

# **European Federation of Explosives Engineers (EFEE)**

## **European Shotfiring Certificate**

### **Requirements for basic training**

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## **European Shotfiring Certificate.**

### **Training and qualification requirements with recommended key words for a manual**

The European Federation of Explosives Engineers EFEE has taken upon itself to prepare a document on the basic training requirements for a shotfirer acceptable for all member nations. The adopted document should then form a statement of the general level of competence required to obtain the EFEE Shotfirer Certificate and establish guidelines for future detailed training manuals.

For countries where blast designers, blast engineers etc. are necessary for formal reasons, EFEE recommends that the same requirements should apply.

While establishing the following requirements, EFEE appreciates that the European shotfirer will face a wide range of operations. Some of the aspects are:

- (i) - Blasting of concrete structures and/or a variety of other materials
  - Blasting in various rock conditions
  - Surface or underground blasting
  - Operating in remote or built-up areas
- (ii) - Different legislation in the various countries
  - Legal responsibilities
- (iii) - The shotfirer may be working within a well developed organisation with competent support and guidance or may be working independently
- (iv) - There are a number of special blasting operations that will need special expertise. These are yet not dealt with. (Some examples: demolition of tall structures, underwater blasting, lake taps, dimension stone industry etc.)

During the process of establishing this document, contributions from the member countries revealed fairly homogeneous thinking on key matters. For special demolition operations, the shotfirer may need additional information as to the actual material to be blasted whereas competence related to rock may be of lesser importance. To cover such requirements, it may be necessary to analyse needs for special certificates to cover special demolition activities.

EFEE appreciates that laws and regulations in the member countries are different. At this time EFEE sees no practical possibility of examining the various laws, regulations or the consequences of the legal position in the various member countries. This document is entirely and solely based on technical matters and accepted safe practice.

# Training Manual

To obtain a harmonised European standard with the aim of introducing equal practice and safety procedures in EFEE member countries, a detailed training manual shall be prepared. The manual shall cover information on all areas and aspects listed, indicate the number of lessons, the duration and format of training courses and a set of practical tests, and refer to useful textbooks.

## Recommended requirements for the shotfirer

### 1 Geology, blastability, drillability

#### a. Geology in general

The shotfirer must be familiar with the basic geology and materials to be blasted.

*Key words for the manual:*

- *Igneous, sedimentary and metamorphic rocks, intrusive rock*
- *Foliation, in situ fracturing, bedding, schistosity*
- *Shear zone, crushed zone, faults, cracks, fissures, weathering, strata.*

#### b. Minerals and composition of rock materials

It is vital to have a knowledge of the most common minerals of the country and/or area of operation. The requirement of basic competence regarding minerals or composition of materials depends on the working conditions. In some areas the composition of materials is quite static, whereas other areas are exposed to great variety. If the shotfirer shall be qualified to operate in wider areas he/she will need a basic understanding of rock types in these areas.

*Key words for the manual:*

- *Structure, texture*
- *Minerals like quartz, feldspar, mica, pyroxene, amphibol*
- *Types of igneous rock like granite, diorite, syenite*
- *Sedimentary rock like claystone, greyvacke, sandstone, chalk*
- *Metamorphic rock like marble, micashist, phyllite, gneiss, quartzite etc.*

#### c. Rock properties and their influence on drilling

Rock structure and properties can have a dominant influence on the drilling deviation, the penetration rate, the wear of drill-bits and the drilling capacity. It is therefore important to have a basic knowledge of the topics.

*Key words for the manual:*

- *Drilling at different angles to the strata.*
- *Hard minerals, soft minerals*
- *Methods of deviation measurement, etc.*
- *Measuring while drilling*

#### d. Rock properties and their influence on blastability

Through mapping of the rock structure and measurements of the rock properties much information is gained which can be used for judging the blastability. A basic knowledge is required to be able to select the proper drill pattern, explosives, charging method, direction of

throw and to judge back breakage, toe breakage, risks of flyrock, fragmentation distribution, quality of blast and so on. The European shotfirer will face a variety of rock qualities and materials and should have a basic training within the subject.

*Key words for the manual:*

- *Powder factor*
- *Explosives properties*
- *Rock density, seismic properties*
- *Layered rock, coarse-grained rock, fine-grained rock*
- *Brittle minerals, grain shape, tough minerals*
- *Fractures, faults, joints, fissures*

#### **e. Drilling methods and commonly used machinery.**

The shotfirer shall be familiar with the various drilling methods and the related machinery and equipment to the extent that he/she is able to inform the driller about preferences of drilling plan, depth, inclination of the holes and matters like health, environment and hazardous situations during drilling. (Operating the drilling rig may not be the shotfirer's duty.)

*Key words for the manual:*

- *Drill bits*
- *Drilling dust evacuation while drilling*
- *Inclination and depth measurements / instrumentation*
- *Hazardous situations while drilling, exposure to dust, etc.*

#### **f. Precise drilling and drill pattern.**

The shotfirer shall understand the importance of precise drilling, the position of the hole, the direction and the depth. Precise drilling is of paramount importance while doing demolition work, tunnelling and high bench quarrying. The shotfirer needs adequate knowledge of the mechanisms of breakage using borehole charges.

*Key words for the manual:*

- *Drill pattern (burden and spacing)*
- *Sub-grade drilling*
- *Accurate drilling, collaring, drilling records*

## **2. Explosives and initiation systems**

### **a. Explosives and main characteristics**

The shotfirer shall be familiar with the composition of commonly used explosives and their performance and handling characteristics. He/she should understand the differences of their sensitivity and transportation classification.

The organisational structure of a blasting operation varies in different countries. In some countries a separate blast designer/engineer will decide. In the majority of countries, however, the responsibility is left with the shotfirer, hence he/she must be trained. He/she must be able to choose the composition of explosives to be used, having in mind the characteristics of the rocks or other materials to be blasted. He/she should be able to plan the quantity and the energy of alternative qualities of explosives to be used for a well-charged drillhole. This ability will be of increasing importance and complexity due to the wide range of explosives

products in the European market. It is required that the shotfirer has knowledge of products and must know in which situation a particular product is the best choice.

*Key words for the manual:*

- *Black powder, NG-explosives, boosters, ANFO, slurries, emulsions*
- *Cartridges, tube charges, plastics, shaped charges*
- *Special charges*
- *Classifications*
- *Commonly used testing methods (e.g. "Fallhammer" test, friction test, air gap test, lead block test, CEN-standards, etc.)*
- *Common European trade names of explosives*
- *Characteristics like density, energy content, detonation velocity*
- *Water resistance, values from different tests (§ 2.0 a)*
- *Format, bulk or cartridges*
- *Toxic fumes*
- *Deterioration of explosives*
- *Sympathetic detonations*

#### **b. Safety aspects.**

The shotfirer must be competent within the practical use and the safety aspects of explosives and initiation systems to be used. He/she must be able to identify the risks and to assure the safety aspects related to the handling of explosives and equipment required for charging.

*Key words for the manual:*

- *Risk for drilling into explosives*
- *Risk for unplanned initiation of electric detonators due to:*
  - *Lightning*
  - *Static electricity (loading equipment),*
  - *Current leakage from electric installations like lamps - auxiliary equipment etc.,*
  - *High voltage transmission lines,*
  - *Electromagnetic risk (R.F. transmitters, etc.)*

#### **c. Be familiar with the limitations while using various qualities of explosives**

The shotfirer must have basic knowledge such as when to refrain from using ANFO (water), the limitations of detonating cord (in combination with emulsions), critical diameter etc.

*Key words for the manual :*

- *Influencing factors and possible failures of the detonation, like radial, axial initiation*
- *Water pockets in the charge*
- *Critical diameter*
- *Desensitisation due to dead pressing etc.*

#### **d. Accidental drilling**

The shotfirer must be familiar with the risks and dangers, with the emphasis on premature initiation due to accidental drilling into explosives and/or detonators, physical impact and fires. This is a key element of safety that should be covered by the training. The shotfirer must know all the important rules on safety including the handling of misfires.

*Key words for the manual :*

- *Never drill into a hole that may have been previously charged.*
- *Safe transport and handling of explosives at the site*

#### **e. Charging systems**

The shotfirer must be familiar with charging methods of the various explosives. He/she shall have knowledge of the characteristics of explosive and initiation systems: viscosity, resistance to water and the delay time to firing. All aspects relevant to manual charging must be covered as well as the use of mechanical charging equipment such as trucks for site sensitised explosives etc. Special training may be needed.

*Key words for the manual :*

- *Explosives or blasting agents*
- *Bulk or cartridges*
- *Loading hose or stemming rod*
- *Electric or non electric initiation systems*
- *Coupling with or without rubber mats cover*

#### **f. Differences in the various initiation systems**

The shotfirer must be familiar with the differences in the various initiation systems in respect of practical use and safety. The shotfirer must initially and at least be competent in using those systems commonly used in his/her area of operation.

*Key words for the manual:*

- *List of advantages and disadvantages*
- *Procedures for connecting detonators and practical use*
- *Delay numbers available*
- *Storage*
- *Risk of misfires, etc.*

#### **g. Connecting the charged holes and controls**

The shotfirer must be able to connect the charged holes, use electrical and non electrical initiation systems, handle matters like current leakage danger, know possible sources of deficiencies with non electric detonators and generally troubleshoot, as well having a basic knowledge of electronic detonators and exploders .

*Key words for the manual:*

- *How to do the practical connecting*
- *How to locate current leakage when coupling in series or parallel with electric detonators*
- *How to locate damage on a non electric initiation system, etc.*

#### **h. Verification and evaluation**

The shotfirer must be able to verify and evaluate the conditions for the shot. He/she must be able to control the risks of a premature initiation and be able to decide on actions in a case of lightning, thunderstorms, stray currents etc.

*Key words for the manual:*

- *Verify drill pattern*
- *Controls*

- *Observe and report deviation from plan*
- *Weather, lightning*
- *Postings, warning signals*

### **3 Surface Blasting**

#### **3.1 Rock blasting theory**

It is required that the shotfirer shall have basic knowledge of the rock-breaking process while blasting, such as fragmentation mechanisms, throw mechanism and wave transmission. The requirements further include basic knowledge of the theories, the ability to judge on the practical consequences of the blast, including when applied to concrete, wood or steel as the case may be.

*Key words for the manual:*

- *Explosives and density/energy*
- *Detonation velocity*
- *Shock and strain wave propagation*
- *Confinement*
- *Gas pressure, mass movement, critical burden, fly rock etc.*

#### **3.2 Charging and blasting**

##### **a. Suitable explosives and detonating systems for bench blasting**

The shotfirer must be able to determine the suitable explosives and detonating systems for bench blasting and trenching, evaluate the blastability of the rock and find the suitable charge. He/she must have the competence to choose the explosives and initiation systems to obtain a safe and economical blast, with good fragmentation.

*Key words for the manual:*

- *Cartridges or bulk explosives/blasting agent*
- *Charging density, powder factor*
- *Stemming*
- *Number of rows*
- *Delay intervals*
- *Initiation systems*

##### **b. Difficult rock and/or demolition conditions**

The shotfirer must be able to undertake the planning and the quality judgement of a blasting operation in difficult rock and/or demolition conditions, proximity to constructions, demand for contour blasting etc. Such operations require special attention. He/she must be supported by a competent specialist or a shotfirer with wide experience. The shotfirer, however, has an independent responsibility to detect the non-conformities of the blasting pattern, inadequacies of a plan and to decide when assistance must be obtained.

*Key words for the manual:*

- *Calculation of a suitable powder factor while blasting close to or under constructions*

- *Prediction of vibration*
- *Contour blasting*
- *Line drilling*

**c. Implementing a plan for drilling, charging and blasting**

The shotfirer must be able to implement a plan for drilling, charging and blasting and its details along with timing. He/she should be able to calculate the volume of rock to be blasted.

*Key words for the manual:*

- *Explain plans for the crew*
- *Calculate volume of solid rock*
- *Documentation*

**d. Determining the consumption of explosives**

The shotfirer must be able to determine the consumption of explosives for the individual holes and the entire round, expressed in kilos per round covering cartridges, bulk loaded explosives, blasting agents etc. The shotfirer shall have the knowledge to undertake a detailed calculation and to do the paperwork required by laws and regulations.

*Key words for the manual:*

- *Volume of the boreholes*
- *Explosive density and energy per volume unit in the boreholes*
- *Charging density*
- *Charging plans and reports*
- *Initiation plans*

**e. Difficult blasting**

The shotfirer must be able to modify the operation and adapt to the local situation when rock conditions and blastability etc. are changed. For operations of special difficulty the shotfirer is responsible for requesting assistance. (Owners, insurers and other bodies may add specific requirements to the contractor. Until informed, such requirements are beyond the responsibility of the shotfirer.)

*Key words for the manual:*

- *Road cuts and trenches*
- *Blasting in bedded and fractured rock, contour blasting*
- *Blasting through a fault in the rock massif*
- *Blasting through intrusive rock and weathered rock*

**f. Blasting close to existing structures**

The shotfirer must be able to compute the quantity of explosives per hole and per each detonating interval and also, as necessary, to divide the charge of a hole into different decks. He/she must be able to blast close to constructions, using electric or non-electric detonators etc. The shotfirer shall be able to compute quantities in detail, and also know how to connect and use several detonators in the same hole for decking operations.

*Key words for the manual:*

- *Distances to constructions*
- *Line drilling*
- *Decks with different initiation intervals*

- *Stemming between charges*
- *Blast direction*
- *Vibration, fly rock, blasting mats*

#### **g. Sensitive surroundings**

The shotfirer must be familiar with the problems related to vibration, air blast (blast wave), noise and dust while blasting close to or between constructions, in narrow streets etc. The shotfirer shall have a basic knowledge of vibrations due to blasting, how to reduce the peaks and also how to judge when special competence is needed

*Key words for the manual:*

- *Design charges to avoid damage from vibration and air blast*
- *Understand when special competence is needed*

#### **h. Fly rock, safety aspects**

The shotfirer must be familiar with the risks of fly rock, fly pieces, and with safe distance, methods and equipment to establish sufficient protection, control of powder factor and stemming, using blasting mats etc.

*Key words for the manual:*

- *Borehole diameter*
- *Energy per loaded metre of borehole related to burden*
- *Anchored blasting mats, sufficient stemming*

#### **i. Warning procedures.**

The shotfirer must be familiar with accepted warning procedures, sound and light signals and number of sentry locations. Blasting represents risks; the shotfirer must be able to evaluate if all the conditions of safety are assured before firing.

*Key words for the manual:*

- *Exclusion zones*
- *Safe distances*
- *Warning procedures*
- *Procedures in compliance with regulations*

#### **j. Dealing with misfires.**

The shotfirer must be aware of the risks of misfires and the methods for removing non-detonated explosives. The shotfirer must know methods of firing a misfired charge, drilling and blasting out a misfired charge, dealing with deteriorated explosives etc.

*Key words for the manual:*

- *Removal of stemming and explosives*
- *New initiation charge*
- *Second blast, safe distance while drilling*
- *Blasting mats covering*
- *Reporting the incident*

#### **k. Size of the charges and possible distance for flyrock/flying debris.**

The shotfirer must be familiar with the relationship between the size of the charges and possible distance for flyrock/flying debris (the bigger the borehole/charge diameter the bigger

the risk, the more densely occupied the area the greater the risks). He/she must have basic knowledge of and be able to evaluate risks. That includes the risks related to simple concrete blocks, stones, roots, trenches in soft ground, trees, ice, seismic operations, and the understanding of the relationship between the characteristics of the charges, the face geometry and the possible distance of flying debris.

*Key words for the manual:*

- *Examples from literature*
- *Case studies*

### **1. Cost estimation.**

The shotfirer should have a fair understanding of the cost components in a blasting operation. This will normally be a good basis for motivation and improved efficiency.

*Key words for the manual:*

- *Cost efficiency of the components of a blasting operation, such as explosives and drilling*

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