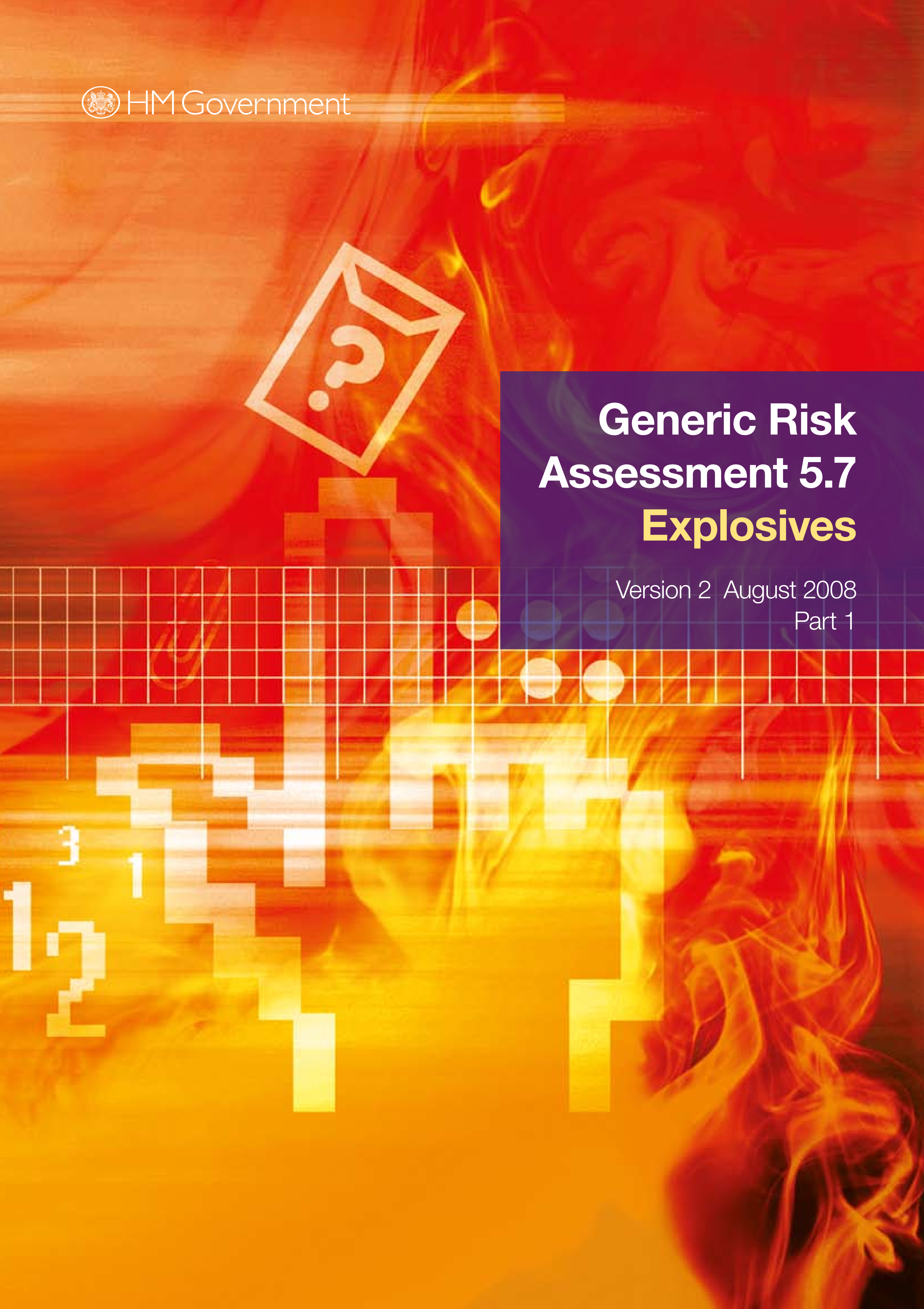

HM Government

Generic Risk Assessment 5.7
Explosives

Version 2 August 2008
Part 1

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Contents

SECTION 1

Aide mémoire

Considerations for Incident Commanders when attending incidents where explosives are or may be involved

The following information should be readily available en-route, in an easy to read and understandable format.

Pre-arrival

Review preplanning information

- are there contingency plans/risk cards available?
- collate information available from the FRS Control
- consider on arrival and approach tactics
- identify type and quantity of explosives
- consider if fire fighting media may have adverse reaction
- assess proximity to neighbouring habitable properties
- assess if there is a life risk
- identify water supplies (open and hydrants)
- identify boundary protection
- take account of any local features that could exacerbate the incident eg industrial premises or an increase in the number of persons that could be affected eg public attractions etc
- obtain contact details of competent person for the site
- assess if resources are sufficient or if there is a need for additional .

Commence DRA on information available.

On arrival

- assess immediate crew and public safety
- consult with the on-site competent person to ascertain:
  - actual type/class and quantity of explosives involved
  - location of explosives
  - life risk
  - other hazards

- set up and maintain a hazard zone and remove non emergency services personnel (refer to annex 1) if doubt exists, increase size of hazard zone, this can always be reduced
- determine safe distances outside of the hazard zone to park and marshall appliances
- assess and request resources needed
- determine operational mode and ensure all personnel are aware of mode
- implement any rescues required, if safe to do so
- consider evacuation at any early stage – this may be time consuming
- ensure all personnel including other emergency services are aware of and understand the evacuation signal
- ensure robust incident command procedures are implemented in accordance with the current National Guidance on the incident command system
- request Police for cordon control
- implement contingency plan as appropriate
- assess the life risk (if there is no life risk the urgency is lower and others may have the responsibility for recovery)
- consider environmental impacts as smoke plumes and water run off may contain high concentrations of chemicals
- consider if there are other hazards present which could prove to be problematic eg pressurised gases
- decide whether there is a risk of several simultaneous incidents
- be aware that an unpredictable, dynamic sequence of damage can be expected
- ensure adequate protection available, from which to undertake firefighting operations
- identify exposure hazards and provide protective spray
- consider whether action already taken is adequate/appropriate.

As the incident develops

Explosives in manufacture/storage

- the prime objective when dealing with **any** incident that could result in the involvement of explosives is to save life and prevent the fire spreading to the explosives
- once explosives are involved in the fire, the application of water will not extinguish the explosives
- the IC's priority **must** be the evacuation of everybody in the hazard zone at which point all emergency service personnel can withdraw

- be aware of any vehicles in the area of FRS operations and determine contents if safe to do so
- if an explosion has occurred, secondary explosions can take place for some considerable time afterwards
- fighting of secondary fires after an initial explosion should not take place until there is confirmation that no more explosives remain on site
- where it is considered safe to do so, firefighting jets should be positioned to prevent fire spread utilising branch holders and ground monitors
- if explosives are not involved in fire – Firefighting should be limited to preventing the fire spreading to structures or other areas containing explosives
- use appropriate number of personnel, in proportion with the tasks to be undertaken
- liaise with site management or competent person
- small buildings or vehicles offer little protection and sheltering behind walls can be dangerous because they will only stop small projectiles and any blast wave may overturn vehicles, demolish walls and in doing so create more projectiles
- fireworks are routinely stored in ISO containers. Under no circumstances should the container doors be opened during firefighting, even if the fire appears to be out. The container doors should not be opened for at least 24 hours and the container treated as a potential source of explosion until that time
- be aware of any explosives that may have been subjected to the blast wave but have remained intact
- if dealing with an incident at a firework display operator's site all buildings should be treated as if they potentially contain hazard type 1.1 explosives unless there is reliable confirmation that they either contain no explosives or they only contain hazard type 1.4 explosives.

Fires that have spread to buildings or areas holding HD 1, 2 or 3 explosives **must not** be fought.

- HD 1.1 explosives stored or transported in ISO containers may mass explode if the container is heated or involved in a fire
- HD 1.2 fragments are mainly munitions. If a container of HD1.2 explosives were involved in a fire they would be likely to produce potentially lethal flying fragments (either from the munitions themselves or from the container)
- HD1.3 explosives may produce a significant explosion, or the doors may burst open under pressure from the build-up of gases and a large fireball produced. It is possible that in extreme circumstances the container may mass explode
- The effects of a fire involving HD 1.4 explosives should normally be contained within the container. However, it may not always be possible to determine type and quantity; therefore, it would be prudent to treat the load as a higher class of explosives i.e. HD1.3.

If there is any doubt whatsoever about the nature or location of the explosives involved, the fire should not be fought and personnel should withdraw to a safe distance.

As stated above, the priority is to save life. This is best achieved by evacuating all those in the immediate vicinity. In exceptional circumstances, this could involve placing Firefighters at a higher risk than would normally be considered as acceptable.

Key considerations for all personnel

- ensure effective communications are established and maintained throughout the incident
- ensure that crews operate in minimum of two persons
- do not enter the immediate hazard zone unless instructed to undertake operational tasks
- remember that vehicles, brick or block structures may afford little protection; use earth embankments or similar substantial cover for protection
- be aware of smoke plume and avoid where possible.

SECTION 2

Key Operational Factors

Scope

This assessment considers the hazards, risks and control measures for operational incidents where explosives, which include fireworks, are or are suspected to be involved.

It is imperative that 'fireworks' are not considered to be anything other than explosives. Important factors to be considered are the type and quantity of firework; this may not be initially determinable or known by the Incident Commander.

This Generic Risk Assessment (GRA) does not cover explosive devices where their intentional use is to cause harm and destruction eg acts of terrorism. However, the principles espoused within this document would still be applicable, subject to information and dynamic risk assessment.

As with all GRAs this assessment provides a starting point for Fire and Rescue Services (FRS) to conduct their own assessments within the context of local conditions and existing organisational arrangements.

Introduction

Incidents involving explosives are fortunately rare, but when they do happen, there is potential for them to be catastrophic. An explosion at the storage site of a firework display operator in the Dutch city of Enschede, resulted in the death of 22 people including four firefighters.

There have been a number of other serious incidents in Britain and abroad including an explosion in Kolding , Denmark when one fire fighter was killed, three were seriously injured, and the explosion at Marlie Farm in East Sussex in December 2006 in which two fire service personnel died.

Duty-holders who are engaged in specific activities such as: selling fireworks and other pyrotechnic articles, storing explosives, firework display operators and explosives manufacturers, are required to have in place robust systems to counter foreseeable eventualities in worse case scenarios.

Hazards and risks

The nature of explosives

The United Nations Committee of Experts on the Transport of Dangerous Goods (UNCOE) classifies dangerous goods in the form in which they are to be transported according to the hazard they present during transport, and defines explosives as follows:

> **Explosives substances:** an explosives substance is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as could cause damage to surroundings. TNT and dynamite are well-known examples of explosives substances.
>
> **Pyrotechnic substances:** a pyrotechnic substance is a substance or a mixture of substances designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as a result of non-detonative self-sustaining exothermic chemical reactions. Pyrotechnic substances are commonly found in fireworks.
>
> **Explosives articles:** an explosives article is an article containing one or more explosives substances. Thus, for example, all nature of ammunition are classified as explosive articles.

How explosives react

Explosives are generally divided between those which:

- **detonate;** a process of supersonic reaction in which a shock wave is propagated forward due to energy release in a reaction zone behind it. In a detonation, the shock compresses the material thus increasing the temperature to the point of ignition. The ignited material reacts behind the shock and releases energy that supports the shock propagation. Because detonations generate high pressures, they are very destructive, and;
- **deflagrate**; a technical term describing subsonic combustion that usually propagates through thermal conductivity (hot burning material heats the next layer of cold material and ignites it). Deflagrations are usually less destructive than detonations.

Explosives, irrespective of whether they deflagrate or detonate produce large quantities of hot gases and proceed without consuming oxygen from the surroundings. Ignited explosives can therefore function, for example, under water. Once initiated the application of water will not extinguish a fire involving explosives.

The types of energetic stimuli that can, in principle, bring about initiations of explosives are:

- impact/friction
- fire/heat
- fragment attack/overpressure
- electrostatic discharge
- electromagnetic radiation (in the case of electro-explosive devises)
- chemical attack.

Explosives – hazard type/hazard division

For transport purposes, explosives (in their packaging) are classified into 'Hazard Divisions', in accordance with the United Nations Recommendations on the Transport of Dangerous Goods ('Orange Book') Licences issued under the regulations on the manufacture and storage of explosives refer to 'hazard type'. With explosives that are packaged for transport, the hazard division and hazard type will be the same, however, in some cases (eg detonators) unpackaged explosives may present a higher hazard. See also annex 2.

Both the UN scheme of classification and the Regulations on manufacture and storage recognise that many substances and articles classified as explosives do not present the same degree of hazard and subdivide them according to their potential for harm:

Division 1.1/Hazard Type 1
Substances and articles which have a mass explosion hazard (a mass explosion is an explosion which affects almost the entire load virtually instantaneously).

Division 1.2/Hazard Type 2
Substances and articles which have a projection hazard but not a mass explosion hazard.

Division 1.3 /Hazard Type 3
Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard:

(a) combustion of which gives rise to considerable radiant heat; or

(b) which burn one after another, producing minor blast or projection effects or both.

Division 1.4/Hazard type 4
Substances and articles which present only a slight risk of explosion in the event of ignition or initiation during carriage, storage or manufacture. The effects are local, largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire shall not cause virtually instantaneous explosion of almost the entire contents of the package.

Throughout the rest of this document the term **hazard division** is used, to mean all aspects of explosives, whether in manufacture, storage or transportation.

It is important to remember that the UN classifications are based on the behaviour of the explosive when burnt in their packaging in the open air on a fire. However, the same explosive may behave very differently when under the sort of pressure that might be encountered in International Standards Organisation (ISO) transport containers, thick-walled steel stores or some process plant. In such circumstances, the very rapid build-up of pressure can cause the explosives to react more violently than the classification would suggest and therefore present a much greater hazard.

Where explosives of different hazard divisions are stored together, they are treated as if they are **all** of the highest hazard division eg 100kg 1.3 and 1 tonne 1.4 is treated as 1,100 kg of 1.3. For transportation purposes the same principle applies for different Hazard Divisions carried together and the vehicle should be placarded accordingly.

For the purpose of information, The UN has defined two further divisions based on risk rather than hazard:

Division 1.5
Very insensitive substances that have a mass explosion hazard. This division comprises substances which have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of a transition from burning to detonation under conditions of normal transport.

Division 1.6
Extremely insensitive articles which do not have a mass explosion hazard. This division comprises articles which contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental initiation or propagation.

We are unable to find evidence of substances of HD 1.5 or articles of HD 1.6 having been imported or exported through ports in Great Britain. In view of their rarity, HD 1.5 & HD 1.6, these divisions will not focus as discussion points in this document.

Blast Exposure

Multi-level injury from blast exposure, referred to as “blast injury,” may result in a group of impairments to body organs and systems. A phenomenon called “blast overpressure” forms from the compression of air in front of a blast wave which heats and accelerates the movement of air molecules. This overpressure phenomenon is considered to be the positive phase of the blast wave. The negative phase of the blast wave occurs later, as a result of sub-atmospheric pressure/under-pressurisation. The amount of damage from the pressure wave depends on the peak pressure, duration, medium in which the explosion occurs (open air, confined space, or water), and distance from the explosion.

The type of explosive will have an impact on the nature and severity of the resulting blast injury. Explosives are categorised as either “high-order” or “low-order.” High-order explosives are chemicals which have a high rate of reaction-including nitroglycerin, dynamite, C-4, and a mixture of ammonium nitrate and fuel oil. When a high-order explosive detonates, the chemicals are converted into gas at a very high temperature and pressure. High-order explosives have the potential to generate a large volume of initial pressure, and a blast wave that may expand outwards in all directions.

Low-order explosives are designed to burn and gradually release energy at a relatively slow rate. This type of explosive are referred to as “propellants” because they propel an object such as a bullet through a barrel. Low-order explosives do not create the shock waves generated by high-order explosives. The “blast wind” of low-order explosives is a “pushing” rather than the “shattering” effect found in the “blast wave” of high-order explosives. See annex 3 for a synopsis of the physical effects of explosives.

Where explosives may be found

The majority of locations holding civilian blasting explosives are quarries. These are typically held in a steel store. For quarrying operations most explosives are mixed on-site from non-explosive ingredients.

COMAH Sites

The Control of Major Accident Hazards Regulations 1999 apply mainly to the chemical manufacture and storage industry, but also to other industries such as explosives where threshold quantities of dangerous substances identified in the Regulations are kept or used. These Regulations, which are referred to in this document as COMAH, relate to the identification, prevention and mitigation of major accidents to people and the environment. The definition of ‘installation’ is broad. It includes storage and is not restricted to a processing or handling activity nor to buildings or particular types of plant.

Local authorities have duties in connection with the preparation, review, revision and testing of off-site emergency plans and they are also involved in the dissemination of operators’ safety information to the public. Employees and the emergency services identified as having a role to play in the emergency response must be consulted during preparation of the plan. There are two categories of COMAH sites:

- **Lower Tier Sites** are required to produce an onsite emergency plan developed in consultation with the emergency services
- **Top Tier Sites** are required to have a safety case which will include the on site plan. In addition an integrated offsite plan must be prepared by the local authority.

Explosives manufacturing

There are only a few locations in the UK where the manufacturing of high explosives or munitions using high explosives, is undertaken. The principal companies are

- Exchem
- Orica
- Chemring
- Ulster Industrial Explosives, and
- BAe Systems.

Other sites and companies are engaged in manufacturing small arms ammunition, munitions, pyrotechnics, detonators, oil well explosives, amongst others. Explosives manufacturing of this nature is not a seasonal activity.

Storage

Where explosives are stored, it is the Net Explosive Content (NEC) that is the licensable amount. The NEC is the amount of explosive in the article, not including the packaging. In the case of fireworks the NEC can be 25 per cent of the weight of the firework, so a store licensed for 2 tonnes NEC, may actually contain 8 tonnes gross weight including packaging.

Licences for storage of less than 2 tonnes (NEC) are issued by the appropriate licensing authority that, depending on the quantity stored and the location in the UK can be the Police, Metropolitan Fire and Rescue Authority, local authority or, in harbour areas and mines, Health and Safety Executive.

Where lower quantities are stored then the appropriate licensing authority may issue a registration rather than a licence.

For stores involving more than 2 tonnes the HSE will issue a licence.

Retail premises

Shops, supermarkets etc usually only store small quantities of fireworks and then only during the peak firework season; either within the shop or in an ISO container in the goods yard. Typically this will be up to 250 kg of HD1.4, or smaller quantities of 1.3, but may be more if separation distances permit.

FRS should also be mindful of transient locations where explosives may be encountered and that operational crews are apprised of these. This may necessitate the provision of temporary mobilising information.

Fireworks

The major proportion of fireworks are sold and used during the October/November firework season. However, professional fireworks displays take place at public and private events at other times of the year and there are a limited number of retailers selling fireworks all year round. FRS could therefore encounter large stocks of fireworks at any time of the year.

Fireworks importation varies according to the time of the year and the special event for which they have been imported. For example, in 2006 approx 1180 containers were brought through the port of Felixstowe. equating to 15,559 Tonnes of fireworks (gross weight). 57 per cent of these were received in August and September.

Fireworks display operators

Fireworks display operators are likely to be using hazard division 1.1 and 1.3 fireworks in addition to hazard division 1.4.

There are two main implications from this:

- hazard division 1.1 presents a mass explosion hazard
- when fireworks of hazard division 1.1 are present in a store together with hazard division 1.3 or 1.4 the whole quantity will behave as if it is, hazard division 1.1

- hazard division 1.3 articles do not present a mass explosion hazard. There is nevertheless a potential for them to explode and produce large fireballs.

Explosives carried in vehicles

Vehicles carrying larger quantities of fireworks and other hazards should carry the appropriate UN hazard division orange diamonds. However, IC's should be aware of the possibility of smaller loads of explosives being carried in un-placarded vehicles. Potential exists for the illegal carriage of explosives. IC's should always consider the possibility of this arising, if for example the driver of the vehicle involved cannot be easily identified at the incident.

International Standards Organisation Transport Containers (ISO)

ISO containers are used for the transportation of fireworks from the port of origin to the port of disembarkation; they are also used for storage of fireworks. They can be found in a number of locations, varying from designated container yards, private properties to derelict sites. A fire involving, or in near proximity to an ISO container should be treated with extreme caution if information about its contents cannot be determined.

In certain conditions selected fireworks stored in ISO containers may be liable to simultaneous detonation. This could result in the fragmentation of the container, therefore every effort should be made to provide complete cooling to the container. If this is not possible, a 600 metre hazard zone should be put in place. This situation may arise when fireworks that contain flashpowder are stored. If only one of the large fireworks detonates, due to localised heating through the container, a shock wave could be produced that provides sufficient energy to detonate all/the majority of this grade of firework at the same time. This will generate high pressure that will likely destroy the container.

Licensing and registration

A licence is required for most manufacturing or storage activities. 'Manufacturing' includes processes where explosive articles or substances are made/unmade or assembled/disassembled, repaired or modified. HSE is the licensing authority for all manufacturing. Depending on the quantity and type of explosives, the licensing authority for storage could be the local authority, Metropolitan Fire and Rescue Service, Police or HSE. There are a number of licensing exemptions for the storage of small quantities and for temporary storage. For example there are allowances for storing limited quantities of shooters' powders, certain lower-risk pyrotechnics and articles such as flares, fog signals, car airbags and seatbelt pre-tensioners.

Unlicensed storage

During the fireworks season IC's should be aware of the possibility that they may encounter illegally-stored fireworks. Situations where this might occur would include:

- transport haulier's depots
- shops on short lets
- warehouse or lockup storage.

Fireground communications

Generally, incident ground communications equipment should not affect explosive articles that have not been prepared eg a fireworks display. However, we are unable to say unequivocally whether display technicians would not use modern technology such as radio frequency as part of the display activation process. To that end, we would advise that the adoption of communications protocols currently used by the Ministry of Defence (MoD) and police bomb search teams for electro explosive devices and adopted by FRS' should be continued.

Unsafe explosives

There are a number of different ways in which explosives can be in a potentially unsafe condition (see Annex 4).

SECTION 3

Key control measures

The safe and successful outcome of a FRS attendance at any incident is reliant upon a number of factors, the primary one being the availability of operational intelligence, gathered and planned for and to a foreseeable incident arising. Generally, this is achieved through discussions with the duty holder. Ultimately, it is the responsibility of the 'duty holder' to notify the FRS of any explosives processes or storage being undertaken on the premises. After which time, the duty is then upon the FRS to "make arrangements for obtaining information needed for the purpose mentioned in subsection 1". Commonly referred to as Fire and Rescue Services Act 2004 s7(2)(d). The Explanatory Note to the 2004 Act states the s7(2)(d). duty as, *inter alia*:

"A fire and rescue authority must also put in place effective arrangements for receiving and responding to calls for help and for obtaining information which it needs to carry out its functions; the latter might include, for example, information about the nature and characteristics of buildings within the authority's area or availability of and access to water supplies".

There may be times when the FRS will not have been informed of the presence of explosives or the information available may be incomplete or suspect. In these situations Incident Commanders will need to take a defensive approach. However, the objective should be to reduce so far as is reasonably practicable the risk that personnel will need to go in blind.

Information gathering

It is estimated that there are between 20 and 30 thousand premises licensed or registered to store explosives. The vast majority of these are shops and supermarkets registered for storing fireworks during the firework season. These premises are licensed or registered either by the FRS (in the metropolitan counties) or by the local council trading standards department.

The sites storing the largest quantities of explosives are licensed by HSE (who licence about 230 sites in Great Britain). These sites range from manufacturers of blasting explosives and munitions, through to firework importers and firework display operators.

Sites holding smaller quantities of high explosives are licensed by the police. These sites are mainly at quarries. The police also grant explosives certificates to private individuals holding black powder ('gunpowder').

HSE is working with Communities and Local Government and local licensing authorities to put in place arrangements for sharing information on explosives sites with FRS's to ensure that this information is available via regional control centres when these come into operation. It is suggested that in the meantime, FRS's contact HSE with a view to identifying HSE-licensed sites in their areas, so that they can undertake s7(2)(d) information-gathering visits. This will give them the information on the most hazardous sites in their area (although some HSE-licensed sites will be relatively low hazard).

FRS's are also strongly encouraged to approach other licensing authorities for information on sites holding smaller quantities.

Effective formalised systems for liaison must be in place to identify what information FRS' require and to arrangements for updating that information at regular intervals.

Operators who manufacture or store any explosives (including fireworks) in excess of the top-tier COMAH quantities, to fulfil their responsibilities for the risk analyses or "predictive" aspects such sites have quantity-safety distances which generally ensures that the off-site risks from the explosion hazards are low. On-site the explosives risks range from low (associated for example with explosives storage) through medium to high (with certain manufacturing operations). Therefore, risks associated with explosives substances at licensed sites are normally dominated by risks on-site. Operators must undertake a suitable and sufficient risk analysis to show that the risks from the installation and the operations undertaken on their sites have been reduced "as low as reasonably practicable" (ALARP).

Operational pre-planning and information gathering

Pre-planning

This will form the basis for strategic and tactical planning for incidents. Arrangements should be made under Fire and Rescue Services Act 2004 s7(2)(d) to gather relevant information pertaining to premises within the FRS area of responsibility where explosives are, manufactured, stored, sold or used.

A close and effective working relationship with the police, HSE, Customs & Excise, the Local Authority Planning and Trading Standards should be adopted to ensure that information about the movement, storage and use of explosives is made available to all partner organisations.

Information which should be gathered would include:

Manufacturers and storage

- location of the explosives
- explosives hazard divisions that may be present
- maximum quantities of each held on site and in each location this information is readily available from the site licence
- construction type of manufacturing and storage buildings; features or structural hazards which may have a profound effect on fire fighting or rescue operations, including:

- potential for rapid fire spread or production of large columns of smoke and toxic products
- lack of compartmentation
- unprotected shafts or openings
- substantial basement areas; *and*
- high potential for structural collapse.

Fire fighting/search and rescue

- access/egress safe routes within the establishment and boundary, in particular for aerial appliances and other specialised vehicles, giving consideration to available headroom, width, ground clearance, hard standing turning circles and load restrictions
- travel distances from access points to various points in the building or around the grounds
- details of fixed fire protection installations eg ventilators, sprinklers, drenchers, fire shutters, any back-up installations etc
- safe areas where firefighting operations can be undertaken
- identify the best locations in which to site command and control units, BA control and special appliances, in order to maximise the overall control of the incident
- are there any communication dead spots
- water supplies, hydrants, open and tanked
- distances from water source and pressure calculations
- establish designated rendezvous points, primary and secondary for initial attendance, are these emergency services as a whole or FRS only. Consideration should be given to dependency on wind speed and direction, and giving alternatives.

Other hazards

- large above or below ground oil or gas pipelines serving the establishment, or supplying products for storage or process
- other hazards eg compressed gases, electrical transformers, sub-stations etc.

Duty holder information

- who is the responsible person for the site and contact details for normal and out of hours?
- access to a current copy of the "on site plan"
- are explosives transported around the site and if so, how is this achieved?
- security regimes employed by duty holder eg electrified fences, guard dogs etc which might impact upon operational tactics
- would the use of mobile communication equipment create a hazard?

- gather any technical data that gives general information on the properties and physical nature of substances.

Hazard zones and evacuation distances

- identify safe distances to establish notional hazard zones associated with quantity, division etc
- anything that has projectile hazard in the event of an explosion eg walls
- evacuation distances.
- environmental
- environmental consequences – identify watercourses, interceptors and plant drainage systems etc
- equipment required to mitigate environmental impact
- any other information which may be considered to be useful.

N.B. This list is not exhaustive.

Preplanning arrangements should also include the development of contingency plans for a range of reasonably foreseeable events. The plans should also make provision for a pre determined response (PDR) that reflects the access and facilities provided for the FRS and the type of incident likely to be encountered. Taking into account the size of the building, the time required to gain access, should this be necessary, to assemble sufficient resources to undertake firefighting and search and rescue operations from the PDR and the effect that this will have on the anticipated mode of operations. PDR should ensure that adequate resources of personnel and equipment are provided to undertake initial assessment and effect an early response to the incident safely.

Consideration should be given to the development and adoption of a system to provide role related relevant information concerning the premises. This should include; call handlers, first and subsequent responders. FRS' should consider the development of common call handling prompts to elicit and gather appropriate, relevant and timely information about the nature of the incident. FRS' should also develop proactive means of call handling, in which the caller is offered reassurance and offered practical advice to minimise risks and injury.

Familiarisation and exercising

It is imperative that personnel required to attend specific explosives manufacturing and/or storage location's, are fully conversant with the layout of the site and all facets of fire prevention contained therein. Moreover, personnel should, on a regular basis, undertake exercises with other emergency services responders and site personnel to ensure that 'response plans' are fully understood. Training and exercising should not be constrained by time, the safe and effective outcome are the crucial factors, to that end, training and exercising should be as realistic as possible, giving due cognisance to the tasks to be undertaken and the levels of command that may be implemented. Consideration should be given to the requirements of specialised equipment that may assist in an incident eg High Volume Pumps could prove to be a valuable asset in the drawing and delivery of large quantities of open water.

The above principles would apply to sites that have been identified as being of high risk, but the level of detail needed will depend on the complexity of each site. Where a FRS has a FRSA s13 arrangement in place with a neighbouring FRS, it is essential that that FRS is also involved in any training and exercises that may arise and pertinent to the overall planning and response.

Technical training should also be undertaken by all personnel who may be expected to attend incidents at identified risk sites. This is particularly important for Crew/Watch Managers and flexi duty officers, who may have to take command at an incident. This should include an understanding of the hazards and risks associated with explosives and operational procedures.

Fireworks display operators

Sites owned and/or used by firework display operators must be treated as falling into the priority group for 7(2)(d) inspection, familiarisation, training etc.

When dealing with an incident at a display operator's site **all** structures including ISO containers should be treated as if they contain hazard division 1.1 explosives, unless there is reliable confirmation that they either contain no explosives or they only contain hazard division 1.4 explosives.

International Standards Organisation Transport Containers (ISO)

As a general rule, shipping containers should be treated with suspicion as they have become a convenient storage facility for all kinds of materials and are often unmarked. IC's must be cognisant that the external heating of a container could have adverse effects on the contents.

Fireground communications

(a) No radio frequency transmission is to be allowed within a radius of 10 metres from the electro explosive device (EED).

(b) Emergency services using vehicle borne sets with an effective radiated power (ERP) greater than 5 watts should not transmit within 50 metres of the damaged equipment.

(c) All non-essential transmitters should be either switched off or removed to a distance greater than 50 metres.

Ministry of Defence (MoD) establishments

The safety of explosives at any MoD site or whilst being transported, together with fire fighting recommendations is determined by the Explosives, Storage and Transport Committee of the MoD. FRS' must ensure: that effective and regular liaison is maintained with MoD establishments; that they are fully aware of the emergency procedures for the establishment ; that they make themselves aware of these procedures via good liaison with the sites to ensure that co-ordination with MoD personnel is arranged during pre-planning and before fire fighting.

Post incident

In incidents involving explosives it is possible for them to remain live post incident when buried under ash, even if they have been involved in a very intense fire. Unexploded parts may also have been projected some considerable distance. Simply stepping on these explosives, particularly detonators, can generate sufficient friction to set them off potentially causing severe injury. We would advise that entry into an explosives storage structure should not be undertaken until it can be confirmed by the duty holder that sufficient steps have been taken to identify and remove any live explosives.

ANNEX 1

Hazard Zones

The table below gives recommended minimum hazard zones for explosives related incidents based on the quantities of explosives that might be stored there.

As it may not always be possible to determine quantity at the early stage of the incident, decision making should always default to the minimum distance. As with any hazard zone, it can be increased or decreased once information or operational intervention dictates otherwise. It should be noted that all non essential personnel should be excluded form the hazard zone and all other FRS personnel withdrawing thereafter.

The term 'Hazard Zone' has been used instead of 'evacuation distance', Hazard Zone is a term which is common to FRS operations and should therefore ensure consistency of approach.

It should be noted that the distances have been increased from those set out in the regulations in premises 1 and 4, so that the minima and maxima are common.

Recommended minimum Harzard Zones for explosive related incidents			
Premises		**Storage**	
Type	Location	Maximum Quantity and Type	Recommended Minimum Hazard Zone
Registered for retail fireworks	Retail outlet within residential or industrial area	250 kg HD1.4	200m
Other registered premises	Retail outlet within residential or industrial area	30 kg HD1.1	200m
		100 kg HD1.3	
		250 kg HD1.4	
Licensed storage of fireworks	Not normally in built up area	Up to 2000 kg HD1.1, HD1.3 and/or HD1.4	600m
Licensed for storage by the Police	Generally remote e.g. Quarries	Up to 2000 kg Generally HD1.1	600m
Licensed site by HSE	Not normally built up area	Limited only by separation distances	Less than 2000kg 600m
			More than 2000kg 1000m

ANNEX 2

Classification codes

Description of substance or article to be classified	Compatibility Group	Classification Code
Primary explosive substance.	A	1.1A
Article containing a primary explosive substance and not containing two or more protective features.	B	1.1B 1.2B 1.4B
Propellant explosive substance or other deflagrating explosive substance or article containing such explosive substance.	C	1.1C 1.2C 1.3C 1.4C
Secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and containing two or more effective protective features.	D	1.1D 1.2D 1.4D 1.5D
Article containing a secondary detonating explosive substance without means of initiation, with a propelling charge (other than one containing a flammable liquid or gel or hypergolic liquids)	E	1.1E 1.2E 1.4E
Article containing a secondary detonating explosive substance without means of initiation, with a propelling charge (other than one containing a flammable liquid or gel or hypergolic liquids) or without a propelling charge.	F	1.1F 1.2F 1.3F 1.4F

Description of substance or article to be classified	Compatibility Group	Classification Code
Pyrotechnic substance or article containing a pyrotechnic substance, or article containing both an explosive substance and an illuminating, incendiary, tear or smoke producing substance (other than a water activated article or one containing white phosphorous phosphides, a pyrophoric substance, a flammable liquid or gel, or hypergolic liquids)	G	1.1G 1.2G 1.3G 1.4G
Article containing both an explosive substance and white phosphorous.	H	1.2H 1.3H
Article containing both an explosive substance and a flammable liquid or gel.	J	1.1J 1.2J 1.3J
Article containing both an explosive substance and a toxic chemical agent.	K	1.2K 1.3K
Explosive substance or article containing an explosive substance and presenting a special risk (e.g. due to water activation or presence of hypergolic liquids, phosphides or a pyrophoric substance) and needing isolation of each type.	L	1.1L 1.2L 1.3L
Articles containing only extremely insensitive detonating substances	N	1.6N
Substance or article so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder or prohibit firefighting or other emergency response efforts in the immediate vicinity of the package.	S	1.4S

ANNEX 3

Effects of exposure to explosive blast

The effects of exposure to any explosive blast are defined as 'modes. The degree of injury are broken down into three distinguishable areas, these are:

Primary blast injuries

Primary blast injuries are caused by the direct action of a blast wave on the body. The two most common injuries are eardrum rupture and lung haemorrhage. Lung haemorrhage is in fact the most likely cause of death in cases where primary blast effects prove fatal.

Secondary blast injuries

Secondary blast injuries are defined as those, which occur as a direct consequence of blast damage to buildings and structures. These injuries include lacerations caused by flying glass, blunt trauma caused by crushing and impact of falling masonry, and suffocation caused by asphyxiating dust. Secondary blast injuries can occur at significantly greater distances from an explosion than either primary or tertiary blast injuries, and indeed experience shows that structural collapse is the dominant mode of death and injury from explosions in built-up areas. Thus secondary blast injuries are normally related to degree of building damage.

Tertiary blast injuries

Tertiary blast injuries are defined as those resulting from body movement induced by the blast wave. Two modes may be distinguished:

- injuries caused by differential displacement of internal body organs following high acceleration
- injuries caused by impact when the body is either blown over or picked up by the blast wave and thrown against an object.

The second of these effects is sometimes called "whole body translation" or "whole body displacement". The extent of injuries caused by this effect is dependent on a number of factors, including: the velocity to which the body is accelerated, the part of the body which impacts the ground or object, the hardness of the ground or impacted object, and whether flailing of the limbs occurs as the body tumbles over the ground.

The constituents of explosives, especially fireworks, significantly varies, compounds such as metals, metal salts, chlorine donors, hydrocarbon fuels, and binders are incorporated into compositions, for colour or sound effects etc. Some of the constituents of fireworks are toxic. Unfortunately, literature relating to fireworks manufacture does not tend to cover this aspect in much detail. For example, most fireworks contain potassium perchlorate which in itself is an irritant to the mucous membrane, can have adverse effects to blood and/or the thyroid gland. There is insufficient information available as to the exposure quantities required, before ill health effects set in.

Effects of small explosions	
Quantity of explosive initiated (g)	**Effect of initiation**
1	Any person holding the explosives could receive serious injury.
10	Any person close to this quantity of explosives at the time of the initiation would receive very serious injuries.
100	Any persons standing approximately 1.5 metres away would be liable to a 1 per cent chance of eardrum rupture. 50 per cent of windows in the room (size 6m x 6m) likely to be blown out. Approximately 1 per cent chance of eardrum rupture at a distance of 3.5 metres. Approximately 50 per cent chance of eardrum rupture at 1.5 metres. Persons in very close proximity to the explosion (e.g. holding the explosives) almost certainly killed.
500	Inside a 6m x 6m brick building, structural collapse is most likely; considerable damage to panels between steel or concrete frames in other structures. Persons very close to the blast almost certainly killed. Persons close to the blast sustain lung and hearing damage, and injuries from fragmentation effects and being thrown bodily. Almost all persons in the room will sustain perforated eardrums.

ANNEX 4
Unsafe Explosives

1. Unsafe packaging of impact-sensitive items

Badly packaged impact-sensitive explosives items could be initiated by the knocks and jolts cargoes typically receive in transit. Such an accident occurred on a road vehicle in the UK as recently as 1989. The explosion caused one fatality and widespread damage.

2. Exudation of explosives material

Exudation is a problem mainly associated with nitroglycerine-based blasting explosives, which may, under certain conditions, exude free nitroglycerine, a substance sensitive to impact and friction. Possible causes of exudation include poor quality control during manufacture, exposure to water, prolonged storage, storage at incorrect temperature and pressure on explosives cartridges. Nitroglycerine-stained packages have been found on a number of occasions within magazines in the UK, and there has been one incident in the last 25 years in which exuding explosives were found on board a ship – the ship was scuttled to avoid the risk of unloading the material. Nitroglycerine-based blasting explosives are currently being phased out and replaced with inherently safer types of explosives.

3. Poor integrity of packaging

Poor integrity of packaging may result in spillage of explosives substances. This in turn may result in the ignition of fire in the event that the spillage is subjected to impact or friction, or the spillage falls through cracks in the floorboards of a vehicle and lands on a hot surface, such as an exhaust manifold. One or two minor explosives events have occurred within UK manufacturing sites in recent times, caused by vehicles running over spilt explosives material, but no such events have occurred during transport of packaged explosives goods.

4. Propellant with depleted stabiliser content

Nitrate-ester based propellants with depleted stabiliser content may ignite spontaneously through the process of autocatalytic decomposition. Within the last 25 years there have been several fires in UK storehouses caused by this process. Within the last 10 years there has been one incident of fire on a rail wagon caused by spontaneous ignition of nitrocellulose, a raw material used in the manufacture of propellants.

5. Leaks from munitions containing white phosphorus

Certain types of munitions contain white phosphorus, a substance that can spontaneously ignite on exposure to air. There have been at least two instances in the UK during the last 45 years when leaks from these munitions have resulted in ignition of fire during rail transport.

6. Munitions with contaminated components

Physical or chemical reactions between contaminants and explosives fillings may lead to the formation of heat-and impact-sensitive explosives crystals or compounds within munitions. These munitions may then become more susceptible to accidental initiation. Migration of sensitive compounds into screw threads and non-continuous welds may further increase the susceptibility of the munitions to accidental initiation by impact. There was a major explosion in a UK military port in 1950 caused by impact-induced ignition of a depth charge that had been sensitised by the presence of impurities in the main explosives filling. A similar accident occurred in Gibraltar a year later.

7. Munitions with cracked warheads

The explosives fillings of certain types of munitions are prone to cracking. Cracking may result in migration of explosives dust into screw threads and non-continuous welds within munitions, and this may increase the susceptibility of the munitions to accidental initiation in two ways:

- impact accidents may result in nipping of dust between metal surfaces and the presence of bare explosives crystals in the cracked surface may increase the chance of an initiation proceeding to full detonation
- The dangers posed by munitions with cracked warhead fillings are well recognised; such munitions are normally subject to Ordnance Board constraints, which would include restrictions on the height to which such munitions can be lifted.

8. Munitions with defective electrical components

Certain types of munitions, such as torpedoes, are equipped with power supplies. There is a possibility that electrical short circuits within these types of munitions may ignite fires which may in turn initiate explosives material. So far as is known, no such accidents have occurred in the UK in post-war times.

9. Spontaneous movement of sensitive items within munitions

Stresses are created when components are installed into certain types of munitions. An explosives event may occur if these stresses relieve spontaneously on some subsequent occasion. There have been a number of such accidents within UK storehouses, though, so far as is known, no such accidents have occurred in ports or during transport.

10. Defective electro explosives devices (EED)

EEDs that have been badly designed, manufactured or packaged, may be susceptible to initiation by radio frequency radiation. There have been a number of such accidents involving unpackaged items on firing ranges, though so far as is known, no such accidents have occurred in ports or during transport.

11. Fuse defects

Munitions fitted with defective fuses may be vulnerable to the sorts of knocks and jolts that cargoes typically receive while in transit. There are three ways in which the safety of a fuse may be compromised:

- mis-assembly in which the fuse is assembled in a manner which “short circuits” the intended safety features
- severe metal corrosion affecting components such as springs, shutters etc, making inoperative the safety features that rely on the correct functioning of these components
- chemical reaction in which the chemical composition of some of the explosives compounds are changed, making them more sensitive to external stimuli.

The above list has been compiled from available accident records and safety reports. It is not necessarily exhaustive, safety flaws in the design, manufacture, processing, keeping, packaging and conveyance of explosives sometimes only come to light after accidents have occurred; future accidents may reveal further types of unsafe explosives material.

Energetic accidents

Explosives cargoes which contain unsafe items may initiate spontaneously, i.e. without involvement of the cargoes in external accidents, such as lorry crashes and falls of loads from cranes. Explosives cargoes that do not contain unsafe items may initiate in the event that they become involved in accidents, such that sufficient energy is imparted to explosives material in the cargo to bring about an explosion or fire.

ANNEX 5

Some common examples of explosives and their uses

Nitroglycerine

A very powerful and extremely sensitive liquid explosive which is usually mixed with other inert materials to form propellant, dynamites and blasting gelatines. The liquid is particularly sensitive to heat, flame, shock, oxygen or UV radiation and is not transported or used in its pure form as it is too dangerous to handle. Some types of explosives containing nitroglycerine, such as dynamite, release nitroglycerine liquid when in contact with water. This can present particular dangers during firefighting or where the explosives are involved in flooding. Nitroglycerine is also transported and used either as a dilute solution in alcohol or as a mixture with a solid dilutent for pharmaceutical purposes.

Nitroglycerine – both the vapour and liquid (which is readily absorbed through the skin) are highly toxic.

T.N.T. (Trinitrotoluene)

A comparatively insensitive explosive mostly used for military purposes. It is a stable solid substance which is generally safe to handle. Small unconfined quantities may burn quietly but larger quantities, particularly under confinement, are likely to burn to detonation.

On decomposition, toxic fumes are given off. It is moderately toxic by ingestion and can be absorbed through the skin.

Nitrocellulose (guncotton, pyrocotton, nitrocotton).

Nitrocellulose is a white or cream coloured fibrous material produced in a range of forms. Its properties depend on the amount of nitrogen in it. Types with a nitrogen level above 12.6% nitrogen are generally used in explosives manufacture. Those below that are used for other purposes. Nitrocellulose is sensitive to impact and friction and easy to ignite by flame when dry and is therefore normally transported either wetted with water or alcohol or plasticised. Explosives grade nitrocellulose can present a fire or explosion hazard depending on its level of dryness and whether it is confined. Non-explosives grade nitrocellulose will normally burn and is often classified as a class 4.1 flammable solid. Its principal uses are as an ingredient in propellant mixtures for ammunition and rocket motors, and in nitroglycerine explosives. Non-explosive grades of cellulose nitrate are used with other substances in the manufacture of paints and lacquers.

Small arms propellant powders

These materials are usually made from nitrocellulose (single base) or nitro-cellulose with nitroglycerine (double base) and are usually in the form of a free flowing granular material. For the most part they burn fiercely but many types can, under confinement, burn to detonation. As a consequence the hazard can be either a fireball or a mass explosion.

Primary explosives such as Fulminates, Azides, and Styphnates

These are initiating explosives which are highly sensitive and dangerous particularly when they contain heavy metals such as lead, silver or mercury. They explode violently and are commonly used in initiators such as detonators and cap compositions. These types of explosive are infrequently transported and are only carried when wetted with water or other suitable liquid to minimise their sensitivity to impact and friction. Transport packages are carefully designed to minimise the risk of leakage of wetting agents and the consequent drying of the explosive. Some forms of these substances, such as styphnic acid or potassium azide, have low explosive properties. These substances can, however, react with other substances such as copper or lead salts to form the highly dangerous forms. This can be a serious problem where these substances have been spilled and allowed to get in contact with copper, lead or other reactive species. Because the sensitive forms tend not to dissolve in water, a hazard could rapidly develop.

Gunpowder/Black powder/Black blasting powder

These are generally made from a mixture of charcoal, sulphur and potassium nitrate and are frequently described as 'low explosives'. They are very sensitive to ignition from sparks, heat and friction. They burn violently even when loose and uncompressed and when confined may explode. They also release volumes of smoke on burning or exploding. Black powder is used as a blasting explosive as well as an ingredient in some types of sporting cartridges, fireworks and pyrotechnics.

Oxidisers

These substances are not explosives in their own right but can, under certain conditions in a fire, explode. Two types commonly used in explosives are worthy of comment.

Nitrates

Nitrates are used in explosives such as gunpowder, emulsion and slurry blasting explosives and pyrotechnic substances. The most common are potassium, sodium, barium and ammonium nitrates. If mixed with a fuel these compounds can burn fiercely or explode. Wood, if impregnated with oxidisers, can burn fiercely and this can be a potential problem on vehicles with wooden floors or in wooden storage buildings where oxidisers have been transported or stored. Care must be taken in warehouses to ensure that oxidisers are segregated from other dangerous goods.

Ammonium Nitrate is used as a fertiliser and is commonly found in farming areas. It is usually supplied as a porous prill which can readily absorb liquids. It forms the basis of Ammonium Nitrate and Fuel Oil (ANFO) explosives much used by terrorist organisations. It is possible that other fuels such as saw dust and metal powders could also form explosive mixtures with ammonium nitrate. There have been a small number of reports throughout the world of nitrates exploding without other chemicals being present when confined or subject to severe heat. In recognition of this danger, the size of stacks of ammonium nitrate in storage is normally carefully controlled.

Chlorates

These substances, mostly in the form of potassium chlorate, are mostly used in pyrotechnic compositions. As with nitrates, chlorates can decompose violently in a fire, particularly if mixed with fuels. As a general rule, chlorates are more aggressive and less stable in a fire than nitrates.

Emulsion and slurry explosives are relatively new type of explosives which are mixtures of nitrates and other substances often in a water-based system. They are now replacing nitroglycerine based explosives for many uses, particularly in quarrying. A small proportion of emulsion and slurry explosives are produced as pre-packed, ready to use, products. The majority of this type of explosives, however, is manufactured at the shot hole, immediately prior to use. This mixing is carried out on a specially designed mixer truck which carries the necessary ingredients for producing a fully active explosive.

Apart from the oxidisers mentioned above some organic peroxides have explosion subsidiary risks. Also, ammonium nitrate can give off a lot of NO_x in a fire.

ANNEX 6
Danger Labels

Divisions 1.1, 1.2 and 1.3

Division 1.4

Division 1.5

Division 1.6

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Notes

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