it again.

That cycle is useful, but it is also why brass does not last forever.

Before going further, it helps to name the main parts of a bottleneck case.

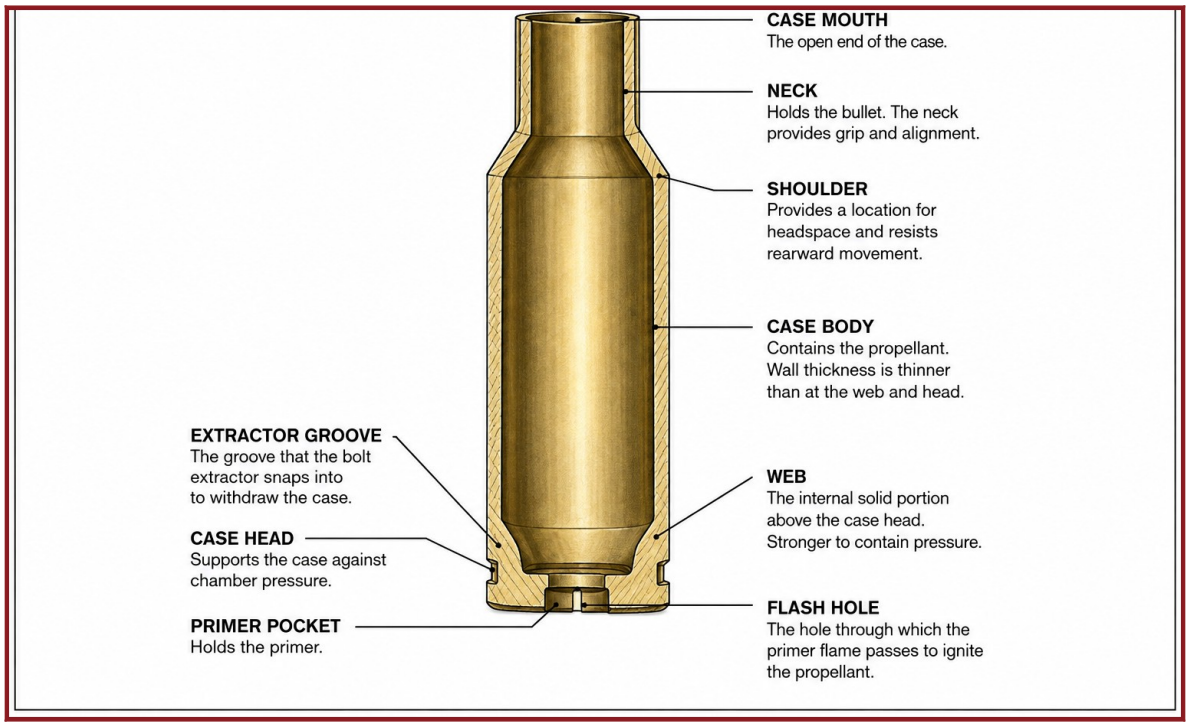


Figure 6.1 — *Anatomy of a modern rimless bottleneck rifle case. Longitudinal section showing the case mouth, neck, shoulder, body, web, extractor groove, case head, primer pocket and flash hole.*

At the rear is the case head. The primer pocket is formed into the head, and the extractor groove and rim area are also found here on most modern designs.

Moving forward, we have the case body. On a bottleneck cartridge, the body narrows into the shoulder, which then meets the neck. The projectile is held in the neck, and the opening at the front is the case mouth.

Inside the case, the area around the web and case head is considerably thicker than the upper walls. That thicker construction matters because the case head is subjected to significant loading when the cartridge is fired.

The wall thickness changes as we move forward through the body. These different areas do different jobs and they do not all wear in the same way.

The Case Head

The case head is the strongest part of the case.

It contains the primer pocket and provides the surface against which the bolt face or breech supports the cartridge during firing.

This is also an area where we should pay attention to unusual changes.

Primer pockets becoming noticeably loose, unusual marks around the head or changes in extraction can all tell us something has changed.

That doesn't mean one sign automatically proves excessive pressure. As we discussed in Chapter 5, pressure should not be diagnosed from one visual symptom alone.

But changes around the case head deserve attention.

The primer pocket is formed into the case head and must match the primer type used by that case.

Small and large primer pockets are the most obvious distinction, although there are other variations depending on the cartridge and manufacturer.

The primer needs to seat correctly and consistently. A primer pocket that has become excessively loose is a sign that the case may no longer be suitable for continued use.

Likewise, a primer that suddenly seats very differently from the rest of the batch deserves investigation.

Later we will look at primer-pocket cleaning, uniforming and the pros and cons of doing more than is actually necessary.

The flash hole connects the primer pocket to the inside of the case.

When the primer ignites, the flame passes through the flash hole and initiates the propellant.

Boxer-primed cases normally have a single central flash hole, while Berdan-primed cases generally use a different arrangement.

For my own case preparation, the flash hole is part of the automatic initial preparation of every case in the batch.

I prepare the flash hole on every case when I initially establish a batch, just as I uniform every primer pocket. The objective is consistency across the whole batch rather than selecting only the cases that appear to need attention. Once a flash hole has been correctly deburred, the manufacturing burr does not grow back, so I don't repeatedly remove brass from it on every subsequent loading cycle.

We will come back to that when we look at case preparation in detail.

The case body expands when the cartridge is fired.

That expansion is not a defect. It is part of the way the cartridge case works.

The brass expands to meet the chamber, then springs back slightly after pressure falls. When we later size the case, we change those dimensions again.

This repeated movement is one of the reasons brass gradually hardens through use. The more we work the case, the more the material changes.

That doesn't mean less sizing is always automatically better, but it does mean sizing should be controlled rather than excessive.

On a bottleneck cartridge, the shoulder is a particularly important reference point.

During firing its position can change, and during sizing we deliberately control that position again.

This is where the idea of shoulder bump comes from.

Rather than blindly sizing the case as far as the die allows, we can measure how much the shoulder is being moved. That gives us much better control over the process.

We will cover shoulder bump in detail later. For now, it is enough to understand that the shoulder is not simply part of the case's shape. It is an important dimensional reference.

The Neck

The neck holds the projectile.

That sounds simple, but the neck becomes one of the most important areas in precision reloading.

Its wall thickness matters. Its diameter before and after sizing matters. How much it is reduced by the sizing die matters. Whether an expander or mandrel is used afterwards matters, and the amount of grip it applies to the projectile matters.

This is where neck tension enters the discussion.

We will eventually go into that in considerable depth. At this stage, just remember that the neck is not simply there to stop the projectile falling out. It is part of the consistency of the finished ammunition.

The case mouth is the front edge of the neck.

It is also the area affected when we trim the case. A freshly trimmed mouth has a sharp internal and external edge, which is why we chamfer and deburr it afterwards.

The internal chamfer provides a lead-in for the projectile during seating, while the outside deburring removes the sharp external edge.

A badly prepared case mouth can make projectile seating more difficult and can damage the projectile as it enters the neck.

What looks like a small finishing operation can therefore matter later in the process.

When the primer ignites the propellant, pressure rises rapidly.

The case is forced outward against the chamber walls. The body expands, the neck expands enough to release the projectile and the case head is driven rearward against the bolt face or breech.

The brass is therefore being stretched and reshaped under load.

Once pressure falls, the case springs back slightly, but it does not return completely to its original dimensions.

That is why a fired case is different from a new one. It has effectively taken on some of the shape of the chamber in which it was fired.

This is one of the reasons I keep reloaded ammunition tied to the firearm for which it was developed. The brass itself has been influenced by that firearm.

There are also specialist methods for sizing further down the case body, including small-base and roll-sizing systems. Those are not part of ordinary case preparation for every reloader, so I will leave them until the sizing chapters where their purpose can be explained properly.

A fired case is not a perfect cast of the chamber.

Brass springs back, pressure varies and the case was itself slightly smaller than the chamber before firing.

But fired brass still tells us useful things.

It gives us a much better idea of the relationship between the case and that particular chamber than a brand-new case does.

This becomes useful when we start measuring shoulder movement and deciding how much sizing is actually necessary.

Instead of simply asking how far the die will push the shoulder back, we can compare the sized case with the fired case.

That is a much more useful way of thinking.

Every time brass is deformed, its physical condition changes.

Repeated firing, sizing, expanding and other operations gradually work-harden the brass.

Work-hardened brass becomes less ductile. Eventually, that can show up as cracking or splitting, particularly in areas that are repeatedly expanded and contracted.

The neck and shoulder are obvious examples.

This is one of the reasons annealing is used.

Annealing does not somehow make an old case new again. What it can do is restore a controlled amount of ductility to the neck and shoulder area.

We will deal with annealing properly later because it is a subject that is often oversimplified.

Brass Does Not Wear Evenly

Different areas of a case experience different stresses.

The neck may split. The shoulder may show signs of repeated working. The primer pocket may loosen. The body may develop a problem further down towards the head.

That means case inspection needs to consider more than one area.

A case can look perfect at the neck while developing a problem elsewhere.

That is why knowing the anatomy of the case matters. You need to know where to look.

Cases can increase in length through firing and sizing.

The exact amount depends on the cartridge, chamber, pressure and how the case is being resized.

That is why we measure case length and trim when necessary.

It is important not to confuse overall case growth with every other dimensional change taking place. The shoulder may move, the body may expand, the neck may change and the case mouth may move forward.

These changes are connected, but they are not all the same thing.

Later, when we discuss trimming and sizing in detail, we can separate them properly.

As we mentioned in Chapter 4, cases from different manufacturers can vary internally even when the outside dimensions are nominally the same.

This can affect weight, neck-wall thickness, internal volume and the way the brass responds to sizing.

Some brass is softer. Some is harder. Some may have very consistent neck walls, while other brass may vary more from case to case.

That doesn't automatically make one manufacturer good and another bad.

It simply means you need to understand the brass you are using.

This is one area where I would rather be over-cautious than casual.

A load developed with one brand of brass should not be assumed safe in another brand without reassessment.

Different makes of case can have different internal capacities, wall thicknesses and hardness. If the replacement brass has less internal volume, the same powder charge is operating under different conditions and pressure can increase.

That increase may be enough to matter.

For that reason, if I change to a different brand of brass, I treat it as a meaningful component change and go back to appropriate published data and redevelop the load rather than simply transferring the old charge straight across.

The same applies if the new brass is obviously different in construction or capacity, even where the cartridge designation is identical.

This is especially important with loads already operating towards the upper end of published data, because there may be less room for variation.

The practical rule is simple: change the brass, reassess the load from appropriate published data.

Do not assume that because the headstamp says the same cartridge, the internal conditions are the same.

Internal case capacity becomes important because the propellant does not burn in empty space that is identical from one case to another.

If one case has less internal volume than another, the same powder charge is operating under different conditions.

This is one reason changing brass can affect pressure and velocity.

A change in case capacity is also one of the reasons a load that behaved normally in one brand of brass may produce excessive pressure in another.

The difference may be small. It may also be enough to matter.

For more carefully controlled loading, measuring case capacity can be useful. Water capacity is a common method.

That doesn't mean every case in every batch needs to be individually measured. Again, the amount of work should match the purpose.

But understanding why capacity matters is important.

Case Weight

Reloaders sometimes sort cases by weight.

The idea is that weight variation may indicate variation in the amount of brass and, indirectly, variation in internal volume.

There can be some value in this, but it is not a perfect method.

Two cases can weigh the same and still distribute that brass differently. Likewise, a slightly heavier case does not tell you exactly how much less internal capacity it has.

Weight sorting is therefore a useful tool in some circumstances, but it should not be mistaken for a direct measurement of internal volume.

We will revisit this when we discuss case sorting and consistency.

Neck-wall thickness becomes increasingly important as we move towards more controlled neck sizing and neck tension.

If one side of the neck is noticeably thicker than the other, that can affect how the case behaves during sizing and how the projectile is held.

This is one reason neck turning exists.

It is not something every case needs.

With good-quality brass and ordinary chambers, neck turning may provide little practical benefit. With tight-neck chambers or ammunition prepared to a very high level of consistency, it can become much more relevant.

Neck turning and tightly controlled neck-tension work belong to the more advanced side of case preparation. They are useful techniques when there is a specific reason for them, not steps I would present as essential for a new reloader.

Again, the operation should have a reason behind it.

New brass, sometimes referred to as virgin brass, simply means brass that has never been fired. I prefer to call it new brass, and that is the term I will use throughout this book.

New brass is often very good, but I never assume that because it is new it is automatically ready to load. Case mouths can be dented during packaging or transit, necks can be slightly out of round and dimensions can vary slightly from case to case.

My own practice is to full-length size all new brass before its first loading.

I want every case in the batch to begin from the same controlled starting point rather than relying on the condition in which it happened to leave the factory or arrive in the box. Full-length sizing also gives me the opportunity to straighten necks and establish the brass in accordance with the sizing process I intend to use from then on.

There is an important difference between this first sizing operation and sizing brass after it has been fired in the firearm.

With new brass, I don't yet have a fired case from that chamber to use as a reference for measuring and controlling shoulder bump. Once the case has been fired, I have that reference and can set the subsequent sizing operation much more precisely to suit the particular chamber.

We will cover that process properly in the sizing chapters.

New brass may also receive other preparation depending on what I am loading it for. As with the rest of my case preparation, I prefer to establish a consistent batch from the beginning rather than discover variations later.

How much additional preparation is worthwhile depends on the intended use. For straightforward ammunition, relatively little may be required beyond inspection and establishing the basic dimensions. For precision ammunition, I may want the entire batch to begin from a considerably more controlled starting point.

The case-preparation and sizing chapters that follow show how I establish new brass as a controlled batch before its first firing.

Once-Fired Brass

Once-fired brass can be very useful, particularly when new cases are expensive or difficult to obtain.

It can also be an unknown quantity.

There is an important point worth making here: brass sold or described as “once-fired” has not necessarily only been fired once.

Unless I know its history, I treat the phrase once-fired as a description rather than a guarantee. It may genuinely have been fired only once, but there is not always a reliable way of proving that simply by looking at it.

If the brass comes from my own firearm and I know it was new before that firing, then I know exactly what I have.

Brass bought second-hand, collected from a range or obtained from another shooter is different.

I may not know how many times it has actually been fired, which firearm or firearms it has been used in, what pressures it has experienced, whether it has previously been resized, how heavily it has been worked or how it has been stored.

For that reason, thorough inspection of any used brass with an uncertain history is essential before I consider loading it.

I want to inspect the complete case rather than giving it a quick glance and assuming that a clean outside means it is sound.

That includes the case head and primer pocket, the body, shoulder, neck and mouth. I am looking for cracks, splits, unusual marks, damage, excessive working and any indication of thinning or stretching towards the case head.

Anything that makes me suspicious is enough reason to put that case aside rather than trying to persuade myself that it will probably be all right.

Used brass can still be perfectly serviceable. Some very good brass is reused successfully for many firings.

But the fact that brass was inexpensive, difficult to replace or advertised as once-fired is never a reason to overlook an uncertain history.

This is especially relevant because, as stated earlier in the book, I don't treat fired brass from one firearm as though it automatically belongs in another.

It needs to be properly inspected and prepared, and the load itself must be developed for the firearm in which it will actually be used.

We will look at exactly how to inspect fired and used brass in Chapter 7, including some of the less obvious problems that cannot always be spotted with a quick glance.

Mixed brass can be perfectly usable for some applications.

For others, it introduces unnecessary variation.

If I am producing ammunition where ultimate consistency is not the main objective, mixed brass may be acceptable provided everything is safe, properly prepared and suitable for the cartridge.

If I am developing precision ammunition, I want fewer unknowns.

I would normally keep manufacturer and preferably lot together.

This is one of those areas where the intended use determines how far I go.

I like cases to have an identity.

That may simply be a box of fifty cases that started life together.

I know how many times they have been fired, how they have been prepared and, if I anneal them, when that was done. If one begins behaving differently from the rest, I know which batch it belongs to.

That information becomes increasingly valuable over time.

The more carefully a load is developed, the more useful it is to know the history of the brass that formed part of it.

How Many Firings Will Brass Last?

This is one of those questions where people often want a number.

There is no reliable universal answer.

Case life depends on too many variables: cartridge design, pressure, chamber dimensions, how much the case is sized, how much the neck is worked, whether it is annealed, the quality of the brass and the individual firearm.

One person may get many firings from a particular case while another has a much shorter life from the same brand and cartridge.

That is why I prefer inspection and case history over relying on a fixed number.

A case does not become safe because it has only been fired five times, nor does it automatically become unsafe because it has been fired ten.

Condition matters.

There is no prize for achieving the highest possible number of reloads from one piece of brass.

When a case is no longer trustworthy, retire it.

Signs may include splits, cracks, loose primer pockets, suspicious thinning, unusual deformation or anything else indicating that the case is no longer behaving normally.

Some defects are obvious. Others require more careful inspection.

That is a subject worth treating separately because it sits at the start of every sensible reloading cycle.

The main lesson from this chapter is simple.

Brass is not a passive container.

It influences case capacity and the way the ammunition fits the chamber. Its neck helps control projectile release, its dimensions are changed by firing and sizing, and its condition changes with repeated use.

When the brass changes, the behaviour of the load can change with it.

That is why I want the case to be treated as a proper component rather than something we simply reuse until it splits.

Understand the brass and a great deal of reloading starts to make more sense.

The next step is inspection.

Before cleaning, trimming, annealing, sizing or doing anything more sophisticated, we need to decide whether the fired case is worth keeping in the first place.

Chapter 7 — Inspecting Fired Cases and Knowing When to Retire Them

Once a case has been fired, the first question is not how to clean it, trim it or size it. The first question is whether it is still worth using.

Case inspection should come before further preparation because there is little point spending time on brass that should already have been taken out of service.

Some problems are obvious. A split neck is easy to see and a badly damaged case mouth is hard to miss. Other problems are much less obvious and only become easier to recognise once you know what normal fired brass from a particular firearm looks like.

That is one reason I like to keep brass in known batches. If fifty cases have been through the same firearm and the same loading process, it becomes much easier to notice when one case looks or feels different from the rest.

The important habit is simple: inspect first, then prepare.

I don't begin by concentrating on one particular area. I look at the whole case first.

Is there anything obviously unusual? Has the case mouth been damaged? Is there a split in the neck? Is the shoulder distorted? Are there unusual marks on the body? Does the case head look different from the rest of the batch?

The more familiar you become with a particular batch of brass, the easier this becomes.

You are not necessarily looking for perfection. You are looking for change, particularly a change from what is normal for that brass and firearm.

A case does not need to be polished to a mirror finish before you can inspect it. It does, however, need to be clean enough that dirt, carbon or range debris are not hiding damage.

Heavy deposits can conceal fine cracks or marks. Likewise, a case covered in dirt after being picked up from the ground is not something I want anywhere near a sizing die before it has been cleaned sufficiently.

The purpose at this stage is visibility and protecting the equipment, not producing shiny brass.

We will compare the different cleaning methods properly in Chapter 8.

The case mouth is one of the easiest areas to damage.

It may be dented during extraction, ejection, handling or simply from being dropped. Small dents can often be corrected during the normal sizing and preparation process.

Severe damage is another matter.

If the mouth is badly crushed, torn or sharply folded, I don't automatically assume that because a die can force it back into shape the brass should still be used.

The question is whether the case remains sound.

A small dent is very different from brass that has been sharply creased or cracked.

Split necks are one of the more obvious signs that a case has reached the end of its useful life.

Repeated firing and sizing work the neck. Over time the brass can harden and eventually crack.

A split may begin as a tiny line at the case mouth and then extend further down the neck.

Once a neck has split, I retire the case. I don't regard it as something worth trying to repair.

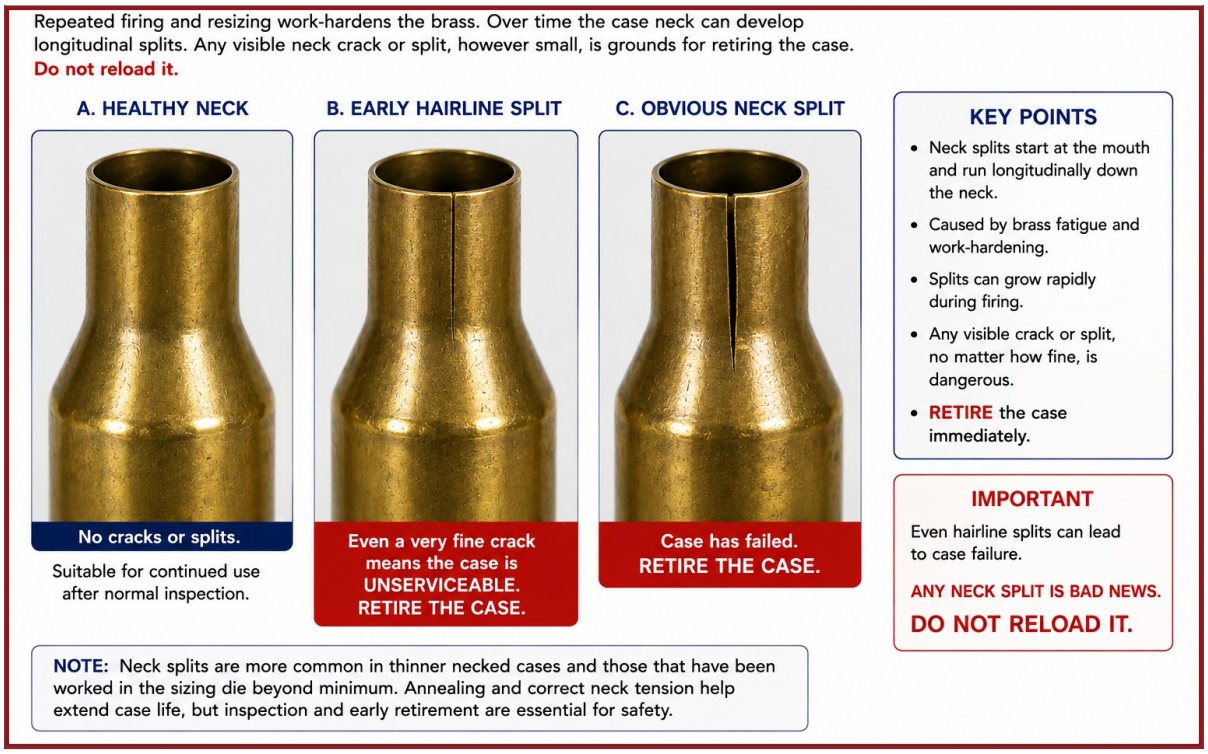


Figure 7.1 — *Case neck splits and brass fatigue. A sound neck is compared with early and obvious splitting; any cracked or split case should be retired.*

If several cases from the same batch begin splitting around the same time, that is useful information as well. It may indicate that the batch has reached a similar stage in its life or that the necks have been worked particularly hard.

This is also one of the areas where our later discussion about annealing becomes relevant.

Fine Neck Cracks

Not every failure begins with a dramatic open split.

Fine cracks can appear first, which is why good lighting matters. Rotating the case slowly under the light can reveal tiny lines that are easy to miss at first glance.

A small magnifier can also be useful if something looks suspicious.

If I am unsure whether a mark is simply cosmetic or the beginning of a crack, I would rather put that case aside and investigate it than try to persuade myself it is fine.

Brass is a consumable component.

The shoulder is another area worth checking.

You may see small dents or unusual marks. Some dents can be caused during sizing, particularly if too much lubricant has been used and lubricant becomes trapped between the case and die.

A lubricant dent is different from a crack. It may look ugly without necessarily meaning that the case is structurally unsafe, although it tells us something about our sizing and lubrication technique.

Cracks or obvious signs of failure around the shoulder are a different matter and deserve considerably more caution.

The useful skill is learning to distinguish a mark caused by the loading process from actual damage to the brass.

The body should be checked for dents, scratches, corrosion, unusual bulges and signs of thinning.

Light surface scratches are not automatically serious.

Deep scratches deserve more attention, particularly if they appear to have removed a meaningful amount of material from the case wall.

Likewise, severe dents or unusual bulges deserve investigation before the case is reused.

If I can't explain why a case looks significantly different from the rest of the batch, I stop and find out.

Brass can become stained or tarnished without being structurally damaged.

That is not the same as corrosion that has actually attacked the metal.

A dull or discoloured case is not automatically unsafe, just as a highly polished case is not automatically sound.

What concerns me is pitting or other evidence that material has actually been removed or badly affected.

If corrosion has eaten into the case wall, I don't use the case.

Condition matters more than appearance.

One of the most important areas to inspect is the lower part of the case body just above the case head.

This is where case stretching can eventually become a problem.

Repeated firing and sizing can move and work the brass, and in some circumstances the wall can begin to thin internally in this area. If that progresses far enough, the case can eventually separate.

This deserves considerably more respect than a simple neck split.

A neck split is normally local and readily visible. A case separation can leave part of the case in the chamber and indicates that a much more structurally important area of the case has failed.

Reloaders often talk about a bright ring appearing around the lower part of the case body.

A visible circumferential line can sometimes be associated with stretching and internal thinning, but I don't regard the appearance of a line on its own as a perfect diagnosis.

Harmless marks can sometimes look similar.

If I see a suspicious ring or line, I investigate further rather than deciding from its appearance alone.

What I want to establish is whether the case wall is actually thinning.

The Paperclip Test

One traditional method of checking for suspected internal thinning is the bent-paperclip test.

A small hook is formed on the end of a paperclip or similar piece of wire. With the case empty, the hook can be passed inside and drawn carefully along the internal wall.

If a groove or step has begun to develop internally, it may be possible to feel it.

It is a simple inspection technique rather than a precision measuring system, but it can be useful when something about a case makes me suspicious.

> **KEY PRINCIPLE**
> *If I can feel a definite internal groove near the case head that indicates significant thinning, I retire the case. There's no reason to try for one more firing.*

Incipient case-head separation is the term commonly used for the early stages of the case wall beginning to fail near the head.

Figure 7.2 — *Case-head separation viewed from inside the case. The sectioned cases show the lower case-wall/web region where internal thinning can develop before complete separation; external appearance alone may not reveal the full condition.*

This is something I take seriously.

The case may still be in one piece and may still chamber normally, but if the brass has thinned significantly in this area it is not something I want to continue using.

Possible warnings include a suspicious circumferential line, a detectable internal groove or a developing pattern of stretching within a batch.

The correct response is not to see how long it lasts.

Retire it.

If one case shows definite signs of this type of failure, I inspect the remainder of that batch particularly carefully.

Case stretching is connected with what happens during firing and sizing.

When the cartridge fires, the case expands against the chamber and the head is driven back against the bolt face or breech. The case has to accommodate the dimensional relationship between itself and the chamber.

What happens during sizing matters as well.

If we repeatedly push the shoulder back considerably further than necessary, the case may subsequently have to stretch further again when it is fired.

Repeated excessive sizing can therefore contribute to unnecessary working and stretching of the brass.

This is one reason I prefer controlled shoulder bump rather than simply pushing the shoulder back as far as possible every time.

We will cover this properly in the sizing chapters. For now, the important point is that the way we size brass can affect the way it ages.

Primer pockets also change over the life of a case.

A primer should seat with appropriate resistance. Once you have handled a known batch for some time, a primer that suddenly seats much more easily than the others is quite noticeable.

That gets my attention.

A significantly loose primer pocket can mean that the case has reached the end of its useful life.

Either way, I don't want a primer that is no longer being retained properly.

Once the pocket is too loose, the case is finished as far as I am concerned.

Various methods have been suggested over the years for tightening or reforming loose primer pockets.

For ordinary reloading, I don't see the value in trying to rescue them.

The case is a consumable component. If the primer pocket has become loose enough that I no longer trust it, I retire the case.

Trying to gain another firing from a questionable case is not worth it.

Primer Appearance

Fired primers can provide useful information, but they need to be interpreted carefully.

A primer that suddenly looks very different from the others in a known load deserves attention.

However, primer flattening on its own is not an accurate pressure gauge.

Primer construction and cup hardness vary. Firing-pin shape matters. The firing-pin aperture matters. The fit and movement of the case within the chamber can also affect what we see.

That's why I regard primer appearance as one part of the overall picture rather than a pressure measuring instrument.

If primer appearance changes at the same time as extraction becomes more difficult, velocity behaves unexpectedly or other case-head signs appear, then I have several reasons to stop and investigate.

A crater around the firing-pin strike is another feature frequently associated with pressure.

Again, it can be relevant, but it is not automatically proof of excessive chamber pressure.

Firing-pin diameter, firing-pin-hole clearance and the characteristics of the primer cup can all influence cratering.

What interests me particularly is change.

If cratering suddenly appears where it was not present before as a load changes, that deserves attention. If the firearm produces a similar appearance with ordinary factory ammunition, it may tell us more about the firing-pin arrangement than the particular reload.

Context matters.

A pierced primer is different.

If the firing pin has actually punctured the primer cup, I stop.

Hot gas can escape rearwards through the pierced primer and may damage the firing pin, bolt face or surrounding parts.

There are several possible causes, including pressure, primer choice and firing-pin geometry.

Whatever the cause, this is not something I simply carry on firing through.

It needs investigating.

A primer that appears to have moved backwards from the case head can also tell us something about what happened during firing and about the relationship between the case and chamber.

There can be several reasons for this appearance, so once again it should not be interpreted in isolation.

The useful question is whether it is normal for that firearm and ammunition or whether something has changed.

A change deserves investigation.

Marks from the ejector or extractor can appear on the case head.

Some firearms leave characteristic marks during completely normal operation.

Others leave very little.

A new or increasingly pronounced mark can sometimes accompany increased case-head load or difficult extraction, but once again the important thing is comparison.

If a firearm has always produced a light mark, that forms part of its normal pattern. If those marks suddenly become considerably heavier as the load changes, that is useful information.

The case itself is not the only thing I pay attention to.

I also want to know how it came out of the firearm.

If extraction suddenly becomes noticeably harder, that matters.

A bolt that becomes stiff to lift, a case that sticks or extraction that simply feels different from normal should not be ignored.

There can be more than one cause. Pressure is one possibility; case dimensions or chamber condition may be others.

Whatever the cause, a change in extraction deserves investigation before continuing.

Soot around the case neck or shoulder can occur when gas passes around the case before a complete seal is established.

A small amount of soot is not automatically a serious problem. It can occur with certain loads, chambers and case conditions.

Heavy or suddenly different sooting may be worth noting.

As with most of this chapter, I am interested in patterns and changes rather than trying to diagnose everything from a single mark.

Dents From Ejection

Some firearms are harder on brass than others.

An ejected case may strike part of the firearm and receive a dent. This is particularly common with some self-loading firearms.

A small dent may be corrected during preparation or disappear on a subsequent firing.

That doesn't mean every dent should be ignored.

If the case is badly crushed or sharply creased, I would rather retire it than assume that chamber pressure on the next firing will conveniently repair everything.

Brass from self-loading firearms often deserves careful inspection because extraction and ejection can be more energetic.

Chambers may also be dimensioned with reliable functioning in mind.

None of that automatically makes the brass unusable.

It simply means its history and condition deserve attention.

If I am dealing with used brass of uncertain origin, knowing whether it came from a self-loading firearm can be useful information.

Range-pickup brass is one of the clearest examples of unknown history.

You may know the cartridge and recognise the manufacturer, but you usually do not know how many times the case has been fired, what it was fired in or how it was previously loaded.

It may genuinely be once-fired factory brass.

It may not.

As we discussed in Chapter 6, I treat the phrase once-fired as a description unless I genuinely know the history.

That doesn't mean range brass cannot be used. It means I treat it as unknown brass and inspect it accordingly.

If there is doubt about its condition, it does not make it into the loading batch.

The headstamp provides useful information.

It can help identify the manufacturer and cartridge, although care still needs to be taken with cases that may have been formed or converted from another cartridge.

For ordinary brass, I also use the headstamp as part of keeping manufacturers and batches organised.

Mixed headstamps can mean mixed brass, and as we discussed in Chapter 6, different makes of case can have different capacities and construction.

Inspection is therefore also a useful opportunity to make sure the case you are holding actually belongs in the batch.

Case forming introduces another layer of inspection.

If a case has been converted from a parent cartridge, I want to know that.

Neck-wall thickness may have changed and the shoulder may have been substantially reformed. The headstamp may still identify the original parent cartridge rather than what the case has become.

That last point deserves particular care because an incorrect headstamp creates an obvious opportunity for confusion.

Case forming is a specialist subject rather than a main step in this book. The important point here is to know what brass you actually have, particularly when a case has been formed from a parent cartridge whose headstamp no longer describes the finished chambering.

I find it easier to inspect brass as a batch rather than casually picking up individual cases.

Lay the cases out and compare them.

Rotate them.

Look at the necks together, then the bodies and case heads.

A case that appears perfectly ordinary on its own can stand out immediately when placed beside forty-nine others from the same batch.

This is one of the advantages of keeping brass together throughout its life.

Consistency makes inconsistency easier to see.

We talked about lighting when setting up the loading bench, and this is one of the jobs where it proves its value.

Fine neck cracks, suspicious rings and changes around the case head are much easier to see under good, even lighting.

I also like to be able to move the case relative to the light. Sometimes a crack or surface defect only becomes obvious as the case is rotated.

A small hand magnifier is inexpensive and useful when something does not look quite right.

Feel Is Useful

Do not rely entirely on your eyes.

Run your fingers over the case.

A ridge, dent or scratch may be easier to feel than see. A primer pocket may feel different during depriming or subsequent priming. Internal thinning may sometimes be detected with the paperclip method described earlier.

Reloading is a surprisingly tactile process.

Learning how normal brass feels is useful.

Some cases are expensive.

Some are difficult to replace.

That can understandably make us reluctant to retire them.

But the price of the case does not change its condition.

If the brass has reached the end of its useful life, it has reached the end of its useful life.

Trying to rescue questionable brass because it was expensive does not make it stronger.

When one case develops a problem, I inspect the rest of the batch carefully.

Sometimes it is simply one damaged case.

Sometimes it is the first indication that several cases are approaching the same stage of wear.

If one neck splits after a large number of firings, look closely at the other necks. If one case shows signs of thinning near the head, check the rest. If several primer pockets begin becoming loose, I want to know why.

The history of the batch matters.

Case failures can provide useful information.

If a batch consistently begins splitting necks after a particular pattern of use, I want to know that.

If primer pockets become loose unusually quickly, that is worth recording.

If a particular sizing setup appears to shorten case life, that is useful information too.

Reloading records should not contain only successful loads.

Failures and wear patterns can teach us a great deal.

There are some conditions where I don't see much reason for debate: a split case, a significant crack, a primer pocket that no longer retains a primer properly, definite internal thinning associated with developing case-head separation, serious corrosion or pitting, or major structural damage.

I also retire a case if its condition leaves me genuinely uncertain about whether it is sound.

There's no need to turn every discarded case into an engineering investigation.

Sometimes the sensible answer is simply to replace it.

Other issues are less serious.

A slightly dented case mouth may be corrected. Minor cosmetic staining may be irrelevant. A small lubricant dent in the shoulder may not represent structural damage. Minor ejection marks may simply be normal for that firearm.

The important distinction is between something that looks imperfect and something that has become structurally questionable.

That judgement develops with experience, but caution is a good starting point.

This is probably the easiest rule in the chapter to remember.

If I inspect a case and am genuinely unsure whether it is suitable to use, I put it aside.

I can always examine it more closely later or compare it with another case.

What I don't do is load it simply because I have already prepared the rest of the batch and do not want to be one case short.

The loading bench is not the place to let inconvenience make a safety decision.

Inspection Does Not End Here

We inspect brass now because this is the first point at which unsuitable cases should be removed.

That doesn't mean this is the only inspection they receive.

A case may reveal something during cleaning. Something may feel wrong during preparation or sizing. A primer may seat differently. A finished cartridge may simply not look right.

Inspection continues throughout the loading process.

The first inspection prevents us wasting time on brass that should already have been retired.

Once I am satisfied that the brass is worth keeping, it can move into the preparation process.

The objective is not simply to produce the shiniest brass possible. It is to produce clean, inspectable cases that are ready for the preparation work that follows.

Chapter 8 — Depriming and Cleaning Cartridge Cases

Once I have inspected the fired cases and decided they are worth keeping, the next job is to remove the spent primers and clean the brass.

I deliberately put depriming before cleaning, because that is the order I use myself.

There are other perfectly workable ways of organising case preparation, and throughout the book I will explain alternatives where they are worth knowing. But I also want to be clear about what I actually do rather than presenting every possible method as though I use them all.

I always deprime my fired cases before cleaning them.

For me, it is the logical starting point. It gets the spent primer out of the case, exposes the primer pocket and flash hole for cleaning and allows me to deal with the dirty fired case without performing the main sizing operation.

Once the primers are out, I can clean the brass properly and inspect it again before moving on to the more detailed case-preparation work.

Removing the spent primer before cleaning has several advantages.

The most obvious is that the primer pocket is open during cleaning. If I wet tumble or use an ultrasonic cleaner, the cleaning solution can reach the pocket and flash hole rather than having the spent primer sitting in the way.

It also means I'm not carrying a fired primer through the rest of the case-preparation process.

There is another reason that matters to me just as much. At this point I want to deprime the case, not size it.

Those are two separate operations in the way I prepare my brass.

Many conventional sizing dies will perform both jobs at once, and there is nothing inherently wrong with that. It simply is not how I prefer to organise the process.

Most conventional full-length sizing dies contain a decapping pin. As the case enters the die, the body and neck are sized, the shoulder is affected according to the die setup and the spent primer is pushed out.

That allows several things to happen in one operation. For my own case preparation, I prefer to separate them.

At this stage I haven't yet reached the point where I want to perform the main sizing operation. I simply want the spent primer removed.

There is also a practical reason for keeping the two operations separate. I don't want dirty fired brass unnecessarily passing through my good sizing dies.

Carbon is one thing, but grit, dirt and other abrasive contamination are quite another. A small piece of grit caught between the case and a close-fitting sizing die can mark the brass and potentially scratch the die. A dedicated depriming operation avoids that.

A universal or dedicated decapping die is ideal for this job. Unlike a normal sizing die, its main purpose is simply to push the spent primer out. It doesn't normally resize the body, shoulder and neck to the cartridge dimensions.

That means I can put a batch of fired cases through the press, remove all the spent primers and leave the main dimensional preparation until later.

There are simple universal decapping dies and considerably more specialised systems available. For this particular job, complicated does not automatically mean better. What I want is a tool that removes the primer reliably without altering the case unnecessarily.

Hand Depriming Tools

A loading press is not the only way of doing it. Dedicated hand-operated depriming tools are also available, and some are extremely convenient.

They allow cases to be deprimed away from the loading press, and many collect the spent primers in a container rather than allowing them to fall around the bench.

For someone working through modest batches of brass, a hand tool can be perfectly adequate. For larger quantities, a press-mounted decapping die may be quicker. Neither method automatically produces better ammunition. It is simply a matter of choosing a tool that makes the operation easy and repeatable.

Depriming is a simple operation, but I still pay attention to how each case behaves. If one case requires noticeably more force than the others, I stop. I don't simply pull harder on the press handle.

There may be a reason. The case may have a different primer arrangement. The decapping pin may not be correctly aligned. The flash hole may be unusually small or off-centre. The case may have been modified, or it may simply not belong with the rest of the batch.

This is particularly important with second-hand brass or cases whose history is uncertain. As we discussed in the previous chapters, the fact that a case is described as once-fired does not prove that it has only been fired once, nor does it tell us everything about its previous use. Unfamiliar brass deserves a little more attention.

Most metallic cartridge cases commonly reloaded use Boxer primers. A Boxer-primed case normally has a single central flash hole, while the anvil is incorporated into the primer itself.

Berdan-primed cases use a different arrangement. The anvil is normally part of the case itself, with flash holes positioned differently. A normal Boxer decapping pin is therefore not something I simply force into a Berdan-primed case.

If something does not feel right, stop and find out why. Broken decapping pins are irritating. More importantly, forcing something when you do not understand why it is resisting is a bad habit to develop anywhere in reloading.

Even amongst Boxer-primed cases, flash-hole dimensions are not always identical. Some brass uses smaller flash holes than the more common sizes, and a standard decapping pin may be too large.

This is particularly worth remembering when using unfamiliar or specialist brass. Trying to force an oversized pin through a smaller flash hole can damage the pin, the case or both. If something suddenly requires much more force than the other cases, stop and inspect it.

Once removed, spent primers need somewhere to go. Many presses and dedicated depriming tools have some form of collection system. I use it rather than allowing spent primers to scatter around the bench and floor.

Fired primers and dirty cases carry combustion residue, and I treat that residue sensibly. I keep the working area clean, dispose of spent primers appropriately and wash my hands after handling dirty fired components and cleaning media. Food and drink stay away from the loading area.

With the spent primers removed, I can clean the cases. Cleaning brass is one of those subjects where it is very easy to turn a straightforward job into a hobby of its own.

There are dry tumblers, wet tumblers, ultrasonic cleaners, stainless-steel pins, different grades of media and a considerable range of cleaning products. All of them have their uses.

But I think it is worth remembering why we are doing the job in the first place. I want brass that is free from harmful dirt and contamination, easy to inspect and suitable for the preparation operations that follow. I'm not trying to produce jewellery.

Why Clean Cases?

Fired brass normally carries carbon and combustion residue. Depending on where it has been used, it may also have dust, mud, grit, moisture, oil or other contamination on it.

Some surface staining is largely irrelevant. Grit is not. I don't want abrasive material passing through dies or being carried onto measuring and preparation equipment.

Cleaning also helps inspection. A fine crack, suspicious line or area of corrosion can be considerably easier to see once the case has been cleaned. Cases should continue to be observed throughout preparation.

There is nothing wrong with wanting bright brass. A freshly cleaned batch of cases looks good, and some cleaning methods can make used brass look almost new.

Figure 8.1 — *Cleaned case at left and an uncleaned case at right, showing the difference that cleaning can make before inspection and further preparation.*

But the appearance of a case tells us very little about the quality of the ammunition we eventually make from it. A mirror-polished case can still have poor dimensional consistency, a loose primer pocket or developing internal thinning. Equally, a slightly dull case can be perfectly sound and produce excellent ammunition.

I would rather spend my time making the brass consistent than endlessly polishing it. For me, the objective is clean brass, not jewellery. If it comes out looking particularly good as well, that is a bonus.

Dry tumbling remains one of the simplest and most established ways of cleaning cartridge cases. The cases are placed in a vibrating or rotary tumbler containing dry cleaning media. Crushed walnut shell and corn cob are two of the most commonly used materials.

Figure 8.2 — *Dry tumbling cartridge cases in cleaning media. The objective is clean, inspectable brass rather than cosmetic perfection.*

As the cases move through the media, dirt and tarnish are gradually removed from their surfaces. Dry tumbling is relatively inexpensive, straightforward to use and capable of handling useful quantities of brass. For ordinary case cleaning, it works very well.

Crushed walnut tends to be the more aggressive of the commonly used dry media. It is useful for cases carrying heavier surface contamination or tarnish.

Different grades are available, and particle size matters. Media that is unnecessarily coarse can become lodged in small case mouths and other openings.

The media also becomes dirty with use. Carbon, dirt and other residue gradually accumulate in it, and its cleaning performance eventually deteriorates. At that point I would rather replace it than continually add more polish to media that is already heavily contaminated.

Corn cob tends to be associated more with polishing. It can produce a very attractive finish, particularly on brass that is already reasonably clean.

Again, the size of the media matters. Large pieces becoming wedged in small-calibre case mouths create an unnecessary job afterwards.

Some reloaders use walnut first to clean the cases and then corn cob to polish them. That certainly works. For most of my own loading, however, I don't see much reason to carry out two separate tumbling operations simply to achieve a brighter finish. Once the brass is properly clean, I am ready to move on.

Various additives can be used with dry tumbling media. They may improve the finish and sometimes speed up the cleaning process.

If I use an additive, I prefer a product intended for cartridge-case cleaning. I don't like experimenting with household metal cleaners without knowing exactly what they contain.

In particular, I avoid unsuitable ammonia-containing cleaners on cartridge brass. Brass is a copper alloy, and ammonia can contribute to stress-corrosion cracking under certain conditions. There are plenty of products specifically intended for cartridge cases, so there is little reason to improvise.

Check the Flash Holes

Because I deprime before cleaning, dry media can find its way into the primer pocket and flash hole. A piece of walnut or corn cob can occasionally become lodged there.

This is not difficult to deal with, but it needs checking. After dry tumbling, I make sure the flash holes are clear before the cases continue through preparation. A blocked flash hole is an entirely avoidable problem.

Dry tumbling can produce dust. That dust contains whatever has been removed from the fired cases, including combustion and primer residue.

I therefore do not want clouds of it around the loading area. I keep the tumbler covered during operation and take reasonable care when separating cases from the media. Used media should also be handled sensibly and replaced when necessary.

As with the spent primers, I wash my hands after handling dirty cases and media. Good reloading practice includes what happens around the ammunition as well as what happens inside it.

Wet tumbling has become extremely popular, and the results can be impressive. Cases are placed in a rotary drum with water and a suitable cleaning solution. Stainless-steel pins are often added to provide additional mechanical cleaning, although they are not essential.

Because I have already deprimed the brass, water and cleaning solution can reach the primer pockets and flash holes as well as the external surfaces. With stainless pins, the internal surfaces and primer pockets can become remarkably clean.

If you want thoroughly cleaned brass, wet tumbling is difficult to beat. It does, however, introduce something that dry tumbling does not: water. And that means drying becomes an important part of the process.

Stainless pins scrub the cases mechanically as the drum rotates. They can clean inside the cases and around the primer pockets extremely effectively.

But every pin that goes into the tumbler needs to come back out again. Pins can remain inside bottleneck cases or occasionally become lodged.

After tumbling, I separate the pins carefully and make sure every case is empty. I don't assume that because most of the pins are sitting in the separator, none remain in the brass. A quick check now prevents a completely unnecessary problem later.

Stainless pins are not compulsory. Water and an appropriate cleaning solution can still clean cases very effectively without them.

Some reloaders prefer this because it makes separation easier and removes any possibility of leaving a pin inside a case. The primer pockets and internal surfaces may not become quite as spotless. Whether that matters depends on what you are trying to achieve.

There are numerous cleaning solutions available for wet tumbling. Whichever product or established method is used, follow an appropriate concentration rather than assuming more chemical must mean cleaner brass.

Too much cleaning agent can create excessive foam or leave residues, and overly aggressive or prolonged chemical treatment serves no useful purpose. The objective is to remove contamination without unnecessarily attacking the brass.

After wet cleaning, I rinse the cases thoroughly. Because the spent primers have already been removed, water can pass through the primer pocket and flash hole as well as through the case mouth.

That helps with cleaning, but it also means water can remain in places that are not immediately obvious. A case can look dry on the outside while still containing moisture.

Drying Wet-Cleaned Cases

The cases must be completely dry before they move towards priming and loading. I don't compromise on that.

Moisture around a primer pocket is unwanted. Moisture inside a case that will eventually contain propellant is equally unwanted.

Cases can be air-dried in a warm, dry environment or dried with equipment intended for the purpose. Whichever method I use, I give the cases enough time. If I am uncertain whether the inside of the brass is completely dry, it gets longer.

Controlled warmth can speed the drying process. The important word is controlled. The objective is simply to evaporate water.

Drying brass and annealing brass are completely different operations. I don't expose cases to excessive heat merely to save a little time. A proper case dryer or another suitable low-temperature method is preferable to improvising with unnecessarily high temperatures.

Ultrasonic cleaners provide another effective method. They use high-frequency sound waves in a liquid to create microscopic cavitation, which helps lift contamination from immersed surfaces.

In practical terms, an ultrasonic cleaner can reach places that are difficult to clean mechanically. Because the primers have already been removed, the solution can reach the primer pockets as well.

Ultrasonic cleaning can be particularly useful for smaller batches. Capacity can be more limited than some tumbling systems, and the cases still need to be properly rinsed and completely dried afterwards. It is another good method rather than automatically the best method.

More cleaning does not automatically produce better brass. Leaving cases in cleaning chemicals for far longer than necessary achieves little and may eventually do more harm than good.

Repeatedly running brass through cleaning cycles simply because it is not quite shiny enough is largely cosmetic. Once my brass is sufficiently clean to inspect and prepare properly, the cleaning stage has done its job.

You do not actually need a tumbler to reload ammunition. For small quantities, cases can be cleaned individually by hand.

A suitable cloth can remove external dirt and carbon, and individual areas can be dealt with as necessary. Obviously this becomes time-consuming with hundreds of cases, which is where powered cleaning equipment earns its place.

But it is worth remembering that convenience and necessity are not the same thing. Reloading equipment has a habit of multiplying. Not every tool you can buy is something you need before you can produce good ammunition.

Carbon accumulates inside the case neck during firing. How much of it should be removed is a subject on which reloaders have different opinions.

Heavy contamination obviously needs attention. What I don't automatically assume is that every neck must be polished back to perfectly bright brass after every firing.

The condition of the inside neck surface can influence the friction between the case neck and projectile. For that reason, consistency is more useful than aggressively cleaning some cases while barely touching others. We will return to the inside of the neck when we deal properly with neck preparation and neck tension.

One advantage of depriming first is that the primer pockets are exposed during cleaning. Wet tumbling and ultrasonic cleaning can leave them extremely clean.

Dry tumbling may remove some contamination but can also leave pieces of media around the pocket or flash hole, which is why I check them afterwards.

Do primer pockets need to be absolutely spotless after every firing? Not necessarily. There is a difference between cleaning a primer pocket and carrying out precision work on one. We will deal with primer-pocket cleaning, uniforming and flash-hole preparation separately.

Cleaning Does Not Repair Brass

A tumbler can make a bad case look beautiful. It cannot make it sound.

Cleaning does not repair a split neck. It doesn't tighten a loose primer pocket. It doesn't replace brass lost through corrosion, and it certainly does not repair internal thinning near the case head.

This is worth remembering because freshly wet-tumbled brass can look almost new. Appearance can be deceptive. Clean is not the same as sound.

Once the brass is clean, I look at it again. The initial inspection removed obvious failures before I spent any more time on them. Cleaning can now reveal things that were previously hidden.

A fine crack may be easier to see. A suspicious ring near the case head may stand out more clearly. What appeared to be simple staining may reveal pitting underneath.

If cleaning exposes something I don't like, that case leaves the batch. Inspection is not a single event performed once and forgotten. I continue looking at the brass throughout preparation.

Cleaning is also one of the easiest points at which carefully organised brass can accidentally become mixed. Two containers of the same cartridge sitting beside a tumbler can very quickly become one batch.

I keep my cases identifiable. If I am processing more than one batch, they stay in separate, labelled containers.

I want to know which manufacturer and lot they belong to, how many firings they have had where appropriate and which firearm they are being prepared for. The history of a case is useful information.

Cleaning equipment itself eventually becomes dirty. Dry media fills with carbon and residue. Wet-tumbling water becomes filthy. Ultrasonic solution becomes contaminated. Drums and separators accumulate dirt.

These things need cleaning or replacing periodically. Otherwise we eventually reach the slightly ridiculous position of trying to clean brass with heavily contaminated cleaning equipment. Good housekeeping makes the whole process easier.

At this stage, my normal process is straightforward:

Inspect the fired brass → deprime → clean → dry completely if a wet process has been used → inspect again.

Only then do I move further into the detailed case-preparation operations.

I like separating the jobs because each stage has a clear purpose. Depriming removes the spent primer without unnecessarily sizing the dirty case. Cleaning removes contamination. Drying makes wet-cleaned cases suitable for further preparation. The second inspection takes advantage of the now-clean surface to catch anything I may not have seen initially.

None of those operations is particularly complicated. The important part is doing them consistently.

Once the cases are deprimed, cleaned, completely dry where necessary and inspected again, we can begin the more detailed case preparation.

We will also look at chamfering and deburring, including why the internal chamfer helps guide the projectile into the case neck during seating.

Chapter 9 — Case Length, Trimming, Chamfering and Deburring

Once the cases have been inspected, deprimed, cleaned, dried where necessary and inspected again, I can start dealing with the dimensions of the brass itself. One of the first things I look at is case length.

Case trimming is a simple operation in principle. Measure the case, decide whether it needs attention and, if it does, remove a small amount of brass from the mouth until the case reaches the length you have chosen. What makes the subject more interesting is understanding why cases change length, when trimming is actually necessary and what needs to be done to the mouth afterwards.

This is also one of the places where my own procedure differs from the sequence commonly shown in some manuals. I prefer to carry out my case preparation, including trimming to length, before the main sizing operation. That is the order that suits the way I work. Other reloaders trim after sizing, and there are perfectly understandable reasons for doing so. I will explain my approach here without pretending it is the only method that can work.

What matters most is that the finished case remains within the correct dimensional limits, that the case mouth is properly finished and that the process is repeatable from one case to the next.

When we talk about case length, we are normally referring to the distance from the case head to the case mouth. On a bottleneck case this is different from measurements involving the shoulder, neck diameter or loaded cartridge overall length. Those dimensions may influence one another during firing and sizing, but they are not the same measurement.

That distinction matters because it is easy to say that a case has 'grown' without being clear about which part of it has changed. The shoulder may have moved forward during firing, the body may have expanded and the case mouth may also have moved. Measuring case length tells us one specific thing: where the mouth now sits in relation to the case head.

Brass is moved and worked every time a cartridge is fired and subsequently prepared. During firing the case expands to the chamber. During sizing the case is reshaped again. Material can be displaced as those operations take place, and over repeated cycles the case may become longer.

The amount of change varies. Cartridge design matters, chamber dimensions matter, pressure matters and the way the case is sized matters. Some batches need trimming relatively often. Others may go several firings with very little change.

That's why I prefer measurement to routine for routine's sake. I don't trim a case merely because somebody says every case must be trimmed after every firing. I measure the batch and decide what it actually needs.

Cartridge specifications provide a maximum case length. That maximum is a limit, not a target that I try to hit exactly.

When trimming is required, I will usually use a known trim length for that calibre from reliable current loading or cartridge information. That published dimension is my normal starting point rather than a number invented from memory.

If a recognised trim length is not available, my alternative is to pull around twenty representative cases from the batch and measure their complete case length. I identify the shortest sound case in that sample and use that as the working batch length, provided it remains within the correct cartridge specification.

I then trim the remainder of that batch to the same length. This gives the batch a uniform case length while keeping the published cartridge limits as the dimensional authority. The full trimming sequence is set out later in this chapter.

Why Excessive Case Length Matters

A case that becomes too long is not merely untidy. The mouth of the case has to fit into the chamber with appropriate clearance.

If a case is allowed to exceed the permitted length, the mouth may reach too far into the chamber neck or throat area. That can interfere with the way the case mouth releases the projectile and can create an undesirable pressure situation.

That is why case length is a safety-related measurement as well as a consistency measurement. A case does not have to look dramatically overlong to deserve checking. We measure it because our eyes are not a reliable substitute for a dimensional specification.

A good set of callipers is perfectly suitable for ordinary case-length measurement.

Figure 9.1 — *Measuring overall case length from the case head to the case mouth with callipers.*

The case needs to be clean, and the head and mouth should be free from anything that prevents the jaws contacting them properly. I close the jaws squarely rather than holding the case at an angle and trying to persuade the display to give me the number I expected.

Consistency of technique matters. If you use different pressure on the calliper jaws or hold the case differently each time, you can create variation in the measurement that came from your hands rather than the brass.

When checking a batch, I normally measure enough cases to understand what the batch is doing. If the cases are close to the limit or I am preparing precision ammunition, I may measure every one. The amount of checking should reflect how close the brass is to requiring attention and the level of consistency I am trying to achieve.

It is important, however, to understand the consequence of doing it this way. Sizing can alter case dimensions, including case length. For that reason I don't assume that a case trimmed before sizing can never need checking again. After sizing, I re-check the dimensions that matter. If the finished sized case does not remain within the correct specification, it gets corrected before it is loaded.

Many reloaders prefer to size first and then trim because the sizing operation can change the case length and they want to establish the final length afterwards. That method is perfectly understandable. My preference is different, but the requirement at the end is the same: the case must be correctly dimensioned before it becomes loaded ammunition.

I also check new brass rather than assuming that every case in a new box is identical.

I full-length size all new brass before its first loading. Before I get to that sizing operation, however, I inspect and measure the brass as part of the preparation process. If I am standardising the batch and trimming is required, I do that as part of the case preparation and then carry out my normal full-length sizing.

Because new brass has not yet been fired in the firearm, it does not provide the fired-case reference that we will later use for controlled shoulder-bump measurements. The first preparation is therefore about establishing a sound, consistent starting batch. After sizing, I still check the dimensions that matter rather than assuming the earlier preparation removed the need to measure again.

Choosing a Trimmer

There are many ways to trim cases, from simple hand-operated tools to powered systems capable of processing large batches very quickly.

The basic purpose is the same in every case: hold or reference the case consistently, present the mouth squarely to the cutter and remove enough material to reach the chosen length.

Figure 9.2 — *A cartridge case correctly held in a case trimmer with the mouth presented squarely to the cutter.*

For small quantities, a simple manual trimmer can do an excellent job. For someone preparing hundreds of cases regularly, powered equipment can save a considerable amount of time.

Speed is useful, but repeatability matters more to me. A trimmer that is slightly slower but gives me a consistent length is more valuable than a fast system whose setting wanders.

Different trimmers establish their reference in different ways. Traditional lathe-style trimmers commonly hold the case by the head and use a pilot or similar arrangement to support the mouth and cutter alignment. Other systems reference from the shoulder and are designed to trim quickly once adjusted for a particular case.

Neither idea is automatically superior in every application. The important thing is understanding what surface the tool is referencing and therefore what dimension it is actually controlling.

Shoulder-referencing trimmers can be particularly quick with batches of consistently prepared bottleneck cases, but their result depends on the shoulder position presented to the tool. Because I carry out my trimming before the main sizing operation, I pay particular attention to this point: fired cases can present different shoulder positions, so a shoulder-referenced trim result may not translate into exactly the same head-to-mouth length from case to case. Case-head-referenced systems use a different datum and are less dependent on shoulder position at that stage. This distinction becomes more meaningful once we start measuring shoulder position properly in the later sizing chapters.

Many trimming systems use a pilot, collet, shell holder or dedicated case holder to locate the case.

The parts need to suit the cartridge. A pilot that is badly matched to the neck can make the operation awkward, while a case holder that does not grip consistently can introduce variation.

As with dies and shell holders, I don't choose something simply because it seems close enough. I use the correct component for the brass and trimmer.

The first case in a batch deserves more attention than the fiftieth.

I set the trimmer cautiously, remove a small amount of material and measure the result. If adjustment is needed, I make it gradually until the case is where I want it.

Only once I am satisfied with that setting do I process the rest of the batch.

This is another example of why measuring equipment belongs beside the preparation tools rather than in a drawer across the room. A trimmer setting is not something I establish by appearance.

Trimming is a cutting operation. Once brass has been removed from the mouth, it is gone.

There is therefore no advantage in cutting a case excessively short simply to guarantee that it will not need trimming again for a long time. The cartridge specification exists for a reason.

I remove what is necessary to bring the batch to the chosen dimension and no more.

Keeping a Batch Consistent

For precision loading, one of the main attractions of trimming is not merely preventing cases becoming too long. It allows the mouths of a batch to begin from the same length.

That gives me a more consistent starting point for the neck and case mouth. It is particularly useful if later operations depend on the mouth or neck geometry being similar from case to case.

For ordinary ammunition, there is little value in obsessing over microscopic differences that cannot influence the use of the cartridge. For precision ammunition, reducing unnecessary variation can be worthwhile. The amount of work should always match the purpose.

Once a case has been trimmed, the job is not finished.

The cutter leaves a fresh edge at the mouth. Depending on the tool and cut, that edge may be sharp both inside and outside.

That is why trimming is normally followed by chamfering and deburring.

These are small operations, but they directly affect the condition of the case mouth that will later guide and hold the projectile.

Chamfering removes the sharp internal edge and creates a controlled lead-in at the mouth of the case.

That lead-in is useful when we eventually seat the projectile. Instead of the base of the projectile meeting a sharp square edge, the chamfer helps guide it into the neck.

This can make seating smoother and can reduce the chance of the case mouth scraping or shaving material from the projectile as it enters.

That is particularly relevant with some flat-base projectiles, where there is less of a natural taper at the rear to help the projectile find its way into the neck.

The chamfer does not need to be dramatic. I am creating a neat lead-in, not trying to turn half the neck into a funnel.

Chamfer tools are available with different cutting angles, and precision tools are sometimes marketed specifically for VLD-style projectiles.

The exact angle can influence how the projectile base enters the neck, but this is another area where the tool should be chosen for a reason rather than because a more specialised name automatically means better ammunition.

For most general loading, a good conventional chamfer applied consistently is entirely satisfactory. If I am working with particular projectile designs or a more specialised precision process, a different chamfer geometry may be useful. We do not need to turn that into a compulsory operation for everyone.

The outside edge of the freshly trimmed mouth also needs attention.

Deburring removes the sharp outer edge and any small burrs left by the cutter. The aim is a clean, even case mouth without loose or raised material around the circumference.

Figure 9.3 — *A case with a combined chamfer/deburring tool. These operations finish the inside and outside edges of the mouth after trimming.*

Again, very little metal needs to be removed. Heavy-handed deburring can alter the mouth far more than necessary.

I want the edge clean, not aggressively bevelled.

Hand chamfering and deburring are simple operations, but they are easy to overdo because there is very little resistance.

A few controlled turns are generally far better than leaning heavily on the tool. If every case is treated differently, the finished mouths will also be different.

Powered preparation centres make the job faster, but the same principle applies. Set the tool properly and use a consistent presentation and amount of contact.

Powered Case-Preparation Centres

A case-preparation centre can make trimming, chamfering and deburring much quicker, particularly with large batches.

Some machines combine several operations, while others provide powered stations for individual tools.

This is one of those places where paying for equipment may primarily be paying for time rather than dramatically better ammunition. A good hand tool can produce an excellent case mouth. The powered system simply lets you produce the same result more efficiently when the quantity justifies it.

Trimming, chamfering and deburring produce small brass shavings.

I don't want those left in the case or around the loading bench. After the mouth preparation is complete, I make sure the case is free of loose material before it moves on.

A quick brush, tap or other appropriate cleaning step is all that is normally required. The important part is simply not forgetting it.

Once the case is trimmed, chamfered and deburred, I look at the mouth.

It should be even, clean and free from obvious burrs. The internal chamfer should look consistent around the circumference rather than heavily cut on one side and barely touched on the other.

If the result looks uneven, I want to know why. It may be the way I held the tool, the trimmer setup or the case mouth itself.

A good trimmer should leave the mouth reasonably square to the case axis.

If the cutter is badly aligned or the case is not held consistently, one side of the mouth can end up longer than the other. That is not the controlled starting point I am trying to create.

This is another reason I value a repeatable tool setup over sheer trimming speed.

Because I perform this case-length preparation before the main sizing operation, I make a point of checking case length and the other relevant dimensions again once sizing has been completed. Sizing can change the final length, so the pre-sizing trim never removes the need for that later check.

This is important. My preferred order of operations does not override the dimensional requirements of the cartridge.

If sizing has changed a case enough that the length is no longer acceptable, I correct it before the case progresses to loaded ammunition.

That simple re-check is what allows me to use the preparation sequence I prefer without pretending that sizing has no effect on case dimensions.

Most trimming problems are fairly ordinary. The case has not been seated consistently in the holder. The trimmer setting has moved. The cutter is dull. Measurements are being taken inconsistently. The operator has decided that more cutting must somehow be better.

None of these requires a complicated solution.

Set the equipment carefully, measure the first cases, check periodically through the batch and stop if the results begin to change.

Good preparation is usually much more about repeatability than cleverness.

One final terminology point is worth making because the two measurements are very different.

Case length is the dimension of the empty case from head to mouth. Cartridge overall length, usually shortened to COAL, is a measurement of the assembled cartridge and includes the seated projectile.

Trimming changes the case length. Projectile seating establishes the dimensions of the finished cartridge.

We will deal with COAL, base-to-ogive measurement and seating depth in detail later. For now, keeping the two ideas separate avoids a great deal of confusion.

My Practical Trimming and Mouth-Preparation Sequence

For a normal batch I measure a representative sample first. My usual method is to measure around twenty cases, identify the shortest sound case in that batch, and use that as the practical trim reference provided it remains within the correct dimensional limits for the cartridge.

I set the trimmer on a setup case, cut lightly, remove the case and measure it. I adjust the trimmer until the result is where I want it, then trim the batch with the case located in the holder the same way each time. I re-measure the first few cases and spot-check periodically rather than assuming the setting cannot move.

After trimming I apply a light, even internal chamfer to guide the projectile during seating, then remove the external burr. I am looking for a clean, square mouth rather than a deep bevel. I clear away loose brass shavings and inspect the mouth before the case moves on.

Because this is my preferred pre-sizing preparation sequence, I check case length again after sizing. If sizing has moved a case outside the acceptable dimensional limit, I correct it before loading.

What I Want at the End of This Stage

At the end of the trimming and mouth-preparation stage, I want a batch of cases that is clean, sound and consistently prepared.

Where trimming was required, the cases should be at the chosen length. The mouths should be neatly chamfered and deburred. There should be no loose cutting debris, and any case that revealed a defect during the work should already have been removed.

I am then ready to move further into the preparation of the case itself.

The next areas to consider are the primer pocket and flash hole.

As throughout the book, the objective will be to understand what the operation changes before deciding whether it belongs in the process.

Chapter 10 — Primer Pockets and Flash Holes

Once the brass has been inspected, deprimed, cleaned and the earlier case-preparation work completed, there are two relatively small areas that deserve attention: the primer pocket and flash hole.

They may occupy very little of the cartridge case, but they sit at the beginning of the ignition process. The primer needs to be held securely and seated consistently, while the flash hole provides the route through which the primer flame and hot gases reach the propellant.

My approach here follows the same principle I use throughout case preparation. If primer-pocket preparation is part of the job, I prepare every case in the batch. I don't pick out only the pockets that look different. The aim is to establish the same controlled starting point across the whole batch.

The primer pocket is formed into the head of the cartridge case and holds the primer. It needs to retain that primer securely and provide a consistent surface against which the primer can be seated.

A primer should not fall into the pocket with virtually no resistance, but neither should normal seating require unreasonable force. Once you have worked with a known batch of brass for some time, differences become quite noticeable. If forty-nine primers seat with a similar feel and the fiftieth feels completely different, I want to know why.

There may be contamination in the pocket, a remaining crimp, a case mixed into the batch from somewhere else, or the primer pocket may have become enlarged. Once a primer pocket is loose enough that I no longer trust it to retain a primer correctly, I retire the case. Primer-pocket preparation is about producing consistency in sound brass; it is not a method of repairing worn-out cases.

Primer pockets are manufactured to dimensional standards, but the dimensions are not identical for every primer system. The following figures are useful approximate references for common Boxer-primed centrefire pockets; the applicable component and tool specifications should always take precedence.

Primer pocket	Approx. diameter	Approx. depth
Small Rifle / Small Pistol	0.173–0.1745 in 4.39–4.43 mm	0.117–0.123 in 2.97–3.12 mm
Large Rifle	0.2085–0.210 in 5.30–5.33 mm	0.125–0.132 in 3.18–3.35 mm
Large Pistol	0.2085–0.210 in 5.30–5.33 mm	0.117–0.123 in 2.97–3.12 mm

The difference between large rifle and large pistol pockets is particularly worth noticing. Their diameters are broadly similar, but the large rifle system uses a deeper pocket and a correspondingly taller primer. That is one reason I use the correct primer-pocket tool for the pocket being prepared rather than assuming that anything described as a large primer system is dimensionally identical.

Primer-pocket depth affects where the primer ultimately sits in relation to the case head, the pocket floor and the flash hole. A correctly seated primer will normally finish slightly below the case head, but simply being below flush is not the whole story.

I want the primer properly seated against the bottom of the primer pocket.

That is the important reference. The objective is not merely to push the primer far enough into the case that it looks right from the outside. It needs to be fully home in the pocket.

The flash hole sits immediately beneath the primer pocket and provides the route through which the primer flame and hot gases enter the case. I want the primer fully seated against the pocket floor, in the position intended in relation to the flash hole, rather than sitting unnecessarily high in the pocket.

We are not trying to push the primer into the flash hole. The primer remains seated in its pocket. The point is the consistent relationship between primer, pocket floor and flash-hole entrance.

That relationship is one of the reasons I pay attention to pocket depth and why I uniform every primer pocket in the batch.

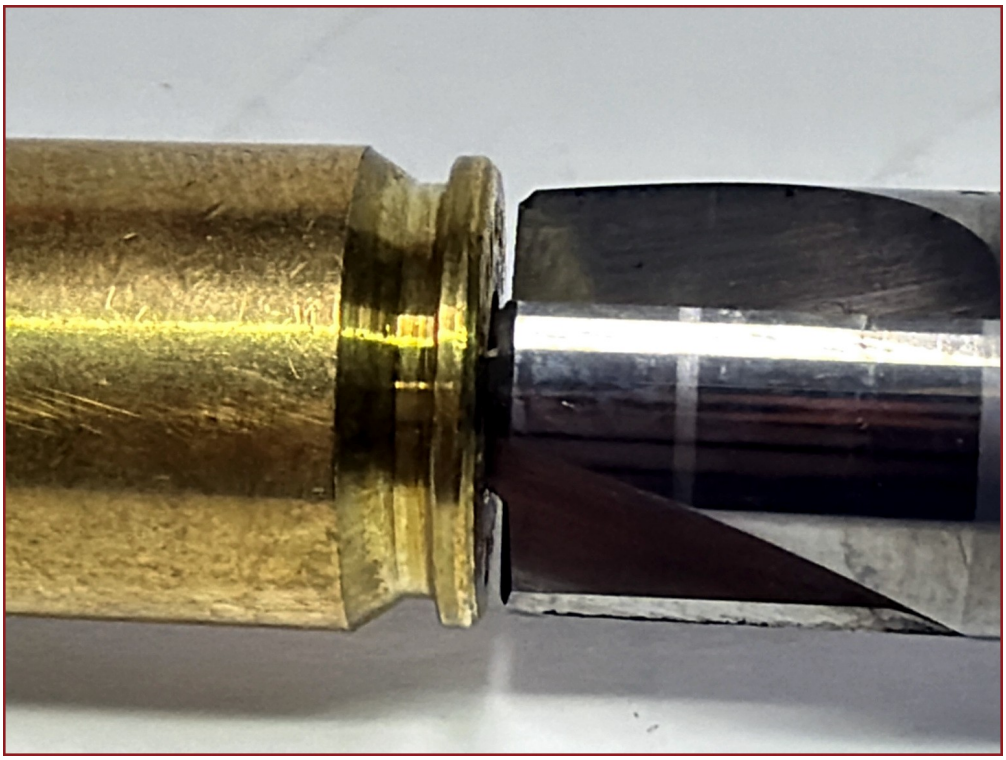


Figure 10.1 — *Primer-pocket uniforming/cleaning tool correctly located in the primer pocket.*

I Uniform Every Primer Pocket

Primer-pocket uniforming is an operation I carry out on every case in the batch. I don't visually select the pockets that appear to need it. If I am preparing fifty cases, all fifty go through the same operation.

A primer-pocket uniformer establishes a controlled depth and seating surface at the bottom of the pocket. When I first prepare a batch, some pockets may produce a noticeable amount of cut material while others may produce almost none. That doesn't concern me. It simply shows that the cases did not necessarily begin in precisely the same condition.

The objective is not to make the cutter remove brass from every case. The objective is to establish a common reference across every case.

There is an important distinction between uniforming a primer pocket and subsequently cleaning it. When I initially uniform the pocket, I am establishing its seating surface and controlled depth. I don't expect to remove a significant new amount of brass every time that case is subsequently fired.

Once the pocket has been correctly uniformed, its geometry has already been established. On later preparation, an appropriate tool may remove carbon or residue from the bottom of the pocket while removing little or no additional brass. If I found myself continually cutting significant amounts of brass from an already-uniformed pocket, I would want to understand why.

Primer-pocket uniforming must not be confused with repairing an enlarged primer pocket. It cannot do that. If repeated use, excessive pressure or another cause has enlarged the pocket sufficiently that the primer is no longer securely retained, cutting the bottom of the pocket will not restore that fit.

Once a primer pocket becomes too loose for me to trust, the case is finished. I don't try to squeeze, peen or otherwise rescue it for another firing. Brass is a consumable component.

Primer residue accumulates in the pocket during firing. How much remains at this stage depends partly on the cleaning method. Because I deprime before cleaning, wet tumbling and ultrasonic cleaning can already do a very effective job of cleaning the primer pockets. Dry tumbling may leave more residue.

Either way, I inspect the pockets. Once a pocket has been uniformed, an appropriate uniforming tool can also provide a consistent method of removing residue from its bottom during later preparation without intentionally deepening the pocket further. The objective is a clean, sound and consistent seating surface.

A primer pocket does not have to be polished to bright bare brass to work correctly. A little staining is not the same thing as contamination that interferes with primer seating. I am much more interested in the dimensions and condition of the pocket than its colour.

Small rifle and small pistol primers are broadly similar in external diameter, and the corresponding pockets share similar basic dimensions. That doesn't mean the primers should simply be regarded as interchangeable.

Primer construction, cup characteristics and ignition characteristics can differ. The fact that a primer physically fits into a pocket is not sufficient reason to substitute it for another type. Primer choice should be based on appropriate published load data and the requirements of the cartridge and firearm.

Large Rifle and Large Pistol Primer Pockets

The difference between large rifle and large pistol systems deserves particular attention. Their diameters are broadly similar, but their pocket depths differ, and large rifle primers are correspondingly taller than large pistol primers.

A component can therefore appear to be approximately the correct diameter while still being the wrong primer for the pocket. Correct components matter.

Some cases, particularly military and service-type brass, may have the primer secured by a crimp or staking operation. After the spent primer is removed, part of that crimp can remain around the entrance to the primer pocket and interfere with seating a replacement primer.

The crimp therefore needs to be dealt with before the case can be reprimed normally. Two common methods are reaming and swaging.

Reaming cuts away the material causing the obstruction. Done correctly, it creates sufficient clearance for the replacement primer to enter the pocket normally. The important thing is to remove only what is necessary. The purpose is not to enlarge the entire primer pocket.

Swaging takes a different approach. Rather than cutting away the crimp, the tool reforms the affected area using pressure. Press-mounted and dedicated bench swaging tools are available, and for larger quantities of crimped brass this can be a particularly efficient method.

Neither method automatically produces more accurate ammunition. The purpose is simply to remove the obstruction while preserving a suitable primer pocket.

If I have a batch of crimped cases, I process the batch systematically. I don't want to discover halfway through priming that several cases still have their original crimps. Complete the operation across the batch and check the result before moving on.

Once you work regularly with a consistent batch of brass, primer seating begins to have a recognisable feel. If case after case behaves similarly and then one feels dramatically different, I stop and look at it.

There may be debris in the pocket, a crimp may have been missed, the pocket may be damaged, the case may not belong in the batch, or the pocket may be becoming loose. The difference is useful information.

SAFETY WHEN PRIMING

Wear safety glasses whenever you are priming cases.
Primers contain an impact-sensitive compound and should always be handled with care. When hand priming, keep the priming tool and case pointed away from your face and body. With tray- or tube-fed systems, avoid positioning your face directly over the primer supply or feed mechanism.
Use smooth, controlled pressure when seating a primer. If one suddenly feels unusually tight, starts crooked or does not feed correctly, stop and find the cause rather than trying to force it into place.
Always follow the instructions supplied with your particular priming tool.

If a primer does not seat normally, I stop. More leverage is not my first solution. There may still be a crimp, the primer may be the wrong size or type, there may be contamination in the pocket, the primer may have entered at an angle, or something may be wrong with the case.

Find the cause. Unexpected resistance is information, not an invitation to pull harder on the handle.

When we eventually install the primer, I want it fully seated against the bottom of the pocket. It will normally end up slightly below the case head, but the fact that it is below flush is not, by itself, what tells me it has been seated correctly.

The important reference is the pocket floor. I want the primer seated properly down in the pocket, close to the flash-hole entrance, in the position intended by the primer and case design. This is where the earlier pocket preparation begins to make sense.

With the primer-pocket work kept together, we can now move to the second part of this chapter: the flash hole. The flash hole provides the connection between the primer pocket and the inside of the cartridge case. When the primer initiates, the flame and hot gases pass through the flash hole and begin ignition of the propellant.

In the Boxer-primed cases most commonly encountered in metallic-cartridge reloading, there is normally a single central flash hole. Berdan-primed cases use a different arrangement, as discussed earlier in the book.

Flash Holes Are Not All the Same Size

Figure 10.2 — *Flash-hole deburring tool viewed from the case-head end; the cutter is visible through the flash hole.*

Flash-hole dimensions vary between case designs and manufacturers. Some brass uses smaller flash holes than others. This matters when selecting decapping pins and flash-hole preparation tools.

A tool that works perfectly with one type of case may be unsuitable for another. If a decapping pin or preparation tool does not fit normally, I don't force it. I establish what I actually have first.

The method used to produce a flash hole can affect its finished appearance. Some manufacturing processes can leave a small burr around the internal edge of the hole, while other methods produce a very clean hole with little or no significant internal burr.

A burr does not automatically make a case unsafe or unusable. Even so, flash-hole preparation is part of my automatic initial case preparation, so I deburr the flash hole on every case in the batch rather than selecting only the ones that appear worst.

A flash-hole deburring tool is designed to remove unwanted burrs from around the internal edge of the flash hole. The objective is exactly what the name suggests: deburring. I'm not trying to drill the flash hole unnecessarily larger.

I carry out this operation on every case during the initial preparation of the batch. I don't select only the handful that appear worst and leave the others untouched; the whole batch receives the same flash-hole preparation.

A manufacturing burr does not grow back after firing. Once the flash hole has been properly deburred, there should normally be no reason to repeat the cutting operation every loading cycle. Every cutting operation removes brass, and once the required material has been removed, continuing to cut serves no useful purpose.

A good flash-hole deburring tool provides some means of controlling the cut. That may involve a stop or another reference that limits how far the cutter can work. This matters because I am trying to remove a burr, not produce a large countersink inside the case.

Set the tool correctly and allow it to perform the operation for which it was designed. Extra pressure does not make the result more precise.

Flash-hole deburring and deliberately enlarging a flash hole are different operations. I don't casually drill flash holes larger because somebody claims a particular diameter will improve ignition.

Changing the flash-hole diameter is a permanent modification to part of the primer and case ignition system. There are specialised applications in which experienced reloaders deliberately control flash-hole dimensions, but that is different from unnecessary enlargement during ordinary preparation.

New brass gives us the opportunity to establish a preparation standard before the first firing. As explained earlier, I full-length size all my new brass before its first loading. New does not necessarily mean every dimensional feature of every case is exactly the same.

Primer-pocket uniforming and flash-hole preparation are therefore both part of establishing my own starting condition. I carry out both operations on every case in the batch. Once those initial operations have been completed, I know how the cases were prepared from the beginning.

High-quality cartridge brass can be remarkably consistent straight from the manufacturer, but I don't prepare only inexpensive brass while assuming that expensive brass should automatically bypass the process.

I still uniform every primer pocket in the batch. With particularly consistent brass, the uniforming tool may barely touch some pockets. That is perfectly acceptable. I am establishing that every pocket has been presented to the same controlled reference, not trying to force the cutter to remove material.

My Practical Primer-Pocket and Flash-Hole Sequence

On a new batch I first confirm that the uniforming and flash-hole tools are the correct type and size for the case. I set the primer-pocket uniformer to its controlled depth and work each pocket squarely, allowing the cutter to establish the reference rather than forcing it deeper.

I then use the correct flash-hole deburring tool from the direction intended by its manufacturer. The cutter removes the internal manufacturing burr; I stop when the controlled cut is complete. I am not trying to enlarge the flash hole or create a deep countersink.

I inspect the first few cases carefully, then process the rest of the batch with the same settings. These are normally one-time preparation operations: once the pocket has been uniformed and the flash-hole burr removed correctly, I do not keep recutting them every firing cycle.

Do Not Mix Differently Prepared Cases

Once I have established a preparation standard for a batch, I preserve it. If fifty cases have had their primer pockets uniformed and their flash holes prepared, I don't casually add another ten cases that have not received the same preparation and regard them as one batch.

They may have the same headstamp, but they do not have the same preparation history. If additional cases are going to join the batch, I want them brought to the same preparation standard first. Otherwise I keep them separate.

There is an important distinction here. I automatically uniform every primer pocket and prepare every flash hole during the initial preparation of a batch. That doesn't mean I believe precision reloading is achieved by performing every operation for which somebody manufactures a tool.

The distinction is between deciding whether an operation has a purpose and performing that operation consistently once the decision has been made. Primer-pocket uniforming is part of my normal case preparation, so every case receives it. Other operations may depend on the brass and what I am trying to achieve.

We cannot make every cartridge case absolutely identical. Manufacturing tolerances exist, internal capacities vary and brass changes as it is fired and worked. What we can do is remove unnecessary variables.

We can keep batches together, use the same equipment and settings, apply the same preparation to every case, inspect the results and record what has happened to the brass. Primer pockets and flash holes are small details, but they are another opportunity to establish that consistency.

With the primer pockets and flash holes prepared, we can move on to a very different part of case preparation: annealing.

Every time cartridge brass is fired and mechanically worked, changes occur in the material. Those changes are particularly relevant around the neck and shoulder, where repeated expansion and sizing can progressively work-harden the brass.

Chapter 11 — Annealing: What, Why and When

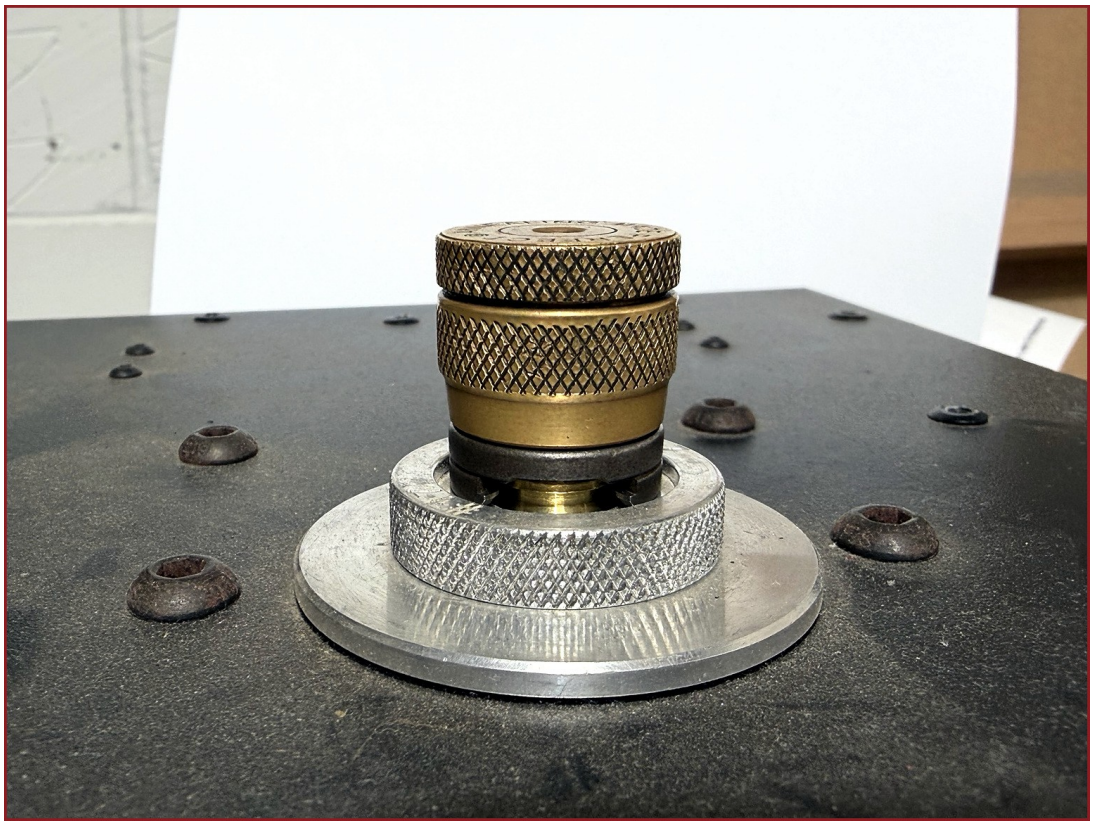


Figure 11.1 — *A practical annealing setup with the case positioned for controlled treatment of the neck and shoulder region.*

By this point the cases have been inspected, deprimed, cleaned and the basic preparation work has begun. The next subject is one that has become increasingly common on reloading benches over the last few years: annealing.

Annealing is also one of those subjects that can become unnecessarily mysterious.

At its simplest, we are trying to control what repeated firing and mechanical working have done to the brass, particularly around the neck and shoulder.

Every time the case is fired, the neck expands. Every time it is sized, it is moved again. Depending on the loading method, the neck may then be expanded or worked again by an expander, mandrel or other tool.

Brass tolerates this remarkably well, but repeated deformation gradually changes its properties. This is known as work-hardening.

Annealing, when carried out correctly, allows us to restore a controlled amount of ductility to the area of the case that has been repeatedly worked.

For me, however, annealing is not simply about trying to make cases last forever. The more interesting reason is consistency.

Cartridge brass is deliberately capable of being deformed. When the cartridge is fired, pressure causes the case to expand against the chamber. The neck expands to release the projectile, and during the subsequent preparation process the brass is reshaped again.

Each time the brass is plastically deformed, its internal structure changes. As this happens repeatedly, the material becomes harder and less ductile.

Eventually, sufficiently work-hardened brass may begin to crack. The most familiar example is a split neck.

But long before a neck actually splits, changes in hardness may influence the way it behaves during sizing and how consistently it grips and releases the projectile. That is why annealing can be relevant before brass reaches the point of visible failure.

Annealing does not turn an old cartridge case back into a new one.

It cannot repair a loose primer pocket, replace material lost through corrosion, repair thinning near the case head, reverse a developing case-head separation or repair a crack that has already formed.

Annealing deals primarily with the metallurgical condition of the brass in the area being treated. If the case is structurally worn out elsewhere, annealing will not save it.

That is why all the inspection work from Chapter 7 still matters.

When reloaders anneal bottleneck cartridge brass, we are interested primarily in the neck and shoulder area. Those are the parts of the case that are repeatedly expanded and resized and where controlled changes in hardness can be useful.

The case head is completely different. I don't want to soften the case head.

The head and web need to retain the strength they were manufactured to have because they form part of the case structure that contains pressure and is supported by the firearm.

That distinction is fundamental to safe annealing: anneal the appropriate neck-and-shoulder area; do not deliberately soften the case head.

That is why proper annealing equipment and controlled technique matter.

There are two commonly discussed reasons for annealing: extending case life and improving consistency.

Both can be relevant, but consistency is the reason that interests me most.

If I have a batch of cases that I am trying to keep as uniform as reasonably possible, I don't want some necks behaving noticeably harder than others. I want them to respond to the sizing and preparation process in a repeatable way.

A properly controlled annealing process can help keep the neck and shoulder metallurgy more consistent from case to case and from one loading cycle to the next.

Extending useful neck life can be a welcome consequence, but I don't regard case longevity as the only reason for doing it.

Annealing and Neck Tension

This is one area where annealing begins to connect with subjects we will cover much more deeply later.

The force required to size, expand and ultimately release a projectile from the case neck is influenced by more than one thing. Case-neck dimensions matter. Neck-wall thickness matters. The sizing method matters. The projectile diameter matters. Surface condition matters. And the physical condition of the brass matters.

If the hardness of the necks varies considerably across a batch, that introduces another variable. Annealing is one way of controlling that variable.

This doesn't mean annealing on its own gives us perfect neck tension. It is one part of a much larger system. We will deal with neck-tension control later in the normal loading sequence.

Brass does not simply remain at every dimension to which it is pushed. There is a degree of elastic recovery, normally referred to as springback.

The metallurgical condition of the brass influences how it responds when it is sized. This is another reason differently hardened cases can behave slightly differently even when they have all been passed through the same die.

For precision work, reducing those differences can be worthwhile. Again, this is not about chasing an imaginary state in which every case is absolutely identical. It is about reducing unnecessary variables.

This is one of the questions that produces a great many different answers.

Some reloaders anneal only when the brass begins showing signs of hardening. Others anneal after a set number of firings. Precision reloaders may anneal much more frequently so that every loading cycle begins with the brass in as consistent a condition as they can reasonably achieve.

My preference is based on consistency of process, rather than waiting for the brass to tell me it is already badly hardened.

If annealing forms part of the preparation routine for a particular batch, I want that batch treated consistently. What I don't like is annealing a few cases because they happen to feel different and then mixing them back into a larger batch that has not received the same treatment.

That simply creates two different preparation histories.

This follows the same principle we used in Chapter 10.

If I decide to anneal a batch, I anneal the batch.

I am trying to establish consistency. Selecting individual cases because one neck feels a little harder defeats much of that purpose.

There may obviously be exceptional situations where an individual case is being investigated, but as a normal preparation method I want every case in that batch treated in the same manner.

Consistency comes from repeating a controlled process.

New brass creates an interesting question: should it be annealed before its first loading?

There is no single answer that applies to every manufacturer and every loading method. New cartridge brass has already undergone manufacturing processes that establish its final mechanical properties, and many high-quality manufacturers supply very consistent neck and shoulder condition.

My own concern is not to perform an operation simply because the machine is sitting on the bench. If new brass is going to be annealed as part of a controlled precision process, I want to understand why I am doing it and what I am trying to standardise.

As with primer-pocket and flash-hole preparation, the important thing is having a deliberate process rather than adding operations for appearance.

The Visible Anneal Mark

Figure 11.2 — *Before-and-after annealing comparison: untreated case at left and annealed case at right. Colour alone is not proof of correct annealing.*

Some new cartridge cases show obvious heat discolouration around the neck and shoulder. Others arrive polished and show very little.

The presence or absence of a visible anneal mark does not, by itself, tell us everything about the metallurgical condition of the case. A manufacturer may leave the heat staining visible or remove it during subsequent finishing.

I therefore do not judge the quality of new brass simply by whether I can see coloured marks around the shoulder. The appearance is not the important part. The condition of the material is.

Flame annealing is probably the traditional method most reloaders recognise.

The case neck and shoulder are exposed to a controlled flame for a repeatable period while the rest of the case is kept away from unnecessary heating.

There are very simple hand-operated methods and sophisticated automatic machines that rotate and feed cases through the process.

Flame annealing can work very well. Its challenge is control.

Flame position, gas supply, case dimensions, exposure time and the consistency with which the case is presented to the flame can all influence the result.

For occasional general-purpose work, a simple arrangement may be sufficient. For more demanding precision work, repeatability becomes increasingly important.

Many flame systems rotate the case while it is being heated. The reason is straightforward: we are trying to distribute the heating around the circumference rather than concentrate it on one side of the neck.

Again, the exact method depends on the equipment. The important principle is even heating of the intended area without unnecessarily heating the lower part of the case.

Automatic flame annealing machines improve repeatability by controlling how the case is presented to the flame.

Depending on the design, they may regulate rotation, case feed and exposure. This removes some of the variation that can occur when every case is held by hand.

They can also make processing large batches considerably faster.

The machine, however, does not remove the need to understand what you are trying to achieve. A repeatable incorrect setup is still an incorrect setup.

Follow the equipment manufacturer's procedure for the case being processed.

SAFETY: Anneal empty cartridge cases only. Cases must contain no live primer, propellant or other ammunition component before annealing.

The Salt-Water Bath Method

Before dedicated annealing machines became commonplace, one traditional method involved standing cartridge cases upright in a shallow tray containing salt water, with the liquid covering the lower portion of the case while leaving the neck and shoulder exposed.

The exposed neck and shoulder were then heated with a flame.

The idea was straightforward: the water acted as a heat sink around the lower case and helped limit heat travelling towards the case head.

Salt was sometimes added as part of traditional versions of the method, which is why older reloading literature may refer specifically to a salt-water bath.

The important part of the method was not that the case needed to be quenched in order to make the brass soft.

Cartridge brass does not respond to quenching in the same way as heat-treated carbon steel.

The water was principally serving as a heat sink for the lower case while the exposed neck and shoulder were treated.

The principle was therefore the same one that matters with modern annealing equipment: heat the neck and shoulder in a controlled way while avoiding unnecessary heating of the body, web and case head.

Limitations of the Salt-Water Method

The salt-water bath method can work, and many reloaders used variations of it successfully for years.

Its weakness compared with good modern equipment is repeatability.

The operator still has to control flame position, exposure time and the amount of heat received by each case. Standing every case in the same depth of water does not automatically make the treatment of every neck identical.

That matters particularly for precision case preparation, where I want the first case in the batch treated as similarly as reasonably possible to the last.

Modern controlled flame machines and induction systems make that consistency easier to achieve.

The salt itself does not make the annealing process more precise.

If a traditional salt-water method is used, the cases should be thoroughly rinsed and dried afterwards so that salt residue is not left on or in the brass.

Chloride contamination and cartridge brass are not things I want left together in storage.

This is one reason plain-water variations are also encountered.

Induction annealing uses an electromagnetic field rather than an open flame to heat the brass.

This allows energy to be applied quickly and with a high degree of control.

Modern induction systems have become popular with precision reloaders partly because they can produce a repeatable process without the variations associated with flame shape or gas pressure.

They are generally more expensive than a simple flame setup, but they can offer excellent consistency.

As always, more expensive does not automatically mean better ammunition. The advantage is the ability to control and repeat the process.

It is easy to talk about induction annealing as though buying the machine solves the entire problem. It doesn't.

The equipment still needs to be configured appropriately for the cartridge case. Different case sizes, brass construction and neck-and-shoulder geometry can require different treatment.

The manufacturer's procedure and validated settings matter.

What induction gives us is a particularly repeatable way of applying energy. The user still needs to use it correctly.

Temperature-indicating products are sometimes used with flame annealing as an aid to setup.

These materials are designed to respond when a particular temperature range has been reached and can therefore help establish how a setup is behaving.

Used properly, they can be useful during calibration or verification. They should be used according to their manufacturer's instructions.

I would much rather rely on a controlled and repeatable method than try to judge annealing purely by eye.

One of the traditional approaches has been to watch the brass change colour in a darkened room.

I don't regard this as a particularly satisfactory way of controlling a precision process.

The apparent colour of heated metal depends on lighting conditions and the observer, and by the time obvious visible glowing is present the process may already be far beyond what was intended.

Likewise, the decorative blue, purple and gold oxide colours that can appear after heating are not a precision measurement of the brass condition.

Colour is not a substitute for process control.

Annealing is useful precisely because heating changes the mechanical condition of the brass.

Too much heating can therefore produce the wrong condition.

The objective is not to make the neck as soft as physically possible. We want controlled ductility while retaining appropriate mechanical properties.

Excessive annealing can leave the treated area softer than intended.

More heat is not better. Longer exposure is not better. The correct process is the one that achieves the desired result repeatably.

The Case Head Must Remain Hard

This deserves repeating because it is one of the most important safety principles in this chapter.

Do not intentionally anneal the case head or web.

The case head is not an area where I am trying to restore ductility. It needs to retain appropriate strength.

If a method causes significant uncontrolled heating to migrate down into the case head, that is not a process I am prepared to use.

That is why proper annealing procedures concentrate the heat at the neck and shoulder and control both the amount and duration of energy applied.

A traditional image of annealing often involves heating brass and dropping it into water. The salt-water bath method discussed above is one reason readers may encounter this in older descriptions.

It is important not to confuse the cooling step with steel heat treatment.

Rapid water quenching is not required to harden or soften cartridge brass in the way quenching is used during heat treatment of some steels.

In older case-annealing methods, water was commonly used for convenience and to limit heat migration into the lower case. The water itself is not what creates the desired annealed condition.

Understanding that prevents a lot of confusion.

For cartridge brass, the critical part of the process is the controlled thermal treatment rather than achieving a steel-like quench.

Depending on the equipment and method, cases may be allowed to cool naturally or handled according to the manufacturer's instructions.

I follow the procedure intended for the annealing system I am using rather than inventing an extra cooling stage because I have seen it used somewhere else.

Again, process control matters more than tradition.

I prefer annealing clean cases.

There are practical reasons. Heavy carbon, oil, cleaning compound or other contaminants on the neck can make the heating process less predictable and can create smoke or residue.

Clean cases are also easier to inspect.

We have already put considerable effort into establishing that the brass is sound. There is no advantage in covering the annealing equipment with dirt that should have been removed earlier.

Case sizing lubricants and annealing do not need to occupy the same stage.

This fits naturally with the way I prepare brass because annealing takes place as part of the case preparation before the main sizing operation.

I want the cases clean and free from unnecessary oil or lubricant before they enter the annealer. The sizing lubricant belongs with the sizing operation later.

Separating operations keeps things simpler.

Reloaders use both sequences, and there are arguments around each.

My own procedure is to anneal before the main sizing operation.

That means the sizing die is working brass that has first been brought to the controlled condition I want.

I find that a logical sequence because the resizing operation then follows the annealing rather than annealing a neck whose final sized dimensions have already been established.

This is my method rather than a claim that nobody can successfully use another sequence. The important thing is that the process is understood and kept consistent.

If annealing changes the way the brass responds to deformation, I want that treatment established before I ask the sizing die to reshape the case.

That allows the subsequent sizing operation to work on brass that is in the intended condition.

Again, the key word is consistent. If one case is annealed after sizing, another before sizing and another not at all, we have created differences in preparation history that serve no useful purpose.

I want the same sequence for the whole batch.

Annealing and Shoulder Bump

Later, when we set shoulder bump carefully, the way the brass responds to the sizing die becomes important.

Springback can influence the final dimension we measure after the case comes out of the die. The metallurgical condition of the shoulder and neck can therefore form part of the consistency of that operation.

This is another reason annealing and sizing should not be thought of as completely unrelated subjects.

We will explore this properly when we reach the sizing and headspace chapters.

Annealing can extend the useful life of the neck and shoulder by reducing the progressive effects of work-hardening.

That can delay neck splitting and may help maintain more consistent behaviour over repeated loading cycles.

But case life is controlled by more than the neck.

A case may still reach the end of its useful life because of loose primer pockets, thinning near the head, corrosion or another problem that annealing cannot repair.

That's why I don't describe annealing as a method of making brass last indefinitely. It is not.

There is no single annealing frequency that every reloader must follow, but my own routine is quite specific. With my controlled AMP induction annealer I normally anneal the brass every time I reload the cases, before the main sizing operation. The repeatability of the induction system is what makes that routine practical for me.

If I were using a gas-flame annealer, I would approach the frequency more conservatively and anneal as little as necessary, because flame systems depend much more heavily on careful setup and control. Whatever system is used, I follow the equipment manufacturer's procedure and keep the treatment consistent across the batch.

That distinction matters: 'anneal every firing' describes my normal controlled induction routine, not a universal instruction that every case on every bench must be heated on every loading cycle.

Once annealing is part of a batch-preparation routine, I want it done at the same point in the cycle rather than randomly.

I am interested in repeatability: clean brass, controlled annealing, then the final sizing and neck-tension operations.

The equipment and method therefore determine how I apply the frequency, but the sequence remains consistent.

A basic flame setup can be inexpensive. Automatic flame systems cost more. Induction machines can represent a significant investment.

Whether that investment makes sense depends on the ammunition you are producing.

Someone loading a small amount of general sporting ammunition may see little benefit from an expensive automated system. Someone processing hundreds of precision cases repeatedly may find the consistency and speed extremely valuable.

Like the press, scale and trimmer, the annealer should match the job.

If I am keeping a case history, annealing belongs in that history.

I want to know when the batch was annealed. For carefully controlled ammunition, I may also want to know which process or equipment was used.

This becomes particularly useful if something changes later.

If a batch suddenly behaves differently, the preparation record gives me something concrete to investigate rather than forcing me to rely on memory.

Good records turn assumptions into information.

Annealing Does Not Replace Inspection

A freshly annealed case is not automatically a good case.

I still inspect it.

If I discover a crack, loose pocket, corrosion or evidence of dangerous thinning, the fact that I have just annealed the case does not give it another life.

One of the easiest traps in reloading is allowing the amount of work already invested in a case to influence whether we are willing to discard it.

The case does not care how much time we spent preparing it. If it is finished, it is finished.

If there is one idea running through the previous few chapters, it is consistency.

We keep brass in batches. We inspect it in batches. We prepare primer pockets consistently. We prepare flash holes consistently. And if annealing forms part of our process, we anneal consistently.

None of this guarantees a perfect cartridge. It simply removes avoidable differences.

That is what good case preparation is really about.

Neck turning is not required for most normal reloading, but some reloaders may choose it for improved neck-wall uniformity and some tight-neck or formed-case applications may require it. If I am going to neck turn a batch, I treat it as a case-preparation operation and complete it before my final sizing and neck-tension work. The detailed turning technique is covered later in the advanced precision section.

Annealing prepares the neck and shoulder metallurgically for the mechanical work that follows. Now we need to actually resize the case.

I will also explain why full-length sizing is my normal approach, why I'm not particularly fond of neck-only sizing, and where bushing dies fit into more precision-oriented loading.

We will introduce the sizing principles there as part of the normal loading sequence. The more specialised case-sorting and neck-turning work remains in the advanced section, while runout and concentricity are dealt with where they naturally arise during sizing, neck preparation and seating.

Chapter 12 — Case Lubrication: Products, Methods and Correct Application

By the time I reach lubrication, all the case-preparation work I intend to carry out before sizing has already been completed.

The cases have been inspected, deprimed and cleaned. Primer pockets and flash holes have been dealt with, the appropriate case preparation completed, and annealing carried out where required.

Only then do I lubricate the cases ready for sizing.

Lubrication is one of the simpler operations in reloading, but it is also remarkably easy to get wrong. Too little lubricant can make sizing unnecessarily difficult and, in the worst case, leave a case stuck firmly inside the die. Too much can create hydraulic dents, contaminate the tooling and make an unnecessary mess.

There is one point I particularly want to establish at the beginning of this chapter:

With case lubrication, it isn't simply how much you use. More importantly, it's where you put it.

A very small amount of lubricant applied in the right places is what I am looking for.

When a bottleneck rifle case enters a full-length sizing die, the die is reducing the dimensions of the brass.

There is considerable contact between the case and the hardened steel surface of the die, and that creates friction. Without suitable lubrication, the force required to push the case into and withdraw it from the die can become excessive.

Eventually, the case can stick.

Correct lubrication reduces that friction, protects the case and tooling, and makes the sizing stroke considerably smoother.

It also helps me feel what is happening.

With a consistently prepared batch of brass, the sizing stroke should feel reasonably similar from one case to the next. If one suddenly requires considerably more force, I want to know why rather than simply leaning harder on the press handle.

My Preferred Method

Figure 12.1 — *A very light film of sizing wax on the upper part of the case. Only a controlled amount of lubricant is required.*

For normal full-length sizing of bottleneck rifle brass, I prefer a good-quality **sizing wax applied directly with my fingers**.

Very little is required.

I take a tiny amount of wax, spread it between my fingers and transfer a thin film to the brass.

I like this method because I have direct control over both the quantity and, more importantly, its location. I can feel where the lubricant has been applied rather than simply coating the case and hoping the areas that need it have received enough.

The case does not need to look wet or greasy. If I can see thick deposits of wax, I have used too much.

For my normal bottleneck rifle sizing, I concentrate the sizing wax on:

the outside of the neck → down across the shoulder → and approximately the top third of the case body.

I apply it directly with my fingers, working a **very thin film** around the neck, across the shoulder and onto the upper part of the case body. I do not routinely coat the entire case from neck to case head.

You will sometimes hear advice that lubricant should never touch the shoulder of a bottleneck case. That is not how I work. A light film across the shoulder is part of my normal method.

The important distinction is between **a thin film and an accumulation of lubricant**.

I want the surface lightly lubricated. I don't want a visible blob or ridge of wax sitting on the shoulder.

This is one of the main reasons I prefer applying wax with my fingers. I can put a very small amount exactly where I want it.

When the case enters the sizing die, there is very little spare space between the brass and the internal surface of the die.

If excessive lubricant becomes trapped between them, particularly around the shoulder, it may have nowhere to escape. The resulting pressure can push the brass inward and leave a smooth depression in the case.

These are commonly referred to as **lubricant dents** or **hydraulic dents**.

If I begin seeing them, it tells me something about my technique. I have either used too much lubricant, allowed it to accumulate in one area, or the die itself has collected enough lubricant to need cleaning.

I correct the cause rather than deciding that the shoulder must never receive lubricant.

The opposite problem is insufficient lubrication.

A poorly lubricated case can become noticeably harder to size. The press stroke gets heavier and the temptation is to use more leverage to force the case farther into the die.

That is when I stop and pay attention.

If a batch has been sizing smoothly and one case suddenly requires considerably more effort, there may be a simple explanation, but I want to find it before continuing.

Possible causes include:

- insufficient lubrication;
- contamination on the case;
- dirt inside the die;
- unusual case dimensions;
- a case fired in a different chamber;
- incorrect die adjustment;
- or damaged brass.

The press is giving me information.

If a case does become stuck, proper stuck-case removal tools and procedures are available. Prevention is considerably easier, and correct lubrication is one of the simplest ways of avoiding the problem.

Lubricating a Conventional Expander or Sizing Button

If I am using a conventional sizing die with an expander or sizing button, there is another area where friction occurs: **inside the case neck**.

During sizing, the die reduces the neck. As the case is withdrawn, the expander is pulled back through it and establishes the final internal diameter.

I don't heavily lubricate the inside of every case neck on every pass.

Instead, **every now and again I apply a tiny amount of sizing lubricant inside the neck** when I am using a conventional sizing button or expander.

A cotton bud or similar small applicator works well because it lets me place a trace of lubricant on the internal neck surface.

The purpose is simply to help the expander move back through the neck smoothly. I don't want a lump of wax sitting inside the case.

If the expander begins to grab or snatch noticeably, I check the button, the condition of the neck and the lubrication rather than simply accepting the extra resistance as normal.

It is worth distinguishing between a conventional die-mounted sizing button and the separate mandrels we will use later for controlling neck tension.

They perform related jobs, but they are different operations.

For a normal **die-mounted sizing button or expander**, I favour sizing wax or a suitable sizing lubricant when lubrication inside the neck is required.

For a **separate neck-tension mandrel**, my preference is a carbon- or graphite-based dry neck lubricant.

So, as a simple guide:

Sizing button — sizing wax or suitable sizing lubricant.

Separate mandrel — carbon/graphite-based dry lubricant.

We will cover the mandrel operation properly in the neck-tension chapter.

If I intend to establish the finished internal neck diameter with a separate mandrel, I will often remove the conventional expander from the sizing die.

There is little point in dragging a normal expander through the neck if I am deliberately going to establish the final internal dimension with a mandrel immediately afterwards.

When using a bushing die followed by a mandrel, I also want a **slightly tighter bushing than I would use if the bushing alone were establishing the finished neck tension**.

That gives the mandrel enough reduction to work with so that it can establish the final internal neck dimension properly.

The exact bushing sizes, neck-tension figures and calculations belong in the neck-tension chapter, where we can deal with them properly rather than duplicate them here.

Traditional lube pads have been used successfully for many years and they certainly work.

Lubricant is distributed across the pad and the cases are rolled over it before sizing.

They are not my preferred method.

I find they can become messy, and they make it relatively easy to put lubricant **everywhere rather than precisely where I want it**. An overloaded pad can also transfer considerably more lubricant than the case requires.

That doesn't make a lube pad wrong. Plenty of good ammunition has been produced using one.

If you use one, keep it lightly charged rather than saturated.

For my own loading, I prefer applying sizing wax directly with my fingers because it gives me much greater control over the application.

Spray Lubricants

Spray case lubricants can be extremely convenient, particularly when processing larger quantities of brass.

A whole batch can be treated relatively quickly.

Different sprays use different formulations, so I follow the manufacturer's instructions for the particular product. Some use a carrier that needs time to evaporate before the cases are sized.

Coverage also needs some thought. Spraying one side of a tray does not necessarily mean every useful surface of every case has received sufficient lubricant. Depending on the product and method, the cases may need to be moved or rolled.

Sprays are perfectly valid sizing lubricants.

For my normal precision-loading routine, I simply prefer the control I get from applying wax directly by hand.

Liquid case lubricants are another established option.

Some are applied directly to the brass, some through lube pads and others through spray systems.

They can work extremely well.

As with spray products, I follow the manufacturer's instructions rather than assuming every liquid lubricant is used in the same way.

My preference for wax is a preference for **the control and application method it gives me**, not a suggestion that other good-quality lubricants cannot work equally well.

Keep the Method Simple

I generally use one known lubrication system for a batch.

There is little advantage in putting wax on a case, adding another liquid lubricant and then spraying something else over it simply because several products happen to be on the bench.

One suitable product, used correctly, is normally all that is required.

The exception is when two genuinely different operations call for different products—for example, sizing the case with wax and subsequently using a carbon- or graphite-based dry lubricant for a neck-tension mandrel.

Those are separate operations with different requirements.

Sizing lubricant does not simply disappear.

Over time, lubricant, carbon and small amounts of dirt can accumulate inside the sizing die. A piece of grit or brass can also become trapped inside and begin marking the cases.

I periodically clean my dies according to the manufacturer's recommendations.

If I suddenly begin seeing hydraulic dents, unexplained resistance or repeated scratches in the same position on several cases, the die is one of the first places I inspect.

I would rather stop and clean the tooling than put the same mark on the remainder of the batch.

Once sizing and any associated neck-tension work are complete, the sizing lubricant has done its job.

I remove it.

Depending on the product and quantity of brass, that may mean wiping the cases clean or giving them an appropriate short cleaning cycle.

I want them **clean and dry** before they move on to priming.

There is no advantage in leaving sizing wax or oil on the brass. It can attract dirt, make handling unpleasant and carry unwanted contamination into later operations.

New brass still receives appropriate lubrication if I am putting it through a steel bottleneck sizing die.

As we have already covered, I full-length size new brass as part of my normal preparation procedure. The fact that a case has never been fired does not remove the friction created by pushing it into a sizing die.

The need for lubrication comes from the **operation being performed**, not from how many times the case has been fired.

Fired brass may require different amounts of sizing effort depending on the chamber it came from and how much dimensional change the die needs to make.

I still use the same basic lubrication method.

If a case requires abnormally high force despite being correctly lubricated, I investigate the reason rather than simply adding more wax.

Many straight-wall pistol sizing dies use a **carbide sizing ring**.

One advantage of carbide is that conventional case lubrication is often unnecessary when resizing suitable straight-wall cases.

Some reloaders still use a very light amount of suitable lubricant because it can make high-volume sizing easier. That is perfectly reasonable if it suits the equipment and the die manufacturer permits it.

A conventional steel straight-wall sizing die may have different requirements, so I don't assume every straight-wall case can automatically be sized dry.

The instructions for the actual tooling take precedence.

Small-base sizing and specialist case-forming operations can involve more case contact or considerably greater brass movement than an ordinary sizing operation.

Correct lubrication becomes particularly important.

Some specialist forming dies have their own recommended lubricants or application methods. Where the tooling manufacturer specifies a particular procedure, I follow it.

Lubrication Cannot Correct a Bad Setup

Lubrication controls friction.

It cannot correct:

- an incorrectly adjusted die;
- excessive shoulder setback;
- the wrong sizing die;
- damaged brass;
- or an unsuitable case.

If something feels wrong, lubrication is one possibility, but it is not automatically the answer.

The tooling still needs to be correctly selected and adjusted.

My Practical Lubrication Method

For my normal bottleneck rifle brass, I keep the process simple.

All the appropriate case preparation has already been completed before I reach this point.

I take a **very small amount of sizing wax** on my fingers and spread a thin film over the **outside of the neck, down across the shoulder and over approximately the top third of the case body**.

I don't coat the whole case.

If I am using a conventional die-mounted sizing button, every now and again I put a **tiny amount of sizing lubricant inside the neck** to keep the button moving smoothly.

I then size the case and pay attention to how the press feels.

If I am establishing final neck tension afterwards with a separate mandrel, I use my preferred **carbon- or graphite-based dry neck lubricant** for that operation.

Once the sizing and neck-tension work are finished, I remove the sizing lubricant and leave the cases clean and dry.

If there is one thing I want the reader to take from this chapter, it is this:

Case lubrication is not simply about how much lubricant you use. More importantly, it is about putting a small amount in the right places.

The cases are now prepared and correctly lubricated, which means they are ready for the sizing die.

Next we will look at **full-length sizing, neck sizing and bushing dies**, before moving into shoulder bump and the control of neck tension.

Our normal working sequence is now:

case preparation → lubrication → sizing → neck-tension control → cleaning → priming.

Chapter 13 — Case Sizing: Full-Length, Neck and Bushing Dies

Once the brass has been inspected, cleaned, prepared and annealed where appropriate, we reach one of the most important stages in the entire reloading process: sizing.

When a cartridge is fired, the case expands under pressure to fit the chamber. The body expands, the shoulder moves forwards and outwards, and the neck expands sufficiently to release the projectile.

When pressure falls, the brass springs back slightly, allowing the case to be extracted, but it does not return completely to its original dimensions.

Before we load that case again, we need to control those dimensions.

That is what sizing is really about.

It is not simply a matter of making the case smaller.

Sizing is about controlling the relationship between the fired case, the sizing die and the chamber in which the ammunition will be used.

For my own bottleneck rifle ammunition, my normal method is full-length sizing.

I want the body, shoulder and neck controlled every loading cycle rather than waiting until the brass becomes progressively tighter in the chamber and then correcting it later.

But full-length sizing does not mean sizing the brass as much as physically possible.

Quite the opposite.

I want to size the case only as much as necessary.

A conventional full-length sizing die acts on three principal areas of the case:

- the body;
- the shoulder;
- the neck.

As the lubricated case enters the die, the body is reduced towards the internal dimensions of the die.

As the case travels farther into the die, the shoulder is moved.

The neck is also reduced so that it can once again hold a projectile securely.

Exactly how the neck is controlled depends on the type of die being used.

A standard full-length die normally has a fixed neck-sizing diameter and may use an expander ball to establish the final internal neck diameter.

Figure 13.1 — *Cutaway of a conventional full-length sizing die showing the central decapping stem and die-mounted expander/button arrangement.*

A full-length bushing die still controls the body and shoulder but uses a removable bushing to give us much greater control over how far the neck is reduced.

Figure 13.2 — *Cutaway of a full-length bushing die. The removable neck bushing is visible above the case path; this example also retains a conventional internal sizing/expander button on the decapping stem.*

The cutaway also shows a sizing/expander button on the stem. In practice that button may be retained, changed or omitted depending on whether the final internal neck diameter is established by the die-mounted expander or by a separate mandrel operation afterwards.

That distinction becomes increasingly important as we move towards more precision-oriented loading.

My Normal Method - Full-Length Sizing

Figure 13.3 — *Case located in the shell holder immediately before entering a full-length sizing die.*

I full-length size my bottleneck rifle brass.

There has historically been a great deal of discussion about neck sizing being the more accurate option, especially for ammunition used in one particular rifle.

I don't regard neck sizing as automatically more accurate.

A correctly adjusted full-length die can produce exceptionally accurate ammunition while maintaining reliable and repeatable chambering.

The important words are correctly adjusted.

I'm not trying to return every fired case to minimum dimensions.

I am trying to establish enough clearance for reliable chambering while avoiding unnecessary movement of the brass.

That is very different from simply screwing the die down as far as possible and accepting whatever result it produces.

This is one of the most important points in this chapter.

A full-length sizing die is capable of moving the shoulder considerably farther than may actually be necessary for a particular rifle.

Just because the die can move the brass that far does not mean I want it to.

If we repeatedly push the shoulder back considerably farther than required, the case must expand farther again when it is fired.

That means more movement of the brass and, generally, more working of the material.

My objective is therefore: reliable chambering with the minimum sensible amount of sizing.

Later we will measure the shoulder position properly and establish what is commonly called shoulder bump.

Before getting into those measurements, however, we need to understand how I actually set the sizing die in the press.

Different die and press manufacturers provide their own setup instructions, and those instructions should always be read because equipment designs can differ.

The manufacturer's instructions give us the mechanical starting point.

My own setup follows a specific sequence.

First, I make sure the correct shell holder is fitted to the press.

I lower the press handle so that the ram rises fully.

With the die's locking ring backed away, I screw the full-length sizing die down into the press until the bottom of the die just barely touches the top of the shell holder.

That contact point is the reference I use.

I then raise the press handle again, lowering the ram and shell holder out of the way.

From that contact position, I screw the die farther into the press by no more than about one-eighth of a turn.

I then bring the outer locking ring down until it is finger-tight against the top of the press.

At this stage I have established the initial mechanical setting.

The next job is to find out what that setting actually does to the brass.

When the case is run fully into the die, I am looking for a slight cam-over effect at the end of the press stroke.

It is easier to recognise through the press handle than to describe on paper.

There should be a definite sense that the press has reached the end of the sizing stroke and gone through that small amount of cam-over.

I'm not trying to force the press.

If something suddenly feels abnormally hard, I stop and investigate.

There may be insufficient lubricant, a different case in the batch, dirt in the die or another problem.

Unexpected resistance is information. It is not a request for more force.

Then I Measure the Case

The physical setup of the die is only the first part of the job.

I also want to know what has actually happened to the brass.

With fired brass, I measure the case before sizing using the same comparator system that I will use afterwards.

I then lubricate and size the case.

After sizing, I measure it again.

In my normal method, I am looking for approximately 0.002 inch of shoulder movement as a starting point.

That figure comes from the brass measurement.

I'm not looking at the die and guessing.

> **BENCH NOTE**
> The basic sequence is: measure fired case → size case → measure again → confirm the result.

If the shoulder movement is not where I want it, I make a controlled adjustment and check again.

The fact that the die touches the shell holder tells me something about the mechanical relationship between the press and die.

It doesn't, by itself, tell me exactly what happened to the shoulder of the case.

Press flex, shell-holder dimensions, die dimensions, brass springback and the particular chamber all matter.

That is why the actual case measurement is the useful reference.

The mechanical setup gets me into the correct working range.

The measurement tells me what the sizing operation actually produced.

Once I am close to the result I want, I make only small adjustments.

A surprisingly small amount of die movement can produce a measurable change at the shoulder.

I therefore do not make large corrections once I am near the target.

I size. I measure. I adjust. Then I measure again.

If I move the shoulder too far back, I can't simply wind the die out and put the brass back where it was. The case will need firing again before it returns towards its fired condition.

So taking a little time at this stage is worthwhile.

Once I believe the die is correctly set, I don't immediately process the entire batch.

I size another case and measure it. Then another.

Brass itself varies slightly, and I want to see that the die is producing a repeatable result across more than one case.

Once the first few are behaving as expected, I am much happier to continue with the rest of the batch.

Once I have established the position I want, I secure the locking ring.

Different dies use different systems. Some use a split locking ring. Some use a set screw. Others use different locking arrangements.

Whatever system is used, I want the die setting to remain repeatable.

Even then, when I return to the die later, I still check the first case.

A setting that was correct previously should be verified rather than simply trusted forever.

The lubrication stage is covered in Chapter 12. By the time I begin sizing, the case body has a thin, controlled film of the appropriate sizing lubricant and, where a conventional die-mounted expander is used,

the inside neck has the small amount of sizing wax needed for a smooth pass. I don't use the sizing die as the place to discover that a case was left dry.

A conventional full-length sizing die is one of the most useful tools in reloading.

It is relatively simple, robust and capable of producing excellent ammunition.

There is sometimes a tendency to assume that because precision reloaders use more specialised dies, the standard full-length die must somehow be inferior.

That is not the case.

A good standard full-length die, correctly adjusted, can produce extremely accurate ammunition.

The main limitation is that its neck-sizing section has a fixed internal diameter.

For many types of ammunition, that does not matter at all.

For more advanced precision work, greater control can become useful.

How a Standard Die Sizes the Neck

Figure 13.4 — *Bushing-die components: die body, removable neck bushing and decapping/expander-stem assembly.*

A conventional full-length die normally reduces the outside diameter of the neck as the case enters the die.

Many designs reduce it somewhat smaller than the final internal diameter required.

As the case is withdrawn, an expander ball passes back through the neck and establishes the internal diameter.

This system has worked successfully for generations.

Its great advantage is simplicity.

The disadvantage is that the neck may be sized inward farther than necessary and then expanded outward again.

That means additional movement of the brass.

For general-purpose ammunition this may be of little practical consequence.

For precision loading, we may eventually want more control.

The expander ball has a straightforward job.

It establishes the internal neck diameter as the case is withdrawn from the die.

But pulling an expander through the neck creates friction.

If the expander is rough, incorrectly dimensioned or inadequately lubricated, it can produce considerable resistance.

That resistance can pull on the neck and shoulder.

This is another reason I pay attention to how the press feels during sizing.

If one case behaves very differently from the rest, I stop and look at it.

If I am diagnosing crooked ammunition, I want to know whether the error is already present after sizing. A concentricity or runout gauge can be used on the case neck before and after the sizing operation.

If a fired case is reasonably straight but the sized neck shows noticeably more runout, I look first at the sizing system rather than blaming the seating die. Die alignment, uneven neck-wall thickness, expander drag, lubrication and the way the case enters and leaves the die can all contribute.

The useful point is not to chase a perfect dial reading. It is to identify whether sizing is introducing a repeatable alignment problem, correct the process if necessary, and then check whether the improvement survives into the finished ammunition.

A neck-sizing die resizes primarily the case neck while leaving the body and shoulder largely in their fired condition.

Historically, this became popular with some target shooters because the case had already expanded to fit one particular chamber.

The theory was that retaining that close chamber fit while resizing only the neck might improve accuracy.

I understand the reasoning.

It is simply not the approach I favour.

The problem is that the rest of the case does not stop changing simply because we only resize the neck.

Each time the cartridge is fired, the case is subjected to pressure again.

The body and shoulder continue to respond to the chamber.

After repeated firings, a neck-sized case will generally become progressively tighter to chamber.

Eventually, the bolt may become noticeably harder to close.

And eventually neck-only sized brass will need full-length sizing to restore the necessary clearance.

That is the part that matters to me.

If the brass is eventually going to require full-length sizing anyway, my view is straightforward: why not full-length size it properly every time?

By full-length sizing correctly every loading cycle, I can control the body and shoulder from the beginning.

I'm not waiting for the case to become tight and then correcting it.

Nor am I suggesting that the brass should be aggressively resized every time.

A properly adjusted full-length die only needs to move the case enough to establish the clearance I require.

That gives me a repeatable sizing history.

For me, that makes much more sense than neck sizing for several cycles and eventually having to return to full-length sizing anyway.

Neck Sizing Is Not Automatically More Accurate

Neck sizing is sometimes described as though it is inherently the precision option.

I don't accept that as a general rule.

Modern precision rifle ammunition is routinely produced using carefully controlled full-length sizing.

Accuracy depends on the complete ammunition and firearm system.

Reliable case fit, shoulder position, neck condition, projectile alignment, seating, components and load development all matter.

Simply leaving the body of the case unsized does not guarantee greater accuracy.

For my loading, the consistency and reliability of controlled full-length sizing make it the better approach.

A bushing die gives us greater control over how much the case neck is reduced.

Instead of relying entirely on a fixed neck diameter machined permanently into the die, a removable bushing controls the outside diameter of the neck during sizing.

Bushings are available in closely spaced diameters.

By changing the bushing, we can change how far the neck is sized.

This is particularly useful when moving into more precision-oriented ammunition.

But there is an important distinction: bushing does not mean neck-size only.

A full-length bushing die sizes the body and shoulder while using a removable bushing to control the neck.

For my approach to precision rifle ammunition, this makes considerably more sense than neck-only sizing.

I retain the dimensional control and reliable chambering benefits of full-length sizing while gaining greater control over how much the neck is worked.

That can be particularly useful when dealing with brass of known neck-wall thickness or when we deliberately change that thickness later.

A full-length bushing die can be installed using the same basic mechanical approach as the conventional full-length die.

The correct shell holder is fitted, the ram is raised and the die is brought to the appropriate contact point according to the press and die design.

From there, I establish the final body and shoulder result by sizing and measuring the brass.

The difference is that I also need the correct bushing installed for the neck dimensions I want.

The principle remains: set mechanically, then confirm by measurement.

Neck-only bushing dies also exist.

They use a removable bushing to size the neck while largely leaving the body and shoulder alone.

The bushing concept is useful, but the fact that a neck-sizing die accepts interchangeable bushings does not change my view of neck-only sizing itself.

I still prefer to control the complete case with a full-length bushing die where that level of precision is required.

Suppose two batches of brass have different neck-wall thicknesses.

With the same projectile seated, their loaded outside neck diameters may be different.

A fixed conventional die has one neck-sizing diameter.

A bushing die allows me to choose the sizing diameter to suit the actual brass and the method I am using.

That can reduce unnecessary movement of the neck and give considerably more control over the preparation process.

Rather than guessing which bushing to use, I calculate a sensible starting size from the actual brass and projectile dimensions.

The simplest method is to measure the outside diameter of the neck of a loaded cartridge or correctly assembled dummy round using the prepared brass and projectile I intend to use.

The basic calculation is:

Starting bushing size = loaded neck outside diameter - desired neck reduction

For example, if the loaded neck measures 0.294 inch and I want approximately 0.002 inch of outside-diameter reduction:

0.294 - 0.002 = 0.292 inch

A 0.292 inch bushing therefore gives me a sensible calculated starting point.

Calculating From Neck-Wall Thickness

If I accurately know the neck-wall thickness, I can also calculate the theoretical loaded-neck diameter.

The equation is:

Loaded neck OD = projectile diameter + (2 x neck-wall thickness)

Then:

Starting bushing size = projectile diameter + (2 x neck-wall thickness) - desired neck reduction

For example, with a 0.264 inch projectile and neck walls measuring 0.014 inch:

0.264 + (2 x 0.014) = 0.292 inch loaded neck OD

If I want approximately 0.002 inch reduction:

0.292 - 0.002 = 0.290 inch

That gives me a 0.290 inch bushing as the calculated starting point.

The calculation from neck-wall thickness is useful, but where possible I prefer to measure the actual loaded outside neck diameter of the brass and projectile combination I am using.

That measurement automatically includes the real brass and projectile rather than relying entirely on nominal dimensions.

I can then subtract the amount of neck reduction I want and choose a starting bushing from that figure.

But it is important to understand that the calculation gives me a starting point.

It doesn't guarantee the exact final gripping force on the projectile.

Brass springback matters.

Annealing condition matters.

Neck-wall variation matters.

The actual bushing may produce a slightly different final diameter than the number alone might suggest.

Whether I subsequently use an expander or mandrel matters as well.

For that reason, I size a case and measure the result.

The equation gets me into the correct range. The brass tells me what actually happened.

One of the strongest practical reasons for using a bushing die appears when we begin neck turning.

We will cover neck turning properly later in the advanced section of the book.

For now, we only need to understand what it does to the dimensions.

When I neck turn a case, I deliberately remove brass from the outside of the neck wall.

The neck wall becomes thinner.

If the same diameter projectile is subsequently seated in that case, the loaded outside neck diameter will now be smaller than it was before the brass was removed.

That matters to the sizing die.

A conventional non-bushing sizing die has a fixed neck-sizing diameter.

That diameter was designed around the expected dimensions of ordinary unturned brass.

If I remove sufficient material from the neck wall, the relationship between the thinner neck and the fixed die changes.

The die may no longer reduce the neck by the amount required for the sizing system I am trying to establish.

The result can be insufficient neck sizing and insufficient grip on the projectile.

That's why I regard a bushing die as particularly important when working with neck-turned brass.

With a bushing die, I can compensate for the material removed during neck turning.

If the neck wall becomes thinner, the loaded outside neck diameter becomes smaller.

I can therefore select an appropriately smaller-diameter bushing.

In simple terms: remove brass from neck wall → neck wall becomes thinner → loaded neck OD becomes smaller → smaller appropriate sizing bushing may be required.

A fixed standard die cannot change its neck-sizing diameter.

A bushing die can.

That is one of its major advantages.

An Example After Neck Turning

Suppose the neck walls originally measure 0.014 inch and the projectile is 0.264 inch.

The theoretical loaded neck diameter is:

0.264 + (2 x 0.014) = 0.292 inch

Now suppose I neck turn the cases to 0.0125 inch wall thickness.

The new theoretical loaded neck diameter becomes:

0.264 + (2 x 0.0125) = 0.289 inch

By removing only 0.0015 inch from each wall, I have reduced the total loaded neck outside diameter by 0.003 inch.

That is a significant dimensional change in bushing terms.

If I carried on using the same bushing without measuring the brass, I could lose much of the neck reduction I originally intended.

This is exactly why neck-turned brass and bushing sizing go naturally together.

The answer is not to install the smallest bushing available.

I measure the brass.

The appropriate bushing depends on factors including:

- loaded neck diameter;
- neck-wall thickness;
- projectile diameter;
- desired amount of neck reduction;
- brass springback;
- whether an expander will subsequently be used;
- whether a mandrel will subsequently be used.

The number engraved on the bushing is therefore part of the setup rather than the whole answer.

Measure the actual result.

Bushing dies are commonly discussed in terms of neck tension.

That is understandable, but the bushing does not independently determine the complete grip of the neck on the projectile.

It controls the outside diameter to which the neck is sized.

The final result is also influenced by the brass itself, neck-wall thickness, springback, annealing condition and any subsequent expander or mandrel operation.

That is why the detailed neck-tension procedure is kept for Chapter 18 rather than being repeated inside the basic sizing setup.

At this stage I want the reader to understand why the bushing exists and what problem it solves.

A bushing die can be used with an expander.

In that arrangement, the bushing controls how far the neck is initially reduced and the expander subsequently establishes the internal diameter.

Because the bushing can be selected more closely to the required dimensions, the neck may not need to be reduced as far as it would with some conventional dies before being expanded again.

A bushing die can also be used without an expander.

That avoids pulling an expander through the neck entirely.

This can work extremely well when the brass is suitably consistent.

But once again, there are more variables involved.

Detailed neck-tension control and mandrel use are covered in Chapter 18. Neck turning is treated later in the advanced precision section because it is an optional case-preparation operation rather than a requirement for most loading.

As I have already explained, I full-length size all new brass before its first loading.

New brass has not yet been fired in my chamber.

That doesn't mean every neck is perfectly round or every case is in precisely the condition I want.

Cases can acquire neck dents during manufacture, packaging and transport.

Running the entire batch through the sizing process establishes my own starting point.

After the first firing I then have something much more useful: a case that has actually been fired in the rifle for which I am loading.

From then on I can measure its fired shoulder position and control subsequent sizing much more precisely.

Used Brass From Another Firearm

Used brass requires additional consideration.

A case fired in another rifle reflects that rifle's chamber, not mine.

If I buy supposedly once-fired brass, I also remember the point made earlier in the book: unless I know its history, I can't automatically prove that it has only been fired once.

I inspect it thoroughly and size it appropriately.

Some cases fired in other firearms may have dimensional changes farther down the body that a conventional full-length die does not completely address.

That brings us eventually to small-base sizing and roll sizing.

Those are sufficiently different subjects that we will cover them separately in Chapter 15 rather than trying to squeeze them into ordinary full-length sizing.

Sizing should become a relatively consistent operation across a well-prepared batch.

That means an unusual change in resistance deserves attention.

If one case suddenly requires substantially more force, I stop.

Perhaps the case is inadequately lubricated. Perhaps it is from another batch. Perhaps the die contains debris. Perhaps the dimensions are different. Perhaps something else is wrong.

Unexpected resistance is information.

Do not automatically answer it with more force.

Sizing dies need maintenance.

Lubricant, carbon and debris gradually accumulate.

A small piece of grit trapped between the case and die can scratch both the brass and potentially the die surface.

I therefore clean my sizing dies periodically and whenever I see or feel something unusual.

A quality sizing die is a precision tool.

Treating it as one costs very little.

Once the die has been set, I don't immediately size hundreds of cases without checking anything.

I size one. Measure it. Size another. Measure it.

Check that the result is repeatable.

Once I am satisfied that the die is producing the dimensions I want, I process the batch.

A few measurements at the beginning are considerably easier than discovering at the end that an entire batch has been sized incorrectly.

The objective of full-length sizing is not to make the case as small as possible.

It is to make it appropriately sized for its intended chamber and use.

That distinction runs through my entire approach to case preparation.

I want:

- reliable chambering;
- controlled shoulder movement;
- appropriate body clearance;
- controlled neck dimensions;
- minimum unnecessary working of the brass;
- repeatability from one loading cycle to the next.

That is what properly adjusted full-length sizing gives me.

If there is one point I want to leave with the reader, it is this:

full-length sizing is not the crude alternative to precision sizing.

Done properly, full-length sizing is precision sizing.

A standard full-length die can produce excellent ammunition.

A full-length bushing die gives us additional control where we need it.

Neck-only sizing can work, but eventually that brass will need full-length sizing anyway.

For me, it therefore makes more sense to full-length size correctly, minimally and consistently every time.

Once neck turning enters the process, the ability to change bushing diameter becomes particularly valuable because we have deliberately changed the dimensions of the neck.

Everything comes back to understanding what we have changed and compensating for it deliberately.

We have deliberately stopped short of giving a complete treatment of shoulder bump in this chapter.

That is because shoulder movement deserves more explanation than a single number.

We will also separate two terms that are very often used as though they mean exactly the same thing: firearm headspace and case head-to-shoulder measurements.

They are related.

They are not identical.

Understanding that distinction is what turns the full-length die setup we have just discussed into a properly measured and repeatable sizing process.

Chapter 14 — Setting Shoulder Bump and Understanding Headspace

In the previous chapter we established how I set up and use a full-length sizing die.

We also introduced one measurement that deserves a chapter of its own: **shoulder bump**.

This is an area where reloading terminology can become confusing very quickly. People talk about measuring headspace, bumping shoulders, setting dies to headspace and measuring cases as though all these things were interchangeable.

They are related, but they are **not quite the same thing**.

Understanding the difference makes full-length sizing much easier to control.

My approach is straightforward.

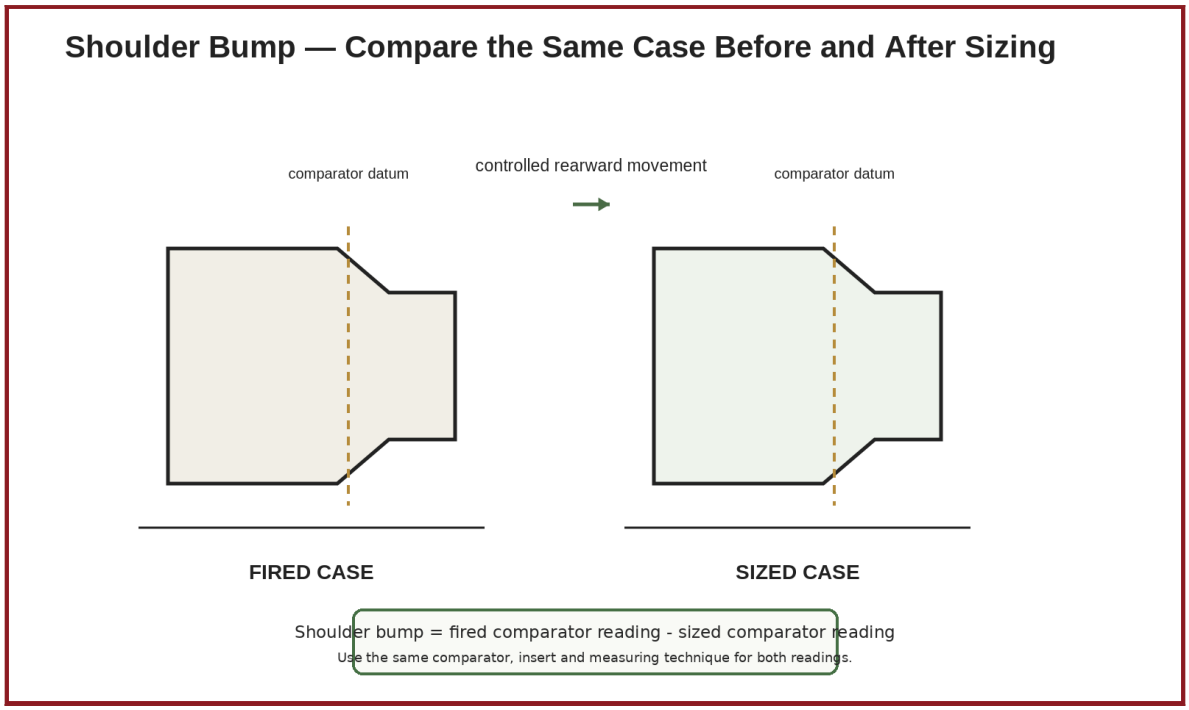


Figure 14.1 — *Shoulder bump is established by comparing the same case before and after sizing with the same comparator setup.*

I measure a fired case from the rifle, size it, measure it again and use the difference between those measurements to establish how far I have moved the shoulder.

For my normal bolt-action rifle ammunition, approximately **0.002 inch** is the starting point I generally work around.

But the number is less useful if we do not understand what we are actually measuring.

What Is Headspace?

Headspace is fundamentally a dimension of the **firearm and cartridge/chamber system**.

With a typical rimless bottleneck rifle cartridge, the chamber controls the cartridge's forward position by means of the shoulder.

The formal headspace dimension is measured from the bolt face to a specified **datum diameter on the chamber shoulder** when the action is closed.

That datum is not necessarily a physical line that you can see on the case.

It is an imaginary reference circle of a specified diameter on the shoulder.

The exact datum diameter depends on the cartridge specification.

This allows chambers, gauges and ammunition to be manufactured and checked against agreed dimensional standards.

Headspace Is Not Simply Case Length

This distinction is important.

Overall case length is normally measured from the case head to the mouth.

Headspace for a bottleneck rimless cartridge is concerned with the relationship between the bolt face and the appropriate shoulder datum.

These are completely different measurements.

A case can therefore be within its correct maximum overall case length while still having a shoulder position that is important to our sizing setup.

Likewise, trimming the case mouth does not set shoulder bump.

They are separate operations controlling different parts of the case.

When I place a fired case into a shoulder comparator and measure it with callipers, I am **not directly measuring the firearm's formal headspace**.

I am measuring a dimension on that particular case.

More accurately, I am comparing the distance from the **case head to a reference point on the case shoulder** established by the comparator insert.

This measurement is extremely useful.

But I prefer to understand it for what it is.

It is a **comparative case measurement**.

That is why these tools are generally described as comparators.

Suppose I measure a fired case and obtain:

1.630\"

I then full-length size that same case and measure:

1.628\"

The important information is the difference:

1.630\" − 1.628\" = 0.002\"

I have moved the shoulder back approximately **0.002 inch relative to that comparator measurement**.

That is the information I need when setting my sizing die.

Whether the comparator's absolute reading exactly matches a formal chamber headspace dimension is not important for this purpose.

I am interested in the **change**.

Before altering the sizing die, I want a reliable fired-case reference.

Ideally, I measure several cases fired in the rifle for which I am loading.

One case can give useful information, but several cases tell me whether the measurement is representative of the batch.

I clean the case head and make sure there is nothing on the surfaces that could interfere with the measurement.

I fit the appropriate shoulder comparator insert to the measuring body and zero or establish my calliper reference according to the measuring system being used.

Then I measure the cases.

The technique needs to be consistent.

I don't squeeze the callipers with enormous force on one measurement and barely touch them on the next.

Consistent measuring pressure matters when we are looking at differences measured in thousandths of an inch.

If most of my fired cases measure very similarly and one is noticeably different, I don't immediately reset the sizing die around the odd case.

I measure it again.

I inspect it.

I compare it with the rest of the batch.

Measurement itself can introduce error, and brass can vary.

The purpose of measuring several cases is to establish a useful picture rather than allowing one unusual reading to dictate the entire setup.

In everyday precision-reloading language, **shoulder bump** describes the amount by which the sizing operation moves the case shoulder rearwards relative to its fired position.

For example:

Fired measurement:

1.630\"

Sized measurement:

1.628\"

Difference:

0.002\"

We would normally describe that as approximately:

0.002\" shoulder bump.

The term is useful as long as we remember that we are comparing measurements taken with the same equipment and technique.

My Normal Starting Point

Figure 14.2 — *A shoulder comparator and callipers measuring a case from the head to the selected shoulder datum.*

For my normal bolt-action rifle ammunition, I generally work around approximately:

0.002\" shoulder bump

as a starting point.

That gives me a small amount of clearance while still avoiding unnecessary movement of the case.

I don't treat 0.002\" as a magical number that must apply to every rifle and every application.

The firearm, chamber, brass and intended use all matter.

The important thing is that I have deliberately established the amount rather than simply accepting whatever the die happened to produce.

It can be tempting to think that if minimum brass movement is desirable, then moving the shoulder **not at all** must be even better.

That doesn't necessarily follow.

A case that is effectively sized to the same shoulder position as its fired condition can leave very little clearance.

Differences between cases, fouling, temperature, chamber condition and repeated firing can then produce tight chambering.

I want ammunition that works reliably.

That means allowing sensible clearance.

For my purposes, a small controlled amount of shoulder movement is preferable to deliberately producing ammunition that is right on the edge of chambering resistance.

At the other extreme, we could simply size the case considerably shorter at the shoulder.

That would certainly create clearance.

But more clearance is not automatically better.

When the cartridge is fired, the case has to expand to conform to the chamber again.

Excessive sizing therefore increases the amount of dimensional change the brass experiences between sizing and firing.

Repeated unnecessary movement can contribute to brass fatigue and case stretching.

So once again, the objective is not maximum sizing.

It is **appropriate sizing**.

When a bottleneck case is fired, chamber pressure causes it to expand against the chamber.

The case does not simply expand uniformly in every direction.

The relationship between the case head, chamber wall and shoulder creates complex movement within the brass.

If the shoulder has been pushed substantially farther back than necessary, the case has more longitudinal clearance to accommodate when fired.

Repeated excessive sizing can therefore contribute to stretching in the case body, particularly in the region forward of the solid case head.

Over repeated cycles, this can contribute to the thinning associated with **incipient case-head separation**.

We discussed inspection for this earlier in the book.

This is one reason correct sizing and case inspection belong together.

Too little shoulder movement creates a different problem.

The case may chamber tightly.

Bolt closing effort can increase.

As the brass continues through repeated firing cycles, the problem may become more pronounced.

This is precisely one of my objections to neck-only sizing.

If the body and shoulder are allowed to become progressively tighter, eventually they have to be corrected anyway.

I would rather control that relationship every cycle.

The way a case chambers can tell me useful things.

If the bolt is noticeably difficult to close on a sized empty case, I know I need to investigate.

But bolt feel alone does not tell me whether I have moved the shoulder 0.001\", 0.002\", 0.004\" or some other amount.

Different actions also feel different.

Mechanical leverage can hide surprisingly small amounts of resistance.

So I use chambering as a functional check.

I use the comparator as the measurement.

The two complement each other.

Setting the Die From the Measurement

In Chapter 13 I explained my basic die setup.

Once I have the fired-case measurement, I can refine that setup using the brass itself.

Suppose the fired case measures:

1.6300\"

I size the case and obtain:

1.6295\"

That represents approximately:

0.0005\" movement.

If I am looking for approximately 0.002\", I need slightly more sizing.

I adjust the die in a controlled amount and try again.

If the next measurement is:

1.6285\"

I now have approximately:

0.0015\" movement.

I am getting close.

A further very small adjustment may produce:

1.6280\"

which gives:

0.0020\"

That is the sort of controlled progression I want.

The thread pitch of the sizing die means that apparently tiny rotational adjustments can produce meaningful vertical movement.

For example, a common **7/8\"-14 die thread** has 14 threads per inch.

One complete turn therefore moves the die approximately:

1 ÷ 14 = 0.0714\"

A quarter turn is approximately:

0.0179\"

An eighth turn approximately:

0.0089\"

And a sixteenth turn approximately:

0.0045\"

That does **not** mean a sixteenth turn automatically produces exactly 0.0045\" of shoulder bump.

The press, die, shell holder, case and brass springback all influence the actual result.

But it demonstrates why small rotational adjustments matter.

When I am close, I make very small changes and measure what they actually do.

Brass does not necessarily remain at exactly the dimension to which the die physically forces it.

After the sizing pressure is removed, the material recovers slightly.

This is **springback**.

The amount can be influenced by the brass alloy, its work-hardening history, annealing condition and the amount of deformation involved.

This is one of the reasons annealing and sizing are connected.

If I am trying to produce consistent sizing, I want the brass itself behaving as consistently as reasonably possible.

Annealing does not determine shoulder bump for me.

The die does that.

But consistent metallurgical condition can help cases respond more consistently to the sizing operation.

If some cases have been repeatedly work-hardened while others are in a different condition, their springback behaviour may not be identical.

This is another reason I prefer to treat brass as a batch and keep its preparation history consistent.

Shoulder comparator systems generally use interchangeable inserts designed to contact the shoulder at a particular diameter.

Different cartridges require different inserts.

The important thing is to use the appropriate comparator for the cartridge and then keep the measuring setup consistent.

For ordinary shoulder-bump work, I am primarily interested in **repeatable comparative measurements**.

Changing inserts halfway through a batch or comparing numbers obtained from different comparator systems without understanding the difference defeats that purpose.

This is worth emphasising.

If my comparator gives a fired measurement of:

1.630\"

that does not necessarily mean the firearm has exactly 1.630\" of formal headspace.

Another manufacturer's comparator might produce a slightly different absolute number on the same case.

That doesn't automatically mean either tool is wrong.

What matters for shoulder bump is that I use the **same tool, same insert and same measuring technique before and after sizing**.

Then the difference becomes meaningful.

Headspace Gauges Are Different

Proper firearm headspace gauges serve a different purpose.

A gunsmith may use **GO, NO-GO and sometimes FIELD gauges** to assess the chamber and action against specified dimensional limits.

Those are not the same thing as the shoulder comparator I use to set my sizing die.

A comparator measures the case comparatively.

A chamber headspace gauge is used to assess the firearm.

Both involve shoulder-related dimensions in a bottleneck cartridge system, but they are not interchangeable tools.

This distinction also has a safety implication.

If I genuinely suspect that a firearm has incorrect or excessive headspace, I don't try to diagnose the firearm solely from my reloading comparator measurements.

That is a matter for appropriate gauges and, where necessary, a competent gunsmith.

My comparator is there to help me control the brass.

It is not a substitute for proper inspection of the firearm.

The amount of shoulder bump appropriate for one application may not be ideal for another.

A carefully managed single-loaded competition rifle operates under different conditions from a hunting rifle that may be exposed to rain, dirt, temperature changes and rapid follow-up shots.

A self-loading or straight-pull rifle can impose different reliability requirements again.

This is why I regard approximately **0.002\" as a useful starting point for my normal bolt-action loading**, not a universal commandment.

Reliable function always comes first.

For precision competition ammunition, I still want reliable chambering.

A match is a poor place to discover that a cartridge is so tightly fitted that the bolt will not close smoothly.

Precision does not mean eliminating all clearance.

It means controlling it.

The best ammunition in the world is of little value if it cannot be chambered when it matters.

For hunting ammunition, reliability becomes even more important.

A cartridge may be chambered in cold conditions.

The rifle may have been carried all day.

There may be dust, moisture or other contamination present.

I don't want ammunition prepared on the absolute edge of chamber fit.

A sensible amount of clearance provides insurance against the real conditions in which the rifle will be used.

Self-loading and some straight-pull rifles can require greater attention to reliable case sizing.

The action does not necessarily provide the same closing leverage or operating conditions as a conventional manually operated bolt action.

Ammunition needs to chamber and extract reliably throughout the operating cycle.

Depending on the firearm and brass, this may require different sizing considerations.

We will cover this more fully when we discuss **small-base sizing and roll sizing** in the next chapter.

A case fired in one rifle has expanded to **that rifle's chamber**.

Another rifle chambered for the same cartridge may have slightly different dimensions while still being completely within specification.

That means ammunition sized very closely for one rifle may not necessarily be ideal for another.

If ammunition is intended to be used across several rifles, I size and check it accordingly.

I don't assume that because both barrels have the same calibre marking, their fired brass dimensions must be identical.

For precision loading, keeping brass associated with the rifle in which it is being used makes life considerably easier.

I know the firing history.

I know the chamber that produced the fired dimensions.

I can compare like with like.

This is particularly useful where I have several rifles chambered for the same cartridge.

Good batch control removes uncertainty.

Measure After Annealing and Sizing

Because my process anneals before the main sizing operation where annealing is being used, the shoulder measurement I care about for the finished case is the measurement **after sizing**.

That is the case that will continue through the loading process.

The objective is always to measure the condition that actually matters at the relevant stage.

Once the die is established, I don't necessarily measure every single case unless the application demands it.

But I do check cases periodically through the batch.

If the first few measure correctly and a later check suddenly differs, I want to know why.

Perhaps the die has moved.

Perhaps the press linkage has changed.

Perhaps the brass is from a different lot.

Perhaps something has contaminated the die.

Periodic measurement catches problems before they affect an entire batch.

Precision measuring equipment is extremely useful.

It can also encourage us to believe that every displayed digit represents meaningful practical information.

There is little value in repeatedly squeezing the callipers until the display gives the number we hoped to see.

Measurement must be repeatable.

If I measure the same case several times and obtain different results because my technique changes, adding more decimal places does not improve the information.

Good measurement is about consistency, not simply resolution.

Let us put the process together.

I have several cases fired in my rifle.

Their comparator measurements cluster around:

1.6300\"

I establish my full-length die as described in Chapter 13.

I lubricate a case and size it.

It measures:

1.6280\"

The difference is:

1.6300 − 1.6280 = 0.0020\"

That gives me approximately **0.002\" shoulder bump**.

I then size another case.

It measures:

1.6281\"

Another measures:

1.6279\"

Those results are sufficiently close for me to know that the process is behaving consistently.

I can now proceed with the batch while continuing to make periodic checks.

That is controlled sizing.

Nothing mysterious is happening.

I am simply measuring before and after and using the difference to tell me what the die has done.

Occasionally a die and shell-holder combination may reach its mechanical limit before producing the required shoulder movement.

Before modifying anything, I check the obvious causes.

- Is it the correct shell holder?
- Is the die installed properly?
- Is the press reaching its full stroke?
- Are the measurements repeatable?
- Is the brass appropriate for the die and chamber?
- Is there debris preventing full movement?

Different die and shell-holder systems also exist specifically to provide additional control over sizing relationships.

I don't immediately start grinding material from dies or shell holders because a number on the comparator is not what I expected.

Understand the cause first.

Permanent modification should not be the first troubleshooting step.

This can initially seem impossible, but reloaders sometimes observe a comparator measurement that increases slightly during an early or partial sizing operation.

The case is being changed in more than one direction as it enters the die.

Body reduction and brass movement can influence the shoulder before the die has progressed far enough to establish the final shoulder position.

The important thing is to complete and control the full sizing operation rather than assuming every intermediate stage must move the shoulder rearwards.

Again, measure the final sized case.

Record the Setting

For ammunition I load regularly, I keep useful setup information with the load and brass records.

That may include:

- rifle;
- cartridge;
- die;
- shell holder;
- fired comparator measurement;
- sized comparator measurement;
- approximate shoulder bump;
- brass manufacturer and lot;
- annealing cycle where relevant.

I don't rely entirely on remembering what I did six months ago.

A written record gives me a starting point the next time I prepare the same ammunition.

The important lesson from this chapter is not that every rifle requires exactly 0.002\".

It is that the shoulder position should be **understood and controlled**.

For my normal bolt-action loading, approximately 0.002\" is the starting point I generally use.

Another application may require something different.

The important thing is that I know what the fired case measured, what the sized case measured and therefore what the sizing die actually did.

That is much more useful than simply saying:

“I screwed the die down until it touched the shell holder.”

Headspace and Shoulder Bump — Keep the Terms Straight

Before we finish, it is worth putting the distinction in its simplest form.

Headspace describes a controlled dimensional relationship in the firearm/chamber and cartridge system.

Case comparator measurement is the measurement I take from the case head to a reference point on its shoulder.

Shoulder bump is the difference between my fired and sized comparator measurements.

Keeping those three ideas separate removes a great deal of confusion.

We have now controlled the ordinary full-length sizing operation and established how I measure shoulder movement.

There are, however, cases that require more.

Brass fired in generous chambers, some self-loading firearms and brass acquired from unknown sources can present dimensional problems farther down the case body where an ordinary full-length die may not provide the result we need.

There is also another method that works the case from a completely different direction.

We will cover what small-base dies actually do, why they are sometimes useful, why they should not automatically be used for everything, and how **roll sizing can resize the lower case body and web area that conventional dies cannot always reach**.

That chapter will be our first clearly marked **advanced sizing chapter**, building on the full-length sizing and measurement principles we have now established.

Chapter 15 — Specialist Sizing: Small-Base Sizing, Roll Sizing and Special Applications

By this point we have covered conventional full-length sizing, shoulder bump and the relationship between the fired case, sizing die and chamber.

For most bottleneck rifle ammunition, that is enough. A correctly adjusted full-length die will size the case body, control the shoulder and resize the neck so that the cartridge chambers and functions correctly in the firearm for which the load is being prepared.

There are, however, situations where ordinary full-length sizing does not solve every dimensional problem. That is where **small-base sizing** and **roll sizing** enter the discussion.

These are not techniques I regard as necessary for everybody. They are specialist tools for specialist situations. The mistake is not using them. The mistake is using them without understanding why.

A conventional full-length sizing die cannot physically size every part of a cartridge case. The case head itself cannot enter the die, and the shell holder has to grip and support the case at the bottom. That means the lowest part of the case body remains partly outside the sizing die.

For normal brass fired in a normal chamber this is rarely a problem. But brass fired in a particularly generous chamber, brass used in some self-loading firearms, or cases with an unknown history can sometimes be expanded farther down the case body than a standard sizing die can completely correct.

A sizing die can therefore be set perfectly for shoulder bump and still leave a dimensional problem farther down the case.

If a case remains tight after ordinary full-length sizing, I don't automatically keep screwing the sizing die farther down. I want to know which part of the case is causing the interference.

The shoulder may already be correct. The neck may already be correctly sized. The case length may be correct. Yet the lower body may still be larger than the chamber will comfortably accept.

More shoulder setback is not the answer to every chambering problem. The first job is to identify the dimension that is actually wrong.

A small-base sizing die is a variation of the conventional full-length sizing die. It generally sizes the case body slightly smaller, particularly through the lower body, than a standard full-length die.

The objective is greater chambering clearance. This can be useful where ammunition must operate reliably in a firearm that is less tolerant of a closely fitted case, or where fired brass has been expanded more than a normal full-length die can comfortably correct.

Small-base sizing and roll sizing are sometimes discussed together because both can address case-body dimensions. They are not the same operation.

A small-base die still works in a conventional reloading press. The case enters the die from the bottom in the normal way and the shell holder still has to support the case. That means the lowest part of the case remains subject to the same basic physical limitation as any press-mounted sizing die.

A roll sizer works differently, and that difference matters when the dimensional problem is very close to the case head.

I don't use a small-base die simply because somebody tells me it makes ammunition more reliable.

If ordinary full-length sizing produces ammunition that chambers and functions correctly in the intended firearm, I see no advantage in making the brass smaller than necessary.

I consider small-base sizing when there is a genuine reason, such as brass fired in a generous chamber, a firearm that genuinely requires additional lower-body clearance, or cases that remain tight after correct ordinary full-length sizing.

As always, I want to solve an actual problem.

The Cost of Additional Sizing

Every time we size brass, we move material. If a small-base die reduces the body farther than a standard die, the brass has to expand farther again when it is fired.

That doesn't automatically make the process harmful, but it is another reason not to size more than required.

Size enough to achieve reliable function, but do not size more simply because the tool can.

Some self-loading and straight-pull firearms can reveal tight-fitting ammunition more readily than a conventional turn-bolt action. The cartridge has to feed, chamber, fire and extract reliably within the operating cycle of the firearm.

That doesn't mean every such firearm automatically requires a small-base die. Many work perfectly well with correctly full-length-sized ammunition.

The requirement should be established from the actual firearm and brass rather than assumed from the action type alone.

We will deal with straight-wall and pistol cases in their own chapter because their sizing, expanding and crimping requirements deserve separate treatment.

A case fired in another rifle reflects **that rifle's chamber**, not mine.

If the previous chamber was larger in the lower-body region, the brass may be expanded farther down than my chamber will comfortably accept. A normal full-length die may correct most of the case while leaving a small amount of lower-body expansion untouched.

This is one reason second-hand brass deserves more caution than brass whose history I know. It is not enough simply to measure the shoulder and assume everything else is correct.

The same principle applies even more strongly to range-pickup brass. I may not know how many times it has been fired, what chamber it came from, whether it was previously resized, or how heavily it has already been worked.

That does not automatically make it unusable. It means I treat it as **unknown brass** until I have inspected and measured it properly.

If a case still has a lower-body problem after ordinary full-length sizing, I investigate rather than forcing it into the chamber.

Roll sizing approaches the problem differently from a conventional die.

Instead of pushing the case axially into a die from the open end, a roll-sizing machine applies controlled pressure around the lower case body as the case passes through the machine.

The process can reach farther down towards the extractor groove and case head than a conventional press-mounted sizing die. That makes it particularly effective for correcting **lower-body or case-base expansion**.

This is the main reason roll sizing exists.

The area close to the extractor groove is one of the hardest parts of the case to resize conventionally. A normal die cannot reach all the way down because the shell holder occupies that space.

If the case has expanded significantly in this region, it may remain difficult to chamber even when the shoulder and upper body have been sized correctly.

Roll sizing allows that lower region to be worked much more directly.

A roll sizer generally does **not** replace the normal full-length sizing operation. It addresses a different area of the case.

After roll sizing, the body, shoulder and neck may still need to be controlled in the normal way with the appropriate sizing die.

I therefore regard roll sizing as a specialist pre-sizing or correction operation rather than a replacement for controlled full-length sizing.

Roll Sizing Before Final Full-Length Sizing

Where roll sizing is being used to correct a lower-body problem, I prefer the final conventional full-length sizing operation to establish the dimensions I care about for the finished prepared case.

That allows me to correct the base or lower body first, then establish shoulder bump, upper-body dimensions and neck condition afterwards.

Whatever equipment is used, the **final prepared case still needs to be measured**.

Roll sizing is particularly well known in high-volume pistol and practical-shooting circles because some fired straight-wall cases can develop lower-body expansion that a conventional sizing die does not fully reach.

That is a valid example of where the process can be useful, but I am deliberately not going deeply into pistol brass here.

Straight-wall and pistol cases have different sizing, expanding, headspacing and crimping considerations, and those deserve their own chapter rather than being squeezed into this one.

If a case has been stretched, cracked, severely bulged, badly corroded or structurally weakened, forcing it back into dimension does not necessarily make the brass sound again.

A sizing machine changes shape. It doesn't replace damaged metal.

So before using any more aggressive sizing method, I inspect the brass carefully. If I don't trust the case structurally, I discard it.

The ability to resize a case is not proof that it should be reused.

Where roll sizing is being used deliberately, measurement is useful. I want to know what problem I started with and whether the operation actually corrected it.

That may involve measuring case-body diameters at consistent reference points and comparing them with known-good cases or appropriate cartridge dimensions.

The exact method depends on the cartridge and equipment. What matters is that I don't simply feed cases into a machine and assume everything coming out is automatically correct.

Measure the result.

A properly made cartridge or case gauge can be useful when dealing with sizing problems. A gauge can quickly show whether a case or finished cartridge falls within the dimensions the gauge is designed to assess.

But a gauge is a reference tool, not necessarily a perfect duplicate of the chamber in the firearm for which the ammunition is being prepared.

For my own ammunition, the gauge provides useful information, while the intended firearm provides the final functional chambering check when handled safely and unloaded for that purpose.

A cartridge that physically chambers in more than one firearm is **not automatically suitable or safe to fire in more than one firearm**.

Two rifles chambered for the same cartridge can still differ in chamber dimensions, throat geometry, barrel dimensions, condition and the way they respond to the same ammunition.

A load developed and proven in one rifle should therefore **not simply be transferred to another rifle because the cartridge fits the chamber**.

The sizing discussion in this chapter is only about whether the case dimensions are suitable for the intended firearm. It is not permission to use a developed reload interchangeably between rifles.

For my own loading, I keep reloaded ammunition associated with the firearm for which it was developed and tested.

If I want to use the same component combination in another rifle, I treat that as a separate load-development exercise and work from appropriate published data for that firearm.

Same cartridge designation does not mean identical pressure behaviour from one rifle to another.

Small-Base Sizing Versus Roll Sizing

Small-base sizing uses a conventional press-mounted sizing die and reduces the lower case body somewhat more than a standard die, but it still cannot completely size the region occupied by the shell holder.

Roll sizing uses specialist machinery and can work much closer to the extractor groove and case head, making it useful where ordinary dies cannot fully correct lower-body expansion.

Neither method is automatically better. They solve different degrees of the same general dimensional problem.

A small-base die still has to be set correctly with regard to the shoulder.

Using a small-base die does not mean the shoulder should simply be pushed backwards as far as possible. Lower-body diameter and shoulder position are separate dimensions.

I can need more body sizing while still wanting controlled shoulder movement.

That is exactly why the previous two chapters matter.

Some manufacturers produce die sets intended specifically for service-rifle, self-loading or other demanding applications.

These can be very useful where their extra sizing is genuinely required. But the label on the box does not remove the need to measure the brass.

I still want to know what the fired case measured, what the sized case measures, whether the cartridge chambers correctly in its intended firearm, and whether the brass is being worked more than necessary.

The equipment assists the process. It doesn't replace understanding it.

If I roll size or small-base size a batch as a deliberate specialist operation, I record it as part of the case history.

If the brass later behaves differently, I want to know what operations it has received.

Good records remove uncertainty.

There is a temptation when dealing with a difficult case to keep applying progressively more aggressive methods.

Full-length size it. Then small-base size it. Then roll size it. Then try something else.

At some point, the sensible question becomes:

why am I trying so hard to save this case?

Brass is consumable.

If one case repeatedly causes trouble while the rest of the batch behaves normally, I am perfectly happy to retire it.

Specialist sizing exists to process appropriate brass, not to rescue every questionable case on the bench.

Roll sizing earns its place when the same lower-body dimensional problem occurs across a significant batch of otherwise sound brass.

Perhaps the cases were all fired in the same generous chamber. Perhaps they came from the same type of firearm. Perhaps they are part of a high-volume competition batch.

In that situation, a controlled roll-sizing process can correct a repeatable dimensional problem efficiently.

That is very different from repeatedly trying to rescue one strange case.

I don't see roll sizing as a routine operation for good new brass.

New brass should already have suitable external dimensions, and my normal preparation includes full-length sizing new brass as described earlier.

Roll sizing is a specialist correction for lower-body expansion or dimensional conditions that ordinary sizing does not adequately address.

The same logic applies to small-base sizing. If normal full-length sizing produces the required result, I don't add more sizing simply for the sake of doing more work.

For brass fired and kept with one precision bolt rifle, properly controlled full-length sizing remains my foundation.

Shoulder bump is controlled, the body is sized appropriately and the brass history is known.

Small-base and roll sizing become relevant when a specific lower-body problem actually exists, particularly with brass from another source or firearm.

That is why this material belongs in a specialist sizing chapter rather than in the basic full-length die setup.

Think About the Problem Before Choosing the Tool

This entire chapter comes back to one question:

what dimension am I trying to correct?

If the shoulder is too far forward, control shoulder sizing correctly.

If the ordinary case body needs reducing, use the correctly adjusted full-length die.

If greater lower-body clearance is genuinely required, a small-base die may help.

If the problem is extremely close to the case head where conventional dies cannot reach, roll sizing may be the appropriate specialist solution.

The tool follows the diagnosis. Not the other way round.

With advanced body sizing covered, we have completed the main sizing discussion for conventional bottleneck cases.

Before moving into precision neck-tension work, there are two case types that deserve their own treatment because they do not fit neatly into the ordinary bottleneck-rifle sequence.

After the specialist case types are covered, the normal sequence moves into neck-tension control, including expanders, bushings and mandrels. Detailed neck turning is reserved for the later advanced precision section.

Chapter 16 — Straight-Wall and Pistol Cases: Sizing, Expanding and Preparing Them Correctly

Up to this point, most of the case-preparation discussion has concentrated on bottleneck rifle cases. Straight-wall and pistol cases need their own treatment because several parts of the process are different.

The basic principles remain the same — inspect the brass, keep batches organised, size correctly, prepare the case mouth properly and avoid unnecessary working of the brass — but the details can change significantly.

A straight-wall pistol case may headspace differently, may use a carbide sizing die, normally needs its case mouth expanded or flared before projectile seating, and may use a taper crimp rather than a roll crimp. Because many pistol cartridges have relatively small internal capacities, changes in seating depth can also have a meaningful effect on pressure.

A straight-wall case has little or no conventional bottleneck shoulder. Some cases described as straight-wall actually have a slight taper. Many familiar pistol and revolver cartridges use this general form, and some rifle cartridges do as well.

The important difference is that we no longer have the pronounced shoulder used by a typical bottleneck rifle cartridge to control much of the chamber relationship. That changes how some cartridges headspace and how we think about sizing and case preparation.

A rimmed case has a rim projecting beyond the case body and normally headspaces on that rim. Traditional revolver cartridges are obvious examples. Rimless cases use an extractor groove and many self-loading pistol cartridges use the case mouth as the forward headspacing reference. Semi-rimmed designs sit between the two.

Many familiar rimless pistol cartridges, including 9mm Luger and .45 ACP, are designed to headspace on the case mouth. That makes the finished case mouth important and is one reason I don't blindly apply a heavy roll crimp to these cartridges.

Where a crimp is required on a case-mouth-headspacing cartridge, a taper crimp is normally the appropriate approach because it removes the flare without rolling the mouth heavily inward.

The same inspection rules used earlier still apply. I look for mouth splits, cracks, corrosion, severe dents, damaged rims or extractor grooves, unusual lower-body bulges, loose primer pockets and any other structural concern.

Straight-wall pistol case mouths can be worked several times during every loading cycle: firing, sizing, expanding, seating and crimping. Excessive flare followed by excessive crimp simply works the brass more than necessary.

Expand only enough to do the job.

My basic preparation philosophy does not change. I deprime before cleaning, dry wet-cleaned brass completely, and inspect again. Primer-pocket uniforming and flash-hole preparation are automatic initial batch-preparation operations for me; once the flash hole has been correctly deburred, I don't keep cutting it every loading cycle.

Straight-wall pistol cases are resized along most of their usable body length. There is no conventional shoulder bump to establish in the way there is with a bottleneck rifle case. The objective is to reduce the fired body sufficiently for reliable chambering while providing the dimensions required for the next loading cycle.

Carbide sizing dies are extremely common for straight-wall pistol cartridges. They normally allow clean straight-wall cases to be resized without the same full case lubrication required for bottleneck rifle brass. This makes high-volume loading faster and cleaner.

Carbide does not mean friction disappears. Clean brass still matters, and some reloaders use a very light lubricant to reduce effort when processing large quantities. What matters is that normal carbide sizing does not depend on the same lubrication regime as a conventional steel bottleneck sizing die.

Tapered Pistol Cases and Lower-Body Sizing

Not every pistol case is truly cylindrical. The 9mm Luger case, for example, has a taper. Lower-body expansion can also occur in brass fired through some self-loading firearms. If ordinary sizing leaves a genuine dimensional problem near the case base, the roll-sizing methods covered in Chapter 15 may become relevant.

> **Roll sizing corrects dimensions. It doesn't repair structurally damaged brass.**

Once the case has been sized, the mouth normally needs to be expanded or flared slightly before projectile seating. I want only enough flare for the projectile to start squarely without shaving lead, coating or jacket material.

If the case mouth looks like a trumpet, I have gone too far. Excessive flare unnecessarily works the brass and then requires more movement to remove it during crimping.

Dedicated expander dies and powder-through expanders can both work well. I set them progressively: start with too little flare, test the projectile, and increase the adjustment only until the projectile starts cleanly and squarely.

Many straight-wall pistol cases do not require the same routine trimming seen with bottleneck rifle brass, but case length is not irrelevant. It can affect both case-mouth headspacing and crimp consistency.

Where a roll crimp is used, cases of significantly different lengths will receive different amounts of crimp. Consistent case length therefore becomes much more important.

Taper and roll crimps do different jobs. A taper crimp mainly removes the case-mouth flare and is commonly used with rimless cartridges that headspace on the case mouth. A roll crimp turns the mouth inward and is normally associated with suitable revolver or other crimp-groove applications.

At this stage I only need the distinction. Chapter 30 deals with setting and using each type in the context of finished pistol and revolver ammunition. Crimp is not a substitute for correct sizing or projectile retention.

Chapter 17 — Belted Magnum Cases: Headspace, Sizing and Case Life

Figure 17.1 — *Two different case-head forms shown side by side, with the projecting rim and belted-magnum belt clearly visible.*

Belted magnum cases deserve their own chapter because they introduce a feature that is easy to misunderstand: the belt.

At first glance, the belt can make the case look stronger or more substantial than an ordinary bottleneck rifle case. That appearance has led to a great deal of confusion over the years.

The belt was not originally added simply to make the case stronger. Its primary purpose was to provide a positive headspacing feature on cartridges whose shoulder geometry was not always ideal for doing that job reliably.

Once that is understood, belted cases become much easier to deal with. For the reloader, the important point is that a belted bottleneck case gives us two useful dimensional relationships: the belt and its

chamber recess, and the shoulder and chamber shoulder. I want to understand both without allowing the belt to distract me from the condition of the rest of the case.

The classic example is the .375 Holland & Holland Magnum.

The original H&H case has a long body and a relatively shallow shoulder. That shoulder geometry was not ideal as the sole feature for controlling the cartridge's forward position in the chamber, so the belt provided a positive reference.

A raised band was formed around the case just ahead of the extractor groove, and the chamber included a corresponding recess. When the cartridge was chambered, the belt stopped forward movement at the intended position.

The concept worked well and became the basis for a large family of magnum cartridges.

Familiar examples include the .300 Winchester Magnum, .338 Winchester Magnum, 7mm Remington Magnum, .264 Winchester Magnum, .458 Winchester Magnum and .416 Remington Magnum, together with numerous wildcats and proprietary developments.

They do not all have identical shoulder designs, capacities or loading characteristics. The belt links them historically and dimensionally, but it does not mean every belted cartridge should be treated as though it is the same case with a different calibre.

In a cartridge designed to headspace on the belt, the front surface of the belt forms the primary headspacing reference and the chamber has a corresponding belt recess. That allows the cartridge to be located correctly even when the shoulder is relatively shallow.

The belt is therefore best thought of as a headspacing feature, not as a pressure reinforcement ring.

A belted case is not automatically stronger than a comparable non-belted case simply because the belt is present. Modern non-belted magnum cases operate at substantial pressures without one. The pressure-containing strength still depends on the complete case design, material, head and web construction, and support from the firearm.

The cartridge must still be loaded within appropriate published data and pressure limits. Nothing about the belt gives permission to exceed them.

The belt may provide the formal headspacing feature, but once a bottleneck belted case has been fired in a particular chamber its shoulder has also expanded forwards to reflect that chamber.

That fired shoulder becomes a useful reference for subsequent sizing. For brass that will continue to be used in the same rifle, I don't see an advantage in repeatedly pushing the shoulder much farther back than necessary simply because the belt can still stop the cartridge moving too far forwards.

There can be clearance between the belt and the forward surface of the chamber recess within normal manufacturing tolerances. If the shoulder is also sized substantially short of the chamber shoulder, the case must expand forwards again when it is fired. Repeating that cycle works the brass more than necessary.

So my principle remains the same as with other bottleneck rifle cases: size for reliable chambering, but control shoulder movement rather than using the belt as an excuse to over-size the case.

Measuring the Shoulder on Belted Cases

A shoulder comparator can be used on a bottleneck belted case in much the same way as on a non-belted bottleneck case. I'm not claiming that the comparator reading is the firearm's formal headspace measurement; I am using it comparatively.

I measure the fired case, size it, and measure it again. The difference tells me how far the shoulder has moved.

For brass dedicated to the same rifle, this gives me a useful and repeatable sizing reference alongside the belt.

One of the most important areas to watch on a belted magnum case is the lower body immediately in front of the belt.

A conventional full-length sizing die cannot simply pass over the belt. It must stop above it, which creates a physical limitation in how completely the die can work the lowest part of the case body.

In some chambers and after repeated firings, brass can expand in this difficult-to-reach region. If that expansion becomes significant, the case may remain tight even though the shoulder and upper body have been sized correctly.

The important question is whether the lower body has expanded enough to affect chambering or whether the case shows evidence of excessive working or structural concern. I don't respond by simply pushing the shoulder farther backwards, because that does not solve a lower-body diameter problem.

Specialist dies are available that use a collet arrangement to size the region immediately above the belt. They apply controlled pressure around the lower body and can reach an area that a conventional full-length die may struggle to correct.

For someone repeatedly working with otherwise sound belted magnum brass from a chamber that produces this dimensional problem, such a tool can be useful.

But it remains a specialist solution to a specific problem. If my brass chambers correctly after normal full-length sizing and the lower body is within suitable dimensions, I don't add another sizing operation simply because the tool exists.

Identify the problem first, then choose the tool. Extra sizing is not automatically better sizing.

Belted magnum brass deserves particular attention for longitudinal stretching, especially if the shoulder is repeatedly set back farther than necessary.

When the cartridge is fired, the case head is driven back against the bolt face while the forward part of the case expands to fill the chamber. If there is unnecessary clearance at the shoulder, the brass has farther to move.

Repeated cycles of excessive sizing can therefore contribute to thinning in the lower case body and eventually to incipient case-head separation.

The fact that the cartridge still chambers readily on the belt can hide this poor sizing practice. Easy chambering alone does not prove that the die is correctly adjusted; I measure what the sizing operation has done.

The same inspection principles from Chapter 7 apply. I pay close attention to suspicious circumferential marks, bright rings, or an internal groove that indicates developing thinning in the lower body.

If I find definite evidence of developing case-head separation, the case is finished. No amount of annealing, full-length sizing or specialist belted-case sizing can restore metal that has already been dangerously thinned.

Annealing treats the neck and shoulder region. It doesn't repair stretching near the case head, tighten a loose primer pocket or restore damaged brass immediately ahead of the belt.

This is another reason not to judge the life of a case by the condition of its neck alone. A case is finished when the first important structural or dimensional limit is reached.

Primer Pockets and Flash Holes

My normal initial case-preparation standard remains the same with belted magnum brass: every case in the batch receives primer-pocket uniforming and flash-hole preparation.

That is an initial consistency operation, not an instruction to keep cutting material away on every loading cycle. Once the flash hole has been correctly deburred, later attention is inspection and cleaning rather than repeated cutting.

Primer-pocket condition also becomes part of the case-life picture. If a pocket becomes sufficiently loose that I no longer trust it to retain the primer correctly, the case is finished for me.

Belted magnum cases can vary substantially between manufacturers and lots. Cases carrying the same cartridge designation can have different internal capacities because of differences in wall and web construction.

That means changing brass can change the load. If I change manufacturer or make a significant lot change, I don't simply assume an established load remains unchanged. I return to appropriate published data and re-establish the load safely.

The classic H&H designs show clearly why the belt existed. Their relatively shallow shoulder geometry made a positive belt reference particularly useful.

Later belted cartridges such as the .300 Winchester Magnum, 7mm Remington Magnum and .338 Winchester Magnum have more defined shoulders. Once those cases have been fired in a known chamber, the shoulder provides a very useful comparative sizing reference even though the belt remains part of the cartridge design.

The exact geometry differs from cartridge to cartridge, but the practical lesson is the same: understand the belt, then manage the fired shoulder and lower body deliberately rather than treating everything above the belt as irrelevant.

As with my other bottleneck rifle brass, I full-length size new belted magnum cases before their first loading. New cases can have dented or imperfect necks from manufacture, packaging or transport, and I want the entire batch established through the same preparation process.

Before the first firing I don't yet have a fire-formed shoulder measurement from my rifle. After firing, I gain the chamber-specific reference that allows subsequent shoulder control to be based on the actual brass from that rifle.

I am particularly cautious with used belted-magnum brass from another rifle or from an unknown source. Its shoulder and lower body reflect somebody else's chamber and its history may not be what the description suggests.

Unless I personally know otherwise, once-fired is a description rather than proof. I inspect used brass as unknown brass, with particular attention to the lower body ahead of the belt, primer-pocket condition and signs of stretching.

The correct headstamp alone does not make the brass suitable for my rifle.

For my own reloaded belted-magnum ammunition, I keep the brass and load associated with the rifle for which they were developed and tested. That gives me a known chamber reference, fired-case measurements and a known load-development history.

A reload that physically chambers in another rifle has only passed a dimensional test. It has not proved that the load is safe in that firearm. Different rifles can have different throats, chamber dimensions, barrels and pressure behaviour even with the same cartridge designation.

If I want ammunition for another rifle, I treat that as a separate load-development exercise using appropriate published data. I don't treat reloads as interchangeable simply because the belt and cartridge designation match.

Measuring Tools and Case Gauges

Specialist tools are available for measuring belt-related dimensions, and case gauges can be useful for checking whether a case falls within the dimensions the gauge is designed to assess.

I use the tool that answers the question I actually have. For routine belted-magnum brass management, my main concerns are reliable chambering, controlled shoulder movement after fire-forming, lower-body diameter and signs of stretching.

A gauge or successful chambering check is a dimensional reference. It doesn't prove that a reload is pressure-safe.

Belted magnum brass can be expensive, which understandably encourages reloaders to make it last. But the price of the case does not change whether it is still suitable to use.

If the primer pocket is loose, the lower body is thinning, the case is cracked or another structural problem appears, the case is finished. I would rather replace expensive brass than try to gain one more firing from questionable brass.

With expensive magnum brass, case-history records become particularly useful. I want to know the manufacturer and lot, rifle, number of firings, annealing history, shoulder measurements, whether specialist lower-body sizing has been used, primer-pocket condition and any developing signs of wear.

Those records help identify patterns before they become surprises.

For fired belted-magnum brass that belongs to a known rifle, my broad approach remains straightforward:

Inspect → deprime → clean → inspect again → complete the established primer-pocket and flash-hole preparation for a new batch → anneal as appropriate → full-length size with controlled shoulder movement → inspect the region ahead of the belt → measure and confirm the result.

If a genuine lower-body sizing issue remains immediately ahead of the belt, only then do I consider the appropriate specialist sizing method.

The belt does not require the entire loading process to become complicated. It simply requires us to understand what it does and what it does not do.

Do not let the belt distract you from the rest of the case.

It has a legitimate headspacing purpose, but the fired shoulder remains a useful sizing reference, the lower body still requires inspection, primer pockets still wear, capacity still varies and the brass still has a finite working life.

A belted case is not mysterious. It simply has one extra dimensional feature that needs to be understood and managed correctly.

With straight-wall/pistol cases and belted magnum cases covered, we have dealt with the main case designs that differ from the ordinary bottleneck rifle case preparation discussed earlier.

The next stage takes us properly into precision neck preparation.

That will lead naturally into expanders, mandrels and neck turning in the chapters that follow.

Chapter 18 — Neck Tension, Expanders, Bushings and Mandrels: Understanding and Controlling the Case Neck

Neck tension is one of those expressions that reloaders use constantly, yet it is often explained too simply.

We might say that a cartridge has 0.002 inch of neck tension, for example, as though we have directly measured how firmly the case is holding the projectile. Usually, we have not. What we have actually measured is a dimensional difference, while the real grip between the case neck and projectile is influenced by the brass, its condition, the sizing method and the surfaces involved.

For normal good-quality reloading I don't believe this needs to become unnecessarily complicated. A correctly set full-length sizing die with its normal die-mounted expander or sizing button can produce excellent ammunition. Bushing dies give us more control, particularly when neck-wall thickness has been changed by neck turning. Separate mandrels can take that control further still and remain a normal optional neck-tension method when that is the system I have chosen.

The important thing is to understand which tool is establishing the final neck dimension, lubricate it correctly, and measure what the brass actually produces rather than relying only on the number engraved on the tool.

When a projectile is seated, the inside diameter of the prepared case neck is normally slightly smaller than the projectile diameter. The neck therefore expands as the projectile enters, and the elastic behaviour of the brass creates grip around the projectile.

Reloaders commonly describe the dimensional difference as neck tension. If a 0.308-inch projectile is seated into a neck whose effective internal diameter before seating is approximately 0.306 inch, we may describe that as about 0.002 inch of neck tension.

0.308 - 0.306 = 0.002 inch

That language is convenient and I use it myself, but technically it is better thought of as dimensional interference. We have not directly measured the actual force required to pull the projectile from the case.

Figure 18.1 — *Neck-tension dimensions. A shows projectile diameter, B the prepared internal neck diameter before seating, C one neck-wall thickness and D the loaded outside neck diameter. The dimensional difference commonly called neck tension describes interference, not a direct measurement of holding force.*

Two cases can show the same measured interference and still grip a projectile differently. Actual retention is affected by several things:

- neck-wall thickness and uniformity
- brass hardness and work-hardening history
- annealing condition
- springback after sizing or expansion
- inside-neck surface condition
- projectile diameter and surface finish
- the amount of sizing applied before expansion
- how consistently the expander or mandrel is lubricated and used

That's why I am interested in consistency of the complete preparation process rather than chasing one isolated number.

So the practical distinction is simple: bushing only or bushing with the normal die expander — around 0.002 inch as the normal starting reduction; bushing followed by a separate precision mandrel — around 0.004 inch reduction before the mandrel. I still measure the actual brass and confirm the final setup through load development.

If I am using the separate-mandrel method of sizing first and then expanding the neck over a separate mandrel, I normally start with approximately 0.004 inch reduction at the bushing. That gives the mandrel enough brass to work consistently rather than barely touching some necks and working others more heavily.

If I am using a bushing die and I'm not running a separate mandrel afterwards, my normal starting calculation is loaded neck outside diameter minus approximately 0.002 inch.

My Bushing Starting Points

These are practical starting points rather than universal laws. The final choice still needs to be confirmed during load development because brass hardness, annealing condition, neck-wall thickness, projectile finish, springback and the sizing system all influence the result.

For my normal precision rifle loading, around 0.002 inch of dimensional neck tension is the practical starting point I generally prefer. I regard approximately 0.001 inch as generally too loose for my liking; around 0.0015 inch can work; around 0.002 inch is where I normally like to begin; and 0.003 inch or more is generally tighter than I want for normal precision loading.

Seating Force — An Advanced Diagnostic

Neck tension and seating force are closely related, but they are not the same measurement. The neck-tension figure we normally quote is a dimensional interference value: the difference between the prepared internal neck diameter and projectile diameter. Seating force is the actual resistance encountered as the projectile is pushed into the case neck.

For advanced precision work, that difference matters. Two cases can measure the same nominal neck tension yet require noticeably different seating force because brass hardness, springback, neck-wall uniformity, annealing condition, internal neck finish, carbon or lubricant, projectile finish and bearing-surface length all influence friction and elastic grip.

My practical interpretation is deliberately simple. Around 0.001 inch of dimensional neck tension will often feel comparatively light. Around 0.002 inch is the useful starting point I generally prefer for precision rifle ammunition because it usually gives positive, repeatable grip without making the seating operation unnecessarily heavy. At around 0.003 inch and above, seating resistance can become noticeably heavier in some combinations. These are practical tendencies, not universal force specifications: the brass and projectile combination still decides what the press actually feels.

The important point is consistency within a known batch. I am not trying to make every cartridge reach a particular published force number. I want the seating events to behave similarly, and I investigate rounds that are obviously lighter, heavier or shaped differently on a force trace than the rest of the batch.

A useful practical guide is:

Nominal dimensional neck tension	Typical seating-force tendency
Around 0.001 in	Usually light seating resistance; useful only if the complete ammunition system gives adequate, repeatable grip.
Around 0.002 in	A strong practical starting point for many precision-rifle combinations; normally gives positive, controllable seating resistance.

Around 0.003 in and above	Can become distinctly heavy depending on brass and projectile condition; excessive resistance deserves investigation rather than simply more press force.

I treat those figures as starting points, not pass/fail limits. A change of 0.001 inch in nominal interference does not translate into a fixed increase in pounds of seating force. The relationship is influenced by the whole neck-and-projectile system.

What Seating Force Can Tell You

Seating force becomes valuable when it is used as a diagnostic measurement rather than another number to chase. A repeatable batch establishes its own normal pattern. If one round suddenly seats much more easily, I consider whether that case has less grip, a different internal neck condition, a dimensional anomaly or some other preparation difference. If one round is markedly harder, I look for excessive neck reduction, a dry or rough neck, unusual brass hardness, a larger projectile, contamination, a damaged mouth or another cause before continuing.

An experienced hand can feel large differences on a conventional press, but feel is subjective. Instrumented arbor presses and load-cell systems remove much of that subjectivity by measuring force throughout the seating stroke. Peak force is useful, but the shape of the curve can be even more revealing because it shows how resistance develops as the projectile enters and travels through the neck.

Reading a Seating-Force Trace

On a force-versus-travel graph, I am interested first in how closely the individual traces follow one another. A batch that produces broadly similar curves is behaving consistently. A trace that sits well below the group, rises unusually quickly, contains an obvious step or finishes much higher than its neighbours is a reason to inspect that cartridge and the preparation steps that produced it.

I do not treat the lowest possible force variation as a guarantee of the smallest group. The graph is a process-control tool. It tells me whether the ammunition is being assembled consistently; the rifle and target still decide whether that consistency translates into useful performance.

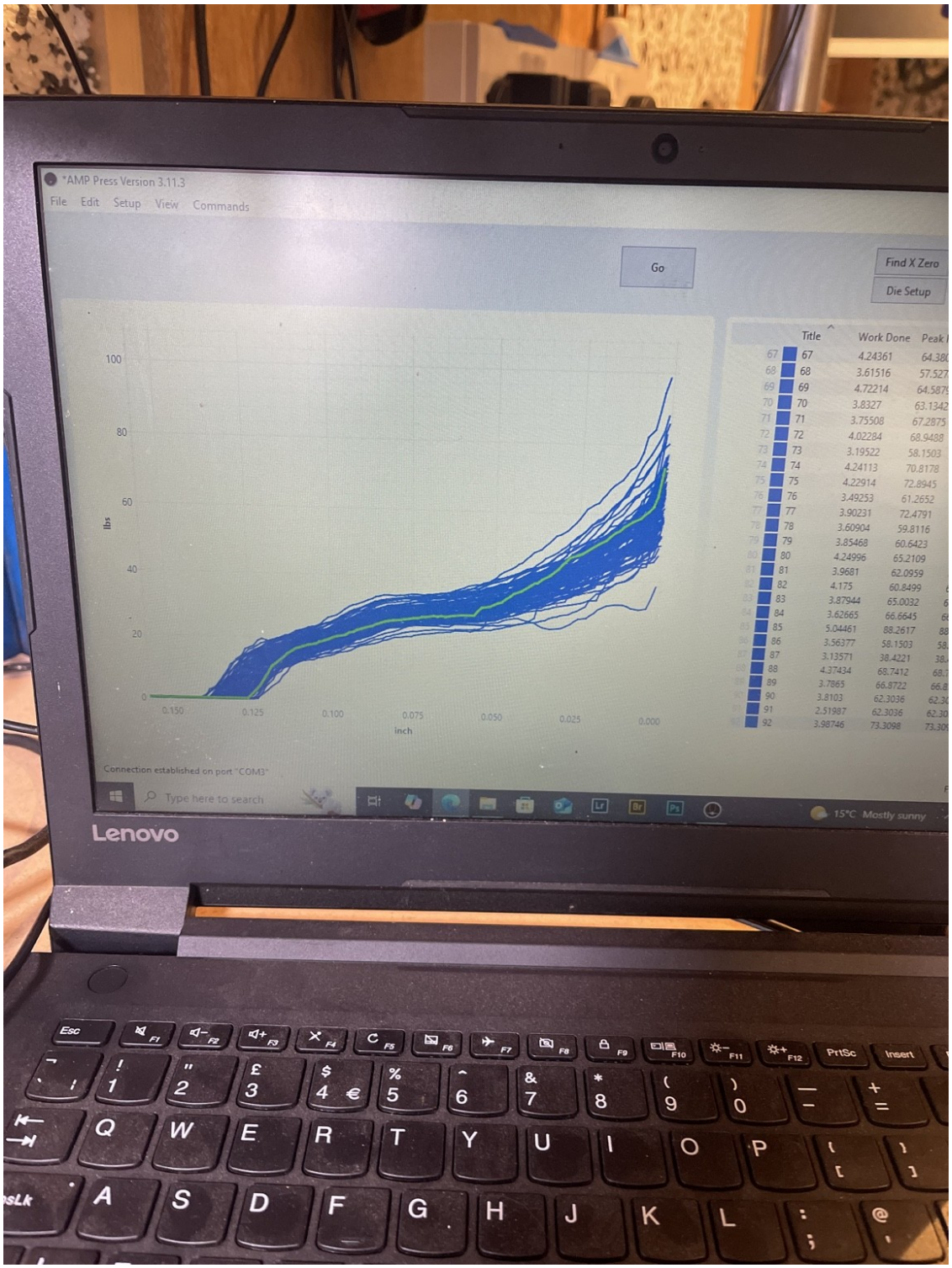


Figure 18.2 — Real seating-force traces recorded by an instrumented arbor press. The group of curves shows the normal spread within a batch and makes unusually light or heavy seating events easier to identify. The graph is a diagnostic comparison, not a universal target force.

Excessive Seating Force and Seating-Stem Marks

When seating resistance becomes unnecessarily high, the seating stem has to transmit that extra load through its contact area on the projectile ogive. If the stem profile contacts over a narrow band, the result can be a visible circular witness mark or, in more severe cases, a deeper ring in the jacket.

A faint witness line is not automatically harmful, but a pronounced mark is useful information. It tells me to check the complete system: neck tension, inside-neck condition, brass hardness, projectile diameter and finish, seating-stem fit and whether the projectile is being asked to compress a powder column. Increasing press force without finding the reason is not the answer.

This is another reason I prefer around 0.002 inch as a practical starting point rather than assuming that more neck tension must be better. I want enough grip to produce consistent ammunition, not so much interference that seating becomes unnecessarily heavy or begins marking projectiles.

For normal reloading, the conventional full-length die with its die-mounted expander or sizing button remains the basic system. The die reduces the outside diameter of the neck as the case enters. As the case is withdrawn, the expander passes back through the neck and establishes the final internal neck diameter.

Standard sequence: die sizes the neck down -> expander passes back through -> final internal neck diameter is established.

This is standard reloading, not an inferior version of precision loading. Properly set up and used, it can produce extremely good ammunition.

For the expander to establish a repeatable internal diameter, the neck first has to be reduced enough for the expander to work on it. If the neck were left at or above the expander diameter, the expander could pass through with little or no contact.

The standard die therefore sizes the neck smaller, then the expander brings the inside diameter back out. That means the brass is moved in two directions, which is why expander finish, lubrication and the amount of sizing all matter.

When I am using a die-mounted expander or sizing button, I prefer a very light film of sizing wax inside the case neck. For this normal sizing operation, wax gives the button a smooth surface to work against and reduces the grabbing or snatching that can occur when a dry expander is pulled back through a freshly sized neck.

The word light matters. I don't pack wax into the neck or leave an obvious lump of lubricant inside the case. The aim is simply to put a thin film on the internal bearing surface that the expander will contact.

A small applicator, cotton bud or suitable neck brush can be used. Whatever I use, I keep it clean and apply the wax consistently from case to case. I don't want some necks nearly dry and others heavily coated.

A heavily dragging expander is more than an irritation at the press. As the case is withdrawn, the expander is pulling through a neck that has already been sized. Excessive drag can pull on the neck and shoulder and may disturb some of the dimensional control we worked to establish during sizing.

What I want to feel is smooth, repeatable resistance. If twenty cases feel similar and the next one suddenly requires much more force, I stop and investigate rather than simply pulling harder.

Possible causes include insufficient wax, a rough or dirty expander, unusually thick neck walls, harder brass, excessive neck reduction, contamination inside the neck or a case that does not belong with the rest of the batch.

Inspect the Expander Itself

The expander should be clean, smooth and appropriate for the cartridge. A damaged or rough surface creates unnecessary friction. Different manufacturers use different expander shapes and materials, including polished steel and carbide arrangements, but the basic objective is the same: establish a consistent internal diameter without dragging or distorting the neck unnecessarily.

Alignment matters too. If the neck is straight before an expander or mandrel operation and noticeably less straight afterwards, that tells me the tooling or the way it is being used deserves attention. Heavy expander drag, a dirty or damaged expander, poor lubrication or misalignment can all influence the result.

When I have a reason to investigate, I measure a few cases at the same point on the neck before and after the operation. I am looking for a pattern, not trying to grade every case by tiny differences on the dial.

A mandrel or expander that improves internal diameter consistency but introduces obvious neck runout has not improved the complete case-preparation process. Conversely, if the finished ammunition already shoots well, a very small gauge movement is not automatically a problem that needs another operation.

The expander can be removed from many sizing dies, but removing it changes the sizing system. I don't remove it simply because somebody has said that expanders are bad for accuracy.

If I remove the expander from a conventional die, the die or bushing is no longer followed by a tool that establishes the final internal diameter. The finished neck dimension then depends on the sizing diameter, neck-wall thickness and brass springback unless I deliberately add another operation.

Removing the expander can reduce drag and remove one possible source of neck displacement, but only when I have another controlled way of establishing the final neck dimension.

A full-length bushing die allows me to choose how far the outside of the neck is reduced. Instead of one fixed neck-sizing diameter machined permanently into the die, I select an interchangeable bushing.

That control becomes particularly useful when neck-wall thickness varies from what a standard die was designed around, and it becomes especially important after neck turning because neck turning physically removes brass from the neck wall.

The detailed bushing calculation was established in Chapter 13. Here I use that calculated size as a starting point and concentrate on what the finished neck actually does.

A useful dimensional check is the amount the neck expands when the projectile is seated:

Approximate neck expansion during seating = loaded neck OD − sized neck OD

For example, if the sized neck measures 0.290 inch and the same neck measures 0.292 inch after seating:

0.292 − 0.290 = 0.002 inch expansion

That 0.002 inch figure is a useful reference for comparing my own setup. It is not a direct measurement of seating force or a complete definition of mechanical neck tension; brass hardness, springback, surface condition and tooling still matter.

This is an important part of my method. If I am using a bushing full-length die with its expander still fitted, I normally want the bushing to size the neck slightly tighter than I would if the bushing alone were intended to establish the finished neck dimension.

The reason is simple: I want the expander to positively work on every case. The bushing reduces the neck, then the expander establishes the final internal diameter as the case comes back out of the die.

Bushing + expander sequence: bushing sizes neck slightly smaller -> expander works every neck -> expander establishes final internal diameter.

If I use such a large bushing that the neck is already almost at the expander's final diameter, the expander may barely contact some cases. With small variations in wall thickness and springback it might work one neck properly and hardly touch the next. That is not the consistency I am looking for.

Do Not Overdo the Tighter Bushing

Using a slightly tighter bushing with an expander does not mean choosing an excessively small bushing and crushing the neck down far more than necessary. That would simply work the brass harder before expanding it again.

I want enough reduction for the expander to perform a positive and repeatable final-sizing operation on every neck, but no more than the system actually needs. The result is established by measurement and feel, not by deliberately making the press harder to operate.

Neck-Turned Brass Changes the Calculation

When I neck turn a case, I remove brass from the outside of the neck wall. The neck becomes thinner, so the loaded outside-neck diameter also becomes smaller. If I continue using exactly the same bushing as before, that bushing may no longer reduce the neck sufficiently.

For example, with a 0.264-inch projectile and 0.014-inch neck walls:

0.264 + (2 x 0.014) = 0.292 inch loaded neck OD

If I turn those neck walls to 0.0125 inch:

0.264 + (2 x 0.0125) = 0.289 inch loaded neck OD

Removing only 0.0015 inch from each wall has reduced the loaded outside diameter by 0.003 inch. That is a significant change in bushing terms. A smaller bushing will normally be required to restore the intended amount of neck reduction.

This is one of the strongest reasons for using a bushing die with neck-turned brass: I can compensate for the material I deliberately removed instead of being stuck with the fixed neck diameter of a standard die.

If the expander is removed and I intend the bushing itself to leave the neck close to its final dimension, my bushing choice changes. I would normally select a bushing closer to the final outside diameter I actually require because there is no die-mounted expander subsequently opening the neck again.

That is why the question "What bushing size do I need?" cannot be answered from calibre alone. I also need to know the loaded neck diameter, neck-wall thickness, whether the brass has been neck turned, whether an expander is being used, and what the brass actually measures after sizing.

A bushing marked 0.334 inch does not guarantee that every neck emerging from it will measure exactly 0.3340 inch. Brass springs back after the sizing pressure is removed, and the amount can vary with hardness, annealing condition, wall thickness and previous working history.

The same principle applies to expanders. The nominal tool diameter is important, but I still measure the case because the finished result is the combination of tool dimensions and brass behaviour.

Annealing does not create a particular neck tension by itself. What it can do is keep the neck and shoulder material in a more consistent condition through repeated cycles. That helps the brass respond more consistently to the bushing or conventional die and to the expander that follows.

If part of a batch is substantially harder than the rest, springback and projectile grip can vary even when every tool setting is unchanged. This is another reason I prefer consistent batch preparation.

The inside surface of the neck contributes to friction during both expansion and projectile seating. I therefore want the preparation method to be consistent. I don't polish a few necks aggressively and leave others heavily carboned, nor do I leave random amounts of wet lubricant in different cases.

With normal sizing-button use, the wax is there to assist the sizing operation. I apply it sparingly and keep the process consistent. Before the cartridge reaches final assembly, I want the neck condition to be deliberate rather than accidental.

A separate expanding mandrel can be used after sizing to establish a controlled internal neck diameter. I regard a separate mandrel as a normal optional method of controlling final internal neck diameter. It is not mandatory, but it belongs in the normal loading sequence when that is the neck-tension system I have chosen.

Figure 18.3 — *Sectioned case showing an expander/mandrel inside the neck. Unlike an external bushing, the mandrel establishes or influences the neck from the inside.*

A typical mandrel sequence is:

Mandrel sequence: full-length/bushing size with the die expander removed -> lubricate inside neck -> run the case over a separate mandrel -> mandrel establishes the final internal neck diameter.

This can provide excellent control, particularly when combined with consistent neck-wall thickness and neck turning, but it adds another operation and another dimensional relationship that the reloader needs to understand.

Carbon or Graphite Lubricant for Mandrels

My Practical Mandrel Sequence

When I use a separate mandrel to establish the final internal neck diameter, I first size the case with the bushing or sizing arrangement chosen for that system. The neck must be reduced enough for the mandrel to work it positively rather than merely pass through without doing anything.

I apply a very light, even film of carbon- or graphite-based dry lubricant inside the neck, then run the case fully and smoothly over the mandrel. I do not force a case that suddenly feels very different from the rest of the batch; I stop and find out why.

I measure representative cases after the operation and confirm the result again after seating a projectile. That tells me what the complete sizing-and-mandrel process is actually producing rather than relying only on the diameter marked on the tool.

For a separate mandrel operation, I prefer a carbon- or graphite-based dry neck lubricant rather than the sizing wax I use with the normal die-mounted expander.

A dry lubricant works well on the mandrel because it gives a smooth, repeatable pass through the neck without introducing an obvious wet film into a separate precision operation. As with wax, I use it sparingly. The aim is a thin and consistent coating, not a neck packed with powder.

A suitable neck brush or applicator can distribute the dry lubricant around the internal surface before the case is run over the mandrel. The applicator needs to remain clean so that I'm not introducing grit into every neck.

A separate mandrel can be extremely useful, but it is still an option rather than a requirement. A normal die-mounted expander works very well when it is set up, lubricated and maintained properly; the mandrel is another normal way of establishing the internal neck dimension when I choose that system.

I choose the separate mandrel when I want it to establish the final internal neck diameter after sizing. I use it because it suits the loading process I have chosen, not simply because somebody else uses one.

Whatever method I use, I measure the result. I can measure the outside neck diameter after sizing, the loaded outside-neck diameter after seating a projectile, and where appropriate the internal diameter with suitable measuring equipment.

I also pay attention to feel. A batch in which expander resistance or mandrel resistance changes dramatically from case to case is telling me something even before I reach the callipers.

Numbers and feel complement each other. Neither should be used blindly.

It is easy to assume that if some projectile grip is good, more must be better. That is not how I approach it. More dimensional interference means more movement of the neck during sizing and seating, and at some point I am simply working the brass unnecessarily.

The objective is sufficient, repeatable projectile retention for the application, not maximum grip. Excessive reduction can also make the expander work harder and increase drag.

Too little grip can create its own problems. The projectile may move too easily during handling, feeding or recoil. In self-loading firearms the feeding cycle can impose additional loads on the cartridge. Insufficient retention can therefore become both a functional and a safety concern.

The solution is correct case-neck preparation. I don't use an excessive crimp to compensate for a neck that was not sized correctly in the first place.

A crimp and neck tension both influence projectile retention, but they are different operations. Neck tension comes primarily from the dimensional and elastic relationship between the case neck and projectile. A crimp mechanically changes the case mouth around the projectile.

The two should not be confused. Crimping will be covered separately later in the book.

For ordinary reloading, I want a correctly adjusted full-length die, a clean and smooth die-mounted expander, a very light film of sizing wax inside the neck and a smooth, repeatable expander feel.

If I use a bushing die with the expander retained, I choose a slightly tighter bushing so the expander positively works every case and establishes the final internal diameter. If the brass has been neck turned, I recalculate and measure because the thinner walls will normally require a smaller bushing.

If I deliberately remove the expander, I make sure another controlled method will establish the finished internal diameter. When that method is a separate post-sizing mandrel, I use a light carbon- or graphite-based dry neck lubricant and treat it as part of my normal neck-tension sequence for that batch.

Above all, I measure what the brass actually produces. The number engraved on a bushing, expander or mandrel is a tool specification. The prepared case is the result that matters.

With neck tension, conventional expanders, bushing dies and the role of separate mandrels understood, the next logical subject is neck turning.

Detailed neck turning is covered later in the advanced precision section. If I decide that a batch needs neck turning, I carry out that operation earlier during case preparation, before the final sizing and neck-tension stages. From here, the normal loading sequence moves on to Chapter 19 — Understanding Primers.

That will take us another step into advanced precision case preparation without losing sight of the basic principle that has run through the book from the beginning: every operation should have a reason, and the result should be measured rather than assumed.

Chapter 19 — Understanding Primers

Once all the appropriate case preparation has been completed and the case has been sized correctly, we can begin assembling the cartridge.

The first component we are going to install is the primer.

Primers are small and relatively inexpensive compared with many of the other components we use, which can make their importance easy to underestimate. Yet the primer starts the entire ignition process.

When the firing pin strikes the primer cup, the priming compound is crushed against the anvil and ignites. The resulting flame passes through the flash hole and into the case, initiating ignition of the powder charge.

The basic principle is simple.

What matters to the reloader is that primers are available in different sizes, constructions and ignition characteristics. Choosing the correct primer is therefore part of developing and reproducing a load.

For most reloading, we do not need to make primer selection unnecessarily complicated. Use the correct primer type for the case, follow reliable published data and record exactly what was used.

For more advanced precision loading, primer choice can later become another variable worth testing.

The important thing is to understand what we are changing and why.

For the majority of modern centrefire rifle and pistol cartridges using Boxer primers, we will encounter four basic primer families:

- Small Pistol
- Large Pistol
- Small Rifle
- Large Rifle

Within those basic families we then find variations including standard primers, magnum primers, match or benchrest primers, primers designed with particular cup characteristics, and specialist primers intended for particular applications.

The fact that two primers look similar—or even share approximately the same diameter—does not automatically make them interchangeable.

That is one of the most important principles to establish from the start.

It is useful to understand the approximate dimensions involved because they help explain why simply asking whether a primer will physically fit into a case is not enough.

The following figures are typical nominal reference dimensions. They should not be treated as manufacturing tolerances or instructions for machining a primer pocket. Exact dimensions and tolerances can vary between manufacturers and particular products.

Primer family	Primer diameter (SAAMI range)	Primer height (SAAMI range)	Pocket diameter (SAAMI range)	Pocket depth (SAAMI range)
Small Pistol	0.1745-0.1765 in / 4.432-4.483 mm	0.115-0.126 in / 2.92-3.20 mm	0.1730-0.1745 in / 4.394-4.432 mm	0.117-0.123 in / 2.97-3.12 mm
Small Rifle	0.1745-0.1765 in / 4.432-4.483 mm	0.115-0.126 in / 2.92-3.20 mm	0.1730-0.1745 in / 4.394-4.432 mm	0.117-0.123 in / 2.97-3.12 mm

Primer family	Primer diameter (SAAMI range)	Primer height (SAAMI range)	Pocket diameter (SAAMI range)	Pocket depth (SAAMI range)
Large Pistol	0.2100-0.2120 in / 5.334-5.385 mm	0.115-0.126 in / 2.92-3.20 mm	0.2085-0.2100 in / 5.296-5.334 mm	0.117-0.123 in / 2.97-3.12 mm
Large Rifle	0.2105-0.2130 in / 5.347-5.410 mm	0.123-0.136 in / 3.12-3.45 mm	0.2085-0.2100 in / 5.296-5.334 mm	0.125-0.132 in / 3.18-3.35 mm

The table immediately shows us something important: Small Rifle and Small Pistol primers are approximately the same basic diameter. That doesn't mean they are the same primer.

Likewise, Large Rifle and Large Pistol primers are approximately the same basic diameter, but their typical heights and corresponding pocket depths differ. A primer entering the hole is therefore not proof that it is the correct primer. Physical fit is not the same thing as correct specification.

Primer pockets are designed to work with the appropriate primer family.

The primer needs to be seated correctly against the bottom of the pocket rather than merely pushed in until its outer face looks about right.

This becomes especially important when comparing Large Rifle and Large Pistol primers.

A typical Large Pistol primer is roughly 0.211" in diameter × 0.120" high, whereas a typical Large Rifle primer is roughly 0.212" in diameter × 0.130" high.

A difference of roughly 0.009" in typical height may sound insignificant when discussing most objects. At primer scale, it is substantial.

The corresponding Large Rifle primer pocket is normally deeper.

That's why I never use “It fits, therefore it must be suitable” as a method of primer selection.

We will look much more closely at primer-pocket condition and correct seating in the next chapter.

Primer Size Is Determined by the Case

The case tells us which basic primer size it requires.

A case manufactured with a Small Rifle primer pocket requires the appropriate Small Rifle primer. A case designed for a Large Rifle primer requires the appropriate Large Rifle primer. The same principle applies to pistol brass.

However, we should not assume the primer size purely from the physical size of the cartridge.

Modern brass designs mean that different versions of what is essentially the same chambering can sometimes be encountered with different primer-pocket arrangements.

That means I work from the actual brass + its correct specification + reliable loading information.

I don't choose a primer simply because a cartridge looks large or small.

Small Rifle primers are used across a very broad range of rifle cartridges. They are familiar in smaller centrefire cartridges but are not restricted to them. Some modern case designs use Small Rifle primer pockets in cartridges that might traditionally have been associated with larger primers.

From the reloader's point of view, the important rule is straightforward: use the primer appropriate to the particular brass and load data.

A larger cartridge does not automatically require a Large Rifle primer.

Large Rifle primers remain extremely common across medium and larger rifle cartridges.

Again, the cartridge name by itself is not always sufficient information.

If I have brass for the same chambering made with different primer-pocket sizes, I regard those as different component combinations for load-development purposes.

The external cartridge dimensions may be the same. The ignition system is not.

Small Pistol primers are common in many straight-wall pistol cartridges, while Large Pistol primers are used in a number of larger designs.

As with rifle brass, different manufacturers or case designs can sometimes use different primer arrangements.

I therefore identify the brass before loading it. I don't decide that a primer is correct merely because I can physically seat it in the pocket.

This is particularly important with the small-primer families.

A Small Rifle primer and a Small Pistol primer are both approximately .175" in diameter. That doesn't make them interchangeable.

Depending on manufacturer and model, differences can include cup thickness, cup hardness, priming compound, ignition characteristics and intended operating conditions.

The same basic principle applies to the large-primer families, with the additional dimensional difference in typical primer height and pocket depth already discussed.

I use the primer type intended for the application.

For a great many loads, a normal standard primer is exactly what is required.

The primer's job is to provide reliable and repeatable ignition of the powder charge.

More ignition energy is not automatically better.

If a standard primer correctly and consistently ignites the chosen powder in the particular cartridge, using a more energetic primer may offer no advantage.

More is not necessarily better. Appropriate and consistent is better.

Magnum primers are generally intended to provide more energetic ignition than their standard counterpart.

They may be specified with combinations involving large powder charges, particular slower-burning powders, certain cartridge designs or conditions where stronger ignition is beneficial.

However, a cartridge having the word “Magnum” in its name does not by itself tell me which primer to use.

I consult reliable data for the actual combination.

Equally, I don't install a magnum primer simply because I believe a more powerful primer must produce better ammunition.

The load determines the requirement.

Magnum Does Not Mean a Different Primer Size

The word Magnum normally describes the primer's specification and ignition characteristics within its basic family.

For example, Small Rifle Magnum remains part of the Small Rifle dimensional family, and Large Rifle Magnum remains part of the Large Rifle family.

Likewise, Match or Benchrest does not create another primer-pocket diameter.

These descriptions tell us more about the primer specification, not that we need a fifth or sixth basic primer-pocket size.

Changing primers means we have changed part of the load.

That is especially obvious when changing between standard and magnum primers, but I apply the principle more broadly.

Different primers can alter the way the powder charge begins burning. That can influence ignition, pressure, velocity, extreme spread, standard deviation and potentially accuracy.

Therefore I don't casually substitute a different primer into an established load and assume nothing else has changed.

If the change is meaningful, I reassess the load accordingly. This is particularly important if the existing load is already towards the upper end of published data.

Primer manufacturers offer products marketed as Match, Benchrest, Gold Medal, or under similar precision designations.

These are generally intended to provide particularly consistent manufacture and performance.

That doesn't necessarily mean they are simply “hotter”, and it certainly does not guarantee that fitting them will make a rifle shoot smaller groups.

A precision primer still has to work with the complete combination: case → primer → powder → projectile → rifle.

If a particular match primer improves the load, that is useful information. If it does not, the wording on the box does not overrule the target.

Two primers belonging to the same broad category are not necessarily identical because they come from different manufacturers.

Construction and ignition characteristics can vary. Consequently, changing primer manufacturer can sometimes affect velocity, extreme spread, standard deviation, ignition behaviour, pressure and potentially group performance.

In some combinations the difference may be very small. In others it can be more noticeable.

That is why my load record does not simply say “Large Rifle primer”. I record the manufacturer and exact primer designation.

Primer cups are not all identical. Cup material, thickness and hardness can vary between primer types and manufacturers.

This matters because different firearms also have different firing systems. One rifle may have a relatively heavy firing-pin strike, another a lighter strike, and firing-pin diameter, firing-pin-hole clearance and firing-pin geometry can also differ.

These factors influence both ignition reliability and what the fired primer looks like. That is why primer appearance has to be interpreted carefully.

Primer Appearance and Pressure

Reloaders have traditionally examined fired primers for signs of pressure. That can provide useful information.

What I wouldn't do is use primer appearance as my only pressure indicator.

A primer can appear flatter because of several factors, including pressure, primer cup characteristics, case fit, firing-pin geometry, firing-pin-hole dimensions and the firearm itself.

Likewise, a primer that still appears nicely rounded does not prove that a load is safe.

Primer appearance is one observation. It is not a pressure gauge.

Sometimes the metal around the firing-pin indentation appears raised or extruded. This is commonly described as primer cratering.

Pressure can contribute to cratering, but so can the relationship between the firing pin and its hole in the bolt face.

Some rifles show a degree of cratering with perfectly normal ammunition. Others may show very little.

I therefore learn what is normal for the particular rifle rather than diagnosing pressure from one photograph or one primer characteristic alone.

A pierced primer is more serious.

Here the primer cup has actually been perforated, commonly around the firing-pin strike. Hot gas can then escape backwards through the hole.

Repeated pierced primers can damage firing-pin and bolt-face components and may indicate a problem involving the load, primer suitability, firing-pin geometry, firing-pin protrusion or another part of the firing system.

I don't simply continue firing ammunition that repeatedly pierces primers. I find the cause.

Gas leakage around the outside of the primer also deserves investigation.

Possible signs include staining around the primer pocket or evidence of gas erosion.

Potential causes can include a loose or damaged primer pocket, unsuitable brass or another problem within the ammunition/firearm combination.

The fact that the cartridge fired does not mean everything was correct.

If a cartridge fails to fire, the primer is an obvious place to investigate, but it is not the only possible cause.

Possibilities include defective primer, incorrectly seated primer, insufficient firing-pin energy, contamination, unsuitable primer, firearm problems, or another loading or handling issue.

One misfire does not automatically prove that an entire batch of primers is defective. I investigate systematically.

The vast majority of conventional reloadable centrefire brass most reloaders encounter uses the Boxer primer system.

In a Boxer primer, the anvil is contained within the primer itself. The case normally has a central flash hole.

When the firing pin strikes the primer cup, the priming compound is crushed between the cup and the internal anvil. The flame then passes through the central flash hole and ignites the powder charge.

This design is particularly convenient for reloading because the spent primer can be removed using a normal central decapping pin.

Berdan priming uses a different arrangement. Instead of the anvil being part of the primer, the anvil is formed into the case itself.

Berdan cases also commonly have offset flash holes rather than the single central Boxer flash hole.

This matters enormously when decapping. A conventional Boxer decapping pin expects to pass through a central flash hole. Trying to force it through a Berdan-primed case can damage the decapping equipment.

This is one of the reasons we inspect and identify cases before processing them.

A Boxer primer has an open anvil side and a closed cup face. The practical orientation during priming is covered in Chapter 20; here the point is simply to recognise the primer construction and never treat orientation as arbitrary.

Primer Contamination

Primers contain an impact-sensitive priming compound and should be handled sensibly.

I keep primers clean, dry, correctly stored and away from unnecessary oils, solvents and chemicals.

The claim that merely touching a primer automatically ruins it is an exaggeration. Nevertheless, deliberately handling primers with greasy or chemically contaminated hands is poor practice.

Good ammunition starts with clean components and an organised bench.

Primers should be stored in accordance with the manufacturer's instructions and applicable requirements.

From a reloading point of view, my basic rules are simple. I keep primers dry, appropriately stored, in their original packaging and clearly identified.

The original packaging is particularly important. Once several similar-looking primer types have been tipped together, reliable identification may be impossible.

The easiest way to solve that problem is never to create it.

When I am priming a batch, I prefer to have only the primer type actually being used at the priming station.

If I change primers, I put the first type away before bringing out the second.

A loose primer can be remarkably difficult to identify positively. Good bench organisation eliminates the possibility of a stray primer from one batch finding its way into another.

If I find loose primers and cannot positively identify them, I don't try to determine what they are from colour, appearance or memory.

Different primer products can look extremely similar.

The value of a few primers is insignificant compared with introducing an unknown ignition component into a carefully developed load.

If I can't positively identify the primer, it does not go into the load.

Straight-wall pistol cartridges deserve mentioning because primer choice can sometimes be treated too casually.

A relatively small powder charge does not make the primer unimportant.

The same rules apply: use the correct primer type, follow reliable data, record the exact primer and treat a meaningful primer substitution as a component change.

Some pistol cartridges can also be encountered with different primer-pocket arrangements depending on the brass. Again, identify what is actually on the bench rather than relying purely on the cartridge name.

At the opposite end of the scale, large-capacity rifle cartridges can place different demands on the ignition system.

A large powder column or particular slow-burning propellant may benefit from or require the ignition characteristics of a specified primer.

That doesn't mean my approach is “large case = hottest primer available”. My approach remains: correct primer for the tested load combination.

Reliable loading data comes before assumptions.

Primer and powder behaviour can be influenced by environmental conditions.

For ordinary reloading, I don't think this needs to become another obsession. Use appropriate components and properly developed loads.

For serious precision or long-range ammunition, however, primer choice can become part of testing the complete load under the sort of conditions in which it will actually be used.

A load tested only in one set of conditions should not automatically be assumed to behave identically in every possible environment.

Once I already have a good, established load, primer testing can become a useful refinement.

I might compare suitable primers while keeping the other important variables unchanged, then examine group size, average velocity, extreme spread, standard deviation, ignition consistency and general behaviour.

> **KEY PRINCIPLE**
> *The key is to change one variable at a time. If I change the primer, powder charge and seating depth together, I have learned very little about what caused the result.*

Chronograph Numbers Are Not Accuracy

A primer that produces a lower extreme spread or standard deviation is interesting. It doesn't automatically mean that primer produces the smallest group.

The chronograph tells me about velocity. The group on the target tells me about accuracy.

They are related pieces of information, but they are not the same measurement. If I am trying to make the ammunition more accurate, the target remains the final judge.

No.

For most shooters, there is no need to buy every suitable primer available and conduct an enormous comparison.

If the appropriate primer from reliable data produces reliable ignition and the ammunition meets the accuracy and consistency required, there may be no useful reason to change it.

Primer testing becomes more relevant when I am deliberately refining an already good precision load.

Precision loading should be systematic, not complicated merely for the sake of being complicated.

Sometimes the primer we normally use simply is not available.

That doesn't mean we cannot ever change it. It does mean I recognise that I have changed a component.

I check appropriate current loading information and reassess the load where necessary.

This becomes particularly important with loads already operating towards the upper end of the appropriate published data.

Component availability is not a reason to abandon normal load-development discipline.

When I record ammunition, the primer is part of the recipe.

Writing something such as “.308 Winchester — 155-grain projectile — Powder X — 46.0 grains” does not completely describe the load.

I also want the relevant component and dimensional information, including the actual primer manufacturer and designation.

Months later, if I reproduce the ammunition and it behaves differently, that information becomes extremely valuable.

Good records allow us to reproduce what actually worked rather than what we vaguely remember using.

The dimensions given earlier in this chapter are there to help us understand the primer system.

They are not an invitation to machine every primer pocket to a number from a table.

Primer and brass manufacturers work to their own specified tolerances.

For normal loading, I don't measure a primer pocket with a calliper and then decide which primer will fit. I identify the case and use the correct primer specification.

Where primer-pocket uniforming or other advanced preparation is appropriate, the tooling and intended specification determine what we are doing.

We will deal with the practical implications of primer-pocket condition in the next chapter.

For normal reloading, I keep primer selection straightforward.

First I identify the actual brass. Then I establish the correct primer family and specification. I use reliable loading information. I record the manufacturer and exact primer designation.

I keep primers in their original packaging and keep different types separated on the bench. I never identify an unknown loose primer by guesswork.

If I make a meaningful primer change, I recognise that I have changed part of the load.

For precision load development, I may later test suitable alternatives. But I don't assume Match means automatically more accurate, Magnum means automatically better, or lower SD means automatically smaller groups.

The primer's fundamental job is to provide reliable and repeatable ignition appropriate to the load.

The gauges and chronograph can help us understand what is happening. But once again: the group on the target tells us whether the ammunition is accurate.

We now understand what the primer is, how the main primer families differ and why selecting the correct primer is part of the load rather than an afterthought.

The next job is to install it correctly.

There we will cover the practical side properly: hand priming, bench-mounted priming tools and press-mounted systems; correct primer orientation; preparing and filling primer trays; safe handling; seating technique; what I actually want to feel through the priming tool; seating the primer correctly against the bottom of the pocket; seating below flush; high primers; crushed or damaged primers; tight and loose pockets; how pocket condition changes with case life; checking primers after seating; and the faults that tell me to stop and investigate rather than simply forcing the next primer into place.

That keeps the distinction clear: Chapter 19 explains the primer. Chapter 20 explains how I prime the case.

Chapter 20 — Priming Cases: Technique, Feel and Consistency

Figure 20.1 — *A hand-held priming tool with prepared cases. Hand tools allow priming away from the loading press while retaining direct feel.*

Once the brass has been fully prepared and sized, the next stage is to install the primer.

Priming is a straightforward operation, but it is also one of the stages where feel, cleanliness, consistency and safe handling matter a great deal.

A correctly seated primer should be fully and consistently seated against the bottom of the primer pocket, correctly positioned over the flash hole, and given the small amount of final seating pressure needed to establish the primer/anvil assembly properly.

For that reason, I don't rush priming. I want every primer to enter the pocket smoothly, squarely and with a very similar feel to the rest of the batch.

SAFETY WHEN PRIMING

Wear safety glasses whenever you are priming cases.
Primers contain an impact-sensitive compound and should always be handled with care. When hand priming, keep the priming tool and case pointed away from your face and body. With tray- or tube-fed systems, avoid positioning your face directly over the primer supply or feed mechanism.
Use smooth, controlled pressure when seating a primer. If one suddenly feels unusually tight, starts crooked or does not feed correctly, stop and find the cause rather than trying to force it into place.
Always follow the instructions supplied with your particular priming tool.

Before I begin, I confirm that the primers on the bench are the exact type intended for the load. That means checking the manufacturer, exact primer designation, size and whether it is the standard, magnum or other specified version.

I don't rely on appearance. Loose primers can be difficult or impossible to identify positively, so I prefer to have only one primer type open on the bench at a time. If I can't positively identify a primer, I don't use it.

By this stage, the cases should already have completed the appropriate preparation sequence:

inspection → depriming → cleaning → case preparation → primer-pocket and flash-hole preparation → annealing where appropriate → lubrication → sizing → neck-tension control → removal of sizing lubricant → final case checks

Only then do I prime them.

Earlier in the case-preparation process, I uniform the primer pockets. I do this because it gives me a flat and consistent pocket bottom for every primer to seat against.

That helps establish the same mechanical relationship from one case to the next. The primer is then seated fully against the bottom of the pocket, directly in the intended position over the flash hole.

The benefit is not cosmetic. It is about consistency. I want each primer to begin from as nearly the same seating condition as practical.

This doesn't mean ammunition made with ordinary factory primer pockets cannot shoot well. It means primer-pocket uniforming is part of my preferred case-preparation method because it removes another variable before load development begins.

A Boxer primer has a definite orientation. The open side containing the anvil faces into the primer pocket. The closed cup face remains visible at the case head and is eventually struck by the firing pin.

Many tray-fed systems make correct orientation easy, but I still check. Automation does not remove responsibility.

There are several common ways of seating primers:

- hand-held priming tools
- bench-mounted priming tools
- press-mounted priming systems
- progressive or automated primer-feed systems

All can produce excellent ammunition. I don't believe one is automatically more accurate simply because it is more expensive.

What I want from any priming tool is simple:

- square case support
- square primer support
- a smooth seating stroke
- useful feedback through the handle or lever

- a repeatable final seating condition

Hand priming tools are popular because they usually provide very good feel. I can feel the primer entering the pocket, the resistance as it moves down, and the definite change when it reaches the pocket bottom. That feedback is extremely useful.

When hand priming, I keep the priming tool and case pointed away from my face and body while seating the primer. It is a simple safety habit and should become automatic.

Bench-Mounted Priming

Bench priming tools provide more leverage while still giving excellent feedback. For larger batches they can be very comfortable to use, and the fixed relationship between the case, primer punch and operating lever can make the process very repeatable.

The sequence I want to feel remains the same: primer enters → steady seating resistance → primer reaches pocket bottom → small controlled final seating pressure.

Many presses have built-in priming systems. They can work extremely well, but the increased leverage of a press means it can also be easier to overpower a problem.

If a primer feels wrong, I don't use the press leverage to force it into place. Mechanical advantage should make a correct operation easier. It should not make a bad decision easier.

Progressive presses may seat one primer on every press cycle. That makes them efficient for larger quantities, but it also means a fault can be repeated very quickly.

I pay close attention to primer feed, primer orientation, seating feel, primer supply and the condition of the finished cases. If the machine suddenly feels different, I stop and investigate.

Many priming systems hold multiple primers together in trays or tubes. These systems are entirely normal, but the presence of multiple primers close together deserves respect.

I keep my face away from the feed path, wear eye protection and use the components intended for the tool. I don't improvise damaged primer tubes or try to force a jammed primer through the system.

A primer is not correctly seated simply because the visible cup face happens to look below the case head. The important event takes place inside the primer pocket.

The primer must first reach the bottom of the pocket. Because I have uniformed the pocket, that bottom surface is flat and consistent. Once the primer reaches it, I apply a small amount of additional controlled seating pressure.

This gives the primer/anvil assembly the slight preload I am looking for. You can think of this as a very small amount of controlled crush, but the wording needs to be understood properly. I'm not trying to visibly flatten or damage the primer. I am applying just enough final pressure to establish the primer correctly.

The sequence is: primer enters pocket → reaches uniformed pocket bottom → slight controlled final pressure → finishes just below flush.

A correctly seated primer will normally sit slightly below the case head. I don't obsess over one universal below-flush figure because primers, pockets and tools vary.

What matters to me is that the primer is fully seated, established against the pocket bottom, given the slight controlled final pressure, not standing proud, not visibly distorted, and consistent with the rest of the batch.

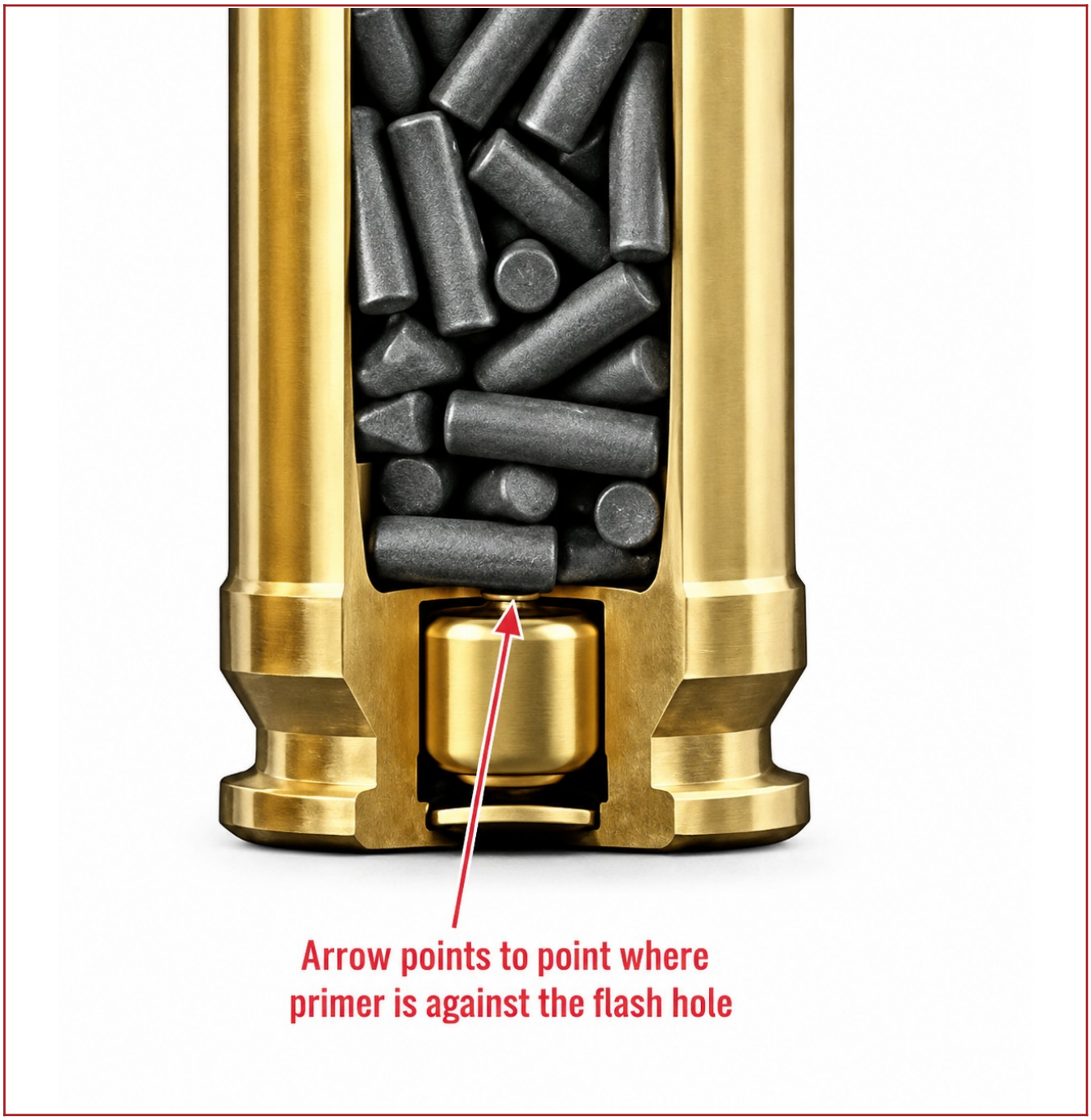


Figure 20.2 — *Correct primer seating and flash-hole relationship.*

A primer sitting above the case head is not acceptable finished ammunition.

Once I have primed a quantity of good, consistent brass, I develop a clear sense of what normal seating feels like. The pattern is usually: initial entry → steady resistance → definite bottoming → slight controlled final pressure.

If fifty cases feel almost identical and the next one feels completely different, that is useful information. I stop and look at it. The difference may come from the primer, case, pocket, tool or contamination. Whatever the cause, I don't simply answer unusual resistance with more force.

A Primer That Feels Too Tight

A primer should fit securely, but it should not require unreasonable pressure. Possible causes of excessive resistance include wrong primer size, primer starting at an angle, debris in the pocket, damaged pocket, incorrect case position or another dimensional problem.

If it feels wrong, I stop and inspect it.

A primer can occasionally begin entering at an angle. If I feel that happening, I stop applying pressure.

Trying to straighten a cocked primer by using more leverage is exactly what I want to avoid. I check the case position, primer position, tool alignment, feed mechanism and pocket condition before continuing.

At the other extreme, a primer may enter with much less resistance than the rest of the batch. That can be just as important.

Repeated firing and pressure cycles can gradually loosen the primer pocket. If a primer slides into the case noticeably more easily than normal, I set that case aside.

Primer seating feel becomes a useful case-life indicator, particularly when I know the history of the brass and know what normal feels like for that batch.

If the pocket has genuinely become too loose to retain a primer properly, the case has reached the end of its useful life for me. I don't try to repair or rescue it. Brass is consumable.

There is a clear difference between the tiny amount of controlled final seating pressure I want and a primer that has been visibly damaged.

A primer that is badly flattened, folded, crushed sideways or otherwise distorted indicates a fault. Possible causes include excessive force, poor alignment, wrong primer, contamination or tool setup.

The same applies to upside-down or sideways primers. Those cases are removed from the normal loading sequence, and I find out why the problem occurred before continuing.

Primer residue, carbon, brass particles and debris can build up on priming equipment. The primer punch, shellholder or case holder all need to remain clean and smooth.

A small piece of contamination can affect how the case sits or how the primer enters. I inspect and clean the priming tool as required according to the manufacturer's instructions.

By the priming stage, sizing lubricant should have been removed from the cases. I don't want unnecessary oil, sizing wax or solvent around the primer pocket, primer, case head or priming tool.

The cases should be clean and dry. Primers should remain clean and uncontaminated.

New brass goes through exactly the same controlled priming process. The primer pocket and flash hole have already been prepared during the initial case-preparation work, so I begin the first loading cycle from the same consistent standard I intend to maintain later.

Used brass gives me more information through feel. If I know the batch history, changes in primer seating resistance can tell me something about how the primer pockets are ageing.

With second-hand or supposedly once-fired brass, I am more cautious because I don't necessarily know how many pressure cycles the pockets have actually experienced. Known case history remains valuable.

BENCH NOTE

I inspect the first few primed cases closely. I confirm correct primer orientation, normal seating feel, the primer sitting slightly below flush, no visible distortion and normal tool operation.

Once I am satisfied, I continue with the batch.

Final Batch Inspection

When the batch is complete, I inspect the case heads. I am looking for correct primer orientation, primers slightly below flush, no obviously distorted primers, no proud primers, no missing primers, no damaged cases and a generally consistent appearance.

Any case that felt different during priming gets extra attention before being allowed back into the batch.

For precision ammunition, I am primarily interested in repeatability. I want the same primer, primer-pocket preparation, priming tool, seating technique and final seating feel.

There are ways of measuring primer seating depth very precisely, but for most precision loading I believe the larger benefit comes from a properly prepared pocket and a primer seated consistently to the bottom with the same small amount of final controlled pressure.

I don't make the process more complicated unless testing gives me a reason to.

Correct primer seating is part of controlling ammunition consistency. It is not itself an accuracy result. A perfectly seated primer does not guarantee a small group. It simply removes another avoidable variable.

As throughout this book: the preparation tells me how tightly I am controlling the ammunition. The group on the target tells me whether the load is accurate.

My Practical Priming Method

My normal process is straightforward.

Wear safety glasses. Confirm the exact primer type and keep only that primer at the priming station. Make sure the cases, primer pockets and tool are clean and dry. Load and orient the primers correctly.

If hand priming, keep the priming tool and case pointed away from your face and body. Place the case squarely in the tool. Apply smooth, controlled pressure. Feel the primer enter. Feel it reach the uniformed pocket bottom. Apply the small amount of final controlled pressure required to establish the primer properly.

The finished primer should sit slightly below flush with the case head without visible damage. If one case feels significantly different, stop and investigate it. Once the batch is complete, inspect every case head.

At that point I have what I want: a clean, fully prepared, correctly sized and consistently primed case ready for powder.

We now have the primed case: the brass has been inspected, fully prepared, lubricated, sized, its neck tension controlled, cleaned and then primed consistently.

The next stage is powder. From here the book moves into understanding smokeless propellant, selecting it from reliable published data, handling and storing it correctly, and then measuring and charging the case consistently.

Chapter 21 — Understanding Smokeless Powder

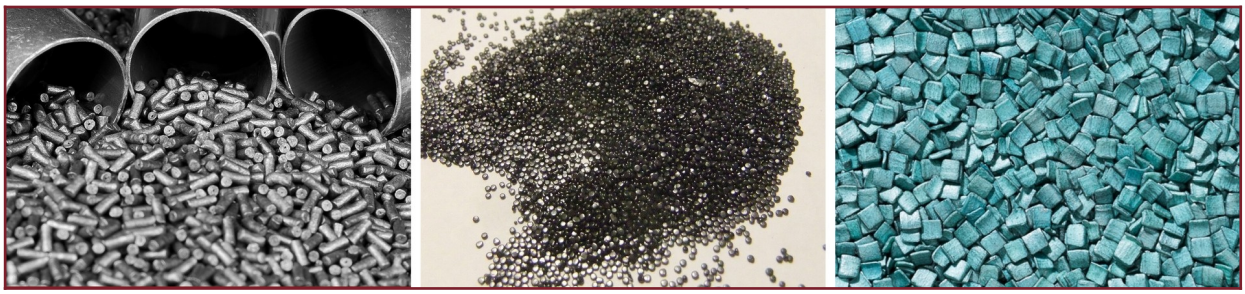


Figure 21.1 — *Three common smokeless-propellant forms shown side by side: extruded/stick powder (left), ball/spherical powder (centre) and flake powder (right). Granule geometry varies markedly between powder types.*

Once the case has been prepared, sized and primed, the next component to consider is the powder. This chapter deals specifically with smokeless propellant; black powder and its substitutes are a separate loading system and are covered later. I never treat smokeless and black-powder data as interchangeable.

Powder is one of the components where it pays to understand what we are dealing with rather than simply choosing a name from a loading manual. Different powders have different burning characteristics, densities, physical forms and intended applications. Those differences affect how they behave in the cartridge and how they handle on the loading bench.

We do not need to become propellant chemists. What matters is understanding enough to choose an appropriate powder from reliable published data, identify it without doubt, store and handle it correctly, and recognise why apparently similar powders cannot simply be substituted for one another.

When the primer ignites, flame passes through the flash hole and initiates the powder charge. Under normal cartridge operation, smokeless powder burns rapidly and progressively, producing hot gas. As that gas expands, pressure rises inside the case and chamber and drives the projectile along the barrel.

The powder does not work in isolation. Its behaviour is influenced by the complete cartridge combination: case capacity, projectile weight and construction, seating depth, primer, chamber and other factors all play a part. Change one component and we may have changed the conditions under which the powder is working.

That is why I always come back to reliable published load data rather than treating a powder charge as a standalone number.

Smokeless powder and black powder are fundamentally different propellants and must never be treated as interchangeable. They have very different characteristics and pressure behaviour. A charge of one cannot simply be replaced with the same weight or volume of the other.

Throughout the normal centrefire reloading sections of this book, when I refer to powder I mean smokeless powder unless I specifically state otherwise.

Smokeless powders are commonly described as single-base or double-base. Single-base powders are based primarily on nitrocellulose. Double-base powders contain nitrocellulose together with nitroglycerin, which changes characteristics such as energy content and gives manufacturers another way of tailoring a propellant for a particular application.

Double-base powders can, but do not always, show a little more sensitivity to changes in ambient temperature than some single-base powders. It is not a rule I would apply blindly. Modern formulations vary considerably: there are double-base powders with very good temperature stability, and individual single-base powders can also show measurable changes as temperature moves.

If temperature stability matters for the ammunition I am loading, I am interested in how that particular powder actually behaves rather than accepting or rejecting it solely because it is single- or double-base.

Smokeless powder is manufactured in several physical forms. Common examples include extruded or tubular powders, short-cut extruded powders, spherical or ball powders, flattened ball powders and flake powders. Shape and kernel size affect how a powder packs into the case and, just as importantly on the bench, how it moves through dispensing equipment.

Extruded powders are particularly common in rifle cartridges. They consist of cylindrical kernels ranging from relatively long sticks to short-cut granules, and many excellent precision rifle loads use them.

Long kernels do not always pass cleanly through every conventional powder thrower. As the rotor or charge mechanism closes, a kernel can become trapped between moving surfaces and be cut or chopped. You can often feel this as a slight crunch or resistance through the handle. It doesn't automatically make the powder unusable, but it can make the measure less smooth and may contribute to variation in the amount thrown.

Short-cut extruded powders generally meter more easily. For my precision rifle ammunition this is less important than it might be for high-volume loading because I weigh every rifle charge rather than relying solely on the volume delivered by a powder thrower.

Ball, Spherical and Flake Powders

Ball or spherical powders normally flow very well through volumetric powder measures and can be particularly convenient when larger quantities of ammunition are being loaded. Their small granule size can also reveal clearances in equipment that handles coarse extruded powder perfectly well, so very fine powders may occasionally leak from some measures.

Flake powders consist of thin, flat granules and are commonly encountered in handgun and shotgun applications, although every powder has its own intended uses. With the relatively small charges found in some handgun cartridges, a small absolute error can represent a significant percentage of the intended charge. That makes disciplined charging technique especially important.

Powders do not all occupy the same amount of space for a given weight. Two different powders can weigh exactly the same yet occupy noticeably different volumes in the case. That is another reason powders cannot be substituted by either weight or volume.

Depending on the cartridge and powder, a published charge may leave considerable empty space, almost fill the case or be listed as a compressed load. None of those observations, by itself, tells us whether the load is safe. The published data does.

Case fill can still be useful information. A powder that fills a sensible proportion of the available volume can make a missed or grossly incorrect charge easier to spot visually. We will use that as one of several checks when we begin charging cases in the next chapter.

Powders are commonly described as faster- or slower-burning. Burn-rate charts arrange powders into an approximate relative order and are useful for understanding broadly where one propellant sits compared with another.

I use a burn-rate chart as a reference, not as load data.

A powder appearing next to another powder on a chart does not mean the two are interchangeable. The numbered position can also give a false impression of precision: different published charts may place certain powders in slightly different positions, and relative behaviour depends to some extent on the conditions under which they are compared.

In broad terms, a faster powder releases its energy earlier in the internal ballistic cycle, while a slower powder is formulated to continue burning progressively for longer. Smaller-capacity cartridges and lighter projectiles often favour relatively faster powders, while larger cases and heavier projectiles can make effective use of slower powders. Those are useful principles for understanding what we see in manuals; they are not a way of inventing a load.

Powder identification and substitution
Use only positively identified powder supported by reliable published data for the cartridge and projectile combination. Never substitute one powder for another because the names, appearance or burn-rate positions seem similar, and never mix different powders together.

When I start with a new cartridge and projectile combination, I look at current data from reputable powder manufacturers and loading manuals. Usually there will be several suitable powders, and only then do I choose between them.

Useful considerations include:

- the velocity range shown in the data
- case fill
- powder availability
- metering characteristics
- temperature behaviour where relevant
- barrel length and intended use
- previous experience with the powder

For competition ammunition, availability can matter more than it first appears. There is little point developing an excellent load around a powder I can obtain only occasionally if I expect to use significant quantities of it. That doesn't justify using an unsuitable powder; it simply makes availability another factor when choosing between powders that are already appropriate.

Nor do I assume the newest or most fashionable powder must be better. A well-established powder that suits the cartridge can produce exceptional ammunition.

Starting Data and Maximum Loads

When developing a new combination, I begin from the appropriate published starting point and follow the instructions associated with that data. I don't jump straight to a maximum charge because somebody else uses it successfully.

Their rifle is not necessarily mine. Chamber, throat, brass capacity, projectile, primer, powder lot, seating depth and barrel can all alter how a load behaves.

A published maximum is not a target. The load that gives the accuracy, velocity and consistency I want may occur well below it. We will deal with the actual process of load development later in the book.

A powder charge cannot sensibly be separated from the components around it. Case capacity matters because the powder burns inside the available internal volume, and two makes or lots of brass with identical external dimensions can have different capacities.

Projectile weight and construction matter. Even projectiles of the same nominal weight can differ in length and bearing surface. Seating depth matters because moving the projectile farther into the case changes the volume available beneath it. Primer choice can also form part of the tested combination.

That's why I record complete loads rather than only a powder name and charge weight. The cartridge is a system.

Some legitimate published loads are described as compressed. This simply means the powder occupies enough space that seating the projectile compresses the charge to some degree.

A compressed load is not automatically a problem when it forms part of properly developed published data. What I don't do is create one simply by continuing to add powder until the case will hold no more. The data still controls the decision.

Ambient temperature can influence powder performance, but the amount varies with the individual propellant. For much ordinary shooting the difference may have little practical significance. For ammunition used at longer range, in competition or across substantially different temperatures, it can matter more.

A load developed on a cold winter day may not behave identically when the ammunition has been sitting in strong summer heat. Where temperature behaviour matters to the application, I prefer to judge it from reliable manufacturer information and sensible testing of the actual load rather than assumptions based solely on powder type.

Manufacturing lots can also vary slightly while remaining within the maker's specification. For precision ammunition I record the powder lot number where practical. If I change to a new lot after closely developing a load, I confirm that the load still behaves as expected and follow any relevant manufacturer guidance.

Powder names can be surprisingly similar. A different letter, number or suffix can identify an entirely different propellant, so I record the full designation exactly as it appears on the manufacturer's container.
I never try to identify loose powder from colour, kernel shape, smell or appearance. Many powders look very similar. If I can't positively identify it, I don't load it.
When I am working with powder, I prefer to have only the powder I am actually using open on the bench. Everything else stays closed and put away. That simple habit greatly reduces the chance of filling a measure with the wrong powder, returning powder to the wrong container or writing the wrong product in my loading notes.
Before changing powders, I make sure the measure, dispenser, drop tube and trickler are empty. Small quantities can remain hidden in corners or around mechanisms, and I don't want remnants of one powder mixed into the first charges of another.

Storage

The basic storage principle is much the same whether the powder is single-base, double-base, extruded, spherical or flake. I keep smokeless powder in its original manufacturer's container, with the original label intact, and store it according to the manufacturer's guidance and the applicable local requirements.
I don't create different homemade storage arrangements simply because one powder is ball and another extruded, or because one is single-base and another double-base. The original container preserves positive identification, lot information and the manufacturer's safety information.
Powder should be protected from excessive heat, inappropriate moisture, ignition sources and contamination. Different formulations can age differently, so with older powder I follow the manufacturer's guidance on condition and deterioration rather than assuming every propellant will show the same signs. If its condition is genuinely doubtful, I don't experiment with it.
I don't use a powder measure or dispenser as long-term storage. At the end of the loading session I empty it. Apart from the obvious risk of later forgetting exactly what is in the hopper, some powders can affect certain hopper materials over extended periods.
Any remaining powder that I can positively identify and know has not been contaminated goes back into the correct original container, following the powder and equipment manufacturers' instructions. I check the label before pouring it back. If there is any doubt about what remains in the measure or trickler, I would rather discard a small quantity than contaminate a whole container of known powder.
My approach to powder is deliberately straightforward. I begin with current reputable load data for the cartridge and projectile I intend to use. From the powders supported by that data, I choose one that suits the application and is realistically available to me.
I identify it by its complete name, record the lot where appropriate and keep only that powder open on the bench. Burn-rate charts remain reference material, not substitution tables. Once the session is finished, the powder goes back into its correctly labelled original container and the dispensing equipment is left empty and clean.
The next stage is the practical one: weighing and charging the primed cases. That deserves its own chapter, because scales, powder throwers, electronic dispensers, tricklers and the way the cases move through the loading block can all introduce errors if the routine is not controlled.

Chapter 22 — Weighing and Charging Powder

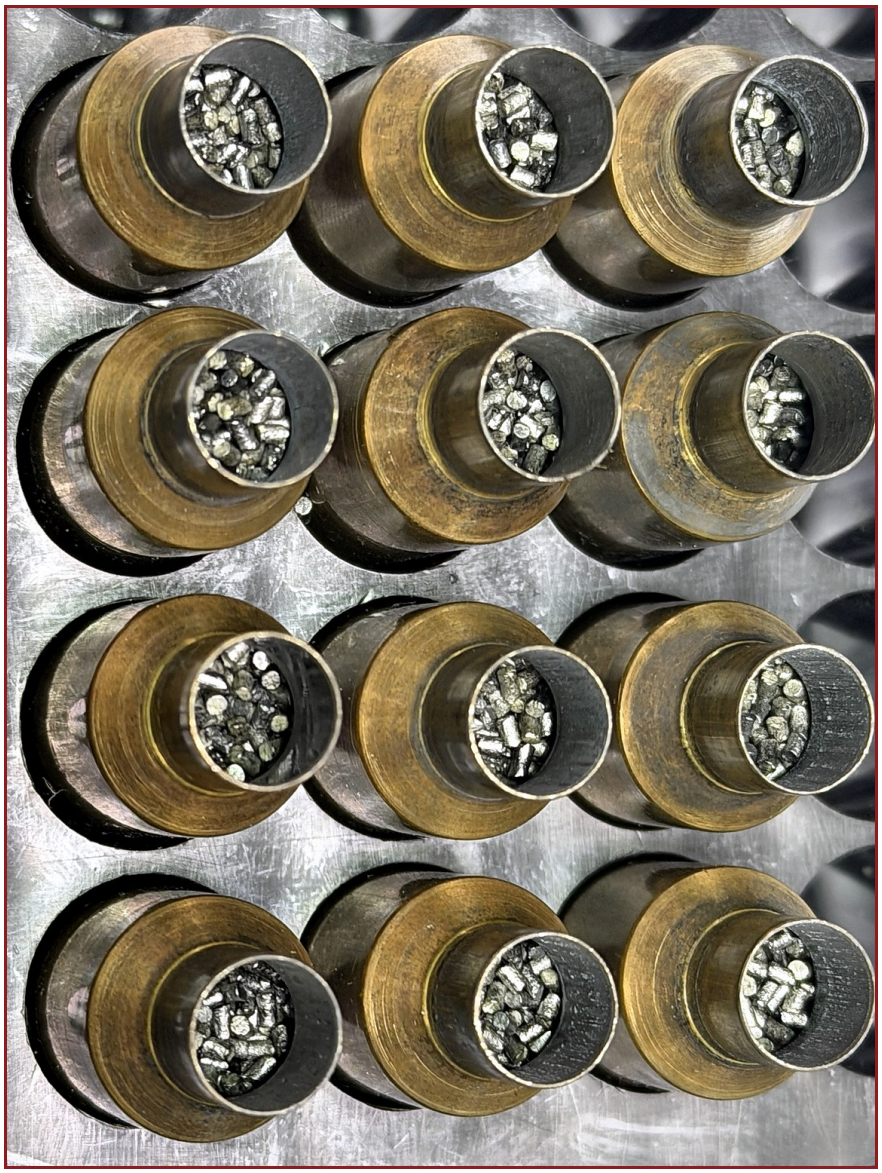


Figure 22.1 — *Charged cases viewed from above in a loading block. Comparing the visible powder level across the batch is an important check before seating projectiles.*

Figure 22.2 — *A manual powder trickler beside a beam scale, used to bring a charge gradually to its final measured weight.*

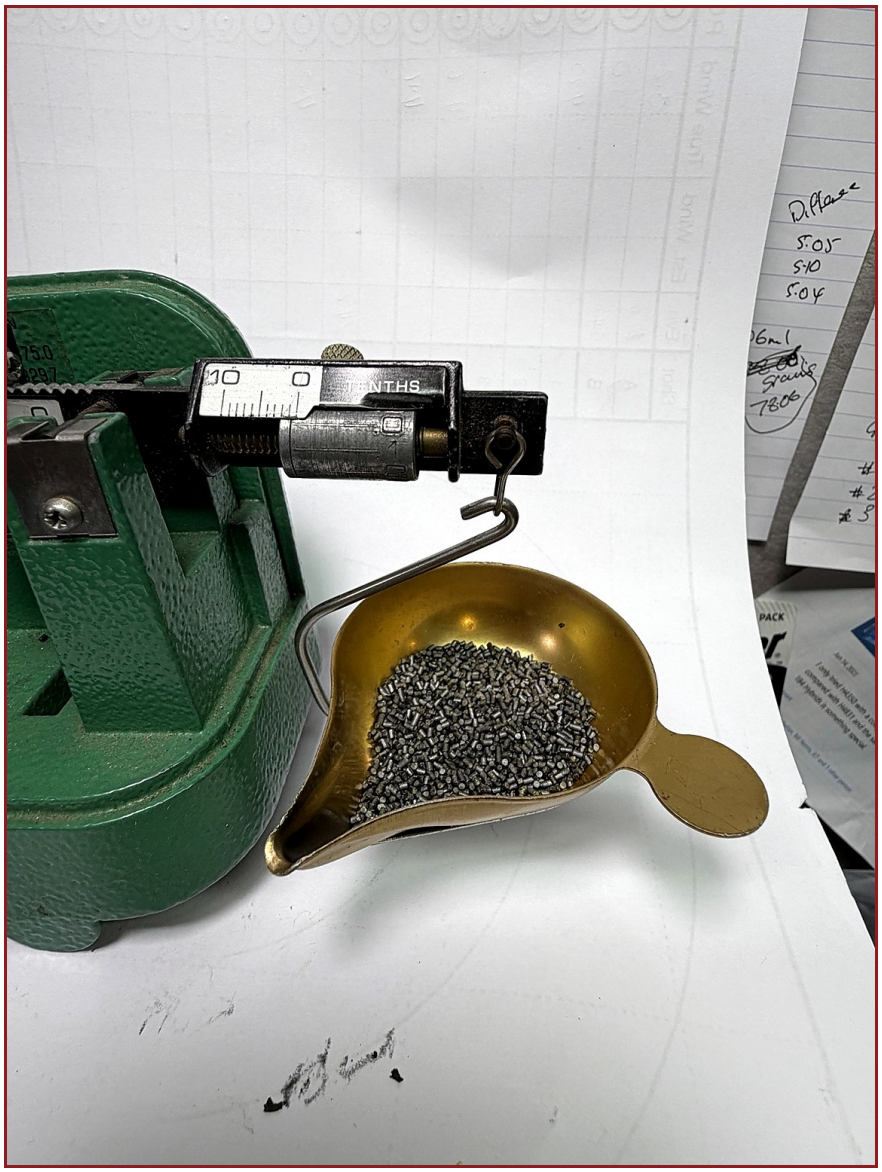


Figure 22.3 — *A powder charge being weighed on a beam balance.*

Once the powder has been selected from reliable published data and the cases are correctly prepared and primed, the next stage is to measure the powder charge and transfer it into the case.

This is an operation where I want a simple, deliberate routine. The charge needs to be what I intended it to be, and I want to know that every case in the batch has been treated in the same way before a projectile is seated.

For my rifle ammunition, I weigh every powder charge. Powder throwers and electronic dispensers are useful ways of dispensing powder, but the scale provides the final verification. I don't rely on an unchecked volumetric charge being thrown directly into a primed rifle case.

The sequence is simple: dispense the powder → weigh the charge → transfer the verified charge to the case.

POWDER CHARGING — SAFETY

Keep only the powder being used open on the bench and positively identify it before charging begins. Every rifle charge in my loading process is weighed before it goes into the case. If the powder, charge weight or status of a case becomes uncertain, stop. Empty an uncertain charge and weigh it again rather than guessing or allowing it to continue to projectile seating.

I start with a clear bench. Other powders, oils, cleaning products and unrelated components are moved away. Only the powder I am using is open, with its original labelled container visible, and I confirm the full powder designation against my loading record before filling a measure or dispenser.

The cases should be the correct prepared and primed batch. Before charging begins I make sure none already contains powder, and I arrange the loading block so the status of every case is obvious.

Whether I am using a beam scale, an electronic scale or an electronic powder dispenser, the weighing equipment needs to be suitable for reloading and repeatable in the range in which I am working. A digital display showing several decimal places does not automatically mean the scale is genuinely accurate to all of them.

I place the scale on a solid, level and stable surface, away from draughts, open windows, fans, vibration, strong direct heat and rapidly changing sunlight. If an electronic scale starts wandering or its zero drifts, I stop and find the cause rather than continually pressing zero and carrying on.

Electronic equipment is allowed to stabilise for the period recommended by its manufacturer. I then zero and calibrate it using the specified procedure and weights. Where suitable check weights are available, I also like to confirm its behaviour reasonably close to the charge range I am about to use.

A good beam scale remains an excellent piece of equipment. It gives a direct mechanical comparison against known weights, although the beam needs time to settle and the pointer must be viewed squarely to avoid parallax.

Electronic scales are faster and very convenient, but they can be influenced by draughts, vibration, temperature change, static and other environmental effects. I treat the reading as a measurement to be monitored, not as something that must be correct simply because it appears on a screen.

My Normal Rifle-Charging Method

For rifle ammunition, I weigh every individual charge.

When I use an electronic powder dispenser working directly with its scales, I deliberately set it to dispense about 0.1 grain below my required final charge. Many of these machines have a stated accuracy or practical resolution around a tenth of a grain, although the exact specification varies by model. I would rather have the machine stop slightly short and add the final tenth myself than have it overshoot and then try to remove powder.

Once the dispenser stops, I use a trickler to bring the charge carefully up to the weight I want. If a charge does overshoot, I correct it properly and verify it again before it goes into the case.

For me the routine is: dispense about 0.1 grain light → trickle up → verify → charge the case.

A conventional volumetric powder measure, or powder thrower, meters powder by volume rather than by directly weighing each charge. They can be useful tools and some powders flow through them particularly well, but I don't regard a volumetric thrower as sufficiently consistent to dump unchecked rifle charges straight into primed cases.

Powder can settle differently in the hopper, operating technique can vary, long kernels can be cut by the rotor, and powder can bridge in the measure or delivery path. For that reason my rule is simple: a volumetric measure may dispense the powder, but every rifle charge is weighed before it goes into the case.

Bridging is particularly important because it can produce two errors in succession. Part of one throw can hang up in the measure or drop path, leaving that charge light. The retained powder can then release on the following operation and join the next charge, making that one heavy.

That gives us a potentially dangerous sequence: too little powder in one charge → retained powder releases → too much in the next.

That's why I prefer a volumetric measure to throw into the scale pan rather than directly into a primed case. The scale checks the complete charge before it reaches the case. Even if the first several throws have been consistent, I still weigh the next one.

Long extruded kernels can sometimes be caught by the rotor or charge mechanism in a conventional thrower. You can often feel a slight crunch or extra resistance as a kernel is cut or chopped. Short-cut extruded powders generally meter more easily, while spherical powders can flow exceptionally well.

How well a powder meters may change how convenient the thrower is, but it does not change my rifle-loading rule: the charge is weighed before it enters the case.

A powder trickler lets me add very small amounts to a charge already sitting on the scale. It suits my normal method of dispensing slightly light and bringing the final charge carefully up to the chosen value.

The trickler is kept clean and contains only the powder currently being used. I position it so I can add powder without disturbing the scale or pan. It is a finishing tool, not a substitute for knowing the final charge weight.

Keep the Intended Charge in Front of You

Before I begin, the intended powder and charge are clearly recorded or displayed. That lets me compare the loading record, equipment setting and scale reading rather than relying on memory. A very accurate machine can still produce the wrong charge repeatedly if I give it the wrong setting.

Once the scale confirms the correct charge, I transfer it into the case using a suitable powder funnel or drop system. I make sure the entire charge has actually left the pan and travelled through the funnel. Long kernels can occasionally hang up in a narrow funnel or drop tube, and fine powder can cling to some surfaces through static.

At this point the charge has already been weighed; I am simply making sure all of that verified charge reaches the case it belongs in.

I use the loading block to make the status of each case obvious. Once a case receives its verified charge, I move it to a clearly different position or into another block. The direction does not matter; using the same system throughout the batch does.

I never want to look at a tray halfway through charging and have to wonder whether a particular case has already been charged.

Interruptions are an easy way to lose certainty. If I leave the bench and cannot immediately establish exactly where I stopped, I don't rely on memory. I recheck the powder identity, intended charge, scale zero, dispenser or measure setting and the cases in the loading block.

If the status of an individual case is uncertain, I empty it and weigh the charge again. That takes very little time compared with allowing an uncertain charge into a finished cartridge.

A missed charge leaves a case with no powder. Depending on the cartridge and firearm, primer energy alone may be capable of moving the projectile into the barrel without driving it clear. An excessive charge creates a different and potentially serious problem.

In some combinations a grossly excessive or duplicated charge may overflow the case and be obvious; in others it may physically fit. I don't rely on case capacity to protect me. The charging routine is intended to prevent the error before it happens.

When every case has been charged, I stop before seating a projectile and inspect every case in the loading block under good light. I compare the visible powder levels and look for an empty case, one that is substantially lower or higher, or anything else that looks out of place.

Powder height will not necessarily be identical because granules settle differently and case capacities vary slightly. This is not an attempt to measure the charge by eye; it is an additional error-detection check after every charge has already been weighed. If something looks wrong, I empty that case and weigh the charge again.

I pay particular attention to the first few charges after setting up a dispenser or measure. I want to confirm that the correct powder is in the equipment, the scale is stable, the setting is correct and the system is behaving as expected.

I continue to watch the scale during the batch. If zero begins to drift or the equipment suddenly behaves differently, I stop and investigate. The fact that the previous twenty charges were correct does not guarantee the twenty-first will be.

Do Not Chase False Precision

It is easy to become obsessed with the last digit on an electronic scale. The number of decimal places on the display is not necessarily the same as the instrument’s true accuracy or repeatability. I use the scale within its specification and work consistently rather than pretending it can measure more accurately than it actually can.

Faster equipment can save a great deal of time, and there is nothing wrong with that. But I don't judge the quality of my charging process by how quickly I can fill a loading block. I judge it by whether the cases contain the correct, verified charges.

Once the routine is reliable, efficiency tends to follow naturally. Removing the verification stage simply to gain speed is not an improvement to my process.

When charging is complete, any uncontaminated powder that I can positively identify is returned to its correct original container in accordance with the manufacturer’s guidance. I check the label before pouring it back.

The powder measure, dispenser, trickler, funnel and other dispensing equipment are emptied. I don't leave powder sitting indefinitely in a hopper or measure, so there is no mystery powder waiting in the equipment when I next return to the bench.

For my rifle ammunition, the routine is deliberately uncomplicated. I clear the bench, confirm the powder and intended charge against my loading record, and check that the prepared and primed cases are empty.

The scale is set up on a stable surface, allowed to stabilise where required, then zeroed and calibrated according to its instructions. Every rifle charge is weighed.

With an electronic dispenser, I deliberately set the machine about 0.1 grain below my required charge and trickle the final amount up myself. I would rather add that last tenth than have to remove powder after an overshoot.

If I use a volumetric measure, it throws into the scale pan. I don't throw an unchecked rifle charge directly into a primed case.

Once verified, the charge goes into the case and that case is moved so its status is obvious. If anything interrupts the process or creates uncertainty, I stop and re-establish exactly where I am. When the

complete batch has been charged, every case is inspected under good light before projectile seating begins.

If a charge is uncertain, it is emptied and weighed again.

Dispense it. Weigh it. Verify it. Then put it in the case.

Chapter 23 — Understanding Projectiles

Figure 23.1 — *Projectiles of different calibres illustrating how bearing-surface length and overall geometry can vary substantially.*

Figure 23.2 — *Different projectile profiles illustrate how nose shape, bearing length and base design vary according to intended use.*

Once the case has been correctly prepared, sized, primed and charged with powder, the final major component is the projectile.

The projectile is the part of the cartridge that leaves the barrel, and its design has a major influence on what the finished ammunition is actually suited to doing. Two projectiles with the same diameter and nominal weight can behave very differently because of differences in length, bearing surface, jacket construction, ogive shape, base design, meplat or tip, ballistic coefficient and intended use.

A projectile designed for long-range target shooting is solving a different problem from one designed for stalking, vermin control, gallery shooting or general practice. The first job is therefore to understand the main features before choosing one for a particular load.

The calibre name of a cartridge does not always tell us the exact projectile diameter. Many cartridges commonly described as .30 calibre, for example, use a projectile approximately .308 inch in diameter. Apparently similar calibre names can also use different projectile diameters.

I therefore work from the specification of the actual cartridge, not from the calibre name alone. The correct projectile diameter is fundamental.

Projectile weight is normally stated in grains. Weight affects velocity, recoil, trajectory, wind drift, seating position and the load data that applies, but weight alone tells us surprisingly little about the complete projectile.

Two projectiles of the same nominal weight can have different lengths, bearing surfaces and nose profiles. I never assume that load data can simply be transferred from one projectile to another because the weight printed on the box is identical.

Projectile length and nose profile can determine whether a particular design is practical in a magazine-fed rifle. A long projectile may be perfectly suitable for the barrel and intended distance yet leave insufficient room for a workable cartridge in the magazine.

I therefore consider magazine constraints when choosing the projectile, but I leave the detailed measurement, clearance and seating procedure to Chapter 24. For a dedicated single-fed rifle, magazine length may be irrelevant.

Most modern centrefire projectiles consist of a lead or lead-alloy core surrounded by a copper-alloy jacket. There are also solid copper and monolithic designs, bonded projectiles, partitioned hunting designs, open-tip match projectiles, polymer-tipped projectiles and various specialist constructions.

Construction affects how the projectile behaves both inside the barrel and after impact. A target projectile may be designed primarily around dimensional consistency and aerodynamic performance, while a hunting projectile also has to provide the intended terminal behaviour.

Conventional jacketed projectiles use a relatively soft core surrounded by a harder jacket. Jacket thickness and construction can vary considerably. Target projectiles may use very consistent jackets to help control balance and concentricity, while hunting projectiles may use changes in jacket thickness or bonding to influence expansion and weight retention.

Monolithic projectiles are normally formed from a single material, commonly copper or a copper alloy. Because copper is less dense than lead, a copper projectile of the same weight will normally be longer than a conventional lead-core design. That extra length can affect seating depth, available case volume, required barrel twist and the relationship between the projectile and the rifle throat. I don't substitute one directly into data for a conventional jacketed projectile simply because the weight is the same.

Target and Hunting Projectiles

Target projectiles are designed primarily for accuracy and consistency. Long-range designs often combine uniform jackets, carefully controlled ogive geometry, boat-tail bases and shapes intended to retain velocity efficiently. Many are relatively long for their calibre, which makes matching projectile length to barrel twist particularly important.

Hunting projectiles have a different job. Accuracy still matters, but terminal behaviour becomes part of the design. Depending on the quarry and expected impact conditions, a hunting projectile may be intended to expand rapidly, expand in a controlled manner, retain weight, penetrate deeply, or combine several of those characteristics.

Projectile choice should reflect the quarry, applicable legal requirements and expected impact conditions rather than simply choosing the highest ballistic coefficient available.

Some match projectiles can produce significant terminal effects, but they should not automatically be treated as hunting projectiles simply because they are accurate. An open tip on a match projectile is often a consequence of manufacture rather than a conventional hunting hollow-point feature. I use the manufacturer's intended application as the starting point.

A flat-base projectile ends with a relatively square base. Flat-base designs can perform exceptionally well, particularly at shorter and medium ranges, and remain highly effective in disciplines such as short-range Benchrest.

A boat-tail projectile tapers towards the rear. This generally reduces base drag and improves aerodynamic efficiency as range increases, which is why boat-tail designs are so common in long-range target shooting. The angle and length of the boat tail vary between designs.

The ogive is the curved portion of the projectile between its full-diameter bearing surface and the nose. Common descriptions include tangent, secant and hybrid ogives. The shape affects aerodynamic behaviour and also the way the projectile relates to the rifle throat and seating stem.

Tangent designs can be comparatively forgiving of changes in seating position. Secant designs can offer excellent aerodynamic efficiency but some can be more sensitive to their relationship with the rifling. Hybrid

designs combine features of both. These are useful general descriptions, not rules that replace testing in the rifle.

The bearing surface is the portion of the projectile that contacts the barrel as it travels down the bore. Its length can influence friction, engraving force and pressure behaviour. This is another reason projectiles of identical calibre and weight should not automatically be treated as interchangeable.

The meplat is the small flat or open area at the tip of many projectiles. On open-tip match projectiles it can vary slightly because of manufacturing tolerances. For normal reloading this is usually of little concern. Meplat trimming and pointing belong in the advanced section of this book, where the possible benefit can be considered against the actual shooting requirement.

Polymer tips can improve aerodynamic shape, help initiate expansion in hunting designs or protect the nose during handling. They also illustrate why the extreme tip is not always the best reference point for precision seating measurements. Small variations at the tip can alter measured COAL even when the projectile is seated to a very consistent ogive position.

Projectile stability depends more strongly on the complete projectile length and shape than on weight alone. Weight is a useful shorthand because projectiles of one design generally become longer as they become heavier, but it is not the whole story.

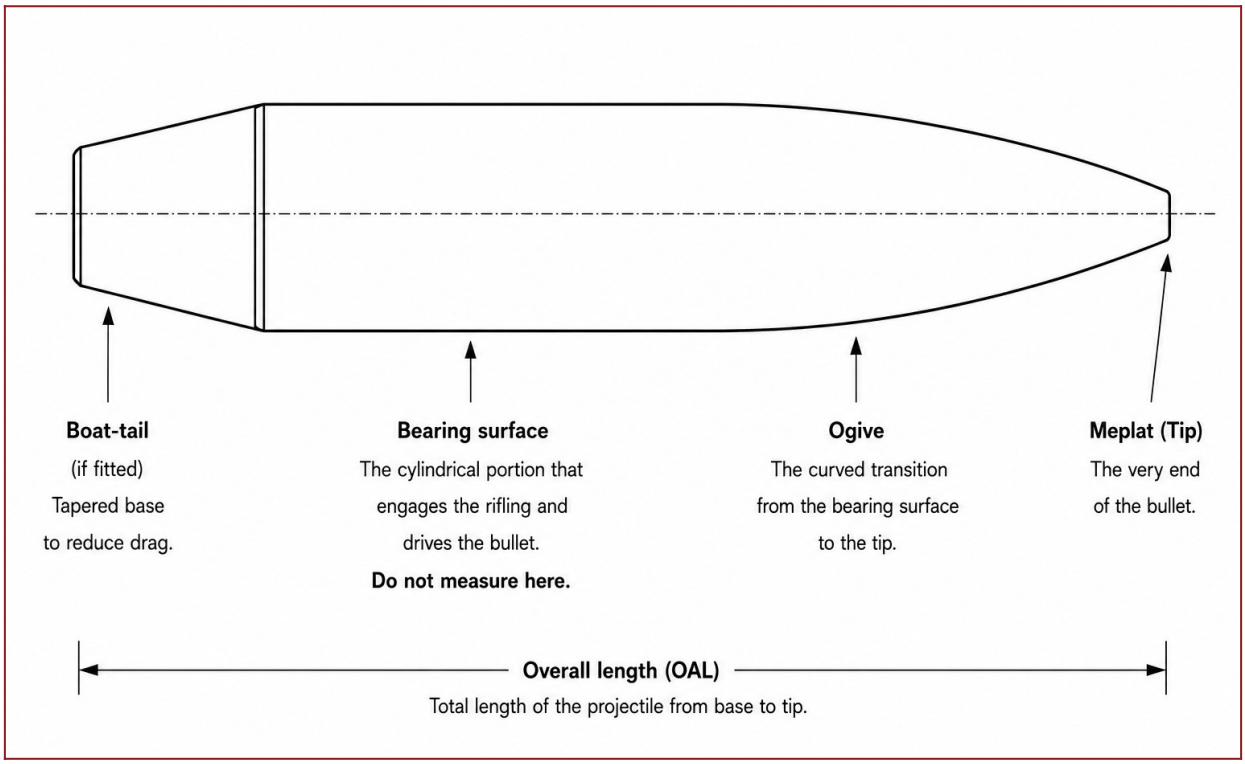


Figure 23.3 — *Projectile anatomy: boat-tail, bearing surface, ogive and meplat.*

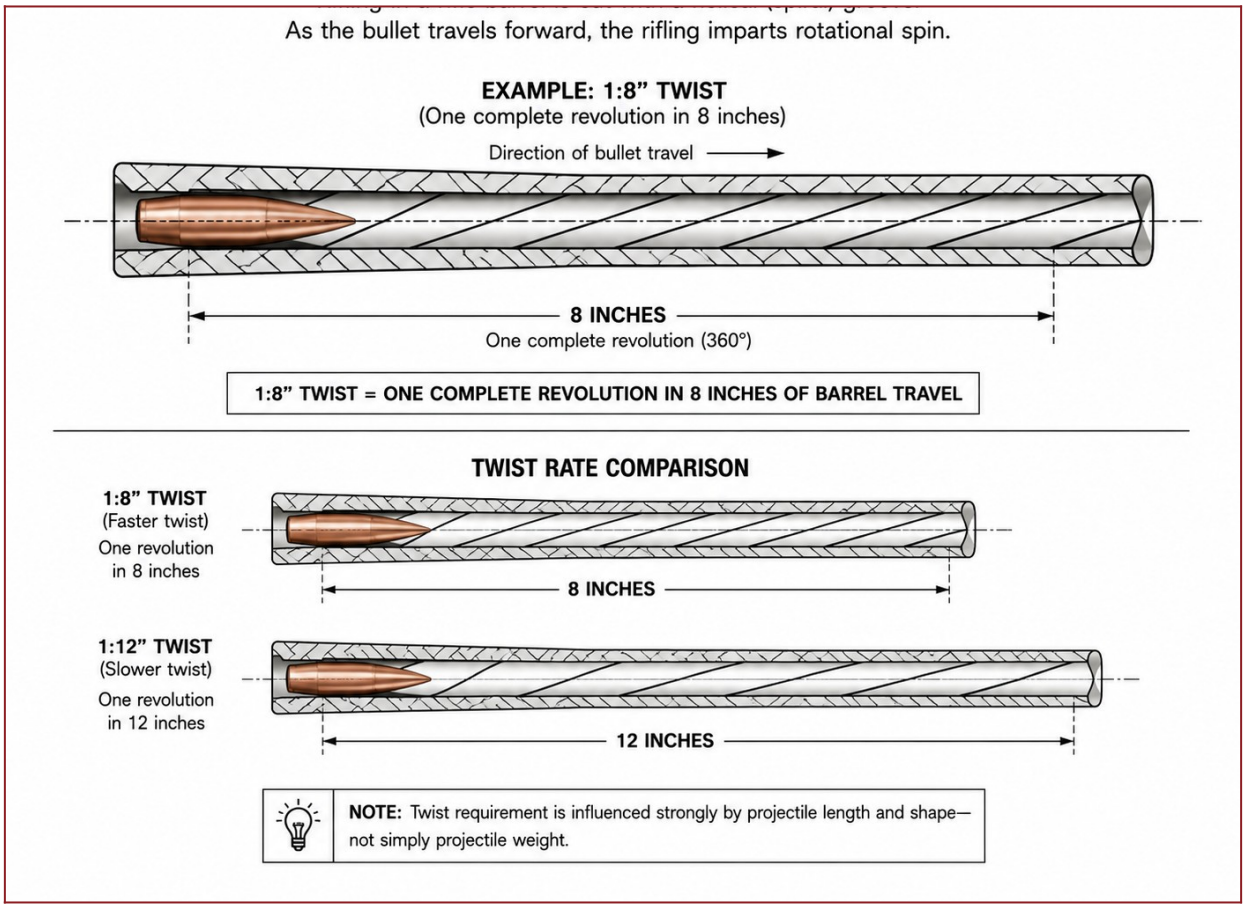


Figure 23.4 — *Understanding barrel twist rate. A 1:8-inch twist completes one revolution in eight inches and is faster than 1:12-inch.*

Longer projectiles generally require a faster twist rate to achieve adequate gyroscopic stability. A twist rate of 1 turn in 8 inches, written 1:8", is faster than 1 turn in 12 inches, or 1:12".

When selecting a projectile near the limits of a particular twist rate, I look at the projectile manufacturer's stability recommendations or use an appropriate stability calculation rather than relying only on a weight-based rule of thumb.

Ballistic Coefficient

Ballistic coefficient, or BC, describes how efficiently a projectile retains velocity compared with a reference projectile model. A higher BC generally means less velocity loss and less wind drift at longer ranges, all else being equal.

BC is useful, but it is not the single measure of projectile quality. A high-BC projectile that does not shoot accurately from the rifle is of little use. A slightly lower-BC projectile that groups consistently may be the better practical choice.

The two BC models most reloaders encounter are G1 and G7. G1 uses a reference shape that is less representative of many modern long-range boat-tail projectiles, while G7 is generally a closer match to that type of projectile. For many modern long-range target designs, G7 is therefore the more useful figure when it is available.

A G1 number should not be compared directly with a G7 number as though they are on the same scale. They are different drag models, and effective BC can also vary through different velocity ranges.

Sectional density relates projectile weight to diameter. It can be useful when comparing projectiles, particularly when penetration is being considered, but construction, shape and impact velocity also matter. Like BC, it is useful information rather than a complete answer on its own.

The chamber also influences projectile choice. Throat and freebore determine where a particular projectile approaches the rifling. Two projectiles loaded to the same COAL can sit very differently in relation to the lands because their ogive shapes are different.

> **KEY PRINCIPLE**
> *That is why COAL and base-to-ogive measurement have different jobs. COAL tells me the total physical cartridge length and is particularly useful when magazine fit is important. Base-to-ogive measurement gives me a more repeatable reference for precision seating-depth work. We will deal with both properly in the next chapter rather than duplicating the full procedure here.*

Higher-quality projectiles are generally manufactured with tighter control over dimensions, weight distribution, jacket thickness and shape. For the great majority of shooting, I use good-quality projectiles and load them. I don't automatically begin weighing and measuring every individual projectile.

For advanced precision work, projectiles can be sorted by weight, base-to-ogive length, bearing-surface length and other characteristics. That can be useful for some long-range, ELR, Benchrest or other high-precision applications, but those are examples rather than rules. Most shooters do not need to sort projectiles at all.

Sorting reduces measured variation; the target tells us whether reducing that variation actually improved accuracy. Detailed projectile sorting belongs in the advanced section of this book.

I keep projectiles positively identified and avoid mixing visually similar types in one container. Once different projectiles of the same calibre and similar weight have been mixed together, positive identification can be difficult.

I keep the exact manufacturer, product designation and lot information where useful in my loading records. Changing projectile manufacturer, design, construction or weight means I have changed a major component. I don't simply keep the same powder charge because the replacement projectile happens to weigh the same.

A different projectile can have a different bearing surface, jacket construction, length or seating position, all of which can alter the internal ballistic conditions. I return to suitable current published data and reassess the load.

Choosing for the Job

There is no universally best projectile. The correct choice depends on what the ammunition is expected to do. Short-range precision may place great emphasis on group size and consistency. Long-range target shooting may put more emphasis on aerodynamic efficiency and wind performance. PRS-type competition may require a balance of accuracy, recoil, magazine compatibility and reliable feeding. Hunting adds terminal performance and legal requirements. General practice may put greater emphasis on availability and cost.

Those are examples rather than laws. The projectile should suit the actual requirement.

When selecting a projectile, I begin with the job I want the ammunition to perform. I confirm the correct projectile diameter, consider the weight, construction and intended use, and check that suitable current published load data exists.

If the rifle is magazine-fed, I consider magazine length early rather than discovering the limitation after developing the load. I check projectile length against the barrel twist and, for longer-range work, consider ballistic coefficient without choosing on BC alone.

Once the projectile has been chosen, I record exactly what it is and treat any meaningful projectile change as a change to the load.

The next stage is deciding where that projectile needs to sit in the case. That takes us into COAL, base-to-ogive measurement, magazine clearance, the relationship with the rifling and why measuring from the projectile tip alone can sometimes give a misleading picture of seating consistency.
Cast projectiles form a large subject of their own. Their alloy, hardness, as-cast diameter, sizing, lubrication or coating, plain-base or gas-check design and intended velocity can all matter. I introduce them here simply as another projectile type. Later chapters will cover casting, finishing and loading them properly rather than trying to compress that subject into the general projectile chapter.

Subsonic ammunition places particular demands on projectile choice because stability and terminal performance must be considered at much lower velocity. The practical development of those loads is covered in Chapter 26.

Chapter 24 — COAL, CBTO, Magazine Length and Establishing Seating Depth

Figure 24.1 — *Loaded cartridges in detachable magazines, illustrating why usable overall cartridge length can be limited by magazine geometry.*

Figure 24.2 — *CBTO measurement: a comparator contacts the projectile ogive, giving a more repeatable reference than the tip on many projectiles.*

Figure 24.3 — *COAL measurement: callipers measure from the case head to the projectile tip.*

Once the projectile has been chosen, the next job is to decide where it needs to sit in the case.

This introduces several measurements that are often confused with one another: COAL — Cartridge Overall Length; CBTO — Cartridge Base to Ogive; magazine length; and the projectile's relationship with the lands.

All of them matter, but they tell us different things. For me, the important starting point is to understand what each measurement actually represents before using it during load development.

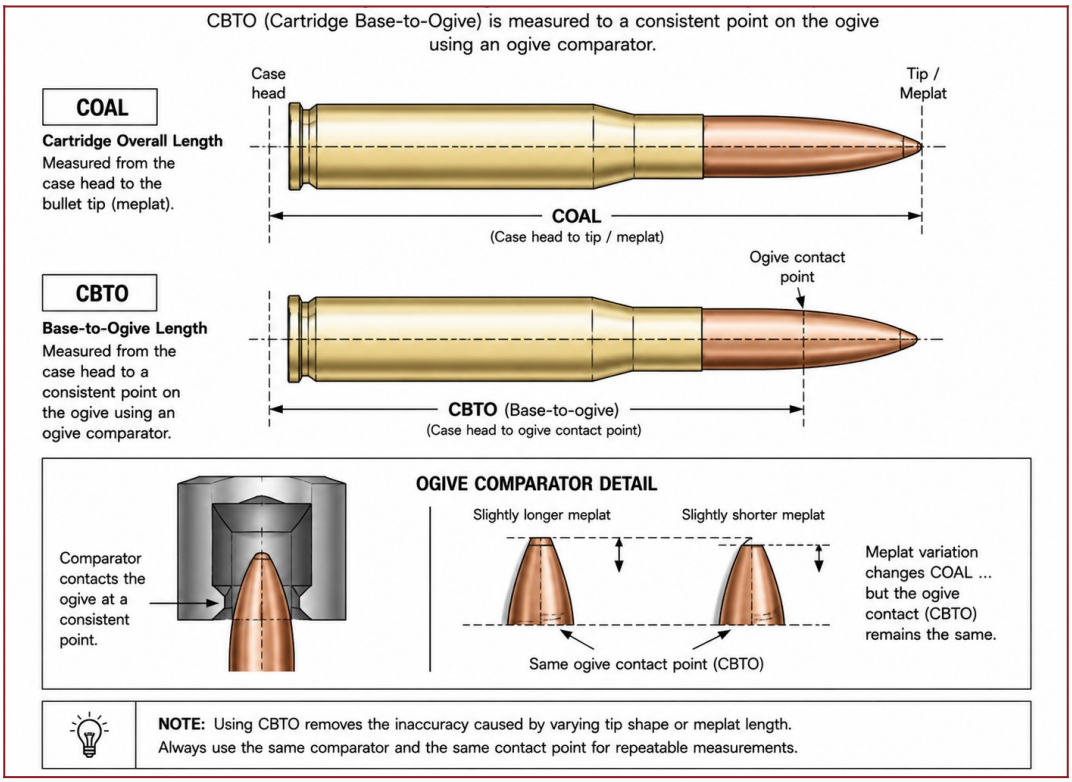


Figure 24.4 — *COAL measures to the projectile tip; CBTO measures to a repeatable reference point on the ogive.*

COAL is the measurement from the case head to the extreme tip of the projectile. It is easy to check with normal callipers and remains an important cartridge dimension.

COAL is useful for confirming:

- the total physical length of the cartridge;
- magazine fit;
- feeding;
- and general dimensional compatibility with the firearm and published cartridge information.

Its limitation appears when we try to use it as a precise measure of seating-depth consistency. The problem is the projectile tip.

The very tip of a projectile is not always a particularly consistent reference point. Open-tip match projectiles can vary at the meplat, and polymer-tipped projectiles can sometimes show surprisingly noticeable differences in tip length.

That means two cartridges can have essentially the same ogive position but still give different COAL measurements. The seating die may have done exactly the same job on both cartridges, while the apparent variation exists entirely in the projectile tip.

For that reason, I don't automatically assume that a small variation in COAL means there is a seating problem. For precision seating work, I check the base-to-ogive measurement.

CBTO measures from the case head to a repeatable point on the projectile ogive. A comparator body and the appropriate calibre insert are normally fitted to a set of callipers.

Instead of measuring to the inconsistent extreme tip, the comparator contacts the projectile at a defined diameter on the ogive. That gives me a much more useful reference for seating-depth work.

COAL tells me the total physical length of the cartridge.

CBTO gives me a more repeatable indication of where the projectile ogive is sitting.

I normally record both.

If the ammunition is going to be magazine-fed, I establish the usable magazine length before getting too involved in seating-depth development. The magazine gives me a real physical limit.

A long, high-BC projectile may look ideal on paper, but if the finished cartridge will not fit or feed from the magazine, I either need to seat it farther into the case, use a different projectile or accept that the ammunition will have to be single-fed.

For magazine-fed ammunition, I want the finished cartridge to:

- fit the magazine with sensible clearance;
- feed reliably;
- cycle correctly;
- and chamber freely.

There is little value in producing extremely accurate ammunition if it cannot be used reliably in the rifle it was intended for.

If I determine the absolute maximum length that will physically fit the magazine, I don't normally use that exact measurement as my working cartridge length. I want a little clearance.

Projectiles vary slightly, magazines are not always perfectly uniform, and ammunition needs to work under real conditions rather than only when carefully inserted on the loading bench. I therefore treat the maximum magazine length as a limit, not a target.

Single-Fed Rifles

In a dedicated single-fed target rifle, magazine length may be irrelevant. That gives much greater freedom to choose the seating position around throat length, projectile geometry, neck engagement and what produces the best results on the target.

Even then, the finished cartridge still needs to chamber freely and remain appropriate for the load.

Ahead of the chamber is the throat. The lands are the raised portions of the rifling that first contact the projectile as it moves into the bore.

The position of those lands relative to the case changes from rifle to rifle, even when both rifles are chambered for the same cartridge. The throat also changes with use. As the barrel wears, throat erosion gradually moves the effective lands position farther forward.

That's why I measure my rifle with the projectile I actually intend to use, rather than copying somebody else's COAL or CBTO measurement.

Once I establish where the projectile first contacts the lands, I have a useful reference point.

Jump means the projectile is seated back from the lands. There is a measurable free distance between the point on the projectile ogive that will eventually contact the lands and the lands themselves. When the cartridge is fired, the projectile moves through that distance before first contact with the rifling.

Touch means the projectile is positioned at the first-contact reference. The appropriate diameter on the ogive has just reached the tops of the lands, with effectively no deliberate free jump, but the projectile has not been seated farther forward to create positive engagement with the rifling.

Jam is different from touch. The projectile is seated beyond the first-contact reference, so chambering the round produces deliberate interference between the ogive and the rifling lands. The lands are no longer merely touching the ogive; they are applying a small amount of positive engagement. That engagement may be slight, but the starting condition is mechanically different from both jump and simple first contact.

None of those positions is automatically the most accurate. They are simply different relationships between the projectile ogive and the throat. The reference is the ogive where it meets the lands, not the projectile tip or meplat.

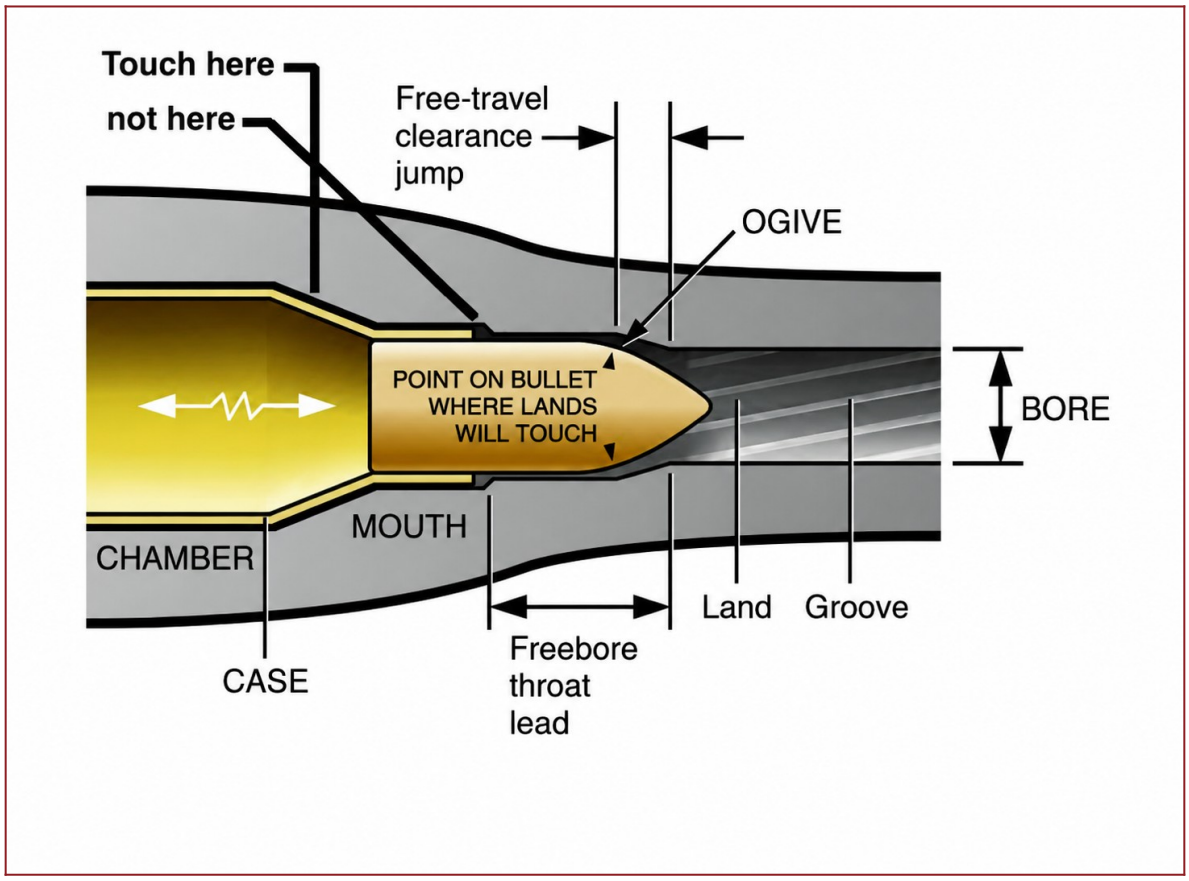


Figure 24.5 — *Jump, touch and jam. The reference is the point on the projectile ogive that meets the rifling lands, not the tip or meplat. Jump leaves a measurable gap, touch is first contact without deliberate engagement, and jam places the projectile slightly beyond first contact so the lands apply positive engagement.*

There are several commercial tools for establishing where a projectile first contacts the rifling. A typical setup might use the chosen projectile, an OAL or chamber measuring tool, an appropriate modified case, callipers, a comparator body and the correct calibre insert.

I allow the projectile to move forward until I can feel it make contact with the lands. The assembly is then carefully removed and measured from the case head to the ogive.

I repeat the measurement several times. For example, I might obtain:

2.2450"

2.2445"

2.2450"

2.2445"

2.2450"

Those readings are close enough to give me confidence that, with that projectile and comparator setup, first contact is approximately 2.245" CBTO. That number is simply my reference point. It is not automatically where I will load the ammunition.

There is sometimes a tendency in precision reloading to assume that the projectile needs to be extremely close to the lands to produce good accuracy. I don't regard jump as something that has to be minimised simply for the sake of it.

Provided sensible measurements are used, a reasonable amount of jump is perfectly normal. As an example, starting around 0.050" — 50 thou — back from my measured lands/contact CBTO can be a perfectly sensible position in many rifles.

> **KEY PRINCIPLE**
> *That 0.050" figure is an example, not a universal prescription. The appropriate starting position still depends on the projectile, chamber, magazine restrictions, published information and the particular rifle.*

Some combinations may ultimately prefer considerably less jump. Others can shoot extremely well with substantially more. What I don't assume is that 0.005", 0.010" or 0.020" off the lands must somehow be better simply because the projectile is closer.

If my lands reference is 2.245" CBTO and I decide to begin testing with 0.050" jump, I subtract the jump from the lands measurement:

2.245" − 0.050" = 2.195" CBTO

I can then set the seating die to produce approximately 2.195" CBTO, confirm the measurement on several cartridges and check magazine fit, chambering and feeding where applicable.

What matters is that 50 thou is only an example. It gives me a known, repeatable starting position which I can test.

More Jump Is Not Necessarily Worse

Some projectiles and rifles shoot extremely well with a considerable amount of jump. If a rifle is producing excellent, repeatable groups with more jump, I see no reason to move closer to the lands simply because a smaller number sounds more precise.

Jump is not a compromise. It is a legitimate seating strategy.

The measurement tells me where the projectile is. The group on the target tells me whether that position works.

For more advanced precision work, I may also establish a jam reference. Jam is essentially the other side of the initial-contact measurement.

If the lands reference is 2.245" CBTO and I deliberately want to investigate 0.005" jam, the nominal reference becomes 2.250" CBTO.

In practice, however, I don't rely solely on arithmetic to establish jam. I confirm the relationship physically with an inert dummy cartridge.

A Practical Jam-Point Method

For this method I prepare a dummy cartridge with no primer and no powder. The projectile is deliberately seated long.

I may apply a very light film of suitable case wax to the outside of the dummy case to help prevent the brass itself binding in the chamber and confusing the feel of the measurement.

The cartridge is then chambered carefully. As the bolt closes, the projectile contacts the rifling and is pushed farther into the case. I then extract the dummy cartridge carefully and measure its CBTO.

I repeat this several times. One measurement is not enough. I want a group of repeatable readings before I accept the result as a useful reference.

A measuring tool that gently moves the projectile forward until it first touches the lands is establishing an initial-contact reference. A long dummy cartridge chambered with the bolt can establish a different reference because the projectile may be pressed more firmly into the rifling.

The result can also be influenced by neck grip, projectile construction, bolt-closing force, extraction and the measuring technique itself. What matters is that I use the same method consistently and obtain a repeatable reference.

SAFETY WHEN USING DUMMY CARTRIDGES

Any cartridge used to establish chamber, lands or jam measurements must contain no primer and no powder.
Keep live ammunition away from the measurement area and make sure the dummy cartridge is positively identifiable. This is a dimensional measuring operation, not a live loading operation.

Jammed Ammunition and Pressure

A projectile already contacting or pressed into the rifling creates a different starting condition from one that has a measurable jump. That can affect pressure.

For that reason, I don't treat moving a projectile from jump into touch or jam as a trivial seating adjustment. It is a meaningful change to the load and needs to be approached accordingly.

There is another issue with jammed ammunition that becomes very obvious at the range.

Imagine I chamber a live cartridge that is deliberately seated firmly into the lands. I then decide not to fire it. Perhaps there is a ceasefire, a target problem or I simply need to unload the rifle.

I lift the bolt and extract the cartridge. The case can come out while the projectile remains stuck in the rifling.

If that happens, the case may separate from the projectile and the powder can spill into the action. Instead of simply having an unfired cartridge in my hand, I may now have a projectile lodged in the throat, loose powder in the action, an empty case, and a rifle that must not be fired until the problem has been dealt with.

SAFETY WARNING

If an unfired cartridge is extracted and the projectile remains in the barrel, stop. Do not chamber another cartridge and do not attempt to fire the rifle. The bore must be confirmed clear and any loose powder safely removed before the rifle is returned to use.

Loose powder in the action is not simply an inconvenience. Powder kernels can find their way into the locking-lug area, magazine, trigger mechanism or other parts of the action.

The rifle needs to be made safe and properly cleared. In competition, this can also cost a significant amount of time. This is one of the practical disadvantages I consider when deciding whether a jammed load is worthwhile.

I don't regard jump as the beginner's option and jam as the advanced or more accurate option. Both are valid seating strategies. Both need to be measured properly. Both need to be tested on the target.

A rifle may prefer a considerable jump, a small jump, approximate contact or some degree of jam. I don't know which until I test it.

The important thing is that each seating position is a controlled, recorded change rather than guesswork.

Suppose the initial lands reference is 2.245" CBTO and my ammunition is seated at 2.195" CBTO. That gives approximately 0.050" jump at that point in the barrel's life.

Later, throat wear might move the lands reference to 2.255" CBTO. If I leave my ammunition at 2.195" CBTO, I now have approximately 0.060" jump.

That doesn't automatically mean anything needs changing. If the rifle is still shooting exceptionally well, I may leave it alone.

Some precision reloaders move the seating depth outward as throat erosion progresses to maintain approximately the same jump. That can be a perfectly valid method, but I don't regard it as compulsory.

Moving the projectile outward also changes COAL, magazine fit, neck engagement and the overall cartridge configuration. I therefore use the measurement to understand what has changed, then look at what the rifle is actually doing.

I don't chase the lands simply because they have moved.

Although CBTO is more useful for precision seating consistency, COAL does not become irrelevant. I still use it to check the total physical length of the cartridge.

It remains particularly important for magazine fit, feeding, dimensional limits and comparison with appropriate published information.

For me, COAL is primarily the practical cartridge-length measurement. CBTO is primarily the precision seating-depth reference.

Seating Depth and Case Volume

Moving the projectile deeper into the case reduces the available internal volume. That can affect pressure. Likewise, changing from a jumping condition to contact or jam changes the projectile's initial resistance to movement.

That is why seating depth is not merely a cosmetic cartridge dimension. It is part of the complete load.

Different projectile designs contact the throat differently. A tangent-ogive projectile, secant design and hybrid design may all produce different COAL values when their ogives occupy a similar position relative to the lands.

Even projectiles of identical nominal weight can therefore require very different seating arrangements. Whenever I establish lands, jump or jam measurements, I record the exact projectile model used.

The seating die normally pushes on the projectile somewhere around its nose or ogive rather than directly on the extreme tip. Different projectile profiles can therefore interact differently with the seating stem.

A conventional seating stem may not suit a long VLD-style projectile particularly well. Some die manufacturers offer alternative seating stems for different projectile shapes. This becomes important when we set up the seating die in the next chapter.

Once I establish a useful seating position, I record:

- projectile manufacturer;
- exact projectile model;
- projectile weight;
- COAL;
- CBTO;
- lands reference;
- intended jump or jam;
- comparator and insert used;
- magazine limit where relevant;
- and the rifle or barrel the measurement applies to.

A number such as 2.195" is almost meaningless months later if I can't remember what it represented.

I begin by deciding whether the ammunition must fit and feed from a magazine. If it does, that practical limit is established first.

I then measure the chosen projectile in the actual rifle and establish a repeatable lands reference. From that point I can define a known amount of jump, touch or jam.

For many rifles, a sensible starting jump such as around 50 thou can be entirely reasonable, but it is only a starting point and not a rule.

I record COAL and CBTO and make sure the finished cartridge still chambers and feeds correctly.

If I test different seating positions, I change them deliberately and record them. I treat jump and jam as equal load-development variables, not as a hierarchy where one is automatically better than the other.

The measurement tells me exactly what I changed. The group on the target tells me whether that change improved the load.

That gives us a reliable seating-depth reference. The next stage is setting up the seating die so it can reproduce that position consistently from cartridge to cartridge.

Chapter 25 — Setting Up a Seating Die, Seating Projectiles and Crimping

Figure 25.1 — *Finished rounds beside a Wilson-style inline seating die used with an arbor press.*

Once I have established where I want the projectile to sit, the next job is getting it there straight, consistently and without disturbing the work already done to the case.

Projectile seating looks simple: place the projectile at the case mouth, raise the ram and let the seating die push it into position. In practice, this is one of the stages where a collection of small details can make the difference between ammunition that merely looks right and ammunition that is genuinely repeatable.

The projectile needs to start straight. The seating stem must suit its nose profile. The die body must be set correctly, especially if the die also has a crimp function. Neck tension and seating force need to feel sensible, and the finished cartridge needs to reproduce the seating depth established in the previous chapter.

This chapter covers the main seating systems and procedures, then shows the way I normally work with them. My own method is not the only valid one, but it is the routine I have settled on because it is simple, measurable and repeatable.

Most conventional seating dies have two separate adjustments: the die body and the seating stem. The die body establishes where the die sits in the press and, on some designs, when a crimp shoulder begins to engage the case mouth. The seating stem controls how far the projectile is pushed into the neck.

Confusing those two adjustments is one of the easiest ways to create trouble. If the projectile needs to go deeper, the seating stem is normally the adjustment I change. Screwing a combination seating/crimp die farther into the press can start applying crimp when I did not intend to apply any at all.

A basic threaded seating die can produce excellent ammunition when it is correctly adjusted. More elaborate designs add convenience or alignment features rather than changing the fundamental job.

Figure 25.2 — *Cutaway seating die showing the case and projectile aligned beneath the seating stem. The cutaway reveals the internal relationship that cannot be seen during a normal seating stroke.*

- Standard threaded seating dies use a conventional adjustable seating stem in a die body mounted in the press.
- Micrometer or vernier seating dies add a graduated top adjustment that makes small seating-depth changes easier to repeat.
- Floating-sleeve or competition seaters support the case and projectile more closely during seating.
- Inline seating dies used with arbor presses hold the case and projectile in a chamber-type body and apply seating force directly in line.

The more sophisticated systems can be very useful, particularly when load development involves frequent small changes, but I still measure the finished cartridge. An adjustment scale is a reference; the cartridge tells me where the projectile actually finished.

The seating stem is the part of the die that actually contacts the projectile. Its internal shape matters because not every projectile has the same nose or ogive profile.

A standard stem is normally shaped around conventional projectile profiles. With a suitable projectile, it should contact a stable part of the nose or ogive without bottoming on the extreme tip.

Long VLD-style, secant-ogive and some hybrid projectiles can need a different stem. If the standard stem is too shallow or the internal shape is wrong, the projectile tip can bottom out before the stem is properly supporting the nose. That can mark the projectile, distort a tip or make the seating operation less repeatable.

Many die makers therefore offer VLD or projectile-specific seating stems. Projectile weight alone does not decide which stem is correct; two projectiles of identical calibre and weight can have very different nose shapes.

A Simple Check for Seating-Stem Fit

If I am unsure, I remove the seating stem and offer a projectile into it by hand. I want the stem to contact the projectile on a sensible part of the nose with clearance around the tip. If the tip bottoms first, or the contact is obviously narrow and poorly matched, I look for a more suitable stem rather than trying to cure the problem with more force.

A faint witness ring from a seating stem is not automatically a problem. A deep ring, visible jacket deformation or a damaged tip is different and deserves investigation.

A complete competition seating die is not always necessary just because I want finer adjustment. Some manufacturers offer vernier or micrometer-style tops that can be fitted to certain standard seating dies.

These add a graduated adjustment to the existing die and make small, repeatable seating-depth changes much easier during development. They are also useful when I want to return to a recorded setting later.

What they do not do is change the basic alignment system inside the die. An add-on micrometer top makes adjustment easier; it does not automatically turn a conventional die into a sliding-sleeve or inline competition seater.

Whatever adjustment system I use, I still seat a cartridge and measure its CBTO. I never assume the markings on the top of the die are a substitute for measuring the result.

My normal setup starts with the seating stem backed well out. I would rather make the first cartridge obviously too long and gradually work down to the required position than seat it too deeply at the first attempt.

I raise a prepared case in the shellholder and set the die body according to the die manufacturer’s instructions. If the die can also crimp and I don't want a crimp, I make sure the body is backed off enough that the crimp shoulder is not engaging the case mouth.

Once the die body is where I want it, I secure the lock ring. I don't need excessive force; I simply need the die to remain in the position I established.

With the die body set, I place a projectile at the case mouth and raise the ram carefully. Because the seating stem is backed out, the first attempt should leave the projectile long or only partly seated.

I then lower the ram, turn the seating adjustment down a little and try again. As I approach the required CBTO, the adjustments become smaller.

The routine is simple: seat a little, measure, adjust, seat a little farther and measure again. It takes slightly longer than trying to guess the final setting, but it gives me much better control and avoids creating cartridges that immediately need dismantling.

For precision rifle ammunition, CBTO is normally my main seating-depth reference because it measures to a repeatable point on the projectile ogive. COAL still matters for magazine fit, feeding and overall cartridge length, but tip variation can make it a poor dimension to chase to the last thousandth.

Once the first cartridge reaches the intended CBTO, I seat several more before committing to the whole batch. If those repeat closely enough for the ammunition I am producing, I know the setup is behaving sensibly. If they do not, I stop and find the source of the variation.

Getting the Projectile Started Straight

A good inside chamfer helps the projectile enter the case mouth cleanly. I place the projectile as straight as reasonably possible before raising the ram. I don't expect my fingers to align it perfectly—that is what a good seating system is there to help with—but I also do not deliberately present the die with a projectile sitting at an obvious angle.

Good seating is usually the result of several small things being right at the same time: a clean case mouth, sensible neck tension, a suitable seating stem, a correctly adjusted die and a consistent press stroke.

My Two-Stage 180-Degree Seating Method

When I use a conventional press and threaded seating die, I often divide the seating stroke into two stages.

I start the projectile and seat it approximately halfway to its final position. I then lower the ram enough to release the cartridge, rotate the case about 180 degrees in the shellholder, and raise the ram again to complete the seating stroke.

So the sequence is: start the projectile → seat approximately halfway → lower the ram → rotate the case 180° → complete the seating stroke.

The idea is to help average out small alignment errors. If the case, projectile, shellholder, ram or die is very slightly out in one direction, completing the whole operation in one orientation can encourage that error to remain in the same direction. Rotating the cartridge halfway through gives the second part of the seating operation the opposite orientation.

I regard it as a useful practical technique rather than a mathematical guarantee. I don't claim it automatically halves runout. If I want to know whether the finished ammunition is straighter, I measure it. The runout gauge tells me about alignment; the group on the target still tells me whether the ammunition is accurate.

Whichever die I use, I operate the press smoothly and consistently. I don't slam one projectile home and then ease the next one in gently.

After seating enough cartridges from a well-prepared batch, I get a good feel for what normal resistance is. A cartridge that suddenly feels dramatically easier or harder than the others gets my attention.

Seating force can change because of neck tension, brass hardness, neck-wall variation, inside-neck condition, projectile diameter, contamination or a problem with the case. I don't expect every stroke to feel laboratory-identical, but an obvious outlier is worth putting aside and checking.

At the advanced end, instrumented presses can record actual seating force. I sometimes use this type of information when I am chasing a higher level of control, because an unusual force trace can identify a round that deserves further inspection.

The relationship between dimensional neck tension, actual seating resistance and force-travel traces is covered in more detail in Chapter 18. The important point here is that an instrumented press is a diagnostic tool: it can reveal an outlying round, but it does not replace careful brass preparation or on-target confirmation.

That is useful information, not a requirement for good ammunition. A conventional press, properly prepared brass and sensible attention to feel can produce exceptional results.

A pronounced ring or indentation on the projectile usually means the seating stem is concentrating force over too small an area or the seating force is higher than expected. Possible causes include an unsuitable stem profile, excessive neck tension, a compressed powder charge or debris inside the die.

If I change to a substantially different projectile, particularly a long VLD or modern high-BC design, checking the seating-stem fit is one of the first things I do before blaming the die for inconsistent seating.

Some legitimate published loads are compressed. When the projectile begins compressing the powder column, seating force can increase and the projectile can occasionally move slightly after seating if the powder is pushing back against it.

With a published compressed load, I pay closer attention to final seating depth. I may measure a cartridge, leave it for a short period and measure it again to make sure the projectile has remained where I put it.

Why Seating Depth Can Vary

If CBTO varies even though the die has not moved, I look at the complete system rather than immediately blaming the seating die.

- projectile-ogive variation;
- debris inside the seating stem or die;
- varying neck tension or case-neck condition;
- shellholder or press movement;
- compressed powder;
- inconsistent measurement technique;
- or a comparator that is not being used the same way each time.

If CBTO is repeating but COAL varies, projectile-tip variation is the first thing I consider. Continually adjusting the die to force variable tips to the same COAL can make the more meaningful ogive position less consistent.

Once the seating die is set, I still confirm the finished cartridge works in the rifle as intended. Magazine-fed ammunition needs sensible magazine clearance and reliable feeding. Single-fed target ammunition may ignore magazine length, but it still needs to chamber freely.

A perfect comparator reading is of little use if the cartridge will not function in the firearm.

For higher-level precision work, I may use an inline seating die with an arbor press. Wilson-style inline dies are a familiar example. The case and projectile are supported closely in line inside the die and seating force is applied directly through the stem.

This removes some of the alignment variables associated with a conventional ram, shellholder and threaded die. It can also provide excellent seating feel. When I am chasing the best precision I can reasonably produce, this is one of the systems I may use.

An inline system does not compensate for poor brass preparation. If neck tension varies from case to case, the most expensive seating die on the bench cannot make that variation disappear.

When setting up or diagnosing a seating process, I may check a finished cartridge on a concentricity or runout gauge. I use it as a quality-control and diagnostic tool, not as a substitute for shooting the ammunition.

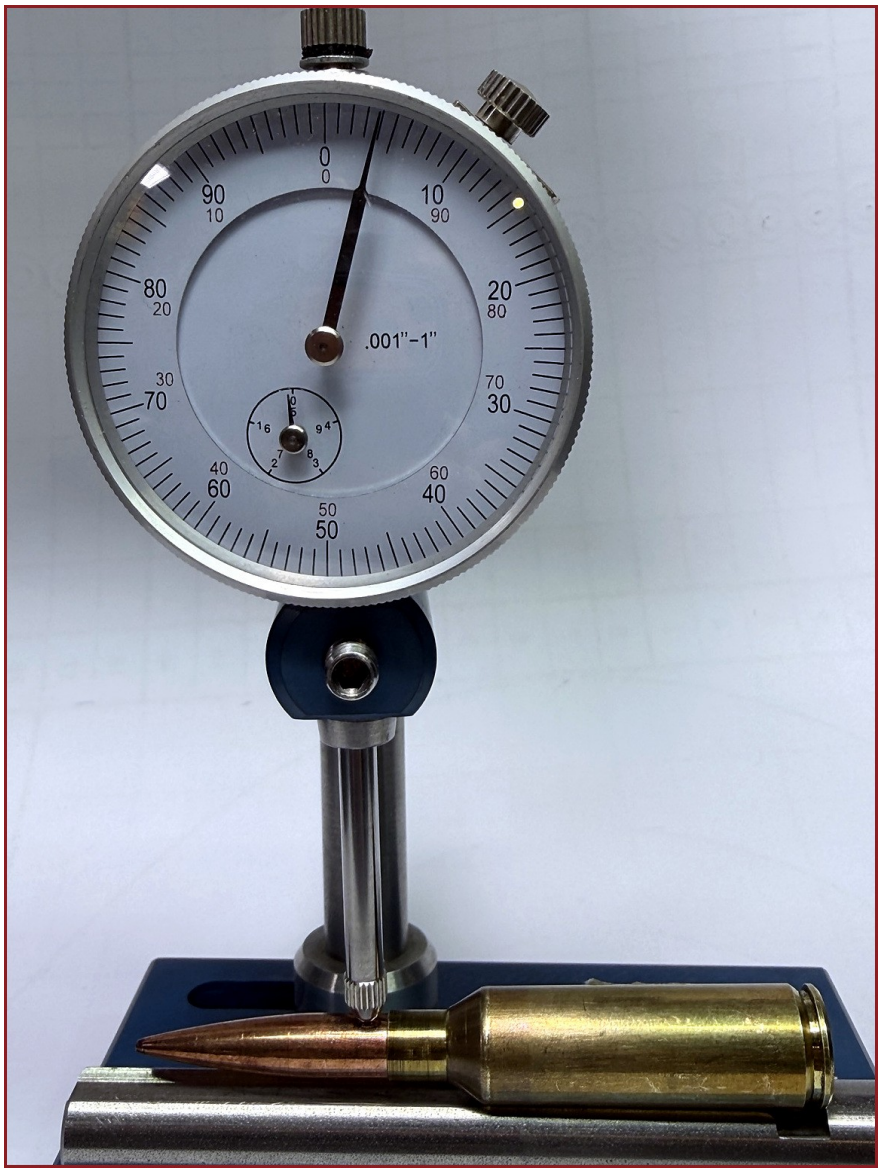


Figure 25.3 — *A loaded round on a concentricity/runout gauge, with the indicator contacting the projectile.*

The dial normally shows total indicator reading (TIR): the total movement seen during one complete rotation. If the indicator moves through 0.003 inch from low point to high point, I record 0.003 inch TIR. For normal reloading work I record the movement the gauge actually shows rather than repeatedly converting it into another figure.

If the sized case neck measures well but projectile runout appears after seating, I look at the seating stage: case-mouth preparation, seating-stem fit, die alignment, neck tension and whether the projectile is starting straight. If the runout was already present in the sized neck, I go back to the sizing and neck-preparation operations rather than trying to correct the finished round.

> **BENCH NOTE**
> This is also where my half-seat, rotate approximately 180 degrees and finish-seating method can be tested rather than assumed. If it produces measurably straighter ammunition in a particular setup, I have a reason to use it. If it makes no difference, I don't turn it into a ritual.

Some gauges allow a loaded cartridge to be pushed or straightened to reduce the dial reading. I am cautious about doing that routinely because side-loading the seated projectile can also alter the case neck and projectile grip. I would rather correct the sizing or seating process that created the runout, then verify the result on the target.

KEY PRINCIPLE

There is no universal runout number that guarantees accuracy. A clear difference between batches can be worth investigating; tiny differences close to the repeatability of the gauge may not be. The target decides whether controlling runout is actually buying anything.

Crimping — Usually a Separate Requirement

Many conventional seating dies can also crimp the case mouth around the projectile. For most of the precision rifle ammunition I load, I don't deliberately add an extra crimp. Correctly controlled neck tension already provides the retention I require.

Crimping is more commonly relevant to some pistol and revolver cartridges, older military cartridge designs, tubular-magazine ammunition, and ammunition used in firearms where heavy recoil, aggressive feeding or automatic operation can subject the cartridge to substantial mechanical disturbance.

The point is not that every military-style or high-recoil firearm automatically needs the heaviest possible crimp. What matters is that a crimp should have a reason.

A roll crimp turns the case mouth inward and is commonly used where the projectile has a cannelure or crimp groove intended to accept it. Case length matters because a longer case reaches the crimp shoulder earlier and can receive a heavier crimp than a shorter one.

A taper crimp gradually reduces the case-mouth diameter rather than rolling it sharply inward. It is commonly used with many pistol cartridges, particularly where the case mouth has an important headspacing function. Roll and taper crimps are different operations and need to suit the cartridge design.

Some dies are designed to seat and crimp in the same stroke. That can work, but setup is more sensitive because the case mouth can begin being formed inward while the projectile is still moving down.

If the relationship is wrong, the result can be a buckled shoulder, damaged case mouth, marked projectile, excessive crimp or inconsistent seating depth. Where I genuinely need a deliberate crimp and have the equipment available, seating and crimping as separate operations can make setup and diagnosis easier.

This is the crimping problem most relevant to ordinary precision-rifle seating. If I am using a combination seating/crimping die but do not want a crimp, I make sure the die body is positioned so the crimp shoulder does not engage the case mouth.

If the projectile needs to go deeper, I adjust the seating stem—not the whole die body. That simple distinction prevents a surprising number of problems.

A military primer-pocket crimp and a case-mouth projectile crimp are completely different things. One retains the primer; the other retains or supports the projectile. They happen at opposite ends of the case and should not be confused simply because both use the word crimp.

For my normal precision rifle ammunition, I begin with the seating position already established. I select a seating stem that actually suits the projectile, and if a standard die can take a useful vernier or micrometer top I may use that for finer adjustment.

I back the seating stem well out, set the die body correctly and make sure a combination die is not applying a crimp unless I specifically want one. I start with the projectile deliberately long and gradually work down towards the required CBTO, measuring frequently.

Once the first cartridge is correct, I seat and measure several more before committing to the batch. With a conventional press, I often use my two-stage method: seat approximately halfway, lower the ram, rotate the case about 180 degrees, then complete the seating stroke.

I pay attention to seating feel and put aside anything that feels markedly different. For the highest-precision work I may use an inline seating die and arbor press instead.

Unless the cartridge and firearm give me a genuine reason to do otherwise, I don't add an extra crimp to my precision rifle ammunition.

The objective is not simply to push a projectile into the case. It is to put it at a known depth, as straight and as consistently as reasonably possible, while preserving the neck tension and case preparation already established.

Once that is achieved, the cartridge is complete. The next stage is testing whether the chosen seating position is actually the one the rifle prefers, using controlled seating-depth development and the group on the target as the final judge.

Chapter 26 — Developing a Load: From Published Data to a Proven Combination

Figure 26.1 — *A genuine range-side development setup, with ammunition, notes, measuring/loading equipment and chronograph equipment kept together.*

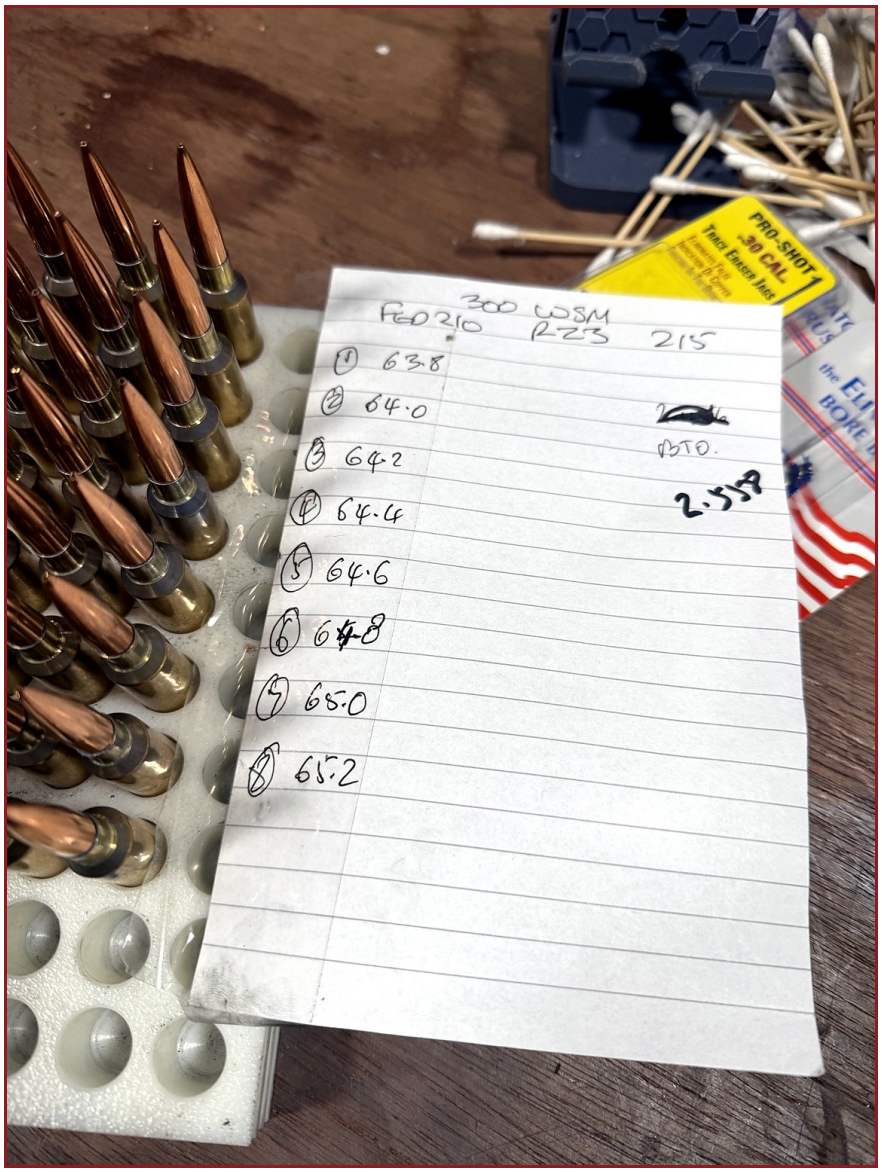


Figure 26.2 — *An organised load-development series with rounds kept in sequence and charge changes recorded alongside the batch.*

By this point we have worked through the individual operations required to produce a cartridge. We have prepared the brass, controlled sizing and neck tension, selected and seated the primer, chosen and accurately weighed the powder charge, selected the projectile and established where that projectile will sit.

Now those individual operations have to come together. This is load development.

Load development is sometimes presented as though there is a secret test or particular sequence of charge weights that will reveal the perfect load. I don't look at it that way. For me, it is a controlled process of finding a combination that is safe, accurate, repeatable and suitable for what I actually want the rifle to do.

The smallest group on one target is interesting. A combination that repeatedly performs is much more useful. Throughout the process I also want to know exactly what I changed. If I alter two or three important variables at the same time and the result improves, I have learnt surprisingly little because I don't know which change was responsible.

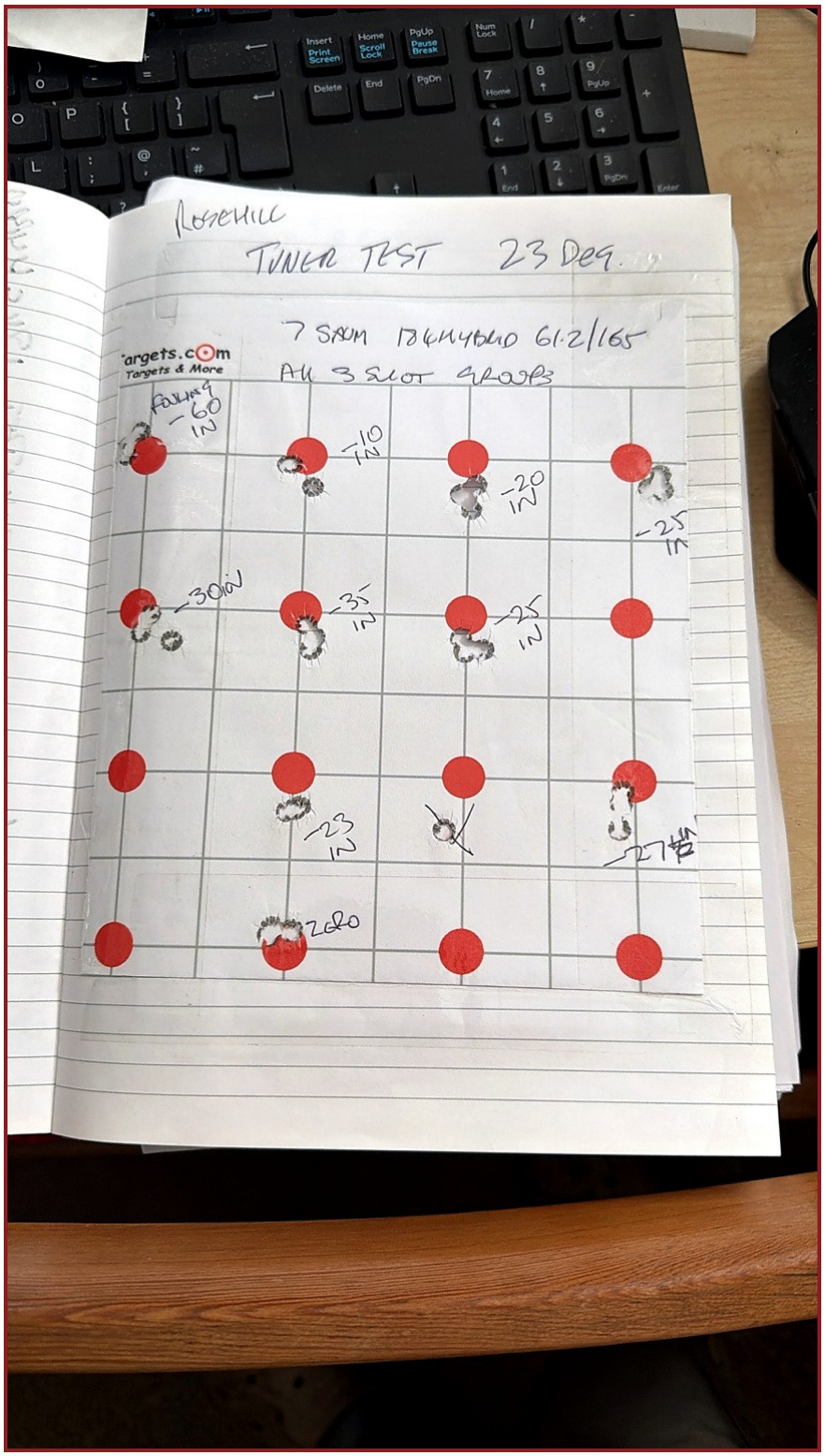


Figure 26.3 — *A tuner-test record with individual groups and their corresponding tuner settings written directly against the test sequence.*

Change one meaningful variable at a time.

Before choosing a powder charge, I decide what I am trying to achieve. A load for a deer-stalking rifle does not necessarily have the same priorities as ammunition for a single-fed F-Class rifle. PRS ammunition, Benchrest ammunition and general sporting ammunition may all place different emphasis on accuracy,

velocity, vertical dispersion, magazine function, recoil, temperature behaviour, ammunition quantity, component availability and reliability.

There is little point developing wonderfully accurate ammunition that will not fit the magazine of the rifle in which I intend to use it. Likewise, I don't automatically chase maximum velocity if a slightly slower load repeatedly gives me the accuracy and consistency I need. Before I start, I define the job. That gives the development process a purpose.

My starting point for a new load is reputable published load data appropriate to the cartridge and components I intend to use. Powder and projectile manufacturers are obvious places to look, along with established loading manuals and other recognised pressure-tested sources.

I look for data matching my combination as closely as reasonably possible: cartridge, projectile weight and preferably exact projectile type, powder, primer where specified, case where specified, and relevant cartridge dimensions.

I don't begin with somebody else's favourite charge simply because it shoots well in their rifle. Their chamber, throat, barrel, brass, primer, projectile and seating depth may all differ from mine. Their load is information about their rifle. It is not pressure-tested data for mine.

Published data will normally give me a range within which development can begin. I pay attention to both ends. The maximum charge is not a target I am obliged to reach. If the rifle gives me the performance I want below it, I have no reason to continue adding powder simply to arrive at the largest number in the manual.

Nor do I assume that because a charge is below a listed maximum it must automatically be safe in every rifle. Published data was produced with a particular combination of components, dimensions and test equipment. My rifle and components are not necessarily identical. That is why I begin sensibly and work methodically.

Why Published Data Can Differ

It is common to find different reputable sources giving somewhat different charge ranges for apparently similar loads. That doesn't necessarily mean one of them is wrong. Differences can come from the exact projectile, projectile construction and bearing surface, case capacity, primer, seating depth, barrel, chamber and throat, powder lot, test equipment and the pressure-testing method used.

Even two projectiles of identical calibre and nominal weight are not necessarily interchangeable from a pressure point of view. I therefore try to use data that matches the actual components as closely as possible.

A burn-rate chart can be useful for understanding roughly where powders sit relative to one another. It is not a substitution chart. Two powders appearing next to one another on a burn-rate chart are not automatically interchangeable grain for grain.

I never take a charge weight for one powder and simply substitute the same weight of another because the two powders appear close together on a chart. If I can't find reputable data supporting a powder for the cartridge and projectile combination, I don't invent the data myself.

Once development starts, I keep the component combination identifiable. Changing the brass manufacturer or lot, primer, powder or powder lot, projectile, seating depth or another significant cartridge dimension can change how the load behaves.

This doesn't mean every minor change automatically creates a dangerous cartridge. It means I don't casually assume that a load remains exactly the same after changing an important component. If the change is significant, I reassess the load rather than simply carrying on from where I stopped.

Cases carrying the same cartridge designation do not necessarily have identical internal capacity. Different manufacturers—and sometimes different production lots—can use different brass thicknesses and internal geometry. A case with less internal volume can behave differently with the same powder charge.

For ordinary reloading I don't think every case needs to be sorted by measured water capacity. That belongs much more naturally in the advanced precision section. I do, however, keep my brass lots together and record which brass was used to develop the load.

Before beginning powder development, I establish a repeatable seating position. For a magazine-fed rifle, magazine length and reliable feeding may dictate much of the decision. For a single-fed precision rifle, I may have considerably more freedom. Either way, I establish an initial CBTO and record it.

At this stage I'm not trying to optimise powder charge and seating depth simultaneously. Initially, I want seating depth to remain constant while I investigate powder charge.

My normal approach is to establish a good powder-charge base first. I choose a sensible initial seating position and leave it alone during the initial powder test. At this stage, powder charge is the variable.

Once I have identified a safe and promising powder charge or charge region, I can keep that charge constant and investigate seating depth if I believe there is something worthwhile to gain. Then seating depth becomes the variable.

If I am changing powder charge, I don't change seating depth at the same time. Suppose I increase the powder charge and also move the projectile closer to the lands. I shoot the new ammunition and the group becomes substantially smaller. Was it the additional powder, the seating-depth change, or the interaction between the two? I have no clean answer because I deliberately changed two variables at once.

Instead, I establish a sensible seating position, develop the powder charge and find a good powder-load base. Only then, if necessary, do I hold that powder charge constant and investigate seating depth. If I deliberately test one variable, I try not to introduce another major variable at the same time.

Choosing the Starting Charge

Once I have suitable published data, I choose a sensible starting point within that data. Exactly where I begin depends upon the particular cartridge, components and published information. The objective is to give myself room to observe what happens as the charge increases.

I don't begin close to the maximum simply because somebody else tells me that is where their rifle shoots best. Nor do I automatically regard the lower development rounds as wasted ammunition. They give me information about my combination.

Before loading the first development cartridge, I decide what I am actually going to test. I establish the powder, starting charge, charge increments, number of rounds at each charge, seating position, chronograph arrangement, target layout and what would make me stop the test.

I record the plan before going to the range. That means I arrive with a controlled test rather than making the process up between groups.

There is no single charge increment that is appropriate for every cartridge. Case capacity, powder, published data and the width of the usable charge range all need to be considered.

For much of my own rifle load development, however, I normally work upwards in 0.2-grain powder-charge increments. That is my usual method, not a universal rule. With a particularly small-capacity case, a very narrow published charge range or another combination where 0.2 grain represents too large a change, I use an increment appropriate to that load and the published data.

I never allow my chosen increment to take me beyond an appropriate published maximum simply because the next 0.2-grain step happens to fall there. The purpose is to move through the useful development range in a controlled way. I'm not trying to reach the largest powder charge; I am trying to find the best useful area.

There is no magic number of rounds that makes a load-development test perfect. Small groups use fewer components and can be useful for initially narrowing the field, but small samples also contain less information. Three shots can produce an extraordinarily attractive group partly through chance.

Larger groups tell me more but consume more ammunition, barrel life and range time. My normal philosophy is to use the early stage to narrow the field, then spend the additional rounds confirming combinations that have actually earned further investigation.

Development ammunition must be impossible to confuse. Every charge weight or test condition needs to be clearly identifiable. I record the rifle and barrel, brass and number of firings where relevant, primer, powder and lot where available, exact powder charge, projectile, CBTO, COAL where useful and the test-round identification.

I record this information while I am loading, not later from memory. Record keeping is part of the operation.

The development ammunition is loaded using the procedures already covered in the book. This is not the time to change case preparation, neck tension or seating technique between charge weights. If powder charge is what I am testing, I want it to be the principal deliberate variable.

If something feels or looks unusual while loading—a primer that does not seat normally, an unexpected seating force or a questionable case—I investigate it. I don't knowingly put an unexplained cartridge into a controlled test.

A Development Test Is Not a Race to Maximum

At the range I normally work from the lower charges upwards. I observe what happens as I go. If I find the performance I want before reaching the upper charges, I don't necessarily need to fire everything remaining in the box. Likewise, if something gives me a reason to stop, I stop. There is no prize for reaching the maximum charge.

A chronograph is extremely useful during load development. It tells me something the target cannot: what velocity the ammunition is actually producing. I can relate the velocity of each shot to powder charge, target result, rifle behaviour and observations from the fired case.

I am interested in the overall behaviour and trends rather than obsessing over one number.

As powder charge increases, I generally expect velocity to increase. The relationship is not perfectly linear and individual shots naturally vary. What interests me is the trend.

If a modest charge increase produces an unexpected change in velocity behaviour, I pay attention. Likewise, if measured velocities are substantially different from what reputable data led me to expect, I don't simply ignore the discrepancy. A chronograph does not directly measure chamber pressure, but unexpected velocity is information worth considering.

ES, or Extreme Spread, is the difference between the fastest and slowest shots in a string. SD, or Standard Deviation, describes how velocities are distributed around the average.

Both can be useful. Neither is the sole objective of load development. A tiny SD looks impressive, but if the ammunition does not group well or produce the down-range performance I require, the number has not rescued the load. I use velocity statistics as evidence, not trophies.

Pressure During Development

Pressure deserves constant attention during load development, but it also needs to be understood properly. Most reloaders do not have equipment capable of directly measuring chamber pressure, so we observe indirect indications. These can provide useful warnings. They are not pressure-measuring instruments.

Primers are commonly inspected during development. A primer that changes appearance noticeably as powder charge increases may give me something worth investigating, but primer-cup construction, firing-

pin fit, firing-pin-hole dimensions, headspace and the firearm itself can all influence the appearance of a fired primer.

A flattened-looking primer cannot tell me an exact pressure. More importantly, a normal-looking primer does not prove that chamber pressure is safe.

A noticeable change in bolt lift or extraction effort gets my attention immediately. If a rifle that has been opening normally suddenly becomes unusually difficult to open as the charge increases, I stop and investigate.

Ejector and extractor marks can also provide useful information, but they require interpretation. I am particularly interested in a change from the previous rounds as development progresses rather than attempting to read an exact pressure from a single case.

I also pay attention to the brass itself. Unexpected case-head marking, difficult extraction, primer pockets behaving differently, gas leakage or a case behaving noticeably differently from those fired immediately before it all deserve investigation. Any indication of gas escape or serious case failure ends the test until the cause is understood.

Pressure Signs Have Limitations

Traditional pressure signs can appear late, and some rifle and component combinations may show surprisingly little visible warning before pressure has already become higher than intended. That is why I don't simply continue increasing the powder charge until I finally see an obvious pressure sign and then back off slightly.

Published pressure-tested data remains the foundation. My observations at the range provide another layer of information. They are not permission to ignore published limits.

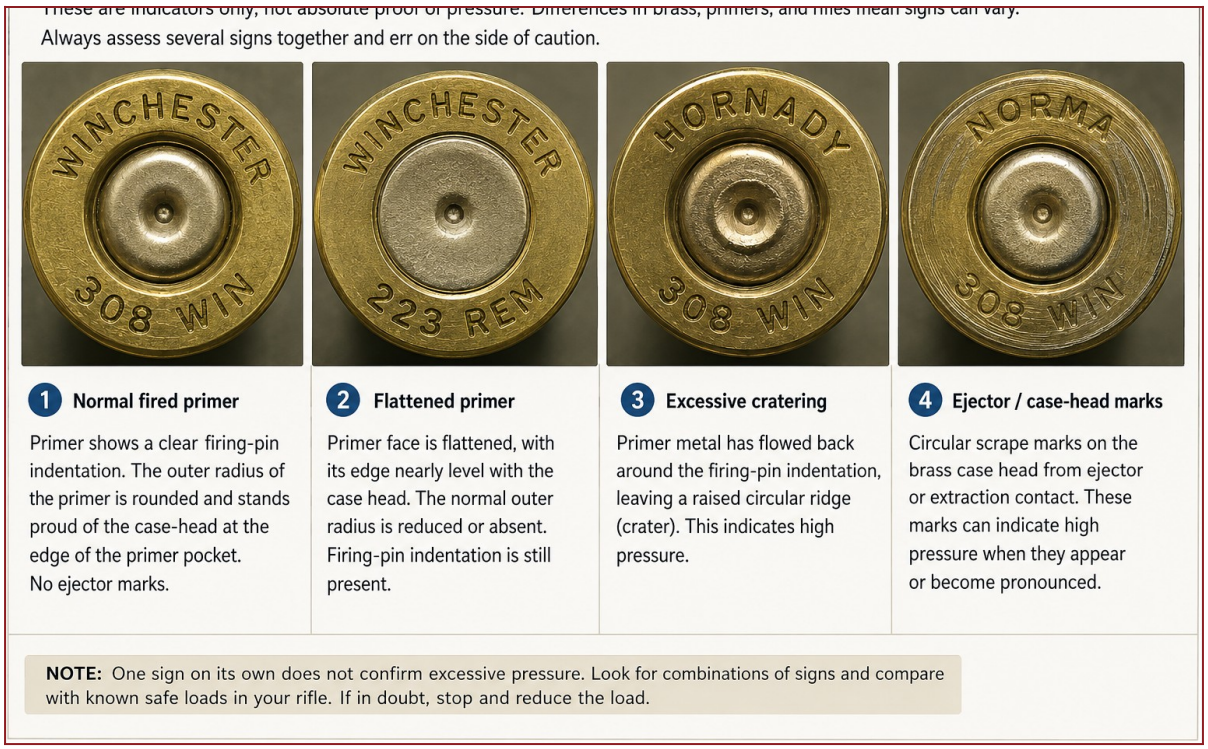


Figure 26.4 — *Common case-head and primer pressure signs. These are indicators only and must be interpreted alongside published data and other evidence; no single visual sign gives a chamber-pressure value.*

SAFETY — ACCURACY NEVER COMES BEFORE SAFETY

Fine tuning is never a reason to exceed appropriate published limits or ignore something the rifle, brass or chronograph is telling me.
If a safe and reliable load already gives me 99% of the performance I want, I would rather keep that load than chase the final one percent by moving into an area where I am no longer comfortable with the safety margin.
Accuracy is something I optimise within a safe load. Safety is not something I trade for accuracy.

During development I am building a picture from several sources: published data, powder charge, velocity, rifle behaviour, brass, primer and target. No single one tells me everything. If several things begin changing together as the charge rises, that is much more meaningful than staring at one primer and trying to assign an exact chamber pressure to its appearance.

The target tells me what the rifle is doing with each combination. I record each group against its charge weight and velocity information. I look at group size, vertical and horizontal dispersion, changes in point of impact, repeated patterns and anything likely to have been influenced by wind, position or shooter error.

A single tiny group gets my attention. It doesn't immediately become my final load.

The target records the complete shooting system: ammunition, rifle, rest or shooting position, scope, shooter, wind, mirage and other conditions. If I know I have pulled a shot, I record that observation, but I am equally cautious about declaring every inconvenient hole a flyer. A group does not become smaller simply because I dislike one of the shots.

When I review the initial test, I am looking for something repeatable and worth pursuing. A single spectacular group can be interesting, but if a sensible powder-charge area repeatedly behaves well, that can give me a much stronger foundation for further development.

What I want at this stage is a good powder-load base. Once I have that, I have something worthwhile to refine.

Once I have a powder charge producing a safe, reliable and decent group, I may decide to investigate it more closely. At this stage I am no longer searching broadly through the development range. I am fine-tuning an area that has already demonstrated that it works.

For my own precision ammunition, particularly when I am looking for the best performance I can reasonably obtain, I may return to that promising area and test much smaller powder-charge changes. I am looking for the final little improvement—the last one percent.

Most reloaders do not need to go this far. For a stalking rifle, sporting rifle or much general target shooting, a safe and reliable load that repeatedly gives good accuracy may already be finished. There is little point consuming components and barrel life trying to turn an already excellent load into one that is fractionally better unless that difference genuinely matters for the intended shooting.

Hunting ammunition is a good example of why I don't define a successful load simply by the smallest group it produces. Of course I want hunting ammunition to be accurate. It needs to place the projectile reliably within the required target area at the distances at which I intend to use it.

But once I have safe, reliable and entirely acceptable accuracy for that purpose, chasing another fraction from the group may achieve very little in practical terms. For hunting ammunition I am also interested in completely reliable chambering and extraction, reliable magazine feeding where applicable, an appropriate projectile for the intended quarry, sensible velocity, consistent point of impact, reliable ignition and ammunition that remains dependable under the conditions in which it will actually be carried and used.

A slightly larger group from an ammunition combination that is safe, predictable and completely reliable can be a much better hunting load than a tiny-group combination that is operating close to a limit or is temperamental about feeding, temperature or seating position.

Do Not Chase Precision You Do Not Need

There is no requirement to turn every sporting rifle into a Benchrest rifle. If a hunting rifle and load repeatedly produce accuracy comfortably inside what I require at realistic shooting distances, I ask what further development is actually going to achieve.

For high-level precision competition, I may have a genuine reason to chase the final small improvement. For a hunting or sporting rifle that already shoots safely, reliably and more accurately than I need in the field, I probably do not. The objective is not to produce the most accurate ammunition I am theoretically capable of making. It is to produce ammunition that safely and reliably meets the requirement.

I wouldn't sacrifice practical reliability for a marginal improvement on paper. I wouldn't deliberately choose a seating arrangement that leaves ammunition marginal in the magazine or unnecessarily close to the lands simply because it produced one slightly smaller test group.

Hunting ammunition may be carried, loaded, unloaded and exposed to considerably less controlled conditions than ammunition used from a competition firing point. It needs to work when required. Once it is safe, reliable and repeatedly accurate enough for the job, I may already have my load.

Even when chasing that last little improvement, the basic rule does not change. If I am fine-tuning powder charge, seating depth stays constant. If I later fine-tune seating depth, powder charge stays constant. Otherwise I lose the ability to understand what produced the result.

Once I have established a good powder-charge base, I can decide whether there is anything to gain from altering seating depth. I don't need to test multiple seating depths at every powder charge. That creates a huge number of combinations and makes the results unnecessarily difficult to interpret.

Instead, I establish the powder load first. Then, if further refinement is worthwhile, I hold the powder charge constant and investigate seating depth.

The earlier seating chapters established the relationship between jump, touch and jam and showed how to reproduce the required seating position. Now those measurements can become development variables. I already know my lands reference and initial seating position, so I can deliberately move the projectile and test the result.

I don't assume that a projectile needs to be extremely close to the lands to shoot well. A sensible amount of jump is entirely normal. Around 0.050 inch—fifty thou—back from the measured contact CBTO can be a perfectly sensible example starting position in many rifles.

That is an example, not a universal prescription. Some combinations may prefer considerably more jump; others may prefer less. The important thing is that I know where I started and can make controlled changes from that reference.

With the powder charge now held constant, I can prepare test groups at deliberately different seating positions. Initially, I prefer changes large enough to show whether the rifle has a meaningful preference rather than immediately disappearing into extremely tiny adjustments.

If an area shows promise, I can refine it further if the intended shooting justifies the effort. Throughout the test I record actual CBTO rather than relying only on the position of the seating-die adjustment. The cartridge measurement is my reference.

Jump, Touch and Jam Are Development Options

I don't regard jump as the beginner option and jam as the precision option. They are different projectile-to-throat relationships. A rifle may prefer substantial jump, moderate jump, very little jump, approximate contact or some degree of jam. The target decides.

Jam does bring additional practical considerations, including its influence on pressure behaviour and the possibility of leaving a projectile in the rifling when an unfired cartridge is extracted. Those disadvantages

need to be weighed against any genuine accuracy benefit. For many rifles, a good jumping load can be both extremely accurate and easier to live with.

Once a powder charge and seating position look good, I load more of them. This is where many supposed miracle loads disappear. A small initial group can be persuasive; more rounds fired over additional testing tell me considerably more.

I want the combination to reproduce its behaviour in accuracy, velocity, ES and SD where relevant, point of impact, feeding, chambering, extraction and general rifle behaviour.

Where the intended use warrants it, I like to see a promising load perform on more than one occasion. Conditions change. So does the shooter. A load that performs well repeatedly is much more convincing than one that produced a remarkable target once.

For competition or long-range ammunition, I may also confirm it at the distances where it will actually be used. A good short-range group is useful information, but it is not necessarily the whole story for ammunition intended to shoot considerably farther.

If the ammunition is intended to feed from a magazine, final development includes actual function testing. I confirm that representative rounds fit with sensible clearance, feed reliably, chamber freely, extract normally and remain appropriate after normal handling.

A precision load that repeatedly creates feeding problems is not a successful magazine-fed load. Reliability is part of performance.

Powder behaviour can change with temperature. Some powders are deliberately engineered for good temperature stability while others can show more change. Double-base powders can sometimes be somewhat more sensitive to ambient temperature, although that is not an absolute rule.

For ammunition that may be used across substantially different conditions, I keep temperature in mind when confirming the load. A load developed on a cold winter morning should not automatically be assumed to behave identically when the rifle and ammunition are considerably hotter. This deserves particular consideration towards the upper end of the appropriate published data.

It is easy to become so focused on the smallest possible group that practical requirements are forgotten. If moving the projectile farther out gives me a tiny improvement but leaves marginal magazine clearance, I have to decide whether I have actually improved the ammunition.

Likewise, if a jammed load produces a small improvement but creates difficulties whenever I need to unload an unfired cartridge, it may be the wrong choice for the job. The best load is not necessarily the most extreme setup. It is the combination that meets the whole requirement.

There is always another variable I could investigate: powder charge, seating depth, primer, neck tension, brass, projectile, powder, case capacity or another preparation method. At some point I have to ask whether the ammunition already does what I need it to do.

Different applications have different finishing points. A competitive precision load may justify further refinement because a very small improvement can matter on the scorecard. A hunting or sporting load may already be completely developed once it is safe, reliable and repeatedly produces accuracy comfortably within what is required for its intended use.

If the ammunition already meets the requirement, endless tuning can consume components, time and barrel life for very little practical return.

Developing Subsonic Ammunition

Subsonic ammunition deserves a section of its own because the objective is different from normal load development. Instead of looking for the best combination somewhere within the ordinary velocity range of

the cartridge, I am deliberately trying to keep the projectile below the local speed of sound while still achieving safe, reliable and useful performance.

That sounds simple until you try to do it well. A load can be below the speed of sound and still be a poor subsonic load. It may be inconsistent, fail to stabilise the projectile, function badly, produce more noise than expected or deliver terminal performance that is completely unsuitable for the job. As with the rest of reloading, the useful result comes from understanding the whole combination rather than chasing one number.

What Subsonic Actually Means

The speed of sound is not one fixed universal number. It changes with atmospheric conditions, particularly temperature. Around normal sea-level conditions it is roughly in the region of 1,100 to 1,125 feet per second, or about 335 to 343 metres per second, but I don't treat one printed figure as an absolute boundary for every day and every location.

If I want ammunition to remain genuinely subsonic, I leave a sensible margin below the expected speed of sound rather than trying to sit immediately underneath it. A load that is just subsonic on a cold morning may move into the transonic or supersonic region under different conditions, and individual rounds will never all produce exactly the same velocity.

The reason this matters is the ballistic crack. A projectile travelling faster than sound produces a shock wave that cannot be removed by a moderator. A moderator can reduce muzzle blast very effectively, but it cannot remove the crack created by a supersonic projectile travelling down range. For genuinely quiet ammunition, both parts of the problem matter.

Use Published Subsonic Data

The most important point is that I don't create a subsonic load simply by taking a normal rifle load and reducing the powder charge until the velocity looks low enough. Some propellants and cartridge combinations do not behave safely or consistently when used far below the conditions for which the published load was developed.

I start with reputable published data specifically suitable for the cartridge, projectile and subsonic application. If suitable data does not exist, I don't improvise by applying an arbitrary percentage reduction to a normal load. Reduced loads can introduce their own ignition and pressure problems, and a book such as this is not the place to invent a powder recipe.

The same principle applies to the powder itself. A propellant that works extremely well in a full-power load is not automatically a good choice for a subsonic load. I want a powder and charge range that the manufacturer or a reputable data source actually supports for the intended use.

Projectile Choice Matters More Than the Number on the Chronograph

Subsonic shooting often favours relatively heavy projectiles because the low velocity limits how much energy can be carried by speed alone. A heavier projectile can retain useful momentum and energy while remaining below the sound barrier, but that additional mass usually comes with additional length.

That immediately brings barrel twist into the discussion. A long, heavy projectile still has to be stabilised properly at the velocity at which it will actually be fired. A projectile that is perfectly stable at normal rifle velocity is not automatically guaranteed to remain adequately stable in a much slower subsonic load.

Before using a moderator, I want to be confident that the projectile is stable. If there is any doubt, I test stability safely without the moderator fitted and examine the target for any sign of yaw or keyholing. A

projectile that is not flying point-forward presents an obvious risk of striking baffles or other internal parts of the moderator.

Projectile construction also matters enormously. This is particularly important for hunting or pest-control ammunition. A conventional hunting projectile designed to expand at normal centrefire impact velocities may show little or no useful expansion when it arrives at subsonic speed. The opposite can also be true: projectiles specifically designed for subsonic or low-velocity use can be engineered to open at velocities where a conventional design would behave almost like a solid.

So I don't judge terminal performance simply by saying that one load is faster than another. The projectile has to be designed for the impact-velocity window in which I intend to use it. That is the caveat that belongs beside any general discussion of velocity and target behaviour: projectile design, construction and intended use can completely change the result.

The Chronograph Is Essential

For normal load development I regard a chronograph as extremely useful. For subsonic development I would go further: it is one of the most important tools in the process.

I need to know the actual velocity from my firearm, not the velocity I hoped the load would produce. Published figures are references. Barrel length, chamber, components, temperature and the individual firearm can all change the result.

I am interested in the average velocity, but I am equally interested in the spread. If the average sits comfortably below the sound barrier but the fastest rounds are crossing it, the ammunition is not consistently subsonic. Likewise, an unusually wide velocity spread can point to an ignition or loading-consistency problem even when every shot remains technically below Mach 1.

As always, the chronograph does not measure chamber pressure. A low velocity does not automatically mean a low-pressure or safe load. That assumption is particularly dangerous with specialised reduced-velocity ammunition. Published data still comes first.

Reliable Ignition Comes Before Quietness

> **KEY PRINCIPLE**
> *The quietest possible shot is of little value if the ammunition is inconsistent or unreliable. I want clean, repeatable ignition and a load that behaves the same way from one cartridge to the next.*

Very low charge densities and unsuitable propellants can create erratic behaviour in some combinations. This is another reason I don't make sweeping rules about how full the case should be or suggest fillers, wads or improvised methods as universal solutions. If a published subsonic load requires a particular approach, I follow the data and the component manufacturer's guidance for that exact system.

Primer choice remains part of the tested combination as well. I don't assume that a hotter primer must be better simply because the load is slow, and I don't substitute primer types casually. Reliable ignition is something I confirm through proper data and testing rather than trying to solve by instinct.

Function and Firearm Type

A subsonic load also has to suit the firearm. In a manually operated rifle, the ammunition only needs to chamber, fire, extract and deliver the required performance. In a self-loading system, the ammunition may also need to produce enough gas and impulse to operate the action, which can make the problem considerably more complicated.

The practical point is that ammunition can be perfectly subsonic and perfectly accurate yet still be unsuitable for a particular firearm because it does not function the action reliably. Function is part of the specification, not an afterthought.

Moderators and Perceived Noise

Subsonic ammunition is often discussed alongside moderators, but the two are not the same thing. The moderator deals principally with the high-pressure gas leaving the muzzle. Keeping the projectile below the speed of sound removes the separate supersonic crack.

Even then, the firearm will not become silent. The action can make noise. The projectile striking the target can make a surprising amount of noise. Gas escaping from other parts of some firearm designs can matter. The surroundings also make a difference; hard surfaces, buildings and enclosed firing points can reflect sound very effectively.

The useful objective is therefore not a film-style silent shot. It is a controlled reduction in noise while retaining the reliability, accuracy and performance required for the task.

Trajectory and Practical Range

The price paid for low velocity is trajectory. A subsonic projectile spends more time in flight and drops much more rapidly than the same projectile at normal rifle velocity. Wind also has more time to act on it.

That doesn't make subsonic ammunition inaccurate. It means range estimation and verified trajectory become more important, and the useful range of the ammunition is normally more limited. I confirm actual velocity, establish a real zero and verify the trajectory at the distances at which the ammunition will be used rather than relying on assumptions.

For hunting or pest-control use, the maximum sensible range is also limited by terminal performance. A projectile may still be stable and capable of hitting the target at a distance where its remaining velocity is below the level at which it will perform as designed. Accuracy alone does not define an ethical or effective range.

My Approach to Subsonic Load Development

My approach is deliberately conservative. I begin with suitable published subsonic data and a projectile that is appropriate for the intended task. I confirm that the barrel twist is suitable for the projectile length and expected velocity. I load a small, clearly identified test batch and chronograph it from the firearm in which it will actually be used.

I am looking first for safe and reliable function, proper projectile stability and consistent ignition. Then I look at velocity and make sure the complete string remains comfortably within the subsonic region under the conditions in which I am testing. Only after those things are established do I spend time refining accuracy.

If the ammunition is intended for use with a moderator, I confirm stability before fitting it and then verify the complete system afterwards. If the application depends on projectile expansion, I use a projectile designed for the relevant velocity range and confirm its intended performance from the manufacturer's information rather than assuming that a conventional high-velocity hunting projectile will behave normally at one third of its usual impact speed.

Subsonic ammunition is a specialist branch of reloading, but the principles are familiar. Start with reliable data. Match the components to the job. Change one meaningful variable at a time. Measure the result rather than guessing. And do not allow the desire for a quieter shot to push the load outside the conditions in which it can be trusted.

Record the Process, Not Just the Winner

I don't only record the final successful load. The development history is valuable. Knowing what did not work can prevent me repeating the same experiment months or years later.

At each meaningful stage I record enough information to reconstruct what I did: components and useful lot information, case history, powder charge, CBTO and COAL where relevant, velocity, target results, conditions, observations from the rifle and fired cases, and any deliberate change made before the next test.

Record keeping is not a separate operation performed after reloading. It is part of reloading.

Put together, my normal approach is straightforward. First I define what the ammunition actually needs to do.

Then I find appropriate published data, select the component combination, establish a sensible initial seating position, choose a suitable starting charge, plan the powder test, load and clearly identify the development ammunition, and work through the powder charges methodically—commonly in 0.2-grain increments where appropriate.

I chronograph and observe the rifle, brass and target, identify a good powder-charge base and confirm it. If the application genuinely warrants it, I may fine-tune that powder area in smaller increments. Only then do I hold the powder charge constant and investigate seating depth if there is anything worthwhile to gain.

Throughout that sequence I keep returning to the same rule: when I am developing powder charge, seating depth stays constant. When I am developing seating depth, powder charge stays constant. One meaningful variable at a time.

Above all of it sits the principle that matters more than the smallest group, lowest SD or highest velocity: safety comes first. I am looking for ammunition that is safe within the appropriate published framework, mechanically reliable, repeatable and accurate enough for the job. Once I have that, the load is already successful. Anything beyond it is refinement.

For some precision work I may deliberately seat the projectiles longer than the final test length at home, then take the seating equipment to the range. An arbor press with a suitable inline seating die is ideal for this, but a compact hand press can also be used with conventional threaded seating dies.

This lets me alter CBTO at the firing point and test seating-depth changes against the same powder-charge base without preparing a completely separate batch for every seating position before I leave home. I still measure and record each change; the convenience of doing it at the range does not change the one-variable-at-a-time rule.

Normally the easy direction is to start long and seat progressively deeper. If I need to recover a small amount of length, a suitable precision bullet puller, including PMA-type pullers, can sometimes be used very carefully to partially draw the projectile before it is reseated to the required measurement. I treat that as a controlled adjustment, remeasure the cartridge afterwards and do not assume the puller has returned it to an exact dimension.

What matters is that the powder charge remains fixed while I am testing seating depth. I already want a good powder-load base before I start this stage.

A barrel tuner gives me another adjustment once the ammunition is already fundamentally sound. I don't use a tuner as a substitute for establishing a safe, accurate load.

My normal order is to establish the powder-charge base first, refine seating depth where it is worthwhile, and only then test tuner position. Once tuner testing begins, the ammunition specification stays fixed and the tuner becomes the variable.

I use comparable five-shot groups through a planned series of tuner settings. If an area looks promising, I can return to it and make smaller adjustments. The same principle applies as everywhere else in development: if I change the tuner setting and the ammunition at the same time, I no longer know which change produced the result.

Chapter 27 — Chronographs: Understanding Velocity, ES and SD

Figure 27.1 — *Chronograph equipment in use during real range testing. Exact positioning depends on the chronograph design and manufacturer instructions.*

A chronograph is one of the most useful measuring tools I can have when developing ammunition. The target tells me where the projectiles went. The chronograph tells me something quite different: how fast they got there.

Used properly, that information can help me understand a load, confirm its real performance and identify changes that might otherwise be invisible. It also gives me the muzzle-velocity figure needed for realistic ballistic calculations and long-range scope adjustments.

But chronographs have also introduced another temptation into modern reloading. It is very easy to become obsessed with numbers. A load produces a very low standard deviation and immediately gets described as excellent; another gives a slightly larger ES and is dismissed.

I don't work that way. The chronograph is a measuring instrument. It doesn't decide whether a load is accurate. I use the chronograph alongside the target, the rifle and my loading records. All of them tell me something.

At its simplest, a chronograph measures projectile velocity. For centrefire rifle ammunition I normally work in feet per second (fps), although metres per second (m/s) is also widely used.

A shot string can then give me individual velocities, average velocity, maximum and minimum velocity, extreme spread, standard deviation and often considerably more depending on the equipment. Modern chronographs do most of the arithmetic automatically. The useful part is understanding what the figures mean and what they do not mean.

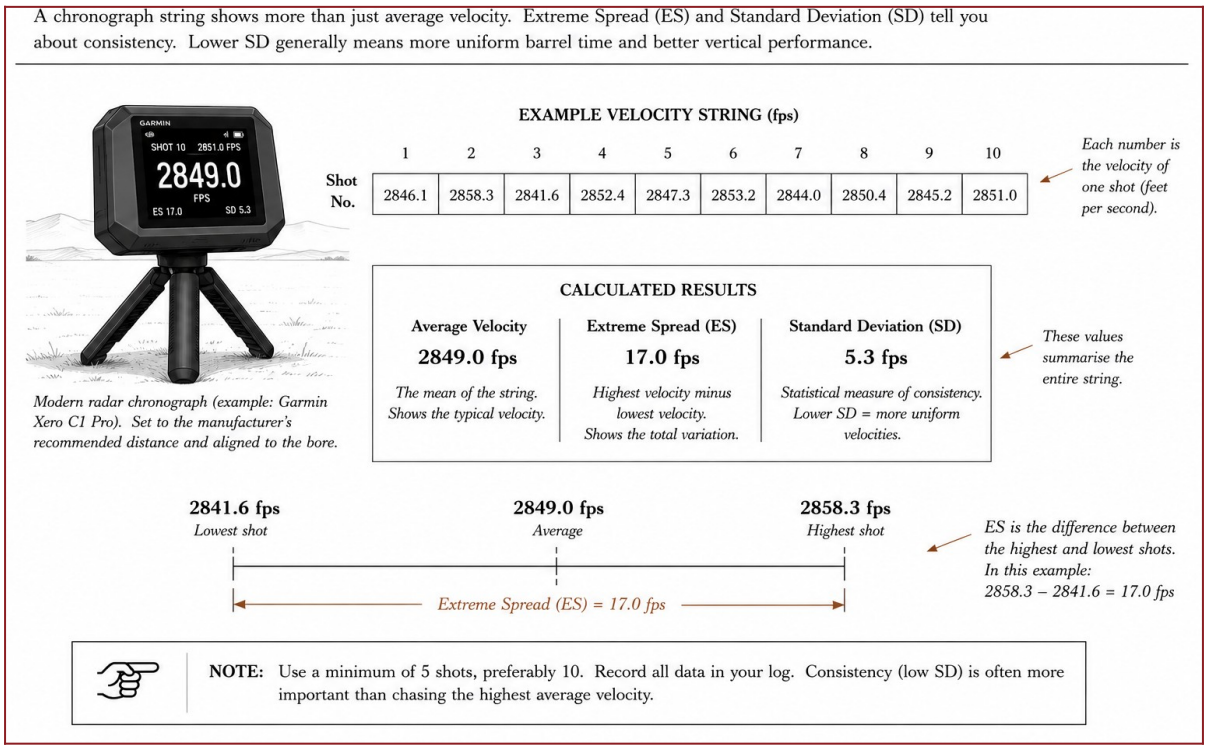


Figure 27.2 — *Reading a chronograph string. Average velocity, extreme spread and standard deviation describe different aspects of a velocity string and should be interpreted alongside the target.*

Velocity influences trajectory, time of flight, wind deflection, retained velocity and energy, projectile performance and—particularly as range increases—the amount of vertical dispersion that can result from shot-to-shot velocity differences.

For hunting ammunition I may need to know the real velocity so I can confirm that the projectile is operating in an appropriate performance window at the distances at which I intend to use it. For long-range target ammunition, velocity consistency becomes increasingly important because small velocity differences have more time to influence vertical position on the target.

For shorter-range or general shooting, tiny differences may matter considerably less. As throughout this book, the intended use determines how much precision I actually need.

One of the most practical reasons for owning a chronograph has nothing to do with chasing the lowest SD. If I am shooting at longer distances, I need a realistic muzzle velocity to calculate trajectory and establish useful scope elevation corrections.

A ballistic calculator normally needs information such as the projectile and ballistic coefficient, muzzle velocity, sight height, zero distance, atmospheric conditions and target distance. From those inputs it predicts the trajectory and gives an elevation correction, commonly in MOA, MILs or the corresponding number of scope clicks.

The important figure is the velocity my rifle actually produces.

A loading manual may show 2,900 fps for a particular combination, but that does not mean my rifle is producing 2,900 fps. The published test may have used a different barrel length, chamber, barrel, component lot and test arrangement. My rifle might actually average 2,840 or 2,850 fps.

At short range the difference may not appear dramatic. As distance increases, the trajectory predicted from the wrong muzzle velocity can increasingly diverge from what the projectile is really doing, and the calculated elevation correction can therefore be wrong.

A Practical Example

Suppose my confirmed load averages 2,850 fps. That is the muzzle velocity I use as the starting value in my ballistic calculator rather than copying a velocity from a manual. The calculator then predicts the elevation required from my zero to the longer distance.

I dial that correction on the scope and then confirm it by actually shooting at distance. If the real impact does not agree with the prediction, I investigate and refine the ballistic inputs rather than pretending the calculator must be right.

Chronograph → ballistic calculation → scope adjustment → confirmation on target.

Converting the solver output into scope clicks is straightforward when the turret value is known. A 0.1-mil-per-click scope needs 10 clicks for each mil, so a 5.6 mil correction is 56 clicks. A 1/4-MOA-per-click scope needs four clicks per MOA, so an 8 MOA correction is 32 clicks.

Clicks required = required angular correction ÷ adjustment per click

Once those corrections are confirmed in the real rifle, they can form the basis of a range card or DOPE for that particular rifle and ammunition combination. A chronograph gives me the velocity input; the target proves whether the resulting elevation is correct.

Chronograph technology has changed considerably, but most systems a reloader encounters fall into three broad groups: optical, magnetic and radar/Doppler.

A traditional optical chronograph uses sensors positioned beneath the projectile flight path. The projectile passes over one sensor and then another, and the instrument calculates velocity from the time taken to cross the known distance between them.

These systems can work very well and have been used successfully for decades. Their weakness is that correct positioning and lighting matter. Changing sunlight, shadows, cloud and some artificial lighting can affect particular models.

CHRONOGRAPH SETUP — MUZZLE AND FLIGHT-PATH SAFETY

Any chronograph placed forward of the firing point must be set up exactly as its manufacturer requires and must never compromise normal muzzle and target safety.
I make certain the rifle is correctly aligned with the target and that the chronograph is positioned safely before firing. I do not allow the desire to capture a velocity reading to alter safe firearm handling.

Magnetic systems attach close to, or directly onto, the barrel and detect the projectile as it passes their sensors. They are much less dependent on lighting and can be very convenient.

The practical consideration is that attaching something to the barrel can alter barrel vibration, point of impact or group behaviour. That doesn't necessarily make the velocity reading wrong; it simply means I should be cautious about using the same string to judge very small differences in group size.

Modern radar-based chronographs detect and track the projectile without placing equipment directly in the projectile path or attaching a sensor to the barrel. That makes them particularly convenient for load development and long-range work.

Depending on the model, they may also record additional velocity information beyond a single muzzle figure. Correct alignment, settings and placement still matter, so I follow the instructions for the actual unit rather than assuming every radar system works identically.

There is no universal positioning rule that suits every optical, magnetic or radar chronograph. I follow the instructions for the equipment I am actually using, including distance from the muzzle, alignment, sensor position, sensitivity, projectile settings and environmental requirements.

Poor setup can produce poor data. A very precise-looking number on a display is not automatically a correct number.

For chronographs positioned in front of the rifle, muzzle blast can interfere with readings if the instrument is too close. Brakes and moderators can also change what the equipment experiences. The correct position depends on the chronograph design, which is another reason I use the manufacturer’s specified arrangement rather than an arbitrary distance.

Average Velocity — Showing the Maths

Average velocity, or the arithmetic mean, is simply the total of all measured shot velocities divided by the number of shots.

Suppose five shots produce:

2,792 2,797 2,801 2,795 2,800 fps

First add the velocities together:

2,792 + 2,797 + 2,801 + 2,795 + 2,800 = 13,985

Then divide by the number of shots:

13,985 ÷ 5 = 2,797 fps

So the average velocity is 2,797 fps. That is usually a much more useful working muzzle velocity than choosing one individual shot and calling that the velocity of the load.

Extreme spread is the simplest of the common velocity-consistency figures. It is the fastest shot minus the slowest shot.

Using the same five-shot string, the fastest shot is 2,801 fps and the slowest is 2,792 fps:

2,801 − 2,792 = 9 fps

The ES is therefore 9 fps.

ES is easy to understand and useful, but it is controlled entirely by two shots: the fastest and the slowest. It says nothing about how the other shots are distributed between those two extremes.

Standard deviation uses the complete shot string and describes how the individual velocities are distributed around the average. Most chronographs calculate it automatically, but seeing the arithmetic makes the number much easier to understand.

Using the same five-shot example, the average is 2,797 fps. First subtract that average from every shot:

- 2,792 − 2,797 = −5
- 2,797 − 2,797 = 0
- 2,801 − 2,797 = +4
- 2,795 − 2,797 = −2
- 2,800 − 2,797 = +3

Now square each difference so the negative and positive deviations do not cancel each other:

- $(-5)^2 = 25$
- $0^2 = 0$
- $4^2 = 16$
- $(-2)^2 = 4$
- $3^2 = 9$

Add the squared differences:

25 + 0 + 16 + 4 + 9 = 54

For a sample standard deviation, divide by one less than the number of shots:

54 ÷ (5 − 1) = 13.5

Then take the square root:

√13.5 ≈ 3.7 fps

So the sample SD for this five-shot string is approximately 3.7 fps.

The Three Useful Formulas

Average = total of all velocities ÷ number of shots

ES = fastest shot − slowest shot

Sample SD = √[sum of squared differences from the mean ÷ (n − 1)]

The point is not that I expect every reloader to calculate SD by hand. The chronograph will normally do it for me. Showing the maths simply explains why SD takes account of the whole string while ES depends only on its two extreme readings.

Suppose I fire three shots and the chronograph reports an SD of 2 fps. That looks fantastic, but I have only measured three rounds. If I fire another twenty, the SD may remain excellent—or it may not.

Small samples can produce attractive statistics through chance. Three or five rounds can be useful during initial development, but they are not necessarily a complete statistical description of the ammunition.

As the sample grows, one unusually fast or slow shot has less power to completely distort my impression of the load. There is no magic shot count that suddenly makes a string scientifically perfect; the appropriate sample depends on what I am trying to learn.

For initial screening, smaller strings may make sense. For a load I intend to use seriously at long range, I generally want more information before deciding what its normal velocity behaviour really looks like. The same principle applies as in load development: screen efficiently, then confirm properly.

Suppose Load A gives an SD of 3 fps but repeatedly groups poorly, while Load B gives an SD of 8 fps and repeatedly produces excellent groups. I'm not automatically choosing Load A simply because 3 is smaller than 8.

The chronograph is telling me that Load A produced more tightly clustered velocities during that test. The target is telling me that Load B put the projectiles closer together. Both pieces of information matter.

For very long-range shooting, I may investigate whether I can improve Load B's velocity consistency without destroying its accuracy. But I don't discard an excellent load simply because another combination gave me a prettier chronograph number.

Low SD is desirable. Accuracy is not defined by SD alone.

At relatively short distances, small velocity differences may produce very little visible vertical separation. As distance increases, the effect has more time to develop. A faster projectile arrives sooner; a slower projectile spends longer in flight and normally drops farther.

That is why I pay more attention to ES and SD in long-range competition ammunition than I might in a short-range sporting load that already shoots comfortably inside the accuracy requirement.

Velocity variation tends to show itself primarily as vertical dispersion at distance, but I never assume that all vertical is caused by ammunition velocity.

Vertical can also come from shooter position, inconsistent support, aiming error, wind effects, mirage, scope tracking, bedding, barrel behaviour and other factors. Chronograph data becomes useful because I can compare the shot velocities with the impacts rather than guessing.

If the high and low impacts correspond closely with high and low velocities, that is useful evidence. If velocity is extremely consistent while the target still shows large vertical, I start looking elsewhere.

Hunting Ammunition and Chronograph Data

A chronograph is still extremely useful for hunting ammunition. Knowing the real muzzle velocity improves trajectory calculations and helps me understand whether the chosen projectile is likely to be operating appropriately at the intended distance.

What changes is the objective. I'm not necessarily trying to produce the smallest possible SD. I want appropriate velocity, reliable function and accuracy comfortably inside the requirement for the way the rifle will actually be used.

If the load safely and repeatedly meets those requirements, it is already doing its job. There's no need to turn every hunting load into a statistical competition.

Chronographs and Pressure

> **KEY PRINCIPLE**
> *A chronograph does not measure chamber pressure, and I can't convert a velocity figure directly into a reliable pressure value. Unexpected velocity behaviour can, however, give me a reason to stop and investigate.*

If measured velocities differ substantially from what reputable data and earlier development led me to expect, I want to understand why. I consider velocity alongside published data, powder charge, rifle behaviour, brass, primers and the target. It adds another piece to the picture; it does not replace pressure-tested data.

One shot slightly faster or slower than expected does not automatically mean something is wrong. Individual variation exists. I am interested in patterns.

As powder charge increases, I generally expect average velocity to rise, but the relationship need not be perfectly linear. If the trend changes unexpectedly, that gets my attention. The chronograph allows me to see behaviour that I could never reliably judge from recoil or muzzle report alone.

Every chronograph can occasionally produce a reading that deserves questioning. A shot appearing hundreds of feet per second away from an otherwise sensible string may be real, but it may also be a detection or setup problem.

Possible causes vary with chronograph type and can include poor alignment, changing light, muzzle blast, sensitivity settings, radar tracking another object or another detection error. I don't automatically delete a number because I dislike it, but neither do I blindly accept an obviously questionable reading without looking at the complete evidence.

The first shot from a cold barrel can be particularly important depending on the application. For hunting, the first shot may be the only shot that matters. For competition, I may be more interested in how the rifle behaves through a longer string.

I therefore note when a shot is cold bore, clean bore, fouled bore or part of an established string. That information can help separate ammunition behaviour from barrel condition.

Temperature can influence velocity. The amount varies with the powder, cartridge and ammunition condition. If I am confirming ammunition intended for serious competition or hunting across substantially different conditions, I record the approximate temperature during testing.

Over time this can show whether the load is particularly sensitive to environmental change. I don't need laboratory control at every range session; I simply want enough information to understand the conditions under which the measurements were taken.

A chronograph displaying 2,798.4 fps looks very precise. That doesn't automatically mean the true projectile velocity is known to a tenth of a foot per second. Every measuring instrument has limitations.

What matters is that the equipment is suitable, correctly set up and used consistently enough for the decisions I am trying to make. More decimal places do not automatically mean better information.

Velocity data becomes far more useful when it remains connected to the ammunition that produced it. For a meaningful test I want to be able to relate the shot string to the rifle and barrel, powder and charge, projectile, primer, brass, CBTO, conditions where useful and the target result.

A saved string labelled simply “.308 good load” tells me very little two years later. Good records allow velocity data to become part of the history of the rifle and load.

A Practical Chronograph Setup Sequence

Before firing, I set the chronograph up in accordance with its manufacturer's instructions and confirm that the unit, sensors or radar are positioned for the type of instrument being used. Optical, magnetic and radar chronographs do not share one universal placement method, so I do not improvise a distance or alignment rule that belongs to a different design.

I make sure the equipment cannot obstruct the bore or projectile path, check alignment from a safe position, and protect the instrument from muzzle blast where its design requires it. I then create or identify the correct shot string and record the rifle, ammunition and conditions I need before the first shot.

I fire a sensible initial shot and confirm that the reading is plausible before committing to the string. During the test I keep the firing position and instrument setup consistent, note any obvious error or missed detection, and do not delete an inconvenient number simply because it spoils the statistics.

At the end I save the raw string as well as the average, ES and SD. The raw velocities let me revisit the calculation later and are much more useful than a photograph of the summary screen with no record of which ammunition produced it.

Confirm the Velocity You Actually Have

Published velocities are useful references; they are not promises. My barrel may be longer or shorter, tighter or looser, newer or more worn, differently chambered or simply different from the test barrel used to generate the published figure.

If my rifle safely produces the performance I need at a different velocity from the manual figure, I work with the velocity my rifle actually produces. That is one of the greatest practical benefits of owning a chronograph: I no longer need to guess.

During early load development, I use chronograph data to understand how velocity is progressing as the powder charge changes. When I find a promising load, I collect more data.

For long-range precision ammunition I pay close attention to ES and SD because velocity variation becomes increasingly important with distance. For hunting and general shooting I still want sensible and repeatable velocity, but I don't automatically chase a single-digit SD if the ammunition already safely and reliably exceeds the accuracy requirement.

If the chronograph says one load has the lowest SD while the target repeatedly says another load shoots better, I listen to both. The chronograph is not there to replace the target. It is there to help me understand it.

Ultimately, I want the chronograph to answer useful questions: What velocity is this load actually producing? Is that velocity repeatable enough for what I need? How does velocity change as I alter the powder charge? Is anything behaving unexpectedly? Could velocity variation be contributing to vertical dispersion? Does the load remain consistent when conditions change?

Those questions are considerably more useful than simply asking how low the SD is. Used that way, a chronograph becomes one of the most valuable diagnostic tools on the loading bench and at the range.

The chronograph gives me information I can't obtain reliably by any other simple means. The final judgement, however, still belongs to the complete shooting system—and one of the most important parts of that system is waiting downrange: the target.

Chapter 28 — Reading the Target and Evaluating Accuracy

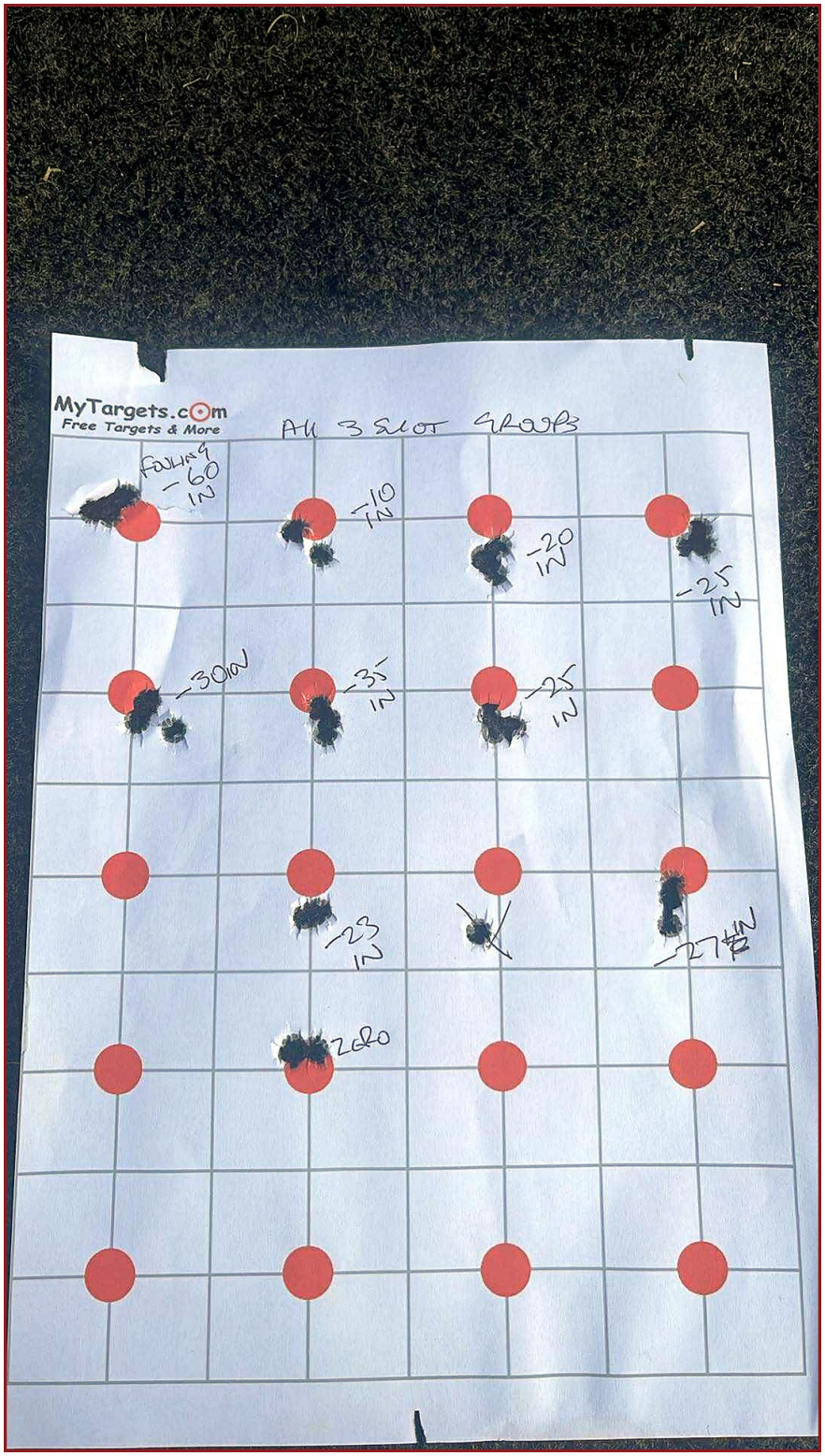


Figure 28.1 — *A real seating-depth development target with the test setting written against each group so the result remains tied to the ammunition that produced it.*

Once I have loaded the development ammunition and collected the chronograph data, the next thing I need to understand is the target.

The chronograph tells me how consistently the ammunition is producing velocity. The target tells me something different: where the shots actually went.

Those two things are related, but they are not the same. A load can produce extremely attractive velocity statistics and still group poorly. Another can produce a slightly larger ES or SD yet repeatedly shoot tighter groups.

That is why I never judge a load from the chronograph alone. **The target remains the final test of accuracy.**

A group is the combined result of the whole shooting system. It reflects the ammunition, rifle, barrel, scope, rest or support, shooter, wind, mirage and the environmental conditions during the string.

I therefore do not assume that every hole on a target represents ammunition quality alone. The target is showing me what the complete rifle-and-ammunition system did during that string.

Group Size — Showing the Maths

The simplest way to describe precision is group size. For a normal centre-to-centre measurement, I measure the distance between the two furthest shot holes and subtract one projectile diameter.

For example, if a .308-calibre group measures 0.808 inch outside to outside:

> **0.808″ outside to outside − 0.308″ projectile diameter = 0.500″ centre to centre**
> **Group size = 0.500″**

That centre-to-centre figure is the measurement I normally use when comparing groups.

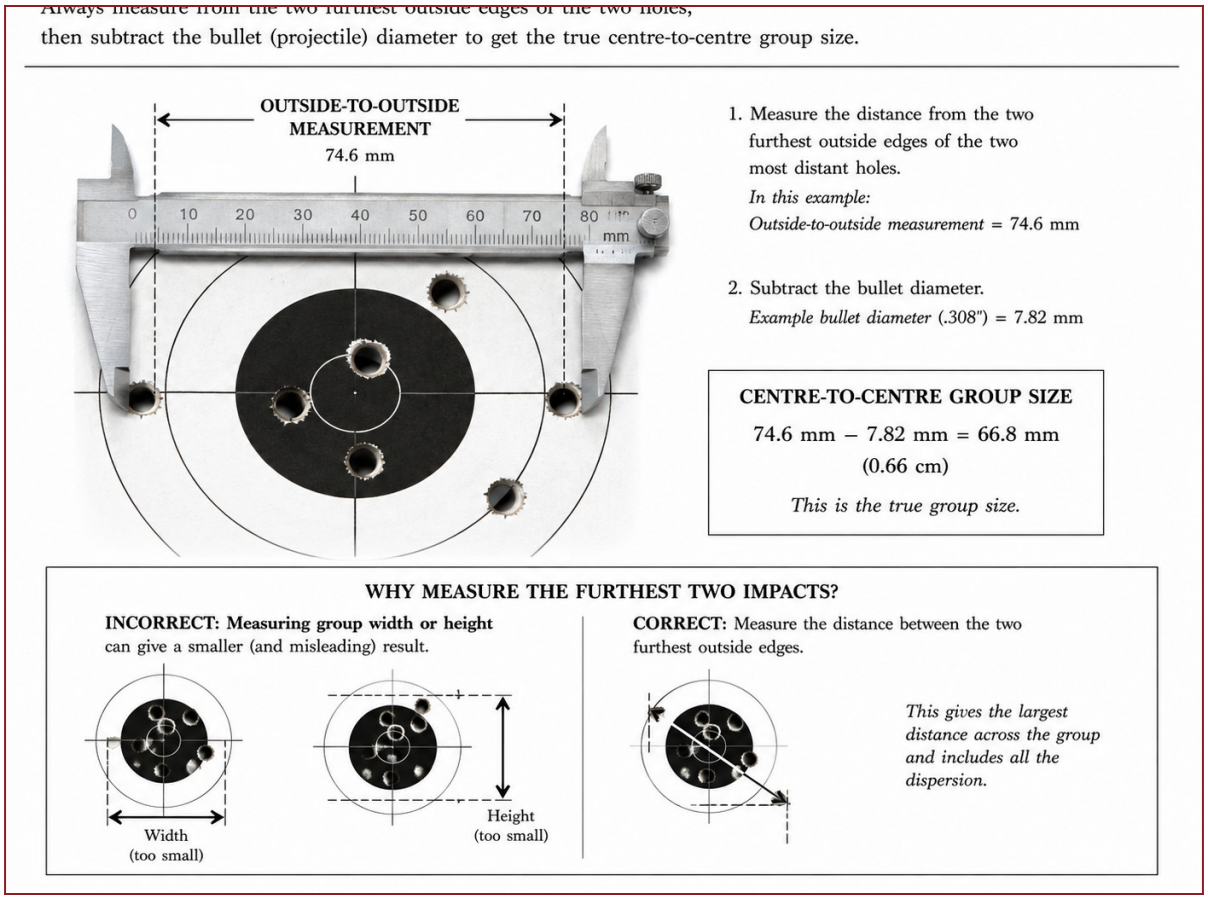


Figure 28.2 — *Measuring a group correctly. Measure outside-to-outside across the widest shots and subtract projectile diameter to obtain centre-to-centre group size.*

Group size is often expressed in minutes of angle, or MOA. One true minute of angle subtends approximately 1.047 inches at 100 yards. For rough field use it is often rounded to about one inch at 100 yards, but when comparing groups I prefer to understand the true figure.

A useful approximate formula is:

MOA ≈ group size in inches ÷ distance in hundreds of yards ÷ 1.047

So a 0.500-inch group at 100 yards is approximately:

0.500 ÷ 1.047 = 0.48 MOA

At 200 yards, one MOA is approximately 2.094 inches; at 300 yards it is approximately 3.141 inches. Angular measurement lets me compare performance at different distances without being misled by the fact that the group is physically larger farther away.

Many modern scopes use milliradians rather than MOA. One mil subtends approximately 3.6 inches at 100 yards, 7.2 inches at 200 yards and 10.8 inches at 300 yards.

MIL ≈ group size in inches ÷ (distance in yards × 0.036)

For a 0.500-inch group at 100 yards: 0.500 ÷ 3.6 = 0.139 mil, or about 0.14 mil. As with MOA, the angular figure lets me compare groups fired at different distances.

For normal load development, five-shot groups are my preferred standard.

They give me substantially more information than three-shot groups while still being practical in terms of ammunition consumption, barrel heating and range time. Five shots make it harder for an average load to look exceptional simply because three rounds happened to land close together.

A five-shot group gives me a better picture of the true group shape, vertical and horizontal dispersion, point-of-impact behaviour and the occasional wider shot that a three-shot group can easily hide.

For me, **five-shot groups are the best practical standard for normal load development.**

Three-shot groups are quick and economical, but they offer considerably less information than five-shot groups. They can be useful for a rough initial check when ammunition, barrel life or time is limited, but they are not my preferred basis for deciding whether one load is genuinely better than another.

Three shots can produce a tiny cluster simply through chance. That result gets my attention, but it does not prove the load will continue doing it.

Once a load looks promising from repeated five-shot groups, I can increase the amount of evidence if the application warrants it. That doesn't necessarily mean firing one enormous group. Several independent five-shot groups often tell me more about repeatability than one isolated cluster.

For example, suppose the same load produces three five-shot groups measuring 0.46, 0.52 and 0.49 inch. The average is:

0.46 + 0.52 + 0.49 = 1.47
1.47 ÷ 3 = 0.49″ average group size

That gives me fifteen shots of evidence spread across three separate groups. I place much more confidence in that than in one exceptional three-shot group.

One Group Is Not Enough

A single group can flatter or punish a load simply through normal statistical variation. A mediocre combination can occasionally shoot a very small group, and a genuinely good load can occasionally produce a poor one.

When something looks promising, I repeat it. If a load produces similar five-shot groups on more than one target and preferably on more than one occasion, I have far more confidence that the result is real.

A single exceptional target is evidence. **Repeatability is stronger evidence.**

Reloaders and shooters are very fond of the word flyer. Four shots sit together and one lands outside the cluster, and the immediate temptation is to say that one does not count.

Sometimes that is fair. If I know I broke the shot badly, saw the crosshair move or had some obvious disturbance, I record it. But I don't automatically remove every inconvenient impact from the group. If I repeatedly produce four close shots and one wider one, that fifth shot may be part of the real dispersion of the system.

Calling the shot helps. Immediately after firing I make a mental or written note of where I thought the shot broke. If I felt the rifle move left and the impact is left, that is useful information. If the shot felt perfect but lands unexpectedly outside the group, I look more closely at the ammunition, conditions and equipment.

I normally carry out the initial accuracy stage of load development at around 100 yards. That distance gives me a practical way of comparing five-shot groups while reducing many of the environmental effects that become progressively more important farther out.

At 100 yards I am mainly trying to identify a good, repeatable load. I also pay attention to the shape of the groups, but I don't try to diagnose every elongated group from one target alone.

If a load repeatedly produces a noticeably tall, narrow group at 100 yards, I take note of it. I may compare the target with the chronograph information, because velocity variation can contribute to vertical dispersion, particularly as distance increases.

But vertical stringing is not automatically a powder or velocity problem. It can also come from rifle support, shooter technique, barrel heating, bedding, scope behaviour, mirage or other factors. One vertical group is a clue, not a diagnosis.

A group that spreads mainly horizontally may also tell me something, but at 100 yards I don't use group width as a way of deciding that one load is more or less wind sensitive. The effects that separate otherwise good combinations often become much clearer only as distance increases.

During the initial 100-yard stage, my aim is simply to test in reasonably manageable conditions so the target has a fair chance of showing differences between the loads.

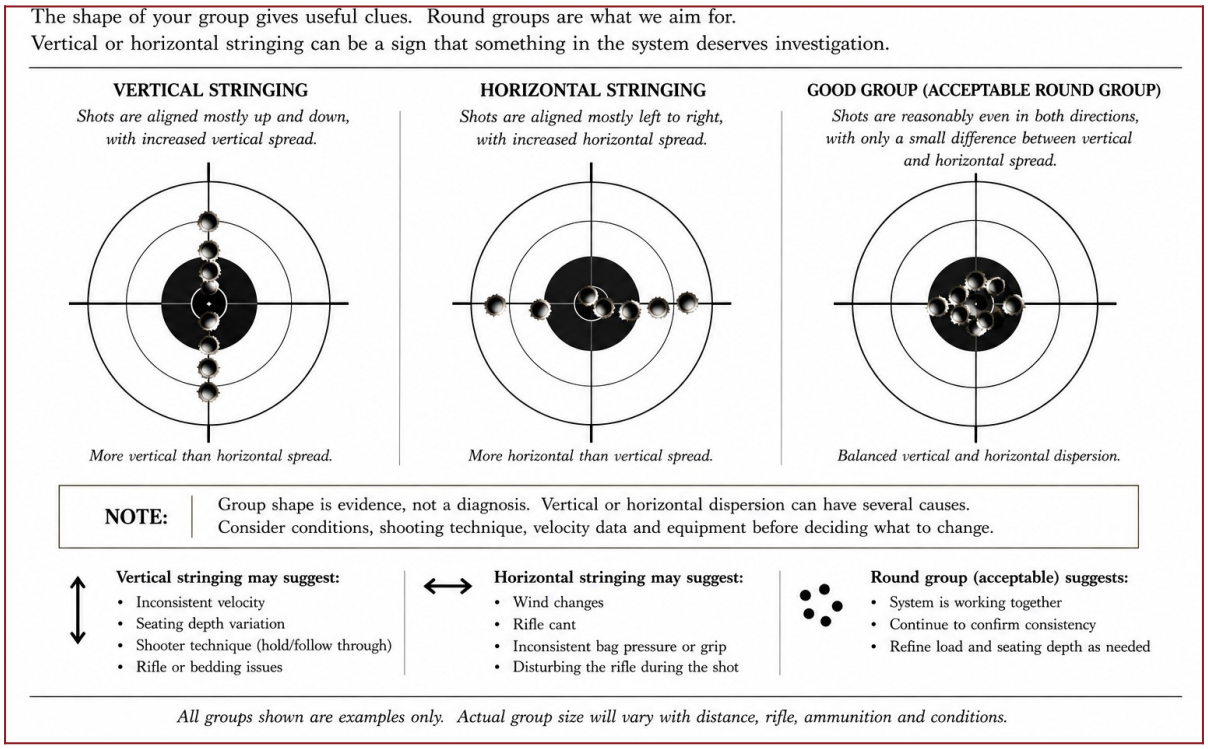


Figure 28.3 — *Understanding group shape and dispersion. Vertical, horizontal and approximately round patterns can suggest different lines of investigation, but should be interpreted with the complete shooting conditions.*

A good 100-yard group is not necessarily the end of development, especially for ammunition intended for long-range shooting.

Once I have established a promising load at 100 yards, I verify it at the longer distances where I actually intend to use it. This is where differences that are difficult to see at 100 yards can become much more obvious.

Small velocity differences have more time to develop into vertical separation. Ballistic-coefficient differences become increasingly relevant. The load is also exposed to the real conditions in which it will be used.

100 yards — develop and compare the load.
Longer distance — verify that the load continues to perform.

For ammunition intended for 600, 1,000 yards or beyond, I wouldn't call the load fully proven simply because it printed an excellent five-shot group at 100 yards. The short-range target tells me I have something worth pursuing. The longer-range target tells me whether it actually works for the job.

The Smallest Group Does Not Automatically Win

Suppose several powder charges produce five-shot groups measuring 0.65, 0.52, 0.28, 0.55 and 0.60 inch. The 0.28-inch group obviously gets my attention, but I don't automatically declare that charge the winner.

I want to know whether it repeats. If the 0.28-inch result never appears again while the nearby charges repeatedly produce sensible half-inch groups, the broader region may be the more useful and tolerant load.

I am interested in a load that continues to perform when normal small variations in ammunition, conditions and shooting technique occur.

The word node is used frequently in load development and can mean different things to different people. It may describe a charge region where groups remain consistently good, a relatively stable point of impact, a velocity plateau or some combination of these.

I use the term carefully. The label matters less than the evidence. I am looking for a combination that performs repeatedly and is reasonably tolerant rather than trying to prove a theoretical node from one target.

Traditional group size uses only the two shots furthest apart. That is easy to understand and remains perfectly useful for most normal load development.

More advanced analysis can use mean radius, which considers the distance of every impact from the group centre. Because every shot contributes to the calculation, it can describe dispersion differently from simple extreme group size.

I don't think every reloader needs specialist target-analysis software. It is enough to understand that one extreme measurement does not describe every characteristic of the group.

A target does not exist in a vacuum. Wind, mirage, light, barrel temperature and shooter fatigue can all alter what appears on the paper.

If I am trying to distinguish relatively small differences between loads, I choose conditions that give the ammunition a sensible opportunity to show those differences. That doesn't mean I need perfectly calm weather, but there is little point comparing two potentially excellent loads while shooting through conditions far larger than the difference I am trying to measure.

I also try to compare like with like: same shooting position, same rest, similar barrel condition, same target type and a consistent test routine.

As a barrel heats, point of impact and group size can change. Some rifles are more sensitive than others. During development I therefore avoid accidentally comparing one charge through a cold barrel with another through an extremely hot barrel unless that is deliberately part of the test.

A freshly cleaned barrel may also behave differently from one with several fouling shots through it. I record whether a group was fired from a clean, fouled, cold or established barrel condition where that information is relevant.

The more precise the ammunition becomes, the more the shooter can limit what the target shows. Trigger control, position, cheek pressure, shoulder pressure and recoil management all contribute.

That is why I want load development to be carried out from a stable and repeatable setup. I am trying to reveal ammunition differences rather than amplify my own variation.

If I know I made a poor shot, I note it honestly. But I also resist the temptation to invent a story for every impact. Often an individual hole is simply part of the normal dispersion of the system.

Scope and Rifle Problems

Not every poor target is a load-development problem. If every load suddenly starts shooting badly, I consider the equipment before dismantling a perfectly good ammunition combination.

Possible causes include loose mounts, scope tracking problems, action screws, bedding, rest movement, moderator or brake issues and crown damage. The target reflects the complete system, not the ammunition alone.

The most useful development information often comes from comparing the target with the chronograph data.

If a group has noticeable vertical and the high and low shots correspond with significant velocity differences, that gives me a sensible direction to investigate. If the velocities are very consistent but the target still has large vertical, the cause is more likely elsewhere.

Likewise, a load with an exceptionally low SD is not automatically the most accurate load. The chronograph and target answer different questions, and I use both.

Hunting ammunition is another good example of why the smallest possible group is not always the objective.

I want hunting ammunition to be safe, reliable, consistent, appropriate for the quarry and comfortably accurate enough for the realistic distances at which it will be used. If the rifle repeatedly produces accuracy well inside that requirement, chasing another tiny reduction in group size may achieve nothing useful in the field.

For a hunting rifle, first-shot point of impact can also matter greatly because the first cold-bore shot may be the only one that matters. I therefore pay attention to how the rifle behaves from the condition in which it will actually be carried and used.

The words accuracy and precision are often used interchangeably, but technically they describe different things. Precision describes how closely repeated shots cluster together. Accuracy describes how close those shots are to the intended point.

A tight group two inches away from the aiming point is very precise but not centred. During load development I am normally comparing precision first because I can adjust the scope afterwards. Once the load is selected, I establish the appropriate zero for its intended use.

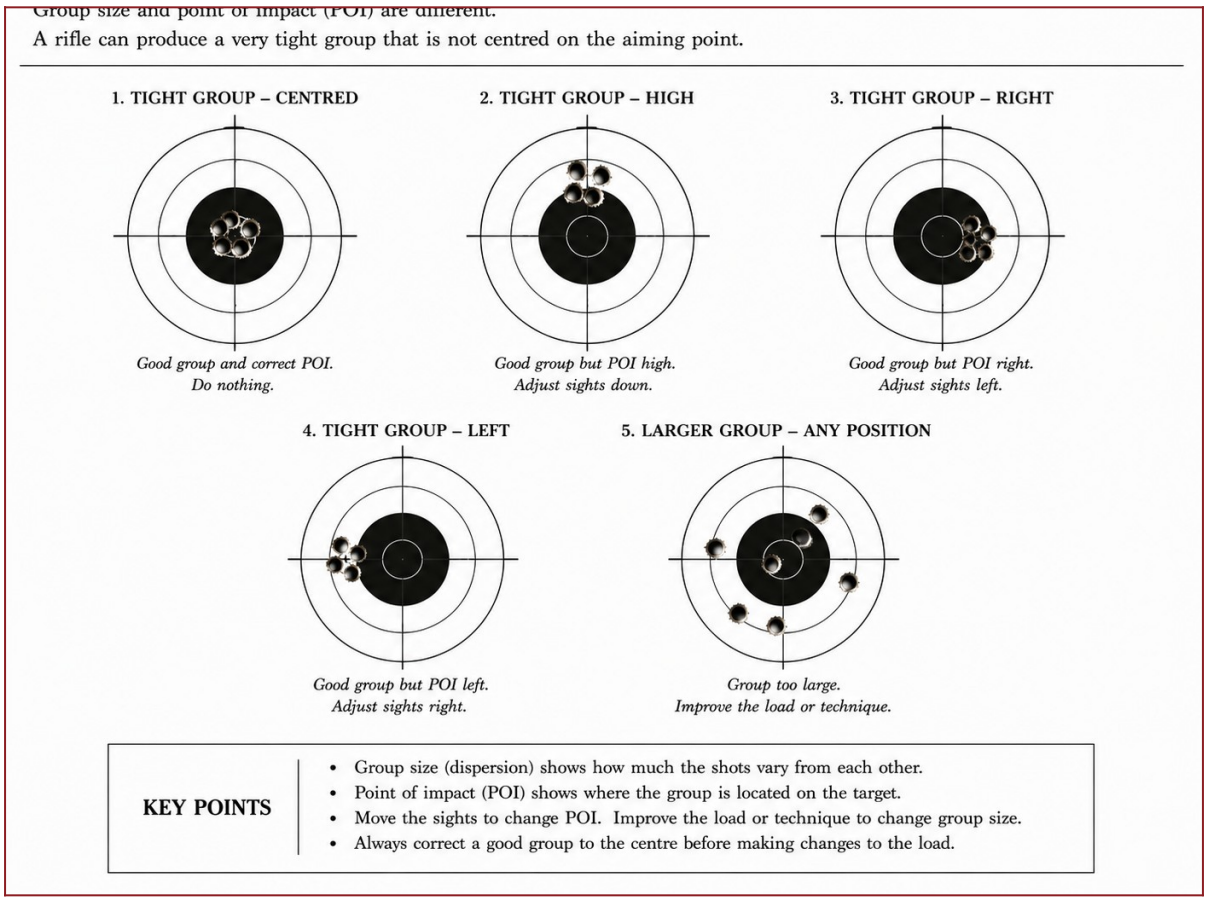


Figure 28.4 — *From group to point of impact. Group size and point of impact are different measurements; a tight group can still require a sight or scope correction.*

A target needs to remain connected to the ammunition that produced it. I mark or record the load identification, powder charge, seating depth where relevant, projectile, date, distance, useful velocity information and any conditions worth remembering.

Photographing or scanning development targets can create a useful permanent record. A beautiful group with no identification written on it is almost useless six months later.

Electronic targets can record exact shot location, sequence, timestamps, group dimensions and mean point of impact. Target-analysis software can add group size, mean radius and other statistics to paper-target photographs.

These tools are useful extensions of measurement, but more data does not automatically mean better interpretation. A program can calculate the geometry of the group; it cannot always tell me whether I changed my position or whether conditions altered during the string.

A promising target is the beginning of confirmation, not the end. Once I have identified the combination I want, I load more ammunition and shoot it again.

I want to see similar group behaviour, repeatable velocity, normal rifle and brass behaviour, reliable function and suitable performance at the distance where the ammunition will actually be used.

That is how a promising load becomes a proven load.

My Approach to Reading Targets

During normal development, I prefer five-shot groups and usually begin at around 100 yards. I use that stage to narrow the field and look for combinations producing good, repeatable groups rather than automatically choosing the single smallest cluster.

I pay attention to group shape, particularly repeated vertical, but I don't over-interpret one target. I compare the target with the chronograph data, rifle behaviour and shooting conditions.

Once something looks genuinely promising, I repeat it with more five-shot groups. If the ammunition is intended for longer-range shooting, I then verify it at the distances where it will actually be used.

For hunting ammunition, I make sure the first-shot and practical field accuracy are comfortably adequate rather than chasing Benchrest-sized groups for no reason.

Chapter 29 — Confirming the Final Load

A promising load is not the same thing as a proven load.

By this stage I should already have a combination that has shown good behaviour through powder-charge development, seating-depth testing where required, chronograph work and repeated five-shot groups. Confirmation is where I stop experimenting and prove that the selected combination will keep doing what I need it to do.

Once I decide which load I want to confirm, I stop adjusting it. I keep the brass preparation, primer, powder and charge, projectile, neck tension, CBTO and loading procedure fixed. If I change one of those deliberately, I have started another development test rather than confirming the original load.

This is also why range-side seating changes and tuner testing belong in Chapter 26. They are development tools. By the time I reach confirmation, those choices should already have been made.

I normally confirm with repeated five-shot groups because Chapter 28 has already established that as my practical development standard. At this stage I am no longer trying to prove why five shots are useful; I am looking for the selected load to repeat its established level of performance across independent groups.

If four groups measure 0.32, 0.54, 0.49 and 0.58 inch, I don't call it a 0.32-inch load. The average is (0.32 + 0.54 + 0.49 + 0.58) ÷ 4 = 0.4825 inch. The small group is real, but it is only one part of the evidence.

Where the application justifies it, I repeat the load on another day. Temperature, light, wind, barrel condition and the shooter will never be identical. If the load performs again, my confidence in it increases. Serious long-range or competition ammunition deserves more confirmation than a general-purpose sporting load.

I chronograph the confirmed load again. By now I am less interested in comparing charge weights and more interested in establishing the normal average velocity, ES and SD of the finished combination. I record the number of shots and useful environmental information so the figures retain context.

I still do not worship the SD. A repeatably accurate load with sensible velocity consistency is more useful than a poor-grouping load that happens to produce a prettier statistic.

For most rifle loads, 100 yards remains a very useful place to confirm the basic accuracy because environmental effects are relatively restrained. If the load will not repeat there, moving farther away will not fix it.

For ammunition intended for longer-range use, however, 100 yards is not the end of the process. Once the load is proven at 100 yards I verify it at the distances where it will actually be used. Velocity-related vertical, aerodynamic behaviour and real elevation requirements become more apparent as distance increases.

I use the measured average muzzle velocity in the ballistic calculator with the projectile data, sight height, zero and current conditions. The solver gives me a predicted elevation correction, normally in MOA or MILs, and I then confirm that prediction on the target.

The sequence is simple: measured velocity → ballistic solution → scope adjustment → actual target confirmation. The confirmed corrections become useful DOPE for that rifle and ammunition combination.

Hunting Ammunition Has a Practical Standard

Hunting ammunition does not need to win a Benchrest match to be a successful load. I want it safe, reliable, appropriate for the intended quarry and comfortably accurate enough for the realistic distances at which it will be used.

Once a hunting load repeatedly meets that requirement, I don't feel obliged to consume components and barrel life chasing another fraction of an inch that makes no practical difference in the field. The first cold-

bore point of impact can also be more important than a long warm-barrel group because the first shot may be the only shot that matters.

If the ammunition is magazine-fed, I confirm sensible magazine clearance, reliable feeding, free chambering and normal extraction. Accuracy alone does not make a successful field or competition load.

Where a projectile is close to, touching or jammed into the lands, I also want to know what happens if I have to extract an unfired round. A theoretically accurate arrangement that creates an avoidable practical problem may not be the right finished load.

For ammunition that will be transported, carried or repeatedly fed from a magazine, I may remeasure representative cartridges after normal handling. I am looking for unwanted projectile movement or any other dimensional change that could affect reliability or performance.

A load may eventually be used in conditions quite different from those in which it was developed. For serious competition, long-range or other demanding applications I keep temperature in mind and make sure the load continues to behave sensibly.

I also confirm in a barrel condition that reflects real use. A competition rifle may normally be fired fouled and through a sustained string; a hunting rifle may make the cold-bore shot the most important one.

Confirmation gives me another opportunity to check the fired brass and rifle behaviour over a larger sample. Any meaningful change in extraction, primer behaviour, case-head marking or other signs deserves investigation. Published data remains the foundation; fired-case observations are supporting information, not a laboratory pressure measurement.

Once the load itself is confirmed, I establish the final zero appropriate to the intended use. For long-range shooting I can then build the range card from the confirmed average velocity, projectile information, sight height and zero, and validate the calculated elevations on actual targets wherever practical.

I keep enough information to reproduce the load later: rifle and barrel, brass and case history where relevant, sizing setup, shoulder bump, neck tension, primer, powder and lot, charge weight, projectile, CBTO, COAL where useful, average velocity, ES and SD where relevant, group results, zero and confirmed elevation data.

I also keep enough information about unsuccessful tests to avoid unknowingly repeating them later. Record keeping belongs throughout the process, not as a separate afterthought.

Long-term changes—new component lots, ageing brass and barrel or throat wear—belong to maintaining a proven load, and are dealt with later in the book. At confirmation I only need to know that the selected load repeats the performance for which it was developed.

The purpose of load development is eventually to finish developing the load. A load is proven when it repeatedly does what I need it to do—not simply when it once produces an impressive target.

Chapter 30 — Reloading Pistol and Revolver Ammunition

Figure 30.1 — *Straight-wall case mouths showing different stages of expansion/flare and the finished mouth condition.*

Pistol and revolver cartridges use the same basic reloading principles as rifle ammunition, but the practical process can be quite different. Most use short, straight or slightly tapered cases, relatively small powder charges, case-mouth expansion before seating and, very often, a crimp suited to the cartridge and firearm.

The basic rule does not change: **use reputable published data, identify every component correctly and make controlled changes rather than guesses.**

A typical sequence is inspect → clean → size/deprime → prime → expand or flare → charge → verify the charge → seat → crimp or remove the flare as appropriate → gauge or chamber-check → inspect → label and record.

Many self-loading pistol cartridges headspace on the case mouth, while many traditional rimmed revolver cartridges headspace on the rim. That difference matters when I set up the crimp.

I inspect pistol and revolver brass for splits, damaged mouths, corrosion, bulges, damaged rims, loose primer pockets and anything else that makes me question the case. Self-loading brass can have a particularly hard life because it may be ejected onto hard surfaces or mixed with unknown range brass.

For normal pistol ammunition I don't apply precision-rifle levels of case sorting. I keep sensible batches where useful and remain aware that makes of brass can differ, but I don't create extra work without a reason.

In particular, **I do not see a useful reason to measure the H2O capacity of ordinary pistol cases.** Water-capacity work can have a place in advanced rifle loading, but it is normally unnecessary here.

Cases only need to be clean enough to inspect and load reliably; they do not need to look new. Many common straight-wall pistol dies use a carbide sizing ring and can normally size suitable cases without the lubrication required by conventional steel rifle dies. I still follow the die manufacturer’s instructions because not every cartridge and die system is the same.

I set the sizing die so the finished ammunition chambers and functions correctly. Reliability matters more than producing an impressive measurement that occasionally fails in the firearm.

Case length still matters, although the reason varies. A self-loading cartridge that headspaces on the case mouth depends on correct mouth geometry. With a roll-crimped revolver cartridge, reasonably consistent case length helps produce a consistent crimp. I work from reputable dimensional specifications and published data.

Before seating, I normally expand or flare the case mouth just enough for the projectile to start cleanly. This is especially important with cast or plated projectiles, where an inadequately prepared mouth can shave lead or damage the projectile.

I use **only enough flare to do the job.** Excessive flare works the brass unnecessarily and can shorten case life.

Many pistol cartridges use relatively small charges of comparatively fast-burning powder. An error can therefore represent a large proportion of the intended charge, and in some combinations an incorrect charge may not overflow the case or otherwise be visually obvious.

SAFETY WARNING

Pistol and revolver cartridges can use small charges of fast-burning powder. Always use reputable published data, positively identify the powder and verify the charge. Never assume that an incorrect charge will be obvious simply because it is wrong.

A suitable volumetric measure can work well with some powders, but I still establish and check the charge with scales. Where the loading process allows, I also look into charged cases before seating. A missing or visibly abnormal powder level should stop the process immediately.

Projectile Profile Matters

Projectile choice is about more than calibre and weight. Round nose, flat nose, semi-wadcutter, wadcutter, hollow-point and other profiles can feed, seat and crimp differently even when their nominal weights are identical.

This is particularly important with underlever rifles that use tubular magazines. In a conventional tube magazine, cartridges sit one behind another, so I use a suitable flat- or blunt-nosed projectile specifically intended for that application unless the projectile manufacturer explicitly approves another design for tubular-magazine use.

SAFETY WARNING

Do not assume that any projectile of the correct calibre and weight is suitable for a tubular magazine. Projectile profile matters. Use a design specifically suitable for the firearm and magazine system, together with reputable published loading data.

COAL can affect chambering, magazine fit, feeding, projectile position, available case volume and pressure. Different projectile profiles can require different seating arrangements, so I don't assume that one overall length suits every projectile of the same weight.

I start with reputable data appropriate to the projectile and combination, then confirm that the finished ammunition fits and functions correctly. In a small case, seating substantially deeper can reduce internal volume and may increase pressure.

SAFETY WARNING

Do not arbitrarily shorten pistol ammunition simply to make it chamber or fit a magazine. Seating depth is part of the load combination and can affect pressure, particularly in relatively small cases using fast-burning powders.

For self-loading ammunition, fitting the magazine is only the beginning. The cartridge also has to feed, chamber, fire, extract and eject reliably. Projectile profile can make a substantial difference to this cycle.

Feeding can also try to push a projectile farther into the case. If I suspect setback, I measure and investigate the cause rather than simply accepting it. Correct case preparation and suitable projectile retention are part of reliable ammunition.

A taper crimp normally removes the flare and brings the case mouth back against the projectile. It is commonly used on self-loading cartridges that headspace on the case mouth. I'm not trying to roll the mouth deeply into the projectile; I want correct chambering while preserving the geometry the cartridge requires.

A roll crimp turns the case mouth inward and is commonly associated with rimmed revolver cartridges, particularly where the projectile has a suitable cannelure or crimp groove. It can help resist projectile movement under recoil. Consistent case length helps make the crimp consistent.

With heavier-recoiling revolver ammunition, recoil can try to pull the remaining projectiles forward. If a projectile moves far enough it can interfere with cylinder rotation, so appropriate retention and crimp can be an important reliability requirement.

Many conventional die sets allow seating and crimping in the same operation, and this can work perfectly well when correctly adjusted. Where I want easier control, I may seat first and crimp separately. That prevents a heavy crimp beginning while the projectile is still moving and makes each adjustment easier to understand.

Revolver ammunition needs to fit the chambers freely, sit correctly against the rim, remain within cylinder length, resist unwanted projectile movement and extract normally. Difficult extraction is something I investigate rather than dismiss.

Self-loading ammunition places greater emphasis on magazine fit, feeding, chambering, suitable projectile retention, correct case-mouth condition, reliable ignition and cycling. A tiny group is of little value if the ammunition repeatedly stops the firearm functioning.

Pistol and revolver cartridges are where many reloaders first encounter cast projectiles. Alloy, hardness, mould design, diameter, sizing, lubrication or coating and gas checks can all matter, but those subjects deserve their own chapters. At this stage the important point is to prepare the case mouth so the projectile is not shaved or damaged during seating.

Plated projectiles also need appropriate handling. Their plating can be relatively thin, so excessive case-mouth tension, inadequate expansion or an unnecessarily aggressive crimp can damage them. I follow the projectile manufacturer’s recommendations, including any stated velocity limits.

Checking Finished Ammunition

A cartridge gauge can be useful for checking finished dimensions, especially with larger batches, but the intended firearm’s chamber remains important. Before boxing ammunition I inspect for damaged cases, incorrectly seated primers, damaged projectiles, inconsistent crimp, unusual overall length and split case mouths.

I also keep the batch identified with the cartridge, projectile, powder and charge, primer, COAL, crimp arrangement, date and load-data source, plus any other information relevant to the application.

Some pistol competitions use power factor as a rules or scoring threshold. It is a simple calculation from projectile weight and measured velocity; it is not a pressure measurement and it does not tell me whether a load is safe.

Power Factor = projectile weight in grains × velocity in fps ÷ 1,000

For example, a 125-grain projectile averaging 1,040 fps gives: 125 × 1,040 ÷ 1,000 = 130 power factor. I use the current rules of the discipline to determine whether a particular threshold applies and still develop the ammunition from appropriate published load data.

Not every pistol or revolver load needs the same degree of refinement. Specialist precision competition may justify more work; general target ammunition may place more emphasis on reliability, manageable recoil and economical production. As throughout this book, I ask what the ammunition actually needs to do and stop adding processes that do not improve that requirement.

inspect → clean → size/deprime → check case condition and length where relevant → prime → expand/flare → charge → verify the powder charge → seat → crimp/remove flare as appropriate → gauge/check → final inspection → label and record

Different presses can combine or rearrange operations, but speed never replaces control.

Pistol and revolver ammunition has brought cast projectiles properly into the discussion. For many traditional revolver cartridges—and especially when we later move into black-powder shooting—casting is not a minor side subject. It is an entire branch of ammunition making.

Before I can load a cast projectile properly, I need to understand how it was made, what it is made from and why its diameter, hardness and design matter. So next we move away from the loading press for a while and make the projectile itself.

Chapter 31 — Casting Projectiles: Equipment, Safety, Moulds, Alloys and Preparation

Casting projectiles takes ammunition making another step back towards the raw material. Instead of starting with a finished projectile, I am choosing the mould, alloy and final projectile dimensions myself.

That gives me control over projectile diameter, weight, nose profile, driving-band dimensions, alloy, hardness, lubrication, coating, gas-check use and ultimately how the projectile fits and behaves in the firearm.

It also introduces hazards we do not normally encounter at the loading press. We are dealing with molten metal, lead contamination and equipment operating at temperatures capable of causing serious burns. So before discussing how to produce good projectiles, I want to establish a safe and repeatable casting method.

Good cast projectiles come from controlling several things together: **alloy → melt condition → mould temperature → pouring technique → cooling rhythm → projectile inspection → sizing → lubrication or coating → gas check where required.**

Change one of those and the result can change. Just as with cartridge load development, I find casting much easier when I change one meaningful variable at a time. If projectiles suddenly start coming out badly, I want to be able to identify what changed.

I use a dedicated casting area rather than treating a kitchen or ordinary household worktop as an acceptable place for molten lead. The bench needs to be solid, stable, uncluttered, well ventilated, resistant to heat and away from children, pets, food and drink.

The furnace should sit where it cannot easily be knocked or pulled over. I arrange the bench before the pot is hot. Once molten alloy is present, I don't want to be reaching across it looking for tools.

Eye protection is one of the things I consider essential. A small splash of molten alloy can cause a severe injury. I wear proper eye protection throughout the casting operation, not just while pouring.

The danger is still present while adding alloy, returning sprues, fluxing, cleaning the pot or dealing with a blocked bottom-pour spout. I also wear sensible covered clothing and closed footwear. I avoid loose synthetic clothing around molten metal because some synthetics can melt when exposed to heat.

SAFETY — MOLTEN METAL

Always wear eye protection when casting or handling molten alloy. Wear sensible covered clothing and closed footwear. Keep the casting area dry and clear of unnecessary items. Molten lead can cause severe burns and should be treated accordingly.

Water and molten lead do not mix. If moisture is introduced below the surface of molten lead it can turn to steam extremely rapidly, and the expanding steam can violently eject molten alloy from the pot.

Anything I put into the melt must therefore be completely dry. That includes fresh alloy, old projectiles, sprues, ingots, ladles, spoons, thermometers, fluxing tools and anything else that may enter the pot.

SAFETY — WATER AND MOLTEN LEAD

Never put wet or damp material into molten lead. Do not assume something is dry because the outside looks dry. If I have any doubt, it stays away from the pot until I know it is completely dry.

Molten lead is not the only issue. Lead contamination on hands and surfaces is something I take seriously. I don't eat, drink or smoke while casting. When I finish, I wash my hands thoroughly before eating or handling food.

I also avoid carrying contaminated tools and casting residue into normal living areas. The casting bench is cleaned sensibly rather than blowing dust around with compressed air. Good hygiene is one of the easiest ways to reduce unnecessary lead exposure.

SAFETY — LEAD HYGIENE

Keep food, drink and smoking away from the casting area. Wash hands thoroughly after handling lead, alloy, dross or cast projectiles, and keep contaminated tools and residues away from normal living and food-preparation areas.

I want ventilation that takes smoke and fumes away from me. Fluxing can produce considerable smoke depending on the material used, and reclaimed alloy may contain contamination that I don't want to breathe.

I don't cast in an enclosed room with no ventilation. At the same time, I don't want a strong draught blowing directly across the pot and mould because that can make temperature control more difficult. Controlled extraction is preferable to simply creating a gale across the bench.

Choosing the Melting System

The two main methods are bottom-pour casting and ladle casting. Both can produce excellent projectiles. They simply use different techniques.

A bottom-pour furnace releases alloy through a valve and spout at the base of the pot. It is quick and convenient, particularly when producing larger quantities. Once the rhythm is established, I can cast a large number of projectiles efficiently.

I watch consistent flow, spout cleanliness, drips, partial blockages and alloy level. As the level in the pot changes, the behaviour of some bottom-pour systems can change slightly as well, so consistency of technique still matters.

With ladle casting I lift molten alloy from the pot and pour it into the mould. It is slower but gives excellent control over how the mould is filled. For larger projectiles and some traditional or black-powder designs, I often regard the slower pace as an advantage rather than a disadvantage.

The method allows me to control the pour and maintain a consistent head of metal over the sprue hole. There is no rule saying precision projectiles must be ladle cast or that bottom-pour projectiles cannot be excellent. The mould and the resulting projectiles tell me what works.

A larger pot holds more alloy and generally changes temperature more slowly, which can be useful during longer sessions. A smaller pot heats more quickly and may be perfectly adequate for short runs of small pistol projectiles.

Most modern electric furnaces use thermostatic control. Some have simple mechanical controls; others use digital or PID-style systems. If temperature really matters to the process, I measure it rather than assuming the number on the dial is exact.

A suitable lead thermometer can be useful when developing a routine, comparing alloys, diagnosing poor fill-out or trying to reproduce a previous successful session. The measurement only matters if it helps me repeat the process.

Before heating a mould I inspect the cavities, mould faces, alignment pins, sprue plate, screws, handles and vent lines. Any manufacturing oil or storage preservative needs to be removed from the cavities before casting because oil commonly produces poor fill-out and wrinkled projectiles.

I clean the mould using a method suitable for its material and follow the mould manufacturer's instructions. I also make sure the mould halves close squarely and that no debris is trapped on the faces or alignment surfaces.

One of the biggest differences between poor casting and consistent casting is mould temperature. A cold mould commonly produces wrinkled or incompletely filled projectiles.

Rather than wasting a large quantity of alloy trying to heat the mould only by repeated pouring, many casters preheat the mould. The objective is controlled heating: I am bringing the blocks towards a useful operating temperature, not trying to overheat them.

Chapter 32 will cover how I use the appearance of the cast projectile and the behaviour of the sprue to judge whether the mould is operating in the correct temperature window.

Aluminium, iron, steel and brass moulds do not heat and cool identically. Aluminium generally responds quickly. A large brass or iron mould may take considerably longer to stabilise but can retain heat very well once it gets there.

That means a casting rhythm that works with one mould may not suit another. The mould effectively teaches me the rhythm it prefers.

Single- and Multi-Cavity Moulds

A single-cavity mould produces one projectile per pour. Multi-cavity moulds may produce two, four, six or more at once. Multi-cavity designs can dramatically increase output, but they also carry more metal and thermal mass.

For large projectiles or work where I am chasing maximum consistency, fewer cavities may be easier to control. For high-volume pistol ammunition, a multi-cavity mould can make a great deal of sense.

The sprue plate covers the top of the cavities. Alloy is poured through its holes and a small pool remains above each cavity as the projectile solidifies. The timing of cutting the sprue affects base quality: too early can tear the base, while too late can make the sprue unnecessarily hard to cut.

The mould halves also need to close squarely and consistently. Dirt or damaged alignment features can produce fins, seams or dimensional variation. Handles and hardware should be secure before the mould is heated; trying to tighten loose screws at casting temperature is best avoided.

The mould determines much more than calibre. It also determines nose profile, driving-band dimensions, lubricant grooves, gas-check shank where present, projectile weight and length, base style and, in specialist moulds, hollow-point or hollow-base features.

The design needs to suit the firearm and application. A traditional revolver projectile and a long black-powder rifle projectile are solving different problems.

For conventional centrefire ammunition used in an underlever rifle with a tubular magazine, cartridges sit nose-to-primer. A suitable flat- or blunt-nosed projectile designed for tubular-magazine use is therefore normally used unless the projectile manufacturer specifically approves another profile for that system.

This applies just as much to a cast projectile as it does to a factory jacketed one. Projectile design is part of the complete ammunition system.

SAFETY — TUBULAR MAGAZINES

Do not assume that any cast projectile of the correct calibre and weight is suitable for a tubular magazine. Use a nose profile specifically suitable for the firearm and magazine system, together with appropriate published loading information.

The mould provides the shape. The alloy determines many of the projectile's physical characteristics. Most conventional cast-projectile alloys contain lead with varying proportions of tin and antimony, and each contributes something different.

Lead provides most of the mass. Pure lead is soft and comparatively easy to deform, which can be exactly what I want for some traditional and black-powder applications. It is not automatically the best choice for every smokeless-powder cast load.

Tin is particularly useful because it can improve the way molten alloy flows and fills the fine details of the mould. A small addition can noticeably improve sharp driving bands, grease grooves, bases and general surface definition. Tin also changes hardness to some extent, but I primarily think of it as an important aid to castability.

More is not automatically better, and tin is comparatively expensive.

Antimony is one of the principal elements used to harden conventional bullet alloys. Increasing antimony generally produces a harder alloy and can be useful for applications where a harder projectile is appropriate.

But harder is not automatically better. A very hard projectile of the wrong diameter can perform poorly. Projectile fit to the throat and bore is often at least as important as the nominal hardness of the alloy.

I choose alloy according to what I expect the projectile to do. A soft projectile intended for a traditional black-powder application may need very different properties from a cast projectile intended for a higher-velocity smokeless load.

That's why I don't recommend one universal alloy for every mould and firearm. Known commercial casting alloys are particularly useful when learning because they remove one major unknown.

Scrap Lead and Unknown Alloy

Scrap can be a useful source of alloy, but it introduces uncertainty. Modern wheel weights, for example, are not automatically a known lead alloy; some may be zinc or steel. I sort reclaimed material carefully before it is heated.

Unknown alloy is another variable. For ordinary practice ammunition that may be acceptable if the material is understood and behaves consistently. For precision casting, known alloy makes troubleshooting much easier.

Zinc is particularly disliked by lead casters because even a relatively small amount can make the alloy reluctant to fill the mould properly and can produce poor surface finish. Careful sorting of reclaimed material and controlled melt temperature help prevent accidental contamination.

Alloy Hardness

Cast-projectile hardness is often expressed using Brinell Hardness Number, or BHN. A higher number indicates a harder material. BHN can be useful comparative information, but it is not a magic accuracy figure.

Leading can result from incorrect projectile diameter, poor throat fit, unsuitable lubricant, damaged projectile bases, excessive velocity for the design, poor bore condition or other factors. I treat hardness as one variable rather than the complete answer.

Different alloys can shrink by different amounts as they cool, so the same mould can produce slightly different projectile diameters depending on the alloy. Alloy composition also changes projectile weight because lead, tin and antimony have different densities.

I therefore measure the actual projectile in front of me rather than assuming the mould's nominal calibre and weight tell me everything.

If I am trying to produce a repeatable batch, I prefer to prepare enough alloy for the intended project where practical. Repeatedly adding random pieces of scrap during a session makes composition harder to control.

Once I have an alloy I intend to keep, I cast it into clearly identified ingots. A pile of similar grey metal bars becomes surprisingly difficult to identify months later, so I label or segregate them properly.

Fluxing is used during alloy preparation and casting to help manage oxides and contaminants and, where appropriate, return useful alloy constituents to the melt. Many materials and methods are used successfully; I use a suitable material in a sensible quantity and provide good ventilation because fluxing can create smoke and fumes.

Oxides and contaminants can collect on the surface as dross. Some material should be removed, but aggressive constant skimming can also remove useful alloy unnecessarily. The aim is a clean, controlled melt rather than endlessly scraping every visible mark from the surface.

Cast projectiles are particularly sensitive to fit. The nominal calibre stamped on a mould does not tell me the complete story. Actual cast diameter can vary with mould, alloy, mould temperature and manufacturing tolerance.

After casting, I measure what the mould actually produced. Later I can size the projectile to the diameter appropriate for the firearm and application. This is one of the areas where casting gives the handloader a level of control that a finished jacketed projectile does not.

A plain-base projectile has a full-diameter base with no reduced gas-check shank. The exposed alloy forms the rear of the projectile. Plain-base projectiles work extremely well in many pistol, revolver, black-powder and moderate-velocity rifle applications when fit, alloy and lubrication are appropriate.

A gas-check design has a reduced section at the base onto which a small metal cup is fitted. The check helps protect and support the projectile base and can be useful where pressure and velocity are higher or where the projectile design specifically calls for one.

A gas check does not magically turn a cast projectile into a jacketed projectile. It is one part of the design, and a mould cut for a gas-check shank should normally be used as intended unless reliable data and experience support otherwise.

Gas checks are normally fitted during projectile finishing. The check is placed squarely onto the reduced shank at the base of the cast projectile. The projectile is then passed through suitable sizing equipment, which seats and usually crimps the check firmly in place.

I want the finished check square to the projectile, securely retained and free from obvious deformation. A crooked or damaged gas check creates variation at the base, exactly where I want the projectile to be as uniform as reasonably possible.

Other Gas-Sealing Methods

Traditional shooting uses other methods of protecting or sealing the projectile base, depending on the cartridge and firearm. Wads and separate base-sealing components can be part of some black-powder systems, but they are different from a gas check.

A gas check is physically fitted to a projectile designed to accept one. **A wad or separate gas-sealing component** is a different part of the loading system. We will deal with those properly in the black-powder chapters.

Traditional cast projectiles commonly have lubrication grooves. Lubricant can help reduce friction, control fouling and reduce leading, and in black-powder shooting it can also play an important role in keeping fouling manageable.

Different lubricants suit different applications. A lubricant that works well with smokeless pistol ammunition is not automatically the lubricant I would choose for a black-powder rifle.

A traditional lubricator/sizer, often called a lubrisizer, can size the projectile while forcing lubricant into its grooves. With a gas-check design it can also seat and crimp the gas check during the same controlled operation.

size the projectile → fill the lubrication grooves → seat/crimp the gas check where applicable

This makes a lubrisizer a very useful piece of equipment for conventional cast-projectile preparation.

With pan lubing, projectiles are stood upright in a shallow tray and lubricant is allowed to surround the lubrication grooves. Once set, the projectiles are removed with the grooves filled. It is slower and more manual, but it can work very well when specialised sizing equipment is not required.

Some projectile designs and lubricants are intended for tumble lubrication. The projectiles receive a thin coating rather than having conventional grooves individually filled. It can be quick and convenient for high-volume ammunition when the lubricant and projectile design are suited to the method.

Powder coating has become a popular alternative to conventional grease lubrication for some cast-projectile applications. The cured polymer coating can reduce direct lead contact with the bore and provide a cleaner handling surface.

The coating can slightly increase projectile diameter, so sizing still needs to be considered. Powder coating is not simply cosmetic: the coating needs to be even, properly adhered, correctly cured and appropriate for the intended application.

Lubrication is part of the system rather than a cure for incorrect dimensions. If the projectile is badly fitted, changing or adding more lubricant does not remove the need to correct the underlying fit.

The projectile base deserves particular attention. Small cosmetic imperfections at the nose can sometimes matter less than a poorly formed base. I want complete fill-out, sound base edges where the design calls for them, no obvious void and, where fitted later, a square gas check.

The projectile is driven from its base and leaves the muzzle base first. Good base consistency matters.

One advantage of casting is that rejects can usually be returned to the melt. I don't feel obliged to use every projectile simply because I spent time making it.

Obvious incomplete fill-out, severe wrinkles, major voids, badly damaged bases or obvious contamination go back into the pot. Slight cosmetic differences may or may not matter depending on the intended ammunition, and Chapter 32 will deal with that judgement in more detail.

My Basic Casting Methodology

select the mould and suitable known alloy → prepare and inspect the equipment → make sure everything entering the melt is completely dry → establish ventilation and PPE → melt and stabilise the alloy → prepare and preheat the mould → begin casting until the mould reaches a consistent working rhythm → inspect the projectiles → return obvious rejects → keep the good batch together → size, lubricate or coat and fit gas checks where required

The exact technique inside that sequence depends on the mould and alloy, but the sequence gives me a controlled starting point and makes troubleshooting much easier.

Where consistency matters, I record enough information to recreate the projectile later. That may include mould manufacturer and design, cavity number where relevant, alloy, casting method, melt temperature where useful, final cast diameter and weight, sizing diameter, gas-check type, lubricant or coating and intended load.

I record information I may genuinely need later, not simply numbers for the sake of collecting them.

A good casting setup should allow me to produce projectiles that are completely filled out, dimensionally suitable, visually sound, sufficiently consistent for the intended use and made from an alloy appropriate to the application.

I don't expect every projectile to emerge absolutely identical. For ordinary pistol ammunition the acceptable tolerance may be fairly generous; for long-range black-powder competition I may become much more selective. The job determines the amount of refinement required.

This chapter establishes the equipment, materials, safety and methodology. Chapter 32 can now concentrate on the actual casting operation: heating the mould, filling the cavities, maintaining rhythm, reading the sprue, cutting it correctly, dropping the projectile, diagnosing wrinkles, frosting and poor fill-out, managing mould temperature and inspecting the finished batch.

Chapter 33 can then deal properly with sizing, lubrication, powder coating, gas-check installation, final projectile measurement and preparation for loading.

Chapter 32 — Casting Projectiles: The Complete Casting Process

Once the equipment is set up, the alloy is ready and the mould has been cleaned and prepared, the next job is the actual casting.

This is where consistency matters.

Good casting is not simply a case of filling the mould and hoping every projectile comes out correctly. The quality of the finished projectile depends on the relationship between alloy temperature, mould temperature, pour technique, casting rhythm, sprue timing, cooling and inspection.

Once those things settle into a repeatable pattern, casting becomes much easier.

The basic process is: heat the alloy → bring the mould to temperature → fill the cavities consistently → allow the sprue to solidify → cut the sprue → release the projectile → inspect it → repeat at a steady rhythm.

The aim is not maximum speed. The aim is to produce a batch of projectiles that are fully formed, dimensionally consistent and suitable for the ammunition I intend to load.

Before casting seriously, I allow the alloy to reach a stable working condition.

The furnace thermostat may say the pot has reached temperature, but that does not necessarily mean the entire casting system is ready. The alloy needs to be fully molten and reasonably uniform, and the mould also needs to be hot enough.

Trying to judge projectile quality while both the alloy and mould are still changing rapidly makes the process unnecessarily difficult.

Where appropriate for the alloy and equipment, I make sure the melt is reasonably uniform before beginning a serious casting run.

I don't aggressively stir molten metal for no reason, but I also do not assume the composition must remain perfectly distributed without any attention.

Any tool used in the melt must be clean and completely dry. That moisture warning from the previous chapter still applies every single time something approaches the pot.

SAFETY — KEEP MOISTURE AWAY FROM THE MELT

Never introduce a damp spoon, ladle, ingot, sprue or other object into molten alloy.
Even a small amount of trapped moisture can turn rapidly to steam and eject molten metal.

Depending on the alloy and condition of the melt, I may flux before starting the main casting session.

Fluxing can help clean the melt and control oxidation. I use an appropriate flux sparingly and with good ventilation.

The object is not to create a cloud of smoke. It is to prepare a clean, workable alloy. Once the melt is settled, I skim only what genuinely needs removing.

A mould that is too cold is one of the most common reasons for poor early projectiles.

Typical symptoms include wrinkles, rounded driving bands, poorly filled grease grooves, incomplete bases and generally soft-looking detail.

The alloy is solidifying before it has fully filled the cavity. Rather than immediately changing alloy composition or furnace temperature, I first ask whether the mould itself is simply too cold.

Preheating can shorten the amount of time required to reach a useful casting rhythm. Methods vary with mould material and equipment, and I follow sensible manufacturer guidance.

The goal is not to get the blocks as hot as possible. I simply want to begin closer to the mould's working temperature. A mould that begins too hot presents a different set of problems.

I don't judge the whole setup from the first projectile out of the mould.

The first few pours often help bring the mould into equilibrium. I inspect them, but I expect the quality to improve as the mould reaches a stable temperature.

Obvious rejects simply go back into the melt later when they are completely dry. Once the projectiles begin showing sharp, consistent detail, I know I am approaching the useful working window.

Filling the Mould

The mould needs to fill completely and repeatably.

Whether I am using a ladle or bottom-pour furnace, I want a consistent amount and flow of alloy. The pour should allow the cavity to fill before the metal freezes.

I normally leave a visible sprue puddle over the sprue plate rather than trying to stop the pour exactly as the cavity becomes full. That small reservoir allows the projectile to draw additional metal as it begins to solidify.

The sprue puddle is useful information. Immediately after pouring, it remains molten.

As the projectile cools and solidifies inside the mould, the sprue also changes appearance and eventually hardens. That gives me a visual clue about timing.

I don't cut the sprue while it is still obviously liquid. Equally, if I leave it for far longer than necessary, it may become unnecessarily hard to cut. Good casting rhythm includes learning when the sprue is ready.

With a bottom-pour furnace, consistency of mould position relative to the spout can help produce repeatable fill.

Some casters prefer a slight gap between the spout and sprue plate. Others use contact or near-contact methods with certain moulds. The correct technique depends on the furnace, mould and projectile.

The important thing is to find a method that gives complete fill-out, consistent bases and a manageable casting rhythm. Once something works, I keep the method consistent rather than randomly changing the pour from one cavity to the next.

Ladle casting gives more direct control over the pour.

For larger projectiles, I may prefer to keep the ladle in contact with the sprue plate for a short period while the cavity fills. Some moulds respond very well to a deliberate pressure-pour technique. Others are perfectly happy with a conventional free pour.

Again, the target is not to copy a ritual. It is to produce well-filled, repeatable projectiles.

A pour that is too hesitant can allow alloy to freeze before the cavity is completely filled. A wildly aggressive pour can create unnecessary splashing and poor control.

I want a smooth, confident fill. The exact speed depends on cavity size, projectile weight, alloy, mould temperature and pour system.

Large projectiles usually require more metal and may reward a slightly different technique from small pistol projectiles.

With a multi-cavity mould, I need to fill each cavity consistently.

If one cavity repeatedly produces a different result from the others, I don't automatically assume the whole mould is bad. There may be a local issue involving cavity temperature, venting, alignment, pour position or the way the alloy is reaching that cavity.

For precision casting, it can even be useful to know which cavity produced which projectile, although that level of tracking is unnecessary for most ordinary pistol ammunition.

The air inside the cavity has to escape as molten alloy enters. Mould blocks are normally designed with fine vent lines or other venting features.

If those become contaminated or blocked, fill-out can suffer. I keep mould faces and vent lines clean but do not attack them aggressively with tools that could damage the mould.

Poor venting can look surprisingly similar to a temperature problem.

Cutting the Sprue

Once the sprue has solidified sufficiently, I cut or swing the sprue plate.

If I cut too early, the projectile base can tear or smear. If I wait excessively, the sprue may become much harder to cut and the casting rhythm slows.

I look for a clean cut and a well-formed base. The base is one of the areas I inspect most carefully.

The projectile leaves the muzzle base first. For that reason, a damaged or badly formed base can matter more than a minor cosmetic imperfection on the nose.

I want the base to be fully filled, square, cleanly cut, free from tears and consistent with the rest of the batch.

If the base is obviously damaged, that projectile is normally a reject.

Once the sprue is cut, I open the mould and allow the projectile to fall onto a suitable surface.

I don't want to damage a still-hot projectile by dropping it onto something hard. Many casters use a folded cloth or another suitable heat-resistant surface.

The objective is simply to support the fresh projectile while it finishes cooling. I also keep anything flammable away from the casting area.

If a projectile refuses to release, I don't start hammering randomly on the mould blocks.

A light tap on the appropriate mould handle hinge or another manufacturer-approved point may help. I avoid striking cavity edges, alignment pins, mould faces or precision surfaces.

A damaged mould can create problems for every projectile that follows.

Once the mould reaches its working temperature, rhythm becomes extremely important.

If I cast too slowly, the mould cools. If I cast too quickly, it can overheat.

The mould temperature is therefore partly controlled by how quickly I cycle through pour → cool → cut sprue → release → close → pour again.

That is why good casting can feel almost rhythmic once everything settles down. I'm not racing. I am simply repeating the same process at roughly the same pace.

Typical signs include pronounced wrinkles, incomplete fill-out, rounded edges, poorly formed grease grooves and inconsistent bases.

The first adjustment I usually consider is allowing the mould to get warmer or slightly increasing the casting pace. I don't immediately assume the alloy needs to be made harder.

At the other extreme, the mould can become too hot.

Signs may include excessive frosting, unusually long sprue solidification time, projectiles taking too long to harden before release, smeared bases and poor handling because the projectile remains soft for longer.

If that happens, I slow down. Sometimes simply pausing briefly is enough. The mould does not need to be cooled aggressively.

A lightly frosted surface is not automatically a reject. Some alloys and temperatures naturally produce a slightly frosted appearance.

A frosted projectile may shoot perfectly well. I become more interested when frosting is severe and accompanied by other indications that the mould or alloy is running excessively hot.

Appearance is a clue. It is not the only measure of quality.

Wrinkles are usually a sign that something prevented the alloy from filling the cavity cleanly.

Common causes include a mould that is too cold, oil or contamination in the cavity, poor alloy flow, insufficient pour rate or inadequate venting.

The pattern matters. If every projectile is wrinkled, I look at the overall setup. If only one cavity is affected, I look more closely at that cavity.

Rounded Bands and Poor Fill-Out

Driving bands, lubricant grooves and base edges should normally look well defined.

If they are rounded or incomplete, the alloy may be freezing too early. Possible causes include low mould temperature, alloy temperature that is too low, insufficient tin in an alloy that casts poorly, poor venting or an overly slow pour.

I change one thing at a time so I can see what actually solves the problem.

Internal voids are more difficult because they are not always visible.

A large unexplained variation in projectile weight can sometimes indicate a void or incomplete fill. For ordinary ammunition, visual inspection may be enough.

For more serious precision casting, weighing projectiles can help identify unusually light examples that deserve rejection. We will deal with sorting in more depth in the finishing chapter.

These two are related but not identical.

A hot alloy cannot always compensate for a mould that is too cold. Likewise, an overheated mould does not automatically need hotter alloy.

That's why I think of casting as controlling two temperatures: the melt temperature and the mould temperature. The mould temperature is heavily influenced by casting rhythm.

There is no universal perfect temperature for every lead alloy. Different compositions behave differently.

Tin content, antimony content, projectile size and mould design can all influence the useful temperature range.

I am looking for the lowest sensible temperature that gives reliable, complete fill-out and a stable process. Unnecessarily overheating the alloy can increase oxidation and make the working environment less pleasant.

Once I find a combination of alloy temperature, mould temperature, pour technique and timing that produces good projectiles, I try to leave it alone.

Casting improves enormously once unnecessary experimentation stops. If I make a major change every few pours, I never give the process time to stabilise.

Sprues and rejected projectiles are valuable alloy. I normally return them to the melt.

But they must be completely dry before they go back. Freshly cast sprues are normally dry because they have just come from the mould.

Anything that has been sitting elsewhere, stored, washed or exposed to moisture is treated differently. If I'm not certain, it does not go into molten alloy.

Eventually the level in the pot drops. Adding new alloy lowers the melt temperature.

So I don't immediately carry on casting and assume nothing changed. I allow the furnace to recover and the new alloy to become completely molten and incorporated.

That brief pause helps maintain consistency. For serious batch work, I also try not to keep changing alloy composition while the session is underway.

Particularly with bottom-pour furnaces, the height of alloy in the pot can influence flow and pressure at the spout.

I therefore avoid running the pot nearly empty before adding more. Keeping the level within a sensible range makes the casting conditions more repeatable.

Small smears of lead can occasionally accumulate around the sprue plate. If they begin interfering with movement or closure, I deal with them carefully.

The mould is hot, so I use suitable tools and methods rather than fingers. I don't scrape precision surfaces aggressively.

Some mould designs benefit from very small amounts of suitable high-temperature lubricant on specific moving points such as the sprue-plate pivot, handle joints or alignment hardware.

The key word is small. I keep lubricant away from the cavity itself.

Oil migrating into the cavity can ruin fill-out until it burns away or is cleaned.

Hollow-Point Casting

Hollow-point moulds introduce another temperature-sensitive component: the hollow-point pin.

If the pin is too cold, the nose cavity may not fill properly. If it becomes too hot or contaminated, the projectile may stick.

That makes casting rhythm and temperature even more important. Hollow-point casting is generally slower than casting solid projectiles because there are more moving parts and more heat to control.

Hollow-base moulds also require good fill around the base pin or plug. A badly formed skirt can destroy the purpose of the design.

With these projectiles I inspect the hollow base very carefully before accepting the casting.

Large black-powder rifle projectiles often contain considerably more alloy than typical pistol bullets.

That means more thermal mass, longer solidification time, more demand on the mould and usually a slower rhythm.

Ladle casting is often particularly well suited to these projectiles, although it is not the only workable method. Consistency of projectile weight and base quality may become much more important when shooting them at longer distances.

Small pistol projectiles can often be produced much faster. Multi-cavity moulds make high output possible.

The danger is becoming so focused on production speed that inspection suffers.

I still want to see proper fill-out, good bases, no major fins and dimensions appropriate for later sizing. Fast production only helps if the projectiles are worth keeping.

I prefer to catch a problem early.

I don't necessarily inspect every projectile under magnification as it drops from the mould, but I regularly look at the output.

If ten projectiles in a row suddenly begin showing the same defect, I want to notice immediately rather than after casting another five hundred. Casting is a feedback process. The projectile tells me what the mould and alloy are doing.

The first sort is visual.

- incomplete projectiles
- badly damaged bases
- large wrinkles
- severe fins
- contamination
- missing or badly formed features

Those can normally be remelted. Minor surface differences may be perfectly acceptable depending on the application. I don't reject a projectile merely because it is not cosmetically perfect if the defect is irrelevant to performance.

For normal pistol ammunition, I don't necessarily weigh every cast projectile. The time may produce no practical benefit.

For precision or longer-range cast-projectile shooting, weight sorting becomes more useful.

If projectiles from the same mould and alloy normally cluster closely around one weight, an unusually light example may indicate incomplete fill or an internal void. That makes weight a useful quality-control tool.

Again, the intended application determines how far I go.

I also measure enough projectiles to know what diameter the mould is actually producing with the alloy I am using.

That gives me the starting point for the sizing operation. I don't assume a mould marked .358 will always produce exactly .358-inch projectiles with every alloy.

The actual projectile is the measurement that matters.

On some multi-cavity moulds, one cavity may produce a slightly different weight or diameter from another.

For general pistol ammunition, that may be completely irrelevant. For specialist precision work, I may choose to identify and compare cavities.

This is another example of not turning every casting operation into a laboratory exercise unless the application genuinely needs it.

Cooling and Hardness

Alloys can change hardness as they cool and age. Some antimony-containing alloys may harden over time.

Certain casters also deliberately water-drop or heat-treat projectiles to alter hardness. Those are specialised techniques. They can materially change projectile properties and require controlled methodology.

I would rather deal with intentional hardness treatment separately than suggest that every cast projectile should be quenched as it leaves the mould. For normal casting, I allow the projectile to cool safely and predictably.

Some casters drop freshly cast projectiles directly into water to increase hardness with suitable alloys.

This creates an obvious conflict with our molten-metal moisture rule. If someone uses this method, the water container must be positioned so there is no realistic way for water to splash or be carried back into the casting pot.

Personally, I wouldn't place an open water container anywhere that creates a moisture risk beside molten alloy.

SAFETY — WATER QUENCHING

Water quenching and molten lead must be kept physically separated.
Never position water where splashes, wet tools or wet projectiles could contaminate the casting pot.

Fresh cast projectiles can remain hot for longer than they appear. I allow them to cool before sorting or handling extensively.

A projectile does not need to be glowing to cause a burn. The same applies to the mould.

Even after the furnace is switched off, the equipment remains hot for a considerable time.

When I finish casting, I shut the furnace down according to the manufacturer's instructions and allow everything to cool safely.

I don't start dismantling hot equipment unnecessarily. I leave the mould open or positioned appropriately for cooling, depending on its material and manufacturer guidance.

Once cool, iron and steel moulds may need suitable rust protection before storage. Any preservative applied to the cavities will need removing before the next casting session.

If a casting session went particularly well, I make a few notes. Useful details can include:

- alloy
- mould
- approximate melt temperature
- whether I used ladle or bottom pour
- mould-preheating method
- casting rhythm
- average projectile weight
- as-cast diameter
- any useful observations

That gives me a much better starting point next time.

My normal process is deliberately straightforward:

prepare a clean, dry and ventilated work area → put on eye protection and suitable clothing → bring the alloy to a stable temperature → flux where appropriate → preheat the mould → cast the first few projectiles

while the mould settles → establish a steady rhythm → maintain consistent pouring and sprue timing → inspect output regularly → reject obvious faults → replenish alloy carefully when required → allow the melt to recover → finish the batch → cool everything safely → record anything worth keeping.

Once the rhythm is right, I try not to interfere with it. A good casting session should become almost repetitive. That is a good thing. Consistency is exactly what I am trying to produce.

At this point I have cast projectiles. They are not necessarily ready to load.

Depending on the design and application, they may still need sizing, lubrication, powder coating, gas checks, hardness checks, weight sorting, diameter sorting or final visual inspection.

That is the next stage.

Chapter 33 — Sizing, Lubricating and Finishing Cast Projectiles

Once the projectile comes out of the mould, the casting stage is complete.

That doesn't always mean the projectile is ready to load.

Depending on the mould, alloy, firearm and intended use, I may still need to size it, fit a gas check, lubricate it, powder coat it, inspect it, sort it, or simply measure it and leave it alone.

The important thing is not to perform every possible finishing operation just because the equipment exists. The finished projectile only needs enough preparation to make it fit the firearm correctly, survive the loading process and perform consistently for the intended application.

For some pistol ammunition that may be very little. For specialist cast-rifle or black-powder ammunition, it can be considerably more.

Before I size anything, I want to know what the mould has actually produced. I measure a representative sample for diameter.

I may also check weight, overall length, base condition, gas-check shank diameter where applicable, and visible consistency.

The mould may be marked with a nominal diameter, but alloy and mould condition can change the actual as-cast dimension. I work from the projectile in front of me.

The as-cast diameter is important because cast projectiles generally depend heavily on fit.

A projectile that is too small for the throat, chamber or bore relationship can allow hot gas to pass around it. That can contribute to poor accuracy and leading.

A projectile that is unnecessarily large may create chambering or pressure problems.

The correct diameter therefore comes from the firearm and application, not from a simplistic rule that every projectile should always be sized to one universal amount over nominal calibre.

Fit Matters More Than Hardness Alone

For finished cast projectiles, fit is normally more useful to establish first than simply chasing a harder alloy. If the diameter is wrong for the throat/bore relationship, changing BHN alone may not solve accuracy or leading. I therefore establish suitable dimensions first and treat hardness as one part of the complete combination.

Where projectile diameter is uncertain, measuring the actual firearm can be useful. Depending on the firearm, this may involve measuring the bore, groove diameter, throat or cylinder throats using an appropriate established method.

I don't force unsuitable objects through a firearm simply to obtain a measurement. The measuring method needs to suit the firearm and be carried out safely.

For revolvers, cylinder-throat dimensions can be particularly important. For rifles, throat and groove dimensions may influence the most suitable finished projectile diameter.

The objective is simple: **I want the projectile to fit the firearm I actually have, not the nominal calibre printed on the barrel.**

Sizing reduces the projectile to a controlled final diameter. This can be done using several types of equipment:

- push-through sizing dies;
- conventional lubricator/sizers;
- nose-first or base-first systems;
- press-mounted sizing dies;
- specialist inline systems.

The method matters less than the result. I want a projectile with a consistent final diameter and an undamaged base.

If the projectile already casts at the diameter I want and is suitably uniform, I may not need to size it at all. Every additional operation introduces another opportunity to distort the projectile.

Sizing should therefore have a purpose. It may be required to establish a known diameter, fit a gas check, lubricate grooves through a lubrisizer, remove minor dimensional variation, or prepare the projectile for a particular chamber or throat.

I don't automatically run every cast projectile through the smallest available die.

Push-through sizing dies are simple and effective. The projectile is pushed completely through a sizing die of the required diameter. Depending on the system, this can be done nose-first or base-first.

They are particularly useful with powder-coated projectiles and high-volume pistol ammunition.

The die should be clean and appropriate for the projectile material and coating. Excessive force during sizing tells me something is wrong.

Perhaps the projectile is far too large. Perhaps the die is dirty. Perhaps lubrication is needed for the particular system. I investigate rather than simply increasing press force.

A traditional lubricator/sizer combines several jobs. It can size the projectile, apply lubricant into the grooves, and often seat or crimp a gas check.

This is extremely useful with conventional grease-groove projectile designs.

The projectile is pushed into a sizing die while lubricant is forced through holes in the die and into the lubrication grooves. Setup needs to match the projectile.

I want lubricant in the grooves where it belongs rather than smeared excessively over the nose or base.

Traditional lubricator/sizers normally use a nose punch or top punch that contacts the projectile while it is being pushed through the sizing die.

The punch needs to suit the nose profile. If it contacts a small area badly, it can mark or deform the projectile.

Just as with seating stems, different projectile profiles may require different punches. A correct fit helps keep the projectile straight and protects the nose.

Gas Checks

If the mould is designed for a gas check, the check is normally fitted during the finishing process.

The small metal cup is placed squarely onto the reduced shank at the projectile base. The sizing operation then presses it firmly into position.

I want the finished check to be square, fully seated, firmly retained and concentric with the projectile. A gas check hanging crookedly from the base defeats much of the reason for using one.

Before processing hundreds of projectiles, I inspect the first few. I make sure the check actually grips the shank correctly.

If the check falls off easily after sizing, something is wrong. Likewise, if it takes excessive force to install, I check the shank diameter, check type, sizing die and projectile dimensions.

I don't try to solve a dimensional mismatch with brute force.

A gas check can protect and support the base in suitable higher-velocity cast applications, but it does not turn a cast projectile into a jacketed one or replace appropriate published cast-projectile data.

Traditional cast-projectile lubrication has several purposes. Depending on the load, it can help reduce friction, manage fouling, limit leading and improve consistency.

The correct lubricant depends heavily on the application. A black-powder lubricant has a different job from a lubricant used with smokeless pistol ammunition. That distinction becomes particularly important in the black-powder section later in the book.

Many conventional cast projectiles have one or more grooves specifically designed to hold lubricant. I want the groove filled sufficiently for the intended application.

More lubricant is not automatically better. Excess lubricant can be messy and can sometimes contaminate areas where I don't want it.

The design of the projectile usually gives a good indication of how the lubrication system was intended to work.

Cast-projectile lubricants vary considerably in consistency. Some are relatively soft. Others are much harder and may require a heated lubricator/sizer before they will flow properly.

Neither category is automatically superior. A lubricant needs to suit the projectile, loading method, velocity, temperature and powder type.

A very hard lubricant may be convenient for handling but completely unnecessary for a mild load. Likewise, a soft black-powder lubricant may be excellent at managing fouling but inconvenient for some high-volume smokeless ammunition.

Some harder lubricants require the lubricator/sizer body or lubricant reservoir to be gently warmed. Purpose-built heaters are available for this.

I use enough heat to allow the lubricant to flow properly. I don't overheat the system in an attempt to make the operation faster. Consistency of lubricant flow matters more than making it liquid.

Pan lubrication remains a perfectly workable method. The projectiles are stood upright in a shallow tray and suitable lubricant is melted or softened around them.

Once the lubricant has set, the projectiles are removed with the grooves filled. This can be particularly useful for low-volume loading, specialist projectile designs, and situations where a conventional lubrisizer is not available.

The method is slower, but slow is not automatically bad.

Some projectiles and lubricants are designed for tumble lubrication. A small quantity of lubricant is distributed over a batch of projectiles, producing a thin coating.

The projectiles are then allowed to dry or cure as required. This can be convenient for high-volume pistol ammunition.

The temptation is to use too much. I want a thin, consistent coating, not projectiles swimming in lubricant.

Powder Coating

Powder coating has become a common finishing method for cast projectiles. The projectile receives a polymer coating which is then cured according to the coating manufacturer’s requirements.

When correctly applied, powder coating can provide clean handling, reduced direct lead contact with the bore, a durable surface and good performance in many smokeless-powder applications.

It can also replace conventional grease lubrication in appropriate loads.

A good powder coat is not just colour stuck to a projectile. The coating needs to cover the projectile adequately, adhere properly, cure correctly, remain intact during sizing and survive seating without being scraped away.

If the coating flakes off when the projectile is sized or seated, I don't regard the process as successful.

Powder coating adds a small amount of material to the outside of the projectile. That means diameter changes.

I therefore measure after coating and size the finished projectile as required. I don't size the bare projectile to the final desired dimension and then assume the coating will have no effect.

The finished coated projectile is the dimension that matters.

Depending on the method, projectile and coating system, some casters pre-size before coating, while others coat first and then size to final diameter.

For most normal powder-coated ammunition, I am interested in ending with a consistent final diameter after the coating has been cured.

If a pre-sizing operation is needed because the as-cast projectile is exceptionally large or difficult to process, that is a separate practical decision. The final measurement still comes after the complete finishing process.

Gas-checked projectiles can also be powder coated. The exact sequence can vary depending on equipment and preference.

The important things are that the coating is correctly cured, the gas check seats properly, the final diameter is correct and the finished projectile remains undamaged.

I avoid turning the sequence into a ritual. I judge it by the quality of the finished projectile.

Before loading coated projectiles, I inspect a sample. I look for bare patches, flakes, obvious contamination, heavy lumps, damaged bases or anything that could interfere with sizing or seating.

A cosmetically imperfect colour is not necessarily a functional problem. A coating that is physically failing is.

Once sizing, lubrication, coating and gas-check fitting are complete, I measure again.

This is the dimension I care about. A finished projectile should have the diameter I intended it to have after all processing.

That is the projectile that will enter the case and firearm.

For most ordinary pistol and revolver ammunition, I don't consider weighing every cast projectile necessary. A good casting process and visual inspection usually provide enough control.

For more demanding applications, especially longer-range cast-rifle or black-powder shooting, weight sorting can become useful.

The goal is generally to identify projectiles that are clearly different from the main batch. A projectile that is significantly lighter than its companions may indicate poor fill, an internal void or another casting defect.

This is the same principle we have used throughout the book. If a batch already meets the accuracy requirement, sorting every projectile into tiny weight bands may achieve nothing useful.

For ordinary pistol ammunition, high-volume practice and much general shooting, visual inspection and sensible dimensional control are normally enough.

For specialist long-range cast-projectile shooting, the threshold for acceptable variation may be much tighter.

Base Quality Comes Before Cosmetic Perfection

When selecting cast projectiles, I pay particular attention to the base. A slightly imperfect nose may make little practical difference. A badly formed base is much more likely to concern me.

The base should be square, complete, undamaged and consistent with the rest of the batch. For a gas-checked projectile, the check becomes part of that base.

Depending on the loading method and lubricant, I generally avoid leaving unnecessary lubricant smeared across the projectile base. I want the base clean and consistent.

That is particularly true where the projectile is being seated over a smokeless-powder charge. Excess lubricant has no useful job inside the powder space.

Finished cast projectiles should be stored cleanly and clearly identified. I keep different alloys, diameters, mould designs, coatings and gas-check configurations separate.

Cast projectiles can look remarkably similar once they are loose in a container. A box marked only ".357 cast" is not enough if I have several different .357 projectiles in use.

Where the project matters, I record the mould, alloy, as-cast diameter, final sized diameter, projectile weight, lubricant or coating, gas check where used, date or batch, and intended load.

This makes later troubleshooting much easier. If a load suddenly begins leading or behaving differently, I can establish whether the projectile batch itself changed.

The finished projectile now needs to survive the loading process. A cast projectile is generally softer and less tolerant of poor case-mouth preparation than a conventional jacketed projectile.

The case mouth needs enough expansion or flare for the projectile to enter without shaving lead, coating or lubricant.

If I see a ring of shaved lead or stripped coating after seating, the case mouth is telling me the setup is wrong.

Just as in Chapter 30, I use only enough flare for the projectile to start cleanly.

Excessive flare works the case unnecessarily. Insufficient flare damages the projectile.

The correct setting is the smallest amount that allows clean, square seating.

Cast projectiles can have nose profiles that differ greatly from conventional jacketed projectiles. Round-nose, flat-nose, semi-wadcutter and specialist black-powder designs may all require different seating-stem contact.

I make sure the stem supports the projectile correctly rather than marking the nose or trying to push on a small unsuitable area.

Crimp requirements depend on the cartridge and firearm. For many revolver cartridges, a roll crimp into the correct groove is normal.

For self-loading pistol cartridges that headspace on the case mouth, a taper crimp is more appropriate where required.

I don't use crimp to compensate for poor projectile fit or incorrect case preparation. A crimp has a specific mechanical job.

With powder-coated projectiles, an excessively aggressive case mouth or crimp can cut through the coating. That defeats one of the reasons for coating the projectile.

I want the case to grip the projectile correctly without scraping or slicing the finished surface.

A pulled test projectile can be useful here: seat one, remove it carefully, and inspect what the case and crimp have done to the coating.

Before loading a large batch, I often sacrifice one or two projectiles to checking the complete setup.

measure → seat → pull → inspect

That tells me whether the case is shaving the projectile, the coating is surviving, the crimp is excessive or the seating stem is marking the nose.

This is much easier to correct before several hundred rounds are loaded.

Leading

Leading is the deposition of lead in the bore. It can range from a light trace to severe buildup.

Possible causes include poor projectile fit, unsuitable alloy, excessive velocity for the combination, damaged projectile bases, inadequate or unsuitable lubrication, rough barrel condition, or gas leakage around the projectile.

What matters is that leading is a symptom, not a diagnosis.
I don't simply reach for a harder alloy every time I see lead.
The position of leading in the bore can sometimes help with troubleshooting. Leading very near the throat may suggest different problems from leading appearing farther down the barrel.
But I avoid pretending there is one absolute diagnostic rule. I consider projectile diameter, alloy, load, lubricant, velocity, throat, barrel condition and overall fit together.
If leading occurs, I remove it using suitable bore-cleaning methods and equipment before continuing serious testing.
I don't keep firing indefinitely through heavy leading and assume it will somehow improve. As deposits build, accuracy and bore condition can change. The cause needs addressing.
When we reach black-powder ammunition, lubrication becomes a different subject. Black-powder fouling needs to remain manageable over a string of shots.
Many lubricants that work well with smokeless loads are not ideal for this job. Likewise, the quantity and groove capacity of a traditional black-powder projectile can form part of the overall fouling-management system.
That deserves proper treatment later rather than being reduced to a paragraph here.
inspect the cast projectile → measure the as-cast diameter → decide whether sizing is required → fit the gas check if the design uses one → size to the required final diameter → lubricate or powder coat according to the chosen method → remeasure the finished projectile → inspect the base and coating/lubrication → sort only as much as the intended use justifies → label the finished batch
The exact order changes with the equipment. For example, a traditional lubrisizer may size, lubricate and seat the gas check in one operation. A powder-coated projectile may be coated first and then push-through sized.
What matters is that the final projectile is correct.
At the end of this process, I want a projectile that is the correct design, made from a suitable alloy, at the correct finished diameter, properly lubricated or coated, correctly gas-checked where required, free from significant defects and clearly identified.
Only then does it move to the loading bench.
The next stage is where all of this work has to function inside an actual cartridge.

Chapter 34 — Loading and Developing Loads for Cast Projectiles

By this stage, the projectile itself is finished.

It has been cast, inspected, sized where necessary, lubricated or coated, and fitted with a gas check if the design requires one.

Now it has to be loaded into a cartridge.

Cast projectiles are not simply cheaper versions of jacketed projectiles. They behave differently, they can be easier to damage during loading, and they usually reward a slightly different approach to case preparation, seating and load development.

The main principles remain familiar: use reputable published data, keep the component combination identifiable, prepare the case correctly, avoid damaging the projectile, change one deliberate variable at a time, and confirm the result on the target.

What changes is the detail.

I begin with load data specifically appropriate to the cartridge, projectile type and powder I intend to use.

I don't assume that data for a jacketed projectile of the same nominal weight can simply be transferred to a cast projectile.

Cast projectiles can differ substantially in bearing surface, hardness, diameter, lubrication, friction, seating depth and intended velocity range.

The projectile manufacturer, mould maker, powder manufacturer and established cast-projectile loading manuals can all be useful sources. The basic rule is simple: I want data that actually supports the combination I am loading.

One of the first differences is that I am usually not trying to drive a cast projectile as fast as physically possible.

The velocity I need depends on projectile design, alloy, fit, lubrication or coating, gas-check use, firearm and intended application.

A mild revolver target load and a gas-checked rifle load are solving completely different problems. The objective is not how fast I can make the projectile go, but what load gives me safe, reliable and accurate performance with that particular cast projectile.

Chapters 31–33 established projectile fit, alloy and finishing. At the loading bench I now treat the finished diameter as a fixed component specification. If the projectile is unsuitable for the firearm, I correct that before beginning powder development rather than trying to tune around it with charge weight.

A cast projectile is generally softer than a jacketed one. Powder-coated projectiles also have a surface I don't want to scrape or damage.

That means the case mouth deserves particular attention.

For straight-wall and pistol ammunition, I normally use enough expander or flare to allow the projectile to begin seating cleanly. For bottleneck rifle cases, an appropriate inside chamfer and suitable neck diameter may be enough depending on the projectile and die system.

The projectile should enter the case without shaving lead, stripping coating or being forced brutally through a sharp mouth.

With pistol and revolver ammunition, I generally expand or flare only enough for the projectile to sit squarely.

Too little expansion can shave the projectile. Too much unnecessarily works the case mouth and can shorten case life.

The projectile should sit securely enough to begin straight, but the case mouth should not be opened more than necessary.

For cast-projectile loading, the diameter of the expander can be important.

If the sizing die reduces the case excessively and the expander leaves the inside diameter too small, the case can squeeze the cast projectile during seating. A projectile carefully sized to the correct diameter may therefore no longer be that diameter once loaded.

For more demanding cast-projectile work, I sometimes check this by loading a dummy round, carefully pulling the projectile and measuring it. If the case has substantially reduced its diameter, the case-expansion and neck-tension system deserves attention.

Do Not Depend on Excessive Neck Tension

A cast projectile does not normally need the same aggressive grip that someone might associate with heavily worked jacketed ammunition.

I want enough retention for the intended firearm and use. I don't want to size the projectile smaller through excessive case tension. Correct expansion and appropriate neck tension work together.

Once the case is charged, the projectile should enter the case straight and cleanly.

I make sure the seating stem matches the projectile profile reasonably well. Cast bullets are available in round-nose, flat-nose, semi-wadcutter, wadcutter, truncated-cone, long-rifle and specialist black-powder profiles.

A seating stem intended for one shape may mark another badly. If the nose is being deformed or the projectile is entering at an angle, I correct the tooling rather than accepting the damage.

Before loading a large batch, I like to make a dummy cartridge with no primer and no powder.

This lets me establish seating depth, COAL, crimp position, chamber fit, magazine fit where applicable, and whether the projectile survives the loading operation.

If I am using a coated projectile or a particularly soft cast projectile, I may carefully pull the dummy afterwards and inspect it for lead shaving, coating damage, heavy case impressions, nose damage or excessive sizing by the case.

Cast-projectile seating depth still matters. It affects cartridge overall length, magazine and cylinder fit, available case volume, crimp position and pressure behaviour.

With revolver bullets, a crimp groove may largely determine the intended seating position. With other projectile designs, the nose profile and chamber can be more influential.

I don't arbitrarily seat a cast projectile deeper simply to make it fit. I work from suitable published data and the requirements of the firearm.

For revolver ammunition, I need the loaded cartridge to fit freely within the cylinder.

A projectile can be perfectly safe from a pressure-data point of view and still be too long for a particular cylinder. Likewise, an unsuitable crimp position can create reliability problems.

Cast or coated projectiles in self-loading pistol cartridges need to meet all the same practical requirements discussed in Chapter 30.

They must fit the magazine, chamber correctly, feed reliably, resist unwanted setback and preserve the case-mouth geometry appropriate to the cartridge.

Projectile profile becomes particularly important. A semi-wadcutter may feed very differently from a round-nose projectile even when both weigh the same.

Where cast projectiles are loaded for an underlever rifle with a tubular magazine, projectile nose profile remains important.

I use a projectile design suitable for that magazine system. A flat or suitably blunt nose is normally appropriate for conventional centrefire tube-magazine use unless the projectile manufacturer specifically approves another design.

That is not merely a feeding preference. It is part of the safe cartridge design.

Cast-projectile ammunition often uses crimping more than precision rifle ammunition does.

A revolver cartridge may use a roll crimp into a crimp groove. A self-loading pistol cartridge may use a taper crimp mainly to remove the case-mouth flare while preserving the geometry needed for headspacing.

I use enough crimp to do the job. I don't regard maximum crimp as maximum reliability.

Many cast bullets are designed with a dedicated crimp groove. If the projectile and cartridge combination is intended to use that groove, seating depth and crimp become naturally linked.

Case length becomes more important because inconsistent case length can produce inconsistent roll crimp.

Do Not Use Crimp to Fix Poor Fit

A heavy crimp does not solve an undersized projectile, poor case expansion, inadequate neck tension, wrong seating depth or poor feeding geometry.

Crimping has a specific mechanical purpose. I don't use it to hide another setup problem.

Powder-coated projectiles can perform extremely well, but the coating needs to survive the loading process.

After seating a test cartridge, I may pull the projectile and inspect it. I don't want to see coating scraped away around the full circumference, deep cuts from the case mouth, heavy crimp damage or large bare patches.

If the coating is being destroyed during loading, I fix the case-mouth preparation or crimp rather than accepting it.

With conventional lubricated bullets, I want the lubricant to remain where it belongs.

Excessive handling or a poor seating setup can push or scrape lubricant out of the grooves. A small amount of displaced lubricant may be of no consequence, but a projectile arriving at the loading stage with its grooves largely empty deserves investigation.

If the projectile uses a gas check, I inspect the check before loading. It should be fully seated, square, firmly retained and undamaged.

The gas check is part of the projectile at this point.

The same development philosophy from Chapter 26 applies here.

I begin with appropriate cast-projectile data and establish a sensible starting load. I keep the other important variables constant.

If I am developing powder charge, powder charge is the variable. I don't simultaneously change projectile diameter, alloy, crimp, seating depth, lubricant and powder charge.

I plan the test before loading it. The exact charge increments depend on the cartridge and the published data. I don't impose one universal increment on every cast load.

I record projectile, alloy, final diameter, lubricant or coating, gas check where used, brass, primer, powder, powder charge, COAL, crimp and test identification.

For normal load development I still prefer five-shot groups. That gives me more information than three-shot groups without making every initial test unnecessarily large.

For pistol ammunition, the test distance and support arrangement should suit the firearm and intended application. For cast-rifle ammunition, I may begin at a shorter practical distance and then confirm farther out if the load is intended for longer-range use.

As always, I am interested in repeatability rather than one lucky group.

Cast projectiles are sometimes treated as though they are inherently crude. That is not true.

A correctly fitted, well-cast projectile loaded appropriately can produce excellent accuracy. The amount of precision needed depends on the application.

Leading is one of the main things I watch for during cast-projectile development.

Possible causes include projectile too small, poor throat fit, damaged projectile base, unsuitable lubricant, inappropriate alloy, excessive velocity for the combination, rough bore condition or gas leakage.

I don't automatically respond by making the alloy harder.

When working with a new cast combination, I check the bore during early testing rather than firing a huge quantity before looking.

I am especially interested after meaningful changes to projectile diameter, alloy, lubricant, coating or velocity.

If a combination is clearly depositing lead badly, I stop and correct it.

Leading appearing very early in the bore can sometimes point towards problems involving fit, gas leakage or the projectile entering the rifling. It is useful evidence, not an infallible diagnosis.

Leading Farther Down the Barrel

Leading that develops farther along the bore may suggest another set of issues, such as lubricant performance, projectile condition or the behaviour of the load as velocity increases.

A good powder coat can greatly reduce direct lead contact with the bore, but coating does not eliminate the need for correct projectile fit. An undersized coated projectile is still undersized.

If a gas-checked load leads or shoots poorly, I still investigate the complete combination rather than assuming the check must cure the problem. By this stage the check should simply be a known part of the finished projectile specification.

A chronograph is extremely useful when developing cast loads. I want to know what the ammunition is actually producing rather than relying only on published figures.

Velocity helps me compare the load with the intended operating range of the projectile, alloy, coating, gas check and firearm. As always, the chronograph does not directly measure chamber pressure.

If a cast load is already accurate and reliable at a sensible velocity, I don't necessarily gain anything by driving it harder.

Higher velocity can increase recoil, leading risk, stress on the projectile and sensitivity to small problems in fit or lubrication.

The alloy has to suit the application. A very soft projectile may not behave the same way at higher smokeless-powder velocities as it does in a traditional lower-velocity application.

Likewise, simply selecting a much harder alloy does not guarantee success.

If I am testing powder charge, I don't change the projectile alloy halfway through the test.

Changing alloy can alter hardness, diameter, weight, friction and how the projectile seals the bore. That is a completely different test.

If I suspect lubrication is limiting a cast load, I can compare lubricants, but I do that as its own controlled test.

I hold projectile, alloy, diameter, powder charge, seating and other meaningful variables constant. Then lubricant becomes the variable.

In more demanding cast-projectile work, final projectile diameter can itself become a development variable.

If the firearm and chamber safely allow it, comparing suitable adjacent sizing diameters can show whether the projectile prefers a particular fit.

Once I have a good basic cast load, I may make small controlled refinements to seating position or crimp where the cartridge design allows it and where there is a genuine reason.

For most pistol or revolver ammunition, if the load is safe, reliable, accurate enough, feeding and chambering correctly, and not leading excessively, I may already be finished.

In self-loading firearms, the load also has to operate the firearm reliably. A very mild load can be accurate but fail to cycle the action correctly.

A load that cycles beautifully but produces poor accuracy or excessive leading is equally unsuccessful.

For revolvers I check chamber fit, extraction, projectile movement under recoil, crimp performance and cylinder clearance.

For cast loads in an underlever rifle, I confirm magazine fit, safe projectile profile, feeding, chambering, extraction and cartridge length.

Cast projectiles can also be used for hunting where lawful and suitable for the quarry and firearm.

In that application I care about far more than the smallest group. The projectile needs appropriate construction, alloy, accuracy, velocity, terminal behaviour and reliability.

I don't assume the hardest possible alloy is automatically the best hunting alloy.

Accuracy Appropriate to the Job

Not every cast load needs to be developed to the last possible fraction of group size.

If an economical pistol practice load is safe, reliable, clean enough, not leading and more than accurate enough for the intended shooting, I don't need to treat it like an ELR rifle load.

For specialist cast-rifle competition, I may become far more demanding.

Many cast projectiles used with black powder look superficially similar to smokeless cast bullets, but the loading system is different.

Black powder brings different powder handling, different case-fill considerations, different lubrication requirements, fouling management and often different projectile-alloy priorities.

I don't simply take a smokeless cast load and replace the propellant with black powder. That is an entirely separate loading system.

I record enough detail to reproduce the projectile as well as the cartridge.

That may include mould, alloy, casting batch, projectile weight, final diameter, lubricant or coating, gas check, cartridge, primer, powder, powder charge, COAL, crimp, velocity, group result and leading observations.

My Practical Cast-Load Development Sequence

My normal approach is: choose a suitable cast projectile → confirm final diameter and condition → find appropriate published cast-projectile data → prepare the case so the projectile will not be damaged → establish seating and crimp → load an inert test cartridge and inspect it → choose a sensible starting charge → prepare clearly identified test ammunition → shoot controlled five-shot groups → chronograph where useful → inspect the firearm and bore for leading → identify a safe and accurate load → refine only if the intended use justifies it → confirm function and repeatability.

The central rule remains exactly the same as it was with jacketed ammunition: one meaningful variable at a time.

If I change powder charge, I leave the projectile setup alone. If I test projectile diameter, I hold the load constant. If I test lubricant, I don't simultaneously change alloy.

A successful cast-projectile load does not have to produce the fastest velocity or the smallest group ever fired.

It needs to do what I require: a mild, clean and accurate revolver load; reliable high-volume pistol ammunition; a traditional underlever load; an accurate gas-checked rifle load; or eventually a carefully prepared black-powder competition cartridge.

Once the load is safe, reliable, suitably accurate and operating without unacceptable leading or other problems, it may already be finished.

The next part of the book takes us into a different propellant system altogether: black powder and black-powder substitutes.

Chapter 35 — Understanding and Loading Black-Powder Cartridges

Specialist contribution by Terry Hibben

Black powder deserves its own section because it is not simply another propellant choice for an otherwise conventional smokeless-powder load. The firearms, cases, primers and cast projectiles may sometimes look familiar, but the way black powder is selected, measured, loaded and managed is sufficiently different that it must be treated as a separate loading system.

Black powder is also subject to specific UK licensing and storage requirements. Those requirements can change, so current legal guidance and the powder manufacturer's instructions take precedence over a book. Never mix black powder with smokeless powder, a substitute, another grade or another make in an attempt to create a personal blend.

Older firearms deserve particular caution. A cartridge may historically have been loaded with black powder, but that does not prove that a particular surviving firearm is safe to fire today. Age, corrosion, metallurgy, previous modification and condition all matter. If the firearm is not known to be suitable, it should be assessed by a competent person before use.

Terry Hibben's Practical Guide

This is a step-by-step guide to reloading black powder cartridges, BPCs, for use in firearms suitable for such and using the 45-70 as a base case – literally.

The principles, tools and components are the same for all cartridges any differences or considerations will be noted as we go along.

> *The basic information will be in straight text in the body of the document, there will be additional information given but in italics and greyed highlight – these are 'tid-bits' for you to think on either additional reading, general information or augmentations to your reloading process – the latter not necessary but to try as you progress.*

First a couple of points to understand:

- Black powder, BP, is classed as an explosive and behaves very differently from modern smokeless propellants such as Vihtavuori N140 or Bullseye.
- As such there are additional safety considerations which will be given.
- Black-powder loads are normally developed by volume rather than from the sort of charge-weight tables used for smokeless powder — more of this later.
- There are a couple more tools and components in addition to those you would normally have kicking round on your reloading bench – again these will be described as we go.

Cartridge components

Figure 35.1 — Components used in Terry Hibben's black-powder cartridge loading example.

Primers. There are no dedicated BP primers as such, so primer choice should be appropriate to the firearm, cartridge, powder and current authoritative guidance. In my own Black Powder Cartridge Rifle loading, e.g. .45-70, .40-65 etc., I have often used Federal Large Rifle Magnum primers. This describes my own practice, not a universal component recommendation. This primer was originally developed for use in the Weatherby Magnums and, in my experience, seems to set off BP more consistently. You can enlarge the flash hole in a .45-70 or similar case using a #41 or 3/32" (2.4 mm) drill, but you MUST permanently mark any case that has been modified so that it cannot later be confused with brass intended for smokeless loads.

Figure 35.2 — A case permanently marked to identify it as modified for dedicated black-powder use.

Brass. Again, modern brass is available, but you will not easily get the same amount of BP into the case as the original loading — e.g. 70 grains in a .45-70. This is because the original brass used a balloon-head design, as opposed to the heavier web construction of modern brass.

Powder. In Great Britain, black powder requires the appropriate explosives certificate. Storage, transfer and security requirements also apply, and Northern Ireland has separate arrangements. Regulations can change, so check the current official requirements for where you live. There are no load tables related to BP, it does though come in different 'grades' and this refers to the size of the BP grains, which starting from smallest is FFFFg (No.1), FFFg (No.2), FFg (No.3), & Fg (No. 1 ½). The two most common grades for BPCs are FFg & FFFg. Note that Swiss BP uses a different grading system, shown by the values in parentheses. FFg would normally be the choice for .45-70, while FFFg is commonly used in pistol-calibre BPCs. 'How much' you use will be explained later — the important rule to follow is no air gaps. The BP fills the case — and some.

Wads. More correctly termed over-powder wads, these are used as a barrier between the bullet's base and the BP. They play a part in compressing the powder and can be made from a variety of materials. The

wads can be purchased ready-made or made yourself using a wad punch of the correct size or a press-mounted wad cutter. The materials are varied. For a basic wad, either fibre gasket sheet in .04” or .06” thickness can be used, or HDPE of similar thickness.

Figure 35.3 — Press-mounted wad cutter used to produce over-powder wads.

The bullet. For BPCs, the bullet will be cast or swaged lead. We will stick with lubricated, grease-groove cast bullets here. The alloy will be a mixture of lead and tin. I would suggest a 20:1 ratio, by weight, for your bullets as a starting point. The bullet should be approx. .001” over land diameter – so in a 45-70 this would be .459. They must be lubed using a BP-specific product. Smokeless lubes will not work in the same way, as the BP lube helps to keep fouling soft between shots. NB you must ensure the lube grooves, ‘cannulas’, near the base of the bullet are fully filled, no air gaps otherwise the BP exploding can deform the base of the bullet to fill the air gap which will affect accuracy. There are also paper-patched bullets that can be used, but this is a different ball game — although interesting if you wish to go down that rabbit hole!

Figure 35.4 — Grease-groove and paper-patched black-powder projectiles.

Developing the load and the loading process

As per my initial notes, there are no load tables for BP, only the rule that the case should have no air gaps i.e. the loaded case is 100% full of BP. The reasoning for this is due to the fact that BP is an explosive so when it goes ‘bang’ if there is an air gap the explosion gains speed instantly and can head forwards, reaches the base of the bullet, which is a ‘lump’ in the way, and heads outwards – creating a ring in the chamber rendering the firearms useless – also potentially dangerous.

The first stage is to determine the height inside the case of the powder and wad column. I will describe the method for a single-shot BPCR like the 74 Sharps, but if you are loading for a lever gun or a cartridge with

a fixed overall length, you can skip this part. You simply subtract the bullet length from the COAL to arrive at the desired powder/wad column height.

For a single-shot rifle, you drop your chosen bullet into the open breech with the barrel pointing down. You then use your vernier callipers to measure the distance from the face of the chamber to the back of the bullet (see image). This distance is the final height of the powder and wad column. Now, if you measure the length of your bullet and add it to this length, you will have the LOA of the loaded round with the bullet just touching the lands. If you wish, you can add .010–.020" to these two measurements, as the closing of a falling-block action will cam the bullet into the lands. You can also buy bullet moulds with a reduced first driving band, which will ride up into the rifling and also allow you to get more powder into the case.

The next part of the process is a bit of trial and measurement. You have to determine the amount of powder you need so that, when it is 'dropped' into the case and the wad placed on top, the column is at the height you measured above. The best accuracy and a clean burn of BP are generally achieved with the powder slightly compressed. For pistol-size cases, .04–.06" would be a good starting point. For larger cases, .45-70, .45-90 etc., then at least 0.1" — you can try more compression during load testing.

To do this you will need a BP powder measure. These differ from standard powder measures in a couple of ways. It will have a metal powder hopper — no plastic to potentially develop static! It will also need a long drop tube, about 18". The drop tube helps the BP stack tightly into the brass, which improves accuracy, enables consistent compression of the powder column (more of this in a moment) and helps prevent any air gaps. Lyman make a BP version of their Ideal powder measure. BTW you do not need to weigh BP charges for rifles — it's just not necessary.

Figure 35.5 — Black-powder measure fitted with a long drop tube.

Taking one of your prepped cases (sized, neck expanded and primed), put a 'best guess' charge into the case to approximately the right height by eye. You can lay your bullet next to the case before doing this to

give an eyeball indication of the approximate amount of powder. Adjust your measure until you feel you are about right.

Now put a wad into the case and push it down until it just touches the top of the powder column. Use a piece of dowel, or similar, close to the case ID to ensure the wad is square; you will feel the wad come to a very noticeable stop when it reaches the powder.

Now measure this powder-and-wad column height and compare it with your measured or calculated height from the base of the case — it can be a bit fiddly with your vernier. If you can have someone turn you up a short metal bar, approx. 1” long with square ends, you can zero your vernier using this short rod. Then drop it into the case on top of the wad and measure the column height directly. You then increase or decrease the amount your measure drops until you reach the desired height.

You can now charge your cases and put the wad on top of the powder, pushing the wad into the case a short way. You will now need to compress the load. This can be done using the bullet and is effective in pistol-size cases, but for larger rifle cases a compression plug is used. This is set up in your press and adjusted to compress the powder-and-wad column to your desired height. Again, the short rod comes in handy for checking this, as you are measuring the actual column height from the base of the case, ignoring any variance in case length.

A point to consider here in your fired-case cleaning and prep routine. As you want to compress the whole powder column, if the inside of your case is dirty the stacked powder column can grip the inside of the case. During compression this can result in you only compressing the top half of the powder column = poor shot consistency and possibly fouling issues. So wash and clean the inside of your fired brass using a test-tube brush on a battery drill.

Once all the cases are charged and the powder compressed, you can seat the bullet, ensuring it touches the wad firmly — even with a small amount of additional compression, say .005”, just to make sure. If your seater-die plunger fits the tip of the bullet and you are using an FP bullet, you should see no issues with the soft lead bullet alloy. If you are using a more pointed bullet, such as a Snover or Money design, then the seater-plunger tip will probably deform the nose of the bullet a little. You can make a fitted plunger by putting a small pea-sized piece of radiator repair putty into the nose of the seater and seating a bullet — making sure you coat the bullet in a release agent of some sort — then leaving it to set.

Figure 35.6 — Additional BPCR tools: custom expander, powder-compression plug and column-measuring cylinder.

Top left custom expander, powder compression plug and in cartridge / callipers the column measuring cylinder.

If you are loading for a lever rifle, then remove the flare and apply a small crimp to the bullet — the crimp does not need to be heavy.

If loading for a single-shot rifle and the flared case will chamber, then leave the case flared. BP is an explosive, so is not reliant on neck tension. Additionally, the flare will scrape any fouling from the inside of the chamber and also help ensure the bullet is centred in the chamber.

Wipe off any bullet lube that might have ended up on the outside of the case and go and shoot the load.

If all goes well then you will see good repeatable results and have a rifle that is not only accurate but also easy to clean.

Figure 35.7 — Five shots at 100 m with Terry Hibben's developed BPCR load.

Chapter 36 — Cast Projectiles for Black-Powder Shooting

Once a cast projectile is intended specifically for black-powder use, the priorities begin to change.

The general casting process does not change. The mould still has to fill properly, the alloy still needs to be controlled, and the projectile still needs to be inspected, sized where appropriate and loaded without damage.

What changes is what I am asking the projectile to do.

- fit the throat and bore correctly;
- upset or obturate appropriately where the design relies on it;
- carry enough suitable lubricant to help manage fouling;
- remain dimensionally consistent over a long shooting string;
- and, in serious target shooting, remain stable and accurate at considerable distance.

That makes projectile choice a central part of black-powder cartridge development.

The most important thing is still fit. A projectile can be made from the “correct” alloy, have the right nominal weight and carry the right lubricant, but if the diameter is wrong for the firearm, the rest of the work may be wasted.

I want the projectile to suit the actual throat and bore rather than simply match the calibre stamped on the barrel.

- groove diameter;
- bore diameter;
- throat diameter;
- chamber transition;
- or cylinder throats in revolvers.

The relevant measurement depends on the firearm. The objective is to establish what the projectile actually needs to fit.

The mould produces an as-cast diameter. That is only the starting point. Different alloys can cast at slightly different dimensions from the same mould.

Before sizing, I measure representative projectiles. If the projectile is already at the useful diameter and sufficiently consistent, I don't automatically size it smaller simply because the equipment is available. Every reduction in diameter should have a reason.

Many traditional black-powder rifle projectiles use relatively soft lead alloys. That is very different from some smokeless cast-projectile applications where harder alloys may be useful.

- engrave the rifling more readily;
- deform appropriately under acceleration;
- work well with traditional long projectile designs;
- and in some applications help the projectile adapt to the throat or bore relationship.

Softness is not a universal answer. A projectile still needs to fit correctly before firing. I don't rely on a soft projectile to magically correct a poor dimensional match.

Pure lead is very soft and is widely associated with muzzle-loading projectiles, hollow-base designs, some traditional black-powder cartridge applications, and situations where substantial deformation or obturation is intended.

Its softness also means it can be easier to damage during handling, sizing, seating and transport. That makes careful tooling particularly important.

Lead and tin combinations are common in black-powder cartridge shooting. Tin improves castability and can sharpen driving bands, grease grooves, bases and fine mould detail.

It also increases hardness somewhat without producing the same sort of hardness increase associated with significant antimony content. Traditional ratios such as 20:1 or 30:1 lead to tin are often encountered. Those ratios describe parts by weight of the alloy.

Suppose I want to make a 20:1 lead/tin alloy.

20 parts lead + 1 part tin = 21 total parts

If I want a total batch of 10.5 lb, each part weighs:

10.5 ÷ 21 = 0.5 lb

Lead = 20 × 0.5 = 10.0 lb
Tin = 1 × 0.5 = 0.5 lb

The finished batch is therefore 10.0 lb lead + 0.5 lb tin = 10.5 lb of 20:1 alloy.

Another Example — 30:1

For a 30:1 alloy: 30 parts lead + 1 part tin = 31 parts total.

If I wanted to make 6.2 lb:

6.2 ÷ 31 = 0.2 lb per part
Lead = 30 × 0.2 = 6.0 lb
Tin = 1 × 0.2 = 0.2 lb

That gives me a repeatable alloy rather than adding tin approximately until the melt “looks about right.”

Antimony produces a much stronger increase in hardness than tin. It is extremely useful in many cast-projectile applications, but traditional black-powder rifle ammunition does not automatically benefit from a very hard antimony-rich alloy.

- resist deformation;
- respond differently to the throat;
- produce different fouling behaviour;
- and alter how the projectile enters the rifling.

That doesn't mean antimony is forbidden. It means the alloy needs to suit the application.

If a projectile leads, shoots poorly or fails to seal correctly, the answer is not automatically to make it harder.

Before changing hardness I consider projectile diameter, throat fit, groove diameter, base quality, lubricant, powder column, wad and overall load behaviour. Hardness is one variable.

BHN — Brinell Hardness Number

Brinell Hardness Number can be useful as a way of describing and comparing alloys, but I don't obsess over the exact number unless it has a practical purpose.

For traditional black-powder ammunition, the known alloy ratio may tell me more than chasing a single BHN figure. If a batch of 20:1 alloy performs well, I would rather reproduce that alloy accurately than spend time forcing every future batch to an arbitrary hardness number.

Measuring Projectile Hardness

When I am experimenting with different casting alloys, describing one batch as soft and another as hard is not particularly useful. If hardness matters to the load, I would rather put a number against it.

A lead-alloy hardness tester allows me to check a sample from the batch and gives me a repeatable reference that can be recorded alongside the alloy and projectile information. For cast projectiles, hardness is commonly expressed as BHN — Brinell Hardness Number.

I don't regard BHN as a target that every projectile has to achieve. Its real value is comparison. If a particular alloy and projectile combination performs exceptionally well, recording its measured hardness gives me another piece of information I can use when reproducing it later.

Types of Hardness Tester

There are several ways of testing lead-alloy hardness. Some purpose-built casting testers apply a known force to an indenter and allow the resulting impression to be measured. Other systems use spring-loaded or comparative arrangements and convert the result to an approximate BHN.

Examples a caster may encounter include Lee-style indentation testers, Saeco-type testers and other purpose-built lead-alloy hardness gauges. They do not all operate in exactly the same way, so I follow the instructions for the instrument being used rather than assuming one machine’s scale transfers directly to another.

The important things are repeatability and understanding what the instrument is actually measuring.

Hardness testing needs a suitable surface. I want the test area reasonably flat, clean, free from lubricant or coating, thick enough that the test is measuring the material rather than flexing it, and away from an obvious casting defect.

Trying to take a meaningful indentation reading from a curved projectile nose or directly over a grease groove is unlikely to produce the best result. I may therefore test a suitable flat sample cast from the same melt rather than damage one of my finished projectiles.

I wouldn't base an important conclusion on one indentation. Where the tester and sample permit, I make several sensible measurements and look for consistency.

For example, if three readings are 9.8 BHN, 10.1 BHN and 10.0 BHN:

(9.8 + 10.1 + 10.0) ÷ 3 = 9.97 BHN

For practical purposes I would record that batch as approximately 10 BHN. Pretending it is exactly 9.966666... BHN would add precision to the notebook that the measurement itself probably does not justify.

Hardness Can Change With Time

This is particularly important with alloys containing antimony. Some lead alloys can age harden after casting, so a measurement taken shortly after casting may not be identical to one taken weeks later.

Other treatments, including deliberate heat treatment or quenching with suitable alloys, can also affect hardness. If hardness is important enough for me to measure it, the age of the sample when tested is worth recording.

For example: Alloy batch BP-04 — tested 14 days after casting — average hardness approximately 10 BHN.

A hardness tester is particularly useful when I have an alloy of uncertain exact composition or when I am trying to reproduce a projectile batch that worked particularly well.

The tester cannot tell me that an alloy contains exactly a given percentage of tin and antimony. It is not a chemical analyser. What it can tell me is that one sample is measurably harder or softer than another.

A hardness tester is a quality-control instrument, not an accuracy tester. Two projectiles with identical BHN can behave differently because of differences in diameter, alloy composition, projectile design, base quality, lubricant, powder charge, throat fit and bore condition.

Likewise, a projectile with a different BHN may shoot better. The target still has the final say.

For someone doing a lot of casting, I think keeping reference samples is a useful habit. When I make an important alloy batch, I can cast a small suitable test sample from the same melt and label it with the date, alloy ratio, source materials and batch number.

Over time I can build a small set of reference samples such as pure lead, 30:1, 20:1 and any other alloys I actually use. That is much more useful than relying on memory for what each alloy was supposed to feel like.

Obturation describes the projectile deforming or expanding under pressure so that it more closely fits the bore or throat. This can be part of the way some black-powder projectile systems work.

I don't treat obturation as an excuse for poor projectile fit before firing. A correctly fitted projectile gives the load a much better starting point.

Many black-powder cartridge rifle projectiles are relatively long for their diameter. That affects stability, seating depth, powder-column space, grease-groove capacity and mould choice.

A long projectile can also be easier to seat crookedly. For serious target ammunition, straight seating becomes increasingly important.

Projectile weight affects recoil, trajectory, stability, velocity, powder-column arrangement and overall cartridge geometry. Heavy-for-calibre projectiles are common in traditional cartridges, but the heaviest projectile is not always best.

The firearm, twist rate and intended distance need to suit the projectile.

Just as with modern jacketed projectiles, a black-powder projectile needs sufficient rotational stability. The longer the projectile, the more twist rate becomes relevant.

A rifle that shoots a shorter traditional projectile perfectly may not stabilise a much longer heavy design. Many traditional rifles have relatively slow twists compared with modern long-range rifles, so I choose a projectile the barrel can realistically stabilise.

The nose profile can affect feeding, chambering, aerodynamic performance, overall length and how the projectile interacts with the throat.

For single-shot target rifles I may have considerable freedom. For underlever or repeating firearms, the projectile must also suit the action and magazine system.

Tubular Magazines

For conventional centrefire ammunition in a tubular magazine, I use a suitable flat- or blunt-nosed projectile unless another profile is specifically approved for that application. A pointed cast projectile does not become acceptable simply because it was made from lead.

Traditional black-powder projectiles often have substantial lubricant grooves. That is deliberate. The lubricant is helping manage fouling through the bore.

A projectile with insufficient lubricant capacity may perform well for the first few shots and then deteriorate as fouling builds. I am therefore asking whether the design carries enough of the right lubricant for the shooting string I intend to fire.

Useful lubricant capacity depends on groove design, projectile length, lubricant consistency, barrel length, fouling and shooting conditions. A load that works perfectly in a short barrel may behave differently in a much longer one because the lubricant has more bore to manage.

Black-powder lubricant needs to help keep fouling manageable. Traditional black-powder lubricants are often relatively soft. The exact formulation varies, but the important thing is that the lubricant is known to work with black-powder fouling.

I don't automatically transfer a hard smokeless cast-bullet lubricant into a black-powder load simply because it fits the grease grooves.

If fouling becomes hard and dry, the projectile entering behind it can experience a different bore condition from the previous shot. That can affect chambering, projectile deformation, velocity and accuracy.

Projectile lubrication and fouling management are therefore closely linked. Chapter 37 will deal with the complete shooting and cleaning routine.

Most traditional black-powder rifle projectiles are plain based. They do not rely on a metal gas check in the same way as many higher-velocity smokeless cast-projectile designs.

That makes base quality, fit, alloy, wad choice and powder-column behaviour especially important.

For precision black-powder shooting, the base is one of the places where I am most selective. I want complete fill-out, consistent edges, no tearing from an early sprue cut, no obvious void and no damage during handling.

Where the cartridge uses a wad, the relationship between powder, wad and projectile base becomes part of the load. I therefore do not randomly change wad material or thickness while simultaneously comparing projectile designs.

Sizing black-powder projectiles should have a purpose. I may size to establish a known diameter, improve uniformity, suit a particular throat or prepare the projectile for the cartridge.

If the projectile casts at the useful diameter already, unnecessary sizing may achieve nothing.

For some precision black-powder applications, shooters prefer minimal sizing or very light diameter reduction. The idea is to preserve the projectile as close as possible to the mould-produced form while still controlling fit.

That can work very well when the mould is appropriate, alloy is consistent and as-cast diameter is suitable.

A conventional lubrisizer can establish diameter and fill grease grooves. The same care with top-punch fit applies because a soft black-powder projectile can be marked surprisingly easily by an unsuitable punch.

Pan lubing is also well suited to some traditional black-powder projectiles and can fill large grease grooves without forcing the projectile through a conventional lubricator/sizer.

Powder coating is extremely useful in many smokeless cast-projectile applications, but it is not automatically the logical finishing system for traditional black-powder rifle ammunition.

Black-powder projectile lubrication often forms part of the fouling-management system. A polymer coating does not perform the same job as a traditional black-powder lubricant.

Seating Depth

Seating depth affects powder-column space, compression, wad position and how many grease grooves remain inside or outside the case. Projectile design and seating position therefore need to be considered together.

Black-powder target ammunition does not necessarily require heavy neck tension. Some shooters use relatively light neck tension or other controlled fitting arrangements. The amount needs to suit the firearm, projectile, cartridge and handling requirements.

Crimp requirements also depend on the firearm. A single-shot target rifle may need little or no crimp, while a revolver or repeating underlever may need considerably more projectile retention.

For normal recreational black-powder shooting, I don't think every projectile needs to be sorted obsessively. For serious long-range or competition work, sorting becomes more useful.

- visual quality;
- base condition;
- weight;
- diameter;
- and possibly cavity identity where a multi-cavity mould shows measurable differences.

Suppose a batch normally weighs around 535 grains and one projectile weighs 528 grains. I would want to inspect it.

535 − 528 = 7 grains

Percentage difference: 7 ÷ 535 × 100 ≈ 1.31%

A difference of about 1.31% is large enough that I would certainly investigate it in a precision batch.

If another projectile weighs 534 grains, the difference is 1 grain:

1 ÷ 535 × 100 ≈ 0.19%

Whether that matters depends on the application. For casual shooting, probably not. For serious long-range competition, a shooter may decide it is worth controlling more closely.

Weight consistency is easier to interpret if the alloy remains the same. Changing alloy changes projectile density and therefore weight. If I change alloy, I start a new reference.

At longer range, small inconsistencies have more time to appear on the target. This is where I become more interested in projectile weight, base quality, diameter, alloy, velocity consistency and fouling control.

A projectile can appear stable at short range yet show poorer behaviour farther out if it is marginally stabilised, which is another reason projectile length and twist rate belong in the selection process.

Where lawful and suitable, black-powder ammunition may be used for hunting. In that application I may want suitable terminal performance, appropriate alloy, enough accuracy for the realistic range, reliable function and dependable first-shot performance.

A projectile optimised to remain dimensionally perfect over a long target string is not automatically the ideal hunting projectile.

A black-powder load that chambers reliably, shoots accurately, manages fouling, maintains velocity sensibly and performs correctly for its intended purpose does not need another ten sorting operations simply because they are possible.

Measure something because the measurement helps you make a decision.

My Black-Powder Projectile Method

My normal approach is: choose a projectile design suited to the firearm and twist → select a sensible alloy → cast a consistent batch → inspect the bases carefully → measure as-cast diameter → size only as required → apply suitable black-powder lubricant → keep the batch identifiable → develop the cartridge around that known projectile → confirm the combination at the distance where it will actually be used.

For ordinary shooting, I stop when the ammunition is doing the job. For serious long-range competition, I may tighten the controls further. The important thing is that the extra work has a purpose.

At this stage we have the correct powder system, a suitable cartridge arrangement and a projectile designed and prepared for black-powder use.

The remaining challenge is keeping the firearm in a sufficiently consistent condition from the first shot to the last. Black-powder fouling can change the bore surprisingly quickly.

Chapter 37 — Fouling Control, Cleaning and Maintaining Black-Powder Consistency

Black-powder ammunition can be beautifully consistent at the loading bench and still perform poorly if the condition of the bore changes significantly from one shot to the next.

That is one of the fundamental differences between black-powder shooting and most modern smokeless-powder shooting.

With black powder, fouling management can become part of the shooting process itself.

The objective is not necessarily to make the bore perfectly clean after every shot. It is to create a sufficiently repeatable bore condition that each projectile encounters something similar to the one before it.

A rifle that shoots exceptionally well from a particular lightly fouled bore may not benefit from being scrubbed completely clean between every shot. Equally, allowing fouling to accumulate uncontrolled may eventually change chambering, velocity and accuracy.

The correct routine depends on the firearm, ammunition, conditions and type of shooting.

When black powder burns, it leaves considerably more solid residue than modern smokeless propellant.

That residue can remain in the bore, throat, chamber, action, case and other areas exposed to combustion gases.

Its physical condition can change surprisingly quickly. Fresh fouling may initially be relatively soft. As it dries, particularly in certain atmospheric conditions, it can become harder.

This means that the bore presented to shot number ten may be quite different from the bore presented to shot number two. For precision shooting, that difference matters.

The presence of fouling does not automatically mean something has gone wrong. Black-powder firearms have operated with fouling for centuries.

The problem is uncontrolled or changing fouling.

If the first shot passes through one bore condition and the tenth through another substantially different one, I should not be surprised if the point of impact or group behaviour changes.

My objective is therefore not simply to remove fouling. It is to control fouling sufficiently to maintain repeatable shooting conditions.

Several things can affect the amount and condition of black-powder fouling.

- powder type and granulation
- powder quantity
- combustion
- projectile lubricant
- lubricant quantity
- barrel length
- bore condition
- temperature
- humidity
- time between shots
- the fouling-management routine itself

That is why a load that behaves perfectly on one day can sometimes require more attention under different conditions.

Atmospheric conditions can have a noticeable influence on black-powder fouling. On a humid day, fouling may remain relatively soft for longer. In hot, dry conditions it may dry more rapidly and become harder.

This is one reason I don't automatically assume that a load which deteriorates during a summer shooting session has suddenly developed an ammunition fault. I consider the conditions as well.

For serious testing I record at least the broad environmental conditions. I don't need a laboratory weather station to write ‘warm and dry’ or ‘cool and humid’. That information can become surprisingly useful later.

Chapter 36 explained why black-powder projectile lubricant has a different job from many conventional smokeless cast-projectile lubricants. This is where we see the practical result.

A suitable lubricant can help keep fouling manageable as successive projectiles travel through the bore. The lubricant therefore needs to work for the whole shooting string, not merely make the first projectile easy to fire.

A combination that produces excellent first-shot accuracy but leaves increasingly hard fouling may not be the best combination for competition.

More Lubricant Is Not Automatically Better

As with so much in reloading, the answer is not simply to add more. The projectile needs an appropriate lubricant and sufficient useful lubricant capacity for the application.

Excessive lubricant can create its own problems with handling, contamination, cartridge storage and consistency. I am looking for enough of the right lubricant to perform the required job.

With some conventionally lubricated black-powder loads, shooters may observe a deposit or lubricant/fouling star around the muzzle.

This can provide useful information that lubricant is being carried through the full length of the bore. I regard it as an observation rather than a pass-or-fail test.

A perfect-looking star does not prove that the load is accurate, and the absence of one does not by itself diagnose a problem. As always, I combine what I see with what happens on the target.

During a shooting session, I can broadly think of fouling management in three ways: shooting without deliberate between-shot treatment; using moisture from a blow tube or similar established technique; or physically wiping the bore between shots.

Different firearms and disciplines favour different approaches. There is no prize for using the most elaborate method. I use the simplest routine that keeps the rifle performing consistently enough for its intended purpose.

Some black-powder ammunition and firearms can maintain acceptable accuracy through a useful string without wiping between every shot. This is particularly desirable in applications where speed of follow-up shots matters or where wiping is simply impractical.

For that to work well, the complete system needs to manage fouling effectively. That includes powder, projectile, lubricant, bore and environmental conditions.

If accuracy remains stable, chambering remains normal and the firearm is functioning correctly, I don't introduce an elaborate wiping routine simply because another shooter uses one.

Blow tubes have traditionally been used in some black-powder cartridge rifle disciplines to introduce moisture into the bore between shots. The principle is to help prevent fouling from becoming excessively hard and dry.

A blow tube is normally inserted appropriately at the chamber end and moisture from the shooter's breath passes through the bore.

The method can work, but the amount of moisture introduced can vary with number of breaths, duration, the shooter, temperature and humidity. If I use a blow tube during load testing, I treat the routine as a variable and keep it as consistent as practical.

In very dry conditions, fouling may harden rapidly. A routine that keeps the bore sufficiently consistent on a cool, humid day may not do so on a hot, dry afternoon.

If groups begin to deteriorate as the string progresses, I consider whether the fouling-management method is still adequate for the conditions. I don't immediately alter the ammunition.

For precision black-powder cartridge rifle shooting, wiping between shots can provide very good control of bore condition.

The principle is straightforward: remove or soften enough fouling to return the bore to a repeatable condition before the next shot.

The exact routine varies. A shooter may use an appropriate damp patch followed by another patch, or another established routine suited to the firearm. What matters most to me is consistency.

If I decide to wipe between every shot, I establish a procedure.

- patch material
- patch size
- amount of moisture
- wiping solution
- number of passes
- whether a dry patch follows
- rod/jag arrangement
- approximately how long the routine takes

I don't need to turn this into a ritual for its own sake. But if I am trying to compare two loads accurately, I don't wipe one group carefully after every shot and then fire the next group with a completely different bore routine. I would no longer be comparing only the ammunition.

Wet Does Not Mean Soaking

When using a damp patch, more liquid is not automatically better. I want enough moisture to perform the intended fouling-control job. I don't want unnecessary liquid running into areas where it does not belong. The chamber deserves particular attention.

A wiping routine aimed at the bore should not leave the chamber unnecessarily wet. The cartridge case needs to function correctly in the chamber.

Excess liquid can also make the next round unpleasant to handle and introduces another uncontrolled variable. After the wiping operation, I make sure the chamber is in the appropriate condition before loading the next cartridge.

Good equipment makes a repetitive process easier. A suitable wiping rod, jag and patches should fit the firearm properly without damaging the crown, chamber, throat or rifling.

Where appropriate, a bore guide or other suitable guide system can help keep the rod aligned. This is especially worthwhile when the operation may be repeated dozens of times during a competition.

A cleaning procedure should not gradually damage the rifle it is supposed to maintain.

There are numerous traditional and commercial approaches to black-powder wiping solutions. For the purposes of this book, I don't think we gain anything by providing a catalogue of recipes.

The useful requirement is simpler. I want a solution appropriate for softening and removing the fouling produced by the propellant I am using, applied in a controlled and repeatable manner.

Plain water or water-based cleaning methods are widely effective with traditional black-powder residue because much of that residue is water soluble. Other suitable products and mixtures are also used.

If I use a black-powder substitute, I check the manufacturer's cleaning guidance because its residue may not behave identically to genuine black powder.

A completely clean barrel does not always put the first shot in exactly the same place as subsequent shots from the established shooting condition. That is not unique to black powder, but it can be particularly noticeable here.

If the rifle consistently puts its first clean-bore shot somewhere different and then settles into a stable group, I want to know that.

For appropriate target shooting, a fouling shot may sometimes be used before the recorded string where the rules and circumstances permit. The important thing is to establish the rifle's behaviour rather than assume the first shot will match the rest.

This becomes particularly important for a firearm intended to fire its first shot from a clean bore. A hunting rifle, for example, may have a completely different practical requirement from a target rifle where fouling shots are permitted.

If the first shot matters, I test the first shot. I don't zero from an established fouled bore and simply assume the clean-bore impact is identical.

For serious load development, a simple note can be extremely useful: clean bore; one fouling shot; wiped between shots; or no wiping — ten-shot string.

That gives context to the group. Without it, I may later compare two targets that were actually fired under substantially different bore conditions.

Fouling can disguise itself as an ammunition problem. Before rebuilding a perfectly good load, I look at when the problem develops.

The pattern through the string can tell me more than the final group size alone.

First Shots Group Well, Then the Group Opens

If the first several shots group tightly and later shots begin spreading, I investigate fouling.

Possible areas to examine include lubricant performance, fouling hardness, wiping routine, environmental conditions and whether the bore condition is changing progressively.

That doesn't prove fouling is the cause. But it gives me a sensible place to look before changing powder charge.

If cartridges that chamber freely at the start of the string become increasingly difficult to chamber, I stop and investigate.

Fouling around the chamber, throat, case mouth area or beginning of the rifling may be contributing. I don't force cartridges into a progressively tighter chamber simply to finish the group.

Increasing vertical dispersion can have many causes. Velocity variation is one. Changing bore condition is another possibility.

If the first half of a string is vertically tight and the second half begins walking or opening, I compare chronograph data, fouling condition, shot timing, environmental changes and my shooting technique.

The correct response is diagnosis, not immediately adding or removing powder.

If the first shot from a clean barrel repeatedly lands away from the following group, that is useful information. I confirm whether the pattern is repeatable.

One unexplained first-shot flyer tells me very little. The same behaviour over several separate clean-bore tests tells me much more.

If accuracy suddenly deteriorates, it can be tempting to immediately clean the rifle completely. Before doing so, I take a moment to observe what is happening.

I may look at the bore, muzzle fouling, chamber, patches, fired cases, target sequence and chronograph results. Once everything has been scrubbed clean, some of that evidence has disappeared.

Fouling Management During Load Development

When developing the ammunition, I decide on the fouling routine before firing the comparison groups.

If I am testing powder compression, for example, I keep the wiping routine constant. If I am testing lubricant, then lubricant is the variable.

If I simultaneously change lubricant and wiping method, I may get a better group without knowing which change caused it. The same basic development discipline we used for smokeless ammunition still works perfectly here: one meaningful variable at a time.

Eventually I may deliberately test the fouling routine itself. Once I have a good ammunition combination, I can compare, where appropriate, no wiping, blow-tubing, one wiping routine or another sensible routine.

Then the ammunition remains constant and fouling management becomes the variable. That is a much cleaner experiment.

Time between shots can matter because fouling is not static. If I fire one shot and reload immediately, the fouling may be in a different condition from a shot fired after several minutes.

This can become particularly noticeable in hot, dry conditions. For serious testing, I try to maintain a reasonably representative rhythm.

There is little value developing a load using an artificially frantic firing schedule if competition shooting will involve much longer intervals.

The firearm is not the only thing exposed to fouling. Fired cartridge cases can also contain substantial residue.

I prefer not to leave dirty black-powder cases sitting for long periods unnecessarily. How quickly I deal with them depends on the shooting situation, but they are normally cleaned considerably sooner than I might worry about ordinary lightly fouled smokeless brass.

Some shooters place fired cases into an appropriate container or cleaning solution relatively soon after firing. Others transport them dry and clean them promptly afterwards. Both approaches can work when done sensibly.

What I avoid is putting damp, dirty cases into a sealed container and then forgetting about them for a week. The aim is to prevent residue and moisture being given unnecessary time to attack the brass.

Depending on my process, I may deprime black-powder cases before their main cleaning. That allows cleaning solution to reach the primer pocket and flash-hole area more easily.

If I do this at the range, I use appropriate equipment and maintain normal primer-handling safety. If I do it at home, I still do not leave the cases dirty indefinitely before getting around to it.

Traditional black-powder fouling responds very well to water-based cleaning. This sometimes surprises shooters accustomed to thinking that every firearm-cleaning problem requires an aggressive solvent.

For black-powder residue, water can be an extremely effective part of the cleaning process. Warm water may make the operation easier.

What matters afterwards is equally important: the firearm and cases must be dried properly.

The exact method can vary. The objective is to remove residue from the case interior, mouth, primer pocket where required and external surfaces.

Depending on my equipment, the cases may subsequently go through another cleaning process to restore them fully. I inspect them afterwards. A shiny case is not automatically a sound case. I still look for the normal signs of case deterioration.

Before cases go back into storage or anywhere near a new powder charge, they need to be dry. That includes the interior.

Moisture trapped inside a case can create corrosion, contamination and obvious problems during the next loading cycle. I don't judge dryness solely by whether the outside feels dry.

End-of-Day Firearm Cleaning

Range fouling management and final cleaning are two different jobs. Wiping between shots is about maintaining a shooting condition. End-of-day cleaning is about removing combustion residue and protecting the firearm.

When I finish shooting black powder, I clean the firearm appropriately rather than treating it like a modern smokeless rifle that can simply be put away after a few rounds.

I think beyond the visible bore. Depending on the firearm, black-powder residue may reach the bore, chamber, breech, action, extractor, cylinder, ignition components on other black-powder firearm types and external metalwork near escaping gases.

The firearm design determines what needs attention. I follow appropriate disassembly and manufacturer guidance rather than taking mechanisms apart unnecessarily.

If water has been used, the metal needs to be dried thoroughly. I pay particular attention to places where moisture can remain hidden.

Once dry, appropriate corrosion protection can be applied. Water is excellent at removing suitable residue. Water left trapped against steel is not a storage treatment.

Once the firearm is clean and dry, I use an appropriate protective product on the surfaces that require it.

Before the firearm is shot again, I consider whether any protective oil or other product in the bore needs to be removed. Again, I want the starting bore condition to be known.

With a valuable black-powder firearm, particularly one I have cleaned after a long shooting session, I like the idea of inspecting it again after storage has begun rather than assuming the job is finished forever.

A quick later inspection can reveal missed residue, moisture or early corrosion before it becomes a significant problem. This is especially worthwhile with older firearms.

Substitutes deserve their own cleaning instructions. I don't assume black-powder substitute means exactly the same fouling and exactly the same cleaning procedure.

Some substitute residues can be particularly demanding if neglected. I follow the propellant manufacturer's current recommendations.

Cleaning Is Not Load Development

There is a danger of endlessly changing the cleaning routine to chase every poor shot. I avoid that.

First I establish a sensible, repeatable routine. Then I evaluate the ammunition. If the evidence shows that bore condition is deteriorating through the string, I investigate fouling management deliberately.

This prevents the cleaning rod becoming another random variable.

When a black-powder load starts behaving badly, I work through the problem approximately like this:

- Did the first shots perform normally? If yes, look for something that changed through the string.
- Is chambering becoming harder? Inspect chamber and throat fouling.
- Is the group progressively opening? Consider changing bore condition, lubricant and environmental conditions.
- Is vertical increasing? Compare chronograph data with bore condition and shooting rhythm.
- Is the first clean-bore shot consistently separate? Test clean-bore versus established fouled-bore behaviour deliberately.
- Did the weather change significantly? Consider whether the fouling routine still suits the conditions.

Only after that do I start changing ammunition components without evidence.

For a precision black-powder rifle, my basic approach is: start from a known bore condition → establish whether a fouling shot is required → use one consistent between-shot routine → keep the chamber appropriately dry → maintain a sensible shooting rhythm → watch chambering and target behaviour → record environmental conditions where useful → change the routine only deliberately → clean the firearm and cases properly after shooting → dry and protect the firearm → inspect it again later if appropriate.

The exact wiping method may change from rifle to rifle. The principle does not: repeatable bore condition produces more useful information than random cleanliness.

A successful black-powder combination is not merely one that produces a small three-shot group from a freshly cleaned barrel. I want to know what it does through a realistic shooting string.

A good system should give me the combination of accuracy, manageable fouling, reliable chambering, consistent velocity, predictable bore condition and a practical shooting routine.

Once I have that, I record it. There's no need to make the process more complicated simply because additional techniques exist. The target remains the final test.

We have now taken black-powder ammunition through the complete process: understanding and loading the cartridge → choosing and preparing the cast projectile → controlling the condition of the firearm while shooting → cleaning and preserving the equipment afterwards.

That gives black powder enough space to be treated properly without turning the entire book into a specialist black-powder manual.

The next part of the book returns to modern metallic-cartridge reloading and asks a different question: once we can already make good ammunition, which additional operations can genuinely make it better?

Chapter 38 — Sorting Brass: Weight, Capacity and Lot Control

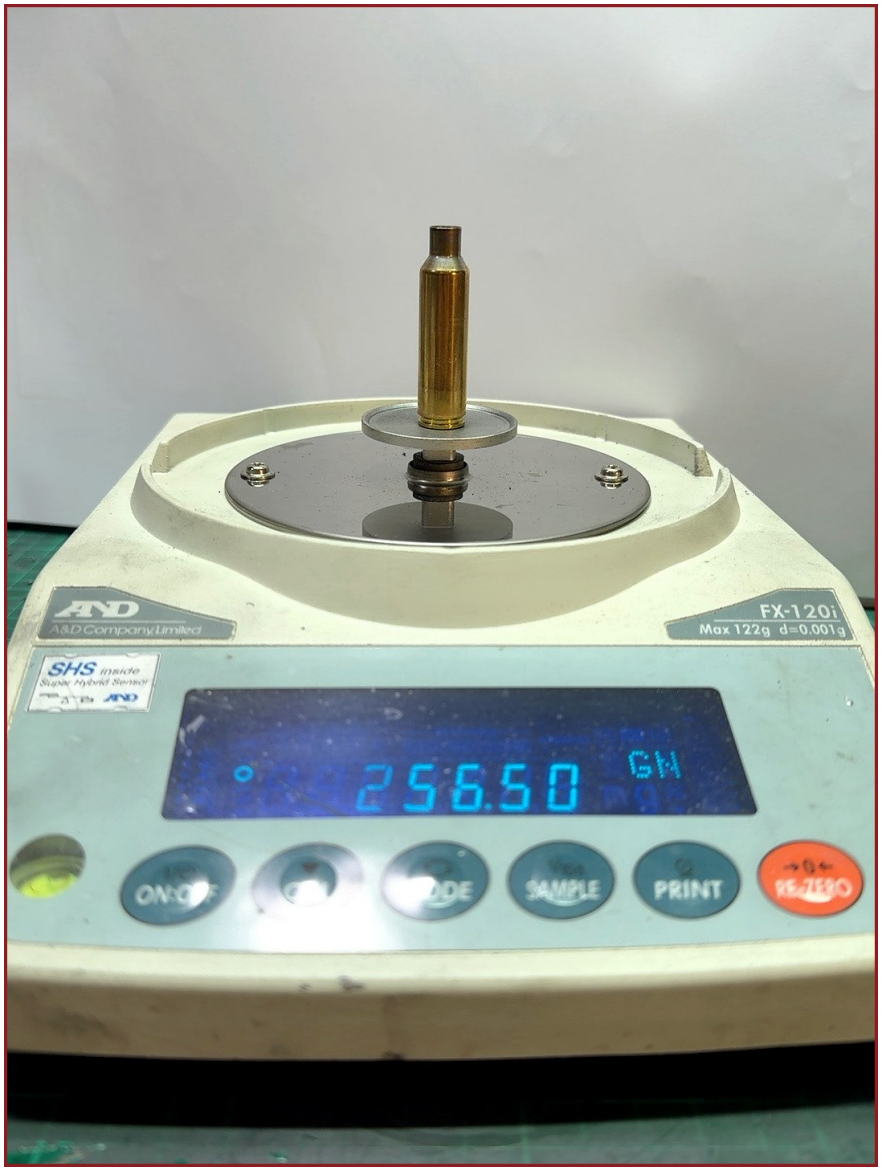


Figure 38.1 — *A cartridge case being weighed on a precision balance as part of batch sorting.*

By this point in the book, we can already make good ammunition. Brass sorting belongs in the advanced precision section because it is an optional way of reducing small sources of variation, not a basic requirement for safe or accurate reloading.

For most hunting, sporting and general target ammunition, good brass from the same make and lot, prepared consistently, is normally more than adequate. I become interested in tighter sorting when I am trying to reduce small variations in disciplines such as F-Class, Benchrest, ELR or other long-range precision shooting.

The question is not simply, “Can I measure this?” It is, “Will measuring it help the ammunition do its job?”

Before weighing individual cases, I control the obvious variables. For serious ammunition I prefer cases from the same manufacturer and, where practical, the same production lot. Different makes—and sometimes different production lots—can vary in wall thickness, head construction, hardness, weight and internal volume.

I also keep the case history together. Cases with substantially different numbers of firings, annealing histories, trimming or neck-turning status are no longer a genuinely matched batch simply because they originally came from the same box.

My useful starting point is therefore simple:

- same manufacturer and lot where practical;
- same number of firings;
- same preparation and annealing history;
- and sound cases that have passed normal inspection.

If that already gives me the consistency I need on the target, I may go no further.

Case weight is quick to measure and useful for identifying obvious outliers. I weigh cases only when they are in the same prepared condition—clean, dry and at the same stage of trimming and preparation.

A difference in case weight tells me that the amount of brass is different. It doesn't tell me where that extra brass is. Two cases can weigh very similarly while distributing that brass differently, so weight is best treated as a screening tool rather than a direct measurement of internal volume.

Suppose five prepared cases weigh 169.8, 170.1, 169.9, 170.3 and 169.9 grains.

169.8 + 170.1 + 169.9 + 170.3 + 169.9 = 850.0 grains

850.0 ÷ 5 = 170.0 grains average

The heaviest is 170.3 grains and the lightest 169.8 grains, giving a total spread of 0.5 grain. I don't need to create tiny sorting bands automatically; the useful question is whether there are meaningful outliers and whether the intended shooting justifies separating them.

For precision work, internal capacity can be more directly relevant than total case weight because the propellant burns inside the available case volume. Cases with different internal capacities can behave differently with the same load.

A common comparison method is to measure how much water a case holds. Capacity is then expressed as grains of water, usually written as grains H_2O.

The Calculation

Figure 38.2 — *Water filled to a repeatable level at the case mouth. The visible convex meniscus shows why the fill endpoint must be kept consistent during water-capacity comparison.*

If an empty case weighs 170.0 grains and the same case, filled consistently with water, weighs 226.5 grains:

226.5 − 170.0 = 56.5 grains H_2O

So the measured capacity is 56.5 grains H_2O. This is a capacity measurement only. It doesn't mean the case should contain 56.5 grains of powder.

The value of H_2O testing comes from repeatability. I choose one method and use it throughout the batch. In particular I keep the following consistent:

- fired or resized case condition;
- spent primer left in place or a consistent method of sealing the primer pocket;
- the fill level at the case mouth;
- freedom from trapped air bubbles;
- and clean, dry cases before the empty weight is recorded.

A fired case has expanded to the chamber while a resized case has been mechanically changed again, so I don't mix the two conditions in one comparison. Likewise, a trapped bubble or inconsistent meniscus can create an apparent capacity difference that is only a measuring error.

Normal workshop changes in water temperature are generally less important than a poor filling technique. For practical reloading, consistency of method matters more than turning the exercise into laboratory metrology.

I normally begin with a representative sample rather than measuring hundreds of cases automatically. If the sample is very uniform, there may be little reason to go further. If it shows obvious variation, more detailed checking may be worthwhile.

For example, if most cases measure around 56.5 grains H_2O and one repeatedly measures 55.7 grains, I would inspect that case and probably keep it out of a serious precision batch until I understood the difference.

Weight and capacity can also be considered together. A noticeably heavier case with lower internal capacity may simply contain more brass occupying the available volume, but the relationship is not exact enough for me to calculate capacity from weight. If I need capacity information, I measure capacity.

Capacity, Pressure and Changing Brass

Internal capacity is one reason I treat a change of brass manufacturer—or a substantially different lot—as a genuine component change. The same powder charge can behave differently in a case with different available volume.

I don't use an H_2O figure to invent my own maximum powder charge. Published loading data remains the foundation. Capacity measurement helps me compare cases and understand why a new brass lot may not behave exactly like the old one.

If I change brass in a developed load, particularly one towards the upper end of appropriate published data, I confirm the load again rather than assuming the old setting transfers unchanged.

I am most likely to spend time on detailed brass sorting when I am:

- shooting at long range where small velocity differences can show as vertical;
- maintaining a high-level F-Class, Benchrest or ELR batch;
- comparing manufacturers or production lots;
- introducing a new batch of brass into an established load;
- or troubleshooting unexplained velocity or accuracy variation.

For stalking, sporting or general target ammunition that already performs comfortably inside the required standard, detailed H_2O sorting may provide no useful return at all.

The best way to find out is to test it. I can compare a normal same-lot batch with a carefully capacity-sorted batch while keeping the rest of the load and test method the same. I then compare chronograph results and, where appropriate, group size and longer-range vertical.

If the sorted cases produce no useful improvement, I have learnt something valuable: that operation may not be worth my time for that rifle and load. A difference visible on a scale does not automatically become a difference visible on the target.

Once I have created a matched batch, I keep it identifiable through firing, cleaning, annealing, sizing and subsequent loading cycles. There is little point carefully sorting brass at home and mixing it together again after the first firing.

For a serious batch I may record the manufacturer and lot, number of firings, annealing and trimming history, neck-turning status, representative case weight and H_2O capacity, and any rejected cases. The record only needs enough detail to let me understand and reproduce the batch later.

My approach is progressive:

same manufacturer → same lot → same history → inspect → sample the batch → weigh or measure capacity only when the application justifies it → remove genuine outliers or create useful matched groups → test whether the extra sorting improves the ammunition.

That keeps advanced case preparation in proportion. I don't measure every possible variable merely because I own the equipment.

Sorting measures and selects the brass. The next advanced operation physically changes it: neck turning.

Because neck turning removes material, I want a clear reason for doing it before the cutter touches the case. Chapter 39 therefore looks at when neck turning is useful, when it is unnecessary, how much material should be removed, and how chamber clearance and neck-wall consistency influence the decision.

For serious match ammunition I also treat the brass as a batch with a history, not just a collection of individual cases. I keep the same manufacturing lot together, record firings and watch attrition. If a mature match batch loses cases, I don't casually replace them with brand-new cases and pretend the batch is unchanged. New brass can be brought into service as a separate batch and proven in its own right. Eventually a batch may still be perfectly serviceable for practice or less demanding work while no longer being the batch I choose for an important match. That is not a fixed firing-count rule; it is a judgement based on inspection, consistency and what the ammunition is being asked to do.

Chapter 39 — Neck Turning: When, Why and How

Figure 39.1 — *A real powered neck-turning setup with cases, measuring equipment and tooling arranged for batch work.*

Neck turning is closely associated with precision reloading, but that does not mean every precision cartridge needs it.

Unlike measuring or sorting brass, neck turning physically removes material. Once that brass has been cut away, it cannot be put back.

So before I reach for the neck turner, I want to know why I am doing it.

For me, there are two main reasons. The first is a cleaning cut to improve the uniformity of case necks that show enough variation to make the operation worthwhile. The second is preparing brass to a particular specification for a tight-neck chamber.

They are different jobs. For my normal cleaning cut, I generally aim to clean up approximately 80% of the neck surface. I'm not trying to make every part of the neck perfectly shiny. For a tight-neck chamber, however, the chamber specification determines how much material needs to be removed.

Case neck walls are not always exactly the same thickness around their circumference. One side may be slightly thicker than another. A neck-turning tool removes material from the outside of the neck while a cutter pilot supports it internally.

The aim is to make the neck wall more uniform or, where required, produce brass suitable for a particular tight-neck chamber. It is a precision cutting operation, but it does not need to become unnecessarily complicated.

Good modern brass can be remarkably consistent straight from the box. Before turning an entire batch, I check representative cases with a suitable ball or tubing micrometer and take several measurements around each neck.

If the variation is already very small and the rifle is performing well, I may leave the brass alone. That is particularly true with a factory or modern no-turn chamber. Buying a neck turner does not create a requirement to use it.

If the measurements show worthwhile high and low areas around the neck, a cleaning cut becomes much easier to justify.

For normal precision brass where I am turning for improved uniformity rather than to meet a tight-neck specification, my target is approximately 80% surface clean-up.

That means I expect the cutter to touch most of the neck while leaving some of the lowest areas visibly untouched. The cutter removes the high spots first. Once approximately 80% of the surface has cleaned up, I have usually achieved what I wanted without unnecessarily thinning the whole neck.

I don't continue cutting merely to make the remaining 20% shiny. A completely bright, fully machined neck may look satisfying, but appearance is not the objective.

The objective is a sufficiently uniform neck while retaining as much brass as practical.

A tight-neck chamber is different. Here, I may need the finished brass to meet a particular specification so that the loaded cartridge has the intended clearance in the chamber. In that situation I work to the chamber and ammunition specification rather than stopping at an arbitrary percentage of surface clean-up.

For most readers the distinction is simple: factory or no-turn chamber — neck turning is optional and, where useful, normally a light cleaning operation. Tight-neck chamber — neck turning may be necessary and is performed to the required specification.

Neck-Turning Mandrels Are Different

It is important not to confuse the mandrels used to prepare cases for neck turning with the mandrels used earlier in the book to establish final neck tension.

For neck turning, I normally use a dedicated neck-turning expander that opens the neck slightly over calibre size so that it will fit correctly over the cutter pilot in the neck-turning tool. This is a tooling operation; I'm not trying to establish final neck tension at this stage.

The neck-turning expander and cutter pilot are intended to work together as a system, so I use the sizes recommended for that particular neck-turning tool rather than substituting my normal neck-tension mandrel simply because it is marked for the same calibre.

Before turning, I want the neck clean, reasonably round, free from significant burrs or damage, and prepared to fit the cutter pilot correctly.

The dedicated neck-turning expander gives me a consistent internal neck condition before the case goes onto the cutter pilot. That makes the actual turning operation much more repeatable.

When I run the case over the neck-turning expander, I use a small amount of suitable sizing wax. Only a light film is required.

The purpose is to reduce friction as the expander passes through the neck and give me a smooth, controlled operation. Too much wax simply creates mess and gives me more to remove afterwards.

I also keep the expander clean. If brass or old lubricant begins accumulating on it, I clean it rather than continuing through the batch.

Once the neck has been expanded correctly, the case moves onto the cutter pilot of the neck-turning tool. The fit should be appropriate for that tooling system.

I don't force a case onto a pilot that is obviously too tight. If something does not feel right, I check the expander, cutter pilot, cleanliness and lubrication rather than applying more force.

For the actual turning operation, I use proper neck-turning oil. This is separate from the wax used on the neck-turning expander.

The turning oil lubricates the case and cutter pilot during the cutting operation, helping prevent galling while giving a smoother, more consistent feel. I use enough to keep the operation properly lubricated without drowning the cutter or case, and reapply it as required during a larger batch.

So the lubrication sequence is straightforward: expanding operation — light sizing wax; neck-turning operation — neck-turning oil.

Initial Cutter Setup With a Feeler Gauge

Before making the first proper cut, I like to establish the cutter position close to where it needs to be without relying entirely on guesswork. Where the design of the neck turner allows it, a clean spark-plug-style feeler gauge provides a simple initial reference between the cutter and the pilot or the appropriate tooling reference.

I use the feeler gauge only to get the initial setting close and repeatable. It is not the final authority on finished neck-wall thickness. The brass itself is still proved on setup cases and measured after cutting with suitable measuring equipment, such as a ball or tubing micrometer.

I start with the cutter backed off, establish the approximate cutter-to-pilot relationship with the gauge, secure the adjustment, and make a very light test pass on a prepared case. I inspect where the cutter has touched and measure the result before moving the cutter any farther in.

From there I make only small controlled adjustments. For my normal cleaning cut I work towards approximately 80% surface clean-up rather than chasing every low spot. For a genuine tight-neck chamber, the known chamber and finished-cartridge dimensions determine the cut instead.

The feeler gauge therefore gets the tool close at the beginning; measurement of the turned case proves the final setting.

I always begin conservatively. The first cut is light. I inspect what the cutter has touched, make a small adjustment if necessary and repeat.

For my cleaning cut, I gradually work towards approximately 80% surface contact. Once I reach that point, I stop chasing the remaining low areas.

IMPORTANT

Neck turning is a one-way operation. I can always take another light cut. I cannot put brass back after cutting too deeply.

The cut itself tells me something about the brass. If a light pass touches nearly all the neck immediately, the neck was already quite uniform. If the cutter removes material heavily from one side while leaving much of the opposite side untouched, the original neck had more variation.

For my normal cleaning operation, I stop at roughly 80%. The remaining untouched patches are not necessarily a fault; they are simply the low areas I chose not to chase.

The Neck/Shoulder Junction

Figure 39.2 — *A close view of the neck/shoulder junction with a witness mark used to show where the turning cut reaches the junction.*

The bottom of the neck deserves care. I want the cutter to reach the neck/shoulder junction appropriately without digging unnecessarily into the shoulder.

I don't want to leave an obvious unwanted ridge immediately above the shoulder, but neither do I want to machine a deep groove into it. This is something I establish on my setup cases before processing the full batch.

Repeated firing and sizing can sometimes produce an internal thickening near the neck/shoulder junction, commonly called a doughnut. It can matter if the projectile bearing surface reaches that area because it may interfere with seating or produce an unwanted change in neck tension.

Outside neck turning can interact with this area, but I don't assume that more outside turning automatically fixes an internal doughnut. If I suspect one, I diagnose it first.

Once the setup is correct, the operation should become very repetitive. I want correctly expanded necks, a clean cutter pilot, neck-turning oil, steady rotation, consistent feed and light cutter pressure.

I let the cutter do the work. Forcing the case harder against it does not improve precision. After several cases I develop a good feel for a normal cut; if one case suddenly feels substantially tighter or rougher, I stop and inspect it.

A powered system can make processing a larger batch much quicker. It can also make a bad cutter setting much more expensive.

I establish the setup on a few cases first and then periodically spot-check the batch rather than assuming the tool cannot move.

After turning, I clean the cases and check representative necks again. For a normal cleaning cut, I am looking for approximately 80% surface clean-up, a sensible and consistent cut, no excessive shoulder cut, no obvious damage and improved neck-wall uniformity.

Once the setup has been proved and remains stable, sensible spot checks are normally enough. I don't need to measure every case at half a dozen points unless the application genuinely warrants that level of control.

The useful neck-turning maths only needs to be taught once. These three calculations cover the dimensions I normally need when checking a loaded neck or preparing brass for a tight-neck chamber.

1. Estimate the loaded-neck outside diameter

Projectile diameter + (2 × neck-wall thickness) ≈ loaded-neck OD

Example: 0.264" + (2 × 0.014") = 0.292" loaded-neck OD.

2. Calculate chamber-neck clearance

Chamber-neck diameter − loaded-neck OD = total diametral clearance

Example: 0.296" − 0.292" = 0.004" total clearance. Approximate clearance per side is 0.004" ÷ 2 = 0.002" per side.

3. Work backwards to the required neck-wall thickness

(desired loaded-neck OD − projectile diameter) ÷ 2 = approximate required neck-wall thickness

Example: (0.292" − 0.264") ÷ 2 = 0.014" neck-wall thickness.

These figures are examples, not universal specifications. For a tight-neck chamber I verify the actual finished cartridge against the known chamber specification. For my normal approximately 80% cleaning cut in a factory or no-turn chamber, I don't keep repeating these calculations throughout the process.

SAFETY WARNING

Adequate neck clearance is essential, particularly with a tight-neck chamber. If the case neck cannot expand appropriately to release the projectile when fired, a dangerous pressure condition can result. Tight-neck ammunition should therefore be prepared to known chamber dimensions rather than guesswork.

The neck was deliberately expanded to fit the cutter pilot, so it is not ready to load simply because the turning operation is finished.

After neck turning I clean the case, then resize it through my normal sizing process before continuing with the loading sequence. That sizing operation brings the case back to the working condition required for the cartridge and allows me to establish the final neck tension using the sizing, bushing or mandrel method appropriate to that load.

This is an important distinction: the neck-turning expander prepares the case for the cutter pilot; the later sizing operation prepares the case for the projectile.

Neck Turning and the Finished Cartridge

Figure 39.3 — *Unturned neck at left and a visibly turned neck at right. The cases are different calibres and are shown only to illustrate the visual difference in surface finish.*

Neck turning can improve neck-wall geometry, but it does not control every variable in the loaded cartridge. Final neck tension is also influenced by brass hardness, annealing, sizing method, bushings or mandrels, springback and projectile diameter.

A more uniform neck can contribute to straighter ammunition, but concentricity is influenced by sizing and seating as well as the brass itself. Neck turning controls one part of the system: neck-wall geometry. The earlier sizing and seating chapters contain the runout diagnostic method, so I don't repeat it here.

Once a batch has been turned, I keep it identified. At minimum I want to know which brass it is, which rifle it belongs to where relevant, whether it received my normal cleaning cut or was prepared for a tight-neck chamber, and its firing and annealing history.

Turned and unturned brass are now physically different components, so I don't casually mix them back together.

For a tight-neck chamber, neck turning may simply be necessary. For a normal or no-turn chamber, I think it is fair to ask whether the operation actually improves anything.

If I want to test it properly, I can compare carefully prepared unturned brass with comparable brass given my normal approximately 80% cleaning cut, while keeping the rest of the load as consistent as practical.

If the rifle cannot show a meaningful improvement in concentricity or target performance, I may not need to spend the time neck turning that particular brass.

My Neck-Turning Method

Figure 39.4 — *Checking neck-wall thickness after turning with a ball/anvil micrometer.*

My normal cleaning-cut procedure is: inspect and measure representative brass → decide whether turning is worthwhile → lightly wax the dedicated neck-turning expander → expand the neck to suit the cutter pilot → apply neck-turning oil → fit the case over the cutter pilot → begin with a light cutter setting → work towards approximately 80% surface clean-up → leave the remaining low areas rather than chasing cosmetic perfection → control the neck/shoulder junction → spot-check the batch → clean the cases → resize through the normal sizing process → establish final neck tension → keep the batch identified.

For a tight-neck chamber, the required chamber and loaded-cartridge specification determines the finished cut rather than my normal 80% cleaning-cut rule.

Neck turning can be very useful, but it does not need to become an exercise in measuring the same thing repeatedly. Measure enough to know what you are doing, remove only the brass that needs removing, resize the case afterwards, and then find out whether the rifle actually benefits from it.

With the advanced brass-preparation stages covered, the next chapter moves to the projectile itself. Rather than separate projectile sorting from meplat trimming and pointing, I treat them together so the reader can see which measurements are useful, which physical alterations are genuinely worthwhile, and when the target says to stop.

Chapter 40 — Advanced Projectile Sorting, Meplat Trimming and Pointing

Figure 40.1 — *Projectile after pointing, showing the finished nose/meplat form.*

Advanced Precision Reloading

By the time I start sorting, trimming or pointing match projectiles, the basic ammunition should already be good. These are refinement operations, not substitutes for good brass preparation, accurate powder charges, sensible load development or consistent seating.

For serious long-range competition, however, very small differences can become worth controlling. My approach is simple: start with good projectiles, keep the manufacturing lot intact, sort them before modifying them, and only perform the operations that have a useful purpose.

Consistency is the objective — not the greatest possible number of measurements or operations.

For serious projectile sorting I prefer a large quantity from one manufacturing lot — ideally around 4,000 projectiles or more when I can obtain them. That gives me enough projectiles in the resulting groups to load

a substantial quantity of ammunition without quickly having to move to a differently measured group. Keeping the manufacturing lot intact remains essential.

If I have projectiles from different manufacturing lots, I regard them as separate sorting jobs rather than combining them merely to create a larger batch. Lot variation is exactly the sort of variable I am trying to control.

Lot number first. Sorting second.

Before I start sorting, I visually inspect the projectiles. Damaged bases, badly deformed tips, jacket damage or anything obviously abnormal is removed from the best competition batch before I reach for measuring equipment.

My normal dimensional sorting measurement is projectile overall length — OAL — measured on the loose projectile from base to tip. This is different from cartridge overall length, COAL, which applies after the projectile has been seated in a case.

Base-to-ogive sorting is also a legitimate method and can be useful, but it is not my normal primary sorting measurement. For my own process I sort by projectile OAL first.

Before sorting the batch, I take one random projectile from the same manufacturing lot and use it to set up the measuring or sorting tool. Once the tool is referenced, I put that projectile aside and keep it separate from the main batch.

That projectile becomes my reference projectile for the entire sorting session. From time to time I put it back into the tool and check that the reading returns to the same reference point. If it does, I know the setup has remained stable. If it does not, I stop and find out what has changed before sorting any more projectiles.

This becomes especially useful with a batch of 1,000 or more, where the sorting operation may continue for a long session or even be resumed another day. The same reference projectile gives me a physical check that the zero or setup has not drifted.

Choose reference projectile → set tool → keep projectile aside → sort → periodically recheck reference.

Before I begin measuring, I prepare the trays, boxes or containers for the groups I expect to use. Each one is clearly identified so that every projectile can go directly from the measuring tool into the correct group.

The working rhythm is straightforward:

pick up projectile → measure → read result → place directly into its group → repeat

I don't measure a pile and then try to remember which reading belonged to which projectile. The projectile goes straight into its sorting group before I pick up the next one.

Twenty Groups Can Be Entirely Practical

With a large same-lot batch, creating around twenty OAL groups can be entirely practical. The central part of the distribution can still contain useful numbers even when the sorting bands are fairly fine.

What matters is that the groups remain usable. I'm not trying to make every box contain exactly the same number of projectiles.

The middle of the distribution will normally contain more projectiles than the shortest and longest ends. At those extremes I may use slightly wider bands so the outer measurements still form useful batches rather than ending up as tiny groups that are no practical use.

Provided there is nothing actually wrong with those projectiles, I don't automatically discard them. The aim is to organise the variation within the lot, not create unnecessary waste.

Imagine a large single-lot batch. The central measurements may naturally contain many projectiles per group, while the shortest and longest measurements may contain only a handful at each individual value. Instead of throwing those extremes away, I can combine adjacent extreme values into wider usable groups while retaining finer grouping through the centre.

That is why a large starting quantity matters. It gives me enough projectiles to sort finely without making the outer groups useless.

During a long sorting session I periodically stop and measure the reference projectile again. If the reading is correct, I carry on. If it has moved, I stop and investigate the tool, contact surfaces, cleanliness and measuring technique before continuing.

I would rather discover a change after 100 projectiles than after 1,000.

Projectile weight can also be checked. I occasionally sort by weight and, when I do, I commonly use 0.2-grain intervals for the selected projectile. I do not automatically make weight sorting compulsory if the batch already shows very little useful variation.

The point is to create usable groups, not to chase meaningless decimal places. If a sample shows the projectiles are already very consistent in weight, weighing every one may add work without producing a useful gain.

Projectiles can also be sorted by base to ogive, and some advanced shooters also examine bearing-surface length. Those are valid methods when they answer a specific question, but I don't automatically sort every batch by OAL, weight, base to ogive, bearing surface and meplat diameter all at once.

The purpose of the chapter is a practical method, not a catalogue of everything that can be measured.

I carry out the sorting before I trim or point the projectiles. Trimming removes material and changes projectile OAL; pointing changes the nose geometry. Sorting afterwards would therefore be measuring a projectile that I have already modified rather than the original manufacturing variation.

same manufacturing lot → inspect → OAL sort → trim only if needed → light point → load

Meplat Trimming — Useful, but Not My Normal Method Now

Meplat trimming is a valid precision-projectile preparation technique. A trimmer removes a small amount from the nose of an open-tip match projectile to make the meplat geometry more consistent before pointing.

I have used meplat trimming and there are still batches where it can be worthwhile, particularly if the meplats show more variation than I am happy with. Nowadays, however, I don't bother trimming nearly as much. With the quality of the match projectiles I normally use, I generally prefer to leave the original meplat alone and simply give the projectile a light point.

So my usual modern process is:

sort by OAL → light point → load

If a particular batch warrants trimming, then I use:

sort by OAL → meplat trim → light point → load

A meplat trimmer removes a controlled amount of material from the nose. Immediately after trimming, the meplat opening will normally be larger because the cutter has moved farther back into the nose. The gain is not a smaller opening at that stage — it is a more consistent starting geometry.

If I trim, I establish the cutter setting on a small sample and remove no more material than needed to make the batch suitably uniform.

For suitable open-tip match projectiles, I will normally give them a small amount of pointing even when I have decided not to trim the meplats.

I'm not trying to radically reshape the projectile or completely close the opening. My aim is simply to close the meplat a little and make the openings more uniform from projectile to projectile.

Uniformity matters more than the smallest possible meplat.

I establish the pointing-die setting using a few projectiles from the sorted batch. I start lightly, inspect the nose and make small adjustments until I achieve the degree of closure and uniformity I want.

Once I have a repeatable result, I leave the setup alone and process the batch consistently. I spot-check during the run rather than continuously adjusting a setup that is already working.

Trying to squeeze the open tip completely shut is not my objective. Excessive pointing can distort the nose or introduce a new variation while I am supposedly trying to remove one. A small remaining opening is perfectly normal.

Making the meplats smaller and more consistent can improve aerodynamic uniformity and may produce a small improvement in ballistic coefficient. For precision shooting I am at least as interested in consistency of aerodynamic behaviour as I am in the absolute BC number.

The benefit is principally a long-range one. At 100 yards I may see little or no measurable difference. At 900 or 1,000 yards and beyond, small aerodynamic differences have had much more time to accumulate.

After sorting and any nose preparation, I keep the groups identified. I record enough information to know the projectile manufacturer, model, nominal weight, manufacturing lot, OAL group, whether meplats were trimmed, and the pointing setup used.
The purpose is reproducibility, not paperwork for its own sake.
Advanced projectile preparation should eventually justify itself on the target. If I want to evaluate pointing, I can compare sorted projectiles from the same lot with otherwise comparable sorted-and-pointed projectiles. If I want to evaluate trimming, I test trimming as its own change rather than altering several other load variables at the same time.
Because nose preparation is mainly about aerodynamic consistency, the most meaningful comparison may be at the distance where the ammunition is actually intended to perform rather than only at 100 yards.

Hunting Projectiles Are Different

The methods in this chapter are aimed principally at suitable match projectiles. I wouldn't normally trim or point hunting-projectile noses, where polymer tips, hollow points, exposed lead or other nose features may be deliberately engineered to control terminal performance.

My Current Method

Figure 40.2 — *A projectile positioned immediately beneath a pointing die before entering the die.*

My current approach is straightforward:

buy enough projectiles from one manufacturing lot → keep that lot intact → visually inspect → choose one random projectile as the tool reference → sort the lot by projectile OAL → recheck the reference projectile periodically → use fine groups through the main distribution and wider useful groups at the extremes → trim meplats only when the batch genuinely warrants it → normally apply a small amount of pointing → keep the finished groups identified → load and test them consistently

The reference projectile stays aside while it is being used to verify the sorting tool. Once the sorting operation for that manufacturing lot is finished, its job as the reference is finished too.

Projectile sorting, meplat trimming and pointing belong near the far end of precision ammunition preparation. They make sense when the basic rifle, ammunition and load are already good enough for small differences to be worth investigating.

For my own process, the most important points are simple: do not mix manufacturing lots, sort before modifying the projectile, use the reference projectile to keep the sorting setup honest, do not trim unless there is a reason, and use only a small amount of pointing to make the meplats more uniform.

That keeps the process controlled, useful and repeatable — rather than turning advanced projectile preparation into work for the sake of work.

Chapter 41 — Advanced Primer Sorting by Weight

Figure 41.1 — *A primer being weighed on a precision balance as part of an optional same-lot sorting exercise.*

A very small refinement at the extreme end of precision reloading

Primer sorting by weight sits right at the extreme end of precision ammunition preparation. For perhaps 99 percent of reloaders, there is no practical need to do it. Modern primers from a good manufacturer and a consistent production lot are already sufficiently uniform for almost every sporting, hunting and target application.

I include the technique because, once the rest of the ammunition is already extremely well controlled, some competitive reloaders may want to investigate one more small source of component variation. Primer weight is one way of doing that.

What matters is that I don't present primer sorting as a requirement for accurate ammunition. It is an optional experiment for the reloader who has already dealt with the much larger variables and wants to see whether this final level of sorting produces anything measurable in their own rifle.

When I place a primer on an accurate scale, I am weighing the complete primer assembly: the cup, anvil and priming compound together.

A heavier primer does not automatically contain more priming compound, and it certainly does not automatically mean that it is more powerful, more consistent or better. Two primers can have the same total weight while the individual components contributing to that weight differ slightly.

IMPORTANT
Primer weight is not a direct measurement of primer energy, brisance or ignition quality. I am simply grouping complete primers of similar total mass.

As with my projectile sorting, lot control comes before fine sorting. I only compare primers of the same manufacturer, primer type and production lot.

I don't mix two primer lots simply to create a larger batch. If I have primers from different lots, I treat them as separate component batches and sort them separately if I decide sorting is worthwhile at all.

This matters more to me than creating extremely narrow weight groups. Fine sorting cannot undo the fact that I mixed two different manufacturing populations together before I started.

Primer sorting requires a genuinely accurate and repeatable scale. A normal powder scale may display a sufficiently small increment, but the important question is whether it can repeat that reading reliably with such a light component.

I set the scale on a firm, stable surface away from vibration and draughts, allow it to stabilise as required by the manufacturer, and confirm its calibration before starting. With very fine measurements, poor technique can easily create more apparent variation than the primers themselves.

I also avoid warming primers unnecessarily in my fingers. The aim is a calm, repeatable measuring routine rather than chasing the last digit on a display that is continually moving.

For a long sorting session, I like to have a way of checking that the scale has not drifted. A suitable certified check weight is the best independent reference where the scale manufacturer provides for one.

I can also keep one representative primer from that lot aside as a working reference. I record its reading at the start and periodically reweigh it during the session. It is not a substitute for proper scale calibration, but it is a useful quick check that my setup is still behaving in the same way.

If the check no longer agrees with the starting condition, I stop and find out why before sorting more primers.

How I Would Sort Them

I first weigh a reasonable sample from the lot to see what the distribution actually looks like. I don't decide on a complicated set of weight bands before I know whether there is enough variation to justify them.

If nearly all of the primers fall into a very tight central population, the most useful action may simply be to identify a few genuine outliers. If I have a large quantity and the weights form repeatable groups, I can separate them into sensible bands and keep those groups labelled.

Each primer goes directly from the scale into its intended container. I don't build a pile of weighed primers and rely on memory to sort them afterwards.

Imagine a sample of primers gives the following readings on a sufficiently precise and repeatable scale:

5.28 gr 5.29 gr 5.28 gr 5.30 gr 5.29 gr

The average of that small sample is:

(5.28 + 5.29 + 5.28 + 5.30 + 5.29) ÷ 5 = 5.288 grains

The spread is:

5.30 − 5.28 = 0.02 grain

Those figures are only an illustration, not a specification for any particular primer. Different primer designs and lots will have different normal weights and distributions. I am interested in the pattern within the lot in front of me, not in comparing it with an arbitrary internet number.

Once primers have been separated by weight, it is tempting to describe one group as the good primers and another as the bad primers. Weight alone does not justify that conclusion.

A group at one end of the lot may shoot exactly as well as the group in the middle. Unless a primer is visibly defective or otherwise unsuitable, the sorting operation has only told me that its total mass differs slightly.

If I want to know whether that difference matters, I have to test it.

If I go to the trouble of sorting primers, I keep the groups clearly identified with the primer make, type, lot and sorting band. I also keep them protected in appropriate primer packaging or trays and handle them in accordance with the manufacturer’s safety instructions.

There is little point spending time making carefully sorted groups and then losing their identity on the loading bench.

This is where the exercise either earns a place in my loading process or it does not.

I would compare ammunition loaded as identically as practical, changing only the primer sorting group being investigated. The powder charge, projectile, brass preparation and seating depth stay the same.

I then look primarily at the things primer consistency might reasonably influence, including ignition behaviour, average velocity, extreme spread, standard deviation and ultimately target performance.

I don't judge the technique from one unusually good chronograph string. Repeated evidence is much more convincing.

Do Not Confuse Sorting With Load Development

Primer sorting is not the stage at which I start changing primer type or primer manufacturer. That is a different load-development variable.

Here I am taking one already proven primer type and lot and asking a much narrower question: does grouping those primers by total weight improve the consistency of an already established load?

That distinction keeps the experiment useful.

Very few people.

For hunting ammunition, practical rifle shooting, most club competition and the overwhelming majority of precision reloading, I would spend my time elsewhere.

Good brass preparation, sensible load development, consistent powder charges, appropriate neck tension, correct seating and good shooting technique all deserve attention long before primer weight sorting.

This technique only becomes interesting to me when those larger variables are already under very good control and I am deliberately investigating the final small differences in serious precision ammunition.

My approach is therefore straightforward:

use one primer manufacturer, type and lot → use an accurate, repeatable scale → verify the scale before starting → weigh a representative sample → see whether a meaningful distribution actually exists → separate sensible groups or obvious outliers → periodically recheck the scale/reference → keep every group clearly identified → load a controlled comparison → let the chronograph and target decide whether the extra work has any value.

For 99 percent of reloaders, the correct conclusion will probably be that primer sorting is unnecessary.

That is not a failure of the technique. It simply means the ammunition already has larger variables worth concentrating on—or that modern primers are sufficiently consistent for the job.

But for the shooter working at the extreme end of precision reloading, it is another small variable that can be measured, controlled and, most importantly, tested rather than assumed.

Chapter 42 — Inspection, Labelling, Storage and Transport

A final pre-storage check within a process of continuous inspection

By the time a batch of ammunition reaches this stage, most of the difficult work has already been done. The brass has been prepared, the primer and powder selected, the projectile seated correctly and the load developed for the firearm in which it will be used.

At this stage the job is simpler: carry out a final pre-storage check, identify the ammunition, store it properly and make sure it cannot become confused with another load. Inspection has already been taking place throughout the loading process; this is the last check before the ammunition leaves the bench. It is quality control, not another advanced reloading process.

IMPORTANT SAFETY RULE

I treat every handloaded or reloaded cartridge as ammunition for one specific firearm only. I do not use my handloaded ammunition in another firearm, even if both firearms are marked for exactly the same cartridge or calibre.

Inspection Starts Long Before the Final Check

Inspection should already have happened throughout the loading process. I have inspected the brass, checked primers while seating them, controlled powder charging and monitored projectile seating. The pre-storage check is simply the last quality-control check, not a replacement for careful loading.

Before ammunition goes into its final box, I look at every round. I am looking for anything that appears different from the rest of the batch: a split or damaged case, damaged case mouth, obviously incorrect seating position, damaged projectile, a primer that does not look correctly seated, contamination, unusual marks or anything else that makes me question the round.

I don't need to inspect every cartridge under magnification. A careful visual check is normally enough to identify something that clearly does not belong with the rest of the batch. If one looks wrong, I put it aside.

At this point I'm not repeating the primer-seating procedure. I simply confirm that nothing obviously abnormal has escaped the earlier checks. A primer that is visibly proud, damaged, incorrectly positioned or otherwise suspicious does not leave the loading bench as normal ammunition.

A correctly established loading setup should produce consistent ammunition without requiring every finished cartridge to be measured again. During loading I may already have been checking cartridge overall length, CBTO where relevant, shoulder position, loaded-neck diameter where appropriate, or another dimension important to that load.

For important ammunition I may spot-check finished rounds, particularly from the beginning and end of a loading session. If those checks show something has moved, I investigate the batch.

Depending on the ammunition and its intended use, a suitable cartridge gauge or other appropriate check can help confirm function. Whatever method I use, I never force a cartridge into a gauge or firearm. If it does not fit normally, I find out why.

SAFETY WARNING

A cartridge that looks wrong, measures unexpectedly or fails to chamber normally is not something I fire simply because I have already spent time making it. Set it aside and investigate.

Sizing wax, case lubricant and neck-turning oil belong in the preparation stages. Before boxing cartridges, I want finished ammunition reasonably clean and dry. This also makes inspection easier because genuine marks are not hidden by residue.

My handloaded ammunition belongs to one specific firearm. It doesn't become general-purpose ammunition simply because another firearm carries the same cartridge designation.

If I have two rifles chambered in .308 Winchester, I treat them as two separate loading systems. Each rifle gets its own load development, ammunition identification and records. I don't assume that a load developed and proven in Rifle A is appropriate for Rifle B.

Two firearms marked with the same cartridge designation can still differ in chamber dimensions, throat length, freebore, headspace relationship, magazine dimensions, barrel dimensions and general manufacturing tolerances. Brass may also have been prepared around one particular chamber and a seating depth established from that firearm.

My rule is therefore deliberately simple: one firearm, one developed handload.

Because of that rule, I identify the firearm on the ammunition box as well as the cartridge. A label such as “.308 Winchester — F-TR Rifle A — Load 07” is far safer than a generic “.308 Winchester — Load 07”. There should be no need to remember.

Different loads stay separate. If I am testing several powder charges, seating depths, projectile lots, primer lots or brass batches, I don't rely on remembering which row of an unmarked box is which. Once visually identical cartridges are mixed, there may be no reliable way to separate them again.

Label Ammunition Immediately

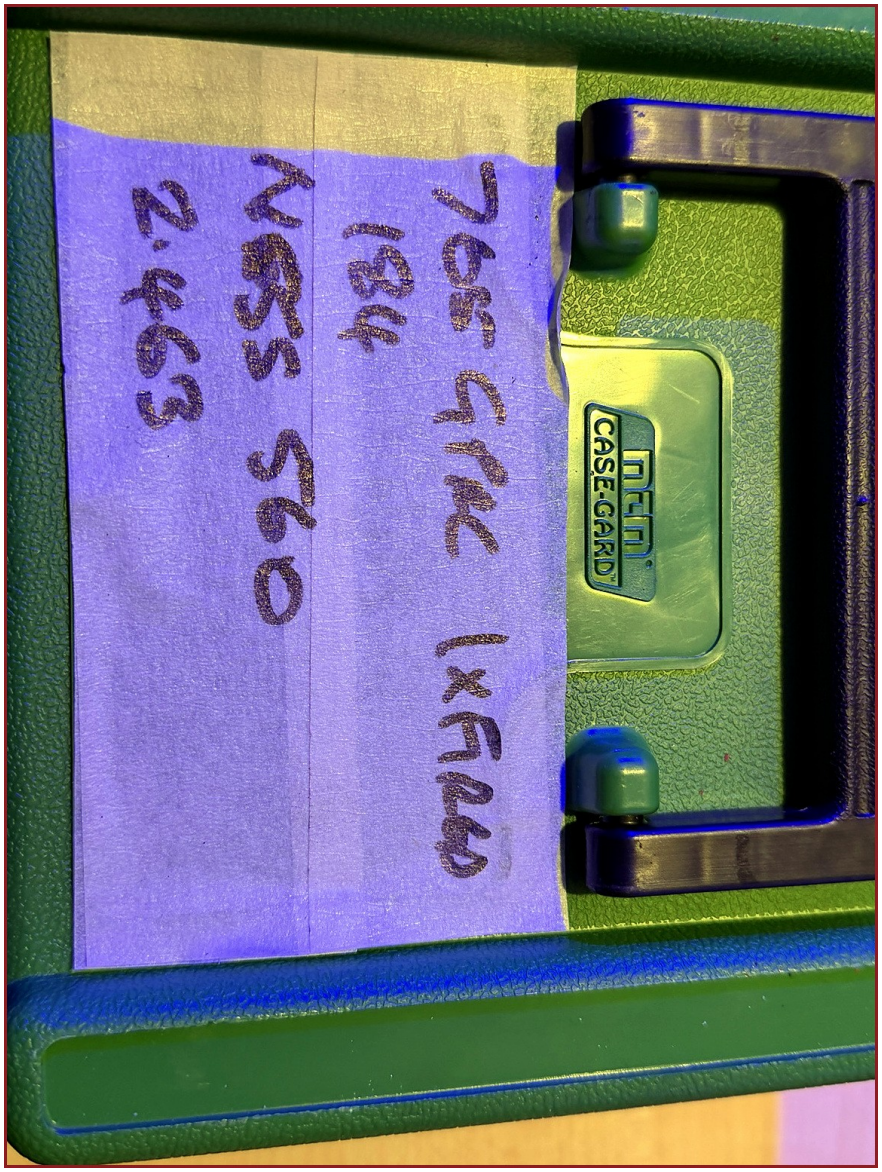


Figure 42.1 — *A real labelled ammunition box. The label preserves the information needed to identify the ammunition and its loading history.*

I label ammunition when it is boxed, not later. A useful box label may include cartridge, firearm, projectile and weight, powder and charge, primer, seating information where relevant, date, and a load or batch identifier. For serious competition ammunition I may keep component lot numbers in the main loading record.

The box does not need every technical detail written across it. It needs enough information to connect the ammunition unambiguously to the complete record.

A simple load identifier makes this easier. Development ammunition needs especially clear identification because confusing two test groups can invalidate the entire experiment. I prepare the range organisation at the loading bench, not while sitting behind the rifle.

A suitable ammunition box protects the cartridges, keeps the batch organised, makes counting easy and provides somewhere for clear identification. I avoid unidentified loose handloads. If I can no longer positively identify a loaded cartridge, I don't guess which load it is.

For serious ammunition, powder, primer, projectile and brass lot numbers can be useful. I don't need to keep every empty packet forever; useful lot information can be transferred to the loading record.

Loaded ammunition should be stored somewhere dry, secure, reasonably stable and protected from excessive heat and obvious contamination. The firearm-specific identity stays with the ammunition throughout storage.

If cartridges have been exposed to significant water or serious contamination, I don't simply wipe the outside and assume everything inside remains unaffected. I also avoid unnecessary exposure to very high temperatures.

When I transport ammunition, I want it to arrive secure, identifiable and still separated by firearm and batch. If I am taking ammunition for more than one firearm, I make sure there is no opportunity for those loads to become confused.

Perhaps another shooter has the same calibre, or I have brought two rifles chambered for the same cartridge. My safety rule does not change at the range.

IMPORTANT SAFETY RULE

Handloaded ammunition stays with the firearm for which it was developed. I do not move my handloads from one firearm to another simply because the cartridge will physically fit.

For an important competition, I want the ammunition side of preparation to be almost boring. I know which rifle it is for, which load it is, how many rounds I have, which are match rounds and which, if applicable, are confirmation or fouling rounds. The boxes are clearly identified before I leave home.

For precision shooting I try to treat ammunition consistently. I don't deliberately leave one box in direct sunshine while another remains shaded and cool. This is simply an easy variable to avoid.

The same firearm-specific rule applies to hunting ammunition. My priorities are safe function, reliable feeding and chambering, correct zero, suitable projectile performance and dependable first-shot accuracy. I still need excellent identification even if competition-style sorting would add no practical benefit.

Hunting or practical ammunition may sometimes be chambered and removed repeatedly. I inspect rounds that have seen significant handling for projectile damage, case damage, contamination or any other change that makes me uncomfortable using them.

When loading larger quantities, batch identification becomes even more useful. Black-powder ammunition follows the same basic identification rule: the finished ammunition remains clearly identified for the firearm and loading system for which it was produced.

Storage and transport law varies by jurisdiction and can change. A reloading book should not pretend that a fixed paragraph can remain authoritative forever. The reader should check the current requirements that apply to ammunition, firearms, powder, primers, transport, storage and travel.

Returning From the Range

After shooting, I separate unused loaded ammunition, fired brass, questionable cartridges and anything requiring investigation. Unused ammunition returns to the correct firearm-specific batch. Fired brass returns to its correct case lot where I am maintaining one. A suspicious cartridge stays separate.

If I own two firearms in the same cartridge, each has its own load record. There is no ambiguous generic “my .308 load”. That small discipline removes a surprising amount of potential confusion.

Final Check Before an Important Shoot

Before leaving for a competition or important day in the field, I confirm the correct ammunition, correct firearm identification, enough rounds, clear labels, no obvious cartridge damage and no mixed loads.

My normal routine is: finish loading → inspect every cartridge → spot-check anything relevant to the load → make sure the ammunition is clean → box it immediately → label it for the specific firearm → connect it to the correct loading record → keep different loads and firearms separate → store it appropriately → transport it in the same clearly identified batches → maintain that separation at the range → return unused ammunition and fired brass to their proper place.

The central rule is worth repeating once at the end: handloaded ammunition is not shared between firearms. One firearm. One developed load. Clearly identified ammunition.

The Final Inspection Has a Simple Purpose

By this stage I'm not looking for another advanced process to perform. I am asking four questions: Is the cartridge safe and correctly assembled? Do I know exactly what load it is? Do I know exactly which firearm it belongs to? Will it stay identifiable and protected until I use it?

If I can't answer all four confidently, the ammunition is not ready to leave the bench. If I can, the loading process is complete.

The Reloading Timeline elsewhere in the book brings these operations together and shows where the process changes for new brass, fired brass and different levels of preparation. Final inspection remains the last check before the ammunition leaves the loading bench.

Chapter 43 — The Reloading Timeline — What You Actually Need to Do

Methodology: 1967Spud Reloading Timeline, developed from practical reloading and competition experience.

A practical working sequence from new brass to finished ammunition, with different routes for stalking, target shooting and F-Class.

By this point in the book, every individual operation can be explained in its own chapter. This chapter has a different job: it shows where those operations belong and, just as importantly, which ones you may not need at all.

I use the same basic reloading timeline whether I am making straightforward stalking ammunition or highly prepared F-Class ammunition. What changes is how many branches I take and how tightly I control them.

The first decision is not “how accurate do I want the ammunition?” It is simpler: am I starting with new brass, or brass that has already been fired? The second decision is how far the intended use justifies taking the preparation.

The core sequence is shown below. The route tables that follow show where new brass, fired brass and advanced preparation differ.

THE CORE 16-STEP TIMELINE			
1	Inspect	**9**	Anneal when required
2	Decap when required	**10**	Resize
3	Trim when required	**11**	Set neck tension
4	Chamfer and deburr	**12**	Prime
5	Primer-pocket preparation	**13**	Charge
6	Flash-hole preparation	**14**	Seat
7	Neck-turn when required	**15**	Final inspection & label
8	Clean	**16**	Shoot & evaluate

The Four Routes Through the Timeline

The timeline is deliberately not a rule that every case must complete all sixteen steps every time. The route depends on the brass and what it needs during that cycle.

Starting condition	Route	What it means
New cases — basic	1 → 4 → 5 → 6 → 10 onward	Inspect; prepare the mouth, primer pocket and flash hole; then enter the normal loading sequence.
New cases — advanced / neck turning	Steps 1–16	The full preparation route when the brass is being prepared at the advanced level, including the one-time neck-turning work where required.

Starting condition	Route	What it means
Once-fired — minimal work	1 → 2 → 5 → 10 onward	Inspect, decap, clean/check the primer pocket, then resize and continue when no trim/clean cycle is needed.
Once-fired — complete trim/clean cycle	1–16, normally omitting Step 7	Use the full fired-brass preparation cycle when the cases need trimming, cleaning and full preparation; neck turning is not normally repeated as a routine cycle.

My timeline also starts with a very simple bench habit. I like two loading trays, one to the left of the press and one to the right. As each case completes the current operation, it moves from the left tray to the right. That separation helps prevent what I think of as “contamination of operation”: an unsized case mixed with sized brass, a charged case confused with an empty one, or a case accidentally processed twice.

I also keep only the tools needed for the current operation on the bench. Good organisation is a safety control, not decoration.

1 — Visual case inspection

Every route begins here. New or fired, the brass is inspected before work starts. If I am in doubt about a case, I reject it.

Used when a fired case needs further preparation before resizing. Removing the primer first lets me trim, clean and prepare the case before the sizing stage. New virgin brass normally skips this step.

Performed when the brass actually needs trimming. I normally use the known trim length for the calibre from reliable data. If one is not available, I measure around twenty representative cases, find the shortest sound case and trim the batch to that length, provided it remains within specification.

After trimming—or as initial mouth preparation on new brass—I lightly chamfer the inside and deburr the outside. I do as little as necessary and avoid leaving a knife edge.

Fired cases have their pockets cleaned as required. With new brass, this is also the point at which any one-time pocket preparation I choose to perform is done.

Normally a one-time new-brass operation where required. Once it has been done correctly, I don't keep repeating it every loading cycle.

An advanced preparation step rather than a normal recurring operation. A cleaning cut is used only where justified, and tight-neck brass is prepared to the chamber requirement. After turning, the brass returns to the normal sizing process.

Cleaning is done when the cases need it rather than simply for appearance. In my own routine I commonly clean around every third to fourth firing, particularly when I am planning a trim cycle or the brass is due for annealing; dirty brass should not be carried into precision dies.

Annealing occurs before the final sizing/neck-control stage. With my AMP induction system I normally anneal every loading cycle; with a gas-flame system I would anneal as little as necessary and place much more emphasis on careful setup and verification.

A specialist branch for appropriate fired-brass problems such as persistent base-area sizing issues. It is not part of an ordinary loading cycle.

This is where I establish the fired case back to the required relationship with its specific chamber. For live-quarry ammunition in particular, reliable chambering matters more to me than the supposed benefit of neck-only sizing.

After sizing, I set neck tension every time using my expander/mandrel method. My normal expander is about 0.001–0.002 inch under calibre diameter, with dry graphite/carbon neck lubricant to make the operation smooth and repeatable.

For me, priming marks the start of rebuilding the finished round after case preparation. I prefer a hand priming tool for feel, and I check that the primer is seated correctly and slightly below flush. Eye protection is worn and the priming tool is kept pointed away from my face.

I positively identify the powder and weigh every rifle charge. I do not dump an unchecked powder-thrower charge straight into a case. With an electronic dispenser I normally set about 0.1 grain below the required weight and trickle the final tenth up manually.

The projectile is seated to the established position for the specific firearm, observing magazine or functional limits where relevant. My normal press technique is to partially seat the projectile, rotate the case about 180 degrees in the shell holder, then complete seating. Advanced projectile sorting, trimming or pointing must already have been completed before this step.

15 — Final inspection and labelling

Every completed cartridge is visually checked and boxed under a clear load and firearm identity. Handloaded ammunition remains specific to the firearm for which it was developed.

This is where the target, chronograph and firearm tell me whether the loading process has produced what I wanted. If the load is proven, preserve the method. If I am developing it, change one meaningful variable at a time.

The timeline gives the order. The intended use decides how much work earns a place within that order. I find it useful to think in three broad levels.

LEVEL 1 — SPORTING / STALKING

Safety, reliable chambering and feeding, a suitable projectile, a proven powder load and dependable first-shot accuracy are the priorities. The basic timeline is normally enough. If the rifle already produces safe, reliable and appropriately accurate ammunition, I stop. I do not add case-capacity sorting, primer weight sorting, projectile pointing or other extreme preparation merely because those methods exist.

LEVEL 2 — PRECISION TARGET / CLUB COMPETITION

Here I may exercise tighter control over case lot, shoulder bump, annealing, neck condition, powder charge, seating depth and chronograph results. Optional processes are added when they answer a real question or improve repeatability. The ammunition can be more controlled without automatically becoming an F-Class preparation programme.

LEVEL 3 — F-CLASS / EXTREME PRECISION

At this level I am prepared to investigate the small remaining variables because the rifle, distance and scoring system may actually expose them. Same-lot brass and projectiles, advanced case sorting, neck turning where justified, controlled powder measurement, OAL projectile sorting, light pointing, range-side refinement and even primer weight sorting can all have a place—but each remains optional until it proves useful.

This is one of the main reasons I wanted the timeline set out as different routes rather than as a single checklist. New brass has not yet been fired in the chamber, so there is no fired shoulder position to work from. Some one-time preparation—such as flash-hole deburring or an advanced neck-turning setup—also belongs naturally at the beginning of a brass lot rather than being repeated forever.

Once the brass has been fired, I now have a case formed by the actual chamber. From there, the fired-brass route can be minimal when the cases need little work, or it can return through the full trim/clean/anneal cycle when required. The timeline is a cycle with branches, not a command to perform sixteen operations on every case every time.

This distinction is particularly important for stalking ammunition. If I have full-length-sized brass that chambers freely, a suitable hunting projectile, a safe proven load and accuracy comfortably inside the requirement, that ammunition has achieved its purpose. Reliability and humane first-shot performance matter more than adding another bench operation in pursuit of a number the field cannot use.

The more advanced route exists for the shooter whose rifle, target and discipline can genuinely expose smaller variations. F-Class is a good example. The underlying timeline is the same, but I may take more of the optional branches because the performance requirement is different.

Optional branch	Where it belongs
Brass sorting / H_2O capacity	After the appropriate case preparation and before rebuilding the round, when the discipline genuinely justifies matched brass groups.
Neck turning	In the early case-preparation branch, followed by cleaning/resizing and then final neck-tension control.
Projectile sorting / pointing	Before seating. My normal method is same manufacturing lot, OAL sorting first, optional meplat trimming, then a light point.
Primer sorting by weight	Before priming, only at the extreme end of precision preparation. Almost everyone can skip it.
Range-side seating / tuner work	After a sound powder load exists. These are refinement tools, not substitutes for the basic load-development process.

The Timeline Is a Decision Tool

The value of the timeline is not that it tells every reloader to do more. It tells me what comes next, and it also gives me permission to skip an operation that the brass or application does not require.

At every optional branch I can ask two questions:

- Does this operation solve a real problem or improve a result I can measure?
- Does the intended use justify the time and control required?

If the answer is no, I remain on the simpler route.

> **SAFETY PRINCIPLE**
>
> The workflow never overrides published loading data or the requirements of the specific firearm. Handloaded ammunition remains firearm-specific. If a case, component, measurement or finished cartridge creates doubt, stop and investigate rather than continuing because the timeline says the next step is due.

If I strip the book back to the decision path rather than the detailed techniques, it looks like this:

START → identify the specific firearm and purpose → NEW or FIRED brass? → choose the appropriate timeline route → perform only the case-preparation steps that route needs → resize → establish final neck condition → add only the precision branches justified by the intended use → prime → charge → prepare/sort projectiles if required → seat → inspect and label for that firearm → shoot and evaluate → preserve the proven method or change one meaningful variable → return the fired brass to the appropriate route for the next cycle.

One Timeline, Different Finish Lines

The core process does not change because I am shooting deer rather than F-Class. What changes is the point at which further preparation stops being worthwhile.

For stalking ammunition, the finish line may be safe, reliable, appropriately accurate ammunition that feeds and chambers every time.

For precision target shooting, the finish line may include tighter component and measurement control.

For F-Class, I may choose to investigate nearly every remaining source of variation—but even there, an operation still has to earn its place.

That is the purpose of the timeline: not to make every round complicated, but to put every useful operation in the right place and show me when I can safely leave it out.

Chapter 44 — When to Stop Tuning

What Actually Matters

Reloading can become an endless search for smaller numbers: smaller groups, lower ES and SD, less runout, tighter weight spreads, more uniform brass and more closely matched projectiles.

There is nothing wrong with trying to improve ammunition. That is one of the reasons many of us reload in the first place. The problem begins when measurement becomes the objective rather than shooting performance.

At some point a load is good enough for the job it has to do. Knowing when that point has been reached is one of the most useful skills a reloader can develop.

I don't judge every load by the same standard. A stalking load, a club target load and an F-Class load have different jobs, so they should not share the same finish line.

For stalking and general hunting, the priorities are safety, reliability, correct chambering and feeding, a suitable projectile, dependable first-shot accuracy and enough precision for the realistic distance at which the shot will be taken.

For serious F-Class or similar long-range competition ammunition, my standard is naturally higher. Here I may care about very small vertical dispersion, repeatable velocity behaviour, carefully controlled brass, consistent seating and projectile preparation because small differences can cost points at distance.

The required standard comes from the job, not from a desire to perform every operation in the book.

When I say a load is good enough, I don't mean careless or second-rate. I mean it has reached the standard required for its intended use.

An F-Class load that repeatedly performs at the level I need can be good enough even if it took a great deal of work to reach that point. A stalking load may reach its own finish line much earlier.

Good enough means the ammunition is safe, reliable, repeatable and doing the job with a margin of confidence.

Most improvement comes from getting the fundamentals right before chasing tiny refinements.

- sound and consistent brass;
- correct sizing and shoulder control;
- sensible neck control;
- appropriate primers and powder;
- accurate powder charges;
- a suitable projectile;
- and a seating depth that has been properly developed.

Those are the large gains. Advanced sorting and fine tuning cannot rescue a poor basic combination.

Once the basic load is working well, the amount of work required for another small improvement can increase dramatically. That is where operations such as case sorting, H2O capacity checks, neck turning, projectile sorting, pointing, primer sorting, runout diagnosis, tuner work and very small seating-depth changes may come into play.

Those techniques can be worthwhile in the right discipline, but they belong after the main load has proved itself.

Fine tuning only tells me something if I know what changed. If I alter powder charge and seating depth together, or change brass preparation, primer, projectile sorting and tuner setting at the same time, I may improve the group without learning why.

The smaller the change I am trying to evaluate, the more important it becomes to control the other variables.

> **My rule:**
>
> Build a sound baseline first, then change one meaningful variable at a time.

My normal method is to establish a good powder-charge region first. Where appropriate for the cartridge and published data, I commonly work in 0.2-grain increments during powder testing.

Once I have a powder charge producing a good, repeatable group and sensible velocity behaviour, I can decide whether seating-depth refinement is worth investigating. I don't continually move powder charge and seating depth together because that removes the baseline I need for a useful comparison.

Small Adjustments Come Later

Once a good combination is established, I may make smaller adjustments if the intended use warrants them. For serious precision ammunition this might include finer powder-charge refinement, small seating-depth changes, tuner adjustment or another controlled comparison.

At that point I am looking for the last small improvement. I'm not expecting a tiny tweak to turn an unsuitable load into a good one.

A micrometer can show a difference. A scale can show a difference. A concentricity gauge can show a difference. A comparator can show a difference. The rifle may not care about all of them.

If I halve a measurable variation but group size, vertical, velocity behaviour and long-range performance remain unchanged, I have improved a number without improving the ammunition.

That is still useful information because it tells me the operation may not be worth repeating for that rifle and purpose.

Average velocity, ES and SD are useful tools, but none of them should become the sole judge of a load. A slightly lower SD does not automatically make one combination better if another repeatedly groups or holds vertical better at the distance that matters.

Likewise, one exceptional group does not prove that a load is finished. I prefer repeatable very good performance to one brilliant target surrounded by ordinary ones.

For normal accuracy testing I prefer five-shot groups. Three shots can produce an attractive group without showing enough of the load's normal variation. Five shots give me more information without turning every initial comparison into an endurance test.

Much load development is sensibly carried out at around 100 yards because it reduces the influence of wind and makes ammunition differences easier to compare.

For long-range ammunition, however, the load still needs to be verified farther out. Velocity variation, ballistic-coefficient variation, stability and other small differences have more time to appear as distance increases.

For serious long-range work I pay particular attention to vertical at the distance where the ammunition will actually be used.

More velocity can be attractive, but it is not automatically better. The load still needs to be safe, accurate and repeatable. Once I have the performance I need, pushing harder merely to gain a small amount of speed may offer no useful benefit.

Hunting ammunition has a very different job from ammunition prepared for F-Class or Benchrest.

For general stalking and hunting, around 1 MOA at 100 yards is a perfectly sensible accuracy standard for a suitable rifle and load. Smaller groups are always nice to see, but once the ammunition is comfortably

accurate enough for the intended quarry and distance, another fraction of an inch on a paper target may make no practical difference in the field.

The animal will not know whether the rifle grouped 0.8 MOA or 0.5 MOA on the range.

What matters far more is that the hunter has complete confidence in the rifle, the ammunition and the shot.

I want hunting ammunition that chambers and feeds reliably, uses a suitable projectile, produces dependable first-shot accuracy and repeatedly puts the projectile where I expect it to go.

If my stalking rifle consistently produces approximately 1 MOA or better with a proven load, I'm not going to start performing every advanced operation in this book simply because I can.

By all means improve the load if there is a genuine reason. A smaller group is never unwelcome. But there comes a point where time is better spent shooting the rifle, confirming the zero and practising realistic field positions than trying to remove another tenth of an inch from a bench-rested group.

For the hunter, confidence is enormously important. When the opportunity arrives, I want to know:

- the rifle is zeroed;
- the ammunition is proven;
- I know where it shoots;
- and I am confident I can make the shot.

That is a successful hunting load.

Competition Changes the Calculation

In F-Class, Benchrest and similar precision disciplines, very small improvements can matter. A little less vertical may save a point, and small gains in aerodynamic or velocity consistency can become worthwhile over a long course of fire.

This is where operations such as projectile sorting, pointing, brass sorting, neck turning and tighter powder control may earn their place. Even then, there is still a point where further work produces no measurable benefit.

Reloading time has value. If an operation takes several hours per hundred rounds and produces no detectable improvement in the rifle, that matters.

That same time might be better spent shooting, practising in wind, checking the rifle, improving positional technique or simply confirming the ammunition I already trust.

A cartridge that produces beautiful numbers but occasionally fails to chamber is not a good cartridge. A hunting load that needs delicate handling is not a good hunting load. A match load that becomes unreliable under competition conditions is not improved by having an excellent spreadsheet.

Reliability is part of performance.

Every shooting test contains variation from the ammunition, rifle, shooter, wind, mirage, rests, barrel condition and simple statistical chance. If I make one tiny change and the next five-shot group becomes smaller, I don't automatically assume the adjustment caused it.

I confirm the result. A genuine improvement tends to show itself again. A lucky group often does not.

There comes a point where I stop asking what I should change next and start asking whether I can reproduce the result.

If the answer is yes, the load may be finished. Confidence comes from repeated evidence, not from endlessly altering a combination that is already working.

Before making another change, I ask:

- Is the load safe?
- Does it function correctly?
- Is the accuracy comfortably good enough for its purpose?
- Is the velocity behaviour acceptable?
- Has the load repeated its performance?
- For long-range ammunition, has it been confirmed at meaningful distance?
- Do I have a specific reason to believe the next change will improve something that actually matters?

If the first six answers are yes and the final answer is no, I stop tuning.

There is nothing wrong with chasing the final one percent. I do it myself when the application justifies it. But I want to know that I really am working on the final one percent.

I don't want to spend hours sorting primers while the main powder combination is still questionable. Advanced refinement belongs at the end, and most shooters do not need every advanced refinement in this book.

The best load is not necessarily the one with the greatest number of operations, the narrowest sorting bands or the most expensive equipment used to produce it.

The best load is the one that safely and consistently meets the requirements of the firearm and shooting discipline.

Sometimes that will be relatively simple. Sometimes it will involve a considerable amount of precision preparation. Both can be correct.

I don't stop because I am tired of testing. I stop because the load has demonstrated that it is finished.

Knowing When to Leave It Alone

A good load can sometimes be made worse by continual adjustment. Once I have a proven combination, I record it carefully. If the components remain the same and the ammunition continues to perform, I leave it alone.

Chapter 45 — Troubleshooting Reloading and Ammunition Problems

Sooner or later, something will not behave as expected.

A bolt becomes tighter than usual. A case comes out of the sizing die with a dent in its shoulder. Cases that were previously clean begin coming out of the chamber covered in soot. Projectile seating suddenly feels different. Velocity changes for no obvious reason. A proven load stops grouping. Or halfway through a load-development test, the rifle tells me very clearly that I have no reason to fire the remaining cartridges.

Troubleshooting is part of reloading.

The important thing is not to respond to every problem by immediately adjusting three dies and changing the load. I want to establish what has actually changed and at what stage it changed.

My normal approach is simple: stop → identify the symptom → compare it with what was normal → find the stage where the problem appeared → measure before adjusting → correct one thing → test again.

That method is far more useful than guessing. If something feels genuinely wrong, whether at the loading press or in the rifle, I stop. Reloading equipment gives a surprising amount of information through feel. Once I know what normal sizing, priming and seating feel like, an unusual amount of resistance—or unusually little resistance—is information worth investigating.

The same applies to the rifle. If a cartridge that normally chambers smoothly suddenly requires force, I don't lean harder on the bolt. I find out why.

Tight Bolts, Chambering Problems and the Case-to-Chamber Relationship

One of the most common problems with bottleneck rifle ammunition is a bolt that has become tight to close. My first thought with fired brass is normally the sizing relationship between the case and chamber.

People often describe this as needing to “sort the headspace”, and in practical reloading language I know what they mean. More precisely, what I can control at the loading bench is the position of the case shoulder relative to the chamber.

If the shoulder has not been knocked back enough during full-length sizing, the case can remain too close to its fired dimension and the bolt may become tight. That's why I measure rather than simply screw the sizing die farther down.

I take a fired case measurement with the appropriate comparator, size the case, measure it again and establish how far the shoulder has actually moved. The amount required depends on the rifle and application. I want enough shoulder bump for reliable chambering without unnecessarily sizing the case more than required.

That balance matters particularly with hunting ammunition. A competition rifle being single-fed under controlled conditions and a stalking rifle expected to chamber immediately in the field do not necessarily require exactly the same degree of clearance. Reliability has to suit the job.

There is also a very useful diagnostic test here. Try the sized empty case in the rifle before blaming the finished cartridge.

If the sized case itself is tight, I know the problem existed before priming, charging and seating. I can concentrate on sizing, shoulder position, case-body dimensions, case length and the condition of the brass.

If the empty sized case chambers beautifully but the completed cartridge doesn't, something later in the loading process has introduced the problem. That immediately narrows the search.

A tight finished cartridge can also result from excessive loaded-neck diameter, an unexpectedly long cartridge, a projectile contacting or jamming into the rifling, incorrect crimping, a damaged case or contamination. The point is not that a tight bolt always means “more shoulder bump”. It often does. But I confirm it.

Once I have established the correct sizing setup for that rifle, I record it and periodically verify the resulting shoulder movement rather than relying solely on where the die happens to sit in the press. For ammunition that absolutely has to feed and chamber reliably, I also check representative sized cases during the loading session.

Hydraulic Dents — Usually a Lubrication Problem

A dent appearing in the shoulder or body immediately after sizing can look alarming, particularly the first time somebody sees one. Quite often it is a hydraulic dent caused by excessive sizing lubricant.

The lubricant becomes trapped between the case and die. Because the lubricant cannot simply compress away, pressure deforms the brass and produces the familiar dent. The solution is not another die adjustment. It is to look at the lubrication process.

I want enough lubricant to prevent a stuck case and reduce unnecessary sizing effort, but I don't want the case covered in excessive lubricant. I also keep the sizing die clean. Lubricant can accumulate inside the die even when the amount applied to each individual case seems reasonable.

A small hydraulic dent may sometimes disappear during firing if the case is otherwise completely sound, but that does not mean I ignore the cause and continue producing them. A severe or questionable case gets put aside.

The preventative lesson is straightforward: use enough lubricant, not as much lubricant as possible.

When the Case Doesn't Seal Properly

A fired case with soot extending down its outside is often telling me that the case has not sealed the chamber particularly well. This is poor obturation.

When a cartridge fires, the case needs to expand sufficiently to seal against the chamber wall. If that seal is incomplete, combustion gas and residue can travel rearwards around the case and leave the characteristic dirty or sooty appearance.

This can occur with a load producing insufficient pressure for the case and chamber combination, although I don't diagnose the entire load from soot alone. The brass itself, chamber dimensions, powder behaviour and other factors can influence what I see.

A little soot around the neck is not automatically a disaster. Heavy soot extending substantially down cases, particularly when accompanied by poor or inconsistent performance, deserves investigation.

I look at the complete picture: charge and published data, velocity, case behaviour, consistency, powder suitability, component combination, and how the rifle is actually performing. The mistake would be to see a dirty case and automatically add powder. Troubleshooting should identify the cause before applying a cure.

Pressure: Too Much, Too Little and the Danger of One-Sign Diagnosis

Pressure deserves particular care because reloaders are often taught to look for one visual sign and make a judgement from it. Real life is not that simple.

A flattened primer by itself is not a pressure gauge. Primer appearance can be influenced by primer construction, firing-pin fit, headspace relationship, firing-pin hole dimensions and the firearm itself. Likewise, a case that looks normal does not prove that a load is safe.

What interests me more is change, particularly when several things change together. If an established load suddenly produces unexpectedly higher velocity, noticeably harder bolt lift, difficult extraction, abnormal

case behaviour or significantly different primer appearance, I stop. I don't keep firing cartridges simply to collect more evidence.

Likewise, unexpectedly low velocity, very dirty cases and poor obturation may indicate that something is not working as intended at the other end of the spectrum. But again, the cure is not automatically “add more powder”. I confirm the powder, charge, components, measurements and published data first.

The chronograph is particularly useful here. If the load is producing substantially more velocity than expected, I want to understand why. I first confirm that the chronograph result itself is credible. Then I look at powder identity, actual charge, powder lot, case capacity, seating, temperature, barrel, and component changes.

Published velocity is a reference, not a promise that my rifle will produce exactly the same number. But an unexpected change in my own established ammunition is information.

Over-Chamfering and Loss of Useful Neck Contact

Chamfering is a small operation that is very easy to overdo. The objective is to remove the sharp internal edge and provide a clean lead for projectile seating. I'm not trying to turn the inside of the case mouth into a funnel.

If I remove excessive material, I reduce the useful contact area at the mouth of the neck. Taken too far, that can contribute to poorer projectile retention and less consistent neck behaviour. This is particularly easy to do when using powered case-preparation equipment because material disappears quickly.

A good chamfer is enough to do its job and no more. If projectile seating suddenly feels unusually light and I have recently changed the chamfering operation, the case mouth is one of the places I inspect.

Projectile Seating, Neck Doughnuts and Unexpected Engagement

Within a properly prepared batch, projectile seating force should normally feel reasonably consistent. I'm not suggesting my hand is a calibrated load cell, but a projectile that suddenly seats with almost no resistance—or requires dramatically more force—is worth investigating.

Possible causes include neck-diameter variation, inconsistent neck-wall thickness, case-mouth damage, incorrect mandrel or bushing setup, contamination, a neck doughnut, projectile variation or an individual case that has simply escaped an earlier preparation check.

With some brass, particularly after repeated firing and sizing or after case forming, material can accumulate around the neck-shoulder junction and form what is commonly called a doughnut. Whether it matters depends on where the projectile sits and the dimensions involved. If the projectile's bearing surface extends into the affected area, the doughnut can influence seating force and neck behaviour.

I don't automatically machine every case because I have heard the term. I establish whether I actually have a doughnut and whether it is interfering with the ammunition.

A projectile contacting the rifling is not automatically wrong. Some precision loads are deliberately developed with the projectile touching or engaging the lands. The problem is unexpected engagement.

A projectile lot can have slightly different geometry. Seating settings can move. The throat changes as the barrel wears. A measurement can be wrong. If an unfired cartridge becomes difficult to chamber or extract, projectile engagement belongs on the list of things I check.

One particularly unpleasant result is withdrawing an unfired cartridge and leaving the projectile stuck in the barrel while the case comes out and spills powder into the action. If that happens, the shooting stops. The firearm is made safe, the bore obstruction is dealt with correctly and the loading setup is investigated before continuing.

Case and Primer Problems

Cases can be damaged at several points in the process. A crushed shoulder during seating may indicate that the seating die is incorrectly adjusted, particularly where a crimp feature is being applied unintentionally. A buckled case mouth can indicate poor projectile alignment or insufficient mouth preparation. Scratches may come from contamination or damage inside a die.

Repeated marks in exactly the same place across several cases strongly suggest tooling rather than random brass defects.

A case stuck in a sizing die normally points me towards inadequate lubrication, incorrect lubricant application or another sizing problem. The important thing with a stuck case is not to turn frustration into greater damage by applying ever more force. Use the appropriate stuck-case removal method for the die and then establish why it stuck before sizing the next case.

Primer seating should have a reasonably consistent feel within a known batch of brass. A primer that suddenly seats with very little resistance gets my attention. A loose primer pocket can indicate that a case has reached the end of its useful life. If this begins happening repeatedly within an established batch, I start thinking about the condition of the batch rather than treating each case as an isolated event.

At the opposite extreme, a primer that will not seat properly may point to contamination, an incorrectly prepared pocket, the wrong primer, a remaining obstruction or a priming-tool problem. A high primer is not something I leave for the bolt face to finish seating. Nor do I accept a primer that has gone in sideways or has obviously been damaged during seating.

Powder, Measurement and Runout Problems

Powder charging deserves a different sort of troubleshooting because an error can remain invisible once the projectile is seated. Powder can bridge in a funnel, drop tube or dispensing system. Some powders meter less consistently than others. Static can cause problems. Electronic scales can drift. A powder measure can change as the hopper level changes.

If a system that normally throws consistent charges suddenly stops doing so, I stop charging cases. I check the dispenser, powder path and scale rather than compensating mentally for a machine I no longer trust.

If using an electronic scale or dispenser, I also consider zero, calibration, drafts, vibration, bench stability, temperature, electrical interference, contamination, and power supply or battery condition. Electronic equipment is extremely useful. It is not incapable of being wrong.

If my seating measurement begins drifting during a batch, I don't immediately start turning the seating die. First I verify the measurement: calliper zero, comparator fit, clean contact surfaces, measuring pressure and projectile lot. Then I inspect the seating equipment. A seating stem can accumulate material. A lock can move. A micrometer setting can be disturbed.

If finished-cartridge runout suddenly becomes worse, I don't immediately condemn the seating die. I work through the process: fired case, sizing, expander or mandrel, then seating. The troubleshooting principle is simple: find the operation that introduced the error before trying to correct it.

When a Proven Load Suddenly Stops Shooting

This is one of the easiest situations in which to waste a lot of ammunition. A load that has shot extremely well suddenly produces a poor group, and the natural reaction is to start changing the ammunition. I don't.

First I consider the whole system. The scope can move. Mounts can loosen. Action screws can change. A moderator or muzzle device can cause problems. The barrel may be unusually dirty—or behave differently after cleaning. Bags or rests can change. Wind and mirage can make excellent ammunition look terrible. And, of course, I can simply shoot a poor group.

Only after considering the rifle, conditions and shooter do I start blaming a previously proven load. Then the loading records become invaluable. Has anything changed? Different powder lot? Projectile lot? Primers? Brass? Number of firings? Annealing? Seating setting?

One poor group is information. It is not always a diagnosis.

A load can look excellent at 100 yards and disappoint farther out. For long-range ammunition, vertical deserves particular attention, but I don't blame every high or low shot on ammunition. Velocity variation can contribute. Projectile variation can contribute. So can aiming, rifle position, wind, mirage and terrain-induced conditions.

A load can also remain mechanically identical while the rifle changes around it. As a barrel accumulates rounds, the throat wears. The relationship between the seated projectile and the rifling therefore changes over time. That doesn't mean I constantly chase the lands. It means that if a long-established load genuinely begins behaving differently and the barrel has accumulated substantial use, throat condition belongs on the troubleshooting list.

Sometimes the ammunition has not changed. The barrel has.

Dismantling Ammunition Is Part of Reloading

There is another troubleshooting tool that deserves far more attention than it usually receives: the bullet puller.

A cartridge does not have to be fired simply because I loaded it.

This is particularly important during load development. Suppose I have prepared a series of cartridges with progressively increasing powder charges. I begin testing and reach a point where the target, chronograph, rifle or cases tell me everything I need to know.

Perhaps I have found the useful region. Perhaps the higher charges no longer offer anything. Perhaps I have encountered behaviour that tells me I should stop.

I don't fire the remaining cartridges simply because they are sitting in the ammunition box. Those cartridges get pulled.

The same applies to ammunition that I have decided not to test, ammunition assembled with an incorrect setting, ammunition from an abandoned experiment or cartridges whose identity or suitability needs resolving.

Stopping a test is not failure. Sometimes it is exactly the correct result of the test.

The familiar inertia or kinetic puller is extremely useful for occasional dismantling. The cartridge is held securely in the tool and repeated impact allows inertia to separate the projectile from the case. For a handful of cartridges it is simple and effective, and it can preserve projectiles reasonably well because the projectile itself is not normally gripped by a collet.

For larger quantities, I generally prefer a press-mounted collet puller where appropriate. The correct collet grips the projectile and the press provides the mechanical movement needed to withdraw the case. It is considerably more convenient when dismantling a substantial batch. The trade-off is that the collet can mark the projectile, depending on the design, adjustment and projectile.

Figure 45.1 — *Collet-style projectile puller with a loaded cartridge positioned in the tool. The collet grips the projectile while the press supplies the controlled mechanical movement needed to separate it from the case.*

A lightly marked match projectile might be removed from my serious competition batch but remain perfectly useful for fouling, practice or another non-critical purpose. I inspect what I recover rather than automatically treating every pulled component as either perfect or scrap.

What Can Be Saved?

One advantage of dismantling unwanted handloads rather than simply disposing of complete cartridges is that much of the material may remain useful.

The case can often be retained if it is sound and has not been damaged. The projectile can often be retained if the pulling operation has not damaged it beyond the requirements of its intended use.

The primer requires more thought. If I have a sound primed case and know exactly what primer is in it, there may be no reason to remove the live primer merely because I have pulled the projectile and emptied the powder. I would rather retain a known primed case than casually decap a live primer for no useful reason.

The powder needs particularly disciplined handling. If I have positively identified powder from a controlled dismantling operation and it has remained completely uncontaminated, I know what I am dealing with. But if powder identity is uncertain, if different loads have become mixed, or if there is any doubt about contamination, it does not go back into the original powder container.

I never identify powder by appearance. Many propellants look remarkably similar. The small value of recovered questionable powder is not worth introducing uncertainty into an entire container of known powder.

Imagine I have loaded twenty test cartridges in increasing charge groups. After firing the lower and middle portion, I decide that the remaining higher-charge cartridges have no useful part in the test. Maybe the load has already shown me the region I want. Maybe velocity is already where I need it. Maybe accuracy has clearly deteriorated. Maybe the rifle or cases have given me a reason to stop.

The remaining cartridges are not an obligation. I pull them.

That lets me retain whatever components remain suitable, keeps unwanted experimental ammunition out of my ammunition stock and avoids firing cartridges that I have already decided serve no useful purpose.

There is an important distinction between dismantling my own clearly documented load and dismantling ammunition whose contents I don't know. With my own test ammunition I know what components went into it. With an unidentified cartridge, I may not know the powder, charge, primer, projectile, brass history, or who assembled it.

Pulling it may allow individual components to be inspected, but it does not magically make unknown powder identifiable.

The principle I use is: if I know exactly what I have, I can make an informed decision about retaining it. If I don't know exactly what I have, I don't guess.

Preventing Problems Is Better Than Diagnosing Them

Most of the problems in this chapter become easier to avoid once I recognise their causes.

Tight bolts are less likely when I measure the sizing result instead of setting the die by assumption. Hydraulic dents are less likely when I use sensible amounts of lubricant and keep dies clean. Poor seating is less likely when case mouths, neck condition and tooling are consistent. Powder errors are less likely when the charging process contains deliberate verification. Unknown ammunition is less likely when everything is labelled immediately. Load-development cartridges are less likely to become confused with proven ammunition when the unused rounds are pulled as soon as I know I no longer need them.

Good troubleshooting therefore changes the way I reload. Every problem I understand should make the next batch slightly harder to get wrong.

When something behaves unexpectedly, I don't start by asking which tool I need to adjust. I start with: What exactly is wrong? When was it last known to be right? What has changed since then? At which operation does the problem first appear? Can I measure or compare it against a known-good reference?

Only then do I alter something. And when I do make a correction, I change one meaningful thing at a time. That leaves me knowing whether the correction actually worked.

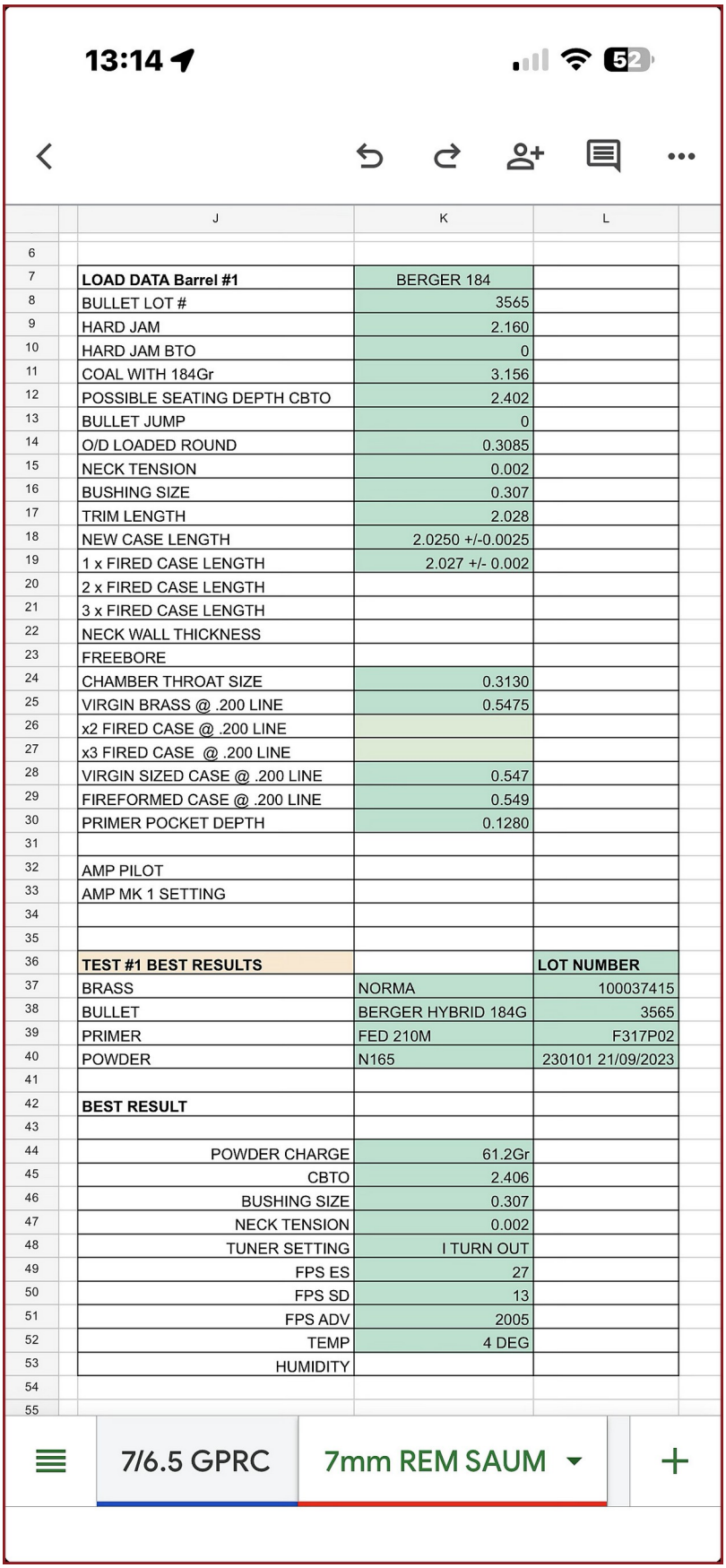
Sometimes the answer will be a die adjustment. Sometimes it will be less lubricant. Sometimes it will be replacing worn brass. Sometimes it will be cleaning a piece of equipment. Sometimes it will be discovering that nothing was wrong with the ammunition in the first place.

And sometimes the correct answer is simply: stop shooting, pull the remaining cartridges and go back to the last combination I know is right.

That is not wasted ammunition. That is controlled reloading.

Chapter 46 — Keeping a Proven Load Proven

Figure 46.1 — *Case batches stored separately and labelled by cartridge and number of firings, preserving the history of each batch.*



	J	K	L
6			
7	**LOAD DATA Barrel #1**	BERGER 184	
8	BULLET LOT #	3565	
9	HARD JAM	2.160	
10	HARD JAM BTO	0	
11	COAL WITH 184Gr	3.156	
12	POSSIBLE SEATING DEPTH CBTO	2.402	
13	BULLET JUMP	0	
14	O/D LOADED ROUND	0.3085	
15	NECK TENSION	0.002	
16	BUSHING SIZE	0.307	
17	TRIM LENGTH	2.028	
18	NEW CASE LENGTH	2.0250 +/-0.0025	
19	1 x FIRED CASE LENGTH	2.027 +/- 0.002	
20	2 x FIRED CASE LENGTH		
21	3 x FIRED CASE LENGTH		
22	NECK WALL THICKNESS		
23	FREEBORE		
24	CHAMBER THROAT SIZE	0.3130	
25	VIRGIN BRASS @ .200 LINE	0.5475	
26	x2 FIRED CASE @ .200 LINE		
27	x3 FIRED CASE @ .200 LINE		
28	VIRGIN SIZED CASE @ .200 LINE	0.547	
29	FIREFORMED CASE @ .200 LINE	0.549	
30	PRIMER POCKET DEPTH	0.1280	
31			
32	AMP PILOT		
33	AMP MK 1 SETTING		
34			
35			
36	**TEST #1 BEST RESULTS**		**LOT NUMBER**
37	BRASS	NORMA	100037415
38	BULLET	BERGER HYBRID 184G	3565
39	PRIMER	FED 210M	F317P02
40	POWDER	N165	230101 21/09/2023
41			
42	**BEST RESULT**		
43			
44	POWDER CHARGE	61.2Gr	
45	CBTO	2.406	
46	BUSHING SIZE	0.307	
47	NECK TENSION	0.002	
48	TUNER SETTING	I TURN OUT	
49	FPS ES	27	
50	FPS SD	13	
51	FPS ADV	2005	
52	TEMP	4 DEG	
53	HUMIDITY		
54			
55			

Figure 46.2 — *A real load record linking cartridge dimensions, component information, charge data and test notes so an established combination can be reproduced and changes tracked.*

Developing a good load can take a surprising amount of work.

There may have been several trips to the range, different powder charges, seating adjustments, chronograph strings and plenty of ammunition that taught me something without ever becoming the final load.

Eventually, though, I reach the point where the ammunition does what I want it to do.

At that stage I stop treating it as an experiment.

It becomes my **known load**.

That change of mindset matters. There is little sense spending weeks developing ammunition and then continually altering it because I have thought of another measurement I could take or another adjustment I could make.

Once a load is safe, repeatable and comfortably meets the standard I need, I want to preserve it.

But preserving a proven load does not simply mean writing the powder charge and seating depth in a notebook. Components change. Brass ages. Tooling moves. Barrels wear. Eventually even the products we rely upon disappear.

What I really want to preserve is the **process that produced the result**.

That means knowing what matters, recording enough to reproduce it and recognising when something genuinely changes.

It gives me a very useful starting question whenever ammunition stops behaving as expected:

What is different from the ammunition I already know works?

Establishing the Load as a Reference

When I finally sign off a load, I record enough information to reproduce it properly.

Exactly how much I record depends upon the ammunition. A stalking load does not necessarily need the same level of documentation as ammunition prepared for serious F-Class competition.

At minimum, I want to know which firearm the load belongs to. As I have said elsewhere in this book, **my handloaded ammunition is for the specific firearm for which it was developed**. Another rifle having the same chambering marked on its barrel does not make that ammunition interchangeable.

Beyond that, I record the components and settings that genuinely define the load: brass, primer, powder, projectile, charge, seating information and the sizing and neck setup where those are important.

For serious competition ammunition I will normally record component lot numbers as well, together with useful velocity information and the history of the brass.

I don't record measurements simply because I own the tool required to take them.

A useful record has two jobs:

allow me to reproduce the ammunition and allow me to recognise what changed if it stops behaving normally.

That second purpose becomes increasingly valuable as time passes.

For an important load, I may also keep a small quantity of known-good ammunition from a batch that has already proved itself.

A few correctly labelled reference cartridges can sometimes answer a question very quickly.

If a fresh batch suddenly behaves differently, I can compare it with ammunition that I already know performed correctly. If the reference ammunition still behaves normally but the new batch does not, I know where to concentrate my attention. If both have changed, I broaden the investigation to the rifle, scope, barrel, conditions or another part of the system.

I use the same idea on the loading bench.

A reference case can help verify a comparator setup. A retained projectile can check the zero of a sorting tool. Proper check weights can verify a scale.

A known reference is much better than remembering roughly what something looked like six months ago.

Once It Works, Stop Interfering With It

Reloaders are very good at disturbing successful ammunition.

We spend weeks finding a load that shoots beautifully and then begin wondering whether another tiny seating adjustment might make it even better.

Perhaps another mandrel would improve it.

Perhaps another small powder adjustment deserves testing.

Perhaps we should sort something more tightly.

There is nothing wrong with experimentation when there is a reason for it. But if the ammunition is already doing everything I require, changing it simply because I haven't changed anything recently is not necessarily development.

Sometimes it is simply disturbing a proven system.

For a stalking rifle, if I have safe, dependable ammunition producing around the 1-MOA standard or better and I have complete confidence in where the first shot is going, I have very little interest in chasing another fraction of an inch merely for the sake of it.

For F-Class the required standard is considerably higher, but eventually exactly the same principle applies.

There comes a point when I stop developing ammunition and start producing it.

That is an important distinction.

Components Will Eventually Change

Even if I leave the loading process alone, components do not remain the same forever.

Eventually I open another container of powder.

I buy another batch of primers.

A new lot of projectiles arrives.

The original brass becomes tired.

Sometimes a favourite component disappears completely.

The important distinction is between the **same product** and the **same manufacturing lot**.

They are not necessarily identical.

For general sporting ammunition, small lot-to-lot differences may make no practical difference at all. I don't want to create work where none is needed.

For carefully tuned competition ammunition, however, I want to know whether a change matters before producing a large quantity.

A new powder lot deserves sensible checking rather than assumption. My established load remains extremely useful information, but I verify the new lot safely against appropriate current published data and the behaviour of my own rifle.

How much confirmation I need depends partly on the load and its intended use.

A moderate sporting load and a highly developed competition load do not necessarily require the same level of investigation.

The same principle applies to primers and projectiles.

A different primer lot may produce no measurable difference whatsoever.

Excellent. I confirm that and carry on.

A new projectile lot may also behave almost identically to the old one, but for serious precision ammunition I still check the measurements that actually matter to my setup rather than assuming everything must be identical.

This is particularly important with the advanced projectile sorting covered earlier. If I am sorting projectiles to a very fine level, I do that **within the same manufacturing lot**.

The purpose of controlling lots is not to make ammunition complicated.

It is to remove unnecessary uncertainty.

Brass Has a History Too

I prefer to think of serious competition brass as a batch with a history.

I know approximately how many firings it has had. I know how I have sized it. I know its annealing history where annealing forms part of my process, and I know when cases have been removed.

That batch gradually becomes smaller.

This is normal.

If I begin with 100 cases and later have 96 genuinely good ones, then I have a 96-case batch.

I don't lower my inspection standard because I want the number written on the box to remain at 100.

Nor do I automatically replace four rejected mature cases with four brand-new cases merely to restore the original count.

For ordinary ammunition that difference may be completely irrelevant.

For competition ammunition where I have deliberately worked to make the batch behave uniformly, the different history may matter.

New brass can be prepared and brought through its own route.

There is no universal number of firings at which every case suddenly becomes finished either.

I look at what the batch is telling me.

One loose primer pocket may be one bad case.

Repeated loose pockets, neck failures, inconsistent sizing or increasing rejection across the batch tell me something about the condition of the batch itself.

Brass that I am no longer willing to use for an important competition may still be perfectly useful for practice.

Again, the required standard depends upon the job.

A Barrel Is a Consumable Product

The ammunition is not the only thing changing.

The rifle changes as well, and nowhere is that more obvious than the barrel.

A barrel is a **consumable product**.

That doesn't mean it is fragile or that I should be frightened of shooting it. The barrel was made to be fired.

It simply means that it has a finite useful life.

In a sense, **a new barrel is already on its way out after the first shot**.

That sounds dramatic, but the principle is straightforward. Every firing exposes the throat immediately ahead of the chamber to extremely hot, high-pressure propellant gases and enormous thermal and mechanical stress.

Very small amounts of material are progressively eroded from the throat.

Shooters often describe this as the throat being **burnt out**, and that is actually quite a useful description.

The process begins with the first firing and continues for the rest of the barrel's life.

The question is therefore not whether the throat is wearing.

It is:

how quickly is it wearing, and when will that wear begin to affect the performance I require?

Why Some Barrels Erode Faster

Some cartridges are considerably harder on throats than others.

As a broad rule, **smaller-bore cartridges pushing projectiles very fast while burning relatively large quantities of powder tend to be particularly demanding on barrels**.

They are putting a considerable amount of very hot gas through a comparatively small bore.

That is why some fast, high-performance small-calibre cartridges have a reputation for relatively short competitive barrel life, while more moderate cartridges may continue performing for considerably longer.

The term **overbore** is sometimes used to describe cartridges with a large powder capacity relative to their bore size. I do not need to become too concerned with the label to understand the principle.

Hotter, faster combinations generally ask more of the throat.

Heat during shooting matters as well.

If I repeatedly fire until the barrel becomes extremely hot, I'm not helping its life.

During a competition the course of fire dictates what I have to do, but during practice and load development there is little sense unnecessarily overheating a barrel merely because I want to finish sooner.

I can't prevent throat erosion.

I can avoid accelerating it unnecessarily.

What Throat Erosion Does to a Proven Load

As the throat erodes, the point at which the projectile first meets the rifling gradually moves farther forward.

That means ammunition seated to exactly the same dimensions as when the barrel was new gradually develops more jump to the lands.

Nothing has moved in my seating die.

The ammunition can be dimensionally identical.

The rifle has changed around it.

For a general stalking rifle this may make no meaningful difference for a long time.

For a highly tuned F-Class rifle, however, there can eventually be a point where the load begins to show a change in grouping or long-range vertical.

That is why seating depth can become relevant again later in the barrel's life.

Not because I have suddenly decided to start experimenting again, but because the geometry around which the original load was developed has changed.

Seating Depth and Chasing the Lands

One way of compensating for progressive throat erosion is to gradually seat the projectile farther out as the throat moves forward.

This is commonly called **chasing the lands**.

Used sensibly, it can help maintain a seating relationship that the rifle has previously shown it likes.

But I don't automatically adjust the seating die every time I measure a tiny amount of throat movement.

The throat is going to move.

That alone is not a fault.

If the rifle continues shooting extremely well, I leave it alone.

The useful question is not:

Has the throat moved?

It has.

The useful question is:

Has it moved enough to affect the performance I care about?

If accuracy or long-range vertical genuinely begins to deteriorate and the rest of the rifle and ammunition check out, seating depth becomes one of the first tuning variables I may revisit.

Sometimes a modest seating adjustment brings a load back into tune and gives the barrel considerably more useful competitive life.

It is important to understand what has happened.

I haven't repaired the throat.

The metal that has eroded is still gone.

I have simply adapted the ammunition to the barrel's new geometry.

Eventually there will also be practical limits to how far I can continue moving the projectile forward. Magazine length may become a restriction in a repeating rifle, while projectile grip, neck length and the geometry of the projectile itself eventually impose limits even in a single-fed rifle.

Chasing the lands is a useful tool.

It cannot make a barrel new again.

Soft Seating

There is another more specialised method used by some precision shooters known as **soft seating**.

Rather than fixing the projectile at a conventional final seating position with normal retention, the ammunition is prepared with controlled, relatively light projectile grip so that the projectile can establish its final relationship with the rifling as the cartridge is chambered.

This is a specialist technique.

It is not something I would use for ordinary stalking ammunition or general magazine-fed loads. Its place is in carefully controlled single-fed precision shooting where the shooter understands exactly what the method is doing.

The attraction in an ageing barrel is fairly obvious.

As the throat gradually moves forward, soft seating can reduce the need to continually alter a fixed seating setting to follow it.

But it comes with its own considerations.

The projectile still has to be retained predictably enough for the way the ammunition is being handled. Brass and neck preparation need to be consistent, and the shooter needs to understand what can happen when an unfired cartridge is extracted.

A projectile held by the rifling can remain in the barrel while the case comes backwards.

That can leave loose powder in the action and a projectile obstructing the bore.

If that happens, shooting stops. The firearm is made safe and the obstruction is dealt with before anything else happens.

Soft seating is not a shortcut around proper load development.

It is another advanced method of managing the projectile-to-rifling relationship where the rifle, discipline and loading method make it appropriate.

Round Count Is Part of the Barrel's History

For a serious competition rifle, I consider round count important enough to record from the first shot.

The number does not tell me the exact firing on which a barrel will cease to perform at the level I require.

Two apparently identical barrels can have different useful lives, and the way they have been used matters.

But round count gives me **history and context**.

If a relatively fresh barrel suddenly stops grouping, I am less inclined to immediately blame normal throat erosion.

If a barrel with a substantial round count starts showing the sort of deterioration I have previously seen towards the end of competitive life, the round count supports what I am seeing on the target.

That makes troubleshooting considerably less speculative.

More importantly for competition shooting, round count helps me plan ahead.

Sometimes the question isn't:

Will this barrel shoot well today?

The question is:

Do I have enough confidence in its remaining life to take it through another full competition?

That is much more useful.

Knowing the History of Previous Barrels

The more comparable barrels I use, the more useful my own records become.

Suppose I have already used four barrels of the same general specification, with broadly the same cartridge, loading approach and accuracy requirement.

Those four barrels have generally maintained the level of F-Class performance I require for around **1,400 rounds**.

My current barrel has now fired **1,320 rounds**.

I have a two-day competition approaching in which I expect to fire approximately **100 rounds**.

That would take the barrel to roughly:

1,320 + 100 = 1,420 rounds.

Could the barrel still shoot extremely well at 1,420 rounds?

Absolutely.

It might continue shooting well beyond that.

But experience from the four barrels before it tells me that I am entering the region where I have historically begun to lose the performance I require.

For me, that is enough reason to change the barrel before an important competition.

I don't want to begin a 100-round weekend with approximately 80 rounds remaining before reaching the region in which previous barrels have tended to deteriorate.

It **possibly** being all right is not good enough for me in that situation.

That doesn't make 1,400 rounds a magic number.

Shot number 1,401 does not suddenly ruin the barrel.

The next barrel may give substantially more life. Another may give less.

What I have built is a history from my own equipment that lets me make an informed decision.

That is much more useful than somebody else telling me how many rounds they get from the same chambering.

Their load may be different.

Their barrel may be different.

Their firing schedule may be different.

Most importantly, their definition of acceptable accuracy may be different.

My own barrel history tells me what happens **for the standard I require**.

The old barrel does not necessarily go in the bin. It may remain useful for practice, testing or another application.

I simply do not need to discover during the second day of an important match whether I tried to take one competition too many from it.

What Does “Shot Out” Actually Mean?

There is no single group size or round count at which every barrel suddenly becomes shot out.

For me, a barrel is effectively shot out when it can no longer consistently produce the accuracy required for the job I am asking it to do.

That makes the definition dependent upon use.

A serious F-Class barrel might begin its life capable of around **¼-MOA performance**.

As the throat erodes, I may be able to maintain that performance for a considerable time. Later, seating-depth adjustment may recover a load that has started to move out of tune.

Eventually, though, there may come a point where a load that I know is good begins to spray rather than group as it once did.

Before condemning the barrel, I eliminate the other sensible possibilities.

I check the ammunition, optics and mounts, rifle setup, fouling, muzzle equipment, conditions and, importantly, the shooter.

If those are all in order, the barrel has a substantial round count and sensible seating adjustment no longer restores the performance, then the barrel may simply have reached the end of the accuracy standard I require.

For F-Class, that can happen while the barrel is still extremely accurate by normal sporting standards.

A barrel that once consistently held around **¼ MOA** but has deteriorated to approximately **1 MOA** may be finished for serious F-Class use.

Yet purely in terms of accuracy, that same barrel could still make an excellent stalking barrel.

As discussed earlier in the book, around 1 MOA at 100 yards is perfectly respectable for general stalking. A smaller group is always nice, but the animal will not know that the barrel once shot quarter-minute groups.

Obviously a very heavy competition barrel and rifle configuration may be completely impractical to carry for stalking. I am talking purely about the accuracy standard.

The example demonstrates an important point:

a barrel can be shot out for one purpose and still greatly exceed the requirements of another.

So when I talk about barrel life, I'm not asking how long the barrel remains capable of hitting a target.

I am asking:

How long does it continue to give me the performance I require?

That is the useful definition.

A New Barrel Creates a New Baseline

When I replace a barrel, I treat it as a significant change.

Even if the new barrel has the same chambering, twist and nominal specification, and even if the same gunsmith chambers it with the same reamer, I don't simply declare the old load proven in the new barrel.

The old load is extremely valuable information.

It tells me what has worked before and may provide an excellent starting point.

But the new barrel has its own bore, throat and chamber relationship.

It gets its own confirmation and whatever load development proves necessary.

The round count returns to zero and another barrel history begins.

After several barrels, those histories become increasingly useful. They help me predict likely life, plan rebarrelling and recognise whether the current barrel is behaving normally compared with those before it.

That is experience becoming useful data.

Chapter 47 — The Reloading Mindset

By the time somebody reaches this point in the book, they have seen just how far reloading can be taken.

At its simplest, the process is straightforward: prepare a case, prime it, add the correct powder charge, seat a suitable projectile and produce safe ammunition for a particular firearm.

At the other end of the scale we can measure shoulder movement in thousandths, control neck dimensions, sort brass and projectiles, analyse velocity variation, follow throat erosion through the life of a barrel and spend considerable time trying to remove the final small variations from ammunition intended for serious competition.

Both approaches can be correct.

The mistake is assuming that the more complicated method must automatically be the better one.

What matters is understanding why I am doing each operation.

A stalking rifle that reliably shoots around 1 MOA with ammunition I trust is doing its job. I don't need to treat that ammunition like an F-Class load simply because the techniques exist.

Likewise, if I am trying to hold extremely small vertical at long range in serious competition, there are variables I may reasonably control that would make almost no practical difference in a general sporting rifle.

The ammunition has to suit the job.

That idea has run through this entire book.

There Is No Magic Recipe

One of the things I have tried to avoid throughout the book is presenting reloading as a collection of magic numbers.

There is no universal shoulder bump that belongs to every rifle. There is no single neck tension that all accurate ammunition must use. There is no seating depth that every projectile prefers. There is no powder charge that becomes correct simply because another shooter uses it successfully.

And there is no fixed number of preparation stages that turns ordinary ammunition into precision ammunition.

Published loading data provides the safe starting framework. Measurements tell me what is actually happening. The rifle and target tell me whether the result works.

That is the process.

The numbers belong to the particular firearm, components and application.

Learn What Normal Looks Like

Experience changes the way I reload.

When I first learn an operation, I may need to think carefully about every movement. After enough repetitions, I begin to recognise what normal looks and feels like.

I know what normal sizing resistance feels like. I know how a sound primer pocket normally feels. I notice when a projectile seats unusually easily. I know how the bolt normally closes on my ammunition. I know what a healthy fired case from that rifle usually looks like.

Those observations do not replace measuring equipment. They tell me when something deserves measuring.

That is one of the great advantages of a consistent loading routine: anything unusual becomes easier to notice.

Measure With a Purpose

Modern reloaders have access to an extraordinary amount of measuring equipment. That is useful. It can also become a distraction.

If I can measure something to another decimal place, that does not necessarily mean the ammunition has improved.

A measurement earns its place when the answer helps me make a decision.

If I measure shoulder position, it is because I am controlling the sizing relationship. If I measure seating depth, it is because that relationship matters to the load. If I measure velocity, it is because I want to understand what the ammunition is doing. If I sort projectiles for serious long-range ammunition, it is because I believe the application may benefit from reducing that variation.

What I try not to do is collect numbers simply because they are available.

A loading notebook full of measurements is not automatically evidence of good ammunition. The target still matters.

Good Reloading Becomes More Purposeful

There is a tendency to assume that experience must lead towards an increasingly complicated process.

I have found that it can also lead in the opposite direction.

As I learn which operations genuinely affect my ammunition, I become more willing to remove the ones that do not.

That is not cutting corners. It is understanding where the corners actually are.

The final process may be extremely detailed for one rifle and much simpler for another. Both can represent experienced reloading.

What matters is that I can explain why each operation remains in the process.

Records Turn Experience Into Something Useful

Memory is surprisingly poor at reconstructing a load from several years ago. Records are better.

A useful loading record allows me to look back at what worked, what changed and how long components lasted.

Over time, that information becomes more powerful.

The barrel-life example from the previous chapter is a good one. After using several comparable barrels, the round counts begin telling me something about what I can reasonably expect from the next one.

The same happens with brass batches. I begin to recognise how my cases behave through their life. I learn whether a particular load is sensitive to component changes. I discover which rifles care about seating depth and which are remarkably tolerant.

That is how experience becomes more than memory. It becomes evidence.

Mistakes Should Improve the Process

Nobody reloads for long without something going wrong.

A stuck case. A hydraulic dent. A primer that does not feel right. A cartridge that will not chamber. A load that looks promising and then refuses to repeat itself. A barrel that suddenly stops behaving as expected.

The useful part is understanding why.

If I solve the immediate problem but do nothing to prevent it happening again, I have only completed half of the job.

Good troubleshooting should improve the loading process. The next batch should be harder to get wrong.

That is how a personal loading method develops.

Do Not Be Afraid to Stop

Sometimes the most important decision in reloading is stopping.

Stop increasing the powder charge because the test has already given enough information.

Stop firing the remaining development rounds and pull them.

Stop adjusting a proven load that is already doing everything required.

Stop using a case whose condition is questionable.

Stop trying to recover the final few competition rounds from a barrel when its history tells me replacing it before the next important event is the sensible choice.

And sometimes simply stop for the day because concentration has gone.

There is no prize for completing a loading session when I am no longer comfortable with what I am doing.

Confidence Is the End Result

For me, one of the main purposes of handloading is confidence.

I want to pick up a box of ammunition and know exactly what it is.

I know which firearm it belongs to. I know the components. I know how it was prepared. I know how it performs.

For a stalking rifle, that confidence means I can concentrate on the shot rather than wondering whether the ammunition will do its part.

For a competition rifle, it means that when a shot does not go where I wanted it to, I don't immediately start doubting every cartridge in the box.

Good ammunition removes uncertainty.

It doesn't remove wind. It doesn't remove poor shooting. It doesn't make an unsuitable rifle suitable.

But it means the ammunition is one less thing I need to question.

Keep Learning, But Keep Testing

Reloading never really stops developing.

New tools appear. New cartridges arrive. Different powders and projectiles become available. Techniques move from one discipline into another.

Some of them are genuinely useful. Others become fashionable for a while and then quietly disappear.

I am interested in new ideas, but I want them to prove themselves.

If a new method produces a real, repeatable advantage in the ammunition I care about, I can adopt it.

If it merely produces a different number on a measuring tool without improving anything that matters, I don't have to keep it.

That is not resistance to change. It is testing the change.

The Aim Was Never Perfect Ammunition

Perfect ammunition probably does not exist.

There will always be another tiny variation to measure. Another tolerance to tighten. Another component to sort. Another adjustment to try.

The practical objective is different.

I want ammunition that is safe, appropriate for its intended use, repeatable, understood and good enough that I can trust it.

For some ammunition, good enough may mean approximately 1 MOA and absolute reliability. For another rifle it might mean considerably better than that. For serious F-Class ammunition, the standard may be exceptionally demanding.

The required result changes. The principle does not.

Make Ammunition, Then Go Shooting

Reloading can easily become a hobby completely separate from shooting.

There is nothing wrong with enjoying the loading bench. I certainly do.

But eventually ammunition has to leave the bench.

The target teaches things that a comparator cannot. A chronograph tells me things the loading manual cannot. A long-range target can expose variation that looked irrelevant at 100 yards. And actual shooting experience tells me whether all the preparation was worthwhile.

That completes the cycle:

load → measure → shoot → observe → learn → improve where necessary → preserve what works.

Then do it again.

That is really what this whole book has been about.

Not finding one perfect recipe. Not buying every tool. Not performing every possible operation.

It is about understanding the process well enough to decide what the ammunition genuinely needs, producing it safely and consistently, and knowing when the result is good enough to leave alone.

Once that point is reached, there is only one useful thing left to do.

> **KEY PRINCIPLE**
> *Fill the ammunition box and go shooting.*

Specialist Introduction — Shotgun Cartridge Reloading

Why it is a separate discipline from metallic-cartridge reloading

Shotgun cartridge reloading is a separate discipline in its own right. The principles of safe ammunition assembly still apply, but the components, data and loading methods differ enough from metallic-cartridge reloading that the subject could easily fill another book. This section is therefore an introduction, not a complete shotgun-loading manual.

The purpose here is simply to explain what changes, why the familiar rules from rifle and pistol loading cannot automatically be carried across, and what a metallic-cartridge reloader needs to understand before deciding whether to explore shotgun loading properly.

A Different Type of Cartridge

A metallic rifle or pistol cartridge is built around a case, primer, propellant and projectile. A shotgun cartridge normally brings several additional relationships into play: the hull, primer, powder, wad system, shot or other approved payload, internal stack height and the closure at the mouth of the hull.

Those parts do not merely occupy the same container. They work together as a tested system. Hull construction changes internal volume. Wads differ in height, cushioning and gas-sealing characteristics. Primers and powders have different ignition characteristics. The payload and closure affect the space available inside the assembled cartridge.

That is the first important distinction. I do not treat a shotgun cartridge as a metallic cartridge with a quantity of shot in place of a projectile.

Published Data Is the Starting Point

With shotgun ammunition, the exact component combination matters. I use tested data from a recognised powder, component or loading-data source and follow the specified combination rather than assuming that apparently similar components are interchangeable.

A hull of the same gauge and length is not necessarily internally identical to another hull. A wad that appears similar may occupy a different amount of space or seal differently. Primers are not automatically equivalent simply because they fit the same pocket. The same applies to propellant and payload.

For that reason, shotgun loading is a particularly poor place for casual component substitution. If the data specifies a particular hull, primer, powder, wad and payload, I regard that complete combination as the load.

Hull Construction and Identification

The hull is the shotgun equivalent of the cartridge case, but identifying it only by gauge, colour or the writing on the outside is not enough. Different hull designs can have different internal construction and usable volume even when their external dimensions appear similar.

Before reusing a fired hull, I need to know exactly what it is and whether suitable published data exists for it. I also inspect it for damage, deterioration around the mouth, splitting, distortion and condition of the base. As with metallic cases, a component of uncertain identity or condition is not something I try to rescue merely because it is available.

Primers, Powder and Wads

Shotgun primers may look broadly alike, but that does not make them interchangeable in loading data. I use the primer specified by the tested recipe unless the data source itself provides an approved alternative.

The same principle applies to powder. Many shotgun loads use relatively fast-burning powders and relatively small charge weights, so an apparently modest change can be significant. Powder identification and disciplined measurement matter every bit as much here as they do elsewhere in this book.

The wad is a major part of the internal system. Depending on the cartridge, it may provide the gas seal, cushioning and a shot cup as well as establishing the correct relationship between the powder, payload and closure. Wad dimensions and design therefore matter; I do not select one simply because it fits into the hull.

Payloads: Lead and Non-Lead

The payload may be lead shot or another material approved for the intended firearm and application. Different shot materials can differ substantially in density, hardness and behaviour. Changing from one material to another is not simply a matter of filling the same space to the same level.

The firearm itself also matters. Chambering, proof status, choke, barrel condition and the suitability of the gun for the chosen cartridge and shot material all need to be considered. Current UK legal requirements and current manufacturer or proof-house guidance take precedence over general information in a book.

Crimp and Finished Cartridge Geometry

Most familiar shotgun cartridges are closed with either a fold crimp or a roll crimp. The closure is not merely cosmetic. It is part of the tested cartridge system and depends on having the correct component stack height inside the hull.

A poor closure can be a useful warning that something in the component combination or setup is wrong. I do not try to hide an obviously incorrect stack height by forcing the crimp until the cartridge looks acceptable. The finished cartridge should match the geometry expected by the published data and loading equipment.

Equipment Is Different Too

Dedicated shotgun-loading presses perform operations that are quite different from the conventional metallic-cartridge press. Depending on the machine, they may resize the base, deprime and reprime, dispense powder and shot, insert the wad and form the final crimp in a sequence of stations.

Single-stage and progressive machines are available, just as they are for metallic cartridges, but the setup and checks are specific to shotshell loading. The press manufacturer’s instructions are therefore part of the working information, not an optional extra.

What Transfers From Metallic Reloading

Although the equipment and components are different, the good habits developed elsewhere in this book still transfer. I identify every component positively, keep the bench organised, work from reliable data, change one thing only when the data permits it, inspect throughout the process and label the finished ammunition properly.

Record keeping matters for exactly the same reason. If a cartridge performs well, I want to know precisely which hull, primer, powder, wad, payload and data source produced it. If something is wrong, those records give me somewhere sensible to begin looking.

Why This Book Stops Here

A proper treatment of shotgun cartridge reloading would need to go much further: gauge-specific equipment, hull families, wad systems, shot materials, pressure-tested data, crimp setup, pattern testing, proof considerations, specialist loads and the practical differences between the many shotgun disciplines.

Trying to compress all of that into a few pages would give a false impression that shotgun loading is simply another short variation of metallic reloading. It is not.

So this introduction is deliberately a boundary marker. If you decide to reload shotgun cartridges, treat it as a new subject, obtain current tested data and the instructions for the exact equipment and components you intend to use, and learn that system properly before loading ammunition.

The same principle that has run through this book still applies: understand what each component and operation is doing, use reliable information, and never substitute guesswork for tested data.

Acknowledgements and Credits

This book grew out of practical reloading, shooting, competition and workshop experience developed through 1967Spud. Along the way, technical terminology, standards and loading principles were checked against recognised standards bodies and current manufacturer material. The detailed source list and methodology credit appear in Appendix C.

A special thanks to my mate Terry Hibben, who contributed the practical black-powder cartridge reloading material in Chapter 35. Terry shared his own methods, examples and range experience, bringing first-hand specialist knowledge to a part of the book that deserved to be covered by someone who knows the subject properly.

The 1967Spud Reloading Timeline and its sequence of operations are my own practical methodology. It is not presented as a SAAMI, C.I.P. or manufacturer-prescribed workflow.

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Appendix A
Glossary of Reloading Terms and Abbreviations

A practical A–Z reference to the terminology used throughout the book

This glossary is written as a practical companion to the book rather than as a general firearms dictionary. Straightforward terms are kept short; commonly confused terms such as headspace, head clearance, neck tension, COAL/CBTO and ES/SD are explained more fully. The book generally uses "projectile", while "bullet" is included because it remains common industry terminology.

A

Ammunition — One or more complete cartridges intended to be fired in a firearm. In this book, handloaded ammunition is always treated as specific to the firearm for which it was developed.

Annealing — Controlled heating of the case neck and shoulder area to manage the effects of work hardening and help maintain consistent brass behaviour over repeated firing and sizing cycles. The case head and web must not be softened.

Air space / **ullage** — Unoccupied internal space in a loaded case between the propellant and projectile. Its significance depends on cartridge, propellant and loading method; published data and established loading guidance always take priority.

Action — The main operating assembly of a firearm, including the locking and firing mechanism and the structure into which the barrel is fitted.

B

Ballistic coefficient (BC) — A numerical expression of how efficiently a projectile retains velocity against aerodynamic drag. BC is model-dependent; G1 and G7 values are not directly interchangeable.

Bearing surface — The main cylindrical portion of a projectile that is guided by the bore and engages the rifling. Changes in bearing-surface length can influence seating, pressure behaviour and friction.

Bell / **flare** — A slight outward expansion of a case mouth, commonly used with straight-wall and pistol cases to allow a projectile to start cleanly without shaving or damaging it.

Belted case / **belted magnum** — A case with a raised belt immediately ahead of the extractor groove. On designs intended to headspace on the belt, the belt provides the chamber seating reference.

Berdan primer — A primer system in which the anvil is part of the case rather than the primer. Berdan-primed cases usually have offset flash holes and require different depriming methods from Boxer-primed cases.

Boat-tail — A tapered rear section of a projectile intended primarily to reduce drag and improve aerodynamic efficiency.

Bore — The internal passage through a barrel. In technical use, bore diameter and groove diameter are different measurements.

Bottleneck case — A cartridge case with a larger-diameter body that narrows through a shoulder into a smaller-diameter neck.

Boxer primer — A primer system in which the anvil is contained within the primer itself and the case normally has one central flash hole. It is the common reloadable centrefire system encountered by UK handloaders.

Brass — Common reloading shorthand for cartridge cases, most of which are made from cartridge brass.

BTO / Base to Ogive — A measurement from the base of a loose projectile to a chosen reference point on its ogive. Do not confuse it with CBTO, which measures a loaded cartridge from case head to projectile ogive.

Bullet — A common industry term for the projectile fired from a cartridge. This book generally uses the word projectile.

Bushing die — A sizing die using a removable bushing to control how much the case neck is sized. Different bushing diameters allow the neck-sizing result to be tailored to particular brass and projectile combinations.

C

Calibre — A general description of bore or projectile diameter. Two cartridges can share a nominal calibre without being interchangeable.

Cannelure — A groove or impressed band around a projectile. Depending on design, it may provide a crimp location, identify a projectile or form part of its construction.

Cartridge — A complete round consisting of a case, primer, propellant and projectile. A cartridge is not simply the projectile.

Cartridge case — The component that holds the primer, propellant and projectile together and expands during firing to help seal the chamber.

Case body — The main cylindrical or tapered portion of a cartridge case between the head/web area and the shoulder or mouth.

Case capacity — The internal volume of a cartridge case. Precision reloaders often compare fired cases using water weight as a practical proxy for internal capacity.

Case forming — Changing a case from one cartridge configuration into another by controlled sizing, expanding, trimming, turning, fire-forming or related operations.

Case gauge — A fixture used to check selected case or cartridge dimensions against a known reference. A gauge is useful, but it does not replace understanding what dimension is actually being checked.

Case head — The rear portion of a case containing the primer pocket and headstamp and bearing against the bolt or breech face during firing.

Case head separation — A structural case failure, usually developing near the lower body/web region, where the case begins to split circumferentially.

Case life — The useful firing/reloading life of a case or batch of cases. There is no universal firing count; condition, cartridge, pressure, sizing and brass quality all matter.

Case mouth — The open end of the case into which the projectile is seated.

Case neck — The portion of a bottleneck case that grips and supports the projectile.

Case shoulder — The angled or tapered section joining the body and neck of a bottleneck case.

CBTO — Cartridge Base to Ogive — A loaded-cartridge measurement from the case head to a chosen reference point on the projectile ogive, normally taken with a comparator. It is often more repeatable for precision seating work than tip-to-base COAL.

Centrefire — A cartridge system in which the primer is located centrally in the case head.

Chamfer — A slight bevel applied to the inside of a case mouth after trimming to remove the sharp edge and help the projectile start cleanly. Excessive chamfering removes useful neck material.

Chasing the lands — Progressively adjusting seating depth as throat erosion moves the rifling forward, usually in an effort to maintain a previously successful projectile-to-rifling relationship.

Chamber — The part of the barrel or firearm that supports and locates the cartridge when the action is closed and the cartridge is fired.

Chronograph — An instrument used to measure projectile velocity.

COAL — Cartridge Overall Length — The overall length of a loaded cartridge from case head to projectile tip. COAL is important for function and magazine fit but projectile-tip variation can make it less suitable than CBTO for fine seating-depth comparison.

Comparator — A measuring attachment that provides a repeatable reference point for comparing case shoulders, projectile ogives or other dimensions rather than relying only on overall length.

Compressed load — A load in which the seated projectile compresses the powder charge. Some published loads are intentionally compressed; compression must never be assumed to be acceptable without suitable published data.

Components — The individual parts used to assemble ammunition: case, primer, propellant and projectile.

Concentricity — The degree to which components or surfaces share a common centreline. In ammunition work the term is commonly associated with case-neck and loaded-cartridge alignment.

Crimp — Controlled deformation of the case mouth into or against the projectile to increase retention or complete case-mouth finishing. Its use depends on cartridge and firearm type.

D

Deburring — Removing burrs or sharp material left by trimming, drilling, manufacture or another preparation process.

Decapping / depriming — Removing a spent primer from a fired case.

Decapping pin — The slender pin in a sizing or decapping die that passes through the flash hole and pushes the spent primer from the case.

Die — A press-mounted tool used to size cases, seat projectiles, crimp ammunition or perform another loading operation.

Doughnut / neck doughnut — A localised thickening around the neck-shoulder junction that can develop through repeated case movement or forming and may interfere with a projectile if its bearing surface reaches that area.

E

Expander — A tool or die component used to establish or restore the internal diameter of a case neck or to flare a case mouth.

Extractor groove — The circumferential groove near the case head that provides space for the firearm extractor to engage the rim area.

ES — Extreme Spread — The difference between the highest and lowest values in a velocity string. For example, 2,850 fps minus 2,820 fps gives an ES of 30 fps. Its usefulness depends strongly on sample size.

F

Fire-forming — Firing a suitably prepared cartridge so the case expands to conform more closely to a chamber, often used when forming wildcat or improved cases.

Flash hole — The passage connecting the primer pocket with the inside of the case through which primer ignition reaches the propellant.

Flat base — A projectile with a flat rear face rather than a boat-tail.

FL / Full-length sizing — Sizing that controls the case body and normally the shoulder and neck sufficiently for reliable rechambering.

Form factor — A comparison between a projectile's drag and the drag of the standard reference projectile used for a ballistic model. Lower form factor generally indicates more efficient aerodynamic shape within that model.

Freebore — The cylindrical section of the throat immediately ahead of the chamber before the rifling begins. Its length and diameter influence projectile-to-rifling relationship.

G

G1 / G7 BC — Ballistic coefficients referenced to different standard drag models. G7 is often more representative of modern long-range boat-tail projectile shapes; the numerical values from G1 and G7 are not interchangeable.

Grooves — The recessed portions of rifling cut or formed into a barrel.

H

Handloading — Manually assembling ammunition from individual components. Reloading is often used interchangeably, although strictly it can imply reusing a previously fired case.

Hangfire — A perceptible delay between primer strike and cartridge discharge. Keep the firearm pointed safely and follow the appropriate range/firearm procedure rather than immediately opening the action.

Head clearance — The distance between the head of a fully seated cartridge and the breech or bolt face when the action is closed. It is commonly confused with headspace but is not the same measurement.

Headspace — The chamber dimension from the closed breech face to the chamber feature that stops forward movement of the cartridge. The controlling feature depends on cartridge design, such as shoulder, rim, belt or case mouth.

Headspace gauge — A firearm/chamber gauge used to evaluate the chamber headspace relationship. It is different from a case comparator used by a reloader to compare shoulder position.

Headstamp — Markings on the case head identifying information such as manufacturer and cartridge designation.

Hybrid ogive — A projectile nose geometry combining tangent and secant characteristics, commonly intended to balance aerodynamic efficiency with less seating-depth sensitivity than a pure secant design.

Hydraulic dent — A dent, often in the shoulder, caused when excess sizing lubricant or another incompressible material becomes trapped between case and die.

I

Ignition — The sequence beginning with primer initiation and continuing into propellant combustion.

J

Jam / jammed into the lands — A seating condition in which the projectile is forced into the rifling when chambered. This is materially different from simply being close to the lands and can alter pressure behaviour.

Jacket — The outer metal covering of a jacketed projectile, commonly copper alloy, surrounding some or all of the core.

Jump — The distance a projectile travels from its seated position before first contacting the rifling.

L

Lands — The raised portions of rifling inside the barrel.

Load — The complete combination of case, primer, propellant, projectile and relevant assembly dimensions used to produce ammunition for a specific firearm.

Load density / loading density — The relationship between the volume occupied by a propellant charge and the usable internal volume available to it in the loaded cartridge.

Load development — The controlled process of establishing a safe, repeatable and suitable component combination for a specific firearm and purpose, starting from appropriate published data.

Loading block — A tray that holds cases upright and organised during loading operations.

Lot / batch number — A manufacturer or producer identifier for material made as part of the same production batch. Lot control can matter in precision ammunition because different lots can show small differences.

M

Mandrel — A precision cylindrical tool passed through a case neck to establish or influence internal neck diameter. Neck-turning mandrels may deliberately be larger than neck-tension mandrels to suit the cutter pilot and process.

Mean / average velocity — The arithmetic average of the measured velocities in a chronograph string.

Meplat — The small flat or open area at the nose of a projectile.

Meplat pointing — Forming the nose of an open-tip match projectile to reduce and make the meplat more uniform.

Meplat trimming — Cutting projectile meplats to improve uniformity before pointing or as a separate operation.

Misfire — Failure of a cartridge to discharge after the firing mechanism operates. Treat it according to firearm and range safety procedure and allow for the possibility of a delayed ignition.

MOA — Minute of Angle — An angular unit. One MOA subtends approximately 1.047 inches at 100 yards; shooters often use one inch at 100 yards as a convenient approximation.

N

Neck clearance — The radial or diametral clearance available between a loaded cartridge neck and the chamber neck. Adequate clearance is essential for safe release of the projectile.

Neck sizing — Sizing primarily the case neck while leaving much of the body and shoulder near their fired dimensions. It is a specialist choice rather than a universal route to better accuracy.

Neck-sizing die — A die designed primarily to resize the neck rather than full-length size the case body and shoulder.

Neck tension — Common shorthand for the case neck's grip on a seated projectile. The dimensional interference used to create that grip is measurable, but the actual holding force also depends on brass condition, friction, neck wall and other factors.

Neck turning — Controlled removal of material from the outside of a case neck to improve wall uniformity or establish a required loaded-neck diameter.

O

Obturation — Expansion under pressure that creates a seal. In cartridge ammunition it commonly describes the case expanding against the chamber wall during firing to reduce rearward gas leakage.

Ogive — The curved forward part of a projectile between its bearing surface and nose. Comparator measurements commonly reference a repeatable point on the ogive.

Overbore — Informal term for a cartridge with relatively large powder capacity compared with bore size. Such combinations often produce high performance but can accelerate throat erosion.

P

Powder charge — The measured amount of propellant placed in a cartridge case.

Powder measure — A device that dispenses propellant, usually by volume, into a case or scale pan.

Powder scale — A scale used to weigh propellant charges or compare component weights. It must be stable, verified and appropriate to the precision required.

Pressure signs — Observable changes that may accompany abnormal or excessive pressure. No single primer or case appearance is a reliable universal pressure gauge; multiple observations and appropriate published data must be considered together.

Press — The mechanical tool that provides controlled leverage for sizing, seating and other die operations.

Press ram — The moving part of many reloading presses that carries the shell holder or shell plate upward into the die area.

Primer — The ignition component seated in the primer pocket that initiates the propellant when struck by the firearm's firing mechanism.

Primer anvil — The internal support against which the primer compound is crushed in a Boxer primer when the primer cup is struck.

Primer cratering — A raised ring or flow of primer cup material around the firing-pin indentation. It can have several causes and must not be interpreted as a stand-alone pressure measurement.

Primer leak — Gas leakage around or through a primer after firing, potentially caused by primer damage, poor fit or abnormal cartridge behaviour.

Primer pocket — The recess in the case head into which the primer is seated.

Primer pocket swaging — Re-forming a crimped or restricted primer-pocket entrance by controlled swaging, commonly used on some military-type brass.

Primer pocket uniforming — Machining primer pockets to a controlled depth or geometry. It is an optional precision-preparation operation, not a requirement for ordinary ammunition.

Primer seating — Installing a primer to the correct orientation and depth in a sound primer pocket.

Progressive press — A press in which multiple cases can occupy different stations so several operations occur with each cycle of the press.

Projectile — The component propelled through the barrel when a cartridge is fired. This is the preferred term throughout this book.

Propellant — The energetic material that burns after ignition to generate gas and pressure that accelerates the projectile. In reloading it is commonly called powder.

R

Rebated case — A case whose rim diameter is smaller than the diameter of the body immediately ahead of the extractor groove.

Reloading — Reassembling a fired case with a primer, propellant and projectile for reuse. In ordinary shooting language it is often used interchangeably with handloading.

Resizing / sizing — Changing the dimensions of a fired or formed case with a die so it meets the requirements of the intended loading process and firearm.

Rifling — The spiral lands and grooves inside a barrel that impart spin to the projectile.

Rimless case — A case whose rim is approximately the same diameter as the case body immediately ahead of the extractor groove.

Rimmed case — A case with a rim that projects beyond the diameter of the main case body and may provide the headspacing feature.

Roll sizing — A specialist process that sizes areas of a case, particularly near the lower body, by passing it through controlled rolling tooling.

Runout — Measured deviation from ideal concentric rotation. Reloaders commonly measure case-neck or projectile runout as an indication of alignment.

S

SD — Standard Deviation — A statistical measure of how individual velocities are distributed around the average. It becomes more informative with a meaningful sample size and should not be over-interpreted from very small shot strings.

Seating depth — The position of a projectile in the case. It can be described using COAL, CBTO or its relationship to the rifling.

Seating die — A die used to seat the projectile to the required depth; some designs can also apply a crimp.

Secant ogive — An ogive geometry in which the curve meets the projectile bearing surface less tangentially. It can provide high aerodynamic efficiency but may be more sensitive to seating relationship in some projectile designs.

Sectional density — Projectile mass relative to the square of its diameter. It is a geometric mass-to-diameter relationship and is distinct from ballistic coefficient.

Semi-rimmed case — A case whose rim projects slightly beyond the body diameter but less prominently than a conventional rimmed case.

Shell holder — The press component that supports and locates the case head during many reloading operations.

Shoulder bump — Common reloading shorthand for the controlled rearward movement of a bottleneck case shoulder during full-length sizing. The appropriate amount is specific to the firearm, brass and required reliability.

Small-base die — A sizing die intended to size the lower case body more aggressively than many conventional full-length dies. It is useful in particular applications but is not automatically required for every repeating firearm.

Soft seating — A specialist single-fed precision technique using controlled light projectile retention so the projectile can establish its final relationship with the rifling during chambering.

Spent primer — A primer that has already fired and is removed during depriming.

Squib — An abnormal discharge in which the projectile may fail to leave the barrel. If a shot sounds, recoils or feels abnormal, stop and confirm the bore is clear before firing again.

Straight-wall case — A case whose body has little or no bottleneck shoulder and is broadly straight or slightly tapered from head toward mouth.

T

Tangent ogive — An ogive geometry that transitions smoothly into the projectile bearing surface. Such designs are often relatively tolerant of seating-depth changes, though actual behaviour depends on the projectile and rifle.

Throat — The transition area immediately ahead of the chamber through which the projectile enters the rifling.

Throat erosion — Progressive wear and burning of the throat from firing. The process begins with the first shot and gradually changes the projectile-to-rifling relationship as the barrel ages.

Trim length — The target case length selected for trimming. It should not be confused automatically with the published maximum case length.

Twist rate — The distance over which the rifling completes one full revolution, commonly written as 1:8, 1:10 and so on. Twist rate is a major factor in projectile stability.

V

Velocity — The speed of the projectile, usually expressed in feet per second (fps) or metres per second (m/s).

W

Web — The relatively thick structural portion of the case immediately ahead of the case head.

Work hardening — The change in brass properties produced by repeated deformation. Case necks and shoulders progressively work harden through firing and sizing.

Z

Zero — The established relationship between point of aim and point of impact for a firearm, sighting system, ammunition and chosen distance.

Common Abbreviations at a Glance

BC — Ballistic Coefficient
BTO — Base to Ogive
CBTO — Cartridge Base to Ogive
COAL — Cartridge Overall Length
ES — Extreme Spread
FL — Full Length
fps — Feet per second
G1 / G7 — Ballistic-coefficient drag models
MOA — Minute of Angle
m/s — Metres per second
SD — Standard Deviation

Appendix B
Useful Formulae, Conversions and Quick-Reference Tables

1967Spud Reloading Reference

This appendix is intended as a bench-side reference for calculations and conversions that are useful during reloading and shooting. It is deliberately not a source of powder-charge data. Published load data and component manufacturers' current information remain the correct sources for pressure-tested loading information.

1. Weight and Mass Conversions

1 grain = 0.06479891 gram • 1 gram = 15.43236 grains

Grains	Grams
1	0.0648
5	0.3240
10	0.6480
20	1.2960
50	3.2399
100	6.4799
150	9.7198
200	12.9598
250	16.1997
500	32.3995
7000	453.592

There are 7,000 grains in one avoirdupois pound. Powder charges are traditionally expressed in grains; do not confuse grains with grams.

2. Length Conversions

1 inch = 25.4 mm • 1 mm = 0.0393701 inch

Inches	Millimetres
0.001	0.0254
0.002	0.0508
0.005	0.1270

Inches	Millimetres
0.01	0.2540
0.02	0.5080
0.05	1.2700
0.1	2.5400
1.0	25.400

In precision-reloading conversation, “a thou” usually means 0.001 inch. Two thou = 0.002 inch, and so on.

3. Velocity Conversions

metres/second = feet/second × 0.3048 • feet/second = metres/second × 3.28084

fps	m/s
1000	304.8
1500	457.2
2000	609.6
2500	762.0
2700	823.0
2800	853.4
2900	883.9
3000	914.4
3200	975.4
3500	1066.8

4. MOA and MIL Quick Reference

Both MOA and milliradians are angular measurements. The exact linear value therefore grows with distance. For most bench calculations, the following relationships are useful.

1 MOA = 1.047 in at 100 yd • 1 mil = 3.6 in at 100 yd

1 mil ≈ 3.438 MOA • 1 MOA ≈ 0.291 mil

Distance	1 MOA	0.1 mil	1 mil
100 yd	1.047 in	0.36 in	3.60 in
200 yd	2.094 in	0.72 in	7.20 in
300 yd	3.141 in	1.08 in	10.80 in

Distance	1 MOA	0.1 mil	1 mil
600 yd	6.282 in	2.16 in	21.60 in
800 yd	8.376 in	2.88 in	28.80 in
1000 yd	10.470 in	3.60 in	36.00 in

The common range approximation of 1 MOA = 1 inch at 100 yards is close enough for many practical uses, but 1.047 inches is the more accurate value.

5. Group Size to MOA

$$\text{MOA} \approx \text{group size in inches} \div \text{distance in hundreds of yards} \div 1.047$$

A convenient equivalent form is:

$$\text{MOA} = \text{group size (in)} \times 100 \div \text{distance (yd)} \div 1.047$$

Example	Calculation	Result
0.50 in at 100 yd	0.50 × 100 ÷ 100 ÷ 1.047	0.48 MOA
1.00 in at 100 yd	1.00 × 100 ÷ 100 ÷ 1.047	0.95 MOA
2.00 in at 300 yd	2.00 × 100 ÷ 300 ÷ 1.047	0.64 MOA
4.50 in at 600 yd	4.50 × 100 ÷ 600 ÷ 1.047	0.72 MOA

6. Group Size to MIL

$$\text{mil} = \text{group size (in)} \div \text{distance (yd)} \times 27.7778$$

Example	Result
3.6 in at 100 yd	1.00 mil
1.8 in at 100 yd	0.50 mil
3.0 in at 300 yd	0.28 mil
6.0 in at 600 yd	0.28 mil

7. Extreme Spread (ES)

$$\text{ES} = \text{highest recorded velocity} - \text{lowest recorded velocity}$$

Five-shot string (fps)	Highest	Lowest	ES
2812, 2801, 2808, 2799, 2806	2812	2799	13 fps

ES is easy to understand, but it is strongly influenced by sample size. A small string can look unusually good or bad simply because it contains fewer opportunities for an extreme value.

8. Average Velocity

$$\text{Average velocity} = \text{sum of all shot velocities} \div \text{number of shots}$$

Five-shot string (fps)	Sum	Average
2812, 2801, 2808, 2799, 2806	14,026	2805.2 fps

9. Standard Deviation (SD)

Chronographs normally calculate SD automatically. The useful practical point is what SD describes: how tightly the individual velocities cluster around the average. It should be judged from a meaningful sample, not treated as an absolute truth from three shots.

$$\text{Sample SD} = \sqrt{[\Sigma(x - \bar{x})^2 \div (n - 1)]}$$

x = each velocity, $\bar{x}$ = average velocity, n = number of shots. In normal bench use there is little reason to calculate this by hand if the chronograph already reports it.

10. Percentage Velocity Variation

$$\text{Percentage variation} = \text{ES} \div \text{average velocity} \times 100$$

Average	ES	Variation
2800 fps	14 fps	0.50%
2800 fps	28 fps	1.00%
3000 fps	15 fps	0.50%

This is not a replacement for SD or target testing; it is simply another way to put a velocity spread into proportion.

11. Case Capacity by Water Weight

When comparing case capacity, the common method is to weigh a fired case dry, fill it consistently with water, weigh it again and subtract the dry weight. The difference is the water capacity expressed in grains of water.

$$\mathbf{H_2O\ capacity\ (grains)} = \mathbf{filled\ case\ weight - dry\ case\ weight}$$

Dry case	Filled case	Capacity
172.4 gr	228.1 gr	55.7 gr H_2O
168.8 gr	225.0 gr	56.2 gr H_2O

Consistency of filling, water level and external drying matters more than chasing unnecessary decimal places. H_2O capacity is a comparison tool; it is not a formula for calculating a safe powder charge.

12. Shoulder Bump — Difference Method

With the same comparator setup, shoulder movement is simply the difference between the fired and sized case readings.

$$\mathbf{Shoulder\ bump} = \mathbf{fired\ comparator\ reading - sized\ comparator\ reading}$$

Fired	Sized	Difference
1.6325 in	1.6305 in	0.0020 in
1.6318 in	1.6298 in	0.0020 in

The required amount is firearm- and application-specific. This calculation only tells you what movement occurred; it does not prescribe the correct value.

13. Neck-Diameter Difference

Reloaders often describe neck setup by comparing the outside diameter of a loaded neck with the sized neck before projectile seating.

$$\mathbf{Diameter\ difference} = \mathbf{loaded\ neck\ OD - sized\ neck\ OD}$$

Loaded neck OD	Sized neck OD	Difference
0.3380 in	0.3360 in	0.0020 in

Loaded neck OD	Sized neck OD	Difference
0.3380 in	0.3350 in	0.0030 in

This dimensional difference is often casually called “neck tension”, but it is not a direct measurement of the actual force holding the projectile. Brass hardness, wall thickness, springback and surface condition also matter.

14. Loaded-Neck Clearance

Where actual chamber-neck diameter is known from a reliable chamber specification or measurement, loaded-neck clearance can be expressed simply as the difference between the chamber neck and the loaded cartridge neck.

$$\text{Total diametral clearance} = \text{chamber neck diameter} - \text{loaded neck diameter}$$

$$\text{Approximate clearance per side} = \text{total diametral clearance} \div 2$$

This is particularly relevant to tight-neck and neck-turned chambers. Do not infer a chamber dimension from cartridge drawings or guesswork.

15. Kinetic Energy — Optional Shooting Reference

Energy is not a measure of accuracy and should not be used as a substitute for legal or quarry-specific requirements. It can, however, be useful when interpreting ballistic data.

$$\text{Energy (ft·lbf)} = \text{projectile weight (gr)} \times \text{velocity}^2\text{ (fps)} \div 450{,}240$$

Projectile	Velocity	Approx. energy
100 gr	3000 fps	1,999 ft·lbf
140 gr	2800 fps	2,438 ft·lbf
168 gr	2650 fps	2,620 ft·lbf
180 gr	2700 fps	2,914 ft·lbf

16. Sectional Density

Sectional density compares projectile mass with its diameter. It is a geometric property and does not itself describe projectile construction, terminal performance or ballistic coefficient.

$$\text{SD} = \text{projectile weight (lb)} \div \text{diameter}^2\text{ (in)}$$

$$\text{Projectile weight (lb)} = \text{grains} \div 7000$$

Projectile	Diameter	Approx. SD
100 gr	0.243 in	0.242
140 gr	0.264 in	0.287
168 gr	0.308 in	0.253

Projectile	Diameter	Approx. SD
180 gr	0.308 in	0.271

17. Temperature Conversions

°C = (°F − 32) × 5/9 • °F = (°C × 9/5) + 32

°C	°F
-10	14
0	32
5	41
10	50
15	59
20	68
25	77
30	86
35	95
40	104

18. Distance Conversions

1 yard = 0.9144 metre • 1 metre = 1.09361 yards

Yards	Metres
100	91.44
200	182.88
300	274.32
500	457.20
600	548.64
800	731.52
900	822.96
1000	914.40

19. Common Numbers Worth Remembering

These are bench-side constants and relationships that are useful often enough to be worth having in one place. They are reference conversions, not loading-data recommendations.

Relationship	Value
1 avoirdupois pound	7,000 grains
1 avoirdupois ounce	437.5 grains
1 inch	25.4 mm
1 thou	0.001 in = 0.0254 mm
1 foot per second	0.3048 m/s
1 MOA at 100 yd	1.047 in
1 mil at 100 yd	3.6 in
1 avoirdupois pound	16 ounces

20. Centre-to-Centre Group Measurement

When a group is measured outside-to-outside, subtract the projectile diameter to obtain the conventional centre-to-centre group size.

Centre-to-centre group size = outside-to-outside measurement − projectile diameter

Example: a .308 in projectile and an outside-to-outside group measuring 0.908 in gives 0.600 in centre-to-centre. That centre-to-centre value is then the one to use when converting the group to MOA or mils.

21. Scope Click Calculation

Once the required angular correction is known, the number of clicks is simply the correction divided by the sight's click value. Keep the units the same throughout the calculation.

Number of clicks = required correction ÷ correction per click

Example: a 1.5 MOA correction on a ¼-MOA-per-click scope requires 6 clicks. A 0.6 mil correction on a 0.1-mil-per-click scope also requires 6 clicks.

22. Powder Inventory and Batch Planning

These calculations are for stock and batch planning only. The charge weight used must already come from appropriate current published data and a safely established load; arithmetic must never be used to invent or extrapolate a powder charge.

Approximate rounds per pound = 7,000 ÷ established charge weight in grains

Powder required (lb) = established charge weight (gr) × number of rounds ÷ 7,000

Example: if an already established load uses 40.0 grains, one pound contains enough powder for a theoretical 175 charges. A 200-round batch at that same established charge requires about 1.143 lb before allowing for normal dispensing and handling losses.

23. Neck-Wall and Bushing Quick Calculations

The detailed method and limitations belong in the neck-tension chapters; these are simply the bench calculations in compact form.

Approximate neck-wall thickness = (loaded neck OD − projectile diameter) ÷ 2

Nominal bushing starting point = (2 × neck-wall thickness) + projectile diameter − chosen dimensional reduction

For the method described in this book, the usual starting calculation is approximately 0.002 in reduction where the bushing establishes the final neck size, or approximately 0.004 in where a mandrel follows. These are setup starting points, not universal specifications; brass springback, chamber dimensions and the actual result must still be measured.

24. Component Cost and Brass Cost per Firing

Cost calculations do not affect load safety, but they are useful when comparing components or planning ammunition for a season.

Approximate component cost per round = projectile cost + primer cost + powder cost per charge + allocated case cost

Case cost per firing = case purchase price ÷ number of firings actually obtained

For powder cost per charge, divide the price per pound by the number of established charges obtainable from 7,000 grains. Keep this as an accounting calculation only; it is not a reason to alter a proven charge.

25. Quick Bench Checklist — What the Number Actually Tells You

Measurement	Useful question it answers
Case length	Does this case require trimming, and is it within the correct specification?
Shoulder comparator	How much did sizing move the shoulder relative to the fired case?
Loaded neck OD	What is the finished neck diameter, and is there adequate chamber clearance?
CBTO	Is seating depth consistent at the projectile ogive reference?
COAL	Will the cartridge meet magazine/function limits and overall-length requirements?
Velocity	What is the actual performance of this load in this firearm?
ES / SD	How consistent is the measured velocity string?
Runout	At which stage is concentricity error being introduced?
H_2O capacity	How similar are case internal capacities within the controlled comparison?
Round count	Where is this barrel or brass batch in its working life?

26. Safety Note on Formulae

None of the formulae in this appendix can determine a safe powder charge or maximum pressure. Internal ballistics are too complex for simple arithmetic based on case capacity, projectile weight or velocity. Always use current published load data from reputable sources and begin development within the stated data for the exact component combination as closely as practical.

The purpose of these calculations is to help interpret measurements you have already taken—not to replace pressure-tested loading data.

Appendix C
Technical Sources, References and Methodology Credits

This book is practical rather than academic, but the technical claims still need a sound foundation. The sources below are the principal standards bodies, manufacturer references and specialist material used to check terminology, dimensions, pressure-tested loading practice and projectile concepts during preparation of the manuscript. Product mentions elsewhere in the book are not automatically source citations, and inclusion here does not imply endorsement by the organisation named.

Current data matters. Cartridge drawings, standards, component specifications and pressure-tested load data can be revised. The reader should always use the current edition of the relevant manufacturer or standards-body information when making a loading decision. This book explains method and judgement; it is not a substitute for current pressure-tested load data.

1967Spud Reloading Timeline — Methodology Credit

Methodology: The Reloading Timeline used in this book — including its sequence of operations, the separate routes for new and fired brass, the decision points for optional case preparation, and the distinction between ordinary sporting ammunition and progressively more advanced precision preparation — is the 1967Spud methodology developed from the author's practical reloading, competition and workshop experience.

It should not be read as a SAAMI, C.I.P. or manufacturer-prescribed workflow. Those organisations and manufacturers provide standards, technical definitions, component specifications and pressure-tested data. The Timeline is the book's own practical method for deciding when and in what order those operations are used.

Principal Technical Standards and Reference Sources

SAAMI — Sporting Arms and Ammunition Manufacturers' Institute

Used as a primary reference for accepted industry terminology, cartridge and chamber nomenclature, dimensional standards, pressure/velocity standards context, and the distinction between commercial standards information and handloading-specific guidance. SAAMI publishes ANSI/SAAMI standards and maintains current and revised cartridge/chamber drawings.

C.I.P. — Commission Internationale Permanente pour l'Epreuve des Armes à Feu Portatives

Used as the principal European reference for cartridge and chamber dimensions, proof-related technical standards and TDCC tables. Particularly relevant to a UK/European readership and to cartridges standardised under C.I.P. practice.

HSE — Health and Safety Executive

Used for current Great Britain guidance under the Explosives Regulations 2014, including shooters' powder, storage, explosives-certificate and transfer requirements. This is the relevant regulatory reference for the book's distinction between black powder and smokeless powder in Great Britain.

Hodgdon Reloading Data Center

Used as an example of current manufacturer-published, pressure-tested reloading data. The book repeatedly stresses that powder type and charge weight must come from current authoritative data rather than from another shooter's recipe.

Vihtavuori Reloading Guide 2026

Used as a current manufacturer reference for smokeless-powder properties, storage and safety guidance, starting/max load practice, and pressure-tested rifle and handgun loading data. Vihtavuori states that its listed loads are pressure tested using C.I.P. methods and that maximum loads must not be exceeded.

Sierra Reloading Manual

Used as a representative projectile-manufacturer manual and cross-check for established reloading practice, projectile-specific data and the principle of using published tested data rather than informal load recipes.

Berger Bullets technical material

Used principally for long-range projectile terminology and concepts, including tangent, secant and hybrid ogive forms, ballistic-coefficient discussion and specialist match-projectile design.

Lapua technical catalogues and guides

Used as supporting component and cartridge reference material, particularly for precision brass/projectile terminology and current manufacturer technical information.

1967Spud technical and help material

Used to cross-check terminology already used in the 1967Spud website glossary and technical-help material so the book and website use compatible language. Definitions in this book have been independently edited for the book rather than copied wholesale from website or third-party wording.

How Manufacturer Load Data Is Used in This Book

The book deliberately does not publish a catalogue of powder charges. Published data changes, component lots change and the correct starting point depends on the exact cartridge, projectile, powder and other components being used. Instead, the book explains how to read and use current pressure-tested data.

Where examples discuss load development, the method is always subordinate to the current data from the powder or projectile manufacturer. A charge weight quoted by another shooter, a forum post or an old notebook is not a substitute for current tested data.

When changing powder, projectile design, brass make, primer type or another material component of a proven load, the new combination must be checked against current published information and confirmed appropriately. "Similar" is not the same as interchangeable.

Terminology and Glossary Sources

The glossary in Appendix A is based primarily on terminology used throughout the manuscript. It was also cross-checked against the 1967Spud website glossary and current industry terminology, particularly SAAMI, to catch useful omissions such as case body, case mouth, extractor groove, head clearance, case gauge and projectile-ogive terms.

The definitions in the book are written in the book's own language. Standards-body and manufacturer terminology has been used to check meaning and consistency, not as text to reproduce verbatim.

Source Use, Copyright and Attribution

Technical facts, terminology and standards can be referenced without reproducing protected layouts, tables, photographs or substantial passages. Where the finished book uses a third-party photograph, illustration, table or other copyright material, that item should receive its own specific credit and permission record where required.

The same applies to C.I.P. and manufacturer drawings: the existence of a public technical document does not automatically make its artwork free to reproduce. Where a diagram is needed, the preferred approach for this book is to create an original explanatory diagram unless there is a clear reason and permission to reproduce the source artwork.

Technical Source Note

Technical terminology and standards were checked against current material from recognised standards bodies and component manufacturers, including SAAMI and C.I.P. Current manufacturer pressure-tested load data must always take precedence over examples or historical information in this book. The 1967Spud Reloading Timeline and its workflow methodology are the author's own practical method developed from reloading and competition experience.

Source List

- SAAMI — ANSI/SAAMI Z299.4-2025 centrefire rifle standard, current technical information, cartridge/chamber drawings and industry glossary. Checked August 2026.
- C.I.P. — TDCC Tables of Dimensions of Cartridges and Chambers and related technical standards. Checked August 2026.
- HSE — Explosives Regulations 2014 guidance, including current shooters' powder, storage, explosives-certificate and transfer guidance for Great Britain. Checked August 2026.
- Hodgdon — Reloading Data Center and manufacturer safety/data material. Checked August 2026.
- Vihtavuori — Reloading Guide 2026 and current manufacturer technical information. Checked August 2026.
- Sierra Bullets — current Reloading Manual and manufacturer technical information. Checked August 2026.
- Berger Bullets — technical articles/catalogue material on match projectile design, ogive forms and ballistic coefficients. Checked August 2026.
- Lapua — current technical catalogues, guides and component information. Checked August 2026.
- 1967Spud — Reloading Timeline methodology, technical-help material and website glossary; manuscript definitions independently edited for this book.

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