Control Systems for the Storage of Explosives, Including Fireworks

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Disclaimer: The views expressed in this paper are those of the author and reflect his understanding of the information collected during a study carried out on behalf of the Ministry of Social Affairs and Employment in The Netherlands. As such, they should not necessarily be taken to be the views of the UK Health and Safety Executive.

ABSTRACT

This paper gives an account of the use of a questionnaire to obtain up-to-date information on control systems for the storage of fireworks and other types of explosives. The study showed that control systems for the storage of explosives based on quantity-distance schemes are used in many countries. In most of these schemes, fireworks are treated in the same way as other types of explosives.

The classification of fireworks is seen to be a particular problem because of the large number of different types that are on the market. There are also concerns about the accurate classification of fireworks stored in steel transport containers or in magazines constructed from brick or concrete. For the storage of mixed fireworks, several countries assign the fireworks to the same hazard division as the most hazardous type of firework in the store.

Keywords: explosives, storage, fireworks, control system

Introduction

This paper presents the results of a project to collect information on control systems for the storage of fireworks and other types of explosives. The project involved sending a questionnaire to organizations such as regulatory bodies, government departments and government laboratories around the world, and it was a part of a study of control systems for explosives that included a review of the literature.[1] For completeness, however, information obtained from the literature on the storage of fireworks is presented in the paper and is identified by a reference to the source material.

Development of the Questionnaire

The objective in developing a questionnaire on control systems for the storage of explosives was to obtain up-to-date information on the practices in use throughout the world. With this in mind, the control system employed in Great Britain was used to identify the issues of concern for inclusion in the questionnaire. Most of the questions had simple yes or no answers so as to obtain a good response from recipients, but a generous amount of space was left for comments or clarification of answers. To help users, guidance material included in the questionnaire was presented in a different format. Many of the recipients were known through professional contacts and others were identified from publications and from searches of the Internet.

The issues addressed in the first part of the questionnaire included the control of the hazards arising from accidental initiation of explosives, the classification of explosives for storage, the use of quantity-distance schemes, and the use of TNT-equivalence. Issues relating to the storage of fireworks were addressed in the second part of the questionnaire and included the role of packaging, the use of UN hazard divisions, storage of mixed fireworks and the type of store. An outline of the questionnaire is included as an Annex at the end of this paper.

The questionnaire was sent to recipients in 11 countries. Responses, which provided much use-

ful information, were obtained from Australia (Queensland and Western Australia), Sweden, France, Germany, Malta, Switzerland, Canada, and the United States.

Analysis of Responses to the Questionnaire

Types of Control System and Background Legislation

All of the countries responding to the questionnaire operate a control system for the storage of explosives that is separate from systems for the control of other dangerous substances. Great Britain also has a separate system for the control of explosives, and the main enabling legislation is the Health and Safety at Work, etc. (HSW) Act 1974.[2] The Explosives Acts of 1875 and 1923 and subordinate legislation are still important, but the earlier requirements are being modified or replaced by new sets of regulations made under the HSW Act. For example, at the time of writing, the public comment period on new regulations on the manufacture and storage of explosives (Manufacture and Storage of Explosives Regulations) had just ended.[3] With a few exceptions, the manufacture of explosives can only be carried out in a factory licensed by the Health and Safety Executive (HSE). Similarly, premises where more than 1800 kg of explosive are kept must also be licensed by HSE.[4] Other types of store are under the control of local authorities.[5]

In the United States, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATFE) in the Department of the Treasury regulates the storage of explosives for civil use. Explosives for military use are controlled by the US Department of Defense. In Germany, different authorities are responsible for regulating the handling of different groups of dangerous substances. In France, the relevant controls are French decree n°79-846 dated 28 September 1979, a French order dated 26 September 1980 and a French information circular dated 8 May 1981. In Sweden, the controls are the Act (1988:868) and Order (1988:1145) of Explosives and Flammables and Regulations of Explosives; the Act and Order contain fundamental provisions whereas the Regulations contain detailed provisions.

Queensland, Australia operates a licensing regime that has some similarities with the British system. The controls are the Queensland Explosives Act 1999 and associated regulations. Licenses are required for the storage of explosives including blasting explosives, fireworks, propellants and emulsions of UN Class 5.1. In effect, the Explosives Act calls up the national Australian Standard AS 2187 Part 1.[6] Western Australia operates a similar set of controls, and these are applied under the Explosives and Dangerous Goods Act 1961 and associated regulations. These controls also call up the national Australian Standard AS 2187 Part 1. In Canada, explosives are controlled under the Canada Explosives Act. Other classes of dangerous goods are not permitted in magazines.

In Malta, three types of explosives are in use—explosives for military purposes, explosives for the blasting of rock, and fireworks manufactured locally. The Armed Forces of Malta are responsible for controlling the storage of military and industrial explosives, whereas local authorities are responsible for the control of fireworks. The legislation on explosives includes the Manufacture and Storage of Explosives Regulations (1937)[7] and the Control of Fireworks and Other Explosives Regulations (1999).[8] The latter regulations define a "fireworks factory" as any premises where fireworks are manufactured or stored and include controls on the discharge of fireworks (both sites and operators).

Use of Quantity-Distance Schemes

The control systems in Great Britain, Australia (Queensland and Western Australia), Sweden, France, Germany, Malta, Canada and the United States are all based on a similar type of scheme (a quantity-distance scheme) in which the quantity of explosives permitted in an installation varies according to the distance from nearby buildings and other facilities. In Queensland, the distances are only guidelines; variations are made as appropriate (e.g., for underground magazines, magazines in mountains etc). In Great Britain, the safety distances may be refined by HSE in the light of the evidence accompanying an application for a license for a store or a factory. In these control systems, the separation distances vary with the type of ex-

plosive being stored and cover separation from other buildings on site as well as separation from buildings and facilities off site. However, in Malta this is only true of stored military and industrial explosives, not fireworks. Canada uses the British table of safety distances (for former categories of explosives X, Y, Z and ZZ).[9]

Switzerland also uses a quantity-distance scheme, but it differs in that the separation distances do not vary according to the hazard division or type of the explosive being stored. The separation distances cover separation from buildings on site as well as separation from buildings off site. Very large (unlimited) quantities of explosives are stored in magazines. Smaller quantities of explosives may be kept in a locker (up to 100 kg) or in a suitable container (up to 25 kg) but only in uninhabited ground floor rooms or in works-yards.

The sophistication of the quantity-distance schemes in terms of on-site and off-site separation distances varies from one country to another. The response from Queensland pointed out that the on-site separation distances are risk-based and include separation from magazines and associated facilities such as workshops. The off-site separation distances cover separation from protected works, Class A (e.g., roads); protected works, Class B (e.g., residences and schools) and vulnerable facilities (e.g., airports and high-rise, glass-fronted buildings). The definitions of protected works (set out in national Australian Standard AS 2187 Part 0[10]) are similar to those used in Great Britain.

In the United States, the tables of separation distances in the ATFE regulations include separation from inhabited buildings, public highways and passenger railways. An inhabited building is defined as any building regularly occupied, in whole or in part, as a habitation for human beings, or any church, schoolhouse, railroad station or other structure where people are accustomed to assemble, except any building occupied in connection with the manufacture, transportation, storage, or use of explosive materials. "The ATF regulations provide safety to the general public, not the persons working in a facility, which manufactures explosives. The US Office of Safety and Health Administration regulates worker safety." In Germany, the off-site separation distances take account of the number and vulnerability of people exposed to risk but not in a quantitative way.

Except in Sweden and Malta, small quantities of explosives may be stored in facilities outside the scope of the quantity-distance control system. In France, "small" means quantities less than 20 kg (e.g. stored in a supermarket). In Western Australia, storage outside the scope of the quantity-distance scheme is limited to 150 kg and must meet regulatory requirements and be approved by an inspector of explosives. In Queensland, such storage is limited to 5 kg of blasting explosives and 50 kg of fireworks, etc. The position in Canada and in the United States is similar. For example, the ATFE regulations in the United States permit limited storage indoors, but the building must not be a residence or dwelling. In Canada, there are magazines for storing small quantities of shop goods (consumer) fireworks, propellant powders and ammunition that are outside the scope of the quantity-distance scheme. In Great Britain, 7 kg of mixed explosives (including detonators) may be stored in a substantial lockable receptacle, used exclusively for explosives and held inside a shop, house, office or warehouse. The corresponding figures for shop goods and professional fireworks are 25 and 250 kg, respectively.[5] In Switzerland, fireworks for sale for the national festival on August 1st and for the celebrations on New Year's Eve are the only instances of the storage of explosives outside the scope of the quantity-distance scheme.

Control of the Hazards Arising from the Accidental Initiation of Explosives

The various control systems differ in the way that they take account of hazards arising from accidental initiation of explosives. The control systems in Great Britain, Germany, Switzerland, Queensland and Western Australia take account of blast, projected fragments from stored material, projected debris from an explosion within a building, thermal radiation and ground shock. The German system also takes account of fire jets, hazardous gases and self-propelling objects such as rockets. The French and Canadian control systems take account of the same hazards as the British system except ground shock, whereas the system in Malta takes account of the same hazards except ground shock and ther-

thermal radiation. The British control system is currently under review, partly because there are concerns that the existing separation distances may not always adequately take account of the hazard from projected debris resulting from a mass explosion in a building constructed from brick or concrete.

Blast overpressure is the main hazard taken into account in the control systems operating in the United States and Sweden. The United States quantity-distance tables for high explosives use a blast criterion with window breakage occurring at an overpressure of two pounds per square inch (13.8 kPa). The Swedish regulations are currently under review, and, at present, only partially address the hazards from projectiles and debris. However, the Act (1988:868) allows the licensing authority to ask for a risk analysis that takes into account debris and thermal radiation.

Use of the Concept of TNT-Equivalence

The concept of TNT-equivalence can be used to compare the performance of the same quantity of different explosives. In Great Britain and France, the TNT-equivalent of an explosive is determined as the mass of TNT that would yield the same peak overpressure at a given distance as the total mass of the material under consideration. The concept of TNT-equivalence is used only rarely in Germany and not at all in Malta, Sweden, Switzerland, Canada and the United States. In the Australian standards used in Queensland and Western Australia, the net explosive quantity (NEQ) in quantity-distance tables is given as the equivalent mass of TNT. The response from Queensland pointed out that this acts as a safety factor because most commercial explosives in use in Queensland are less powerful than TNT. If an explosive is more powerful than TNT, the NEQ is increased accordingly to determine satisfactory safety distances.

Classification of Explosives for Storage and the Effect of Packaging

Queensland, Western Australia, Canada and Sweden all classify explosives for storage using the UN transport classifications, modified as necessary in the light of test data, experience or historical data and by analogy. For example, Queensland accepts the ingredients of emulsion explosives as Class 5.1 for transport but storage has to be licensed. Sweden pointed out that the UN scheme is only designed for the classification of packaged articles and for individual unpacked articles. Storage in freight containers may change the classification because of the quantity or because of self-confinement. In Canada, the classifications for storage are set out in the Canada Explosives Act.

Switzerland also classifies explosives for storage using the UN transport classifications, modified as necessary in the light of test data or by analogy, but at present, the control system does not differentiate between the various hazard divisions within Class 1.

The German scheme for the classification of explosives for storage is essentially the same as the UN scheme except that it does not have the Hazard Divisions 1.5 and 1.6. The differences from the UN scheme reflect the history of the legislation on explosives in Germany. In France, explosives are given a new classification for storage based on the UN compatibility group. However, this can be changed in the light of test data.

Neither the United States, Great Britain nor Malta use UN transport classifications for classification of explosives for storage. In Malta, industrial and military explosives are stored according to their hazard division and compatibility group. There are no classifications for fireworks. In the United States, ATFE classifies explosives for storage as high explosives, low explosives or blasting agents:[11]

a) **High Explosives.** Explosive materials which can be caused to detonate by means of a blasting cap when unconfined (e.g., dynamite, flash powders and bulk salutes).

b) **Low Explosives.** Explosive materials which can be caused to deflagrate when confined (e.g., Black Powder, safety fuses, igniters, igniter cords, fuse lighters and "display fireworks" classified as UN0333, UN0334 or UN0335 by the Department of Transportation (DOT).

c) **Blasting Agents.** (e.g., ammonium nitrate-fuel oil and certain water gels).

The storage of explosives is regulated in the United States to protect the public and to secure

explosives against theft. ATFE regulations differ from the transport requirements "because, once the explosives arrive at their final destination they may be stored with larger or mixed quantities of explosives and/or removed from the shipping container, which changes the designation". The ATFE regulations do take account of the nature of the packaging, but only in a limited number of circumstances. For example, high explosive detonators may be stored as low explosives provided that they are packaged so that they do not present a mass explosion hazard.

In Great Britain, HSE uses a system of hazard types to classify explosives for storage.[4] The hazard types were developed because there are certain conditions of storage (and manufacture) where a different hazard may be presented from that recognized in the UN classification for transport. The four hazard types use descriptions similar to those used in the UN scheme:

Hazard Type 1: having a mass explosion hazard;

Hazard Type 2: having a serious projection hazard but not a mass explosion hazard;

Hazard Type 3: having a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard;

Hazard Type 4: having a fire or slight explosion hazard or both, with only local effect.

Some of the control systems based on the UN Scheme (Queensland, Western Australia, Sweden and Germany) take account of the nature of the packaging. In Canada, there is no relaxation of the classification on the grounds of packaging. Queensland does not have confidence in the UN classification of large metal containers filled with bulk product such as emulsions. All emulsions are considered to be explosives even if not allocated to Class 1 when tested.

Effect of the Type of Storage Building

With the exception of the French control system, all the control systems take account of the type of storage building in some way. In Sweden, this is most likely to be done if a risk assessment is carried out on the facility. Germany, Queensland, Western Australia and the United States have specific requirements for the construction of magazines and other storage facilities. For example, in the United States, high explosives must be stored in a Type I or Type II magazine, which provides protection against penetration by bullets. In Queensland, magazines have to be of robust construction in order to secure the stored explosives against theft. Such magazines are considered to be a source of debris and shrapnel in the event of an incident.

The national Australian Standard AS 2187 Part 1 used in Queensland and Western Australia contains specific requirements for the construction of magazines, including separation distances, lighting, lightning protection and the use of holding-down bolts to secure certain portable and re-locatable magazines.

In Canada, there are specific stacking requirements for large stacks of propellants that have been classified for transport as Hazard Division 1.3C.

Impact on the Environment

The control systems in Queensland, Sweden, Switzerland and Germany take account of effects on the environment, although in Sweden, there are no specific regulations. The situation in Queensland and Western Australia is similar to that in Great Britain. For example, in Queensland, any local authority concerned about effects on the environment can add environmental requirements to the controls in the Explosives Act 1999. In the United States, the ATFE regulations do not contain specific requirements to protect the environment, but before a manufacturing or storage site is approved by ATFE, the site must meet all federal, state and local regulations.

Use of Quantitative Risk Assessment

Quantitative risk assessment (QRA) is used in Great Britain, France, Switzerland, Queensland and the United States. In Switzerland, the control system relies entirely on the use of quantitative risk assessment with a target level of residual risk. In Sweden, the use of QRA with respect to storage facilities is under discussion. However QRA is used for refining separation distances at manufacturing sites. In the United States, QRA is used to estimate the risk to members of the public. It is also used exten-

sively at fireworks manufacturing sites where loose, dry explosive powders and/or explosive materials are present during various stages of the fireworks assembly process. In Queensland, the Chief Inspector of Explosives can over-ride the quantity-distance tables on the basis of a competent QRA. QRA is also used to provide the basis for exemptions from the regulations and during consideration of the safe handling of explosives at ports.

Storage of Fireworks and Use of the Net Explosive Quantity (NEQ)

Queensland, Western Australia, Sweden, France, Germany and the United States all treat fireworks in the same way as other explosives. In Malta, fireworks are only used by professionals. The storage of fireworks in Malta is not controlled using a quantity-distance scheme; instead, fireworks are stored in licensed "fireworks factories". As long as a factory is situated at least 200 m away from inhabited areas, there is no restriction on the quantity of explosives stored in that factory. The regulations in Malta prohibit the use of high explosives in the manufacture of fireworks. In Queensland and in Western Australia, the use of fireworks by the general public is prohibited. The prohibition came into effect in Western Australia in 1967. Fireworks may only be used by trained, licensed operators at public displays.

The storage of fireworks in Canada differs from the storage of other explosives in that different standards for magazines are applied. In Switzerland, storage of fireworks differs from the storage of other types of explosive in that up to 300 kg may be kept in living areas.

In the United States, consumer (small) fireworks are outside the scope of the ATFE storage regulations. However, each state or municipality can make its own regulations in addition to the ATFE regulations. Federal explosive manufacturing and storage regulations must be enforced as the minimum requirements. (Note: the ATFE regulations include a simple quantity-distance table for the storage of display fireworks except bulk salutes. Bulk salutes are stored using the quantity-distance scheme for high explosives.) In France, fireworks are brought into the quantity-distance scheme by means of their TNT-equivalence.

With the exception of Switzerland, all countries responding to the questionnaire use the net quantity of explosive (NEQ) to determine the quantity of both consumer and professional fireworks permitted in storage. In Canada, separation distances for magazines use the NEQ but the licensed quantity is the gross weight. In France, Queensland and the United States, the gross weight may be used if the net weight is unknown. As noted above, in the United States, the ATFE regulations only cover professional fireworks. According to ATFE, packaging does not directly influence the storage of fireworks in the United States, but use is made of the NEQ. In guidelines established in 1991 in conjunction with experts from industry, the approximate weight of explosive materials in display fireworks is calculated for storage as 50% of the weight of the completed fireworks, unless the actual weight of the explosive material can be determined. For example if a display shell has a mass of 500 g, the net mass of pyrotechnic compositions, explosive materials and fuses would be 250 g. According to ATFE, these values are approximate industry averages, and should be within 10% of the actual mass. The estimate reflects the average composition found in both domestic and imported aerial shells. For fireworks stored loose in bins, the proprietor has to supply the mass of each shell before the mass of explosive materials can be estimated. For fireworks such as "cakes" (batteries) etc., a 25% mass calculation is sometimes applied.

In Great Britain, the gross mass rather than the net mass is used to determine inventories of manufactured fireworks in storage. Another way in which fireworks are treated differently from other types of explosive is that HSE has introduced a scheme whereby a default UN transport classification of fireworks may be claimed under the Classification and Labeling of Explosives Regulations 1983 (CLER).[12] The default system has been agreed upon by HSE and the British fireworks industry and was introduced to cope with the large number of different types and sizes of firework currently on the market or about to be placed on the market. The system provides a list of classifications according to the type of firework. Some examples of the types identified are two sizes of rocket (with or without sticks), two types of Roman candle, report shells (not in mortars) and shells (in mortar).

The publishing of the default list does not replace the requirement for HSE to classify all individual fireworks and is not intended to be used as a basis for applicants to classify fireworks themselves. Classification by the default route may be claimed where test results are not available or where no satisfactory documentary evidence of classification in the country of manufacture can be obtained.

Hazard Classification of Stored Fireworks

In most countries (France, Germany, Queensland, Western Australia, Canada and Sweden) the maximum permitted quantity of stored fireworks does depend on the UN hazard division of the stored fireworks. In France, fireworks are divided into four groups according to their mass and according to the distance that material is projected from the burning fireworks. A quantity-distance scheme is used for the storage of fireworks and is organized according to the UN transport classification of the fireworks. In Germany, fireworks are also divided into four classes according to their mass, with very small fireworks in Class 1 and large fireworks in Class 4. As in France, a quantity-distance scheme is used for the storage of fireworks and is organized according to the UN transport classification of the fireworks.

In Great Britain, the maximum permitted quantity of stored fireworks depends on the hazard type mentioned earlier. In Sweden, fireworks sold to the public are usually assigned to Hazard Division 1.3. When fireworks are stored in shops, the packaging (cardboard box) is often removed. The regulations only take mass explosion hazards into account. As noted earlier, in the United States, ATFE does not use UN transport classifications for the storage of explosives. However ATFE does distinguish between consumer fireworks defined by the US Consumer Product Safety Commission, display fireworks (defined as low explosives) and aerial salutes which contain flash compositions. Flash compositions, whether in the raw state or in a finished salute, are stored as high explosives. According to ATFE, consumer fireworks are equivalent to Hazard Division 1.4 and low explosives are equivalent to Hazard Division 1.3.

In Switzerland, the maximum permitted quantity of stored fireworks depends on the gross mass of the type of firework involved and also on the type (only for the short-term storage of professional fireworks).

France and Canada were the only countries responding to the questionnaire to confirm that the assignment of fireworks to hazard divisions for storage depends on the confinement provided by the type of store. In France, this is especially true for assignment to Hazard Divisions 1.1 and 1.2. Experience in Sweden has also shown that the type of store is important. Queensland shares British concerns about the accurate classification of fireworks stored in steel transport containers or in magazines constructed from brick or concrete. Against a background of accidents involving stored fireworks at places such as Uffculme, United Kingdom (1998)[12] and Enschede, The Netherlands (2000),[13] HSE has commissioned the Health and Safety Laboratory to undertake research on the effects of confinement on fires involving stored fireworks. Recently a bid for research in this area has been accepted as a part of the European Union's Fifth Framework Programme and involves partners in the United Kingdom, The Netherlands and Germany. Pending the results of the research, HSE has issued interim guidance on the assignment of fireworks stored in steel magazines to Hazard Types. For example, the fireworks assigned to Hazard Type 1 are all sizes and types of shell in a mortar, report shells and aerial maroons with a diameter greater than 75 mm and any items classified UN Hazard Division 1.1 by HSE under CLER. It is worth noting that these concerns are also recognized in the recent UN Recommendations on the Transport of Dangerous Goods, Model Regulations.[14] Paragraph 2.1.3.2.3 states that "The scheme of assessment is only designed for the classification of packaged substances and articles and individual unpacked articles. Transport in freight containers, road vehicles and rail wagons may require special tests which take into consideration the quantity (self-confinement) and kind of substance and the container for the substance".

In Canada, magazines for the storage of fireworks are usually of light construction. Inspectors consider the suitability of the construction of a magazine when making decisions on the maximum quantity of fireworks that may be stored.

Mixed Storage of Fireworks

In Great Britain, France, Germany, Queensland and Western Australia, mixed fireworks are assigned to the same hazard type or hazard division as the most hazardous type of firework in the store. In Sweden, shops selling fireworks to the public are permitted to store up to 100 kg of fireworks.

In the United States, aerial salutes are considered to be high explosives. However when they are mixed 50/50 with aerial shells, their classification is reduced to low explosive. In Canada, display fireworks are normally classified as Hazard Division 1.3 and this classification is used even though a small quantity of report shells classified as Hazard Division 1.1 may be present.

Conclusions

Control systems for the storage of explosives based on quantity-distance schemes are used in many countries. In most of these schemes, fireworks are treated in the same way as other types of explosives. In addition, the maximum permitted quantity of stored explosives generally depends on the hazard division or a modified form of the hazard division within Class 1 of the United Nations scheme for classifying explosives for transport.

The classification of fireworks is seen to be a particular problem because of the large number of different types that are on the market. However, a default classification scheme can help in this respect as can the use of generic definitions.

There are also concerns about the storage of fireworks in steel transport containers or in magazines constructed from brick or concrete. The confinement provided by the store may affect the classification of the fireworks. Until the problem of classification for storage is resolved, the practice of assigning fireworks that are on a borderline to the more hazardous group should provide a margin of safety.

Acknowledgements

I should like to thank the Ministry of Social Affairs and Employment in The Netherlands for funding the work described in this paper and for encouraging its publication. I should also like to thank the specialists in Queensland, Western Australia, Sweden, France, Germany, Malta, Switzerland, Canada and the United States who responded to the questionnaire.

References

1) M. J. Bagley, "A Review of Controls for the Storage of Explosives", *Propellants, Explosives, Pyrotechnics*, paper in preparation.

2) P. G. Jones, "The Law and Explosives", *Explosives Engineering*, Vol. 2, No. 4 (1988) pp 1–9.

3) Health and Safety Commission, *Proposals for New Regulations on the Manufacture and Storage of Explosives*, Consultative Document CD174, HSE Books, 2002, 296 pp.

4) Health and Safety Executive, *Guidance for Applicants for an Explosives Factory or Magazine*, Health and Safety Executive, 1999, 16 pp plus appendices.

5) Health and Safety Executive, *Summary of the Acts concerning Sale of Explosives*, Health and Safety Executive, 1986, 14 pp [ISBN 0 7176 02478].

6) Standards Australia, *Australian Standard AS 2187.1-1998: Explosives-Storage, Transport and Use-Storage*, Standards Australia, 1998 [ISBN 0 7337 1782 9].

7) Government of Malta, *Subsidiary Legislation 33.01, Manufacture and Storage of Explosives Regulations*, http://justice.magnet.mt/Documents/ENGLISH.

8) Government of Malta, *Subsidiary Legislation 33.03, Control of Fireworks and Other Explosives Regulations*, http://justice.magnet.mt/Documents/ENGLISH.

9) J. H. Thomson, *Guide to the Explosive Act 1875*, Her Majesty's Stationery Office, 1962, 297 pp.

10) Standards Australia, *Australian Standard AS 2187.0-1998: Explosives-Storage, Transport and Use-Terminology*, Standards Australia, 1998 [ISBN 0 7337 1781 0].

11) U.S. Department of the Treasury, Bureau of Alcohol, Tobacco and Firearms, *Federal Explosives Law and Regulations*, ATF P 5400.7 (09/00).

12) R. Merrifield, "Hazards Associated with the Storage of Fireworks", *Journal of Pyrotechnics*, No. 14 (2001) pp 1–14.

13) C. P. Weeth, "Enschede: Lessons to Relearn", *Proceedings of the 6th International Symposium on Fireworks*, Walt Disney World Resort, Lake Buena Vista, FL, USA (2001) pp 367–383.

14) *Recommendations on the Transport of Dangerous Goods, Model Regulations*, 11th rev. ed., ST/SG/AC.10/1/rev. 11, United Nations, New York and Geneva, 1999.

Annex

Outline of Questionnaire on Controls for the Storage of Explosives Including Fireworks

1) In your country, do you operate a control system for the storage of explosives that is separate from systems for the control of other dangerous substances?

2) Does the control system for the storage of explosives take account of the following hazards arising from accidental initiation:
   a) blast;
   b) projected fragments from stored material;
   c) projected debris resulting from an explosion within a storage building;
   d) thermal radiation;
   e) ground shock?

3) Does the control system for the storage of explosives take account of any other hazards arising from accidental initiation? If yes, please state the hazards.

4) Does the control system for the storage of explosives require the classification of different types of explosive according to the hazard (e.g., mass explosion hazard, projection hazard, etc.)?

5) Does the control system for the storage of explosives take account of the nature of the packaging or containment vessel? If the answer is yes, please say how this is done.

6) Does the control system for the storage of explosives take account of the nature of the storage facility/building? If the answer is yes, please say how this is done.

7) Are explosives classified for storage using their UN transport classifications?

8) (.1) If changes are made to the UN transport classifications, are these made on the basis of:
   a) test data;
   b) analogy;
   c) other information (please state)?

   (.2) If explosives are not classified for storage using their UN or modified UN transport classifications, what system is used?

9) Does the control system make use of the concept of TNT-equivalence for determining inventories of stored explosives?

10) If the answer to Question 9 is yes, how is the TNT-equivalence determined? For example, is a correction factor used?

11) Is the control system for the storage of explosives based on fixed quantity-distances? If the answer is no, please go to Question 17.

12) Do the separation distances vary according to the hazard division or type of the explosive being stored?

13) Do the separation distances cover separation from other buildings on site as well as separation from buildings and facilities off site?

14) For buildings and facilities on site, does the separation distance vary with:
    a) the type of building/facility;
    b) the number of people exposed to risk;
    c) the vulnerability of people exposed to risk?

15) For buildings and facilities off site, does the separation distance vary with:
    a) the type of building/facility;
    b) the number of people exposed to risk;
    c) the vulnerability of people exposed to risk?

16) Are there any explosives stores that are not covered by the quantity-distance control system (e.g., shops storing fireworks, stores at a quarry)?

17) Does the control system take any account of the impact on the environment (e.g., sites of special scientific interest, endangered species, etc.)?

18) Does the control system permit the use of quantitative risk assessment to estimate the risk to workers and/or members of the public?

19) Does the control system rely entirely on the use of quantitative risk assessment with a target level of residual risk?

20) (.1) If the answer to Question 19 is no, is quantitative risk assessment used to refine or reduce the separation distances in a quantity-distance scheme?

    (.2) What other use is made of the risk estimates?

Please Note: some of the following questions on fireworks make a distinction between fireworks sold in shops (consumer fireworks) and fireworks usually used only by professional operators. Consumer fireworks are of the type assigned to UN hazard divisions 1.4G and 1.4S for transport, whereas fireworks used by professional operators are of the type assigned to UN hazard divisions 1.3 (mainly), 1.2 and 1.1 for transport.

21) Does the control system for the storage of explosives treat the storage of fireworks differently from the storage of other types of explosives?

22) Because of the possible role of packaging in respect of the hazards posed by the storage of fireworks, is the net quantity of explosive (NEQ) used to determine the quantity of the following types of fireworks permitted in storage:
    d) consumer fireworks;
    e) fireworks used by professionals?

23) If the answer to all or part of Question 22 is no, is the gross weight of fireworks used to determine the quantity of the following types of fireworks permitted in storage:
    f) consumer fireworks;
    g) fireworks used by professionals?

24) Is the maximum permitted quantity of stored fireworks dependent on the UN hazard division of the fireworks?

25) If the maximum permitted quantity of stored fireworks is not dependent on the UN hazard division, are fireworks divided into different categories for storage by:
    a) size;
    b) gross weight;
    c) type (e.g., shop goods fireworks and fireworks used by professional operators);
    d) another system (please state)?

26) Does the assignment of fireworks to hazard divisions for storage depend on the confinement provided by the type of store (e.g., steel container)?

27) Does the control system for the storage of explosives set maximum permitted quantities for the mixed storage of different types of fireworks?

28) If the answer to Question 27 is yes, are the mixed fireworks assigned to the same hazard division as the most hazardous type of firework in the store?