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AMAT INSIGHTS

Reducing Risks Associated with Ammonium Nitrate

GICHD

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Securing ammunition, protecting lives

INTRODUCTION

Improperly manufactured, transported, handled and stored explosive materials, such as ammonium nitrate, are a safety risk to local communities and a security threat to states and societies. Ammonium nitrate is commonly used as a fertiliser or as an industrial explosive. Ammonium nitrate is a strong oxidiser and can react violently with incompatible materials. It is very important to handle, store and monitor ammonium nitrate correctly. When improperly managed and exposed to stress (such as heat and pressure), ammonium nitrate can become increasingly unstable and explode. As well as the safety risks, there are also significant security concerns. The commercial availability of ammonium nitrate as a fertiliser has made it attractive to terrorists and armed groups, who use it as a main explosive charge in improvised explosive devices (IEDs).

WHAT IS AMMONIUM NITRATE?

Ammonium nitrate is a commercially available white crystalline solid consisting of ions of ammonium and nitrate. It is highly soluble in water and is hygroscopic (it absorbs water from the air). It is predominantly used in agriculture as a high-nitrogen fertiliser, and can also be used as a nutrient in producing antibiotics and yeast.[i] It is also used in industrial explosive mixtures for mining, quarrying and civil construction purposes.[ii] Its availability in the commercial sector is largely due to its use in ammonium nitrate fuel oil (ANFO) and in water based commercial high explosives, which has largely displaced the industry's reliance on nitroglycerine based high explosives such as dynamite.[iii] In addition, ammonium nitrate is used for military purposes, namely in the creation of high explosives **(Box 1)**.[iv]

While in its pure state ammonium nitrate does not burn readily, it will support and accelerate the rate of combustion if contaminated or mixed with combustible material. This reaction will occur even in the absence of atmospheric oxygen. Ammonium nitrate will also accelerate the burning of combustible material.

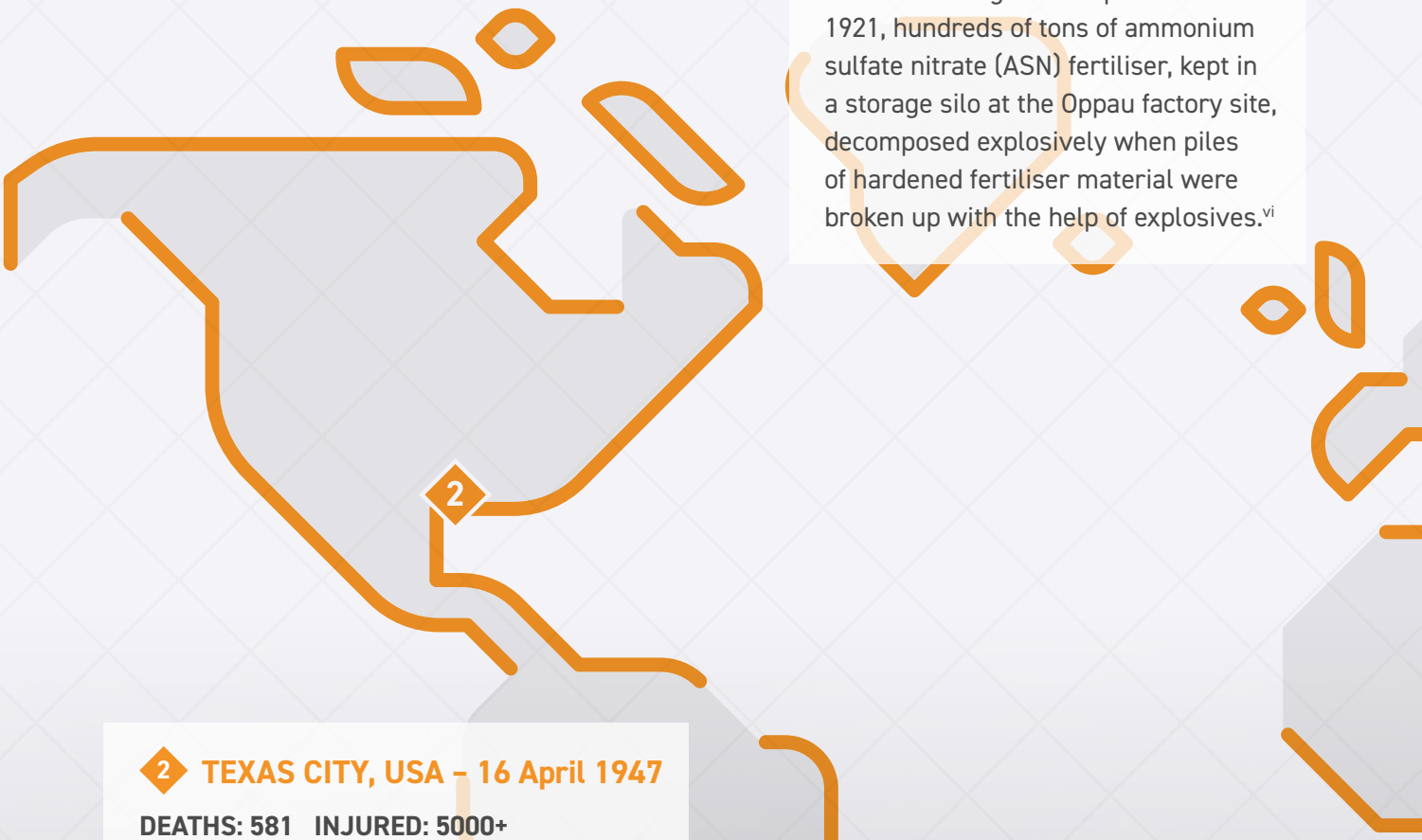
THE RISKS POSED BY AMMONIUM NITRATE

Industrial explosions

The 4 August 2020 explosion in Beirut is the latest in a long history of disasters involving ammonium nitrate. In its aftermath, the Ammunition Management Advisory Team (AMAT) compiled a dataset of major explosions involving ammonium nitrate that have occurred in the last 100 years.[v] The data analysis suggests that mismanaged ammonium nitrate increases the probability that the substance will be exposed to heat and pressure which, in turn, increases the risk of explosion.

A failure to put in place appropriate and effective management practices can have devastating consequences. Poorly managed ammonium nitrate may ignite, leading to detonation, and destroy and contaminate the environment. As industrial stockpiles of ammonium nitrate often run into thousands of tonnes, a single explosion can lead to a considerable loss of life and destruction of infrastructure, environmental contamination, as well as having a grave impact on the local and national economy and politics.

Industrial explosions involving ammonium nitrate, 1921 to 2020 >



1 OPPAU, GERMANY – 21 September 1921

DEATHS: 507 INJURED: 2000+

On the morning of 21 September 1921, hundreds of tons of ammonium sulfate nitrate (ASN) fertiliser, kept in a storage silo at the Oppau factory site, decomposed explosively when piles of hardened fertiliser material were broken up with the help of explosives.[vi]

2 TEXAS CITY, USA – 16 April 1947

DEATHS: 581 INJURED: 5000+

The cargo ship Grandcamp was being loaded when a fire was detected in the hold; 2,300 tons of ammonium nitrate in sacks were already aboard. 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 tons of sulfur and 960 tons of ammonium nitrate. The High Flyer exploded the next day. 500 tons of ammonium nitrate on the quayside also burned, but without exploding.[vii]

4 PORT OF TIANJIN, CHINA – 12 August 2015

DEATHS: 165 INJURED: 798

Nitrocellulose stored at a hazardous goods warehouse spontaneously combusted after becoming overly hot and dry, resulting in a fire that, 40 minutes later, triggered the detonation of about 800 tonnes of ammonium nitrate stored nearby. 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 further explosions.[ix]

5 BEIRUT, LEBANON – 4 August 2020

DEATHS: 190+ INJURED: 6000+

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. The explosion happened at 18:10, causing immense damage throughout the entire city.[x]

3 TAROOM, AUSTRALIA – 30 August 1972

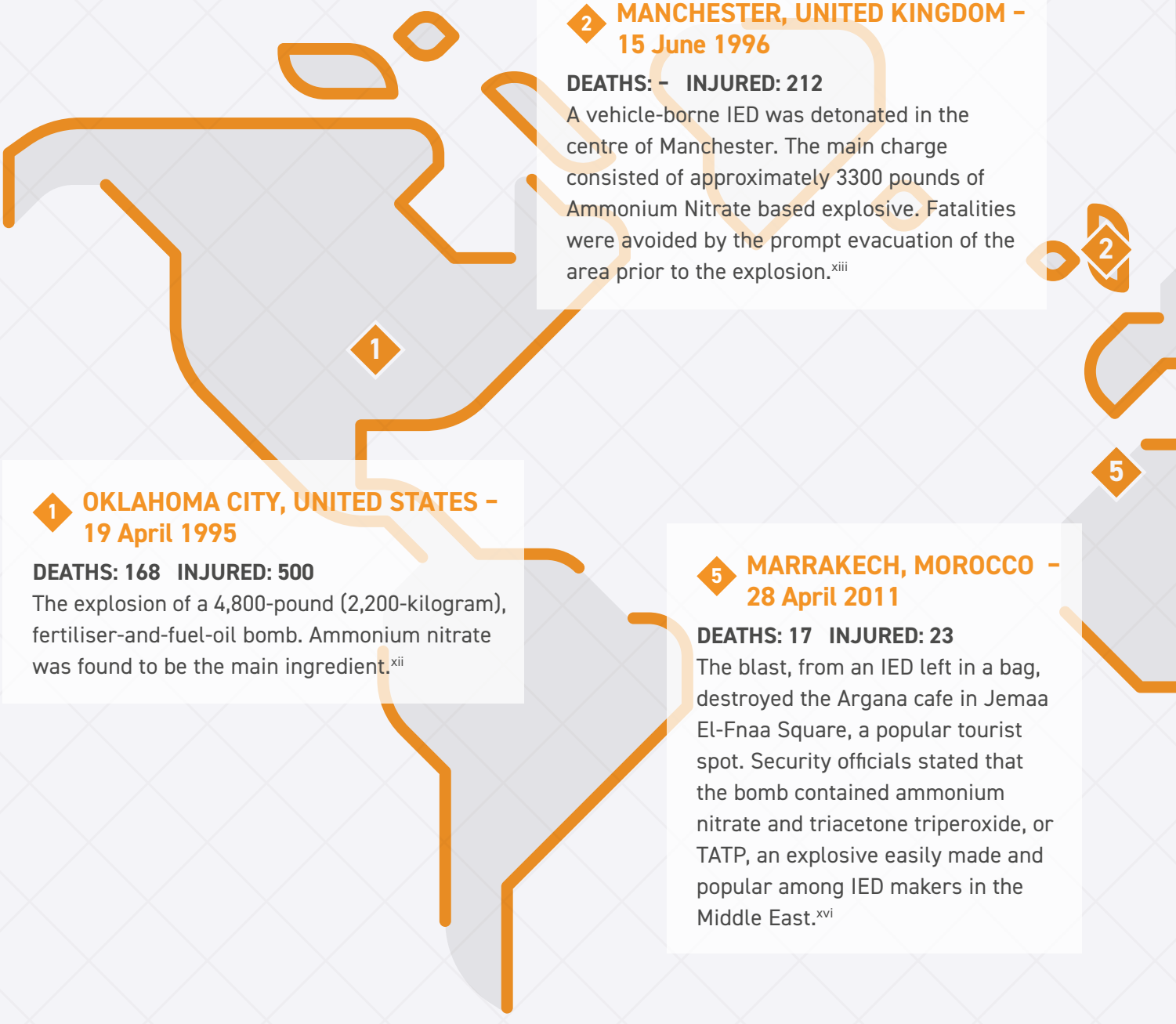
DEATHS: 3 INJURED: –

A truck carrying 12 tons of ammonium nitrate experienced an electrical fault and caught fire north of Taroom. 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.[viii]

Use in terrorist attacks and Improvised Explosive Devices

The commercial availability of ammonium nitrate in many countries has contributed to its widespread use by criminals, terrorists and other armed groups, for the manufacture of IEDs. The following illustration provides an overview of some of the major terrorist attacks committed using ammonium nitrate between 1995 and 2017. One of the largest confiscations of ammonium nitrate allegedly stockpiled for terrorist purposes occurred in May 2015, when Cypriot police made an arrest following a surveillance operation indicating a suspect was stockpiling explosives. The police seized over eight tons of ammonium nitrate chemicals from the suspect's home.[xi]

Major terrorist attacks involving ammonium nitrate, 1995 to 2017 >



1 OKLAHOMA CITY, UNITED STATES – 19 April 1995

DEATHS: 168 INJURED: 500

The explosion of a 4,800-pound (2,200-kilogram), fertiliser-and-fuel-oil bomb. Ammonium nitrate was found to be the main ingredient.[xii]

2 MANCHESTER, UNITED KINGDOM – 15 June 1996

DEATHS: – INJURED: 212

A vehicle-borne IED was detonated in the centre of Manchester. The main charge consisted of approximately 3300 pounds of Ammonium Nitrate based explosive. Fatalities were avoided by the prompt evacuation of the area prior to the explosion.[xiii]

5 MARRAKECH, MOROCCO – 28 April 2011

DEATHS: 17 INJURED: 23

The blast, from an IED left in a bag, destroyed the Argana cafe in Jemaa El-Fnaa Square, a popular tourist spot. Security officials stated that the bomb contained ammonium nitrate and triacetone triperoxide, or TATP, an explosive easily made and popular among IED makers in the Middle East.[xvi]

6 HYDERABAD, INDIA – 23 February 2013

DEATHS: 16 INJURED: 100+

Two blasts occurred within 100 metres of each over a short time frame. The bombs, believed to be a mixture of TNT and ammonium nitrate, were delivered by bicycle.[xvii]

4 OSLO, NORWAY – 22 July 2011

DEATHS: 8 INJURED: –

Ammonium nitrate was used in a car bomb placed in Oslo's government quarters.[xv]

3 BALI, INDONESIA – 12 October 2002

DEATHS: 202 INJURED: –

A series of nightclub bombings. According to investigators the primary ingredient of the main bomb that exploded in the Kuta nightclub district was ammonium nitrate.[xiv] (other sources state that Potassium Chlorate was used).

7 MOGADISHU, SOMALIA – October 2017

DEATHS: 500+ INJURED: –

A truck bomb exploded at a junction where people were selling petrol. The explosion ignited a fuel tanker. The main charge of the IED is believed to be a mixture of explosives harvested from conventional ammunition and ammonium nitrate; although this has not been officially confirmed.[xviii]

Fertilisers rich with ammonium nitrate are frequently used by armed groups in conflict-affected settings. For instance, in Afghanistan, the Taliban has historically utilised various kinds of fertilisers – including potassium chlorate, ammonium nitrate, and calcium ammonium nitrate (CAN) – in IEDs. To help counter this, Programme Global Shield was started in 2010. This Programme aims at monitoring the licit movement of 13 of the most common chemical precursors and other materials that could be used to manufacture IEDs in order to counter their illicit trafficking and diversion.[xix]

When international regulations are not enforced, armed groups can obtain ammonium nitrate legitimately. A report by Conflict Armament Research examining the supply of IED components in Iraq and Syria indicates that the Islamic State almost exclusively use homemade explosives produced from fertilisers, such as ammonium nitrate and urea, mixed with other chemical precursors. Moreover, it appears that the Islamic State readily obtained ammonium nitrate, detonators and other precursor materials through legal means from trade with regional retail and distribution companies.[xx]

BOX 1.

International Ammunition Technical Guidelines (IATG) guidance for conventional ammunition containing ammonium nitrate explosives.

Ammonium nitrate has been used as an ingredient for conventional ammunition since the beginning of the 20th century. It is mixed with high explosive substances and used to provide additional oxygen during detonation. For example, Amatol, which is a mixture of ammonium nitrate and Trinitrotoluene (TNT), was used extensively during World Wars 1 and 2 as the explosive filling in bombs, projectiles, mortars, and naval depth charges and mines. The use of Amatol and other similar ammonium nitrate explosives in military ammunition has decreased as more robust and efficient high explosive compounds have been developed.

Ammunition with an ammonium nitrate explosive filling is still encountered in many states.

The IATG were developed in 2011 and the UN SaferGuard Programme was established as the corresponding knowledge management platform. The IATG form a frame of reference to achieve and demonstrate effective levels of safety and security of ammunition stockpiles. They provide a coherent approach, are based on sound and accepted explosive science, recommend an integrated risk and quality management system, and allow for a progressive, integrated improvement in safety and security.

The IATG provide guidance for ammunition containing ammonium nitrate explosives:

IATG Module 06.30 Para 9.1.c.(1) outlines general safe storage and handling measures to be adopted for ammonium nitrate:

"the efficiency, storage life and safety of some explosives, particularly propellants, are also adversely affected by storage at high temperatures. The use of adequate ventilation, approved air conditioning, or insulation, should be considered in order to keep temperatures in storehouses to a minimum. The ammunition containing Ammonium Nitrate/TNT (Amatol) or TNT natures should be stored in the coolest accommodation possible."

IATG Module 06.80 Annexes T & AA provide advice on the inspection of ammunition containing ammonium nitrate explosives.

It should be noted that ammunition storage areas should not be routinely used for the storage of ammonium nitrate and ammonium nitrate explosives (unless contained as the filling, i.e. Amatol, in a conventional ammunition article).

Further information on the IATG can be found at https://www.un.org/disarmament/convarms/ammunition/

PROPERTIES AND DANGERS OF AMMONIUM NITRATE

Ammonium nitrate is stable in solid, molten or in solution, and it will not explode as a result of impact and friction found in normal handling. However, under certain conditions, ammonium nitrate is capable of explosive reaction, explosive decomposition or detonation. The substance is more likely to detonate due to the presence of combustible or incompatible contaminants,[xxi] if it has become compacted, if it is exposed to high temperature (greater than 160°C) or undergoes severe shock.[xxii]

In the case of a fire, ammonium nitrate can melt - if the molten mass becomes confined (e.g. in drains, pipes, plant or machinery) it could explode. Explosion is particularly likely if the substance is mixed with contaminants.[xxiii] As it burns, ammonium nitrate will melt, decompose and give off irritating fumes or toxic gases, including nitrogen oxides and gaseous ammonia.[xxiv]

Poorly stored ammonium nitrate can clump or cake together. This occurs when water is allowed to contaminate it or when large amounts of ammonium nitrate are stored in one stack, where the weight of the stack compresses it into a solid mass. This compacting effect, or caking as it is called, increases the likelihood of a detonation if the ammonium nitrate is exposed to heat or shock.[xxv]

Ammonium nitrate is generally classified in different grades, usually reflecting the percentage of nitrogen contained in the substance. Depending on the grade, ammonium nitrate can be classified as:

- Security Sensitive Ammonium Nitrate (SSAN)
- Technical Grade Ammonium Nitrate (TGAN), for use in the manufacture of civilian explosives and blasting agents;
- Fertiliser Grade Ammonium Nitrate (FGAN), for use in the manufacture of fertilisers.

The grade of ammonium nitrate impacts the physical explosive properties of the substance. This being said, ammonium nitrate of any grade can be mixed with contaminants and should be considered a high explosive capable of detonation by combustion or by explosion of adjacent explosive materials.[xxvi] States have developed various criteria for classification of ammonium nitrate products and may classify all above a certain percentage of content as SSAN. Australia, for instance, classifies all ammonium nitrate products (including TGAN and FGAN, ammonium nitrate emulsions and mixtures) with more than 45% (by mass) nitrogen content as SSAN.[xxvii]

SAFE AND SECURE MANAGEMENT OF AMMONIUM NITRATE

As a result of the role ammonium nitrate in industrial explosions and its use in terrorist attacks and by armed groups, states have placed greater emphasis on strengthening safety and security procedures related to the production and distribution of ammonium nitrate **(Box 2)**.

BOX 2.

National regulation of ammonium nitrate

Many states have legislation for dealing with ammonium nitrate. The guidance may be spread across various government departments which approach the subject from different perspectives such as public health, environmental protection, civil protection, transport and storage, manufacturing, import/export, security, disposal, and mining/quarrying. It is the responsibility of those involved in dealing with ammonium nitrate to apply all the pertinent national regulation(s) and guidance.

The links below are examples of publicly available documents issued by USA, UK, Australia, India, Abu Dhabi and South Africa.

- United States Department of Labor, Occupational Safety and Health Administration (1910), Guidance on the Ammonium Nitrate Storage Requirements in 29 CFR 1910.109(i). Available from: https://www.osha.gov/laws-regs/standardinterpretations/2014-12-03.
- Government of Western Australia, Department of Mines and Petroleum (2013) CODE OF PRACTICE, Safe storage of solid ammonium nitrate, Third edition, Available from: https://www.dmp.wa.gov.au/Documents/Dangerous-Goods/DGS_COP_StorageSolidAmmoniumNitrate.pdf.
- United Kingdom Health and Safety Executive (2007) Ammonium nitrate [Online], Available from: https://www.hse.gov.uk/explosives/ammonium/index.htm.
- Australian Standard (1995) The storage and handling of oxidizing agents, AS 4326—1995. Available from: https://www.saiglobal.com/pdftemp/previews/osh/as/as4000/4300/4326.pdf.
- Queensland Government (2020), Storage requirements for security sensitive ammonium nitrate (SSNA), Explosive information bulletin no. 53, Version 6. Available from: https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/explosives/storage-req-security-sensitive-ammonium-nitrate-ssan.
- United Kingdom Health and Safety Executive (1996) Storing And Handling Ammonium Nitrate https://www.hse.gov.uk/pubns/indg230.pdf.
- India, Department of Commerce and Industry, Ammonium Nitrate Rules (2012). Available from: https://peso.gov.in/PDF/Ammonium_Nitrate_Rules_2012_English_Version.pdf
- South Africa, Consolidated Regulations, Explosives Regulations (2003). Available from: http://www.saflii.org/za/legis/consol_reg/er266/
- Abu Dhabi Occupational Safety and Health System Framework, Code of Practice 1.0, Hazardous Materials (2018). Available from: https://www.oshad.ae/Lists/OshadSystemDocument/Attachments/6/1.0%20-%20Hazardous%20Materials%20v3.1%20English.pdf

IDENTIFYING HAZARDS AND RISKS

In accordance with existing risk management practices, wherever ammonium nitrate is manufactured, transported **(for transport see Box 3)** and stored, a safety and security risk assessment should be conducted. The owners and operators of a site that stores or uses ammonium nitrate should also develop an Emergency Response Plan (ERP), based on the findings of the assessment.

Safety risk assessment

The safety risk assessment should:

- Identify the hazards from ammonium nitrate in the context it is being handled, transported, stored or used in.
- Determine the nature, likelihood and severity of an incident (e.g. spillage, fire or explosion) and its consequences to persons, infrastructure and environment.
- Inform the development and implementation of preventive and mitigation measures for minimising the risk to people, infrastructure and environment.

Security risk assessment

The security risk assessment should:

- Identify existing security measures and examine the level and type of security risks (internal and external) to the ammonium nitrate stockpile.
- Consider whether current security arrangements leave the ammonium nitrate vulnerable to diversion (theft or loss), fraud or deliberate interference, and consider security improvements appropriate to manage the assessed risk.
- Inform the development of a security plan, which will identify the security risks and the measures for identifying and addressing these risks.

Emergency response plan

The emergency response plan should contain the following:

- List the signs or indicators of abnormality at and in proximity to the ammonium nitrate storage location. (e.g. discovery of smoke or fire, spillage of ammonium nitrate). This information must be freely available to workers and first responders.
- Initial response to an incident, taking into account the findings of the safety and security assessments. Employees will likely be the first to see smoke, a fire or other abnormality. They need to be trained on how and when to respond.
- Specific response procedures (and their rehearsal).
- Professional emergency response teams; they need to be aware of the hazards on site, routine coordination needs to take place along with joint training.
- Community outreach.
- How hazards and emergency equipment are marked.
- A site plan showing hazards, emergency equipment, assembly locations and evacuation areas.
- Up to date quantities and locations of hazardous materials.
- Any other information relevant to the site.

Proper planning and preparation are key to the safety and security of any hazardous site. Planning is also central for effective and timely reaction in case of an accident or security incident. Safety and security risk assessments should be reviewed periodically and must be reviewed after an accident or incident of diversion. Emergency response plans should also be regularly reviewed and updated to reflect the changes in the safety and security risk assessments.

Unplanned/unexpected storage of ammonium nitrate

Port authorities, customs officials, logistic hubs and distribution centres may experience situations where loads of hazardous materials, including ammonium nitrate, may have to be stored for unexpected reasons. Proper planning for such an event will enable the correct initial procedures in safe handling and storage, communication, and security thus helping to minimise risks. In the absence of national regulations or actionable risk mitigation plans, reference is made to the above safety and security risk assessments and to the guidance in IATG Volumes 02, 05, 06 and 09.

SPECIAL STORAGE CONSIDERATIONS FOR AMMONIUM NITRATE

The following measures provide an overview of general good practice for reducing and managing the hazards and risks stemming from ammonium nitrate, based on existing national legislation (see Box 2).

Storage

- Storage buildings should be single storey buildings and constructed of non-flammable materials such as brick, concrete or steel.
- Storage buildings should be well-ventilated to prevent pressurisation in the event of fire.
- Floors should be non-flammable material with no open drains, pits, or voids, to prevent accumulation of molten ammonium nitrate.
- If ammonium nitrate is stored outside then it should be protected from the weather, i.e. sealed in waterproof packaging.
- The ammonium nitrate should be kept dry as the risk of explosion increases if it becomes caked.
- Keep buildings weather-proof and ventilated. Caking of ammonium nitrate will occur if water is present and this will increase the risk of explosion.
- Ammonium nitrate should be stored away from sources of heat, fire and explosion (e.g. fuels, compressed gas, fireworks, ammunition).
- Electrical equipment must be serviceable and regularly maintained.
- Ammonium nitrate should be stored in a separate building without other potential contaminants and incompatible materials, and especially flammable or explosive products. If this cannot be achieved, then do not store ammonium nitrate in the same stack as other products and provide suitable separation. The risk of fire and explosion increases if other materials are present.
- Combustible materials (such as wooden pallets and empty packaging) must be stored away from ammonium nitrate or separated by a suitable non-flammable barrier. This should also apply to a designated distance outside the building.

The UK Health and Safety Executive (HSE) has produced a self-help checklist to help those storing ammonium nitrate to ensure safe handling and storage of ammonium nitrate. The checklist is available online at: https://www.hse.gov.uk/explosives/ammonium/chklist.pdf

Stacks

- Stacks of ammonium nitrate should have a specified maximum size, in line with national laws, regulations and standards.
- National regulations should define the dimensions of ammonium nitrate stacks. In general, it is recommended that the stack is no more than two meters high and three meters wide.
- There should be at least one-metre wide aisles between ammonium nitrate stacks and between the stack and the walls, roof and lights of the storage building (this keeps the ammonium nitrate away from sources of contamination and heat). These gaps also allow access by authorised professionals in an emergency.
- Providing at least one-metre distances around the stack assists with pressure release if there is a fire.
- Stacks should be stable to prevent toppling.
- Ammonium nitrate (including when molten in a fire) should not come into contact with materials such as flammable liquids, powdered metals, acids, chlorates, nitrates, zinc, copper and its salts, oils, grease, gas cylinders and chemicals of incompatible or unknown properties.
- For ease of movement and stability of the stacks, bags and containers of ammonium nitrate should be palletised where possible.

Storage of ammonium nitrate in large stacks can increase the risk of a detonation of the whole stack in a fire. Stacks should be limited to the minimum amount required and in accordance with national health, safety and security legislation.

Housekeeping

- Proactive, preventive maintenance and stringent housekeeping rules are critical to minimise the risks associated with ammonium nitrate.
- Keep the area clean. Any spillages are to be cleaned up quickly and the waste disposed of in accordance with national directives.
- Organic materials, such as sawdust, are not to be used to aid cleaning. Leaking containers shall be put into an overpack to prevent further spillage.
- Ammonium nitrate should be moved to a safe distance and the area cleaned before any hot work (exposing electrical systems, cutting, welding etc.) is conducted. Suitable firefighting precautions shall be in place whilst the work is conducted.
- Vehicles and mechanical handling equipment are to be in good condition and properly maintained to prevent ammonium nitrate from coming into contact with fuel, oil or grease.
- Charging and fuelling points are to be located away from the storage area. Engines are not to be left running whilst unattended. Ensure vehicles and other mechanical equipment is kept clean to prevent contamination with fuel, oil and grease.

Fire precautions

Fire protection strategies for ammonium nitrate stores need to be designed around the chemical properties of the substance – i.e. it does not burn but is a strong supporter of combustion of any combustibles (such as pallets) that may be present.

- Smoking and other flame producing materials should be banned in the storage location. Display prominent NO SMOKING notices.
- Fires involving ammonium nitrate cannot be extinguished by oxygen deprivation i.e. by smothering fires with dry chemical carbon dioxide or with foam. The only effective means for firefighting in this case is with water. The use of automated sprinkler and alarm systems is recommended.
- Dry chemical extinguishers must be on hand to allow immediate response to electrical or vehicle fires.
- Personnel should be trained in the use of firefighting equipment and be given training and guidance on when to engage in firefighting activities.
- The choice of fire extinguishers is important as not all are suitable for use near ammonium nitrate.
- Fixed firefighting equipment and hydrants should be maintained regularly to ensure they do not leak water and contaminate the ammonium nitrate.
- When a fire involving ammonium nitrate is judged to be out of control it is recommended that evacuation is conducted to an appropriate separation distance.

The authorities in charge of the storage area should assess the risks from fire and produce a Fire Plan. The Fire Plan needs to be available to all staff and emergency procedures practiced on a regular basis. If a state's national standards do not provide effective guidance for implementation of effective fire precautions and development of a Fire Plan, reference can be made to the IATG Module 02.50 Fire Safety available at: https://www.un.org/disarmament/un-saferguard/guide-lines/

Security considerations

There are numerous security measures to put in place to safeguard ammonium nitrate. These measures should derive from the security risk assessment. Minimum security requirements include:

- Access to areas where ammonium nitrate is stored should be limited to authorised individuals only. Authorised individuals should go through a stringent background check and relevant training.
- 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.
- Record keeping and inventory procedures should be in place and records maintained and retrievable for a determined period of time, as indicated in the national regulations and standards.
- Records of ammonium nitrate should include purchase/acquisition and sales/supply of ammonium nitrate, loss due to leakage, movement of ammonium nitrate, and security incidents (theft, loss).

Ammonium nitrate is attractive to criminals, terrorists and other armed groups. Stringent security controls should be put in place to prevent unauthorised access to and use of ammonium nitrate. If a state's national regulations and standards do not give adequate guidance for effective security of ammonium nitrate stockpiles, reference can be made to the IATG Module 09.10 Security Principles available at: https://www.un.org/disarmament/un-saferguard/guide-lines/

Separation Distances

The use of separation distances is a common practice when storing certain hazardous goods. For example, they are routinely used when storing Class 1 Explosives. A separation distance is the minimum distance between a hazard and an area at risk from that hazard so that the risk is deemed tolerable.

Separation distances give an additional level of protection if a catastrophic event occurs. They will not prevent an incident occurring but will mitigate the effects if properly applied.

Separation distances are not a replacement for the diligent application of prevention controls. Ammonium Nitrate storage sites should apply the maximum separation distance as advised by the national legislation or other applicable regulation. Some states' legislation contains guidance on the use of separation distances. In the absence of effective national regulation, the United Nations (UN) SaferGuard Programme has developed helpful tools, available at https://www.un.org/disarmament/un-saferguard/.

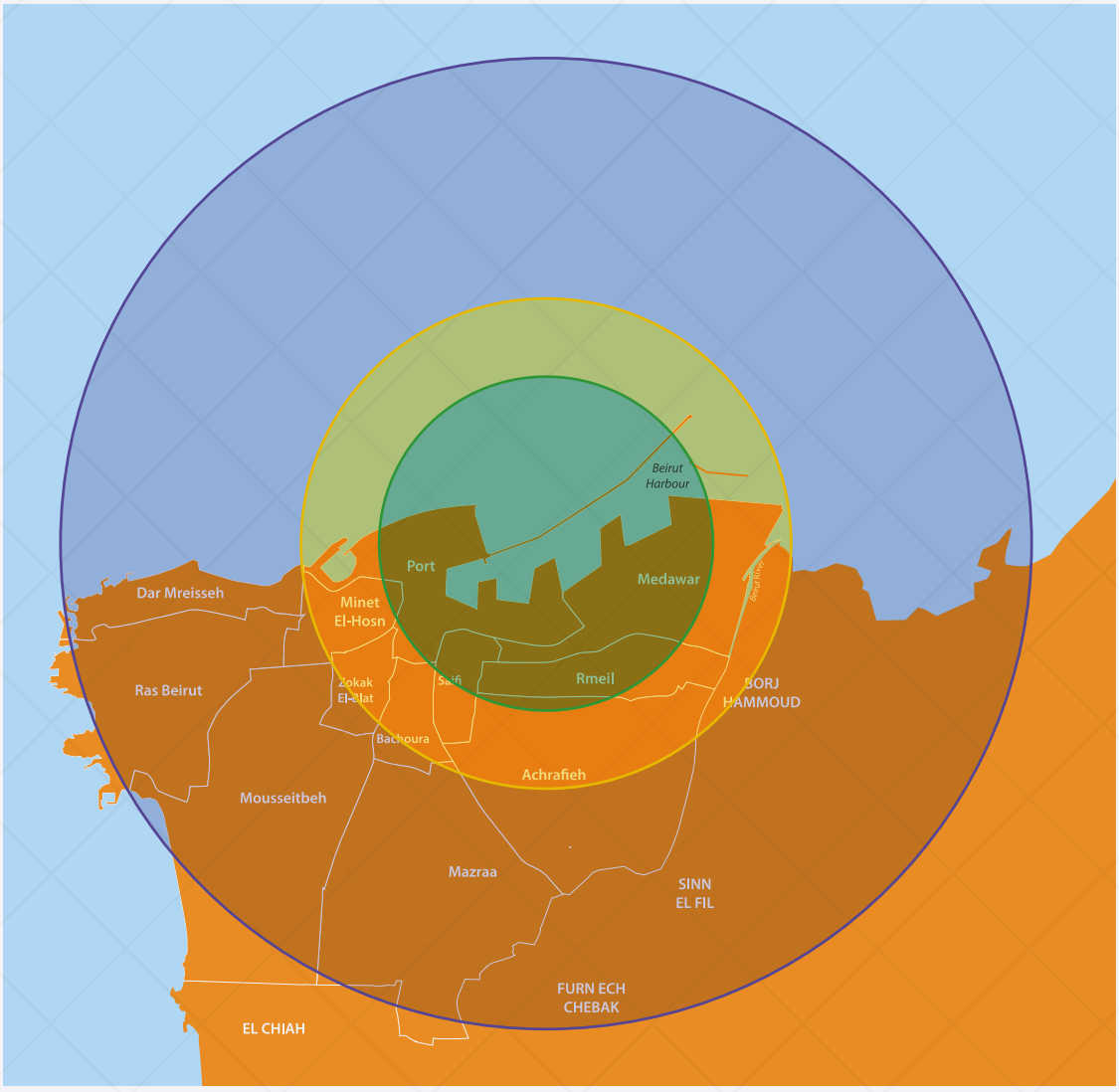
As part of carrying out the safety risk assessment and the development of an Emergency Response Plan, it is important to know the predicted range of effects of a detonation of the ammonium nitrate stock. This information is not normally contained in the state legislation.

The UN SaferGuard programme has two tools that can be used as part of the risk assessment process for a site storing ammonium nitrate. These tools show the predicted effects of a worst-case scenario i.e. a mass explosion of all the ammonium nitrate in a site.[xxviii]

First, the Quantity Distance (QD) mapping tool, available at https://www.un.org/disarmament/un-saferguard/map/, indicates how far away a building should be from a potential explosion site. It shows three different types of separation distance.

Figure 1 shows Beirut Port using the QD tool. The circles indicate the separation distances i.e. how far away infrastructure should be; the green circle should have no public traffic routes inside it, the yellow circle no public inhabited buildings, and the purple circle no public vulnerable buildings. This calculation is based on ammonium nitrate having a 40% TNT equivalence, thus 2750 metric tonnes of ammonium nitrate equals 1100 tonnes of TNT.

FIGURE 1: **The UN SaferGuard Quantity Distance mapping tool being used to show separation distances.**



- Vulnerable Building Distance (VBD) - **4583m**
- Inhabited Building Distance (IBD) - **2292m**
- Public Traffic Route Distance (PTRD) - **1528m**

Figure 2 details the effects of the complete detonation of a known quantity of explosives by using the Explosion Consequence Analysis (ECA) tool, available at https://www.un.org/disarmament/un-saferguard/explosion-consequence-analysis/.

This example also uses the figure of 1100 tonnes of TNT.

The IATG tools are designed for use by ammunition and explosives experts as part of a technical risk assessment process. The information therein should only be used to give an indication of the probable effects of an explosion with the given input figures.

FIGURE 2: **An extract from the UN SaferGuard ECA tool.**

GROUND VIBRATION (m)
Maximum Effected Range
33561.88

INJURY/FATALITY TO PERSONNEL RANGE (m)

Fatal Distance
238.25

Lung Damage
377.61

Eardrum Rupture
970.96

DAMAGE TO BRICK STRUCTURES (m)

Houses completely demolished
392.27

Houses badly damaged, beyond repair, require demolition
578.08

Houses rendered uninhabitable, can be repaired with extensive work
990.99

Houses rendered uninhabitable, can be repaired reasonably quickly
2890.38

Houses require repairs, serious inconvenience but remain habitable
5780.76

BOX 3.

Hazard Class for Transport and Storage of Ammonium Nitrate

Hazardous materials have an internationally recognised system to provide guidance on their safe transport. The UN Recommendations on the Transport of Dangerous Goods - Model Regulations (known as 'The Orange Book')[xxix] groups hazardous materials with similar risks together and provides guidance on how to transport them safely. There are currently nine (9) classes of hazardous goods. Some specific transport systems are covered by other regulations, two examples are the International Maritime Dangerous Goods (IMDG)[xxx], and Dangerous Goods Regulations of the International Air Transport Association.[xxxi] The guidance in the above transport regulations, particularly the hazard classification system, is often used during storage.

The composition, purpose and percentage of ammonium nitrate in an ammonium nitrate-based product will determine the hazard class; the hazard class is then sub divided into divisions. Ammonium nitrate can be classified into two hazard classes:

Class 1 Explosives

This class is sub-divided into 6 divisions, of which ammonium nitrate can only be in:

- **Hazard Division 1.1** - Substances and articles which have a mass explosion hazard (a mass explosion is one which affects almost the entire load virtually instantly)

Or

- **Hazard Division 1.5** – Very insensitive substances which have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport.

Class 5 Oxidising Substances and Organic Peroxides

This class has two different products which are split into two divisions, of which ammonium nitrate can only be;

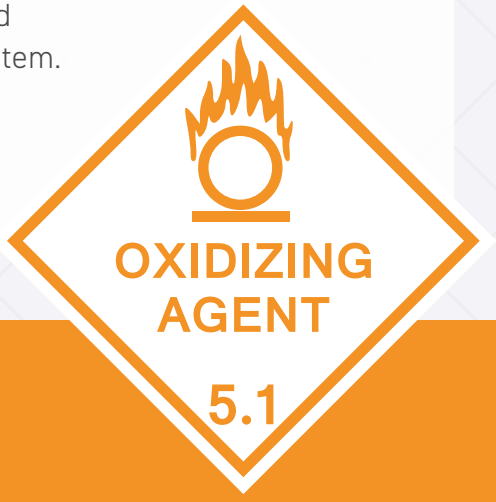
- **Hazard Division 5.1** – Oxidising Substances – Substances which, while in themselves not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.

Broadly speaking, ammonium nitrate products designed for explosive use or blasting use will be class 1 explosives (due to higher percentage of ammonium nitrate or combustible ingredients); and ammonium nitrate products designed for fertiliser use (or for blasting use prior to additional ingredients being added) will be class 5.1 oxidising substances. This classification will depend on the specific characteristics of the product.

How an ammonium nitrate product should be classified is specified in a series of tests which is detailed in the UN Manual of Tests and Criteria.[xxxii] The manufacturer should conduct these tests so they can apply the appropriate hazard class to their products. This information will be included on the product Hazard Data Sheet and shown on the packaging.

It should be noted that the classification only applies to a product in good, uncontaminated condition, and within its authorised packaging. If ammonium nitrate in hazard class 5.1 becomes contaminated (e.g. with organic material) or becomes caked, then it can become liable to detonation with the hazardous effects associated with hazard class 1.

The IATG Module 01.50 UN Explosive Hazard Classification System and Codes[xxxiii] also provides information on the UN hazard classification system.



CONCLUSION

Ammonium nitrate has the potential to cause catastrophic events involving significant loss of life and property. However, with the implementation of appropriate preventive and mitigative controls, the frequency of these events can be radically reduced and the effects when they do occur, significantly lessened. Guidance for reducing and managing the hazards and risks from ammonium nitrate should be based on existing national legislation, underpinned by the principles and guidance provided in the IATG where relevant.

ENDNOTES

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[ii] National Center for Biotechnology Information (2020). PubChem Compound Summary for CID 22985, Ammonium nitrate. Available from: https://pubchem.ncbi.nlm.nih.gov/compound/Ammonium-nitrate.

[iii] Kirk-Othmer (1980) Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984, p. V9 600.

[iv] Ammonium nitrate is used in military explosives such as amatols, ammonals, and amatexes as a partial replacement for alpha-2,4,6-trinitrotoluene (TNT) or cyclotrimethylenetrinitramine (RDX). See: National Centre for Biotechnology Information, PubChem Compound Summary for CID 22985, Ammonium nitrate.

[v] AMAT dataset does not include ammonium nitrate-related accidental explosions that have occurred during mining or construction activities.

[vi] Kristensen Tor E. (2016) A factual clarification and chemical-technical reassessment of the 1921 Oppau explosion disaster: the unforeseen explosivity of porousammonium sulfate nitrate fertiliser, FFI-rapport: FFI-RAPPORT 16/01508. Available from: https://ffi-publikasjoner.archive.knowledgearc.net/bitstream/handle/20.500.12242/1259/16-01508.pdf.

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[xxi] The following contaminants can cause ammonium nitrate to become less stable and at greater risk of detonation: chlorides metals such as chromium, copper, cobalt, and nickel. The stability of ammonium nitrate can also be affected by a decrease in pH (increased acidity), and if bubbles are permitted to form in molten ammonium nitrate or solutions of ammonium

nitrate. See: Workplace Health and Safety Electrical Safety Office Workers' Compensation Regulator (2017) Ammonium nitrate.[Online]. Available from: https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-chemicals/specific-hazardous-chemicals/ammonium-nitrate#:~:text=Solutions%20and%20ammonium%20nitrate%20products,also%20include%20non%2Ddangerous%20goods.

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[xxiii] Ibid.

[xxiv] Ibid.

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About AMAT Insights

AMAT Insights serves to analyse and clarify issues pertaining to safe, secure and sustainable ammunition management, and, in turn, provides a source of technical advice and guidance to state representatives, operational decision-makers and practitioners. AMAT Insights supports the dissemination and practical application of the International Ammunition Technical Guidelines (IATG) in context.

About AMAT

The Ammunition Management Advisory Team (AMAT) is a shared initiative of the Geneva International Centre for Humanitarian Demining (GICHD) and the United Nations Office of Disarmament Affairs (UNODA). AMAT is a response to the urgent need for practical, authoritative and sustainable technical support to states in the safe, secure and effective management of ammunition in accordance with the IATG. AMAT works to strengthen the capacities of states to improve the safety and security of ammunition stockpiles (in line with the IATG), thus contributing to the global reduction of the risk of accidental explosions and illicit diversion, ensuring safer communities and more stable states and societies.

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