UK Pyrotechnics Society

Good Practice Guidance on the Manufacture of Experimental Pyrotechnic Compositions and Articles

AUTHORS

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APPROVALS

Date	Document Version	Approver Name and Title	Approver Signature

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I. Introduction

This guide describes good practice for the non-commercial manufacture of experimental pyrotechnic compositions and articles and identifies the authorisations that may be required under the provisions of the Explosives Regulations 2014 (ER2014). It also supports the overarching guidance on the safety and security provisions Explosives Regulations 2014 published by the HSE as L150 and L151 (see VI.Further reading).

It contains information that will primarily be of use to those people currently interested or involved in experimental manufacture of pyrotechnic articles outside of a licenced manufacturing facility. This guide will help individuals or likeminded groups to execute manufacturing activities safely, securely and within the legal requirements of ER (Explosive Regulations) 2014. Poor manufacturing practises can lead to situations in which individual experimenters, their neighbours and surrounding property are put at risk. A failure to follow good practice may also result in a person manufacturing pyrotechnic substances and articles inadvertently breaching legislation.

Whilst every effort has been made to cover appropriate legislation, regulations and good practice when this guide went to print, the authors, the UK Pyrotechnic Society nor its servants or agents can accept responsibility for, or liabilities incurred directly or indirectly as a result of any errors or omissions in this guide. Those involved in the pyrotechnics experimentation are responsible for taking their own legal and other advice as they see fit. Readers are strongly advised to check whether there is any change in legislation or regulation since the publication of this guide.

II. Aims

The aims of this document are to:

- provide guidance on the fundamental licensing and certification requirements underlying ER2014;
- identify the health and safety legislation associated with the non-commercial manufacture and storage of pyrotechnic compositions and articles.
- identify other guidance directly relevant to the scope of experimental activities involving pyrotechnic substances and articles.

The guidance focuses on the explosives hazards associated with experimental manufacture of pyrotechnic compositions and articles. It does not attempt to address health and safety issues that are common to other operations such as noise, manual handling, etc. as guidance to these issues is available in other publications.

III. Target Audience

This document has been produced for individuals and likeminded groups of hobbyists and other similar people who want to safely and lawfully manufacture experimental pyrotechnic compositions or articles.

It will also be of interest to scientific institutions, regulatory authorities and emergency services such as the Police and Fire Service, particularly where those authorities fulfil a regulatory role under the Explosives Regulations 2014 (ER 2014).

This guide is not intended as a technical document on the manufacture of pyrotechnic compositions nor the construction of pyrotechnic articles, therefore this guide assumes an appropriate competence and understanding of pyrotechnic theory and practice.

IV. Legislation

There are two main pieces of legislation to consider when pursuing the manufacture of experimental pyrotechnics compositions and articles. These are:

1. Explosives Regulations 2014
2. Control of Explosives Precursors Regulations 2014

IV.a Explosives Regulations 2014

The ER 2014 provides the legal framework for experimental manufacturing activities. Regulation 6(2)(a) of ER 2014 generally disapplies the requirement for a licence to manufacture explosives to:

> ***"The manufacture of explosives for the purpose of laboratory analysis, testing, demonstration or experimentation (but not for practical use or supply) where the total quantity of explosives being manufactured at any time does not exceed 100 grams, but nothing in this sub-paragraph shall be taken as authorising any acquisition or keeping of explosives for which an explosives certificate is required by virtue of regulation 5, without such a certificate."***

In effect regulation 6 (2) (a) means an individual or likeminded group who wish to manufacture experimental pyrotechnic compositions and articles without a licence must:

- manufacture no more than 100g of pyrotechnic compositions at any one time;
- only manufacture pyrotechnic articles containing 100g or less net mass of pyrotechnic substances ;
- **be in possession of an explosive certificate if the explosive being manufactured is not listed in the schedule 2 of ER 2014;**

in addition manufactured compositions or articles can **only** be used for laboratory analysis, testing, demonstration or experimental, purposes **and cannot be supplied to other people**.

It is recommended that an individual registers their intention to undertake experimental pyrotechnic manufacture with the UK Pyrotechnics Society. This will help them to demonstrate that the activities they are undertaking are being done for legitimate and lawful reasons. An application for this can be found here:

http://www.pyrosociety.org.uk/join/

IV.b Explosives certificates

An explosive certificate is required if the individual wishes to acquire (including by way of manufacture) or acquire and keep an explosive which is not listed in schedule 2 of ER 2014. Such explosives are referred to as relevant explosives in the regulations. It is recommended that an explosives certificate is obtained if the individual is in any doubt that one is required.

Explosive certificates can be obtained from the police by application to your local ELO (Explosive Liaison Officer). You can find your local officer here:

http://www.hse.gov.uk/explosives/elo.htm

There are currently two types of certificate available:

- acquire; and
- acquire and keep

In most cases a person will require an "Acquire" certificate – because the explosives are not being "Kept". However in certain circumstances (see VII.c Explosive substance storage process map) an "Acquire and Keep" certificate may be required.

The intention of the certification process is to ensure that the individual is a fit and suitable person who has good reason for acquiring relevant explosives and is a person who can be expected to take all reasonable steps to prevent unauthorised access to and loss of the explosives.

People who require a certificate for the experimental manufacture of pyrotechnic substances should typically complete the application as follows:

Reason of use	"Pyrotechnic substance and device manufacture (less than or equal to 100g) for the purpose of laboratory analysis, testing, demonstration or experimentation as per ER 2014 regulation 6(2)(a)"
Explosive requested	**UN 0027 & UN 0028** - Black powder **UN 0305** - Flash powder **UN MAN2** - Any pyrotechnic substance or article subject to these regulations that is within the meaning of explosive contained within regulation 2

Laboratory analysis, testing, demonstration and experimentation are not defined in the regulations but in order to ensure the purposes for which an explosive can be acquired or acquired and kept are consistently described and understood the enforcing authorities have agreed that:

- "laboratory analysis" - is an examination of the physical and chemical composition and properties of an explosive where that examination has been undertaken by following a systematic methodology.

- "testing" – is the initiation of an explosive solely for the purposes of evaluating the explosive performance of that article or substance where that evaluation has been undertaken by following a systematic methodology.

- "demonstration" – is the giving of a practical exhibition and explanation of how an explosive is manufactured or how it behaves as part of a recognised training event or recognised educational activity.

- "experimentation" - is any act of manufacture of an explosive that follows a systematic methodology and which is undertaken to make a discovery or test a hypothesis, and which results in the collection of data.

An 'acquire' certificate is associated with a person, not a site, and it may be appropriate for an individual to hold such a certificate for the activities they carry out in preparation and storage away from the manufacturing site. The requirements of other regulations (particularly the classification and safe transport arrangements of the Carriage of Dangerous Goods and Use of Transportable Pressure Vessels Regulations 2009) should be complied with in such cases.

IV.c Control of Explosives Precursors Regulations 2014

This regulation controls the supply and acquisition of chemicals which are deemed to be an explosive precursor or a poison. The regulated chemicals of general interest for experimental pyrotechnics are:

- Potassium Chlorate
- Potassium Perchlorate
- Barium Chlorate
- Barium Nitrate

but it is the responsibility of the individual to ensure that any regulated chemicals used are appropriately licenced (see VI.Further reading for a link to the regulations).

If an individual wishes to acquire any of the regulated chemicals they must be in possession of an explosives precursors licence. A licence application can be submitted here:

https://eforms.homeoffice.gov.uk/outreach/epp-licence-new.ofml

People who require a licence for the experimental manufacture of pyrotechnic substances should typically complete the application as follows:

For each chemical requested:	
Reason of use	"Pyrotechnic substance and device manufacture (less than or equal to 100g) for the purpose of laboratory analysis, testing, demonstration or experimentation as per ER 2014 regulation 6(2)(a)"
Concentration	100%
Amount	An appropriate amount for experimental purposes without stock piling (<= 10 kilograms recommended)

V. General Principles of Operation

V.a Suitable facilities

Any experimental pyrotechnic manufacturing activity should always be performed in a suitable working environment with the necessary facilities. The manufacturing process building should be external to any domestic dwelling or other building that is being used for other purposes, with sufficient separation from other buildings to ensure safety. It should be dedicated for the purpose, for example, a workshop positioned away from a house. The facility should also be capable of ensuring that any explosives that are present are kept secure.

V.b Safety

The safety of others and oneself must always be the first priority. An individual undertaking experimental pyrotechnic manufacturing activities is expected to conduct their work in accordance with ER 2014 regulation 26. The reader is expected to review, understand and implement the duties under this regulation and the requirements of the supporting overarching guidance in L150 before any manufacturing activity is undertaken. The main points to be addressed being:

- **Appropriate competence**:
  - combination of training, skills, experience and knowledge and the ability to apply those to perform an activity safely. This can be gained by such means as membership of the UKPS or other professional body related to explosives or pyrotechnics, attending events organised by the UKPS, reading literature on the subject and general experience in experimental pyrotechnic manufacture.

- **Prevention of fire or explosion by excluding sources of initiation including:**
  - naked flames
  - electricity (including static electricity and electromagnetic energy)
  - sparks from mechanical or frictional contact between metal surfaces
  - heat and temperature
  - pressure
  - impact and friction
  - chemical incompatibility between certain substances

- **To limit the extent of fire or explosion by :**
  - managing stocks of explosive to limit the amount of explosive in areas in which people are likely to be present
  - limiting the number of people in areas where explosives are present.
  - keeping explosives away from flammable or combustible materials which could fuel a fire, and away from toxic substances which could be released in the event of a fire.

- **To protect persons from the effects of fire or explosion by implementation of:**
    - emergency procedures.
    - fire precautions.
    - fire detection and warning systems.
    - means of escape and evacuation.
    - appropriate fire-fighting
    - physical measures to protect people against explosion.

Before any experimental activity is carried out, an understanding of the experiment to be performed should be developed. The potential energetic chemical reactions and incompatibilities of the compounds involved should be always considered. Appendix 1 of L150 contains further information on the identification and evaluation of hazards arising out of the manufacture and storage of explosives and the assessment of explosives risks. This consideration of chemical reactions and incompatibilities and the assessment of explosive risks can be can be structured around and supplemented by the experiment log sheet detailed in Annex VII.b.

Notwithstanding the 100g of composition that may be manufactured in accordance with Reg 6(2)(a), consideration should be given in all circumstances to the use of lesser amounts where possible. Quantities of exposed loose composition should be minimised.

Experimental manufacturing process buildings should:

- be subject to effective and practised emergency procedures;
- contain suitable fire fighting equipment to stop and fight fires where it would be appropriate to do so;
- have exits that are kept clear at all times;
- have designated work stations for operators that are protected by screens or remotely operated equipment where appropriate.
- be dry and clean;
- be kept tidy and free from waste or residual explosive compositions.

It is also advisable that a suitable first aid kit with eye wash station is available.

The number of people in the process building should always be kept to a minimum and only those involved directly in the experimental manufacturing activity being carried out should be present.

Appropriate Personal Protective Equipment (PPE) should be worn at all times by all persons engaged in experimental manufacturing activities. The nature of the PPE will depend on the compositions or articles being manufactured and their ingredients. This could consist of:

- flame resistant or flame retardant clothing that will not generate or accumulate a static charge;
- safety glasses, goggles or full-face visor;
- dust mask or respirator as appropriate;
- gloves or gauntlets.

All tooling and machinery should be made of non-sparking materials and properly guarded and suitably earthed.

Any tooling which exerts pressure or friction upon an explosive composition should be properly guarded or operated remotely.
Chemicals and other ingredients or components should always be stored:

- in an environment free from moisture,
- in the suppliers approved packaging and in accordance with the data sheets provided
- separately from all experimental manufacturing activities.

All containers should be clearly labelled with their contents and chemicals should only be stored in the suppliers approved packaging. All oxidisers should be stored separately from other chemicals that could act as fuels. Chemicals with known incompatibilities should be stored away from each other.

V.c Storage of pyrotechnic substances and articles

ER 2014 provides a framework for authorising the keeping and storage of explosives including pyrotechnic substances and pyrotechnic articles.

There will generally be three specific areas of storage for consideration in respect of experimental manufacture:

- storage of loose unfinished pyrotechnic compositions
- pyrotechnic compositions or articles in a state of being dried, e.g. firework stars
- storage of finished pyrotechnic articles

The acquisition and/or keeping of any explosive not listed in Schedule 2 of ER 2014 will be subject to the explosive certificate requirements of regulation 5 of ER2014 .

A licence to store explosives (regulation 7 of ER2014) may be required depending on the type of composition and storage period. See annex VII.c & VII.d for storage process diagrams which will assist in defining your storage requirements.

Although though ER 2014 will permit experimentally manufactured compositions and articles of up to 100g to be stored without consideration of separation distances (see regulation 27), such compositions and articles should be stored in a closed and sealed non-sparking container in a safe place away from all manufacturing activities. Where several quantities of explosives or articles are stored together it is the total net mass of explosive that is used to determine the separation distance to be maintained.

Loose pyrotechnic compositions:
Compositions in a loose powder state should only be stored if required for further processing or testing, and in all cases in quantities not more than 100 grams.

Drying pyrotechnic compositions or articles:
Compositions or articles being dried should not be exposed to proximate manufacturing activities. No more than 100 grams of drying compositions should be stored at any one time. As soon as the composition is sufficiently dry, it should be stored in a sealed container in a safe location.

Finished pyrotechnic articles:
Should be kept in a closed container in a safe place.

Separation distances:
All explosives in storage should meet the separation distance requirements of regulation 27 of ER2014 and the separation distances prescribed in Schedule 5 of the regulations where appropriate. These are detailed in ER 2014 and further guidance on how to apply separation distances can be found in L150. There are only two of the exceptions listed in regulation 27 of ER2014 that are generally relevant to experimental manufacture and which mean that separation distances are not required. These are:

- when the amount of explosive to be stored is less or equal to 100g In accordance with ER 2014 regulation 27(3)(a).

- when the explosive is black powder and is stored in accordance with Appendix 7 of L150 (see regulation 27 (3) (c) & (d).

V.d General housekeeping

Anyone undertaking experimental pyrotechnic manufacture should implement high standards of housekeeping. There are a number of housekeeping tasks that should be performed. These are:

- waste disposal
- cross contamination limitation
- cleanliness
- regular safety checks
- chemical & explosives record keeping and MSDS maintenance

Waste disposal: All waste created as a result of a manufacturing activity should be disposed of carefully. All explosives or explosive contaminated material should be safely incinerated or doused with sufficient amounts of water (or other suitable solvent) to be made safe before disposal. Where hazardous (non-explosive) chemicals are present, the waste should be double bagged and lawfully disposed of through an appropriate waste handling facility.

Cross contamination limitation: Decanting operations should always be performed in a manner that limits any possible cross-contamination. All containers should be closed and sealed once the necessary amounts of chemical have been decanted.

Cleanliness: All work surfaces, flooring, walls and tooling should be kept clean and free from all chemical and explosive dusts. All spillages should be cleaned up immediately and the residue disposed of safely.

Any person carrying out an experimental manufacturing activity should always take precautions to keep skin, eyes, nose and mouth free from any chemical contamination. Consideration should also be given to identifying

and treating contamination on an individual's clothing for before they leave a process building.

Chemical record keeping and MSDS: Records should be kept that either identify or include:

- name of substance
- date purchased
- quantity purchased
- where purchased
- quantity used
- storage location

These records will allow:

- an assessment to be made on whether or not a chemical is likely to remain fit for use; and
- information to be provided to the emergency services as appropriate

All chemical records should be accompanied with its associated MSDS (Material Safety Data Sheet). The supplier of the chemical should always be able to supply the relevant MSDS for the chemical purchased.

V.e Testing

The testing of a composition or pyrotechnic article should always be carried out away from any manufacturing process buildings unless the building has been designed and equipped for that purpose. Consideration should also be given to the location in respect of:

- safety of others;
- fire risks;
- annoyance to neighbouring dwellings and the creation of a public nuisance; and
- necessary free space to execute the required tests

Testing should not be conducted before 7am or after 11pm in order to comply with the requirements of the Firework Regulations 2004.

V.f Record keeping

Records should be kept of:

- explosives manufactured, acquired, used and disposed of.
- all chemical purchased, used and stored
- all risk assessments
- all experiments performed.

Keeping accurate records should enable a person undertaking the experimental manufacture of pyrotechnic compositions and articles to demonstrate that they are a fit person and to discharge any duties they may have under regulation 35 and 37 of ER2014

Explosives manufactured: If the individual carrying out experimental manufacture acquires or keeps relevant explosives (i.e. is in possession of an explosive certificate or acquires explosives that require such) they will need to be able to identify and report any losses of explosives. Keeping records in line with Regulation 35 of ER 2014 should ensure that losses can be properly identified and reported(see VI.Further reading). It is recommended that records are made and maintained for any explosive manufactured, or otherwise acquired and also record its eventual use or disposal. Statutory records should be kept safely and must be retained for a minimum of 3 years from the last entry.

Chemicals: As previously detailed, all chemicals purchased, used and stored should be recorded.

Risk assessments: All risk assessment performed should be recorded.

Experiments: Experimentation should be preceded by completion of a pre-experiment checklist. An example pre-experiment checklist can be found in annex VII.a

The results of all experimental manufacture should be recorded as an aid to other experimenters in terms of the behaviour of compositions and for the avoidance of unnecessary duplication of experiments. An example experimentation log sheet can be found in annex VII.b.

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VI. Further reading

Name	Link
The UK Pyrotechnic Society A large resource and information with an active member forum.	http://www.pyrosociety.org.uk/ http://www.pyrosociety.org.uk/media/er-2014-good-practise-guidance/
Explosives Regulations 2014	www.legislation.gov.uk/uksi/2014/1638/contents/made
Explosives Regulations 2014. Guidance on Regulations Safety Provisions. L150 This overarching guidance includes links to a wide range of general and topic based guidance that will be relevant to people manufacturing or storing pyrotechnic substances and articles.	www.hse.gov.uk/pubns/priced/l150.pdf
Explosives Regulations 2014 . Guidance on Regulations – Security provisions L151 This overarching guidance includes links to topic based guidance that will be relevant to people manufacturing or storing pyrotechnic substances and articles.	www.hse.gov.uk/pubns/priced/l151.pdf
Control of Explosives Precursors Regulations 2014	https://www.gov.uk/government/publications/licensing-for-home-users-of-explosives-precursors/licensing-for-home-users-of-explosive-precursors

VII. Annexes

VII.a Example pre-experiment checklist

MANUFACTURING PROCESS BUILDING

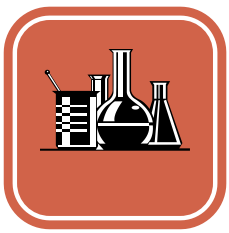
	Are all exits clear?
	Are all surfaces clean?
	Are there controls in place to limit the number of people in the building?

FIRE SAFETY

	Are appropriate firefighting facilities available?
	Is work area free from flammable materials?
	Is all tooling protected against static and spark generation?
	Is clothing made from a non-static generating material?
	Is area free from sources of ignition?

PPE

	Respirator?
	Is clothing appropriate to activity?
	Gloves/Gauntlets
	Goggles
	Should the activity be undertaken remotely or behind a screen?



CHEMICALS

	Are all chemicals other than those required in the experiment stored away?
	Are there any incompatible chemicals in this experiment?
	Are all chemical mixing tools clean and free from contamination?

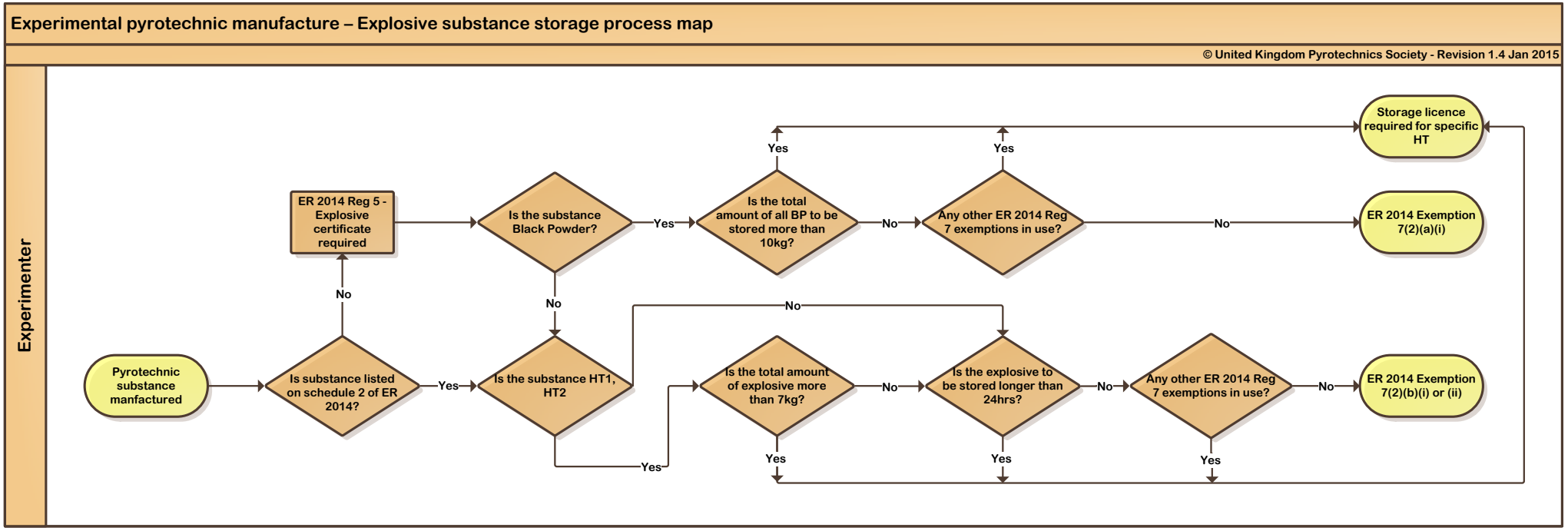
MISCELLANEOUS TASKS

	Do you fully understand the emergency procedure?
	Have you created an experiment log sheet?
	Is the first aid kit complete and non-expired
	Are there eye wash facilities?

VII.b Example experimentation log sheet

Pyrotechnic substance/article Test & Experiment Form:		
Composition reference:		
Test number:		
Composition name:		
Result:	Excellent [] - Good [] - Usable [] - Poor [] – Failed []	
Test date:		
Author / Source:		
Composition		
Component:	Parts by weight:	
Manufacturing specifics		
Consolidation:		
Choke:		
Pressure (PSI):	Powder:	Gauge:
Solvent:	Type: *Water*	Amount (%):
Binding system:	Solid [ ] - Paste [ ] – In Solution [ ]	
Burning characteristics		
Priming required:		
Burning rate and stability:		
Combustion products:		
Ash characteristics:		
Non-combusted materials:		
Effect appraisal		
Visual:		
Audible:		
Notes		

VII.c Explosive substance storage process map

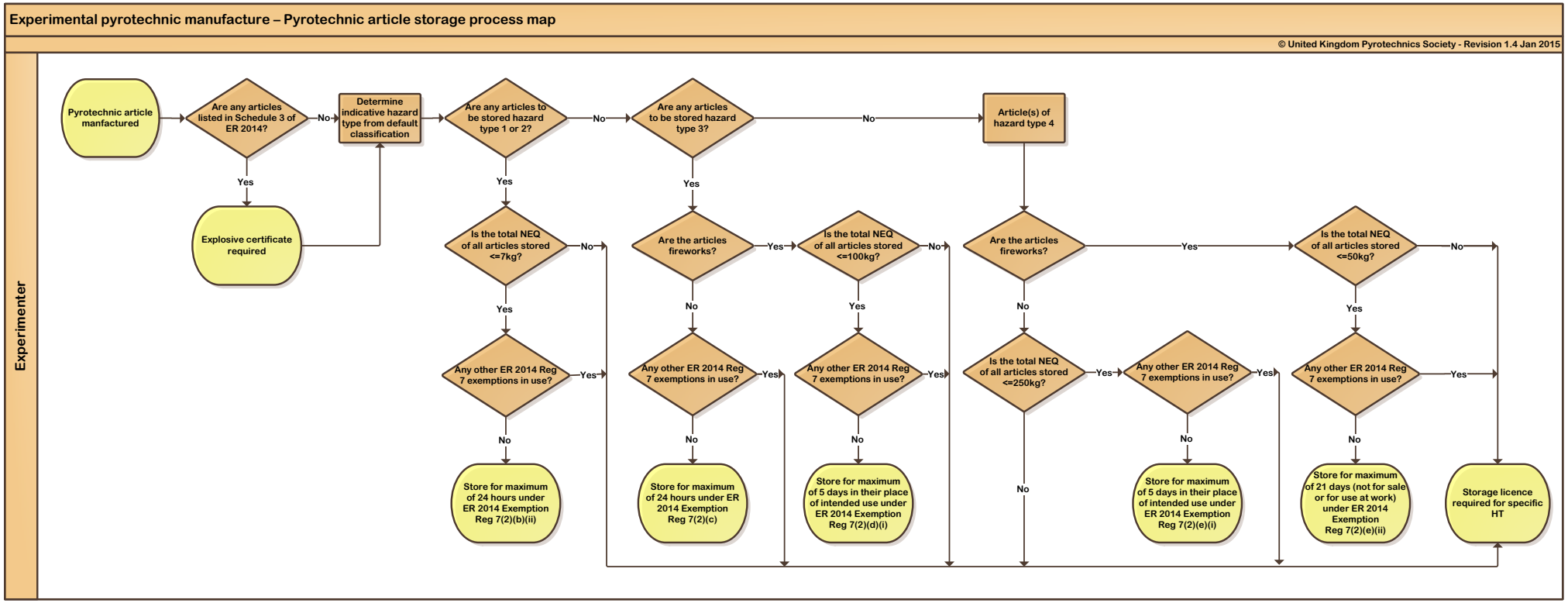


Note

Black powder and flash powder will generally be expected to behave as hazard type 1. Hazard types for all other unclassified pyrotechnics substances should have their hazard type determined on a case-by-case basis but pyrotechnic substances will generally be expected to behave as hazard type 1 (HT1), especially when confined. L150 contains guidance on the determination of hazard type. For more information on pyrotechnic substance classification (and presumptive hazard type) see sub-section 2.1.3 and Chapter 3 of the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR). This can be found at:

http://www.unece.org/trans/danger/publi/adr/adr2013/13contentse.html

VII.d Explosive article storage process map



Note

Guidance from Paragraph 2.2.1.1.7 of the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) can be used to determine the default classification and indicative hazard type of any manufactured articles that are fireworks. This can be found at:

http://www.unece.org/trans/danger/publi/adr/adr2013/13contentse.html

VIII. References

Pyrotechnic Articles (Safety) Regulations 2010	http://www.legislation.gov.uk/uksi/2010/1554/contents/made
The Firework Regulations 2004	http://www.legislation.gov.uk/uksi/2004/1836/made
Disposal of explosives guidance	http://www.hse.gov.uk/explosives/disposal.htm
UN ADR	http://www.unece.org/trans/danger/publi/adr/adr2013/13contentse.html
Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009	http://www.legislation.gov.uk/uksi/2009/1348/contents/made
Management of Health and Safety Regulations 1999	http://www.legislation.gov.uk/uksi/1999/3242/contents/made
Health and Safety at Work Act 1974	http://www.legislation.gov.uk/ukpga/1974/37/contents

IX. Your Notes