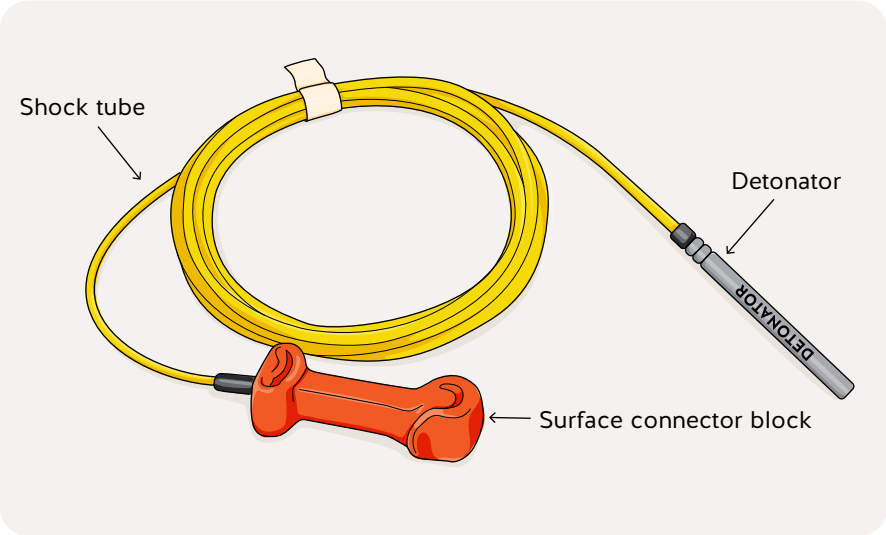
Chapter 19:
Shock tube assemblies

An excerpt from an update to the Blasters' Handbook (currently in revision)

Contents

Overview

A shock tube assembly is a length of shock tube with a high explosive detonator on one end and a surface connector block or a connecting clip on the other end. The assemblies are available in a range of lengths and delay-timing options.



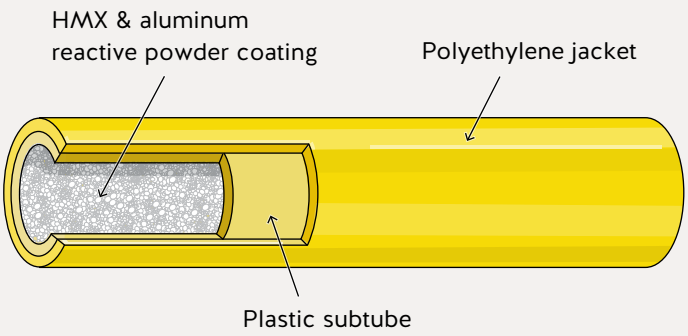
A shock tube assembly

A shock tube assembly is a non-electric type of initiation system. Shock tube assemblies are widely used and are highly preferred in industry over electric initiation. That's because of their electrical insensitivity, durability, flexibility, and ease of hookup. The main advantage of a shock tube assembly is its lower sensitivity to stray current. The main shortcoming is the inability to test the circuit prior to initiation.

Components

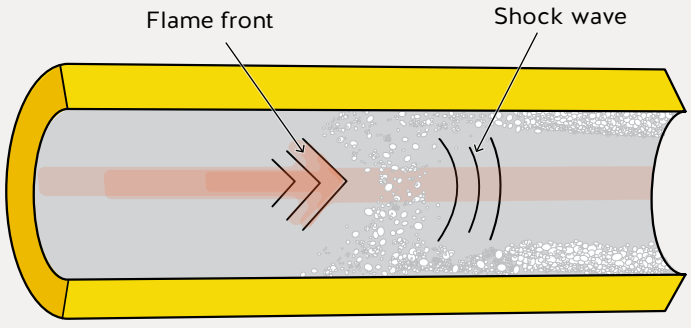
Shock tube

Shock tube is a plastic tube coated with a thin layer of reactive powder on the inside. This reactive powder is usually a composition of HMX (a high explosive) and aluminum. A static charge holds the powder on the inside wall of the tubing.



Cutaway view of shock tube

When sufficient external shock is delivered to the tubing, the reactive components shake loose from the wall and the ignition occurs. This reaction continues and generates a shock wave. The shock wave travels internally through the tube at about 2000 m (6,560 ft.) per second.

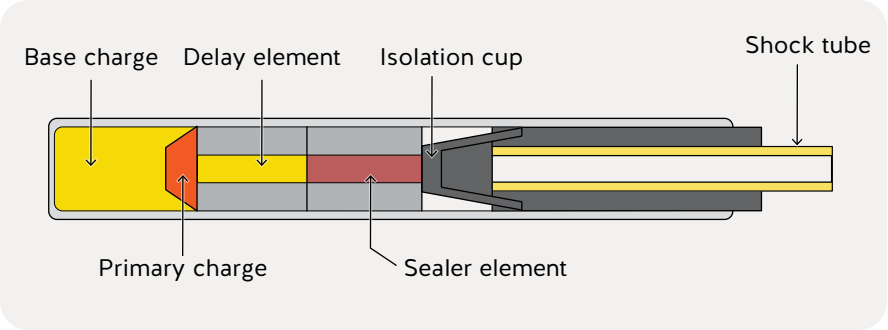


Cutaway view of the reactive powder igniting and generating a shock wave inside a shock tube

The shock wave's energy stays contained in the tube, which remains intact due to the strength of the plastic. This feature allows a shock tube assembly to be used with any explosive, regardless of its sensitivity. The shock wave will not initiate explosives within contact until it reaches the detonator.

Detonator

The detonator has an aluminum shell about 7.5 mm (1/3 in.) in diameter and between 58 and 84 mm (2 1/4 and 3 1/4 in.) long, depending on the delay period. The primary charge is lead azide, a heat-sensitive explosive. The base charge is PETN, a high explosive. The shell also contains a millisecond (ms) delay element.



Cutaway view of a shock tube detonator

The shock wave from the shock tube enters the shell, bursts through the isolation cup, and reacts through the sealer element and delay element. This ignites the primary charge, which in turn detonates the base charge.

Surface connector block or clip

A surface connector block or clip connects the shock tube assembly to one of the following:

- Another shock tube assembly in a nearby hole
- An initiation source at the top of the hole

A surface connector block is also used to initiate an entire blast. This is usually done by removing the block from a shock tube assembly or surface delay and splicing it to the lead-in line. Always follow the manufacturer's recommendations for these procedures.

Safety features

There are three main features that contribute to the electrical safety of a shock tube assembly:

- Isolation cup
- Plastic tubing
- Electrostatic bleeder

Isolation cup

The most important safety feature is the detonator's isolation cup (or anti-static cup). The cup is made of a conductive plastic. It provides a path for any electric current travelling down the tube to be dispelled from the detonator shell.

Plastic tubing

Shock tube may conduct static electricity or stray current. However, the plastic tubing is highly resistant, and the conductivity is much lower than with electrical leg wires.

Electrostatic bleeder

The detonator's sealer element contains an electrostatic bleeder. The electrostatic bleeder's purpose is to disperse any electric current or static electricity that has travelled down the tube.

Note

Despite these safety features, blasting operations involving shock tube assemblies must be suspended in the presence of lightning or approaching storms. A lightning strike has the potential to set off the assemblies.

Delay options

Shock tube assemblies offer a range of delay-timing options. These options allow blasters to set up a variety of efficient blast patterns. This section explores several common delay options.

Dual-delay assemblies

Dual-delay shock tube assemblies are made up of the following:

- A high-strength detonator on one end
- A length of shock tube
- A low-strength initiator on the other end, contained within a plastic housing called a surface connector block

The term *dual-delay* means there is a delay in the detonator and a delay in the surface connector block.

The surface connector block allows for quick, easy connection to other shock tube assemblies or to tubing. This allows the blast to be expanded to any size.

Dual-delay shock tube assemblies are more commonly used today than single-delay assemblies.

A worker holds several standard 25/500 ms dual-delay shock tube assemblies.

The surface connector block contains a low-strength initiator that is suitable only for initiating other shock tubes. This reduces the

risk of cutoffs due to shrapnel. The surface connector block should clip to the next shock tube assembly to fire. Then the connector should be slid toward the collar of the borehole. This removes slack and allows for good pre-blast visual inspections.

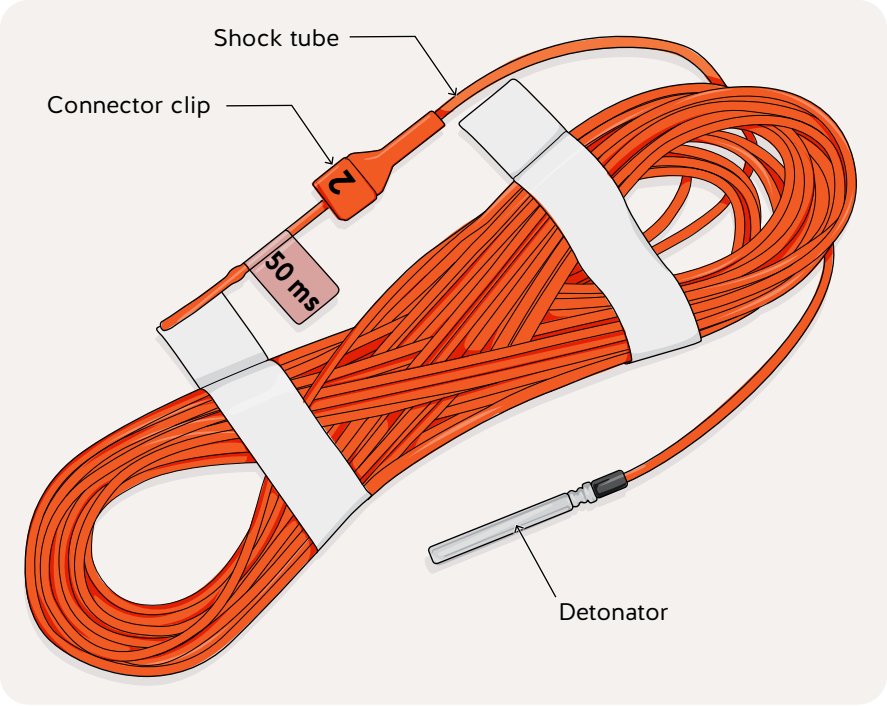
The most common dual-delay combination is a 25/500 assembly (25 ms surface and 500 ms downhole). The downhole detonator initiates after the surface initiator. This prevents cutoffs to downlines and trunklines during ground movement within a blast. A number of timing combinations are available to help blasters accomplish complex delay patterns.

Single-delay assemblies

Single-delay shock tube assemblies come with a predetermined length of shock tube. One end has a heat seal with a plastic connector clip. The other end has a high-strength detonator.

Single-delay assemblies are designed to be used as downhole detonators for initiation. Single delays come equipped with a connector clip that works with the following initiators:

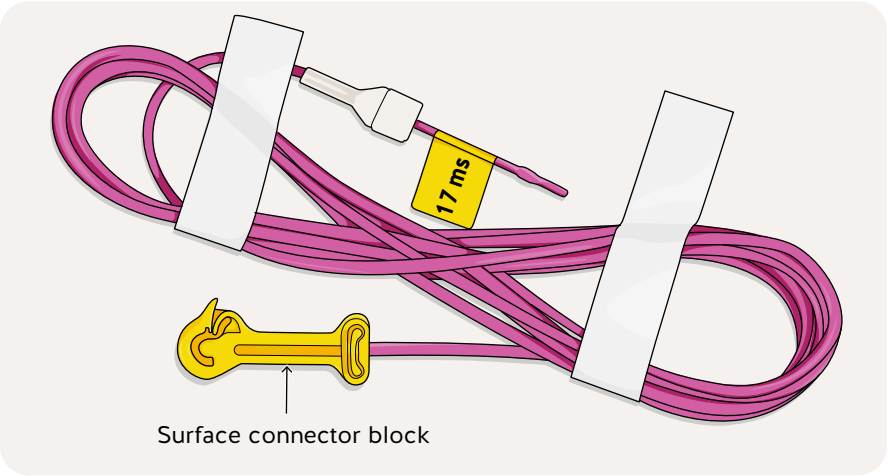
- Detonating cord
- Electric or non-electric detonators
- Shock tube starter devices



A single-delay assembly with a connector clip

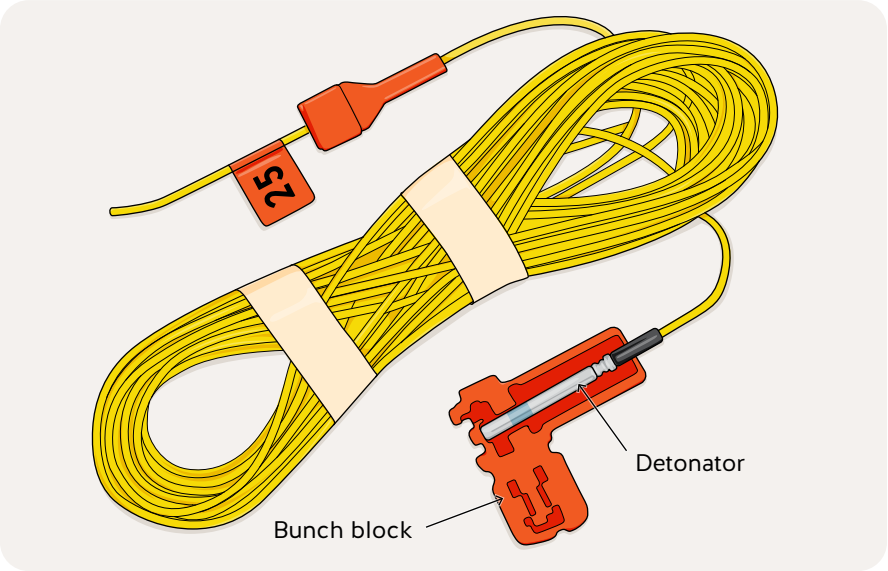
Surface-delay assemblies (trunkline delays)

Surface-delay shock tube assemblies provide out-of-hole delays in non-electric blast patterns. Most surface-delay assemblies use the same surface connector block found on dual delays. This type of connector is only suitable for initiating other shock tubes.



A surface-delay assembly (trunkline delay)

Other kinds of surface delays may have the detonator end contained within a removable “bunch block” (or other plastic fitting capable of holding multiple shock tubes in close contact with the detonator). These are used with detonating cord downlines or other shock tube detonators. Always consult the manufacturer’s recommendations for proper use.



A surface-delay assembly with the detonator end contained in a removable bunch block

Product delay times

Shock tube detonators are either short- or long-delay types. Manufacturers produce shock tube assemblies with various colour codes. The connector block colour represents the delay time. The delay time is also displayed on a tag or on the connector block. The shock tube colours represent either the tube length or its tensile (breaking strength). While these colours are usually universal (i.e., used across products and manufacturers), always consult your manufacturer's technical data sheets.

Surface delay times by connector block colour

Surface delay time (in ms)	Connector block colour
17	Yellow
25	Red/orange
33	Green
42	White

At left, dual-delay shock tube assemblies. At right, surface-delay assemblies.

Timing with shock tube

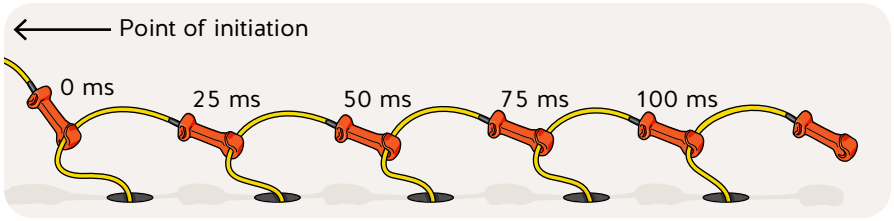
Not only can the delays be timed between holes in a row, but the individual rows can also be delayed.

Surface delay timing

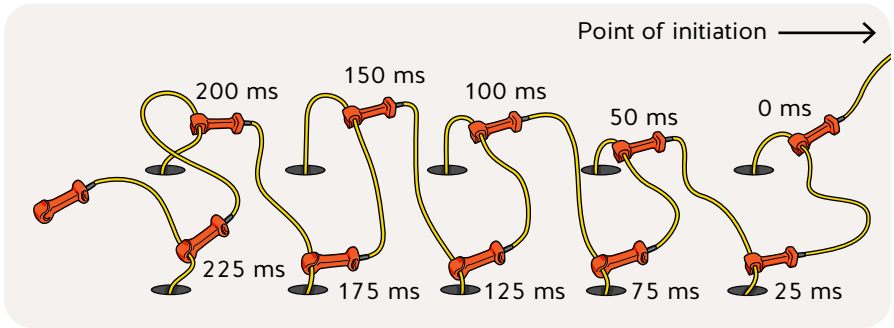
Surface delays can be used to create the timing needed between blast holes and rows in various patterns of all sizes. The goal is to produce an efficient blast with enough time between each hole to achieve good fragmentation and less throw or heave.

In a single-row pattern, the shock tube assemblies are usually connected from one hole to the next hole to fire (i.e., daisy chained). See the “single-row pattern” drawing below.

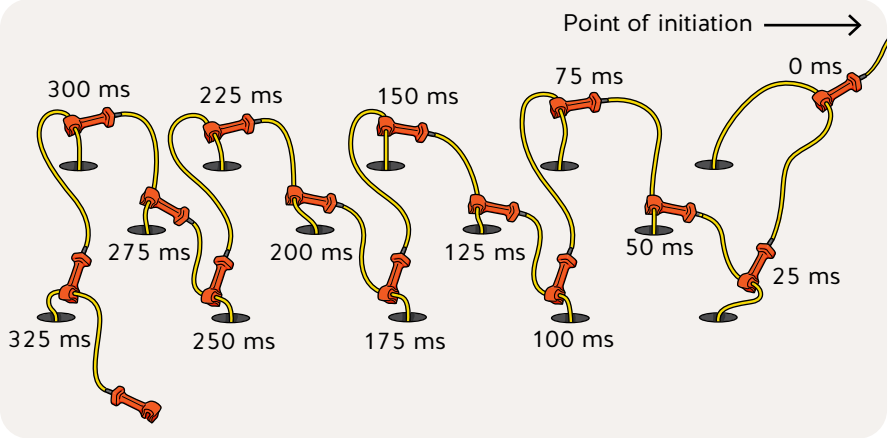
The following drawings show examples of using dual-delay shock tube assemblies to achieve one hole per delay of timing.



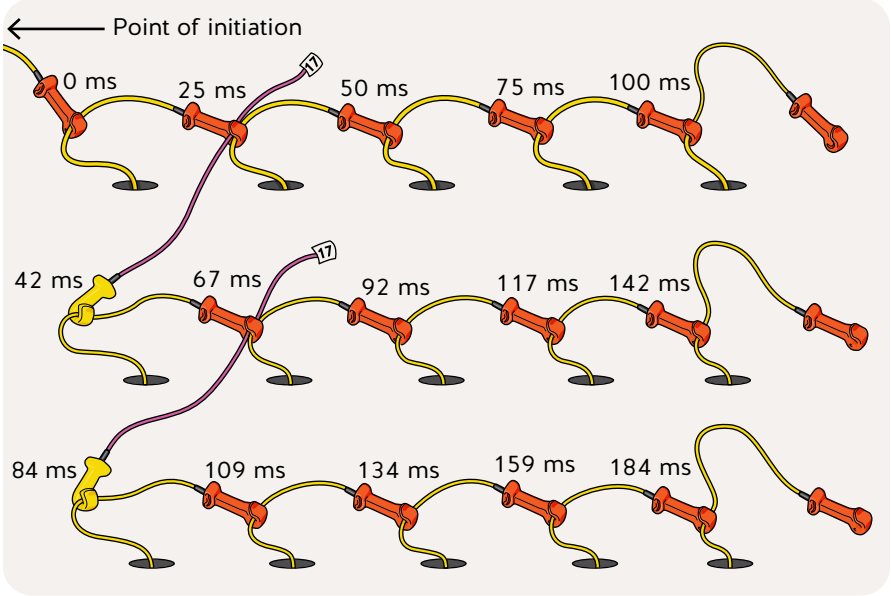
This is a single-row pattern of dual-delay shock tube assemblies with the surface delay times marked.



This is a simple example of a trench pattern with surface delay times marked.



This is a five-of-dice trench pattern with surface delay times marked.



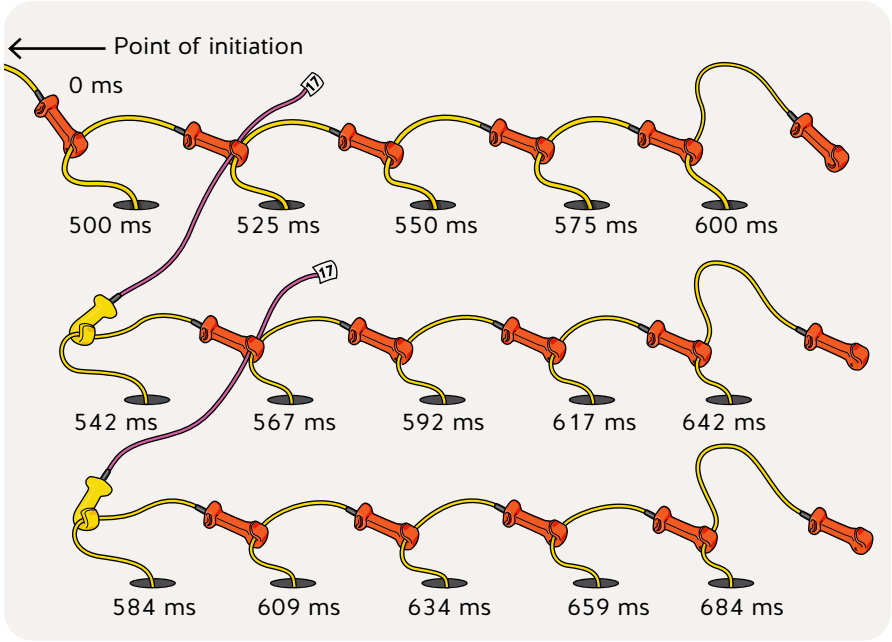
This is an example of using surface delays to fire additional rows of dual-delay assemblies. The surface delay times are marked.

When calculating the timing of surface delays for dual-delay shock tube assemblies, the first hole to fire is considered to be zero milliseconds. The time for additional surface delays is added from there.

In other applications, a single surface connector block can be used to connect to more than one hole at a time. However, this requires accounting for holes firing at the same time.

Downhole delay timing

Calculating the complete timing of a blast includes factoring in the downhole delay time on the first hole. At the end of the downhole delay time, the first hole initiates. The holes that follow will then initiate based on their surface delay timing, as shown in the diagram below.



This is an example of calculating timing, including downhole delays and using surface delays. The delay times are marked.

Storage and handling

Shock tube assemblies must be properly stored and treated with care. Since the detonators contain sensitive explosives, all shock tube assemblies must be stored with detonators, not with detonating cord or other explosives.

Shock tubes must remain undamaged. Do not throw them or allow them to contact tools, rocks, or other sharp or jagged objects. If cut, nicked, or otherwise punctured, shock tube may not function properly. The location of the damage may become a point where the shock wave that travels within the tube can vent out, stopping the reaction from progressing.

No one should hold shock tube when it is initiated. A manufacturing flaw or damage to the tubing could cause serious injury.

Shock tube must be kept sealed, dry, and uncontaminated. Unspliced tubing and detonators are impervious to moisture, but fuel oil can penetrate the plastic tubing. Prolonged exposure to ANFO mixtures can result in failure to initiate or propagate. Shock tube must not be exposed to ANFO mixtures or other oil-containing explosives in a loaded hole for more than a few days.

Assemblies must be protected from high temperatures and damaging substances. Temperatures in excess of 75°C (167°F) can cause the tubing to soften. At lower temperatures, the tubing stiffens but will not shatter or crack unless it has surface nicks or abrasions. With careful handling and loading, shock tube assemblies have been used in temperatures as low as -40°C (-40°F).

Damage to shock tube can occur as a result of the following:

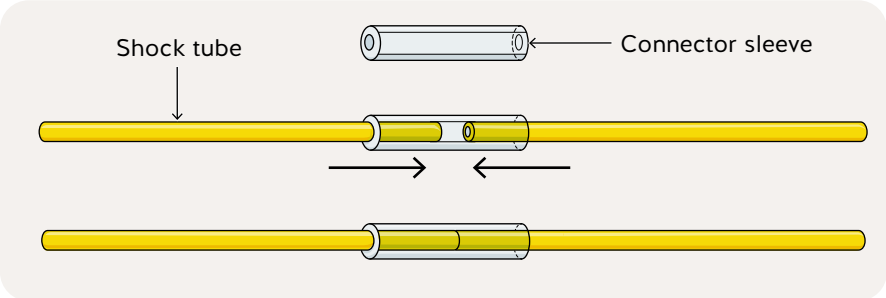
- Scraping action on metal and rock surfaces
- Contact with equipment
- Workers tripping over connected tubing
- Vehicles driving over the tubing
- Contact with shovels used to place stemming
- Contact with coarse or jagged stemming material
- Contact with frozen chunks of stemming material
- Dragging action when placing blasting mats with an excavator
- Explosive ejection of the coverings from detonating cord as it detonates

Splicing

To provide a safe distance from the blast to the blaster upon initiation, the blaster will run a lead-in line of shock tube. (A lead-in line is a long line of shock tube between the point of initiation and the blast.) This requires a factory-installed or spliced connector block on one end of the lead-in line used to connect and initiate a loaded blast.

The act of splicing is precise and may only be done when taking every reasonable care. Manufacturers do not permit spliced connections anywhere in a blast other than to initiate the first hole. The reason for this is that the amount of movement a blast creates will cause cutoffs. Using the last connector of a blast row (the tattletale) to initiate a blast is also not recommended. This is because the tattletale provides visual evidence that all holes have successfully fired or not.

Splicing procedures for an assembly are specific to the manufacturer's recommendations. The manufacturer's accessories and techniques for splicing must be used. Otherwise, moisture can enter the explosive lining and render it insensitive. Also, a blowout may occur through the open end and prevent the shock wave from reaching the detonator.



Splicing shock tube with a connector sleeve. At bottom, the shock tubes are coupled tightly together and ready for taping.

While preparing a lead-in line connection for initiation, best practices for splicing shock tube are as follows:

- Always use a clear, clean connector sleeve.
- Keep the sleeve and the connections completely dry. Wet connections may fail to propagate.

- Cut the tube at clean, straight angles. Take care not to crush or collapse the ends.
- Push the two ends together tightly in a connector sleeve.
- Using electrician's tape, tape one side of the tube and the connector. Then give the other side a firm push inward. This helps ensure the ends are still connected tightly. Then tape the other side of the connector and the tube. Double wrap the tape to ensure the two ends don't come apart.
- Do not place spliced shock tube under pressure.
- Ensure that the cut end of the tubing (i.e., from the spool or the tail of an assembly with the connector block removed) is tied in multiple knots, tapped, or capped with the manufacturer's supplies. This helps prevent moisture from entering the tubing or loss of the explosive powder core.
- When cutting lead-in line from a spool, always cut off at least 30 cm (1 ft.) of tubing before attaching a connector block. This helps ensure a fresh, dry powder core.

Priming and loading

A shock tube assembly contains a high-strength detonator capable of initiating many types of explosives. To reliably initiate insensitive explosives, a primer or a high-strength booster is required.

Under normal conditions, plain tubing may be appropriate. Under adverse conditions, reinforced tubing may be required.

When loading a hole with a shock tube assembly, do the following:

- For a dual-delay assembly, use sufficient tubing to allow enough tail to be present outside of the hole to reach the next hole.
- Lower the primer into the hole. Do not drop ("airmail") it.
- Do not use the shock tube as a lowering line on a heavy primer. The weight of a primer can damage or stretch the tubing and cause a failure. Use a special lowering rope with a self-releasing hook.
- Ensure the primer is in the desired position in the hole, preferably at the bottom (toe).
- Hold the shock tube taut to one side of the hole during loading and stemming. This helps prevent damage to the shock tube and displacement of the detonator.
- When loading bulk explosives, ensure the shock tube does not tangle around the bulk loading hose. Also, check that the primer does not "float" up as the hole is being loaded.
- Never pull on shock tube to the point of breakage. If it breaks, there is a slight chance that it may initiate ("snap, slap, and shoot") and fire the hole.

Prior to adding stemming, secure the tubing to prevent it from being kicked into the hole or pulled in by explosives slumping in the hole. Leave sufficient slack to allow for some slumping.

Use care in stemming the hole. Avoid using frozen chunks and jagged material as stemming. Also avoid contacting the tubing with shovels or other tools.

Connecting shock tube assemblies

Follow the manufacturer's directions for using shock tube assemblies and trunkline delays.

Some recommendations for connecting shock tube assemblies are as follows:

- Do not connect shock tube until all holes are loaded and stemmed.
- Do not connect shock tube until the last practicable moment before the intended time of detonation. Accidental detonation will initiate all connected charges.
- Keep connections tight and clean. Loose, dirty connections can result in cutoffs.
- Use assemblies with the appropriate length of tubing.
- Do not cut (trim) or lengthen shock tube assemblies.
- Ensure there is no damage to the tubing and no excessive slack.

What does *practicable* mean?

Under the Occupational Health and Safety Regulation, *practicable* "means that which is reasonably capable of being done."

Initiation options and procedures

No person should hold shock tube when it is initiated. A manufacturing flaw or damage to the tubing could cause a blowout and result in serious injury.

Follow the manufacturer's instructions concerning the correct trunkline and connection configuration for each type of assembly.

Shock tube and shock tube lead-in line were originally designed to be initiated by a high-strength detonator. Examples of high-strength detonators include electric detonators and safety fuse assemblies. Other types of explosives are considered unreliable for initiation.

Today, the most commonly used initiation sources for shock tube are mechanical devices that use a shot shell primer activated by a firing pin. Examples of shock tube initiators include thumper or mushroom starters and hand starters (shot shell starters).

Thumper or mushroom starters

Follow the manufacturer's directions for using the starter. Use the starter only to initiate shock tube lead-in line.

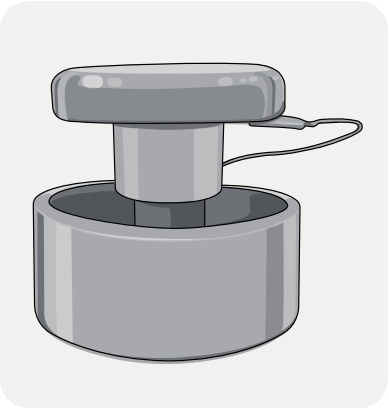
When preparing to use a thumper or mushroom starter, do the following:

1. Insert shock tube from the outside through the upper hole in the safety ring on the starter base.
2. Pull through 15–20 cm (6–8 in.) of shock tube.
3. Pass the shock tube back over the rim of the safety ring.
4. Pass the shock tube through the lower hole into the port in the barrel as far as possible.
5. Pull the loop formed as tight as possible.

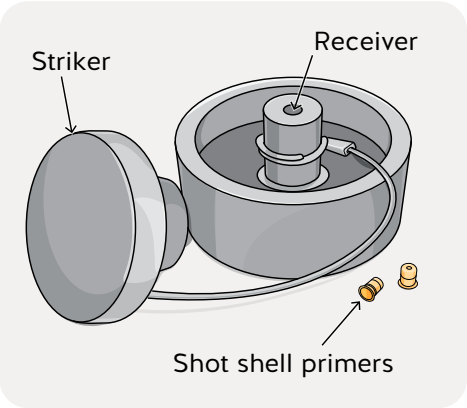
To fire:

1. Remove the striker from the receiver.
2. Place a shot shell primer in the receiver.
3. Place the striker back in position gently, allowing the spring to hold the striker up in the ready position.

4. Set the starter on the ground or a solid object.
5. Strike the starter firmly with a foot or a fist.



A thumper or mushroom starter

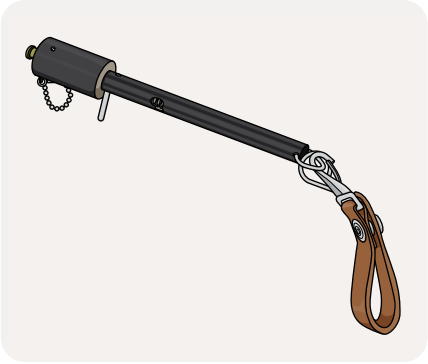


Preparing a thumper or mushroom starter for firing

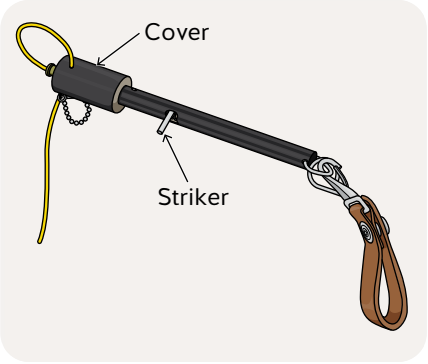
Hand starters (shot shell starters)

To initiate shock tube with a hand starter, do the following:

1. Pull the striker back so it locks in place.
2. Slide down the cover.
3. Load the shot shell primer in the receiver.
4. Slide the cover back up.
5. Gently place the striker back in its starting position (to avoid accidental initiation).
6. Thread the shock tube through the cover and then into the receiver hole.
7. Pull the striker back. When ready, release it to fire the shooter.



A hand starter



An armed hand starter, shown just before releasing the striker

High-strength electric detonators

> **Note**
>
> An electric single-series endorsement (an add-on to the blaster's certificate) is required to initiate shock tube assemblies with this method.

To initiate with a high-strength electric detonator, do the following:

1. Attach the detonator to the shock tube by securely taping them together with electrical tape. Ensure that the detonator's business end points in the direction of initiation.
2. Ensure the lead-in line is long enough to prevent detonator shrapnel from cutting off the blast.
3. Place the detonator on the ground and carefully cover it with dirt or sand to contain shrapnel and prevent cutoffs. High-strength detonators (electric or non-electric) produce large amounts of metallic shrapnel when they detonate.
4. Check the resistance of the shot line (firing cable) and the detonator prior to blasting.
5. Fire the blast with a blasting machine.

Safety procedures

When using shock tube assemblies, do the following:

- Select the proper assembly and trunkline for the job.
- Avoid abrasion to the shock tube from sharp or jagged objects.
- Do not use damaged tubing, as it may not initiate or propagate.
- Follow the manufacturer's recommendations for cutting and splicing shock tube for lead-in lines and trunklines.
- Do not connect the assemblies until the last practicable moment.
- Ensure the trunkline is not damaged or located near a sensitive explosive.
- Make proper connections. Ensure they are tight and clean, and are at right angles to, or in the general direction of, the detonation path.
- Where necessary, use two detonators at each initiation point.
- Collect all scrap tubing and destroy it. (You may attach unused connector blocks to the last row of holes to fire them.)
- Return all unused shock tube assemblies and other explosives to a safe location.
- Avoid situations where initiation system components can become entangled in machines, equipment, vehicles, or their moving parts.
- Unhook surface delay connectors before dealing with a misfire.
- Protect surface delay connectors from unintended energy sources such as the following:
  - Impact from falling rock
  - Impact from tracked vehicles, other mobile equipment, or drilling equipment
  - Flame
  - Friction

    - Electrical discharge from power lines
    - Static electricity
    - Lightning
- Do not drive vehicles over shock tube.
- Do not pull, stretch, kink, or put tension on a shock tube such that the tube could break or otherwise malfunction.
- Do not hook up a surface delay connector to its own shock tube.
- Do not leave an unhooked surface delay connector near the shock tube of a loaded bore hole.