



The following is a guidance for ammonium nitrate storage developed by Swiss Re Corporate Solutions Risk Engineering Services. It is intended to help customers, brokers and internal stakeholders navigate the difficulties and mitigate the hazards posed by this material.

Ammonium nitrate is a white, crystalline solid that looks like salt. It can occur naturally but is also manufactured in large quantities by the reaction of ammonia with nitric acid, with its main use being as a fertilizer. However, it is also utilized in pyrotechnics, herbicides, insecticides, an oxidizer for rocket propellants and explosives. There have been instances of the materials being used as part of criminal activities.

Ammonium nitrate in pure form is stable, such that it will not explode due to commonly experienced friction or impact. Heat and confinement or a severe shock can lead to detonation, however. For example, in a fire, molten ammonium nitrate may become confined (e.g. in drains or machinery) and it could explode if it becomes contaminated. Typically, an initiating explosion is required with ammonium nitrate already sensitized by heat and/or contaminants. It is hygroscopic, which means it readily absorbs moisture from the air, which can cause it to clump together. When heated, decomposition products are oxides of nitrogen and water but, provided there is adequate space, this combustion will not result in the material catching fire. However, if confined the gases cannot escape and the heat will increase. The major risk posed by long term storage of ammonium nitrate is due to contamination. Ammonium nitrate will react violently with various materials, particularly organics such as fuel oil. While the thermal decomposition temperature of ammonium nitrate is 200°C, the presence of contaminants can significantly reduce this. Solid ammonium nitrate-based fertilizers can pose a similar threat. Depending on their concentration, specifically blends containing 60% or more, or 40% or more ammonium nitrate mixed with ammonium sulphate. Percentages are by weight. We recommend applying the same guidance to such fertilizers as you do to pure ammonium nitrate.

Recent Loss History

In the past 100 years, there have been several large ammonium nitrate explosions. Including one in Oppau, Germany, in 1921, in Texas City, USA, in 1947 and in Toulouse, France in 2001. The most significant recent events have been in West, Texas, in 2013, Tianjin, China, in 2015 and, most recently, in August of 2020, in Beirut, Lebanon.

Explosions in the early twentieth century, such as at Oppau, were due to the practice of using explosives to break up caked stockpiles of ammonium nitrate. The Texas City disaster started as a fire in a ship that was docked at port; the fire led to a detonation event that killed more than 580 people. The ship had 2,100 metric tons of ammonium nitrate storage on-board in the form of prills that had been coated in wax to prevent caking. It is now known that contamination with organics, such as wax, and heating until molten, particularly in a fire, will sensitize ammonium nitrate to the point that an initiating explosion can detonate it.

With regards to contamination, it is now understood that contamination with many materials, such as organics, chlorides, metals and acids will also sensitize ammonium nitrate and contamination of any form (debris, litter, etc.) should be avoided. Heating ammonium nitrate to melting point will sensitize it, reducing the energy required for it to detonate, but it is understood that an exterior explosion or very significant shock is still required to detonate the ammonium nitrate. In the case of Beirut, this may have been provided by fireworks.

In West, Texas, a fire broke out in a warehouse storing a variety of materials. The fire fighters attempted to control the blaze but were not aware of 30 metric tons of the bulk

ammonium nitrate stored in a bin inside the wooden warehouse. A combination of the heat and contamination led to a massive explosion. The initiating shock or explosion is believed to have been due to a “back-draft” type event caused by a wall collapsing allowing oxygen into the seat of the fire.

The incident at Tianjin was eerily similar, in that an initial fire in a chemical goods logistics facility led to overheating nitrocellulose causing an explosion. This explosion then caused the detonation of some 800 metric tons of ammonium nitrate stored nearby. There were multiple further explosions and the ensuing fireballs and explosion damage destroyed a large part of the port area.

At Beirut the material was seized from a ship six years prior and stored in large bulk bags in a warehouse. The storage conditions remain uncertain. It has been surmised that as the ammonium nitrate was in bags it would have absorbed large amounts of water given Beirut’s humid climate, making each bag more like a large consolidated mass from which heat build-up would be much more difficult to escape. While allowing ammonium nitrate storage to cake up is not advised, the effects of that are not clear-cut. Given the length of time that the chemical was stored there, contamination would be a higher probability. Footage from the incident shows a fire in an adjacent warehouse, with some footage also showing evidence of fireworks. The fire most likely heated the ammonium nitrate to the point where all 2 750 metric tons exploded, causing a massive shock wave inflicting devastation on the city and its residents.

What Should We Do?

The hazards of ammonium nitrate are well known by the people that manufacture it, but less so by the multiple organizations that transport and store it around the world. Because of its widespread use, it can be found in ports, warehouses and other logistical facilities in all corners of the world. In all of these incidents there is a common theme, which is a lack of knowledge and understanding of the hazards involved with storing ammonium nitrate (and ammonium nitrate-based fertilizers.)

We have identified the main threats for ammonium nitrate storage as contamination, confinement and construction. The following needs to be taken into consideration by any facility storing ammonium nitrate:

- **Contamination** – ammonium nitrate needs to be stored away from combustible materials or any other sensitizers, which include acids, chlorides, chromates and metals; in general contamination with any substance, even litter or lube oil leaking from machinery, should be avoided. Ideally, ammonium nitrate should be stored in bags rather than bulk piles, as this poses less of a risk from contamination. It also makes the material less likely to absorb water over time. However, as seen during the explosion in Beirut, bag storage alone is not an adequate control measure.
- **Confinement** – ammonium nitrate should be stored outside where possible or in a well segregated and well-ventilated structure
- **Construction** – ammonium nitrate should NEVER be stored in a combustible building and ideally should be stored well away from any sources of heat, combustion or hot work (e.g. welding.)
- Ammonium nitrate should be stored well away from areas where people live and work.
- Anyone storing ammonium nitrate should be aware of its origins. Ammonium nitrate originating in the EU and UK should be subject to a detonation resistance test carried out by an accredited laboratory, confirming a sufficient degree of detonation resistance.
- On no account should “off-spec” (unregulated) ammonium nitrate be stored in any significant quantities. Typically, such material should be retained by manufacturers for re-processing.

Obviously, the best risk mitigation measure is elimination, but it is recognized that ammonium nitrate is a very valuable chemical with a myriad of uses. It is also noted that there has been no explosion involving ammonium nitrate where it has been stored without contamination, without combustible materials or in a non-combustible building. Regardless, limiting quantities and opting for bags rather than bulk are both significant mitigation strategies.

Technical References:

- NFPA Standard 400, Hazardous Materials Code, Chapter 11; 2019
- “Explosion Hazards of Ammonium Nitrate Under Fire Exposure” US Department of the Interior, Bureau of Mines, Report of Investigations 6773; 1966
- “Guidance Note for Manufacturers, Importers, Blenders, Transporters, Store Keepers and Suppliers of Ammonia Nitrate Based Fertilisers” AIC, Defra and HSE, Version 1; September 2007
- “Storage and Handling of Ammonium Nitrate” (INDG 230), HSE; Reprinted 11/04
- “The Storage, Handling and Transportation of Ammonium Nitrate-Based Fertilisers” AIC; 2015
- “The Explosion Hazards of Ammonium Nitrate and Ammonium Nitrate-Based Fertilizer Compositions: A Summary” Department of Mining Engineering, Queens University, Kingston Ontario; November 1982
- FM Global Property Loss Prevention Data Sheet 7-89, “Ammonium Nitrate and Mixed Fertilizers Containing Ammonium Nitrate” October 2013

The guidance contained in this document, in the opinion of Swiss Re Corporate Solutions, is sound, reasonable and may help to reduce the risk of property loss and business interruption. Swiss Re Corporate Solutions does not warrant that all losses will be avoided or that all reasonable preventive measures have been taken if advice in this document is followed. By sharing its opinion as to certain sound and reasonable practices, Swiss Re Corporate Solutions does not relieve the insured of its own duties and obligations with respect to assessing and implementing loss prevention measures and Swiss Re Corporate Solutions disclaims any liability as respects loss prevention.