Institute of Explosives Engineers
VOICE OF THE EXPLOSIVES INDUSTRIES

The Academy

# IExpE ET01
# Explosive Safety Foundation Course
# Short Course

STUDY GUIDE

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## 2 Record of changes

2.1 **This is a controlled document. Additional copies should be obtained through the issuing authority. In the extreme event of copying locally, each document shall be marked "Uncontrolled Copy".**

2.2 **Proposals for change to this document should be forwarded in writing to the originator.**

2.3 **Originator: BT Wilson, Explosives, Training and Standards Manager**

| Issue | Date | Detail of Changes |
|---|---|---|
| 1.0 | 20 Mar 2019 | Initial Issue |
| 2.0 | 21 May 2019 | Corrections and adjustments from pilot course. |
| 3.0 | 16 Dec 2020 | Adjust to match short course profile |
| | | |
| | | |

## 3 Aim of Basic Explosive Course

3.1 This course has been designed in consultation with the Sector Skills Strategy Group (SSSG) and is designed to give you the basic theory knowledge to enable you to carry out duties associated with Ordnance Munitions and Explosives (OME) across the UK explosives sector.

## 4 WARNING

*THIS DOCUMENT WAS ISSUED TO QINETIQ PERSONNEL ATTENDING A SPECIALIST COURSE.*

*WHILST THE INFORMATION CONTAINED IN THIS DOCUMENT WAS ACCURATE AT THE TIME OF ISSUE, IT SHOULD NOT BE USED AS AN AUTHORITY FOR ANY TASK.*

*THIS DOCUMENT MAY BE RETAINED FOR REFERENCE PURPOSES ONLY.*

*FOR AUTHORITATIVE INFORMATION, PERSONNEL SHOULD ALWAYS CONSULT THE SOURCE PUBLICATIONS REFERRED TO IN THE DOCUMENT.*

## 5 Topic 3: The nature and characteristics of explosives and pyrotechnics.

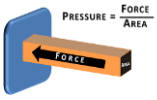
Definition of an Explosive:

Explosives are substances which contain their own oxygen to support the decomposition reaction and provided with the right stimulus will detonate.

Definition of an Explosive Substance:

An explosive substance is a substance capable by chemical reaction in itself of producing gas at such a temperature and pressure and at such a speed as could cause damage to surroundings.

Effects produced by an explosion:

| | |
|---|---|
| Light | Heat |
| Sound | Pressure   |

Definition of a Pyrotechnic:

Pyrotechnics are substances which are capable of undergoing a self-contained, self-sustained, exothermic chemical reaction.

Definition of a Pyrotechnic Substance:

A pyrotechnic substance is a substance designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these as a result of a non-detonative, self-sustaining, exothermic chemical reaction.

Effects produced by a pyrotechnic:

Heat – Flame – Light – Noise – Smoke – Gas

Explosives produce two main effects:

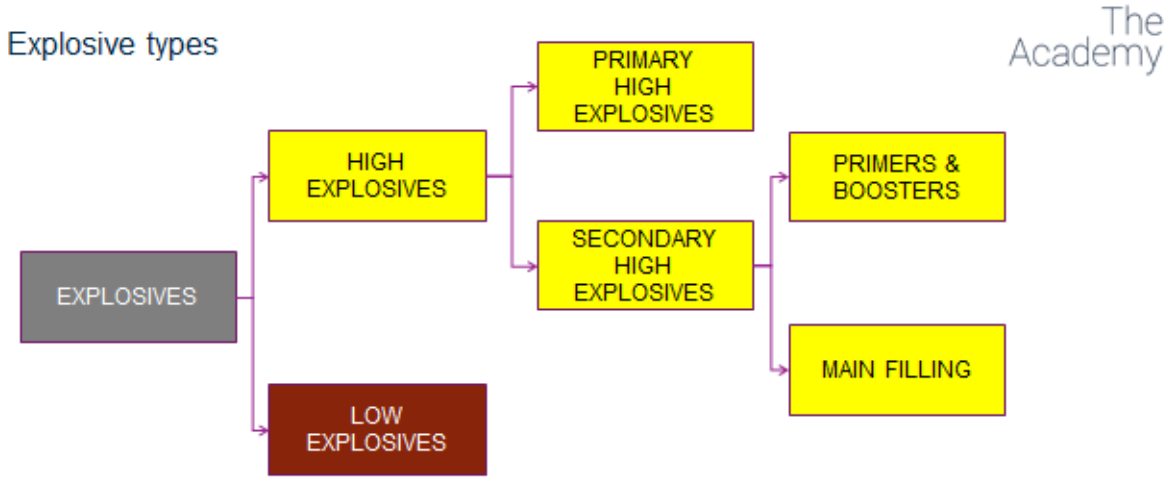
Deflagration (Lat: de + flagrare, "to burn down") is subsonic combustion propagating through heat transfer; hot burning material heats the next layer of cold material and ignites it. It burns at less than speed of sound 340 m/s.

Examples are propellants, power cartridges and fireworks.

Detonation (from Latin detonare, meaning 'to thunder down') is a type of combustion involving a supersonic exothermic front accelerating through a medium that eventually drives a shock front propagating directly in front of it. The shock wave travels through the explosive at speeds between 2000 and 10000 m/s.

Examples are warheads, aircraft bombs.

Explosives are split into two main types:




Low explosives – such as:

| LOW EXPLOSIVES | | |
|---|---|---|
| Flares | Propellants | Power Cartridges |
| | | |

High explosives, High explosives are further split into: Primary high explosives – such as:

| HIGH EXPLOSIVES – PRIMARY HIGH EXPLOSIVES |
|---|
| Detonators |

Secondary high explosives:

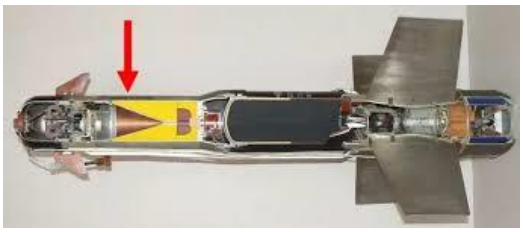
Secondary high explosives are further split into:

Primer/Boosters – such as:

| HIGH EXPLOSIVES – SECONDARY HIGH EXPLOSIVES – PRIMERS & BOOSTERS | |
|---|---|
| Cartridge Primers | Main Charge Boosters |

Main Filling – such as:

| HIGH EXPLOSIVES – SECONDARY HIGH EXPLOSIVES – MAIN FILLING | |
|---|---|
| Missile Warhead | Aircraft Bombs |



## 5.1 Hazard division, hazard types, compatibility groups, hazard classification codes.

For STORAGE and TRANSPORTATION Dangerous Goods (DG) have been placed into one of 9 United Nations (UN) DG classes.

| | | |
|---|---|---|
| Class 1 | Explosives | |
| Class 2.1 | Flammable Gas | |
| Class 2.2 | Non-Flammable Non- Toxic Gas | |
| Class 2.3 | Toxic Gas | |
| Class 3 | Flammable Liquids | |
| Class 4.1 | Flammable Solids | |
| Class 4.2 | Spontaneously Combustible | |
| Class 4.3 | Dangerous When Wet | |

| | | |
|---|---|---|
| Class 5.1 | Oxidizing substances | |
| Class 5.2 | Organic Peroxides | |
| Class 6.1 | Toxic Substances | |
| Class 6.2 | Infectious Substances | |
| Class 7 | Radioactive | |
| Class 8 | Corrosive Substances | |
| Class 9 | Miscellaneous | |

Shapes, colours and pictographs are used in signage as these signs are used throughout the world and therefore need to be obvious to all persons regardless of their language or culture.

This is Equality and Diversity in operation:

*Equality is not about treating all people in the same way. It's about recognising and respecting diversity enough to adapt practice and procedure to suit all.*

Class 1 is defined as: Any explosive substance, solid or liquid and/or any pyrotechnic substance, or any explosive article.
Hazard Division is the term used by the UN for DG transportation and the MOD in relation to explosives which are packaged for transportation and storage and does not change.

| Hazard Division Placard | Description |
|---|---|
| | The major hazards of this division are blast, high velocity projections and other projections of low velocity.<br>An explosion could result in severe structural damage, the severity and range being determined by the amount of explosive involved and the distance from the explosion site.<br>There may be a risk from heavy debris propelled from the structure in which the explosion occurs, or from the crater.<br>May display hazards associated with other HD. |
| | Projection hazard but not a mass explosion hazard<br>An explosion results in items burning and exploding progressively, a few at a time.<br>Furthermore, fragments, firebrands and unexploded items may be projected in considerable numbers; some of these may explode on impact and cause fires or explosions.<br>Blast effects are limited to the immediate vicinity. |
| | Fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.<br>Includes some items that burn with great violence, and intense heat, emitting considerable thermal radiation (mass fire hazard), and others which burn sporadically.<br>Items in this division may explode but do not usually form dangerous high velocity fragments. However, firebrands and burning containers may be projected. |
| | Includes items that are primarily a moderate fire hazard.<br>They do not contribute excessively to a fire.<br>The effects are largely confined to the package unless the package becomes degraded due to the effects of the fire.<br>No fragments of appreciable size or range are to be expected.<br>An external fire does not cause the simultaneous explosion of the total contents of a package of such items. |
| | Mass explosive hazard but are so insensitive that there is very little probability of initiation or of transition from burning to Detonation under normal conditions of transport.<br>The probability of transition from burning to detonation is greater when large bulk quantities are transported or stored.<br>For the purposes of determining Quantity Distances, explosives of HD 5 are deemed to belong to HD 1. |
| | Explosive Extremely Insensitive (EEI) articles that do not have a mass explosion hazard.<br>Includes those articles which contain only extremely insensitive detonating substances, and which demonstrate a negligible probability of accidental initiation or propagation as assessed at Test 7 of AASTP-3.<br>The risk from articles of HD 6 is limited to the explosion of a single article. |

Hazard Type (HT) is the term used by the UK HSE, it describes the nature of the hazard arising from an explosive in manufacture and storage conditions and can change, for example a box of 5.56mm rounds packaged in a metal ammunition container is classified as HD 1.4, however when unpacked it would then represent a "projection" hazard and therefore it would be classed as HT 2.

Hazard type defines and describes the nature of the hazard arising from an explosive in manufacture and storage conditions.

*Hazard Type 1: '…an explosive which, as a result of, or as a result of any effect of, the conditions of its storage or process of manufacture, has a mass explosion hazard'* (a mass explosion can be one in which the entire body of explosives explodes as one; where a substantial proportion of the explosives present could explode in such a way that the practical hazard should be assessed by assuming simultaneous explosion of all of the explosives present; or one which is associated with a serious blast hazard).

*Hazard Type 2: '…an explosive which, as a result of, or as a result of any effect of, the conditions of its storage or process of manufacture, has a serious projectile hazard but does not have a mass explosion hazard'* (where a fragment hazard arises solely as a consequence of the building or structure in which the explosives are located, breaking up, the explosives would normally be treated as Hazard Type 1).

*Hazard Type 3: '…an explosive which, as a result of, or as a result of any effect of, the conditions of its storage or process of manufacture, has a fire hazard and either a minor blast hazard or a minor projectile hazard, or both, but does not have a mass explosion hazard'* (i.e. those explosives which give rise to considerable radiant heat or which burn to produce a minor blast or projection hazard).

*Hazard Type 4: '…an explosive which, as a result of, or as a result of any effect of, the conditions of its storage or process of manufacture, has a fire hazard or slight explosion hazard, or both, with only local effect'* (i.e. those explosives which present only a relatively low explosives hazard in the event of ignition or initiation, where no significant blast or projection of fragments of appreciable size or range is expected).

- Hazard Division – Hazard Type equivalents:

| Hazard Division | Hazard Type |
|---|---|
| 1.1 | 1 |
| 1.2 | 2 |
| 1.3 | 3 |
| 1.4 | 4 |
| 1.5 | 1 |
| 1.6 | Individually assessed |

5.2 **Compatibility Groups (CG):**

Explosives are classified into one of 13 compatibility groups for storage and transportation (only 12 CG for transportation, CG K not permitted).

| | |
|---|---|
| A | Primary Explosive |
| B | Article containing a primary explosive substance and not having two or more effective protective features. |
| C | Propellant explosive substance or other Deflagrating explosive substance or article containing such explosive substance. |
| D | Secondary Detonating explosive substance or black powder, or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and containing two or more effective protective features. |
| E | Article containing a secondary detonating substance, without means of initiation, with propelling charge (other than on containing a flammable or hypergolic liquid). |
| F | Article containing a secondary explosive substance with its own means of initiation and with a propelling charge (other than on containing a flammable or hypergolic liquid or without a propelling charge). |
| G | Pyrotechnic substances, or article containing a pyrotechnic substance, or article containing both an explosive substance and illuminating, incendiary, lachrymatory, or smoke-producing substance (other than water-activated article or one containing white phosphorous, phosphide or flammable liquid or gel). |
| H | Article containing both an explosive substance and white phosphorous. |
| J | Article containing both and explosive substance and a flammable liquid or gel. |
| K | Article containing both an explosive substance and a toxic chemical agent. |
| L | Explosive substance or article containing an explosive substance presenting a special risk needing isolation of each type. |
| N | Articles containing only extremely insensitive detonating substances. |
| S | Substances or articles so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder or prohibit fire-fighting or other emergency response efforts in the immediate vicinity of the package. |

## 5.3 Hazard Classification Code (HCC):

The HCC is used on explosive placards to show the UN Class, Hazard Division and Compatibility Group.

| Example Placards | CG | Available HCC |
|---|---|---|
| | A | 1.1A |
| | B | 1.1B<br>1.2B<br>1.4B |
| | C | 1.1C<br>1.2C<br>1.3C<br>1.4C |
| | D | 1.1D<br>1.2D<br>1.4D<br>1.5D |
| | E | 1.1E<br>1.2E<br>1.4E |
| | F | 1.1F<br>1.2F<br>1.3F<br>1.4F |
| | G | 1.1G<br>1.2G<br>1.3G<br>1.4G |
| | H | 1.2H<br>1.3H |

| | | |
|---|---|---|
| | J | 1.1J<br>1.2J<br>1.3J |
| | K | 1.2K<br>1.3K |
| | L | 1.1L<br>1.2L<br>1.3L |
| | N | 1.6N |
| | S | 1.4S |

5.4 **Net Explosive Quantity (NEQ) and Net Explosive Content (NEC).**

The Net Explosive Quantity (NEQ), also known as Net Explosive Content (NEC) or Net Explosive Weight (NEW), of a shipment of munitions, fireworks or similar products is the total mass of the contained explosive substances, without the packaging, casings, bullets etc.

In the UK the term used is Net Explosives Quantity (metric) in the US the term used is Net Explosive Weight (Imperial).

Net Explosives Content is usually used for individual articles within a multiple article munition.

NEQ is always shown in kg and generally to two decimal places.

An item has an explosive content of 5 g (5 g = 0.005 kg)

0.005 rounded to two decimal places = 0.01.

NEQ = 0.01 kg.

## 5.5 Explosive identification – Colour Coding.

There are lots of indicators to the function of an explosive article, shape and size are two, but one key factor is colour.

The use of colour on munitions is there to help you understand their role and the type of hazard they represent.

Ammunition is split into two distinct groups; under 20 mm and over 20 mm.

On ammunition under 20 mm the colour is applied to the tip of the bullet, this is to prevent the paint fouling the bore of the weapon.

Example colours used for ammunition under 20 mm:

| Colour | Interpretation |
|---|---|
| | Identifies an armour piercing round. |
| | Identifies an armour piercing incendiary round. |
| | Identifies an incendiary round. |
| | Identifies an observing round. |
| | Identifies a tracer round. |

Example colours for ammunition 20 mm and over

| NATO Colour | Interpretation | UK equivalent colour |
|---|---|---|
| | Identifies HE ammunition or indicates the presence of high explosive. | Golden Yellow |
| | Identifies low explosive items or components or indicates the presence of low explosives. | Middle Brown |
| | Identifies ammunition containing a riot control, toxic chemical or incapacitating agent filler. | Light Grey |
| | Identifies a riot control agent. | Cherry Red |
| | Identifies a toxic chemical agent. | Deep Chrome Green |
| | Identifies Experimental ammunition, normally applied in the form of longitudinal stripes. | Dark Violet |
| | Identifies an armour defeating ammunition. | Black |
| | Identifies countermeasure ammunition. | Silver |
| | Identifies screening or marking smoke ammunition. | Eau-de-Nil |
| | Identifies incendiary ammunition or indicates the presence of highly inflammable material. | Signal Red |
| | Identifies illuminating ammunition or ammunition producing a coloured light. | White |
| | Identifies practice ammunition used in place of combat equivalent. * | Deep Saxe Blue |
| | Identifies drill ammunition. * | Oxford Blue |
| | Identifies nuclear ammunition or indicates the presence of radioactive materials | Light Orange |
| | Identifies certain evaluation or training versions of guided missions where photographic records are required. | International Orange |
| | Identifies certain acquisition training versions of guided missiles. | Shell Pink |

***IMPORTANT**

**PRACTICE AMMUNITION CAN CONTAIN EXPLOSIVES.**

**DRILL AMMUNITION WILL NEVER CONTAIN EXPLOSIVES.**

Role Colour Coding – Application:

The primary role of the ammunition shall be indicated by the appropriate colour code.

Where the ammunition has more than one essential role, these shall be indicated by a combination of the appropriate colour code. These colour codes shall be applied by one of the following methods, which are given in order of preference:

- Overall body colour.
- Main identification markings.
- A coloured, circumferential band of a width not exceeding one-half of the calibre, with a maximum width of 50 mm. The band shall be marked on a non-significant overall body colour.
- Coloured discs, which are to be as large as possible consistent with the use, size and shape of the item. This method should also be used in conjunction with a non-significant overall body colour.

*Example of role colour as overall body colour – Eau-de-nil rear mortars 81 mm smoke.*

*Example of role colour as main identification markings – Golden yellow, front 81 mm HE.*

Hazard Colour Coding – Application:

The primary hazard of the ammunition shall be indicated in the appropriate colour code.

Hazard bands shall only be used where the hazard colour differs from the colour denoting the primary role.

The width of hazard bands shall not exceed one-quarter of the calibre (or half the width of the role band if present), with a maximum width of 25 mm. The presence of a tracer or tracer composition shall be indicated by the tracer symbol and not by a hazard band.

*Example of role colour as overall body colour – deep saxe blue, 3 kg practice bomb and primary hazard colour – middle brown, low explosives*.

## 6 Module 2: Explosives Principles.

## 7 Topic 1: Explosives, Propellants and Pyrotechnics.

It is important that we understand terminology and use the same definition, for explosives the controlling document which has legal interpretations is, The Explosive Regulations 2014.

Definitions from ER 2014:

Explosive:

> Any explosive article or explosive substance which would:
>
> If packaged for transport, be classified in accordance with the United Nations recommendations as falling within Class 1.

Explosive substance:

> Means a substance or preparation, not including a substance or preparation in a solely gaseous form or in the form of vapour, which is:
>
> Capable by chemical reaction in itself of producing gas at such a temperature and pressure and at such a speed as could cause damage to surroundings; or
>
> Designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these as a result of a non-detonative, self-sustaining, exothermic chemical reaction.

Propellant:

> Means a deflagrating explosive used as a propellant in firearms.

Pyrotechnic article:

> Means any article containing explosive substances or an explosive mixture of substances designed to produce heat, light, sound, gas or smoke or a combination of such effects through self-sustained exothermic chemical reactions.

## 8 Topic 2: Explosion types.

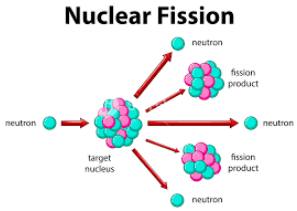
There are three types of explosions; the first type is a "**Physical Explosion**"

This can occur from man-made causes, such as the bursting of a high-pressure boiler, or gas cylinders can explode if broken.

*Note that high temperature is not a pre requisite for an explosion.*
*Physical explosion are still inherently destructive and are capable of causing damage by airblast and the propulsion of debris at high velocity*.

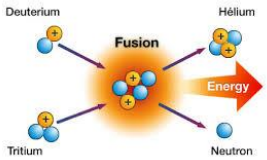
The second type is a "**Nuclear Explosion**"

These result either nuclear Fission:




A large nucleus splits into several small nuclei when impacted by a neutron, and energy is released in this process.

Or Fusion:




Several small nuclei fuse together and release energy.

Nuclear explosions release enormous amounts of heat very rapidly by rapid expansion of the air surrounding the device, damage is caused by airblast and heat. The radioactive elements which produce nuclear explosions are not referred to as explosives, but it is necessary to use chemical explosives to trigger a nuclear weapon.

That last type of explosion is the "**Chemical Type**".

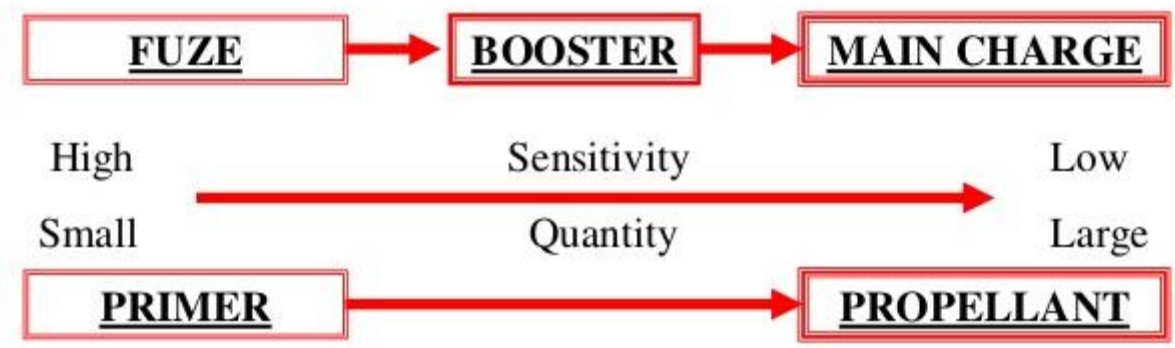
This is caused by the rapid decomposition of a chemical which results in heat and gas.

In general, the decomposition takes the form of combustion, an exothermic oxidation reaction which produces some visible manifestation such as flame or smoke.

## 9 Topic 3: The explosive train.

The explosive train is a sequence of energetic materials beginning with priming or initiating material (Primer or Fuze), through boosting material, and finally to the main charge.

The sequence is typically a small quantity of low-yielding, but very sensitive material (Primary Explosive) to a large quantity of high-yielding but not as sensitive material High Explosive.




The explosive train provides:

- A method of initiating the main charge.
- And if the train is broken it makes the article safer to transport.

Picture of HE aircraft bombs with no fuzes fitted.

*Note HCC of 1.1D*

## 10 Topic 4: Circumstances than can make explosive unsafe.

Poor storage conditions – leading to exposure to;

- Moisture and Humidity.
- Temperature.

Not monitoring the age of the explosives, as the explosives age they can decompose.

*Picture showing old dynamite: Over time, the dynamite will "weep" or "sweat" its Nitroglycerine, which can then pool in the bottom of the box. Crystals will form on the outside of the sticks.*

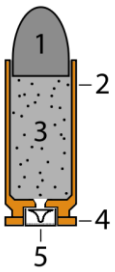
Poor or incorrect handling resulting in exposure to:

- Friction.
- Impact.
- Ignition by flame.
- Ignition by spark.
- Ignition by heat.
- Electrostatic discharge.

## 11 Topic 5: Basic munition design.

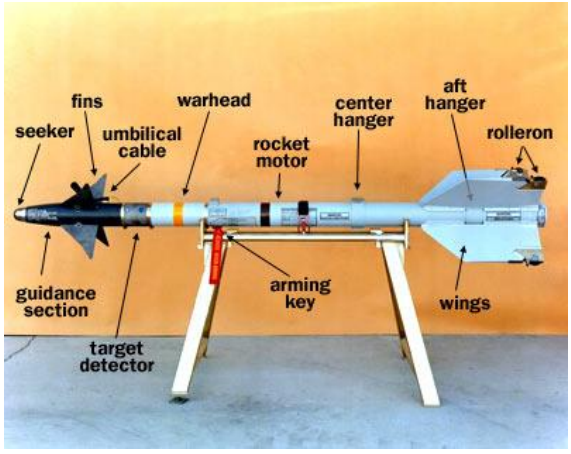
When designing a simple munition, i.e. a small arm round the following features should be included.

A modern cartridge consists of the following:




1. The bullet, as the projectile.
2. The case, which holds all parts together normally made out of a soft metal which expand (obturate) to seal the case inside the breech.
3. The propellant, for example gunpowder or cordite.
4. The rim, which provides the extractor on the firearm a place to grip the casing to remove it from the chamber once fired.
5. The primer, which ignites the propellant.

For a more complex weapon system, let's consider an air-to-air missile.




The Sidewinder missile comprises of;

A Guidance Section, which contains the in this case a seeker, fins to steer and an umbilical cable to connect the missile electronics with the aircraft systems.

A Target Detector, this operates in different ways for different missiles, this one is a proximity sensor which will send a signal to the detonator to initiate the warhead.

A warhead, again different types, this one is an expanding rod type, basically titanium rods around a main charge.

A motor section, in this case a solid rocket motor, initiated by an electrical signal, there is also usually a safety key, this will offset the connection between the primer and the main rocket motor. Other missiles can have engines, such as cruise missiles, these will then require a fuel tank to be located within the missile.

Wings are fitted for aerodynamic stability, this missile has rollerons.

A rolleron is a type of aileron placed at the trailing end of each wing and used for passive stabilization against rotation. Inherent to the rolleron is a metal wheel with notches along the circumference. On one side, the notches protrude into the airflow. During flight, this will spin the wheels up to a substantial speed. The wheels then act as gyroscopes. Any tendency of the rocket to rotate along its major axis will be counteracted by the rollerons: the gyroscopic precession acts to move the rolleron in the opposite direction to the rotation.

Lastly the missile has some form of way to attach to the aircraft, in this case hangers as this missile is rail launched. The front hanger also contains the rocket motor fire connector.

## 12 Topic 6: Factors which may affect explosive stability.

In the strictest technical sense, the word "stability" is a thermodynamic term referring to the energy of a substance relative to a reference state or to some other substance. However, in the context of explosives, stability commonly refers to ease of detonation, which is concerned with kinetics (i.e., rate of decomposition).

Temperature of storage:
The rate of decomposition of explosives increases at higher temperatures. All standard military explosives may be considered to have a high degree of stability at temperatures from –10 to +35 °C, but each has a high temperature at which its rate of decomposition rapidly accelerates, and stability is reduced. As a rule of thumb, most explosives become dangerously unstable at temperatures above 70 °C.

Exposure to sunlight:
When exposed to the ultraviolet rays of sunlight, many explosive compounds containing nitrogen groups rapidly decompose, affecting their stability.

Electrical discharge:
Electrostatic or spark sensitivity to initiation is common in a number of explosives. Static or other electrical discharge may be sufficient to cause a reaction, even detonation, under some circumstances. As a result, safe handling of explosives and pyrotechnics usually requires proper electrical grounding of the operator.

Ensure correct packaging:
Correct temperature and humidity of storage environment.

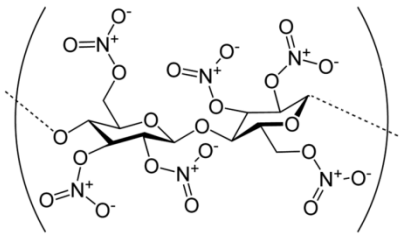
## 13 Topic 7: Basic explosive chemistry.

Black powder was one of the first explosives to be actively analysed from a chemical perspective. A mixture of potassium nitrate, charcoal, and sulphur, black powder undergoes a highly reactive combustion which produces large quantities of heat and gas in the process. The use of the charcoal, however, produces copious amounts of smoke in the process, making black power an inherently messy explosive. Smokeless powder quickly proved a safer, less messy alternative to black powder as an explosive.

| | | |
|---|---|---|
| 75% | 15% | 10% |
| Potassium Nitrate (Saltpeter) | Carbon (Charcoal) | Sulphur |
| $KNO_3$ | C | S |

Black Powder

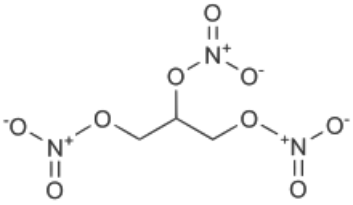
By the 1840s, two particularly promising smokeless chemicals were discovered: nitroglycerine and nitrocellulose.



Nitrocellulose

Colloquially called “guncotton,” nitrocellulose was first produced when cotton was treated with nitric acid in 1833. However, it was not until 1846 that nitrocellulose was created by placing the cotton into a mixture of nitric acid and sulphuric acid. Nitrocellulose has a simple structure and is aptly named; the compound consists only of cellulose with nitro-groups attached via the oxygen in cellulose.
Nitrocellulose is considered to deflagrate rather than detonate.

Nitroglycerin's molecular make up allows it to exothermically decompose into gases without an external oxygen source; rather than deflagrating, nitroglycerine detonates. Unfortunately, the combustion of nitroglycerine has a very low activation energy barrier; which makes nitoglycerine susceptible to explosion upon physical contact and thus impractical for use in most contexts.

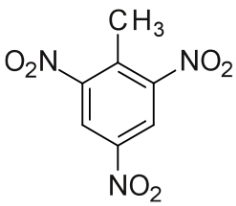


Nitroglycerine

By 1867, however, Alfred Nobel was able to calm the shock sensitivity of nitroglycerine to produce dynamite. While nitroglycerine may have been the first practical explosive stronger than black powder, dynamite was the first explosive that was also safe and manageable. The chemical marvel of dynamite lies not in its reaction (it is still nitroglycerine), but in its successful use of absorbents to stabilize nitroglycerine. Alfred Nobel found that liquid nitroglycerine is effectively absorbed by diatomaceous earth, a highly porous fossil product of diatoms. The absorption of the explosive into this new medium successfully diffused the sensitivity of nitroglycerine and made the production and transportation of dynamite much more practical than that of nitroglycerine. Due to dynamite's relative stability, it came to replace the use of pure nitroglycerine in high-order explosives.

Dynamite
*Image credit: Nobel Museum*

TNT exhibits several important differences from the nitroglycerine in dynamite. Unlike nitroglycerine, the detonation of TNT has an unusually high activation energy barrier. Its stability makes the transportation of TNT safe, with little chance of accidental detonation. This stability, however, also means that TNT is much more difficult to detonate. In fact, its insensitivity prevented it from being seriously considered for use as an explosive until the early twentieth century.



2,4,6-Trinitrotoluene (TNT)

TNT equivalent is a convention for expressing energy, typically used to describe the energy released in an explosion.

The relative effectiveness factor (RE factor), relates an explosive's demolition power to that of TNT, in units of the TNT equivalent/kg. The RE factor is the relative mass of TNT to which an explosive is equivalent: The greater the RE, the more powerful the explosive.

| Explosive | Velocity of Detonation m/s | RE Factor |
|---|---|---|
| Black Powder | 600 | 0.55 |
| ANFO | 5270 | 0.74 |
| TNT | 6900 | 1 |
| Nitrocellulose | 6400 | 1.10 |
| Dynamite | 7200 | 1.25 |
| C4 | 8040 | 1.34 |

The Atomic Bomb that was dropped on Nagasaki on 9th August 1945 contained the equivalent of 20 Kilotons of TNT and had a RE factor of 4500.

## 14 Topic 8: Shelf life.

The safe (storage) life, also called chemical shelf life, covers the period of time during which the explosive can safely be stored without representing any hazard to its environment. The safe life is limited by the extent of chemical ageing reactions. This is the “best before” or “use by” date.

The life-expiry (life-ex) date is the finite life of the explosive. For military in-service munitions the life-ex date that is to be added to the listing will most likely be that provided for that store, i.e. accepted number of years from date of manufacture. For commercial stores this will be that provided by the manufacture.

All dates are calculated from the date of manufacture and LOT number.

## 15 Topic 9: Effects of ageing, humidity and temperature.

Explosives are energy-rich substances capable of releasing their energy after initiation at a high rate. Like all other energetic substances, explosives are thermodynamically unstable. As a consequence, most explosives undergo slow chemical decomposition reactions at room temperature and even more at elevated temperatures.

This process involves numerous chemical decomposition mechanisms such as unimolecular decay (each molecule will breakdown into one or more different products) with the formation of free radicals (unpaired electrons) and consecutive radical reactions, oxidation and hydrolysis processes, and so on.

These decomposition reactions cause two major problems, namely.

Instability: The safety and functional features of the explosive change during ageing.

Thermal explosion: As the decomposition reactions are strongly exothermic, conditions may appear in which the rate of heat release becomes larger than the rate of heat loss to the surroundings, leading to a temperature rise up to self-ignition (thermal explosion).

Moisture is one factor that adversely affects factors affect the stability of explosives. The presence of moisture in explosives is undesirable because it reduces the sensitivity, strength and velocity of detonation.

Sensitivity

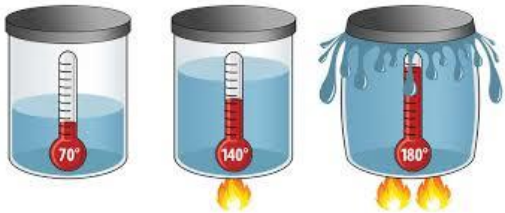
Strength

Velocity of detonation

Moisture affects the explosive adversely by acting as an inert material that absorbs the heat when vaporised. When moisture content evaporates during detonation, it reduces the temperature of the reaction.

The effects of high temperatures on explosives can be divided into the physical and chemical effects, however, in some cases, these combine to produce an overall effect.

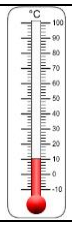
Physical Effects:
In the explosives, the physical effect of abnormally high temperatures is that a high level of stress occurs between components. The stresses are caused by the different expansion rates of the individual materials used in manufacture of the components, e.g. different metals, alloys, rubbers and plastics all have different expansion rates.




Chemical effects:
Explosive Compositions - The chemical effects may be direct, where the explosive compositions deteriorate and reduced performance becomes apparent, or indirect, where the deterioration leads to the production of gases that cause a propellant motor to crack. Melting and uncontrolled cooling of TNT mixes may result in TNT “needles” which can detonate when broken.

Chemical deterioration has a profound effect on the shelf-life of many explosives, but especially on propellants.

As a guide for prolonged periods of storage, the rate of chemical deterioration is approximately doubled for every 10°C rise in temperature above 30°C.

| | | |
|---|---|---|
| 2x |  | 30° C |

## 16 Module 3: Regulation and legislation.

## 17 Topic 2: Explosive signage

Signs used on buildings containing explosives

HD 1

HD 2

HD 3

HD 4

These signs represent that a quantity of that HD is present in that location, not the overall hazard, when HD 5 & 6 are present HD 1 sign will be displayed.

If explosives are present, then no attempt is to be made to fight the fire.

Supplementary signs which are displayed in storage areas

Radiological hazard

Breathing apparatus to be worn

Protective clothing to be worn

No water to be used

## 18 Topic 4: The term ALARP and the use of risk assessments

"ALARP" is short for "as low as reasonably practicable". "SFAIRP" is short for "so far as is reasonably practicable".

The two terms mean essentially the same thing and at their core is the concept of "reasonably practicable";

This involves weighing a risk against the trouble, time and money needed to control it.

Thus, ALARP describes the level to which the HSE expect to see workplace risks controlled.

What is meant by reasonably practicable?

Edwards v. National Coal Board was an important case in English case law. The 1949 case revolved around whether it was "reasonably practicable" to prevent even the smallest possibility of a rock fall in a coal mine.

Mr Edwards died in an accident after the supporting structure for the mine roadway gave way. The National Coal Board argued that it was too expensive to shore up every roadway in all of the mines.

The definition set out by the Court of Appeal (in its judgment in Edwards v. National Coal Board, [1949] 1 All ER 743) is:

"'Reasonably practicable' is a narrower term than 'physically possible' … a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them."

In essence, making sure a risk has been reduced ALARP is about weighing the risk against the sacrifice needed to further reduce it.

The decision is weighted in favour of health and safety because the presumption is that the duty-holder should implement the risk reduction measure. To avoid having to make this sacrifice, the duty-holder must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. Extreme examples might be:

- To spend £1m to prevent five staff suffering bruised knees is obviously grossly disproportionate; but

- To spend £1m to prevent a major explosion capable of killing 150 people is obviously proportionate.

Of course, in reality many decisions about risk and the controls that achieve ALARP are not so obvious. Factors come into play such as ongoing costs set against remote chances of one-off events, or daily expense and supervision time required to ensure that, for example, employees wear ear defenders set against a chance of developing hearing loss at some time in the future. It requires judgment. There is no simple formula for computing what is ALARP.

Hazard or risk?

A hazard is something (e.g. an object, a property of a substance, a phenomenon or an activity) that can cause adverse effects. For example:

- Water on a staircase is a hazard, because you could slip on it, fall and hurt yourself.
- Loud noise is a hazard because it can cause hearing loss.
- Breathing in asbestos dust is a hazard because it can cause cancer.

Definition of a risk

A risk is the likelihood that a hazard will actually cause its adverse effects, together with a measure of the effect. It is a two-part concept and you have to have both parts to make sense of it.

Likelihoods can be expressed as probabilities (e.g. “one in a thousand”), frequencies (e.g. “1000 cases per year”) or in a qualitative way (e.g. “negligible”, “significant”, etc.). The effect can be described in many different ways.

For example:

- The annual risk of a worker in Great Britain experiencing a fatal accident [effect] at work [hazard] is less than one in 100,000 [likelihood];

- About 1500 workers each year [likelihood] in Great Britain suffer a non-fatal major injury [effect] from contact with moving machinery [hazard];

Or
The lifetime risk of an employee developing asthma [effect] from exposure to substance X [hazard] is significant [likelihood].

Safe Systems of Work (SSOW) are known by various names e.g. working procedures (WPs), standard operating procedures (SOPs), method statements etc.

They are all variations of the same theme which is to accurately document how you consider the work of the company should be done by your employees, particularly with regard to hazardous work processes.

Simply put, they are the detailed instructions given to employees to enable them to work safely.

As an employer you are required by law to implement SSOW.

These are developed by a process of firstly recognising the significant hazards which are applicable to your workplace, then subjecting each hazard to a risk assessment process The result of the risk assessment process is the detail used to develop a safe system of work.

## 19 Topic 6: OME Security.

The HSE have published Security Provisions, this is guidance on what is required to comply with Explosive Regulations.

Security is required because;

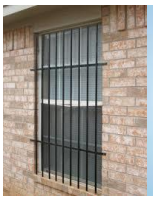
Explosives have the potential to be misused and that misuse can cause both harm to people, the damage or destruction of property and infrastructure, and disruption to wider daily life.

In addition, inadequate controls can result in unauthorised people having access to places where explosives are manufactured, stored, kept or used which can increase the likelihood of a fire or explosion occurring through inappropriate actions or behaviours.

Robust security controls need to be in place before explosive operations start and they should remain in place and be effective for as long as the operations continue.

Areas which need consideration are:

- Effective access control;
- Use of correct fencing & gates;
- Type and position of Lighting;
- Effective key security;
- Use of Intruder Detection Systems (IDS);
- Use of Closed-Circuit Television (CCTV);



- Building construction including:
    - Windows
    - Grills, Bars
    - Glass bricks
    - Floors
    - Roofs
    - Doors, frames and hinges
    - Door locks and bolts
    - Ventilation

- Small arm stores have additional security conditions applied.

## 20 Module 4: Explosives Safety.

### 21 Topic 1: Safety Management System

A Safety Management System (SMS) is a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures.

HSE define safety management systems as:

A formal management system or framework can help you manage health and safety

Examples include national and international standards such as:

BS OHSAS 18001:2007 Occupational health and safety management systems

BS EN ISO 9001:2008 Quality management system

In-house standards, procedures or codes sector-specific frameworks such as the:

Energy Institute's High-level framework for process safety management

Chemical Industries Association's Responsible Care framework

Although the language and methodology vary, the key actions can usually be traced back to Plan, Do, Check, Act.

Plan – Determine the Policy/ Plan for implementation.
Do – Profile risk, implement your plan.
Check – Measure performance (monitor before, investigate after)
Act – Review performance/Act on lessons learnt.

QinetiQ policies and procedures are on the Operating Framework.

Contractor control is an example of a SMS.

Contractor Control is important because:

For contractors to understand the risk they will be exposed to.

For us to understand the risk contractors pose to the explosives and us.

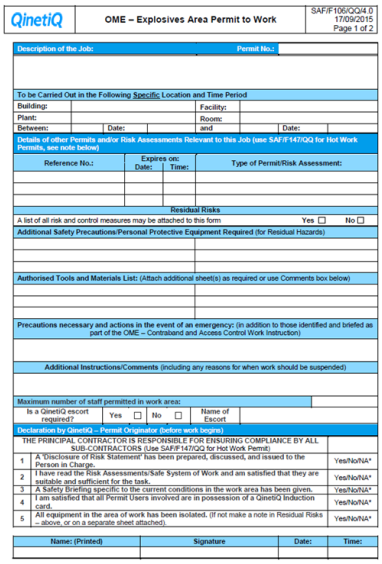
To reduce the potential for any incidents.

To comply with QinetiQ Operating Framework and ER 2014

We need to know:

- Location of work.
- Type of work.
- Duration of work.
- Number of personnel.
- Tools and equipment required.

As this is a legal requirement, we will issue a Permit to Work, full details on the operating framework.



QinetiQ | OME – Explosives Area Permit to Work | SAF/F105/QQ/4.0 17/09/2015 Page 1 of 2

**Description of the Job:** **Permit No.:**

**To be Carried Out in the Following Specific Location and Time Period**

| | | | |
|---|---|---|---|
| Building: | | Facility: | |
| Plant: | | Room: | |
| Between: | Date: | and | Date: |

**Details of other Permits and/or Risk Assessments Relevant to this Job (use SAF/F147/QQ for Hot Work Permits, see note below)**

| Reference No.: | Expires on: Date: | Time: | Type of Permit/Risk Assessment: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**Residual Risks**

A list of all risk and control measures may be attached to this form Yes ☐ No ☐

**Additional Safety Precautions/Personal Protective Equipment Required** (for Residual Hazards)

**Authorised Tools and Materials List:** (Attach additional sheet(s) as required or use Comments box below)

**Precautions necessary and actions in the event of an emergency:** (in addition to those identified and briefed as part of the OME – Contraband and Access Control Work Instruction)

**Additional Instructions/Comments** (including any reasons for when work should be suspended)

**Maximum number of staff permitted in work area:**

| Is a QinetiQ escort required? | Yes ☐ | No ☐ | Name of Escort |
|---|---|---|---|

**Declaration by QinetiQ – Permit Originator (before work begins)**

THE PRIBCIPAL CONTRACTOR IS RESPONSIBLE FOR ENSURING COMPLIANCE BY ALL SUB-CONTRACTORS (Use SAF/F147/QQ for Hot Work Permit)

| | | |
|---|---|---|
| 1 | A 'Disclosure of Risk Statement' has been prepared, discussed, and issued to the Person in Charge. | Yes/No/NA* |
| 2 | I have read the Risk Assessments/Safe System of Work and am satisfied that they are suitable and sufficient for the task. | Yes/No/NA* |
| 3 | A Safety Briefing specific to the current conditions in the work area has been given. | Yes/No/NA* |
| 4 | I am satisfied that all Permit Users involved are in possession of a QinetiQ Induction card. | Yes/No/NA* |
| 5 | All equipment in the area of work has been isolated. (If not make a note in Residual Risks – above, or on a separate sheet attached). | Yes/No/NA* |

| Name: (Printed) | Signature | Date: | Time: |
|---|---|---|---|
| | | | |

## 22 Topic 3: Risk Assessment.

In practical terms, a risk assessment is a thorough look at your workplace and tasks to identify those things, situations, processes, activities, etc that may cause harm, particularly to people.

After identification is made, an evaluation of the likelihood and severity of the risk is made, and then decide what measures should be in place to effectively prevent or control the harm from happening.

It is important to document risk assessments so you can:

Identifying hazards - Finding out what could cause harm.

Assessing risks (if necessary) - Understanding the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening.

Controlling risks - Implementing the most effective control measure that is reasonably practicable in the circumstances.

Communicate risks and controls - Ensuring everyone who needs to know is consulted and briefed on risks and controls and their understanding is routinely tested.

Reviewing assessments and control measures - Ensuring risk assessments remain accurate and control measures are working as planned.

An Explosive Risk assessment identifies the approach to the risk assessment of explosives, and specifically the approach to addressing fire and explosion hazards (i.e. for the prevention, limiting spread, and the protection of people).

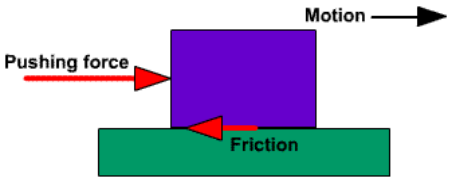
It specifically relates to explosive hazards; their identification, evaluation and assessment.

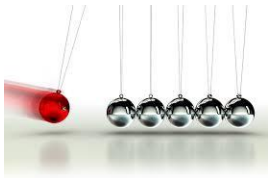
## 23 Topic 4: Explosive disposal safety constraints

When carrying out explosive disposal you should consider previous incidents which have shown there is a range of circumstances which can lead to premature, unwanted or unplanned events and explosions.

The common issues are:

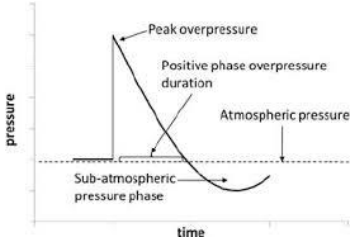
- Friction
- Impact
- Ignition by flame
- Ignition by heat
- Electrostatic discharge
- Inadequate procedures
- Inadequate supervision
- Poor maintenance
- Ignition of solvent vapour, dust or reaction by-product
- Inadequate removal of explosive material
- Lack of knowledge of presence of explosive material 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 process area

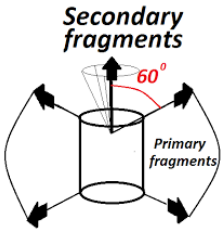




Hazard identification should consider:

- Shock or other effects derived from the brisance of explosives
- Blast overpressure
- The formation and propulsion from an event of primary and secondary fragments
- Projected burning brands
- Projected pyrotechnic effects
- Projected explosive sub-assemblies or complete pyrotechnic and/or explosive articles.





The following incidents have been taken from the HSE Guidance for the Safe Management of the Disposal of Explosives publication Jan 2007.

HSE
Health & Safety Executive

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.

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 the subsequent inspection.

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

## 24 Topic 6: Safety data sheets.

Safety Data Sheets (SDS) are required by the REACH Regulation.

*REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) is the system for controlling chemicals in Europe. It became law in the UK on the 1st June 2007. REACH adopted some of the older aspects of the chemicals system in Europe, including Safety Data Sheets (SDS).*

SDS are key documents in the safe supply, handling and use of chemicals. They should help to ensure that those who use chemicals in the workplace do so safely without risk of harm to users or the environment.

An SDS will contain the information necessary to allow employers to do a risk assessment as required by the Control of Substances Hazardous to Health Regulations (COSHH). The SDS itself is not an assessment. However, it will describe the hazards helping employers assess the probability of those hazards arising in the workplace.

The safety data sheet shall be dated and shall contain the following headings:
1. Identification of the substance/mixture and of the company/undertaking;
2. Hazards identification;
3. Composition/information on ingredients;
4. First-aid measures;
5. Fire-fighting measures;
6. Accidental release measures;
7. Handling and storage;
8. Exposure controls/personal protection;
9. Physical and chemical properties;
10. Stability and reactivity;
11. Toxicological information;
12. Ecological information;
13. Disposal considerations;
14. Transport information;
15. Regulatory information;
16. Other information.

## 25 Topic 7: iREP.

IRep (Incident Reporting) is an online incident reporting system that enable capture of consistent data across four different incident types:

1. Behaviour,
2. Hazard,
3. Near miss,
4. Injury.

IRep is linked from the Global Portal, to start click on “Submit”

Incident reporting enables:

- Prompt action to be taken,
- Reduces the chances of further incidents,
- Helps develop the Safe System of Work,
- Assists in monitoring policy,
- Assists in future decision making, planning and resources allocation,
- Accurate recoding of incidents ensures QinetiQ meets its statutory obligations and reporting requirements.

## 26 Topic 8: Difference between conventional fire and a fire involving explosives.

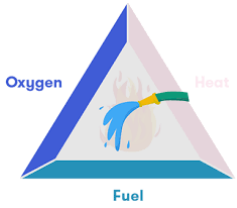
The Fire Triangle or Combustion Triangle is a simple model for understanding the necessary ingredients for most fires.

The triangle illustrates the three elements a fire needs to ignite:

Heat,
Fuel,
And an oxidizing agent (usually oxygen).

If we remove one of the elements the fire will be extinguished.

Normally to do this we use a fire extinguisher, for example, remove the HEAT with water.




Fires involving explosives are far more complicated.

DSEAR stands for the Dangerous Substances and Explosive Atmospheres Regulations 2002.

DSEAR puts duties on employers and the self-employed to protect people from these risks to their safety in the workplace, and to members of the public who may be put at risk by work activity

Because of the danger involved:

**WE DO NOT FIGHT FIRES INVOLVING EXPLOSIVES**

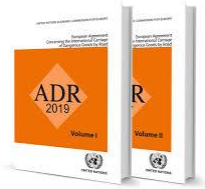
**27 Module 5: Processing, Storage and Transportation.**

**28 Topic 1: Secure storage and transport.**

OME security is covered in Module 3 Topic 6.

Transport of explosives is split into 3 main areas, covered by separate regulations:

| Road | Air | Sea |
|---|---|---|
| | | |
| ADR (Accord européen relatif au transport international des merchandises Dangerous par Route). | IATA (International Air Transport Association) | IMDG (International Maritime Dangerous Goods) |



These regulations classify some dangerous goods as High Consequence Dangerous Goods:

High consequence dangerous goods are those which have the potential for misuse in a terrorist event and which may, as a result, produce serious consequences such as mass casualties, mass destruction or, particularly for Class 7, mass socio-economic disruption.

There are restrictions regarding the transportation of High Consequence Dangerous Goods apply above certain threshold limits, for class 1 these are:

| Class | Division | Substance or article | Qty Packages (kg) |
|---|---|---|---|
| 1 | 1.1 | Explosives | 0 |
| | 1.2 | Explosives | 0 |
| | 1.3 | Compatibility Group C explosives | 0 |
| | 1.4 | Explosives of UN numbers, 0104, 0237, 0255, 0267, 0289, 0361, 0365, 0366, 0440, 0441, 0455, 0456 and 0500 | 0 |
| | 1.5 | Explosives | 0 |

Security of Dangerous goods is there to minimise the potential of:

Theft and misuse that might endanger persons, property and/or the environment.

**29 Topic 2: Safe storage.**

Certain factors are used to ensure safe storage of explosives, these are:

- Hazard Divisions and Compatibility Groups. (Module 1, Topic 3)
- Shelf life. (Module 2, Topic 8)
- Humidity and temperature. (Module 2, Topic 9)

Other factors are:

- Use of licensed storage facilities.
- Correct and safe stacking.
- Use of racking, dunnage.

- Lightning protection.
- Correct packaging/labelling.
- Good Housekeeping.
- Competent people.

## 30 Topic 3: Antistatic and conductive regimes.

There are three precaution regimes used to control the risks associated with static electricity.

ER2014 calls these:

- First degree
- Intermediate, and
- Second degree precautions.

Traditionally these were called:

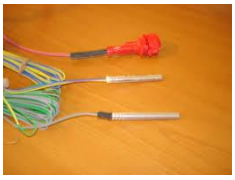
- Intermediate – Anitstatic
- Second degree – Conductive

These regimes relate to the electrostatic sensitiveness of the explosives involved.

The test used to determine this is called:

Energetic Materials Test and Assessment Policy (EMTAP)

And specifically Test 6 and 7 are used to find the minimum ignition energy for Electro Explosive Devices (EEDs.)



The precautions to be used are based upon the ignition energy as calculated by the EMTAP test shown in Millijoules (mJ)

| Electrostatic sensitiveness rating | Ignition energy | Regime required |
|---|---|---|
| Comparatively insensitive | > 450 mJ | First degree precautions |
| Sensitive | 1 mJ to 450 mJ | Intermediate precautions (antistatic) |
| Very sensitive | < 1 mJ | Second degree precautions (conducting) |

The following are covered under regimes:

Flooring
Flooring must have a resistance to suit the regime.
Antistatic = 50 kΩ (kilo Ohm) and 2 MΩ (Mega Ohm)
Conductive = < 50 kΩ

Humidity
The relative humidity must not be less than:
Antistatic = 40%
Conductive = 65%

Work Equipment
Benches – 500 mm from external walls
Chairs – covered with conductive material
Racking – 500 mm from external walls
Structural metalwork – Connected to earthing system
Wrist or leg straps – to BS EN standards

Clothing
Antistatic
No clothing liable to generate a static charge
No gloves – unless identified in Risk Assessment.
Antistatic footwear
Conductive
No external clothing liable to generate electrostatic charge.
Conductive footwear

There are rules regarding the testing of:

- Personnel – Use of Hazardous Area Personnel Meter (HAPTM) in all buildings with conductive regime.
- Flooring – Tested to ESTC standard 6

Full details are in SAF/INS/0170, OME – EMC, Static and Lightning on the Operating Framework.

**31 Topic 4: Storing sensitive substances.**

Special arrangements need to be made for the storage of explosives which cannot be classified, for example:

- New explosives for which no explosive hazard data sheet has been completed.
- Deteriorated explosives
- Experimental explosives
- Explosives with doubts about their safety or stability.
- Explosives in damaged packages.

Arrangements to be decided on by Head of Site, but may include:

- Reduced explosive limits
- Reduced man limits
- Segregation
- Isolation

Typical stores which may require segregation or isolation are:

- Unserviceable store that are suspected of being unsafe.
- Salvaged stores recovered after a trial, explosion, fire or accident.
- Stores that have failed to function and are unsafe for use, but not unsafe for storage.
- Explosives recovered during EOD operations
- Upon instruction form MoD PT or supplier
- Experimental explosives.

## 32 Topic 5: Monitoring and maintaining storage conditions

It is the responsibility of the site management to ensure inspection and maintenance checks are carried out at the required frequency.

Failure to keep buildings up to the required standard will endanger not only the explosives but personnel, furthermore, the failure to maintain buildings to the correct standard will ultimately lead to the withdrawal of the explosive licence for that facility and potentially for the whole site or even Company.

### 32.1 OME Checklist for Potential Explosion Site (PES)

There is an OME Checklist for Potential Explosion Site (PES) on the Operating Framework which indicates the typical areas for inspection.

QINETIQ

OME Checklist – Potential Explosion Site (PES)

| | |
|---|---|
| Location: | Review No: |
| Department: | Reviewer's Name: |
| Review Date: | Reviewer's Signature: |

| Questions | Finding | | | Comments |
|---|---|---|---|---|
| **Part 1 – State of Repair Check – External** | | | | |
| Is the security fence damaged or otherwise compromised? | Yes | No | N/A | |
| Are the security lights damaged or corroded? | Yes | No | N/A | |
| Is the building structure damaged in any way? | Yes | No | N/A | |
| Is the external paint work damaged or corroded? | Yes | No | N/A | |
| Are any attachments and fittings damaged or corroded? | Yes | No | N/A | |
| Are roads/sidings free from damage/pitting, rubble, etc.? | Yes | No | N/A | |
| Has there been any general storm damage? | Yes | No | N/A | |
| Are designated areas / Safe Headings suitably demarcated? | Yes | No | N/A | |
| Are all PES and their immediate adjacent areas clean, tidy and free from wind-blown combustibles? | Yes | No | N/A | |
| **Part 2 – Dampness (Structural/Condensation)** | | | | |
| Have all buildings been checked externally for damp patches? | Yes | No | N/A | |
| Is the roof, especially the eaves, free from mould/fungus? | Yes | No | N/A | |
| Is there damage to fabric of building that allows ingress of water? | Yes | No | N/A | |
| **Part 3 – Lightning Protection Systems** | | | | |
| Is there any evidence of lightning strikes? | Yes | No | N/A | |
| Has the integrity of bonding - to the air terminals - to the ground terminals – to all doors when open or closed been checked? | Yes | No | N/A | |
| Is all internal bonding properly connected to benches, structures, earth points and electrical hoists? | Yes | No | N/A | |

### 32.2 OME – Potential Explosive Site (PES) Logbook

All records relating to the PES checks are normally retained by the site Facilities Management, however a summary of the inspections and maintenance status is recorded on the OME – Potential Explosive Site (PES) Log Book.

QINETIQ | OME - Potential Explosive Site (PES) Logbook | SAF/FRM/0062/1.0 Page 1 of 2

Site: Area/PES/Bldg No: Year:

| Ref No | Inspection Area | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Part 1 | State of Repair Check – External | | | | | | | | | | | | |
| Part 2 | Dampness (Structural/Condensation) | | | | | | | | | | | | |
| Part 3 | Lightning Protection System (LPS) | | | | | | | | | | | | |
| Part 4 | Traverses | | | | | | | | | | | | |
| Part 5 | Vegetation | | | | | | | | | | | | |
| Part 6 | Fire Fighting | | | | | | | | | | | | |
| Part 7 | Fire Appliances – External | | | | | | | | | | | | |
| Part 8 | Drains and Gutters | | | | | | | | | | | | |
| Part 9 | Doors | | | | | | | | | | | | |
| Part 10 | Locks and Labelling of Keys | | | | | | | | | | | | |
| Part 11 | Windows | | | | | | | | | | | | |
| Part 12 | State of Repair Check – Internal | | | | | | | | | | | | |
| Part 13 | Heating, Ventilation & Air Conditioning | | | | | | | | | | | | |
| Part 14 | Cleanliness | | | | | | | | | | | | |
| Part 15 | Electrical Bonding/Conducting/Anti-Static Floors | | | | | | | | | | | | |
| Part 16 | Explosives Contents | | | | | | | | | | | | |
| Part 17 | Sealing and Marking of Packages | | | | | | | | | | | | |
| Part 18 | Electrical Installations | | | | | | | | | | | | |
| Part 19 | Lifting Tackle | | | | | | | | | | | | |
| Part 20 | Fire Appliances – Internal | | | | | | | | | | | | |
| Part 21 | Fire Practices/Evacuation | | | | | | | | | | | | |
| Part 22 | Process Buildings | | | | | | | | | | | | |
| Part 23 | Designated Smoking Area | | | | | | | | | | | | |
| Part 24 | Empty Box Areas | | | | | | | | | | | | |
| Part 25 | Licenses and Posters | | | | | | | | | | | | |
| Part 26 | Outstanding Defects | | | | | | | | | | | | |
| Part 27 | Documentation | | | | | | | | | | | | |
| | Inspector's Initials<br>Date | | | | | | | | | | | | |
| | Site Explosives Manager 3monthly check | Sig<br>Name<br>Date | | | Sig<br>Name<br>Date | | | Sig<br>Name<br>Date | | | Sig<br>Name<br>Date | | |
| | Offsite / External Inspector or Auditor | Sig | | | | | | Name | | | Date | | |

Detailed instructions are on the Operating Framework in SAF/INS/0554, OME – Site Facilities Inspection and Upkeep.

## 33 Topic 6: Ammunition markings

Ammunition is marked according to the Defence Standard (DEF Stan) 00 – 810 Marking of Ammunition and Associated Packages.

The purpose of ammunition and packaging markings is:

- Identification and management purposes.
- Enable the correct nature and type of ammunition to be issued to the user.
- Enable the ammunition to be correctly identified by the user under all conditions of service.
- To provide sufficient information to enable the ammunition to be stored handled and transported correctly.
- To assist in the tracing of ammunition and aid investigation into ammunition incidents.

The principles to be observed are:

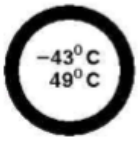
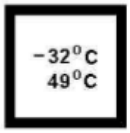
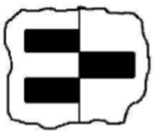
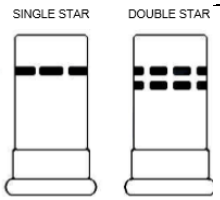
Clarity:
Markings necessary for item identification shall be made more prominent in size and position than those required for detailed identification.

Uniformity:
Uniformity in marking shall be maintained wherever practicable for groups of stores having similar characteristics.

Simplicity:
Complicated symbols and superimposed colours shall be avoided wherever possible

Position of Markings:
Shall be the same wherever possible.

Colour coding covered in Module 1 Topic 3, other markings which could be present.

| • Special Feature Marking | Symbol |
|---|---|
| NATO Design Mark.<br>Used for ammunition manufacture which satisfies NATO | |
| NATO Symbol of Interchangeability<br>Required only when store conforms in overall dimensions, performance and serviceability to a model approved under the provisions of NATO | |
| Parachute Symbol<br>To indicate presence of a parachute attached to an illuminating or signal device. | |
| Temperature limitation Symbol.<br>Safety limits for user e.g. firing.<br>Denotes critical temperature figures where restricted to a temperature range. |  |
| Temperature limitation Symbol.<br>For storage and transit.<br>Denotes critical temperature figures where restricted to a temperature range. |  |
| Tracer Symbol.<br>Indicates the presence of a tracer or tracer composition. | |
| Alignment symbol.<br>May be required when two sections of ammunition are to be joined. |  |
| Broken Coloured Bands.<br>Bands denoting coloured effects<br>For certain signal cartridges. When two coloured bands are used the upper shall indicate the colour of the star which appears first. |  |
| Centre of gravity Symbol.<br>To facilitate lifting operations | |

Examples of approved abbreviations.

| Term | Abbreviation |
|---|---|
| Acquisition | ACQN |
| Aluminium Powder | AL |
| Anti-riot | AR |
| Anti-personnel | APERS |
| Armour-piercing | AP |
| Bandolier | BDR |
| Calibre | CAL |
| Charge | CHGE |
| High Explosive Dual Purpose | HEDP |
| Torpex | TX |
| Target Practice | TP |

**34 Topic 7: Lotting and batching.**

Lotting and batching discrete quantities of ammunition.

It is applied in the following order:

- Manufacturer's Monogram, (Maker) in this case the letters RG.

*RG stand for Radway Green, part of BAE Systems Global Combat Systems.*

- The date of filling – 15/3/85 (*used to calculate the Shelf Life of the explosives)*
- Lastly the Lot/Batch number – 011. *(Underline denotes it is a lot number)*

*This ammunition was made by FNB = Fabrique National Beligue*

All together this is known as the Batch Identity – BI or also as BKI – Batch Key Identity

## 35 Topic 8: Bans and constraints

Ordnance, Munitions and Explosive (OME) are designed and constructed so as to be safe and without risks to health to the user and others who are not the intended target of their effects.

There is legal requirement for the Duty Holders to ensure the timely dissemination of information regarding munitions controls and limitations for use by munition technical personnel and ultimately the end user.

This safety information will be published within the Joint Service Munitions Control Register (JSMCR).

Controls and limitations that affect handling and use of munitions are defined as follows:

Ban. A Ban is a temporary or permanent instruction ordering the immediate prohibition of use of a munition, which may also extend to the processing, transportation, carriage (e.g. in/on platforms) or disposal of that munition

When notified of a munition ban the following action is to be taken:

(1) Stop affected stock that has been issued for training or operations from being fired. This action should be pursued with the utmost urgency.

(2) The banned munition is to be segregated and containers clearly marked with the following information:
(a) "NOT FOR ISSUE OR USE". (b) The ban serial number. (c) Any special instructions.

(3) The unit accounting officer is to maintain a Bans Register. When a ban has been lifted the register is to be annotated with the ban serial number and the date lifted.

Constraint. A Constraint is the imposition of a specific limitation or restriction within the whole life of the munition

Constraints normally remain in force for the life of ammunition.

Constraints are normally printed on ammunition issue vouchers.

Advice is to be obtained from the unit's Ammunition Technical Adviser if it appears that a constraint may apply to the planned use, movement or storage of any explosive or ammunition held by a unit.

Examples of constraints include:

- Changes to storage temperatures.
- Special handling instructions.
- Item for training use only.
- Change of Life parameters

## 36 Topic 9: Transport Policy

QinetiQ policy on the transport of explosives, SAF/INS/0189, OME-Transport.

Key requirements

Explosives shall not be transported or shipped beyond the boundary of a site until classified in accordance with ADR.

Once classified explosives shall not be transported off-site unless they are:

- Packed in an approved manner
- In an approved package
- Properly marked and labelled
- Carried on a suitable vehicle
- The receiving site has the relevant regulatory approvals
- There is an appropriate OME-Secure Transport Plan in place.

Consignor has the responsibility to ensure dangerous goods shall be packed in good quality packaging which shall be strong enough to withstand the shock and loadings during normal carriage.

Class 1 packages shall be so designed that:

- They will protect the explosives, prevent them from escaping and cause no increase in the risk of unintended initiation.
- The complete package can be handled safely, and
- Be able to withstand any foreseeable loading due to stacking.

All packaging for Class 1 is to comply with the general provisions as detailed in ADR Chapter 4.1 and the Special packing provisions 4.1.5.

Dangerous goods must be packed in UN approved packages.
These can be identified by the UN package marking, a U and an N in a circle.

Consignor has to mark the packages with:

- The UN number preceded by the letters UN.
- The Proper Shipping Name.
- And the Primary Hazard Label, this is to be positioned near the Proper Shipping Name.

Placards are to be affixed to both sides and the rear of the vehicle. Except HD1.4S. Orange plates are displayed front and rear.

Containers then placards are required to be affixed to all four sides, again except HD 1.4S.

Explain that the most dangerous division placard is to be displayed, the order of danger is:
1.1 – 1.5 – 1.2 – 1.3 – 1.6 – 1.4

Compatibility groups shall not be indicated on placards if more than one compatibility group is transported.

The carrier is responsible for selecting correct vehicle type.

The two types of vehicles are EXII and EXIII. These vehicles must have an annual technical inspection to ensure they comply with the requirements of the ADR regulations. They will be issued with a Certificate of Approval which must be carried on the vehicle.

## 37 Topic 10: Certifying Free From Explosives

QinetiQ policy on Certifying Free From Explosives, SAF/INS/0165, OME-Certifying Free From Explosives.

FFE – Free From Explosives, explain the definition but also this means it is TOTALLY SAFE and that NO HAZARD exists, including chemical.

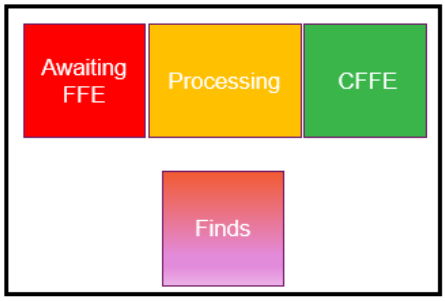
FFEH – This means there is still some chemical residue present, but it does not pose and explosive hazard.

CFFE and CFFEH – if you carry out the FFE process formally then you will issue a certificate to prove the items is FFE or FFEH.

CFFE/CFFEH is an explosive process to be carried out in a LICENSED AREA, also this area is to be identified as CFFE ONLY.

Key Requirements that the process is to have separate areas for:

- Packages awaiting CFFE
- Processing the packages
- The isolation of any live articles found
- Packages that have been CFFE' d




DETAILED WORK INSTRUCTIONS/PROCEDURES AND RISK ASSESSMENT ARE TO BE PREPARED FOR EACH SEPARATE TASK AND SUPERVISED TO ENSURE THEY ARE FOLLOWED.

Key requirement is that all packages are inspected, and a thorough examination carried out to ensure that they are free from explosives, this is to include the removal of all internal packaging and fitments.

If after inspection it can be stated with CERTAINTY that the package is FFE then a certificate is to be issued by a competent individual.

Discuss that EVERY package is to have the following removed or obliterated

- UN Number, Proper Shipping Name, Hazard Label.

Once packages have been CFFE'd then they must be SEALED or ISOLATED in such a way that there is NO POSSIBILITY of any article or package finding its way into the CFFE'd area.

**38 Topic 11: Authenticity sealing**

Authenticity sealing is method where a seal is applied which will show if tampering has taken place.

Authenticity sealing will not stop anyone opening box.

Various methods, security seals, plastic tie wraps, lead seals.

What if seal is broken?

If you did it, that fine, if authorised fit new seal and tell supervisor.

If you found it broken, inform supervisor.

Box contents will need to be verified.

**39 Module 7: Buildings and facilities**

**40 Topic 1: ESD, PES and explosive licence.**

Electrostatic discharge (ESD) is the sudden flow of electricity between two electrically charged objects caused by contact, an electrical short, or dielectric breakdown. A build-up of static electricity can be caused by tribocharging or by electrostatic induction.

Tribocharging is a contact electrification process that enables build-up of static electricity due to touching or rubbing of surfaces in specific combinations of two dissimilar materials.

Potential explosive site, any area where explosives could be stored, examples are:

- Buildings
- ISO containers
- Overnight parking areas
- Marshalling yards

ER 2014 require that every site is licensed to store and process explosives, our sites comply with this, for example this site (define site) has an explosive licence issued by the HSE.

There is only one explosive licence, each area is defined by its own schedule.

Each Potential Explosion Area or PES has its own schedule

Copy of the HSE schedule for building N6 in the New Mag Area of Shoeburyness.

HSE

Health and Safety Executive

XI/4111/807/2

**EXPLOSIVES SITE LICENCE**
**BUILDING SCHEDULE**

| Distinguishing number, letter or name of building, room or place on plan to Licence | NEW MAGS AREA N6 |
|---|---|

| **Construction of building, mound or work** | |
|---|---|
| Walls: | 355mm Block Construction |
| Roof: | 150mm Reinforced Concrete |
| Floor: | Concrete (dressed) |
| Internal Surfaces: | Painted or otherwise finished so as to present a smooth grit free surface |
| Mounds: | Mounded natural angle of rest |

| **Permitted use of building** | |
|---|---|
| Use of building, room or place or process to be carried on therein. | Explosives allowed or ingredients or articles liable to spontaneous ignition, or inflammable or otherwise dangerous, and the limitation of the quantity to be in each building, room or place. |
| ROOM R2 STORAGE | Explosives of Hazard Types 1, 2, 3 and 4 as required for this application, in all.....150kg<br><br>Provided that :-<br>i) if no explosives of Hazard Type 2 having a net mass of explosives per item >0.7kg are present, this quantity may be increased to, in all.....200kg<br>ii) if no explosives of Hazard Type 1 or 2 having a net mass of explosives per item >0.7kg are present, this quantity may be increased to, in all.....1000kg<br>iii) if no explosives of Hazard Types 1 or 2 are present this quanity may be increased to, in all.....5000kg<br>iv) if no explosive of Hazard Types 1, 2 or 3 are present this quantity may be increased to, in all .....15000kg |
| ROOMS R1 & R3 LOBBY<br>ROOM 4 PLANT ROOM<br>ROOM 5 NON HAZARDOUS STORE | No explosives permitted, materials used in relation to Room 2. |

Outside buildings and works distances

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| to Class A: | 46 | Metres | to Class B: | 69 | metres | to Class C: | 139 | metres |
| to Class D: | 156 | Metres | to Class E: | 156 | metres | | | |

You can see this information is printed in the box on the top right-hand side.

Just above this box is a number XI/4111/807/2, this is the licence number, there is generally only ONE licence per site, but larger sites might have more if the areas are separated by sufficient distance.

The next box shows the building construction detail.

Then we come to the permitted use of the building, in this case it is storage in room 2, it also details the use of rooms 1, 3 to 5, the schedule will cover all separate rooms etc.

When you look to the right-hand column you can see text which details the maximum amount of explosives which can be stored, this varies depended upon the Hazard Type, but is we look at the top statement it allows for up to 150 kg of HT 1-4.

The bottom of the schedule shows outside building and works distances – note on newer schedules this has been changed to – distances to protected places.

The classes on the schedule are as follows

Outside buildings and works distances:

- Class A – Footpaths, Bridleways, Waterways used by >20 people and roads >20 ≥500 cars per 24-hour period.

- Class B – Docks, Jetties, Piers, Railway lines, Reservoirs, River walls, Runways and Roads >500 ≥10,000 cars per 24 hours.

- Class C – Place of Public resort. >100 persons and Roads >10000 cars per 24 hours

- Class D - Used for buildings normally occupied, including: Dwellings, Shops, Churches, Colleges, Schools, Hospitals, Theatres and other buildings where public assemble.

- Class E - Used for vulnerable buildings, buildings or structures that are particularly vulnerable to blast effects, these are defined as;
Buildings of more than 3 storeys above ground or 12m in height constructed of glazed or frangible panels.
Any structure that subject to an event such as an explosion may be susceptible to disproportionate damage such as progressive collapse.

New PES schedules have the following extra distances, under the heading

Distances to protected places:

• Class F - Used for buildings within the explosive site other than:
Buildings occupied by persons other than licensee – Class D.
Vulnerable buildings – Class E.
Buildings normally occupied by more than 20 persons.
Buildings used for the bulk storage of dangerous goods.

•Class G - Used for buildings within the explosive site that are used for the storage of explosives:
Also known as Magazine to Magazine distance.

•Class H - Used for buildings within the explosive site that are used for the manufacture or processing of explosives.
Also known as Process Building Distance

Topic 1 B: Explain the purpose of an explosive licence and its contents.

ER 2014 require that every site is licensed to store and process explosives, our sites comply with this, for example this site (define site) has an explosive licence issued by the HSE.

There is only one explosive licence, each area is defined by its own schedule.

New PES schedules have the following extra distances, under the heading

Distances to protected places:

• Class F - Used for buildings within the explosive site other than:
Buildings occupied by persons other than licensee – Class D.
Vulnerable buildings – Class E.
Buildings normally occupied by more than 20 persons.
Buildings used for the bulk storage of dangerous goods.

•Class G - Used for buildings within the explosive site that are used for the storage of explosives:
Also known as Magazine to Magazine distance.

•Class H - Used for buildings within the explosive site that are used for the manufacture or processing of explosives.
Also known as Process Building Distance

The distances shown are those which are to be maintained to allow the storage of quantities as shown, they do not represent the distance of these from the building.
N6 Building Schedule.

| Class | Distance |
|---|---|
| A | 46 |
| B | 69 |
| C | 139 |
| D | 156 |
| E | 156 |

These are represented by coloured lines on the Safeguarding Map
- Green - Class B
- Yellow – Class D
- Purple Class E

Safeguarding Map for ETC

Copy with site ammunition team, on local server, with local planning authority and HSE.

HSE and MOD terminology is:
Green Class B – PTRD, Public Traffic Route Distance
Yellow Class D – IBD, Inhabited Building Distance
Purple Class E – VBD, Vulnerable Building Distance

## 41 Topic 2: Contraband controls.

Control of equipment used in explosive areas is important to ensure the equipment does not pose a risk to the explosives. These controls also apply to vehicles, including vehicle trackers.

Full details are in SAF/0168, OME – Contraband and Access Control.

Certain articles are prohibited and called contraband and are not permitted into an explosive area without the authorisation of the Head of Site.

Prohibited items are:

- Alcoholic liquor.
- Metal shod footwear.
- Magnetic therapy products, e.g. copper bracelets, spot magnets.
- Privately owned vehicles.
- Tobacco in any form and any article used for the purpose of smoking or carrying tobacco.
- Lanterns, oil lamps, fire or flame producing appliances.
- Petrol operated vehicles or equipment.
- Unauthorised tools, equipment or general stores.
- Cameras.
- Medicines.
- Matches, lighters or any other means of producing a spark or flame.
- Battery powered equipment and mains powered appliances.
- Firearms.
- Food or Drink
- Medical aids.
- Spark or heat producing items
- Radio Frequency (RF) transmitters (Mobile phones, iWatch etc.)

All personnel, including visitors are to deposit any prohibited article at the secure location before entry into the explosives area.

All personnel in or visiting an explosive facility may, if they consent, be subject to a thorough search at the entrance before entering and when leaving, or at any time whilst they are in the explosives area.

Anyone unwilling to consent to be searched in not to be admitted to the explosive's facility.

Any person who finds they are in possession of a contraband article inside the explosives are shall inform their supervisor immediately.

In the interests of safety, anyone who declares they have inadvertently taken contraband articles inside the explosives area must not be penalised.

## 42 Topic 4: Earthing and lightning protection

Information about earthing and lightning protection on the Operating framework SAF/0170, OME – Static, EMC and Lightning.

Any item which is connected to the equipotential earthing system is not to be used for explosive storage outside the working day.

This removes the possibility of electrical currents through the explosives in the event of lightning during the night.

Items which may need to be connected to the equipotential bonding system are:

- Processing benches
- Chairs and containers
- Racking
- Structural metalwork

The function of a lightning protection system is to protect structures from fire or mechanical destruction and to prevent that persons in buildings are injured or even killed. An overall lightning protection system consists of external lightning protection (lightning protection/earthing) and internal lightning protection (surge protection).

Lightning Protection System (LPS) to BS EN 62305

All structures and buildings used for explosive storage or processing shall have an internal lightning protection installation, which shall comprise of equipotential bonding.

## 43 Topic 5: Tool control and calibration

Tool control is a method to quickly determine that all tools are accounted for at the end of a maintenance task. This can only be done if each tool has a specific place where it is stored that allows quick identification if the tool is missing.

Calibration is checking the accuracy of a measurement instrument by comparing it to reference standards.

The result of equipment calibration is higher accuracy.

Electronic calibration is one of three main types of calibration methods used today.

Other types of modern calibration methods include mechanical and thermal calibration.

Electronic calibration deals with the calibration of electric and electronic instruments.

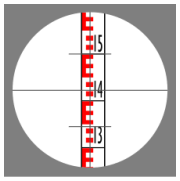
Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument.

Typically, the accuracy of the standard should be ten times the accuracy of the measuring device being tested.

However, accuracy ratio of 3:1 is acceptable by most standards organizations.

Calibration of your measuring instruments has two objectives.

It checks the accuracy of the instrument and it determines the traceability of the measurement.



In practice, calibration also includes repair of the device if it is out of calibration.

A report is provided by the calibration expert, which shows the error in measurements with the measuring device before and after the calibration.

## 44 Module 8: Environmental

### 45 Topic 1: Looking after the environment.

At QinetiQ we are committed to embedding an environmentally sustainable approach to business because we know it is important for our business, our customers, our employees and our communities. Our overall aim is to deliver continual improvement underpinned with a clear and focused strategy, instilled throughout our operations and implemented by an engaged and informed workforce. This policy applies to all QinetiQ businesses, employees, and facilities worldwide

### 46 Topic 2: Disposal of explosives and contaminated waste.

What is waste?

May seem simple, however there are strict rules regarding the transportation of wastes, so establishing if an explosive is waste is very important.

If you have used some explosives during disposal but have some left, is it waste?
No – this is still explosive and must be classified and transported as such.

If you cut a rocket motor on a bandsaw, is the swarf waste?
Again No – even though it is small it is still explosive and must be classified as such.

This is a complicated subject; however, all items must be classified correctly prior to transport. There is guidance on the HSE website, and a technical document called waste classification.

Contaminated waste will fall into two areas:
Free from Explosives, Free From Explosive Hazard.

Again, ensuring it is classified correctly is essential.

**47 Topic 3: Explosive disposal, environmental constraints.**

There are five main methods for the safe disposal or destruction of explosives:

- Functioning in the design mode
- Burning
- Detonation
- Dissolving or diluting by a solvent or
- Chemical destruction

Environmental Protection Act

The Environmental Protection Act 1990, a UK act of parliament relating to controlled wastes is the successor to the Control of Pollution Act 1974 and makes provision for the management of pollution from industrial processes.

This covers contamination of or by:

- Contamination of the land or water
- Smoke
- Fumes
- Noise

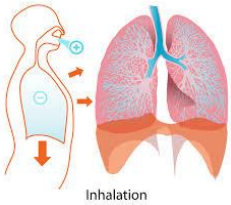
Also consider:

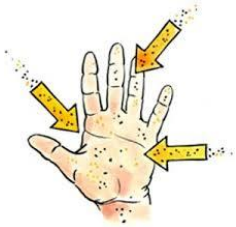
- Vibration
- Ground shock
- Light
- Heat

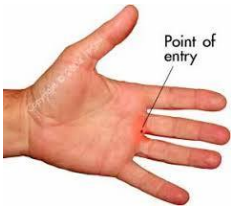
**48 Topic 4: Toxic routes**

There are four major routes of entry chemicals can follow:

- Inhalation (breathing)
- Absorption (skin contact)
- Ingestion (eating)
- Injection








The most common way workplace chemicals enter the body is by breathing.
Other chemicals can be absorbed through the skin into the bloodstream.

They can also be accidentally swallowed if hands or cigarettes are contaminated.

Contaminated cigarettes also pose an inhalation risk, which can be elevated since the cigarette is heating and/or vaporising the chemical contaminant.

Injection is another way that chemicals enter the body. Though less common in most workplaces, it can occur when a sharp object (e.g., a needle) punctures the skin and injects a chemical (or virus) into the bloodstream.

This can also occur when a chemical is sprayed at the body at high pressure

Chemicals can enter the environment via:

- Ground contamination
- Water contamination
- Air pollution
- Waste products