

# Recommended Practice for Oilfield Explosives Safety

API RECOMMENDED PRACTICE 67  
SECOND EDITION, MAY 2007





# Recommended Practice for Oilfield Explosives Safety

**Upstream Segment**

API RECOMMENDED PRACTICE 67  
SECOND EDITION, MAY 2007



## SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Where applicable, authorities having jurisdiction should be consulted.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises in determining the appropriateness of applying the RP. At all times users should employ sound business, scientific, engineering, and judgment safety when using this RP.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and other exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

*All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, N.W., Washington, D.C. 20005.*

## FOREWORD

This publication is under the jurisdiction of the API Executive Committee on Drilling and Production Operations.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standards, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

Suggested revisions are invited and should be submitted to the Standards and Publications Department, API, 1220 L Street, NW, Washington, D.C. 20005, [standards@api.org](mailto:standards@api.org).



# CONTENTS

	Page
1 GENERAL.....	1
1.1 Scope .....	1
1.2 Application.....	1
1.3 Human Factors.....	1
1.4 Attitude.....	1
1.5 Technical Innovation.....	1
1.6 Security and Oilfield Explosives.....	1
2 NORMATIVE REFERENCES.....	1
3 TERMS AND DEFINITIONS .....	2
4 SYMBOLS AND ABBREVIATED TERMS .....	4
5 SURFACE EQUIPMENT.....	4
5.1 Introduction .....	4
5.2 Electrical Power.....	4
5.3 Cable Safety System .....	4
5.4 Firing System Requirements .....	4
5.5 Communication System.....	5
5.6 Inspection and Maintenance .....	5
5.7 Electrical Grounding/Bonding System.....	5
5.8 Electrical Detonator Safety Tube .....	5
5.9 Electrical Detonator Circuit Testing Instruments .....	5
5.10 Explosives Warning Signs (Land Operations).....	5
5.11 Chemical Cutter Protective Sleeve.....	5
5.12 Pressure Testing of Surface Pressure Control Equipment.....	5
6 DOWNHOLE EQUIPMENT .....	6
6.1 Introduction .....	6
6.2 Primary High Explosives.....	6
6.3 Detonators and Initiating Devices.....	6
6.4 Downhole Firing Systems.....	7
6.5 Other Downhole Equipment .....	7
6.6 Special Provisions for Shallow Operations.....	7
6.7 Electric Downhole Tractors.....	7
7 FIELD SAFETY PROCEDURES .....	8
7.1 Introduction .....	8
7.2 Transportation of Explosives.....	8
7.3 Arrival at the Wellsite .....	8
7.4 Loading or Unloading of Explosive Devices at the Wellsite .....	9
8 ELECTRIC LINE CONVEYED OPERATIONS .....	10
8.1 Well Site Preparation.....	10
8.2 Pre-checks .....	11
8.3 Preparation for Explosive Device Attachment .....	11
8.4 Arming the Explosive Device .....	11
8.5 Deploying the Explosive Device.....	12

	Page
8.6 Recovery of the Explosive Device .....	13
9 TUBING CONVEYED PERFORATING (TCP) AND OTHER NON-ELECTRIC LINE CONVEYED OPERATIONS. ....	14
9.1 Well Site Preparation. ....	14
9.2 Preparing the Explosive Device .....	14
9.3 Arming the Explosive Device .....	14
9.4 Deploying the Explosive Device.....	15
9.5 Recovery of Explosive Devices.....	15
10 SPECIAL CATEGORIES OF EXPLOSIVE DEVICE .....	16
10.1 Setting Tools.....	16
10.2 Cased Hole Formation Testers.....	16
10.3 Propellant-activated Sidewall Sample Takers, Select Fire, and Bullet Perforating Guns .....	16
10.4 Perforating Guns with Power Safe Devices.....	16
11 PERSONNEL TRAINING .....	16
11.1 Introduction.....	16
11.2 Classification of Personnel.....	16
11.3 Qualifications .....	17
11.4 Training .....	17



# Recommended Practice for Oilfield Explosives Safety

## 1 General

### 1.1 SCOPE

This publication is applicable to explosives used in oil and gas producing operations, and more specifically to the use of explosives inside a wellbore. The purpose of this Recommended Practice is to prevent the inadvertent detonation of explosives.

### 1.2 APPLICATION

Operating companies and/or service companies may establish more stringent and additional policies and procedures, as they deem appropriate for their particular situation(s).

### 1.3 HUMAN FACTORS

Human error is the principle cause of accidents and incidents involving explosives. Persons who use explosives on a regular basis over a long period of time must guard against becoming complacent and taking “short-cuts” in the required operations and procedures. Established procedures should be faithfully observed in order to prevent explosives accidents.

### 1.4 ATTITUDE

The total commitment of all individuals and their respective companies is necessary to achieve the safe use of oilfield explosives.

### 1.5 TECHNICAL INNOVATION

New technologies will be developed that offer opportunities for improved safety and increased operational efficiency. These may fall within the intended scope of this RP, but may not be specifically addressed in the current version. Any proposed changes to current procedures as a consequence of new technology shall include a demonstrated safe design. This shall include a rigorous review of potential failure points and their consequences, validated by an independent, recognized testing agency. Operation under such a change shall require prior review by, and agreement between, the service company and operator.

### 1.6 SECURITY AND OILFIELD EXPLOSIVES

Many of the materials referred to in this document are attractive to those with criminal intent. It is therefore recommended that each user establish consistent security measures. These should be routinely applied and should not be subject to the varying threat levels reported by Government or other agencies, such as the United States Department of Homeland Security (DHS). However, enhanced security measures may be required when operating in specific geographical areas or markets identified by such agencies, and each user should prepare action plans to be enacted in the event of increased threat.

Note that the party responsible for defining and implementing security measures may be the user, operator, or other agency as will be defined by federal, state or local law. The responsible party may change depending on the level of security and when the custody of explosive materials changes.

The IME (Institute of Makers of Explosives) has recommended that all explosives be stored in anti-theft magazines under lock and key. Users should report the loss or theft of explosives, in compliance with prevailing law.

Federal, state, and local laws, rules and regulations pertaining to the security of explosives products shall be strictly adhered to in all cases. For additional reference material, refer to IME Safety Publication No. 27 *Security in the Manufacturing, Transportation, Storage and use of Commercial Explosives*<sup>1</sup> and IME Safety Publication No. 17 *Safety in the Transportation, Storage, Handling and Use of Explosives Materials*<sup>2</sup>.

## 2 Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions to, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

- [1] IME Safety Publication No. 27 *Security in the Manufacturing, Transportation, Storage and use of Commercial Explosives*, available from the Institute of Makers of Explosives, 1120 19th Street, N.W., Suite 310, Washington, D.C. 20036-3605.
- [2] IME Safety Publication No. 17 *Safety in the Transportation, Storage, Handling and Use of Explosives Materials*, available from the Institute of Makers of Explosives, 1120 19th Street, N.W., Suite 310, Washington, D.C. 20036-3605.
- [3] MIL-DTL-23659D *Initiators, Electric, General Design Specifications for Naval Surface Warfare Center*, U.S. Department of Defense.
- [4] Title 49 *Code of Federal Regulations*, U.S. Department of Transportation, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- [5] HSAC-RP 92-2 *Perforating Operations—Helideck/Heliport Operational Hazard Warnings/Procedures*, available from the Helicopter Safety Advisory Conference (HSAC), P.O. Box 60220, Houston, Texas 77205.
- [6] IME Safety Publication No. 20 *Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps)*, available from the Institute of Makers of Explosives, 1120 19th Street, N.W., Suite 310, Washington, D.C. 20036-3605.
- [7] ANSI/IEEE C95.4-2002 *Recommended Practice for Determining Safe Distances from Radio Frequency Transmitting Antennas When using Electric Blasting Caps During Explosive Operations*, available from the Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, New York, NY 10016-5997.

### 3 Terms and Definitions

For purposes of this standard, the following terms and definitions apply:

- 3.1 armed explosive device:** A **loaded explosive device** to which the detonator or initiating device has been secured mechanically and/or electromechanically and is ready for use.
- 3.2 arming:** The process of mechanically and/or electromechanically attaching a detonator or initiating device to a **loaded explosive device**.
- 3.3 ballistic arming:** The mechanical alignment of all the elements of an explosive train for the purpose of unimpeded transfer of the detonation wave.
- 3.4 blasting ohmmeter/blasting multimeter/blasting galvanometer:** A test instrument with built-in current limiting features used to measure electrical resistance or conductivity in a blasting circuit.
- 3.5 bullet perforating gun:** A perforating gun utilizing propellant-driven hardened steel bullets to penetrate the casing, cement and formation. Their use has been largely supplanted by jet perforating but is still used.
- 3.6 cable safety circuit:** A circuit which is an integral portion of the electric wireline unit which opens the electric wireline cable to the application of current and resistively shunts the conductor to the cable armour.
- 3.7 cathodic protection system:** A method of corrosion control utilizing an impressed DC current making the structure a cathode, minimizing or eliminating corrosion.
- 3.8 charged explosive device:** A mechanical device to which the explosive components have been inserted or attached, with the exception of the initiating device (see **unarmed**). Sometimes used interchangeably with **loaded explosive device**.
- 3.9 chemical cutter:** A downhole tool used to sever tubular goods in pipe recovery operations utilizing the action of bromine trifluoride to sever ferrous metals.
- 3.10 detonator safety tube:** A tubular vessel used to contain the detonator during electric arming designed to contain the fragments and most of the blast should the detonator inadvertently function.
- 3.11 downhole tractor:** An electric or electro-hydraulic system used to deploy tools, equipment and perforating guns in horizontal or highly deviated wells.
- 3.12 drop bar initiation:** An initiation system for tubing conveyed perforating systems utilizing a gravity drop bar to initiate a percussion detonator.
- 3.13 Electrically (Armed) before Ballistically Armed (EBBA):** The electrical attachment of an electro-explosive device to a source of electrical power, prior to the mechanical alignment of all the elements of an explosive train.

- 3.14 electric arming:** The electrical attachment of an electro-explosive device to a source of electrical power prior to energizing the circuit.
- 3.15 electric detonator:** A detonator designed to be initiated by electric current or a current pulse.
- 3.16 essential safety systems:** Those systems that are critical to maintaining a safe working environment, and for the safe completion of explosives operations.
- 3.17 exploding bridgewire detonator:** A detonator utilizing a bridgewire but requiring a high-voltage, high-current pulse to initiate the device. It contains no primary explosive.
- 3.18 exploding foil initiator:** A detonator utilizing a metallic foil, which when vaporized by a high-voltage pulse, drives a flyer plate into a secondary explosive pellet, initiating the explosive. It contains no primary explosive.
- 3.19 formation tester:** A tool run on wireline for the purpose of pressure measurement and the extraction and identification of formation fluid samples.
- 3.20 hydraulic/pressure actuated firing head:** An initiation system utilizing hydraulic or downhole pressure to initiate a tubing conveyed perforator string.
- 3.21 loaded explosive device:** A mechanical device to which the explosive components have been inserted or attached, with the exception of the initiating device (see **unarmed**). Sometimes used interchangeably with **charged explosive device**.
- 3.22 lockout:** A positive mechanical locking device usually by keyswitch to prevent the inadvertent energizing of equipment.
- 3.23 lubricator:** A device mounted on the wellhead used to introduce tool strings, chemicals, instruments and perforating guns into a well under pressure.
- 3.24 no-fire rating:** The maximum “no-fire” power level is the maximum DC or RF power at which a detonator will not fire with a probability of 0.999 at a confidence level of 95% as determined by test and computation.
- 3.25 misfire:** The failure of an **armed explosive device** to properly function, e.g., detonate, when subjected to the proper impulse for firing, either mechanically or electrically.
- 3.26 percussion detonator:** A detonator designed to be initiated by mechanical impact.
- 3.27 phase transition temperature:** The temperature at which the onset of a change in the crystal structure of a material takes place.
- 3.28 power safe device:** A device installed on a wireline tool string between the wireline and the detonator which permits downhole arming of the detonator.
- 3.29 primary explosive:** A very sensitive explosive compound used as the first material in an explosive train that is initiated by the appropriate application of flame, friction, heat, impact, or spark. Also referred to as **primary high explosive**.
- 3.30 regulations:** Any prescribed local, state, or Federal rule or ordinance pertaining to the subject at hand.
- 3.31 safety sub:** Used in tubing conveyed perforating gun strings, the safety sub is the very top section that does not contain shaped charge perforators. The purpose is to place the perforator-loaded guns below the rig floor when the firing head is installed to augment rig crew safety.
- 3.32 secondary explosive:** A high explosive that is less sensitive than a primary explosive to heat and shock. Also referred to as **secondary high explosive**.
- 3.33 select fire perforating gun system:** A method of sequentially firing a number of perforating guns in a gun string after relocation of the gun string to perforate a number of intervals in a single run.
- 3.34 setting tool:** An electro-explosive downhole tool that is mechanically actuated by the initiation and gas generation of a propellant charge.
- 3.35 sidewall sample taker:** A ballistic or mechanical tool used to extract and retrieve formation core samples from the sidewall of the wellbore.
- 3.36 single point safety switch:** A single keylock safety switch with a properly secured single key which isolates all power from the wireline prior to attachment of an explosive device.

**3.37 top drive:** A hydraulic or electric motor driving the rotary motion of the tool string from the swivel. used in place of a rotary table and kelly, and kelly bushing.

**3.38 unarmed:** A **loaded explosive device** (see definition above).

**3.39 wireline safety valve:** A downhole safety valve that can be set and retrieved by wireline or slickline.

## 4 Symbols and Abbreviated Terms

AC	Alternating Current
ANSI	American National Standards Institute
API	American Petroleum Institute
DC	Direct Current
CO <sub>2</sub>	Carbon Dioxide
EBBA	Electric before Ballistic Arming (see definition above)
EBW	Exploding Bridgewire Detonator, (see definition above)
EFI	Exploding Foil Initiator, (see definition above)
H <sub>2</sub> S	Hydrogen Sulphide
HMX	Octogen or Octohydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IEEE	Institute of Electrical and Electronics Engineers
IME	Institute of Makers of Explosives
RF	Radio Frequency
RP	Recommended Practice
TCP	Tubing Conveyed Perforating
V	Volts

## 5 Surface Equipment

### 5.1 INTRODUCTION

This section describes surface equipment recommended for use at the well site during operations involving explosive devices.

### 5.2 ELECTRICAL POWER

When using an electric wireline unit, there shall be a main power switch in the unit to control all power to the shooting system.

### 5.3 CABLE SAFETY SYSTEM

#### 5.3.1 Location

The cable safety circuit should be inside the electric wireline unit.

#### 5.3.2 Safe Mode

When in safe mode, the cable circuit shall open all cable connectors from the electric wireline unit circuits and all conductors shall be shunted to armor through a nominal resistance of 5,000 ohms. This resistance shall be provided by a minimum of two similar resistors in parallel with the net resistance being 5,000 ohms.

#### 5.3.3 Lockout

The safe mode shall be assured with a lockout feature.

#### 5.3.4 Electrical Continuity

Electrical continuity shall exist from the cable safety circuit to the cable conductor and the wiring providing this continuity shall have mechanical protection.

### 5.4 FIRING SYSTEM REQUIREMENTS

**5.4.1** At least three deliberate actions shall be required to fire the explosive device.

**5.4.2** At least one action shall require the use of two hands.

**5.4.3** At least one action shall involve a spring-loaded switch.

## **5.5 COMMUNICATION SYSTEM**

There shall be effective communications between the electric wireline unit and those areas where explosive devices are to be armed or disarmed.

## **5.6 INSPECTION AND MAINTENANCE**

Equipment shall be inspected and maintained by qualified personnel in accordance with the manufacturer's recommendations and specifications.

## **5.7 ELECTRICAL GROUNDING/BONDING SYSTEM**

A grounding system shall positively electrically bond the electric wireline unit to the casing/wellhead/blowout preventer and the rig (sheave support system).

### **5.7.1 Cable Construction**

Bonding cables shall consist of a stranded copper conductor, insulated with a wire size of at least No. 10.

### **5.7.2 Attachment**

**5.7.2.1** Bonding cables shall be attached to the rig and wellhead/casing using "C" clamps, firmly secured by a pin-type screw fitting with a sharpened point.

**5.7.2.2** A positive electrical bond shall be provided between the electric wireline unit and the cable armor.

## **5.8 ELECTRICAL DETONATOR SAFETY TUBE**

The electrical detonator safety tube shall be a heavy-walled tube with one end closed and a cover at the other end. Each tube design shall be shown to contain the fragments of the detonator in use and mitigate the blast.

## **5.9 ELECTRICAL DETONATOR CIRCUIT TESTING INSTRUMENTS**

The only instruments recommended for use when testing electrical detonators and detonator circuits are those specifically designed and/or qualified for checking explosives and explosives circuits. The test current from the meter used to perform resistance checks shall not exceed 25 milliamperes or 10% of the no-fire rating of the detonator in the circuit, whichever is less.

## **5.10 EXPLOSIVES WARNING SIGNS (LAND OPERATIONS)**

Explosives warning signs shall include the words "DANGER EXPLOSIVES," or equivalent. In operations involving electric detonators, warning signs should also include the words "TURN OFF RADIO TRANSMITTERS," or equivalent. The explosives warning signs should be durable and should be visible and legible from a distance of 50 ft (15 m). See 8.1.1 for additional information.

## **5.11 CHEMICAL CUTTER PROTECTIVE SLEEVE**

Chemical cutters shall have a sleeve (also known as a protective sleeve) that shall: cover the severing head; be made of aluminum; be of sufficient thickness to provide effective deflection; be open on both ends; have an inside diameter adequate to pass over the severing head; and have a means for positively securing to the severing head.

Note: Field modifications shall only be made to chemical cutter sleeves if written approval has been received from the equipment manufacturer.

## **5.12 PRESSURE TESTING OF SURFACE PRESSURE CONTROL EQUIPMENT**

### **5.12.1 General Practice**

Exposure to pressure can cause explosive charges and detonators to self-initiate. Therefore, it is important that explosive devices not be exposed to any greater pressure than is necessary for their deployment into the well. Once exposed to pressure the explosive device shall immediately be deployed into the well in order to minimize risk to personnel.

Well site pressure testing of pressure control equipment should be completed prior to inserting a loaded explosive device into the lubricator. Integrity of the surface pressure control equipment can be tested and maintained using a Quick Test Safety Sub or a Wireline Safety Valve. These devices enable re-testing of the broken connection after introduction of the explosive device without applying pressure to the device itself.

### 5.12.2 Pressure Equalization

When preparing to enter a well under pressure, the pressure control equipment should be loaded with a non-volatile liquid (typically, a 50/50 mix of glycol and water) prior to equalizing the lubricator pressure to well pressure. Pressure equalization should be accomplished using well pressure or an appropriate low-volume, high-pressure pump equipped with adequate over-pressure protection.

Note: Under no circumstances shall a loaded explosive device be placed in a situation where it could be exposed to a pressure greater than 80% of its rating while at surface.

### 5.12.3 Safety of Personnel

Only personnel essential to the operation shall be involved in the use of pressure control equipment. During well site pressure testing of pressure control equipment containing explosives, all personnel shall be located at least 75 ft (23 m) from the equipment under test.

## 6 Downhole Equipment

### 6.1 INTRODUCTION

This section describes recommended features and minimum requirements for downhole equipment to ensure personnel safety.

### 6.2 PRIMARY HIGH EXPLOSIVES

Primary high explosives are only permitted in electric and percussion detonators. Detonators or initiators shall not contain any exposed primary explosive.

### 6.3 DETONATORS AND INITIATING DEVICES

#### 6.3.1 Critical Features

Electric detonators and initiators shall incorporate at least one of the following features:

1. DC resistance of not less than 50 ohms and a “no-fire” current of not less than 200 milliamperes.
2. A high-voltage exploding bridge wire (EBW) design.
3. A high-voltage exploding foil initiator (EFI) design.
4. Features providing protection substantially equivalent to that afforded by the features described in items 2 and 3, and which have been validated by an independent, recognized testing agency.

*Special Provision:* Propellant activated sidewall sample takers, select fire, and bullet perforating gun designs do not lend themselves to the incorporation of initiators meeting the requirements of 6.3.1. These tools should have a minimum of 50 ohms resistance in the downhole firing circuit and either:

- a. A feature that prevents electrical connection to the initiating device prior to running in the hole
- b. A ballistic interrupter that can be deactivated after the cable head has been connected to the tool; or,
- c. Another equivalent safety contingency.

Operation of these devices should be determined to be safe through prior review by and agreement between the service company and operator.

#### 6.3.2 Pull Strength

Electric detonators and initiators shall be designed and manufactured to withstand at least 7 lb pull applied between the detonator body and the lead wires.

*CAUTION:* Do not field test this capability, since pulling wires from a detonator or initiator body could cause detonation.

#### 6.3.3 Electrostatic Resistance

Electric detonators and initiators used in the oilfield shall be capable of passing the shunt-to-shell and through-the-bridgewire electrostatic tests described in MIL-DTL-23659D, Paragraph 4.4.3.2[3].

### **6.3.4 Impact Resistance of Percussion Detonators**

Percussion style detonators and initiators that will not be exposed to well fluids or pressure shall be designed to withstand an impact of at least 2 ft-lb without functioning. Percussion style detonators and initiators that will be exposed to well fluids or pressure shall be designed to withstand an impact of at least 5 ft-lb without functioning.

### **6.3.5 Temperature and Pressure Rating**

Specifications for the temperature and pressure rating of detonators that will be exposed to the wellbore shall be based on tests that involve the simultaneous application of temperature and pressure.

## **6.4 DOWNHOLE FIRING SYSTEMS**

### **6.4.1 Capacitive Discharge Systems**

Capacitive discharge systems shall incorporate a permanent bleed-off resistor that should discharge the capacitor to below 50% of the minimum required firing voltage within 60 seconds.

### **6.4.2 Non-electric Downhole Firing Systems**

Non-electric downhole firing systems shall either:

1. Require at least two independent actions to function the detonator/initiator on or near surface,
2. Incorporate at least two independent safety features that prevent inadvertent functioning; or,
3. Have a combination of such actions and safety features.
4. Categories of acceptable actions and features are:
  - Mechanical designs that physically restrict or limit those actions required to cause functioning.
  - Mechanical designs that cause the detonation train to cease.
  - Pressure activation.

### **6.4.3 Drop Survival**

Downhole firing systems shall not function when dropped in a manner simulating accidental dropping of the explosive tool from a height of not less than 30 ft (9.1 m) in air onto a steel plate supported by concrete.

### **6.4.4 Electrical Connection**

Downhole firing systems that require an electrical connection to be made to the detonator while on or near the surface shall be designed such that the detonator can be armed electrically before being armed ballistically.

## **6.5 OTHER DOWNHOLE EQUIPMENT**

### **6.5.1 Downhole Power Source**

Any downhole power source must incorporate at least two independent safety features that prevent inadvertent functioning when used in combination with a detonator or initiator.

### **6.5.2 Trapped Pressure Relief**

Tools shall be designed such that, upon retrieval from the wellbore, internal trapped pressure can be safely bled down. All threaded connections shall incorporate a feature that allows trapped pressure to be vented.

## **6.6 SPECIAL PROVISIONS FOR SHALLOW OPERATIONS**

Certain operations may require explosive services at depths shallower than 200 ft (60 m). If well conditions permit the explosive device should be lowered to at least 200 ft (60 m) before restoring power and continuing with the operation. Shallow explosive operations may require extra safety precautions to protect against fluids being ejected from the well. Pack-offs may be used and personnel shall be cleared from the drill floor.

## **6.7 ELECTRIC DOWNHOLE TRACTORS**

A multi-point failure analysis shall be completed for any downhole tractor to be used with explosive devices. A downhole tractor may only be used if this analysis confirms that no single-point failure will cause or permit tractor voltage to be applied to the explosive device.

There shall be at least one independent electrical isolation device between the tractor and the explosive device, and the isolation device shall have a voltage rating greater than the potential output of the tractor. Each electrical isolation device design should be validated by an independent, recognized testing agency through a multi-point failure analysis.

Only high-voltage initiators such those described in 6.3.1 (list items 2 – 4) shall be used when conveying explosive devices on an electric downhole tractor.

## **7 Field Safety Procedures**

### **7.1 INTRODUCTION**

This section describes recommended procedures for the transportation of explosive devices and for their handling at the wellsite.

### **7.2 TRANSPORTATION OF EXPLOSIVES**

The conveyance of explosives to or from the well site, whether by roadway, air, or water, shall be in compliance with applicable regulations. Within the United States this shall include Title 49 *Code of Federal Regulations*<sup>4</sup> issued by the U.S. Department of Transportation.

### **7.3 ARRIVAL AT THE WELLSITE**

Upon arrival at the wellsite the service company shall designate an Explosive User in Charge. The Explosive User in Charge shall establish a safe, controlled working environment for explosives operations in consultation with the operator on location, tool-pusher, and any other personnel involved.

#### **7.3.1 Existing Wellsite Hazards**

Any well site conditions that might contribute to a safety hazard during the handling and operation of explosive devices should be identified and where necessary corrected. This should include consultation between the onsite operator, contractor, and service company representatives.

#### **7.3.2 Smoking Area/Open Flames**

Designated smoking areas and repositories for smoking materials shall be identified and enforced. Smoking shall only be permitted within these areas and smoking materials shall be confined to these areas at all times.

Neither open flames nor flame-producing devices shall be permitted within 50 ft (15 m) of any operation involving explosives, unless an appropriate radiant heat barrier has been installed. Local regulations shall be applied if they require the separation of flames from explosives operations to be greater than 50 ft (15 m).

#### **7.3.3 Explosives Packing and Identification**

Explosive materials arriving at the well site shall be properly packed and clearly labeled in accordance with applicable regulations (see 7.2).

#### **7.3.4 Temporary Explosives Storage**

Designated location(s)/facilities shall be established for the temporary storage of explosive materials, and used whenever such storage is required. These areas should be removed from any potential source of heat, impact/shock hazards, and living accommodation by the distance specified in applicable regulations or in the explosives manufacturing or service company guidelines, whichever is the greater.

#### **7.3.5 Designated Gun Loading Area and Explosive Device Assembly Area**

Designate a gun loading area (if required) and the location at which explosive devices will be assembled. This will not necessarily be where these devices are armed.

These areas shall be located at least 50 ft (15 m) from any source of heat, such as open flame or welding operations, unless an appropriate radiant heat barrier has been installed. Local regulations shall be applied if they require the separation of flames from explosives operations to be greater than 50 ft (15 m).



### 7.3.6 Storage of Charged Explosive Devices on Location

When not in use, charged perforating guns and sidewall sampling guns shall be stored in accordance with applicable regulations. Propellant activated sidewall sample takers, bullet perforating guns, and select fire guns that have been ballistically armed shall not be placed on the catwalk or in any other area where logging tools may be powered up.

### 7.3.7 Safety Meeting

The Explosive User in Charge shall conduct one or more safety meeting(s) with the explosive service crew, the wellsite personnel, and supervisory staff. The purpose is to inform all personnel about the explosive operations to be performed, potential hazards, and the responsibilities of each individual.

Topics to be covered during the safety meeting(s) may include:

- General safety and potential hazards at the wellsite.
- Activities with elevated risk.
- Pressure, H<sub>2</sub>S, and/or CO<sub>2</sub> concerns.
- Designated gathering areas in the event of an emergency.
- Designated smoking areas.
- Designated areas for gun loading, assembly and explosives storage.
- Labels and warning signs associated with the explosive materials and devices that will be used.
- The proximity of any Radio Frequency antennas (such as mobile phones, two-way radios, and pagers) and any requirement for them to be shut down.
- Individual responsibilities and the processes that will be followed when arming explosives devices and when opening the well.

Safety meeting(s) shall also be conducted whenever wellsite personnel change, or when there is a significant change in plan, such as in the event of a mis-run.

## 7.4 LOADING OR UNLOADING OF EXPLOSIVE DEVICES AT THE WELLSITE

### 7.4.1 Designated Area

Explosive devices shall only be loaded or unloaded within the area designated in 7.3.5.

### 7.4.2 Warning Signs

Signs reading "DANGER EXPLOSIVES," or equivalent, shall be prominently displayed at the immediate loading/unloading site (see 8.1.1 and 5.10)

### 7.4.3 Personnel

Only personnel authorized by the Explosive User in Charge may be present in the loading/unloading area at any time during such operations.

### 7.4.4 Explosives Handling

**7.4.4.1** Neither detonators nor initiating devices shall be permitted within the loading area during the loading process, except when approved by the Explosive User in Charge.

**7.4.4.2** Explosives shall only be removed from their packaging within the loading area, using tools recommended by the manufacturer. Only the quantity of explosives required for the immediate loading operation shall be unpacked. Unpackaged explosives shall not be permitted to accumulate.

**7.4.4.3** Only approved loading tools, approved detonating cord severing devices, and techniques recommended by the explosive manufacturer, or authorized by the service company, shall be used.

**7.4.4.4** Attention shall be paid to proper fit during the handling and assembly of explosive devices. Parts should not be forced. Avoid impacts, pinching, crushing, and generating sparks from any source.

**7.4.4.5** A handling cap, plug, or other closure device shall be installed in both ends of loaded hollow carrier type guns at all times during handling and storage. The closure device must include a feature to relieve pressure from within the gun in case of excess heat or fire. Guns or explosive devices with exposed detonating components (such as expendable or strip guns) must be appropriately protected from damage.

**7.4.4.6** As soon as loading operations are completed, loose, remnant, or unused explosives shall be repackaged in compliance with 7.2 for shipment from the well site.

**7.4.4.7** Loaded explosive devices shall be staged in a designated area (see 7.3.6)

### **7.4.5 Housekeeping**

The loading area shall be cleaned up as soon as loading or unloading operations are completed. Separate containers shall be used for ordinary trash and explosive remnants. All explosive materials must be removed from the well site, as well as any explosive packaging materials. These materials should be disposed of properly and *must not be mixed with ordinary trash*.

**7.4.5.1** All residual explosives such as pieces of detonating cord, defective charges, or misfired detonators shall be located and packaged in proper shipping containers for transportation from the well site (see 7.2).

**7.4.5.2** All trash and debris associated with the operation, including empty explosive containers, packaging, spent gun tubes etc., shall be organized and appropriately packaged for transportation from the well site and proper disposal.

**7.4.5.3** Federal, state, and local regulations should be checked to determine applicable requirements for the disposal of explosive materials, explosives packaging materials, and associated debris.

## **8 Electric Line Conveyed Operations**

### **8.1 WELL SITE PREPARATION**

#### **8.1.1 Land Operations**

Warning signs reading “DANGER—EXPLOSIVES—TURN OFF RADIO TRANSMITTERS,” or equivalent, shall be prominently displayed at the site and at all entrances.

When initiating devices are to be used that have been established as insensitive to potentials from electromagnetic fields created by RF transmitters (such as those described in 6.3.1, list items 2 – 4), and where permitted by local law, the section reading “TURN OFF RADIO TRANSMITTERS” may be removed or covered.

Note: All signs shall comply with local regulations, which in the USA shall mean the U.S. Department of Transportation, Federal Highway Administration’s “Manual on Uniform Traffic Control Devices,” Chapter 6F, Sections 6F.38 through 6F.41. This regulation requires warning signs in the USA to include the text “TURN OFF RADIO TRANSMITTERS,” or equivalent, whenever the operation is to be conducted within 1000 ft of the nearest public highway, irrespective of the initiating device to be used.

#### **8.1.2 Offshore Operations**

Warning procedures similar to those specified in HSAC-RP 92-2 *Perforating Operations—Helideck/Heliport Operational Hazard Warnings/Procedures*<sup>5</sup> should be prominently displayed in any restricted area where helicopter operations are anticipated.

#### **8.1.3 Eliminate Sources of Stray Electrical Energy**

**8.1.3.1** Turn off electrical cathodic protection systems unless the manufacturer of the electric detonator or initiator specifies that disabling such systems is unnecessary.

**8.1.3.2** Discontinue all electric welding operations unless the manufacturer of the electric detonator or initiator specifies that stopping such activities is unnecessary.

**8.1.3.3** Precautions shall be exercised to prevent radio frequency radiation hazards. Warning signs shall be posted and other appropriate measures taken so that radio and radar frequency units will be shut off when within hazardous distances of explosive operations.

See the latest edition of IME Safety Publication No. 20 *Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps)*<sup>6</sup>, and ANSI/IEEE C95.4-2002 *Recommended Practice for Determining Safe Distances from Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations*<sup>7</sup> for recommended distances for posting signs and shutting off radio, radar, cellular telephone, and pager radio frequency transmitting units.

**8.1.3.4** Check for stray voltage between the wellhead and rig, wellhead and perforating unit, wellhead and generator skid, wellhead and rig auxiliary power source, and wellhead and barge (if applicable). If stray voltage is measured, attempt to eliminate it at its source.

**8.1.3.5** Only after stray voltage has been eliminated or reduced to not more than 0.25 volts, the perforating unit, rig, and well-head shall be connected together electrically with grounding/bonding cables (see 5.7).

Note: Stray voltages shall always be resolved prior to arming any explosives device.

**8.1.3.6** Remove or de-energize for the duration of the operation any electrical wiring that might contact the electric wireline unit, cable, or explosive device. Top drive systems should be electrically isolated in accordance with the manufacturer's procedures.

**8.1.3.7** The discharge of a static charge has been suspected in a number of incidents involving the inadvertent initiation of a detonator or initiating device. Proper grounding methods must be employed to minimize the risk of electrostatic discharge, prior to handling explosive devices, explosive charges, propellants or propellant devices.

*Exception:* Compliance with 8.1.3.1, 8.1.3.2, and 8.1.3.3 is unnecessary when using initiating devices defined in 6.3.1, list items 2 – 4 (EBW, EFI or equivalent), and the stray voltage limit in 8.1.3.5 may be increased to 5 volts (AC and DC).

## **8.2 PRE-CHECKS**

### **8.2.1 Cable Conductor Continuity**

Proper insulation and continuity of cable conductors shall be verified prior to arming the explosive device.

### **8.2.2 Gun Circuits**

Only those circuit testing instruments specified in 5.9, shall be used when checking continuity or insulation of a gun circuit.

### **8.2.3 Detonators**

Detonators and other initiation devices shall be contained within a safety tube during checking operations (see 5.8).

### **8.2.4 Checks Using Unit Power (Check Fire or Hot Check)**

When unit power is to be used to test cable head or accessory equipment, the equipment to be tested shall be in clear view of the person applying the power. Power shall not be applied while any explosive device is being armed, nor shall it be applied to a gun or explosive device at any time while it is at surface.

## **8.3 PREPARATION FOR EXPLOSIVE DEVICE ATTACHMENT**

### **8.3.1 Isolate the Cable Circuit**

The cable circuit shall be disconnected from unit instrumentation with a positive disconnect. A Single Point Safety Switch with key lockout is the preferred method for achieving this disconnect.

### **8.3.2 Remove Instrument Panel Power**

Turn off all instrument power switches.

Note: Safety equipment such as unit pressurization, low pressurization warning, wellhead potential monitor, H<sub>2</sub>S warning, weight indicator, etc. may remain switched on if they operate on a separate circuit.

### **8.3.3 Isolate Unit Power Source**

Turn off all the main circuit breaker(s) in the unit except for those required for essential safety systems (see 5.2).

### **8.3.4 Activate Current/Voltage Limiting Circuits**

All electrical cable conductors shall be grounded to the unit ground through a nominal resistance of 5,000 ohms (see 5.3.2). This should preferably be accomplished using a Single Point Safety Switch.

### **8.3.5 Lock Circuits in Safe Mode**

After placing the cable circuit in safe mode (see 8.3.1 and 8.3.4), the key to the lockout device shall be removed and shall remain outside the electric wireline unit until the explosive device has been introduced into the well to a minimum depth of 200 ft (60 m) below ground level or below sea floor.

## **8.4 ARMING THE EXPLOSIVE DEVICE**

*CAUTION:* The arming and/or handling of explosives should not be attempted on the approach of, or during, an electrical storm. Electrical storm activity can occur during rain or snowstorms and, more rarely, during dust and sand storms. Arming should not

be performed during the arrival of helicopters or boats at an offshore location. Arming should not be commenced if such circumstances are expected to arise before the arming operation can be completed and the gun introduced into the well to a minimum depth of 200 ft (60 m) below ground level or below the sea floor.

#### **8.4.1 Responsibility**

The designated Explosive User in Charge or his qualified designee (see 11.2.2 and 11.3.2) shall perform all explosive device arming operations.

#### **8.4.2 Stray Voltage Check**

Verify that the voltage between the wellhead and rig, unit, generator skid and barge (where applicable) does not exceed the limit specified in 8.1.3.5. Do not proceed with arming operations until the measured voltage meets the specified criteria.

#### **8.4.3 Personnel**

Relocate all personnel unnecessary to the operation to a safe area. Ensure all personnel are clear of the line of fire of the explosive device.

#### **8.4.4 Verify Lockout**

Confirm that the key to the cable circuit lockout device remains outside the electric wireline unit.

#### **8.4.5 Arm the Explosive Device**

**8.4.5.1** Connect the cable head and any accessory equipment to the *unarmed* firing subassembly to complete the electric circuit from the wireline unit to the point where the detonator will be attached.

**8.4.5.2** Remove the detonator from its storage container and verify that it is shunted.

**8.4.5.3** Insert the detonator into the detonator safety tube and convey to the arming area.

**8.4.5.4** If the detonator is to be checked, such checks shall only be made while the detonator is contained within the safety tube (see 5.8 and 8.2.3)

**8.4.5.5** Verify that no voltage exists between the points where the detonator is to be attached.

**8.4.5.6** With the detonator still in the safety tube, connect the detonator lead wires to the electric line circuit. The ground connector should be connected first.

**8.4.5.7** Remove the detonator from the safety tube and connect it to the detonating cord or device to be fired.

**8.4.5.8** Complete assembly of the device, taking care not to pinch, crush or impact the explosive components or wiring.

### **8.5 DEPLOYING THE EXPLOSIVE DEVICE**

#### **8.5.1 Restoring Power (Exiting Safe Mode)**

When the explosive device has been deployed to a depth of not less than 200 ft (60 m) below ground level or below the sea floor, the cable safety circuit may be taken out of safe mode.

*Exception:* When operating offshore in deep water, power may be restored at 200 ft (60 m) below sea level, rather than below the sea floor/mudline, provided the consequences of an unintended detonation at that depth have been properly investigated on a case-by-case basis and shown to present an acceptable level of risk, and that such practice has been reviewed and agreed between the service company and the operator.

#### **8.5.2 Deployment to Depth**

The explosive device should be run to depth without undue delay but at a descent rate not exceeding any limits recommended by the manufacturer. Depth control procedures should then be completed and the device positioned ready for initiation.

#### **8.5.3 Initiating the Explosive Device**

Prior to commencing the initiation sequence, the Explosive User in Charge shall verify with the operator that conditions are acceptable for commencing the firing sequence.