Guidance for the Safe Management of the Disposal of Explosives
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A guide to the safe disposal of explosives, the relevant legislation, the techniques used for disposal and associated risk control systems

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SECTION 1  FOREWORD

1.1 This Guide has been produced by a joint working party of the Explosives Industry Group of the Confederation of British Industry, including the Ministry of Defence and the Health and Safety Executive. Its work has also been supported by the Department of Environment Food and Rural Affairs, the Environment Agency and Merseyside Fire and Rescue Service.

1.2 Whilst every effort has been made to cover appropriate legislation, regulations and good practice when this guide went to print, neither the CBI nor its servants or agents can accept responsibility for, or liabilities incurred directly or indirectly as a result of any errors or omissions in this Guide. Those involved in the explosives industry are responsible for taking their own legal and other advice as they see fit. Readers are strongly advised to check whether there is any change in legislation or regulation since the publication of this Guide.

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1.4 This guide is not intended to be used as a technical manual by those inexperienced in the management of the disposal and destruction of explosives, to enable them to carry out disposal or destruction activities. Those not experienced in the management of the disposal and destruction of explosives should seek expert assistance.

1.5 This guide is not intended to be used as a technical manual for “Bomb Disposal”, Explosives Ordnance Disposal (EOD) or Improvised Explosive Device Disposal (IEDD). The guidance presented in no way supersedes any local or national arrangements in place for the deployment of military or Metropolitan Police EOD assets in support of the work of the civil authorities or the general public.

1.6 This guide is not intended to be used to provide guidance in the safe decommissioning of explosive sites, focusing on plant, equipment and buildings. Previous guidance in relation to these matters has already been published by the CBI Explosives Industry Group as Management Guidance for the Safe Decommissioning of Explosives Sites (ISBN 085201-598-4).
SECTION 2  INTRODUCTION

2.1 The history of explosives manufacture has seen the production of a diverse range of explosive compounds such as nitroglycerine, nitrocellulose, TNT, PETN, RDX, HMX and metallic azides. The explosives industry has also manufactured and used a range of explosive mixtures such as blackpowder, pyrotechnics, slurries and emulsions and has manufactured and/or used a wide range of explosive articles such as detonators, shells, mines, bombs, flares, smokes and fireworks.

2.2 The health and safety issues associated with explosive materials tend to be well known but the potential impacts on the environment may be less certain. Many explosives are complex organic chemicals that do not readily degrade in the environment and may therefore prevent an explosive risk for many years if not disposed of appropriately. In addition many compounds can produce complex by-products during their manufacture or during their natural degradation.

2.3 Despite a general decline in the size of the explosives industry as an employer, explosive substances and articles continue to have a wide range of uses in both civil applications and military fields. Their uses can range from the obvious such as warheads for weapons, blasting explosives and accessories, fireworks and flares; through to the more obscure such as in components of fire fighting systems and vehicle safety restraint systems. Given that explosives will continue to be used in a wide range of applications into the future there will be a continuing requirement for the disposal and destruction of explosives substances and articles.

A search of the HSE/MoD EIDAS Database has identified 371 incidents that have occurred during the disposal of explosives since 1950.

Examples of these incidents have been included in this document to illustrate the issues involved in the disposal of explosives, the applicability of the guidance and some of the lessons, usually painful, that have been learned in the past.

2.4 Regulation 6(1) of the Manufacture and Storage of Explosives Regulations 2005 (MSER) requires that “Any person who disposes of explosives shall ensure, so far as is reasonably practicable, that they are disposed of safely.” It is therefore necessary for sites licensed and registered under the Manufacture and Storage of Explosives Regulations 2005 and for any other person manufacturing, storing or using explosives to have in place arrangements for the management of the disposal and destruction of explosives and materials contaminated with such.

2.5 The explosives industry uses terms that apply in everyday language and to avoid danger of misinterpretation, the following definitions, at 2.5.1 to
2.5.3 are included at the outset for clarity and will apply throughout this document;

2.5.1 Explosives requiring disposal or destruction include: -

- explosive substances or articles generated as an unwanted by-product during manufacturing processes, storage or use;

- materials contaminated by explosives substances or articles to such a degree that they are believed to present an enhanced risk of fire or explosion;

- explosives articles and substances that are no longer required by the person holding them;

- explosive substances that no longer have a market or use, or that have been withdrawn from the market for whatever reason.

2.5.2 For the purposes of this guidance the definition of “disposal” of explosives is taken to be the destruction of the explosives or explosives contaminated materials; otherwise rendering them permanently explosively inert; or the safe and legal transfer of the explosives or explosives contaminated material to another competent party. It will be seen that this definition is wider than that given in the MSER 2005.

2.5.3 For the purposes of this guidance the destruction of explosive items and substances or explosive contaminated materials is defined as being any treatment which, at its completion, will have rendered the explosives or explosives contaminated materials permanently explosively inert. In an explosives context this will include permanently eliminating those properties of the items, substances or contaminated materials that would cause them to be considered, in broad terms, an explosive.
SECTION 3  AIM OF THIS GUIDE

3.1 Paragraph 428 of the Approved Code of Practice and Guidance (ACOP) to the Manufacture and Storage of Explosives Regulations 2005 (MSER) states

“Explosives must be disposed of safely and not as general waste. Waste explosives may only be disposed of in a designated disposal area with facilities appropriate to the type and quantity of explosives to be destroyed. A safe system of work must be in place, and suitable training must be provided for the people involved in the disposal of explosives”

3.2 The aim of this guide is to provide guidance on the safe management of explosives requiring disposal or destruction. The guide provides an overview and highlights issues that need to be considered when planning and undertaking such activities. The guide also provides some more detailed technical advice on how to manage particular aspects of the disposal and destruction processes. The disposal of military or war-like ammunition that combine an explosive and a shrapnel or fragmentation effect is often treated as a specialist field within explosives work and this guidance only considers the underlying principles associated with the disposal of such materials.

3.3 The reader is reminded of the previous comments with respect to “bomb disposal” at paragraph 1.5.

3.4 The guidance focuses on those aspects of the explosives industry that are specific to explosives hazards, and does not attempt to deal in detail with health and safety issues that are common to other operations such as noise at work and manual handling as guidance to these issues is available in other publications.

3.5 Para 429 of the ACOP to MSER states

“Anyone disposing of explosives should be aware that they have duties to do so in a way that is not harmful to the environment. If in doubt, further information and advice may be obtained from the Environment Agency (England and Wales) or the Scottish Environment Protection Agency.”

3.6 In addition to health and safety and other management requirements, the environmental implications of the disposal and destruction of explosives are considered in brief. It is not the intention of the guide to cover these issues in detail, and the reader is directed to other sources of information, including publications, professional advice and the environmental regulators.

3.7 This guidance is aimed at those responsible for the management of the disposal and destruction of explosives and the planning and implementation of disposal activities at licensed explosives sites and their advisors. It is also aimed at professional explosives users such as firework display operators, demolition operators and shot firers.
3.8 The guidance may be of interest to regulatory authorities and emergency services such as the Police, Fire Brigades, Local Authority Trading Standards Officers particularly when those authorities fulfil a regulatory role under the Manufacture and Storage of Explosives Regulations 2005. This guidance may also be of interest to other Government or Regulatory Agencies such as the Coastguard as well as for Waste Disposal Operators who may be called upon to manage waste explosives and explosives contaminated waste as part of their work activities.
SECTION 4 LEGISLATIVE REQUIREMENTS

4.1 The aim of this section is to provide a general overview of the key health and safety requirements that apply to the disposal of explosives. Further, in this section reference will be made to environmental legislation, the aim is to make the reader aware of its existence but not to provide detailed guidance since this already exists in other published references.

4.2. Health and Safety Requirements

4.2.1 There is a considerable amount of health and safety legislation, which has a bearing on the management of explosives requiring disposal and/or destruction but there is no specific set of regulations dealing solely with this activity in detail. The list below demonstrates the principal legislation dealing with the management of explosives requiring disposal and/or destruction.

- Manufacture and Storage of Explosives Regulations 2005
- The Explosives Act 1875
- Health and Safety at Work etc Act 1974
- Classification and Labelling of Explosives Regulations 1983.
- Control of Noise at Work Regulations 2005
- Electricity at Work Regulations 1989
- The Control of Explosives Regulations 1991
- Workplace (Health, Safety and Welfare) Regulations 1992
- Personal Protective Equipment at Work Regulations 1992
- Placing on the Market and Supervision of Transfers of Explosives Regulations 1993
- Provision and Use of Work Equipment Regulations 1998
- Lifting Operations and Lifting Equipment Regulations 1998
- Management of Health and Safety at Work Regulations 1999
- Control of Major Accident Hazard Regulations 1999
- Control of Substances Hazardous to Health Regulations 2002
- Control of Lead at Work Regulations 2002
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Carriage of Dangerous Goods and Use of Transportable Pressure Vessels Regulations 2004 (CDG 2004)

- Chemicals (Hazard Information and Packaging for Supply Regulations) 2002 (CHIP 3)

4.2.3 Annex A contains a brief description of the relevance of each of the regulations detailed above.
4.3 Environmental Legislation

4.3.1 Overview

4.3.1.1 The following sections are not intended to be a comprehensive guide to environmental legislation and its application to the disposal or destruction of explosives and materials contaminated with explosives. Compliance with the law remains the responsibility of those involved in the disposal and destruction of explosives.

4.3.1.2 There are many aspects of the disposal and destruction of explosives that can have an impact on the environment, directly or indirectly, and which may be subject to statutory control, for example:

- Vehicle movements – noise, dirt and disruption to the locality;
- Wastes – keeping, treating or disposal of liquid and solid wastes on and off site;
- Effluvia – smoke, odours, discharges to watercourses;
- Any activity which may create nuisance, smoke, odours, noise etc;
- Existing statutory controls on prescribed process – IPC, LAPC, PPC etc;
- Contamination of land, surface water and groundwater.

The disposal of explosives by burning is currently subject to the provisions of the **Clean Air (Emission of Dark Smoke (Exemption) Regulations 1969 (SI/1969/1263)).**

4.3.1.3 Once the scope of the activity has been defined, operators embarking on a disposal or destruction of explosives should consult with the appropriate authorities to ensure that appropriate controls, permissions and/or consents are obtained before starting work.

4.3.1.4 The Environment Agency (EA) in England and Wales, the Scottish Environment Protection Agency (SEPA) in Scotland and the Environment and Heritage Service in Northern Ireland, are the regulatory authority for waste management activities, regulation of discharges to controlled waters, IPC/PPC (Part A (1)) and designated Part IIA special sites.

4.3.1.5 It is also advisable to contact the local authority in whose area the site is situated to discuss the proposals for the site.

4.3.2 Statutory Nuisance

4.3.2.1 There are a number of Acts and Regulations, which vary across the UK, which incorporate some element of nuisance. If any aspect of the disposal or destruction process generates noise, smoke, fumes, gas, dust, steam, odours, deposits or accumulations of refuze which affects the health of people in the locality or adversely affects their legitimate use of land, these could be subject to statutory control. Such activities may attract complaints, either directly or to the Environmental Health Office of the Local Authority. It
is good management practice to have in place procedures for monitoring activities which may impact on the wider population and to take measures to reduce or eliminate where possible such impacts.

4.3.2.2 It should however be noted that Section 79(2) of the Environmental Protection Act 1990 specifically excludes smoke and noise from the definition of statutory nuisance in certain circumstances.

4.3.3 Wastes

4.3.3.1 In the majority of instances following the disposal or destruction process 'directive waste' will be generated. (Directive waste is often referred to as 'controlled waste', or 'industrial' waste in the waste industry.) Once this waste has been certified free from explosives hazard, UK Statutory waste management legislation will apply. Where the operation will keep (store), treat or finally dispose of waste, then the relevant environmental regulator should be contacted to establish whether a Waste Management Licence or Permit is required.

4.3.3.2 Where waste that has been certified free from an explosive hazard is destined for landfill it has to be classified as 'hazardous' or 'non-hazardous' according to the requirements of the Hazardous Waste Regulations 2005. It may also be necessary to additionally determine whether waste is 'stable non-reactive hazardous waste', a biodegradable waste, or an inert waste in order for it to be sent to the correct type of landfill. There will also be requirements for waste to have been 'pre-treated' and for it to meet the relevant 'Waste Acceptance Criteria'.

4.3.3.3 If there is uncertainty as to whether the activity will generate 'directive waste' or hazardous wastes, advice can be obtained by contact with the environmental regulator or by following the Hazardous Waste Assessment framework found in the EA Hazardous Waste Guidance Note WM2. This document is available from the Environment Agency web site at www.environment-agency.gov.uk/subjects/waste/1019330/1217981/1384307/

Waste that comprises an explosive hazard should not be disposed of to landfill.

4.3.3.4 A company involved in disposal and destruction activities has a Duty of Care to take all reasonable measures:

- To prevent the unauthorised or harmful disposal of waste by another person.
- To prevent the escape of the waste from the company’s or any other person's control.
- On the transfer of the waste, to secure:
that the transfer is only to an authorised person or to a person for authorised transport purposes; and

that there is transferred such a written description of the waste as will enable other persons to avoid the unauthorised or harmful disposal of the waste and to comply with their own Duty of Care.

4.3.3.5 The proper and safe disposal of waste even after it has been passed on to another party such as a waste contractor, scrap merchant, recycler, local council or skip hire company must be ensured. The Duty of Care has no time limit, and extends until the waste has either been disposed of or fully recovered.

4.3.4 Controlled Processes

4.3.4.1 The activities which are carried out may be controlled processes under the Environmental Protection Act, 1990 e.g. IPC, LAPC and the Pollution Prevention and Control Regulations 2000 (PPC), as amended. Under these regimes there is a general requirement to apply Best Available Techniques through good management in the form of:

- preventive maintenance;
- proper operation and supervision of processes (including associated pollution control equipment);
- proper training and instruction of all staff;
- good housekeeping;
- minimising pollution that might arise during delivery, storage and handling of materials.

In addition PPC increases the emphasis on accident prevention, energy efficiency and waste reduction.

4.3.4.2 Since new regulations were introduced in 2000, existing processes are being phased into the Integrated Pollution Prevention and Control (IPPC) regime.

Useful information can be obtained from the Best Available Techniques Briefing Notes (BREFS) located at http://www.sepa.org.uk/ppc/brefs/ and the UK Sector Guidance Notes Available at www.environment-agency.gov.uk/business/444217/444663/298441/.

4.3.5 Pollution of Controlled Waters

4.3.5.1 Under S85 of the Water Resources Act (WRA) 1991 it is an offence to cause or knowingly permit pollution (poisonous, noxious or polluting matter or any solid waste matter) to enter controlled waters.
Controlled waters include rivers, lakes, ponds, lochs, docks, streams, canals, coastal waters, estuaries and groundwater. The environment agencies regulate discharges to controlled waters, for which authorisation is required. These usually stipulate that discharges should be free of polluting matter, but may also set limits on the concentrations of specific substances with a requirement to monitor and report the quality of the discharge.

4.3.5.2 Activities ancillary to the destruction of explosives by burning, such as the damping down of hearths (either by the use of a hose or similar or by the use of natural phenomena such as rainfall), will generate water run-off that would have the potential to pollute controlled waters. Care therefore should be taken when designing and identifying the locations of disposal areas to prevent run-off contaminating controlled waters. For example it would not generally be appropriate to locate a burning area near to a groundwater extraction borehole.

4.3.5.3 The environmental regulator has the power to serve a Works Notice (s161A WRA1991) to prevent or remedy water pollution. Such notices can be served before pollution has occurred if, in the opinion of the regulator, a polluting substance is likely to enter controlled waters. The regulator may also serve a Works Notice to ensure that waters are cleaned up after pollution has occurred. (This only applies in England and Wales)

4.3.5.4 Some useful guidance for the construction industry has been produced by CIRIA in conjunction with the Department for Trade and Industry and the Environment Agency – “Guide to good practice on site”.

4.3.6 Contaminated Land

4.3.6.1 Where land is contaminated in its current state, regulatory control may apply through Part IIA EPA 1990. Part IIA defines land, which

“appears to the local authority in whose area it is situated to be in such a condition, by reason of substance in, on or under the land, that significant harm is being caused; or pollution of controlled water is being, or is likely to be caused.”

Statutory guidance for this describes regulatory responsibilities for identifying contaminated land and securing its remediation.

4.3.6.2 Where land is found to be a ‘special site’, EA/SEPA take over regulatory responsibility from the local authority. Special sites are described in the Environmental Protection Act 1990 and include “land on which any of the following activities have been carried on at any time – the manufacture or processing of explosives.”

4.3.6.3 The enforcing authority is required to seek remediation of the land wherever possible by the ‘appropriate person’ i.e. the one who caused or
knowingly permitted the land to be contaminated land, or in some cases the 
owner/occupier of the land.

4.3.6.4 It is in the interests of those who may be responsible for 
contamination, or who own land where contamination may be present, to seek 
advice to identify and deal with contamination.

4.3.6.5 When buying, selling or leasing land that could be affected by 
contamination, it is important to be aware of possible implications and 
liabilities associated with contamination.

4.3.6.6 Where land is to be redeveloped for a new land use, the local 
planning authority is responsible for regulating the development of the land, 
under the planning regime set out in the Town and Country Planning Acts.

4.3.7 Records

4.3.7.1 Many items of environmental legislation require the keeping of 
records. In addition, it is good management practice to prepare and maintain 
good records of your activities, particularly where the objectives for the 
disposal and destruction of explosives include the sale of the site. Records of 
what has been done to land and buildings, and verification of their condition, 
can increase confidence for potential purchasers.

4.3.8 Guidance

A great deal of useful information on environmental legislation can be 
obtained from the following two sources: -

- The “NetRegs “website (address below) is sponsored by the EA, SEPA 
  and the Environment and Heritage Service (Northern Ireland) and 
  provides guidance on many aspects of environmental legislation for 
  small and medium sized businesses.

  - http://www.environment-agency.gov.uk/netregs/

- The Pollution Handbook published by the National Society for Clean Air 
  and Environmental Protection, ISBN 0 9034 7453 0, is revised annually 
  and contains useful summaries of most aspects of environmental 
  legislation.
SECTION 5 SAFETY MANAGEMENT SYSTEMS

5.1 Overview

5.1.1 Disposal and destruction activities in the explosives industry are high hazard and comprise one of the main causes of accidents and incidents in explosives work. Many incidents do not involve injury but injuries and deaths have nevertheless occurred. Incidents can happen because of:

- a failure to recognise that explosives requiring disposal or destruction are accumulating in process or storage areas.

- casual attitudes when dealing with the disposal and destruction of explosives often arising out of a lack of competence or a failure to properly supervise, inspect and audit the disposal activity;

- people not appreciating the properties and behaviour of explosives under certain conditions (products requiring disposal or destruction may be unusually sensitive due to changes in rheology and morphology, deterioration, contamination or inadequate stabilisation);

- ill-considered systems of work or no basic safety precautions often arising out of a failure to conduct suitable and sufficient risk assessments or a failure to follow prescribed procedures;

There is also a risk of insufficient time and money being devoted to disposal and destruction activities because of the potentially non-productive, non-profit making nature of the job.

While clearing out the stock room at a theatre, a man came across some old flash powder, used for stage effects, which he was instructed to destroy. This he was doing by putting a little at a time into an empty drum and igniting it, when there was a sudden explosion which injured him severely. It is considered possible that some of the flash powder had caked into a solid lump, and this exploded on falling into the drum.

5.1.2 A fully developed and functional safety management system (SMS) is essential to ensure that all aspects of the work are conducted in a safe manner. It is not the intention here to prescribe in detail the elementary aspects of SMS since this information is readily available in HSE publications and guidance.

5.1.3 The key elements of successful health and safety management, with particular reference to the disposal and destruction of explosives are set out in the summary below. Diagram 1 outlines the relationship between them. Guidance on aspects of these elements can be found in later sections of this document.
5.2 Policy

5.2.1 Effective health and safety policies set a clear direction for an organisation contemplating or conducting disposal and destruction activities to follow. They contribute to all aspects of business performance as part of a demonstrable commitment to continuous improvement. Responsibilities to people and the environment should be met in ways that fulfil the spirit and letter of the law. Stakeholders' expectations in the activity (whether they are shareholders, employees, or their representatives, customers or society at large) should be satisfied. There are cost-effective approaches to preserving and developing physical and human resources, which reduce financial losses and liabilities.

5.2.3 Effective health and safety policies can have a significant effect on the control and reduction of risks generated by the disposal and destruction of explosives and the management of associated processes.

5.2.4 Schedule 1 to the Management of Health and Safety at Work Regulations 1999 identifies that risks should be controlled by

a) Avoiding risks;
b) Evaluating risks that cannot be avoided;
c) Combating the risks at source;
d) Adapting the work to the individual, especially as regards the design of work places, the choice of work equipment and the choice of working and productive methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;
e) Replacing the dangerous by the non-dangerous or the less dangerous;
f) Developing a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;
g) Giving collective protection measures priority over individual protective measures;
h) Giving appropriate instructions to employees.

5.2.5 Health and safety policies should reflect the hierarchy implicit in these principles and systems of work should be developed throughout an organisation in order to achieve these objectives throughout the procurement cycle.

For example: -

- the selection of competent persons to carry out manufacture, storage and use activities can eliminate or reduce the requirements to dispose of or destroy explosives.
• in both manufacturing and storage, systems and techniques can be designed to eliminate or minimise both waste and any requirement to store and/or rework materials that do not meet specification.

5.2.6 Robust quality assurance and quality control procedures can identify problems at source such that the requirement to manage the storage and destruction of explosives requiring disposal is minimised. The standard of such systems should not only be important to manufacturers of explosives but also to importers, wholesalers, users and others in the supply chain who may be called upon to manage explosives. Taking this into account as part of a policy for identifying suppliers for both explosive articles and explosive substances can reduce the requirement to manage or re-work off specification material etc.

5.2.7 It is also important that clear policies are in place such that likely demand for a product is taken into account during manufacture or purchase. As well as having a significant business cost, holdings of explosives for which there is effectively no market or potential use will result in unnecessary disposal or destruction operations having to take place. Such holdings may also result in inadequate licensed storage space being available for explosives for which there is a business or other requirement.

5.3 Organising

5.3.1 An effective management structure and arrangements should be in place for delivering the policy. All staff should be motivated and empowered to work safely and to protect their long-term health, not simply to avoid accidents. The arrangements should be:

• underpinned by effective staff involvement and participation; and

• sustained by effective communication and the promotion of competence which allows all employees and their representatives to make a responsible and informed contribution to the health and safety effort.

5.3.2 There should be a shared common understanding of the organisation's vision, values and beliefs. A positive health and safety culture should be fostered by the visible and active leadership of all supervisors, including senior managers.

5.3.3 An effective structure and arrangements will operate at different levels during the management of explosives requiring disposal or destruction. Not only will it be evident in implementing the high level risk control systems identified in support of the policy but it should be closely involved in organising and supervising the day-to-day management of disposal and destruction related activities.
5.3.4 Evidence from accidents involving the disposal or destruction of explosives indicates that a high degree of supervision is required to ensure that competence is maintained, effective communication takes place and that unnecessary deviation from prescribed procedures does not occur.

5.4 Planning & Implementation

5.4.1 There should be a planned and systematic approach to implementing the health and safety policy through an effective health and safety management system. The aim is to minimise risks. Risk assessment methods are used to decide on priorities and to set objectives for eliminating hazards and reducing risks. Wherever possible, risks should be eliminated through selection and design of facilities, equipment and processes. If risks cannot be eliminated, they should be minimised by the use of physical controls or, as a last resort, through systems of work and personal protective equipment. Performance standards should be established and used for measuring achievement. Specific actions to promote a positive health and safety culture should be identified.

5.4.2 An important part of planning is risk assessment, which is introduced in Section 6.

5.4.3 As has been previously stated the aim of a planned and systematic approach to implementing the health and safety policy is to minimise risks.

5.4.4 Health and safety policies should reflect this hierarchy and systems of work should be developed in order to achieve the control of risks at source wherever they are generated in the procurement cycle not only during disposal or destruction activities.

For example: -

- Methods for elimination or minimization of the generation of explosives requiring disposal or destruction should be considered, identified, assessed and where appropriate implemented as part of the design processes not only for the explosives themselves but also with respect to any plant, equipment and facilities used in their manufacture and storage. One example of such an approach could include washing out process equipment with a suitable solvent during the manufacturing process such that explosives requiring disposal or destruction do not accumulate in the plant.

- The disposal of substances and articles should be considered prior to manufacture or procurement and appropriate methods identified for their disposal or destruction.

- Systems should be in place that will identify when and how unexpected quantities of material requiring disposal or destruction are generated.
and will ensure that actions necessary to correct any deficiencies are taken.

- Sizes of pre-production runs, trial, quality assurance and quality control samples should be limited to those necessary for the tasks identified.

- In both manufacture and procurement the application of quality control and quality assurance procedures, including the employment of appropriate supervision and competent persons can eliminate or minimize the manufacture or supply of off-specification material that will require disposal or destruction and for the certification of any residual material as being free from explosives.

- The selection and use of analytical techniques that minimises the size of quality assurance and quality control samples can significantly reduce the requirement to transport, store and subsequently dispose of or destroy excess material.

- Both manufacture and procurement should be matched, so far as is reasonably practicable to the likely requirement for the substance or article. This should take into account shelf life and any re-lifeing procedures as well as foreseeable demand.

- Only competent persons, aware of the implications of generating explosives that will require disposal or destruction should be employed in the manufacture, storage, transport and use of explosives.

5.4.5 It is fundamental to safety that the disposal and destruction of explosives as well as the various activities that lead up to disposal or destruction are planned and actively managed. The objectives of a safety management system with respect to the disposal and destruction of explosives should be intended to achieve: -

- The identification of all processes, process elements and locations that are involved in the generation, accumulation and storage, and transport of explosives for disposal or destruction.

- The provision of plant and systems of work for activities involving the generation, accumulation and storage of explosives requiring disposal or destruction that are, so far as is reasonably practicable, safe.

- The identification of all processes, process elements and locations that are involved in the actual disposal or destruction of explosives.

- The provision of plant and systems of work for activities involving the actual disposal or destruction of explosives that are, so far as is reasonably practicable, safe.
5.4.6 The planning and implementation of a safety management system should also include the production of systems of monitoring, inspection and audit that will:

- Identify whether the plant and systems of work provided; including the management arrangements, risk control systems, workplace precautions, written instructions and procedures; are adequate to control, so far as is reasonable practicable the risks to safety arising out of the generation, accumulation, storage and transport of explosives for disposal or destruction as well as for the actual disposal and destruction activities.

- Identify so far as is reasonably practicable the extent of compliance with the provided plant and systems of work (including the management arrangements, risk control systems and performance standards) of activities involving the generation, accumulation and storage of explosives for disposal and destruction, as well as the actual disposal and destruction activities themselves,

5.4.7 Similar objectives should also be in place to control risks to persons’ health and to the environment.

5.4.8 Essentially therefore it is necessary to define the system and the relevant inputs and outputs that lead to a requirement to dispose of or destroy explosives. This can be achieved by a number of techniques, one of which is a process flow map. Examples of process flow maps can be found in Annex B.

5.4.9 Each task or step in the process flow should be subjected to a hazard analysis and an assessment of the associated risks. It may be that the nature and degree of risks associated with several steps are so similar that they can be covered by a single risk assessment. Risk assessment is an essential part of planning and implementing a safety management system and is introduced in Section 6.

5.4.10 It is important that risk assessments are developed into workable procedures that contain sufficient detail and prescription to meet not only the requirement for operators to carry out tasks safely but also meets the requirement on supervisors and other persons with an monitoring or auditing role to identify when any basis of safety will be or has been departed from. Examples of the information that would be expected to be found in a procedure for a disposal or destruction area can be found at Section 13.8 of this document.

5.5 Measuring performance

5.5.1 Performance should be measured against agreed standards to reveal when and where improvement is needed. Active self-monitoring reveals how effectively the health and safety management system is functioning. This looks at both hardware (premises, plant and substances) and software
(people, procedures and systems) including individual behaviour and performance. If controls fail, reactive monitoring discovers why, by investigating accidents, ill health or incidents, which could cause harm or loss. The objectives of active and reactive monitoring are:

- to determine the immediate causes of sub-standard performance; and
- to identify the underlying causes and the implications for the design and operation of the health and safety management system.

Longer-term objectives are also monitored.

5.5.2 One of the key methods for ensuring that systems for measuring and monitoring performance is workplace inspection by operators, line managers and those with an internal role in ensuring regulatory compliance such as Safety, Health and Environment Advisors.

5.6 Auditing and reviewing performance

5.6.1 The organisation should learn from all relevant experience and apply the lessons. There should be a systematic review of performance based on data from monitoring and from independent audits of the whole health and safety management system. These form the basis of self-regulation and of complying with sections 2 to 6 of the Health and Safety at Work etc Act 1974 (HSW Act) and other relevant statutory provisions. There should be a strong commitment to continuous improvement involving the constant development of policies, systems and techniques of risk control. Performance should be assessed by:

- internal reference to key performance indicators such as:
  - the quantity i.e. mass of explosives or number of articles awaiting disposal
  - the quantity of explosives disposed of or destroyed
  - the number of destruction or disposal operations that have to take place including those that result from failures in quality systems
  - the quantity of “directive” or “controlled” waste produced as a consequence of disposal or destruction operations
  - the quantity of explosives failing to meet a prescribed quality standard.
- external comparison with the performance of business competitors and best practice, irrespective of employment sector.

5.6.2 Performance is also often recorded in annual reports.
Diagram 1  The key elements of successful health and safety management

Policy objectives can include:
- Improving competence in disposal
- Improving safety through the systematic identification of hazards and the provision of a safe system of work.
- Preventing uncontrolled events and ensuring that any that do occur are properly reported and investigated.
- Minimising the generation of explosives requiring disposal.

Organising - Communication
- Written systems with a clear methodology as to how to carry out tasks and that identify hazards and associated controls.
- Keeping records and sharing experiences.

Organising – Competence
- Operators must be suitably qualified to carry out tasks, and provided with good and thorough training.
- Route available to obtain “expert” help.
- Trained supervision.

Organising – Control
- Clearly allocated roles and responsibilities for the design, implementation and monitoring of the individual tasks and the system as a whole.

Organising – Co-operation
- High user involvement in the development and operation of the system.
- Consider a team approach to ensure standards.

Establish Rules and Performance standards which identify
- Why the system is necessary and how it has been designed to work.
- Who does what and who is responsible for what.
- What materials are covered by the system.

- Check operation of procedures against process criteria.
- Establish investigation procedure to check performance against relevant standards.
- Carry out checks on the quality of the operation and service provided.
- Establish measure of performance.

- Review and analyse information and data from operation of the system.
- Review and analyse data from investigations.
- Identify lessons learnt from operation of the system or investigations.
- Identify areas for improvement.
SECTION 6  RISK ASSESSMENT

6.1 Key Messages

6.1.1 There is a requirement for risk assessments to be used to develop appropriate hazard and risk control measures and workplace precautions. This requirement should form part of a developed and functional SMS.

6.1.2 Those carrying out risk assessments, work involving explosives requiring disposal or destruction and the management thereof should be experienced, trained and competent to carry out their assigned tasks as well as being competent to make any necessary decisions.

6.1.3 Incidents have identified that close supervision is fundamental to the safe operation of disposal and destruction activities. It is therefore important that the risk assessment or the associated written procedures include the checks that are in place to ensure that the necessary controls to prevent or mitigate an event are in place and are operating.

6.1.4 Incident histories indicate that procedural controls based on, for example, the competence of the operator or upon supervision by a line manager will occasionally fail and that unexpected events will occur during disposal or destruction processes. The physical segregation so far as is reasonably practicable, of explosives undergoing disposal or destruction from operators and other persons and other explosives remains key to the safe disposal of explosives.

Contrary to instructions, two workers tipped a box of waste firework composition on to the burning ground, and stirred or spread the material with a steel pole.

The waste composition ignited causing burns to both workers.

6.2 Overview

6.2.1 An essential element of any disposal or destruction process involving explosives is hazard identification and risk analysis. Paragraph 431 of the ACOP to MSER states:

“A risk assessment is required to decide the most suitable method of disposal. The assessment needs to consider the nature of the explosive and its hazards, the disposal method and hazards created during the disposal process, and the type and position of the disposal site”

It is not the purpose of this document to describe in detail the essential elements of risk assessments. Many HSE publications exist and cover this
subject in far greater depth and it is important that risk assessments conducted in respect of the management of the disposal or destruction of explosives take account of the extensive guidance relating not only to the risk assessment process but also to the relevant controls for preventing unwanted fires and explosions that is contained within the ACOP to MSER. It is also expected that guidance with respect to risk assessment in the explosives industry will be published in the near future.

6.2.2 The flowchart below (Diagram 2), demonstrates the essential role of risk assessment in the risk reduction process. Risk assessment is a critical step in determining the appropriate risk control system and workplace precautions. **It is important to remember that this guidance essentially covers the risks arising out of the explosives hazards associated with disposal and destruction processes. Other hazards will exist and the associated risks will need to be assessed if the risk assessment for the task, process or process element is to be regarded as being suitable and sufficient.**

Three soldiers died when inspecting a disposal site. Munitions had been detonated in an unventilated area and the soldiers succumbed to carbon monoxide poisoning during subsequent inspection.

6.2.3 The topics listed below are particularly relevant to the management of explosives requiring disposal and destruction and include some of the key risk control systems for these activities: -

- Identification of locations where explosives requiring disposal or destruction have accumulated and the safe recovery of those explosives from those locations.

- Identification of locations where explosives requiring disposal or destruction can be safely kept whilst awaiting disposal or destruction.

- Identification and understanding of any inherent properties of the explosives requiring disposal or destruction that makes them more prone to initiation than would normally be expected.

- Internal Transfer of Materials.

- Off-site Disposal or destruction.

- Controls in place to prevent premature initiation of explosives.

- Appropriate segregation of the disposal site from people, plant, property and other explosives that could be at risk during the disposal or destruction activity.
• Prediction of the most likely and the potential worst case effects on people and buildings in the vicinity during both the preparation for and whilst carrying out the disposal or destruction activity. Further information can be found in Section 10.

• Certification of residues etc as being free from explosive hazards (CFFE).

Section 8 contains further specific guidance with respect to the above.

6.3 Premature, Unwanted or Unpredicted Events

6.3.1 Previous incidents have shown there to be a range of circumstances leading to premature, unwanted or unpredicted events and explosions. Summarised below are the common issues associated with explosives hazards leading to fire and explosion within the overall disposal and destruction processes.

• Friction
• Impact
• Ignition by flame
• Ignition by spark
• Ignition by heat
• Electrostatic discharge
• Inadequate procedures
• Inadequate supervision
• Poor maintenance
• Ignition of solvent vapour, dust or reaction by-product
• Inadequate removal of explosive material
• Lack of knowledge of presence of explosive material requiring disposal or destruction.
• Lack of knowledge of the properties of explosive materials
• Inappropriate confinement.
• Poor control of equipment requiring treatment, modification or disposal at facilities outside of process areas.
It is therefore important that each of these factors is considered as part of the risk assessment process. Further guidance as to how some of the unwanted initiating stimuli listed above can be generated are given in Annex D and some mechanisms for their control are listed in Section 8.

6.4 Hazard Identification and Analysis

6.4.1 Incidents have also identified that a blanket application of either the UN classification of an explosive or the Hazard Type (as defined in MSER) ascribed for storage or processing with respect to the explosives present may not always be an appropriate technique for identifying the actual hazards associated with explosives requiring disposal or destruction.

6.4.2 Hazard identification should take account of both local effects, (of primary concern to operators particularly during handling and maintenance operations) and distant effects and should consider the potential extent and severity of

- Shock or other effects derived from the brisance of the explosives.
- Blast overpressures.
- The formation and propulsion from an event of primary and secondary fragments
- Thermal effects.
- Projected burning brands.
- Projected pyrotechnic effects.
- Projected pyrotechnic effects, explosive sub-assemblies or complete explosive and/or pyrotechnic articles that can have an explosive or incendiary effect remote from the original point of initiation.

6.4.3 When taken into account with the circumstances leading to premature, unwanted or unpredicted events and explosions hazard identification studies can form the basis for identifying the likelihood that an event could occur during the management of explosives requiring disposal or destruction, who and what is at risk, what controls are in place or are necessary to prevent an event occurring and what controls are in place to mitigate against an event should one occur.

Empty fibreboard cases for explosives were being burned some 30 yds from the Explosives Store at a Colliery when an explosion occurred. A man in the store suffered cuts from flying glass.

It is probable that some blasting cartridges were inadvertently involved in the fire.
Diagram 2  Risk assessment flowchart
SECTION 7 PRINCIPAL EXPLOSIVE TYPES & THEIR PROPERTIES

7.1 Overview

7.1.1 Generally, explosive materials are categorized into compounds or compositions. Organic materials form the majority of high explosive compounds. They may be used individually or as part of a composition. Pyrotechnics and propellants are almost always mixtures of materials, and may include organic compounds together with inorganic materials such as metals and oxidisers.

7.1.2 Explosives may be categorised by their function (high explosives, initiators, propellants, pyrotechnics, fireworks etc.) or by UN Hazard Classification. It is important to remember that explosive properties and performance are not necessarily only a function of chemical make up but also of form, mode of employment and method of initiation.

7.1.3 The properties of a range of common explosives are described in Annex D. These are just some of the materials that may be encountered during disposal and destruction work. Other materials may also be present and not be expected.

7.1.4 Some of the materials have very specific properties. A range of properties therefore has to be considered. Any person responsible for the management of the disposal and destruction of explosives must ensure that they have a detailed understanding of the nature and properties of the explosive materials involved in the operation. A comprehensive literature search will often be essential to identify the specific properties of an explosive substance or article. Appropriate information may also be found in Materials Safety Data Sheets; Explosive Hazard Data Sheets or Explosives Safety Data Sheets; Product Safety Data Sheets; or derived from appropriate testing.

7.2 Raw Materials

7.2.1 Raw materials/precursors used in the manufacture of the explosives that require disposal or destruction may also have explosive properties in their own right. They may also be toxic.

7.3 Breakdown Products

7.3.1 Most explosives remain relatively stable under the correct storage conditions. However, some materials may suffer degradation as they age, and may in some circumstances produce breakdown products, which pose explosive or toxic hazards.

7.3.2 The decomposition rate of explosives is dependent upon a number of factors, which may include the following:
• the prevailing conditions, e.g. temperature; relative humidity around the explosives; moisture content

• pH - certain explosives can decompose in acidic environments by a process known as acid catalysed decomposition

• physical form of the explosive material

• concentration of the explosive

7.3.3 For example:

• NC/NG based gun propellant contain stabilisers to counteract the breakdown of the two explosive constituents. As the stabiliser chemically depletes, breakdown of the NC and NG occurs, especially when stored in dry, warm conditions. This chemical breakdown can accelerate to the point where heat builds up. If this heat is not dissipated spontaneous combustion can result. Storage of such gun propellant e.g. bulk cordite, over decades has been known to result in a deflagration and destruction of buildings.

• Picric acid will react with metals, corroding them and forming impact sensitive salts (picrates). These picrates are very sensitive explosive compounds, which are far more hazardous than the picric acid, which formed them.

• Copper reacts with lead azide to produce the very sensitive explosive copper azide. Additional care would therefore need to be taken in the selection and management of tools used in the disposal of lead azide.

7.3.4 In some circumstances, the rate of decomposition can become autocatalytic, leading to thermal runaway and the risk of explosion.

7.3.5 Additionally, metals contamination may occur from the corrosion of shell casings, paints, pyrotechnic or initiator compounds.

7.3.6 The ingress of moisture into compositions containing reactive metals can result in the generation of flammable gasses (e.g. hydrogen) and can also result in self-heating reactions occurring. Reactions can also result in the integrity of any casing containing the explosives rupturing, weakening or otherwise becoming damaged. This is an example of why it is important that explosives are destroyed before a significant risk of their breaking down or degrading into a dangerous state occurs.
7.4 Thermal decomposition and combustion products

7.4.1 Some of the disposal and destruction methods used may involve the burning of materials. Very careful consideration may have to be given to the concentrations and toxicity of any thermal decomposition or combustion products that may be formed. These products may consist of polyaromatic hydrocarbons (PAHs), carbon monoxide, nitrogen oxides, etc.

7.5 Other factors

7.5.1 There may be other factors, which have to be considered related to the properties of explosives and their ingredients, which may affect the way in which disposal and or destruction operations have to be conducted.

7.6.1 Consideration has to be given to the manufacturing processes used and any additional reagents that may have been used as part of the process. Disposal of any reagents also has to be considered.

Two operators were killed whilst opening a barrel of spent acid from nitroglycerine manufacture which had been stored for a long time. Due to poor separation, a layer of nitroglycerine had formed on the surface of the acid and detonated from mechanical stress.
SECTION 8 PRACTICAL APPLICATION – GENERAL GUIDANCE

8.1 Overview

8.1.1 This section includes general guidance and examples of why the principles and advice in the previous sections are relevant and how the controls identified by risk assessment as being required to safely conduct the explosives related aspects of a disposal related task can be implemented. It supports the guidance contained with paragraphs 87 to 153 of the ACOP to MSER 2005.

8.1.2 It is important to recognise that the destruction and disposal of explosives can rarely be considered to be a generic activity. All such processes should be fully supported by technical justifications that include any necessary risk assessments along with the results of analytical work, predictive trials such as type testing, literature searches, modelling and information received from suppliers etc.

8.1.3 The main risks associated with the disposal and destruction of explosives are: -

- Unwanted or unexpected fire and explosion involving the explosives requiring disposal or destruction. This may arise from the accidental ignition of unknown material during disposal activities or the ignition of known material by incorrect procedures, tools or equipment.

- Fire or explosion of unexpected severity. The amount of injury and damage caused by the explosion will vary with the quantity and type of explosive, and the conditions under which it is initiated.

8.2 Typical sources of ignition

8.2.1 All explosives will initiate when subjected to the input of sufficient energy from such sources as:

- Impact
- Friction
- Sparks
- Flame
- Shock
- Heat
8.2.2 The amount of energy required will vary from explosive to explosive, primary explosives (e.g. lead azide) being in general more sensitive than secondary explosives (e.g. PETN).

8.2.3 It should be assumed that all explosives could be initiated given sufficient energy under fault or accidental conditions.

8.2.4 It should be remembered that even small quantities of explosives, less than one gram, for example, could cause serious injury if in close proximity to a person or if they generate shrapnel/projectiles.

8.2.5 Annex C contains more detailed considerations of some of the more typical sources of ignition.

8.2.6 One of the objectives of a safe system for the destruction of explosives involving some form of initiation would be to identify the most appropriate method from those listed above for the initiation of the explosives in the given circumstances and then eliminate all other potential sources of ignition.

8.3 Aggravating circumstances

8.3.1 Self or external confinement of explosives, propellants and pyrotechnics during burning and other destruction operations can result in an unwanted deflagration or even detonation. The degree of confinement required for the transition from a controlled burn to an unwanted deflagration or detonation can be as little as the proprietary packaging in which the explosives are supplied.

8.3.2 Collections of articles can also self-confine resulting in unwanted deflagrations and detonations, and the unwanted communication of an explosion from one article to another potentially resulting in a mass explosion. Inappropriate external confinement of an article during disposal can cause both an acceleration of the burning rate of the explosive in the article leading to a violent deflagration or detonation and fragmentation of the confinement producing a shrapnel-type hazard, as well as unpredicted thermal effects, projected burning brands, articles and effects.

8.3.3 Failure to take account of the effects of confinement of substances and articles can not only result in an explosion being more likely but can also result in inadequate protective and mitigatory measures being in place should an explosion occur.

8.3.5 The primary controls for preventing inappropriate confinement are to ensure that explosives etc are not disposed of in quantities, conformations or circumstances where they can be subject to confinement that will result in an unwanted deflagration or detonation. This will normally require the critical
depth or diameter of an explosive to be identified or determined for the conformation in which the explosive is to be disposed of and for destruction techniques to be developed using rigorous scientific principles and engineering methods and techniques before they can be brought into routine use.

8.3.6 More detailed guidance on how to control the risks associated with inappropriate confinement of explosives can be found in the later parts of this section.

8.4 General Controls and actions to avoid sources of ignition

8.4.1 Overview

8.4.1.1 Correct action and the correct application of controls will prevent ignition. If there is a known desensitisation method for the explosive in question, e.g. NG destroyer for NG and NG based explosives, or PETN destroyer for PETN, or water for black powder, then its use should be considered and assessed as part of the disposal process. However, always be careful if there is the possibility of more than one explosive being present in case the treatment of one explosive leads to adverse effects on, or sensitisation of the other(s).

8.4.1.2 Even where effective chemical desensitisation is not possible, the addition of water as a coolant may help to reduce the possibility of ignition.

8.4.1.3 Ensure that the desensitisation method is clearly understood. For example: -

- the addition of large amounts of NG destroyer onto NG based explosives, particularly when confined, should be avoided in case the heat generated by the desensitisation reaction causes over-heating and ignition of the explosive;

- the use of PETN destroyer can sensitise TNT.

8.4.1.4 When initiating controlled explosions or controlled fires, ensure that the initiation procedure is safe; this includes correct selection of detonator or ignitor type for the working environment, e.g. shock tubing, non-electric detonators and igniferous fuzes etc. where there is electrical equipment or sources of radio frequency (R.F.) such as overhead or buried cables, transmitters, radio signals, etc.

8.4.2 Impact/Friction

8.4.2.1 Sources of ignition arising from impact or friction can be controlled by: -

- Avoid excessive force in recovering, collecting or handling explosives requiring disposal or destruction.
• Use tools made of suitable material, e.g. non-sparking metal with secondary explosives such as NG based and PETN or non-metal tools with primary explosives.

• When collecting exposed explosive, use suitable methods with minimum force, correct tools and a suitable container.

• Avoid getting grit mixed in with any explosive.

8.4.3 Static

8.4.3.1 Sources of ignition arising from static electricity can be controlled by taking appropriate electrostatic precautions such as those described at paragraphs 107 to 118 of the ACOP to MSER and including

• Wearing correct clothing, including socks, and antistatic or conductive footwear, as appropriate and taking account of the prevailing environmental conditions.

• Regularly testing footwear for conductivity using an approved tester.

• Avoiding the build-up of dirt, oil, etc. on soles of footwear, which may cut down antistatic or conductive properties.

• Using correct tools and equipment for all operations involving explosives or explosive contamination, including collection, storage and transport, and particularly for static sensitive primary explosive.

• Only using correct handling procedures.

8.4.3.2 The use of conductive and antistatic footwear outside buildings or environments specifically designed to control risks to explosives from static electricity can increase non-explosives risks to safety. Alternative methods of controlling the risks to explosives from static electricity, such as the desensitisation of explosive substances and the use of earthing rods, may therefore be appropriate.

8.4.4 Spark (incendive or electrical)

8.4.4.1 Sources of ignition arising from sparks can be controlled by: -

• Using non-sparking hand tools.

• Using electrical equipment of the correct classification whenever possible.
• If using non-classified electrical equipment, e.g. a portable generator, then only use as part of a robust permit to work scheme.

• Ensure electrical isolation, when required.

• Hot work should not be allowed in areas where explosives requiring disposal or destruction are being collected, stored transported or destroyed other than as part of a robust permit to work scheme.

• When possible, mitigate the effects of controlled explosions, e.g. by covering with sand bags, by use of proprietary explosion mitigation systems or by using other physical controls.

• When carrying out destruction by controlled burning, consider hosing down with water any area to which the fire could be reasonably be expected to spread and also consider putting up a water curtain downwind of the fire.

• Controlling contraband items such as battery powered personal property.

8.4.5 Flame

8.4.5.1 Sources of ignition arising from flames can be controlled by:

• Avoiding hot work/open flame in areas of where explosives requiring disposal are known to accumulate.

• When deliberately producing a flame, as in a controlled burn/fire, ensure procedures for remote ignition and observation are in place.

• After a controlled burn/fire, always allow plenty of time for any residual hot spots to have become thoroughly cold before any approach or intervention.

• Controlling contraband items such as matches and other smoking materials.

• Keeping disposal areas and their immediate vicinities free of unnecessary or uncontrolled vegetation that could act as fuel for a fire.

8.4.6 Decomposition

8.4.6.1 Sources of ignition arising from decomposition can be controlled by:

• Always treating any explosive or explosive contamination that is old or in poor condition with more care/caution than for the same explosive in good/standard condition.
• This particularly applies to explosives, including propellants that may contain NG, which could have “weeped”, i.e. separated out from the explosive giving free NG liquid.

8.4.6.2 Before using any chemical destroyer, ensure that it is appropriate to the explosive or mixture of explosives to be treated, and that its use cannot generate excessive heat in large quantities of hidden contamination, or cause decomposition or sensitisation of one explosive in a mixture.

8.4.7 Housekeeping

8.4.7.1 One of the key controls for preventing unwanted initiations in any explosives work is ensuring that high standards of housekeeping are maintained. Detailed guidance with respect to housekeeping can be found in paragraphs 156 to 158 of the ACOP to MSER 2005.
SECTION 9 SELECTION OF A DISPOSAL/DESTRUCTION METHOD

9.1 Overview

9.1.1 Before any explosive substance or article is manufactured, purchased or otherwise obtained arrangements should have been made for its destruction or disposal. The means of destruction or disposal of an explosives item at the end of its life should be considered at the design stage of that item in order to make its destruction or disposal as simple and as safe as is reasonably practicable.

9.1.2 These arrangements should include an identification of the method and potentially the location of the disposal or destruction as well as the mechanisms whereby explosives requiring disposal are to be managed from their generation or identification through to them or items contaminated with them ceasing to comprise a risk to health or safety from fire or explosion.

9.1.3 These arrangements, which should have been derived from suitable and sufficient risk assessments, should be subject to periodic review and these reviews should take account of factors including increases in quantities of explosives manufactured or procured, increases in quantities likely to require disposal or destruction and increased knowledge of the explosive in question as well as the effectiveness of the initially identified controls and any loss of competence and/or facilities.

A man received fatal injuries whilst destroying obsolete signal distress rockets. The rockets were being destroyed by lighting the fuze and pointing the rocket into an incinerator.

The man was killed when a rocket discharged backwards.

9.2 Disposal or Destruction?

9.2.1 Given that the destruction of explosives is a high hazard activity the following questions should be addressed before destruction is identified as the preferred method for disposal: -

- Are the explosives safe to transport and use as is? If they are then reasonably practical disposal methods such as disposal by use or a legal sale or transfer to another person should be considered before destruction is chosen as the disposal method. Disposal by use has the advantages that normally the performance during use of an explosive substance or article is predictable and is has been well characterised.

- Would the explosives be safe to transport and use if reworked? If it would be reasonably practicable to rework explosives requiring disposal then the balance of risks between reworking and destruction
should be considered and assessed before destruction is chosen as the disposal method.

- If the explosives require disposal because they have failed to meet a prescribed quality standard, can the explosives be used legally in an environment where that failure to meet the quality standard will not have a materially detrimental impact on safety, health or the environment? If they can then the balance of risks between disposal by use and disposal by destruction should be considered and assessed before destruction is chosen as the disposal method.

- If the explosives require disposal because they have become life expired can the explosives be re-lifed or requalified? If it would be reasonably practicable to re-life or requalify explosives requiring disposal then the balance of risks between re-lifing and re-qualifying and destruction should be considered and assessed before destruction is chosen as the disposal method.

- Is the nature of the explosive such that particular specialist competence and/or equipment will be required for the safe disposal of the explosives and is this competence and/or equipment available?

- Is there a recognized method or scheme in place for the disposal of the particular explosive? For example schemes are in place for the disposal of time expired flares and other life saving pyrotechnics.

9.3 Selection of A Destruction Method

9.3.1 There is generally more than one-way to destroy an explosive. The selection of the most suitable method or combination of methods will be determined by two factors

- the nature of the explosive substance or article and its hazards, taking in to account the following:
  - quantity
  - type – propellant, explosive, pyrotechnic, loose, solid, liquid, water wet etc.
  - condition – uncontaminated, contaminated, aged, unstable etc.
  - composition and potential combustion products
  - likelihood of propulsion – e.g. rocket charges
- projection – enclosed items (fuzes, fireworks, igniters etc), fragments, burning brands.

- Whether the item or device can be safely broken/stripped down prior to the disposal or destruction activity (see Section 11.6)

- The likely extent and severity of the disposal/destruction event as planned and the maximum extent and severity of the any event should the controls up to and including the disposal/destruction event fail.

- The potential disturbance and disruption caused away from the disposal site by loud or unexpected events.

- The type and the position of the disposal site. It would be reasonable, for example to destroy blasting explosives in the open in large unit quantities by detonation on a remote site, whereas such a method would be unacceptable on a site close to housing or other inhabited buildings. This should be taken account of in extent and severity studies carried out in the risk assessment process.

An explosion occurred during the disposal of 50lbs of waste blasting explosives at a burning ground. Considerable minor structural damage was caused to buildings inside and outside the factory but luckily no one was injured.

One person suffered shock when part of the ceiling came down in her house.

9.3.2 The ACOP to MSER identifies that there are four distinct ways to dispose of or destroy explosives:

- burning;

- detonation;

- dissolution or dilution by a solvent;

- chemical destruction.

9.3.3 These methods are not mutually exclusive and on some occasions it may be appropriate to carry out elements of these methods in series, such as for example pre-soaking of some types of fireworks prior to destruction by burning or the collection of quality assurance samples of high explosives in organic solvents.
9.3.4 Not withstanding the environmental implications, open hearth and caged burning, detonation, incineration and other techniques that result in the immediate destruction of explosives requiring disposal or explosives contaminated waste remain the preferred method for the elimination of the explosives hazards associated with such materials. Where disposal is by dissolution or dilution it may be that if the resultant solution or suspension is not handled, stored and disposed of properly the explosive could precipitate out or otherwise reform, or by-products with explosive or other properties that are a risk to health, safety or the environment could be produced.

9.3.5 There are additional methods for the destruction of explosives including bio-degradation and bio-remediation, however these have not yet been widely employed throughout the explosives industry. These can generally be considered to comprise a mixture of the above methods, for example bio-degradation can be considered to be dilution by a solvent and chemical destruction by a biological system. The predominant advantage of such techniques is that the risk of fire and explosion during the actual destruction process is negligible. These methods also have the potential to have a negligible effect on the environment.

9.3.6 Annex E indicates those methods generally recognised as being best suited to various common types of explosives. In cases of doubt or where there are discrepancies between Annex E and any Materials Safety Data Sheets etc., seek advice from the supplier of the explosives or another appropriate source – such as the Manufacturer or Design Authority.

9.3.7 The ACOP to MSER identifies that sea dumping and burial are no longer, on environmental grounds, considered to be suitable methods of disposal for explosives. In addition recent experience has shown that sea dumping and burial cannot be considered to be methods that will result in the permanent disposal of the explosives.

9.3.8 Where explosives are to be disposed of by their safe and legal transfer it is essential that any person who supplies explosives to another person provides them with adequate information to ensure that any explosives articles or substances can be put to use, stored, used in manufacture, transported or disposed of safely and without risks to health. Such information would be expected to include:

- The reason that the explosives are being disposed of.
- Any particular risks to safety or health inherent to the explosives being transferred.
- Any recognised methods for safe disposal or destruction associated with the explosives.
• Any aspects of its history, such as storage conditions etc. that might have consequences with respect to the reliability, susceptibility to initiation from recognised stimuli or performance of the explosives.

• Any necessary technical information such as chemical composition and where appropriate sensitiveness and sensitivity data.
SECTION 10 IDENTIFICATION AND QUANTIFICATION OF POTENTIAL EFFECTS AND SELECTION OF THE DISPOSAL SITE

10.1 Overview

10.1.1 It is essential that before any disposal or destruction activity takes place the potential likely and maximum credible events are identified i.e. any explosion or fire that could occur should all the procedural controls in place to prevent or mitigate against an event fail.

10.1.2 Likely and worst-case events can be identified and quantified using a range of techniques. These can include: -

- Hazard Identification and Analysis techniques such as HAZOP and FMEA
- Information in the literature
- The use of mathematical models and a range of models for predicting explosive performance and effects exist. A number of these are described in the HSE publication *Selection and Use of explosion effects and consequence models for explosives* (ISBN 0-7176-1791-2).
- Extrapolation from small scale laboratory trials or published data.
- Full size trials including type testing where the maximum credible event is induced and effects such as brisance or shock effects, blast overpressures, fireball diameters and intensities, and fragment throw are identified and assessed or measured.

10.1.3 It is important to recognise that the identification of potential likely and maximum credible events is not only relevant to the disposal and destruction activity but is also relevant to developing management systems for: -

- the management and cleaning of locations where explosives requiring disposal and destruction can accumulate during manufacture and storage
- identifying how and in what quantities explosives requiring disposal or destruction should be stored.
- how and in what quantities explosives requiring disposal and destruction are brought to and treated at the disposal site.

10.2 Identification of the Destruction Site Location

10.2.1 Overview

10.2.1.1 The principal criterion for the siting of a disposal facility is the assumption that the entire mass of explosives being disposed of or destroyed could initiate and the maximum credible event occur. Consequently the site
must be segregated from its associated workplaces and any surrounding buildings, public areas or other explosives.

A fire in a naval arsenal of the Russian Pacific fleet apparently started while engineers were destroying old 30mm munitions. Fire spread to an open storage area & caused the explosion of 12 rail wagons of old artillery shells.

10.2.1.2 A burning place or other disposal site should not be used if there is any exposed fire that is upwind from it, or which is likely to become upwind from it, at a distance at which there is a real albeit small possibility or hot ash or burning brands igniting explosives at the burning place or vegetation in the immediate vicinity of that place. It has been generally recognised that a burning place should not be used if there is any exposed fire less than 200m up wind of it.

10.2.1.3 Environmental conditions, such as likely wind speeds and directions as well as the potential implications of rain, fire-water or damping-water run-off from the disposal site should be considered, along with any segregation and separation safety requirements, as being key to the selection of an area for the destruction of explosives or explosives contaminated materials.

10.2.2 Segregation and Separation

10.2.2.1 Segregation can be achieved by both distance and passive engineering controls such as standoff, blast suppression systems including water curtains and water bags, mounds, barriers, building hardening and window filming. The necessary separation distances will depend on the potential extent and severity of the maximum credible event, the mechanisms whereby harm can be caused and the extent of any engineering controls.

10.2.2.2 Segregation and separation distances should be derived by considering each of the potential effects that the disposal of destruction activity could have. These generally comprise blast effects, fragment effects, thermal effects and the projection effects, particularly those with the capacity to act as sources of ignition.

10.2.2.3 Annex F contains a set of quantity distance relationships with respect to each of these effects along with an explanation of the criteria upon which they are based. Where the circumstances of a disposal or destruction activity deviate significantly from these criteria a detailed assessment of potential extent and severity should be made.

10.2.2.4 Where information, models or competence are not available to calculate the probability of persons or occupied buildings being struck by
burning brands or projected pyrotechnic effects, or where engineering controls have not been taken to eliminate or mitigate such risks, the precautionary principle should be applied. The maximum range of any projected effects such as stars, rockets or sound and light units plus a margin of safety of 100\% should be used to establish the distance between the disposal site and any persons in the open, occupied buildings or buildings containing explosives. The maximum range of any projected effects should be determined from manufacturers information or from appropriate trials.

10.2.2.5 In addition where a disposal activity is assessed as having the potential to generate primary or secondary fragments (including for example fragments of wood from a fire) it should be conducted within a mounded or other protected area unless it is so remote that the risk to persons or explosives from any generated fragments is negligible. For the purposes of this aspect of this guidance a face is considered to be fully mounded when the material of the mound will not be completely penetrated by any likely fragment and the angle between any material that could comprise a fragment and the top of the mound is 60° i.e.

\[
\text{Mounds that result in an angle of less than 60° are unlikely to substantially reduce the maximum distance travelled by fragments or projected effects. They can however significantly reduce the likelihood of persons or property outside the mound being struck by reducing the number of fragments or projected effects leaving the destruction site.}
\]

Where disposal is a continuous process (i.e. at a demilitarisation site) and where explosive events are frequent mounds will eventually be destroyed, become non-effective or become a potential source of secondary fragments and will have to be rebuilt. In extreme cases this could happen after each event. Pits can therefore comprise an attractive alternative to mounded areas because they have the benefits of mounds with respect to control of fragments and projected effects without the problems of repeated destruction. All that is required is a check that the contours of the pit still achieve the 60° angle from the top of the explosive articles to the lip of the pit.

10.2.2.6 Wherever possible the relevant segregation criteria contained within Annex F must be met between each location within the disposal facility where explosives are to be disposed of, kept or processed. If these criteria cannot be met then it must be assumed that communication of an explosive event will occur and any quantity distance or other segregation relationships
external to the disposal location should be determined accordingly. For the purposes of this aspect of this guidance any mounds should meet the requirements detailed in paragraphs 388 to 391 of the ACOP to MSER.

10.3 Control of The Disposal Location

10.3.1 Overview

10.3.1.1 One of the additional factors that will effect the decision on where a disposal location will be established is the degree of control that can be exercised over an area such that employees not involved in the disposal activity and members of the public can be appropriately segregated from the activity.

10.3.2 Practical Application

10.3.2.1 Before a destruction activity commences, the disposal area and any other areas identified as being at significant risk from any explosive event that could occur as a consequence of the disposal operation should be cleared of personnel and any entrances closed.

10.3.2.2 In facilities licensed under MSER 2005 or other places where explosives are routinely used such as ranges etc. a red flag can be used as a warning that a burning ground is operational. If the destruction activity is likely to cause loud reports, a warning hooter or klaxon may be sounded. The operator in charge should ensure that all personnel involved in the destruction operation are in a designated safe place before initiating the destruction, and check throughout the duration of the disposal that nobody has entered the area requiring access control. It is essential that there is visibility of the destruction activity and surrounding area. This may be achieved by operating in large open space areas or by using CCTV monitoring. Warning signs may need to be placed around the perimeter of the destruction ground to warn others of the proximity of an area where explosives are being destroyed.

10.3.2.3 Where the destruction activity is taking place away from a licensed facility or other area under similar degree of control it will be necessary for alternative arrangements to be put in place to prevent persons either deliberately or inadvertently entering the disposal area or other areas where they may be at significant risk from the consequences of an explosive event during the disposal activity. This will often require a manned or otherwise monitored perimeter to be established at an appropriate distance form the disposal location. Any persons patrolling this perimeter should be appropriately protected from any anticipated explosive effects or consequential hazards, such as vegetation fires etc. that they may be called upon to deal with.
SECTION 11 DESTRUCTION OF EXPLOSIVES – PRACTICAL GUIDANCE

11.1 Overview

11.1.1 This section provides practical guidance with respect to the employment of four main methods for the disposal of explosives by destruction. Guidance is provided with respect to burning in Section 11.2, with respect to detonation in Section 11.3, with respect to dissolution or dilution in Section 11.4 and with respect to desensitisation and chemical destruction in Section 11.5.

11.1.2 It includes more detailed examples of why the principles and advice in the previous sections are relevant and how the controls identified by risk assessment as being required to safely conduct the explosives related aspects of a disposal related task can be implemented.

11.2 Burning explosive substances and specific articles

11.2.1 Overview

11.2.1.2 The ACOP to MSER states:

*When burning explosives, the risk of burning to detonation must be taken into account, and measures taken to minimise the risk and to protect against the effects of a detonation should it occur. The general rule is to only burn small quantities at any one time while avoiding excessive transport movements. Items which might be propelled form the fire when burned must be suitably contained without confining the explosive.*

*Incompatible explosives must not be burned together. If there is any doubt about compatibility of explosives they must be burned separately.*

11.2.2 General procedures and Risk Controls

11.2.2.1 Overview

11.2.2.1.1 As has previously been stated, subject to some form of pre-treatment or special precautions, most explosives substances can be burned safely provided that:

- as far as possible, burning is controlled, and the operation is designed to minimise the possibility of the explosive burning to detonation, deflagrating violently, projecting primary or secondary fragments and burning brands or producing excessive thermal effects;

- it is assumed that the maximum credible event will occur and sufficient precautions are taken to mitigate any resultant hazards.
11.2.2.2 Control of Confinement

11.2.2.2.1 These objectives can often be achieved, at least in part by controlling confinement and by limiting the quantities of explosives that can be burned in any one place at any one time. Where the destruction by burning of explosives or explosive contaminated materials is proposed, experiments should be carried out to establish the maximum depth of explosive which will not burn to detonation (critical depth). The explosive should then be burnt at a depth not exceeding half the critical depth. **Bed depth is more important than quantity.** Such trials are inevitably hazardous and appropriate systems of work should be implemented for safety.

11.2.2.3 Limiting Number of Operators at Risk

11.2.2.3.1 As in all operations involving explosives the number of people working in the burning area should be limited to those necessary to complete and properly supervise the task at hand.

11.2.2.4 Controlling Risks from Previous Activity

11.2.2.4.1 Previous activity at a disposal site should not cause a premature or unexpected initiation. Therefore before any explosive is laid, the intended burning area must be checked to ensure that there are no hot spots from any earlier fires or any other potential sources of ignition that are effectively uncontrolled.

11.2.2.4.2 Hot spots can be identified by a combination of visual inspections and the use of temperature probes. The risk of a hot spot can be controlled by using burning areas in rotation and allowing sufficient time between fires for any hot spots to cool. The time required for hot spots to cool will depend on the nature of any previous fire, the materials burned and ambient weather conditions therefore best practice would generally involve damping the burning area with water as a precautionary measure before any explosive is laid. If the presence of hotspots is identified or suspected another burning area should be selected or the hotspots treated such that they do not comprise a mechanism for ignition.

11.2.2.5 Burning Surfaces

11.2.2.5.1 The ideal surface for a burning or any other disposal area is sandy barren soil because the potential for any explosion to produce secondary shrapnel or fragmentation effects is eliminated. Alternatively compacted fine ash, crushed clinker or clay with the minimum of rock or other debris can be considered provided it is inspected for the presence of material that could comprise a fragment hazard should an explosion occur. One method for checking such a surface is to rake it smooth. The depth of the burning surface and the nature of the explosives being destroyed should be taken into account when the potential for the generation of shrapnel or fragment effects is being considered. A number of mathematical models are available for the prediction of crater depths and diameters which could be
used to identify the depth of burning surface required. These include, amongst others, the CONWEP model referred to in the Advisory Committee on Dangerous Substances' publication "Selection and use of explosion effects and consequence models for explosives" HSE Books, 2000, (ISBN 0 – 7176 – 1791-2)

11.2.2.5.2 If liquid wastes are to be burned, the fire should be built on shallow metal trays to prevent liquids seeping into the ground and contaminating the disposal site. It should be recognised that this control measure is a compromise because should an explosion occur the metal trays could fragment and contribute to any effects. Systems to mitigate the fragmentation of the trays (such as mounding) should therefore be put into place. Trays should not be lined where there is the potential for the lining to degrade during use and act as a source of grit, or where the lining could otherwise act as a source of premature ignition.

11.2.2.6 Control of Confinement

11.2.2.6.1 Loose propellants including cordite's and small arms nitro-compound, loose pyrotechnics, powdered propellant wastes and swarf and propellant granules will self sustain burning and can be burned by laying out directly onto the ground. These materials can under certain conditions, burn to detonation; some flash and military pyrotechnic compositions are particularly prone to this behaviour. Before burning propellants and pyrotechnic powders the critical depth should be determined. Such explosives should be laid in trails of depth of no more than half the critical depth on a flat even surface. Normally the best surfaces for this sort of operation are smooth sandy barren soil, compacted fine ash or clay. If a concrete burning surface is to be used, it should be of a type not likely to degrade under heat such that it could develop fissures likely to confine explosives or produce secondary fragments should an explosive event occur. It should also be inspected for fissures or degradation prior to use.

11.2.2.6.2 Cartridged explosives should be laid in a layer of one cartridge deep provided that the wrappings have been removed to reduce confinement and the diameter of the cartridge does not exceed the critical diameter. The cartridges should be sufficiently separated to eliminate the risk of a cartridge detonating causing the sympathetic detonation of its neighbours.

11.2.2.6.3 Large tubed or wrapped cartridges should have their wrappings removed. For the purposes of this guidance a large cartridge is defined as one whose diameter exceeds the critical diameter of the explosive it contains or comprises. Large cartridges should be cut up such that the size of the lumps does not exceed the critical diameter of the explosive. Cartridges or portions thereof should be sufficiently separated to eliminate the risk of a cartridge detonating causing the sympathetic detonation of its neighbours.

11.2.2.6.4 As a general rule, explosives such as wet cordite pastes and wet blasting explosives may be laid to a maximum depth of 4 cm however before
routine destruction by burning takes place the critical depth should have been determined.

11.2.2.7 The Fire and the Use of Accelerants

11.2.2.7.1 The combustible base material used must be hot enough and burn long enough to fully destroy the explosives. This normally requires a considerable amount of fuel for example:

- Water wet or solvent wet explosives and slurries and emulsions are best burnt on a bed of wood.

- Water wet nitrocellulose may be laid on a wood base and soaked in kerosene or other appropriate accelerant to encourage complete combustion.

The combustible base can comprise wood and wood shavings, and “recycled” materials such as cardboard and shredded paper. The nature of the most appropriate material will depend on the nature and circumstances of the disposal, as well as the potential extent and severity of explosive events. For example pieces of wood could increase the fragment risks arising from an explosion during disposal but shredded paper may not be appropriate in other circumstances such as high winds or because it does burn for a long enough period.

11.2.2.7.2 To maintain the fire and ensure continued combustion the materials can be wetted with an appropriate accelerant such as kerosene before laying the ignition trail. One method for ensuring that the fire will burn sufficiently strongly is to pre-soak wood shavings in kerosene prior to construction of the fire. This activity carries its own consequential risks and should therefore only be carried out in an appropriate location once those risks have been subject to a suitable and sufficient risk assessment.

11.2.2.7.3 Kerosene is considered to be an appropriate accelerant because it has a relatively high flash point and produces relatively small quantities of smoke when burnt on an open hearth.

11.2.2.7.4 When adding kerosene to a bed of propellants or explosives due care must be taken due to the flammability of kerosene. Highly flammable fuels such, as petrol must never be used. When considering the use of kerosene compatibility with the materials on the bed must be taken into account.

11.2.2.7.5 As well as ensuring that the combustible base burns hot enough and long enough to destroy the explosives accelerants also increase the likelihood that fires will catch hold thereby reducing the likelihood of a misfire.
11.2.2.8 Lighting the fire

11.2.2.8.1 There should be a safe system for igniting the fire and the standards of operation should be at least as rigorous as those expected in the use of similar quantities of the same explosives. All sources of ignition in the burning area should have been identified and appropriately controlled prior to any work commencing and cables and firing equipment should be tested prior to use.

11.2.2.8.2 Fires should only be lit when there will be sufficient resources available to maintain control the burning area until such time as it can be confirmed that no significant risk remains to the health and safety of persons from fire or explosion and that no significant risk remains to the security of the explosives being disposed of in the fire.

11.2.2.8.3 Fires can be lit using a slow burning “trail” (such as a quantity of kerosene soaked wood shavings) or by ignitor cord leading to the main bulk of the fire. In the event of accidental ignition of the trail it should be of a sufficient length to allow the operator time for escape and retreat to a safe place. Direct ignition of a fire or of a quantity of a self-sustaining propellant or pyrotechnic material by, for example, the use of an electric ignitor is also possible. However it should be borne in mind that, depending on the layout and construction of the fire etc. it might be more difficult to resolve misfires safely.

11.2.2.8.4 The trail should be lit remotely from a safe place, preferably by an electric ignitor or ‘puffer’. Alternatively, fires may be lit by a non-electrical system such as ignitor cord or other igniferous fuze. An electro-mechanical exploder is preferred to fire the ignitor. A system using a battery or dry cell may be used, providing the battery or cell is tested before firing. Either operators should keep the key to the electric exploder on them or the exploder, battery or dry cell should be kept in a locked box. The operators should keep the key. Whatever means of ignition is used, there should be a system to prevent accidental or unauthorised ignition.

11.2.2.8.5 Where an igniferous fuze is used it should be lit from a position or in such a manner that the person lighting it is not at risk from the act of lighting the fuze causing the premature ignition of the fire. Where fires are lit using igniferous fuzes it is likely that any residual risks to the person lighting the fuze will need to be controlled by their wearing appropriate PPE.

A charge hand attempted to destroy a small quantity of blackpowder which should have been returned to the explosive store of a quarry. The blackpowder was in a cardboard box & it is thought the man used a piece of safety fuze to ignite it.

The flash caused fatal burns
11.2.2.8.6 The likelihood that a fire will catch can be improved by including a small igniferous booster, such as a gerb or fountain like pyrotechnic device or a small quantity of relatively slow burning propellant or similar. The likelihood that a fire will fail to ignite can be reduced by incorporating redundancy into the firing system. An example of such redundancy would include laying two trails into the bulk of the fire, one from each end such that if the fire fails to ignite or only partially burns a second attempt can be made to ignite the fire without anyone having to approach it.

11.2.2.8.7 Should the primary and secondary ignition systems fail to light the fire, no approach to the fire should be made for a predetermined time. This is often set to at least 30 minutes however this may need to be increased depending on the nature of the explosives, the nature of the ignition system, the type of fire and the prevailing weather conditions. If no signs of combustion are apparent after that time, the operator should isolate the exploder and disconnect the ignitor leads if an electrical initiation system is being used. Predetermined procedures should then be followed to render the initiation system (and where necessary the explosives requiring disposal), safe before any approach to be made to the fire itself. It is for example appropriate in some circumstances to pull the ignitor clear of the fire by the firing cable or, where one has been used, the igniferous fuze, provided that this activity has been subjected to a suitable and sufficient risk assessment and is carried out from a safe location. All misfired igniters should be treated with suspicion, held by the leads and not handled directly.

11.2.2.8.8 Alternative fixed ignition systems, such as glow plugs, may be used. In such cases keys should be controlled as above. In the same manner as above, no approach to a fire is to be made for at least 30 minutes in the event of a misfire.

11.2.2.8.9 It is often convenient to provide a means of earthing firing lines when electrostatic sensitive explosives are handled or are used as part of the disposal activity.

11.2.2.9 The Burn and its Conclusion

11.2.2.9.1 Propellants or other explosives or fuels should never be added to a fire once it is burning. The fire should not be approached while there are visible signs of combustion, but should be kept under observation until it has burnt out. Any person observing the fire should be appropriately segregated from it. This may necessitate the use of remote equipment such as CCTV systems.

11.2.2.9.2 Once the fire has burnt out a delay should be allowed before the fire is approached. This should be determined by the circumstances of the fire and the nature of the explosives being disposed of but should be at least the duration of the “soak-time” allowed in the misfire procedures. Depending on the residual risks it may be necessary to thoroughly hose down the burning area. Alternatively where the items being burnt are listed in Schedule 1 to the Control of Explosives Regulations 1991, where control of the burning area can
be maintained and where there is no risk of any further fire developing from
the spread of smouldering embers, the fire can be left to cool completely,
particularly where it can be expected to be damped down by rain. It is
important to recognise that charred wood, card and paper can act as a good
insulator. Therefore if a fire has not been properly damped down the action of
disturbing the ash bed can cause a fire to reignite.

Some contaminated linoleum had been burned on a factory burning
ground and it is believed that, despite some hours' rain, hot embers
remained the next day.

When explosive waste was being laid on the same site for destruction it
ignited prematurely and two workers received slight injuries.

It had been decided to destroy a number of flares owing to a modification
in design. Flares were destroyed by the ignition of one flare in a set of 8.
One such set had been ignited and on visual inspection it appeared that
all the flares had been burned off. A second set had been laid out and
destroyed, and during visual inspection of these a flare from the previous
set exploded. The company's investigator concluded that a hang-fire of
approximately 10 minutes had occurred and that the localised hot
environment generated by the ignition of the single flare took some time
to transfer through the brass case of an ignitor.

One of the operators suffered a badly lacerated left leg and slight burns
whilst the other suffered shock.

An operator was spreading a quantity of firework composition containing
potassium perchlorate and magnesium/aluminium powder on a stretch of
ground where composition had been burned not long before. The
composition caught fire and set the man's clothing alight.

The man was burned extensively and severely.

11.2.2.9.3 Rake or otherwise sift the debris carefully and examine it for
undestroyed explosives as part of a procedure for certifying any residues and
the area itself free from explosives (see Section 19). Depending on the nature
of the explosives that have been burned, it may be necessary to conduct this
sifting operation remotely.
11.2.2.9.3 Any tools used for raking a burnt out fire should be appropriate for use with both the burned residue and any unconsumed explosive. An example of such a tool would be a wooden rather than a steel rake.

11.2.2.9.4 Procedures should be in place for the identification and assessment and treatment of undestroyed explosives. It is important to recognise that undestroyed explosives may be partially consumed, contaminated with grit or ash or otherwise damaged and may therefore be more susceptible to initiation.

11.2.2.9.5 It is important to recognise that depending on the nature of the explosives being burnt there may be environmental implications from the water run off of damping down fires and the reader is referred to section 4.3.5 of this guide.

11.2.2.10 Electrostatically Sensitive Compositions

11.2.2.10.1 When electrostatically sensitive compositions are involved in any destruction operation including burning, the explosive material requiring disposal should be kept in conductive containers which must be earthed during all handling operations. It may help to lightly dampen such compositions with water to reduce the build-up of electrostatic charges, provided that this does not inhibit the burning process.

11.2.2.11 Weather Conditions

11.2.2.11.1 Consideration must be given to weather conditions before preparing to set up for burning. Explosives should not be burned during high winds or heavy rain. The direction of the wind may carry smoke and combustion products towards inhabited areas and transport routes. Under certain wind directions it may not be appropriate to burn explosives. Heavy rain can result in fires failing to ignite or failing to burn completely. On the approach of thunder any setting up or preparation of fires should cease.

11.2.2.11.2 Many explosives compositions are fine powders or finely divided granular materials, these explosives should not be brought into burning areas in windy conditions.

11.2.2.12 Compatibility

11.2.2.12.1 Take care that only compatible explosives are burned together. For example, compositions containing sulphur and those containing chlorate should not be burned together (see Regulation 24 of MSER 2005). Also, blasting explosives or other secondary explosives and detonators or primary explosives should not be burned together because of the risk of detonators or primary explosives causing a mass explosion in the blasting or other secondary explosives. If there is any doubt about compatibility, explosives should be burned separately.
Further guidance relating to common categories of explosives which might be used as a basis for segregation is given at Annex G.

A drum caught fire when explosive waste was added. The drum was found to have previously contained red phosphorus and had been used for waste collection contrary to instructions.

Luckily no one was injured.

**11.2.3 Additional Precautions and Controls for the burning of certain types of explosives substances and articles.**

**11.2.3.1 Overview**

This section contains guidance on how some of the risks associated with the burning of some specific types of explosives can be controlled.

**11.2.3.2 Liquid Explosives**

11.2.3.2.1 Liquid explosives such as nitroglycerine and other nitrate esters, after dilution or desensitising with a suitable agent, should be absorbed in a combustible medium such as sawdust, wood shavings or clean shredded paper. This action reduces sensitivity to impact and friction and is normally best carried out in a process building before collection for destruction. Care should be taken if sawdust is used as an absorbent as it can form lumps.

11.2.3.2.2 If liquid wastes, such as solvents containing explosives, slurries and process wastes are to be burned, the fire should be built on shallow trays to prevent liquids seeping into the ground. The trays will need to be compatible with the explosives, the process and any possible delays. This often means that only metal trays are identified as being appropriate. It should be recognised that this control measure is a compromise because should an explosion occur the trays could fragment and contribute to any effects of an event. Systems to mitigate the effects of the fragmentation of the trays should therefore be put into place.

11.2.3.2.3 As has been noted above small quantities of liquid wastes may be absorbed in a combustible medium such as sawdust or wood shavings. Liquid wastes which may exhibit explosive properties, should be treated in the same way as liquid explosives.

11.2.3.2.4 The system of work should take account of the potential effects of solvent evaporation either as a mechanism whereby the characteristics of the solution of explosives could be changed or whereby a flammable or explosive atmosphere could be created.
11.2.3.3 Dry Propellant Pastes

11.2.3.3.1 Dry propellant pastes can be soaked in water so that the paste is thoroughly wet before burning. This should normally be carried out at the originating area before collection. Soaking the propellant can reduce the likelihood of an unwanted ignition and can reduce the violence of any fire.

11.2.3.4 Detonating Cord

11.2.3.4 Flexible detonating cords to be disposed of by burning should be cut into short lengths (0.5 m) in order to control the risks of it burning to detonation. It may be necessary to cut detonating cord with heavier loadings into shorter lengths. This should be determined as part of the process of development of the disposal technique. Cutting or untying any knots and removing any crimped on end caps or detonating relays will also reduce the risks of detonating cord burning to detonation.

11.2.3.5 Combustible Contaminated Waste

11.2.3.5.1 Combustible waste such as combustible cartridge cases, paper, cardboard, wood, contaminated clothing and cleaning cloths etc that may be contaminated with explosives needs no special treatment before burning.

11.2.3.5.2 It can be burned in a wire mesh cage to prevent the wind carrying glowing embers or ash. It is important that such waste be checked for gross explosive contamination before burning, taking suitable precautions. Explosives contaminated packaging such as bags and, in particular, boxes, must be checked to ensure that they are actually empty as part of a process for certifying them free from explosives (CFFE), prior to their being burned.

Two men received burns when an explosion occurred in an incinerator at a licensed factory. The waste being burned consisted of packing cases and cardboard packing tubes in which filled 35 mm shell had been consigned to the factory. Metallic fragments were found which showed that a filled shell had been present in this packaging material when fed into the incinerator.

11.2.3.5.3 Such fires should be built at a sufficient distance from any place where explosives are being kept such that glowing or smouldering embers will not comprise a risk of fire to the explosives. This distance will depend on the size of the fire, the nature of the material being burned and the wind strength, direction and variability.

11.2.3.5.4 The likelihood of bulk explosive substances or articles not being identified during the CFFE process should be taken account of in the risk assessment. Where there is a significant likelihood of the CFFE procedures
not being effective then the waste should be treated as though it actually comprised explosives rather than contaminated waste.

11.2.3.5.5 Where the degree of contamination of combustible waste is such that an enhanced risk of fire or explosion does not exist the contaminated material can be burnt in such a manner that a very high degree of protection to the environment can be provided. It is expected that this would normally involve the use of some type of incinerator.

11.2.3.6 Propulsive Explosives

11.2.3.6.1 Propulsive explosives such as rocket motors should be burned so that any movement of the item is restrained. Restraining of rocket motors can result in an accelerating burning rate caused by a local increase in pressure. This accelerating burning rate can progress to deflagration or detonation.

11.2.3.6.2 The flight of rocket motors should be therefore restrained in a special rig or sufficiently strong structure during burning and preferably motors should be vented at each end to prevent the build up of excessive pressures. Such venting would probably require the safe removal of any payload. The risks associated with payload removal, particularly with respect to firework type rockets, should be considered and controlled and any requirements under Regulation 9 of MSER 2005 would need to be met. Annex H contains further guidance with respect to Regulation 9 of MSER.

11.2.3.6.3 The critical diameter of the rocket motors propellant element under the conditions likely to be encountered during the disposal and the confining effects of any casing must be considered before restrained and vented burning is identified as an appropriate method for the disposal of rocket motors. Alternative specialist techniques for the disposal of rocket motors, including the use of linear cutting charges, do exist but the detailed description of these techniques falls beyond the scope of this guidance.

11.2.3.6.4 Tubular rocket propellant charges with a central conduit or hole which is clear throughout are less likely to burn to deflagration or detonation than charges with no clear through conduit or hole.

11.2.3.6.5 Loose rocket propellant charges can be burned in a pit covered by a heavy-duty mesh cover that will not act as a mechanism of confinement but will prevent burning propellant escaping. The critical diameter of the propellant element must be considered before loose pit burning is identified as an appropriate method for the disposal of loose propellant charges.

11.2.3.6.6 The destruction of rocket propellant charges may be accompanied by intense high frequency noise, in which case hearing protection will be required.
11.2.3.7 Gun Propellants

11.2.3.7.1 Tubular gun propellant stick is often cut into small pieces before burning. This should be carried out in a licensed process area.

11.2.3.7.2 Complete combustible cased gun propellant charges may be burned intact in a small single layered groups in a shallow pit or between protective barriers provided that an assessment of the properties of the charges has identified that they will not burn to detonation under the conditions of the disposal.

11.2.3.7.3 The destruction of tubular gun propellants may be accompanied by intense high frequency noise, in which case hearing protection will be required.

11.2.4 Proving of Scrap and Plant

11.2.4.1 Overview

11.2.4.1.1 Before scrapping plant from an explosives site; the items must be declared and proven “free from explosives”. This is commonly done by burning in a fire to prove the item free from explosives. The final release from site as “Free from Explosives” should be made by a designated responsible signatory as described in Section 19.

Two workmen and a passer by were killed during an attempt to cut a pipe with a saw to use as part of a garden fence. The pipe had been on service on a RDX plant and presumably was contaminated with the explosive.

11.2.4.2 Decontamination Before Proving

11.2.4.2.1 Plant items must be decontaminated as far as is reasonably practicable at the originating area. This will reduce the potential severity of an event should one occur. Plant should be disassembled to its smallest component parts if practicable and safe to do so.

11.2.4.2.2 Old corroded plant may be considered unsafe to dismantle to component parts and may have to be burned without disassembly. Chemical treatment of such components may be considered – e.g. immersion in a caustic solution.

An explosion occurred killing two workers when a steel pipe which had been used to carry toluene containing dissolved wax recovered from phlegmatized RDX was put into a fire to remove a hard crust.

The crust turned out to be pure RDX.
11.2.4.3 Preparation for Proving

11.2.4.3.1 Pipelines pose particular problems and any pipe sent for burning must be open through its length and capable of passing a flow of water. Bends are to be removed if possible. This is because the burning of blocked or heavily contaminated pipes can result in an explosion.

11.2.4.3.2 Valves and pumps must be removed and dismantled if practicable. This will reduce the likelihood that any enclosed explosive could explode in a fire.

11.2.4.3.3 Particular attention should be paid to lead (Pb) components from nitroglycerine plants, as there is a potential for entrained droplets of nitroglycerine within the lead metal.

11.2.4.3.4 Some explosives, e.g. nitrocellulose, are very difficult to remove by washing or dissolution and plant from such areas must be considered as potentially contaminated.

11.2.4.3.5 All plant received at the burning area for burning must be inspected for suspected gross contamination, preferably before despatch to the burning area. The nature, degree and amount of contamination should be estimated and recorded.

11.2.4.4 Proving Activities at the Burning Ground

11.2.4.4.1 Any items of plant not disassembled fully must be specifically highlighted to the person in charge of the burning area, who may then have to set up special arrangements to burn that item.

11.2.4.4.2 Burning of plant and scrap must be carried out in a mounded or protected area as there is a significant potential for detonations or explosions from trapped explosives or propellants and a risk of projection.

11.2.4.4.3 Burning of plant and scrap should take place on a bed of wood sufficient to subject the entire surface of the items in question to prolonged heat at an appropriate temperature.

11.2.4.4.4 Fires should be lit remotely as per 11.2.2.8.

11.2.4.4.5 After burning, plant or scrap should be inspected before removal from the fire. If there is any doubt as to the complete decontamination of the items they must be subjected to further burning.
11.2.4.4.6 The burning area should have systems and methods for strictly segregating “contaminated” and “clean” scrap. Access to these areas should be strictly controlled to prevent unauthorised access and dumping.

11.2.4.4.7 Scrap and plant may also be heat treated in an oven. In such cases the required temperature must be high enough to ensure complete decomposition of any likely contamination and that the residence time must be adequate to enable all parts of the item to reach the required temperature. The use of temperature indicator strips is recommended to provide evidence of the attainment of temperature. The procedures listed above must still be applied for oven decontamination.

11.2.4.4.8 When the explosives can be chemically destroyed, dissolved or washed out of the scrap or plant then there is no requirement to burn the items in question. The steps described above for the strip down and inspection of plant should still be applied as part of the disposal process.

11.3 DETONATION

11.3.1 Overview

11.3.1.1 The approved code of practice to MSER 2005 states: -

“While disposal by detonation is relatively simple, it is essential to use a suitable site large enough to contain the effects of detonation. This method is most appropriate in “use” situations, for example at quarries or other sites where blasting is performed. After detonation, the site needs to be checked for unconsumed explosives. Clear procedures are essential for checking whether all explosives have been fired, and all staff involved in this work must clearly understand the steps to take in the event of misfires.”

11.3.1.2 It is implicit in the above statement that not all spacious sites are suitable. A playing field surrounded by houses, for example, would clearly be unsuitable for the destruction of explosives by detonation unless the quantity were small and appropriate additional engineering controls were in place. Blast design therefore needs to be recognised as a specialist activity requiring appropriate competencies. This is particularly important when the aspects of blast design, including engineering controls (e.g. water mitigation devices such as water curtains and water bags), that could mitigate the effects of any blast are considered.

11.3.1.3 The issues surrounding the choice of destruction by detonation, or other methods of disposal where destruction activities are essentially similar to use, reinforce the importance of recognizing why materials are no longer required or can be considered to be waste. i.e. are the explosives surplus to requirements or time expired etc. but otherwise safe to use or transfer to a person who would have a legitimate use for them, or have they suffered some degradation that means that they are not safe to transport or rework or store and therefore require disposal in situ.
11.3.1.4 Annex F contains guidance on quantity distance relationships applicable to the destruction of explosives by detonation or by another method that is likely to result in an explosion with significant blast effects.

11.3.2 Incorporation in Routine Blasts

11.3.2.1 Where small quantities of waste or slightly deteriorated explosives are involved, it may be feasible to incorporate them in a routine blast. The waste explosives should be loaded into the shot hole so as to minimise any effects on the performance of the blast. If the waste explosives are of a lower performance than the normal explosives, the blasting pattern may need changing.

11.3.2.2 Not withstanding the above detonation is particularly suitable for explosives which are filled into rigid cartridges and which might detonate if burned.

11.3.3 Destruction of Demolition Detonators and Blasting Caps

11.3.3.1 Detonation can also be used to destroy unwanted demolition detonators and blasting caps, provided that the process is carried out so that the detonators are destroyed rather than scattered about the disposal site.

11.3.3.2 One method of achieving this would include bundling detonators together in canvas bags or small fibreboard boxes. A length of detonating cord should be tied tightly around the bundle so that it is in contact with the primary or base charge of each detonator and a fresh detonator attached to a tail of the detonating cord.

11.3.3.3 The assembled charge should be buried in a prepared hole, the minimum depth of which should be of the order of 0.6 m i.e. the hole should be deep enough that any effects at the ground surface from the explosion of the detonators are negligible. This depth may need to be determined by testing. The hole should then be filled with damp sand such that any fragments generated by the explosion are captured. After detonation, the area should be carefully raked and examined for debris or any unfired detonators.

11.3.3.4 Several such charges may be detonated together, but the distance between buried charges should be such that the initiation of one bundle should not disrupt its neighbours and increase the chances of a misfire. Alternatively, small quantities of demolition detonators or blasting caps may be destroyed by insertion into holes pricked in a cartridge of blasting explosives, primed with a fresh demolition detonator and buried as previously described. After detonation, the explosion site should be checked for unconsumed explosives.
11.3.4 The EOD Interface

11.3.4.1 It is important for anyone considering the disposal of explosives by detonation to identify whether or not they are crossing the boundary into Explosives Ordnance Disposal (EOD) and Improvised Explosive Device Disposal (IEDD). For example where explosives substances are identified as requiring disposal as a consequence of criminal or illegal activities, which can potentially include unlicensed manufacture or storage of explosives, advice should be sought from the relevant authorities. Similarly where explosives that are not safe to transport are identified as requiring disposal in situ, particularly when it is identified that there is a significant risk of those explosives initiating and causing injuries to persons, damage to buildings or the initiation of other explosives, specialist advice should be sought from the relevant authorities and a competent EOD specialist.

11.3.4.2 Advice and assistance with respect to explosives ordnance disposal can be obtained from a number of sources including the Emergency Services. Where the situation is not believed to require the attention of the Emergency Services, advice and assistance can be obtained via EOD professionals operating in the private sector. The contact details of some of these specialist contractors can be obtained via the Institute of Explosives Engineers (www.iexpe.org) or the CBI-EIG (www.eig.org.uk).

11.4 DISSOLUTION OR DILUTION

11.4.1 Overview

11.4.1.1 The ACOP to MSER 2005 states: -

“Some explosives can be destroyed or desensitised by a compatible solvent or diluent. The resulting waste can then be disposed of by burning. Most powdery pyrotechnic compositions which contain a water soluble component can be destroyed by immersion in water. The resultant liquor must then be filtered and the solids sent for burning.”

11.4.1.2 This process will invariably result in a liquid or slurry waste which should present a reduced explosive hazard, and which can be disposed of by burning (see 11.2 etc.).

11.4.2.2 Consequential Risks

11.4.2.2.1 Where dissolution is used it is important to ensure that the consequential risks are considered and controlled. These risks include: -

- Solvent evaporating to produce a flammable vapour. It is therefore important that the use of any flammable solvents in the disposal or destruction process is supported by a suitable and sufficient risk assessment carried out under the provisions of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
• Solvent evaporating and regenerating the original explosive.

• Solvent reacting with the explosive to produce a flammable gas such as hydrogen. Again any such reaction would need to be assessed with respect to the provisions of DSEAR.

• Solvent reacting with the explosive to produce an uncontrolled exothermic reaction. Some such reactions can further result in the ignition of the explosives, and components thereof (e.g. sodium and water), and any flammable gas produced.

• The production of solutions that pose a greater risk to health or the environment than the original explosive.

11.4.2.2.2 Some pyrotechnic compositions may become more dangerous if merely damped and/or allowed to dry out. This is because some compositions containing finely divided metals, such as aluminium, may give rise to flammable gases, such as hydrogen when wetted with water or because the soluble component, such as oxidising agents can recrystallize and reform an explosive with any residual fuels.

11.4.2.2.3 The use of low flash point or highly volatile solvents should be avoided for these processes. For the purposes of this guidance a low flashpoint solvent is one which would be classified as a highly flammable liquid under the provisions of the Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP) or a liquid which will be heated above its flashpoint as part of the disposal process. For the purposes of this guidance a highly volatile solvent is considered to be one which would produce significant volumes of flammable, toxic or otherwise harmful vapour under the conditions of the disposal operation.

11.4.2.3 Deactivation and Desensitisation of Explosive Properties

11.4.2.3.1 The consequential risks notwithstanding, explosives which contain a soluble component can often be completely deactivated by a solvent. The majority of powdery pyrotechnic compositions, which contain a water-soluble component (e.g. nitrates, chlorates, perchlorates) are readily destroyed by immersion in water, although larger pieces including fireworks may require prolonged steeping.

11.4.2.3.2 Care should be taken that there is enough solvent to thoroughly wet the composition and to ensure that it remains wet. This will desensitize the explosive and will ensure that the entire soluble component is taken up into solution.

11.4.2.3.3 A large quantity of a non-flammable solvent can also act as a heat sink and reduce the likelihood of a exothermic reaction reaching runaway, it can prevent an ignition communicating to or between explosives.
substances and articles being soaked and can act as a mechanism for mitigating an explosion should one occur.

11.4.2.3.4 Liquid explosives such as nitroglycerine, ethylene glycol dinitrate (EGDN) and casting liquids often exhibit reduced sensitivity to friction or impact when diluted with miscible compatible liquids. A typical example is triacetin which is used as a diluent for nitroglycerine. However this treatment does not destroy the explosives and should only be used to desensitise them before burning or other approved treatment (see section 11.2).

11.4.2.4 Chemical Compatibility

11.4.2.4.1 Information relating to the risks of mixing explosives or their individual chemical components with solvents can be found in Materials Safety Data Sheets, Explosives Hazards Data Sheets and Product Safety Data sheets, many of which are freely available via the internet. Materials Safety Data Sheets are generally a good source of information with respect to risks of evolution of flammable gasses and the compatibility of materials. Where such information is not available then it may be necessary to carry out appropriate compatibility testing.

11.4.2.5 Clothing

11.4.2.5.1 The washing of contaminated clothing can, under some circumstances be considered to comprise the disposal of explosives by dissolution or dilution.

11.4.2.5.2 Systems or procedures will therefore need to be established in order to prevent the accumulation of quantities of explosives or explosive components within washing machinery or drains etc. that could comprise a significant risk to persons, property or the environment from fire or explosion.

11.5 Desensitisation and Chemical Destruction

11.5.1 Overview

11.5.1.1 The ACOP to MSER 2005 states:

“Chemical destruction is normally only relevant to the decontamination of plant or spillages where ‘on the spot’ destruction of small amounts of explosives is required. It may also be appropriate to use this method for very sensitive explosives which may be too dangerous to transport in other ways.

Any secondary waste from chemical destruction must be assumed to be an explosion risk, and be dealt with accordingly.”

11.5.1.2 Chemical destruction fulfils a very important role in some aspects of the explosives industry and in some ways can be considered to be analogous to dissolution and dilution techniques. The information contained in that section of this guidance is therefore applicable to this.
11.5.2 Examples of Chemical Destroyers

11.5.2.1 Probably the best-known example chemical destruction is the use of nitroglycerine destroyer, such as alcoholic potassium hydroxide. The application of nitroglycerine destroyer causes an exothermic reaction, liberating heat and, for this reason, its use should be limited to small areas of contamination and it should not be used to destroy complete cartridges.

11.5.2.2 Other examples include the use of sodium hydroxide to destroy nitramines such as RDX and HMX contaminating equipment. Again exothermic reactions can occur if solid sodium hydroxide or sodium hydroxide solutions at high concentration come into contact with explosives. It is therefore fundamental to the safety of such processes that solid sodium hydroxide cannot come into contact with explosives, that the concentration of sodium hydroxide is known to be appropriate prior to destruction of the explosives commencing and that the concentration of sodium hydroxide is periodically monitored through-out the process.

An explosion destroyed an annexe to a building in which a plate of defective detonators was being destroyed by immersion in caustic soda solution. It appears the caustic soda solution was too strong and the heat generated as the aluminium dissolved detonated the explosives.

Luckily no one was injured.

11.5.3 Wider Applications

11.5.3.1 It should also be recognised as part of the waste management process that all explosives can reach a state of decay where they become too dangerous to transport. There are therefore circumstances where chemical destruction techniques can have wider applications. However should such a position be reached it may be necessary to consider any such circumstances with respect to the specific advice and guidance that can be provided by the manufacturer or supplier of the explosive, the licensing authorities, and the EOD communities.

11.5.4 Secondary Wastes

11.5.4.1 Chemical destruction of explosives will always result in secondary waste which, unless known to be otherwise, must be assumed to be an explosion risk and dealt with accordingly. This is usually achieved by burning, although bioremediation may be an appropriate alternative.

11.5.4.2 The precautionary principle indicates that the characteristics of the secondary waste should be investigated before large-scale chemical
destruction takes place and that the planned monitoring of any secondary (or tertiary waste etc.) generated should take place.

11.6 Disposal of Explosive Articles

11.6.1 Overview

11.6.1.1 The ACOP to MSER 2005 states: -

“The method of disposal for explosive articles will depend on the nature of the individual device. The hazards and risks arising from each method need to be considered before deciding on the appropriate one to use.

Disposal can sometimes be safely achieved simply by exploding the article under controlled conditions at a suitable location. Alternatively destruction of small articles may be possible in an armoured furnace. Disassembly or breakdown of articles should only be considered as a last resort. It should also be borne in mind that disassembly is an act of manufacture and must be carried out in a place licensed for manufacture. An exception to this is ordnance disposal for public safety carried out under the direction of a police officer or a member of HM forces.”

11.6.1.2 Each of the four techniques described previously can be applied to the disposal of the explosive components of explosive articles.

11.6.1.3 The range of devices containing explosives is very wide and it is not possible to give detailed guidance on this subject. In this context, device means articles containing explosives, including fireworks or detonators for blasting and can include cartridge blasting explosives. Examples of such devices are primers, percussion caps, explosive actuators, fuzes and power cartridges. It is important to recognise that some of the competencies required for the disposal of some explosive articles may only be possessed by professional Explosive Ordnance Disposal personnel.

11.6.2 Breakdown of Articles and Devices

11.6.2.1 Given the risks likely to be associated with the process, disassembly or breakdown of devices should not be undertaken unless absolutely necessary or unless it is part of a safe system for the normal use of the article. Disassembly must be carried out in a facility licensed under the MSER 2005. Annex H contains guidance from HSE’s Explosive Inspectorate on whether certain activities relating to the disposal of explosives require a licence.

11.6.2.2 Since breakdown may involve cutting or other mechanical operations, certain basic precautions must be observed in addition to any identified as being required under the provisions of Regulation 4 of MSER 2005. These basic precautions would include compliance with the following:
• disassembly (with consequent exposure of powdery or sensitive explosives) can be a high risk activity because of the potential for the exposure of composition or because explosives can be subjected to a range of energetic stimuli and therefore remote breakdown should be adopted if possible;

• if remote breakdown is impracticable, localised screening which will contain the potential effects of the device must be installed between the operator and the device. This should supported where appropriate by suitable PPE;

• all tools, as far as possible, should be appropriate to the task and take account of the potential for exposed composition to be initiated. Where cutting and other operations are conducted remotely mitigatory provisions may permit the use of tools that possess an inherently higher risk of causing an initiation that other less effective tools;

• where practicable, the item should be broken down under water, oil or another desensitising medium, so that any exposed explosive is quickly desensitised. However this activity should take account of any potential interactions between a desensitising medium and the explosive article and its contents.

While an experienced man was preparing waste detonators for disposal there was an explosion, and he suffered lacerations of both eyeballs, a toe and forearm and various puncture wounds.

The man had not used the safety screen and protective goggles provided.

11.6.2.3 Effectively therefore no decision to conduct disassembly and breakdown operations should be made until a suitable and sufficient assessment of the explosive and other risks involved in the process have been made.

11.6.3 Control of Confinement

11.6.3.1 Articles including fireworks should not be burned together where there is a risk of the explosion of one article being communicated to its neighbours such that a mass explosion will result. This is particularly relevant to fireworks and other pyrotechnic articles containing significant quantities of flashpowder where increasing self-confinement can result in a greater likelihood of a mass explosion. The results of United Nations Series 6 tests carried out for classification and the Default List for the classification of
fireworks may provide useful information on the expected behaviour of articles in fire situations.

11.6.4 Use of Remote Firing Rigs

11.6.4.1 Once it has been identified that disposal by destruction is necessary it should be established whether the device can be disposed of by simply using it as it was designed to be used. This can often be achieved by use of a remote firing rig. As has been previously noted this is because the behaviour of explosive articles in normal use has generally been characterised and is fully understood.

11.6.4.2 It may be that the effects of the device can be contained within an armoured firing rig that could contain the effects of the device whilst allowing any fumes etc. generated to be treated. Such devices are currently under development for the disposal of air bags.

11.6.4.3 It is important to recognise that persons who are competent to manufacture and/or store explosives may not be competent to use or fire them (and vice versa).

11.6.5 Armoured Furnaces

11.6.5.1 Destruction in an armoured furnace may be possible for relatively small articles and devices.

11.6.5.2 For the purposes of this guidance a relatively small article or device is one whose initiation within a container will have no effect outside that container. This characteristic will probably need to be determined by trials work and type testing. Articles including fireworks should not be burned under confinement unless the confining structure has been built to a standard where it will either contain the effects generated by the article during disposal or vent them safely. This standard of performance can be demonstrated by the type testing of safety equipment with explosives of a performance at least as great as that expected from the maximum credible event in the circumstances of the disposal. It will be necessary to identify that the standard of performance of any confining structure is being maintained by instituting a scheme to examine the furnace or other confining structure for signs of deterioration that could affect safety. This is particularly important with respect to many explosives because their combustion products are corrosive.

11.6.5.3 The use of an armoured furnace fitted with appropriate remediation equipment would be preferred as a method of destruction for relatively small articles and devices where any emissions could be harmful to the environment.

11.6.5.4 Percussion igniters, small percussion detonators, percussion caps, nail gun cartridges, small arms/sporting ammunition and similar devices are best burnt in an armoured furnace or a fire in a steel enclosure. Small
quantities may be burned in heavy perforated metal boxes on an open fire. In this instance a small quantity is defined as that quantity which will not have a significant effect outside the metal box or other enclosure. This quantity should be determined by type testing.

11.6.5.5 Armoured furnaces may be set up for remote addition of the explosive devices. These should be added in small amounts with no further additions until a time interval has elapsed from the previous addition. With small devices it is not normal to hear each individual explosion. With larger devices when an appropriate number of explosions have been distinctly heard further additions may be made.

11.6.6 Caged Burning

11.6.6.1 Where fireworks (including rockets and other types that contain projected effects such as stars, or sound and light units) and other explosives can be propelled from fires their effects can often be adequately contained by burning them in a suitable structure such as a for example a gated pit or a mesh steel cage.

11.6.6.2 Articles including fireworks should not however be burned under confinement unless the confining structure has been built to a standard where it will either contain the effects generated by the article(s) during disposal or vent them safely. This standard of performance can be demonstrated by type testing.

11.6.6.2 The strength of any mesh or barrier used should be matched to the strength of any potential assault. The diameter of any mesh should whenever practicable, be smaller than the diameter of the smallest projected effect. This can be achieved by offsetting a series of meshes one over the other with an appropriate standoff between them such that the confinement of the explosives being burned is not significantly increased. This should be demonstrated by type testing.

11.6.6.3 It will be necessary to identify that the standard of performance of the cage or other structure is likely to be maintained by instituting a scheme of examination for signs of deterioration that could affect safety. This is particularly important with respect to many explosives because their combustion products are corrosive.

11.6.7 Separation Distances

11.6.7.1 Where the risks of propulsion from fires of items such as small percussion detonators, percussion caps, nail gun cartridges, small arms/sporting ammunition and similar devices appropriate for burning in furnaces have been controlled the segregation distances can be reduced to those required to protect people, explosives and buildings from the thermal effects of the fire, the distance travelled by glowing or smouldering embers and any residual blast effect.
11.6.7.2 Where type testing of cages or other containing structures has shown that the projected effects are fully contained and the likelihood of a significant explosion has not increased the segregation distances can be reduced to those required to protect people, explosives and buildings from the thermal effects of the fire, the distance travelled by any glowing or smouldering embers, and any residual blast effect.

11.6.7.3 Alternatively where type testing has shown that the projected effects have not been fully contained but any projected effects have been significantly reduced below their potential maximum it may be possible to demonstrate that a reduced segregation distance to protected persons, explosives and buildings would be appropriate. i.e. where rockets have been contained but not the stars that they contain the segregation distance would be related to the radius of effect of the stars rather than the potential distance travelled by the rockets.

11.6.7.4 Finally, where the risk of a projected effect causing a fire to the structure of a building itself, (or to flammable materials whose ignition would comprise a risk to persons in the open, buildings containing people or buildings containing explosives and other hazardous or potentially hazardous materials) is negligible, screens and barriers can be used to protect the entrances and openings in occupied buildings or buildings that contain explosives from projected pyrotechnic effects. Again the size of any mesh and the strength of the barrier will need to be matched to the diameter of any projected effects and the strength of any potential assault and this can be demonstrated by type testing.
SECTION 12  FACILITIES AND EQUIPMENT

12.1 Overview

12.1.1 As has previously been stated the principal criterion for the siting of a disposal facility is the assumption that the entire mass of explosives being destroyed could explode or that the maximum credible event could occur. Consequently the site must be remote from its associated workplaces and any surrounding buildings or public areas.

12.1.2 The necessary safety distance will depend on the maximum quantity of explosives present at the disposal facility including any being disposed of and any engineering controls that are in place to mitigate the effects of any such event. These controls could, for example, include compartmentalisation and the unit risking of quantities of explosives. Again as has previously been stated Annex F provides guidance relating to the segregation of people, occupied buildings and buildings containing explosives from destruction activities.

12.1.3 Where explosives requiring disposal or destruction are processed or kept at a disposal site they will be subject to the requirements of MSER 2005.

12.1.4 It is important to recognise that Environmental Impact factors such as the generation of smoke and noise, may need to be considered in addition to safety factors in the identification of the location of a disposal site. As far as possible, the site should be positioned so that it is downwind of adjacent working and residential areas. This will reduce the likelihood of smoke, fume odour or other nuisances as well as risks to health and safety, including burning brands etc. affecting persons away from the disposal site.

12.2 The disposal site location

12.2.1 Positioning of the site should also take into account prevailing wind directions, particularly when the destruction of explosives is to be achieved by burning. In the case of licensed or registered explosives facilities, the siting of the disposal area will also depend on the uses of neighbouring licensed buildings or registered facilities in order to control the risks of any explosives present being initiated as a consequence of the disposal activity.

12.2.2 Consideration should also be made of the effect that the disposal activity could have on services and utilities, both above ground and subsurface, that can be found either within or in close proximity to the disposal site.

12.3 Further Guidance on surfaces in the Disposal Site

12.3.1 The site should be level and well drained in order to minimise the risks of slipping and tripping whilst working with explosives on the disposal site. It is important to recognise that a well-drained site can have implications for groundwater contamination.
12.3.2 Ideally any surface that is at risk of being disrupted by an explosive event and comprising a secondary fragment hazard should be earth, sand or crushed clinker. However provided that the actual disposal areas are kept clear, short grass, that will not pose a significant risk of fire and which will not hide live materials that may be thrown from a fire or explosion etc. is acceptable in other parts of the disposal site.

12.3.3 In particular, places used for burning explosives should be surfaced with non-combustible material such as earth, crushed clinker and sand and should be free from holes or fissures. Asphalt or tarmac surfaces are not suitable not only because they are likely to include cracks and fissures but also because they can burn or distort when subject to heat. Concrete can be an appropriate surface for disposal areas either when it is sufficiently segregated from the burning surface such that there in no risk of an explosion generating a secondary explosion hazard or where it provides a smooth surface that will not confine the explosive being disposed of and the nature of that explosive is such that it will not generate secondary fragments should the maximum credible event occur.

12.4 Separation of Activities at the Disposal Site

12.4.1 The site should be as large in area as possible with good separation between the various places of activity. This will prevent clutter and will allow workers and supervisors a clear view of the site. It will also allow the risks of an event at one location on a disposal site being communicated to another to be controlled by segregation. Separation between disposal places and unitisation of risk is likely to be achieved by a combination of distance, and engineering controls such as earth mounds. Where segregation hinders the direct observation of disposal operations the use of remote and indirect observation systems such as CCTV should be implemented.

12.4.2 If waste is to be destroyed regularly then a number of disposal places can be provided and used in rotation. This will reduce the risks of materials from a previous disposal acting as a source of ignition or initiation during a subsequent disposal activity and will allow maintenance and refurbishment activities to take place without excessive quantities of explosives requiring disposal accumulating elsewhere.

50 kg of waste explosive black powder in small grains, agglomerated with nitrocellulose exploded when two operators tipped the waste over the glowing embers from the previous days waste disposal operation.

Both were killed.
12.5 Firing/Control Points

12.5.1 All disposal operations should be initiated remotely from a safe control point. Wherever reasonably practicable a building should be provided to act as this safe control point and to protect disposal area personnel during disposal operations as well as housing any firing, control, surveillance or other necessary disposal related equipment. Such a building should be located and constructed to provide protection from the maximum credible event which may occur with the explosives being disposed of. The likely threat to and the location of the safe control point should have been identified by suitable and sufficient risk assessments. Further guidance relating to the location of control rooms has been published by the CBI-EIG and HSE in the document *Requirements for Remote Explosives Manufacturing Facilities.*

12.6 Water Supplies

12.6.1 Where there is a risk of any disposal activity resulting in a fire that has the potential to spread to other locations or where it will be necessary to damp down disposal locations following use, such as at burning grounds, the disposal site should have a water supply with sufficient stand pipes and hoses to allow access to all areas. At remote sites where a suitable supply of running water is unavailable, alternative arrangements using static tanks should be made. At locations where the use of water would not be compatible with the disposal activity taking place alternative fire fighting arrangements should be made.

12.6.2 An assessment should be conducted to ensure that the water or other fire fighting provisions are appropriate to the use that they are being put and to the potential extent and consequences of any likely fire.

12.7 Lighting

12.7.1 Where disposal is by burning sufficient time should be allowed between the start of the final burn of the day and stopping work to allow the fire to die down fully and the area to be checked for misfired or unburnt items. Work should be organised to ensure that all activities are completed under appropriate lighting conditions. This means that it may be necessary for suitable and sufficient artificial lighting to be provided at the disposal site.

12.8 Access Control

12.8.1 Access to all disposal sites should be controlled at all times that they are in use or when explosives are present in order to control access to potential danger by those not involved in the disposal process. For licensed explosives facilities or other locations where explosives are routinely disposed of the disposal site should be fenced and have only one entrance in normal use. The fence should be sufficient to prevent inadvertent entry.
12.8.2 A means of warning people of the danger should be used, to deter unauthorised entry. A red flag is often used for this purpose. All entrances to the disposal site should display notices indicating the nature of the site and warning against unauthorised entry. Where this is not practicable it will be necessary to implement alternative arrangements such as a manned perimeter at an appropriate distance.

12.8.3 It is important to recognise that the area within which people will be at risk from the disposal activity could potentially be larger than the disposal site and its immediate environs.

12.8.4 The disposal activity and the area within which people, occupied buildings and other explosives would be at risk should be observed until such time as the risk of any event communicating, either by explosion or the spread of fire, is negligible.

12.9 Communications Arrangements

12.9.1 Wherever possible, the disposal site should be connected by telephone, or other communication system to enable emergency calls to be made.

12.9.2 Any risks to the explosives present from the communications equipment proposed should be assessed prior to its selection and use.

12.9.3 All persons engaged in disposal operations should be familiar with the use of the communications equipment provided and checks should be carried out to ensure that it is working prior to the disposal or destruction activity taking place.

12.10 Storage of Explosives at Disposal Sites

12.10.1 The disposal site should not normally be used for storage unless special facilities exist there to handle this requirement. If bad weather or other circumstances delay disposal the explosives or any contaminated waste should be collected and returned to a segregated store or stores. A sufficiently secure explosive store can be located at the disposal site subject to compliance with relevant licensing or registration conditions.

12.10.2 Any explosives identified during CFFE procedures (see Section 19) should be secured until the disposal activity is complete, the disposal area checked and any remedial action has been taken.
SECTION 13  OPERATIONAL PROVISIONS AT DISPOSAL SITES

13.1 Overview

This section identifies some of the wider issues associated with the operations of places used for the disposal of explosives.

13.2 Competence

13.2.1 The destruction of explosives must only be carried out by competent persons. All persons involved in the disposal of explosives should be provided with sufficient training such that they can identify when safe systems of work are being deviated from.

13.2.3 Given the high risk nature of the disposal of explosives the competence of operators and supervisors should be subject to appropriate monitoring including, for example, competency testing.

13.3 Supervision

13.3.1 All disposal and related operations should be under the direct control of a person who has sufficient technical expertise to ensure that a safe system of work derived from the relevant risk assessments is being followed and that the risk assessments remain valid for the tasks at hand. This person should also possess sufficient technical competence to bring work to a stop safely should deviations from procedures be identified or should emergency or unsafe conditions arise.

13.3.2 Where there is more than one destruction/proving area on a site, overall control should be clearly allocated to a single person to ensure that multiple disposal operations do not occur without sufficient segregation either by distance or time.

13.3.3 In addition disposal operations should be subject to regular inspection and audit as described in the safety management systems section of this guidance.

13.4 Staffing Levels

13.4.1 Destruction operations should be kept under sufficient surveillance such that any incident can be reported to the emergency services etc as soon as possible. This will normally mean that at least two persons will need to be present during the preparation and conduct or the destruction activities including any remedial activities including CFFE.

13.4.2 At least one of the people present should be sufficiently segregated from any explosives related activity such that they are unlikely to be suffer any injury that would prevent them from raising the alarm should an incident occur. This is particularly important at remote sites.
13.5 Provision of PPE

13.5.1 It is extremely unlikely that it will be possible to conduct all the tasks required by a disposal operation without some requirement for PPE, particularly when the explosives being disposed of are identified as comprising a thermal hazard or are to be disposed of by burning.

13.5.2 Any requirement for PPE during disposal operations should be derived from a suitable and sufficient risk assessment. It would normally be expected that any PPE required for disposal operations would be of at least a similar standard to that employed during the manufacture or use of the explosives. In many circumstances the risks associated with aspects of disposal operations are such that a higher standard of PPE to that employed in the manufacture or use of the explosives would be expected.

13.5.3 PPE is likely to include fire-retardant clothing, face guards, gloves and or gauntlets, aprons and boots. Hoods and hearing protection may be required to protect people against risks to health as well as risks to safety. It may also be required to reduce the risk of an electrostatic discharge causing a risk of ignition. Additional guidance on the requirement for and the selection of PPE in an explosives environment can be found in Fire Protective Clothing, CBI EIG Guide, ISBN 0852015135 and Head and Eye Protection, CBI EIG Guide.

13.5.4 It has generally been considered to be good practice in the explosives industry for clothing not to have pockets. The absence of pockets makes it much less likely that contraband items such as matches or other sources of ignition such as tools or electrical equipment can be brought into disposal areas.

13.6 Tools

13.6.1 All tools and other equipment which are used on the disposal site should be of a design and be constructed of materials that are appropriate to the explosives and waste being manipulated. It is therefore customary to use tools and other equipment that do not present a spark or friction hazard. Tools for handling and spreading explosives, e.g. scrapers, scoops, rakes, should be made of ‘soft’ materials such as wood or plastics, providing that these materials are appropriate to any electrostatic precautions that need to be taken with the materials being manipulated. Other tools, such as knives, screwdrivers etc could be non-ferrous or covered with a safe and suitable material, provided that such coating is regularly inspected for integrity.

13.6.2 In order to control the tools used during disposal operations a use list specifying which tools are permitted on the disposal site should be displayed at the site. Regular checks should be made to ensure that other tools are not taken onto the site.
13.6.3 Where difficulty is experienced in maintaining a cutting edge on non-ferrous tools, a steel knife may be used, provided that a wooden cutting block is used so that no steel to steel contact can occur during the cutting operation.

13.7 Records

13.7.1 Wherever practicable a log book detailing the daily activities of the disposal area should be kept, recording details of which explosives are received, and the date and circumstance of their destruction. Such information will be a key element of a system for keeping records of explosives under the Control of Explosives Regulations 1991, and for demonstrating compliance with environmental legislation.

13.7.2 Where the explosives are not subject to the Control of Explosives Regulations 1991, logbooks still fulfil an important function. They can provide evidence of adequate supervision and information necessary for monitoring, audit and review of the disposal activities as part of an effective safety management system and for demonstrating compliance with environmental legislation.

13.8 Operating Instructions

13.8.1 Detailed operating instructions should be prepared and made available at the disposal area. These instructions should cover both general procedures and any necessary specific details that are required to carry out operations safely. It is likely that different types of explosives and articles disposed of at a single site would require different procedures to be followed because of potential differences in the behaviour of the explosives and the associated risks.

13.8.2 It is particularly important to ensure that such instructions and procedures are kept up to date and are subject to regular monitoring to ensure that they are being complied with as well as to facilitate systematic audit and review.

13.8.4 Operating instructions will vary from site to site but should be derived from and integrated with integrated with the relevant risk assessments. They should typically include:

- explosive limits for each task that takes place and each type of explosive that is likely to be present
- The minimum and maximum number of persons who should be present, their roles and responsibilities.
- The specification of any PPE that is required for the process or individual elements of such.
• The precautions and other controls that are necessary to carry out the disposal operation safely including pre-use and post completion checks.

• Method statements describing how to carry out the necessary tasks.

• The communications system that should be in place;

• Medical arrangements

• List of prohibited articles and substances.

• Accident and emergency procedures

• Actions to be taken in the event of foreseeable incidents such as the presence of unauthorised persons or an incident potentially necessitating the cessation of the disposal activity such as a fire alarm elsewhere on site.

• Authorised means of ignition, initiation or otherwise starting the act of disposal.

• Records to be kept

• And finally what to do when a deviation from the operating instructions is identified.
SECTION 14  THE GENERATION AND ACCUMULATION OF EXPLOSIVES REQUIRING DISPOSAL

14.1 Overview

14.1.1 In addition to the actual disposal or destruction activity itself the processes involved in the generation and accumulation of explosives requiring disposal will need to be actively controlled.

14.1.2 The guidance in this section should be taken into consideration as part of the controls in place to prevent fire and explosion under Regulation 4 of MSER and the associated ACOP. This guidance is applicable when a process results in the generation and accumulation of explosives requiring disposal.

14.1.3 The locations where explosives requiring disposal are generated and accumulated should be identified if risks are to be properly controlled. Similarly any implications of this generation and accumulation with respect to licensing and registration requirements under Regulation 9, 10 and 11 of MSER 2005 will need to be identified.

14.1.4 These matters are particularly significant when

- the explosives requiring disposal present a different hazard type to that recognised by the terms and schedule to any licence or registration.

- the presence and nature of the explosives requiring disposal significantly increases the likelihood that an explosive incident could occur.

- the ongoing presence of explosives requiring disposal within a process effectively means that a facility is being used for the storage of explosives.

14.2 Segregation, Labelling and Collection of Explosives Requiring Disposal

14.2.1 A collection system for explosives requiring disposal or destruction should cover a number of functions. These include:

- the segregation of explosives requiring disposal or destruction into clearly labelled containers; and

- the collection of explosives requiring disposal and destruction including any preparations for onward transport operations either within a licensed facility, a place where explosives are being used, or on the public roads as well as its delivery to any receiving location.
14.2.2 Where the explosives requiring disposal or destruction have originated from a manufacturing operation carried out at a facility licensed under MSER 2005 the segregation is usually best performed in the process areas where the explosives requiring disposal or destruction originate. However the likelihood and consequences of any incident involving such segregation should be taken account of during the identification of an appropriate location for this activity.

14.2.3 All explosives requiring disposal should be clearly and unambiguously labelled or otherwise identified at their point of origin as soon as it is reasonably practicable to do so. This identification should carry full details of the type of explosives, special precautions if required, the originator, and the name of the person responsible for the disposal of the explosives.

14.2.4 Ways of identifying explosives for disposal within a facility licensed or registered under the provisions of MSER 2005 include using different distinct types of container, colour coding or simply painting the nature of the waste on the container. In any event, the purpose of each container should be clearly understood and systems should be in place for their control and the management of their contents.

Two employees received injuries, one seriously, when a container of waste products that was giving off smoke exploded.

Further investigation into the explosion revealed the cause to be the mixing of waste products which resulted in an adverse chemical reaction. One container held sweepings of emulsion product mixed with ammonium nitrate; the other container held a highly concentrated solution of sodium nitrite with crystalline sodium nitrite at the bottom. Prior to the incident an empty container was required and on viewing the containers in the area an employee believed that the container holding the solution of sodium nitrite was water and that the crystals were those of ammonium nitrate and, therefore, there would be no problem in mixing it with the ammonium nitrate and emulsion sweepings. Two hours after the mixing of the products, smoke was observed coming from the container and whilst employees were approaching the area with fire extinguishers the container exploded.

14.2.5 One practical method for ensuring that the requirements of the segregation, collection and identification processes are met is to make the persons who are actually involved in any disposal or destruction activities responsible for collection. The reason for taking this approach is that these people are those most likely to be put at risk should procedures fail to be complied with.

A cleaning lady inadvertently mixed waste thermite composition with an ammonium nitrate based crystallized emulsion when emptying waste bins in a laboratory. The waste ignited.
14.2.6 Where explosives requiring disposal or destruction are routinely or regularly generated their collection should typically be subject to a timetable or rota based on the production schedules, the quantity of explosives requiring disposal or destruction that are generated and the operating system for the disposal.

14.2.7 Explosives requiring disposal should be collected often enough to prevent their excessive accumulation in process areas and at least daily in areas or locations that are not licensed for the storage of such explosives or where that accumulation has not been recognised as part of any licensing or registration arrangements. For example in the case of sumps, labyrinths or catchalls designed to trap explosives in effluent, or in buildings where only small amounts of waste are generated, the rate of accumulation of explosive may be sufficiently low to make less frequent collection acceptable and should have been recognised in the licensing of the facility. An excessive accumulation of explosives is considered to comprise accumulation where there is a significant increase in the likelihood or potential extent and severity of an explosive event above that identified or implicit in any licensing, registration or use requirements.

14.2.8 The choice of container used for the collection of the explosives requiring disposal will depend on the explosives involved and it is important to remember that packaging can play a role in the prevention and mitigation of incidents. Some general points are:

- the container must be non-absorbent and compatible with the explosives involved;

- lids should be non-nipping and screw tops should not be used;

- conductive containers should be used for electrostatic sensitive compounds;

- containers should be non-ferrous or coated such that no ferrous metal is exposed or likely to become exposed during the use of the container.

- any container should be considered with respect to the requirements of CLER and CDG when the disposal activity will require the explosives to be transported on the public roads.
14.2.9 It is important to recognise that persons involved in the collection and or segregation of explosives requiring disposal or destruction may be involved in activities that require them to be issued with suitable PPE. It should also be recognised that this PPE requirement may be over and above that necessary to protect those persons involved in the generation of the explosives requiring disposal and or destruction.

14.3 Storage of Explosives Requiring Disposal or Destruction

14.3.1 Where there will be a delay between identifying the requirement to dispose of or destroy explosives and their disposal and destruction, storage may be required at the disposal site or at another location to accommodate the accumulated material.

14.3.2 An example of such a delay could include the accumulation of explosives articles such as fireworks or ammunition for which a disposal requirement exists but which have been identified as not comprising an enhanced risk to safety during storage. It would be reasonable to allow such materials to accumulate to a point where disposal activities become viable on the grounds that the risks associated with the disposal and ancillary activities have not increased significantly despite the accumulation of increased quantities of explosives and provided that the explosives do not present a significantly increased risk of initiation during storage.

14.3.3 Further guidance with respect to this matter can be found in Section 16

14.4 Explosives presenting an increased risk of initiation

14.4.1 It should be recognised that where explosives are identified as requiring destruction due to an increase risk of initiation then they should be destroyed as soon as is reasonably practicably safe to do so.
14.5 Pre-treatment of Explosives Requiring Disposal by Destruction

14.5.1 Pre-treatment of explosives requiring disposal by destruction is often appropriate to ensure that the explosives are in a safe or safer form for transport to and handling at the disposal site. Where it is so far as is reasonably practicable safe to do so any pre-treatment should be carried out at the location where the explosives requiring destruction are generated. The generally recognized principles of pre-treatment are:

- Liquid explosives such as nitroglycerine can be absorbed on wood meal and the resulting material placed in plastic or polythene-lined containers.

- Explosives which are friction or impact or electrostatically sensitive when dry can be damped with water or other suitable liquid (not low flashpoint solvents). The damping agent should not increase the risk of chemical decomposition (e.g. water is not appropriate for metalised pyrotechnic compositions).

- Other sensitive explosives can also be pre-treated. The objective of this pre-treatment can be to either reduce sensitivity to initiation or to control and reduce the burning rate of a composition should an event occur e.g. use of diesel or dichloromethane (DCM) with magnesium Teflon Viton (MTV) and the dilution of powdery firework compositions in sawdust following breakdown for sulphur/chlorate testing.

- Small explosive devices, such as primers and percussion caps, can be immersed in oil or similar materials such as diesel.

- Any pre-treatment activities should be considered with respect to the requirements of CLER and CDG when the disposal activity will require the explosives to be transported on the public roads.

- Pre-treatment activities may themselves comprise acts of manufacture as defined in MSER 2005 and therefore require a licence. Annex H includes a list of pre-treatment activities that have been considered by the Health and Safety Executive’s Explosive Inspectorate with respect to this matter and provides general guidance as to whether or not a licence would be likely to be required. Where any doubt exists specific advice should be sought.

- Where pre-treatment activities take place within a facility licensed under MSER 2005 those activities should be recognised on the relevant building schedules.
SECTION 15 TRANSPORTATION OF EXPLOSIVES REQUIRING DISPOSAL

15.1 Overview

15.1.1 There are two alternative scenarios for the transport of explosives requiring disposal. The first is transport within a facility licensed under MSER, the second is transport operations that involve journeys on the public roads.

15.1.2 The first consideration that should be made in both scenarios is whether or not the explosives requiring disposal or destruction are safe to transport.

15.1.3 If the explosives are not safe to transport then the advice of competent persons should be sought as to how the explosives can be made safe for transport or otherwise disposed of in situ.

15.2 Transport Within a Licensed Facility

15.2.1 For transport within a licensed facility, where no part of any journey will be on the public roads, vehicles should be appropriate for the purpose.

15.2.2 For example explosives must be well protected from the weather and sufficient restraint provided to prevent possible spillage during conveyance. Suitable materials of construction should be used for any part of the vehicle which may come into contact with explosives material, with particular consideration given to shielding moving parts. Any exposed steel on the vehicle must be completely covered with paint or other suitable non-metallic material. Vehicle electrics should be to the appropriate standard and consideration should be given to the use of engineering controls to mitigate the effects of any event during transportation. Such controls could include the use of trailers or barriers that would segregate the driver and any passengers from the effects of an explosive event and the compartmentalisation of the load such that the level of unit risk is reduced.

15.3 Transport on Public Roads

15.3.1 Where explosives requiring disposal are to be conveyed on the public roads the requirements of CDG, including those relating to the construction of vehicles should be complied with.

15.3.2 In addition it is important to recognise that it will be necessary for the explosives for disposal to be classified under CLER and that depending on the reasons for explosives requiring disposal any previously granted classification may no longer be valid.

15.3.3 If explosives requiring disposal are to be transported on the public roads, or are to be transferred to another person it is essential that the segregation, collection and identification processes in place include
procedures to ensure that any requirements under CLER, CDG and POMSTER are met.

It is inherently obvious in disposal and destruction operations that explosives on occasion will: -

- Not be in the packaging in which they were classified.
- Not have been through the classification process.
- Differ significantly from the state in which they were classified e.g. water damaged, corroded, partly dissembled etc.

Procedures should be in place to recognise this and where appropriate either make application for a new classification or apply to the competent authority via HSE for an authorisation to transport the explosives under Regulation 36 of CDG.

15.4 Transport Risk Assessments

15.4.1 The risk assessment for all transport activities on site, including the choice of vehicle, should take account of the likely nature of the road surface or other ground that the load is to be expected to be transported over.

15.4.2 Similarly where the transport activity is being undertaken under the provisions of CDG 2004 and where the risks associated with the transport of the explosives requiring disposal are not explicitly or implicitly addressed in the requirements of the regulations it is recommended that additional account should be taken of those risks as part of a specific risk assessment.
SECTION 16 FURTHER GUIDANCE ON THE STORAGE OF EXPLOSIVES REQUIRING DISPOSAL

16.1 Overview

16.1.1 As has previously been stated the risks associated with storage of explosives prior to disposal should be subjected to a suitable and sufficient risk assessment and any necessary controls should be put in place.

16.2 Licensing Implications

16.2.1 Where the characteristics and properties of the explosives requiring disposal are such that there is no significant increased likelihood of a fire or explosive event occurring during any storage over that that would normally be expected for the explosives and which has been recognised in any licence or registration of the facility no additional precautions above those normally required by the licence and the provisions of MSER 2005 will need to be taken. However it is important for the storage to be actively managed and for disposal to be arranged as soon as is reasonably practicable such that the explosives being kept do not significantly deteriorate.

16.3 Compatibility

16.3.1 One of the issues that will need to be taken into account of in the arrangements for storage is the compatibility of different types of explosives. Annex G contains further detailed guidance on the incompatibilities between different types of explosives.

16.3.2 Annex G can be used as a starting point for assessing the compatibility of explosives requiring disposal during storage, however any additional properties of the explosive including known contaminants or diluents such as solvents etc. and other factors that may increase the likelihood of a fire or explosion should also be considered.
SECTION 17  THE RETURN OF EXPLOSIVES INCLUDING TIME-EXPIRED OR DETERIORATED EXPLOSIVES

17.1 Overview

17.1.2 Many explosives manufacturers and suppliers are often prepared to accept and dispose of returned explosives. Such explosives could include excess stock as well as time-expired or deteriorated explosives. Before any explosive is returned it must be assessed in order to determine that it is safe to transport. This assessment may involve examination and testing of articles in order to determine the nature of any change in the hazards and risks of initiation associated with an explosive.

17.1.3 It is important to recognise that whilst deteriorated explosives are likely to be less safe to use than explosives that have not deteriorated, time expired explosives may be explosively safe but be less reliable in use, or provide a lower performance in use than a set standard. It may therefore be possible for time expired explosives to be disposed of by being used as intended.

17.1.4 If there is any doubt on the condition of explosives, consult the manufacturer, the supplier or their agents for advice.

An operative was very seriously injured by an explosion which occurred while he was handling a batch of old detonators in preparation for their destruction. It is thought that moisture had attacked the detonators leading to formation of the very sensitive explosive copper azide.

17.2 Principles for Minimisation of Returns etc.

17.2.1 Wherever possible the generation of explosives requiring return to the manufacturer including time expired or deteriorated explosives should be eliminated or minimised. This can be achieve by effective stock rotation, ensuring that explosives are appropriately stored, not delivering an excess of explosives into an environment where they are likely to deteriorate and where reasonably practicable, the re-lifing of time expired stocks.

17.3 Recognised Schemes for Return or Collection of Explosives

17.3.1 There may be particular schemes in place for certain explosives, such as those in place with respect to Saving of Life at Sea (SOLAS) type pyrotechnic articles. Information on these schemes and the requirements should be available from the manufacturer or supplier of the explosives, or their UK agents.

17.4 Preparation for Transport

17.4.1 Before explosives are transported as a return they should be examined to ensure that they are not excessively deteriorated and that they are appropriately packaged. It is important to therefore to recognise that the
original transit packaging may no longer be available or the manufacturer may be overseas or no longer in business. Where this situation occurs it may be necessary to reclassify the explosive or obtain an approval from HSE under CDG.

17.5 Potentially Sensitive Explosives that are not Safe for Transport

17.5.1 Explosives such as deteriorated blasting gelatines, sensitive ingredients or heavily corroded detonators, which are not safe for conveyance, should either be destroyed safely on site, packed for transport such that any event is no more likely than with undeteriorated or non-sensitive items, or packaged in such a way that any event will have no effect outside the packaging.

17.5.2 The advice of the manufacturer and competent EOD professionals should be sought before dealing with deteriorated explosives in-situ or on a licensed site.
SECTION 18  FIRE PRECAUTIONS

18.1 Overview

18.1.1 Destruction areas at Explosives Sites in Scotland licensed under the Manufacture and Storage of Explosives Regulations 2005 are subject to the Fire Certificates (Special Premises) Regulations 1976. Destruction areas not so licensed or at licensed Explosives Sites in other parts of the United Kingdom may be subject to other legislation. During 2006 the Fire Precautions (Workplace) Regulations 1997 and the Fire Precautions Act 1971 will be replaced in England and Wales by the Regulatory Reform (Fire Safety) Order 2005 (the RRO). The RRO covers 'general fire precautions' and other fire safety duties, which are needed to protect 'relevant persons' in case of fire in and around most 'premises'. The order requires fire precautions to be put in place "where necessary" and to the extent that it is reasonable and practicable in the circumstances of the case. Responsibility for complying with the Fire Safety Order rests with the 'responsible person'. In a workplace, this is the employer and any other person who may have control of any part of the premises, e.g. the occupier or owner. In all other premises the person or people in control of the premises will be responsible. If there is more than one responsible person in any type of premises, all must take all reasonable steps to work with each other. The responsible person must carry out a fire risk assessment, which must focus on the safety in case of fire of all 'relevant persons'. If you employ five or more people you must record the significant findings of the assessment.

18.2 General elements of Fire Precautions

18.2.1 Three general elements of fire precautions should be considered at disposal locations:

- Adequate means of escape from all parts of the destruction site should be provided. Take care to identify and eliminate dead ends where people could be trapped during a fire.

- Exit doors/gates which are not used for general access or egress, should be fitted with push-bar mechanisms for easy escape.

- In addition to the water supply provided for damping the burning area etc, appropriate ‘first-aid’ fire-fighting equipment should be provided.

18.2.2 First aid fire fighting is defined as fire fighting equipment necessary to allow persons to escape from a fire and once at a safe location to prevent it from spreading to other property including explosives.
18.3 Risk Assessment

18.3.1 It is important for employers and the self employed to recognise that they have duties under Regulation 3 of the Management of Health and Safety at Work Regulations 1999 to conduct suitable and sufficient risk assessments for the purpose of identifying the measures that they need to take to comply with the requirements and prohibitions imposed upon them by, for example, Part II of the Fire Precautions (Workplace) Regulations 1997 (as amended) and other legislation.

18.4 Notification of the Emergency Services etc.

18.4.1 Depending on the nature of the disposal site and its environment, the proximity of any neighbours, the likely effects of the destruction of the explosives by burning and other local circumstances, it may be necessary for agencies such as the fire brigade to be informed prior to commencing burning operations. This action could reduce the likelihood of the fire brigade etc. having to attend the disposal site as a consequence of reports in error of incidents from members of the public.

18.5 Communications

18.5.1 Appropriate means of communication should be available at the disposal location provided to allow assistance to be summoned in the event of an accident or emergency such as the start or uncontrolled spread of a fire. The performance of this equipment should be checked before disposal activities take place and its compatibility with the explosives being disposed of should be assessed.

18.6 Further Guidance

18.6.1 Further detailed guidance relating to fire precautions can be found at paragraphs 208 to 239 of the ACOP to MSER 2005.
SECTION 19  CERTIFYING FREE FROM EXPLOSIVE HAZARDS

19.1 Overview

19.1.1 All of the disposal activities described in this document will result in a requirement to certify equipment, debris, packaging, or a disposal area free from explosive hazards.

19.1.2 Certifying free from explosive hazards (CFFE) is a procedure to ensure that all explosives, and significant explosives contamination have been removed from the material or area in question prior to the onward transmission of any residues or a disposal area being left unsecured following the conclusion of a disposal activity.

19.1.3 It is important to remember that even though equipment, debris and packaging etc. are free from explosives to such an extent that they do not comprise an explosive hazard they may still be contaminated with explosives or other chemical species that would bring them within the requirements of environmental legislation and health and safety legislation such as COSHH.

19.2 The CFFE Process

19.2.1 CFFE usually involves some form of visual inspection following the removal of explosives from a container, or following explosives or explosives contaminated items having been subjected to a disposal technique. It may also be necessary in some circumstances to conduct chemical tests on collected samples. If there is any doubt as to the complete destruction of the explosives or the decontamination of the items, any residues or the disposal location must be subjected to further disposal activities.

19.2.2 CFFE should be carried out by competent persons who have received appropriate training and who are subject to appropriate supervision. It is good practice for materials or an area that have been subject to CFFE procedures to be issued with a certificate signed by the person conducting the certification.

19.2.3 The certificate should include sufficient detail for the procedure to be audited and the history of the article, substance, residue or area to be traced.

19.2.4 Once articles and other materials have been certified as being free from explosive hazards they should be clearly identifiable as such and should be kept separate from any explosives.

19.2.5 CFFE procedures can take place at different stages of the disposal process dependent on the operations that have taken place or those that are likely to occur.

19.2.6 Examples of this include: -
• Packaging and clothing may be subject to examination prior to its being reused or disposed of in order to ensure that its is free from any gross contamination that would comprise a significantly enhanced risk of fire or explosion under the conditions of the re-use or disposal. Any residue following disposal would then need to be inspected in order to ensure that it is free from explosives such that it can be disposed of in an appropriate waste stream or appropriately recycled.

• A similar situation can apply to large quantities of fired small arms ammunition. The fired ammunition can be visibly checked but where large quantities of ammunition are consigned it must be recognised that there is the possibility that some misfires or other live rounds may not be identified. It would therefore be good practice for large quantities of fired ammunition not to be certified FFE until they have been proved by heating to a suitable temperature either in a fire, an oven or an incinerator and any other appropriate checks, such as a further visual examination, carried out.

• When articles are disposed of by functioning e.g. fireworks or flares any residual material should be examined. Where there is uncertainty as to whether the residues remain contaminated with significant quantities of explosives (i.e. sufficient explosives for there to be enhanced risk of fire or explosion above that normally expected from inert waste) the residues can be proved by for example burning in a fire or by being treated in a similar manner to fired small arms ammunition or contaminated equipment.

One person was killed and one person injured when a scrapped shell was being handled in a scrap metal yard. An explosion occurred, demolishing a hut in which it is believed, a workman was handling the shell. The scrap had been guaranteed free from explosive but further dangerous ammunition was later found.

19.3 Certifying The Disposal Area Free From Explosive Hazards

19.3.2 Following destruction activities disposal areas should also be examined for un-consumed materials that may, for example have been thrown from a fire. Procedures should be in place for the subsequent control, safe handling and/or further disposal of such materials.

19.3.3 Where it is not possible to declare a disposal area free from explosive hazards appropriate signage should be posted, appropriate security and access control should be established. Procedures relating to any further disposal activities should reflect the contaminated nature of the site.
19.4 Licensing Implications

19.4.1 There may also be licensing implications with respect to CFFE processes particularly when there is a requirement to breakdown or disassemble articles or where it has not been possible to declare a disposal area free from explosive hazards. It is recommended that in these situations the relevant licensing and other enforcing authorities are consulted.

19.5 CFFE and Through Life Management Plans

19.5.1 Through life management plans should recognise that there will be a requirement for certifying residues from disposal activities as being free from explosive hazards and that procedures and method statements etc. should be in place for the safe execution of this task.

19.6 Additional Guidance

19.6.1 Additional guidance can be found in the HSE leaflet INDG 335 “Is It Explosive” (ISBN 0-7176-1935) which is available from the HSE website at www.hse.gov.uk/pubns/indg335.pdf.
SECTION 20 THROUGH LIFE MANAGEMENT PLANS

20.1 The issues and additional difficulties surrounding the safe disposal of explosive articles highlights the importance of all explosives, having a through life management plan that recognises disposal activities will ultimately have to take place.

20.2 The inclusion of disposal activities in the development of through life management plans allows safe disposal techniques to be identified prior to full scale manufacture as part of the research and development process, prior to explosives being brought to the market or prior to explosives substances and articles being brought into service.
BRIEF DESCRIPTION OF RELEVANT HEALTH AND SAFETY LEGISLATION

1 Manufacture and Storage of Explosives Regulations 2005 (MSER)

1.1 MSER requires that, with certain exceptions, explosives may only be manufactured in a facility licensed under the regulations, and only be kept at a licensed facility or premises registered under the regulations. All licenses and the conditions of registration of premises specify the locations where explosives may be stored and manufactured, and the maximum quantities and types of explosives, which may be present at each location. The regulations also require that any person who disposes of explosives shall ensure, so far as is reasonably practicable, that they are disposed of safely and that any person who decontaminates explosive-contaminated items shall ensure, so far as is reasonably practicable, that they are decontaminated safely.

2 The Explosives Act 1875

2.1 Most of the provisions of the Explosives Act 1875 have been repealed or amended. Details of most of the sections of the act that have been repealed or amended by MSER are detailed within schedule 5 to MSER 2005.

2.2 The most relevant of the remaining, albeit amended, provisions under the act are the requirements under Section 23 of the Act and the requirements under Order of Secretary of State 11 (3). Section 23 requires the occupier of every premises at which explosives are manufactured or stored to take all due precaution for preventing unauthorised persons having access to the premises or to the gunpowder therein. Order of Secretary of State 11 (3) requires persons not to deposit explosives in receptacles or places appropriated for refuse and states that explosives shall not to be handed or forwarded to persons or vehicles employed or appropriated for the removal or conveyance of refuse.

3 Health and Safety at Work etc Act 1974 (HSWA)

3.1 This Act covers the health and safety of people through work activities. It has a number of objectives, primarily to secure the health, safety and welfare of persons at work. It applies to all persons at work irrespective of the work done or the premises where it is done.

3.2 Under Section 2, employers are required to ensure, so far as is reasonably practicable, the health and safety at work of their employees.

3.3 Duties placed on employers and the self-employed under Section 3 of HSWA are relevant to persons who are not employees, for example contractors. The Act also protects people other than those at work (i.e. the
general public) against risks to their health and safety arising out of work activities.

3.4 The Act imposes duties on everyone concerned with work activities ranging from employers, employees, self-employed, manufacturers, designers, suppliers and importers, people in control of premises and even extends to members of the public.

4 Classification and Labelling of Explosives Regulations 1983 (CLER)

4.1 CLER specifies that with certain exceptions, an explosive substance may not be imported or conveyed unless it has been classified by the UK competent Authority and it complies with specified labelling requirements. There is Health and Safety Executive guidance on these Regulations.

5 Control of Noise at Work Regulations 2005

5.1 These are relevant to the control of noise exposure in working areas. There is guidance on these regulations “Controlling noise at work – The control of Noise at Work Regulations 2005” L108.

5.2 The regulations set exposure action values and exposure limit values. The lower exposure action values are—

(a) a daily or weekly personal noise exposure of 80 dB (A-weighted);

and

(b) a peak sound pressure of 135 dB (C-weighted).

The upper exposure action values are—

(a) a daily or weekly personal noise exposure of 85 dB (A-weighted);

and

(b) a peak sound pressure of 137 dB (C-weighted).

The exposure limit values are—

(a) a daily or weekly personal noise exposure of 87 dB (A-weighted);

and

(b) a peak sound pressure of 140 dB (C-weighted).
5.3 The regulations require an employer who carries out work which is liable to expose any employees to noise at or above a lower exposure action value to make a suitable and sufficient assessment of the risk from that noise to the health and safety of those employees. The risk assessment needs to identify the measures which need to be taken to meet the requirements of these Regulations.

In conducting the risk assessment, the employer needs to assess the levels of noise to which workers are exposed by means of—

(a) observation of specific working practices;

(b) reference to relevant information on the probable levels of noise corresponding to any equipment used in the particular working conditions;

and

(c) if necessary, measurement of the level of noise to which his employees are likely to be exposed

and the employer needs to assess whether any employees are likely to be exposed to noise at or above a lower exposure action value, an upper exposure action value, or an exposure limit value.

5.4 Many disposal operations will occur without significant noise being generated, provided that the necessary controls to prevent an explosive event are in place. It is important to recognise that the selection of appropriate techniques for the disposal of explosives that appropriately control the risks of an explosion occurring are also likely to form at least some of the controls with respect to persons exposure to noise whilst at work.

5.5 The quantity-distance relationships given in Annex F follow the essentially precautionary approach previously taken in legislation and guidance intended to control many of the risks associated with operations involving explosives. These risks include deficiencies in the characterisation of all of the behaviours of explosives substances and articles as well as deviations from working procedures and recognised good practice. The quantity-distance relationships describe potential hazards to which people may be exposed as a consequence of the potential explosive event that could occur during disposal and destruction operations (e.g. blast effects). They assume that the risks associated with noise have been appropriately controlled and that precautions have been put in place to prevent noisy events, where this is reasonably practicable.

5.6 Without the necessary controls to prevent an explosive event there is a potential for persons in the open, (and potentially persons within buildings) to be subject to levels of noise at or above the peak threshold of 140dB(C). Therefore a suitable and sufficient assessment of the risks associated with potential noise effects should have been made for all destruction processes and controls must be in place to prevent an explosion where it has been
identified that an explosion is possible but unlikely, or possible but unexpected. Compliance with the guidance given and techniques described in this document should identify those controls.

5.7 Consideration should be made of the controls that could be implemented to mitigate the effects of not only any destruction activity where it is expected that noise will be generated but also those that have the potential to result in an explosion or other significant noise. These could include:

- Destroying explosives in the smallest unit quantity conducive to the control of the explosive risks such that the potential impulse of any blast effect is minimised
- The use of blast mitigation systems.
- Designing the disposal location such that the effects of any explosion are contained, absorbed or deflected.
- The application of exclusion zones greater than those detailed in this guidance.
- The soundproofing of occupied buildings including those provided as refuges
- The provision of suitable hearing protection to employees.

5.8 Where the only reasonably practicable disposal technique is one where the balance of risks are such that an explosion is to be expected it will be necessary to ensure that persons are located at distances that will prevent them being exposed to noise above the relevant action levels or to ensure that they are otherwise protected from the effects of noise.

5.9 Where such disposal activities take place on a routine basis it is expected that they would be subjected to routine noise monitoring.

5.10 In any case, if it is anticipated that any employee is likely to be exposed to noise at or above the upper exposure values then the wearing of hearing protection becomes mandatory. The hearing protection should be effective enough to reduce the exposure to below the limit value. If exposure above the upper action values occurs regularly then it is recommended that employee should be provided with hearing checks. For more information see L108.

6 Electricity at Work Regulations 1989

6.1 These regulations place duties on employers, the self-employed and employees and apply to all workplaces. In the context of this guide, their requirements will need to be complied with in relation to any item of electrical equipment, which forms part of the workplace.
6.2 Amongst the areas that the Regulations address, there are two that are especially important in relation to equipment in explosives working areas. Regulation 6 deals with adverse or hazardous environments, and requires inter alia that electrical equipment which may reasonably foreseeably be exposed to any flammable or explosive substance including dusts, vapours or gases shall be of such construction or, as necessary, protected to prevent, so far as is reasonably practicable, danger arising from such exposure.

6.3 Regulation 8 deals with earthing or other suitable precautions. There is general Health and Safety Guidance on these regulations. There is a Health and Safety Executive Guidance Note PM82, which gives detailed advice relevant to meeting the requirements of Regulations 6 and 8 for electrical equipment for use in and around explosives working areas.

7 Control of Explosives Regulations 1991 (COER)

7.1 These regulations include requirements that an explosives certificate issued by the chief officer of police is required to acquire or keep certain explosives, and that records of explosives possessed are to be maintained.

8 Manual Handling Operations Regulations 1992 (MHOR)

8.1 The requirements of these Regulations need to be considered for any activity involving manual handling. There is Health and Safety Executive guidance on these Regulations. This includes tools for the conducting of manual handling risk assessments which are available at www.hse.gov.uk/msd/mac.

9 Workplace (Health, Safety and Welfare) Regulations 1992

9.1 The requirements of these regulations need to be met to ensure that workplace facilities meet certain standards. There is Health and Safety Executive guidance on these Regulations.

10 Personal Protective Equipment at Work Regulations 1992

10.1 MHSWR requires employers to identify and assess risks to health and safety in the workplace. The risks should then be reduced to an acceptable level by the most appropriate means. Engineering controls or safe systems of work should be considered first in the hierarchy of controls. PPE should be regarded as the last resort to protect against risks. However given the nature of most disposal operations there is likely to be a requirement for some kind of PPE at some stage of the process.

10.2 When PPE is necessary, it only protects the person wearing it, theoretical maximum levels of protection are seldom achieved and PPE often restricts the wearer by limiting mobility or visibility. It is therefore essential that appropriate PPE and training in its use is provided when there is a risk to health and safety that cannot be adequately controlled by other means.
10.3 The regulations place requirements on employers to provide PPE that is suitable for the purpose, that is maintained or replaced as necessary, that is provided with suitable accommodation when not in use and that suitable information, instruction and training is given in its use.

10.4 The regulations also place duties on employees to make full and proper use of PPE when it is provided. Employees also have a duty to report any loss or defect.

10.5 Further guidance on the use of PPE in an explosives environment can be found in Fire Protective Clothing, CBI EIG Guide, ISBN 0852015135 and Head and Eye Protection, CBI EIG Guide.

11 Placing on the Market and Supervision of Transfers of Explosives Regulations 1993 (POMSTER)

11.1 These regulations include requirements for certain explosives to undergo testing and meet certain essential safety requirements before they are placed on the market. They also require that certain security controls be complied with.

12 Provision and Use of Work Equipment Regulations 1998 (PUWER 98)

12.1 PUWER 98 applies to the provision and use of all work equipment, including mobile and lifting equipment, and to all workplaces and work situations where HSWA applies. PUWER 98 came into force in December 1998, but some of the regulations dealing with mobile work equipment did not come into effect until 5 December 2002. The Regulations define work equipment as “any machinery, appliance, apparatus, tool or installation for use at work (whether exclusively or not)”. 

12.2 Regulation 4 deals with the suitability of work equipment. In Regulation 5 there is a requirement that work equipment is maintained in an efficient state, in efficient working order, and in good repair. Regulation 6 deals with inspection, including inspection of equipment after installation or reinstallation, before it is put into service and inspection of equipment such as complex automated equipment where the safe operation is critically dependent on its condition in use and deterioration would lead to a significant risk to the operator or other worker. This Regulation also requires that a record of the latest inspection is kept until the next inspection has been recorded.

12.3 Regulation 7 addresses cases where the use of work equipment is likely to involve a specific risk to health or safety. In such cases, this Regulation requires that equipment is only allowed to be used by those whose task it is to use it, and that repairs, modifications etc shall only be carried out by a specifically designated person (who could also be the operator of the equipment). Regulation 8 deals with information and instruction and Regulation 9 with training. Regulation 10 covers the conformity of work equipment with legislation, which brings into effect the requirements of EC
Directives on product safety, such as the Supply of Machinery (Safety) Regulations 1992 as amended.

12.4 Regulations 11 to 24 of PUWER 98 deal with the physical aspects of work equipment. They cover for example, the guarding of dangerous parts of work equipment, the provision of appropriate controls and suitable warning markings or devices.

12.4 There is an approved code of practice and guidance for PUWER 98.

13 Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)

13.1 Although PUWER 98 applies to all lifting equipment, LOLER applies over and above the general requirements of PUWER 98 with regard to specific hazards and risks associated with lifting equipment and lifting operations. There is an approved code of practice and guidance for these regulations.

14 Management of Health and Safety at Work Regulations 1999 (MHSWR)

14.1 An important requirement of these regulations is for an employer to make a suitable and sufficient assessment of the risks to the health and safety of employees and other persons arising from the employer’s undertaking in order to identify the measures the employer needs to take to comply with health and safety legislation. Similar duties are placed on the self-employed. These regulations also (in Schedule 1) lay down a set of principles to be followed in identifying the appropriate protective measures to control the risks identified by the risk assessment. There is an approved code of practice and guidance for these regulations.

15 Control of Major Accident Hazards Regulations 1999 (COMAH)

15.1 These regulations apply to any establishment, which has, or anticipates having, any substance specified in Schedule 1 to COMAH above the qualifying quantity. The qualifying quantities of explosives for the application of COMAH are such that currently there are relatively few sites licensed under the Manufacture and Storage of Explosives Regulations 2005 which are subject to COMAH. At establishments where COMAH does apply, advice in the guide will be relevant to various aspects of the general duty under the regulations for the operator of the establishment to take all measures necessary to prevent major accidents and limit their consequences to people and the environment. It should be emphasised however that the protection of the environment per se is out with the scope of this publication. There is Health and Safety Guidance on these regulations.

16 Control of Substances Hazardous to Health Regulations 2002 (COSHH)
16.1 COSHH applies to substances that have already been classified as being very toxic, toxic or harmful, corrosive, or irritant under the Chemicals (Hazard Information and Packaging for Supply Regulations) 2002 (CHIP 3) as amended, and to those substances, which have maximum exposure limits (MELs) or occupational exposure standards (OESs). COSHH also covers other substances that have chronic or delayed effects, for example substances that are carcinogenic, mutagenic or teratogenic and biological agents. A substance should be regarded as hazardous to health if it is hazardous in the form in which it occurs in the work activity, whether or not its mode of causing injury to health is known, and whether or not the active constituent has been identified. A substance hazardous to health includes mixtures as well as single substances. Regulation 3 places duties on an employer in respect of employees and extends to any other person who may be affected by the work of the employer. These regulations apply to a self-employed person as if that person were both an employer and an employee. Regulation 6 requires that a suitable and sufficient assessment to be undertaken of the health risks created by work involving substances hazardous to health, and Regulation 7 requires that exposure to substances hazardous to health is prevented, or failing this, controlled. Regulation 8 places duties on employers and employees to properly use or apply control measures. Regulation 9 deals with the maintenance, examination and test of control measures, Regulation 10 with workplace monitoring and Regulation 11 with health surveillance. Regulation 12 deals with information, instruction and training.

16.2 Regulation 5 exempts certain substances, which are subject to more specific legislation on the control of health hazards, such as asbestos and lead, from the requirements of Regulations 6 to 12 inclusive of COSHH.

16.3 There is an approved code of practice for these regulations.

17 Control of Lead at Work Regulations 2002 (CLAW)

17.1 The main requirements for employers are:

- to assess health risks created by work involving exposure to lead
- to prevent or control exposure to lead
- to provide controls on eating, drinking and smoking
- to maintain, examine and test control measures
- to undertake air monitoring
- to undertake medical surveillance
- to provide information, instruction and training

There is an approved code of practice for these Regulations.
18 Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)

18.1 These regulations apply to all dangerous substances at nearly every business in Great Britain. They set minimum requirements for the protection of workers from fire, explosion and similar (energy releasing) events, which are caused by dangerous substances and potentially explosive atmospheres. The regulations are complementary to the general duty to manage risks under the Management of Health and Safety at Work Regulations 1999. The main requirements are that employers and the self-employed must:

- Carry out a risk assessment of work activities involving dangerous substances
- Provide technical and organisational measures to eliminate or reduce as far as is reasonably practicable the identified risks
- Provide equipment and procedures to deal with accidents and emergencies
- Provide information and training to employees
- Classify places where explosive atmospheres may occur into zones, and mark the zones where necessary.

There are approved codes of practice for these Regulations.

19 Chemicals (Hazard Information and Packaging for Supply Regulations) 2002 (CHIP 3)

19.1 CHIP 3 applies to suppliers of dangerous chemicals. Its purpose is to protect people and the environment from the effects of these chemicals by requiring suppliers to give information and to package them safely. The idea is that when people know about the dangers of a chemical, and what they can do to avoid them, they will be less likely to harm themselves, others or the environment.

19.2 CHIP applies to most chemicals. The exceptions, which are identified in regulation 3(1), are specialised chemicals such as cosmetics, medicines, wastes and several others all of which are covered by other regulations.

19.3 It is a fundamental requirement for suppliers to decide, using a set of rules, whether a chemical is dangerous or not. If the supplier decides that the chemical is dangerous (i.e. ‘classified’) then a number of further requirements are triggered.

19.4 HSE is of the view that any finished and closed munitions or other explosive articles (which have no exposed explosive composition) should be generically considered complete articles, rather than substances or preparations, and, therefore, are outside the scope of the current CHIP regulations. If work causes composition to become exposed as part of an
action by users etc. then there will be duties under the HSWA to provide necessary information for ensuring health and safety with respect to any chemical hazard.

19.5 There is an Approved Code of Practice and further guidance for these Regulations.

20 The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004 (CDG)

20.1 CDG regulations essentially bring the provisions of the European agreement for the transport of dangerous goods by road (ADR) into British law. The Carriage Regulations set the legal framework in Great Britain, as ADR itself has no provision for enforcement. The regulations include a number of exemptions and make substantial changes to the previous requirements for the domestic carriage of many explosives.

20.2 The regulations are complex and extensive because they draw together and replace many previous pieces of legislation. With the exception of the carriage of radioactive substances, the regulations cover every aspect of the carriage of dangerous substances by road and rail.
Figure 4 - Generic Example of A Process Flow Map for the Disposal of Explosives

- Explosives Requiring Disposal Generated
- Explosives Requiring Disposal Accumulate
- Safe Recovery of Accumulated Explosives
- Explosives are prepared for disposal, collection and/or transport
- Explosives are transported to an intermediate holding/storage area
- Explosives held in storage to await disposal
- Explosives Transported to Disposal Area
- Explosives/Facility prepared for disposal
- Disposal activity takes place
- CFFE activities
1 Figure 4 – Comments

1.1 Figure 4 comprises a generic example of a process flow showing the lifetime of an explosive requiring disposal from its generation to the CFFE activities that take place following the disposal activity itself.

1.2 The different stages of the lifetime of the explosive could be used as a basis for identifying the coverage of a risk assessment system. For example, the properties of the explosive, the initiatory stimuli to which it may be subjected, and the controls in place to prevent or mitigate initiations may be different for each stage of the lifetime or for each of the tasks that it will be necessary to carry out.

1.3 It is important to recognise that a number of the steps in the disposal process could result in additional explosives requiring disposal being generated, such as sweepings from intermediate storage etc.

1.4 If a process flow were to be drafted for each activity that resulted in explosives requiring disposal being generated then it would be possible to draw up a matrix against which risk assessment coverage could be developed and measured.

1.5 Such activities could include:

- Deliveries i.e. the recovery of leaked materials
- Placing into storage i.e. any spills or damages
- Storage i.e. any spills or deterioration during storage.
- Manufacture i.e. spills, arisings and waste generated during manufacturing operations.
- Material generated during analytical or QA work.
- Product rejected as a consequence of QA procedures.
TYPICAL SOURCES OF IGNITION AND INITIATION

1 Friction

1.1 Friction can set off explosives, and can come from a wide range of sources, often associated with operator actions, including:

- Dismantling, including unbolting or unscrewing
- Machine/equipment movement, collapse or failure.
- Scraping material off surfaces.
- Using incorrect tools; appropriate non-metal tools are less likely to cause ignition than metal tools.
- Mishandling explosives during collection, transport, storage and preparation for disposal.
- The collapse of stacks of packaged explosives during storage.
- Walking on or dragging materials over spills of explosives or otherwise exposed compositions.
- Explosives being inadequately packaged or restrained during transport operations.
- The presence of grit will sensitise explosives to initiation by friction.

1.2 The possibility of chemical sensitisation having taken place with time should be considered, e.g. the formation of copper azide from lead azide in the presence of copper and moisture. Copper azide is much more sensitive to friction than the original “expected” lead azide.

2 Impact

2.1 Impact from a variety of sources can cause ignition, including:

- Dismantling of machinery/equipment to recover explosives requiring disposal leading to movement or collapse.
- Failure of machinery during normal operation.
- Using incorrect tools; appropriate non-metal tools are less likely to cause ignition than metal tools.
- Mishandling explosives requiring disposal during collection.
• Walking on contaminated floors, remembering that the contamination may be below the floor surface, i.e. hidden from view.

• The presence of grit will sensitisate explosives to initiation by impact.

2.2 The possibility of chemical sensitisation having taken place with time should be considered, e.g. the formation of copper azide from lead azide in the presence of copper and moisture. Copper azide is much more sensitive to impact than the original "expected" lead azide.

3 Static

3.1 Static is particularly important when treating/handling primary explosives, electrically initiated devices such as detonators and materials that can evolve hydrogen as a consequence of reactions with moisture or other materials. Static can arise from many sources, including:

• Incorrect clothing.

• Footwear that does not allow charge to dissipate.

• Use of incorrect tools and equipment, such as plastic collectors and containers.

• Inappropriate techniques for gathering materials, such as sweeping up dry powders.

• Static and sources of static are a greater problem when the contamination and the ambient air conditions are dry.

4 Spark (Incendive or Electrical)

4.1 Sparks of all types present a possible source of ignition, either directly or as a source of fire. Some sources of spark are:

• Incorrect use of sparking (ferrous) tools.

• Thermite reaction, i.e. aluminium struck by a rusty metal or rust struck by aluminium.

• Hot work such as use of grinding tools.

• Electrical equipment.

• Debris thrown from controlled explosions and other concurrent disposal operations, including "jet" from shaped charges, etc.
• Debris from controlled burning operations including those not under the control of the person responsible for the disposal or destruction of the explosives.

5 Flame

5.1 Some sources of flame are:

• Hot work such as flame cutting.
• Controlled explosion or burning operations.
• General fires from grass/vegetation fire spread.

6 Decomposition

6.1 Some sources of decomposition are:

• Old explosive, particularly if kept under hot conditions.
• Acidic explosive, particularly for nitrated explosives (NG, PETN, etc.).
• Use of excessive amounts of chemical "destroyer" in inappropriate conditions such as excessive contamination in a confined condition where the heat from the chemical reaction cannot escape.
• Incorrect use of desensitiser or destroyer, e.g. use of PETN destroyer can increase the sensitiveness of TNT.

7 Electromagnetic Radiation

7.1 Overhead or buried cables, transmitters, radio signals, etc. can all induce currents in electrically initiated explosive devices or articles.
Properties of Common Explosive Substances

1. Overview
1.1 This Annex gives a brief description of some of the properties of a range of common explosives substances and types of explosives i.e. high explosives, propellants and pyrotechnics. It is important to remember that the behaviour, explosives properties and associated hazards of an explosive substance or formulation or even explosive type can depend on the amount of material present, the degree of confinement to which it is subjected and the mode of initiation. More detailed information is available from a range of books and academic and industry journals and publications.

2 Organic explosive compounds

2.1 Many explosives exist as individual compounds. The compounds fall into three main classes: nitrate esters, nitro aromatics and nitramines. They contain their own oxygen to support the decomposition reaction and provided with the right stimulus will detonate. Typical examples of the most commonly encountered organic explosive compounds are:

- EGDN  ethylene glycol dinitrate or nitroglycol
- HMX  cyclotetramethylene tetranitramine
- HNS  hexanitrostilbene
- NC    nitrocellulose
- NG    nitroglycerine
- PETN  pentaerythritol tetranitrate
- picric acid  2,4,6- trinitrophenol
- picrite  nitroguanidine
- RDX  cyclotrimethylene trinitramine
• tetryl trinitrophenylmethylnitramine

• TNT 2,4,6- trinitrotoluene

2.2 Details of the chemical structures, official technical terms and the commonly used alternative names may be found in standard references such as Explosives (5th Ed) – R Meyer, J Köhler and A Homburg (2002), which details many of these technical and colloquial terms.

3 Metal salts of organic molecules

3.1 In addition to the individual organic explosive compounds there are a number of inorganic compounds with explosive properties. Many of these substances are highly sensitive and will detonate readily with only the slightest stimulus. They are commonly used as initiators. Typical examples of such explosives are:

• lead azide;

• lead azotetrazole;

• lead dinitroresorcinate (LDNR);

• lead monoresorcinate (LMNR):

• lead styphnate;

• mercury fulminate.

4.1 Chlorate and perchlorate based explosives

4.2 These explosives consist of intimate mixtures of hydrocarbons (e.g. waxes or polymeric binders and rubbers) as the fuel, and metal chlorates, perchlorates or ammonium perchlorate as the oxidiser. Certain commercial mining explosives were chlorate or perchlorate based explosives. However, the main current application of this family of explosives is in composite propellants in which ammonium perchlorate is incorporated into a rubbery composition.

4.3 Although technically a powerful oxidising agent, ammonium perchlorate can under certain conditions detonate.
5 Ammonium nitrate based explosives

5.1 When mixed with a fuel, ammonium nitrate is a powerful explosive. ANFO (ammonium nitrate and fuel oil), slurry and emulsion explosives are all mixtures of ammonium nitrate and fuels. They are mainly used as commercial explosives for blasting operations. Slurry and emulsion explosives often contain other additives as sensitizers e.g. aluminium powder which modifies their explosive properties. During the First World War, amatol compositions (mixtures of ammonium nitrate and TNT) were widely used as military high explosives.

Ammonium nitrate can under certain conditions detonate without a fuel being present.

6 High Explosives

6.1 The principal explosion hazards associated with high explosives result from blast waves and fragments that may arise from any container or adjacent structure. A full quantification of these effects is outside the scope of this document, but some indication of the potential involved is given by considering the effects of explosions of small quantities of high explosives inside a small single storey (6m x 6m) building:

1g of Explosive:

- any person holding the explosive could receive serious injury.

10g of Explosive:

- any person close to this quantity of explosive at the time of initiation would receive very serious injuries. 1% of persons at a distance of 1.5 metres away are also liable to ear-drum rupture.

100g of Explosive:

- 50% of windows in room likely to be blown out.
- 1% ear-drum rupture at distance of 3.5m.
- 50% ear-drum rupture at distance of 1.5m.
- persons in very close proximity to explosion (e.g., holding the explosive) almost certainly killed.

500g of Explosive:

- complete structural collapse of brick-built building is most likely.
- steel or concrete framed building would probably survive.
- persons very close to blast almost certainly killed.
- persons close to blast will be seriously injured by lung and hearing damage, fragmentation effects, and from being thrown bodily.
- almost all persons within the room will sustain perforated ear-drums.
7 Pyrotechnics

7.1 Pyrotechnic is a name given to mixtures of fuel and oxidant that may contain other ingredients such as a binder or burning rate moderant. They are almost always solid mixtures. Materials used in compositions will be dependent on the type of pyrotechnic effect desired and on the colours of smokes or flares. The compositions burn rapidly to produce effects such as heat, flame, light, noise, smoke, gas production or burning delays.

7.2 Applications include:

- delay compositions;
- igniter compositions;
- primer compositions;
- signal/flare compositions;
- smoke compositions;
- tracer compositions;
- report compositions;
- firework compositions

7.3 Typical materials used in the production of pyrotechnics include:

- Oxidisers – molybdenum trioxide, bismuth trioxide, potassium nitrate, potassium perchlorate, sodium nitrate, barium nitrate, barium peroxide, strontium nitrate, potassium chlorate
- Fuels – Magnesium, aluminium, boron, silicon, manganese, phosphorus, tungsten, charcoal
Other additives – acaroid resin, chlorinated rubber, boiled linseed oil, calcium oxalate, butyl rubber, zinc stearate, various waxes, dyes, PVC, Viton

7.4 It is important to remember that many pyrotechnic mixtures can deflagrate or detonate under conditions of confinement e.g. fireworks etc. and/or when subjected to sufficient stimulus.

7.5 The burning characteristics of pyrotechnic substances generally range from slow to very violent burning. German legislation controlling the manufacture of pyrotechnics requires individual manufacturers to assign their pyrotechnic compositions, semi-finished products and finished articles into five groups according to their sensitiveness and burning characteristics. At the slow burning end of the range, Group 5, the compositions burn slowly and articles either burn or explode singly. At the opposite end, Group 1, the compositions burn very violently and even without confinement small quantities can explode. Also they are mechanically and thermally very sensitive and Group 1 articles are capable of mass explosion. Examples of both composition and article assignments are as follows:

GROUP 1:

Compositions: (burn very violently)
- Chlorate and metal perchlorate report or whistling compositions.
- Dry non-gelatinised cellulose nitrates.
- Barium peroxide/Zirconium compositions.

Articles: (mass explosion risk)
- Flash shells (maroons).
- Casings containing flash compositions.
- Sealed hail preventing rockets.

GROUP 2:

Compositions: (burn violently)
- Nitrate/metal/sulphur compositions.
- Compositions with >65% chlorate.
- Black powder.
- Nitrate/boron compositions.

Articles: (accelerating single-item explosions)
- Large firework shells.
- Fuze unprotected signal flares.
- Non-pressed report bullets (bird scarer).
- Report cartridges, unpacked.
- Black matches, uncovered.

GROUP 3:

Compositions: (burn fast)
Nitrate/Metal compositions without sulphur.
Compositions with up to 35-65% chlorate.
Compositions with black powder.
Lead oxide/silicon with >60% lead oxides.
Perchlorate/metal compositions other than report.

**Articles: (burn very violently with single-item explosions)**
Large firework shells.
Fuze protected signal flares.
Pressed report cartridges in primary packagings.
Quickmatches in transport packagings.
Waterfalls; Silver wheels; Volcanoes.
Black powder delays.

**GROUP 4:**

**Compositions: (low/medium speed burning)**
Coloured smoke compositions.
White smoke compositions (except those in Group 5)
Compositions with <35% chlorate.
Thermite compositions.
Aluminium/phosphorous pesticide compositions.

**Articles: (single-item ignitions/explosions)**
Large firework shells without flash compositions in transport packagings.
Signal ammunition without flash compositions, up to 40g of composition.
Small fireworks, fuze protected (except volcanoes and silver wheels).

**GROUP 5:**

**Compositions: (burn slowly)**
Slow burning heating compositions.
White smoke compositions based on hexachloroethane with zinc, zinc oxide and <5% of aluminium, or <10% of calcium silicon.

**Articles: (slow single-item ignitions/explosions)**
Small fireworks in primary packagings.
Signal ammunition in transport packaging.
Delays without black powder.
Coloured smoke devices.
Sealed table bombs.
White smoke devices unpacked (see Group 5 composition).

7.6 For each type of processing or storage activity, and for each type of pyrotechnic, German regulations prescribe how the pyrotechnic should be handled, including maximum quantity per room and number of occupants. The greatest restrictions are placed upon Group 1 explosives and articles. To reproduce here lists of groupings for specific formulations and articles, together with the corresponding restrictions that apply in Germany, would occupy several pages and probably not accord completely with UK products.
Annex D

The examples given here of the groupings are useful though both in demonstrating the vast range in burning behaviour of these materials, and an indication of the likely behaviour of generic types.

7.7 It is important to understand the possible behaviour of small quantities of pyrotechnic substances or a single article, and the possible effects of self-confinement. Bundles of pyrotechnic articles (e.g. fireworks) may burn much more vigorously and even violently (with sufficient numbers of items) than single items.

7.8 An estimate of the size of fireball from a “fast” burning pyrotechnic, high explosive or propellant is given by the expression:

\[ D = 3.77Q^{1/3} \]

\( D \) is diameter of fireball in metres.
\( Q \) is weight of substance in kilograms.

Thus 2kg of pyrotechnic composition might be expected to give a fireball of approximately 5m diameter. A graph showing quantity (kg) of explosive versus fireball diameter (m) is given below.

7.9 Persons engulfed within a fireball and not wearing fire resistant protective clothing, are likely to receive very serious if not immediately fatal
bums. Persons in close proximity to the fireball are also vulnerable, depending upon size and duration of the event.

8 Propellants

8.1 The potential hazards from propellants are generally very similar to those from pyrotechnics, i.e. vigorous burning and fireball effects are typical; see previous paragraph for fireball diameter estimates. Confinement, however, has the effect of increasing the burning velocity of propellant materials and with sufficient confinement, detonation occurs on initiation. Situations in practice that might encourage this transition from burning to detonation might be where propellant is present in relatively large quantities and in containers, or potentially in fissures in concrete etc, which provide significant confinement.
# Suggested Methods of Disposal for Commonly Encountered Explosives

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<th>Detonate</th>
<th>Dissolve</th>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nitroglycerine</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Slurry explosives</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Emulsion explosives</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Contaminated paper waste</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fireworks (finished)</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Initiatory explosives</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Propellants</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Non NG-based blasting explosives</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Shotgun cartridges</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sporting/small arms ammunition</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Annex F

Recommended Minimum Separation Distances

OVERVIEW

This annex contains criteria describing the maximum degree of potential hazard to which people, property, explosives and other dangerous substances may be exposed as a consequence of the potential explosive events that could occur during disposal and destruction operations i.e. blast effects, fragment effects, projected effects and thermal effects. These criteria are summarized below in Charts 1 to 3.

When events have been assessed as being possible but unlikely or possible but unexpected the annex assumes that this guidance and/or relevant good practice is being followed and that relevant controls to prevent or mitigate explosive events have been implemented. Therefore in such situations the mechanisms for an event occurring would generally be expected to arise from a failure to follow procedures derived from this guidance or other relevant good practice, or from a failure to fully understand or characterise the behaviour of the substance or article being disposed of.

The physical constraints on a site and its local environment will determine the extent of the exclusion zones that can be implemented. The risk assessment should take account the following factors to establish whether the necessary reasonably practical controls have been put in place:

- the likelihood of an event
- the consequences of the event (e.g. the peak level of noise from the potential explosion)
- the maximum separation distances
- the suitability of appropriate mitigatory measures (e.g. hearing protection)
- the risk to members of the public.

For example, when the ear is subjected to a damaging blast the impact of a single event has the potential to result in permanent damage to the individual’s hearing.

Clearly in establishing reasonably practicable separation distances to mitigate the consequence of unexpected and unplanned event consideration of the likelihood and the consequences of an event need to be taken into account.

The annex also contains sets of quantity distance tables that meet some of these criteria and that have been based on the sets of assumptions given below. It is not possible to provide generic quantity distance tables that are applicable to the disposal of all explosives, be they substances or articles, in all circumstances and in all environments that are likely to be encountered. Therefore where the circumstances of the disposal operation and/or the properties of the explosives deviate significantly from the assumptions given the quantity-distance relationships in the various tables etc. may not be valid.
In such circumstances it would be appropriate for a more specific assessment to be carried out based on data from tests and trials, suitable models or information published in the literature.

Similarly there may be circumstances where the assumptions made in this annex are very conservative when compared to the properties of the explosive being disposed of and the environment in the vicinity of the disposal location. In such circumstances test and trials data, suitable models and a review of information published in the literature may, as part of a specific assessment, demonstrate that the relevant criteria would be met at reduced distances when compared to those given in the tables below.

In addition where there is a recognised code of practice or generally recognised industry specific guidance for a disposal or use activity or when disposal is by use it is recommended that that code or generally recognised guidance is followed whilst taking account of the criteria contained within this annex.
## Annex F

### Criteria Chart 1

<table>
<thead>
<tr>
<th>Potential Hazard</th>
<th>Persons In the Open</th>
<th>Persons Indoors</th>
<th>Explosives Or Dangerous Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast Overpressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• That there will be no significant risk of injury from blast effects or secondary fragments. 1.1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but unlikely the blast overpressure will be $\leq 3.5kPa$ 1.1.1 &amp; Table 1.3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but not expected the blast overpressure will be $\leq 1.8kPa$ 1.1.1 &amp; Table 1.3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is expected the Control of Noise at Work limits will not be exceeded. 1.1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• That there will be no significant risk of injury from blast effects or secondary fragments. 1.1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but unlikely the blast overpressure will be $\leq 3.5kPa$ 1.1.1 &amp; Table 1.3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but not expected the blast overpressure will be $\leq 1.8kPa$ 1.1.1 &amp; Table 1.3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is expected the Control of Noise at Work limits will not be exceeded. 1.1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Some cracking of windows will be acceptable 1.1.2, 1.3.1.1 &amp; Table 1.3.1 Column 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There will be no significant risk from flying glass 1.1.2, 1.3.1.1 &amp; Table 1.3.1 Column 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No significant be risks or inconvenience to building occupants 1.1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but unlikely the probability of a pane of glass cracking will not exceed 5% Table 1.3.2 Column 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect is possible but not expected the probability of a pane of glass cracking will not exceed 2% 1.1.3 Table 1.3.2 Column 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Where a blast effect can be expected the probability of a pane of glass cracking should be minimised 1.1.3 Table 1.3.2 Column 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There should be a high degree of protection from the communication of an explosion and potential domino effects 1.1.4 &amp; 1.1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The distance to explosives not involved in disposal operations or to other dangerous substances should $\geq 220Q^1/3$ 1.1.4 &amp; Table 1.3.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• For risks within the disposal site to be unitised any propagation will not result in enhanced effects 1.1.5 &amp; Table 1.3.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Criteria Chart 2

<table>
<thead>
<tr>
<th>Potential Hazard</th>
<th>Persons In the Open</th>
<th>Persons Indoors</th>
<th>Explosives Or Dangerous Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragments or Projected Effects including fireworks</td>
<td>On-site</td>
<td>Off-site</td>
<td>Off-site or where the occupants derive no direct benefit from the explosives activity</td>
</tr>
<tr>
<td>• should not be at risk of being struck by a fragment or projected effect capable of causing injury 2.1.1.1 &amp; 2.1.3 for fragments, 2.2.1.1 &amp; 2.2.3 for projected effects</td>
<td>• should not be at risk of being struck by a fragment or projected effect capable of causing injury 2.1.1.1 &amp; 2.1.3 for fragments, 2.2.1.1 &amp; 2.2.3 for projected effects</td>
<td>• should not be at risk of being struck by a fragment or projected effect capable of causing injury 2.1.1.1 &amp; 2.1.3 for fragments, 2.2.1.1 &amp; 2.2.3 for projected effects</td>
<td>• Should not be at risk of being struck by a fragment capable of causing and explosion, loss of containment or other potentially dangerous effect 2.1.1.2 &amp; 2.1.4 for fragments, 2.2.1.2 &amp; 2.2.3 for projected effects</td>
</tr>
<tr>
<td>• Projected effects should not cause fires that can cause harm to persons 2.2.1.3 &amp; 2.2.3</td>
<td>• Projected effects should not cause fires that can cause harm to persons 2.2.1.3 &amp; 2.2.3</td>
<td>• Projected effects should not cause fires that can cause harm to persons or damage property 2.2.1.3 &amp; 2.2.3</td>
<td>• Projected effects should not cause fires that can ignite other explosives or dangerous substances 2.2.1.3 &amp; 2.2.3</td>
</tr>
<tr>
<td>• Significant Inconvenience to persons who do not derive a direct benefit from the explosives activity should not be generated 2.1.1.3, 2.1.3 for fragments, 2.2.1.4 &amp; 2.2.3 for projected effects</td>
<td>• Projected effects should not cause fires that can cause harm to persons or damage property 2.2.1.3 &amp; 2.2.3</td>
<td>• Significant Inconvenience to persons who do not derive a direct benefit from the explosives activity should not be generated 2.1.1.3, 2.1.3 for fragments, 2.2.1.3 &amp; 2.2.3 for projected effects</td>
<td>• Significant Inconvenience to persons who do not derive a direct benefit from the explosives activity should not be generated 2.1.1.3, 2.1.3 for fragments, 2.2.1.3 &amp; 2.2.3 for projected effects</td>
</tr>
</tbody>
</table>

For risks within the disposal site to be unitised any propagation will not result in enhanced explosive effects 2.1.1.4 & Table 1.3.3 for fragments 2.2.1.5 & Table 1.3.3 for projected effects.
## Criteria Chart 3

<table>
<thead>
<tr>
<th>Potential Hazard</th>
<th>Persons In the Open</th>
<th>Persons Indoors</th>
<th>Explosives Or Dangerous Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Hazard</td>
<td>On-site</td>
<td>Off-site</td>
<td>On-site/Buildings under the Control of the Person Conducting the Disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Persons involved in or directly benefiting from the disposal activity will be exposed to thermal flux $\leq 75%$ of the threshold of Pain 3.2.1 &amp; Table 3.4</td>
<td>• Persons not involved in or not directly benefiting from the disposal activity will be exposed to thermal flux $\leq 75%$ of the threshold of Pain 3.2.1 &amp; Table 3.4</td>
<td>• Persons involved in or not directly benefiting from the disposal activity will be exposed to thermal flux $\leq 75%$ of the threshold of Pain 3.2.1 &amp; Table 3.4</td>
<td>• Persons not involved in or not directly benefiting from the disposal activity will be exposed to thermal flux $\leq 50%$ of the threshold of Pain. 3.2.2 &amp; Table 3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There will be no communication of an explosion or associated domino effect to explosives or dangerous substances outside the disposal 3.2.3</td>
<td>• Flammable materials comprising or in the vicinity of buildings or structures used for the storage of explosives or other flammable substances will subject to $\leq 50%$ of the thermal flux required for their auto ignition. 3.2.3 &amp; Table 3.6</td>
<td>• Any propagation between locations within the disposal location will not result in an increased unit risk or increased risk to persons or property. 3.2.4 &amp; Table 3.7</td>
<td></td>
</tr>
</tbody>
</table>
Annex F

SECTION 1 OPERATIONS WHERE THERE IS THE POTENTIAL FOR BLAST EFFECTS

1.1 Criteria

1.1.1 That persons in the open and in buildings should not be at significant risk of significant injury from noise, blast effects or from any secondary fragments i.e.

• that where a blast effect is possible but unlikely (e.g. the burning of emulsions or water wet explosives and similar circumstances where a review of records has indicated that historical frequency of incidents would be of the order of once every 50 to 100 years), persons should not be subject to a blast overpressure in excess of 10% of the threshold for eardrum rupture (3.5kPa);

• that where the nature of the technique, the nature of the materials or a history of events indicates that blast effect is possible but not expected (e.g. the burning of nitroglycerine type explosives or small quantities of flash powders and similar circumstances where a review of records has indicated that historical frequency of incidents would be of the order of once every 20 to 25 years), persons should not be subject to an overpressure in excess of 5% of the threshold for eardrum rupture (1.8kPa);

• that where a blast or other noise effect is expected e.g. disposal by detonation or the burning of large quantities of flashpowder, exposure of persons will not exceed the exposure limit values as defined in the Control of Noise at Work Regulations 2005.

1.1.2 That the cracking of windows in buildings under their control will be acceptable to the person conducting the disposal but that the generation of fragments of glass comprising a significant risk to persons within or without those buildings will not.

1.1.3 An explosion during the disposal activity should not generate significant risks or inconvenience to persons in buildings who do not derive a direct benefit from the explosives activity. In this context blast over pressures at buildings not in the control or occupation of the person conducting the disposal will be such that damage to any one pane of glazing would not be expected more often than once every 50 to 100 years. This criteria can be met (on the assumptions that a building will have 10 qualifying glazing panes) by:

• The probability of a pane of glass breaking where a blast effect is possible but unlikely not exceeding 5%

• The probability of a pane of glass breaking where a blast effect is possible but not expected not exceeding 2%.
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- and where the nature of the technique, the nature of the materials or a history of events indicates that blast effect can be expected the probability of a pane of glass breaking being minimised.

1.1.4 The distance in metres to any other location where explosives or dangerous substances are present should be $22Q^{1/3}$ where $Q$ is the net explosive quantity in kg. This criterion follows established standards from previous guidance and experience shows that it provides a high degree of protection from communication of an explosion from whatever cause and from potential domino effects.

1.1.5 That for individual locations at a disposal site to be considered to comprise a unit risk there will be no propagation of an explosion at a disposal location to explosives present at a second or further location that will result in any blast or other explosive effect being enhanced or in an increased risk to people or property.

1.2 Assumptions

1.2.1 That any primary or secondary fragment hazard (i.e. stones, detritus, and fragments of any disposal location structure) with the potential to injure people, damage property or initiate other explosives has been managed by mounds constructed in accordance with Section 10.2.2.5 of the main body of the guidance or by other equally effective measures.

1.2.2 That glazing in buildings under the control or occupation of the person conducting the disposal operation comprises 1.55m x 1.25m panes of 4mm annealed glass. i.e. that compliance with the distances given in the table will provide an appropriate degree of protection to panes of glass that are of 4mm thick annealed glass and up to 1.55m x 1.25m and to any other panes of a similar area where the glass exhibits greater resistance to blast overpressure loading.

1.2.4 That glazing in buildings not in the occupation of the person conducting the disposal comprises 1.83m x 1.52m panes of 6mm thick plate annealed glass. i.e. that compliance with the distances given in the table will provide an appropriate degree of protection to panes of glass that are of 6mm thick plate annealed glass and up to 1.83m x 1.52m, panes of 3mm thick plate annealed glass up to 1.07m x 0.91m and to any other panes of a similar area where the glass exhibits exhibit greater resistance to blast overpressure loading.

1.2.5 That the minimum distance in metres from an explosion at which sound levels will not exceed 140dB(C) is given by the expression $215Q^{1/3}$ where $Q$ is the net explosive quantity in kg.

1.2.6 That any fireball etc. likely to be produced will have a radius of less than half the distance between two disposal locations if they are to be considered as comprising a unit risk.
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1.2.7 That sufficient distance or barriers obscuring line of sight are in place to prevent the initiation of explosives at one disposal location by the explosion of explosives at another as a consequence of any subsidiary thermal effect.

1.2.8 That controls are in place to prevent hot ash or other source of ignition being transmitted from a disposal or burning location to another location where explosives or other dangerous or flammable substances are being kept or disposed of.

1.3 Quantity – Distance Tables

1.3.1 Table of Recommended Minimum Distances to Persons in the Open and to Occupied Buildings in the Occupation of the Person Conducting the Disposal

<table>
<thead>
<tr>
<th>Weight Explosive in kg (TNT Equivalent)</th>
<th>Column 1 Persons in the open where a blast effect IS expected (m)</th>
<th>Column 2 Persons in the open where a blast effect is possible but NOT expected (m)</th>
<th>Column 3 Persons in the open where a blast effect is possible but unlikely</th>
<th>Column 4 Buildings in the occupation of the Person conducting the disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>215</td>
<td>48</td>
<td>31</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>271</td>
<td>62</td>
<td>38</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>368</td>
<td>84</td>
<td>52</td>
<td>58</td>
</tr>
<tr>
<td>10</td>
<td>463</td>
<td>108</td>
<td>85</td>
<td>91</td>
</tr>
<tr>
<td>20</td>
<td>584</td>
<td>134</td>
<td>82</td>
<td>138</td>
</tr>
<tr>
<td>50</td>
<td>792</td>
<td>183</td>
<td>111</td>
<td>225</td>
</tr>
<tr>
<td>100</td>
<td>998</td>
<td>230</td>
<td>140</td>
<td>300</td>
</tr>
</tbody>
</table>

1.3.1.1 The distances given in the table above are likely to result in any qualifying window cracking should an explosion occur. It is therefore recommended that greater distances that those given are maintained if window breakage is to be avoided. These distances may be reduced or the factor of safety improved where the glazing is of a different type. e.g. thicker, fitted with anti-shatter film, toughened, laminated or part of a double-glazed unit or where the building has been designed to be a protective shelter. Similarly it may be necessary to increase this distance where the building has several stories and/or overlooks traffic routes or pedestrian access because of the risk of cracked panes falling from their frames.

1.3.1.2 The distances given in column 1 of the table will limit the noise level to which persons will be exposed to approximately 140dB(C) and should therefore be assumed that hearing protection would be required in order to comply with the requirements of the Control of Noise at Work Regulations 2005.

1.3.1.3 Where a building is unlikely to provide protection to its occupants from external noise the values given in column 1, 2 or 3 (depending
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on the nature of the disposal) should be used where they are greater than the value given in column 4.

1.3.2 Table of Recommended Minimum Distances to Buildings not in the Occupation of the Person Conducting the Disposal and to prevent the communication of an Explosion or other Domino Effects

<table>
<thead>
<tr>
<th>Weight Explosive in kg (TNT Equivalent)</th>
<th>Column 1 Prevent the communication of an Explosion or other Domino Effects Distance (m)</th>
<th>Column 2 Buildings not in the Occupation of the Person conducting the disposal where a Blast Effect IS expected (m)</th>
<th>Column 3 Buildings not in the Occupation of the Person conducting the disposal where a Blast Effect is possible but NOT expected (m)</th>
<th>Column 4 Buildings not in the Occupation of the Person conducting the disposal where a Blast Effect is possible but unlikely (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>11</td>
<td>143</td>
<td>61</td>
<td>53</td>
</tr>
<tr>
<td>0.5</td>
<td>18</td>
<td>245</td>
<td>105</td>
<td>91</td>
</tr>
<tr>
<td>1</td>
<td>22</td>
<td>310</td>
<td>132</td>
<td>114</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>390</td>
<td>167</td>
<td>143</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>530</td>
<td>227</td>
<td>194</td>
</tr>
<tr>
<td>10</td>
<td>52</td>
<td>670</td>
<td>285</td>
<td>245</td>
</tr>
<tr>
<td>20</td>
<td>64</td>
<td>850</td>
<td>360</td>
<td>309</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
<td>1150</td>
<td>486</td>
<td>419</td>
</tr>
<tr>
<td>100</td>
<td>105</td>
<td>1450</td>
<td>615</td>
<td>528</td>
</tr>
</tbody>
</table>

1.3.3 Table of Recommended Minimum Distances Required for the unitisation of risk at different disposal locations

| Recommended Minimum Distance for the unitisation of different disposal locations |
|----------------------------------|----------------------------------|-------------------------------------------------|-------------------------------------------------|
| Weight Explosive in kg (TNT Equivalent) | Distance (m)                       |
|--------------------------------------|----------------------------------|-------------------------------------------------|-------------------------------------------------|
| 0.1                                  | 1.5m                             | 2                                               | 2.5                                              |
| 0.5                                  |                                  | 3                                               | 4.5                                              |
| 1                                    | 2.5                              | 5.5                                             | 7                                                |
| 2                                    |                                  | 9                                               | 9                                                |
| 5                                    |                                  |                                                | 11                                               |
| 10                                   |                                  |                                                |                                                  |
| 20                                   |                                  |                                                |                                                  |
| 50                                   |                                  |                                                |                                                  |
| 100                                  |                                  |                                                |                                                  |
SECTION 2  SEPARATION DISTANCES RELATING TO DISPOSAL OPERATIONS WHEN THERE IS EITHER A SIGNIFICANT FRAGMENT HAZARD OR A SIGNIFICANT HAZARD RELATING TO PROJECTED EFFECTS INCLUDING FIREWORKS AND SHAPED CHARGES.

2.1 Disposal Operations where there is a Significant Fragment Hazard

2.1.1 Criteria

2.1.1.1 No person either in the open or in a building should be at a significant risk of being struck by a fragment capable of causing injuries.

2.1.1.2 No explosives or other dangerous substances either in the open or in a building should be at a significant risk of being struck by a fragment capable of causing an explosion, loss of containment or other potentially dangerous effect.

2.1.1.3 Significant inconvenience to persons who do not derive a direct benefit from the explosives activity should not be generated. Significant inconvenience includes damage to property and an inability to quietly enjoy private property. However, as identified at para 4.3.2.1 at the main body of the guidance, Section 79(2) of the Environmental Protection Act 1990 specifically excludes smoke and noise from the definition of statutory nuisance in certain circumstances.

2.1.1.4 That for individual locations at a disposal site to be considered to comprise a unit risk there will be no propagation of an explosion at one disposal location to explosives present at a second or further location that will result in any explosive effect being enhanced or an increased risk to people or property.

2.1.2 Assumptions

2.1.2.1 That any primary or secondary fragment hazard (i.e. stones, detritus, and fragments of any disposal location structure) with the potential to injure people, damage property or initiate other explosives has been managed by mounds constructed in accordance with Section 10.2.2.5 of the main body of the guidance or by other equally effective measures.

2.1.2.2 That any fireball etc. likely to be produced will have a radius of less than half the distance between two disposal locations if they are to be considered as comprising a unit risk.

2.1.2.3 That sufficient distance or barriers obscuring line of site are in place to prevent the initiation of explosives at one disposal location by the explosion of explosives at another as a consequence of any subsidiary thermal effect if those to disposal locations are to be considered as comprising a unit risk.
2.1.2.4 That controls are in place to prevent hot ash or other source of ignition being transmitted from a disposal or burning location to another location where explosives or other dangerous or flammable substances are being kept or disposed of.

2.1.3 Minimum Distances to Persons, and Buildings Not Containing Explosives or Dangerous Substances

2.1.3.1 It is not possible to produces generic quantity distance tables for disposal activities where there is a significant fragment hazard.

2.1.3.2 Safety distances will need to be developed on a case by case basis and based on either rigorous modelling, previous experiences or testing, providing that the modelling, experience and testing matches the circumstances of the disposal.

2.1.3.3 For example the mode of initiation of a cased explosive charge, such as initiation by a detonator or burning to detonation in a fire, can change the size distribution, velocities and distances travelled by any fragments generated.

2.1.3.4 The safety distance should then be set at the distance travelled by the furthest fragment plus an appropriate safety margin. It is recommended that this be set at 100%. The resultant distance can then be reduced by mounding (generally providing that the angle subtended between the explosives and the mound exceeds 60°), building hardening or other fragment capture measures.

2.1.3.5 It is important to recognise that even where mounding or other mechanisms of containment do not reduce the maximum distance travelled by fragments they remain relevant tools for the reduction of risk because they can capture or otherwise control low angle fragments. In this way they can reduce the likelihood of persons, property or other dangerous substances being struck.

2.1.3.6 It is expected that any reduction in safety distance would be supported by a suitable and sufficient risk assessment.

2.1.4 Minimum Distances to Explosives or Dangerous Substances Not Involved in the Disposal Activity.

2.1.4.1 Tables 6 and 7 of Schedule 2 to MSER provide appropriate separation distances for the disposal of small quantities of explosives (up to 100kg NEC) assessed as possessing a shrapnel or fragment hazard. The use of these tables includes a margin of safety over the normal operation of licensed explosives sites to take account of the increased incidence of events during disposal operations. The application of these tables would presume that mounds or other protective measures would be in place to prevent high velocity fragments from an event impacting any explosives or dangerous substances.
2.1.5 Minimum Separation Distances between different locations required for the unitisation of risk.

2.1.5.1 Provided that the assumptions at 2.1.2 are valid the quantity-distance relationships in table 1.3.3 can be applied.

2.2 Disposal Operations where there is a Significant Hazard from Projected Effects including fireworks

2.2.1 Criteria

2.2.1.1 No person either in the open or in a building should be at a significant risk of being struck by a projected effect capable of causing injuries.

2.2.1.2 No explosives or other dangerous substances either in the open or in a building should be at a significant risk of being struck by a projected effect capable of causing an explosion, loss of containment or other potentially dangerous effect.

2.2.1.3 There should be no significant risk of the generation of fires remote from the disposal location that are capable of causing harm to persons, damage to property or risks of ignition to other explosives or dangerous substances.

2.2.1.4 Significant inconvenience to persons who do not derive a direct benefit from the explosives activity should not be generated. Significant inconvenience includes damage to property and an inability to quietly enjoy private property. However, as identified at para 4.3.2.1 at the main body of the guidance, Section 79(2) of the Environmental Protection Act 1990 specifically exclude smoke and noise from the definition of statutory nuisance in certain circumstances.

2.2.1.5 That for individual locations at a disposal site to be considered to comprise a unit risk there will be no propagation of an explosion at one disposal location to explosives present at a second or further location that will result in any explosive effect being enhanced or an increased risk to people or property.

2.2.2 Assumptions

2.2.2.1 That any primary or secondary fragment hazard (i.e. stones, detritus, and fragments of any disposal location structure) with the potential to injure people, damage property or initiate other explosives has been managed by mounds constructed in accordance with Section 10.2.2.5 of the main body of the guidance or by other equally effective measures.
Annex F

2.2.2.2 That mounding or other equally effective measures are in place to intercept projected effects capable of causing an ignition at another disposal location.

2.2.2.3 That any fireball etc. likely to be produced will have a radius of less than half the distance between two disposal locations if they are to be considered as comprising a unit risk.

2.2.2.4 That sufficient distance or barriers obscuring line of site are in place to prevent the initiation of explosives at one disposal location by the explosion of explosives at another as a consequence of any subsidiary thermal effect.

2.2.2.5 That controls are in place to prevent hot ash or other source of ignition being transmitted from a disposal or burning location to another location where explosives or other dangerous or flammable substances are being kept or disposed of.

2.2.3 Minimum Distances to Persons, and Buildings, Explosives and Dangerous Substances

2.2.3.1 It is not possible to produce generic quantity distance tables for disposal activities where there is a hazard from projected effects because of the variation in types and modes of operation.

2.2.3.2 Safety distances will need to be developed on a case by case basis and based on either rigorous modelling, previous experiences or testing providing that the modelling, experience and testing matches the circumstances of the disposal.

2.2.3.3 For example prior treatment, such as soaking prior to burning, and mode of initiation of an explosive, such as initiation by a detonator or burning to detonation in a fire, can change the size distribution, velocities and distances travelled by fragments or projected effects.

2.2.3.4 The safety distance should then be set at the distance travelled by the furthest projected effect plus any radius of effect that the projected article may have plus an appropriate safety margin. It is recommended that this safety margin be set at 100%. The resultant distance can then be reduced by mounding (providing that the angle subtended between the explosives and the mound exceeds 60°), and other measures such as cages etc. building hardening or other mitigation measures as discussed in Section 11 of the main body of this guidance.

2.2.3.5 It is important to recognise that even where mounding or other mechanisms of containment such as mesh screens or other barriers do not reduce the maximum distance travelled by projected effects they remain relevant tools for the reduction of risk because they can capture or otherwise control low angle projected effects. In this way
they can reduce the likelihood of persons, property or other dangerous substances being struck.

2.2.3.5 It is expected that any reduction in safety distance would be supported by a suitable and sufficient risk assessment.

2.2.5 Minimum Separation Distances between different locations required for the unitisation of risk.

2.2.5.1 Provided that the assumptions at 2.2.2 are valid the quantity-distance relationships in table 1.3.3 can be applied.

2.3 Allowances for Reductions in Separation distances that can be made where appropriate and effective containing structures such as mounds, barriers and cages have been put in place.

2.3.1 This section provides guidance on how mitigation measures intended to reduce the likely maximum distance of flight of thrown fragments and projected effects can be applied in order to reduce separation distances. It does not apply to the recommended minimum distances for the unitisation of different disposal locations.

2.3.2 A number of possible scenarios describing the separation distances required for destruction operations that include fragment hazards or projected effect hazards are shown in Diagrams 5 to 8 below.

For the purposes of these diagrams:

- $d_1 = \text{distance travelled by any fragment or thrown projected effect} \times 2$

  or

- $d_1 = 2x (\text{the distance travelled by any thrown fragment or thrown projected effect}) + \text{the separation distance associated with any remote effect}$.

  Whichever is greater, and

- $d_2 = 2x (\text{distance travelled by any fragment or thrown projected effect as reduced by the height of any containing structure and associated subtended angle}) + \text{the separation distance associated with any remote effect}$.

  and

- $d_3 = \text{the separation distance associated with any uncontained remote effect assuming that thrown or projected effects have been fully contained}$.
Annex F

or

- \( d_3 \) = the default distance described in Section 4 of this Annex when any thrown fragments, projected effects and remote effects have been fully contained.

Whichever is greater.

Diagram 5 – Rectangular Destruction Area with One Open Face, Three Containing faces and an Open Roof.

Diagram 6 – Rectangular Destruction Area with Four Containing Faces and an Open Roof.
Diagram 7 Rectangular Destruction Area with One Open Face, Three Containing Faces and a Containing roof.

Diagram 8 Rectangular Destruction Area with all Containing Faces and a Containing Roof e.g. an effective cage.
2.3.3 Where a destruction area has an open or non-containing roof the maximum distance travelled by any fragment or projected effect can, in the absence of detailed modelling or testing be multiplied by the value given in the table below to give a reduced separation distance. This might not however apply to projected effects that have their own method of propulsion.

<table>
<thead>
<tr>
<th>Subtended Angle</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 60^\circ$</td>
<td>0.86</td>
</tr>
<tr>
<td>$\geq 65^\circ$</td>
<td>0.76</td>
</tr>
<tr>
<td>$\geq 70^\circ$</td>
<td>0.64</td>
</tr>
<tr>
<td>$\geq 80^\circ$</td>
<td>0.34</td>
</tr>
</tbody>
</table>

2.3.4 The subtended angle should be taken as being that which will exist between the top of the explosive and the top of the containing face at the most distant corner. Where explosives can be expected to travel or move during the destruction operation or where the location of the explosives within the destruction area is not prescribed the subtended angle can be taken as being that from the maximum height within the destruction area that the explosives can be expected to reach to the top of the containing face along an axis of the two most widely separated corners.

2.3.5 Where the vertical or horizontal movement of explosives is expected during a destruction operation it may be possible to control that movement by the use of additional barriers such as meshes etc that will limit the movement of the explosives but which will not act as confinement or aggravate the effects of any explosion etc.
SECTION 3 SEPARATION DISTANCES RELATING TO DISPOSAL OPERATIONS WHEN THERE IS A SIGNIFICANT THERMAL HAZARD

3.1 Overview

3.1.1 This section relates to thermal effects. It is most applicable to Hazard Type 3 materials whose initiation generates fireballs or flares or to explosives whose initiation results in vigorous deflagrations.

3.2 Criteria

3.2.1 That persons involved in or directly benefiting from the disposal activity will be exposed to a thermal flux no greater than 75% of the threshold for pain as described by Stoll and Greene. Analysis of the data described by Stoll and Greene results in the following relationship between the duration of a fireball and the constant flux that will result in the threshold of pain being reached.

<table>
<thead>
<tr>
<th>Duration of Fireball (s)</th>
<th>Constant Flux that will Result in Threshold of Pain being Reached (kWm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>1.5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>2.5</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>3.5</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>4.5</td>
<td>9.3</td>
</tr>
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<td>5</td>
<td>9</td>
</tr>
<tr>
<td>5.5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>7.6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>6.4</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>5.4</td>
</tr>
</tbody>
</table>

3.2.2 That persons not involved in or not directly benefiting from the disposal activity will be exposed to a thermal flux no greater than 50% of the threshold for pain as described by Stoll and Greene.
## Annex F

### 3.2.3 That there will be no communication of an explosion or associated domino effect as a consequence of a thermal hazard and that flammable materials comprising or in the immediate vicinity of a building or structure being used for the storage of explosives or other dangerous substances will not be subject to greater than 50% of the thermal flux required for their auto ignition.

### 3.2.4 That there will be no near-instantaneous propagation of an explosion at one disposal location to explosives present at a second or further location that results in an increased unit risk or and increased risk to persons and property.

### 3.3 Assumptions

#### 3.3.1 A set of standard assumptions have been made and the set of quantity-distance tables given below have been derived from these assumptions.

These assumptions are:

- The resultant event will be a fireball or relatively short duration (up to 10 seconds).
- That the contribution to the overall thermal output of any fireball derived from a fire in which material is being burned will be negligible.
- That the surface temperature of any fireball will be approximately 2500K.
- That the surface of any fireball will reach 2500K instantaneously and will maintain that temperature for the full duration of the fireball.
- That the diameter of the fireball can be expressed by the equation
  \[ D = aQ^b \]
  where \( D \) is the diameter of the fireball, \( Q \) is the net explosive weight in kg, \( a = 3.77 \) and \( b = 1/3 \).
- That the likely duration of the fireball can be expressed by the equation
  \[ t = 3.2Q^{0.126} \]
  (where \( t \) is time in seconds and \( Q \) is the net weight of explosive) for quantities of explosive up to 800kg.
- That the thermal flux at the surface of a fireball can be expressed by the equation
  \[ Q_s = \sigma \varepsilon T_F^4 \]
  where \( Q_s \) is the thermal flux at the surface of the fireball, \( \sigma \) is the Stefan-Boltzmann constant \( (5.67 \times 10^{-8} \text{ JK}^{-1} \text{m}^{-2} \text{s}^{-1}) \), \( \varepsilon \) is the emissivity of the flame and \( T_F \) is the temperature of the fireball.
- That any event will behave as an idealised fire.
- That because sudden heat pulses can easily break glass by thermal shock possible attenuation of thermal radiation by glazing will be ignored.
Annex F

- That there is an inverse square relationship between the thermal flux generated at the surface of a fireball of radius \( r \) and a point a distance \( x \) from the centre of that fireball i.e. \( x = r \left( \frac{\text{flux}_r}{\text{flux}_x} \right)^{1/2} \) where \( \text{flux}_x \) is either 75% or 50% of the threshold for pain.

These assumptions are conservative when considered with respect to the properties of most common explosives, propellants and pyrotechnics. More specific data, either from tests or the literature or more detailed modelling may identify that shorter (or longer) distances would be an appropriate mechanism for meeting the criteria given with respect to harm to people etc.

3.3.2 Additional assumptions have also been made with respect to the circumstances of the disposal and the unitisation of risk. These are:

- That any fireball likely to be produced will have a radius of less than half the distance between the disposal locations.

- That sufficient barriers are in place to prevent high-speed fragments or effects from communicating any explosive effects between different locations being used for disposal.

- That controls are in place to prevent hot ash or other source of ignition being transmitted from one burning location to another.

3.4 Table of Recommended Distances to people in the open or in buildings who are involved in or directly benefiting from the disposal

<table>
<thead>
<tr>
<th>Recommended Minimum Distance to Persons in the Open and to Occupied Buildings (m)</th>
<th>Weight of Explosive (kg)</th>
<th>0.1</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of Fireball (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>9.5</td>
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<td>95.3</td>
</tr>
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<td>23</td>
<td>29</td>
<td>39.5</td>
<td>49.5</td>
<td>62.5</td>
<td>84.5</td>
<td>106.3</td>
</tr>
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<td></td>
<td>11.5</td>
<td>20</td>
<td>25</td>
<td>31.5</td>
<td>43</td>
<td>53.5</td>
<td>67.5</td>
<td>92</td>
<td>115.3</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td>13</td>
<td>22</td>
<td>27.5</td>
<td>34.5</td>
<td>47</td>
<td>59</td>
<td>74.5</td>
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<td>37.3</td>
<td>51</td>
<td>64</td>
<td>80.5</td>
<td>109</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>14.5</td>
<td>24.5</td>
<td>31</td>
<td>39</td>
<td>53</td>
<td>66</td>
<td>83.5</td>
<td>113</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>26</td>
<td>32.5</td>
<td>41</td>
<td>55.5</td>
<td>70</td>
<td>88</td>
<td>119.5</td>
<td>150.5</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>15.5</td>
<td>27</td>
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<td>42.5</td>
<td>57.5</td>
<td>72.5</td>
<td>91</td>
<td>124</td>
<td>156</td>
<td></td>
</tr>
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<td>5</td>
<td>16</td>
<td>27.5</td>
<td>35</td>
<td>44</td>
<td>59.5</td>
<td>75</td>
<td>94.5</td>
<td>128</td>
<td>161.5</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>17</td>
<td>29</td>
<td>36.5</td>
<td>46</td>
<td>62</td>
<td>78</td>
<td>98.5</td>
<td>135.5</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>6</td>
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<td>29.5</td>
<td>37.5</td>
<td>47</td>
<td>64</td>
<td>80</td>
<td>101</td>
<td>137</td>
<td>172.5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>31</td>
<td>39</td>
<td>49</td>
<td>66.5</td>
<td>83.5</td>
<td>105.5</td>
<td>143</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>19</td>
<td>32</td>
<td>40.5</td>
<td>51</td>
<td>69.5</td>
<td>87.5</td>
<td>110</td>
<td>149.5</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>19.5</td>
<td>34</td>
<td>42</td>
<td>53</td>
<td>72</td>
<td>90.5</td>
<td>114</td>
<td>154.5</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>20.5</td>
<td>35</td>
<td>44</td>
<td>55.5</td>
<td>75</td>
<td>94.5</td>
<td>119</td>
<td>161.5</td>
<td>203</td>
<td></td>
</tr>
</tbody>
</table>
3.4.1 Note that the bold value gives the recommended distance corresponding to the expected duration of the fireball as derived from the expression given above in the assumptions (3.3.1) and these values should be used in the absence of any other data.

3.4.2 Where testing or the history of a disposal activity identifies that the fireball lasts for a different period to that expected from the formula given above, it may be necessary or appropriate to use the values in the table that correspond to the actual or historical duration of the fireball.

3.5 Table of Minimum Distances to people in the open or in buildings who are NOT directly involved in or benefiting from the disposal

| Recommended Minimum Distance to Persons in the Open and to Occupied Buildings (m) |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Weight of Explosive (kg) | 0.1 | 0.5 | 1 | 2 | 5 | 10 | 20 | 50 | 100 |
| Duration of Fireball (s) |  |  |  |  |  |  |  |  |  |
| 1 | 12 | 20 | 25.5 | 32 | 43 | 54 | 68.5 | 92.5 | 116.5 |
| 1.5 | 13 | 22.5 | 28 | 35.5 | 48.5 | 60.4 | 76.5 | 103.5 | 130.5 |
| 2 | 14.5 | 24.5 | 30.5 | 38.5 | 52.5 | 65.5 | 83 | 112.5 | 141.5 |
| 2.5 | 16 | 27 | 33.5 | 42.5 | 57.5 | 72.5 | 91 | 123.5 | 156 |
| 3 | 17 | 29 | 36.5 | 46 | 62 | 78 | 98.5 | 133.5 | 168.5 |
| 3.5 | 18 | 30 | 38 | 48 | 65 | 81.5 | 103 | 139.5 | 176 |
| 4 | 18.5 | 31.5 | 40 | 50 | 68 | 85.5 | 108 | 146.5 | 184.5 |
| 4.5 | 19.5 | 33 | 41.5 | 52 | 70.5 | 89 | 112 | 152 | 191 |
| 5 | 20 | 34 | 42.5 | 54 | 73 | 92 | 115.5 | 157 | 197.5 |
| 5.5 | 21 | 35.5 | 44.5 | 56 | 76 | 95.5 | 120.5 | 163.5 | 206 |
| 6 | 21.5 | 36.5 | 45.5 | 57.5 | 78 | 98 | 123.5 | 168 | 211.5 |
| 7 | 22 | 38 | 47.5 | 60 | 81.3 | 102.5 | 129 | 175 | 220.5 |
| 8 | 23 | 39.5 | 50 | 62.5 | 85 | 107 | 135 | 183 | 230.5 |
| 9 | 24 | 41 | 51.5 | 64.5 | 88 | 110.5 | 139 | 189 | 237.7 |
| 10 | 25 | 43 | 54 | 68 | 92.5 | 116.5 | 147 | 199 | 250.6 |

3.5.1 Note that the bold value gives the recommended distance corresponding to the expected duration of the fireball as derived from the expression given above in the assumptions (3.3.1) and these values should be used in the absence of any other data.

3.5.2 Where testing or the history of a disposal activity identifies that the fireball lasts for a different period to that expected from the formula given above, it may be necessary or appropriate to use the values in the table that correspond to the actual or historical duration of the fireball.
3.6 Table of Recommended Minimum Distances to Explosives and Dangerous Substances in the Open or in Buildings

<table>
<thead>
<tr>
<th>Weight of Explosives (kg)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>8</td>
</tr>
<tr>
<td>0.5</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>100</td>
<td>75</td>
</tr>
</tbody>
</table>

Note that these distances are applicable to explosives in the open or to dangerous substances where the properties of these materials are known and they have been assessed as not being at risk of ignition as a consequence of the thermal flux generated by a fireball.

3.7 Table of Minimum Separation Distances between different disposal locations required for the unitisation of risk.

<table>
<thead>
<tr>
<th>Weight of Explosives (kg)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>2</td>
</tr>
<tr>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>6.5</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>14</td>
</tr>
<tr>
<td>100</td>
<td>18</td>
</tr>
</tbody>
</table>

Where suitable and sufficient barriers are not present it is recommended that the distances given in the table at 3.6 are used.
SECTION 4 SEPARATION DISTANCES RELATING TO DESTRUCTION OPERATIONS WHEN THERE IS NO SIGNIFICANT BLAST, FRAGMENT, PROJECTED EFFECT OR THERMAL HAZARD.

4.1 Where the nature of the explosive substance or article being destroyed is such that there is no significant blast, fragment, projected effect or thermal hazard a default precautionary distance to people, buildings and dangerous substances including explosives can be applied. This distance should relate to tightly specified and supervised operations. Where quantities being disposed of are small (up to 5kg) or any explosive articles present a limited unit risk, such as safety cartridge type small arms ammunition, a minimum default distance of 10m is recommended.

4.2 Similarly where sufficient passive engineering controls are in place to ensure that any blast, fragment, projected effect or thermal hazard that is realised is either contained within the destruction location or will not effect persons, property or dangerous substances (including explosives) outside the destruction location a default precautionary distance can be applied. This distance should relate to tightly specified and supervised operations. Where quantities being disposed of are small (up to 5kg) or any explosive articles present a limited unit risk, such as safety cartridge type small arms ammunition a minimum default distance of 10m is recommended.

4.3 It is not possible to provide detailed guidance with respect to the thermal hazards associated with open fires that are used for the disposal of explosives or materials contaminated or potentially contaminated with such. Any fires should be located at sufficient distance from persons that they cannot cause pain and should be located at a sufficient distance from buildings and dangerous substances such that they do not cause their spontaneous or piloted ignition or the spontaneous or piloted ignition of flammable materials in their immediate vicinity. For example in the absence of detailed and specific modelling or testing buildings that are not at risk of piloted ignition should not be subjected to a constant thermal flux in excess of 12kW/m² (i.e. 40% of HSE’s Land use Planning value for the constant flux required for the spontaneous ignition of buildings).
Annex F

Minimum Separation Distances Proforma

<table>
<thead>
<tr>
<th>Weight of Explosives (kg)</th>
<th>TNT Equivalence (%)</th>
</tr>
</thead>
</table>

The required distances listed below are those determined from the relevant criteria listed in Annex F to the Guidance and allowing for account having been taken of the preventive or protective effects of any engineering controls.

A) Is the destruction operation one where there is a blast hazard?

Yes – complete A1 to A4

No – Go to B).

A1) What is the minimum recommended distance to persons in the open (Table 1.3.1)?

m.

A2) What is the minimum recommended distance to occupied buildings in the occupation of the person conducting the disposal (Table 1.3.1)?

m.

A3) What is the minimum recommended distance to occupied buildings not in the occupation of the person conducting the disposal (Table 1.3.2)?

m.

A4) What is the minimum recommended distance to explosives or other dangerous or flammable substances (Table 1.3.2)?

m.

B) Is the destruction operation one where there is a fragment hazard or projected effect hazard?

Yes – complete B1 to B2

No – Go to C).

B1) What is the minimum distance to Persons and occupied Buildings not containing Explosives or Dangerous Substances?
Annex F

Face 1 _________ m
Face 2 _________ m
Face 3 _________ m
Face 4 _________ m

B2) What is the minimum distance to Explosives or Dangerous Substances?

   Face 1 _________ m
   Face 2 _________ m
   Face 3 _________ m
   Face 4 _________ m

C) Is the destruction operation one where there is a thermal hazard?

   Yes – complete C1 to C3
   No – Go to D).

   C1) What is the minimum distance to people in the open or in buildings who are involved in or directly benefiting from the disposal (Table 3.4)?

       ________________ m.

   C2) What is the minimum distance to people in the open or in buildings who are not involved in or directly benefiting from the disposal (Table 3.5)?

       ________________ m.

   C3) What is the minimum distance to Explosives and Dangerous Substances in the Open or in Buildings (Table 3.6)?

       ________________ m

D) Is the destruction operation one where there is no significant blast, fragment, projected effect or thermal hazards?

   D1) The default distance is ________________ m.
Summary of Minimum Recommended Distances.

E1) The minimum recommended distance to persons in the open who are involved in or directly benefiting from the disposal is: -

__________m (the greatest of A1), B1) or C1); or D1))
Face 2_____ m, Face 3_____ m, and Face 4_____ m

E2) The minimum recommended distance to persons in the open who are not involved in or directly benefiting from the disposal is: -

__________m (the greatest of A1), B1) or C2); or D1))
Face 2_____ m, Face 3_____ m, and Face 4_____ m

E3) The minimum recommended distance to occupied buildings in the occupation of the person conducting the disposal is: -

__________m (the greatest of A2), B1), C1); or D1))
Face 2_____ m, Face 3_____ m, and Face 4_____ m

E4) The minimum recommended distance to occupied buildings not in the occupation of the person conducting the disposal is: -

__________m (the greatest of A3), B1) or C2); or D1))
Face 2_____ m, Face 3_____ m, and Face 4_____ m

E5) The minimum recommended distance to explosives or other dangerous or flammable substances is: -

__________m (the greatest of A4), B2) or C3); or D1))
Face 2_____ m, Face 3_____ m, and Face 4_____ m
COMMON CATEGORIES OF EXPLOSIVES WHICH MIGHT BE USED AS A BASIS FOR SEGREGATION

It is advised that these categories are applied above and beyond those detailed in the table of Compatibility Groups published at 7.5.2.2 of ADR 2005

- Pyrotechnic compositions containing chlorate
- Pyrotechnic compositions containing sulphur
- Compositions containing red phosphorous
- Compositions containing metal powders
- Single, double and triple base propellants
- Blasting explosives based on nitrated esters
- Water-based slurries and emulsions
- Ammonium Nitrate/Fuel oil explosives (ANFOs)
- Nitro compounds, eg RDX, PETN, TNT
- Devices – detonators, primers, actuating devices
- Fireworks
- Pyrotechnic articles
- Composite rubbery/plastic propellants
- Compositions containing white phosphorous

This Annex does not necessarily mean that all explosives of one category can be destroyed together.
PRETREATMENT ACTIVITIES THAT HAVE BEEN CONSIDERED BY THE HEALTH AND SAFETY EXECUTIVE’S EXPLOSIVE INSPECTORATE

Most of the activities listed below would be expected to be covered (in some way) by the facility licence if they were taking place on a site licensed by HSE under MSER 2005.

Activity 1 Taking apart an explosive article that has been designed to be taken apart as part of normal use?

- Removing a fuze from a fuze pocket.
- Unloading a rocket from a launcher.

Should this activity be licensed? - Maybe

i.e.

Taking a fuze from a fuze pocket is because two explosive items of different UN number have been created.

Removal of tail fins from a bomb isn’t.

Removal of a misfired cartridge from a firearm does not require a licence.

Removal of an airbag from a car does not require a licence.

The replacing of pyrotechnic articles on helicopters/aircraft does not require a licence.

Principle – The activity is not manufacture when the explosive properties of the explosive article are effectively unchanged and protective features inherent in to the explosive article are not being removed.

Activity 2 De-sticking a rocket/ Removing end caps from flares.

Should this activity be licensed? - No

Provided that the stick is not in intimate contact with the explosive filling, that it does not involve the exposure of the composition or the removal of safety systems such as a label securing a fuze.

Principle – The activity is not manufacture when the items being removed are peripheral, inert and the integrity of the explosives themselves are not being disturbed.

Activity 3 Removing the payload from a rocket motor

Should this activity be licensed? - Yes
With fireworks composition will be exposed.

*Principle* - One article is being changed into two different articles. This is clearly unmaking.

**Activity 4  Cutting open a firework/explosive article**

*Should this activity be licensed?* - Yes

Even when wet because it is not known how well wetted the contents will be.

*Principle* – This is clearly unmaking

**Activity 5  Mixing an explosive substance/article with a desensitising agent.**

e.g. soaking fireworks/flares

- adding diesel to MTV
- adding diesel to pyrotechnic substances.

*Should this activity be licensed?* - Depends.

The soaking of fireworks and flares in large volumes of water is probably best considered as being storage.

Where there is an explosive, a physical activity and the material that is generated remains is an explosive, albeit different to the original then manufacture has probably taken place. Where this takes place at the point of disposal immediately prior to the disposal activity this can probably be best considered to be use.

Putting detonators into sawdust – no this is effectively packing.

**Activity 6  Adding a chemical “destroyer” to an explosive**

e.g. use of NG destroyer

“drowning” small (g) quantities of pyrotechnic substances/AN based explosive substances in water.

*Should this activity be licensed?* - Depends

Not in small (i.e. g) quantities provided that the addition of the “destroyer” produces something that is not an explosive and that cannot easily recombine or fall out of solution to produce an explosive substance.
Annex H

Activity 7 Explosives and explosive articles being kept in a desensitising or destructive medium.

e.g. fireworks or other pyrotechnics being soaked in water.

Should this activity be licensed? – Depends

Unless one of the provisions in Regulation 10 (2) of MSER can be met a licence will be required until such time as it can be demonstrated that the materials being kept are no longer explosives or would be classified outside Class 1 under the UN scheme – provided that they cannot easily recombine or fall out of solution to produce an explosive substance.
**GLOSSARY**

<table>
<thead>
<tr>
<th><strong>Amatols</strong></th>
<th>Pourable mixtures of ammonium nitrate and trinitrotoluene of widely varying compositions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ammonium Nitrate</strong></td>
<td>A constituent of commercial explosives, e.g. ANFO, slurries, emulsions. Also a constituent of fertiliser.</td>
</tr>
<tr>
<td><strong>ANFO</strong></td>
<td>Ammonium nitrate plus fuel oil. A common commercial blasting explosive.</td>
</tr>
<tr>
<td><strong>Attenuate</strong></td>
<td>Used to describe the weakening of a shock wave by decreasing its amplitude or duration.</td>
</tr>
<tr>
<td><strong>Azides</strong></td>
<td>Salts of hydrazoic acid (N₃H).</td>
</tr>
<tr>
<td><strong>Ball Powder</strong></td>
<td>Small arms propellant manufactured in the form of small spheres.</td>
</tr>
<tr>
<td><strong>Ballistic Modifier</strong></td>
<td>An additive incorporated in a propellant composition to alter its rate of burning.</td>
</tr>
<tr>
<td><strong>Baratol</strong></td>
<td>Barium nitrate and TNT, used in grenades and anti-tank mines.</td>
</tr>
<tr>
<td><strong>Base Charge</strong></td>
<td>An increment of secondary high explosive (commonly tetryl or PETN) in the base of a composite detonator to enhance the shock wave.</td>
</tr>
<tr>
<td><strong>Bioremediation</strong></td>
<td>The use of biological agents, such as bacteria or plants, to remove or neutralize contaminants, as in polluted soil or water.</td>
</tr>
<tr>
<td><strong>Black Powder</strong></td>
<td>Gunpowder consisting of charcoal, potassium nitrate and sulphur.</td>
</tr>
<tr>
<td><strong>Blast</strong></td>
<td>A supersonic longitudinal wave produced in the surrounding atmosphere by an explosion.</td>
</tr>
<tr>
<td><strong>Blast Impulse</strong></td>
<td>The time integral of the overpressure exerted by a blast wave.</td>
</tr>
<tr>
<td><strong>Blasting Explosive</strong></td>
<td>An explosive designed for industrial mining, quarrying, civil engineering and demolitions.</td>
</tr>
<tr>
<td><strong>Blast Wave</strong></td>
<td>A shock front with an area of high pressure behind it, followed by a rarefied zone.</td>
</tr>
<tr>
<td><strong>Blending</strong></td>
<td>The mixing of gun propellant grains or sticks to achieve regular ballistics.</td>
</tr>
</tbody>
</table>
Booster Used in an explosive train interposed between a detonator and high explosive charge (see also primer).

Bridgewire An electrical filament used to ignite a pyrotechnic or primary explosive in contact with it in an igniter or detonator.

Brisance The shattering property of an explosive.

Burning The propagation of combustion by a surface process. (See deflagration).

Calorimetric Value The amount of heat evolved by the combustion of a propellant in a closed vessel in the absence of air or oxygen.

Cap A small metal container filled with a flame producing explosive composition. See also detonator.

Capped fuze A length of safety fuze already fitted with a detonator.

Cartridge A general term that can have a wide range of usage. It usually refers to a package or assembly of propellant explosive although it can sometimes describe a complete round of ammunition. In commercial explosives it is a general term for an individual explosive package. i.e. a wrapped or otherwise protected cylinder of defined size of a homogeneous explosive material.

CE “Composition Exploding”, (also called Tetryl). N-methyl-N-nitro-2,4,6-trinitroaniline. A secondary high explosive.

Charge A bagged, wrapped or cased quantity of explosive without its own integral means of ignition.

Cleaning The removal of bulk materials from a piece of plant, building or facility followed by removal of visible traces of contamination from exposed surfaces using a brush, water or solvent wash-down.

Colloid State A dispersion of one substance in another in which the particles of the dispersed substance (colloid) have dimensions 0.1 to 0.001\(\mu\)m.

Combining The mixing of different explosives, stabilisers or other ingredients.

Combustion An exothermic oxidation reaction producing flame, sparks or smoke.
Compatibility The possibility of one or more substances remaining in contact with an explosive without adverse physical or chemical effect.

Compatibility Group A system of classifying bulk explosives and live ammunition into groups, so that items are not transported or stored together, which would, if accidentally initiated, increase the hazards by their interaction.

Composite Propellant A solid propellant, usually for rockets, which comprises an inorganic and a polymeric fuel matrix.

Cook-off The initiation of an enclosed explosive by the conduction of heat through its container. E.g. Live ammunition left loaded in hot guns.

Cordite Historical name for double base (nitroglycerine/nitrocellulose) gun propellants in the UK and can be extended to triple base propellants.

Critical depth The depth of bed of explosives at which transition from a burning to a detonative mode of explosion will occur.

Decommissioning The process of taking plant, equipment and buildings out of normal use and leaving in a safe condition by the removal of bulk explosives.

Decomposition, Thermal The breakdown of materials into smaller constituent molecules by the action of heat alone.

Decontamination The process of removing the residue (of explosives, or ingredients used in their manufacture) from plant, equipment, buildings or land to allow demolition or remediation to be carried out.

Deflagration Reaction where materials decompose at a rate much below the sonic velocity of the material without any excess of atmospheric oxygen being required. It is propagated by the liberated heat of reaction. Hazards produced are fireball, thermal radiation and jets of flame.

Detonating Fuze (Cord) Flexible (plastic) tubing filled with a powdered core of secondary high explosive. Used to transmit a detonation wave over any required distance.

Detonation A form of reaction given by an explosive substance in which the exothermic chemical reaction produces a shock wave. High temperature and pressure gradients are created in the wave.
front so that the chemical reaction is initiated instantaneously. Hazards are blast, fragments and collapse of buildings.

**Detonation Pressure**  The dynamic pressure in the shock front of a detonation wave.

**Detonator**  The component within an explosive train which, when initiated, in turn detonates a less sensitive but larger high explosive (usually the booster), or when containing its own primer initiates the detonation. An instantaneous or delay initiator for explosive materials and containing a charge of high explosive fired by a flame, spark or electric current or percussion. A cap is a similar component designed to initiate a deflagration.

**Doping**  The addition of a marker material to an explosive composition.

**Double base**  Group of gun propellants based on nitrocellulose and nitroglycerine. Usually more energetic than single base propellants.

**Drying**  Drying of explosives or ingredients in a drying room or over a desiccant to facilitate the removal of solvents (used in some mixing processes) or to achieve a specified moisture level.

**Dynamite**  Explosive containing typically 20-50% NG, 4% NC, sodium nitrate and woodmeal.

**EGDN**  Ethylene glycol dinitrate. \((\text{CH}_2\text{ONO}_2)_2\). A liquid secondary high explosive.

**Emulsion Explosive**  A blasting explosive consisting of ammonium nitrate with added fuels and other ingredients. Waterproof explosives that contain sensitizers, oxidisers and fuels dispersed as emulsions.

**Exothermic Reaction**  A chemical reaction accompanied by a loss of heat into the surroundings.

**Exploder**  A device specially designed for firing electric detonators, from a safe distance.

**Explosive**  A chemical substance or mixture which can react to produce an explosion. Any substance, whether or not contained in a device, used or manufactured with a view to producing a practical effect by explosion.

**Explosiveness**  The rate at which a particular explosive, when subjected to a given stimulus, gives up its energy, and/or the degree to which it does so.
Explosive Power  The work capacity of an explosive, usually referred to high explosives.

Explosion  Chemical reaction or change of state effected in an exceedingly short period of time with the generation of a high temperature and generally a large quantity of gas. An explosion can produce a shock wave in the surrounding medium. (See also detonation and deflagration).

Explosive train  A train of combustible and explosive elements arranged in order of a decreasing sensitivity. The explosive train accomplishes the controlled augmentation of a small impulse into one of suitable energy to actuate the main charge. May be igniferous or detonative.

Figure of insensitiveness  A figure determined by a Rotter Impact Test, which is a measure of the sensitiveness of an explosive to an impact. The higher the result, the less sensitive the explosive. E.g. RDX = 80.

Flame  Luminous phenomenon accompanying gas phase combustion.

Flare  Pyrotechnic device designed to produce a single source of intense light.

Flash  A brief radiation pulse accompanying an explosion. A short lived flame used to ignite safety fuze, a detonator or igniter.

Flash over  Sympathetic detonation/deflagration from a cartridge to another one adjacent to it.

Fragmentation  The shattering effect of an explosive upon its container.

Free from explosives  Items can be certified free from explosive contamination when the competent person who signs the certificate is certain that the item has come from a non-explosives building, or that the decontaminated item has gone through a proving procedure.

Fuel  Any substance capable of reacting with oxygen and oxygen carriers with the evolution of heat.

Fulminate  Salt of fulminic acid. Most commonly encountered is mercury fulminate, a primary explosive, Hg(ONC)$_2$.

Fuzehead  A hot wire bridge ignition system coated/filled with explosive composition. Used to initiate an explosives train.
Fuze or fuze  A compact engineered assembly with explosive or pyrotechnic components and safety devices, designed to initiate the main charge of a munition. Cord or tube for the transmission of detonation or flame.

Gaine  Small explosive charge that is sometimes placed between the detonator and the main charge, designed to achieve, maintain or enhance detonation.

Gelignite  A gelatinous blasting explosive of plastic consistency, containing about 60% NG, 5% NC, potassium nitrate and woodmeal.

Glazing  The addition of a surface lubricant coating usually to propellant grains. A typical glazing agent would be graphite. Alternatively windows or similar structures primarily comprising glass or similar materials.

Guncotton  Nitrocellulose with a nitrogen content of > 12.9%.

Gunpowder  See Black Powder.

Hazard Assessment  The assessment of degree of hazard posed to personnel and property by the storage, handling, transportation, use, etc., of a particular explosive.

Hazard Division  A system of classifying bulk explosives and live ammunition, etc, into categories, based on the nature of hazard, which they pose if accidentally initiated.

High explosives  A true explosive is characterised by the fact that in its combustion process an exothermic (that is, heat liberating) reaction wave passes through it, following and supporting a 'shock front'. This phenomenon is described as 'detonation' and the velocity of the wave is the 'velocity of detonation'.

High Order Detonation  Detonation at a velocity approaching the maximum stable velocity of detonation for the system.

HMX  Cyclotetramethylenetetranitramine. A secondary high explosive.

Hollow (Shaped) Charge  A charge, usually cylindrical, having a cavity opposite the point of initiation, to exploit the Munroe Effect. The cavity may be lined with metal to enhance performance.

Hot Spot  A small localised region in an explosive substance which is characterised by a temperature much higher than that of its surroundings. Of relevance to the mechanisms of initiation.
**Hydrolysis**
The decomposition of a compound by the action of water. Relevant to the chemical stability of explosives.

**Hygroscopic**
The property of a substance to absorb and retain moisture from the atmosphere.

**Hypergolic**
Term to describe certain liquid bipropellant combinations which ignite spontaneously on mixing.

**Incendiary**
A highly exothermic composition or material that is primarily used to start fires.

**Incorporators**
Used in the pour filling of high explosive munitions. Usually TNT mixtures are melted in an incorporator to form a slurry which is then poured into a shell casing and allowed to solidify. Also used to mix explosive compositions, e.g. propellants.

**Initiating Explosives**
Explosives that can detonate by the action of a relatively weak mechanical shock, heat or by an electric current used to initiate the main explosive charge. Sometimes called primary explosives.

**Initiation**
To set off explosives. To detonate.

**Initiator**
A device for igniting or detonating explosives. Also an abbreviation for initiatory compositions, i.e. primary explosives.

**Low Explosive**
An explosive which does not detonate under normal conditions of use.

**Low Order Detonation**
A detonation in which the charge is completely consumed but the velocity of detonation is well below its maximum value, and therefore its effect is lessened.

**Magazine**
Any building or structure approved for the storage of explosive materials. Also a removable case holding several rounds or cartridges used in some types of firearms.

**Mothballed**
A term used to describe plant or facilities which have been deemed to be surplus to current operational needs but may be required at some stage in the future. Such plant and facilities are maintained to a standard that will keep them in a state of readiness for future operational use. Plant may be disconnected and put into storage. Services are left connected.

**Munroe Effect**
A local concentration of shock wave energy, which occurs when the wave emerges from a detonating charge via a re-entrant shape in the charge surface, e.g. a cone.
NC Nitrocellulose. Nitric esters of cellulose.

NG Nitroglycerine. Glyceryl 1,2,3-trinitrate. \( \text{CH}_2(\text{ONO}_2)\text{CH(ONO}_2)\text{CH}_2(\text{ONO}_2) \). A liquid secondary high explosive.

Nitration The process of adding a nitro- group to an organic molecule. Usually achieved using concentrated nitric acid (sometimes in admixture with other concentrated acids).

Non-permitted Explosive An explosive which is not among those authorised for use in gassy coalmines.

Out of Use A term used to describe plant or facilities, which have been temporarily taken out of operational use. (e.g. For repair to be carried out.)

Oxygen Balance The percentage of oxygen by weight (+ve or –ve) of an organic explosive containing carbon, hydrogen, oxygen and nitrogen, remaining after combustion, assuming that all the carbon and hydrogen is converted to carbon dioxide and water. It is the oxygen content of an explosive in relation to the fuel elements.

Partial Detonation A detonation which fails to propagate right through a charge leaving it partly chemically unchanged.

Partial Ignition An ignition in which the burning fails to propagate throughout the sample.

PBX Polymer bonded explosive. Generally explosive constituents bound in a rubbery matrix, which improves their mechanical properties and thermal resistance, making them inherently safer and less vulnerable to accidental initiation. Used in insensitive munitions.

PE Plastic explosive. Used for improvised demolitions. Achieved by mixing powdered explosive with oil or grease.

Permitted Explosive Explosive authorised for use in gassy coalmines. Characterised by a low explosion temperatures and low detonation velocities.

PETN Pentaerythritol tetranitrate. A secondary high explosive. \( \text{C(CH}_2\text{.ONO}_2)_4 \)

Phlegmatisation The desensitisation of an explosive by mixing soft or viscous substance with it, e.g. wax, grease, oil, polymer. Such substances are phlegmatisers.
Phytoremediation  The use of plants or algae to remove or neutralise contaminants in soil or water.

Picric Acid  2,4,6-Trinitrophenol. A secondary high explosive. \((\text{NO}_2)_3\text{C}_6\text{H}_2\text{OH}\). Can react with metals to form impact sensitive salts (picrates).

Plain detonator  A detonator designed for use with safety fuze.

Plastic igniter cord  A flexible cord of incendiary compositions which emits an intense side flame when burning. The cord can be used to ignite individual safety fuzes when groups of shots are being fired in sequence.

Polymorphs  Different crystalline forms of chemically identical substances.

Primary Explosive  An explosive, which is readily ignited or detonated by a small mechanical or electrical stimulus.

Primer  In a gun cartridge is the explosive device containing a cap and a flame producing pyrotechnic or gunpowder, which ignites the propellant charge. The term is also used for the percussion cap in a small arms cartridge. Also used to indicate a high explosive blasting primer. A cartridge, cord or container of explosive into which a detonator or detonating cord is inserted or attached, designed to initiate a larger charge.

Propellant  An explosive, which burns to produce high pressure gas used to propel a projectile, missile or to do other work, e.g. for starting engines.

Proving  Proving is a process that follows after decontamination when there is a requirement to demonstrate that the decontaminated item is free from explosives.

Pyrotechnic  A stable mixture of an oxidising agent and a fuel, capable when initiated, of combustion to give a desired special effect, such as, heat, flame, smoke, gas, noise or delay.

Rate of Burning  The rate of regression of the burning surface of an explosive, usually referred to propellant grains.

RDX  Cyclotrimethylenetrinitramine. 1,3,5 trinitro–1,3,5 triaza–cyclohexane. A secondary explosive.

Redundant  A term used to describe plant or facilities for which there is no foreseeable operational use.
Remediation  The process of preparing a site to ensure that is suitable for its intended end use.

Resorcinate  Salts of resorcinol. Lead salts of mononitroresorcinol (LMNR) and dinitroresorcinol (LDNR) are primary explosives.

R F Hazard  The danger of accidental initiation of an electro-explosive device by radio frequency electromagnetic radiation.

Rotter Test  An empirical test to determine the sensitiveness of explosive materials to mechanical impact. Results are calculated as Figure of Insensitiveness.

Safety Fuze  Flexible tube for the transmission of flame in an explosive train. Contains an internal burning medium by which fire is conveyed at a continuous and uniform rate for firing plain detonators, black powder or other pyrotechnic substances, without initiating burning in a similar fuze that may be in lateral contact alongside.

Secondary Explosive  Explosives in which the detonation is initiated by the detonation impact of an initial (primary) explosive.

Sensitise  To increase the sensitiveness or the sensitivity of an explosive.

Sensitiviteness  A measure of the relative probability with which an explosive may be ignited or initiated by a prescribed stimulus.

Sensitivity  A measure of the stimulus required to cause reliable design-mode functioning of an explosive system.

Shock Front  A discontinuous change in the pressure propagating through a medium at supersonic speed.

Shock Wave  A shock front, together with its associated phenomena, e.g. blast, elevated temperature.

Shutter  A safety device in an explosive train for isolating the initiating explosive.

Sieving  The sieving of explosives is undertaken in order to achieve a known particle size. Also used in propellant manufacture to remove fuzes or unwanted particles. May also be used in processing of ‘wet’ mixed compositions to achieve granulation.

Single Base  Collective term for gun propellant compounds based on nitrocellulose with small amounts of stabiliser, plasticiser or coolant added.
**Slurry Explosive**  
A blasting explosive consisting of solid ammonium nitrate suspended in a gelled, saturated, aqueous solution of same, with added fuels and other ingredients.

**Small arms ammunition**  
Generally taken to be ammunition with a calibre up to and including 12.7mm. Shotgun cartridges up to 20mm.

**Stabilisers**  
Compounds which when added in small amounts to other chemical compounds or mixtures impart stability to the latter.

**Steeping**  
Where an explosive or ingredient is submerged in a liquid in order to either coat it, add a further ingredient, change its properties or to remove a solvent.

**Stoving**  
The process of heating to cure paints, lacquers, or thermosetting Polymer Bonded Explosives (PBX). Can also be used to describe solvent removal from nitroglycerine based propellants.

**Styphnate**  
Salts of trinitroresorcinol (styphnic acid). Lead and barium styphnates are the most common. They are used as primary explosives.

**Sympathetic Detonation**  
The initiation of an explosive charge without a priming device by the detonation of another charge in close proximity.

**Temperature of Ignition**  
The temperature at which an explosive ignites.

**Tetrazene**  
1-amino-1-[(1H-tetrazol-5-yl)azo] guanidine hydrate, a primary explosive used as a sensitising ingredient in primary compositions.

**Tetryl**  

**TNT**  
2,4,6-Trinitrotoluene. CH$_3$C$_6$H$_2$(NO$_2$)$_3$. A secondary explosive.

**Tracers**  
Slow burning pyrotechnic compositions used in tracer bullets, signalling charges, tracer rockets etc. Colour is due to the presence of added salts of metals such as sodium, barium, and strontium etc.

**Triple Base**  
Group of gun propellants based on nitrocellulose, nitroglycerine and nitroguanidine.

**UXB**  
Unexploded bomb. Sub group of UXO.

**UXO**  
Unexploded ordnance.
| **Velocity of Detonation** | The speed at which the detonation wave progresses through an explosive. When it attains a value that it will continue without change, it is called the stable velocity of detonation. |
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