Report on any risk posed by the ammonium nitrate storage at Sharpness docks on the proposed Sharpness Vale Development

Commissioned for

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1.2			

Reference Table	
Term	**Meaning**
AN	Ammonium Nitrate
Laws	Created and recorded by the UK Government – Statutes
Regulations	Created, recorded and enforced by the HSE. Regulations modify Laws
HSE	Health and Safety Executive
CA	Competent Authority (combination of HSE and Environmental Agency)
COMAH 2015	Control of Major Accident Hazards Regulations 2015
HASWA 1974	The Health and Safety at Work Act 1974
MHSWR 1999	The Management of Health and Safety at Work Regulations 1999
COSHH	The Control of Substances Hazardous to Health Regulations 2002
RRFSO	The Regulatory Reform (Fire Safety) Order 2005
ACoP	Approved Code of Practice – a HSE document to explain Regulations. The ACoP also creates a standard of conformance that can be tested in courts
Guidance Documents	Published by the HSE. Do not have lawful status but are useful in enabling understanding and implementation of Laws and Regulations
SDS	Safety Data Sheets. Under COSHH Regulations, all deleterious substances (including AN) must have safety information supplied by the manufacturer. This information must include, for instance, how these substances are to be handled, stored, transported and disposed of, safely
MAPP	Major Accident Prevention Policy
Combustion	The combination of fuel, oxygen and heat to produce fire
Ignition	Source of heat (flames/friction/sparks) that starts fire
Flash Point	The temperature at which combustion (via ignition) starts but is not sustained
Ignition Point	The temperature at which combustion (via ignition) becomes self-sustaining
Auto-Ignition Point	The temperature at which fire spontaneously combusts without ignition
Decomposition	When a material breaks down into its constituent parts A precursor to AN detonation
SSD	Self Sustained Decomposition
Exothermic	Creating heat which is transmitted into the surrounding atmosphere
Detonation	Creation of a supersonic exothermic front accelerating through a medium that propagates a shock wave directly in front of it
Explosion	A rapid expansion in volume associated with an extremely vigorous outward release of energy, usually with the generation of high temperatures

1. Executive Summary

Regulatory compliant storage of Ammonium Nitrate (AN) is both safe and globally ubiquitous.

The reason for the large-scale production of AN is to provide a low cost, extremely effective synthetic fertiliser for the Worldwide agricultural industry.

Approximately half of the World's Human population (circa 3.7 billion people) are dependent upon the increased crop yield that AN promotes (please see appendix 9.5).

Disasters involving AN storage such as that tragically suffered in Bierut on 4th Aug 2020, are examples of major breaches of mandated safety practices, combined with additional factors such as failures of local authorities neglecting to monitor and identify poor storage practices within their own areas of responsibility.

If regulatory compliant storage of AN was **not** safe, then its production and storage would be banned by Governments around the World, led by the UK.

The UK Government sets and monitors safety criteria to the highest of Domestic and International standards and where breaches are established, imposes severe punishments which include not only significant commercial fines and other deterrents, but also personal fines and prison sentences.

Sharpness Docks is subject to regular inspections by the HSE, where the objectives are primarily to ensure Public Safety and to also enforce strict compliance of AN storage regulations.

The safe storage of AN at Sharpness Docks is not a matter of subjective, self-imposed protocols, but the result of a highly controlled, externally monitored and verified set of UK Government regulations.

There are no public records to indicate that HSE inspectors have raised concerns over Sharpness Docks' storage and management of AN.

It is therefore our conclusion that the storage of AN at Sharpness Docks does not constitute any recognised risk to residents of the proposed Sharpness Vale development, particularly as all habitable areas are outside of the HSE's Consultation Distance and Risk Zones.

2. Background

Ammonium Nitrate (AN), if manufactured, transported, handled and stored as per regulations, is a safe product, with the primary of objective of these regulations being Public Safety.

Companies and people breaching these regulations face severe penalties.

External monitoring of AN storage facilities is undertaken by a Competent Authority (CA), a combination of the HSE and the local Environment Agency.

Laws and regulations governing the manufacturing, transportation, management, and storage of AN apply not only to the operator, but also to the CA, leading to more comfort that the Sharpness Docks facility is regulatory compliant and therefore poses no elevated risk to the local existing and proposed Sharpness Vale development populations.

If the AN at Sharpness Docks is managed as per regulations and the manufacturer's issued Safety Data Sheet, then the risk of a major accident can be considered remote and comporting with all published guidelines and Government requirements.

Significant deviation from regulation must occur before AN becomes a risk.

Decomposition conditions (a pre-cursor to detonation) only occurs if AN becomes contaminated / exposed to moisture / heated to above 200^{o}C (or so) / exposed to instigators.

All recorded Worldwide explosions of AN over the past 25 years were, according to publicly available information, caused by poor storage or transportation issues.

Changes to legislation to eradicate identified adverse practices arising from studies of these explosions have all been considered, and where necessary, subsumed into UK legislation.

To assist planning consent and to allow for other safety considerations, the HSE establishes a Consultation Distance - a "radius" from the centre of the major accident facility, beyond which it is considered that there is **no significant impact** regarding Public Safety.

Other than a small area of proposed Green Infrastructure and Public Open Space, the Sharpness Vale development is outside the HSE Consultation Distance and all three of the HSE indicated risk zones.

Environmental damage caused by storage of AN at Sharpness Docks can also be considered a remote risk if all governing legislation and AN Safety Data Sheet information is observed.

There is no public record of any unsafe event at Sharpness Dock, which would result in a HSE improvement/prohibition/contravention notice, RIDDOR report or HSE investigation, which is an indication that AN is being correctly stored and handled at Sharpness Docks.

Objections relating to the proposals for the new settlement based on risk of Public Safety and environmental impact should not be upheld for the following reasons;

- Conformance to governing legislation means that associated risks have either been eliminated or have been reduced to an acceptable level, as allowed by UK Law.
- All planned habitable areas are outside the HSE CD and 3 risk zones.
- Planning consent was given to increase the stored tonnage from 10,000t to 15,000t in 2005, when existing conurbations were (and remain) well within the HSE risk zones, including the inner risk zone.
- The UK safety record for storing AN is exemplary.
- There are no recorded safety issues on Public record at Sharpness Docks.

3. Introduction

3.1. Remit

This report has been prepared for Sharpness Development LLP, the promoters for a new settlement known as 'Sharpness Vale' on land to the south and east of Sharpness Docks.

Sharpness Vale has been identified as a draft allocation under site reference PS36: New Settlement at Sharpness, in the emerging Stroud District Local Plan (Draft for Consultation) dated November 2019.

The proposed allocation will deliver a sustainable new settlement and the first phase of the proposals will comprise of: approximately 2,400 dwellings;
New education facilities;

- 10ha employment land;
- New retail and community uses; and
- Green Infrastructure including:
- Nature reserve with no public access;
- Suitable Alternative Natural Green Space (SANG) including a wetland park;
- Allotments and orchards; and
- Other sustainable alternative natural greenspace.

3.2. Purpose of this Report

Sharpness Docks currently has facilities for the storage of Ammonium Nitrate Storage, which is classified as a major hazard site, under COMAH Regulations and the HSE's "Major Hazard Regulatory Model - Safety management in major hazard sectors."

This report has therefore been commissioned by Sharpness Developments LLP to determine what, if any, risk is posed by the Sharpness Docks Ammonium Nitrate Storage facility to the safety of the proposed Sharpness Vale development areas and the impact of this on the proposed allocation of the site, and any potential planning application in the future.

As discussed later in this report, all but one small area (proposed as recreational public open space) of the proposed Phase 1 Sharpness Vale Development area is situated outside of the HSE's CD (Consultation Distance).

4. Sharpness Docks

Is operated by the Victoria Group and is located at.
Sharpness Dock
Sharpness
Gloucestershire
GL13 9UK
Tel: 01453 811644
info@sharpnessdock.co.uk

The Victoria Group is an independent operator, managing six port facilities.
Victoria Wharf (Plymouth)
Corporation Wharf (Plymouth)
Sharpness Dock (Gloucestershire)
Mersey Wharf (Bromborough, Wirral)
Seaham Harbour (County Durham)
Port of Boston (the Wash)

The Victoria Group website state that they are “a reliable and proven business partner offering supply chain solutions through port operations, logistics, storage, handling and distribution”.

Port operations are accredited with:

- the United Kingdom Warehousing Association
- COMAH (Control of Major Accidents Hazards) Lower Tier for Ammonium Nitrate Fertiliser
- TASCC (Trade Assurance Scheme for Combinable Crops)
- FIAS (Fertiliser Industry Assurance Scheme)
- OFF (Organic Food Federation)
  Security of the Port facilities is undertaken in accordance with the ISPS (International Ship and Port Security Code).

The Victoria Group states on their website that they are “committed to maintaining high standards of Health and Safety, and operating in an environmentally-responsible manner”.

The Victoria Group can be contacted by the following methods;

General Enquiries: Tel. 03301 239232
email: enquiries@victoriagroup.co.uk

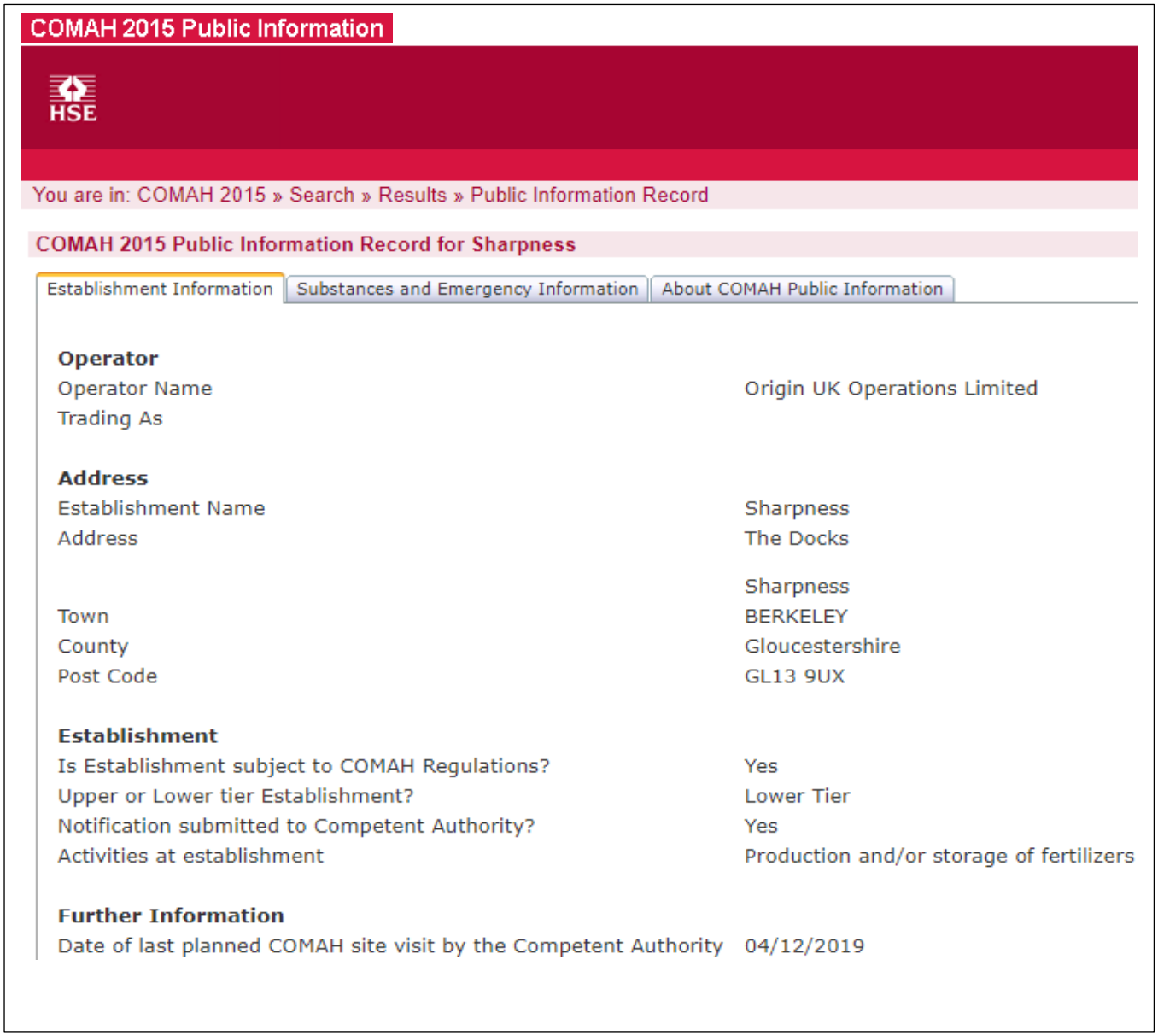
Sharpness Docks are licensed to store 15,000 tonnes of Ammonium Nitrate.

This license is subject to;

- HSE on-going approval via site inspections
- Conformance with COMAH Regulations 2015
- Conformance with other H&S and Buildings related legislation
- That UREA is not stored with any Ammonium Nitrate stocks

Sharpness Docks are classified as **Lower Tier** under COMAH 2015 Regulations, meaning the Competent Authority does not need to produce an External Emergency plan.

However, as a Lower Tier establishment under COMAH 2015 Regulations, Sharpness Docks must produce a safety management system and a MAPP (Major Accident Prevention Policy)



COMAH 2015 Public Information

HSE

You are in: COMAH 2015 » Search » Results » Public Information Record

COMAH 2015 Public Information Record for Sharpness

Establishment Information | Substances and Emergency Information | About COMAH Public Information

Operator

Operator Name	Origin UK Operations Limited
Trading As	

Address

Establishment Name	Sharpness
Address	The Docks
	Sharpness
Town	BERKELEY
County	Gloucestershire
Post Code	GL13 9UX

Establishment

Is Establishment subject to COMAH Regulations?	Yes
Upper or Lower tier Establishment?	Lower Tier
Notification submitted to Competent Authority?	Yes
Activities at establishment	Production and/or storage of fertilizers

Further Information

Date of last planned COMAH site visit by the Competent Authority	04/12/2019

https://notifications.hse.gov.uk/COMAH2015/PublicInformation.aspx?piid=2628

The following table details which storage areas at Sharpness Docks are allowed to have AN stocks, and who is responsible for the individual storage areas (this information is the latest Publicly available).

Location	Used By	Area (m^2)	Capacity In Tonnes (at 1.59t m^2)
No. 3 Shed	J&H Bunn Ltd	5574	8,857
No. 4 Shed	J&H Bunn Ltd	3762	5,979
No. 4a Shed	J&H Bunn Ltd	1560	2,480
No. 5 Shed	J&H Bunn Ltd	2369	3,764
		Total	**21,080**
C Shed	Sharpness Dock	1021	1,624
D Shed	Sharpness Dock	1218	1,937
E Shed	Sharpness Dock	3344	5,314
F Shed	Sharpness Dock	2230	3,543
J Shed	Sharpness Dock	2230	3,543
		Total	15,961
Total Covered Storage Capacity @ 1.59t/m^2			**37,041**

This table details the total physical storage capability at Sharpness Docks.

However, the amount of AN allowed to be stored is subject to the conditions contained within the AN storage license, issued by the HSE, and is currently limited to 15,000 tonnes.

This means that there is ample space to correctly store AN, and potentially increase the separation distances between stacks of AN.

This allows extra safety measures to be undertaken, over and above the official guidance requirements.

5. Overview

5.1 Ammonium Nitrate (AN)

Is safe, if manufactured and managed to governing legislation.

Its primary function is a controlled-release nitrate fertilizer used by the World's agricultural industry, which delivers significantly increased crop yields.

It is used extensively around the World, with many thousands of large-scale storage facilities successfully managing this product, with no adverse incidents in their history.

Due to its chemical composition (a combination of two ionic salts) it is also used as an explosive in the munitions and blasting industries (e.g., ammunition and mining respectively).

It has also been used in illegal activities due to its explosive characteristics.

AN only detonates under specific conditions, primarily once it is heated to circa 200ºC and above, otherwise it is quite inert, and under normal and ambient heat conditions, it is virtually impossible to detonate by impact forces.

However, it is recognised that large quantities of AN when detonated, release gases that travel at super-sonic speeds, creating shock waves with sufficient energy to cause significant material damage and regrettably, the potential for significant levels of loss of life.

Such detonations have resulted in large-scale disasters around the World and have therefore alerted the Public to the potential hazards of storing and transporting AN.

Globally, 14 such AN disasters have occurred in the past 25 years – but none in the UK, which suffered its last AN explosion event in April 1916, 105 years ago.

For AN to become a hazard, its treatment and particularly storage, must be significantly miss-managed to create the conditions whereby it will decompose and subsequently detonate.

5.2 UK Law

AN production, transportation, management and storage are subject to the highest and most stringent sets of regulations, verified and monitored by independent HSE inspections. These standards and controls can be considered as the best in the World.

One primary regulation governing the storage of AN is COMAH – the Control of Major Accident Hazards Regulations 2015, which places significant liability upon operators of major accident sites to ensure that Public Safety is not compromised as a result of their operations.

While the management of the AN storage facility legally resides with the operator, UK law requires that a Competent Authority (the HSE and Environmental Agency) is involved to make certain that major accident sites are operated so as to ensure Public Safety. For instance, duties under COMAH Regulations places a legal obligation on the CA to monitor the operator's compliance with all relevant H&S regulations, including COMAH.

This duty requires the CA to assess the AN storage operator's safety management arrangements which must be confirmed by on-going mandatory HSE inspections. These inspections must be carried out on a frequency determined by CA evaluation of the risks posed by the AN storage facility, and in any event, at least every 3 years.

This means that the safety arrangements at Sharpness Docks are not limited to in-house processes and internal audits, but are also checked and verified by an independent, impartial UK Government

Authorities (the CA) on a regular basis, with legal responsibilities being conferred to the persons undertaking these external inspections.

In addition, to obtain a lower tier license to store AN, the operator must provide certain information to the CA, which includes a safety management system (SMS) and a Major Accident Prevention Plan (MAPP). The controls, processes and protocols contained in these reports are verified by the CA and must meet stringent safety standards for the license to be granted, and they also form part of the on-going CA inspection regime for the operator to retain their license to store their allowed quantities and concentrations of AN.

5.3. Verification of Regulatory Compliance at Sharpness Docks

While Sharpness Docks have not allowed an independent audit of their AN storage facilities to confirm regulatory storage and management compliance, currently there is no evidence, based on accessible Public Records, to indicate any deviance from legal safety practices.

All but one small area (proposed as Green Infrastructure and Public Open Space) of the planned Sharpness Vale Development area is outside of the HSE Consultation Distance. This would indicate that all habitable parts of the proposed development are considered by the HSE to be beyond the area that would be affected by any major accident occurring at Sharpness Docks.

Existing conurbation is already located in the inner HSE risk zone, indicating that the HSE are satisfied with the management of AN at Sharpness Docks.

5.4. Ammonium Nitrate – Safety Precautions

Storage and handling safety protocols are basic, inexpensive and easily implemented, requiring no complex processes, expensive equipment or sophisticated controls or high-levels of supervisory effort.

The mandated controls required for the safe storage and handling of AN are;

- Keep it dry
- Keep it ventilated
- Segregate it from sources of heat
- Segregate it from sources of contamination, which may initiate decomposition
- Use intrinsically safe electric circuits and equipment (eliminates ignition & heat sources)
- Store for less than 6 months
- Store in segregated, fire-resistant compartments
- Store in small stacks (say <2.0t per m²) with segregation between the stacks
- Isolate drainage from potential AN liquid run-off
- Provision of suitable security to deter unauthorised access.

As can be seen from the above controls (taken from HSE ING230 and AN Safety Data Sheets), they are not onerous and should be well within the capacity of the average operator.

A condition for the AN license at Sharpness Docks is that Urea (a decomposition initiator and combustible fuel) must not be stored in the same area as AN.

For AN to decompose, multiple breaches of these basic controls must occur. Segregation, fire resistant compartmentation, ventilation, small stack quantities and storage for less than 6 months all give, in effect, independent and multiple “lines of defence”.

Established accident analysis (Heinrich’s Domino Effect – see appendix 9.2) indicates that statistically, a number of adverse events / conditions contribute to an accident occurring. In effect, these basic AN management controls can be considered to provide protection against multiple adverse conditions arising together, the accepted conditions that result in accidents.

5.5. Sharpness Dock's Independent safety inspection.

We were unable to perform an inspection of Sharpness Docks AN storage facilities, meaning this report is limited in scope and no conformance or compliance with governing legislation regarding storage, handling and transportation of Ammonium Nitrate (AN) can be confirmed by Advanced Safety Plus Ltd on a first hand basis.

However, Sharpness Docks is a privately owned organisation and have no legal imperative to allow external, non-official inspections and therefore no adverse conclusions can be drawn from their refusal to allow Advanced Safety Plus to inspect their storage facilities.

The lack of any unfavourable reports (see below) would provide evidence that Sharpness Docks is operating to required regulatory standards and therefore the AN stores are being managed, as legally required, to eliminate, so far as is reasonably practicable, any Public Endangerment.

As mentioned elsewhere in this report, Sharpness Docks is subject to regular (at least every 3 years) audits conducted by the HSE, with the responsibility resting with the CA to ensure such storage facilities do not pose Public health risks.

5.6. Sharpness Dock Public Record Searches

Performing the basic Public Domain record searches, records of HSE notices or HSE-lead prosecutions regarding Sharpness Docks could not be found. Similarly, no Public record of local authority concerns were obtained.

While this is not proof of compliance, it is an indicator of lawful conformance.

6. Report and Findings

6.1. Ammonium Nitrate (AN)

Chemical Composition, Uses and what makes AN dangerous.

Ammonium Nitrate is a combination of two separate salt ions: one atom of Nitrogen combining with 4 atoms of hydrogen and one atom of Nitrogen combined with 3 atoms of Oxygen, represented by the chemical formula NH4NO3.

Atoms are comprised of a nucleus made up of Protons (positively charged particles) and Neutrons (particles with no charge). This nucleus is surrounded by a “cloud” of electrons, where the number of electrons match the number of protons in the nucleus.

Therefore, most atoms have no charge.

An ion is an atom with either extra electrons (a negatively charged ion or **anion**) or with electrons missing (a positively charged ion or **cation**).

This combination of the two ionic salts gives AN it’s distinctive reactive characteristics, allowing the break-down of its constituent elements. to provide high-energy plant nutrients (nitrogen) and it’s explosive-like characteristics by the rapid decomposition of the two salts, under certain conditions.

Ammonium nitrate is explosive because its chemical composition contains both fuel and an oxidizer component, which is a property of all explosives.

Ammonium nitrate is classified as a high secondary explosive, meaning that while it can detonate, it is stable until exposed to specific conditions that makes it decompose.

Ammonium nitrate is the least sensitive to impact of all secondary explosives and has high energy of activation about 109 kilojoules per mole (kJ/mol), which makes it very stable until exposed to relatively high temperatures or specific initiators.

Although it starts decomposing at temperatures of about 388 F (170 C), relatively pure ammonium nitrate does not typically explode until temperatures between 500–572 F (260–300 C) or higher are reached.

During a typical explosion, ammonium nitrate can (almost) instantaneously releases a significant amount of energy, nitrogen gas, water vapor, and reddish-brown nitrogen dioxide gas.

The high temperature generated at the core of the explosion pressurizes these gases and propels them outward at supersonic speeds, with velocities ranging from circa 3,300 feet per second (ft/s) to 15,000 ft/s in extreme cases – or about three to 13 times faster than the speed of sound.

Ammonium nitrate is approximately 75% as powerful as TNT, but it has only 54% of its brisance (the shattering capability of a high explosives), which is largely due to its 20%+ oxygen balance and slower kinetics (speed of expanding materials). This gives AN the explosive capability of circa 43% that of TNT. This percentage can increase, if AN is mixed with fuels and other chemicals.

Nitrogen is released quickly from the NH4 ion on contact with water and nitrogen is released more slowly by the NO3 ion, meaning plants received a dose of nitrogen more or less immediately by the application of AN, and the ammonia constituent is absorbed along with the nitrogen at a later stage, ensuring ammonia does not become an environmental hazard by being left in the soil.

AN is used as an agricultural fertilizer and (when correctly processed) as an explosive – either for munitions or as an explosive charge for say ground-clearance in the mining industry. Its explosive characteristics have also been used for criminal purposes.

The benefits of AN is that it is a relatively cheap, safe, easily managed, energy-dense fertilizer, which is used extensively world-wide to significantly boosts crop yield.

The downside is that due to its chemical composition, it has a complex chemical behaviour and accordingly presents main three types of hazards:

If stored incorrectly, it can decompose with the formation of toxic gases and toxic liquid run-off.
The propagation of fire, due to its strong oxidizing properties and the toxic gas formation.
It can detonate, given the correct conditions, releasing large amounts of energy at supersonic speeds.

The most important parameters influencing the above hazards are; contamination (exposure to other substances), porosity and density of the AN granules.

Pure AN begins to decompose if heated above 170ºC.

Below 170ºC it is considered to be stable, under the correct condition.

Between 170 and 250ºC, it releases nitrogen oxide and water vapour.
Between 250ºC and 292ºC it releases ammonia and nitric acid.
Above 292ºC, it releases nitrogen, nitric acid, oxygen and water vapour.

If it is contaminated / blended / reacts with other substances, then more complex substances and toxins will be released.

AN is not itself flammable (i.e., it does not chemically bond with Carbon and Oxygen to produce fire). However, due to its oxidizing properties (oxygen is an intrinsic component of AN, which is available to combine with fuels to produce fire), can maintain and intensify fire without the presence of air – therefore fire involving AN cannot be extinguished by suffocation.

The application of water to extinguish an AN fire will do so by reducing the temperature of the AN to below its decomposition point, rather than by excluding air. On fires, water both cools the fuel and removes oxygen from the combustion process.

The melting point of pure AN is at 169.6ºC. The melting process results in the AN mass absorbing heat, which can in turn, be transferred to the ground, the storage container, nearby structures and the free atmosphere and create combustion conditions on nearby flammable materials (i.e., propagate fire within nearby structures and materials).

AN in liquid (melted) form is more sensitive to detonation and any heavy object falling into the pool of liquid AN can initiate an explosion.

AN is difficult to detonate by impact and if stored to standards and conditions as set out by governing UK legislation, then it will not be a hazard.

6.2 HSE Methodology on Development near Major Hazardous Sites and HSE Consultation regarding Development

The Health and Safety Executive (HSE) is a statutory consultee on certain developments in the vicinity of major hazard sites and major accident hazard pipelines. HSE's land use planning (LUP) advice is based on the risk posed by the major hazard site on the proposed development plans.

Major accidents at sites storing hazardous substances are rare, but when they do happen, the effects on people living nearby can be devastating. This became apparent following the Flixborough incident in the UK in 1974, more recently at Buncefield in 2005 and across Europe for example at Enschede in The Netherlands in 2000.

HSE first offered advice to Planning Authorities (PA) in 1972 and this was introduced across the EU by the 1996 Seveso II Directive, which was replaced in 2012 by the Seveso III Directive. The simple aim is to manage population growth close to such sites to mitigate the consequences of a major accident.

HSE sets a consultation distance (CD) around major hazard site after assessing the risks and likely effects of major accidents at the site. CDs are based on scientific knowledge using hazard /risk assessment models updated as new knowledge comes to light.

Major accidents are also closely studied.

The PA is notified of this CD and has a statutory duty to consult HSE on certain proposed developments within it. HSE's response will be that HSE either 'advises against' or 'does not advise against' the granting of planning permission on safety grounds that arise from the possible consequences of a major accident at the major hazard. The PA must take this advice into account when they make a decision on the planning application.

HSE's land use planning methodology is based on the following principles:

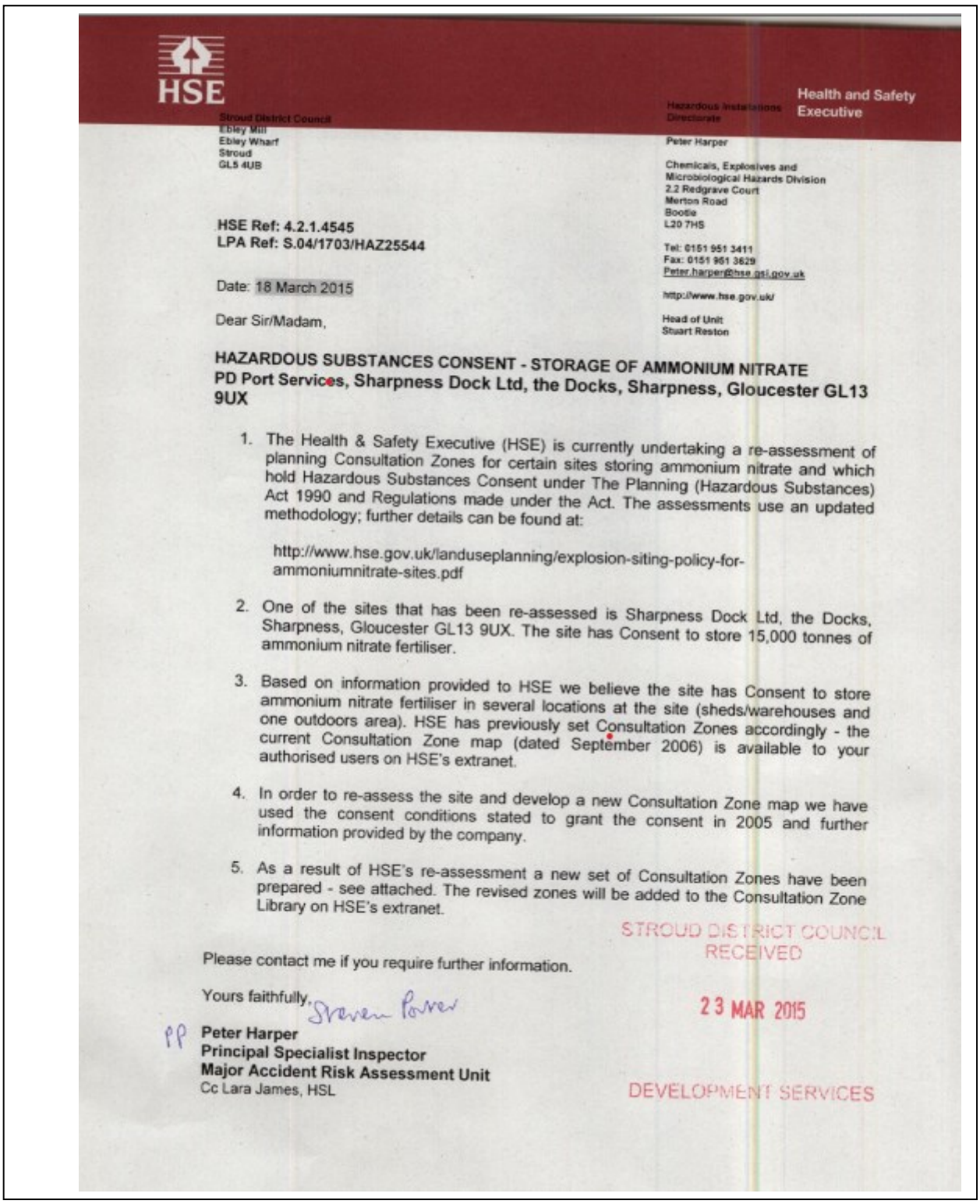
- The risk considered is the residual risk which remains after all reasonably practicable preventative measures have been taken to ensure compliance with the requirements of the Health and Safety at Work etc. Act 1974 and its relevant statutory provisions

- Where it is beneficial to do so, advice takes account of risk as well as hazard, that is the likelihood of an accident as well as its consequences.

- Account is taken of the size and nature of the proposed development, the inherent vulnerability of the exposed population and the ease of evacuation or other emergency procedures for the type of development proposed. Some categories of development (e.g., schools and hospitals) are regarded as more sensitive than others (e.g., light industrial) and advice is weighted accordingly.

- Consideration of the risk of serious injury, including that of fatality, attaching weight to the risk where a proposed development might result in a large number of casualties in the event of an accident.

6.3. Consultation Distance (CD) and the 3 risk Zones



HSE

Health and Safety Executive

Stroud District Council
Ebley Mill
Ebley Wharf
Stroud
GL5 4UB

Hazardous Installations Directorate

Peter Harper

Chemicals, Explosives and Microbiological Hazards Division
2.2 Redgrave Court
Merton Road
Bootle
L20 7HS

Tel: 0151 951 3411
Fax: 0151 951 3629
Peter.harper@hse.gsi.gov.uk

http://www.hse.gov.uk/

Head of Unit
Stuart Reston

HSE Ref: 4.2.1.4545
LPA Ref: S.04/1703/HAZ25544

Date: 18 March 2015

Dear Sir/Madam,

HAZARDOUS SUBSTANCES CONSENT - STORAGE OF AMMONIUM NITRATE
PD Port Services, Sharpness Dock Ltd, the Docks, Sharpness, Gloucester GL13 9UX

1. The Health & Safety Executive (HSE) is currently undertaking a re-assessment of planning Consultation Zones for certain sites storing ammonium nitrate and which hold Hazardous Substances Consent under The Planning (Hazardous Substances) Act 1990 and Regulations made under the Act. The assessments use an updated methodology; further details can be found at:

   http://www.hse.gov.uk/landuseplanning/explosion-siting-policy-for-ammoniumnitrate-sites.pdf

2. One of the sites that has been re-assessed is Sharpness Dock Ltd, the Docks, Sharpness, Gloucester GL13 9UX. The site has Consent to store 15,000 tonnes of ammonium nitrate fertiliser.

3. Based on information provided to HSE we believe the site has Consent to store ammonium nitrate fertiliser in several locations at the site (sheds/warehouses and one outdoors area). HSE has previously set Consultation Zones accordingly - the current Consultation Zone map (dated September 2006) is available to your authorised users on HSE's extranet.

4. In order to re-assess the site and develop a new Consultation Zone map we have used the consent conditions stated to grant the consent in 2005 and further information provided by the company.

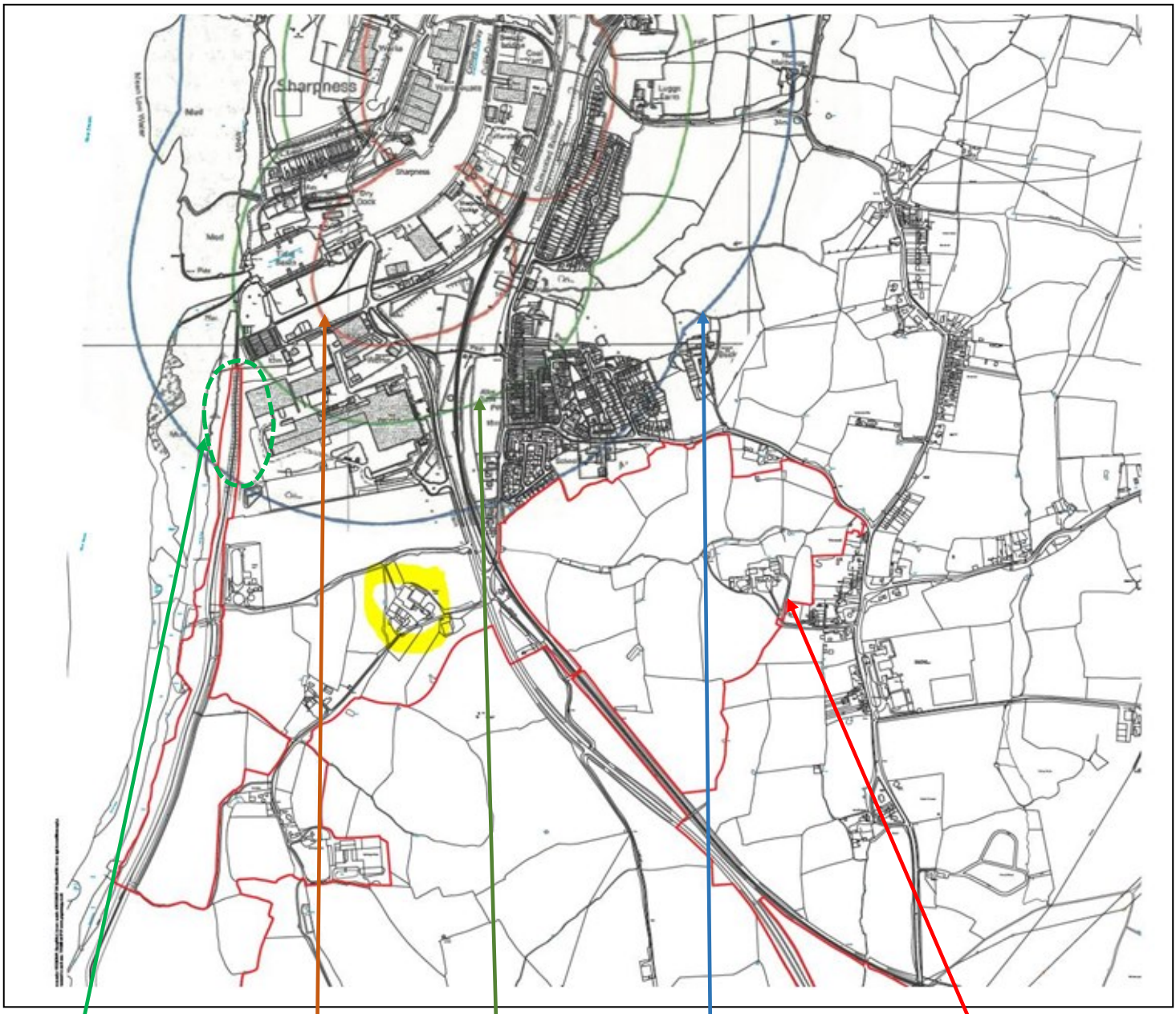
5. As a result of HSE's re-assessment a new set of Consultation Zones have been prepared - see attached. The revised zones will be added to the Consultation Zone Library on HSE's extranet.

STROUD DISTRICT COUNCIL
RECEIVED
23 MAR 2015
DEVELOPMENT SERVICES

Please contact me if you require further information.

Yours faithfully,

pp **Peter Harper**
Principal Specialist Inspector
Major Accident Risk Assessment Unit
Cc Lara James, HSL



Inner Zone
Highest
Risk Area

Middle Zone
Moderate
Risk Area

Outer Zone
Least
Risk Area

Development Boundary
All proposed residential development is outside the Consultation Distance.

This is the only area that falls within any Risk Zone, which is the outer, lowest risk area.

Planning application states this area of open countryside is restricted to recreational use.

Consultation Distance (CD), contains all 3 risk zones.
The HSE sets a consultation distance (CD) around major hazard sites after assessing the risks and likely effects of major accidents at the major hazard site. Development outside of the CD therefore does not need to take into consideration risks from the hazard site.

7. Regulations governing storage, transportation and use of Ammonium Nitrate

Notes	All UK regulations are reviewed and updated on a regular basis, to incorporate applicable technological advances and to implement lessons learnt, derived from related domestic and International adverse events. The UK Government's stance on the application of all Laws, regulations, ACoP's and guidance documents is that they are of the highest standards and when full compliance is achieved, then it can be assumed that the relevant processes and the management of hazardous substances pose no unacceptable threat, so far as is reasonably practicable, to the health, safety and welfare of persons and to the environment at large. Accordingly, UK workplaces are amongst the most regulated and heavily inspected in the World, translating to enviable industrial safety records. Applicable laws can be based on common law, statute laws and regulations that modify laws. ACoPs (Approved Codes of Practice) are used to assist Duty Holders with interpreting legislation and to set standards for legal compliance. ACoPs are recognised in Law and can be used in court, to determine whether companies and people have met their legal obligations. HSE Guidance documents have no legal standing but assist with devising controls and procedures to meet relevant legislation.		
Legislation	**Approved Code of Practice (ACoP)**	**Summary**	**Relevance to Sharpness Docks**
The Health and Safety at Work Act 1974 and the Management of Health and Safety at Work	L21	This Act and Regulations place a duty of care on all employers to provide a safe working environment, safe equipment, safe transportation & storage of materials, to undertake suitable risk assessments and develop safe systems of work for their employees and all those affected by the works operations. Other and later sets of legislation may rely upon basic requirements taken from the Health and Safety at Work Act 1974	This creates a general requirement on Sharpness Docks to ensure all of their work's activities are safe and to ensure the health, safety and welfare of their workforce and all those affected by their works operations. Under section 20 of the Health & Safety at Work Act 1974, HSE inspectors have the right to enter works premises and conduct

Regulations 1999			inspections to measure compliance to all relevant legislation. Where material breaches of legislation are detected, the HSE have the option to take legal action, from insisting on improvements, to prohibiting works operations and seeking prosecutions of companies and individuals. This process results in the HSE recovering costs (Fees for Intervention) and the potential for fines and prison sentences.
The Control of Major Accidents 2015 Regulations (COMA**H**)	L111	COMAH Regulations govern the storage, use and transportation of any substance that may pose Public hazards on a large scale. The purpose of the COMAH Regulations is to prevent major accidents involving dangerous substances and limit the consequences to people and the environment of any accidents which do occur. COMAH Regulations are regularly updated and operators subject to them must abide by any and all relevant changes, at all times. For example, an incident in Seveso, Italy, in the 1970's (a large-scale release of Dioxin) lead to the Seveso Directive (resulting in a 3-part strategy – identification of sites, major accident control measures and mitigation measures) were incorporated into COMAH Regulations. Changes contained in the COMAH 1999 Regulations brought protection of the environment into scope in addition to the protection of people	Ammonium Nitrate (AN), due to its explosive characteristics are subject to COMAH Regulations. To obtain a licence to store AN, proof of compliance with COMAH Regulations is required. Part of the evidence to prove compliance is development of a Major Accident Prevention Plan (MAPP), a Safety Report and internal emergency plan, all of which must be submitted to the Local Authority. Sharpness Docks will also have had to cooperate and provide information to the HSE, for the HSE to prepare their statutory inspections under COMAH Regs. Without such proof of compliance and cooperation, Sharpness Docks would not have obtained an AN storage license. Further, the COMAH Regulations require testing of the internal emergency plans at no more than 3-year intervals.

Ammonium Nitrate Materials (High Nitrogen Content) 2003 Regulations **NOTE:** **This regulation may not apply if AN at Sharpness is less than 28% Nitrogen**		These regulations outline how any AN (which exceeds 28% nitrogen by weight) that is manufactured or imported into the United Kingdom must have detonation resistance certification to prove that the AN batches are sufficiently resistant to accidental detonation during transportation, storage, and usage. All certifications must be kept for a minimum of two years after the batch of AN has been removed/modified/distributed/sold/destroyed. It outlines when the testing should be undertaken, as well as any exceptions to the timeline for testing. The importing regulations within apply to both European Union countries and non-European Union countries, with more stringent requirements made of non-EU countries, so as to include a number of factors including detonation resistance, quantities, if imported quantities have been reduced into smaller batches and individual detonation resistance of each sub-batch. Within Schedule 2 describes the means by which testing is to be safely undertaken.	The relevance of these regulations should be somewhat self-explanatory, as the docks are storing up to 15,000 tons of AN which include imported AN. All certifications will be included within the scope of the audits performed under the COMAH regulations as stated above.
HSE Guidance on Storing and Handling Ammonium Nitrate	INDG230	The Health and Safety at Work etc Act 1974 imposes general duties to ensure that workers and others are protected against risks to their health and safety from work activities. INDG230 was produced to cover safety aspects of managing AN, specifically to help duty holders to ensure the safe storage and handling of this substance. INDG230	Sharpness Docks would take note of the controls and procedures contained in INDG230 (or devised others to the same or higher standards), to assist them comply with other sets of legislation.
Planning (Hazardous Substances) 2015 Regulations		These regulations outline the requirements for in depth plans for any site handling hazardous substances. These regulations outline the requirement of the management of the land user to seek consent for the storage / use / distribution of hazardous substances, as well as defining which authorising bodies are in charge of granting such consent.	These apply to Sharpness Docks due to the array of stored hazardous materials on site. These regulations are separate to COMAH regulations as these apply to hazardous substances which may not necessarily cause a major incident.

		The guidance references COMAH competent authorities for the granting, reviewing and ensuring expertise in granting such consent for the storage/use of hazardous substances. There is no specified minimum quantity for these regulations to apply, however previsions are made for what is described as “Small quantities” to be excluded.	Conformance with these regulations would have been required for granting the Sharpness Docks AN license
Building Regulations – buildings other than dwellings	Approved Document Part “B” volume 2	UK Building Regulations provide standards that must be met to ensure that the design of buildings take into account the risk of fire, and specifically cover • Means of warning and escape • Internal fire spread (linings) • Internal fire spread (structure) • External fire spread Requirement • Access and facilities for the fire service Based on the specific function and use of the building.	Conformance with these regulations would have been required for granting the Sharpness Docks AN license and on-going compliance an element of the on-going HSE inspections. Compliance will be a condition of retaining their AN license.
The Regulatory Reform (Fire Safety) Order 2005 (RRSFO)		These regulations outline the requirement for fire safety management. This extensive set of regulations start with outlining responsible duty holders and the duties which are assigned to them. These duties generally break down into several categories: fire prevention and detection, fire safety arrangements, firefighting and detection, escape routes and measures, the maintenance of fire safety equipment and measures, fire load, the dissemination of relevant information to employees and visitors, general duties, and co-operation and coordination. The regulations also outline the enforcing authorities for ensuring the previously mentioned duties are undertaken. Offenses, defences, appeals and other criminal charges are covered within these regulations. An array of other miscellaneous duties, requirements, and suspension of bylaws are included. Outlined within the regulations are a Responsible Person (RO) who is personally responsible for any and all fire measures	These regulations include a number of essential factors in the safe containment of flammable and explosive materials, including fire and explosion detection and suppression, evacuation, and other aspects of fire safety. The provision of all relevant information, are covered under the audits performed in accordance with the COMAH regulations.

		undertaken, and to ensure that all firefighting and detection measures are adequate, up to date. The RO is personally liable for any criminal charges due to negligence or other failure of the fire detection, fighting, and evacuation procedures.	
Control of Pollution Act 1974 Environmental Protection Act 1990 Environment Act 1995		These regulations cover a wide array of circumstances, from river pollution, noise pollution, atmospheric pollution, street cleaning, controlled waste, radiological contamination, containment of genetically modified organisms and beyond. The scope of these regulations covers just about any task which involves the environment whether directly or indirectly. These regulations have had a number of revisions undertaken, with redactions and references to other, similar legislation documents.	Sharpness Docks comes under several sections of these legislations, the water course adjacent to the storage facilities requiring to be protected from any potential contamination from not only ammonium nitrate, but other chemicals stored on site. Protection of the water courses and drains to prevent both explosion and water course contamination are required by these documents. The site must also adhere to dust containment and other atmospheric contamination control. The control measures to ensure that all materials are contained, and pollution is controlled will be included within the scope of the COMAH inspections referenced above.
Control of Substances Hazardous to Health 2002	L5	These regulations outline what constitutes a 'hazardous substance', as well as requirements for the storage, manufacture, usage, removal, incident handling and other aspects of how hazardous materials can be used. Guidance documents and ACoP documents outline methods which can be used to handle and otherwise use or clean up hazardous substances. A wide range of guidance is available depending on which industry one is working within, from woodwork to catering, printing to welding and so on. COSHH is most known for the requirement of datasheets for hazardous substances, such as bleach or laboratory chemicals, as well as the application hazard symbols associated with warning signs and storage areas.	These regulations apply to the ammonium nitrate stored at the docks due to its hazardous nature. The regulations will guide the storage and transport of not only the ammonium nitrate but also anything that may contribute to a chemical complication, such as any sulphites, metal oxides.
Dangerous Substances (Notification and	Indg467 HS(R)29	These regulations cover the requirement of any facility storing more than 25 tonnes of any dangerous substance to notify a number of bodies to the	These regulations apply to the storage facilities at Sharpness Docks due to the site

Marking of Sites) Regulation 1990		materials stored and their methodology for storage. It also outlines exceptions.	having the licence to store up to 15,000 tonnes of AN.
Ammonium Nitrate Safety Data Sheet	SDS	Safety Data Sheets (SDS) are a legal requirement for all substances that are defined as hazardous to health under COSHH Regulations. SDS's are produced by the supplier of the hazardous substance. SDS's can be attached to the container of the substance, or more commonly are issued as supplementary pamphlets, when the substance is dispatched. All SDS's have the same format and contain the same information, such as chemical composition, date of production, batch identification number, how to store it, how to dispose of it, how to clean up spillages, what PPE to wear, what first aid and further treatment is necessary if persons are exposed to the hazardous substance. SDS's must be specific to the precise chemical compounds contained in the substance and therefore the SDS for pure AN may differ radically to the SDS issued for AN mixed with UREA.	It is a legal requirement for Employers and Employees to follow the safety controls contained in the SDS for the hazardous substances being used in the workplace. Therefore Sharpness Docks must comply with all of the storage, handling, transportation and other management controls stated in the SDS for the specific AN being stored by them. Again, compliance with COSHH and Safety Data Sheet information regarding storage etc. of AN, will be an important element of the HSE inspections required under COMAH Regulations.
HSE Guidance for Operators – What to expect from the Competent Authority (CA)		The CA has statutory responsibility to provide regulatory oversight of high-hazard industries using or storing quantities of dangerous substances. A primary function of the CA is to assure the public that onshore major hazard businesses are meeting their responsibilities under COMAH Regs Other CA statutory functions include assessing safety reports and accident prevention policy, organising a system of inspections, investigating, and reporting on major accidents.	Sharpness Docks would have to have complied with all of the conditions agreed with the CA, when initially registering for their AN license and then when they applied to increase their AN storage capacity in 2005. The CA inspection targets Sharpness Dock's safety management systems and how well their major accident prevention policy (MAPP) is being implemented.

8. Study of Ammonium Nitrate Incidents in last 25 years.

8.1. Table of Incidents

Where	When	Tonnes	What Happened	Root Causation	Can it happen at Sharpness?	
					Y/N	Why
Bierut Lebanon	4th Aug 2020	2,750	A major fire broke out in a Port of Beirut warehouse and spread to 2,750 tonnes of AN 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 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. 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. Up to 300,000 people lost their homes. 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 "reasonable upper bound estimate", a study from the Blast and Impact Research Group at the University of Sheffield shows.	AN should not be stored for more than 6 months, otherwise chemical changes may occur that can alter its physical makeup in a way that makes explosion more likely. A fire broke out in the AN storage warehouse, along with a significant amount of fireworks. The resultant fire raised the temperature of the AN to above 200C and the total 2,750 tonnes of AN detonated	No	If the AN is stored as per statutory requirements, i.e. if the storage facility is cleaned, if it is stored in less than 1 cubic metre stacks, in dry, ventilated conditions, in single storey fire resistant rooms, kept separate from sources of heat/ignition, kept sound, kept in water-proof packaging and stored for less than 6 months, then this will eliminate these root causes

Port of Tianjin China	12th Aug 2015	800	Nitrocellulose (flashpoint of 12.7º, autoignition temperature of 170º) stored at a hazardous goods warehouse in Tianjin, spontaneously combusted after becoming overly hot and dry, resulting in a fire that 40 minutes later, at around 23:30, triggered the detonation of circa 800 tonnes of ammonium nitrate stored nearby. 110 emergency personnel, 55 residents and employees were killed, and 798 people were injured. 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.	Insufficient control of environmental storage conditions of a highly flammable substance (nitrocellulose - AKA flash paper, flash cotton, guncotton, pyroxylin and flash string) combined led to the spontaneous combustion of this substance. Storage of other hazardous chemicals such as calcium carbide. Fire-fighters attempting to extinguish the initial fire used water, unaware that that this caused a series of more violent chemical reactions - calcium carbide, combined with water releases acetylene, a highly flammable gas, which added fuel to the initial fire, allowing the fire to reach the ammonium nitrate. Problems with documentation and licensing arrangements led to unknown hazardous substances, with their amounts and storage conditions also unknown.	No	As above plus if all hazardous substances are known, are stored correctly and correct fire-fighting measures are known to the local emergency services
Wyandra Queensland Australia	5th Sept 2014	56	A truck (part of a "road train" 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.	A fire (possibly an over-heated/faulty front tyre) was noticed by the "prime-mover" truck driver who decided the safest course of action was to steer the "road train" off the road. However, this caused the truck to roll over and the fire spread to the AN cargo. The other factor was that the AN containers were made of aluminium, rather than the Australian	No	If all transportation of AN is in accordance with UK regulations

				approved material. The driver was also accused of making incorrect decisions as he had not taken the mandatory rest-breaks, but this allegation was not proven.		
West Texas USA	17th April 2013	240	A fertilizer company in West, Texas, caught fire. At around 19:50, ammonium nitrate stored there exploded, levelling roughly 80 homes and a middle school. 133 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.	The facility had a history of OSHA violations, including not declaring the storage of AN, when required to do so. The official investigation ruled out natural causes, hazardous materials present and storage arrangements. It was officially concluded that the initial fire was deliberately set, but this conclusion was criticized by legal and forensic experts	?	It is obviously difficult to comment on causes that are not completely established. However, it is impossible to completely eliminate acts of arson.
Bryan Texas	30th July 2009	Not known	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	Root causation is reported to have been a fire breaking out due to the blending of AN processes being undertaken at the storage facility, which then spread to the AN storage area.	?	If no blending (or other heat/ignition - producing process) is carried out at Sharpness, then this type of incident is unlikely to occur.

Monclova Coahula Mexico	9th Sep 2007	22 (ANFO)	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	Root causation for the truck losing control was never established, as all witnesses were killed at the scene. The death toll was increased as the trailer loaded with the AN was reported to have no signs or markings to indicate it was transporting explosive materials, and therefore rescue services did not expect an explosion of the resultant magnitude	?	Road traffic accidents cannot be eliminated, but if AN is transported in accordance with all UK legislation, then the risk of AN detonation is minimised. In addition, the collateral damage will be minimised, and rescue services would be able to instigate procedures based on the emergency management of explosive substances
Estaca De Bares Spain	2007	400	The NPK (Nitrogen, phosphorous and potassium) fertilizer cargo of the ship Ostedijk suffered a self-sustained decomposition 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.	Self-sustaining decomposition incidents can be initiated by self-heating or external heat sources. Self-heating is the phenomenon in which the temperature in a body of material rises due to heat being generated by some process taking place within the material. If this heat cannot be lost to the surroundings at a rate greater than that at which it is generated, then a thermal runaway may occur [2]. Self-heating of fertilizers is promoted when large quantities of material remain undisturbed for a long time e.g., in bulk storage or transportation, or if there is contamination with organic material with which ammonium nitrate will start to react directly at around 100C [3]. Local external heat sources (e.g.,	No	If AN is stored as per UK legislation, then this SSD phenomenon is unlikely to occur. It is unknown whether Sharpness Docks store NPK, either blended or as separate substances.

				hot work, hot surfaces and embers) can also initiate a SSD event. (University of Edinburgh, SSD research paper).		
Ryongchon North Korea	22nd April 2004	Not Known	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	Two possible causes have been offered. 1). Two trains, carrying petrol and LPG collided, bursting into flames which spread to the train carrying the AN. 2). Containers of AN, while being shunted, made contact with overhead electric cables, causing the AN to decompose, resulting in the explosion. The latter is the favoured explanation.	No	It is reported that the North Korea railway infrastructure (at the time) at Ryongchon was in a poor state of repair, which contributed to the accident. If train transportation to/from Sharpness complies with UK legislation and Network Rail standards, then a repeat of this sort of incident is highly unlikely.

			North Korean leader Kim Jong-il, who was due to be passing through the station at the time.			
Mihailesti Buzau Romania	24th May 2004	20	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.	The managers involved in the transportation of the AN were successfully charged with "homicide by negligence", as they were proven to have exerted Insufficient transportation safety measures.		While it is impossible to eliminate human failures and wilful acts, if AN is transported to / from Sharpness to comply with UK legislation, then both of these conditions are minimised
Barracas Spain	9th March 2004	25	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.	Road traffic accident resulting in fire which spread to the AN.	No	Road traffic accidents cannot be eliminated, but if AN is transported in conformance with all UK legislation, then the chances of AN detonation is minimised in these incidents

Saint-Romain-en-Jarez France	2nd October 2003	3-5	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	Poor conditions regarding the storage of AN, which were in material and significant breach of regulatory requirements. Cited as possibilities were an electrical overload on the facility, which shortly before had undergone remodelling to accommodate the cold storage rooms; fermentation of stored hay; or simply a lit cigarette. The most plausible explanation however would be a burst light bulb on the mezzanine that apparently had been left on (the switch was found in the "on" position during the field investigation).	No	If AN is stored as per statutory requirements, then these root causes are eliminated.
Cartagena, Murcia Spain	Jan-03	Not Known	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	Root causation is unclear, but proximity of decomposing organic matter to the silo in which the AN was stored has been cited. Heat generated by the decomposing organic matter may have transferred to the AN, triggering the SSD conditions	No	If the AN is stored as per statutory requirements, then these root causes are eliminated.

Touluse France	21st Sept 2001	200-300	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. Material damage was circa 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	?	Terrorist attack can never be eliminated. If Sharpness Docks are taking sufficient measures against such attacks, then this cause would be minimised
Xingping Shaanxi	13th Dec 1994	27.6	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. 22 lives were lost in the explosion, with a further 56 wounded. The explosion was officially announced as an accident	Root causation remains unverified.	?	Without root causation, no opinion can be formed
Faversham, Kent, UK	2nd April 1916	700	On April 2, 1916, a munitions 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.	A mixture of AN and TNT (80:20 ratio) was used to produce Amatol, used in bullets and large shells. The Faversham factory was producing Amatol at the time of the explosion. The exact cause of the fire that caused the AN to detonate remains unclear, but exceptionally hot weather has been cited	No	It is assumed that these processes do not take place at Sharpness. In addition, safety standards have significantly improved since 1916.

8.2. Analysis of Ammonium Nitrate Incidents in last 25 years.

There have been no recorded AN explosions in the UK in the past 25 years.

The last one occurred during the first World War in 1916 (details provided in the above table for reference purposes). There were exceptional circumstances surrounding this event and it occurred during imperative and expeditionary times.

Of the fourteen recorded major AN explosions in the past 25 years, six of them (some 43%) occurred while in transit, rather than when stored.

Four of the six were due to road traffic accidents, one involved a train and the last one was a self-sustaining decomposition (SSD) event on board a cargo ship.

It is our opinion that all root causes represented material breaches of the contemporaneous regulations of the Governing Countries.

These incidents have all been investigated, resulting in changes to legislation (where necessary) being enacted by the relevant governing bodies to eliminate such root causes in the future.

The UK Government have analysed these incidents and have, where necessary, changed UK legislation to consider any lessons learnt, to ensure similar root causation conditions are unlikely to occur in the UK, if AN storage and management is compliant with UK legislation.

On the evidence reviewed, the majority (and all storage related) AN explosion events were eminently avoidable, if basic safety precautions had been implemented and maintained.

9. Appendices

9.1. Copy of Sharpness Docks Licence

Stroud District Council

Planning (Hazardous Substances) Act 1990

Hazardous Substance Consent

Under the above Act the District Council as Local Planning Authority HEREBY GRANTS HAZARDOUS SUBSTANCE CONSENT for the works described below in accordance with the submitted application and accompanying plan(s) but subject to the conditions stated:

Agent:
Chris Dent
5 North Avenue
Exeter
EX1 2DU

Applicant:
Sharpness Dock Ltd
Sharpness Dock
Gloucestershire
GL13 9UX

Planning Ref.S.04/1703/HAZ
Application Date: 02/08/2004
Site No: 25544
Dated: 11/01/2005

Description of Land
Sharpness Docks, Sharpness, Gloucestershire, GL13 9UX

Description of Development
Amendment to condition for existing Hazardous Substances Consent to allow an increase in storage of Ammonium Nitrate up to 15000 tonnes.
Hinton Parish Council 367190 202253

Conditions attached to permission and reasons therefor:

1. When Storing Ammonium Nitrate compounds and fertiliser (substance No 1, Part A, Schedule 1 of the 1999 Regulations: Notes 1 and 2), the building will not be used for the co-storage of Urea.

   Reason: In order to comply with HSE Regulations.

2. The hazardous substance shall not be kept or used other than in accordance with the application particulars provided in Form 1, nor outside the area marked for storage of the substance on the plan which formed part of the application.

   Reason: In order to comply with HSE Regulations.

9.2. Accident Causation

Accidents are considered by the safety industry as being unplanned, unintended, and unexpected events that result in harm to people and / or damage to property.

AN explosions are obviously classed as accidents.

Large scale analysis of accidents across many industry sectors have revealed that accidents rarely have one single cause and in the vast majority of cases, multiple failures of safety systems must occur for an accident to manifest.

Herbert W Heinrich was an innovative H&S researcher, whose foundational 1931 book "*Industrial Accident Prevention: A Scientific Approach"* summarised the results of a study covering a large amount of accident information, derived from many industry sectors, collated by his employer, a major insurance company at the time.

His work into accident causation continued for more than thirty years and included physical and psychological reasons for occupational accident causation, which included;

- Unsafe acts of people
- Unsafe mechanical conditions
- Unsafe physical conditions
- Safety management systems failures

The results of this research was to establish the "5 Domino Theory" of accident causation, which became the standard H&S model for accidents in the workplace.

This theory is based on if one domino in a vertical line of dominos falls over (an adverse incident in the workplace) then, unless safety protocols stop it, this domino will cause 4 more dominos to fall over, leading directly to loss and or injury.

"Heinrich 5 Steps" to accidents occurring is;

1. Lack of management control (leading to)
2. Basic causes (which give rise to)
3. Immediate causes
4. Accident/Incident
5. Loss/Injury

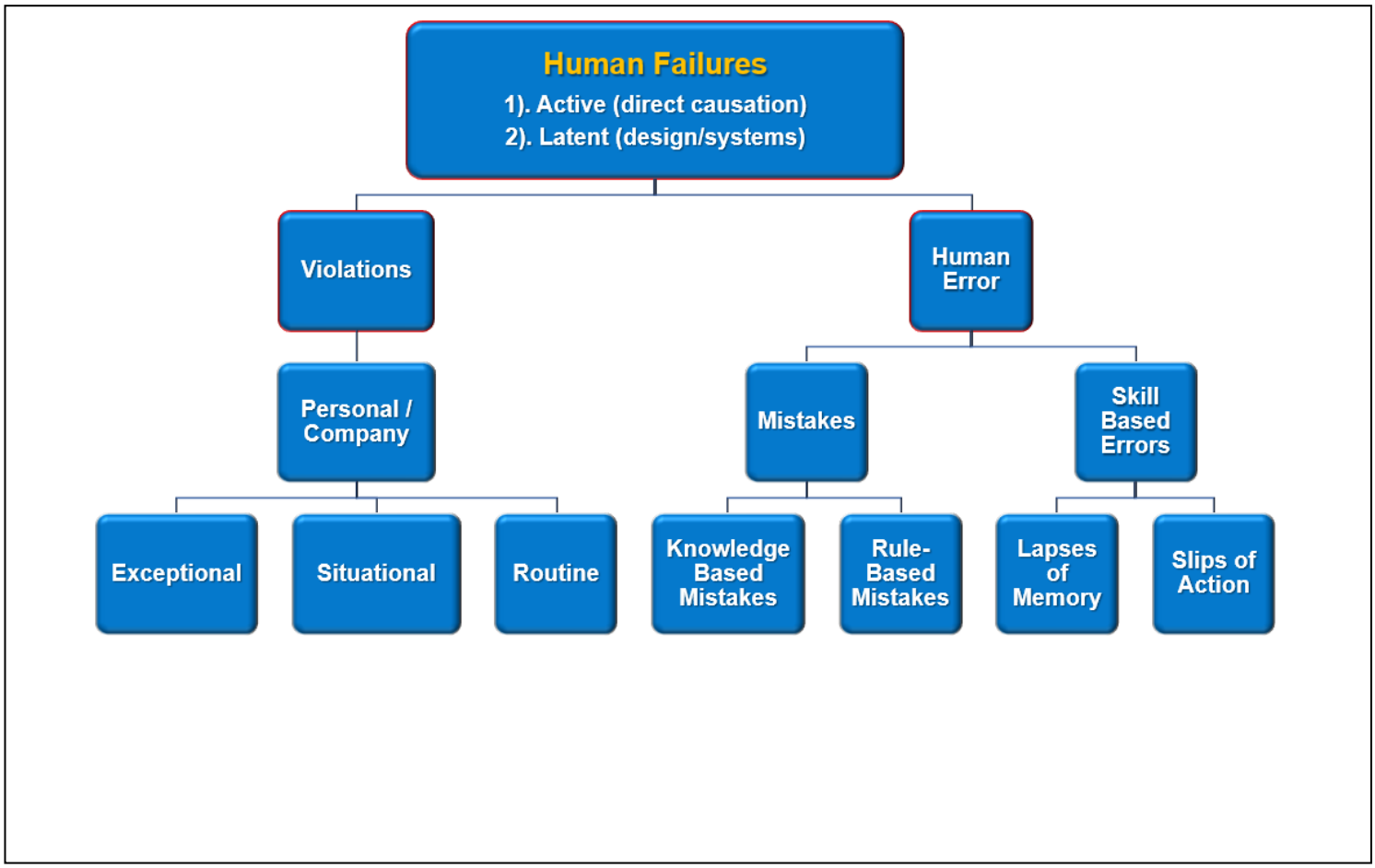
This 5-step theory was further developed by Bird and Loftus in 1976, and includes the influence of management in accident causation. This modified the 5-step version to create a 6-step process, starting off with external factors as step no. 1.

The British Safety Services (BSS) organisation recognised that in 2010, the domino theory should be updated, and accepted as the new H&S standard model for occupational accident causation.

The relevance of this model to Sharpness Docks is that it is recognised that single causes for accidents are extremely rare and the mandated controls of AN have been developed to ensure that this established "Domino Effect" is broken by the application of multiple and different systems as required by the relevant and applicable Laws and Regulations.

These controls, such as segregation / removal of heat sources etc., are in place to mitigate this "ripple" effect (one adverse incident leading to another, etc.) and therefore events leading to an accident are highly unlikely to occur.

Classification of acts / conditions and situations that contribute to accident causation.



9.3. CA Inspection relevant to Sharpness Docks

The following is a summarised extraction from “Understanding COMAH: What to expect from the Competent Authority: Guidance for COMAH operators”, published by the HSE and Environmental Agency.

The Inspection

CA regulators will advise Sharpness Docks in advance what they plan to inspect and when.

Where necessary they will also send a draft COMAH intervention plan and, where applicable under EPR (Environmental Protection Regulations), a Compliance Action Plan.

As Sharpness Docks is a lower-tier establishment, inspections will target the safety management systems and how well the major accident prevention policy (MAPP) is being implemented.

The CA inspecting officer will conduct the inspection to ensure that Sharpness Docks has put in place and is maintain robust arrangements to manage their activities that could lead to a major accident.

CA Inspectors focus on the most critical control measures, especially those which are most vulnerable to failure. Inspectors also assess the emergency arrangements in place to protect people and the environment by limiting the consequences if there is a major accident.

This CA inspection is planned to avoid unnecessary duplication and overlap between health, safety and environment regulatory regimes.

The CA view inspection as the most effective way to determine control of major accident risks and includes checking progress with outstanding actions identified during previous inspections.

The CA, to prepare for the inspection, will issue a draft Intervention Plan, which details what will be contained in the planned inspection, such as details of the critical controls to be inspected, inspection priorities that relate to strategic topics (where they apply) and prioritised ongoing work to follow up outstanding compliance actions that inspectors must ensure you have completed.

This notification allows Sharpness Dock to prepare for the inspection, allow time for Sharpness Docks to liaise, if necessary, with the COMAH Intervention Manager prior to the inspection and to make the inspection as efficient as possible.

Every element of the plan is intended to focus on Sharpness Dock’s approach to major hazard and environmental risk management and/or arrangements to mitigate the off-site impact in the event of an accident.

The CA inspector may also be accompanied by one or more specialist inspectors, depending on the range of specific technical topics within the intervention plan.

The CA inspector will concentrate on how well you Sharpness Docks is implementing their MAPP and the relevant parts of their safety management system (SMS) as a key part of a lower-tier site inspection.

At the end of the inspection, there is a feedback session between the CA inspector and Sharpness Docks – this is intended to ensure that Sharpness Docks are happy with the inspection and if not, allows an opportunity to discuss any areas of contention or miss-understanding.

Unresolved challenges regarding any regulatory actions against Sharpness Docks can be raised via the COMAH Challenge Mechanism.

The CA inspector evaluates all controls, measures and practices against published guidance standards, to eliminate any subjective appraisals by the CA inspector and to ensure that mandatory management standards are being met, as required by the relevant Laws and Regulations.

The CA strategic topic delivery guides (including the compliance scoring criteria) are available online at www.hse.gov.uk/comah/ca-guides.htm. Sample extract:

"14. Inspectors should check that the principles considered when preparing a MAPP and SMS include planning for emergencies and the adoption of procedures to: a) Identify foreseeable emergencies by systematic analysis, proportionate to the MAH risks presented by the establishment; b) Prepare, test and review emergency plans to respond to such emergencies; and c) Provide specific training for all persons working in the establishment."

Enforcement

Where there is a serious breach of the law, where necessary The CA will take formal enforcement action – this may be against Sharpness Docks directly, another duty holder or an individual at Sharpness Docks.

The CA for Sharpness Docks is bound by the Regulators' Compliance Code (www.hse.gov.uk/regulation/compliancecode) and Code for Crown Prosecutors (www.cps.gov.uk/publications/docs/code2013english_V2.pdf).

Enforcement decisions will be made in line with the HSE enforcement policies to ensure that they are proportionate to the risks and seriousness of any breach and are applied consistently. The CA Enforcement Management Model (www.hse.gov.uk/enforce/emm.pdf) is available to speed up decision making about recommended enforcement action.

Enforcement action can range from issuing notices (contravention, improvement, prohibition), removal of all or part of their license to store AN, to prosecutions against the company and individuals. Outcomes of prosecution can include fines and imprisonment.

Following an inspection

Within four weeks (nornally) the CA issues a report on the inspection. CA inspection reports follow the same standard format and may include both actions and recommendations.

Where weaknesses in control of major accident risks have been identified, the CA inspection report will clearly describe the actions needed to comply with COMAH, including references to the relevant legislation, approved code or other standards. Sharpness Docks must respond in writing how they intend to deal with any items of non-compliance within four weeks.

Inspectors will always check to see that appropriate remedial action has been taken and advise Sharpness Docks when the items have been closed out satisfactorily.

Should Sharpness Docks does not comply within the stipulated timescale, the CA will most probably take enforcement action to ensure the matter is resolved.

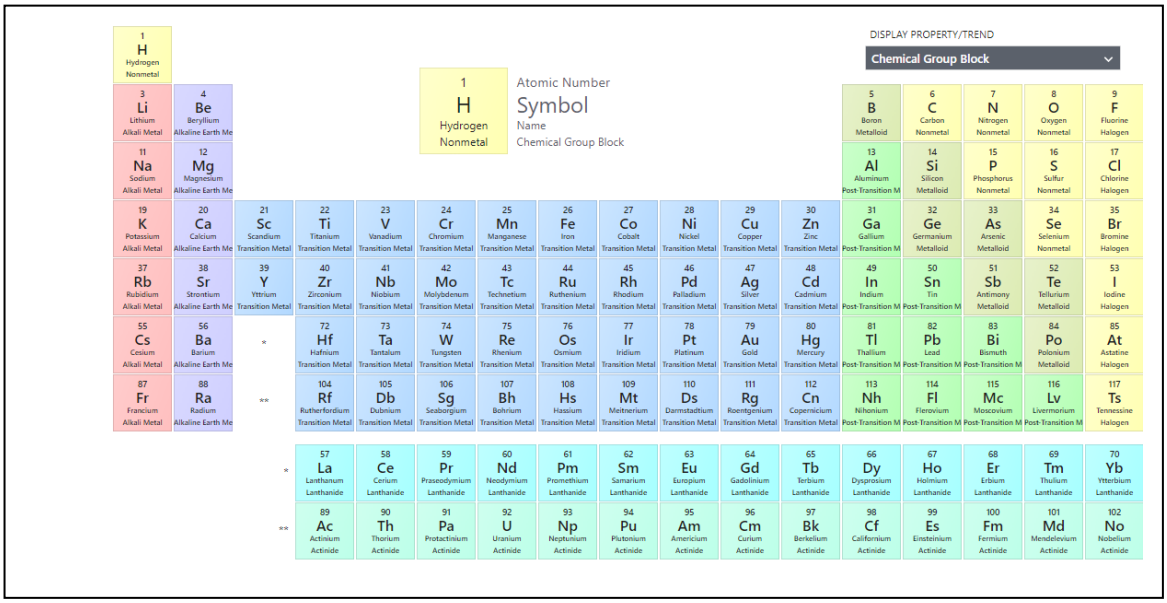
9.4. Understanding Ammonium Nitrate

Terms defined:
Element: a single atom, such as a single Carbon atom, or a single oxygen atom, usually depicted chemically as C, or O.

Compound: Multiple atoms arranged together, such as Water, which consists of two hydrogen atoms and a single oxygen, usually depicted as H_2O, or atmospheric oxygen O_2. The subscript number depicts how many of that specific atom is inside that compound. A non-subscript number prefixing the compound will represent how many of that compounds are used.

Mole (also spelled mol): A mole is a quantity of material, where the mass in Grams is the same as the atomic number, so 1 mole of Carbon is 12.0221 grams of carbon. It is dictated by Avagadro's number, which is 6.022×10^{23}, this number is the number of atoms it takes for the mass of an element to equal its atomic mass. Moles are used to simplify chemical reactions so meaningful numbers are used (2grams, or 1 mole of hydrogen gas (H_2) easier to measure and interpret than 602,214,076,000,000,000,000,000 molecules of hydrogen gas)

Periodic table: The table of elements, normally organised so, from smallest atom to largest in blocks based on chemical and physical properties, typically portrayed like this:



(Table provided by PubChem, https://pubchem.ncbi.nlm.nih.gov/periodic-table/)

Atomic number: The number of protons in the element's nucleus

Atomic mass/ atomic weight: the total weight of the protons and neutrons within an element. The number portrayed is the average mass due to different numbers of neutrons within the atoms.

Reactants: the compounds that are used at the start of a reaction, or a step of a reaction.

Products: The end compounds which are produced by the reaction.

Atomic symbols: as represented above with letters, e.g.: Silver = Ag. Every symbol is capitalised for the first letter and subsequent letters are lower case to prevent confusion in formulae, for example:

Nobelium's symbol is No, if it is incorrectly typed as NO then it will be confused for a nitrogen-oxygen group. Consecutive capital letters denote multiple elements together, e.g., carbon dioxide as CO_2.

Reaction: The action of elements and/or compounds changing from one or more into a different set of compounds. Reactions are typically represented to appear like mathematic equations. One example of such would be Hydrogen and Oxygen combining to make Water:

$2H_2 + O_2 = 2H_2O$

Reversible reaction: The same as a reaction, however the reaction will reverse back into reactants with relatively little energy input.

Chemical Formula / Formulae: Written with subscript numbers and letters which describe which elements and in what proportion are found in the chemical. For example: Glucose, or sugar $C_6H_{12}O_6$.
Where there are brackets it is specifying how the groups are organised to some limited degree, so for example:

$CHO(CHOH)_5H$

which specifies the form of glucose from the Fischer projection.

Where there is a subscript letter in brackets it refers to the state if the products are in a different state to the reactants. For example, hydrogen gas and oxygen gas reacting to make liquid water.

$H_{2(g)} + O_{2(g)} = H_2O_{(l)}$

Atom: the smallest that matter can be broken down in chemical terms.

Atomic nucleus (or just the nucleus): the centre of an atom (protons and neutrons).
Proton: A positively charged particle within the atomic nucleus, the number of protons within an element is the same as the element's number on the periodic table of elements (A hydrogen atom contains 1 proton and its atomic number is 1, carbon contains 6 protons).

Neutron: An uncharged particle within the atomic nucleus, the number of protons usually is equal to the number of protons (however frequently there are more or fewer, which is why atomic masses are not whole numbers).

Electron: A negatively charged particle which orbits the atomic nucleus. The number of electrons orbiting an atomic nucleus is the same number as the number of protons in the nucleus.

Isotopes: An element with a different number of neutrons to the number of protons (Such as Deuterium as referenced is sci-fi pop culture, is hydrogen with 2 neutrons as opposed to the usual 1.)

Ion: An element with a charge, which is caused by there being more or fewer electrons orbiting the nucleus, so for example, a positive ion is the sodium in table salt (Na^+) which has one less electron and a negative ion would be the chlorine in table salt (Cl^-) which has one more electron.

Cation: A positively charged molecule.

Anion: A negatively charged molecule

Covalent bond: The strongest type of atomic bonding, where two atoms share electrons, on a picture representation of an atom it is typically represented as an unbroken line. In instances where 2 or more bonds have been made, they will be depicted with additional lines. (Atmospheric oxygen, O_2 is O = O, for example)

Van der Waals bond: A weaker atomic attraction, where parts of a molecule are negatively charged and other parts are positively charged, an example of this is the attraction that water molecules have to other water molecules, this results in a substance which will melt and evaporate at higher

temperatures than its molecular mass would suggest it should (water boils at 100°c, while methane boils at -161.6°c despite being very similar in atomic mass). Atoms with a larger quantity of protons will attract the electrons within a covalent bond toward themselves more than an element with a smaller number of electrons, resulting in a slight negative charge in one area and a slight positive charge in another.

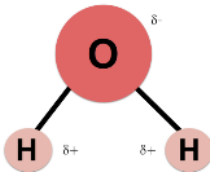
Ammonia: 1 nitrogen and 3 hydrogens, NH_3. It is a colourless gas with a pungent smell.

Nitric acid: HNO_3 previously known as aqua fortis and spirit of nitre, it's a highly corrosive mineral acid. A colourless liquid normally diluted with water for chemistry purposes.

Ammonium Nitrate: The product of ammonia and nitric acid being reacted to form $(NH4)^+(NO3)^-$. For the rest of this discourse, it shall be referred to as AN for short.
Salt: A configuration of a cation and an anion which join to make a crystalline substance, such as table salt.

Acid salt reactions: The occurrence of reacting an acid and an alkaline together generates water and salt. For example, Hydrochloric acid and Sodium Hydroxide (alkaline). HCl + NaOH = H_2O + NaCl (Water and table salt)

Atomic diagram: the simplified picture of molecules represented by their periodic symbol, sometimes reflecting the actual shape of the molecule, but frequently not, for example, water:
H-O-H
Or



Exothermic reaction: A reaction which generates heat. (Hand warming packs sold in outdoors shops are an example of an exothermic reaction.)

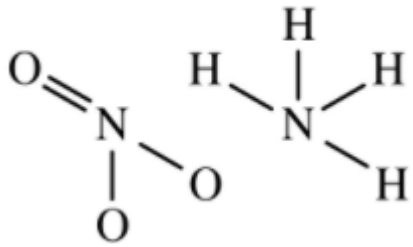
Endothermic reaction: A reaction which removes heat. (Instant ice bricks or cooling packs found in first aid kits is an example of an endothermic reaction.)

Flammable/inflammable: both mean the same thing, that the item/material can be set aflame. (Inflammable does not come from the in-prefix meaning not, it comes from the Latin verb Inflammare meaning "to cause to catch fire" as outlined by the Merriam-Webster dictionary).

Oxidiser/Oxidising agent: there are two definitions for this, the chemistry definition and the dangerous goods definition. The chemistry definition is a substance which will accept electrons from other substances, which usually results in a transfer of oxygen and the release of energy. From a dangerous goods/ materials definition an oxidising substance is one which can cause or contribute to the combustion of other material. (Note: not every chemically oxidising agent will be defined as an oxidising agent by the tests of the dangerous goods / materials requirements, such as potassium dichromate.)

Reducing agent: A substance which in a reaction with an oxidiser will give electrons.

<u>Ammonium Nitrate</u>
Ammonium Nitrate, NH_3NO_3, is a salt, two groups which are attracted to each other to form a crystalline substance, consisting of an NH_4^+ group and an NO_3^-. The diagram looks like this:

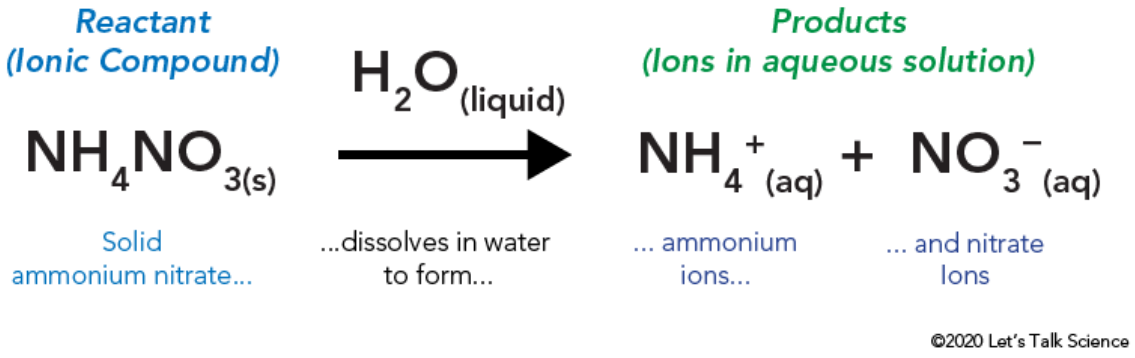


What is the mechanism for the detonation?
There are multiple ways for ammonium nitrate to detonate, however the majority of routes for detonation start with the decomposition of the ammonium nitrate salt, which looks like this:

$$NH_4NO_{3(m)} \rightarrow N_2O_{(g)} + 2H_2O_{(g)}$$

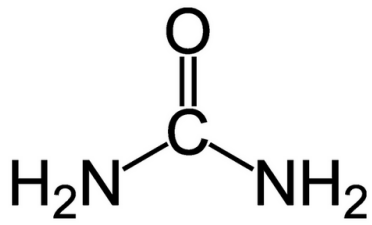
AN

However, ammonium nitrate can assist other fires or explosions by providing a source of oxygen independent to atmospheric oxygen by providing nitrous oxide, which is an oxidising agent and will provide its oxygen when heat is applied. Ammonium nitrate will release heat when dissolved in water, which is why it is so important for it to be stored dry and to prevent ingress of any ammonium nitrate into any drains as this causes a build-up of heat while being in an enclosed space.
The equation for the dissolution in water looks like this:



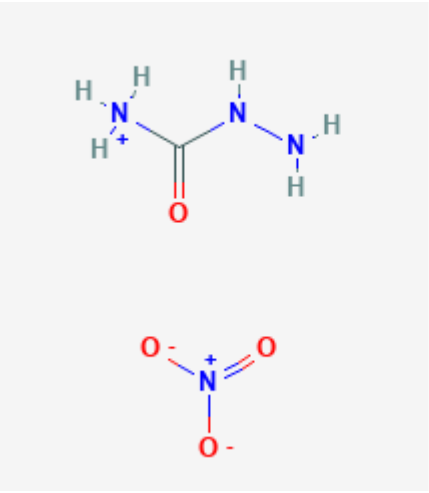
<u>Urea:</u>
Urea (plus water, H20) is a common additive to ammonium nitrate, as it increases Ammonium Nitrate's effectiveness as a fertilizer.

The addition of urea to ammonium nitrate creates what is known as UAN, urea ammonium nitrate, which has a low critical level of humidity, meaning if the relative humidity is above 18% at 30°C, meaning it will absorb atmospheric water and start to liquify in even arid condition. UAN is dissolved in water generally at a 1 in 200 to 1 in 50 ratio of UAN to water.
Urea's formula is: CH_4N_2O, or $CO(NH_2)_2$
The diagram of what it looks like is this:



The safety concerns of urea consist mainly of skin and eye irritation, adverse environmental impacts such as algal blooms which can produce toxins in the environment, and above the melting point it can decompose to produce toxic gases, and can react violently with strong oxidants, nitrites, inorganic chlorides, chlorites, and perchlorates, causing fire, and explosion.
Urea on its own will decompose in similar circumstances to ammonium nitrate creating toxic gases, the formula below;
$CO(NH_2)_2 = HNCO_{(g)} + NH_{3(g)}$
In the decomposition of ammonium nitrate the carbon group of the urea will provide a fuel source for fire to break out.

UAN looks like this:



(To explain, in organic chemistry the presence of a carbon atom forming a chain has a shorthand the centre point of the Y joint in the top molecule is the carbon atom.)
However, urea ammonium nitrate is not stored for any significant length of time due to its low critical level of humidity, it is created and distributed direct to end users.

Uses:

Fertiliser:
The primary usage of ammonium nitrate is in fertiliser.
How?
AN is applied to fields by different methods - it can be tilled directly in to the soil or sprayed over fields, once dissolved in water.

Why?
Ammonium nitrate is used to increase the nitrogen content of soil which has proven benefits to improving crop yield. It is used over other ammonia containing compounds as it is less readily leeched into the soil and is taken up rapidly.

Explosives:
Historically AN was first mass produced in the 1940s for use in weapons munitions.

Instant cold packs:
Dissolving AN in water results in an endothermic reaction (which releases heat into the atmosphere, thereby cooling the cold pack).

Space craft propellent (research stage)

Chemical composition:
$(NH_4)(NO_3)$

Instability based on composition, storage, and ignition sources:
Ammonium nitrate is a relatively stable salt, being able to be stored at room temperature and a relative humidity below 60%, with it starting to decompose above its melting point of 170°C.

When AN decomposes, it generates heat, and will continue to decompose faster in a runaway reaction, the products from the decomposition are Nitrous Oxide (NO_2) and water vapour, which occupy more volume than the AN salt. This rapid expansion of gasses can exceed supersonic speeds which causes the detonation.

The Nitrous Oxide will then readily oxidise with any nearby materials, including metals, or other contaminants available to be combusted or oxidised.

Controls for safe storage:

Safe storage for Ammonium Nitrate has been documented by the HSE, in refence document INDG230, however a summary of it is here:

It must be stored dry, cool, and in less than 300-ton stacks (unless suitable facilities allow more to be stored). It may be stored externally as long as it is suitably protected from rain/standing water and sunshine.

Drainage channels in proximity to any stored AN must be protected, to prevent any potential liquid AN run-off entering the draining system.

Internally stored AN must be kept in structures made of non-combustible materials, such as brick, fire resistant concrete, or steel. Such storage structures must be cleaned prior to any AN storage, to eliminate possible sources of adverse contamination.

Contact with other substances like chlorates, mineral acids, and metal sulphides can lead to vigorous, violent or solid-state detonation exothermic decomposition.

All sources of combustion must be controlled, and any electrical systems must be suitably isolated to prevent sparking.

The AN is best stored pure as any contamination will increase the risk of combustion.

Molten AN is very sensitive to shock and ignition, so all reasonable efforts are to be taken to prevent AN from being in contact with too much humidity or water.

9.5. The role of Ammonium Nitrate in Feeding the Human Race.

Background.
In the 18th century the English cleric Thomas Robert Malthus hypothesized that gains in per capita resources would inevitably be outstripped by human population growth until food supplies could no longer support the predicted growth in population.

This assertion has continued to be put forward, with some scholars predicting mass starvation as anticipated food production fails to keep up with increased demand.

However, technological advancements in the past 150 years enabled increases of yield and the rapid growth in crops around the World.

None of these innovations have had a more dramatic impact on food production than the ability to synthesise nitrogen-based fertilizers, with the outcome that nitrogen fertilizer is now responsible for feeding approximately half of the global population, some 3.7 billion.

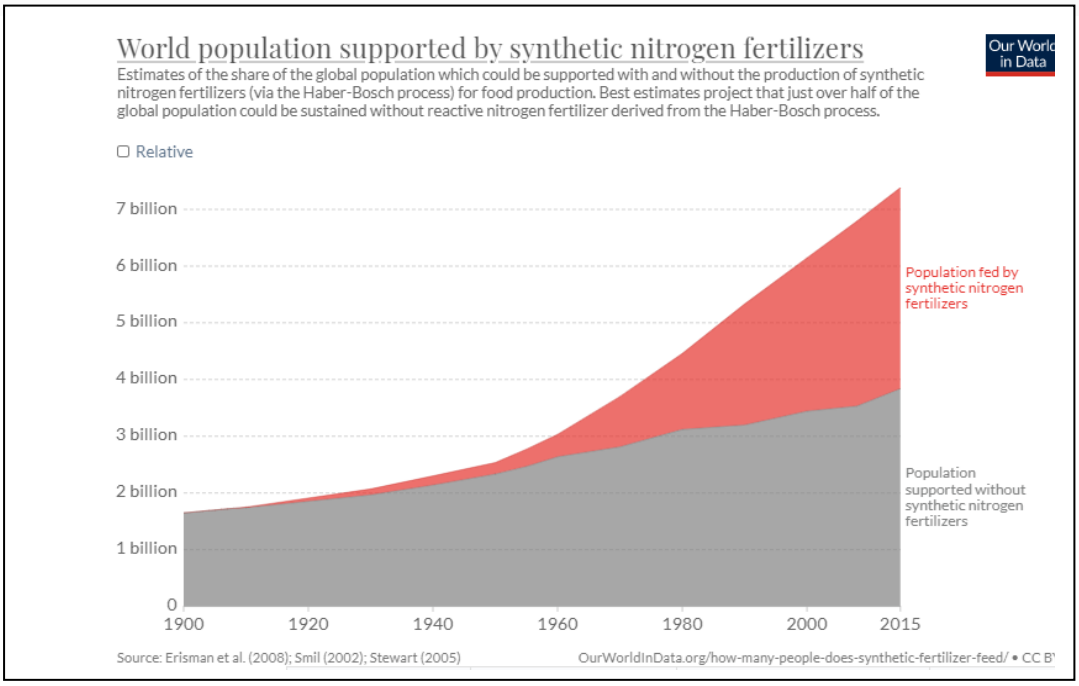
Being arcane - without AN, either half of the World's population would have starved to death / not been borne, or significant – and enforced – population control would have had to have taken place.

The problem
To grow, crops need sunlight, water and three key nutrients: nitrogen, phosphorous and potassium. Nitrogen is commonly scarce in soil, compared to phosphorous and potassium and therefore crop growth can be limited by this comparative lack of naturally occurring nitrogen.

The Solution
While our atmosphere is 78% Nitrogen, it is in a form that cannot be used by plants (N_2).

The above ecosystem balance remained until 1908, when Fritz Haber (a German Chemist), invented the means to convert the unreactive nitrogen in our atmosphere into reactive (NH_3), a form that can be used by plants and crops.

Another German chemist and engineer, Carl Bosch took Haber's innovative process out of the laboratory and made it scalable to meet commercial needs. This "Haber-Bosch" process remains the main method for large-scale production of AN.



9.6. Citations

Standards for CA Inspections **www.hse.gov.uk/comah/ca-guides.htm**.

Competent Authority Guidance for Inspectors on Emergency Arrangements for COMAH
https://www.hse.gov.uk/comah/inspectors-emergency-arrangements-comah-establishments.pdf

Wikipedia

HSE website

PubChem (facility for information on Chemistry)
https://pubchem.ncbi.nlm.nih.gov/periodic-table/

Publicly available information on COMAH facilities
https://notifications.hse.gov.uk/COMAH2015/PublicInformation.aspx?piid=2628

British Safety Services (BSS)

Our World in Data (how ammonium nitrate feeds the World)