

Code of practice for the safe use of explosives in the construction industry

ICS 71.100.30; 91.200

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents



Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/513, Construction equipment and plant, and site safety, to Subcommittee B/513/3, Safe use of explosives, upon which the following bodies were represented:

- British Tunnelling Society
- Construction Health and Safety Group
- Construction Industry Training Board
- Health and Safety Executive
- Imperial Chemical Industries Limited
- Institute of Explosives Engineers
- Institution of Chemical Engineers
- Institution of Structural Engineers
- Ministry of Defence
- National Federation of Demolition Contractors

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 December 1998

© BSI 1998

Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference B/513/3
Draft for comment 97/106293 DC

ISBN 0 580 28244 9

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 General recommendations	3
5 Tunnelling and shaft sinking	20
6 Demolition	26
7 Underwater blasting	29
8 Land excavation	34
9 Other forms of blasting	38
10 Cartridge operated fixing tools	38
Annex A (informative) Shotfiring training	39
Annex B (informative) List of legislation	40
Annex C (informative) Summary of the Construction (Design and Management) (CDM) Regulations 1994	43
Annex D (informative) Explosives engineering training	45
Annex E (informative) General properties of explosives	45
Annex F (informative) Competent engineer in charge of demolition work	45
Table 1 — Storage of explosives	7
Table 2 — Recommended minimum distances from underwater blasting operations	31
Figure 1 — Procedure to remedy misfires	16
Figure 2 — Exclusion zones for shaft sinking and tunnelling	21
Figure 3 — Relationship of blast area and exclusion zones in underwater blasting	31
Figure 4 — Exclusion zone for land excavation	36
Bibliography	46

Foreword

This revision of BS 5607 has been prepared by Subcommittee B/513/3 and supersedes BS 5607:1988, which is withdrawn.

This code of practice aims to define good practice in the handling, transport and storage of explosives during the varied uses to which explosives may be put by the construction industry. Emphasis throughout the code has been placed on safety, particularly the safety of those engaged in using explosives for work on site and the safety of others who may be in the vicinity of that work.

Clause 4 contains general recommendations and information on legislative requirements relating to most uses to which explosives are put in the construction industry. Clauses 5 to 10 address major specialist uses and are where particular general recommendations are extended and specific recommendations added.

The importance of security is recognized but this standard is not intended to address detailed security measures.

This code of practice also lists the legislative requirements at present in force concerning explosives. These should be closely studied and carefully followed.

All legislative requirements relating to explosives in Great Britain form “relevant statutory provisions” as defined in the Health and Safety at Work etc. Act 1974. The advice on legal requirements given in this code relates to the law at the date of publication of this code.

In this revision of the 1988 edition, changes have been made to take account of the following principal factors:

Legislation and the management of safety

Industry has developed new philosophies on the management of safety and this has been reinforced by the Construction (Design and Management) (CDM) Regulations. There has also been a total re-appraisal of the acquisition, storage, transport and use of explosives and accessories due to the re-writing of the 1875 Explosives Act and the harmonization with European Standards. Additionally the standard has taken account of other parallel legislation such as “The Explosives in Quarries Regulations”.

Changes in technology

Since BS 5607:1988 was issued there have been significant changes in the types of explosives and initiation systems in general use and a greater awareness and sophistication has developed at the user end.

Training

There is now a recommendation for training leading to competency in the use of explosives and for management at all levels to achieve a successful outcome.

The text of the standard has been restructured to take into account the above factors with particular emphasis on training and course syllabi.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

It is the responsibility of contracting parties to invoke standards in such a way that their provisions can be enforced between them.

The use of explosives in civil engineering projects differs in some respects to other explosives use, for example, quarrying and mining, where specific regulations apply.

It is assumed that the execution of the procedures recommended in this British Standard is entrusted to appropriately qualified and competent people.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 46, an inside back cover and a back cover.

1 Scope

This British Standard gives recommendations for the safe storage, handling, transport and use of blasting explosives and accessories in construction and demolition operations.

Clause 4 covers general recommendations for handling and safety. Subsequent clauses are concerned with safety in the use of explosives in special applications and situations such as tunnelling, demolition, excavation and underwater working.

This standard does not apply to blasting on offshore oil and/or gas platforms or structures or any associated works.

2 Normative references

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

BS 4078-1, *Powder actuated fixing systems — Code of practice for safe use.*

BS 5930, *Code of practice for site investigations.*

BS 6031, *Code of practice for earthworks.*

BS 6164, *Code of practice for safety in tunnelling in the construction industry.*

BS 6187, *Code of practice for demolition.*

BS 6472, *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz).*

BS 6657, *Guide to prevention of inadvertent initiation of electro-explosive devices by radio-frequency radiation.*

BS 7385-1, *Evaluation and measurement for vibration in buildings — Guide for measurement of vibrations and evaluation of their effects on buildings.*

BS 7385-2, *Evaluation and measurement for vibration in buildings — Guide to damage levels from groundborne vibration.*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1

air blast

production of air over-pressure caused by an explosion

3.2

ANFO

mixture of ammonium nitrate and fuel oil that can be used as an explosive

NOTE The preparation of ANFO outside a licensed explosives factory is required to conform to the Health and Safety Executive licence granted under the provisions of the Ammonium Nitrate (mixtures) Exemption Order, 1967 [1].

3.3

approved

authorized for use by an authority having jurisdiction

3.4

authorized explosive

explosive that is available legally in the United Kingdom

NOTE Such explosives are listed annually by the statutory authority of central government.

3.5

blackpowder

gunpowder used in blasting

3.6

blast area

area within which all the debris from the blast is calculated to fall and come to rest

3.7

blast plan

charging plan and, where applicable, the drilling pattern

3.8

bulk explosives

explosives that fill the complete cross-section of a shot hole to provide 100 % coupling with the substrate

3.9

burden

shortest distance between explosives and any free face

3.10

canister

portable container specifically intended and designed to carry a small quantity of explosives or accessories

3.11

cap (deprecated)

American synonym for detonator

3.12

capped fuse

length of safety fuse fitted with a plain detonator

3.13

cartridge

wrapped or otherwise protected cylinder of defined size of a homogeneous explosive material

3.14

competent person

a person who, by reason of theoretical and practical training or actual experience or both, is competent to perform the task or function or assume the responsibility in question and is authorized to perform such task or function



3.15

deflagrating compounds

materials which enable the subsonic propagation of a reaction front

3.16

delay detonator

detonator with a predetermined delay between initiation and detonation

3.17

detonating cord

flexible cord of spun textile fibres containing an explosive, and with a plastics coating, which, when initiated, propagates a detonation along its length

NOTE There is a significant explosive effect outside the cord as the detonation propagates (see also 3.43).

3.18

detonating relay

device for inserting into a detonating cord to produce a predetermined delay in the transmission of a detonation wave

3.19

detonator

initiator for explosives materials that contains a charge of high explosive fired by means of a flame, spark, electric current or shock tube

3.20

emulsion explosive

waterproof explosive that contains sensitizers, oxidizers and fuels dispersed as an emulsion

3.21

exclusion zone

zone from which all site personnel and the public are excluded

NOTE In certain situations the shotfirer may be positioned within the exclusion zone provided that they are protected.

3.22

exploder

device designed for firing detonators

3.23

explosive

article, substance or mixture of substances that is manufactured to produce a practical effect by explosion

3.24

explosives store

building or structure for the storage of up to 1 800 kg of explosive and licensed by a local authority

3.25

fly

projected material beyond the exclusion zone

3.26

fume characteristics

nature of fumes produced by the detonation of an explosive, particularly as regards the noxious gases contained therein

3.27

fuse-lighter

device designed for igniting safety fuse and igniter cord

3.28

high explosive

explosive that detonates and produces an intense shock wave

3.29

igniter cord

flexible cord with core of incendiary composition used mainly to ignite individual safety fuses when groups of shots are being fired in a sequence

NOTE An intense side flame is emitted when burning.

3.30

low explosive

explosive that produces large volumes of gases without creating an intense shock wave

3.31

magazine

building or structure used for the storage of explosive and licensed by the Health and Safety Executive for this purpose

3.32

Misfires

3.32.1

type A misfire

misfire in which testing before firing a shot reveals broken continuity which cannot be rectified

3.32.2

type B misfire

misfire in which any shot fails to explode when an attempt is made to fire it

3.33

Permitted explosives and detonators

3.33.1

permitted explosives

explosives of a type approved by the Health and Safety Executive for use in safety lamp mines (in compliance with regulation 5:1 of the Coal and Other Safety-Lamp Mines (Explosives) Regulations 1993 [2])

3.33.2

permitted detonators

detonators of a type approved by the Health and Safety Executive for use in safety lamp mines (in compliance with regulation 5:1 of the Coal and Other Safety-Lamp Mines (Explosives) Regulations 1993 [2])

3.34**pre-splitting**

blasting technique to prevent overbreak by creating a fracture plane on the perimeter of an excavation using shot holes which are fired simultaneously before the main shot holes and which are lightly charged and closely spaced

3.35**primary blasting**

blasting by which material is dislodged from its original location

3.36**primer**

cartridge or container of explosive into which one or more detonators or detonating cord is inserted or attached, in order to initiate or boost a larger charge

3.37**registered premises**

premises registered with the local authority and used for the keeping of small quantities of explosives

3.38**round**

group of shots fired in one operation

3.39**safety fuse**

flexible cord that contains an internal burning medium by which fire is conveyed at a continuous and uniform rate for the purpose of firing plain detonators or blackpowder, without initiating burning in a similar fuse that may be in lateral contact alongside

3.40**secondary blasting**

blasting to reduce oversize material to the dimensions required

3.41**sensitivity**

measure of ease with which a substance or article can be made to explode, or its liability to explode, when subjected to deliberate or accidental shock, friction or heat

3.42**shaped charge**

explosive device designed to concentrate the explosive force in a particular direction

NOTE A shaped charge is sometimes known as a cavity or hollow charge.

3.43**shock tube**

flexible tube coated on the inside with a reactive composition that, when initiated, propagates a shock wave along its length and initiates a detonator

3.44**shotfirer**

appointed person in immediate control of the use of explosives

NOTE See annex A.

3.45**smooth blasting**

blasting technique to minimize overbreak in which a number of shot holes, lightly charged and closely spaced, are positioned on the perimeter of an excavation and fired simultaneously after the main blast but in the same round

3.46**Signals****3.46.1****warning signals**

predetermined visual and/or audible signals prior to the initiation of an explosion

3.46.2**all clear signals**

predetermined visual and/or audible signals given after an explosion after checking that there have been no misfires and the area is safe to enter

3.47**slurry explosive**

waterproof explosive which contains sensitizers, oxidizers and fuels dispersed in a gel

3.48**stemming**

inert incombustible material used to confine explosives in a shot hole

4 General recommendations**4.1 Preliminary procedures****4.1.1 General**

All uses of explosives should be preceded by consideration of the following:

- is the proposed procedure within the law (4.1.2)?;
- is it safe or does it put people at risk (4.1.3)?;
- who has responsibility and supervisory control of the operation (4.1.4) and for completion of the method statement (4.1.5)?

It may be decided that the use of explosives is inappropriate and an alternative approach is required.

To complete the preliminary procedures, site survey(s), blast design and development of the method statement (4.1.5) should be carried out.

4.1.2 Legislation

4.1.2.1 General

Legislation relating specifically to explosives and which may be referred to is listed in **B.1**.

Legislation relating to work on construction sites and which may be referred to is listed in **B.2**.

NOTE The lists are not exhaustive and all legislation is subject to review and amendment.

4.1.2.2 Construction, Design and Management Regulations

Although the Construction, Design and Management (CDM) Regulations [3] apply to most explosives work within the construction industry, their principles should be adopted for all explosives work (see annex C).

4.1.2.3 Local authority powers of control

Certain local authorities have special powers of control granted under local act of parliament; permission may be required before blasting can take place.

4.1.2.4 Other regulations

Special regulations may apply in Scotland, Northern Ireland, the Channel Islands, Isle of Man and the Scilly Isles, and should be checked prior to operations in these areas.

4.1.3 Risk assessment

4.1.3.1 General

The Management of Health and Safety at Work Regulations, 1992 [4] require, under Regulation 3, that an assessment of risks is carried out before commencing any operations. This risk assessment should:

- identify the significant risks arising out of the work;
- enable identification and prioritization of the measures that need to be taken to comply with the relevant statutory provisions;
- be appropriate to the nature of the work and be such that it remains valid for a reasonable period of time.

This assessment should include and take cognizance of the general considerations of **4.1.3.2** to **4.1.3.14**, but should not be limited by them.

4.1.3.2 Survey

4.1.3.2.1 General

Before any works involving the use of explosives are started, a detailed survey and examination of the site, buildings or structures and adjoining areas and property should be made. Procedures for the survey of sites are set out in BS 5930. When earthworks, tunnelling or demolition are involved, reference should be made to BS 6031, BS 6164 and BS 6187 respectively.

4.1.3.2.2 Geological structure

Attention should be given to the character and structure of the geological strata present on site and how they will react to blasting. Additionally, the interaction of the geological structure with excavations or cuttings should be considered and the stability and safety assessed. Due care should also be taken to avoid disruptions or damage to underground features such as wells, tunnels, storage tanks, mine workings and other underground voids.

4.1.3.3 Utilities

Special consideration should be given to the proximity of underground and overground services before blasting operations are carried out. Consultations should be carried out with the necessary bodies who are responsible for existing underground utilities.

4.1.3.4 Ground/airborne vibrations

Many excavation operations in construction have to be carried out in the proximity of existing buildings or existing and new structures such as bridges, retaining walls and underground services. Additionally, where the public are involved, their sensitivity to ground-borne vibration from blasting and their concerns in respect of potential damage to their property dictates that a great deal of attention should be paid to this aspect of the blasting operation.

Although no statute exists, a contractual limit may be specified or the relevant British Standards which address damage levels from vibration and human exposure levels to vibration should be consulted (BS 7385-1, BS 7385-2 and BS 6472 respectively). In situations where ground or airborne vibrations may constitute either a nuisance or a potential damage risk, structural surveys pre- and post-blasting, together with consultations with owners or occupiers of the buildings/structures concerned, should be undertaken.

Initial trial blasting may be carried out with small isolated charges to allow the transmission properties of the ground in that particular location to be characterized; vibration effects from production blasting operations can then be calculated with a degree of confidence.

Human beings are very sensitive to vibration and can perceive vibration levels of a very low order. This can readily lead to complaints during production blasting operations, therefore effective consultation and communication with owners and occupiers should take place, and vibration levels should be controlled by proper blast design.

4.1.3.5 Hazards from electrical sources

Attention should be paid to the presence of power cables and radar, radio and television transmitting stations near intended blasting operations, since under special conditions these can cause premature firing of electric detonators (see BS 6657). On-site use of citizen's band radios, site radio transmitters and mobile telephones should be strictly controlled during blasting operations.

Premature initiation may also result from electrical discharges, for example, direct lightning strikes or from resulting stray currents of sufficient magnitude.

No presently available initiation system offers complete protection against direct lightning strikes, therefore if a lightning storm approaches a blast site charging should cease and the blast area be vacated of all personnel. If stray currents from any sources are apparent, initiation systems offering protection against them should be employed, for example, shock tube detonators or transformer coupled detonators.

Extreme caution should be exercised when using electric detonators adjacent to public highways as illegal over-powered transmitters could be carried on vehicles passing close to the area of blasting. Consideration should also be given to the use of non-electric detonating systems or electric systems incorporating additional safeguards, for example, high firing current fuseheads or transformer coupled circuits. **WHERE ANY POSSIBLE DOUBT REMAINS NON-ELECTRICAL MEANS OF FIRING SHOULD BE ADOPTED.**

4.1.3.6 Flammable or explosive substances

Expert advice or help should always be obtained where the following sources of danger are found or could be expected:

- a) flammable or toxic gases, liquids or dusts;
- b) unexploded missiles or mines;
- c) waste explosive.

NOTE In existing industrial plants or areas, the appropriate managements should be consulted.

4.1.3.7 Exclusion zone

The risk to third parties not directly involved in the blasting operation should be assessed and an exclusion zone established which ensures that the risk of injury to all personnel is prevented. Under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) [5], the projection of material beyond the limit of exclusion is a reportable incident.

The shotfirer, who will always be positioned outside the blast zone but may be within the exclusion zone, should be protected by a blast shelter.

4.1.3.8 Blast warning procedures

Before any blasting commences on the construction site a suitable system of signs, signals and sentries should be established which uses both audible and visual signalling systems to give warning of blasting operations. It is essential that these signs and signals may be clearly seen and heard by site personnel working within the site areas, and also by others who may be affected, including the general public.

4.1.3.9 Audible warning systems

Audible warning systems should be used to signify to all persons that they withdraw from the exclusion zone. The warning should comprise a series of readily recognizable and identifiably different signals such as may be given by a hooter or whistle with a distinctive tone. A typical example may be:

- a) five 5 s hoots at 5 s intervals made 5 min to 10 min before blasting, at which time sentries should go to their designated locations; followed by
- b) a continuous hoot when blasting is imminent.

Before the blast is fired the blast and exclusion zones should be physically cleared by the shotfirer, perhaps in conjunction with site personnel and police in the case of major blasting operations where there are large blast and exclusion zones.

Immediately before firing it is essential that the shotfirer makes contact with all sentries and supervisors of shelters where personnel are taking cover to ensure that all personnel are accounted for and that no-one has entered the exclusion zone.

Only after this process has been completed should the blast be fired.

The "all clear", which may be six to ten short, sharp hoots should be sounded after the shotfirer has checked that there have been no misfires and that the area is safe to enter.

No persons should return to any location within the exclusion zone until the "all clear" signal has been given.

The actual code of signals may be varied from the above to suit site conditions, but once established for a particular site, it is essential that they are not altered without good reason and adequate communication to all personnel.

4.1.3.10 Visual warning systems

Visual signs should comprise large clear notices in accordance with the Health and Safety (Safety Signs and Signals) Regulations [6], posted on all access roads to the site and located safely outside the exclusion zone. At blasting times the accesses should have sentries posted, with clear instructions as to when they have to stop access to the site, and when they can allow access. Where public roads pass close to the site there may be danger to traffic from projected material. The assistance of the police should be obtained in controlling traffic.

Where sentries are not in visual contact with the shotfirer a suitable means of communication should be introduced to stop blasting if anyone enters the exclusion zone. This may be by radio communication using hand-held radios provided that they are not taken within 10 m of a circuit containing standard electric detonators and are switched off at the firing point or preferably not taken within 5 m of the firing point.

Special sentries should be appointed to warn personnel who might fail to hear warning signals because of noisy machinery or other diversions during blasting.

In situations where control of public access to the site is difficult, it is important that the use of additional visual signals, such as a red flag or flags which are commonly indicative of danger should be considered. When blasting is in progress these should be displayed in prominent positions, e.g. on a tower, flag pole or high fence so as to be generally visible over a wide area.

Where control of site personnel is awkward because of the presence of different contractors and progression of different jobs on the site, special shelters with sentries should be appointed. Each sentry should check that all working groups and individuals under their control have retired to shelter during the blasting period.

4.1.3.11 *Advanced warning*

Advanced warning of the programme of blasting should be given to the owners or occupiers of any premises which are likely to be affected by the blasting events.

4.1.3.12 *Smoking and fires*

Smoking, fires, use of flame or heat producing equipment such as welding or cutting torches, or equipment which could cause or produce sparks should not be allowed near stored explosives or any place where explosives are being handled, transported or used.

Precautions should be taken when using explosives in the presence of waste paper, dry timber and vegetation, especially after a hot dry spell of weather which might produce unusual hazards. If an occasion arises where there is a need to burn rubbish on site, this should be done either before explosives are brought on site or after their removal. If explosives are already present on site, predetermined procedures should be followed to ensure that the fire produces no hazard. Any such fires should be closely contained and well supervised. Fire fighting procedures should be established.

4.1.3.13 *Advance notices and consultation*

Prior to carrying out the works, consultation should take place with the relevant authorities and advance notification given, where applicable, to:

- police;
- statutory authorities;
- local authority;
- building control;
- Health and Safety Executive;
- local residents;
- highways and roads authorities;
- fire authority;
- other interested or affected parties.

4.1.3.14 *Security and transport of explosives*

The acquisition of explosives is governed by legislation. The Control of Explosives Regulations 1991 [7] require that those purchasing and/or using explosives should obtain a certificate to either acquire or acquire and keep explosives; the certificate being issued by the local police authority.

The keeping of explosives, or their storage is also covered by these Regulations (see Table 1).

The following Regulations should be read and understood and advice obtained as required. Transfer of explosives is covered by The Control of Explosives Regulations 1991 [7] in terms of the requirements to record transactions, and possession of a Recipient Competent Authority (RCA) document is required under The Placing on the Market and Supervision of Transfers of Explosives Regulations [8]. However, any physical transport of explosives is required to conform to the relevant regulations covering packaging and transport i.e. The Packaging of Explosives for Carriage Regulations 1991 [9], The Carriage of Explosives by Road Regulations 1996 [10] and The Carriage of Dangerous Goods by Road (Driver Training) Regulations 1996 [11].

Movement of explosives within the site should be in sealed manufacturers' cases or containers and in vehicles clearly displaying that they are carrying explosives. Detonators should always be transported in a separate sealed and secured container designed for the purpose. Movement of explosives or detonators should always be under the direct control of an authorized person (see 4.1.4.1).

Damaged or contaminated explosives should be handled with extreme care and disposed of in a safe manner on site if at all possible. If they are to be returned to a secure store it is essential that they be securely packed and labelled in accordance with the relevant regulations and with advice taken from the manufacturer.

Table 1 — Storage of explosives

Maximum quantity allowed kg	Method	Authority
5	Police Private Use Certificate	Under local authority control
7	Mode B Registered Premises	
30	Mode A Registered Premises	
75	Division A Licensed Store	
150	Division B Licensed Store	
450	Division C Licensed Store	
900	Division D Licensed Store	
1800	Division E Licensed Store	
Unlimited (by licence)	Magazine	Under HSE control
NOTE This table is a simplification of the requirement for bulk explosives and detonators but is not applicable to fireworks, gunpowder or ammunition.		

NOTE 1 An “acquire and keep” certificate is required for all the stored quantities of explosives given here.

NOTE 2 The storage of quantities of explosive in excess of 1 800 kg is covered by Home Office Regulations and can only be approved and a licence issued by the Health and Safety Executive, Explosives Inspectorate.

NOTE 3 Storage of quantities of less than 1 800 kg is covered by local authority certificates which are issued in consultation with the relevant local police authority. Construction and security requirements for these explosive stores are set out in updated Guidelines issued by the Health and Safety Executive under the Explosives Act 1875 [12].

4.1.4 Supervision and responsibility

4.1.4.1 When blasting operations are to take place or are taking place on a construction site, it is essential that they should be under the control of a person competent in explosives engineering and/or shotfiring. These competent persons should be responsible for the acquisition, storage, handling, transport and use of all explosives, detonators and accessories, and should be given a clear statement in writing of their duties and jurisdiction. Other persons who are to assist them in the performance of their duties in connection with the use of explosives should also be authorized in writing.

4.1.4.2 No person other than those designated in **4.1.4.1** should be in possession of explosives on site.

4.1.4.3 Competency in explosives engineering requires the ability to demonstrate the successful completion of a course of training which should include:

- a) shotfiring (see annex A); and
- b) explosives engineering (see annex D);

together with the accumulation of the practical and theoretical knowledge and experience necessary to carry out the full range of explosives engineering duties.

4.1.4.4 Competency in shotfiring requires the possession of evidence of the successful completion of a course of training which should cover the subjects set out in annex A and evidence of sufficient knowledge and experience for the performance of the full range of shotfiring duties.

4.1.4.5 When one or more contractors are taking part in the work on the same site, the main or managing contractor should ensure close liaison and collaboration with the explosives engineer and/or the shotfirer responsible for the explosives work, both in the planning and in the execution of the work so as to prevent any hazard to personnel, materials or equipment when carrying out work with explosives. All site personnel present during blasting operations should come under the control of the explosives engineer and/or shotfirer.

4.1.5 Method statement

4.1.5.1 General

On completion of the risk assessment (see **4.1.3**) the method statement for the works should be prepared (see **4.7**). The purpose of the method statement is to ensure that when explosives are used on a construction site they will not give rise to danger. Section 2(2) of the Health and Safety at Work etc. Act 1974 [13] requires the provision of safe systems of work; drawing up and gaining approval for a method statement should be seen as an essential step in demonstrating compliance with that obligation.

The method statement should include procedures and practices drawn from company instructions and site rules specified by the company to ensure compliance with current legislation, codes of practice and guidance notes. It should identify problems and their solution and form a reference for site supervision. The method statement should be easy to understand, be known and accepted by all levels of supervision including shotfirers and any contractors involved on the site.

On sites where the CDM Regulations apply, the method statement should be an integral part of the health and safety plan (see **C.8**) developed by the principal contractor.

4.1.5.2 Shotfirer's responsibilities

One of the shotfirer's responsibilities is to ensure that explosives are stored, handled and used in accordance with the method statement. When it is not possible to comply with the method statement, operations should be suspended until approval has been obtained for any amendments to it, which amendments would normally be made by the explosives engineer in consultation with site management.

4.1.5.3 Explosives engineer's responsibilities

Where amendments need to be made to the method statement, the explosives engineer should ensure that the amended version is passed to every person who was in receipt of the original, in time for their consideration before the operation continues.

4.2 Safety and security of explosives during acquisition, transport and storage on site

4.2.1 General

In Great Britain, the law requires that explosive materials or detonators should be stored in a magazine or local authority licensed store or, possibly, in the case of smaller amounts, in registered premises. Before explosives can be acquired it is necessary to obtain a certificate from the police which certifies that a named person is fit and proper to acquire and store explosives. Without a certificate it is not possible to acquire explosive materials from a manufacturer or supplier. In addition, the named person will be required to have an RCA document (see 4.1.3.14) issued by the Health and Safety Executive unless the explosive is used immediately at the place of manufacture.

Persons wishing to keep explosives should apply for the necessary certificate and RCA document in ample time. The local authority officer responsible for explosives should be consulted as soon as the need to keep explosives has been established.

4.2.2 Planning

The requirements regarding transport and storage of explosives depend on the type and quantities of materials to be used. It is important, therefore, that the techniques which are to be applied should be decided before any action is taken to arrange storage or transport. Once this has been decided, the best position for any store needed should be determined in consultation with the local authority officer responsible for explosives. It may not be possible to obtain storage facilities for the required quantity of explosives because of the proximity of structures and services which need to be protected. It should be realized that the local licensing authority has no discretion whatsoever to reduce the safety distances

required by the stores under the Stores of Explosives Orders [14]. The police should also be consulted when the matter of siting is under consideration as they will be concerned as to the vulnerability of any store to an attempt at theft. There are stringent requirements for the construction of stores to ensure that they are secure. Local authority explosives officers should be consulted for detailed advice as to the standards of construction required, sources from which stores may be purchased and the method of mounting such stores.

If it is proposed to use ammonium nitrate/fuel oil (ANFO) types of explosive (including either bulk emulsion or emulsion ANFO blends prepared on site) it will be necessary for the user to obtain a licence to mix such explosives. Application should be made to HM Explosives Inspectorate for the licence.

In general, the types of explosives used in Great Britain may all be stored in the same place whether they be nitro-glycerine, trinitrotoluene (TNT) based explosives, slurry explosives, emulsions or of the ANFO type. Detonating cord may also be stored in the same compartment, but it is essential that detonators be stored separately. Most of the commercially available explosives stores have attached to them a separate structure suitable for the storage of detonators. It should be noted that special conditions apply to explosive devices containing exposed iron or steel. Care should be taken to ensure that any store or magazine used is licensed for the type of explosive to be stored within it and where there is any doubt the explosives officer for the area concerned should be consulted.

NOTE Site mixed explosives are made for immediate use and in general are not stored except in exceptional circumstances.

The transport of classified explosives is subject to special regulations as prescribed by The Placing on the Market and Supervision of Transfers of Explosives Regulations 1993 [8] and The Carriage of Explosives by Road Regulations 1996 [10].

As the techniques to be used and the phasing of work on a site will influence both the size of explosives store needed and the transport arrangements necessary, it is essential that these be established at the planning stage

4.2.3 Responsibility for storage

The shotfirer should be made responsible for the explosives store or magazine, for its cleanliness, for the proper rotation of stock, the keeping of records (see 4.2.4) and for good housekeeping in general.

NOTE It is a legal requirement that copies of the appropriate general rules for explosives stores (or magazines) be displayed in the place used to store explosives.

4.2.4 Storage procedure

Extreme caution should always be exercised during the unloading of explosives. Cases containing explosives should never be roughly handled, slid on ramps or dropped. The explosives should be handled only by the supplier's own operatives, by the shotfirer, or by the storekeeper. If it is necessary to use unskilled operatives for this purpose, they should be allowed to handle the materials only under the direct supervision of the shotfirer. Care should be taken to ensure that, during delivery of explosives to a storage place or during the removal of material from it, no grit is allowed to contaminate either the cases or the store and the floor of any such storage place should be thoroughly swept after any delivery or withdrawal of explosives. The cleaning of such stores should be carried out by the shotfirer, by the storekeeper or by someone under the personal supervision of the storekeeper. During storage all cases of explosives should be stored flat with their top side uppermost and in such a way as to allow the identifying name of the explosive and of its manufacturer and the date of manufacture to be clearly visible. Cases of explosive should be so stacked that any pile of boxes is stable and is positioned so as to allow all-round ventilation.

It is legally required that an up-to-date record is kept of all incoming and outgoing explosives and explosive items (including detonators, detonating cords, safety and other fuses), as is checking that the weight of explosives in the store does not exceed the licensed quantity. The store licensee should retain records of receipts, issues and transfers from the store which should be kept at the office. For the purposes of such calculations, plain or electric detonators may be reckoned to weigh 1 kg per thousand. Linear cutting charges or similar explosive articles should be reckoned on net explosive quantity or charge. On delivery to the site all explosives should be transferred either to their place of immediate use or to the licensed place of storage without delay.

Care should be taken to ensure that explosives are used in the order in which they have been delivered and old stocks should not be allowed to accumulate. Stocks of explosives should be regularly checked for signs of deterioration.

If explosives have been issued in excess of requirement and it is desired to return them to their licensed place of storage, they should be examined by the shotfirer before return. If they are neither wet nor contaminated in any way, they should be taken into store as normal but should be kept separately and should be the first material to be re-issued.

When explosives are returned to store special care should be taken that detonators and blasting explosives are kept completely separate, each in its appropriate place and repackaged in accordance with the current packaging and labelling regulations.

Any explosives which have been contaminated, whether by water or dirt, should be examined to make sure that detonators and blasting explosives are separated. They should be specially wrapped to ensure that contamination of the store does not occur and should be placed in a clearly identified container within the store itself. Efforts should be made to use up or dispose of any such material within one week of its being returned to store. In any event, contaminated material should not be allowed to accumulate over long periods.

If deterioration is observed in any explosive, the material should not be touched and expert advice should be obtained as to the best method of removal from the place of storage. The first step should be to contact the manufacturer or agent for such advice.

4.2.5 Fire

It is essential that contraband, i.e. smoking materials, matches, lighters or any other sources of ignition, is not taken into an explosives store. Fires, naked lights or lighted cigarettes are not permitted within 25 m of any explosives store. No petrol, oil, flammable solvents, wastepaper or similar material, the ignition of which might imperil the explosives store, should be permitted within 25 m of any place where explosives are stored. Furthermore, care should be taken that grass and undergrowth in the vicinity of an explosives store is cut regularly to minimize the fire hazard. (See also 4.2.13.)

4.2.6 Tools and equipment

No tools or equipment should be kept in an explosives store except those required for keeping the store clean. Cleaning equipment should not incorporate parts made of iron or steel.

Where tools are required for opening cases care should be taken to avoid frictional events which may generate sparks.

4.2.7 Store cleanliness

The inside of an explosives store should be kept clean and free from dust or grit. This problem is best considered during the planning stage and the store should, if possible, be located so that it is protected from the prevailing wind across the site concerned.

When inside a store, personnel should take suitable precautions as regards footwear (e.g. rubber overshoes) to prevent contamination with grit. Under no circumstances should boots or shoes with exposed metal studs, nails or metal protectors be worn in an explosives store.

The cleanliness of the explosives store should be made the direct responsibility of the shotfirer or storekeeper (see 4.2.4).

All sweepings from inside any explosives store should be removed from the store itself and treated as explosives for destruction (see 4.2.13).

4.2.8 Repairs to stores

Before any repairs or alterations are made to a store it is essential that all explosives are removed to another licensed store or placed under constant attendance and the police advised. Should welding, flame cutting or cold cutting be required then the wooden lining should be carefully examined for explosives contamination and the wood removed. Only after careful examination for sparks and after the cooling of any hot spots should the lining and the explosives be replaced.

4.2.9 Workshops for explosives

When a considerable amount of work is envisaged on a site, a properly prepared and constructed workshop should be used for preparing charges for use on that site. There are legal requirements as to the positioning of such workshops and to the type of work which can properly be carried out within them (see section 47 of the Explosives Act 1875 [12]). It is necessary for any person keeping any explosives in a store to notify the local licensing authority of their intention to construct such a workshop. The local authority officer responsible for explosives will be in a position to give advice as to the siting which is permissible and as to the type of work which may be carried out within it.

4.2.10 Transport of explosives on site

Where practicable all vehicles used for the conveyance of explosives on a working site should conform to the requirements for vehicles for the conveyance of explosives by road (see 4.2.2). Where site conditions do not allow such vehicles to be used the following general conditions should apply to any vehicle used:

- a) the vehicle should be cleaned out, and clean sheeting, for example, a tarpaulin, laid for receipt of explosives boxes;
- b) the vehicle should be in a safe mechanical condition and carry an adequate fire extinguisher;
- c) the vehicle should be supervised by the shotfirer;
- d) no flammable liquids or gases should be carried other than in the vehicle's fuel tank;
- e) detonators should be kept in a suitable container which should be kept locked when access is not required to the contents;
- f) detonators should be carried, effectively separated from explosives by at least 1 m and both in accordance with 4.2.12;
- g) explosives should be protected from weather during transit;
- h) it is essential that "No Smoking" restrictions are observed;
- i) it is essential that charges of explosives which have already been fitted with detonators are not carried in any vehicle; and
- j) it is essential that the vehicle should be clearly marked.

4.2.11 Transport of explosives by air

4.2.11.1 General

The transport of explosives by air is regulated by The Air Navigation (Dangerous Goods) Regulations 1985 [15].

NOTE The Regulations permit only low hazard explosives, i.e. those of 1.4 or some of 1.3 division, to be transported routinely by air. Large consignments of more hazardous types are handled generally by charter flights from specified airports under individually specified conditions.

It is also necessary to comply with both The Technical Instructions for the Safe Transport of Dangerous Goods by Air [16], and the United Nations Recommendations on the Transport of Dangerous Goods [17], as per date issue. This latter is known colloquially as the "Orange Book".

It is strongly recommended that the advice of a forwarding agent or airline should be taken before attempting to transport any explosives by air.

4.2.11.2 Methods of air transport

In general terms, explosives may be carried as follows.

a) Passenger aircraft	Civil Aviation Authority (CAA) classification 1.4S (e.g. safety fuse, safety electric fuse, beanhole connectors)
b) Cargo aircraft	CAA classification 1.4S CAA classification 1.4G (e.g. igniter cord, portfires) CAA classification 1.4B (e.g. electric detonators in special packing)
c) Charter aircraft	All classes The aircraft is dedicated <i>solely</i> to transport of explosives and prior permission has to be obtained from the CAA by the airline concerned.

4.2.12 Portable containers

4.2.12.1 Explosives

Small quantities of explosives being conveyed on site should be carried either in their original packing or in soundly constructed containers. The containers should be made of non-ferrous material such as leather, moulded rubber or plastics, wood or reinforced canvas.

Each container should be fitted with a strap attached to its main body and should be fitted with a closely fitting cover. The cover should be fitted with a non-ferrous lock.

4.2.12.2 Detonators

These should always be carried either in their original packing or in separate containers and separate from other explosives. Preferably they should be carried by a second person. It is recommended that, where practicable, the interior design of any container used to carry detonators be such that it is divided into compartments each allowing sufficient space for each detonator.

4.2.13 Disposal of unwanted explosives or explosives which have deteriorated during storage

Extreme care should be taken when dealing with any blasting materials which have apparently deteriorated whether they be explosives or detonators. It is strongly recommended that before handling any such material or disposing of unwanted explosives, advice should be obtained from a supplier or manufacturer's literature; failing this from the local authority or finally from HM Inspectorate of Explosives (see HSE booklet *Disposal of explosives waste and the decontamination of explosives plant* [18]).

Care should be taken when disposing of packing materials such as cases, case linings wrappers, or other materials used in cleaning up waste explosives. These materials may have become impregnated with explosives. Disposal operations should not be carried out within 50 m of the magazine.

Burning on site should only be considered as a last resort and only for the disposal of very small quantities of explosives or explosives-contaminated material, because of the possibility of an explosion. The quantity burnt in any one fire should be limited to no more than the equivalent of 2.5 kg of blasting explosive. It is therefore essential that the quantities of explosives burnt on any one occasion should be related to the size of the disposal site and a procedure adopted for the safety of personnel and public as in any blasting operation.

4.3 Safety when using explosives

4.3.1 General

This clause is concerned with those aspects and procedures of preparing blasts which relate to conducting such operations safely and efficiently. Since different blasting operations call for widely differing blasting methods and techniques, it is the main purpose of this clause to cover general principles applying to various stages of the blasting process.

Consideration should be given to introducing a formal "permit to blast" system.

Clauses 5 to 10 should be consulted for details of the safe handling of explosives under specific use conditions.

Whether very simple or very complicated in design terms, every blast design should be carefully considered. A simple design may only require a brief input by an explosives engineer, whereas a large complex design may require the input of several specialists.

In designing a blast, due consideration should be given to the site survey/risk assessment, the exclusion zone and the blast protection required.

The design should be set out formally on paper showing the number of shot holes, their placement and their depth and diameter. The type(s) and weights of explosives to be employed in each shot hole as well as the charge placement and stemming should be detailed. The time delays and sequences should be clearly shown.

In practice, the blast design drawings should become the blast charge schedule.

4.3.2 Maltreatment of explosives

When shotfirers are handling and charging explosives at the blast site they should be conscious at all times that maltreatment of the explosives which involves shock and friction can cause accidental initiation of the charges.

Maltreatment may be from such causes as:

- a) the over-vigorous use of stemming rods to force explosives into a shot hole;
- b) the use of drill rods or other metal tools in a shot hole containing explosives;
- c) drilling into sockets containing explosives;
- d) vehicles running over explosives;

Other eventualities which have to be recognized as possible hazards are those involving impact or concussion.

NOTE 1 Major concerns in this context are, for example, vehicle collisions and runaway vehicles and the site conditions as regards, for example, traffic density, road or rail gradients and stability may well prompt the formulation of special local rules on individual sites.

e) projectiles — rock, stone or similar material projected from the blast can cause an accidental detonation of explosives. Excess explosives should be removed from the blast site to a place of safety before blasting takes place;

f) "snap, slap and shoot" — shock tube detonators may be initiated when subjected to a process known as "snap, slap and shoot". The process involves stretching the shock tube to breaking point so that it snaps and recoils producing a high velocity whiplash action. If the exposed core of the severed tubing then impacts against a hard surface during this motion, initiation may occur.

NOTE 2 "Snap, slap and shoot" incidents are very rare and only a small number have been recorded around the world. However, the consequences of such incidents can be very serious if a detonator fires.

To avoid the circumstances which may give rise to “snap, slap and shoot”, shock tubing should never be subjected to excess pulling or sudden jerking. If explosives charging vehicles operate in a blast area it is essential that all excess tubing be coiled compactly to prevent tangling in any moving parts, for example wheels and other rotating parts, and extreme care be taken when driving between shot holes to avoid the coils. At no time should vehicles be driven directly over shock tube as damage can occur, giving rise to misfires.

4.4 Types of explosives

4.4.1 General

There are many types of explosives which have been classified and authorized prior to being supplied to the UK market. The properties of these explosives vary and many have been developed for specific applications, therefore care should be taken in selecting the most suitable explosive for the particular work activity. Annex E should be consulted for information on the general properties of explosives.

Due regard should be given to the shelf life of explosives and accessories. This may vary according to the conditions of storage. Manufacturer's data sheets should be consulted and the advice in 4.2.4 followed.

In certain conditions of extremes of temperature some types of explosives are unsuitable and can be dangerous, therefore manufacturers should be consulted, especially where work is proposed in prefrozen ground or in hot furnaces.

4.4.2 Nitro-glycerine based explosives

Nitro-glycerine (NG) can be obtained in powder and gelatine form for use in small diameter and more commonly in gelatine form for large diameter applications. The water resistance of gelatines is good, powders, however, have little or none.

No NG composition should be used if it shows signs of exudation, that is, a separation of the oily liquid NG from the cartridge.

CAUTION This should not be confused with surface moisture of salt solutions which can be present especially in humid conditions. NG has an oily appearance and remains as separate drops in water, the salt solutions dissolve immediately. If exudation is observed the explosive is very sensitive, has failed to an irreversibly dangerous condition and expert advice should be sought from the manufacturer. Respiratory and cutaneous contact with NG/nitro-glycol explosives may cause very unpleasant headaches but not everyone is affected by these. In some extreme cases, however, the headaches are so severe that work has to be suspended for those who have been affected.

NG based explosives are less prone to pressure desensitization and may be used where delayed action techniques are being employed in complex, closely spaced drill patterns.

4.4.3 TNT based explosives

A variety of both pressed and cast charges can be obtained based on TNT, the most common being:

- a) cast mixtures of pentaerythritol tetranitrate (PETN) with TNT which have high detonation rates and can perform as good primers;
- b) mixtures containing TNT and cyclotrimethylene trinitramine (RDX), sometimes with wax added.

4.4.4 Plastic explosives

Some commercially available explosives based on RDX and PETN which were developed for military demolition can be obtained for metal cutting. Care should be taken to ensure that priming is carried out according to the manufacturer's instructions.

4.4.5 Slurry explosives

Slurry explosives may have one or more of a large range of sensitizers which can be either explosive or non-explosive, the most common ones being methylamine nitrate, “paint grade” aluminium powder, TNT and smokeless powder.

Performance in field applications is dependent on formulation. The means of initiation is variable, some slurries are detonator or cord sensitive, others require boosters. Further, some slurries may be affected by shock, gas or hydrostatic pressure effects and technical advice should be sought from the manufacturer. Slurries contain water as part of the formulation and can be considered safer than other high explosives. Dried slurry residues, especially those with insoluble sensitizers, can burn to detonation and in practice when handling, storing, using or disposing by burning, slurries should be considered to be as dangerous as other high explosives.

4.4.6 Emulsion explosives

Emulsion explosives contain similar ingredients to slurries but their structure is quite different and this is reflected in their properties and performance. Generally, emulsions have a higher velocity of detonation than slurry explosives and better after-detonation fume characteristics than other explosives. However, when gas sensitized, emulsion explosives can suffer from the same pressure effects as slurry explosives.