Technical Pistol Safety

Version 1.4
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1. Firearm Safety

Firearm safety encompasses several topics, namely firearm handling skills, technical design, equipment and ammunition. The safety requirements are hugely dependent on the intended use of a firearm. Be it for example for military or law enforcement duty, private armed security, civilian self defense, hunting or sports shooting. In this article, we will have a closer look at the technical design of safety features of pistols with a focus on relevance for dynamic sports shooting and duty use. We have picked some specific models that serve as examples of popular pistol types. Their firing mechanisms and safety features are described in detail. Of course, there are many variants and alternative solutions out there that may not be specifically represented herein.

The mechanical safety of pistols is a topic that is often insufficiently understood or neglected. In particular, this frequently affects sports shooting communities. A lot of shooters are ignorant of basic facts around the mechanical safety of the equipment they use. Of course, everybody will quickly assure the paramount importance of safety. But the knowledge about the mechanical workings of a pistol is regularly superficial, clouded by hearsay and weakened by routine malpractice. However, overall safety around firearms does not only concern the skills of the shooter but also includes the mechanical design of the firearm. With a better understanding of this topic, a responsible shooter can make an educated decision about the safety level and risks associated with certain pistol designs. This includes additional topics such as the replacement or modification of relevant parts and the influence of factors such as manufacturing quality, tolerances, wear and tear and material fatigue.

In static precision sports shooting, the shooter remains in the same position and the gun either rests on a table or, if held in hand, is always pointed straight downrange. In contrast to that, in dynamic sports shooting, the shooter may have a loaded gun in the holster or in the hand, run in all directions, negotiate obstacles, go in and out of kneeling and prone positions, open doors and windows and even experience a certain level of physical and mental stress. While pistol features like for example extremely low trigger pull weights or super short trigger and reset travels may be acceptable in static sports, they can create an unacceptable high level of risk in a dynamic shooting sport.
Technical safety requirements such as drop safety and prevention of negligent and accidental discharges become much more important in the latter case. That's where technical safety features are playing a major role.

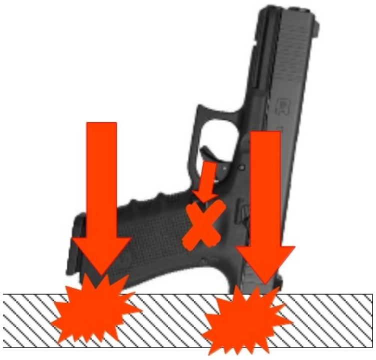
The goal of this article is to help understand potential safety hazards and resilient technical design that minimizes the associated risks.

2. Typical Safety Hazards

Dropping, impact, vibration and shock

A loaded pistol should be prevented from firing when dropped onto a hard surface or when subjected to other kinds of impacts or vibrations. Some typical considerations for safe technical design are:

1) The firing pin moving forward by mass inertia in the event of a frontal impact.



2) The trigger being activated by mass inertia in the event of a rear impact.

3) The hammer or striker skipping over the detent by vibration or shock.

4) The hammer transferring the force of a rear impact to the firing pin.

Important factors include drop height, angle of impact, force of impact, floor hardness, intensity of vibration, firing pin mass, trigger mass, concerned spring forces and so on. A particular unsafe pistol may be dropped multiple times without firing and then actually fire the very next time when the above factors cumulate in a negative way.

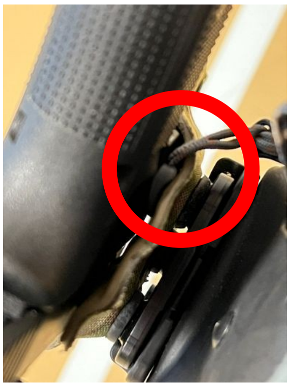
Drop safety has been a topic since handguns have been invented. However, still today, there are manufacturers offering new pistol designs that fail basic drop tests.

Holstering

When holstering a loaded pistol, the pistol should be prevented from firing. When in the holster, the pistol should not go off when force is applied to the pistol or the holster, for example when moving, hitting against obstacles or when struggling with a suspect who is attempting to get a hold of the pistol. Typical considerations include:

- the trigger being activated by a defective or unsafe holster
- the trigger being activated by foreign objects in the holster or while holstering
- the hammer or striker skipping over the detent by vibration or shock

1) Unsafe holster



2) Foreign object in the holster

3) Foreign object while holstering

Negligent discharge

Negligent discharges are caused by the shooter not adhering to the universal safety rules. However, the mechanical characteristics of a firearm can greatly influence the probability of a negligent discharge to happen.
For example: the likelihood of the trigger being accidentally pulled under high stress and with diminished fine motor skills is increasing significantly the lower the trigger pull weight and trigger travel distance are.

Accidental discharge

Accidental discharges are caused by defective or poorly designed pistols. Typical considerations include:

- the pistol firing when out of battery (the slide has not moved fully forward) for example caused by a faulty disconnector mechanism
- the pistol firing multiple shots with one trigger pull for example caused by a faulty disconnector mechanism or an unsafe (too short) reset travel distance
- accidental discharges caused by broken parts, tolerance stack up, wear and tear of individual parts, lacking maintenance or any combination thereof

The above typical hazards are not a comprehensive list of risks and potential dangers. But those are common and well known potential incidents that need to be addressed in the design of the technical safety of a pistol. A resilient, robust, fail-safe design can significantly lower risks and potentially prevent accidents from happening entirely.

3. Typical firing mechanisms

Striker fire pistols

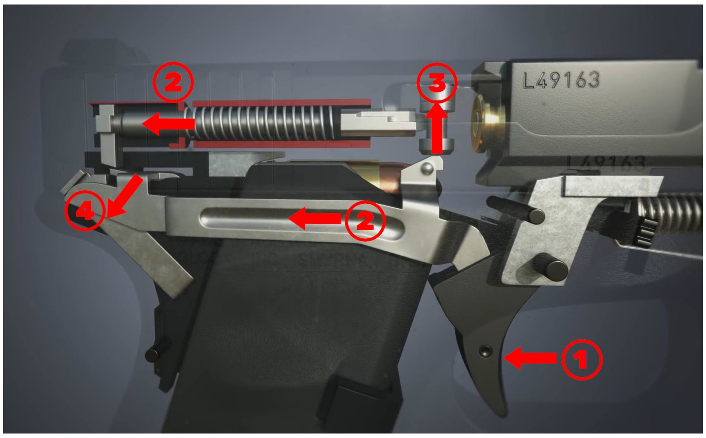
Striker fire pistols are widely used today as police and military duty sidearms. The main advantages of this pistol type are the safety, simplicity and reliability. Most striker fire handguns rely on automatic safeties and do not have additional, manually operated safety mechanisms. If the pistol is loaded and the trigger is pulled, it will fire. However, there are several built-in automatic safeties and other features that are designed to maximize overall safety.

Let's have a closer look at the process of igniting a loaded round and the main components involved using cut away views of a Glock 19 pistol.

Main components

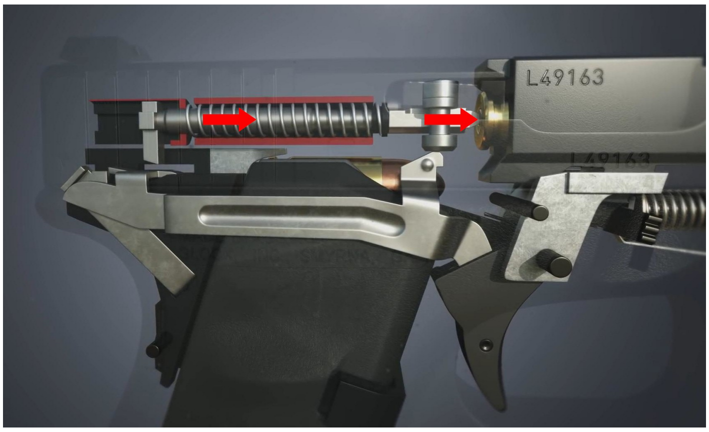
The pistol as shown is loaded and ready to fire. The striker is held back in a partially cocked position by the trigger bar. All automatic safeties are engaged.

1) Trigger
2) Trigger bar
3) Striker
4) Connector



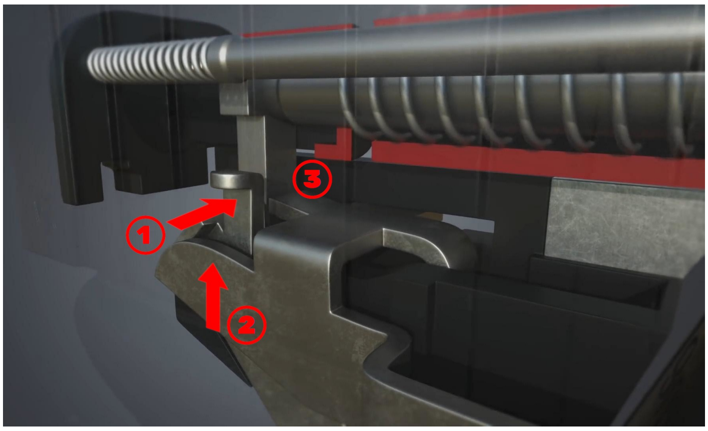
Pulling the trigger

1) The trigger safety is deactivated and the trigger is pulled
2) The trigger bar moves backwards, fully cocking the striker
3) The trigger bar deactivates the striker safety by pushing it upwards
4) The rear of the trigger bar is forced downwards by the connector, releasing the striker



Igniting the round

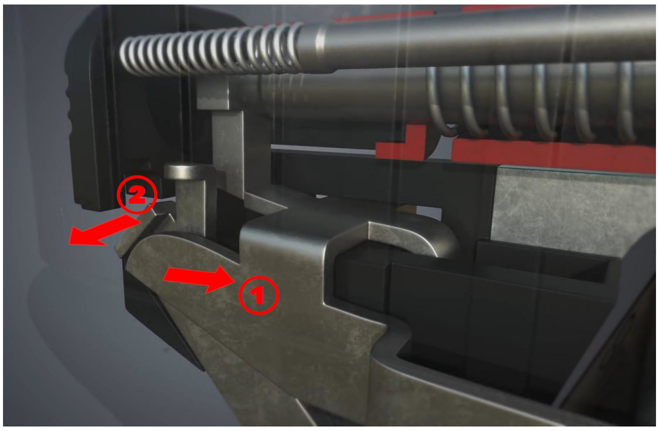
The striker is accelerated forward by the striker spring and hits the primer of the loaded round in the chamber, igniting it.



Disconnecting

1) When the slide cycles backwards, it forces the connector inwards, it's control curve is now out of the way of the trigger bar
2) The trigger spring (not seen here) in turn forces the trigger bar upward
3) When the slide moves forward again, the striker is held back by the trigger bar

However, with the connector moved inwards, the trigger bar remains forced up by the trigger spring and holds the striker back.



Resetting

1) When the trigger is released, the striker spring moves the trigger forward
2) At the reset point, the connector snaps back into position

The trigger can be pulled again, firing the pistol another time.

DA/SA pistols

"Double Action/Single Action" pistols have an external hammer and are usually carried with the hammer de-cocked. Many practical designs have no manually operated safety levers. For the first shot, the hammer needs to be cocked by pulling the trigger. That's where the designation "double action" originates from: first cock and, second, release the hammer. The double action trigger pull is comparably long and heavy, which is also intended to prevent negligent discharges.
Subsequent shots are fired with the hammer already cocked by the reloading cycle of the slide. In this mode, the trigger pull will just release the hammer, hence the name "single action". Here, trigger pull weight and travel distance are much lower than in DA mode.
When loading the first round into the chamber, the slide is cycled manually, leaving the hammer in the cocked position. Most DA/SA pistols have a de-cocking lever to safely lower the hammer and make the pistol ready for carrying.

There are many variants and specialties of DA/SA pistols, for example:

- with an external safety that allows to carry the pistol with the hammer cocked and safety on - essentially similar to a SA pistol but actually making the DA design and its complexity unnecessary
- without a decocking lever, in which case the hammer has to be de-cocked manually after loading: the operator needs to pull the trigger, hold the hammer back and lower it by hand – something often done wrong and incorporating a considerable risk of a negligent discharge

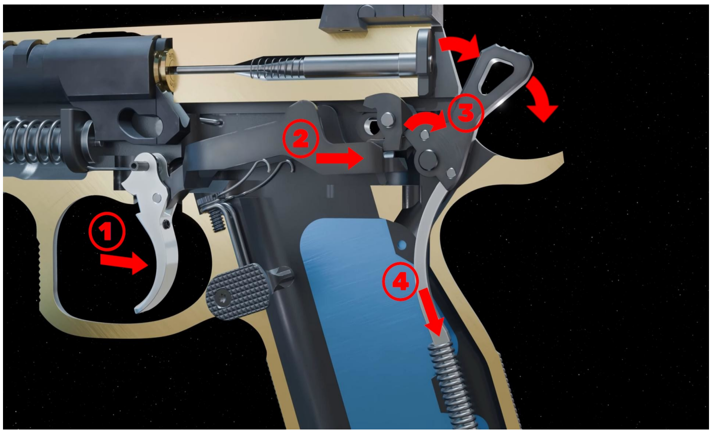
- DAO (double action only) where the hammer is automatically de-cocked again during the cycle of the slide, providing a long and heavy but constant trigger pull for every shot

Let's have a closer look at the process of igniting a loaded round and the main components involved using cut away views of a CZ Shadow 2 pistol.

Main components
The pistol is loaded and ready to fire with the hammer de-cocked.

1) Trigger
2) Trigger bar
3) Sear cage, containing disconnector and sear
4) Hammer
5) Hammer strut and hammer spring
6) Firing pin

Not shown: trigger spring, sear spring



Double action trigger pull

1) The trigger is pulled
2) The trigger bar is moved backwards and acts on the disconnector
3) The disconnector rotates the hammer backwards
4) The hammer strut is moved downwards and compresses the hammer spring

Igniting a round
The trigger is fully pulled.

1) The trigger bar is moved downwards and rearwards, releasing the disconnector and rotating the sear, releasing the hammer
2) The hammer spring decompresses and rotates the hammer forward
3) The hammer strikes the firing pin
4) The firing pin moves forward and ignites the loaded round

Disconnecting and catching the hammer
When the slide is cycled forward:

1) The trigger bar is moved downwards away from the sear by the slide
2) The recoil spring moves the slide back forward
3) The hammer is caught by the sear in the full cock notch

Resetting
With the slide in battery (fully forward):

1) When the trigger is released, it is moved forward by the trigger spring
2) The trigger bar is moved forward and upwards, into position to engage the sear

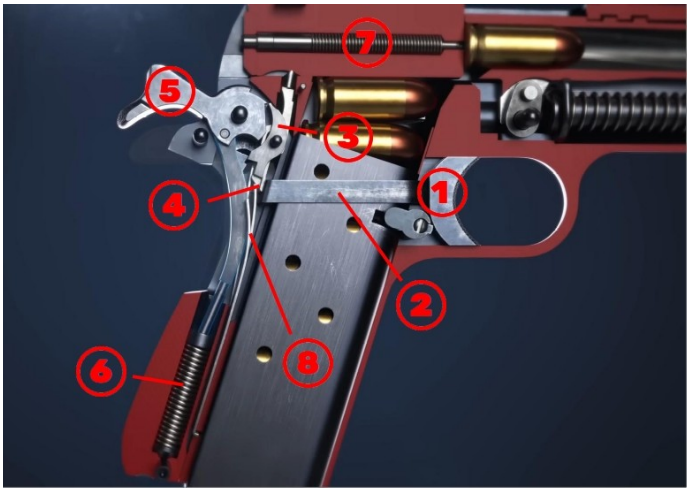
The forward movement of the trigger is stopped by the disconnector. The firearm is now ready to be fired again, with a cocked hammer and in single action mode.

A main disadvantage of DA/SA pistols is the changing trigger pull weight from the first to the second shot. Many shooters feel that this is confusing and would requires too much practice to do effectively.

SA pistols

Single action pistols have an external hammer that needs to be in the fully cocked position for the pistol to be able to be fired. The trigger pull weight and trigger travel are usually comparably low. They have an external manual safety and are commonly carried with the hammer cocked and the manual safety engaged, i.e. "cocked and locked". For the first shot, the shooter needs to actively disengage the safety before the pistol can be fired.

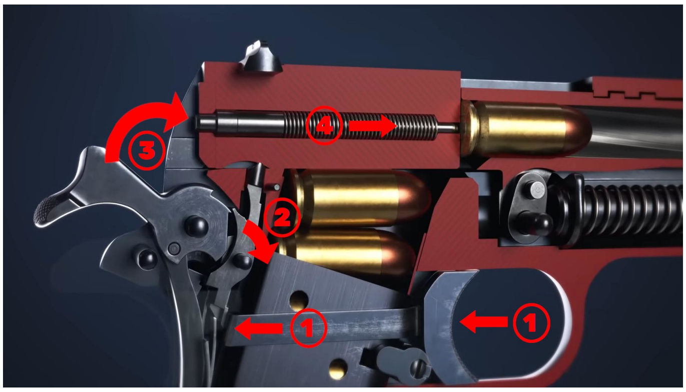
Let's have a closer look at the process of igniting a loaded round and the main components involved using cut away views of a 1911-type pistol.



Main components

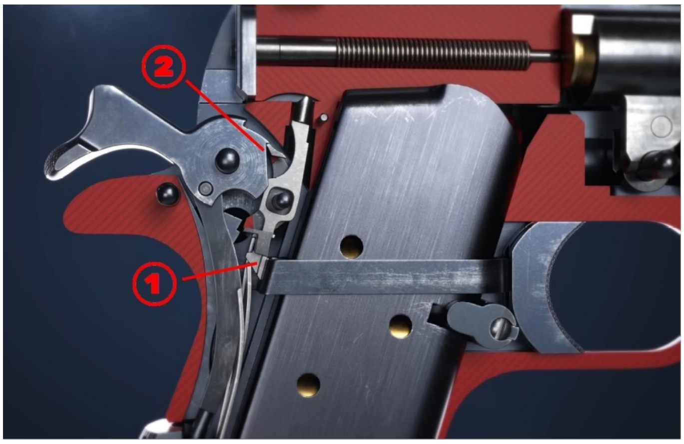
The pistol shown is loaded and ready to fire with the hammer fully cocked.

1) Trigger
2) Trigger bar
3) Sear
4) Disconnector
5) Hammer
6) Hammer strut and hammer spring
7) Firing pin
8) Multi-leaf spring with leafs for sear, grip safety and disconnector and trigger reset combined



Pulling the Trigger and igniting a round

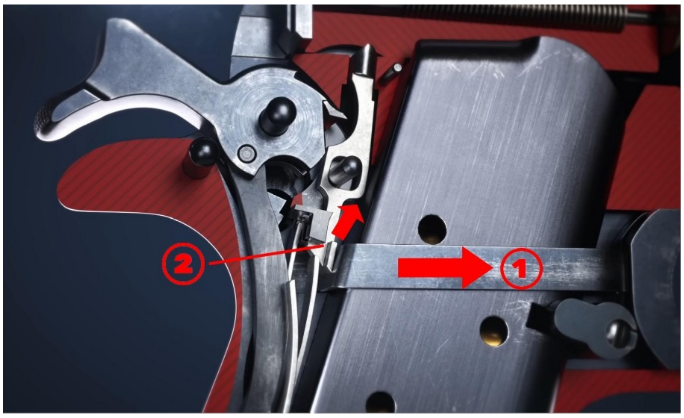
1) The trigger is pulled and the trigger bar moves backwards
2) The trigger bar pushes via the disconnector onto the sear and rotates it
3) The sear releases the hammer which is rotated forward by the hammer spring
4) The firing pin is hit by the hammer and driven forward, igniting the loaded round



Disconnecting and catching the hammer

When the slide has cycled:

1) With the trigger fully pulled, the disconnector has moved below the sear, which in this case cannot be acted upon by the trigger bar
2) The sear has caught the hammer in the full cock notch



Resetting
With the slide in battery (fully forward):

1) When the trigger is released it is driven forward by the disconnector/trigger leaf of the multi-leaf spring
2) The disconnector is moved forward and upwards

The pistol is now ready to be fired again.

The main disadvantage of SA pistols is the external safety, that many shooters feel to be too cumbersome to disengage easily before the first shot.

4. Typical safety features

In a duty context, pistols are used as an emergency self defense tool. Due to their small size, compared to a rifle, they can be carried conveniently in a holster during all kinds of activities. They must be quickly accessible, offer fast and effective firing capability, be easily manipulated and cause minimal safety risks, all at the same time. Some of those requirements are, at least to some degree, mutually exclusive.
Pistol design has therefore always been a struggle between overall safety on the one hand and fast, easy and reliable application on the other hand. Serious problems can occur, when the safety requirements don't get the necessary attention over the other criteria.

Manual safety levers
The manual safety lever is an external lever that is either engaged or disengaged manually. They are a good means against many safety hazards. For the technical understanding, it is important to know what parts are actually blocked by the safety lever. For example, if the manual safety only blocks the trigger but not the sear, the hammer might still be accidentally released. Blocking the sear will block the hammer from being released but will not prevent the firing pin from moving forward on front impact.

Some issues that may come with manual safeties are for example:

- safeties that don't block the sear, hammer or striker
- difficulties by the shooter to disengage the safety lever when under stress and with diminished fine motor skills
- unintended disengaging of the safety, for example when brushing a holstered pistol against something or when the lever gets caught by clothing during movement
- unintended engaging when the pistol is used, for example with a bad grip during recoil or when manipulating the pistol

Some times shooters install bigger (wider) safety levers that can be operated with less resistance. Those are easier to disengage but they are also easier to be moved accidentally. Such issues are a reason not to have manual safeties on many DA/SA or striker fire pistol models. Manual safeties are, however, indispensable on SA pistols. It is widely accepted that carrying a pistol with the hammer fully cocked and no safeties engaged is very dangerous. The gun is just a light and short single action trigger pull away from firing.

Manual safety engaged
Example: 1911 pistol

The safety blocks the movement of the sear. This positively prevents the hammer from being released by a trigger pull or any other cause, for example shock or vibration.
In the case of the 1911, the safety also blocks movement of the slide. Other pistol designs allow the slide to move with the manual safety engaged.

Manual safety disengaged
Example: 1911 pistol

When the trigger is pulled, the sear is free to rotate and release the hammer.

Grip safeties

Some pistol designs, like for example the 1911-type pistols, have grip safeties. Grip safeties are usually blocking the trigger. They are disengaged by applying a proper grip on the pistol, and when the grip is released, the safety is automatically re-engaged.

Grip safety engaged
Example: 1911 pistol

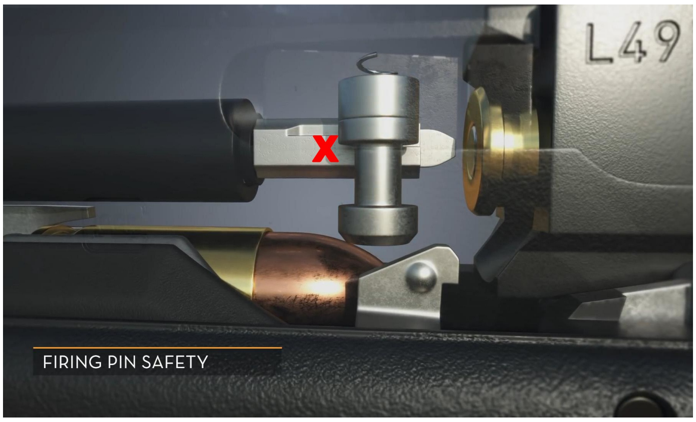
The grip safety is held in the engaged position by one leaf of the multi-leaf spring. It blocks the trigger from contacting the sear.

Grip safety disengaged
Example: 1911 pistol

When the shooter applies a proper grip on the pistol, the grip safety is rotated forward and upward, out of the way of the trigger bar. When the trigger is now pulled, the trigger bar can reach and rotate the sear, releasing the hammer.

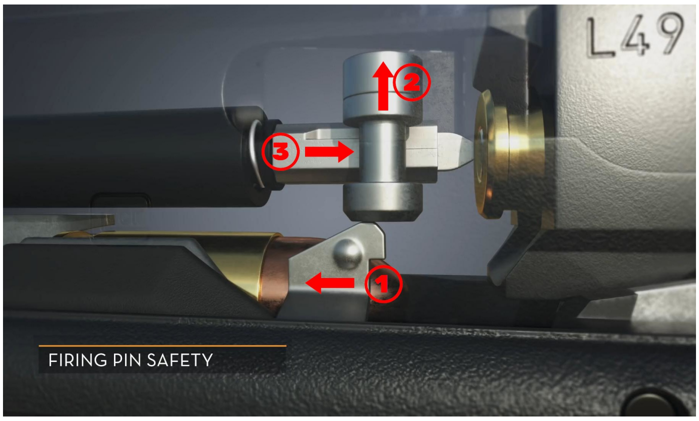
Firing pin safeties

The firing pin safety (also called striker safety or firing pin block) is blocking the firing pin, or striker, from moving all the way forward and making contact with a round in the chamber. It is automatically disengaged when fully pulling the trigger. The main purpose is to prevent the pistol from firing in case the firing pin or striker is moving forward for any reason other than a full trigger pull. In a striker fire pistol, this could be an accidental release of the striker. In a DA/SA or SA pistol, this could be an acceleration of the firing pin by mass inertia when the pistol is dropped and impacts muzzle first on a hard surface.



Striker safety engaged
Example: Glock pistol

The striker safety is pushed down by its spring and positively blocks the striker from making contact with a loaded round in the chamber.



Striker safety disengaged
Example: Glock pistol

1) When the trigger is pulled and the trigger bar moves rearwards
2) it pushes the striker safety upwards and
3) the striker can move past the striker safety and ignite a loaded round in the chamber

As soon as the trigger is released, the striker safety is automatically engaged again.

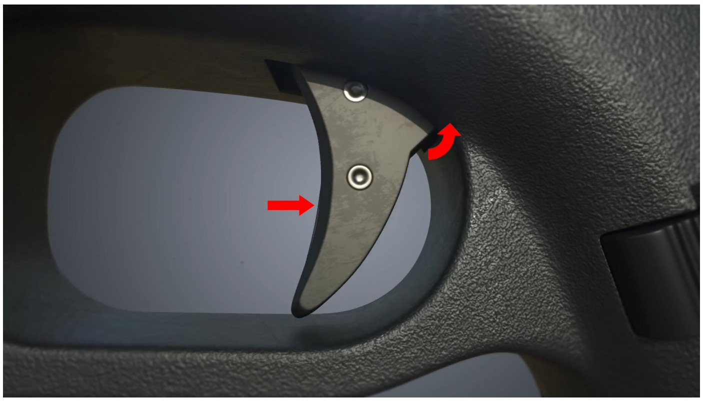
Firing pin safeties have been included in pistol design since more than 50 years. They are an effective means against many safety hazards.

Trigger safety

The trigger safety is a small spring loaded lip that protrudes forward from the face of the trigger. When engaged, it prevents the trigger from being moved backwards. When the trigger finger is properly positioned on the trigger, the trigger safety is disengaged. As the finger is taken off the trigger, the safety is automatically re-engaged. The trigger safety's main purpose is to prevent the pistol from firing when dropped and impacting rear first on a hard surface. It prevents the trigger from being activated by mass inertia. A further purpose is to block the trigger unless properly pulled.

Trigger safety engaged
Example: Glock pistol

The trigger safety is pushed forward by its spring and blocks the trigger from rotating backwards.



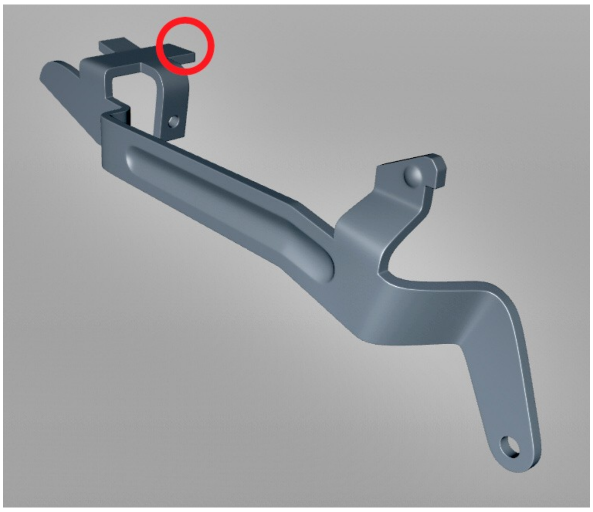
Trigger safety disengaged
Example: Glock pistol

When the trigger finger is properly placed on the trigger, the trigger safety is disengaged. This allows the trigger to be fully pulled.
As soon as the trigger finger is taken off the trigger, the trigger safety is engaged again automatically.

Trigger safeties are found on almost all striker fire pistols, they enhance the overall safety considerably.

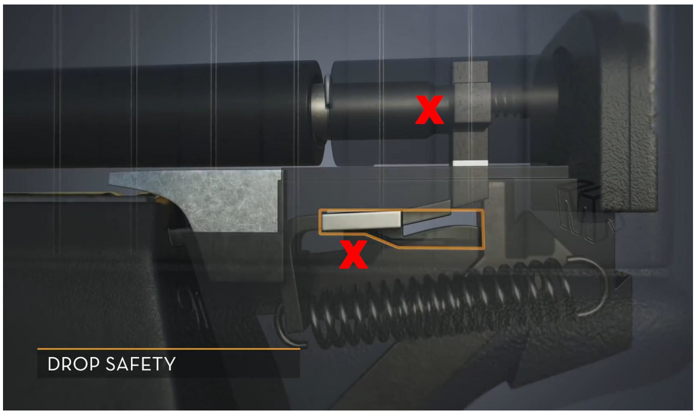
Drop safety (Glock)

Glock pistols are using a partially cocked striker system called "Safe Action". When pulling the trigger, the striker is first moved backwards and fully cocked and only then, when the trigger is pulled all the way, it is released. In the partially cocked position, the trigger bar is positively prevented from moving downwards and releasing the striker.



Drop safety
Example: Glock pistol

The trigger bar extends on the left side of the pistol into a control curve of the trigger housing.



Drop safety
Example: Glock pistol

When the striker is in the partially cocked position, the trigger bar is prevented from moving downwards and releasing the striker by the control curve in the trigger housing.

Drop safety
Example: Glock pistol

When the trigger is pulled and the trigger bar moves backwards, fully cocking the striker, the control curve allows the downward movement of the trigger bar. The trigger bar is moved downwards by the connector, releasing the striker.

Trigger pull weight
The trigger pull weight is a relatively easily measurable indicator of the trigger bar to striker or sear to hammer overlap and surface pressure. The higher the overlap and the higher the pressure the less easily the striker or hammer can skip off the detent. As a rule of thumb, the lighter the trigger, the higher the chance of unwanted striker or hammer release.

Examples of common trigger pull weights are:

Duty Pistols	Striker	2.0-2.5 kg
Duty Pistols	DA/SA	DA: 4.0-5.0 kg, SA: 2.0-2.5 kg
Sport Pistols	Striker	1.5-2.0 kg
Sport Pistols	DA/SA	DA: 3.0-3.5 kg, SA: 1.5-2.0 kg
Sport Pistols	SA	1.35-2.0 kg

Trigger pull weights below 1.36 kg (3.0 lbs) can be considered to cause unnecessary high safety risks.

A lot of new shooters overestimate the benefits of lower trigger pull weights. A lighter trigger is often deemed a "better" trigger. However, going below a reasonable trigger pull weight degrades overall safety considerably. If a shooter cannot shoot straight with a 2.0 kg trigger, the cure should be to improve the shooting technique and not to search for an even lighter trigger pull.

Trigger travel
From the initial position, through pre-travel up to the pressure point and finally the breaking point the trigger travel is the total distance measured at the tip of the trigger. A longer trigger travel, especially paired with a heavier trigger pull weight is an effective safety measure.
Examples of common trigger travel distances are:

Duty Pistols	Striker	10-15 mm
Duty Pistols	DA/SA	DA: 15-20 mm, SA: 3-6 mm
Sport Pistols	Striker	5-15 mm
Sport Pistols	DA/SA	DA: 10-15 mm, SA: 3-6 mm
Sport Pistols	SA	2-3 mm

After firing, when releasing the trigger, it is pushed forward. After passing the reset point, the pistol can be fired again. If that reset travel is too short, the recoil paired with some minimal movement of the trigger finger can cause the next shot to be fired immediately and without control, essentially causing a negligent discharge. Typical safe trigger reset distances are 5-8 mm.

Generally, trigger travel and reset distances below 2 mm are considered to increase safety risks considerably.

Hammer safety notch

Most hammers have a safety notch, also called safety catch or safety hook. The hammer should be positioned just slightly back so it cannot make contact with the firing pin when in this notch. It is usually more pronounced, i.e. higher than the normal full cock notch.
The purpose of the safety notch is to catch the hammer in case it skips the full cock notch for any reason without the trigger actually being pulled. Furthermore, if the pistol is carried with the hammer lowered to the safety notch, the hammer is prevented from making contact with the firing pin. This adds to the drop safety characteristics, for example in case the pistol impacts hammer-first on a hard surface.

Hammer positions: fully down
Example: SIG P220 pistol

1) The hammer is all the way down

When firing, the hammer is immediately cocked again by the slide movement. A loaded P220 cannot be carried in this way.

Hammer positions: de-cocked to the safety notch
Example: SIG P220 pistol

2) The hammer on the safety notch from being de-cocked by the de-cocking lever

After loading the pistol, the hammer is lowered to the safety notch for carrying. The first round is fired in double action mode.

Hammer positions: fully cocked
Example: SIG P220 pistol

3) The hammer fully cocked by the slide movement after loading or firing

The pistol should never be carried like that.

Mass of parts and spring forces

Pistols without features such as trigger or firing pin safeties, often rely on the relation of mass of the involved parts and spring forces acting on those parts.

A good example is the firing pin and its spring. The firing pin spring holds the firing pin back in position. The spring force is overcome when the firing pin is driven forward after being struck by the hammer. After firing it then pushes the firing pin back again and keeps it in position, preventing it from protruding out from the breech face.
In case the pistol is dropped onto the muzzle, mass inertia will keep the firing pin moving forward. The firing pin spring works against that movement, preventing the firing pin from reaching a loaded round, if strong enough. The relation between firing pin mass and firing pin spring force is essentially providing the required drop safety quality of the pistol.

Another example is the trigger mass in relation to the trigger pull weight. In case of an impact to the rear of the pistol, mass inertia will keep the trigger moving backwards. The relation between trigger mass and trigger pull weight provides the required safety, keeping the trigger from being fully pulled and the pistol from firing.

Obviously, safety characteristics that rely on parts mass to spring force relations are much less dependable than positive blocking mechanisms.

5. Modifications

In the quest for ever faster shots and lower split times between shots, many competitive shooters are seeking an advantage by modifying their pistols. For example, they like to have ever lighter trigger pulls along with shorter trigger and reset travels. The aftermarket industry is offering countless tuning parts and the internet and social media is full of tuning tips on these topics. However, both installing aftermarket parts and modifying factory components can substantially reduce the technical safety characteristics of the concerned firearm. Without in-depth knowledge of the technical safety aspects, the correlation of the involved parts, including acceptable tolerances, spring forces, surface hardness, wear and tear characteristics and in absence of comprehensive test programs, modifying the firearm can cause indeterminable safety risks.

Most reputable firearms manufacturers strive to incorporate high safety standards in their products. Especially for duty and self-defense guns intended for everyday carry. Changing or altering safety relevant parts of the firing mechanism can lead to unpredictable effects and ultimately to unsafe situations.

6. Conclusions

The sports shooting scene has grown significantly and competition among the leading competitors is fierce. Many top shooters have sponsoring contracts and advertise firearms, tuning parts, specialized gear and training classes aggressively through various channels. Needless to say, there can be a lot of money involved. That probably can't be avoided. However, common sense and hard-earned technical expertise should not be swept under the carpet lightly.

The goal here is not to be alarmist but rather to foster knowledge about technical firearms safety and providing the ability to correctly assess the risks associated with certain pistol designs and modifications.

7. Acknowledgments

Cut away views	The views are screen shots from videos by Matt Rittmann www.mattrittman.com
Technical advice	Bruno Wyss, Wyss Waffen Burgdorf, Switzerland wysswaffen.ch
Pictures	Holster safety: www.baltic-shooters.de Raphael Vöglti SwissAAA www.swissaaa.org
Proof reading	Björn Thomann, CMA Instructor Silvio Pfenninger, CMA Instructor