Australasian Explosives Industry Safety Group Inc.

Code of Practice

STORAGE AND HANDLING OF SOLID AMMONIUM NITRATE

Edition 1

June 2022

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About AEISG

The Australasian Explosives Industry Safety Group (AEISG) is an incorporated association of leading Australasian explosives manufacturers and suppliers originally formed in 1994.

Since then, AEISG membership has grown substantially to include most of the Australasian explosives industry. A full list of all current member organisations can be found on the AEISG website, www.aeisg.org.au

The goal of AEISG is to continuously improve the level of safety and security throughout the industry in the manufacture, transport, storage, handling and use of explosives and related materials.

One of the strategies adopted by AEISG in this regard is to identify areas where improved and consistent standards of operational safety and security need to be applied, and then develop appropriate codes which reflect industry best practice in these areas.

AEISG codes of practice are adopted by members for the benefit of their employees, their customers and the general community. In the interest of promoting safety and security, the codes are freely available on the AEISG website.

To keep abreast of technological advancements, industry progress and regulatory changes, AEISG codes of practice are subject to regular review and updated through the issue of amendments or revised editions as necessary. It is important that users ensure they are in possession of the latest edition and aware of any amendments. References to superseded versions should be updated accordingly.

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PREAMBLE

Ammonium nitrate is a chemical manufactured and used on a large scale globally (many millions of tonnes annually) in the fertiliser and explosives industries, split approximately 60% fertiliser / 40% explosives. It is the primary ingredient in the vast majority of commercial bulk explosives, and as such it is common for mining and quarrying sites, and for bulk explosives or related manufacturing sites to have on-site ammonium nitrate stores. There are also some ammonium nitrate stores operated by transport contractors. Stores generally range in size from a few tens of tonnes up to hundreds and less commonly thousands of tonnes.

Properties and hazards of ammonium nitrate are described in Appendix B. Pure ammonium nitrate is not explosive, but it can become explosive with only a small amount of mixed or embedded fuel, or a contaminant, and it has been involved in a number of accidental explosions.

Pure ammonium nitrate is not combustible and does not burn but, being an oxidising agent, it can facilitate the initiation of fire and will assist the combustion of other materials, even if air is excluded. Fires involving ammonium nitrate cannot be extinguished by oxygen deprivation because of the provision of oxygen from the ammonium nitrate. Although contamination is believed to have led to one major accidental explosion, most have occurred as a result of prolonged and extensive fire engulfment, and many of the requirements of this and other ammonium nitrate codes are aimed at controlling the risk of fires that can lead to explosion.

There are many standards and codes globally and in Australia there are several State Codes or guidance notes which apply at least partially to ammonium nitrate, and many of the requirements are aimed at reducing or eliminating the risk of accidental explosion. Many of these Codes, however, cover a much broader scope than is applicable to the commercial explosives industry, as they may include a range of additional United Nations (UN) numbers, including fertilisers, and stores associated with activities other than mining, quarrying and construction (such as retail, farm supply, fertilizer mixing, etc). Similarly, although Australian Standard AS 4326 has sections dedicated to ammonium nitrate, and is a source of reference, it has a much broader scope than this Code, as it aims to cover all Division 5.1 oxidisers, solid and liquid.

AEISG has produced **this** Code in order to focus exclusively on the storage and associated handling of the types of solid ammonium nitrate commonly used in the commercial explosives industry in servicing mines, quarries and construction in Australasia. The Scope and application of this Code are detailed in Section 1 below. A summary of this Code, along with additional explanation of the intent underlying each requirement and some explanatory background is included as Appendix A, and it is recommended that new readers start with appendices B then A. Several photos are included throughout this code; these are intended to illustrate examples of typical situations, and are in no way meant to infer mandatory requirements.

The abbreviation "AN" is often used as a general short form of "ammonium nitrate" which can include types of ammonium nitrate that are excluded from the scope of this Code, however in this Code "AN" always means solid Ammonium Nitrate in Division 5.1 – oxidising substances, as tested and classified into United Nations numbers UN 1942 or UN 2067, as specified within the most recent editions of the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG), and the *Recommendations on the Transport of Dangerous Goods: Model Regulations* (published by the United Nations). Note that Ammonium Nitrate used in the explosives industry should be classified under UN 1942 and AEISG encourages the exclusive use of this number, but some international manufacturers continue to manufacture ammonium nitrate grades which are suitable for use in explosives under the UN 2067 number, and some of this may be imported into Australasia.

Appendix F lists all known significant explosions (and many significant fires) involving AN since approximately 1916. A review of these events clearly illustrates that all could have been prevented, or the consequence significantly reduced, had appropriate engineering and operational standards been in place **and rigorously applied.** Those involving storage (rather than transport or manufacturing) are analysed in Table D1 (in Appendix D) with the conclusions that none of them would have fallen within the scope of this code, and that if the basic principles for safe storage and handling of AN had been followed (as detailed in this Code) the event would not have occurred. However it is obvious from the descriptions that in each case at least some of the basic principles for safe storage and handling of AN were not followed - all of the events reviewed indicate that multiple failures occurred in the preventative and mitigative layers of protection (controls).

Controls broadly fall into two categories. "Hard Controls" are designed-in, and include Elimination or reduction, Substitution, Isolation and Engineering controls. "Soft Controls" are typically administrative in nature or PPE. It is generally accepted that soft controls are less reliable over time than hard controls. It should however be noted that "hard" controls may also become less effective over time and require continual reinforcement (including inspections, maintenance and audits) to remain effective.

In Australia, all AN covered by this Code is, by definition, Security Sensitive Ammonium Nitrate (SSAN) and must therefore be managed in accordance with the Council of Australian Governments (COAG) Guidelines (2004) and associated state and territory legislation. Security requirements are detailed in Section 7.

This Code sets out our industry's experience in the safe and secure storage of AN, which can be summarised at high level as:

INITIAL SET UP AND APPROVAL	ONGOING OPERATION	EMERGENCY
Minimise the amount stored.	Do not exceed licence limits. Do not exceed approved stack sizes. Use simple tools such as floor markings.	
Verify that it is AN.	Ensure that all incoming product complies with the classification and testing as per its UN number.	
Set out and maintain separation distances.	Maintain approved separation distances. Maintain stack separations.	Provide plans to the emergency services.
Set out and maintain segregation to other chemicals and combustibles.	Do not allow combustibles to accumulate. Do not allow non-approved chemicals to accumulate.	
Construct the facility from approved materials.	Maintain fire systems.	Fight or flight. ONLY fight small fires. Then EVACUATE.
Emergency Response.	Develop an emergency response plan (ERP) with appropriate stakeholders, and maintain and practice it. Co-ordinate and practice with emergency services.	Provide product and site information to emergency services. ERP, SDS, etc.

	Maintain known evacuation points and road closure points. Provide all information to local emergency services. Maintain information at evacuation points and gates.	
Security provisions.	Undertake security risk assessment. Ensure a security plan is in place and practised. Ensure security personnel where relevant. Maintain appropriate site security measures.	

This Code has a great deal in common with the relevant parts of many global codes and standards, in particular:

1. AS 4326-2008: The storage and handling of oxidizing agents.
2. *Safe Storage of Solid Ammonium Nitrate* (Fourth Edition, 2021) published by Department of Mines, Industry Regulation and Safety, WA. (Figure 3 and some of the wording in this Code are copied (with permission which is gratefully acknowledged) directly from this code.)
3. Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate (GPG 02 rev02, March 2014) published by SAFEX International.
4. *Information Bulletin* No 53 (Version 5, 31 Oct 2017) published by Explosives Inspectorate, Department of Mines and Energy (subsequently Department of Natural Resources and Mines, then Resources Safety & Health Queensland), Queensland Government.
5. NFPA 400: *Hazardous Materials Code* (2019 edition) published by National Fire Protection Association (US). (The Ammonium Nitrate section was formerly published as NFPA 490.)

However, these other standards and codes are not uniform - there are some significant differences between them. It therefore follows that this Code will differ significantly in at least some respects from some or all of them. In preparing this Code, AEISG has researched and drawn from these other codes, as well as the knowledge and experience of its members, and is of the view that the requirements detailed in this Code are the most appropriate set of controls for AN storage and handling at sites that fall within its scope. It should also be noted that some regulators may set very stringent, or even deliberately "excessive" requirements, in the knowledge that they have the power to approve derogations where appropriate. AEISG has no such power so this is not an approach available to AEISG.

Requirements detailed in this Code are always supplementary to, and never take precedence over, explicit minimum regulatory requirements. This Code is intended to supplement any such requirements in a nationally uniform way and to, as far as possible, clarify any ambiguity or uncertainty in them. AEISG understands that some of the requirements of this Code are more stringent, or less stringent, than some other codes, standards, or regulatory requirements. In preparing this Code, AEISG has avoided reproducing specific requirements simply because they exist in other codes, or because they may be currently mandatory in some jurisdictions. The intention behind the requirements detailed in this Code is explained in the body of the code or in Appendix A and it is expected that over time there may be some increased alignment of other codes and this Code.

Definitions of key terms can be found in Section 2 of this code and abbreviations are listed in the Glossary in Appendix C.

The information in this Code is provided in good faith and without warranty.

Publication History

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June 2022	Edition 1	Initial publication

1.0 Scope and Application

1.1 Scope

This Code sets out the requirements and recommendations to control the risks arising from the storage, and associated handling and security, of AN intended for use in the commercial explosives industry in servicing mines, quarries and construction within Australasia.

Note that:

1. Some AN Stores may be, or may be part of, a Major Hazard Facility (MHF). In this instance the safety case or other specific risk assessment for the store takes precedence over this Code. For MHF sites, parts of this Code may be referenced as a guideline.
2. The ownership or operational control of an AN Store does not affect whether it is included in the scope of this Code. Some AN stores may be owned and/or operated by a customer of an explosives or related materials supplier, or by a third party, e.g., a haulage contractor. Such stores are not intended to be excluded from the scope of this Code.

1.2 Application

Except as provided for in 1.3 below, the requirements in this Code apply as relevant to:

- Any person handling AN;
- Any holder of a licence for storage of AN; and
- The occupier of any premises where any AN is stored or handled.

1.3 Exclusions

This code does not apply to:

1) ammonium nitrate substances classified as non-dangerous goods;
2) ammonium nitrate substances classified into a UN Number other than UN 1942 or UN 2067, (e.g. Class 1 explosives; Class 9 miscellaneous dangerous goods; ammonium nitrate solutions);
3) ammonium nitrate manufacturing plants, including AN stores directly associated with, or on the same premises as, ammonium nitrate manufacturing;
4) AN and AN stores that are part of any manufacturing or mixing operation (see Notes 1 and 2 below);
5) premises with less than 1,000kg of AN;
6) transport of AN (except where relevant to on-site transport);
7) AN being handled through ports (AS 3846 is the applicable standard);
8) transit storage of AN (see Note 3 below);
9) Mobile Processing Units (AEISG *Code of Practice 'Mobile Processing Units'* is the applicable code);
10) AN stored with explosives in a Class 1 explosives magazine;
11) AN stored Underground, i.e., stored in underground mine workings (see Note 4 below).

NOTES:

1) Operations at AN stores may include activities such as debagging / splitting / decanting packaged AN into tipper trucks, transferring AN from a store to a different building or area of

a premises, loading AN from a silo into an MPU, etc. These operations are not considered manufacturing or mixing and do not exclude an AN Store from the scope of this Code.

2) AN may be an ingredient in a manufacturing or mixing process. For example, the Class 1 explosive ANFO is normally manufactured by passing porous prilled AN through a mixing device where diesel fuel is added. A building where this process occurs will often include some storage of AN (in addition to other ingredients needed for the process, such as diesel). Such buildings are “process buildings" and, by their nature, include operational activities and potentially fuels and other chemicals that would be inappropriate or prohibited inside an AN Store. Any such process building is excluded from the scope of this Code.
3) Transit Storage usually means storage within defined time limits (e.g., at least 12 hours and less than five days), and where the stored material is intended for further transport to another location. Transit Storage sites are excluded from the scope of this Code, but it may be referenced as a guideline.
4) The exclusion of AN stored underground is not intended to apply to AN stores that could be considered “underground” simply by virtue of being partly recessed into the surrounding land, e.g. the side of a hill.

1.4 General

The risk control information in this Code is based on current knowledge, a practical understanding of the properties and hazards of AN gained from testing and research, and the experience and learnings from past fires and explosions. AN properties and hazards are described in Appendix B.

To comply with the UN numbers that are within the scope of this code AN must have not more than 0.2% combustible substances, including any organic substance calculated as carbon, to the exclusion of any other added substance. One acceptable method for determining the combustible content is noted at Reference 11 (Appendix H). Alternative methods may be used where shown to be acceptable.

At a high level, the following hierarchy of “Good Practice” may provide a useful framework for the consideration of risk controls appropriate to AN:

Hierarchy	Preventative Controls
Eliminate (or Reduce)	Minimise the amount of AN stored.
Substitute	N/A
Isolate	Situate the AN site at appropriate safety separation distances from other external activities. Segregate AN from heat sources or hot work. Segregate AN from other activities. Segregate AN from fuels; fuels stored in appropriate containers. Segregate AN from incompatible chemicals.
Engineering Controls	Construction of AN storages from non-combustible materials. Fire extinguishers provided at approved locations. Electrical equipment standards.
Administrative Controls	Only store AN in approved locations and containers. Do not exceed licence limits. Minimise stock holding to as low as reasonably practicable. Trained operators. Do not leave powered equipment with on-board fuel parked in an AN storage area.

	Do not allow rubbish, vegetation or combustible materials to accumulate in AN storage areas or near AN stacks – this includes wooden pallets if not in use. Control any changes using the Change Management process. Maintain and practice evacuation plans. Maintain fire extinguishers and related signage. Maintain electrical systems. Maintain Permit systems for hot work. Maintain evacuation / exclusion zones. Notify emergency services of evacuation / exclusion zones.
PPE	Standard site PPE, such as boots, long pants, long sleeves and safety glasses are only suitable for initial firefighting with extinguishers. They are not suitable for fighting any intense fires. (Fires significantly involving AN shall not be fought as evacuation is required.)

This Code is not intended to limit continuous improvement and innovation, and does not preclude the use of novel materials, designs, methods of assembly, procedures and the like that do not comply with a specific requirement of the Code, or are not mentioned in it, but which can be shown to give equivalent or superior levels of safety to those specified. Where one or more specific requirements of this Code are not met, either due to innovation or for another reason, a detailed risk assessment should be undertaken to demonstrate that the risk is acceptable. The level of detail required by the risk assessment and what is deemed acceptable risk will need to be discussed and agreed with those authorities who will have ultimate responsibility for approving and/or licensing the activity.

The philosophy of AEISG is that codes such as this should be continuously improved over time, and users are encouraged to submit comments and suggestions to AEISG.

This Code applies to new AN premises from its date of publication but is not intended to be applied retrospectively. Any premises that fall within the scope of this Code which are operating with a current valid licence and complying with applicable regulations may continue to operate unchanged.

Photo 1: typical AN prills

2.0 Definitions

Many of the terms used in this Code have the same meanings as are defined in other codes or standards. In these cases, the origin is explained via the table notes. Undefined terms have their plain English meaning.

Term	Meaning	Origin / Notes
AN	Solid Ammonium Nitrate in Division 5.1 – Oxidising Substances, as tested and classified into United Nations numbers UN 1942 or UN 2067, as specified within the most recent editions of *the Australian Code for the Transport of Dangerous Goods by Road and Rail* (National Transport Commission), and the *Recommendations on the Transport of Dangerous Goods: Model Regulations* (published by the United Nations).	1
Bin	A weatherproof structure capable of receiving and discharging bulk solids. May be fabricated metal, concrete or other material.	1
Bulk	Not in a package.	2
Bunker	A partially enclosed storage space with at least two walls, inside a bulk storage building.	1
Combustible materials	Materials that can contribute to sustaining a fire.	2
Compatible	Materials that are known to be safe to mix or come into contact with AN without: 1) reacting to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours, or 2) interacting with the AN so as to increase the hazard.	1
Contaminated AN	AN which does not meet the definition of Uncontaminated AN.	1
Dome	(Also known as dome shelter, or igloo) A type of structure generally consisting of plastic sheet material stretched over a curved structural metal framework. (See photos in Section 3)	1
ES	Exposed Site: a location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosion site (PES). (This is the term used in the IMESAFR blast modelling software.)	5
IBC	Intermediate Bulk Container (which includes both rigid and flexible).	1 (IBCs are more comprehensively defined and described in the ADG Code)

Term	Meaning	Origin / Notes
Igloo	Another name for a dome shelter.	1
Incompatible	Materials which if they mix with or come into contact with AN may: • react to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours, or • interact with the AN so as to increase the hazard.	1
Loose Bulk AN	Refers to AN that is not contained in a package or an IBC.	3
Major Hazard Facility (MHF)	The model WHS Regulations define a MHF as a facility: 1. at which Schedule 15 chemicals are present or likely to be present in a quantity that exceeds their threshold quantity 2. that is determined by the regulator to be a MHF.	From Safe Work Australia website
Metal Shed	Building constructed from metal cladding over a steel frame.	1
Mobile Processing Unit (MPU)	For the purposes of this Code an MPU means a vehicle-mounted processing plant which carries raw materials required to manufacture or blend a Class 1 explosive and incorporates a blast-hole delivery system for the finished product. It includes charge cars and kettles used mainly in underground applications to charge blast-holes.	4
Overhead Silo	(See also "silo") A type of silo with the lowest AN-containing parts at least 3m above surrounding ground level	1
PEMB	Pre Engineered Metal Building (This is the term used in the IMESAFR blast modelling software to describe a metal shed, as defined above.)	5
PES	Potential Explosion Site: the location of a quantity of material (in this code AN) that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents. (This is the term used in the IMESAFR blast modelling software.)	5
Pile	Loose bulk AN irrespective of what type of store it is in.	1
React Dangerously	React to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours.	1
Reasonably Practicable	An action is reasonably practical if the cost and effort of doing it is not grossly disproportional to the benefit gained.	1

Term	Meaning	Origin / Notes
Significant fire	A fire that affects a substantial amount of AN sufficiently to potentially cause decomposition or fumes or explosion.	1
Significantly involved	(In the context of AN being significantly involved in a fire) AN is significantly involved if a substantial quantity is exposed to the fire and is being heated enough to potentially or actually melt and/or evolve fumes or vapours. Evolution of fumes is a sign that the fire is out of control.	1
Silo	An above-ground, tower-like, weatherproof structure capable of receiving and discharging bulk solids. (See also "overhead silo".)	2
Stack (of AN)	A number of packages, pallet-loads, intermediate bulk containers or freight containers (of AN) grouped together, but without racking or other supporting structures.	1 (derived from AS 4326)
Sympathetic Initiation	An explosion initiated by the effects of a prior explosion nearby.	1
Uncontaminated AN	AN which: • has not been removed from the packaging, IBC or bulk container in which it was delivered to the site; or • is inside handling equipment or in a bulk store, and where there is no evidence of contamination (e.g., visible contaminants, apparent heat/fumes); or • has been immediately recovered from a clean impervious surface after a spillage.	1

Notes to definitions table:

1. This definition was written for this Code.
2. Definition from AS 4326-2008: The storage and handling of oxidizing agents.
3. Definition from Safe Storage of Solid Ammonium Nitrate (Fourth Edition, 2021) published by Department of Mines, Industry Regulation and Safety, Western Australia.
4. Definition from AEISG Code of Practice MOBILE PROCESSING UNITS Edition 4 September 2018.
5. Definition from IMESAFR Version 2.1 User's Reference Manual 3rd Edition

Photo 2: FIBC's of solid AN (Australian EIP labelling)

3.0 AN Store Design and Construction

3.1 Types of Store

AN is typically stored in the same form in which it is delivered. It may be delivered to a store as loose bulk or it may be in some kind of package or container. Permitted configurations of AN stores are summarised in Table 3.1.

Photo 3: Bulk AN truck being emptied

Photo 4: Dangerous Goods vehicle loaded with bags of AN

Most AN stores are dedicated - i.e., they are not used to store any substance other than AN, but this code does not prohibit co-storage (i.e., the storage of other substances in an AN store) provided such co-storage is permitted by Table 3.1, and subject to complying with further requirements detailed in 4.3. However the entire store shall meet the requirements of this Code irrespective of the amount of AN in relation to co-stored material.

Table 3.1: Types of AN Store

Type	**Permitted Configurations**			
	Packages (including IBCs) without pallets	**Packages (including IBCs) with pallets**	**Loose Bulk**	**Co-storage (of other substances) permitted**
Stand-alone storage building	Yes	Yes	Yes	Yes
A store within or attached to another building	Yes (Up to 10 t AN)	Yes (Up to 10 t AN)	No	Yes
One or more silos, bins or similar structures, outside	Not Applicable (NA)	NA	Yes	NA
One or more freight container(s)	Yes	Yes	Yes	No
Open (may be covered by a tarpaulin or similar)	Yes	Yes	No	No

Photo 5: Overhead silo

Photo 6: AN bins

A type of structure known as a dome or igloo (see photos) has become popular in recent years for use as a store for AN in IBCs. In some cases this kind of structure is supported on shipping containers that form walls of the structure. For the purpose of this Code, such structures, with or without shipping containers, shall be treated as a type of building.

Photo 7: Igloo secured to containers

Photo 8: Igloo storage

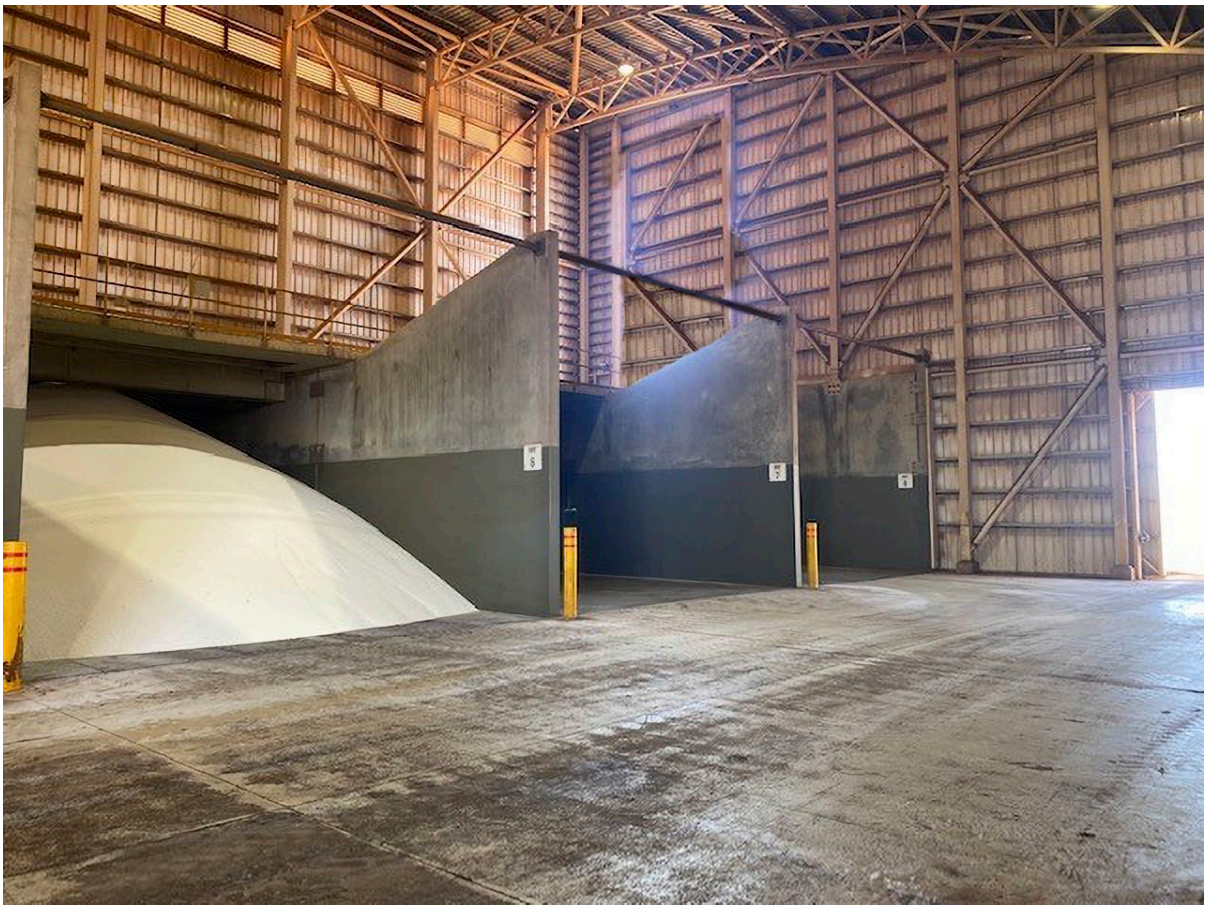


Photo 9: Pile of AN in a type of bunker known as a "squash court"

Photo 10: Open AN store with tarps over stacks

3.2 General Requirements

The requirements in this section apply to all types of store. There are some other requirements which only apply to particular types of store, and these are detailed in 3.4 and 3.5 below. (There are no further requirements for types of store not covered by 3.4 or 3.5.)

1. Explosives or detonators shall not be used to break up caked AN.
2. Buildings and structures containing AN shall as far as reasonably practicable be made from non-combustible materials, with the following exceptions:
    a) Where a combustible material (e.g., timber) forms a substantial part of the construction of a building, the non-combustibility requirement may be satisfied by the use of a suitable non-combustible coating.
    b) A timber frame with non-combustible internal and external cladding is deemed to meet the non-combustibility requirement.
    c) Wooden floors in shipping containers are permitted as they represent a relatively minor fuel load.

    This clause does not preclude the use of plastic packagings, tarpaulins or similar materials, such as dome covers, nor the use (in the construction of the store) of small quantities of combustible materials such as plastic-sheathed electrical cabling, wooden door frames, rubber or plastic hoses, and the like, since such materials represent a relatively minor fuel load.
3. Every AN store shall have a clear area of at least 5m surrounding it, with no vegetation, combustible materials, parked vehicles, or non-associated equipment within this area. Trees should be cleared for a distance of at least 15m or 1.5 times the height of the trees if greater.
4. Unused wooden pallets, empty bags, and packaging shall be removed promptly from the AN store and kept at least 5m from the store.
5. Pallets, ropes, covers or other equipment shall be prevented from becoming impregnated with AN.
6. Any spills from on-site flammable or combustible liquid storages, if not retained within a secondary containment, shall be designed to flow away from stored AN.
7. Any spillage, solid or liquid (including flow paths), from on-site storages of any substance which is incompatible with AN (and is not a co-storage inside an AN store as permitted under section 4.3) shall be kept at least 5m away from any AN store. A list of incompatible substances is included in Appendix G.
8. In any conceivable fire there shall be sufficient venting provided to enable the release of fumes without any significant pressure build-up. Note: for buildings, the ventilation required for occupational health and safety as a workplace is adequate to meet this requirement.
9. Molten AN from any conceivable fire shall flow away from the AN store in a known safe direction, to an area where it can be recovered after solidification and shall not become confined (e.g. in covered drains, pipes or tunnels).
10. Any materials or fittings likely to come into direct contact with AN (excluding dust) in normal operation or due to spillage shall not contain copper, zinc or other known incompatibles unless suitably protected (e.g., by an appropriate coating). For clarity, galvanized steel and metal sheeting coated with zinc or zinc alloys do not normally require protection from contact with AN if the only likely contact is airborne dust, but the possibility of accelerated corrosion and structural weakening should be taken into account in deciding whether protection is required.
11. Where there is a risk of internal corrosion from AN dust, electrical equipment shall have a rating of not less than IP55 in accordance with Australian Standard 60529-2004: Degrees of

Protection Provided by Enclosures (IP Code). In dusty situations (e.g., some bulk stores) service life of electrical equipment may be improved by adopting IP65.

12. Where reactive or hot ground conditions may exist, measures shall be in place to ensure stored or spilled AN is not affected by it.
13. The store layout shall be such as to permit the unimpeded exit of personnel and vehicles.

3.3 General Recommendations

1. In addition to the minimum 5m combustible-free area required around every AN store by 3.2.3, AN stores should be located away from possible sources of fire, explosion, or excessive heat, such as oil storages, gas or fuel pipelines, timber yards, flammable liquids, flammable solids, and large electrical transformers. It should be noted that old areas of coal mines may be susceptible to spontaneous combustion.
2. Adequate weather protection should be provided to reduce the likelihood of AN deteriorating due to moisture absorption or heat cycling.
3. Where reasonably practicable, AN stores should not be located at low points where fuels could accumulate below or around them, and should be kept dry and free from water seepage (but this may not be reasonably practicable for igloos or similar open-ended or open-sided structures).
4. Given AN's tendency to cake, appropriate measures should be in place to ensure that it is not stored for longer than necessary, especially when stored loose, such as in a silo.
5. Where reasonably practicable, any spills from on-site flammable or combustible liquid storages, even if retained within a secondary containment, should be designed to flow away from stored AN.
6. Any materials or fittings likely to come into extended contact with AN in normal operation or due to spillage should be suitably corrosion resistant or protected. In particular, mild steel that may come into contact with AN should be protected to prevent accelerated corrosion. Note that AN does not react dangerously with zinc, but does cause corrosion; galvanised steel should therefore be protected from direct contact to prevent structural weakening, and to prevent corrosion products from contaminating the AN.
7. Concrete floors are recommended in AN storage buildings containing loose bulk AN.
8. It is recommended that all concrete (in particular floors and foundations) which may be exposed to AN is protected by the use of suitable additives or coatings.
9. This Code does not require lightning protection for AN stores, but if lightning protection is being considered (e.g., to protect personnel or equipment) the methodology specified in Australian Standard AS/NZS 1768: Lightning Protection should be followed. In assessing the level of lightning protection required, AN is deemed to be non-flammable, non-combustible and non-explosive. (See also 4.5.4: response to the approach of lightning.)
10. Wooden or other combustible pallets are not prohibited but constitute a fuel source, which, along with any other combustibles that may be present should be allowed for in assessing fire risk and planning emergency response.
11. Where stores have a floor area greater than 250 m^2, at least two means of egress should be provided.
12. Extra ventilation is generally considered advantageous, and it is preferred to avoid blocking any vents (e.g., if stacks are located against walls).
13. There is no direct requirement to separate AN stores from site boundaries, but it is recommended that stores be sufficiently clear of boundaries to ensure that the 5m clear zone required under 3.2.3 can be maintained irrespective of property ownership or occupancy.

14. Where there is a risk that light fittings may fall (e.g., due to corrosion of mountings) and cause sparks, ignition or injury, it is recommended that the light fittings have additional safeguards to prevent falling.
15. Sealed hollow sections (e.g., steel handrails, or pipes used as structural members, welded in such a way that the hollow section is sealed) have been known to develop cracks, allowing AN to enter. There have been accidents where welding activities have caused localised explosions. It is therefore recommended that such hollow sections are avoided in situations where AN is likely to penetrate any cracks, or should have holes drilled in locations that allow venting and/or flushing.

3.4 Additional Requirements for Storage in a Building

1. AN shall be stored on a level with immediate ground access from outside the building.
2. The building shall be adequately ventilated, taking into account the likely amounts of dust and any vehicle exhaust.
   NOTE: Ventilation should be sufficient to maintain exposure levels to any fumes or dusts in the storage area below recommended workplace exposure standards.
3. Access and escape routes shall be clearly defined and kept clear.
4. A bulk store building floor shall not be earth or compacted road base or any bituminous material.
5. A package store building floor shall be of concrete, compacted road base, low bitumen (less than 9%) asphalt, earth, or other suitable materials.
6. A package store building floor shall be sufficiently impervious to allow spilled AN to be readily recovered without contamination.
7. Naked flames shall not be permitted inside AN store buildings (except under a hot work permit), and notices to this effect and prohibiting smoking shall be displayed at each entrance.
8. Where an AN store is either attached to or located inside a building which may be used for any purpose other than the storage of AN (and any permitted co-storage material):
   a. the store shall have a maximum capacity of 10 tonnes
   b. the store shall be isolated by a horizontal distance of at least 5m that is left clear (Figures 3.3a, 3.3b). This distance may be measured around a wall extending 1m above the roof of the AN store and having a 240/240/240 fire resistance level (FRL), as per the National Construction Code of Australia (Figures 3.3c, 3.3d).
9. If an AN store is located inside a building, at least one wall of the store shall be an external wall of the building, constructed to allow:
   a. natural ventilation and the escape of potential decomposition gases;
   b. molten AN to flow clear of the building in the event of a fire; and
   c. firefighting using water jets from outside the building.

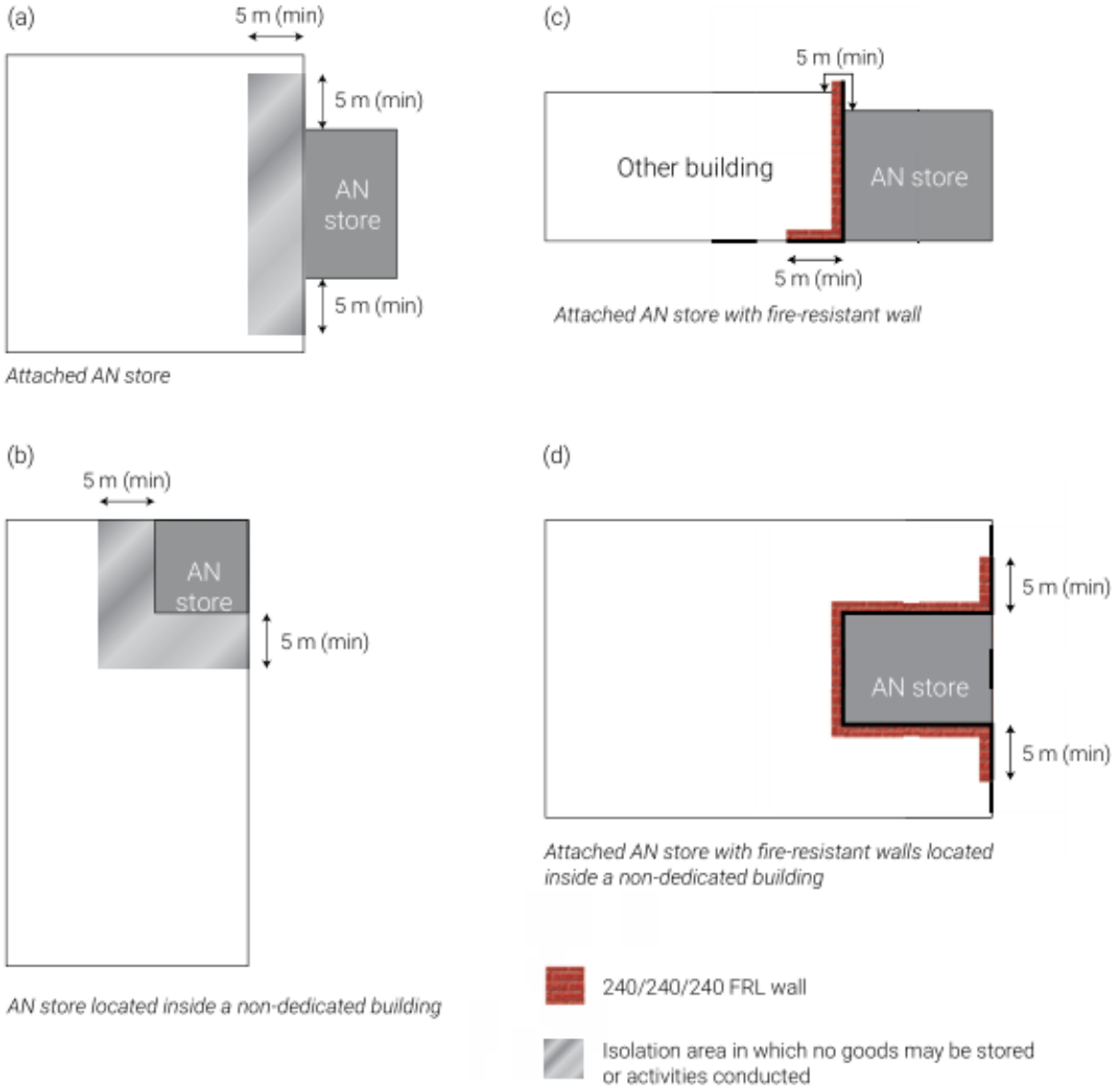


Figure 3.3 Examples illustrating the required isolation of AN stores of 10 t or less

3.5 Additional Requirements for Storage in a Silo or Bin, or Similar Structure

1 Silos (including overhead silos), bins and similar structures shall be designed and constructed to be capable of resisting all foreseeable forces to which they may be exposed. It is important to take into account AN's tendency to cake and allow for impact stresses from large, caked portions falling within the structure.

2 To facilitate clean-up of spilled AN, areas of transition where spillage of AN is likely in normal operation shall be made from materials that are impervious and easy to clean, such as concrete, painted concrete, steel, or similar.

4.0 AN Store: Operation

4.1 Regulatory Approval

Any AN store shall not be put into operation before all required licences or other formal approvals from relevant regulators have been granted.

4.2 Size and Arrangement of Stores, Stacks, and Piles

1. While this Code does not mandate a limit to the size of an AN store, stack, or pile, it should be noted that subdividing a store into smaller stacks or piles (sufficiently separated to prevent sympathetic initiation) will reduce the size of a worst-case explosion and the distances at which the effects of such an explosion would be felt. Section 5 details sufficient stack separation.
2. Notwithstanding clause 1 above, it is recommended that large stores be suitably divided into separate stacks or piles to facilitate stock rotation, improve access, and limit the extent of an event, such as a contamination incident.
3. This Code does not mandate any limit to the height of stacks of packages (including IBCs) of AN, but the following requirements shall be met:
    a. stacks shall be stable and safe from toppling or the risk of stock movement;
    b. stack heights shall not exceed the stacking limits specified for the packaging being used;
    c. stack heights shall be suitable for the handling equipment being used; and
    d. in a building, clearance from the roof and other structural components shall be adequate for operational requirements of the store.
4. In a package store building where AN is stored on combustible pallets, there shall be an access way of at least 600mm free air space between the stored AN and the outer walls of the building.
5. In a package store building where AN is stored without combustible pallets there is no requirement for stacks to be separated from walls, provided the walls are structurally adequate to support any foreseeable load (e.g., from collapsed stacks) and provided requirement 3.2.13 (unimpeded exit of personnel and vehicles) is met.

4.3 Co-storage of Other Substances or Materials Inside an AN store

1. Class 1 explosives shall not be stored in an AN store. If AN is co-stored with or in the immediate vicinity of Class 1 explosives the requirements of AS 2187 apply.
2. Some (but not all) compatible and incompatible substances and materials are listed in Appendix G. Substances and materials not listed shall be assumed incompatible unless proven to be compatible.
3. Where co-storage is permitted in an AN store (as detailed in Table 3.1):
    a. Compatible substances or materials are permitted but shall be segregated within the store by a minimum 5m distance; and
    b. Incompatible substances or materials are only permitted based on a site-specific risk assessment, provided they are not combustible and do not react dangerously with AN. Such substances or materials shall be segregated within the store by a minimum 5m distance and there shall be arrangements to ensure there is no mixing under normal or abnormal conditions, including spillage.

4.4 Other materials in an AN store

1. Fire extinguishers, spill kits, eyewash kits, first aid kits, brushes and shovels, etc, may be kept in an AN store provided they do not contain significant quantities of any incompatible substance as listed in Appendix G.
2. Unpowered tools and equipment routinely used during store operation and removed from the store when no longer in use are deemed to be compatible. This applies even though some items may contain materials that would otherwise be incompatible.
3. Chemicals such as cleaning fluids shall be assessed and only permitted if they do not react dangerously with AN.

4.5 Safety and Security Management System

Every holder of a licence to store AN shall have in place a safety and security management system (SSMS) covering all activities related to the storage of AN from receipt at the store through to despatch from the store, as appropriate to the licence holder's activities.

The SSMS shall be documented and meet local regulatory requirements. AS/NZS 4804-2001 should be used as guidance. The SSMS shall include at least the following elements:

1. A Safety Policy;
2. A Safety and Security Management Plan;
3. Training;
4. Operating Procedures covering each AN premises; and
5. Procedures to control all transfers of custody of AN (including waste).

The SSMS shall be implemented in such a way that the relevant requirements of this Code are met at all stages of the lifecycle of the AN relevant to every AN premises.

The SSMS shall apply to all employees and contractors involved in any aspect of AN storage, handling or on-site transport, and to all visitors to AN premises.

4.5.1 Safety Policy

This is generally a short public formal statement of policy by the Chief Executive Officer of the organisation which sets out the safety expectations of the organisation and outlines how these will be achieved.

4.5.2 Safety and Security Management Plan (SSMP)

The SSMP shall include the following features:

1. regular safety meetings for all employees with minutes and actions recorded;
2. a schedule of audits covering safety and security at all AN premises and a system to initiate corrective or improvement action whenever deficiencies are identified;
3. a system for reporting, investigating and learning from accidents and incidents, including management reporting, analysis and review and continuous improvement and a process for reporting significant incidents to regulatory authorities;
4. Emergency Response Plans (ERP) for each AN premises, which shall be reviewed (and updated as appropriate) at least annually;
5. Risk Assessment(s) for all new AN stores and/or premises; and
6. a system for change management.

4.5.3 Training

As part of the SSMS, training systems are required in the following areas:

1. induction for new employees, contractors and visitors, including use of PPE, any specific hazards on site, the evacuation plan, the location of first aid stations, communications, hot work permits, confined space entry, and any other additional safety or environmental considerations applicable to the site;
2. an employee training system, covering standard operating procedures (SOP), site specific procedures and job responsibilities This should include training specific to the hazards and controls relating to AN storage, including precautions against fire and precautions against contamination. The system shall include documentation of training, re-training and verification of competency;
3. a system to train employees in the correct procedures for the selection, maintenance and use of PPE; and
4. emergency response plans.

4.5.4 Procedures

Procedures shall be in place to cover the following:

1. obtaining SDSs for all chemicals on the site;
2. preparing SOPs for all routine tasks, including maintenance of (as a minimum) all powered AN handling equipment;
3. control of lock out/tag out, confined space entry and hot work permits. This shall include, as a minimum, training, documentation, responsibilities and identified authorisation levels;
4. authorisation of all processes being conducted on site, including commissioning and waste disposal;
5. inspection and cleaning of AN storage and handling equipment. (Note that unnecessary cleaning should be avoided to limit generation of waste.);
6. control of the modification of processes and equipment (change management);
7. control of all non-routine work or tasks (i.e., without an SOP)
8. safe disposal of waste materials (recognising that waste may still be SSAN);
9. response to the approach of lightning. (Note that for the purpose of assessing lightning risk AN is deemed to be non-flammable, non-combustible and non-explosive, and as such the presence of AN at a site does not create any requirement to evacuate at the approach of lightning.);
10. no parking of Class 1 explosives vehicles close enough to potentially cause sympathetic initiation of AN. Generally this will mean that vehicles transporting Class 1 explosives are not permitted to park within the AN premises;
11. managing all aspects of custody transfer (in or out) of AN, including ensuring that AN is only released into the custody of persons or organisations which are:
    a. appropriately licensed;
    b. aware of the requirements of this Code; and
    c. likely to comply with regulatory requirements and this Code (to the best knowledge of the person or entity handing over custody of the AN).

4.5.5 Emergency Response Plan (ERP)

An Emergency Response Plan (ERP) shall be in place as further detailed in Section 9.

4.5.6 Other

Other items which should be covered by the SSMS include:

1. a chemicals register containing SDS for all chemicals;
2. placarding and signage of all dangerous goods;
3. first aid system including the provision of first aid boxes and a list of personnel trained to provide first aid. Ideally, at least one person working at the site should be trained in first aid;
4. supervision of visitors and contractors in all areas where AN is stored;
5. vehicle operation, control and maintenance system;
6. non-smoking policy;
7. non-drug and alcohol policy;
8. management of critical equipment systems;
9. hot work (work involving open flames or risk of creating sparks); and
10. system to check trips and alarms, including the documentation of test results.

5.0 AN Store: Location and Layout

5.1 General

In the absence of control measures, stored AN has some risk of an explosion, which may be initiated by one or a combination of fire, contamination and shock (including impact from a high-energy projectile). In general, for any well-managed store which complies with the requirements of this Code, the risk of explosion is negligible, but despite this (and usually because a store has not been well-managed) catastrophic explosions of ammonium nitrate have continued to occur around the world. In light of that situation, the basic requirement of this Code is that AN Stores shall not be located where the risk they pose to surrounding off-site land uses, exceeds the risk criteria specified in this Code.

(The properties of AN, and the hazards associated with it, are more fully reviewed in Appendix B.)

The framework of land uses and individual risk criteria used in this Code is drawn from the NSW Hazardous Industry Planning Advisory Paper No 4: *Risk Criteria for Land Use Safety Planning* (HIPAP 4). The land uses and individual risk criteria are reproduced as Table 5.1.

Table 5.1 HIPAP 4 Land Uses and Risk Criteria

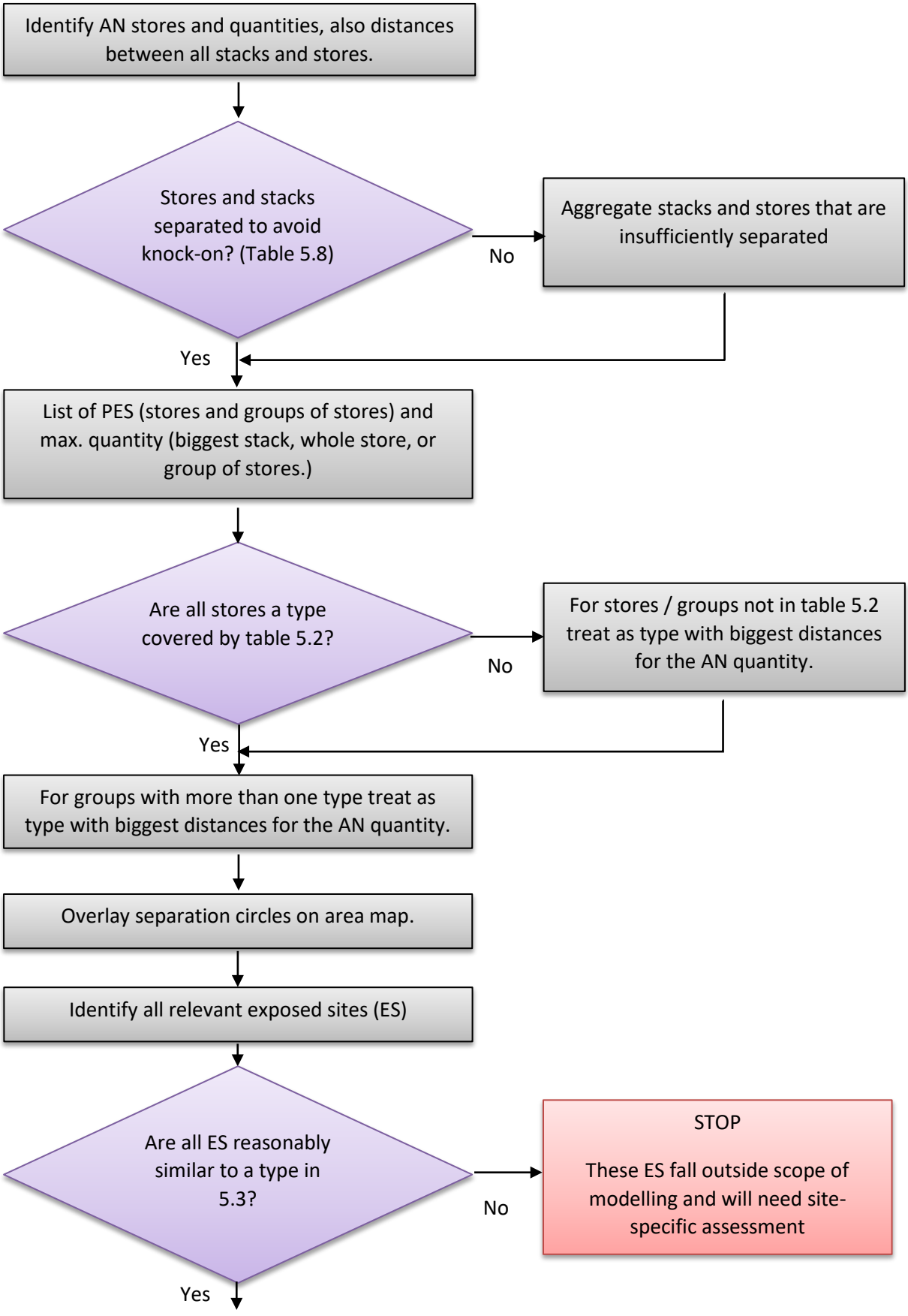
HIPAP 4 Land Use (summary)	**HIPAP 4 Risk Criteria (individual fatality per year)**
Hospitals, schools, child-care facilities, old age housing	0.5 E-6
Residential, hotels, motels, tourist resorts	1 E-6
Commercial developments including retail centres, offices and entertainment centres	5 E-6
Sporting complexes and active open space	10 E-6
Industrial	50 E-6

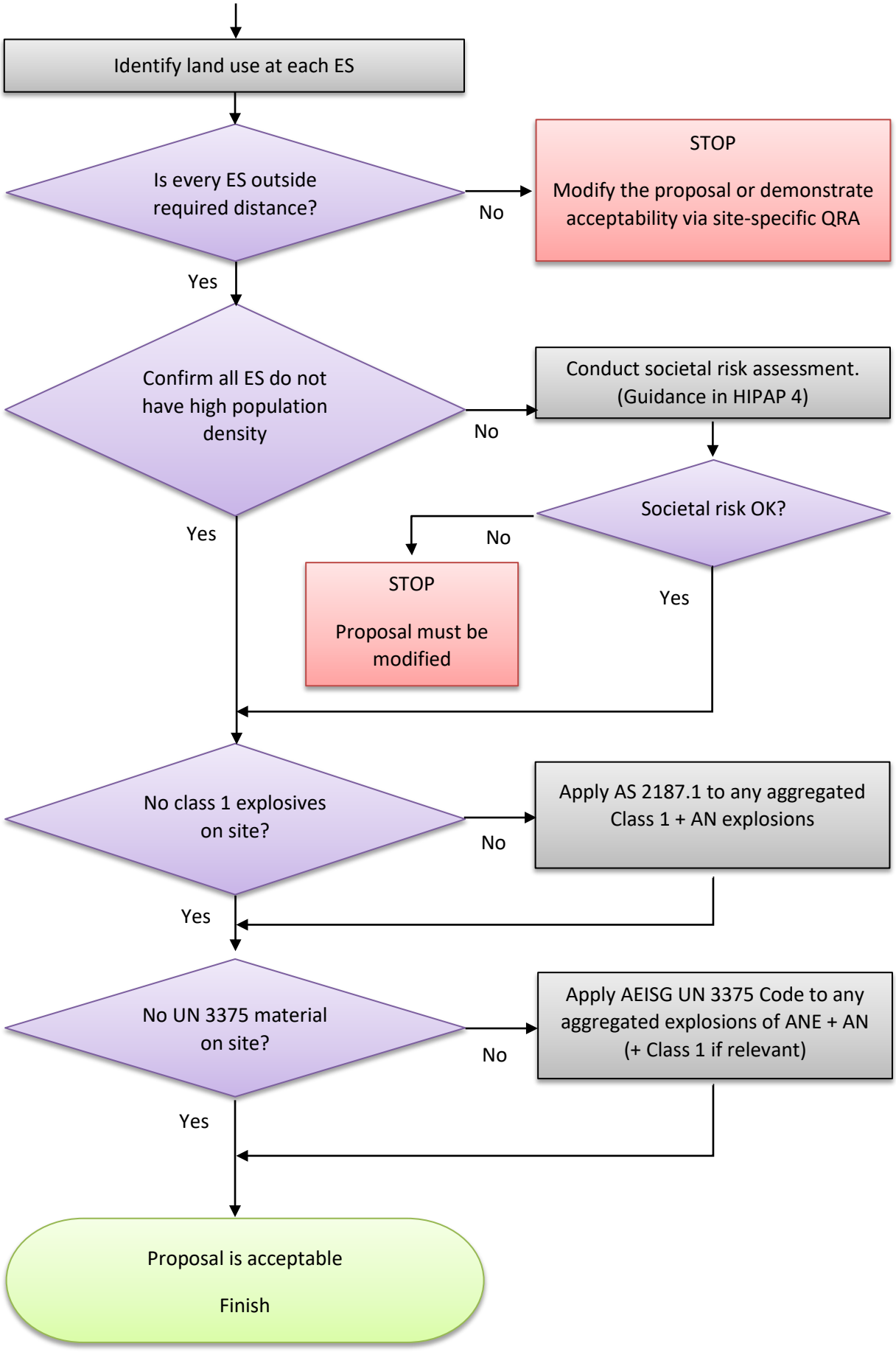
The flowchart in Figure 5.1 illustrates the steps involved in determining whether the separation distances required from an AN store are met. (The flowchart assumes a proposal has been developed, with all AN store locations and relevant distances known, and is being checked for compliance.) For convenience the definitions of two key terms used in the flowchart are repeated here:

PES (Potential Explosion Site): the location of a quantity of material (in this code AN) that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents.

ES (Exposed Site): a location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosion site (PES).

Figure 5.1: Separation Distances Flowchart




Identify land use at each ES
Is every ES outside required distance?
No
STOP
Modify the proposal or demonstrate acceptability via site-specific QRA
Yes
Confirm all ES do not have high population density
No
Conduct societal risk assessment. (Guidance in HIPAP 4)
Societal risk OK?
No
STOP
Proposal must be modified
Yes
Yes
No class 1 explosives on site?
No
Apply AS 2187.1 to any aggregated Class 1 + AN explosions
Yes
No UN 3375 material on site?
No
Apply AEISG UN 3375 Code to any aggregated explosions of ANE + AN (+ Class 1 if relevant)
Yes
Proposal is acceptable
Finish

5.2 Separation Distance Requirements

1. Except for mine site premises and facilities as detailed in clauses 5.2.6 and 5.2.7, separation distances to off-site surrounding land uses shall be either:
   a. At least the distances specified in Tables 5.3 to 5.7; or
   b. Distances that are sufficient (as demonstrated by a Quantitative Risk Assessment (QRA)) to ensure that the individual fatality risks at surrounding land uses meets the relevant HIPAP 4 Risk Criteria (as reproduced in Table 5.1 above).
2. If a QRA is conducted, it is recommended that the methodology detailed in Appendix D is followed.
3. Separation distances shall be applied from each AN stack or store unless the AN in a stack or store does not meet the stack separation distances detailed in Table 5.8 to one or more other stacks or stores, in which case the separation distances shall be applied from the aggregated group of such stacks or stores, based on the combined quantity of AN.
4. Appendix D gives additional background to the considerations relevant to the location of AN stores, and in particular the methodology used to determine the distances detailed in Tables 5.3 to 5.7. The modelling and assessment work carried out in developing the distances highlighted significant differences in the risk depending on the combination of land use and type of AN store. In particular it became apparent that some types of store are consistently of less risk than others. For that reason different distances are specified for different types of AN store.
5. For high population densities, an additional assessment of societal risk may be necessary as Tables 5.3 to 5.7 are based on individual fatality risk. The need for consideration of societal risk may arise for areas with high population density such as large mine camps/mess facilities, large sports stadiums, large shopping centres, or high-rise apartment buildings. HIPAP 4 includes guidance on assessing societal risk.
6. Appendix E provides guidance and examples of typical facilities, especially at mine sites, which may be Exposed Sites requiring separation from stores of AN and recommends how those facilities should be classified (i.e. which land use) for the purpose of determining appropriate separation.
7. For mine site premises or facilities, if the AN storage is permitted by the mine on which it is located:
   a. Where the classification recommended by Appendix E is Vulnerable or Residential the HIPAP4 criteria and the relevant separation distances from Tables 5.3 to 5.7 shall be complied with; and
   b. Where the classification recommended by Appendix E is Commercial, Open or Industrial, the HIPAP4 criteria and Table 5.3 to 5.7 distances are recommended but not mandatory. In such cases, if the recommended distances for Commercial land uses are not reasonably practicable, they may be reduced to the Open distances (which are the same as Industrial). If there are any exposed sites where:
      (1) the land use classification is Commercial, Open or Industrial and
      (2) the Open distances are not reasonably practicable

   then a site-specific QRA should be conducted to determine the most appropriate separation distance that is in keeping with the corresponding risk criteria from HIPAP 4, while seeking to maximise the separation as much as is reasonably practicable.

5.3 Basis of Separation Distances Tables

As detailed in Appendix D, the minimum separation distances in Tables 5.3 to 5.7 were determined using the AN module of a blast-modelling software package called IMESAFR, which analyses the risk to people at an Exposed Site (ES), from an explosion at a Potential Explosion Site (PES). In doing so the software takes account of the physical construction details of both the PES and the ES. (The IMESAFR software is more fully described in Appendix D, particularly D 2.5 and D 2.6.3.) The distances in the tables are always based on AN as the substance that explodes and the PES is always an AN stack, or store, or a group of stacks/stores. AEISG selected five different types of AN store construction to represent a spectrum of different types of store that collectively includes the storage situations commonly encountered in Australasia. Likewise, five different types of ES were defined, again aiming to represent the types of buildings commonly found at sites neighbouring AN stores. Full details of the AN store types and ESs used in the modelling are included at D 4.2 in Appendix D. In summary they are:

AN Store (PES):

1. Overhead Silo(s) (one or more overhead steel silos of nominal 60 tonne capacity)
2. Metal Shed (shed with metal cladding over a steel frame; also known as a PEMB)
3. Open (AN stored in the open)
4. Shipping Container(s) (one or more 20 foot container, assuming a capacity of 20 tonnes per container; also known as ISO(s), or ISO-container(s))
5. Concrete Shed

Exposed Site (ES):

1. Large unreinforced masonry
2. Small unreinforced masonry
3. Small wood frame
4. Large Metal shed (also known as large PEMB)
5. Open (people in the open)

There is one table for each type of AN store, so 5 tables in total (table 5.3 to 5.7). Each table details the minimum separation distances required between that type of AN store and each of the five HIPAP 4 land uses, with the distances based on meeting the risk target applicable to that land use. Note that the tables are based on land uses, not ES types. With one exception, the land uses in themselves generally do not describe or necessarily relate to the type of construction of the ES. For instance, if the land use is "hospital, school, child-care facility or old age housing" a risk target of 0.5E-6 applies. But the physical construction of the ES being used for that land use could be any of "large unreinforced masonry", "small unreinforced masonry", "small wood frame", or even in some cases "large metal shed". The same type of ES could also be used for a residential or commercial or industrial land use, in which case the risk target would be different. **So the distances tabulated are the biggest distance at which the applicable risk target is met for ANY of the types of ES construction that might be used for that land use.**

The one exception mentioned above is for the land use "sporting complexes and active open space", which aligns with just one type of ES ("open") and the distances in tables 5.3 to 5.7 for the sporting complexes and active open space land use are based only on the modelling for an open ES - that is, they are the distances at which the risk target applicable to sporting complexes and active open space is met for people in the open.

For land uses other than sporting complexes and active open space, because the distances are the biggest of four distances – i.e., biggest for any relevant ES type - it is not necessary to establish the construction of the ES - the tabulated distances apply to any structure, provided it is reasonably similar to one of the 4 listed (large unreinforced masonry, small unreinforced masonry, small wood frame, or large metal shed). If there are any ES structures which are NOT reasonably similar to one of these four then the tabulated distances may not apply and a site-specific assessment will be required. Examples where the tabulated distances may not apply are:

- buildings with more than 2 storeys; and
- buildings with more than 40% glass (in the direction of the AN Store)

5.4 Application Notes: Which Separation Distance Table to Use

Table 5.2 gives guidance on which separation distance table should be used, according to the construction of the AN store (and which photo (where one exists) best represents that kind of construction). Most AN stores should be reasonably similar to one of the five types listed, but if the construction of a particular AN store is substantially different to any of the five then, unless guidance is given in Table 5.2, either the most conservative distance for that AN tonnage should be used (i.e., that tonnage in any type of AN Store), or a site specific assessment may be conducted.

Table 5.2 Which Separation distance Table to Use

AN Store Construction (representative photo)	Notes / Details	Which PES Table to use
Overhead silo (60 tonnes) (Photo 5)	Fabricated metal silo with all AN > 3m above ground level, and capacity 60 tonnes.	Table 5.3: AN stored in Overhead Silos
Overhead Silo (capacity other than 60 tonnes) (Photo 5)	Fabricated metal silo with all AN > 3m above ground level, and capacity other than 60 tonnes. Although the modelling was based on 60 tonnes fabricated steel overhead silos, different sizes should make only a minor difference, since the available mass of steel (and therefore the debris hazard) should be similar – e.g., 4 x 30 tonnes silos would have a similar mass of steel to 2 x 60 tonnes silos. For silos made of a lighter metal (e.g., aluminium) or other lighter material (e.g., fibreglass) the debris hazard will be less so the table will be conservative and can be used.	Table 5.3: AN stored in Overhead Silos
Concrete or masonry silo or bin	Any silo (whether overhead or low level) or bin made of concrete or masonry.	Table 5.7: AN stored in Concrete Shed
Non-concrete/masonry silo or bin (Photo 6)	Silo (other than an overhead silo) or bin made of fabricated metal or other non-concrete / non-masonry material.	Table 5.6: AN stored in Shipping Containers
Metal Shed (Up to ~ 250 sq. m area by 3.7m high) (Photo 12, in background)	Shed with metal cladding over a steel frame, with floor area up to 250 sq. m. and walls 3.7m high.	Table 5.4: AN stored in Metal Shed

Big Metal Shed (significantly bigger than 250sq.m. floor area by 3.7m high). (Photo 12, in background)	Modelling for Table 5.4 (AN stored in Metal Shed) was based on a shed of dimensions (L x W x H) 22 x 11 x 3.7m. A shed bigger than the one modelled will have a greater mass of steel available as debris. The shipping container table is based on one container for every 20T of stored AN, so the mass of steel increases with tonnage, and although this table will be conservative for metal sheds it should be used for metal sheds significantly bigger than the one modelled.	Table 5.6: AN stored in Shipping Containers
Open (Photo 10)	AN stored in the open or under lightweight cover, e.g., tarp.	Table 5.5 AN stored in the open
Igloo without shipping container walls. (Photo 8)	Igloo without shipping container walls. Floor may be hardstand (rock / clay) or concrete.	Table 5.5: AN stored in the Open
Shipping Containers	AN stored in shipping containers.	Table 5.6: AN stored in Shipping Containers
Igloo with shipping container walls. (Photo 7)	Igloo with shipping container walls. (Irrespective of the presence or absence of any airgap between stored AN and the shipping containers.) Floor may be hardstand (rock / clay) or concrete.	Table 5.6: AN stored in Shipping Containers
Concrete Shed (up to 900 sqm. by 12m high)	AN stored in a concrete shed.	Table 5.7: AN stored in Concrete Shed
Very large concrete building (significantly bigger than 900sq.m. floor area by 12m high).	Modelling was based on a shed with dimensions (L x W x H) 30 x 30 x 12m, with 100mm reinforced concrete walls and a steel panel roof. A significantly bigger shed would have a greater mass of concrete available as debris, which is generally more hazardous (although this is not a given). The issue of significance is the mass of debris available - so a shed with double the perimeter but half the height would have similar mass, and table 5.7 would apply. And a shed with walls of lower density than poured concrete (e.g., "breeze blocks") would have lower mass for the same dimensions. So some judgement is required in deciding whether table 5.7 may be applied.	Table 5.7: AN stored in Concrete Shed OR Site-specific assessment required.
Building with masonry walls (bricks / blocks).	With any type of roof.	Table 5.7: AN stored in Concrete Shed
Composite construction. (Photo 9)	With significant masonry or concrete – e.g., masonry or concrete lower walls with portal frame/metal cladding above.	Table 5.7: AN stored in Concrete Shed

5.5 Minimum Separation Distances for AN Stores: Table 5.3 to 5.7:

The tables use the AEISG Short Name to represent the full HIPAP 4 Land Use descriptions as follows:

AEISG Short Name	HIPAP 4 Land Use description
Vulnerable	Hospitals, schools, child-care facilities, old age housing
Residential	Residential, hotels, motels, tourist resorts
Commercial	Commercial developments including retail centres, offices and entertainment centres
Open	Sporting complexes and active open space
Industrial	Industrial

Notes to Tables 5.3 to 5.7

1. For the purpose of the tables, "Quantity of AN Stored" means the total quantity of AN stored at maximum licensed capacity in the biggest stack within a store or in the aggregated group of stacks and/or stores, as detailed in 5.2.3.
2. The HIPAP4 Risk Criteria are expressed as individual fatality risk per year.
3. Quantities shown without an asterisk are based on specific modelling, as detailed in Appendix D. Quantities shown with an asterisk are interpolated on a straight-line basis between the nearest modelled values.
4. Distances are rounded (up or down) to the nearest 5m.
5. For quantities of stored AN which are not tabulated, interpolation may be used to calculate the required distance.
6. Distances apply on an edge to edge, not centre-to-centre basis (i.e., to the shortest distance between any part of the boundary of the AN store or group of stores and the edge or boundary of the exposed site; if the exposed site is open and has no boundaries the distance applies to the nearest point where people are likely to be present).

Table 5.3: Separation from AN stored in Overhead Silo(s)

AEISG Short Name	Vulnerable	Residential	Commercial	Open	Industrial
HIPAP 4 Risk Criterion	5.0E-7	1.0E-6	5.0E-6	1.0E-5	5.0E-5
Quantity of AN stored (tonnes)	Minimum Distance Required (metres)				
10	130	100	55	20	20
20	165	135	75	25	25
30*	190	155	85	30	30
40	210	180	100	35	35
50*	220	190	105	35	35
60	235	205	115	40	40
80*	260	225	130	45	45
100	285	250	145	45	45
120*	305	265	160	55	55
140	320	285	170	65	65
160*	330	295	180	70	70
180*	345	305	185	75	75
200	355	315	195	80	80
300	385	355	225	100	100
400*	435	375	250	110	110
500	480	395	270	120	120
750*	555	455	305	145	145
1000	630	515	345	170	170

Table 5.4: Separation from AN stored in a Metal Shed

AEISG Short Name	Vulnerable	Residential	Commercial	Open	Industrial
HIPAP 4 Risk Criterion	5.0E-7	1.0E-6	5.0E-6	1.0E-5	5.0E-5
Quantity of AN stored (tonnes)	Minimum Distance Required (metres)				
10	300	250	125	75	75
20	325	265	140	90	90
30*	335	275	160	95	95
40	345	285	175	95	95
50*	355	295	185	105	105
60	365	305	190	110	110
80*	380	320	205	115	115
100	400	340	220	120	120
120*	415	355	230	125	125
140	430	370	240	130	130
160*	445	380	250	135	135
180*	460	395	260	135	135
200	475	405	265	140	140
300	540	450	295	160	160
400*	590	490	320	170	170
500	640	530	340	185	185
750*	Distances not modelled; tonnage not feasible in building modelled.				
1000					

Table 5.5: Separation from AN stored in the Open

AEISG Short Name	Vulnerable	Residential	Commercial	Open	Industrial
HIPAP 4 Risk Criterion	**5.0E-7**	**1.0E-6**	**5.0E-6**	**1.0E-5**	**5.0E-5**
Quantity of AN stored (tonnes)	**Minimum Distance Required (metres)**				
10	170	155	110	70	70
20	230	200	145	90	90
30*	265	235	165	105	105
40	300	265	190	120	120
50*	330	290	205	130	130
60	355	315	220	145	145
80*	395	350	245	160	160
100	430	385	270	175	175
120*	455	410	290	185	185
140	480	435	305	200	200
160*	500	455	320	210	210
180*	520	475	335	220	220
200	535	490	350	230	230
300	610	560	410	270	270
400*	655	600	450	300	300
500	700	635	485	330	330
750*	775	695	535	375	375
1000	855	750	580	420	420

Table 5.6: Separation from AN stored in Shipping Container(s)

AEISG Short Name	Vulnerable	Residential	Commercial	Open	Industrial
HIPAP 4 Risk Criterion	**5.0E-7**	**1.0E-6**	**5.0E-6**	**1.0E-5**	**5.0E-5**
Quantity of AN stored (tonnes)	**Minimum Distance Required (metres)**				
10	290	245	135	100	100
20	320	280	175	125	125
30*	360	310	205	150	150
40	400	345	230	175	175
50*	425	370	250	190	190
60	450	390	265	205	205
80*	485	420	285	225	225
100	515	450	310	245	245
120*	530	470	325	265	265
140	545	490	340	280	280
160*	555	500	350	290	290
180*	565	515	360	300	300
200	575	525	370	310	310
300	610	565	420	350	350
400*	625	585	450	380	380
500	640	605	480	415	415
750*	670	635	515	455	455
1000	695	660	550	495	495

Table 5.7: Separation from AN stored in a Concrete Shed

AEISG Short Name	Vulnerable	Residential	Commercial	Open	Industrial
HIPAP 4 Risk Criterion	5.0E-7	1.0E-6	5.0E-6	1.0E-5	5.0E-5
Quantity of AN stored (tonnes)	Minimum Distance Required (metres)				
10	430	405	320	275	275
20	475	445	350	305	305
30*	505	470	370	320	320
40	530	495	390	335	335
50*	545	510	400	345	345
60	560	525	415	355	355
80*	585	545	430	370	370
100	605	565	445	385	385
120*	620	575	460	395	395
140	635	585	470	405	405
160*	640	595	475	410	410
180*	650	600	485	415	415
200	655	610	490	425	425
300	670	635	520	445	445
400*	680	650	535	460	460
500	695	670	550	475	475
750*	730	685	565	490	490
1000	765	700	580	500	500

5.6 Stack / Pile Separation

If stored AN is subdivided into separate stacks or piles and one stack or pile were to explode, and if adjacent stacks or piles are unaffected by the circumstances that caused the initial explosion, the likelihood of the explosion causing sympathetic initiation (knock-on) of adjacent stacks or piles is influenced by four significant factors:

- The distance between stacks/piles (smaller distance increases likelihood).
- The density of the AN (lower density increases likelihood).
- The shape of the edges of the stacks (closer to vertical increases likelihood).
- The effect of any physical barrier between stacks (barriers generally reduce likelihood).

5.6.1 AN Stacked with a Physical Barrier

Physical barriers between stacks of AN are not common, but in some stores piles or stacks may be separated by concrete or other walls (e.g., concrete walls between compartments of a bunker), and any such wall may have some effect as a physical barrier. However, there is no accepted methodology for assessing the effect of physical barriers between stacks. If such physical barriers exist:

1 their effect on required stack separation shall be ignored and Table 5.8 shall apply, or
2 any reduction in stack separation due to the physical barrier shall be analysed and justified.

5.6.2 AN Stacked without a Physical Barrier

For all types of store, if stacks or piles without physical barriers are not separated by at least the distances detailed in Table 5.8, it shall be assumed that an explosion in one stack or pile will propagate to adjacent stacks/piles. (These distances are as specified in the SAFEX Good Practice Guide.)

Table 5.8: AN Stacks or Piles without Physical Barriers

Slope of stack edge (from vertical)	Stack separation (m) required for AN density (g/cc)			Examples – AN stored:
	Low <0.75	Medium 0.75 to 0.85	High >0.85	
Steep sided (< 45° from vertical)	16	9	1	• In IBCs stacked with small (e.g., half-bag) setback on successive layers • In silos • In freight containers (including a single layer of containers) • Against steep or vertical retaining walls (e.g. walls of bunkers)
Shallow sided (45 ° or more from vertical)	9	7	1	• In IBCs in single layers • In IBCs stacked with 1 to 1.5 bag setback on successive layers
Undefined	"Toes" of unsupported piles shall not overlap			• As loose bulk piles

5.7 Sympathetic Initiation

It is possible that AN stored at a store that falls within the scope of this Code may be within range of sympathetic initiation by Class 1 Explosives and/or by UN 3375 material stored nearby. In such cases, in addition to the separation distance requirements detailed above (which apply to the AN store) there are also separation requirements which apply to all of the materials which may be part of an aggregated explosion. These requirements are detailed in:

- AS 2187.1 Explosives - Storage, transport and use, Part 1: Storage sets out the requirements for managing the potential effects of AN which is within sympathetic initiation distance of Class 1 explosives.
- The AEISG UN 3375 Code sets out the requirements for managing the potential effects of AN which is within sympathetic initiation distance of UN 3375 material.

The separation distances from an AN store shall meet all of the applicable separation requirements (i.e., generally the most stringent).

5.8 Separation from Roads and Passenger Railways

People moving along a road or railway have only transient exposure to the risk of an explosion at an AN store. Exposure will vary depending on the amount of AN stored, typical traffic speeds, and the distance from the store to the road or railway. At worst, with a road running alongside an AN store, the total exposure time for a single journey would be measured in seconds or minutes rather than hours; i.e. for a regular traveller passing, for example, twice per weekday, exposure is likely to be less than an hour per week. Given that there are over half a million minutes in a year, a few minutes exposure to an extremely unlikely event

presents a negligible risk. It is also likely that any potential AN explosion would be preceded by a significant fire and subsequent implementation of an emergency response plan (ERP), which is likely to close any potentially affected roads or railways.

Given the negligible risk to individuals, separation distances from AN stores to roads and railways are not mandated by this Code. This is consistent with both HIPAP 4 and the WA DMIRS Code, neither of which include roads or railways in any of the land use definitions. However, it is recommended that a site-specific risk assessment be conducted for roads carrying 10,000 or more vehicle movements per day (or equivalent for passenger railways), which is defined in some jurisdictions as the threshold of very high-density passenger traffic.

Irrespective of traffic density, if a passenger-carrying railway line is closer than the "Open" distance to an AN store, it is recommended that a societal risk assessment also be conducted to assess a worst-case breakdown, i.e. train stopped at closest approach to AN store. HIPAP4 includes guidance on societal risk.

5.9 Layout of AN Storage Sites

Risk arising from a potential explosion at an AN store can be significantly influenced by the type of structure that stores the AN (e.g., an open store versus a concrete shed), and the types of structure that may be exposed to the effects. The orientation of structures in relation to each other, and the presence of mounds or intervening hills can also be significant. For these reasons it is recommended that proposed AN stores are modelled, and layouts optimised, using the AN module of IMESAFR at the planning stage, even where the required separation distances specified in tables 5.3 to 5.7 are met. In addition, organisations using standardised or modular designs are likely to benefit from the use of IMESAFR to model these designs in typical situations.

6.0 Powered AN Handling Equipment

This section applies to all powered equipment that is used to transport, move or position AN (as loose bulk, in freight containers, or in packages (including IBCs)) into, within, or out of an AN store. This includes any road vehicles that enter an AN store building but excludes road vehicles that do not, even if they deliver AN to the site. Note: vehicles used for transport of AN on public roads must comply with applicable Transport of Dangerous Goods regulations.

Photo 11: Front end loader operating within a bulk AN store

Photo 12: FIBC being handled by forklift

6.1 General Requirements

All powered AN handling equipment shall:

1. be free of any leaks of fuel, lubricating oils, or hydraulic fluid;
2. if equipped with a battery or batteries, be provided with a battery isolation switch and have an insulated cover over the terminals of all batteries;
3. be regularly maintained;
4. unless it is a vehicle, be provided with a clearly labelled and readily accessible emergency stop(s);
5. be cleared of as much AN as is reasonably practical after use;
6. not include in its construction any unprotected copper, zinc (including galvanised iron or steel), cadmium or their alloys that normally come into contact with AN; and
7. be attended at all times when operating.

6.2 General Recommendations

Where reasonably practicable, it is recommended that:

1. All powered AN handling equipment should:
   a. be constructed from materials that, if in contact with AN, will not corrode, or are protected to prevent corrosion;
   b. have all non-essential electrical equipment removed, and all remaining electrical equipment sealed against dust ingress in accordance with IP55 of the IP Code or, where such equipment is not produced, comply with the highest rating possible. Equipment should be designed and constructed to resist dust ingress as far as is reasonably practicable and be inspected and cleaned regularly; and
   c. be designed and constructed, including consideration of failure modes, to avoid situations where AN may become trapped, heated, or brought into contact with incompatible substances. Items to consider include: suitability of seals, gaskets, bearings and clearance distances; use of solid rather than hollow equipment components; provision of alarms and shut-down systems for over-speed, under-speed, no-flow and over-heat situations.
2. Road vehicles that deliver AN or co-stored substances into an AN store should not enter a store building immediately after arriving at a site. They should be parked outside until any hot components (tyres, bearings, brakes) have had time to cool.
3. Vehicles that deliver AN or co-stored substances into or out of an AN store should have direct egress that does not involve the vehicle having to manoeuvre or reverse.
4. Conveyer belts should have fire-resistant belt and rollers, and be regularly maintained.

6.3 Additional Requirements Applicable to Mobile Equipment

1. Control measures shall be in place to prevent contaminants (e.g., dirt, other products) being brought into bulk AN store buildings on vehicles (e.g. vehicles such as front-end loaders should be dedicated to AN activities).
2. With the exception of electrically powered items of mobile machinery that are set up in a permanent or semi-permanent configuration (e.g. wheels removed or chocked), vehicles and powered mobile machinery operated within a store building shall:
   a. be kept outside the store when not in use;
   b. be garaged at least 10m from the store;
   c. be attended at all times while inside the store;
   d. have unhindered egress from the store at all times; and
   e. be re-fuelled or recharged at a distance of at least 10m from the store.

6.4 Additional Requirements Applicable to Internal Combustion Engines

Where a vehicle or machinery is powered by an internal combustion engine and is operated in or within 5m of a store it shall:

1. be powered by diesel or liquefied petroleum gas (LPG); and
2. be provided with a dry-powder fire extinguisher with a rating of at least 40B 2.5kg.

6.5 Additional Recommendations Applicable to Augers

Following the investigation of relevant incidents, some problems have been identified with augers handling AN, including the following.

- Foreign materials such as tramp metal, metal grindings, rust flakes, loose bolts or fibrous material from bags, etc., can become caught in between the auger spiral and the auger casing, generating heat, sparks or other potential means of ignition or initiation of any combustible materials associated with the activities.
- AN has the potential to facilitate corrosion of materials used in construction of the augers.
- There is potential for build-up of fines of AN both within the auger and around its bearings.

It should be noted that, due to the insensitivity of AN, these problems are generally not directly hazardous, but may significantly impact quality. From a hazard perspective any generation of heat or sparks, or confinement of AN should be strictly avoided.

As a result of the above findings, the following considerations are recommended:

1. At least one end plate of the auger assembly should be flanged or designed in such a way that it can be removed to allow for inspection. The auger may need to be substantially modified to achieve this.
2. Particular note should be taken of how the stub shaft (if any) is attached to the auger shaft if a demountable internal connection is used.
3. The preferred construction will not have any bolts, pins, nuts, screws or protrusions within the auger tube, nor will it have any internal connections of the auger shaft.
4. End bearings should be external to the end plates and any seals which are on the inside of the auger tube should be attached by a method which ensures that any necessary bolts, pins, nuts and screws within the tube cannot become loose.
5. There should be an air gap between the bearing mounts and the adjacent seals to allow any leakage from the seals to fall free and not enter the bearing. Any guards (to prevent contact with moving machinery) should have the same or similar sized air gap(s) to allow any leakage from the seals to escape.
6. Seals and bearings should not have cotton or other fibrous materials as part of their construction as these have been known to overheat and ignite.
7. As a general rule packed glands should not be used but should be replaced with lip seals or similar seals which minimise the chance of overheating and do not allow AN to become confined.
8. Materials that are not readily ignitable are preferred materials for seals and bearings.
9. All parts should be checked for corrosion and wear. Any damaged part or part which is likely to fail, become detached, become loose, or generate heat or sparks should be replaced.
10. The behaviour of the material used in construction should be critically assessed; for example, mild steel will corrode at a faster rate than stainless steel.
11. Tolerances between the auger spiral and the auger tube should be checked to ensure that they have not differed materially from the design specifications.

Augers need to be carefully and thoroughly washed down, and checked for foreign material such as tramp metal, fibres, metal grindings, rust flakes, etc. on a regular basis. Loose nuts, bolts, screws, pins, etc., should be tightened.

Decontamination is particularly important immediately before any welding or cutting operations take place to ensure there is no entrapped AN in the equipment being worked on. Trapped AN has been known to explode when heated in such operations.

The owner/operator of equipment has the responsibility to ensure the equipment is suitable for its intended use and that at all times the equipment is maintained in a safe condition.

Photo 13: FIBC splitting for loading an MPU

7.0 Security Requirements

In Australia, all AN covered by this Code is Security Sensitive Ammonium Nitrate (SSAN), and is to be managed in accordance with the COAG Guidelines and associated state and territory legislation.

Outside Australia locally applicable security requirements shall be met (this section may be referenced as a guideline).

The COAG Guidelines pertaining to storage include relevant definitions and are reproduced in full as Appendices I (Principles) and J (Storage) and are summarised here.

Note: COAG guidelines include definitions that may differ from those in Section 2 of this Code. The COAG definitions apply to this section (i.e., section 7) and only to this section.

To obtain an authority to store SSAN, a security plan shall be developed and implemented. The security plan should begin with a security risk assessment to provide information to the regulatory authority about security measures to address the risk of theft, sabotage, unexplained loss, and unauthorised access.

7.1 Minimum Security Requirements

The security plan will provide information to the regulatory authority about how security requirements will be met. The minimum security requirements are:

1. SSAN shall be kept in a secure store. (Note that a secure open area may be a store.)
2. There shall be procedures for controlling access to the secure store.
3. There shall be procedures for checking and authorising persons with unsupervised access to SSAN, including:
   a. designating a responsible person to maintain the security plan;
   b. instruction of workers on the security plan procedures; and
   c. ensuring people with unsupervised access to SSAN have had the necessary police and Politically Motivated Violence (PMV) checks.
4. There shall be accurate record keeping to reconcile incoming and outgoing quantities of SSAN, and to ensure that SSAN is obtained from and removed by authorised persons.
5. There shall be procedures for reporting to authorities any unexplained loss, theft, or attempted theft of SSAN, and of any other security incident involving SSAN.

7.2 Security Plan

Detailed requirements for the security plan elements are described in the COAG Guidelines (Appendices I and J) and in locally applicable regulations and guides.

The principal objectives of the security plan are:

1. To provide a controlled process for daily security activities;
2. To provide secure storage of AN (including in handling equipment, as waste, etc);
3. To detect as soon as possible, any tampering, theft, attempted theft or unexplained loss, and to advise the authorities; and
4. To identify and report security related incidents.

The security plan will have four main elements:

1. Security Risk Assessment;
2. Personnel management;
3. Site security (physical requirements);
4. Procedures governing the above.

A Security Risk Assessment shall be conducted to determine the level of controls required. When conducting an assessment, it is important to take into consideration the potential threats, vulnerabilities, and severity of the potential security risk.

8.0 Environmental and Waste Controls

8.1 Introduction

Environmental protection and waste management programs shall be incorporated into the design, siting and operation of all AN storage facilities. These management programs shall be in place during the early planning stages and before commencement of operations and shall:

1. consider any potential environmental impacts; and
2. be compliant with relevant jurisdictional regulatory requirements to control and/or manage the potential for soil, surface water and groundwater contamination.

(Note: This section is generally aligned with NSW EPA, 'Environmental Solutions', Ammonium Nitrate – Environmental Guidelines for explosives and explosive precursors facilities in NSW, Draft, November 2021.)

8.2 Design of an AN Facility

The design should:

1. minimise the potential for waste;
2. provide for the capture and containment of any spills (including provision of spill kits as appropriate);
3. enable the rapid clean-up of any spills or contamination;
4. minimise material handling and tracking;
5. control the potential for stormwater / surface water / groundwater contamination; and
6. include systems that alert operators of system failures that may lead to a loss of containment, e.g. high / low level alarms.

8.3 Siting of an AN Facility

It is critical to identify potential pathways and receptors that may be subject to AN contamination. Locations with lower environmental risk should be pursued, whereas sensitive environments should be avoided.

The following factors should be included for consideration:

1. potential receiving environs for any AN spills, e.g., drinking water supply, aquatic recreational area, wetland, lake, river, groundwater, at risk ecosystems;
2. proximity to surface waters;
3. depth to groundwater and geology;
4. topography around the areas of operation to avoid sites subject to flooding and/or waterlogging, and minimise the potential for migration of contaminated soil / water to outside of the operation;
5. soil type and drainage characteristics of the site; and
6. historical rainfall for the site.

8.4 Spilled and Contaminated AN

The following factors are relevant in managing spills:

1. spillages shall be prevented from entering waterways;
2. floors, walls, and equipment should be kept clean and any spillages cleared promptly;
3. organic materials (e.g., sawdust) shall not be used to clean floors;
4. a spill kit shall be readily available;

5. where AN is spilled on a clean impervious surface, has not mixed with any other materials and is immediately recovered, it may be treated as uncontaminated. All other recovered AN should be treated as contaminated;
6. contaminated AN should be treated as incompatible and be kept in a designated place until it is removed for disposal. Provision should be made to store the quantity of contaminated AN that may arise from any reasonably foreseeable event;
7. contaminated AN shall be disposed of via a specified process. The preferred process is dry sweep-up / collection and if possible on-site recycling, dissolution and re-use. Alternatively, (subject to customer acceptance) disposal could occur in a blast hole (typically on top of a charge before stemming is added).

Note: contaminated AN may no longer comply with the requirements for the relevant UN number; it may exceed the 0.2% allowable total combustible material, making it less predictable in a fire.

AS 4326 section 9.7 details the following methods of disposal of AN residues:

- recovery by a licensed operator (recommended);
- alternatively:
  - recovered residues may be recycled through various types of consuming plants. In such situations, safety considerations, including the possibility of contamination, need to be taken into account, or
  - recovered residues may (subject to approval from relevant environmental regulator) be disposed of by dilution to less than 45% and spreading on vegetated land, at dosage rates recommended by an agronomist.

8.5 Waste Controls

There shall be a specified process for disposing of waste arising from the operation of the AN facility, including as relevant:

- waste arising from cleaning;
- waste arising from maintenance; and
- used packaging (where packages are emptied on site or arising from spills / burst packages). (Used packaging should be arranged such that Dangerous Goods marking / labelling is not visible.)

All contaminated AN and waste AN should continue to meet the security provisions of Security Sensitive AN (SSAN) and this Code, unless it is known to no longer meet the requirements for inclusion as SSAN.

8.6 Prevention of soil, surface water and groundwater contamination

8.6.1 Minimum Recommendations

Operational procedures for handling, loading, unloading and transporting AN on and off-site should be developed to minimise the potential for spillage and to avoid the potential creation of pathways for environmental exposure.

All storage, handling and operational areas require appropriate containment measures to be implemented so that any spills or leakages of AN are prevented from access to the surrounding soil, surface water or groundwater. This may be achieved via impermeable hardstands that drain to an appropriately sized containment system for all areas that may be subject to AN contamination taking into consideration local rainfall which may limit available capacity (with a preference where applicable to cover storage areas).

The containment system should include the following aspects:

1. the drainage from all areas that will mobilise contaminants when stormwater runs over these areas should be controlled and diverted through appropriate capture and containment systems;
2. any contaminated water should be collected and stored in a dam or equivalent structure that is impervious;
3. the containment system should be designed, built and operated to prevent contamination of groundwater;
4. dams / structures should be fitted with monitoring equipment to prevent overfilling;
5. dams / structures should be capable of at least accepting the run-off generated by any 1 in 10-year, 24-hour-period storm event without overflowing;
6. the areas of the site that have the potential to generate contaminated stormwater when water runs over them should be minimised;
7. measures should be in place to ensure that within 5 days of the end of a rainfall event, water captured in the containment system is appropriately removed to prepare the containment system for any future rainfall event; and
8. the drainage network must be open or grated to reduce the potential for confinement of any molten AN arising from a potential fire situation.

8.6.1 Best Practice Recommendations

The following additional environmental controls are recommended for AN:

1 capture and containment of dust generated from de-bagging and handling;
2 containment of tracked material;
3 regular housekeeping, maintenance and spill / loss prevention;
4 stormwater ingress prevention (clean and dirty water separation);
5 adequate supervision during loading and unloading activities to promptly identify and clean up spills;
6 minimise the distance that AN is moved around on site;
7 implement a routine cleaning program for AN dust / spills; and
8 wheel washes (or other measures) to prevent tracking of AN on vehicle tyres.

9.0 Emergency Planning and Response

9.1 Emergency Response Plan (ERP)

1. An Emergency Response Plan (ERP) shall be in place and shall include as a minimum:
   a. Emergency contact numbers;
   b. A site plan showing emergency equipment location;
   c. A premises and area evacuation plan, showing evacuation routes and defined evacuation points (refer AS 3745);
d. Procedures that address any reasonably foreseeable emergency, specifically including fires; and
e. Procedures that address the loss of normal communication systems.
2. Persons expected to assist in an emergency shall be trained to an appropriate level.
3. The ERP shall be reviewed (and updated as appropriate) as required, e.g., after an incident or when improvements are identified, or at least annually. The review shall demonstrate the effectiveness of actions taken at the premises and all associated communications, but physical evacuation and actual operation of equipment (such as fire extinguishers) are not required. The results of the review shall be documented.
4. In addition to, or as part of the review required by 9.1.3 above, it is recommended that an emergency drill be conducted regularly, with outcomes documented and appropriate actions put in place to address any deficiencies.

9.2 Fire Protection

1. In addition to any fire extinguishers required by Section 6 of this code, there shall be sufficient (as determined by the risk studies for the site) fire-fighting facilities (fire extinguishers and / or hose reels and / or automatic sprinkler systems) to allow any reasonably foreseeable fire to be fought and extinguished in its early stages by the numbers of people likely to be present. Reasonably foreseeable fires include:
   a. tyre fires on road vehicles/other equipment;
   b. fires involving internal combustion engines and their fuel;
   c. fires caused by electrical short circuits (including vehicle batteries);
   d. fires caused by friction (e.g., from rubbing mechanical parts, conveyors, seized bearings, etc); and
   e. any other fire scenarios identified as part of the risk studies for the store.
2. The design of the fire protection system should be generally in accordance with Section 12 of AS 4326 (and the other Australian Standards it references) as relevant, except that fire protection will typically take the form of fire extinguishers only. Fixed fire systems and hose reels are typically not required on the basis that:
   a. fire extinguishers should normally be the adequate (and often the preferred) means of fighting the reasonably foreseeable fires detailed above in their early stages;
   b. this code requires that combustible materials and incompatible products have been minimised from the vicinity of the AN store;
   c. if a fire has taken hold and is significantly involving AN, the appropriate response is evacuation;
   d. personnel evacuated to designated evacuation points are deemed to be not endangered by the worst-case explosion that may occur, or by any associated toxic fumes;
   e. use of fixed fire systems can have unintended environmental consequences if activated by mistake; and
   f. AN stores within the scope of this code are typically in remote locations where:
      i) off-site effects arising from fires or explosions at the AN store are minimal;
      ii) a reliable supply of firewater is unlikely to be available;

iii) AS 4326 clause 12.2 (c) permits the owner to dispense with fixed fire protection and accept the risk of destruction, provided a destructive fire will not endanger persons on or off the site, and will not endanger any property under other ownership; and
iv) for AN stores on mine sites or quarries the owner of the mine or quarry typically owns the AN store or agrees that any risk to their property is acceptable.

3. Firefighting facilities or systems should be capable of single-person operation where AN stores are operated by a small number of people.
4. Fixed fire systems may be used where expressly required by the regulations.
5. Fixed or automated fire systems may be used where a risk or financial assessment justifies the cost of installation. Automatic or remotely actuated fire sprinkler systems, or hydrant systems that can be left unattended, while not required by this Code, may be installed should an adequate risk or cost-benefit argument be derived.
6. Where a fixed or automated system is provided, it shall be of a type that can either be automatically or remotely actuated, or that can be set up and left unattended, so personnel can be evacuated. Systems that require personnel to be in attendance in order for them to continue to work are not permitted.

9.3 Firefighting and Interaction with Emergency Services

Fires significantly involving AN shall NOT be fought, except that unattended systems (e.g., fire monitors, sprinklers) may be used/left in operation. The logic is that the appropriate response to a fire significantly involving AN is that, if it cannot be extinguished by hand-held extinguishers then evacuation is the best response. Fires significantly involving AN, once they take hold, require large amounts of water to contain. At this point, it is likely that NO_x will be generated and the AN may transition to an exothermic reaction, posing serious risk to those attempting to fight the fire.

Note that:

1. AN is significantly involved if a substantial quantity is exposed to the fire and is being heated enough to potentially or actually melt and/or evolve fumes or vapours.
2. Whatever is fuelling the fire (i.e., not the AN itself) is likely to create smoke / fumes as it burns, and it may not be obvious whether there are any fumes from the AN. However if there are any fumes from the AN it shows that the AN has begun to decompose - that is the AN is already significantly involved and an explosion may be imminent. Initially any decomposing AN is likely to produce white fumes, but orange / red fumes (of nitrogen dioxide) are a sign that the fire is out of control and an explosion is increasingly likely.

As soon as a fire develops to the extent that AN is significantly involved, the evacuation plan shall be initiated immediately, and ALL personnel shall evacuate. This should include emergency response personnel. Such personnel may have authority to override any instructions from site staff, but every attempt should be made to ensure they appreciate the danger and participate in the evacuation.

In recent years, the vast majority of fatalities arising from an AN explosion caused by fire have been firefighters and other emergency response personnel. Fighting a fire of this type should not be attempted by anyone – either employees or professional fire fighters – unless life is at risk.

The various stages of fire significantly involving AN are shown below.

DECOMPOSITION OF SOLID AN				
Stage	**Observation**	**Chemistry**	**Comments**	**Appropriate Response**
Heat source applied (e.g., diesel fire)	Nothing		It has been observed that large quantities of AN subjected to intense fire will typically take at least 45 minutes to reach the Decomposition and Deflagration / Detonation stages.	Use fire extinguishers if the fire is small. If the fire cannot be brought under control by this method, then proceed immediately to evacuation.
Decomposition	Venting of white and/or orange fumes	AN reverts to ammonia and nitric acid (endothermic process) initially. Then AN decomposes to N_2, NO_x and H_2O exothermically. The mixture's temperature increases rapidly. Gases generated in this process help sensitise the mixture to detonation.	Confinement increases the rate of exothermic reactions and the mixture can transition to a "runaway" reaction.	Initiate emergency response, including evacuation, to predetermined evacuation points. Do not attempt to fight the fire. Brief emergency response personnel. Establish an evacuation / exclusion perimeter – to be stated in the site Emergency Response Plans.
Deflagration/ Detonation	Violent reaction and/or explosion; rupture of containers; shrapnel.	Majority of reaction contents react almost simultaneously to give gaseous products at high temperature.	Deflagration (Low VOD explosion) or Detonation (high VOD explosion) of the heated mixture. Facts and circumstances of the situation with regards to AN and contaminants, rate of heating, quantity and degree of confinement determine the outcome. Larger quantities are typically associated with explosion.	Maintain evacuation / exclusion distance. Maintain comms with emergency response personnel.

9.4 Evacuation

If an evacuation is initiated the minimum evacuation distances are:

1. For Emergency response personnel: the distance that would apply to a "vulnerable" land use, but not less than 400m;
2. For persons not involved in the emergency operation: double the distance that would apply to a "vulnerable" land use, but not less than 400m.

The selection of evacuation points involves some compromise. An ideal evacuation point would:

1. be easy for people to recognise;
2. be easy to reach;
3. be far away from any dangerous effects (fire/fumes/explosion) and not in likely fume dispersal paths arising from the emergency;
4. have communications with whoever is controlling the emergency response; and
5. have facilities to accommodate evacuated personnel for the likely duration of an emergency, or until headcounts are completed and personnel are allowed to leave.

The selection of evacuation points will always be highly site specific and separation may exceed the minimum distances mandated by this Code.

10.0 Risk Assessment

To assess the risk associated with a proposed new or upgraded AN store and confirm that it is acceptable, a Risk Assessment (or series of Risk Assessments) shall be conducted and documented, covering all activities related to the storage and handling of AN. Risk identification should be based on the planned facilities and operations.

Identified mitigation and contingency plans are to be implemented in the formal management system and are to be subject to ongoing compliance audits.

Risk studies shall be conducted by appropriately qualified, multi-disciplinary teams and should include both engineering and operational personnel. Identified risks and controls should be documented in a site risk register, with key controls also documented in procedures. Site operating procedures are to be cross-referenced with the relevant risk assessments to ensure key risk controls are documented in procedures. In such studies consideration should be given to the issues outlined below.

10.1 Site

1. Off-site facilities that could be affected by worst-case potential fire, fume, and blast effects within an appropriate radius (typically consider at least 2 kilometres).
2. General site layout for the flow of materials.
3. Fire scenarios and flow path of any potential molten AN.
4. Fires that could affect more than one store, stack, or pile.
5. Provision for firefighting controls, emergency response, and control of spills.
6. Separation and segregation.
7. Site requirements for storage (minimum quantity to support operations; maximum quantity to manage risk).
8. Mitigation of the effects of incidents and accidents, e.g. by reduction of quantities, adequate separation distances.
9. Spill scenarios and recovery.
10. Recovery from emergencies.
11. Federal, state/territory, and local regulations.

10.2 Plant

1. Materials of construction for silos, bins, bunkers, buildings and other materials in contact with, or exposed to, AN.
2. Building or equipment design codes.
3. Material handling procedures, ergonomics, equipment types and classification.
4. The containment on-site of all waste or residue from chemicals or materials.
5. The prevention or minimization of waste generation.
6. Lightning hazard.
7. Health, safety, and environmental issues and quality control.

10.3 Operational Requirements

1. Standard operating procedures (SOPs), training and qualifications.
2. Hazardous chemicals, their physical properties and compatibilities, and the provision of SDSs.
3. Personal exposure and requirements for the use and care of PPE.
4. The management reporting structure and lines of communication.
5. Site-specific conditions including the staff's language(s) and customs.

Appendix A: Code Summary and Supplementary Information

AEISG intends that this Code unambiguously and transparently provides the reasoning behind and the intended outcome of the requirements and recommendations. Much of that reasoning and intent is included alongside the requirements and recommendations in the body of the Code, and a great deal of background is provided in other appendices. This appendix summarises the structure and key points of the Code and supplements the information provided elsewhere.

Many of the requirements and recommendations in this Code can be grouped under seven safe-storage principles listed below. Where relevant, the following table identifies which of these principles the various requirements and recommendations are predominantly upholding or aligned with:

A. Prevent external fires from impacting on AN by removing all combustible material and sources of ignition from the vicinity;
B. Preserve the purity and quality of AN and prevent incompatible material mixing with it;
C. Guard against theft and sabotage;
D. Do not confine decomposing molten AN;
E. Implement safety distances to reduce the consequence of an explosion to nearby occupancies;
F. Prepare a site-specific emergency plan including evacuation.
G. Prevent adverse environmental impacts.

Section	**Key Points**	**Supports principles**	**Additional Intent / Comments**
Preamble			
	Introduction, and reason for producing this Code.		The preamble introduces the Code, tries to set it in context and explain some of the core philosophy underpinning it.
	In this code AN means only 2 UN numbers (1942 or 2067) (In Australia both are SSAN)		
	Introduces ammonium nitrate properties, hazards and history		
	Many standards and codes exist for AN. This code focuses on narrower scope, specifically aligned with commercial explosives industry.		

Section	Key Points	Supports principles	Additional Intent / Comments
	All significant historical fire and explosion events (involving AN) listed in appendix F; all could have been prevented by rigorous application of appropriate standards.		
	Presents a high level structure of key controls.		
	Notes lack of uniformity in other relevant codes.		
	Recognise that other regulations, codes, standards may be more (or less) stringent.		
1. Scope and Application			
1.1 Scope	Solid AN (two UN numbers) servicing mining, quarrying and construction.		This Code has significantly narrower scope than most other relevant AN codes. It does not cover agricultural/fertiliser applications, or many other situations that would fall within the scope of some or all of the other relevant codes.
1.2 Application	Unless excluded, code applies to any person handling AN plus AN storage licence holders and occupiers		
1.3 Exclusions	Other UN numbers or non-DG, MHF's, manufacturing of ammonium nitrate, AN and AN Stores that are part of any mixing or manufacturing operation, stores < 1 tonne, transport, ports, transit, MPU's, AN with Class 1, AN stored underground. (Debagging etc does not create exclusion)		
1.4 General	Based on knowledge and experience; not intended to limit improvement; alternatives may be OK; not retrospective.		
	AN must have < 0.2% combustibles; one analytical test method referenced, other methods can also be OK.		
	Presents "good practice" hierarchy.		
	If any requirement not met need detailed risk assessment and agreement from authorities.		
	Not retrospective; applies to new premises from date published		

Section	Key Points	Supports principles	Additional Intent / Comments
2. Definitions			Definitions included to promote clarity; origin stated if sourced from other codes.
3. AN Store: Design and Construction			
3.1 Types of store:	Lists 5 types; specifies 10t limit for stores within or attached to another building; specifies when co-storage permitted; introduces "igloo" (aka "dome") stores, which are to be treated as a type of building.		
3.2 General Requirements	Don't break up with explosives or detonators.		A lesson from history.
	Buildings and structures non-combustible.	A	Also allows practical exceptions.
	5m fuel free zone all around.	A	
	Unused pallets, etc., removed promptly. No combustibles stored or left unattended in or <5m from store except pallets and packaging, and as permitted under 3.2.2.	A	
	Prevent AN impregnation of pallets, etc.	A	
	Fuel spills contained or flow away from AN.	A, G	
	Spillage of incompatibles kept away from AN.	B	
	Enough venting; no pressure build-up in fire.	D	For buildings, ventilation for OHS reasons is also adequate for fires.
	Molten AN unconfined and flow away for later recovery.	D	
	No unprotected copper/zinc/incompatibles in contact with AN.	B	Clarify airborne dust no issue with galvanized steel or metal sheeting coated in zinc or zinc alloys, but note possibility of structural weakening
	If there is a risk of internal corrosion electrical minimum IP55. In dusty situations (e.g., some bulk stores) service life of electrical equipment may be improved by adopting IP65	B	The dust test to achieve an IP5x rating involves locating the enclosure under reduced pressure in a suspension of fine talcum-powder dust. To pass, there must be no accumulation of a harmful level of dust inside. This is a very severe test

Section	Key Points	Supports principles	Additional Intent / Comments
			compared to dust levels typically present in AN stores, including bulk stores, where there is no pressure differential between the enclosure and surrounding environment. Experience shows that AN dust does not in practice penetrate IP5x enclosures in typical situations. The water test to achieve an IPx5 rating involves spraying the enclosure with small water jets from any angle without harmful entry of water into the enclosure. AN dust does not give rise to any dust-explosion hazard.
	Ensure no effect from hot or reactive ground.	B	
	Unimpeded exit of vehicles and personnel.	F	
3.3 General Recommend-ations	AN Stores away from possible big heat, etc., sources (oil stores, gas pipelines, etc).	A	This is a prompt to ensure these issues are considered.
	Protect from weather, reduce moisture absorption/heat cycling.	B	AN very hygroscopic and prone to caking; keeping dry / shaded helps keep AN in good condition.
	Where reasonably practicable building to be dry (but not always reasonably practicable e.g., open-ended igloo).	B	
	Maintain stock rotation to avoid caking.	B	Helps keep AN in good condition.
	Where reasonably practicable, flammable and combustible spills, even with secondary containment, should flow away from stored AN.	A	Some accidents can e.g. rupture a tank and simultaneously compromise the secondary containment (especially for double-skinned tanks) so where reasonably practicable it is good practice to have spills flow away from stored AN.
	Fittings, etc., in extended contact suitably corrosion resistant or protected.	B	Corrosion products may mix with AN. Corrosion reduces the expected life of the equipment.
	Concrete floors (with protection) recommended for loose bulk.	B, G	Supports maintainability and housekeeping.
	Protection (additives or coatings) recommended for all exposed concrete	B, G	AN is known to attack and damage concrete over time. Concrete generally serves some useful purpose so it usually makes sense to protect it from attack.

Section	Key Points	Supports principles	Additional Intent / Comments
	Lightning protection not a requirement of this code, but if considering use AS 1768 with AN non-flammable and non-explosive.		Lightning protection is not an automatic requirement.
	If wooden pallets present, allow for fuel when considering fire.	A	
	If floor >250 sq m recommend two exits.	F	
	Extra ventilation advantageous, prefer to not block vents.	D	
	No boundary separation mandated, but recommend at least 5m to control fuel free zone.	A	
	If light fittings may fall and cause sparks/ignition or injure people provide additional safeguard.	A	
	Avoid sealed hollow sections.	D	
3.4 Additional requirements in a building	AN on a level with immediate ground access.	F	
	Enough ventilation to prevent harmful dusts/vapours.	D	Workplace OHS requires breathable/safe atmosphere.
	Access and escape routes defined, kept clear.	F	
	Bulk store floor not earth, road base or bituminous.	B, G	Needs to be impervious to contain AN. Bitumen can be a fuel and can become mixed with AN (e.g., through front end loader scraping, etc)
	A package store building floor shall be of concrete, compacted road base, low bitumen (less than 9%) asphalt, earth, or other suitable materials.	A, B	Bitumen is common as road base material; limit is to avoid acting as fuel.
	Package store floor sufficiently impervious to recover spills.	B, G	Allows uncontaminated spill recovery.
	No smoking or naked flames, with signs at entrances	A	
	If AN store is in or attached to another building, max 10t AN, and 5m clearance or wall with 4hr fire resistance to other (non AN) parts of building, or attached building.	A	Protects AN from fire risk from adjacent activities.
	If store is in a building must have an external wall.	D	

Section	Key Points	Supports principles	Additional Intent / Comments
3.5 Additional Requirements in a silo, bin, etc.	Resist forces, e.g., caked AN falling within.		Structural integrity.
	Transition areas where AN spillage likely in normal operation made from impervious, easy to clean material.	B, G	Facilitate spillage recovery and avoid spillage reaching environment.
4. Store: Operation			
4.1 Regulatory approval	Have all licence(s) / approval(s) before operating.		
4.2 Size and Arrangement of Stores / Stacks / Piles	No mandatory limits to size of stack or store, but note subdivision can reduce explosion size...	E	This section differs substantially from other codes, which generally impose limits on stack height or size, and/or store size, and require separation from building walls for packages (including IBCs) with or without pallets. The contradiction (in the other codes) is that there are fewer, or less well-defined, restrictions for bulk stores, and no requirement for separation from walls. AEISG considers that, for AN stores that fall within the scope of this Code, these restrictions are usually not required, although a walkway to outside walls is necessary to allow access if combustible pallets are used. Broadly, AEISG would like to avoid forcing designers of AN stores to meet requirements that may be unnecessary. Therefore, this Code allows unlimited stack heights provided stability of stacks and integrity of packaging are maintained. While stack sizes and store sizes are not limited, subdivision of stores may be necessary or advisable in some circumstances.
	... but recommend subdividing large stores.	E	
	No height limit for stacks but they must be stable/safe, and within capability of packaging, and of handling equipment.		
	If AN on combustible pallets in a building maintain 600mm access way to outside walls.	A	
	If no pallets do not need separation from walls, provided walls can support any loads, and egress unimpeded.		
4.3 Co-storage of other substances inside AN store	No Class 1 explosives in AN store		Substances can be incompatible with AN for 2 reasons - they may react dangerously, and/or they may otherwise increase the hazard, e.g., by changing AN from class 5 to class 1. If substances do not react dangerously there is no compelling
	Some compatible and incompatible substances listed in Appendix G; if not listed assume incompatible unless proven compatible.	B	
	Compatibles permitted in store if segregated by 5m.	B	

Section	Key Points	Supports principles	Additional Intent / Comments
	Incompatibles only by exception and subject to specific risk assessment, and only if they are not combustible and do not react dangerously. Segregated by 5m, and no mixing under normal or abnormal conditions.	B	reason to keep them out of AN stores, provided a reasonable segregation is maintained.
4.4 Other materials in AN store	OK to keep fire extinguishers, spill kits, etc., in store provided no significant quantity of incompatibles.	A, G	This section aims to give some clarity to the use of ancillary or minor equipment and to avoid unnecessary exclusions.
	Unpowered tools and equipment temporarily in store are deemed compatible.		
	Chemicals (e.g., cleaning fluids) to be assessed, must not react dangerously.	B	
4.5 Safety and Security Management System (SSMS)	SSMS documented & meet regulatory requirements, implemented in such a way that code requirements met at all stages of lifecycle, and applies to all personnel including employees, contractors and visitors	All	
	SSMS must include at least • A Safety Policy; • A Safety and Security Management Plan (SSMP); • Training; • Operating Procedures covering each AN premises; • Procedures to control all transfers of custody of AN (including waste).	All	
	SSMP features detailed	All	
	Training coverage detailed	All	
	Topics to be covered by procedures defined	All	
	Emergency Response Plan to be in place (per Sect 9 of code)	F	
	Other SSMP components detailed	All	

Section	Key Points	Supports principles	Additional Intent / Comments
5. AN Store: Location and layout			
5.1 General	Intro; AN store not to be located where risk to surrounding off-site land uses exceeds criteria specified in code (HIPAP 4).	E	Properties and hazards of AN are known and a well managed store complying with this code should have negligible risk of explosion, but (globally) explosions continue to occur.
	Framework of land uses and risk criteria from NSW HIPAP 4.	E	
	Introduce flowchart; PES and ES defined.	E	
	Flowchart shows steps in checking whether required distances are met.	E	Gives an overview of applying / checking distances.
5.2 Separation Distance Requirements	Must meet tables 5.3 to 5.7 unless on a mine site, or have QRA demonstrating risk targets met.	E	The background and intent of these requirements are detailed in the body of the Code and in Appendix D.
	If QRA is used, the recommended methodology is the same as used in this Code, as detailed in App. D.	E	
	Distances applied from each stack/store unless they do not meet stack separation distances, then apply distance to aggregated group of stacks / stores.	E	
	Note: Appendix D gives background on separation distances and details methodology used to develop tables. Different types of store generate different risk hence 5 tables for 5 types of AN store.	E	
	For high population densities, an additional assessment of societal risk may be necessary e.g. large sports stadiums, etc.	E	
	Note: Appendix E gives guidance on what fits into which land use.	E	
	On mine sites, if owner permits AN storage, distances are mandatory for vulnerable or residential, recommended for commercial, open/industrial; need QRA if less than "open".	E	It is widely accepted that risk to the public should be lower than the risk that is acceptable to users of material giving rise to the risk.
5.3 Basis of Separation Distance Tables	Tables developed using IMESAFR, with 5 types of AN store construction which could be a Potential Explosion Site (PES) and 5 types of Exposed Site (ES) construction.	E	

Section	Key Points	Supports principles	Additional Intent / Comments
	Note that tables are based on HIPAP Land Uses, not ES types; land uses do not align with types of ES construction, except for "sporting complexes and active open space" which aligns with the "open" ES.	E	
	Other than the column for land use "open", each distance in tables is biggest of four (i.e., the biggest of any of the four ES construction types). Therefore distance allows for any ES construction, provided it is reasonably similar to one of the 4 modelled.	E	
	Site-specific assessment may be needed for non-typical ES's.	E	
5.4 Application Notes: Which Table to Use	Explains types of AN store modelled; if actual situation is substantially different then use most conservative (biggest) distance for that tonnage or do site specific assessment.	E	
	Table 5.2 gives guidance which table applies to some situations that may be encountered, including igloos.	E	
5.5 Minimum Distance Tables	Short names used in tables are defined	E	
	Table notes explain: • quantity stored means total max licensed unless subdivided with complying stack separation • quantities are rounded to nearest 5m, and with no asterisk are modelled, with asterisk are interpolated • can interpolate for values not shown • distances apply edge to edge, not centre to centre	E	
	5 tables covering 5 types of AN store. Each table details minimum distances to surrounding land uses.	E	
5.6 Stack/pile separation	Lists factors affecting likelihood of stack to stack explosion propagation (distance, density, edge slope, physical barrier).	E	

Section	Key Points	Supports principles	Additional Intent / Comments
	Stacks with physical barrier – not common, but ignore physical barrier, or analyse/justify.	E	
	Stacks without physical barrier – separation required to prevent knock-on defined in table 5.8, with examples of storage configurations.	E	
5.7 Sympathetic Initiation	Stored AN may be in range of sympathetic Initiation by Class 1 explosives, or UN 3375. If so, in addition to separation distances already detailed, must meet requirements for aggregated explosions as detailed in AS 2187 and AEISG UN 3375 code.	E	
5.8 Separation to Roads and Railways	No separation required since exposure is so transient / minor. But if traffic >10,000 vehicles/day (or passenger rail equivalent) recommend a site-specific assessment.	E	
	If passenger railway closer than “Open” recommend societal risk assessment.	E	
5.9 Layout of AN Storage sites	Recommend using IMESAFR to understand risk / optimise layout for proposed sites, and standardised designs.	E	
6. Powered AN Handling Equipment			
	Section applies to all powered equipment handling AN (loose bulk / in shipping containers / in IBCs). The requirements also apply to road vehicles if they enter an AN store.		
6.1 General Requirements	No fuel or oil leaks.	A	
	Battery isolation switch and insulated covers.	A	
	Regular maintenance.	A	
	E-stop (unless a vehicle).	A	
	Reasonably cleared of AN after use.	A, B	

Section	Key Points	Supports principles	Additional Intent / Comments
	No unprotected copper/ zinc / cadmium normally in contact with AN.	B	
	Attended when operating.	A	
6.2 General Recommendations	Corrosion resistant.	B	
	Remove non-essential electrics, rest to IP55 (or highest available)	A	
	Avoid situations (normal and abnormal) where AN may be trapped, heated or contact incompatibles.	D	
	Road vehicles cool down before entering store.	A	
	Vehicles able to exit without manoeuvre or reversing.	A, F	
	Conveyer belts should have fire-resistant belt and rollers.	A	
6.3 Additional Requirements Applicable to mobile equipment	Prevent vehicles bringing contaminants into store.	B	
	Except electrically powered items set up (semi) permanently, all vehicles & powered mobile machinery: • Kept outside when not in use; • Garaged minimum 10m away; • Always attended when in store; • Unhindered egress at all times; and • Refuelled / recharged at least 10m away.	A	
6.4 Additional Requirements for Internal Combustion Engines	Only diesel or LPG.	A	
	Have min 40(b) 2.5kg dry-powder fire extinguisher.	A	To allow rapid response to any vehicle fire and extinguish / prevent spread of fire quickly.
6.5 Additional Recommendations for Augers	One end plate removable e.g., flanged.		Various materials or items can become caught between auger spiral and tube, and can cause heating or sparks. AN can facilitate corrosion.
	If stub shaft is used for a demountable internal connection take note of how it is attached.		

Section	Key Points	Supports principles	Additional Intent / Comments
	Prefer no internal protrusions (bolts, pins, nuts, etc) and no internal shaft connection.		AN fines can build up. These issues generally not significantly hazardous but should be avoided.
	Bearings should be external, with an airgap to allow leakage to drop free and not enter bearing; any guards should not trap AN.		
	Seals inside tube attached such that fasteners cannot come loose.		
	Avoid packed gland - lip seals preferred, and no cotton / fibrous material in seal.		
	Materials that are not ignitable are preferred for seals and bearings.		
	All parts should be checked for corrosion and wear and replaced if suspect.		
	Assess materials of construction e.g. corrosion of mild steel.		
	Spiral to tube clearance/tolerance should be checked for compliance with design specifications.		
	Regular wash down and inspection.		
	Wash down and ensure no trapped AN before hot work.		
7. Security Requirements			
7.1 Minimum Security Requirements	In Australia all AN in scope is SSAN - manage in accordance with COAG guidelines 2004. Other jurisdictions: comply with local legislation (can use this section as guide).	C	
	Licence depends on security plan, which starts with a security risk assessment.	C	
	SSAN must be in a secure store.	C	
	Need access control procedures.	C	
	Need procedures to check / authorise unsupervised access.	C	

Section	Key Points	Supports principles	Additional Intent / Comments
	Keep records for stock reconciliation and ensure authorised supplier and recipient.	C	
	Have procedures for reporting unexplained loss, etc.	C	
7.2 Security Plan	Details security plan objectives and main elements.	C	
	Must do security risk assessment.	C	
8.Environmental and Waste Controls			Note: This section is generally aligned with NSW EPA, 'Environmental Solutions', Ammonium Nitrate – Environmental Guidelines for explosives and explosive precursors facilities in NSW, Draft, November 2021.)
8.1 Introduction	Waste and environmental programs must be incorporated in design, and in place before operations start.	B, G	
8.2 Design of an AN facility	Minimise potential for waste.	G	
	Capture and contain spills.	G	
	Enable the rapid clean-up of any spills or contamination.	G	
	Minimise material handling and tracking.	G	
	Control the potential for contamination of stormwater / surface water / groundwater .	G	
	Include systems that alert operators of system failures that may lead to a loss of containment, e.g., high / low level alarms.	G	
8.3 Siting of an AN facility	Identify potential contamination pathways.	G	
	Prefer locations with lower environmental risk - consider where spills will go (e.g., watercourses, etc); proximity to surface waters; depth to groundwater; topography around the area; soil type / drainage characteristics / historical rainfall.	G	
	Prevent spillages from entering waterways.	G	

Section	Key Points	Supports principles	Additional Intent / Comments
8.4 Spilled & Contaminated AN	Keep clean, clear spillages promptly, no organic / combustible cleaning material (e.g., sawdust), consider spill kits.	B, G	
	Clean spills recovered immediately = uncontaminated. All else = contaminated, may no longer be within UN number and will be unpredictable in fire.	B, G	
	Treat contaminated AN as incompatible, keep in designated place with room for all foreseeable contaminated AN.	B, G	
	Dispose of contaminated AN via specified process; preferred process is dry sweep-up / collection and on-site recycling.	G	
	Note possibility of disposal in blast holes if customer agrees.	G	
	Refer to AS 4326 for disposal methods.	G	
8.5 Waste Controls	Need a specified disposal process for other waste (from cleaning, maintenance, used packaging).	G	
	Waste / contaminated AN to continue meeting SSAN requirements.	C, G	
8.6 Prevention of soil, surface water and groundwater contamination	Minimum recommendations: • develop procedures to minimise potential for spillage and avoid creating pathways for environmental exposure; • storage, handling and operational areas to have containment measures so that any spills/leakages of AN are prevented from access to the surrounding soil, surface water or groundwater; • containment system to include: drainage controlled; contaminated water collected & stored; dams/storages impervious, sized for 1 in 10 year 24 hour storm, monitored, and emptied within 5 days after rain; minimise area where stormwater can be contaminated; drains open or grated.	G	Recommendations are aligned with NSW EPA guideline on minimising nitrate contamination
	Best practice recommendations:	G	

Section	Key Points	Supports principles	Additional Intent / Comments
	• Capture and containment of dust generated from de-bagging and handling; • Containment of tracked material; • Regular housekeeping, maintenance and spill / loss prevention; • Stormwater ingress prevention (clean and dirty water separation); • Ensure loading and unloading activities are adequately supervised to promptly identify and clean up spills; • Minimise the distance that AN is moved around onsite; • Implement a routine cleaning program for AN dust / spills; • Wheel washes (or other measures) to prevent tracking of AN on-vehicle tyres.		
9. Emergency Planning & Response			
9.1 ERP	ERP to include: • Emergency contact numbers; • A site plan showing emergency equipment location; • A premises and area evacuation plan, showing evacuation routes and defined evacuation points; • Procedures that address any reasonably foreseeable emergency, specifically including fires; • Procedures that address the loss of normal communication systems.	F	
	Persons to be trained; plan to be updated post-incident / annually.	F	
	Recommend regular drill with documented outcomes.	F	
9.2 Fire protection	Enough firefighting facilities (in addition to those required by sect 6) to extinguish any reasonably foreseeable fire (examples listed) in early stages.	A, F	

Section	Key Points	Supports principles	Additional Intent / Comments
	Fire protection design generally per sect 12 of AS 4326, except that usually only need extinguishers.	A, F	
	Don't typically need fixed systems or hose reels because: • extinguishers normally adequate and often preferred way to fight early stage fires; • combustibles & incompatibles are minimized near store; • if fire is significant and involving AN should evacuate, not fight; • people at evacuation points not at risk; • fixed systems can have unintended environmental consequences, if activated by mistake; • in-scope stores typically remote, so minimal off-site effects, AS 4326 allows owner to accept risk of destruction, mine owner normally accepts risk, firewater likely to be scarce.	A, F	
	Facilities capable of single person operation if store operated by small number of people.	A, F	
	Fixed system may be used if expressly required by regulations.	A, F	
	Fixed system may be used if risk- or cost-justified.	A, F	
	If there is a fixed system it must be able to actuate remotely or automatically and/or leave running unattended. Systems that require personnel to be in attendance in order for them to continue to work are not permitted.	A, F	
9.3 Firefighting and Interaction with Emergency Services	Only fight fires if not significantly involving AN, otherwise evacuate. (Unattended systems can be left operating.)	A, F	The logic is that the appropriate response to a fire significantly involving AN is that, if it cannot be extinguished by hand-held extinguishers then evacuation is the best response. Fires significantly involving AN, once they take hold, require large amounts of water to contain. At this point, it is likely that NO_x will be generated and the AN may transition to an exothermic
	Significantly involved means significant quantity being heated enough to potentially or actually melt/decompose.	A, F	

Section	Key Points	Supports principles	Additional Intent / Comments
			reaction, posing serious risk to those attempting to fight the fire.
	If AN is significantly involved in a fire, the evacuation plan shall be initiated immediately and ALL personnel shall evacuate. This should include emergency response personnel.	A, F	Emergency response personnel may have authority to override any instructions from site staff, but every attempt should be made to ensure they appreciate the danger and participate in the evacuation.
	Stages of AN decomposition during a fire explained.	A, F	
9.4 Evacuation	Minimum evacuation distances: • emergency response people Vulnerable distance; • anyone else double Vulnerable distance; • but minimum always 400m.	F	The distances tabulated are based on risk; if circumstances are such as to cause an evacuation to be initiated it is almost certain that the probability side of the risk equation is already higher than "normal" so it is prudent to overcompensate on the consequence side by having large distances.
	Selection of evacuation points site-specific, striking balance across 5 listed criteria.	F	
10. Risk Assessment			
	Must do and document risk assessment for proposed new premises. Issues to be considered listed.		Risk assessment is an inherent part of ensuring the whole of life safety of any facility.

Appendix B: Ammonium Nitrate Classification, Risk and Evacuation

B1 Ammonium Nitrate Classification

The generally accepted framework for classifying dangerous goods is embodied in the United Nations publication “Recommendations on the Transport of Dangerous Goods Model Regulations” and the companion publication “Manual of Tests and Criteria”. While this system applies to transport, it is accepted by many authorities as providing valuable insight into the behaviour of a material in storage as well as transport situations.

To be accepted as ammonium nitrate of UN 1942 and/or UN 2067 within Division 5.1 classification (for transport) a substance must:

- have not more than 0.2% combustible substances, including any organic substance calculated as carbon, to the exclusion of any other added substance (an acceptable test method is detailed at Appendix H Reference 6); and
- have passed UN Test Series 2 (from the UN Manual of Tests and Criteria).

To pass UN Test Series 2 the material must meet defined criteria for:

- insensitivity to shock;
- insensitivity to the effect of heating under confinement; and
- insensitivity to the effect of ignition under confinement.

B2 Ammonium Nitrate Properties

Pure AN (NH_4NO_3) is a white, odourless salt with a melting point of about 170°C. AN is highly soluble, tends to absorb water from the atmosphere, and can attract enough water to dissolve into aqueous solution if kept at high humidity. Such solutions, as well as solid AN, are corrosive and specialised coatings are often needed to protect structures (including concrete, steel, and galvanised steel) from deterioration.

Solid AN occurs in five different stable crystalline forms, depending on the temperature. Heat cycling, especially around 32°C, is likely to cause the crystalline (and usually porous) structure of the AN to break down and generate fines/AN dust. This, in combination with AN's propensity to absorb moisture, often leads to "caking" where AN granules or prills clump together - sometimes to the extent an entire IBC, or bin etc. can become one solid mass. Such caking can make AN very difficult to handle and various means of breaking up clumps (typically mechanical force) are often needed. Caking can also have significant quality implications as accurate quantities / proportions are needed when AN is blended / processed to make explosives. Caking can be reduced by protecting AN from temperature cycling and moisture, and by rapid stock turnover.

AN is not combustible and does not burn but, being an oxidising agent, it can facilitate the initiation of fire and will assist the combustion of other materials, even if air is excluded. Fires involving AN cannot be extinguished by oxygen deprivation because of the provision of oxygen from AN. Water is the most effective means of firefighting — attempts to smother fires with dry chemical, carbon dioxide or foam extinguishers will not succeed.

If AN is heated, it will decompose to give off toxic gases. In an open and unconfined situation, it will decompose completely to give gaseous products of nitrous oxide (N_2O), ammonia (NH_3) and nitric acid

(HNO_3) in a steady controlled way, with white fumes and vapours. If heated sufficiently (such as in a fire) and contaminated and/or confined (such as in enclosed drains or enclosed parts of equipment), the explosion sensitivity of AN will increase and other gases, including brown vapours of toxic nitrogen dioxide (NO_2), will be produced. Through self-accelerating reactions, the temperature will continue to rise and detonation can occur.

B3 Explosion Hazards Associated with Ammonium Nitrate

B3.1 General

In the absence of control measures, all AN has some risk of:

1. explosion due to:
    a. fire;
    b. contamination; and/or
    c. shock (including impact from high-energy projectile)
2. release of toxic fumes due to fire; and
3. environmental impact.

The most significant of these is the risk of explosion caused by fire, contamination, or shock. (Malicious action is sometimes viewed as a fourth mechanism that can lead to an explosion of AN, but a malicious actor who wanted to cause such an explosion would have to make their attempt using one of the same three mechanisms.)

Pure AN is difficult to detonate under ambient conditions of temperature and pressure, and potential energy sources such as flame, spark, impact, friction, and rough handling are not known to cause detonation.

An explosion of pure AN can be initiated with high explosives under ambient conditions, and explosives must never be used to break up or loosen caked AN. Under ambient conditions, it is not possible to initiate AN by means of a rifle bullet. However, the shock sensitivity of molten AN increases significantly and severe mechanical impact can lead to detonation.

AN can explode without shock if heated sufficiently, but only if contaminated, under confinement, or both. Under these circumstances, the temperature will quickly rise above 300°C, giving off other gases including brown vapours of toxic nitrogen dioxide (NO_2). The temperature will continue to rise through self-accelerating reactions, and a detonation may occur. In a fire, for example, pools of molten AN may be formed and if the molten mass becomes confined, such as in drains, pipes, plant or machinery, it could explode, particularly if it becomes contaminated. Fires involving AN have caused many explosions in the past, particularly in transport situations. It is also true that there have been many more fires involving AN that did not lead to explosions.

AN dust, being non-combustible, does not give rise to dust explosion hazards such as those commonly associated with organic dusts like grain or flour.

Appendix F lists all known significant accidental explosions of AN since industrial production began in the early 1900s. Each of these, as well as many fires (many of which are also listed), have provided opportunities to learn, and over time some of the causes of historical explosions have been eliminated (e.g., caked AN is no longer loosened by explosives, and wax is no longer used as a coating for AN prills). It is now well understood that fire engulfment, especially when combined with contamination, is by far the most likely cause of an accidental explosion of AN.

Chemical contamination (without associated fire) is believed to have been the cause of only one significant accidental explosion of AN (Toulouse, September 2001). Due to this event "contamination" is now widely accepted as a potential third mechanism that can initiate an explosion of solid AN (the first two being shock and fire).

B3.2 Explosion Hazard at AN Stores

Through its lifecycle, AN will normally experience several situations:

- manufacture;
- transport;
- storage;
- use.

Of these, storage is the simplest, most predictable, and least risky. In a manufacturing context, temperatures and pressures can be far above the ambient levels common to stores, and manufacturing plants can have process equipment with the potential to act as a source of shock initiation, as well as various potential contaminants. In transport, and when being used, there are many more variables that can affect the risk, including the presence of fuels and other incompatible materials (e.g., the large AN explosion at Tianjin was caused by fires and possibly explosions of other materials that were being handled nearby).

As illustrated by having passed UN Test Series 2, AN is very insensitive to overheating and shock, and very difficult to initiate. For AN stores within the scope of this Code, the likelihood of an AN explosion being initiated by shock or by chemical contamination is extremely low, perhaps negligible. If any explosion were to occur, the most likely initiation mechanism is fire.

Fires and resulting explosions are avoided by rigorously eliminating or reducing the amount of potential fuel (e.g., combustibles) in and around the storage site. If all potential sources of fuel can be eliminated, the chance of an accidental explosion is remote. Suitably designed, constructed and maintained AN storage facilities and AN transfer equipment play a vital role in minimising the risk of fire - as does appropriate training of all relevant persons.

Experience of fires in transport and at fertiliser stores suggests that explosion of AN will not occur for some time after a fire starts – at least 20 to 30 minutes, but usually around 60 to 70 minutes. (For instance, there were explosions following truck crashes at Taroom in 1972 and Angellala Creek in 2015. In both incidents the explosions eventuated after significant lead times – in excess of 60 to 70 minutes.)

B4 Other Hazards Associated with Ammonium Nitrate

The most significant hazard associated with AN is explosion. In addition, AN has the potential to decompose and release toxic fumes if exposed to significant heat and/or fire. There is also some potential for adverse environmental impact in the form of ground or water contamination.

Although primarily intended to reduce, mitigate, or eliminate the risks arising from explosion, the requirements detailed in this Code are considered adequate to also manage the risk arising from release of toxic fumes.

The risk of adverse environmental impact is addressed through requirements and recommendations detailed in Section 8.

B5 Evacuation

When a fire significantly involving AN is judged to be out of control, or if the fire is engulfing the AN, evacuation is mandatory. Everyone, including fire fighters and other emergency response personnel, should move a safe distance away where they will not be harmed if there is an explosion. The evolution of toxic brown nitrogen dioxide is a sign that the fire is out of control and immediate evacuation is required.

The process of promptly evacuating on-site and off-site people in the event of a fire significantly involving AN must be clearly documented in the emergency response plan for the site, with a clearly established process for alerting people and preventing entry into an evacuated area.

An explosion caused by fire would be a “With-Warning” explosion, meaning the fire would be apparent to people nearby before the explosion occurred. For such “With-Warning” explosions, evacuation can help reduce the consequences. It is likely that, in many circumstances, even a partial evacuation would reduce risk substantially.

Appendix C: Glossary

ADG Code	Australian Code for the Transport of Dangerous Goods by Road & Rail
AEISG	Australasian Explosives Industry and Safety Group
AN	See Definitions
APT	A-P-T Research Inc., Huntsville, AL, US
AS	Australian Standard
COAG	Council of Australian Governments
EIP	Emergency Information Panel
ERP	Emergency Response Plan
ES	Exposed Site
FIBC	Flexible Intermediate Bulk Container
HIPAP	Hazardous Industry Planning Advisory Paper
IBC	Intermediate Bulk Container
IME	Institute of Makers of Explosives
IMESAFR	Institute of Makers of Explosives Safety Analysis for Risk (blast-modelling software)
IP Code	Australian Standard AS 60529 Degrees of Protection Provided by Enclosures
LPG	Liquefied Petroleum Gas
MHF	Major Hazard Facility
MPU	Mobile Processing Unit
PEMB	Pre Engineered Metal Building (also known as a metal shed)
PES	Potential Explosion Site
PMV	Politically Motivated Violence
PPE	Personal Protective Equipment
QRA	Quantitative Risk Assessment
SAFEX	SAFEX International
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SSAN	Security Sensitive Ammonium Nitrate
TNT	Tri-Nitro Toluene
UN	United Nations
UN 3375 material	Ammonium Nitrate Emulsions, Suspensions and Gels, conforming to UN3375
VOD	Velocity of Detonation
WA	Western Australia

Appendix D: Basis of Minimum Separation Distances

D1 Introduction

This appendix explains how the minimum separation distances in tables 5.3 to 5.7 (Section 5) were calculated. It is AEISG's intention that the origin of these distances is fully transparent, and that the distances can be independently reproduced by anyone who follows the same methodology.

D2 Basis of Distances

D2.1 AN Hazards and Risk

The properties of AN, and the hazards associated with it, are more fully reviewed in Appendix B, however, in the absence of control measures, all AN has some risk of:

1. explosion due to:
    a. fire;
    b. contamination; and/or
    c. shock (including impact from high-energy projectile)
2. release of toxic fumes due to fire
3. environmental impact.

The most significant of these is the risk of explosion, and measures which reduce, mitigate, or eliminate the risks arising from explosion are considered adequate to also manage the risk of release of toxic fumes. Environmental impact is a relatively lesser concern and is adequately addressed through normal management and waste management practices (as detailed in Section 8). The three mechanisms of concern are therefore fire, contamination, and shock. (Malicious action is sometimes viewed as a fourth mechanism than can lead to an explosion of AN, but a malicious actor who wanted to cause such an explosion would have to make their attempt using one of the same three mechanisms.)

D2.2 The Basic Requirement

In general, for any well-managed store complying with the requirements of this Code, the risk of explosion is negligible. Nonetheless, catastrophic AN explosions have continued to occur around the world, usually because a store has not been well-managed. Thus, it is a requirement of this Code that AN stores shall not be located where the risk posed to surrounding land uses exceeds the risk criteria detailed in this appendix.

D2.3 Risk Criteria

Risk has two significant dimensions: the likelihood of an event occurring, and the consequences if it does occur.

Risk can be expressed numerically, and can be represented as:

"Risk" (annual fatality risk) = "event likelihood per year" multiplied by "likelihood the event causes death"

The NSW Hazardous Industry Planning Advisory Papers (HIPAPs) detail various aspects of the management of risk from a land-use planning perspective, and HIPAP 4 details quantitative risk criteria that are deemed tolerable when used as the target for assessments at the planning stages of intended

developments. These criteria are generally consistent with criteria adopted in other developed economies such as the UK, and other European and US jurisdictions. As these criteria are generally considered acceptable by Australian regulatory jurisdictions for assessing risks from hazardous industries, AEISG believes these criteria are also appropriate for AN stores.

D2.4 AEISG Approach

The hazards associated with AN, particularly explosion, and the control measures appropriate to manage them are well understood and documented in several standards and codes globally. If these control measures are followed, the likelihood of an explosion of AN in a storage situation (excluding AN manufacture and transport) is negligible. In fact, the likelihood of an explosion of stored AN is generally so low that, in the majority of jurisdictions globally, no particular distances are prescribed to separate AN stores from other land uses. Larger stores, however, are likely to be subject to risk assessment along similar lines as the Australian MHF processes.

While most control measures influence the “likelihood” side of the risk equation, separation distances influence the “consequence” side. AEISG recognises that Australian regulatory authorities are generally in favour of prescribing minimum distances for AN stores and has therefore developed tables of distance based on meeting defined risk outcomes.

One way to calculate distances is a conventional Quantity-Distance (QD) approach. But while a QD approach is common for Class 1 explosives, it has several flaws:

- A QD approach sets separation distances based on calculated overpressure (typically via a formula which calculates the peak incident side-on overpressure). But the way a structure at an exposed site (ES) responds to overpressure can vary significantly depending on its construction.
- Since most QD tables are based on TNT, using a QD approach for AN requires the AN to be treated as "equivalent" TNT. While TNT is routinely chosen as a reference explosive because the blast waveform from TNT explosions has been well characterised by experiments, there is still much debate, and little consensus, about the appropriate conversion factor or factors for AN.
- A QD approach does not explicitly take into account debris (projections or shrapnel), and so required distances are the same for storage in a tent on a sandy floor (zero significant debris) as they are for an unreinforced brick building (very high debris).
- A QD approach does not take into account directionality, but recent large-scale testing shows debris distribution from rectangular structures is significantly directional, and that very little debris is projected directly away from corners.
- A QD approach is consequence based and hence does not reflect risks or allow risks to be minimised or better managed.

Rather than a QD approach, which sets standard distances based solely on the quantity of material that may explode, AEISG believes that a quantitative risk approach is a superior way of calculating appropriate separation distances for AN stores to ensure acceptable risk levels are achieved.

The basic requirement is to locate new AN stores such that the risk they pose to surrounding land-uses meets the HIPAP criteria. The intention is to meet this requirement by using a quantified risk assessment (QRA) process. This may be done either on a site-specific basis or by using the default distances specified in this Code, which have been developed by conducting QRAs of multiple combinations of typical site conditions and selecting the “worst-case”. These distances will, on the basis of conservative assumptions, reduce the risk of individual fatality to the criteria detailed in HIPAP 4 or less.

If assessing on a site-specific basis, the QRA process must be acceptable to the licensing authorities and must demonstrate that the HIPAP 4 individual fatality criteria are met. AEISG recommends using the AN module of IMESAFR with the inputs as detailed in this appendix (except that site-specific details of construction types and occupancy should be used). It is likely that most site-specific assessments will result in smaller distances than the defaults because the default distances are based on a number of very conservative or worst-case assumptions, not all of which are likely to apply to any particular store.

Irrespective of whether site-specific or default distances are used, AEISG recommends using IMESAFR modelling not only to assess the consequences of any potential explosion, but also to identify opportunities where one choice may be significantly superior to another in terms of explosion risk. For example, the orientation of a proposed store may be optimised to minimise debris in the direction of exposed sites, or an open or silo store may be selected over a concrete or masonry building, and so on.

Because the minimum separation distances are based on individual fatality risk, the need for consideration of societal risk may arise for places with high population density, such as a sports stadium, a large shopping centre, a high-rise apartment building, etc.

In AEISG's quantitative approach, the calculation of distances begins with the risk equation:

(Risk from explosion) = (likelihood of explosion) multiplied by (consequence of explosion)

To base separation distances on risk we need to estimate the likelihood of explosion as well as the consequences of explosion at different distances.

D2.5 Establishing Consequences

The consequences to be avoided are primarily fatalities and injuries. For a given explosion scenario, irrespective of how unlikely it may be, it is possible to estimate the probability of fatalities and injuries occurring if that scenario occurred. This can be done semi-quantitatively using the descriptions in several publications, including the SAFEX Good Practice Guide and HIPAP 4. These descriptions, like QD tables, are based on expected overpressure and provide relatively coarse estimates. More precise, numerical estimates can be obtained by using a blast assessment tool or calculator. In AEISG's opinion, the best and most comprehensive of these tools is IMESAFR. It is the most detailed and is believed to be the most firmly anchored to actual test data gained from multiple test programs, including at a large scale (multiple tonnes). IMESAFR overcomes many of the flaws inherent in a QD approach as it has many variables that can be adjusted to better represent a real-world situation, (such as building type, percentage glass, etc) and it is believed to generate the most accurate estimate of the likely effects of an explosion.

Historically, AN explosions (like those caused by other materials) have been modelled as an "equivalent" amount of TNT. IMESAFR now has a module specifically for AN explosions, without converting to a supposedly equivalent quantity of TNT.

In AEISG's view, the "consequence" part of the risk equation can be estimated to a high degree of accuracy and with a well-defined degree of conservatism by using the AN module of the IMESAFR blast assessment tool.

D2.6 Estimating Likelihood

AEISG has considered four sources which may offer conservative but reasonable estimates of the likelihood of an AN explosion occurring:

1. Typical estimates that have been used in QRA's / site assessments to support MHF or similar licencing.
2. The baseline event frequencies and allowable reductions detailed in the SAFEX "Good Practice Guide for the Safe Storage of Solid Technical Grade Ammonium Nitrate" Revision 02, March 2014 (GPG 02 rev02).
3. The frequencies determined by the IMESAFR Technical Panel, and which appear as the IMESAFR defaults.
4. AEISG's own "ground up" estimates based on history.

D2.6.1 Typical Estimates used in QRA's

To AEISG members' knowledge, AN explosion event frequencies ranging from 1E-5 to 1E-7 have been used globally in risk assessments. Although this is a fairly wide range, it does give some insight into the bottom end of the range, suggesting anything more than ~10 explosions per million site-years is unusual.

D2.6.2 Event Frequencies from SAFEX "Good Practice Guide for the Safe Storage of Solid Technical Grade Ammonium Nitrate" Revision 02, March 2014

The SAFEX baseline event frequencies for AN explosions were derived by taking a conservative view of the historical rate of non-transport AN explosions **relevant to AN manufacturing plants**. They are defined separately for each of three initiating mechanisms (fire, contamination, and shock/projectile), and the GPG advises that "these likelihoods can be reduced based on implementation of 'best practice' control measures".

Control measures that reduce likelihood are listed in Appendix A.4 of the GPG but the degree of reduction attributable to specific measures is not defined. It is, however, clear that (for developed economies) the baseline frequencies represent something like a bad- or worst-case.

The GPG also notes that: "shock initiation may be ignored if not on a manufacturing site. For a high velocity projectile to initiate an explosion of solid TGAN it must have a very high momentum. Such a projectile may originate from a process plant explosion or detonation. This mode of initiation can be eliminated for stores at sufficient distances from sources of highly energetic projectiles (e.g. process plant, trucks carrying explosives or other potentially detonable substances, etc)."

Table B3 below is reproduced from SAFEX GPG02 Rev 02:

Table B.3: Baseline Event Likelihoods (F_{event}) for an AN Manufacturing Site[15]

<table>
<tr><th rowspan="2">STORAGE TYPE</th><th colspan="4">F_{event} BY INITIATION MECHANISM</th></tr>
<tr><th>Contamination</th><th>Fire</th><th>High Energy Impact</th><th>Malicious Acts</th></tr>
<tr><td>AN Bulk
(Per pile up to 5,000 tonnes)</td><td>[10x10 -6 /yr]</td><td rowspan="2">[50x10 -6 /yr]</td><td rowspan="2">[10x10 -6 /yr]</td><td rowspan="4">Consult National Security Authority</td></tr>
<tr><td>Off-spec pile
(Per pile up to 500 tonnes)</td><td>[50x10 -6 /yr]</td></tr>
<tr><td rowspan="2">AN Bags or Containers
(Per stack up to 2,500 tonnes)</td><td rowspan="2">[25x10 -6 /yr]</td><td>[50x10 -6 /yr]
(with pallets)</td><td rowspan="2">[5x10 -6 /yr]</td></tr>
<tr><td>[25x10 -6 /yr]
(no pallets)</td></tr>
</table>

Footnote: 15 Derived from historical incident data

Removing “off-spec piles” (which are out of scope of the AEISG Code) this can be rearranged as:

SAFEX Event Likelihoods (explosions per million plant-years)			
Mechanism	**Likelihood for (type of storage):**		
	AN Bulk (Per pile up to 5,000 tonnes)	AN Bags or Containers (No pallets) (Per stack up to 2,500 tonnes)	AN Bags or Containers (With pallets) (Per stack up to 2,500 tonnes)
High Energy Impact (consumes 100% of AN)	10	5	5
Contamination (consumes 50% of AN)	10	25	25
Fire (consumes 10% of AN)	50	25	50
Total	70	55	80

In summary, the SAFEX estimate of total explosion frequency at an AN manufacturing site (and excluding off-spec piles) ranges between 55 and 80 explosions per million plant-years. And the guide advises that shock initiation may be ignored if not on a manufacturing site.

For stores within the scope of this Code, the risk of initiation from contamination or shock is likely negligible, which would suggest that an appropriate rate is the baseline rate for fire of 25 - 50 explosions per million years before allowing for reduction due to adoption of best-practice controls. All of the significant best-practice controls detailed in the SAFEX guide are required by this Code, so in AEISG’s view an appropriate reduction from the SAFEX baseline frequencies would be a likelihood in the range of 10–20 explosions per million store-years, all with fire as the initiation mechanism. It should also be noted that if following the SAFEX guide, all of these explosions would involve only 10% of the AN present.

D2.6.3 IMESAFR Default Explosion Frequencies

A full history of the origins of the IMESAFR modelling software is beyond the scope of this appendix, but in summary, it is a QRA software tool developed by the specialist explosives research company APT as part of a joint effort with the Institute of Makers of Explosives (IME) and North American regulators. It was developed in the USA and derived from extensive earlier work done to create blast modelling software for the US military. The civil and military versions have each benefitted from ongoing collaboration, including shared access to many large-scale test programs, which have been used to refine the models.

The IMESAFR software includes default explosion event frequencies, which vary according to various aspects of the situation that is being assessed. (For example, the manufacture of Class 1 explosives has a higher default frequency than the long-term storage of Class 1 explosives; operations in sub-standard conditions increase the frequency; etc) For the Class 1.1 explosives and the Class 1.5 blasting agents included in the software, the event frequencies were, where possible, based on the historical rate (in North America) of real explosions. The specific default frequencies in the software are considered, decided, reviewed, and updated by a technical advisory group (IMESAFR Development Team), which

includes representatives from the US IME and the explosives regulator (Bureau of Alcohol Tobacco Firearms and Explosives) as well as various global explosives experts. The default frequencies are widely accepted throughout the Americas and, to an extent, globally.

Historically, explosions of AN (like other materials) have been modelled as an "equivalent" amount of TNT (which is a very well-characterised explosive). When the IMESAFR AN module was developed in 2016, it became possible to move away from the historical method of treating AN as some equivalent percentage of TNT and instead model the explosion directly as an AN explosion. At the same time it was necessary to decide what default explosion frequency should be loaded into the software. The IMESAFR Development Team decided to adopt the SAFEX structure of recognising three different mechanisms through which AN can explode, and also to adopt from SAFEX as defaults the amount (i.e., the % of the AN present) involved for those mechanisms. In deciding an appropriate event frequency for each mechanism, the IMESAFR Development Team considered the SAFEX baseline frequencies, and reduced them substantially because:

- the vast majority of stores which are of interest to the IME are not part of AN manufacturing sites;
- a very high proportion (~90%) of the AN stores known to the IMESAFR Development Team are overhead silos, of which there is no recorded instance of an explosion (and some doubt whether any credible scenario could result in an explosion);
- the explosion frequency for AN is very unlikely to be higher than the frequencies for Class 1.1 explosives or Class 1.5 blasting agents.

The chosen default % AN involved and default frequencies are:

- Fire: involves 10% of the AN present at a frequency of 2.34E-6 per year
- Contamination: involves 50% of the AN present at a frequency of 1.17E-6 per year
- Shock/projectile: involves 100% of the AN present at a frequency of 1.17E-6 per year

Note that when using the IMESAFR software the modeller can override the default event frequencies and/or % contributions, thereby allowing a range of scenarios and what-ifs to be modelled.

D2.6.4 AEISG's own "ground up" estimate based on history

One way to estimate the frequency of an event is to measure the historic rate of occurrence over a suitable timeframe. In AEISG's view the last 50 years is a reasonable timeframe to consider because changes to the standards and precautions for AN manufacture, transport, and storage over that time have been incremental rather than fundamental.

To establish a frequency the following information is required:

1. the number of AN Stores within the scope of this Code where an explosion COULD have happened, and
2. the number of explosions at AN stores within the scope of this Code that DID happen.

D2.6.4.1 Global Number of In-scope Stores

Based on a survey of members, AEISG estimates that, as of 2021, there are approximately 200 to 250 AN stores in Australasia that will fall within the scope of this Code. (This includes some stores owned or operated by haulage contractors and/or customers but excludes stores at AN [and other] manufacturing plants.) This number has been fairly steady over the last 20 to 30 years and would have been a little

smaller earlier. Many AEISG members are part of global organisations with access to various views of the global ebb and flow of solid AN (both fertiliser and non-fertiliser grades). Pooling of knowledge indicates that a global average of 1000 in-scope AN stores over the last 50 years is likely to be significantly conservative, so that is the estimate AEISG has adopted.

D2.6.4.2 Number of Explosions at In-scope Stores

Appendix F of this Code lists all known significant explosions (and many significant fires) involving AN since approximately 1916. They are categorised as one of Manufacturing (including AN stored at AN manufacturing sites), Transport, or Storage. Manufacturing and Transport are excluded from the scope of this Code. Three explosions are categorised as Storage, being;

1. October 2003; Saint-Romain-en-Jarez, France;
2. April 2013; West, Texas, US; and
3. August 2020; Beirut Lebanon

Table D1 presents an analysis of these three storage explosions, plus two other significant explosions (Toulouse, France in November 2001 and the Port of Tianjin, China in August 2015). The analysis assesses whether the relevant store would fall within the scope of this Code and concludes that none of them would. (It is also obvious from the descriptions that in each case at least some of the basic principles for safe storage and handling of AN were not followed, and that if they had been, the event would not have occurred.)

AEISG therefore concludes that over the past 50 years there have been zero explosions at AN stores that would be within the scope of the AEISG Code.

Table D1: Analysis of AN Storage Explosions

Place & Date	Deaths	Event / Storage Description	Would store fall under scope of AEISG AN Code? / Why?	
Toulouse, France (Nov, 2001)	31	Believed to be the only known explosion caused by contamination. Occurred at a warehouse used for the temporary storage of out-of-specification AN, which was waiting to be recycled into AN-based fertiliser mixtures. May also have included customer returns and store may have been operated by various contractors. Estimated explosion equivalent to 20-40 tonnes of TNT, from approx. 400T AN present.	No	Part of an AN Manufacturing plant, so excluded.
Saint-Romain-en-Jarez, France (Oct, 2003)	0	Fire then explosion in a farm barn containing some AN (~3 tonnes) plus multiple fuels and combustibles. Estimated explosion equivalent to 80 to 160 kg TNT.	No	AN not intended to support mining / quarrying (and almost certainly fertiliser grade).
West, Texas, US (Apr, 2013)	15	Fire then explosion at a fertiliser and rural supply business with approx. 30 tonnes AN stored in wooden bins.	No	AN not intended to support mining / quarrying (and almost certainly fertiliser grade).
Port of Tianjin, China (Aug, 2015)	173	Large fire (of Nitrocellulose) at a hazardous goods warehouse operated by logistics company within Port area; AN was adjacent to fire and exploded. Approx. 800 tonnes AN believed to have been present / involved.	No	AN was under the control of Port Authority (in Australia would have fallen under AS 3846) so not in scope.
Beirut, Lebanon (Aug, 2020)	218	Large fire then explosion. Reportedly 2750 tonnes AN present, impounded some years earlier from a ship and put into a store at the docks. Photos and reports indicate absence of housekeeping and co-storage of a large quantity of fireworks plus various fuels and combustibles.	No	AN was under the control of Port Authority (in Australia would have fallen under AS 3846) so not in scope.

D2.6.4.3 Event Frequency Based on History

As detailed above, AEISG estimates there has been an average of at least 1000 in-scope AN stores globally over 50 years, giving a total history of 50,000 store-years. There have been zero explosions at such stores. If an explosion were to occur now, the rate would be 1 explosion per 50,000 store years, which is 20 per million store-years, an annual frequency of 2E-5. AEISG therefore estimates that the explosion event frequency based on history for in-scope stores is not more than 2E-5.

D2.6.5 Overall Explosion Event Frequency

As noted above, AEISG has considered 4 sources that may offer reasonable / conservative estimates of the likelihood of an explosion occurring:

1. Typical estimates that have been used in QRAs and site assessments to support MHF or similar licencing;
2. The baseline event frequencies and allowable reductions detailed in the SAFEX "Good Practice Guide for the Safe Storage of Solid Technical Grade Ammonium Nitrate GPG02 Rev 02 Published March 2014";
3. The frequencies determined by the IMESAFR Technical Panel and loaded in IMESAFR as defaults;
4. AEISG's own "ground up" estimate based on history.

The ranges of estimated explosion frequency and (where relevant) the split across mechanisms is summarised in Table D2 below, along with the values used by AEISG in developing the minimum separation distances. The values used by AEISG are believed to be significantly conservative.

Table D2: Summary of Estimates of AN Store Explosion Event Frequency

Total explosions per million store-years					
Origin of Estimate	**Total / Range**		**Split by initiation Mechanism**		
	Low	**High**	**High Energy Impact**	**Contamination**	**Fire**
			100% of AN	**50% of AN**	**10% of AN**
Typical estimates that have been used in QRAs	0.1	10	n/a		
SAFEX GPG 02: Raw	55	80	5 to 10	10 to 25	25 to 50
SAFEX GPG 02, with reductions and exclusions per AEISG Code scope and SAFEX best practices	10	20	0	0	10 to 20
IMESAFR defaults	4.68		1.17	1.17	2.34
AEISG estimate based on history	20		n/a		
Frequency/split adopted by AEISG	20		2	6	12

The event frequency AEISG has decided to adopt for the purpose of calculation is deliberately conservative, both in light of the other estimates that have been used more widely, and also given that:

1. The scope of this Code excludes manufacturing, transport, and any processing or mixing operation.
2. This Code incorporates the significant "best practice" control measures, which reduce SAFEX baseline event frequency.
3. Due to the nature of operations at in-scope stores, the risk of shock or contamination as a source of initiation is likely to be negligible.

Note that the frequencies adopted by AEISG for the purpose of developing risk-based distances are nominally split across the three initiation mechanisms, but AEISG prefers to view the total (per million store-years) as representing:

- 2 explosions that involve 100% of the AN present, irrespective of how the explosion is initiated, plus
- 6 explosions that involve 50% of the AN present, irrespective of how the explosion is initiated, plus
- 12 explosions that involve 10% of the AN present, irrespective of how the explosion is initiated.

In AEISG's view this approach is conservative, and allows for some variability in the level of AN contribution. For instance, in some large fires it is likely the AN becomes contaminated as a result of the

fire, so it is then more likely to explode, and more of the AN may be involved. Even though High Energy Impact is not credible at in-scope sites, and the SAFEX Guide specifies that this mechanism can be discounted, it is deliberately conservative to allow for some level of 100% AN contribution explosions.

D3 Development of Minimum Separation Distances

The AEISG separation distances in this Code specify distances which are based on meeting HIPAP 4 individual fatality risk criteria. HIPAP 4 suggests different criteria for different land uses, and AEISG has adopted the same land uses in this Code. The land uses and risk criteria are:

HIPAP 4 Land Use (summary)	AEISG Short Name	HIPAP 4 Risk Criteria (Individual fatality per year)
Hospitals, schools, child-care facilities, old age housing	Vulnerable	0.5 E-6
Residential, hotels, motels, tourist resorts	Residential	1 E-6
Commercial developments including retail centres, offices and entertainment centres	Commercial	5 E-6
Sporting complexes and active open space	Open	10 E-6
Industrial	Industrial	50 E-6

As noted above, AEISG has adopted an estimated annual explosion event frequency of 20 E-6. The risk criterion for the "Industrial" land use is therefore met, irrespective of consequence, so it is not possible to set these distances by modelling to establish the distance at which the risk target is met. For that reason the distances tabulated for Industrial land use are set at the same distances applicable to sporting complexes and active open space.

The IMESAFR modelling software analyses the risk to people at an Exposed Site (ES) of an explosion at a Potential Explosion Site (PES). In doing so the software takes account of the physical construction details of both PES and ES. The modelling used for this Code is always based on AN as the substance that explodes and the PES is always an Store (or a group of adjacent stores). AEISG selected 5 different types of AN store construction to represent a spectrum of different types of store that collectively includes the storage situations commonly encountered in Australasia. Likewise, 5 different types of ES were defined, again aiming to collectively represent the types of building commonly found. Full details of the AN stores and ES's used in the modelling are included in section D4 below. In summary they are:

AN Store (PES):

1. Overhead Silo(s) (one or more 60 tonne capacity overhead silos)
2. Metal Shed (shed with metal cladding over a steel frame)
3. Open (AN stored in the open)
4. Shipping Container(s) (one or more 20 foot containers, assuming a capacity of 20 tonnes per container)
5. Concrete Shed (100mm concrete walled shed)

Exposed Site (ES)

1. Large unreinforced masonry
2. Small unreinforced masonry
3. Small wood frame
4. Large Metal shed
5. Open (people in the open)

The land use "sporting complexes and active open space" aligns with Exposed Site "open". Apart from that there is no alignment between type of ES and land-use; any of the other 4 types of ES construction might be used for any of the other 4 land uses. As noted, no modelling was required for the "industrial" land use so the modelling was carried out (at each tonnage level) for the following combinations:

Land Use	Risk target	ES	PES				
			Open	Metal Shed	Shipping Containers	Overhead Silos	Concrete Shed
Hospitals, schools, child-care facilities, old age housing	5.0E-7	Large Masonry	Yes	Yes	Yes	Yes	Yes
		Small Masonry	Yes	Yes	Yes	Yes	Yes
		Small Wood Frame	Yes	Yes	Yes	Yes	Yes
		Large Metal Shed	Yes	Yes	Yes	Yes	Yes
Residential, hotels, motels, tourist resorts	1.0E-6	Large Masonry	Yes	Yes	Yes	Yes	Yes
		Small Masonry	Yes	Yes	Yes	Yes	Yes
		Small Wood Frame	Yes	Yes	Yes	Yes	Yes
		Large Metal Shed	Yes	Yes	Yes	Yes	Yes
Commercial developments including retail centres, offices and entertainment centres	5.0E-6	Large Masonry	Yes	Yes	Yes	Yes	Yes
		Small Masonry	Yes	Yes	Yes	Yes	Yes
		Small Wood Frame	Yes	Yes	Yes	Yes	Yes
		Large Metal Shed	Yes	Yes	Yes	Yes	Yes
Sporting complexes and active open space	1.0E-5	Open	Yes	Yes	Yes	Yes	Yes
Industrial	5.0E-5	NA	No	No	No	No	No

In short, 65 combinations of PES, ES, and risk target were modelled at each of 10 tonnage levels. For each of these 650 combinations the distance at which the risk criterion was met was calculated.

This modelling and assessment work highlighted significant differences in the risk depending on the combination of land-use and type of AN store. In particular, it became apparent that some types of store are consistently less risky than others. For that reason, different minimum separation distances are specified for each of the five types of AN store.

In summary:

- distances for an Open ES (sporting complexes and active open space) are based on the specific modelling from the relevant type of AN store;
- distances for a Vulnerable ES (hospitals, schools, child-care facilities, old age housing) from a type of AN Store are the biggest distance for any of the 4 types of ES construction from that type of AN store.
- distances for a Residential ES (residential, hotels, motels, tourist resorts) from a type of AN Store are the biggest distance for any of the 4 types of ES construction from that type of AN store.
- distances for a Commercial ES (commercial developments including retail centres, offices and entertainment centres) from a type of AN Store are the biggest distance for any of the 4 types of ES construction from that type of AN store.

In this way the separation distances for a particular type of AN store are always based on the "worst-case" combination of that type of store with any of the types of ES relevant to that land use. Because of this (and also because of the many other layers of conservatism used in the modelling) the mandated distance will typically be more than is actually required to meet the relevant risk criterion.

D 4 IMESAFR Modelling Details

D 4.1 Layers of Conservatism

In setting up and running the calculations within IMESAFR, a number of conservative assumptions were made to ensure that the specified distances will meet HIPAP 4 criteria even for "worst case" situations. The table below details the conservative assumptions used in this modelling.

Conservative Assumption	Comments
The Explosion Event Frequency	As noted in section 2 of this appendix there have been zero explosions ever reported globally at in-scope stores. It could be argued that this shows that, despite differing standards and practices around the world, AN is generally robust against all but extreme sets of conditions, and for in-scope AN stores, no separation distances are required. However, in the interest of conservatism, it is assumed that even though an explosion has never happened at an in-scope store, it could be imminent.
No reliance on evacuation	The modelling assumed all exposed sites are occupied continuously and risk targets are met on that basis. In practice, it is likely that in most situations there would be at least some attempt to evacuate, and any success in this would further reduce risk.
Any AN store is always filled to full licence capacity	In practice, the amount of AN present at most stores varies between near-zero and 100%, with a time-based average of ~60%. IMESAFR is able to take this into account and two values (MAXIMUM and EXPECTED) can be defined for the amount present and also the amount which contributes to the explosion. IMESAFR routinely calculates all 4 combinations of these, but the MAX/MAX combination (i.e., worst case) was always used.

The type (construction) of Exposed Site is the worst (relevant) type in combination with the type of AN Store	Hence, for other types of Exposed Site the risk would be less.
Every Exposed Site is in the most hazardous orientation in relation to the PES	The modelling in IMESAFR can allow for variations in the direction that most debris will scatter to align with real-world testing. This variation was selected and the ES was always placed normal to the front wall, where the debris hazard is usually highest.
Every Exposed Site is continuously occupied	This is particularly conservative for non-residential land uses (commercial and sporting/open).
The modelling calculates distances on a centre-to-centre basis (centre of PES to centre of ES)	When the distances are applied in practice they will follow the convention of being measured edge to edge, so the actual centre to centre distances will be bigger than the modelling requires.
IMESAFR high-level choices or switches were set to what is normally the more conservative choice, including:	
Uncertainty is ON	Uncertainty is a factor which increases the calculated results to ensure estimates of risk are safe-sided.
Used default velocity scaling factor	When using the AN module of IMESAFR the initial velocity of debris fragments is calculated as a % of the value that would be used for TNT. There is an option to select a lower velocity scaling factor which may be more realistic. In this exercise the more conservative default scaling was used.
Unreacted AN was not considered	IMESAFR can take account of unreacted AN, so that when the % that contributes to the explosion is set to 10%, for example, the other 90% is entrained in the blast wave. The effect of making this choice is sometimes conservative, but sometimes is not conservative. For this exercise it was not selected.
No frangible walls at PES	Frangible walls at a PES can help relieve and direct the blast effects. They are occasionally used in explosives manufacturing plants but not common elsewhere and were not used in this exercise.
No credit / allowance for barricades or terrain (hills, trees)	Worst case is that there is no barricade (mound) or other features that may intercept or reduce debris (including other buildings).
Activity is always AN Storage with no “environmental factors” set	IMESAFR takes account of the type of activity at a PES, and also whether the risk is influenced by environmental factors (which can increase or reduce risk). No environmental factors were set.

D 4.2 PES and ES Details

The construction details used in the modelling were:

AN Store Types (Potential Explosion Sites (PES))

Name	Description / Construction	Frangible parts	Soil type	Dimensions (m)		
				Length	Width	Height
Open	AN stored in the open or under lightweight cover, e.g., tarp.	Nil	Rock or hard clay	30	30	NA

Metal Shed	Pre-engineered Metal Building (PEMB): Profiled metal cladding over steel structure.	Nil	Concrete	22	11	3.7
Shipping container	20 foot shipping container: 1.5mm corrugated steel panels over steel structural members	Nil	Rock or hard clay	6.1	2.4	2.6
Overhead Silo	60 tonne capacity steel bin with supporting legs to allow truck to drive under	Nil	Concrete	3	3	9 (incl legs)
Concrete Shed	All-concrete: 4" concrete walls; corrugated steel panel roof with bracing.	Nil	Concrete	30	30	12

Exposed Site Types (ES)

Name	Description / Construction	% Open area	Window Type	Dimensions (m)		
				Length	Width	Height
Large masonry	Large unreinforced masonry (bricks / blocks), medium metal roof.	40	Annealed	45	45	8
Small wood frame	Stud wall building with plywood or board cladding and thin metal roof	40	Annealed	15	15	1-2 storey
Small masonry	Small unreinforced masonry, with thin metal roof (e.g., Corrugated)	40	Annealed	15	15	1-2 storey
Large Metal Shed	Large Pre-engineered Metal Building (PEMB): Profiled metal cladding over steel structure. Note that this metal shed is significantly bigger than the "metal shed" used as a type of AN Store.	25	Unglazed	45	45	8
Open	People in the open.	NA	NA	30	30	NA

D4.3 IMESAFR Modelling Inputs

The information here is intended to allow any person trained and accredited in IMESAFR Version 2.1.21 or later to set up and run the same modelling as was used to determine the AEISG's minimum separation distances.

D4.3.1 Methodology

The methodology used is:

1. Set up Scenario A with three "Open" PES on same location with one PES fire-initiated, one contamination, and one shock, using the default % AN involved per mechanism, but with the event frequencies detailed below, and starting charge weight of 10 tonnes. Add all 5 ES as detailed. Locate all ES's on zero azimuth and initially "far" from PES.
2. Save this scenario file.
3. Drag the Open ES gradually closer until risk target 1E-5 is reached, note the distance. (Return the Open ES to a far distance if necessary.)
4. Drag the next ES (e.g., Large Masonry) gradually closer until the first relevant risk target (5E-7) is reached, note the distance. Continue to reduce distance and note for the other two risk targets. (Return the ES to a far distance if necessary.)
5. Repeat for the other three ESs. That completes the 10 tonne row for this scenario and should produce 13 data points (distances).
6. Adjust the tonnage in each of the three PESs to the next value (20 tonnes) and repeat, to get the next 13 data points.
7. Repeat this process until all rows are complete for this scenario. All 130 data points for the "Open" PES should now be populated.
8. Repeat for the other 4 PES scenarios, resulting in 650 data points in total.
9. Note that Shipping Containers can hold 20 tonnes each, so the appropriate number of shipping containers also needs to be specified.
10. Similarly Silos can hold 60 tonnes each so the number of silos must be specified.

D4.3.2 Other IMESAFR Inputs

Event frequencies per mechanism:

PES	1	2	3
Mechanism	Shock/projectile	Contamination	Fire
% AN involved	100	50	10
Event Frequency	2.00E-06	6.00E-06	1.20E-05

Additional inputs:

1 Uncertainty is ON

2 Activity: Storage – AN with no environmental factors required

3 Zero people at any PES

4 Use Maximum Quantity / Maximum Contribution

5 No frangible walls or roof at PES or ES

6 PES operating hours 8760 per year

7 Risk Based Evaluation Distance 3000m

8 Explosives Type – Hazard Division 5.1, No primary fragments. Maximum NEWQD was varied by scenario. Expected was 1.0kg. Max/Max was always used.

9 AN – all three initiation mechanisms were used, each with a defined explosion event frequency.

10 PES: UBM of 1 and 8760 operating hours. Neither "set velocity scaling factor" nor "consider effects created by unreacted AN" were selected.

11 Barricade – No barricading was used.

12 There is no correlation between amount of AN present and number of people exposed

13 There is no correlation between PES activity and number of people exposed

14 Size and Position: ES sizes varied. The coordinates for each of the ESs was set at a relative distance to the PES that varied but always on the zero degrees azimuth.

15 ES occupancy is 1 person, 8760 hours/year, with high confidence.

16 Percentage of time people and AN are present is 100%

Warning flag noted for AN tonnages >500T (IMESAFR extrapolates model algorithms for these).

D5 Results Obtained from IMESAFR Modelling

The tables in this section list all of the distances obtained by following the methodology described in D4.3.1.

Scenario A	PES->	3 x Open												
	ES->	Open	Large Masonry			Small Masonry			Small Wood Frame			PEMB		
	Risk target ->	1.0E-5	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6
	Tonnes	Distance where Risk Target is just met												
	10	69	147	117	87	172	153	108	172	150	104	171	150	103
	20	92	202	159	117	228	202	143	228	200	138	227	200	138
	40	121	272	220	154	301	266	189	300	265	183	302	266	184
	60	143	323	263	180	352	311	221	351	311	216	355	314	217
	100	174	390	326	217	422	380	269	423	380	264	430	383	267
	140	199	432	369	246	470	428	306	470	427	301	481	434	306
	200	229	473	415	282	521	481	350	521	480	346	537	492	352
	300	269	509	460	326	583	544	407	582	543	402	608	561	410
	500	328	567	517	389	654	611	481	653	610	477	699	637	487
	1000	422	661	630	496	751	708	579	736	698	569	855	750	582

Scenario B	PES->	3 x Metal Shed												
	ES->	Open	Large Masonry			Small Masonry			Small Wood Frame			PEMB		
	Risk target ->	1.0E-5	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6
	Tonnes	Distance where Risk Target is just met												
	10	76	299	247	111	286	231	119	302	250	125	301	249	108
	20	90	324	264	132	319	258	142	324	267	139	323	266	130
	40	96	346	284	153	344	282	173	347	285	157	347	287	147
	60	110	359	295	170	361	299	192	361	296	170	364	304	159
	100	121	376	319	192	380	330	221	378	314	195	399	338	182
	140	128	392	343	211	404	356	242	393	328	213	431	368	197
	200	142	419	368	238	436	396	266	409	348	239	476	406	218
	300	159	461	400	267	479	436	297	432	378	265	539	451	253
	500	185	525	462	310	548	501	341	473	434	303	640	528	302
	1000	222	623	577	385	695	619	416	569	520	369	844	665	392

Scenario C	PES->		3 x (Groups of) Shipping Containers												
	ES->		Open	Large Masonry			Small Masonry			Small Wood Frame			PEMB		
	Risk target ->		1.0 E-5	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6
	Tonnes	No. of Containers	Distance where Risk Target is just met												
	10	1	100	288	242	121	284	238	124	289	247	137	288	241	122
	20	1	126	318	275	157	316	273	161	319	280	177	317	274	160
	40	2	173	400	342	215	400	343	217	401	344	230	400	342	219
	60	3	205	450	387	250	451	391	252	452	391	265	451	390	254
	100	5	247	508	444	295	513	450	299	512	451	308	512	450	300
	140	7	278	539	482	319	545	489	335	545	489	338	545	488	331
	200	10	309	568	517	344	577	527	368	577	527	366	575	526	366
	300	15	349	598	551	376	610	565	419	610	565	416	609	565	417
	500	25	413	626	587	437	637	601	478	637	602	476	639	605	477
	1000	50	496	652	627	505	679	654	543	679	654	543	696	660	548

Scenario D	PES->		3 x (Groups of) Overhead Silos												
	ES->		Open	Large Masonry			Small Masonry			Small Wood Frame			PEMB		
	Risk target ->		1.0 E-5	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6	5.0 E-7	1.0 E-6	5.0 E-6
	Tonnes	No. of Silos	Distance where Risk Target is just met												
	10	1	19	114	77	36	119	100	54	131	91	38	106	71	33
	20	1	25	151	113	48	154	135	74	166	122	56	145	109	44
	40	1	33	191	155	70	194	178	98	209	161	79	190	150	61
	60	2	38	212	176	85	221	204	115	233	185	96	215	175	73
	100	2	47	267	224	113	270	249	146	285	228	125	275	226	98
	140	3	63	295	254	136	301	284	169	320	263	148	314	265	118
	200	4	78	330	290	161	338	313	195	357	296	172	352	303	143
	300	5	98	363	320	190	371	354	227	368	322	203	387	338	172
	500	9	122	405	368	232	442	394	270	388	367	242	479	394	213
	1000	17	170	508	448	306	560	493	343	474	429	309	631	515	295

Scenario E														
	PES->	3 x Concrete Shed												
	ES->	Open	Large Masonry			Small Masonry			Small Wood Frame			PEMB		
	Risk target ->	1.0E-5	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6	5.0E-7	1.0E-6	5.0E-6
	Tonnes	Distance where Risk Target is just met												
	10	274	428	403	317	427	401	305	428	403	318	428	402	316
	20	304	476	446	352	475	444	341	476	447	352	475	446	352
	40	336	528	495	389	527	493	387	529	495	390	527	494	388
	60	357	561	524	413	560	523	411	561	525	413	560	524	412
	100	384	605	563	446	605	561	443	605	563	446	603	562	445
	140	403	632	586	468	632	586	464	633	587	469	631	586	468
	200	423	657	607	491	656	606	490	657	608	492	657	607	492
	300	447	665	629	519	664	629	512	666	630	518	668	634	519
	500	476	686	655	546	687	655	540	688	657	546	695	668	550
	1000	500	696	672	572	699	675	578	697	672	568	767	699	580

Appendix E: Land Use Classification of Typical Exposed Sites for Separation Distance Assessment

This Appendix provides guidance and examples of typical facilities, especially at mine sites, which may be exposed sites and so require separation from stores of AN, and how those facilities should be classified for the purpose of determining appropriate separation.

The classifications used in this code are based on the land use descriptions relevant to Individual Fatality Risk in the NSW Planning Advisory Paper HIPAP 4. As such, the land use descriptions only include facilities which may be Exposed Sites (ES), i.e. where people (as opposed to property) may be exposed to risk. Table 2 of HIPAP 4 is reproduced here for reference:

HIPAP 4 Table 2: Individual Fatality Risk Criteria		**AEISG Short Name**
Land Use	**Suggested Criteria (risk in a million per year)**	
Hospitals, schools, child-care facilities, old age housing.	0.5	Vulnerable
Residential, hotels, motels, tourist resorts.	1	Residential
Commercial developments including retail centres, offices and entertainment centres.	5	Commercial
Sporting complexes and active open space.	10	Open
Industrial.	50	Industrial

Guidance for classification of places where people may be present is detailed in Table E1: Classification for Separation below.
The AEISG AN Code includes only AN Stores which are servicing the commercial explosives industry. As such many of the AN Stores in scope are likely to be on the property of a mine or quarry. In these cases, for the purpose of classification, exposed sites where people are likely to be present are grouped into 3 categories, being:

1. On-Site: means under the same occupancy as the AN Store;
2. On Mine: means within the boundaries of the mine (or quarry) but not “On-site”;
3. Public: means everything else.

Although separation distances to unoccupied property are not mandated, the risk of damage to property / assets should be considered. Guidance for some typical situations is provided as a 4th category in Table E1.

Table E.1: Classification for Separation		
Typical Mine/Nearby Infrastructure	**Classification**	**Comments**
1. On-Site (i.e., under the same occupancy as the AN Store)		
Offices - Related to AN Storage	Not classified	No separation is required from an explosion risk perspective, but normal on-site separations apply (e.g., incompatible segregation, fire separation etc)
MPU workshop & service-bay		
ANE manufacturing building	Not classified	In the same way as offices, workshops, etc., that are part of the AN storage site, an on-site ANE or ANFO manufacturing building does not require separation FROM the AN store. But note that: • any AN in the manufacturing buildings is excluded from the scope of this code (since it is part of a manufacturing process) • the requirements of AS 2187 will apply to the ANFO manufacturing building and any explosives that may be present there, and there will be a separation distance required FROM the ANFO manufacturing building TO the AN shed, to avoid sympathetic initiation and / or to meet associated works separation.
ANFO manufacturing building		
2. On Mine (within the mine (or quarry) boundaries but not on site)		
Site of Indigenous significance (Inhabited)	Residential	
Camp	Residential	
Mine Offices	Commercial	
Private Airport Terminal - adjacent to mine	Commercial	May need different distance / classification if the airport is needed as part of emergency response plans. Recommend at least Vulnerable in such a case.
Private Airport runway - nearest corner	Open	
Mine Workshops	Industrial	
Mill or Wash Plant	Industrial	

Mine Portal	Industrial	At Industrial distance the overpressure from a worst-case explosion would typically be of the order of 21kPa, which would not be expected to have any effect on the structural integrity of a concrete portal, but may significantly damage buildings, plant and equipment. If a portal or associated plant & equipment is needed as part of emergency response plans a bigger distance is likely to be appropriate and should be assessed on a site-specific basis.
Haul Roads	Not classified	No separation required from an explosion risk perspective due to low / transient exposure.
3. Public		
Hospitals	Vulnerable	May also require societal risk assessment (see HIPAP 4 for guidance).
Aged Care Facilities	Vulnerable	
Schools or child-care facilities	Vulnerable	
Places of worship	Vulnerable	
Large Public Airport Terminal	Vulnerable	
High Density housing	Residential	
Low density housing	Residential	
Shops	Commercial	
Public Airport runway - nearest corner	Open	
Factory or industrial area	Industrial	
Port - Large	As appropriate (typically Industrial)	Classification should be based on the facilities included within the port site boundary - likely to be Industrial or in some cases commercial.
Port - Local	As appropriate (typically Industrial)	Classification should be based on the facilities included within the port site boundary. For small ports likely to be Industrial (unless accessible to / frequented by the public, in which case possibly Open). Potentially commercial if commercial premises (e.g., boatyards with offices, etc) are present.

4. Unoccupied property / assets		
Critical Infrastructure (as defined in the *Security of Critical Infrastructure Act 2018* (Cwth).	Consider on a site specific basis	For powerlines servicing >100,000 people see below. For other facilities / assets appropriate separation distances should be assessed on a site-specific basis based on the likelihood and extent of possible damage. For example, buried pipelines or cables are practically immune to blast damage whereas buildings may be significantly damaged at distances closer than Residential.
Significant infrastructure (e.g., public utility substations, dams, pumping facilities, large dangerous goods storages, fuel terminals, LPG terminals, complex processing plants, etc)	Consider on a site specific basis	Some significant infrastructure will require "Industrial" distance due to the likely presence of people. However appropriate separation distances should be assessed on a site-specific basis based on the likelihood and extent of possible damage.
Sites of significant cultural significance (e.g., heritage listed, sacred sites, major tourist attractions)	Consider on a site specific basis	Appropriate separation distances should be assessed on a site-specific basis based on the likelihood and extent of possible damage.
Off-site power lines: where supply interruption would affect > 100,000 people. (Note: any such power lines are Critical Infrastructure.)	Apply distance listed for "Commercial"	Overhead power lines could be damaged by an explosion if very close to an store, but the type of damage would likely be similar to natural events such as cyclones, and repairable within reasonable timeframes. The distances specified here for powerlines servicing large populations should ensure powerlines would suffer limited if any damage, and be easily repairable, i.e., pylons and the like should be unaffected and at worst some conductors could be severed.
Off-site power lines: where supply interruption would affect >50,000 and <100,000 people	Apply distance listed for "Industrial"	

Appendix F: Significant AN Explosions and Fires

The table below lists all known significant explosions (and many significant fires) involving AN. None are directly relevant to this Code since many involve other materials (including explosives) and / or are in situations which are not in the Scope of this Code. However all help to illustrate the behaviour of ammonium nitrate.

Date	Location	Fatalities	Category	(Origin) and Notes
14 Jan 1916	Gibbstown, New Jersey, US	1	Manufacture	(Wikipedia) In an evaporating pan of the Repauno works, du Pont Co., 4,000 pounds of ammonium nitrate exploded, possibly caused by a clogged air lance leading to overheating of the nitrate. 1 man was killed and 12 were injured.
2 Apr 1916	Faversham, Kent, UK	115	Manufacture	(Wikipedia) The Great Explosion: On April 2, 1916, at 14:20, a factory in Uplees, Faversham, exploded after a fire spread to a store of 25 tons of TNT and 700 tons of ammonium nitrate. The blast at the Explosives Loading Company killed 115 people and shattered windows in Southend-on-Sea across the Thames Estuary while the tremor was felt in Norwich.
15 Sep 1916	Oakdale, Pennsylvania, US	6	Manufacture	(Wikipedia) An Aetna Chemical Co. plant suffered an explosion of 3,000 pounds of ammonium nitrate, while concentrating it in a pan by evaporation. The speculated cause was impurities within the nitric acid used to produce the ammonium nitrate. Six men were killed and eight injured. The shock wave was felt at a distance of 7 miles.[2]
21 Sep 1921	Oppau, Germany	561	Manufacture	(Wikipedia) Explosion at BASF plant Oppau: Another attempt at disaggregation of a fertilizer mix with industrial explosives caused the death of 561 people and left more than 2,000 injured. The explosion happened at 7:32 a.m. The fertilizer was a 50:50 mixture of ammonium nitrate and ammonium sulfate and the factory had used this method of disaggregation over 20,000 times without incident. It is thought that, on this occasion, poor mixing had led to certain parts of the mass containing more ammonium nitrate than others. Only 450 tonnes exploded, out of 4500 tonnes of fertilizer stored in the warehouse.[4][5]

Date	Location	Fatalities	Category	(Origin) and Notes
1 Mar 1924	Nixon, New Jersey (now Edison Township) US	20	Manufacture	(Wikipedia) 1924 Nixon Nitration Works disaster: On March 1, 1924, at 11:15 a.m., a fire and several large explosions destroyed a warehouse containing 4800 pounds of ammonium nitrate at the Nixon Nitration Works. The explosiveness of the product was perhaps enhanced, as it had been prepared using nitric acid that had previously been used for the production of TNT.[2]
1940	Gibbstown, NJ, US	0	Manufacture	(Greiner: Ammonium Nitrate Fertiliser - Exploding the Myth) 147,000 pounds of uncoated AN in paper sacks
29 Apr 1942	Tessenderlo, Belgium	189	Manufacture	(Wikipedia) An attempt to disaggregate a pile of 150 tonnes of ammonium nitrate with industrial explosives killed 189 people and wounded another 900.[8]
1 Jan 1947	St. Stephen, New Brunswick, Canada	0	Manufacture	(Wikipedia) (Listed simply as 1947) The Summers Fertilizer Company plant suffered a fire, causing 400 tons of stored ammonium nitrate to be consumed by fire. There was no explosion.[2]
26 Aug 1947	Presque Isle, Maine,US	0	Manufacture	(Wikipedia) An A.W. Higgins Company plant was destroyed by a spontaneous heating in a pile of mixed fertilizer. Stored in the plant were 240 tons of Ammonium Nitrate.[2]
9 Jan 1963	Oulu, Finland	10	Manufacture?	(Wikipedia) On January 9, 1963, an explosion at the Typpi Oy industrial site in the Takalaanila neighbourhood of Oulu killed ten people. The accident happened past midnight, at 12:54 AM. The blast shattered hundreds of windows in the city center, over two kilometres away, and hurled bricks and chunks of concrete several kilometres away. The blast was heard 45 km away, and registered by the seismographs at the Sodankylä geophysical observatory, over 270 km away.[16] The cause of the explosion was the ignition of ammonium nitrate used as raw material for fertilizer and explosives.
10 Nov 1966	Mt Vernon MO, US	?	Manufacture?	(FM Global Property Loss Prevention Data Sheet 7-89 (published Oct 2013)). Various newspaper clippings report a Monsanto fertiliser plant had a fire for some hours then an explosion.

Date	Location	Fatalities	Category	(Origin) and Notes
1 Sep 1967	Unknown location, UK	0	Manufacture	(Industry information) Combined ammonium nitrate ammonium phosphate melt underwent explosive decomposition within minutes of the plant being shut down. A small section of the line full of the melt continued to be heated by the jacket steam (190 ºC). Also, carbon contamination of the melt due to soot.
1 Jan 1969	Unknown location, Switzerland	?	Manufacture	(Industry information) Contamination of ammonium nitrate melt with calcium chloride. The melt increased in temperature from 140 ºC to 200 ºC over a three hour period, then exploded.
17 Jan 1973	Pryor, OK, US	0	Manufacture	(Industry information) Fire in AN store. 14,000 tons bulk AN. Wooden building Aluminium roof. Explosion was at front end loader at loadout hopper at one end, well after fire started. Whole building burned down around the remainder of the AN (Press / Google) Cherokee Nitrogen Co, Ammonia plant explosion
1979	Moreland, Idaho, US	0	Manufacture	(Greiner: Ammonium Nitrate Fertiliser - Exploding the Myth) Fire involved the wood framework and belting of the overhead conveyor system in a fertilizer distribution plant while it was being used to unload a railroad car of AN fertilizer. The fire spread from the conveyor system to the roof. About 200 tons of AN were involved. There was no explosion.
1 Dec 1984	Unknown location, US	4	Manufacture	(Industry information) A major explosion occurred in an ammonium nitrate neutraliser and associated plant as the plant was being restarted after being offline for some days. The blast killed four employees.
2 Aug 1994	Porgera Gold Mine, PNG	11	Manufacture	(Wikipedia) At 9:45 am, 2 August 1994, 11 workers were killed when the sensitised AN emulsion plant they were working on exploded at the Porgera Gold Mine. The fatal explosion involved at most a few tonnes of explosive. A larger explosion of about 80 tonnes of emulsion (Ammonium Nitrate Emulsion, ANE, UN 3375) was caused by fires under storage facilities at the site at 11:02 AM. There were no fatalities in the second explosion because the site had been evacuated. A mushroom cloud was seen to rise.[23] ANE is an emulsion of ammonium nitrate, fuel and water.

Date	Location	Fatalities	Category	(Origin) and Notes
13 Dec 1994	Port Neal, Iowa, US	4	Manufacture	(Wikipedia) Port Neal fertilizer plant explosion: (Terra) At about 6:06 AM on December 13, 1994, two explosions rocked the Port Neal, Iowa, ammonium nitrate processing plant operated by Terra Industries. Four people were killed and 18 injured. Approximately 5,700 tons of anhydrous ammonia were released and releases of ammonia continued for six days after the explosions. Groundwater under the processing plant was contaminated by chemicals released as a result of the blast. The timing of the explosion occurred prior to the start of the arrival of the 8:00 AM shift personnel, or the death toll might have been larger.[24][25]
6 Jan 1998	Xingping, Shaanxi, China	22	Manufacture	(Wikipedia) At 23:03 on January 6, 1998, the Xinghua Fertilizer company had a series of explosions in the plant. About 27.6 tons of ammonium nitrate liquor was in a container there. The explosion claimed 22 lives, with a further 56 wounded. The explosion was officially announced as an accident.[26][citation needed]
21 Sep 2001	Toulouse, France	31	Manufacture	(WA AN Code issue 4) The only known industrial accident where chemical contamination was most probably the root cause took place at the AZF fertiliser plant. This marks it as an exception in the history of accidental storage explosions; the other exception from the normal fire-initiated explosion was the shock-initiated explosion at Oppau, Germany in 1921. The explosion occurred in a warehouse used for the temporary storage of out-of-specification AN, which was waiting to be recycled into AN-based fertiliser mixtures. While the original cause of the explosion is not agreed between the numerous investigating parties, it is generally agreed that the most likely cause was identified as a reaction between AN and sodium dichloroisocyanurate, or AN and trichloroisocyanuric acid; both reactions release trichloramine (NCl_3), an explosion sensitive substance. There seemed to have been poor management of a warehouse allowing different contractors to operate it independently, which explains the mixing of AN with sodium dichloroisocyanurate, a pool chlorine biocide. INERIS estimated that the TNT equivalent of the explosion was in the range

Date	Location	Fatalities	Category	(Origin) and Notes
				20 to 40 t involving approximately 400 t of AN. The explosion resulted in 31 fatalities and 2,442 injured persons. The blast wave shattered windows up to 3 km away. The crater was 10 m deep and 50 m wide. (Wikipedia) AZF: On September 21, 2001, at 10:15 AM, in the AZF (Azote de France) fertiliser factory in Toulouse, France, an explosion occurred in a warehouse where the off-specification granular AN was stored flat, separated by partitions. About 200–300 tonnes were said to be involved in the explosion, resulting in 31 people dead and 2,442 injured, 34 of them seriously. The blast wave shattered windows up to 3 km away, and the resulting crater was 10 m deep and 50 m wide. The exact cause remains unknown. The material damage was estimated at 2.3 billion euros. France's Environment Minister initially suggested the explosion "may have been a terrorist attack" as it occurred soon after the September 11 attacks and one worker may have had militant views.
Jan. 2003	Cartagena, Murcia, Spain	0	Manufacture	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) The fertilizer Storage facility of Fertiberia had a self-sustained decomposition (SSD) fire in January 2003. The fire was controlled after most of the material was removed by mechanical means.
30 Jul 2009	Bryan, Texas, US	0	Manufacture	(Wikipedia) A plant in Bryan, Texas (El Dorado Chemical Company), which processes ammonium nitrate into fertilizer, caught fire at about 11:40 AM on July 30, 2009. Over 80,000 residents in the Bryan/College Station area were asked to evacuate south of town due to the toxic fumes this fire generated. Texas A&M University provided shelter at Reed Arena, a local venue on campus. Only minor injuries were reported.[32][33]
1920	Brooklyn, NY, US	0	Transport	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) A total of 1,944,500 pounds of AN were consumed in a fire in the holds of the Norwegian freighter, the S.S. Hallfried. No explosion.

Date	Location	Fatalities	Category	(Origin) and Notes
26 Jul 1921	Kriewald, Germany	19	Transport	(Wikipedia) On July 26, 1921, in this railway town (now in Poland) workers tried to dislodge 30 tonnes of ammonium nitrate that had aggregated (solidified into one mass) in two wagons. When mining explosives were used on this solid mass the wagons exploded and killed nineteen people.
3 May 1925	Muscle Shoals, Alabama, US	0	Transport	(Wikipedia) On April 4, 1925, and May 3, 1925, two carloads, each containing 220 barrels of ammonium nitrate, were dispatched from Muscle Shoals, Alabama, and caught fire in transportation. The barrels had been stored in a warehouse with varying humidity for 6 years, so it is believed that they were ignited by friction with their nitrate-impregnated manila paper lining. Other shipments were reportedly more successful.[6]
5 Aug 1940	Miramas, France	0	Transport	(Wikipedia) 240 tonnes of ammonium nitrate in sacks exploded after being hit by a shell from a nearby fire in a munitions train.[7]
16 Apr 1947	Texas City, US	581	Transport	(Wikipedia) Texas City disaster: The cargo ship Grandcamp was being loaded on April 16, 1947, when a fire was detected in the hold: at this point, 2,300 tons of ammonium nitrate in sacks were already aboard.[9] The captain responded by closing the hold and pumping in pressurised steam. At 9:12, the ship exploded, killing several hundred people and setting fire to another vessel, the High Flyer, which was moored 250 metres away and which contained 1,050 tonnes of sulfur and 960 tons of ammonium nitrate. The Grandcamp explosion also created a powerful earthshock that broke windows as far as 40 miles away and knocked two small planes flying at 1,500 feet (460 m) out of the sky. The High Flyer exploded the next day, after having burned for sixteen hours. 500 tonnes of ammonium nitrate on the quayside also burned, but without exploding, probably because it was less tightly packed. All but one member of the Texas City fire department died.
28 Jul 1947	Brest, France	29	Transport	(Wikipedia) The Norwegian cargo ship Ocean Liberty was loaded with 3,309 tonnes of ammonium nitrate and various flammable products when it caught fire at 12:30 July 28, 1947. The captain ordered the hold to be sealed and pressurised steam was pumped in. As this did not stop the fire, the vessel was towed out of the harbour at 14:00 and exploded at 17:00. The

Date	Location	Fatalities	Category	(Origin) and Notes
				explosion caused 29 deaths and serious damage to the port of Brest.[2][10][11]
23 Jan 1953	Red Sea	0	Transport	(Wikipedia) A fire was detected on the Finnish cargo ship Tirrenia on January 23, 1953, while it was carrying ammonium nitrate. Attempts to extinguish the fire with steam were unsuccessful, and the ship was abandoned before it exploded later in the night.[12]
7 Aug 1959	Roseburg, Oregon, US	14	Transport	(Wikipedia) The Roseburg Blast: A truck carrying dynamite and 4.5 tons of ammonium nitrate caught fire early in the morning of August 7, 1959. The explosion happened at 1:14 a.m. and killed 14 people and injured 125 more. Several blocks of downtown Roseburg were destroyed. The accident is locally referred to as “The Blast”.[13]
17 Dec 1960	Traskwood, Arkansas, US	0	Transport	(Wikipedia) On December 17, 1960, a 96 freight car train suffered partial derailment, in which the last 23 cars were derailed. The derailed cars included: four fuel oil tank cars, two tank cars of gasoline, three tank cars of petroleum oil, four cars of lube oil drums, three cars of liquid fertilizer, one car of fuming nitric acid and two cars of fertilizer grade ammonium nitrate. In this particular accident, neither car of ammonium nitrate exploded.[14] However, the nitric acid reacted with the fuel oil, possibly creating nitrated aromatic compounds, whose explosion resulted in the spread of the ammonium nitrate material around the incident site.[15]
1967	Potosi, Wisconsin, US	0	Transport	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) A boxcar loaded with 50 tons of AN caught fire. The boxcar was steel with a wooden interior. All of the wood burned, melting the nitrate and leaving a large crusted mass. No explosion.

Date	Location	Fatalities	Category	(Origin) and Notes
30 Aug 1972	Taroom, Queensland, Australia	3	Transport	(Wikipedia) In the 1972 Taroom explosion, a truck carrying 12 tons of ammonium nitrate experienced an electrical fault and caught fire north of Taroom, Queensland. After the driver stopped and parked the burning truck, two brothers from a nearby cattle property who saw the fire rode up on motorbikes to assist. The three men were killed when the truck exploded at around 18:15. The explosion burnt out more than 800 hectares (2,000 acres) of surrounding bushland and left a deep crater where the truck had been parked. A memorial to the three men was unveiled at the accident site in 2013.[17][18][19][20]
29 Nov 1988	Kansas City, Missouri, US	6	Transport	(Wikipedia) On November 29, 1988, at 4:07 AM two trailers containing approximately 50,000 lb (23,000 kg) of the explosive ANFO (ammonium nitrate with fuel oil) exploded at a construction site located near the 87th street exit of Highway 71 in Kansas City, Missouri. The explosives were to be used in the blasting of rock while constructing Highway 71. The result of the explosions were the deaths of six firemen from the Kansas City Fire Department's Pumper Companies 30 and 41. Both companies were dispatched after 911 calls indicated that a pickup truck located near the trailers had been set on fire. The responding companies were warned that there were explosives on-site; however, they were unaware that the trailers were essentially magazines filled with explosives. At 4:07 AM one of the "magazines" caught fire and a catastrophic explosion occurred, killing all six firemen instantly — only sparing remains were found. A second blast occurred 40 minutes later, although all fire crews had been pulled back at this time. The blasts created two craters, each approximately 100 feet (30 m) wide and 8 feet (2.4 m) deep. The explosions also shattered windows within a 10-mile (16 km) area and could be heard 40 miles (64 km) away. It was later determined that the explosions were acts of arson, set by individuals embroiled in a labour dispute with the construction company contracted to build the highway.[21][22]

Date	Location	Fatalities	Category	(Origin) and Notes
8 Oct 1997	Unknown location, Brazil	?	Transport	(Industry information) Brazil Truck Accident 8 October 1997 [AFEX International, *Accident Report No. 606 Major Accident Ammonium Nitrate in Transit*, SAFEX International, Ayrshire, Scotland, 8 October 1997.]
9 Mar 2004	Barracas, Spain	2	Transport	(Wikipedia) A truck carrying 25 tonnes of ammonium nitrate fertilizer exploded half an hour after a traffic accident on March 9, 2004 at 12:45, killing two people and injuring five others. The explosion, which could be heard at a distance of several kilometres caused a crater five metres deep.[28]
22 Apr 2004	Ryongchŏn, North Korea	162	Transport	(Wikipedia) Ryongchon disaster: A freight train carrying ammonium nitrate exploded in this important railway town near the Chinese border on April 22, 2004 at around 13:00, killing 162 people and injuring over 3,000 others. The train station was destroyed, as were most buildings within 500 metres, and nearly 8,000 homes were destroyed or damaged. Two craters of about ten metres in depth were seen at the site of the explosion. The authorities blamed “human error” for the explosion, although rumours persist that it was in fact an attempt to assassinate the North Korean leader Kim Jong-il, who was due to be passing through the station at the time.
24 May 2004	Mihăileşti, Buzău, Romania	18	Transport	(Wikipedia) Mihăileşti explosion: A truck carrying 20 tonnes of ammonium nitrate tipped over on the European road E85 near Mihăileşti at 4:57 AM on May 24, 2004. Shortly afterwards, a fire started in the cabin. Two reporters got to the site of the accident and started filming while firemen were trying to stop the fire. Around 5:50 AM the truck exploded, killing 18 and wounding 13 people. A crater 6.5 meters deep and 42 meters in diameter was formed by the explosion.
15 June 2006	Mesa, Arizona, US	0	Transport	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) On 15 June 2006, a truck carrying dynamite, blasting caps, and 11 tons of AN (four times the amount of AN involved in the Oklahoma City bombing) caught fire on Loop 202 in Mesa, Arizona. Fortunately, the trucking company had another employee following the truck who noticed the fire and alerted the driver and emergency crews. The fire was quickly extinguished before it could spread to the cargo.

Date	Location	Fatalities	Category	(Origin) and Notes
17 Feb 2007	Estaca de Bares, Spain	0	Transport	(Wikipedia) The NPK fertilizer cargo of the ship Ostedijk sustained a self-sustained decomposition (SSD) fire for 11 days. The ship carried a total of 6012 tonnes of NPK. Cargo hold 2, where the decomposition occurred, contained 2627 tonnes of fertilizer. NPK fertilizer contains about 15% ammonium nitrate. The fire plume reached 10 m in diameter and several hundred meters in length. Special water spears were inserted inside the cargo to extinguish the fire.[29]
9 Sep 2007	Monclova, Coahuila, Mexico	28	Transport	(Wikipedia) On September 9, 2007, at around 20:00, near Monclova, Coahuila, México, a pickup truck lost control and crashed into a trailer loaded with 22 tons of ammonium nitrate and fuel oil explosives (ANFO) leaving three occupants in the pick-up truck dead in the crash. A fire then started in the trailer's cabin and at around 20:43, a huge explosion occurred, resulting in 28 deaths and around 150 more people injured. A crater 9 m (30 ft) wide and 1.8 m (6 ft) deep was created due to the explosion.[30][31]
5 Sep 2014	Angellala Creek, Queensland, Australia	0	Transport	(Wikipedia) A truck carrying 56 tonnes rolled on a rural road, exploding shortly after the driver was rescued. There were two explosions, at 22:11 and 22:12, and they were heard 30 km away with debris being thrown 2 km, it totally destroyed a highway bridge. The driver and six firemen were injured.[36][37]
12 Aug 2015	Port of Tianjin, China	173	Transport	(WA AN Code issue 4) An overheated container of dry nitrocellulose was the cause of a fire in a dangerous goods warehouse that triggered two explosions 30 seconds apart. Based on the seismic waves generated, the detonations were estimated to be equivalent to 2.9 t and 21.9 t of TNT respectively. There were 173 fatalities and 797 people injured. Of the fatalities, 93 were firefighters. (Wikipedia) 2015 Tianjin explosions: Nitrocellulose stored at a hazardous goods warehouse spontaneously combusted after becoming overly hot and dry, resulting in a fire that 40 minutes later, at around 23:30, triggered the detonation of about 800 tonnes of ammonium nitrate stored nearby. 110

Date	Location	Fatalities	Category	(Origin) and Notes
				emergency personnel and 55 residents and employees were killed, while eight are missing[needs update]. 798 people were injured.[38] There was extensive damage to structures and goods at the port, damage to surrounding apartment blocks, and severe damage to a railway station. On August 15, 2015, there were again 8 consecutive explosions, at around 23:40.
1920	Barksdale Wisconsin, US	0	Storage?	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) A total of 30,000 pounds of AN were destroyed in a well-vented storage building fire. No explosion.
1947	St Stephen, Canada	0	Storage?	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) 400 tons of AN fertilizer were consumed in a fire. No explosion
1949	Independence, Kansas	0	Storage?	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) Building containing nearly 1400 tons of wax coated bagged AN fertilizer destroyed by fire; no explosion
1960	Boron, CA, US	0	Storage?	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) 20 tons of prilled AN were destroyed in a burning warehouse. At the peak of the fire the h eat was so intense the steel roof glowed red and collapsed on the burning and molten AN. No explosion.
1978	Rocky Mountain, North Carolina, US	0	Storage	(Greiner: Ammonium Nitrate Fertilizer - Exploding the Myth) A storage facility containing 500 tons of AN fertilizer was destroyed by fire. No explosion
30 Dec 2002	Cartagena, Murcia, Spain	0	Storage (possibly Manufacture)	(Wikipedia) The fertilizer storage facility of Fertiberia held a self-sustained decomposition (SSD) fire in January 2003. The fire was controlled after most of the material was removed by mechanical means.[citation needed]

Date	Location	Fatalities	Category	(Origin) and Notes
2 Oct 2003	Saint-Romain-en-Jarez, France	0	Storage	(WA AN Code issue 4) A fire broke out in a farmer's barn containing a petrol-powered forklift, two 13 kg gas bottles, farm machinery, 500 wooden crates, 6–7,000 plastic crates, bales of hay and straw and 6 x 500 kg IBCs of AN. The explosion occurred approximately 70 minutes after the start of the fire and injured 26 persons, mainly firefighters. The force of explosion was estimated to be 80 to 160 kg of TNT, which indicates that only two IBC were involved in the explosion, with a total TNT equivalence of 8 to 16%. (Wikipedia) A fire broke out in Saint-Romain-en-Jarez (Loire) in a barn, which at the time of the accident contained a gasoline-powered forklift, a battery charger, two 13-kg gas bottles, miscellaneous farm machinery, 500 kg of quicklime, 500 wooden crates, 6,000 to 7,000 plastic crates, and between 3 and 5 tonnes of ammonium nitrate packaged in big bags. Bales of hay and straw were being stored on the mezzanine and ≈500 kg apples kept in the cold storage rooms. The fire started around 3 PM, and fire-fighters were notified of the blaze at 4:02 PM. They arrived on the scene at 4:23 and started to extinguish the fire. At 5:12 PM the explosion occurred. Twenty-six people were injured from the blast, most of them fire-fighters.[27]
17 Apr 2013	West, Texas, US	15	Storage	(WA AN Code issue 4) A warehouse from a fertiliser and seed company caught fire holding approximately 30 tonnes of AN. The building and storage bins were made of wood. There was no segregation from combustible materials. AN was stored as a fertiliser, without attention to its hazards. The explosion occurred 20 minutes after the fire was first reported and resulted in 15 fatalities, including 13 firefighters, and 260 injured persons. The crater was 3 m deep and 9 m wide. (Wikipedia) West Fertilizer Company explosion: A fertilizer company in West, Texas, caught fire. At around 19:50, ammonium nitrate stored there exploded, leveling roughly 80 homes and a middle school. 133

Date	Location	Fatalities	Category	(Origin) and Notes
				residents of a nearby nursing home were trapped in the ruins. In all, 15 were killed, and about 200 injured. There were reports that the facility had stored more ammonium nitrate than it was allowed to, without regulation by the Department of Homeland Security.[34][35]
4 Aug 2020	Beirut, Lebanon	218	Storage	(WA AN Code issue 4) A major fire broke out in a Port of Beirut warehouse containing, among other things, fireworks and 2,750 t of AN. The AN had been impounded and stored for six years after it was seized from an abandoned ship in 2014. The explosion occurred as the result of a fire involving fireworks. An intense shock wave caused cause immense damage throughout the city resulting in over 190 fatalities, 6,500 injured persons, 300,000 displaced persons and $10 - 15 billion (US) in property damage. A giant orange-brown cloud was present just before and during the explosion. (Wikipedia) 2020 Beirut explosion: On August 4, a major fire broke out in a Port of Beirut warehouse and spread to 2,750 tonnes of ammonium nitrate which had been impounded and stored for six years after it was seized from an abandoned ship in 2014.[39][40] The explosion happened at 18:10, causing immense damage throughout the entire city from the shock wave that was reportedly so intense it was felt in Cyprus, an island about 250 km (150 miles) north-west of Lebanon.[41] A giant orange cloud was seen following the detonation. As of August 20, 2020, there are at least 6500 confirmed injuries and over 200 confirmed deaths.[42][43] According to Beirut's city governor, up to 300,000 people have lost their homes.[42] The yield of the explosion in terms of TNT equivalent mass was estimated to be 0.5 kilotons as a "best estimate" and 1.12 kilotons as a

Date	Location	Fatalities	Category	(Origin) and Notes
				“reasonable upper bound estimate”, a study from the Blast and Impact Research Group at the University of Sheffield shows.[44]

Appendix G: Compatibility of Substances and Materials with AN

The tables in this appendix show lists of substances and materials which are classified as compatible and incompatible with AN and clarify (in the notes after each table) the origin or basis of the classification.

Note that in this Code:

"Compatible" means: Materials which are known to be safe to mix with or come into contact with AN without:

- reacting to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours; or
- interacting with the AN so as to increase the hazard.

"Incompatible" means Materials which if they mix with or come into contact with AN may:

- react to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours; or
- interact with the AN so as to increase the hazard.

By comparison, the definition of "compatible" in AS 4326-2008 The storage and handling of oxidizing agents is "In relation to two or more substances or items, those that will not react together to cause a fire, explosion or harmful reaction, or evolve flammable, toxic or corrosive vapours." Under the AS 4326 definitions materials such as diesel are listed as incompatible, but also meet the definition of compatible.

Table G.1: Substances and Materials that are compatible with AN

Substance or Material	Origin of classification	Notes
potassium nitrate	A, B	
sodium nitrate	A, B	
calcium nitrate	A,B	
ammonium sulphate	A,B	
ammonium nitrate-based fertilizer mixtures of nitrogen, phosphate or potash types	A,B	
calcium sulphate	A,B	
calcium ammonium nitrate	A,B	
calcium carbonate or magnesium carbonate	A,B	
superphosphate	A	
ammonium phosphate	B	
Inert non-combustible materials such as bricks, sand, steel, etc.	C	This group included to avoid classifying obviously inert materials by default as incompatible

Origin of classification:

A: These are listed in AS 4326-2008 The storage and handling of oxidizing agents section B3.2 Compatible fertilizers.

B: These are listed in the Code of Practice: Safe storage of solid ammonium nitrate (fourth edition) published by the WA DMIRS section 5.6.1 as compatible substances.

C: AEISG decision for this Code

Table G.2: Substances and Materials that are incompatible with AN

Substance or Material	Origin of classification	Notes
Flammable and combustible liquids, e.g. petrol, kerosene, solvents, diesel fuel, lubricating oils, fuel oils, oil-based pesticides.	D, E	
Flammable gases, e.g. LP Gas, acetylene, hydrogen	D, E	WA code also includes ethylene
Sulphur	D, E	WA Code lists under "Reducing agents"
Hexamine	D, E	WA Code lists under "Reducing agents"
Finely divided metals, including metal powders and dusts	D, E	WA Code lists under "Reducing agents"
Copper, cadmium, chromium or zinc metals or salts	D, E	WA Code notes that these increase AN's explosion sensitivity in a fire
Substances that are sensitive to explosive decomposition	D	
Readily combustible solids, e.g. hay, straw, grain, animal fodder, wax, paper, cotton	D	
Urea	D (also E, see next row)	
Solid fuels such as combustible solids such as rubber tyres, conveyor belt matting, wax, wood, paper, hay, straw, grain, grain husks, animal feed, urea and cotton	E	
Explosives	D, E	
Other Division 5.1 dangerous goods e.g. calcium hypochlorite, chromates, chlorates, nitrites, perchlorates, chlorites, permanganates, chloroisocyanurates, tetranitromethane, or di- or tri-chloroisocyanuric acid.	D, E	
Corrosive liquids	D	
Acids	E	
Reducing agents	D	
Reducing agents such as sulphur, hexamine, finely divided metals, organic and inorganic amines and ammonium compounds, organic and inorganic sulphides	E	

Products that can liberate ammonia gas if mixed with ammonium nitrate, e.g. cement, lime, basic slag or other alkaline substances	D	
Alkaline substances react to liberate ammonia gas if mixed with AN	E	
Metal chlorides, such as potassium chloride (a potash fertiliser)	D	WA Code notes that these increase AN's explosion sensitivity in a fire

Origin of classification:

D: These are listed in AS 4326-2008 The storage and handling of oxidizing agents section B 3.3 as substances which are incompatible with, or can react dangerously with ammonium nitrate.

E: These are listed in the Code of Practice: Safe storage of solid ammonium nitrate (fourth edition) published by the WA DMIRS section 5.6.2 as incompatible substances which are not to be stored in any building used to store AN nor within any building attached to an store.

Appendix H: References

Where no date is specified the reference is to the latest published edition.

No	Short form	Full Title
1	ADG Code	Australian Code for the Transport of Dangerous Goods by Road and Rail
2	AEISG UN 3375 Code	Code of Practice Storage and Handling of UN3375 Edition 5 July 2018
3	AS 1768	AS 1768 Lightning protection
4	AS 2187	Explosives - Storage, Transport and Use (Note: this standard is published in 4 parts; references when used in this Code are to the relevant part according to the context.)
5	AS 3745	AS 3745 Planning for emergencies in facilities
6	AS 3846	AS 3846 The Handling and Transport of Dangerous Cargoes in Port Areas
7	AS 4326	AS 4326 The Storage and Handling of Oxidizing Agents
8	AS/NZS 4804	AS/NZS 4804-2001: Occupational Health and Safety Management Systems - General guidelines on principles, systems and supporting techniques
9	AS 60529	AS 60529 Degrees of Protection Provided by Enclosures
10	COAG	Council of Australian Governments: Principles for the Regulation of Ammonium Nitrate, and Council of Australian Governments: Guidance note No 2: Storage
11	EEC Test method	European Regulations for AN Fertilisers (Method 3 in Annex III)
12	FM Global data sheet	FM Global Property Loss Prevention Data Sheet 7-89 (published Oct 2013)
13	Greiner	Greiner: Ammonium Nitrate Fertlizer - Exploding the Myth; link http://www.efilmgroup.com/Exploding-the-Myth.html
14	HIPAP 4	NSW Hazardous Industry Planning Advisory Paper No 4: Risk Criteria for Land Use Safety Planning
15	IMESAFR	IMESAFR blast-modelling software
16	AEISG MPU Code	AEISG Code of Practice Mobile Processing Units Edition 4 September 2018
17	NCC	National Construction Code of Australia
18	NSW EPA Guidelines	NSW EPA, 'Environmental Solutions', Ammonium Nitrate – Environmental Guidelines for explosives and explosive precursors facilities in NSW, Draft, November 2021.
19	Qld IB53	Information Bulletin No 53 (Version 5, 31 Oct 2017) published by Explosives Inspectorate, Department of Mines and Energy (subsequently Department of Natural Resources and Mines, then Resources Safety & Health Queensland), Queensland Government.
20	SAFEX guide	Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate (GPG 02 rev02, March 2014) published by SAFEX International
21	UN Model Regulations	Recommendations on the Transport of Dangerous Goods: Model Regulations (published by the United Nations).
22	WA code	Safe Storage of Solid Ammonium Nitrate (Fourth Edition, 2021) published by Department of Mines, Industry Regulation and Safety, WA
23	Wikipedia	Wikipedia

Appendix I: COAG Principles for the Regulation of Ammonium Nitrate

Principles for the Regulation of Ammonium Nitrate

Policy aims

1. A nationally consistent, effective and integrated approach to control access to security sensitive ammonium nitrate to those with a legitimate need.
2. To ensure accountability at all stages of the ammonium nitrate supply chain, in order to address security and safety concerns.
3. To establish a framework for control which may be applicable for other materials of security concern.

Agreed principles

1. An authority would be required to import, manufacture, store, transport, supply, export, use or dispose of security sensitive ammonium nitrate (SSAN).
2. Security sensitive AN (SSAN) shall be defined as ammonium nitrate, ammonium nitrate emulsions and ammonium nitrate mixtures containing greater than 45% ammonium nitrate, excluding solutions. (These include dangerous goods under the Australian Dangerous Goods Code with the UN numbers 1942, 2067, 2068,2069, 2070, 2071, 2072, 3375 and 3139 where applicable.)
3. Persons seeking an authority will be required to:
   a) demonstrate a legitimate need for access to SSAN [1];
   b) provide safe and secure storage and handling procedures;
   c) report any loss, theft, attempted theft or unexplained discrepancy to the regulatory authority and police in each jurisdiction;
   d) undergo background checking; and
   e) be a minimum of 18 years of age, and
   f) provide verifiable proof of identity, and if a company, details of the company.
4. Background checking must include police and ASIO checks.
   a) As a minimum, background checks will be required for the person responsible for the security of SSAN at a workplace ('responsible person'), as well as for any person who has unsupervised access to SSAN.
   b) The owners and directors of companies which are not publicly listed will also undergo background checking.
   c) Police checking should be done regularly.
   d) ASIO checks need only be done once, provided ASIO is notified of the change of name of a person who is subject to security checking.
5. An authority to import, manufacture, store, transport, supply, export, use or dispose of SSAN will impose requirements on the holder of that authority.
   The following is a description of the requirements for each type of authority.

6. Importation from overseas:
   a) Importers of SSAN must have an authority to import and must inform the regulatory authority of each importation at least seven days prior to import.

[1] Legitimate need is likely to include use in commercial production processes, mining, quarrying, the manufacture of fertilizer and explosives, educational, research and laboratory use, commercial agricultural use by primary producers, and services for transportation, distribution, and use of the product. Household and domestic use, and the fertilisation of recreational facilities will not be considered a legitimate need.

b) This notification must include:
   i) Vessel identification,
   ii) details of the quantity to be imported,
   iii) location of arrival,
   iv) authorisation details of the recipient and contact details,
   v) storage location of the SSAN,
   vi) authorisation details of the agent transporting from the arrival point, and
   vii) confirmation of dangerous goods classification, with a certificate of analysis for each batch comprising the imported SSAN.

c) The Australian Customs Service should notify the regulatory authority of each importation of ammonium nitrate, and hold any importation which is not properly authorised. (This could be done by placing ammonium nitrate on the prohibited import list, unless authorisation conditions were satisfied. Note: This outcome pending consultation with ACS.)

7. Manufacture
   a) Manufacturers of SSAN must have an authority to manufacture (including storage) from the regulatory authority.
   b) An application for an authority to manufacture SSAN must be accompanied by an approved security plan based on a risk assessment and which is to include:
      i) the location and details of the manufacturing facility (and note storage requirements below),
      ii) details of the production process to be used,
      iii) details of the ingredients to be used, and their sourcing if dangerous goods,
      iv) recording and reconciliation protocols,
      v) designating a responsible person to maintain the security plan, and in the case of a company or other entity, training audits and ongoing maintenance of the plan must be confirmed regularly by the owners and senior officials,
      vi) procedures for checking and authorising persons with unsupervised access to SSAN,
      vii) certificate of analysis for each batch,
      viii) confirmation of dangerous goods classification,
      ix) the recording system for authorisation details of any recipient of SSAN and the quantities taken by them, and
      x) procedures for reporting to authorities any loss, theft, or attempted theft of SSAN.
8. Storage
   a) Those who store SSAN must have an authority to store from the regulatory authority.
   b) An application for an authority to store SSAN must be accompanied by an approved security plan based on a risk assessment and which must include:
      i) the location and details of the facility,
      ii) precautions to ensure it is safe,
      iii) procedures for controlling access,
      iv) recording and reconciliation protocols,
      v) procedures for checking and authorising persons with unsupervised access to SSAN and designating a responsible person to maintain the security plan. In the case of a company or other entity, training audits and ongoing maintenance of the plan must be confirmed regularly by the owners and senior officials,
      vi) the recording system for authorising details of persons taking SSAN from the storage and the quantities taken by them, and
      vii) procedures for reporting to authorities any loss, theft, or attempted theft of SSAN.

c) As a minimum, SSAN must be stored in a locked facility/container or be under constant surveillance. (A detailed national code for safe and secure storage will be developed.)
d) The storage facility must also conform to Australian Standards and the Australian Dangerous Goods Code.

9. Transport:
   a) Transporters of SSAN must have an authority to transport from the regulatory authority.
   b) An application for an authority to transport SSAN must be accompanied by an approved security plan based on a risk assessment, and which must include:
      i) precautions to ensure it is secure for the duration of the entire journey,
      ii) procedures for checking and authorising crew members and designating a responsible person to maintain the security plan. In the case of a company or other entity, training, audits and ongoing maintenance of the plan must be confirmed regularly by the owners and senior officers.
      iii) the recording system for authorisation details of persons taking delivery of SSAN and the quantities taken by them, and
      iv) procedures for reporting to authorities any loss, theft or attempted theft of SSAN.
   c) As a minimum, SSAN must be transported in a locked container or vessel or be under constant surveillance by an authorised crew member.
   d) An authority would not be required for the transport of quantities of SSAN of 20kg or a lesser weight.
   e) The transportation must also conform to Australian Standards and the Australian Dangerous Goods Code.
10. Supply:
   a) A person may only supply SSAN to another authorised person, under the conditions of their authority.
   b) Records must be kept of all transactions, including the recipient's authorisation type and number of the recipient, the date, quantity, and a description of the product (name and UN number).
   c) The supplier must sight the authorisation or a certified copy of the authorisation (and if applicable, proof of employment) and confirm the bona fides of the purchaser, and as a minimum sight and record photo identification details.
11. Export
   a) Exporters of SSAN must have an authority to export and must inform the regulatory authority of each exportation at least seven days prior to the date of exportation.
   b) This notification must include details of the type and quantity to be exported, to where the goods will be sent, and documentation confirming that the shipment complies with import regulations in the receiving country.
   c) The Australian Customs Service should notify the regulatory authority of each exportation of SSAN.
   d) The exporter of SSAN must keep records of all transactions, and report any loss, theft, or attempted theft.
12. Use/disposal
   a) A person may only acquire SSAN from another authorised person.
   b) Records must be kept of all transactions, including the authorisation type and number and identification details of the supplier, the date, quantity, and a description of the product (name and UN number).
   c) Records must also be kept of use or disposal.

13. Offences
    a) It will be an offence to import, manufacture, store, transport, supply, export, acquire, use or dispose of SSAN without an authorisation.
    b) It will also be an offence to breach the requirements of an authorisation.
    c) Penalties will be consistent with penalties for breaches of explosives legislation in each jurisdiction.
    d) Penalties will include loss of authorisation and confiscation of the product.
14. Reporting of loss, theft, attempted theft and discrepancies
    a) Such incidents must be reported to the regulatory authority in each jurisdiction, as well as to the police in each jurisdiction.
    b) The police will be responsible for reporting these types of incidents, as well as discoveries of abandoned or illegally held SSAN to the Australian Bomb Data Centre, which will maintain a national data base of such incidents.
15. Explosives regulations

    In view of these measures to be introduced for SSAN, which in some cases are more stringent than those for the control of explosives, states and territories should review their explosives regulations. In particular, states and territories should quickly move to:
    a) implement security checking for persons having access to explosives, and
    b) ensure penalties for breaches of explosives regulations are appropriately severe.

Appendix J: COAG Ammonium Nitrate Guidance Note No. 2: Storage

AMMONIUM NITRATE GUIDANCE NOTE No. 2 (Nov 2004) STORAGE

1. PURPOSE

On 25 June 2004 the Council of Australian Governments (COAG) agreed to a national licensing system to limit access to security sensitive ammonium nitrate (SSAN). Each state and territory have introduced legislation and / or regulations to give effect to the COAG agreement.

These guidance notes outline the minimum requirements to obtain a licence to store SSAN. While they give an outline of national standards, precedence should be given to the specific requirements of state or territory legislation.

2. SCOPE

These guidance notes are designed for businesses that store any quantity of (SSAN). This may include manufacturers, the mining industry, agricultural and mining suppliers, importers and exporters. Primary producers who store for personal use should consult a separate guidance note on Agricultural Use.

Educational, research and analytical laboratories storing less than 3 kg may be exempted from the new security regulations and not require licensing. Check with the regulatory authority in your state or territory.

These guidance notes address security issues. Storage of SSAN must also meet safety requirements as outlined in state and territory based dangerous goods legislation and you should also take note of relevant product safety data sheets.

3. DEFINITIONS

security sensitive ammonium nitrate (SSAN) means—

ammonium nitrate, ammonium nitrate emulsions and ammonium nitrate mixtures containing greater than 45% ammonium nitrate, excluding solutions and ammonium nitrate products classified as class 1 explosives.

(Note: This includes substances such as calcium ammonium nitrate that are not classified as dangerous goods and dangerous goods with UN numbers 1942, 2067, 2068, 2069, 2070, 2071, 2072, 3375 and 3139 where applicable. Explosives of Class 1 are excluded.)

secure means secure from—

a. detectable theft

b. unexplained loss

c. sabotage

d. unauthorised access

security risk means risk of—

a. theft of security SSAN; or

b. unexplained loss of SSAN; or

c. possible sabotage of SSAN; or

d. unauthorized access to SSAN.

Security plan means –

a plan that has been put in place to effectively minimize all security risks relevant to the storage of SSAN.

The authority holder, or licence holder means –

the person who has applied for and received a licence to store SSAN from a regulatory authority. This person will have undergone police and PMV checking.

An authorised person means-

a person (in addition to the authority holder) who is named in the security plan and authorised by the regulatory authority under that plan to have unsupervised access to SSAN. This person will have undergone police and PMV checking.

Unsupervised access means –

access to SSAN when no other person with authorised access is present or has control over the SSAN. This includes:

• access to the secure store; and

• access to the keys to the secure store.

All those with unsupervised access to SSAN will need a police and PMV check.

Supervised access means –

where access to SSAN by a worker occurs under the supervision of an authority holder or authorised person, or when working in a defined supervised area as detailed in the security plan.

Under lock and key would normally include one of the following -

• a locked building; or

• a secure shed with lockable entrances, and if windows, that are locked or barred; or

• a secure and lockable freight container or explosives magazine; or

• in the case of ammonium nitrate emulsions a lockable tank.

Quality security locks must be employed; electronic type locks may be acceptable.

Constant surveillance means –

the presence of an alert and authorised person or the continuous monitoring by video or electronic surveillance.

Secure store means –

a physically secure place where SSAN is kept under lock and key or constant surveillance, and where there are procedures for:

• controlling access;

• secure control of keys; and

• documenting the receiving and dispatching of measured quantities of SSAN.

PMV (politically motivated violence) check means -

a security assessment in respect of a person, issued by ASIO.

Explained loss means -

any documented loss caused by such things as product density changes, spillage, calibration variances, effects of humidity, etc.

Unexplained loss means -

any documented loss that cannot be explained.

If there are reasonable grounds to believe that SSAN has been stolen or lost, this is a matter to be reported to the local police and the regulatory authority.

Regulatory Authority means -

in each state or territory the regulatory authority is the authority that issues the licence or permit.

UN number means -

the identifying number assigned to dangerous goods by the United Nations Committee of Experts on the Transport of Dangerous Goods, and outlined in the Australian Dangerous Goods Code.

The UN number should be on the packaging of bagged fertilizer products that are classified as dangerous goods, and fertilizer suppliers should be able to provide UN numbers where applicable. (Note: Some SSAN products, such as calcium ammonium nitrate, will not have a UN number).

4. REQUIREMENTS

To obtain a licence to store SSAN, a security plan must be submitted to the regulatory authority for approval. (The licence to store may also authorise the purchase, sale or use of SSAN, depending on the nature of the business.)

The security plan will begin with a security risk assessment, to provide information to the regulatory authority about current security measures and about the risk of theft, unexplained loss, sabotage and unauthorised access.

The security plan will provide information to the regulatory authority about how you will meet security requirements. The minimum security requirements are:

1) SSAN must be kept in a secure store;
2) there must be procedures for controlling access to this secure store;

3) there must be procedures for checking and authorising persons with unsupervised access to SSAN, including:
   a) designating a responsible person to maintain the security plan,
   b) instruction of workers on the security plan procedures; and
   c) ensuring people with unsupervised access to SSAN have had police and PMV checks;
4) record keeping to reconcile incoming and outgoing quantities of SSAN and to ensure that SSAN is obtained from an authorised person and removed by an authorised person; and
5) procedures for reporting to authorities any unexplained loss, theft, attempted theft or any other security incident involving SSAN.

5. THE SECURITY PLAN

Security risk assessment

A security risk assessment is a necessary preamble to developing a security plan. This assessment will describe existing security measures and examine the level and type of security risks to your particular business. In clarifying those risks it is necessary to consider outside threats and also the security risk from staff or contractors who have access to your premises and SSAN. You should consider whether current security arrangements leave the SSAN vulnerable to theft or sabotage, and consider security improvements appropriate to manage the assessed risk. Security risk assessments should be reviewed periodically, particularly after security incidents.

Security plan

The security plan will describe how you will meet the minimum requirements and any other security measures to be introduced.

The security plan will have three main elements:

− personnel management;

− site security; and

− procedures.

Personnel management

Minimum requirement 1: List of authorised persons

The security plan must contain a list of all those who will have unsupervised access to SSAN. This will include the licence applicant. These people will be required to undertake a police and PMV check and, after clearance by the regulatory authority, will be authorised under the security plan to have unsupervised access to SSAN.

Minimum requirement 2: Staff recruitment

The security plan must include the provision for adding new workers to the list of authorised persons. Should the licence holder wish to add new workers to the list these persons will be required to undertake a police and PMV check and, when cleared, can be added to the security plan in the form of a dated amendment to the list of authorised persons.

The security plan must also detail the checks that will be made to confirm the identity of new workers who will have unsupervised access to SSAN. Identification must be confirmed using the 100-points identification system [2] , and checks should also be made with the applicant's referees and previous employers.

Minimum requirement 3: Maintaining the security plan

The security plan must include the nomination of a responsible person/security manager to implement and maintain the security plan, including the instruction of workers in the relevant access controls, recording procedures and reporting of security incidents.

Site Security

Minimum requirement 4: Details of your secure storage arrangements for SSAN

The security plan must contain details of your secure storage facility, including type and dimensions of structure, number and type of doors and windows, type of lock, etc. SSAN must be in a secure store under lock and key or constant surveillance (refer to definitions).

Ideally, a suitable padlock should be pick protected and shackle protected (e.g. concealed shackle using case hardened steel body with raised shoulders) and not be re-keyable. Ideally a padlock should also be bolt cutter resistant and have protection against the lock being drilled out. Further information regarding padlock specifications and locksets for doors in buildings can be found in Australian Standards AS 4154.4 – 2002 and AS 4154.2 – 1993 respectively.

IBCs in the open

As an exception to the above requirement, Intermediate Bulk Containers (IBCs) are permitted in open-

air/uncontained/outdoor compounds as long as:

- the IBCs are sealed with tamper-proof seals so that theft of product is easily detectable; and
- a security fence is in place. (The chain wire part of the fence should be at least 2000 mm high and separated from the nearest IBCs by at least 3000 mm. It should be galvanised with both selvedges twisted and barbed, capped with three rows of barbed wire at 150 mm spacing. Further information on construction details can be obtained from AS 1725 – 2003: "chain-link fabric security fences and gates").

Procedures

Minimum requirement 5: Controlling access to the secure store

Procedures for supervised and unsupervised access to the secure store of SSAN must be developed and checks put in place to monitor the effectiveness of these controls.

- Persons having unsupervised access to the secure store must be clearly identified in the security plan. These people will require a police and PMV check. They may supervise the access of others to the secure store.

[2] The 100-point identification system is generally used by financial institutions to confirm identity. A summary is at http://www.aussiemigrant.com/your_finances/f.htm

- A 'key plan' must exist that identifies who has access to the keys to the secure store and where the keys are securely kept.

Minimum requirement 6: Record keeping and inventory procedures

Records must be kept for a minimum of five years and there must be systems and procedures in place to record:

- purchases/acquisitions and sales/supply of SSAN, to ensure that changes in custody occur only between licence holders;
- movements of SSAN into and out of the secure store, so that reconciliation is possible; and
- security incidents, including thefts, attempted thefts, unexplained losses, sabotage or attempted sabotage, break ins, attempted break-ins and any other security incidents, so that these incidents are recorded, investigated and reported to the regulatory authority and the police.

The information contained in this document is provided to offer guidance. It is not to be taken as a statement of law and must not be construed to waive or modify any legal obligations.

Appendix A: (to COAG Guidance Note No.2)

Additional measures

Licence holders may be required by the regulatory authority to implement other security measures in addition to the *minimum* requirements outlined above.

One important factor will be the location of the facility. If the location is in close proximity to population centres or critical infrastructure, so that a potential explosion caused by sabotage could lead to a disaster, consideration will need to be given to:

- reducing storage quantities and / or stack sizes; and / or
- increasing security measures beyond the minimum requirements, so as to deter, detect and prevent after-hours intrusion.

On the other hand, there may be some flexibility within minimum requirement 4 for equivalent security outcomes to be achieved by alternate measures. This will most likely be in exceptional circumstances such as very remote locations. In this case the security plan must justify the departure from the minimum requirements.

Additional measures could improve perimeter protection, stopping intruders at the edge of a facility's property long before they reach vital assets and operational areas. Measures to control the movement of people within the general facility can also greatly enhance security.

Additional measures could include:

Physical security

- Post "No Trespassing" and "Authorized Access Only" signs;

Note: In some jurisdictions it will be mandatory to post "Authorized Access Only" signs at each secure store;

- Upgrade fences with barbed wire;
- Install bollards and trenches that prevent vehicles from driving into the site at points other than official entrances;
- Vehicle gates with retractable barriers;
- Personnel gates and turnstiles;
- Lighting that makes it easier for employees and even passers-by to observe and possibly identify intruders;
- Employ natural surveillance by arranging reception, production, and office space so that unescorted visitors can be easily noticed;
- Install appropriate locks on exterior and interior doors;
- Install appropriate, penetration-resistant doors and security hinges;
- Install secure windows with appropriate locks; and
- Install electronic security measures such as motion sensors, monitored alarms and CCTV.

Procedures

- Establish a system for determining which cars, trucks or rail cars may enter the site, through which gates, docks or other entrances, and under what conditions. Such a system may be part

of the pedestrian access control system, relying on access cards carried by vehicle operators, or it may be an independent system relying on staffed security posts;

- Require visitors to be signed in and escorted; and
- Pay close attention to access control at loading and unloading areas.

The appropriate level of security can vary significantly from facility to facility. It depends on the number of employees, the level of pedestrian and vehicular traffic into and out of the facility, the attractiveness of the facility as a target of various threats, the proximity of the facility to populated areas, and many other actors.

Appendix K: Audit Checklist

Site Name:		Audit Date:	
Auditors			
Site personnel			
Notes			

The audit checklist below is derived from Appendix A - the code summary - and includes a condensed version of most of the text from the body of the code. The content has been regrouped so that all of the requirements (i.e., must-do's) are grouped together at the top, followed by the recommendations, which in turn are followed by content which is primarily informative in nature. The third column describes the type of content for that row, where M = Mandatory, R = recommended, I = information

Section	Content	Type	Complies	Notes	Action / Follow-up
Requirements:					
3.1 Types of store:	Storage configuration complies with table 3.1	M			
	If any co-storage, it is permitted by table 3.1	M			
3.2 General Requirements for stores	Don't break up with explosives or detonators.	M			
	Buildings and structures non-combustible. (Note allowed practical exceptions.)	M			
	5m fuel free zone all around.	M			
	Unused pallets, etc., removed promptly. No combustibles stored or left unattended in or <5m from store except pallets and packaging, and as permitted under 3.2.2.	M			
	Prevent AN impregnation of pallets, etc.	M			
	Fuel spills contained or flow away from AN.	M			
	Spillage of incompatibles kept away from AN.	M			
	Enough venting; no pressure build-up in fire. (Note: For buildings, ventilation for OHS reasons is also adequate for fires.)	M			
	Molten AN unconfined and flow away for later recovery.	M			
	No unprotected copper/zinc/incompatibles in contact with AN.	M			
	If there is a risk of internal corrosion electrical minimum IP55.	M			
	Ensure no effect from hot or reactive ground.	M			
	Unimpeded exit of vehicles and personnel.	M			

3.4 Additional requirements in a building	AN stored on a level with immediate ground access from outside the building.	M			
	Enough ventilation to prevent harmful dusts/vapours. (Workplace OHS requires breathable/safe atmosphere.)	M			
	Access and escape routes defined, kept clear.	M			
	Bulk store floor not earth, road base or bituminous.	M			
	A package store building floor shall be of concrete, compacted road base, low bitumen (less than 9%) asphalt, earth, or other suitable materials.	M			
	Package store floor sufficiently impervious to recover spills without contamination.	M			
	No smoking or naked flames, with signs at entrances	M			
	5m clearance or wall with 4hr fire resistance to other (non AN) parts of building, or attached building.	M			
	If store is in a building must have an external wall.	M			
3.5 Additional Requirements in a silo, bin, etc.	Resist forces, e.g. caked AN falling within.	M			
	Transition areas where AN spillage likely in normal operation made from impervious, easy to clean material.	M			
4.1 Regulatory approval	Have all licences & approvals before operating.	M			
4.2 Size and Arrangement of Stores / Stacks / Piles	No height limit for stacks but they must be stable/safe, and within capability of packaging, and of handling equipment.	M			
	If AN on combustible pallets maintain 600mm access way to outside walls.	M			
4.3 Co-storage of other substances inside AN store	No Class 1 explosives in AN store	M			
	Compatibles permitted in store if segregated by 5m. (Note: Some compatible and incompatible substances listed in Appendix G; if not listed assume incompatible unless proven compatible.)	M			
	Incompatibles only by exception and subject to specific risk assessment, and only if they are not combustible and do not react dangerously. Segregated by 5m, and no mixing under normal or abnormal conditions.	M			
4.4 Other materials in AN store	Chemicals (e.g., cleaning fluids) to be assessed, must not react dangerously.	M			

4.5 Safety and Security Management System (SSMS)	SSMS documented & meet regulatory requirements, implemented in such a way that code requirements met at all stages of lifecycle, and applies to all employees, contractors and visitors		M			
	SSMS must include at least:	A Safety Policy;	M			
		A Safety and Security Management Plan (SSMP);	M			
		Training;	M			
		Operating Procedures covering each AN premises;	M			
		Procedures to control all transfers of custody of AN (including waste).	M			
	SSMS shall include:	Regular safety meetings / minutes / actions.	M			
		Schedule of audits and corrective action system.	M			
		Accident and incident management and reporting system.	M			
		ERP.	M			
		Risk assessment for new AN premises.	M			
		Change management system.	M			
	Training system required for:	Induction of new employees, contractors and visitors.	M			
		SOP's, site procedures and job responsibilities.	M			
		Selection and use of PPE.	M			
		Emergency response plans.	M			
	Procedures in place to cover:	obtaining SDSs for all chemicals on the site;	M			
		preparing SOPs for all routine tasks;	M			
		control of lock out/tag out, confined space entry and hot work permits (including training, documentation, responsibilities and identified authorisation levels);	M			
		authorisation of all processes being conducted on site, including commissioning and waste disposal;	M			
		inspection and cleaning of AN storage and handling equipment;	M			
		control of the modification of processes and equipment (change management);	M			
		control of all non-routine work or tasks (i.e., without an SOP)	M			

		safe disposal of waste materials (recognising that waste may still be SSAN);	M			
		response to the approach of lightning. (Note that for the purpose of assessing lightning risk AN is deemed to be non-flammable, non-combustible and non-explosive, and as such the presence of AN at a site does not create any requirement to evacuate at the approach of lightning.);	M			
		no parking of Class 1 explosives vehicles close enough to potentially cause sympathetic initiation of AN. Generally this will mean that vehicles transporting Class 1 explosives are not permitted to park within the AN premises;	M			
		managing all aspects of custody transfer (in or out) of AN, including ensuring that AN is only released into the custody of persons or organisations which are appropriately licensed, aware of the requirements of this Code, and likely to comply with regulatory requirements and this Code.	M			
	Emergency Response Plan to be in place (per Sect 9 of code)		M			
5.1 Store Location: General	AN store not to be located where risk to surrounding off-site land uses exceeds criteria specified in code (HIPAP 4).		M			
5.2 Separation Distance Requirements	Must meet tables 5.3 to 5.7 unless on a mine site, or have QRA demonstrating risk targets met.		M			
	Distances applied from each stack/store unless they do not meet stack separation, then apply distance to aggregated group of stacks/stores		M			
	On mine sites, if owner permits AN storage, distances are mandatory for vulnerable or residential, but not mandatory for commercial, open or industrial; need QRA if less than "open".		M			
5.4 Application Notes: Which Table to Use	Type of store selected complies with guidance in Table 5.2.		M			
5.5 Minimum Distance Tables	Distances to surrounding land uses comply with relevant table (5.3 to 5.7).		M			

5.6 Stack/pile separation	Stack separation rules complied with (table 5.8)		M			
	Physical barriers ignored (for stack separation) or justified.		M			
5.7 Sympathetic Initiation	AS 2187.1 complied with (for aggregated explosions of combinations of AN and explosives)		M			
	AEISG UN 3375 Code complied with (for aggregated explosions of combinations of UN 3375 and AN/explosives)		M			
6.1 Powered AN handling equipment: General Requirements	No fuel or oil leaks.		M			
	Battery isolation switch and insulated covers.		M			
	Regular maintenance.		M			
	E-stop (unless a vehicle).		M			
	Reasonably cleared of AN after use.		M			
	No unprotected copper/ zinc / cadmium normally in contact with AN.		M			
	Attended when operating.		M			
6.3 Additional Requirements Applicable to mobile equipment	Prevent vehicles bringing contaminants into store.		M			
	Except electrically powered items set up (semi) permanently, all vehicles & powered mobile machinery:	Kept outside when not in use;	M			
		Garaged minimum 10m away;	M			
		Always attended when in store;	M			
		Unhindered egress at all times; and	M			
		Refuelled / recharged at least 10m away.	M			
6.4 Additional Requirements for Internal Combustion Engines	Only diesel or LPG.		M			
	Have min 40(b) 2.5 kg dry-powder fire extinguisher.		M			
7.1 Minimum Security Requirements	In Australia all AN in scope is SSAN - manage in accordance with COAG guidelines 2004. Other jurisdictions: comply with local legislation (can use this section as guide).		M			
	SSAN must be in a secure store.		M			
	Need access control procedures.		M			
	Need procedures to check / authorise unsupervised access.		M			
	Keep records for stock reconciliation and ensure authorised supplier and recipient.		M			
	Have procedures for reporting unexplained loss, etc.		M			

7.2 Security Plan	Must do security risk assessment.		M			
8.1 Environmental & Waste: Introduction	Waste and environmental programs shall be incorporated in design, and in place before operations start.		M			
8.4 Spilled & Contaminated AN	Prevent spillages from entering waterways.		M			
	Clean spills recovered immediately = uncontaminated. All else = contaminated, may no longer be within UN number and will be unpredictable in fire.		M			
	Dispose of contaminated AN via specified process; preferred process is dry sweep-up / collection and on-site recycling.		M			
8.5 Waste Controls	Need a specified disposal process for other waste (from cleaning, maintenance, used packaging).		M			
9. Emergency Planning & Response	ERP in place and shall include:	1) Emergency contact numbers;	M			
		2) A site plan showing emergency equipment location;	M			
		3) A premises and area evacuation plan, showing evacuation routes and defined evacuation points;	M			
		4) Procedures that address any reasonably foreseeable emergency, specifically including fires;	M			
		5) Procedures that address the loss of normal communication systems.	M			
	Persons expected to assist in an emergency to be trained;		M			
	Plan to be updated post-incident / annually.		M			
9.2 Fire protection	Enough fire fighting facilities (in addition to those required by sect 6) to extinguish any reasonably foreseeable fire (examples listed) in early stages.		M			
	If there is a fixed system it must be able to actuate remotely or automatically and/or leave running unattended. Systems that require personnel to be in attendance in order for them to continue to work are not permitted.		M			
9.3 Firefighting and Interaction with Emergency Services	Only fight fires if not significantly involving AN, otherwise evacuate. (Unattended systems can run.)		M			
	If AN is significantly involved in a fire, the evacuation plan shall be initiated immediately and ALL personnel shall evacuate. This should		M			

	include emergency response personnel. Emergency response personnel may have authority to override any instructions				
9.4 Evacuation	Minimum evacuation distance: emergency response people Vulnerable distance; anyone else double Vulnerable distance; but minimum always 400m.	M			
10. Risk Assessment	Was a risk assessment completed and documented before site in operation, and covering all issues listed.	M			
Recommendations:					
3.3 General Recommendations	AN Stores not near possible big heat, etc., sources (oil stores, gas pipelines, etc).	R			
	Protect from weather, reduce moisture absorption/heat cycling.	R			
	Where reasonably practicable stores not at low points and to be kept dry (but not always reasonably practicable, e.g., open-ended igloo).	R			
	Maintain stock rotation to avoid caking.	R			
	Where reasonably practicable, flammable and combustible spills, even with secondary containment, should flow away from stored AN.	R			
	Fittings, etc., in extended contact suitably corrosion resistant or protected.	R			
	Concrete floors (with protection) recommended for loose bulk.	R			
	Protection (additives or coatings) recommended for all exposed concrete	R			
	Lightning protection not a requirement of this code, but if considering use AS 1768 with AN non-flammable and non-explosive. Lightning protection is not an automatic requirement.	R			
	If wooden pallets present, allow for fuel when considering fire.	R			
	If floor >250 sq m recommend two exits.	R			
	Extra ventilation advantageous, prefer to not block vents.	R			
	No boundary separation mandated, but recommend at least 5m to control fuel free zone.	R			
	If light fittings may fall and cause sparks/ignition or injure people provide additional safeguard.	R			

	Avoid sealed hollow sections.	R			
4.2 Size and Arrangement of Stores / Stacks / Piles	Recommend subdividing large stores.	R			
4.5 Safety and Security Management System (SSMS)	Other recommended SSMP components detailed	R			
5.2 Separation Distance Requirements	If QRA is used, a methodology is recommended.	R			
5.4 Application Notes: Which Table to Use	Table 5.2 gives guidance which table applies to some situations that may be encountered, including igloos.	R			
5.8 Separation to Roads and Railways	If traffic >10,000 vehicles/day (or passenger rail equivalent) recommend a site-specific assessment.	R			
	If railway line passes closer than “open” distance recommend societal risk assessment	R			
5.9 Layout of AN Storage sites	Recommend using IMESAFR to understand risk / optimise layout for proposed sites, and standardised designs.	R			
6.2 Powered AN handling equipment: General Recommendations	Corrosion resistant.	R			
	Remove non-essential electrics, rest to IP55 (or highest available)	R			
	Avoid situations (normal and abnormal) where AN may be trapped, heated or contact incompatibles.	R			
	Road vehicles cool down before entering store.	R			
	Vehicles able to exit without manoeuvre or reversing.	R			
	Conveyer belts should have fire-resistant belt and rollers.	R			
6.5 Additional Recommendations for Augers	One end plate removable, e.g., flanged.	R			
	If stub shaft is used for a demountable internal connection take note of how it is attached.	R			
	Prefer no internal protrusions (bolts, pins, nuts, etc) and no internal shaft connection.	R			
	Bearings should be external, with an airgap to allow leakage to drop free and not enter bearing; any guards should not trap AN.	R			

	Seals inside tube attached such that fasteners cannot come loose.		R			
	Avoid packed gland - lip seals preferred, and no cotton / fibrous material in seal.		R			
	Materials that are not ignitable are preferred for seals and bearings.		R			
	All parts should be checked for corrosion and wear and replaced if suspect.		R			
	Assess materials of construction, e.g., corrosion of mild steel.		R			
	Spiral to tube clearance/tolerance should be checked for compliance with design specifications.		R			
	Regular wash down and inspection.		R			
	Wash down and ensure no trapped AN before hot work.		R			
8.2 Environmental & Waste: Design of an facility	Minimise potential for waste.		R			
	Capture and contain spills.		R			
	Enable the rapid clean-up of any spills or contamination.		R			
	Minimise material handling and tracking.		R			
	Control the potential for stormwater contamination.		R			
	Include systems that alert operators of system failures that may lead to a loss of containment, e.g., high / low level alarms.		R			
8.3 Siting of an facility	Identify potential contamination pathways.		R			
	Prefer locations with lower environmental risk - consider where spills will go (e.g., watercourses, etc); proximity to surface waters; depth to groundwater; topography around the area; soil type / drainage characteristics / historical rainfall.		R			
8.4 Spilled & Contaminated AN	Keep clean, clear spillages promptly, no organic / combustible cleaning material (e.g., sawdust), consider spill kits.		R			
	Treat contaminated AN as incompatible, keep in designated place with room for all foreseeable contaminated AN.		R			
8.5 Waste Controls	Waste / contaminated AN to continue meeting SSAN requirements.		R			
8.6 Prevention of soil, surface water and	Minimum recommendations:	develop procedures to minimise potential for spillage and avoid creating pathways for environmental exposure;	R			

groundwater contamination		storage, handling and operational areas to have containment measures so that any spills/leakages of AN are prevented from access to the surrounding soil, surface water or groundwater;	R			
		containment system to include: drainage controlled; contaminated water collected & stored; dams/storages impervious, sized for 1 in 10 year 24 hour storm, monitored, and emptied within 5 days after rain; minimise area where stormwater can be con	R			
	Best practice recommendations:	Capture and containment of dust generated from de-bagging and handling;	R			
		Containment of tracked material;	R			
		Regular housekeeping, maintenance and spill / loss prevention;	R			
		Stormwater ingress prevention (clean and dirty water separation);	R			
		Ensure loading and unloading activities are adequately supervised to promptly identify and clean up spills;	R			
		Minimise the distance that AN is moved around onsite;	R			
		Implement a routine cleaning program for AN dust / spills;	R			
		Wheel washes (or other measures) to prevent tracking of AN on-vehicle tyres.	R			
9. Emergency Planning & Response	Recommend regular drill with documented outcomes.		R			
9.2 Fire protection	Fire protection design generally per sect 12 of AS 4326, except that usually only need extinguishers.		R			
	Facilities capable of single person operation if store operated by small number of people.		R			

Information:					
Preamble	Introduction, and reason for producing this Code.	I			
	In this code AN means only 2 UN numbers (1942 or 2067) (In Australia both are SSAN)	I			
	Introduces ammonium nitrate properties, hazards and history	I			
	Many standards and codes exist for AN. This code focuses on narrower scope, specifically aligned with commercial explosives industry.	I			
	All significant historical fire and explosion events (involving AN) listed in appendix F; all could have been prevented by rigorous application of appropriate standards.	I			
	Presents a high level structure of key controls.	I			
	Notes lack of uniformity in other relevant codes.	I			
	Recognise that other regulations, codes, standards may be more (or less) stringent.	I			
1.1 Scope	Solid AN (two UN numbers) servicing mining, quarrying and construction.	I			
1.2 Application	Unless excluded, code applies to any person handling AN plus AN storage licence holders and occupiers	I			
1.3 Exclusions	Other UN numbers or non-DG, MHF's, manufacturing of ammonium nitrate, AN and AN Stores that are part of any mixing or manufacturing operation, stores < 1 tonne, transport, ports, transit, MPU's, AN with Class 1, AN stored underground.	I			
1.4 General	Based on knowledge and experience; not intended to limit improvement; alternatives may be OK; not retrospective.	I			
	AN must have < 0.2% combustibles; one analytical test method referenced, other methods can also be OK.	I			
	Presents "good practice" hierarchy.	I			
2. Definitions		I			
4.2 Size and Arrangement of Stores / Stacks / Piles	No mandatory limits to size of stack or store, but note subdivision can reduce explosion size...	I			
	If no pallets do not need separation from walls, provided walls can support any loads, and egress unimpeded.	I			
	OK to keep fire extinguishers, spill kits, etc., in store provided no significant quantity of incompatibles.	I			

4.4 Other materials in AN store	Unpowered tools and equipment temporarily in store are deemed compatible.	I			
5.1 General	Using land uses and risk criteria from NSW HIPAP 4.	I			
	Refer to flowchart	I			
5.2 Separation Distance Requirements	Note: Appendix D gives background on separation distances and details methodology used to develop tables. Different types of store generate different risk hence 5 tables for 5 types of AN store.	I			
	For high population densities, an additional assessment of societal risk may be necessary, e.g., large sports stadiums, etc.	I			
	Note: Appendix E gives guidance on what fits into which land use.	I			
5.3 Basis of Separation Distance Tables	Tables developed using IMESAFR, with 5 types of AN store construction which could be a Potential Explosion Site (PES) and 5 types of Exposed Site (ES) construction.	I			
	Note that tables are based on HIPAP Land Uses, not ES types; land uses do not align with types of ES construction, except for "sporting complexes and active open space" which aligns with the "open" ES.	I			
	Other than the column for land use "open", each distance in tables is biggest of four (i.e., the biggest of any of the four ES construction types). Therefore distance allows for any ES construction, provided it is reasonably similar to one of the 4 modelled	I			
	Site-specific assessment may be needed for non-typical ES's.	I			
5.5 Minimum Distance Tables	Short names used in tables defined	I			
5.6 Stack/pile separation	Lists factors affecting likelihood of stack to stack explosion propagation (distance, density, edge slope, physical barrier).	I			
6. Powered AN Handling Equipment	Section applies to all powered equipment handling AN (loose bulk / in shipping containers / in IBCs). The requirements also apply to road vehicles if they enter an store.	I			
7.1 Minimum Security Requirements	Licence depends on security plan, which starts with a security risk assessment.	I			
7.2 Security Plan	Details security plan objectives and main elements.	I			
	Note possibility of disposal in blast holes if customer agrees.	I			

8.4 Spilled & Contaminated AN	Refer to AS 4326 for disposal methods.		I			
9.2 Fire protection	Don't typically need fixed systems or hose reels because:	extinguishers normally adequate and often preferred way to fight early stage fires;	I			
		combustibles & incompatibles are minimized near store;	I			
		if fire is significant and involving AN should evacuate, not fight;	I			
		in-scope stores typically remote, so minimal off-site effects, AS 4326 allows owner to accept risk of destruction, mine owner normally accepts risk, evacuated people not at risk, firewater likely to be scarce;	I			
		fixed systems can have unintended environmental consequences, if activated by mistake.	I			
	Fixed system may be used if expressly required by regulations.		I			
	Fixed system may be used if risk- or cost-justified.		I			
9.3 Firefighting and Interaction with Emergency Services	Significantly involved means significant quantity being heated enough to potentially or actually melt/decompose.		I			
	Stages of AN decomposition during a fire explained.		I			
9.4 Evacuation	Selection of evacuation points site-specific, striking balance across 5 listed criteria.		I			

About AEISG

The Australasian Explosives Industry Safety Group (AEISG) is an incorporated association of Australasian explosives manufacturers and suppliers originally formed in 1994.

Since then, AEISG membership has grown substantially to include most of the Australasian explosives industry. A full list of all current member organisations can be found on the AEISG website, www.aeisg.org.au

The goal of AEISG is to continuously improve the level of safety and security throughout our industry in the manufacture, transport, storage, handling and use of explosives and related materials.

One of the strategies adopted by AEISG in this regard is to identify areas where improved and consistent standards of operational safety and security need to be applied, and then develop appropriate codes that reflect industry best practice in these areas.

AEISG codes of practice are adopted by members for the benefit of their employees, their customers and the general community. In the interest of promoting safety and security, the codes are freely available on the AEISG website.

To keep abreast of technological advancements, industry progress and regulatory changes, AEISG Codes of Practice are subject to regular review and updated through the issue of amendments or revised editions as necessary. It is important that users ensure they are in possession of the latest edition and aware of any amendments. References to superseded versions should be updated accordingly.

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