

CODE OF PRACTICE

# Safe storage of solid ammonium nitrate

Second edition



Government of Western Australia  
Department of Mines and Petroleum  
Resources Safety





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Further details of publications produced by Resources Safety can be obtained by contacting:

### Resources Safety

Department of Mines and Petroleum  
100 Plain Street  
EAST PERTH WA 6004

**Telephone:** + 61 8 9358 8002 (general queries)  
+ 61 8 9358 8154 (publication orders)

**NRS:** 13 36 77

**Facsimile:** + 61 8 9358 8000

**Email:** ResourcesSafety@dmp.wa.gov.au  
(general queries)  
RSDComms@dmp.wa.gov.au  
(publication orders)

# Foreword

## The Act

A key focus of the *Dangerous Goods Safety Act 2004* (the Act) is the duty to minimise risk from dangerous goods. This duty not only applies to employers and employees but to all persons, including members of the public. This duty is placed on everyone involved with dangerous goods and goes beyond the workplace duties of the *Occupational Safety and Health Act 1984* and the *Mines Safety Inspection Act 1994*. Public safety is one of the most important features of the Act.

## Regulations

The Act is supported by the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 for safety requirements and the Dangerous Goods Safety (Security Risk Substances) Regulations 2007 for security requirements.

All storages of ammonium nitrate (AN) require a security licence under the Dangerous Goods Safety (Security Risk Substances) Regulations 2007, except where less than 3 kg of AN is stored for use at laboratories under specific conditions.

Safety requirements exist for the storage and handling of AN, with quantities exceeding 10 t also requiring licensing under the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007.

Some sites where AN storage and/or handling occurs may be classified as major hazard facilities (MHFs) and will be subject to the Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007, with the requirement to produce a safety report. In such cases, compliance with the approved safety report will be required.

The regulations are enforceable, and breaches may result in licence suspension, prosecution or directions to cease operations and undertake remedial action.

## Codes of practice

Approved codes of practice provide safety recommendations to assist people in meeting their obligations under the Act and regulations. The codes are approved and gazetted by the Minister under section 20 of the Act, and may be used as a defence in law (s. 62 of the Act). Although compliance with an approved code is not mandatory, it is expected that deviations from recommended practice will be justified and it can be demonstrated that the use of alternative risk control measures provides an equivalent or lower level of risk. The codes are not intended to prevent innovative safety practice or use of equipment that improves safety performance.

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# 1 Introduction

## 1.1 Scope

This code of practice has been produced to assist those storing or handling solid ammonium nitrate (AN) to meet their safety obligations under the *Dangerous Goods Safety Act 2004* (the Act) and associated regulations. The code provides practical guidance on managing many of the risks associated with AN, and is an approved code of practice under section 20 of the Act. It describes the preferred safe work practices that can be readily used at places such as ports, merchant stores, mine sites and manufacturers' facilities.

The risk control information is based on current knowledge, a practical understanding of the properties and hazards of solid AN gained from testing and research, and the experience of past fires and explosions. However, people who have duties under the Act and relevant regulations should remain alert to developments and hazards that may not be fully dealt with by this code of practice or other guidance material. They should assess what further measures may be necessary or desirable, considering good working practice and local circumstances.

A glossary of terms used in this code of practice is given in Appendix 1.

*Note: This code of practice should be read and applied in conjunction with the code of practice on the storage and handling of dangerous goods, available from the Resources Safety website.*

## 1.2 Application

The code applies to the storage of solid AN in Division 5.1 – oxidising agent, as classified into United Nations numbers UN 1942 and UN 2067 by the 7th edition of Australian Code for the *Transport of Dangerous Goods by Road and Rail* (ADG7) and the 15th edition of *Recommendations on the Transport of Dangerous Goods: Model Regulations* (UN 15), published in 2007 by the United Nations.

The code does not apply to AN substances classified as Class 1 explosives, Class 9 miscellaneous dangerous goods or non-dangerous goods.

The safety provisions of the code apply to storages of solid AN of Division 5.1, except for:

- sites storing less than 1,000 kg of AN; or
- a "rural dangerous goods location", where AN is stored and used (not retailed) on an agricultural site of more than 5 hectares that is used exclusively for primary production.

*Note: Under the Act, a general duty exists in relation to minimising the risk to people, property and the environment from dangerous goods, such as AN, in any quantity.*

# 2 Properties and hazards of ammonium nitrate

## 2.1 Properties

Pure AN ( $\text{NH}_4\text{NO}_3$ ) is a white, odourless salt with a melting point of about  $170^\circ\text{C}$ .

AN is highly soluble, tends to absorb water from the atmosphere, and can absorb enough water from the air to dissolve into aqueous solution if kept at high humidity.

Solid AN has five transitional crystalline forms depending on the temperature. Changes of form result in density changes that may lead to breakdown of the AN prill structure and caking of the product.

Appendix 2 contains more detailed information on the properties of AN, and what makes it hazardous.

## 2.2 Hazards

AN has three main hazards:

- fire
- decomposition with the formation of toxic gases
- explosion.

### Fire

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.

AN products contaminated with oil or combustible materials can initiate a fire when hot. Similarly, combustible materials impregnated with AN have been known to start burning spontaneously when left on hot surfaces.

Hot AN melt or solutions can initiate fires when coming into contact with combustible materials such as rags, wooden articles or clothing. Hot AN solutions present the additional hazard of causing burns if in contact with the skin.

### Decomposition

If AN is heated, it will decompose to give off toxic gases. In an open and unconfined situation, it will decompose completely to the gaseous products of nitrous oxide ( $\text{N}_2\text{O}$ ), ammonia ( $\text{NH}_3$ ) and nitric acid ( $\text{HNO}_3$ ) in a steady controlled way, with white fumes and vapours.

If heated sufficiently (such as in a fire), and combined with contamination, confinement (such as in enclosed drains or enclosed parts of equipment) or both, other gases, including brown vapours of toxic nitrogen dioxide ( $\text{NO}_2$ ), are given off, and the explosive sensitivity of the AN increases. Through self-accelerating reactions, the temperature will continue to rise and detonation could occur.

Fires involving AN have caused many explosions but there have been many more fires involving AN that did not lead to explosions.

### Explosion

AN is a potentially explosive substance because it comprises the oxidising nitrate ion in intimate contact with the fuel element, the ammonium ion. Only small amounts of contaminants are required to act as a catalyst, explaining the unpredictability of AN under fire conditions.

As a result of the decomposition reactions of AN, the risk of an explosion is increased by heating AN in combination with contaminants, confinement or both.

In a fire situation, pools of molten AN may be formed. If the molten mass becomes confined, such as in drains, pipes, plant or machinery, or combines with contaminants, it can explode.

## 2.3 Hazard management

Fires are avoided by rigorously eliminating and reducing the amount of potential fuel, combustible materials and dangerous contaminants in and around the AN store.

Fires involving AN cannot be extinguished by oxygen deprivation because of the provision of oxygen from AN. Water is the most effective means of fire fighting — attempts to smother fires with dry chemical, carbon dioxide or foam extinguishers will not succeed.

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.



The risk of an explosion is decreased by reducing the potential for the AN to be:

- heated, such as in a fire
- contaminated
- confined.

Given the nature of modern formulations of AN, explosions of solid AN (excluding those initiated by explosives) without prior fire are very unlikely. If all potential sources of fuel can be eliminated, the chance of an accidental explosion is remote. However, such explosions can and have occurred with concentrated hot solutions, particularly during manufacture.

## 2.4 Evacuation distances

Explosions resulting from fires involving AN, even in recent years, have killed and injured emergency personnel and others.

When a fire involving AN is judged to be out of control, or if the fire is engulfing the AN, everyone, including fire fighters, should be evacuated to a safe distance where they will not

be harmed if there is an explosion. The evolution of toxic brown nitrogen dioxide is a sign that immediate evacuation is required.

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

For a storage quantity greater than 1 t but not exceeding 500 t per individual stack or pile, where the stacks or piles are separated from one another by a distance sufficient to prevent a detonation in one propagating to another (see Chapters 4 and 5), the recommended minimum evacuation distance for all personnel (including emergency personnel) is 2,200 m. Where the quantity of AN that may detonate in a single event exceeds 500 t then an evacuation distance of greater than 2,200 m needs to be considered.

*Note: Further information on emergency planning is contained in "Dangerous goods sites – emergency planning code", available from the Resources Safety website.*

# 3 Store design and construction

## 3.1 Types of stores

AN may be stored in a number of recognised ways, including:

- open-air storage — intermediate bulk containers (IBCs)
- freight container storage — IBCs or loose bulk
- dedicated, stand-alone building storage — packages, IBCs or loose bulk
- storage attached to, or within, a non-AN dedicated building — packages or IBCs (10 t limit)
- storage in silos and bins — loose bulk
- storage in blasting explosive magazines — packages.

Providing it is in a secure area away from combustible materials and sources of contamination, storage in a completely open-air store or freight container offers distinct safety advantages compared with storage in a building.

The presence of reactive or hot ground should be considered when designing, constructing and locating an AN store.

## 3.2 Open-air storage

In open-air stores, the risk from accidental fire, explosion and arson is reduced due to the lack of combustible materials, sources of ignition and situations leading to confinement.

For safe storage in open-air stores, no special construction requirements apply except to provide adequate protection from the weather, as well as security controls.

IBCs in an open-air store should be located on slightly raised ground to prevent the accumulation of rainwater. The ground should slope such that, in the event of a fire, any molten AN flows away from surrounding structures or storages.

Adequate security for open-air storage in IBCs usually involves security fencing as one of the security control measures.

*Note: Guidance on AN security requirements is available from the Resources Safety website in the security risk substances section.*

## 3.3 Freight container storage

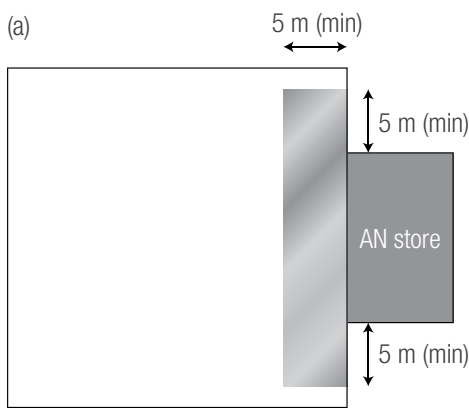
A freight container may be used for the dedicated storage of AN provided it is constructed in accordance with Australian Standard AS/NZS 3711:2000 *Freight containers* or the relevant International Organization for Standardization (ISO) standard for freight containers used to transport dangerous goods. It should not contain any wood lining nor have a wooden floor.

## 3.4 Building storage

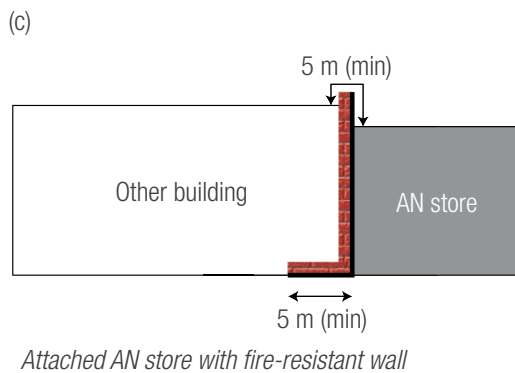
All buildings used for AN storage should be designed and constructed to comply with the requirements listed below. Where relevant, these requirements also apply when AN is stored in a tent-type structure.

- Provide adequate ventilation.
- Store the AN on a level that has immediate ground access from outside the building.
- Construct the entire building from non-combustible material, with the floor made of concrete (protected from AN attack where necessary) or other suitable material.
- Ensure any materials or fittings used in the building construction that could come into contact with AN during normal operations or in the event of spillage do not contain zinc, copper or other incompatibles unless suitably protected (e.g. by coating with suitable epoxy-based materials or chlorinated rubber). Mild steel may require suitable protection to prevent corrosion by AN.
- Design the AN store and its surrounds so that, in the event of fire, molten AN does not become confined within the building in which it is being stored or other enclosures such as covered drains, pipes, and tunnels. Any molten AN should flow clear of the storage area, all other storages, buildings and combustible materials, and be retained on the site.
- Design and construct the AN store, including any shelving or racking, so that spilt AN can be easily detected and cleaned up.
- Do not store AN in a cabinet or similar enclosed and confined manner.
- Keep the entire building dry and free from water seepage.
- Provide additional safeguards for lighting to prevent it from falling.

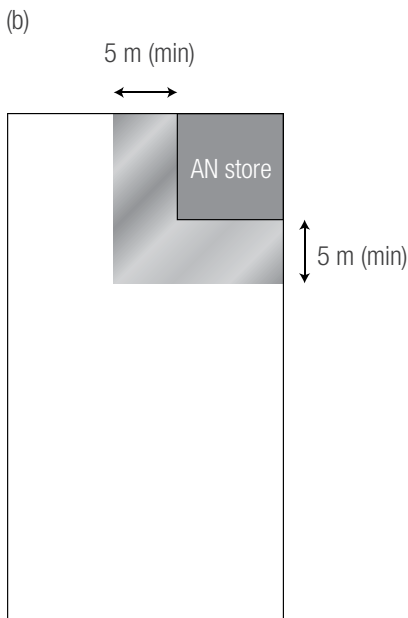
- Where there is a risk of corrosion from AN, ensure electrical equipment has a rating of not less than IP65 in accordance with Australian Standard AS 60529 *Degrees of protection provided by enclosures* (IP Code).
- Protect buildings against lightning strike as specified in Australian Standard AS/NZS 1768:2007 *Lightning protection*. In assessing the level of lightning protection required, AN is deemed to be non-flammable and non-explosive.
- Where an AN store of 10 t or less is either attached to another building or located inside a building that is not dedicated to the storage of AN, isolate the store by a horizontal distance of at least 5 m that is left clear (Figures 3.1a, 3.1b) This distance may be measured around a wall extending 1 m above the roof of the AN store and having a 240/240/240 fire resistance level (FRL), as per the *Building Code of Australia* (Figures 3.1c, 3.1d)
- If an AN store is located inside a building, at least one wall of the store must be an external wall of the building to allow molten AN to flow clear of the building in the event of a fire.



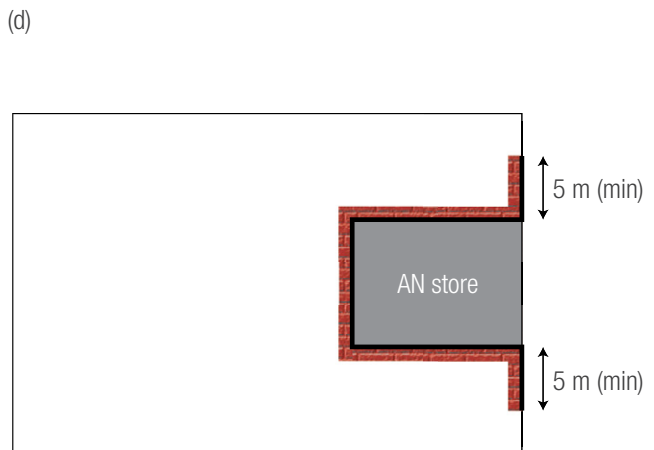
Attached AN store




Attached AN store with fire-resistant wall



AN store located inside a non-dedicated building



Attached AN store with fire-resistant walls located inside a non-dedicated building

 240/240/240 FRL wall

 Isolation area in which no goods may be stored or activities conducted

Figure 3.1 Examples illustrating the required isolation of AN stores of 10 t or less

### 3.5 Silo and bin storage

All silos and bins used for AN storage should comply with the requirements listed below.

- Construct the silo or bin from non-combustible, corrosion-resistant materials.
- Ensure any materials or fittings used in the building construction that could come into contact with AN during normal operations or in the event of spillage do not contain zinc, copper or other incompatibles unless suitably protected (e.g. by coating with suitable epoxy-based materials or chlorinated rubber). Mild steel may require suitable protection to prevent corrosion by AN.
- Design and construct the silo or bin so it is capable of resisting all foreseeable forces to which it may be exposed. It is important to take into account AN's tendency to cake when determining the magnitude of potential forces.
- Construct the area beneath the AN silo or bin from concrete (protected from AN attack where necessary) or other suitable material.
- Where there is a risk of corrosion from AN, ensure electrical equipment has a rating of not less than IP65 in accordance with the IP Code.

- Protect the silo or bin against lightning strike as specified in AS/NZS 1768:2007. In assessing the level of lightning protection required, AN is deemed to be non-flammable and non-explosive.
- Design and construct the silo or bin to prevent the ingress of water and allow for the release of gases in the event of a fire.
- Position the silo or bin so that, in the event of a fire, molten AN cannot enter any enclosure such as a drain, bund, pit or tunnel, and will flow clear of all other storage areas, buildings and combustible materials, and be retained on the site. Take into account the topography around the silo or bin to prevent any flammable or combustible liquids at the site from flowing towards the AN store.
- Ensure silos are stand-alone AN storages. Do not locate them inside or attached to buildings.

### 3.6 Magazine storage

Storage of packaged AN is allowed inside a blasting explosive magazine subject to it being treated as an explosive. AN stored in a blasting explosive magazine must comply with the Dangerous Goods Safety (Explosives) Regulations 2007.

# 4 Store location

## 4.1 Separation distances

The location of an AN store is subject to acceptance by Resources Safety with respect to its proximity to sites such as residential occupancies, places of public assembly, academic establishments, health care facilities and pipelines.

Recommended minimum separation distances to on-site and off-site protected works as well as vulnerable facilities and critical infrastructure are described below. These separation distances are intended to help minimise impacts on people, property and the environment in the highly unlikely event of an AN detonation.

When considering the location of an AN storage, it is advisable to maximise separation distances as far as is reasonably practicable, and consider how all on-site and off-site people can be promptly alerted and evacuated to a safe distance in the event of a fire involving the AN.

If the separation distance between a store of AN and off-site protected works, vulnerable facilities or critical infrastructure that are not potential terrorist targets is less than that indicated in Table 4.1, additional risk control measures need to be adopted or the maximum stack size of AN suitably reduced. Such risk control measures may include additional means to prevent, detect and mitigate fire.

*Note: In some cases, Resources Safety may require separation distances that differ from those indicated here. Consult the regulator in all cases where more than one AN store is proposed for a site or where the quantity of AN exceeds 250 t.*

### AN stores of 10 t or less

Stores of AN of 10 t or less should be separated from the site boundary and on-site protected works by a minimum distance of 5 m. The separation distance should be at least 15 m for off-site protected works, and 50 m for vulnerable facilities.

### AN stores of more than 10 t

Where AN is stored in quantities exceeding 10 t, it should be separated from the boundary of the site and from on-site protected works by a distance of at least 15 m. For off-site protected works, vulnerable facilities and critical infrastructure, recommended minimum separation distances are determined using Table 4.1.

If the separation distances given in Table 4.1 cannot be met then additional risk control measures need to be adopted, in consultation with Resources Safety. However, for residential buildings and locations with high population densities, the recommended separation distances may still be required, irrespective of any additional control measures.

Where AN is stored in a manner that would prevent sympathetic detonation between individual stacks or piles, separation distances may be calculated on the basis of the quantity in the largest individual stack or pile.

## 4.2 Storage with high explosives and detonators

A store of AN must be separated from high explosives and detonators by the minimum distances given in Australian Standard AS 2187.1:1998 *Explosives – Storage, transport and use – Storage*. Where mounding is used, it must comply with the requirements of AS 2187.1:1998.

If AN is stored with high explosives, treat it as though 50 per cent of the quantity of AN was an explosive. The AN storage must comply with the Dangerous Goods Safety (Explosives) Regulations 2007.

Table 4.1 Recommended minimum separation distances for AN stores

Quantity of AN stored (kg)	Recommended minimum separation distances (D)	
	Off-site protected works (m)	Vulnerable facilities and critical infrastructure (m)
10,001	240	300
15,000	280	350
20,000	330	410
30,000	350	440
40,000	380	480
50,000	410	520
75,000	470	590
100,000	520	650
125,000	560	700
150,000	600	740
175,000	630	780
200,000	660	820
250,000	710	880
300,000	750	940
350,000	790	990
400,000	825	1,030
450,000	860	1,070
500,000	890	1,110

Notes:

- "Quantity of AN stored" means the quantity in the largest individual stack or pile, not the total quantity stored, subject to sufficient separation between stacks or piles to prevent a detonation in one propagating to another (see Section 5 for guidance on inter-stack separation distances)
- Distances in Table 4.1 from off-site protected works were obtained by using the formula  $D = 17.8 Q^{1/3}$ , and from vulnerable facilities and critical infrastructure using  $D = 22.2 Q^{1/3}$ . Q is the quantity of explosive stored – see note below. Distances have been rounded to closest multiple of 10 m
- In calculating separation distances, AN is taken to have a TNT equivalence of 25%, as sourced from "Proceedings No. 580 – Safety Testing of Ammonium Nitrate Products", published in 2006 by The International Fertiliser Society, which indicates: "The TNT equivalence, used for practical situations, is a combination of the 'explosive power' and the 'efficiency' (i.e. the part of the bulk which contributes to the blast effect in a detonation). The 'explosive power' is based on the TNT equivalence of the full scale test. Based on a combination of the results of the tests and the TNT equivalence in accidents for TGAN (Technical Grade AN) a TNT equivalence of 20-25% appears appropriate for practical situations."
- Guidance regarding risk assessment in relation to AN storages may be sought from "SAFEX International – Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate", available at [www.safex-international.org](http://www.safex-international.org)
- The figures used are based on current information and may be subject to change

# 5 Storage requirements

## 5.1 General

AN should be stored in an adequately ventilated place away from possible sources of excessive heat, fire or explosion, such as oil storages, gas pipelines, timber yards, flammable liquids, flammable solids and explosives.

A suitable means of protecting AN from the weather is important to help prevent caking and deterioration of the AN prill structure, which is particularly important if it is to be used to make AN fuel oil (ANFO) explosives.

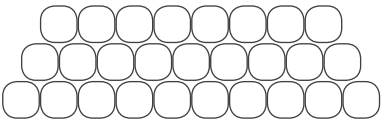
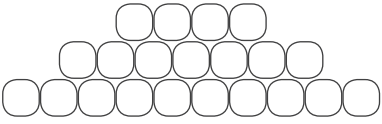
## 5.2 Storage of AN

- Wooden pallets should not be used when storing more than 10 t of AN in IBCs.
- AN in packages, IBCs or as loose prill may be stored in maximum stack sizes of 500 t, separated from each other in a manner that prevents sympathetic detonation (see Table 5.1 for IBC stack separation distances). For loose prill stores in locations where no impact to off-site persons can occur, this 500 t maximum stack size does not apply but is encouraged.

*Note: Where piles of loose AN prill are separated by only a single concrete wall, assume that sympathetic detonation between piles is possible and use the aggregate quantity of AN in the piles when calculating separation distances.*

- The stacking height should not exceed three IBCs of AN or three pallets of AN packages, with stack stability being maintained at all times.
- For packaged AN and AN in IBCs, maintain a free air space of a least 1.2 m between the AN and the outer walls of the buildings and the lowest support beam of the roof.
- Every AN store should have a clear area of at least 5 m surrounding it, with no vegetation, combustible materials, vehicles and non-associated equipment within this area. Trees should be cleared for at least 15 m from the AN store.
- Do not permit smoking and naked lights inside AN stores, and display notices to this effect.

Table 5.1 Table showing the recommended minimum distances to be maintained between stacks of AN IBCs in order to minimise the likelihood of a detonation event in one stack from propagating to an adjacent stack. Separation distances were derived from small-scale gap tests performed between ANFO and AN to determine the critical initiation pressure to produce sympathetic detonation, followed by simulations

Type of storage	Stacking configuration	Separation between stacks (metres)
IBC's	Normal configuration where each successive layer is set back half an IBC diameter from the layer below 	16 (low density) 9 (medium density) 1 (high density)
IBC's	Pyramidal configuration where each successive layer is set back one and a half IBC diameters from the layer below 	9 (low density) 7 (medium density) 1 (high density)

Notes:

- Low density AN: less than 0.75 g/cc
- Medium density AN: equal to or greater than 0.75 g/cc, but less than or equal to 0.85 g/cc
- High density AN: greater than 0.85 g/cc

- Floors, walls and equipment should be kept clean and spillages cleared promptly. Organic materials (e.g. sawdust) should not be used to clean floors.
- Unused wooden pallets, empty bags and packaging should be removed promptly from the AN store and kept at least 5 m from the store.
- Do not allow pallets, ropes, covers or other equipment to become impregnated with AN.
- 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.

*Note: Never use explosives or detonators to break up caked AN.*

- Ensure appropriate measures are in place to prevent the introduction of contaminated AN (e.g. contaminated through spillage) into an AN store of uncontaminated product.

### 5.3 Storage of other substances and equipment

A dedicated store is required when storing more than 10 t of AN. For a building, this means a stand-alone structure that contains no other substances or equipment unless approved by Resources Safety.

For a store containing 10 t or less of AN, any building in which the AN store is located should not be used for any other purpose. However, if this is not practicable then all other substances (including compatible substances) and equipment should be located at least 5 m from the AN store, as indicated in Figure 3.1. Where the other substances are liquid and incompatible with AN, provide fire-resistant spillage containment capable of holding at least 100 per cent of the liquid volume stored, and designed so that liquid cannot encroach within 5 m of any stored AN.

Those substances listed as "Incompatible substances that are to be excluded from AN storage buildings" should never be stored in the same building as AN nor within a building attached to an AN store.

#### Compatible substances

Unless substances are known to be compatible with AN, assume they are incompatible and treat them accordingly.

The following fertilisers are considered compatible with AN but should still be separated from AN as indicated above:

- potassium nitrate
- sodium nitrate
- calcium nitrate

- ammonium sulphate
- AN-based fertiliser mixtures of the nitrogen, phosphate or potash type
- calcium sulphate
- ammonium phosphate
- calcium ammonium nitrate
- calcium or magnesium carbonate.

Seek expert advice when deciding on the compatibility of other fertilisers.

#### Incompatible substances that are to be excluded from AN storage buildings

Do not store the following incompatible substances in any building used to store AN nor within any building attached to an AN store:

- flammable or combustible liquids such as petrol, kerosene, solvents, diesel fuel, lubricating and fuel oils or hydrocarbon formulated pesticides
- flammable gases such as LP gas, acetylene, ethylene and hydrogen
- sulphur, hexamine and finely divided metals
- explosives and substances sensitive to explosive decomposition
- readily combustible solids such as hay, straw, grain, grain husks, animal feed, wax, paper and cotton
- fertilisers containing trace metals and organic substances
- Division 5.1 dangerous goods such as calcium hypochlorite, chromates, chlorates, nitrites, perchlorates, chlorites, permanganates, chloroisocyanurates, tetranitromethane or di- or tri-chloroisocyanuric acid.

Many pesticide formulations contain appreciable quantities of combustible solvents and also should not be stored in any building used to store AN nor within any building attached to an AN store.

Other known incompatible substances include:

- corrosive liquids
- reducing agents
- products that can liberate ammonia gas if mixed with AN, such as cement, lime, basic slag and other alkaline substances
- urea
- copper, cadmium, chromium and zinc metals and their salts
- chlorides.



## 5.4 Fire protection

Fires involving AN cannot be extinguished by oxygen deprivation, and attempts to smother fires with dry chemical, carbon dioxide or foam extinguishers will not succeed.

Water is often the most effective means of fire-fighting, and in many instances should be applied promptly to any external fire threatening the AN, as well as to the AN storage to keep it cool.

Fire protection in relation to AN storage must comply with regulation 73 of the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007.

If water carts will be used as the source of fire fighting water, as is the case at many mine sites, then the water capacity, availability and response time, as well as application ability need to be considered when determining compliance with regulation 73.

Consider providing appropriate AN-compatible fire extinguishers to deal with vehicle and electrical fires.

Guidance regarding fire protection for AN is available in Australian Standard AS 4326:2008 *The storage and handling of oxidising agents*.

Where a fire involving AN is judged to be out of control, or the fire is engulfing the AN, everyone should be evacuated to a safe distance (see Section 2.4).

# 6 Powered transfer equipment

## 6.1 General

Powered transfer equipment refers to all powered equipment that may be used to move AN into, within or from a store, and includes forklift trucks, front-end loaders, augers, chain-conveyors and belt-conveyors.

The use of suitably designed, constructed and maintained powered transfer equipment is essential where AN is involved in order to reduce the risk of contamination, fire and explosion.

One of the most serious contamination hazards arises where AN comes into contact with combustible liquids, since AN readily absorbs spills such as oil and fuel by capillary action.

Vehicles used to move AN into, within or from an AN store may be powered by electricity, diesel fuel or LP gas, but not petrol.

*Note: "Store" must be taken to include the entirety of any building in which AN is stored and any attached buildings.*

## 6.2 Equipment requirements

Unless approved by Resources Safety, powered transfer equipment (other than vehicles such as forklift trucks and front-end loaders) should only be used to move AN if:

- it is powered by electricity or diesel fuel
- its power source (i.e. power outlet or generator) is located outside, and at least 5 m from, the AN store
- it is electrically or hydraulically driven.

All powered AN transfer equipment should:

- be free of any leaks of fuel, lubricating oils or hydraulic fluid
- not include in its construction any copper, zinc (including galvanised iron), cadmium or their alloys that can come into contact with AN
- be constructed from materials that, if in contact with AN, will not corrode
- have all non-essential electrical equipment removed, and all remaining equipment sealed against dust ingress in accordance with IP65 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 inspected and cleaned regularly \*

- where mobile, be kept outside of the AN store when not in use and parked at least 10 m from the AN store (unless alternative measures are in place to prevent any adverse impact on the AN from the mobile vehicle, especially in a fire scenario) — control measures must be in place to prevent contaminants (e.g. dirt, other products) being brought into the AN store on vehicles (e.g. vehicles such as front-end loaders should be dedicated to AN activities)
- be refuelled or recharged at a distance of at least 10 m from the AN store
- be fitted with a spark arrester and started outside of the AN store if they use diesel fuel or LP gas \*
- be provided with a dry-powder fire-extinguisher having a rating of not less than 40(B)
- if it incorporates a battery, be provided with a clearly marked battery isolation switch and insulated cover for the battery terminals \*
- if it is a vehicle, be attended at all times when it is inside the AN store, and for all other transfer equipment, be attended when operating
- if it is a vehicle, have unhindered egress from the store at all times
- 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
- if it is a conveyer belt, have fire-resistant belt and rollers
- be regularly maintained
- unless it is a vehicle, be provided with a clearly labelled and readily accessible emergency stop
- be cleared of as much AN as is reasonably practical after each use.

*Note: Items that are asterisked do not apply to vehicles that deliver AN to the site but do not enter the actual AN store.*

# Appendix 1 Glossary

**Ammonium nitrate (AN):** The ammonium salt represented by the formula  $\text{NH}_4\text{NO}_3$ .

**Compatible:** In relation to two or more substances or items, they will not react together to cause a fire, explosion, harmful reaction or the evolution of flammable, toxic or corrosive vapours.

**Critical infrastructure:** Those physical facilities, supply chains, information technologies and communication networks that, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security. Critical infrastructure involves the sectors of energy, utilities, transport, communications, health, food, supply, finance, government, services, national icons and essential manufacturing.

**Dedicated, stand-alone building storage:** A stand-alone building used only for AN storage and no other purpose.

**Intermediate bulk container (IBC):** A rigid or flexible portable packaging for the transport of dangerous goods that:

- has a capacity:
  - for solids of Packing Group I packed in a composite, fibreboard, flexible, wooden or rigid plastics or wooden container – of not more than 1,500 L
  - for solids of Packing Group I packed in a metal container – of not more than 3,000 L
  - for solids or liquids of Packing Groups II and III – of not more than 3,000 L
- is designed for mechanical handling, and
- is resistant to the stresses produced in usual handling and transport.

**Loose bulk:** Refers to AN that is not contained in a package or IBC.

**Package:** Refers to a container designed to hold not more than 500 kg of solid AN.

**Protected works:** These are deemed to include a dwelling, public building, place of worship, theatre, cinema (or other building or structure where the public is accustomed to assemble), shop, factory, warehouse, store, building in which any person is employed in any trade or business, store for the keeping of dangerous goods.

**Rural dangerous goods location:** A place that:

- is outside the part of the State that comprises the metropolitan region as defined in the *Planning and Development Act 2005* [s. 4(1)] or a townsite as defined in the *Land Administration Act 1997* [s. 3(1)]
- occupies an area of 5 hectares or more
- is used by the operator for agricultural, horticultural, floricultural, aquacultural or pastoral purposes, and
- at which dangerous goods are stored or handled for the purposes other than for sale.

**Security risk substance (SRS):** Any substance that contains more than 45% AN is a security risk substance unless it is an:

- explosive or
- aqueous solution, being a homogeneous mixture of two or more components in a single phase.

**UN number:** The identification number assigned to dangerous goods by the United Nations Committee of Experts on the Transport of Dangerous Goods, as published in the 15th edition of *Recommendations on the Transport of Dangerous Goods: Model Regulations* (UN 15) and outlined in the 7th edition of the *Australian Dangerous Goods Code* (ADG7). Some SRS, such as calcium ammonium nitrate, do not have a UN number.

**Vulnerable facility:** A category of facility that includes, but is not restricted to, multistorey buildings (e.g. above four storeys), large glass-fronted buildings of high population, health care facilities, childcare and aged care facilities, schools, major traffic terminals (e.g. railway stations and airports), major public utilities (e.g. gas, water and electricity works) and sports stadiums.

# Appendix 2 AN properties and hazards

## Physical and chemical properties

Pure AN is a white, odourless salt with a melting point of 169.6°C, molecular formula  $\text{NH}_4\text{NO}_3$  and molecular weight 80.

Solid AN occurs in five different stable crystalline forms, depending on the temperature. Pure AN undergoes phase changes when heated. Of most commercial significance is the phase change occurring near ambient temperatures at 32°C. This transition results in a density change with an increase of 3.6% in volume.

The major problems associated with the storage of AN are hygroscopicity and phase changes leading to the breakdown of the prill and caking of the product. Very small amounts of various proprietary additives are therefore used to minimise, but not eliminate, the effects of hygroscopicity and phase changes. The amount of carbonaceous additives must be kept below 0.2% of carbon in order for the product to be classified as a Division 5.1 oxidising agent. The UN classification system for dangerous goods classifies AN with a higher carbon content as a classification code 1.1D explosive.

AN is highly soluble in water, with solubility increasing rapidly with temperature. At 20°C, 1 mL of water will dissolve 1.877 g of AN, and at 50°C, it will dissolve 3.440 g of AN.

AN is hygroscopic and deliquescent in that it tends to absorb water from the atmosphere, and is capable of attracting so much water that it dissolves into an aqueous solution. Aqueous solutions are slightly acidic (i.e. a 0.1 Molar solution has a pH of 5.4).

While it is not in itself combustible, it is an oxidising agent so it can facilitate the initiation of fire and will assist combustion of other materials, even if air is excluded.

## Fire hazard

AN itself does not burn, but being an oxidising agent it can facilitate the initiation of fire and intensify fires in combustible materials.

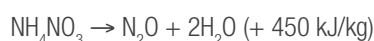
Hot AN solutions can initiate fires when coming into contact with rags, wooden articles and clothing. Other combustible materials impregnated with AN have been known to start burning spontaneously when left on hot surfaces. Similarly, AN products contaminated with oil or combustible materials can start a fire when hot.

Fires involving AN cannot be extinguished by the prevention of air ingress because of the in situ provision of oxygen from AN.

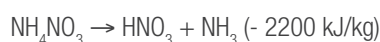
## Decomposition hazard

Molten AN decomposes at about 210°C to give off toxic gases.

If AN is heated in an open and unconfined situation, it will decompose completely to give gaseous products in a steady controlled way with white fumes and vapours. The primary reaction is irreversible, exothermic and produces nitrous oxide ( $\text{N}_2\text{O}$ ), a medical anaesthetic, and water.



If the reaction temperature is allowed to exceed 250°C then it is accompanied by an endothermic reaction producing ammonia ( $\text{NH}_3$ ) and nitric acid ( $\text{HNO}_3$ ).



Providing gases can escape freely, this combination of exothermic and endothermic reactions can provide a temperature limiting mechanism so that the temperature does not rise above 300°C, even with the input of a considerable amount of external heating.

## Explosion hazard

Pure AN is difficult to detonate, and flame, spark, rough handling, impact or friction are not known to cause a propagated detonation.

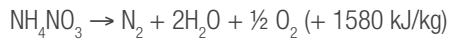
An explosion of pure AN can be initiated with high explosives under ambient conditions, and explosives must never be used to break up or loosen caked AN. Under ambient conditions, it is not possible to initiate AN by means of a bullet. However, the shock sensitivity of molten AN increases significantly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

AN can also 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 ( $\text{NO}_2$ ). 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 but there have been many more fires involving AN that did not lead to explosions.

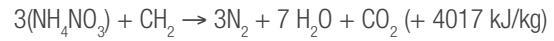
AN is ideally set up as an explosive substance, since it carries the oxidising nitrate ion in intimate contact with the fuel element, the ammonium ion. All that is required are small amounts of contaminants to act as a catalyst, explaining the unpredictability of AN under fire conditions.

A list of potentially dangerous contaminants, including combustible liquids, metals and fuels of any type as well as any of the incompatible substances, is given in Chapter 5.

The potential for an explosion is always present when the AN melt is contaminated and the following explosion reaction is catalysed:



An explosion is favoured by the increased heat of explosion and increased sensitivity when further mixed with the optimum amount of fuel (such as diesel fuel, a hydrocarbon represented by  $\text{CH}_2$  in the equation below) so that the following oxygen-balanced (no net oxygen produced or required) reaction (as in the explosion of ANFO) occurs:



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







Government of **Western Australia**  
Department of **Mines and Petroleum**  
Resources Safety

Resources Safety  
Department of Mines and Petroleum  
100 Plain Street  
EAST PERTH WA 6004

Telephone: + 61 8 9358 8002  
NRS: 13 36 77  
Facsimile: + 61 8 9358 8000  
Email: [ResourcesSafety@dmp.wa.gov.au](mailto:ResourcesSafety@dmp.wa.gov.au)  
Website: [www.dmp.wa.gov.au/ResourcesSafety](http://www.dmp.wa.gov.au/ResourcesSafety)