

A Synopsis of the 2020 Explosion at the Port of Beirut for the Commercial Explosives Industry

Joshua Hoffman, PhD, P.E.; Institute of Makers of Explosives; Washington, DC, USA

Alexandria Caron, B.S.; Institute of Makers of Explosives; Washington, DC, USA

Abstract

On August 4, 2020, an explosion involving a large store of ammonium nitrate occurred at the Port of Beirut in Lebanon. The event resulted in hundreds of deaths, thousands of injuries, and billions of dollars in damage. Many media outlets reported on the explosion both shortly after the event and in the months that followed. Several investigative reports, technical studies, and post blast analysis have also been created since the 4th of August which are either publicly accessible or published in scholarly journals.

This paper draws upon these credible and publicly accessible sources to summarize facts, figures, timelines, findings, and recommendations relevant to the commercial explosives industry. Commentary and counterpoints to key conclusions are also provided from the standpoint of the commercial explosives industry. Finally, this papers briefly reports on actions, discussions, symposia, and other fora at the international level which examined and addressed the tragic event.

Keywords: Ammonium Nitrate, Beirut, Explosion, Explosives Industry, Lebanon

Table of Contents

1. Background.....	3
2. In the Media.....	7
3. Commentary from the Commercial Explosives Industry.....	9
4. International Response.....	14
5. Conclusion.....	16
6. References.....	18

Background

On September 23rd, 2013, the *Rhosus*, a Moldovan flagged cargo ship had a bill of lading issued from Batumi Georgia detailing the transport of 2,750.4 MTS of high density ammonium nitrate. The ammonium nitrate was packaged in 2,750 bags and was set to be discharged at Beira-Port Mozambique (Bill of Lading, 2013). On November 21, 2013, the *Rhosus* arrived in Beirut to pick up additional cargo. Its unified cargo list now identified its hazardous cargo as “2750 Big Bags”, and failed to mention that the bags contained ammonium nitrate (*Rhosus*’ Transit Manifest, 2013; *Rhosus*’ Notice and Recognition Form, 2013). On November 25, 2013, the *Rhosus* was detained, after an investigation found that the ship’s hatches, including those carrying the ammonium nitrate, were buckling from the excessive weight of the ship’s cargo (Ministry of Public Works Ship Inspection and Report, 2014; Vasolyeva, 2020), and therefore did not meet Lebanon’s international maritime safety regulations. Over several months, the ship’s owners and crew were asked about the conditions of the ship, and the lack of transparency in their unified list (National Trading and Shipping Agency, Official Correspondence, 2014; General Directorate of Customs, Official Report, 2020; Beirut Harbor Master, Official Correspondence, 2014). By April 2014, the Inspection Services Captain reported that the *Rhosus* contained hazardous cargo, and recommended removing the ship from the port of Beirut “since it poses a permanent threat to the safety of maritime navigation and to the protection of the marine ecosystem from pollution.” (Directorate General of Land and Maritime Transport, Official Correspondence, 2014).

Throughout April 2014, the Directorate General of Land and Maritime Transport at the Ministry of Public Works and Transport received several letters regarding the *Rhosus*. These letters from the harbormaster and the law firm representing the ship’s captain all contained warnings of hazardous substances on board the *Rhosus* and the potential impact they may have had on the marine ecosystem. The Directorate sent letters following up with the Case Authority in this matter and relayed the danger of the “hazardous substance” on board, however, he failed to mention that ammonium nitrate is an explosive precursor (Directorate General of Land and Maritime Transport, Official Correspondence, 2014). It is not until June of 2014 that a judge of urgent matters ruled that the *Rhosus* should be re-floated and that its cargo should be moved and stored “in an appropriate place under its custody, after taking the necessary measures given the hazardous material onboard the ship” (Ruling by the Judge of Urgent Matters, 2014). In October 2014 the port’s director general assigned part of a hangar, though the hangar number itself is left blank, as “designated for the storage of hazardous substances”, two days after this designation the cargo

is finally moved from the *Rhosus* to Hangar Twelve (Beirut Port's Director General, Official Correspondence, 2014; General Security Office's Information Report, 2014; Head of the Manifest Department, Official Correspondence, 2014; Directorate of Land, Official Correspondence, 2014). Shortly after, the head of the Manifest Department sends a letter to the Director of Customs' Port of Beirut Service. He warned the Director that he must immediately approve handing over the ammonium nitrate to the Lebanese Army Command as the port does not have the required storage facilities "to avoid any potential disaster resulting from the ignition of the material" (Manifest Department, Official Correspondence, 2014).

The next year contains several correspondences between departments, urging a quick sale of the *Rhosus* and its dangerous cargo. After a 2015 inspection of the *Rhosus*' cargo, it was reported that the ammonium nitrate was "in dire condition" with contaminated material leaking out of torn bags (Cargo Inspection Expert's Report, 2015). Prior to accepting any of the stored ammonium nitrate, the Lebanese Army Command requested a nitrogen grade test, as the grade was not marked on the bags (Army, Official Correspondence, 2015). In February 2016 the nitrogen grade was recorded as 34.7 percent (Customs, Official Correspondence, 2016), confirming it was a restricted explosive material that fell under Legislative Decree (Human Rights Watch, 2021). In April of 2016 the Lebanese Army Command responded to the confirmed nitrogen grade by stating the army does not need any new explosives and suggests that the Customs Administration sell the ammonium nitrate to the Lebanese Explosives Company or re-export the material back to Moldova at the expense of the owner. (Army, Official Correspondence, 2016; Customs, Official Correspondence, 2016). Throughout this process letters are received by the judge of urgent matters and case authority, updating them on the situation. On May 21, 2016, the judge of urgent matters confirmed receipt of a request from the customs department, requesting that the material be re-exported immediately "to preserve the safety of the port and those who work in it" (Judge of Urgent Matters, Receipt of Request, 2016). This request is reiterated in further letters to the judge of urgent matters, and to the case authority throughout the next twenty-two months (Human Rights Watch, 2021). During this time, most of the correspondence regarded who had the authority to issue an order to re-export the ammonium nitrate, as the judge of urgent matters and the case authority continue to forward correspondences and requests to one another.

On February 18, 2018, the *Rhosus* sank (Customs Report, 2018). In March of 2018, after much urging, the Case Authority requests that the Enforcement Department sell the sunken ship and cargo at auction or prepare it for re-export. Once again, the urgency of this request is emphasized by the sunken ship's impact on the port's maritime

safety and environment. At no point in this correspondence does the case authority mention the dangers posed by the ammonium nitrate stored in Hangar Twelve (Ministry of Public Works and Transport, Official Correspondence, 2018). Amid similar requests to those sent in 2016, urging for the resolution of the *Rhosus*' case and re-export of its cargo, a Customs Directorate request for diesel engines was submitted and denied, due to those engines being stored in Hangar Twelve, which was currently filled with ammonium nitrate bags (Head of the Manifest Department, Official Correspondence, 2018). On October 15, 2018, the Enforcement Department approved the Case Authority's long-standing request to sell what was left of the *Rhosus*, after an expert appraisal. However, nothing in the written decision includes the cargo left in Hangar Twelve (Enforcement Department, Decision, 2018).

In December 2019, Joseph Naddaf sent out an alert that there is ammonium nitrate stored in Hangar Twelve and that Hangar Twelve is not secure. An investigation of Hangar Twelve led by the State Security Office takes video of the ammonium nitrate, some of which was spilling out of visibly torn bags (Head of State Security at Beirut Port, Report, 2020; Human Rights Watch, 2021).

On February 7, 2020, the expert appointed by the Enforcement Department conducted his first site visit to the port. His report included that Hangar Twelve contains "hazardous material used to make dynamite but can be used as fertilizer". He recommended assessing the material via a specialized committee before auctioning it (General Security Office, Information Report, 2020). On May 28, 2020, the completed investigation report included a consultation with a chemical specialist, who confirmed that "ammonium nitrate, in case it caught fire, would cause a huge explosion with catastrophic consequences on the port of Beirut." (Head of State Security at Beirut Port, Report, 2020). This report was then turned over to the military and cassation public prosecutors. Reportedly, the Cassation public prosecutor began an investigation by immediately requesting the interrogation of two port officials (Human Rights Watch, 2021).

The Prime Minister of Lebanon first heard about the stored cargo in Hangar Twelve via a phone call on June 3, 2020. Unfortunately, the State Security director general who informed the Prime Minister of the potentially explosive content described it as "2,700 kilograms of TNT" (Human Rights Watch, 2021). When the prime minister decided to arrange his own investigation into Hangar Twelve, he was informed by the head of his ministerial guard that the cargo was in fact 2,700 tons of ammonium nitrate, which had been stored there since 2013 (Human Rights Watch, 2021). The very next day the Cassation Public Prosecutor sent a letter to the port authority and requested the posting of guards at Hangar Twelve, as well as the repair of all the doors and walls in Hangar Twelve, specifically a

“cavity/hole” in the southern wall (State Security, Official Correspondence, 2020). Multiple reports and correspondences reiterating the danger of the “hazardous material” in Hangar Twelve were filed throughout June and July, now including the Higher Defense Council, the Ministry of Public Works and Transportation, and the Ministry of Justice, who were making requests for any information available on the stored cargo (Human Rights Watch, 2021).

At 6:08 pm on August 4, 2020, an explosion originating within Hangar Twelve in the port of Beirut killed over 200 people, injured over 7,000 people, and displaced over 300,000 people (Legal Action Worldwide, 2020). Thousands of buildings were destroyed, and the city’s grain storage was incinerated. By monitoring the plume of smoke originating in Hangar 12, researchers at Forensic Architecture (FA) were able to assign approximate time stamps to public footage based on the plume’s size and color (Forensic Architecture, 2021). Ultimately, four major plumes of smoke were identified. The first two are attributed to the same source on the southeast side of the warehouse. The third is attributed to the northeast side of the warehouse. The fourth plume is attributed to the center of the warehouse and accompanied the final spherical blast.

The timeline begins at 5:54 PM, but even prior to that at 5:54 PM, the warehouse fans were seen depositing plumes of white smoke into the air. While this initial plume of smoke was very light in color, the smoke quickly darkened within two minutes to black. This color change indicates that different materials were beginning to burn. According to witness footage, Fire brigades arrived at approximately 5:58 PM - four minutes after a call to emergency services was placed regarding the smoke. The sound of pyrotechnics can be heard in the background of the brigade’s footage. The heat within the warehouse would have continued to increase, and by 6:07 PM an additional, larger, and darker plume of smoke, accompanied by visible flames and sparks, could be seen from St. George’s Hospital. These sparks were one of the first indicators of additional, smaller, articles being stored in the warehouse. At 6:08 PM, approximately thirty-five seconds after the sparks were witnessed, a spherical blast was visible encapsulating the warehouse. The spherical shape of the blast suggests a singular originating blast according to FA (Forensic Architecture, 2021).

In the Media

Initial reports from quick coverage media outlets such as CNN, NPR, and the BBC depict the explosion at the Port of Beirut as an accident, and then quickly evolve into speculation of regulatory neglect, and governmental

corruption. As the number of reported casualties and injured increased, so did accusations from displeased and bereaved Beirut citizens. Initial reports detailed 135 deaths (Regan, et al., 2020), which later increased to over 200 deaths and over 7,000 injuries after further investigation (Legal Action Worldwide, 2020). These reports also originally indicated that the explosion was due to a major fire at the warehouse, as well as the “firecrackers” stored (Yeung, et al., 2020) in the warehouse. Only two days after the blast, most reports included the Prime Minister’s disclosure of 2,700 tons of ammonium nitrate being stored in Hangar Twelve “without preventative measures” (John, et al., 2020).

As more information became available, investigative news outlets began reporting on the incident, and its potential causes. On August 5th, AP News reported that a U.S. Defense Department Official told AP that at that time the explosion was believed to have been caused by “improper storage of explosives”. AP references a letter from the Lebanese customs department, which confirms ammonium nitrate has been stored in the port. AP describes ammonium nitrate as “a component of fertilizer that is potentially explosive” and establishes a timeline of events where 2,750 tons of ammonium nitrate caught fire, and then detonated (Mroue, et al., 2020).

Similarly, a corrected version of Reuter’s initial report: *Beirut's accidental cargo: how an unscheduled port visit led to disaster*, indicates that the explosion was due to the ammonium nitrate stored in Hangar 12 “for safety reasons” (Vasolyeva, 2020). Reuters describes the chain of events as beginning with the stored ammonium nitrate catching fire and then exploding. On August 14th, Reuters published a deeper analysis of the event, comparing the explosion to a scaled-down nuclear bomb. At this time, Reuters published an estimated TNT equivalency of 200 to 300 tons of “high explosives.” The same article provided an infographic demonstrating this equivalency as parallel to percentages of military weaponry, such as the hellfire missile, and an analogy was made to the 1995 Oklahoma City bombing. Reuters also provided an analysis of seismological data that indicated six blasts, at eleven-second intervals, occurred during the incident. At the time, the analyzing expert Boaz Hayoun (Tamar Group, Israel) noted he could not speak to what caused the blasts, just that they occurred within the same location. Contrarily, the director of IRIS data services was also interviewed by Reuters and stated he did not believe the smaller blasts were associated with the explosion seen in Beirut (Hernandez, et al., 2020).

In November 2020, Legal Action Worldwide (LAW) published its *Report on Behalf of the Victims of the Beirut Explosion* which states that the August 4th blast killed over 200, injured 7,000, and displaced approximately 300,000 people. Furthermore, it is reported that the blast destroyed “thousands” of buildings and “incinerated”

Beirut's grain storage facilities. It should be noted that at this time, nearly three months after the blast, LAW was advocating for an independent and impartial investigation, to be followed by prosecution, on behalf of the victims, and requesting that any information related to the explosion be publicized. This indicates that even three months after the accident there were still uncertainties about the cause and full impact of the explosion.

In August of 2021, Human Rights Watch published their report *They Killed Us from the Inside* after nearly a year of investigations into the explosion had elapsed. Their report details the timeline of the cargo ship *Rhosus*, using publicly available records and correspondence from Lebanese government officials. This report includes several recommendations to Lebanese governing bodies and international associations, including that Lebanese guidelines and investigative practices related to hazardous material be updated to reflect international guidelines.

The New York Times (NYT) compiled coverage from social media and first responders and unearthed years of government documents to create a timeline of the incident, as well as its potential causes. At the time of publication, it is clear from this editorial that the NYT believed the explosion to be the result of a preventable accident, as they include comments from Dr. Glumac of the University of Illinois: "You're putting all the ingredients into a box, and you're playing a dangerous game....This is an accident waiting to happen." The report crucially outlines the hazardous environment the ammonium nitrate was stored in. The report notes that Hangar 12 was not outfitted with smoke alarms or sprinklers, as would be required by current best practices. Visuals of Hangar 12 before the explosion show the ammonium nitrate being stored alongside fireworks, as well as what the NYT describes as "fuses" and "fuel". Additionally, while no theories of the cause of the explosion have been confirmed, the NYT offers a "most likely scenario". Their report states that on August 4th a team of welders was sent to fix Hangar 12 and that perhaps the welders accidentally ignited a fire during their work, which subsequently led to the explosion.

Commentary from the Commercial Explosives Industry

The U.S. commercial explosives industry manufactures, handles, transports, stores and uses ammonium nitrate in two physical forms: one form a solid, referred to as technical grade ammonium nitrate ("TGAN"), and the other form a liquid, referred to as ammonium nitrate solution ("ANS"). Together, TGAN and ANS account for over 90% of the raw material feed used to manufacture modern commercial explosive materials.

The use of AN has become ubiquitous in the commercial explosives industry. Since the 1950s, AN-based explosives have largely supplanted nitroglycerine explosives used in mining and other industries, because of their relative stability. Ammonium nitrate is also used extensively by the fertilizer industry. The form of solid AN used in fertilizer production is commonly referred to as fertilizer grade ammonium nitrate, or “FGAN.” Solid TGAN and FGAN prill are chemically identical. The only difference between the two products is the density. TGAN has a lower density to better retain additives used to produce blasting agents. Because IME represents the commercial explosives industry, the term TGAN is used frequently throughout this paper as these practices and recommendations are by and for the commercial explosives industry. Nevertheless, the recommendations in this paper are equally relevant to the handling and management of FGAN. Because TGAN and FGAN are chemically identical, both forms of the material present the same potential hazards if improperly managed or subjected to similar stressors. In addition, while ANS is commonly used by the explosives industry, this paper addresses the management of solid ammonium nitrate in “prill” form.

There are several recognized and readily available AN management guidelines and industry best practices detailing the proper storage and handling of AN. These practices are not complicated and are simple to implement and maintain with appropriate attention and oversight. The guidelines and best practices have been observed by the commercial explosives industry for decades and the authors of this paper have no knowledge of any accidents that have occurred at any facility where proper storage procedures were followed.

While no official investigation report has yet been issued, the review of media reports on the Beirut explosion appears to be well-researched and credible as the basis for any commentary. Given what is known to date of the conditions in the Beirut facility, it appears that none of the accepted best practices were followed, leading directly to the tragic consequences. Had existing, proper AN management practices been followed, the accident would not have occurred.

Although TGAN is stable under normal conditions of storage, it can become unstable and potentially detonable under certain hazardous conditions. The primary safety hazards associated with TGAN are shock, contamination, and fire. In fact, CAS, a division of the American Chemical Society notes that AN explosions are “almost always preceded by fires or other ignition sources” (CAS, 2020). As a result, Hazard avoidance should be the first measure to consider for preventing certain conditions which could cause a partial or complete detonation.

Confinement has the potential to create conditions where the AN will react more energetically than unconfined. Confinement can be brought about by the vessel in which it is stored, consolidation in enclosed traps such as floor drains, or in extreme cases by its own mass. The AN involved in the Beirut incident is known to have been in 1-tonne supersacks however their packing configuration in the warehouse is not known.

TGAN's bulk density can change over time due to environmental and transportation stimuli due to the prills friability, hygroscopicity, and thermally induced phase changes. This change in bulk density affects its bulk energy density which has the potential for changing the violence of an accidental detonation. The AN involved in the Beirut incident had been present for seven years in a humid coastal environment and rehandled during that time an unknown number of times. These conditions would lead to a degradation in the AN and an alteration of its bulk density.

The mode of initiation will have the greatest effects on the TNT equivalency of TGAN. The most plausible modes of initiation, in order of severity, are shock, contamination, and fire. IME has significant concerns about the reports regarding TNT equivalence. The nature of the physical mechanics, chemical kinetics, and detonics of AN explosions are not easily comparable to those of ideal or molecular explosives, such as TNT. Given the extreme conditions that AN must be subjected to and the different initiation mechanisms that could result in detonation, there are two widely accepted TNT equivalencies for Ammonium Nitrate. 42% (Braithwaite, 2008) is the maximum thermochemical energy available relative to that of TNT and 32% (Nygaard, 2008) which accounts for the high non-ideal nature of pure AN explosions (Swisdak, 2018). Furthermore, a recent peer-reviewed study of the Beirut explosion has yielded TNT equivalencies estimates at a lower bound estimate of 407 tons and an upper bound estimate of 936 tons (Stennett, 2020). Estimates reported well above these accepted values are called into question.

Despite the shortcomings inherent in assigning TNT equivalency to TGAN this metric is used in the following discussion for comparative purposes. When reference is made to higher or lower TNT equivalencies it is always in reference to the maximum theoretical value of 42% as the ceiling. The magnitude of the potential detonation risks (blast effects) arising from each of the three TGAN safety hazards mentioned is expressed in terms of TNT. Further, the TNT equivalency of TGAN is conditionally dependent on confinement, prill density, and mode of initiation (SAFEX, 2011).

Shock initiation refers to driving AN to detonation by means of a strong shock (supersonic velocity) through direct contact with high explosives, proximity to a high explosive event leading to sympathetic detonation, and direct

impact from high-velocity fragmentation or projectiles. This mode of initiation is accepted as the scenario that could release the highest energy with accepted values of TNT equivalency to be between 25-32% (IME SLP30).

When stores of AN are in proximity to explosive materials, AN should be considered a potential acceptor of shock and fragmentation effects from those explosive materials. If explosive materials are accidentally detonated, the resulting shock wave has the potential to detonate nearby AN. Reducing the weight of the explosives, separating the explosives from the AN and blocking the donor shock wave, or fragmentation by a substantial barricade are the primary means to eliminate the shock hazard. When barricades are not used, further reducing the donor weight, and increasing the separation distance between the donor and acceptor are measures to prevent the sympathetic detonation of the acceptor. It has been reported that in Beirut the AN was inappropriately stored together with other energetic materials such as pyrotechnics which could have created a mode of initiation.

Contamination of AN can alter its sensitivity to initiation, change its calorific value, and even lead to runaway exothermic reactions. Organic chemicals and acids, or other corrosives, are identified TGAN contaminants that can cause explosive reactions. Compressed flammable gases, flammable and combustible materials (solids or liquids), including wood chips, saw dust, lubricants, greases, and oils are known organic contaminants. Inorganic TGAN contaminants that contribute to its sensitivity to explosion include, but are not limited to, chlorides, phosphorus, sulfur, and some metals, such as chromium, copper, copper alloys (brass and bronze), cobalt, and nickel, and finely divided or powdered metals such as aluminum and magnesium. Contamination is a hazard of concern associated with TGAN that may cause an energy release equivalent to 3-16% of TNT (SAFEX). These materials should be kept away from TGAN to eliminate the potential explosive hazard. Conducting a workplace hazard assessment to eliminate the known TGAN contaminants is an essential step to eliminating this potential risk.

While the potential for contamination of the AN involved in the Beirut incident is unknown, photographic evidence suggests deterioration in its packaging did occur, which could increase the chance for foreign contaminants to come into contact with the AN. Documentation of an inspection in 2015 by Lebanese authorities reported degraded and contaminated AN (Head of State Security at Beirut Port, Report, 2020; Human Rights Watch, 2021). Given the amount of time the AN was stored and potentially rehandled the chance of some degree of contamination is probable.

Fire is a hazard concern associated with TGAN that may lead to an energy release equivalent to 5% of TNT (SAFEX, 2011). Fire is of particular importance due to the high percentage of oxygen present in the TGAN

molecule (60%.) with it being one of the requisite ingredients for combustion. Equally important factors are fuel and heat. In a fire, TGAN does not burn, because it is not combustible. However, when TGAN is involved in a fire, it becomes an excellent source of oxygen to sustain combustion.

TGAN has a melting point of 1700C (3370F) and if involved in a fire could become molten and become more sensitive to detonation by shock. When temperatures reach 2100 C (4100 F) it will begin to decompose. At lower temperatures, it will decompose into nitrous oxide and water. Nitrous oxide supports combustion since it is an excellent oxidizing agent. At higher temperatures, it can decompose into toxic fumes (oxides of nitrogen), which are red, orange, or brown in color. This effect is also seen in incomplete or low-order detonations of AN and present in videos of the Beirut explosion (Forensic Architecture, 2021).

A fire was present before the explosion and pyrotechnic effects can be seen in the video evidence. The warehouse was not equipped with any fire suppression devices and as the fire moved through it the smoke color changed suggesting different fuel sources. Just before the large-scale detonation, smaller reports of pyrotechnic materials or articles were both heard and seen.

The presence of multiple hazards involving TGAN may significantly increase the probability of an event. For example, if TGAN is contaminated with a fuel, and then a fire occurs, both hazards significantly compound the probability of an event. In addition, when TGAN is in its liquid state because of heating beyond its melting point, it is significantly more sensitive to shock. While these hazards are cumulative in their risk for initiation, they are not cumulative in their TNT equivalency.

The Beirut Port Hangar 12, in which the AN was stored, also had fireworks, fuel, wooden pallets, and other combustible materials co-located, in violation of well-established and accepted best practices for AN storage (Human Rights Watch, 2021). These storage conditions introduce the potential for a combination of the chief hazards resulting in the detonation of the AN present in warehouse 12.

Many IME member companies manufacture, transport, store, and use AN and AN-based explosives and blasting agents. It is through its member companies that IME and partner organizations compile and publish guidelines and best practices to advance the safe handling and use of AN. These recognized and readily available AN management guidelines and industry best practices detailing the proper storage and handling of AN come from decades of technical expertise and experience in managing and using the material. These best resources include:

- IME SLP-30: Safe Handling of Ammonium Nitrate, 2017 Ed.

- IME Guideline for the Responsible Transportation of Solid Ammonium Nitrate by Motor Vehicle, 2020
- IME White Paper Ammonium Nitrate Detonability Question, 2019
- IME Guidance Document Regarding Acceptors Under ATF Regulations at 27 CFR 555.220
- IME SLP-31: Methods and Algorithms Used for Quantitative Risk Analysis, 2018 Ed.
- IME Guidelines for IMESA-FR-Based QRAs for Ports, 2018
- SAFEX International Good Practice Guide: Storage of Solid TGAN
- U.S. Gov. Chemical Advisory: Safe Storage, Handling, and Management of Solid AN Prills (EPA, OSHA, and ATF)
- NFPA 400: Hazardous Material Code, 2022 Ed.

The event did not expose a hazard unknown to the explosives industry. Had the knowledge and recommendations these documents provide been in effect the incident at the Port of Beirut would have almost certainly been prevented.

International Response

Two international organizations of note that have or will be addressing the port of Beirut incident include The Global Congress on Chemical Security and Emerging Threats (Global Congress), and the United Nations.

Global Congress is an international network of experts addressing the threat of the use of chemicals or explosives for terrorism and malicious purposes. It was created in 2018 collaboratively by INTERPOL, the US Department of Homeland Security (DHS), the US Defense Threat Reduction Agency (DTRA), and the US Federal Bureau of Investigation (FBI). The Global Congress meets annually to identify solutions to detect, deter, and disrupt the use of chemical and explosives materials. Best practices, mitigation methods, and security measures are shared through panel discussions and presentations during the annual meeting. Due to the COVID-19 pandemic, the Global Congress was unable to convene in 2020 or 2021, and instead a series of webinars have been facilitated in its place.

The first session in a four-part 2021 series “A multi-sectoral approach to new and persisting vulnerabilities in the chemical security arena” was held in January 2021 and titled “Port of Beirut Explosion: Lessons spurring global change.” The presentations focused on what was publicly known at the time with no acknowledgment of existing rules and regulations in the context of their ability to prevent what took place in Beirut. Two of the speakers focused on heavily restrictive regulatory regimes for the handling of AN within their jurisdictions. While perhaps

warranted and understandable in the context of their specific geopolitical security concerns it is of concern to see such examples being discussed in the context of an industrial incident as potential models for improvement.

The United Nations and the Organization for Economic Co-operation and Development (UN/OECD) are co-organizing an international forum “UN/OECD seminar in follow-up to the 2020 Beirut port explosion: Lessons learned, experiences and good practices in managing risks of ammonium nitrate storage, handling and transport in port areas, preventing accidents and mitigating their consequences.” The United Nations organizations party to organizing the seminar are the United Nations Economic Commission for Europe, the International Labour Organization, the International Maritime Organization, the United Nations Environment Programme/Office for the Coordination of Humanitarian Affairs Joint Environment Unit, and the United Nations Office for Disaster Risk Reduction (Regional Office for Arab States).

The scope of the seminar includes risk management of AN and AN-based fertilizers in ports including storage, handling, and transport with special attention to high-population areas. Accident prevention, preparedness, and response methodologies will be discussed by authorities having jurisdiction. The objectives of the seminar are to:

- Identify lessons learned from the Beirut port incident;
- take stock of international laws, policies, guidelines, best practices, etc. relevant to AN; and
- exchanges lessons, experiences, and good practices on both risk management for AN, and needs associated with prevention, preparedness, and response associated with typical accident scenarios (UNECE Events, 2021).

With that, the outcomes may serve to highlight the legal frameworks and control measures for addressing the risks associated with the handling, storage, and transport of AN in port areas. As such seminar conclusions will also provide a basis for possible future action to be carried out by participating entities.

IME has accepted an invitation to present along with the Australasian Explosives Industry Safety Group, Fertilizers Europe, SAFEX, and National Fire Protection Association however all five associations must share a 15-minute presentation time.

It is of note that IME has participated in an Advisory Group under its consultative status before the UN Sub-Committee of Experts on the Transportation of Dangerous Goods. The Advisory Group provided expert advice

to the Organizing Committee in the development and conduct of the seminar.

Conclusion

Ammonium nitrate is classified as an oxidizer primarily used as a fertilizer, an explosive precursor, and for chemical manufacture. While it is a very stable compound it also requires strict controls for safe storage and transport. Because of this, it is a heavily regulated dangerous good (hazardous material). The primary hazards of heat/fire, chemical contamination, and shock are well known and understood.

Organizations including IME specify the required controls to avoid these hazardous conditions through best practices, guidance, and other safety publications. These industry publications prescribe controls required for the safe storage of ammonium nitrate and are made freely available.

Over the decades, millions of tons of AN have been safely stored, transported, and used. Where there have been incidents, the resultant investigations have shown that failure to observe prescribed and/or accepted controls led directly to unfortunate event.

IME holds that any accident must be explored and explained. While this may never be fully possible for the incident at the Port of Beirut, from what is known, it is clear that improper storage practices were the primary underlying factors leading to the explosion.

IME has the following policy recommendations regarding the presence of AN at ports:

- The focus should be made on raising awareness among government and industry on the risks and potential impacts of poorly managed AN;
- Efforts should be made to clarify roles and responsibilities for implementing known best practices noting that, in the Beirut Port event the port was under the jurisdiction of the Port Authority;
- Safety and security risk vulnerabilities should be assessed for AN; and
- Any quantitative risk assessments are best made using accepted tools that incorporate AN explosion physics.

As a safety and security organization whose members have longstanding and comprehensive expertise in the management of ammonium nitrate, IME is committed to participating in any conversation or public forum to share its knowledge as more is learned about the tragic events at the Port of Beirut.

References

1. Amos, et al., BBC News, Beirut blast was 'historically' powerful. October 5, 2020
<https://www.bbc.com/news/science-environment-54420033>
2. Army, Official Correspondence Request for a Sample to be Analyzed to Customs, November 19, 2015
3. Army, Official Correspondence to Customs, April 7, 2016
4. BBC News, Beirut explosion: What we know so far, August 11, 2020
<https://www.bbc.com/news/world-middle-east-53668493>
5. Beirut Harbor Master, Official Correspondence to the Head of Maritime Transport Service, March 17, 2014
6. Beirut Port's Director General, Official Correspondence to the Directorate General of Land and Maritime Transport, October 21, 2014
7. Braithwaite, et al., Ammonium Nitrate: Fertilizer, Oxidizer, and Tertiary Explosive, UKELG, Loughborough, September, 2008
8. Cargo Inspection Expert's Report, February 16, 2015
9. CAS, Ammonium Nitrate Explosions: Lessons Learned, 2020
10. Customs Report Related to the Sinking of Rhosus, February 20, 2018
11. Customs, Official Correspondence to Judge of Urgent Matters, May 20, 2016
12. Customs, Official Correspondence to the Army, February 27, 2016
13. Decision by the Enforcement Department, October 15, 2018
14. Directorate General of Land and Maritime Transport, Official Correspondence to the Case Authority, April 14, 2014
15. Directorate General of Land and Maritime Transport, Official Correspondence to the Case Authority, April 8, 2014
16. Directorate of Land and Maritime Transport, Official Correspondence to Case Authority, November 26, 2014
17. Forensic Architecture, Beirut Explosion Model, March 1, 2021
<https://forensic-architecture.org/investigation/beirut-port-explosion>

18. General Directorate of Customs, Official Report to the Minister of Finance, August 11, 2020
19. General Security Office's Information Report, February 7, 2020
20. General Security Office's Information Report, October 23, 2014
21. Head of State Security at Beirut Port Report, May 28, 2020
22. Head of the Manifest Department, Official Correspondence to Head of the Customs Port of Beirut Service, October 24, 2014
23. Head of the Manifest Department, Official Correspondence to the Head of the Customs Port of Beirut Service, October 24, 2014
24. Head of the Manifest Department, Official Correspondence, April 10, 2018
25. Helen Regan, Tamara Qiblawi, Ghazi Balkiz, Ben Wedeman and Luke McGee. 2020. Ammonium nitrate stored in a warehouse linked to catastrophic Beirut explosion. August 6.
<https://www.cnn.com/2020/08/05/middleeast/beirut-port-explosion-ammonium-nitrate-intl-hnk/index.html>
26. Hernandez, et al., Reuters, How powerful was the Beirut blast?, August 14, 2020
<https://graphics.reuters.com/LEBANON-SECURITY/BLAST/yzdpxnmqbpX/>
27. Human Rights Watch, Lebanon: Evidence Implicates Officials in Beirut Blast, August 3, 2021
<https://www.hrw.org/video-photos/interactive/2021/08/02/lebanon-evidence-implicates-officials-beirut-blast-targeted>
28. Human Rights Watch, They Killed Us From the Inside, August 3, 2021
<https://www.hrw.org/report/2021/08/03/they-killed-us-inside/investigation-august-4-beirut-blast#>
29. IME, SLP-30 Safe Handling of Ammonium Nitrate, June, 2018
30. John, et al., CNN, Beirut explosion rocks Lebanon's capital city, August 6, 2020
https://www.cnn.com/middleeast/live-news/lebanon-beirut-explosion-live-updates-dle-intl/h_899205b6017c9c015c20806e59e02284
31. Judge of Urgent Matters, Receipt of Request from Customs, May 21, 2016
32. Legal Action WorldWide, Report on Behalf of the Victims of the Beirut Explosion, August 4, 2020

https://www.legalactionworldwide.org/wp-content/uploads/REPORT-ON-BEHALF-OF-VICTIMS_compressed.pdf

33. Maria Vasolyeva, Reuters, Beirut's accidental cargo: how an unscheduled port visit led to disaster, August 6, 2020
<https://www.reuters.com/article/us-lebanon-security-blast-ship/beirut-accidental-cargo-how-an-unscheduled-port-visit-led-to-disaster-idUSKCN25225M>
34. Ministry of Public Works and Transport Ship Inspection and Report, April 2, 2014
35. Ministry of Public Works and Transport, Official Correspondence to Case Authority, March 5, 2018
36. Mroue, et al., AP News, Negligence probed in deadly Beirut blast amid public anger, August 5, 2020
<https://apnews.com/article/virus-outbreak-global-trade-ap-top-news-international-news-middle-east-4475998de078a93bbe91b7ac9d43ada2>
37. National Trading and Shipping Agency, Official Correspondence, February 28, 2014
38. Nygaard, Yara International ASA, Storage of Technical (Porous) Ammonium Nitrate, presented at International Society of Explosives Engineers Conference, Porsgrunn, Norway, 2008
39. Regan, et al., CNN, Ammonium nitrate stored in a warehouse linked to catastrophic Beirut explosion, August 6, 2020
<https://www.cnn.com/2020/08/05/middleeast/beirut-port-explosion-ammonium-nitrate-intl-hnk/index.html>
40. Rhosus' Bill of Lading, September 23, 2013
41. Rhosus' Notice and Recognition Form, November 16, 2013
42. Rhosus' Transit Manifest, November 16, 2013
43. Ruling by the Judge of Urgent Matters, June 27, 2014
44. SAFEX International, SAFEX Good Explosive Practice Series, Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate, March, 2011
45. State Security, Official Correspondence to the Port Authority of Beirut, June 4, 2020

46. Stennett, et al. Prop., Explos., Pyrotech, An Estimate of the TNT-Equivalent Net Explosive Quantity (NEQ) of the Beirut Port Explosion Using Publicly Available Tools and Data, 2020
47. Swisdak, M.M., Evans, B., APT Research Inc.; Huntsville, AL “Ammonium Nitrate Modeling in the AN Module of IMESA FR”; Proceedings from the International Explosives Safety Symposium & Exposition, August 6-9, 2018
48. Vasilyeva, Reuters, CORRECTED-Beirut's accidental cargo: how an unscheduled port visit led to disaster, August 6, 2020
49. Yeung, et al, CNN, What we know about the Beirut blast, August 6, 2020
<https://www.cnn.com/2020/08/05/middleeast/beirut-blast-explainer-intl-hnk/index.html>