

Workplace Health and Safety Bulletin



Guidelines for the Safe Operation of Tubing Conveyed Perforating Systems



Table of Contents

| | | |
|--------|-----------------------------------------------------------------------|-------------------------------------|
| 1.0 | Scope and content..... | 4 |
| 2.0 | Definitions..... | Error! Bookmark not defined. |
| 3.0 | Downhole equipment..... | 6 |
| 3.1 | Detonators and initiating devices | 6 |
| 3.2. | Downhole firing systems..... | 6 |
| 3.3 | Other downhole equipment | 7 |
| 4.0 | Field Safety Procedures..... | 7 |
| 4.1 | Service representative qualification..... | 7 |
| 4.2 | Records and procedures..... | 8 |
| 4.3 | Transportation..... | 8 |
| 4.4 | General practices | 8 |
| 4.4.1 | Shop loading..... | 8 |
| 4.4.2 | Pre-job safety meeting at the well site | 8 |
| 4.4.3 | Well site loading/unloading of explosive devices..... | 10 |
| 4.4.4 | Post job operations | 11 |
| 5.0 | Mechanical and Hydraulic Tubing Conveyed Operations..... | 12 |
| 5.1 | Gun make-up | 12 |
| 5.1.1. | Supervision..... | 12 |
| 5.1.2 | Personnel safety..... | 12 |
| 5.1.3 | Avoiding explosive component impacts/mechanical interference..... | 12 |
| 5.1.4. | Gun arming — mechanical and hydraulic arming and firing sequence..... | 12 |
| 5.1.5. | Gun arming/firing bottom-up..... | 13 |
| 5.1.6 | Gun detonation | 13 |
| 5.2 | Recovery of the gun from the well | 13 |
| 5.2.1 | Supervision of gun recovery | 13 |
| 5.2.2 | Drop bar..... | 13 |
| 5.2.3 | Notification to lease owner/operator | 13 |
| 5.2.4 | Personnel safety..... | 14 |
| 5.2.5 | Gun disassembly | 14 |
| 5.2.6 | Internal pressure | 14 |
| 5.2.7 | Disassembly | 14 |
| 5.3.8 | Misfires..... | 14 |

| | | |
|--------|------------------------------------------------------|----|
| 6.0 | Electrical tubing conveyed operations | 15 |
| 6.1 | Well site preparation..... | 15 |
| 6.1.1 | Warning signs..... | 15 |
| 6.1.3 | Eliminating sources of stray electrical energy | 15 |
| 6.2 | Pre-Checks..... | 16 |
| 6.2.1 | Checking system circuits..... | 16 |
| 6.2.2 | Checking detonators..... | 16 |
| 6.2.3 | Stray voltage check..... | 16 |
| 6.2.4 | Personnel..... | 16 |
| 6.3 | Gun/explosive tool arming sequence..... | 17 |
| 6.4 | Running gun/explosive device into well | 17 |
| 6.4.1 | Restoring power | 17 |
| 6.4.2 | Descent | 17 |
| 6.5 | Gun detonation | 18 |
| 6.6 | Recovery of guns/devices from the well | 18 |
| 6.6.1 | Recovery..... | 18 |
| 6.6.2 | Powering down | 18 |
| 6.6.3 | Personnel | 18 |
| 6.6.4. | Internal pressure | 18 |
| 6.7. | Disarming misfired devices | 18 |
| 7.0 | Special provisions..... | 19 |
| 7.1 | Snubbing operations | 19 |
| 7.2 | Coiled tubing operations..... | 19 |
| | For more information..... | 19 |

1.0 Scope and content

These Guidelines are intended to promote consistent operating practices within the perforating industry by describing good practices and procedures for Tubing Conveyed Perforating (TCP) operations. The Guidelines are also meant to help employers and workers comply with regulatory requirements.

These Guidelines are based on industry best practices, experience and engineering judgment. They must be applied using sound technical knowledge and decision-making.

Developed by the Petroleum Services Association of Canada (PSAC), these Guidelines have been accepted by Alberta Employment and Immigration as recommended practices that should be followed in order to comply with Alberta's *Occupational Health and Safety Act* and regulations. Companies performing TCP operations are expected to establish detailed policies and procedures that cover all aspects of TCP for use by their workers. These policies and procedures should describe safety measures that are equivalent to or exceed those described in these Guidelines.

Alberta Employment and Immigration gratefully acknowledges PSAC's contribution to promoting safe work practices and the preparation of these Guidelines.

These Guidelines were originally published in 1992 as a booklet but never reprinted. They have been updated and are now presented as a Safety Bulletin.

2.0 Definitions

approved — refers to current applicable regulations as outlined in provincial or federal legislation governing the handling of explosives;

arming — installing a detonating device into an explosive assembly i.e. a perforating gun assembly;

booster — an explosive device used with detonating cord or primer-cord to transfer the detonation train from one device to another i.e. detonator to primer-cord end, or primer-cord end to primer-cord end;

gun (gun assembly) — a carrier designed to transport perforating charges into the wellbore;

gun spacer — a spacer used to separate the firing mechanism from the top perforating charge or to provide a space between two perforating intervals;

lease owner/operator — a person, partnership, company or group of persons who, under contract and agreement of ownership, direct the activities of one or more employers involved at a work site;

licensed qualified representative — a person holding a valid blaster's permit;

perforating — the use of shaped explosive charges to perforate well casing to allow the flow of oil and/or gas into the wellbore;

service company — a person, corporation or association that is contracted to supply, sell, offer or install a product or service to another company, usually the owner of the work site;

snubbing — the act of moving tubulars into or out of a wellbore when pressure is contained in the well through the use of stripping components or closed blowout preventers (BOPs) and mechanical force is required to move the tubing in order to overcome the hydraulic force exerted on the tubular in the wellbore;

Tubing Conveyed Perforating (TCP) — perforating guns that are run on pipe, including tubing strings, drill pipe and coiled tubing. TCP guns are fired by dropping a drop bar or can be pressure activated once in position.

3.0 Downhole equipment

This section presents information about the various types and recommended safety features of downhole equipment used in TCP operations.

3.1 Detonators and initiating devices

3.1.1 Only high energy type electric detonators and initiators offering protection against stray current/voltage and radiofrequency (RF) energy are to be used. These detonators/initiators must incorporate at least one of the following features:

- minimum DC resistance of 50 ohms and minimum “no-fire” current of 200 milliamps
- exploding bridge-wire (EBW) design
- exploding foil initiator (EFI) design

3.1.2 Electric detonator/initiator lead wires must not pull out of the detonator when pulled with 5 kilograms force (or less) tension between the detonator body and the wires.

3.1.3 Percussion style detonators/initiators must be able to sustain a minimum impact of 0.7 kilogram-metre (5 foot-pound) without actuating.

3.1.4 Detonators/initiators must not contain any exposed primary high explosive e.g. lead azide, etc.

3.1.5 Specifications for the temperature and pressure rating of detonators exposed to the wellbore must be based on tests that simultaneously apply temperature and pressure.

3.2. Downhole firing systems

3.2.1 Downhole firing systems must have at least two independent safety features designed to prevent inadvertent actuation of the detonator/initiator.

3.3 Other downhole equipment

- 3.3.1 Downhole systems that require the detonator to be electrically connected while at the surface must be of a type that
- (a) the detonator can be armed electrically before being armed ballistically, or
 - (b) the detonator/initiator must incorporate at least two independent safety features that prevent inadvertent actuation.
- 3.3.2 Tool designs must be such that upon retrieval from the wellbore, trapped pressure can be safely bled down. Threaded connections must incorporate a feature that vents trapped pressure.
- 3.3.3 Radioactive marker subs must be handled by a representative of the supplier when running the radioactive marker and when retrieving subsurface TCP equipment. Radioactive markers must be marked with the service company's name and telephone number.
- 3.3.4 When using a gun spacer, the service company must have written procedures in place for its proper use and specific safety features.

4.0 Field Safety Procedures

This section contains guidelines for the safe handling, transportation and operation of explosive devices used in connection with TCP operations.

4.1 Service representative qualification

- 4.1.1 The service company representative performing TCP operations must hold a valid "Oil/Gas Well Perforating" Blaster's Permit as required by Alberta's Explosive Safety Regulations.

4.2 Records and procedures

- 4.2.1 The lease owner/operator must keep adequate well records on file while TCP equipment is in the well. The records must include the name(s) of the supplier/maker of the TCP equipment. The supplier/maker must provide written safe use procedures, including those to be followed when retrieving, disarming and disassembling TCP components. Documentation provided by the supplier/maker must also include an emergency response number.

4.3 Transportation

- 4.3.1 The requirements of the *Explosives Act (Canada)*, the *Dangerous Goods Transportation and Handling Act*, the regulations made under these *Acts*, and all other applicable provincial regulations and municipal by-laws must be followed at all times during the transportation of explosives by road, air or water.

Readers should refer to PSAC's "Perforating Industry Code of Practice" for recommended practices involving the transportation of perforating guns in attended and unattended vehicles.

4.4 General practices

4.4.1 Shop loading

Perforating equipment must be loaded in designated shop areas and in accordance with applicable regulations. Readers should refer to PSAC's "Perforating Industry Code of Practice" for recommended practices involving the loading of perforating guns and their storage. (See "For more information")

4.4.2 Pre-job safety meeting at the well site

A pre-job safety meeting involving representatives of the lease owner/operator and the service company providing TCP services must be held before starting any TCP operations.

The following topics must be discussed:

(a) *Identification of well site hazards*

Identify safety hazards associated with the well site, particularly those hazards that affect the ability of workers to safely handle and operate the explosive devices being used. All reasonable steps must be taken to remove any safety hazards identified during the pre-job safety meeting. The hazards must be removed before starting the TCP operation.

The scope of the work to be done must be explained to all parties involved. The authorized blaster has control and authority over the explosive devices being used.

(b) *Smoking areas/open flames*

Identify (by appropriate signage, markings, etc.) and enforce the use of designated smoking areas. Smoking must not be permitted except within the designated areas. Smoking materials in use must remain within the designated areas at all times.

No open flames or flame producing device are permitted within 15 m (50 ft) of operations involving explosives.

(c) *Temporary explosive location(s) facilities*

Establish and inspect approved location(s)/facilities for the temporary storage of explosive materials. These location(s)/facilities must be located away from sources of heat, impact/shock hazards, and any living accommodations by a distance specified by current applicable regulations.

(d) *Explosive packaging/identification*

Explosive materials arriving at the well site are to be properly packaged and clearly labelled in accordance with current applicable regulations.

(e) *Establish gun loading/make-up site*

Establish the location where guns will be loaded, if applicable, and where guns will be made up.

4.4.3 Well site loading/unloading of explosive devices

4.4.3.1 Designated site

Explosive devices must only be loaded within the designated site. The loading site must be located at least 15 m (50 ft) or more (as required by current applicable regulations), from any source of heat or open flames e.g. welding activities.

4.4.3.2 Warning signs

Signs reading “**DANGER EXPLOSIVES**” or “**CAUTION EXPLOSIVES**” must be displayed at the designated site.

4.4.3.3 Personnel

Only authorized personnel may be present in the loading area during loading operations.

4.4.3.4 Handling explosives

The following requirements apply to the handling of explosives:

- (a) Explosives must only be stored in approved packaging.
- (b) Detonators and initiating devices are not permitted within the loading area during loading.
- (c) Explosives are to be removed from their packaging within the loading area and only using approved tools.
- (d) Explosives are to be removed from their packaging only as required for immediate loading. Unpacked explosives must not be allowed to accumulate in the loading area.
- (e) Only approved loading tools must be used. Only approved detonating cord cutting devices and techniques must be used.

- (f) Proper procedures must be followed when handling and assembling explosive devices. Force must not be used to fit explosives. Impacts, pinching, crushing and sparks from all sources must be avoided.
- (g) As soon as loading is completed, all loose, remnant, damaged or unused explosive must be collected and repackaged in approved storage containers. Storage containers must be secured for shipment off the well site.
- (h) Loaded guns must be stored at the designated site (see clauses 4.4.3.1 and 4.4.3.2)
- (i) A handling cap, plug or other closure device must always be installed in the ends of hollow carrier-type loaded guns during handling, transportation, and/or storage. The closure device must have a feature that will relieve pressure from within the gun in case of fire or excess heat. Guns or devices with exposed detonating components — such as the expendable or strip types — must be protected from damage.

4.4.3.5 Housekeeping

Remnant explosives must not be mixed with ordinary trash.

Clean up must happen immediately after loading. Waste materials, including empty explosive packaging, must be removed from the well site for proper disposal.

4.4.4 Post job operations

4.4.4.1 Handling remnant explosives

All remnant explosives such as pieces of detonating cord, defective or damaged charges, and misfired detonators and packaging must be placed into proper shipping containers for transportation off the well site (see clause 4.3).

4.4.4.2 Disposal of trash

All trash and debris associated with the operation, including empty containers or packaging, spent gun tubes and the like, must be collected and placed in appropriate containers for transportation off the well site.

5.0 Mechanical and Hydraulic Tubing Conveyed Operations

5.1 Gun make-up

5.1.1. Supervision

Gun make-up is to be supervised by a licensed qualified representative designated by the company supplying the TCP services.

5.1.2 Personnel safety

All personnel not associated with the TCP operations must be moved to a safe location. All personnel must be removed from the line of fire during the arming process.

5.1.3 Avoiding explosive component impacts/mechanical interference

When making a vertical gun connection, the handling cap must be removed from the suspended gun before it is removed from the lower section. Immediately before connection, ensure that no material or objects that could interfere with the connecting process are present within the gun end cavities.

The explosive connection at tandem subs must be assembled in such a manner as to ensure that the detonating cord and boosters are not by-passed or exposed to the risk of being crushed.

5.1.4. Gun arming — mechanical and hydraulic arming and firing sequence

The service company providing TCP services must have written arming procedures specific to the type of mechanical or hydraulic firing system being used.

5.1.5. Gun arming/firing bottom-up

Only firing heads demonstrated by design to prevent accidental firing when exposed to wellbore conditions during gun installation shall be installed at the bottom of the loaded gun assembly. The use of this configuration must be jointly reviewed and approved by the service company and lease owner/operator.

5.1.6 Gun detonation

A licensed qualified representative of the service company that provided the TCP system must be on location to detonate the perforating guns.

5.2 Recovery of the gun from the well

5.2.1 Supervision of gun recovery

A licensed qualified representative of the service company providing the TCP system must be on location while guns are being recovered from the well.

5.2.2 Drop bar

The drop bar must be retrieved before a gun is brought to the surface, unless there is positive indication that the gun has fired.

The service company providing the TCP system must have written procedures in place for the safe recovery of TCP equipment in the event that the drop bar cannot be recovered.

5.2.3 Notification to lease owner/operator

The service company providing TCP services must make the lease owner/operator aware that

- (a) a licensed qualified representative of the service company must be on location to detonate the perforating guns and while guns are being recovered from the well, and
- (b) written procedures must be in place for the safe recovery of TCP equipment in the event that the drop bar cannot be recovered.

5.2.4 Personnel safety

All personnel not associated with the TCP operation must be moved to a safe location. All personnel must be removed from the line of fire during the disarming process.

5.2.5 Gun disassembly

The service company providing TCP services must have written procedures in place for the safe disassembly of all types of guns used by the company. These procedures must address the disassembly steps to be taken in the event that the gun has either fired or is suspected of misfiring.

5.2.6 Internal pressure

Guns such as hollow carrier guns must be checked for evidence of internal pressure when returned to the surface. If internal pressure is encountered, all non-essential personnel must be moved to a safe location. The pressure must then be bled off in accordance with the service company's written procedures.

5.2.7 Disassembly

The firing mechanism must be removed immediately. The gun must then be broken down in the reverse manner to that described in clause 5.1.3.

5.3.8 Misfires

Misfired detonating components must be immediately removed and properly stored in an approved transportation container.

6.0 Electrical tubing conveyed operations

6.1 Well site preparation

6.1.1 Warning signs

Warning signs with the following words should be prominently displayed at the well site and at all entrances to the well site if initiating devices sensitive to radiofrequency energy are in use:

“DANGER: EXPLOSIVES — TURN OFF RADIO TRANSMITTERS”

or

“CAUTION: EXPLOSIVES — TURN OFF RADIO TRANSMITTERS”.

- 6.1.2 If the initiating devices are insensitive to radiofrequency energy e.g. exploding bridge-wire detonators or exploding foil detonators, the warning signs need only read as:

“DANGER — EXPLOSIVES”

or

“CAUTION — EXPLOSIVES”.

6.1.3 Eliminating sources of stray electrical energy

The following sources of stray electrical energy must be eliminated:

(a) *Cathodic systems*

Turn off electrical cathodic protection systems.

(b) *Electric welding*

Stop all electric welding operations.

(c) *Radiofrequency energy*

If an electric detonator is being used, ensure compliance with the “Minimum Distance vs. Transmitter Power Table” found in Alberta’s Explosives Safety Regulations. The Table applies to all radiofrequency emitting devices including radio towers, two-way portable radios and cellular telephones.

(d) *Stray voltages*

Before attaching ground cables, eliminate all sources of voltage difference in excess of 0.25 volts (+/- 10%) between the wellhead, rig and any other units. This must be done before, and then maintained during, the arming or disarming of any explosive device.

(e) *Rig wiring*

Remove or de-energize, for the duration of the entire TCP operation, any rig electrical wiring that might come into contact with the explosive devices.

6.2 Pre-Checks

6.2.1 Checking system circuits

Only an approved blasting ohmmeter can be used when checking the continuity or insulation of a gun system.

6.2.2 Checking detonators

When detonators are being checked using an approved blasting ohmmeter, all blasting caps, detonators and other initiating devices must be contained within a safety loading tube.

6.2.3 Stray voltage check

Verify that the voltage difference between the wellhead and rig (including generator skid and barge where applicable) does not exceed 0.25 volts (+/- 10%) before and during the arming and disarming of any explosive device.

6.2.4 Personnel

All personnel not associated with the TCP operation must be moved to a safe location. All personnel must be removed from the line of fire.

6.3 Gun/explosive tool arming sequence

- 6.3.1 All potential sources of static electricity must be grounded using appropriate methods and non-static clothing must be worn.
- 6.3.2 Confirm that all sources of stray electrical energy are eliminated in accordance with clause 6.1.3.
- 6.3.3 Verify that there is no voltage difference between the points where the blasting cap wires will be attached.
- 6.3.4 Remove the detonator from the approved container, making sure that the leg wires are shunted. Insert into the detonator safety tube, taking it to the arming area and then checking the detonator resistance.
- 6.3.5 With the detonator still in the safety tube, connect the detonator's lead wires to those of the gun, ground connector first.
- 6.3.6 Remove the detonator from the safety tube and connect it to the detonating cord or the device to be fired.
- 6.3.7 Complete the assembly, taking care not to pinch, crush or impact the explosive components.

6.4 Running gun/explosive device into well

6.4.1 Restoring power

Once the gun/explosive device is 66 m (200 ft) or more below ground level (or sea floor if applicable), power can be restored.

6.4.2 Descent

The gun/explosive device can now be run to depth. The gun/explosive device should be tied-in for depth control.

6.5 Gun detonation

- 6.5.1 A licensed qualified representative from the service company that provided the TCP system must be on location to detonate the perforating gun.

6.6 Recovery of guns/devices from the well

6.6.1 Recovery

A licensed qualified representative from the service company providing the TCP system must be on location while equipment is being recovered from the well.

6.6.2 Powering down

Once the gun/explosive device is 66 m (200 ft) or more below ground level (or sea floor if applicable), all potentially dangerous electrical circuits i.e. battery pack, etc. must be returned to their safe mode or removed from the well as noted in clause 6.1.3.

6.6.3 Personnel

All personnel not associated with the TCP operation must be moved to a safe location. All personnel must be removed from the line of fire.

6.6.4. Internal pressure

If evidence of internal pressure is present, all non-essential personnel must be moved to a safe location. The pressure must then be bled off in accordance with the service company's written procedures.

6.7. Disarming misfired devices

- 6.7.1 Misfired devices must not be disarmed during a thunderstorm, dust storm or sand storm. Disarming must not be started if such weather is expected to arrive before the disarming operation can be completed.

6.7.2 Misfired devices must be disarmed immediately as follows:

- (a) Remove the detonator from the detonating cord or device.
- (b) Put the detonator in a detonator safety tube.
- (c) Disconnect the detonator's lead wires from the circuit.
- (d) Shunt the detonator lead wires together. Remove the detonator from the safety tube and place it into a container for transportation off the well site (see clause 4.3).

7.0 Special provisions

7.1 Snubbing operations

If snubbing a TCP system is a possibility before or after the guns have been fired, then a pre-job planning meeting must be held between the lease owner/operator and the service company that provides the system. All safety aspects of the snubbing operation must be addressed at this pre-job meeting and proper procedures must be agreed upon before any TCP operation begins.

7.2 Coiled tubing operations

The requirements of clause 7.1 apply to coiled tubing operations.

For more information

The Petroleum Service Association of Canada (PSAC) publishes the Perforating Industry Code of Practice which defines safety standards applicable to the perforating industry. Compliance with the Code is a condition of the operating license issued by Natural Resources Canada (NRCan) Explosives Regulatory Division, and applies to both PSAC and non-PSAC members.


Copies of the Code of Practice can be purchased by contacting:

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Phone (403) 264-4195
www.psac.ca

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