



# AN AVOIDABLE TRAGEDY

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The 2013 ammonium nitrate explosion that devastated much of West, Texas, could have been prevented by applying some simple and long-known fire safety principles.



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**MANY EXPLOSIONS** have complicated causes and no simple safety solutions. But ammonium nitrate fertilizer explosions in storage or transport are an exception in that accidents analyzed to date have had a single root cause: uncontrolled fire due to inadequate fire safety provisions. The 2013 disaster that devastated a significant part of the town of West, Texas, serves as an object lesson of the consequences of uncontrolled fire hazards. Some very simple, traditional, and long-known fire safety principles, if accepted and implemented, would have precluded the Texas disaster. A reorientation of the thinking of industry and government is needed to avoid future disasters.

Ammonium nitrate,  $\text{NH}_4\text{NO}_3$  (AN), has been used as a fertilizer for about a century. For even longer, AN has been used as an ingredient in making explosives. Since the 1950s, the latter use is most commonly as ANFO, which denotes a combination of AN with fuel oil. Even without the fuel oil addition, AN is an explosible substance — despite U.S.<sup>[1]</sup> and international regulations<sup>[2]</sup> classifying it as an oxidizer rather than as an explosive. Compared to other, more potent explosives such as TNT or RDX, AN is less powerful and also less sensitive, with sensitivity meaning the ease by which the substance can be detonated.<sup>[3]</sup> Some even more commonly encountered substances classified as oxidizers, such as calcium hypochlorite, tend to accelerate a fire but do not show a significant propensity for exploding. However, AN not only accelerates fires and causes hypergolic ignition of cellulosic fuels when in its molten state, but also it is well-known for *A Century of Explosions*, as characterized by Pasturenzi.<sup>[4]</sup> A more detailed examination of this century of explosions — limited solely to AN fertilizer in storage or transport environments and where not accompanied





Photos 1 and 2: The site of the West Fertilizer Company before and after the explosion (Source: ATF)

by other explosible substances — has shown about 60 serious accidents.<sup>[5]</sup> Highly disturbing is that this database shows that given an uncontrolled fire, there is about a 30 percent likelihood of an explosion, but also a 15 percent probability of loss of life.

Despite this tragic record of *A Century of Explosions*, no useful safety improvements have been undertaken. Many chemicals are dangerous, for various reasons. Thus, it is an elementary principle of chemical engineering that to improve safety, accidents must be studied with an eye toward determining the common thread within a class of accidents.<sup>[6]</sup> Once this is recognized and identified, appropriate safety measures can be considered. However, in the case of AN disasters, the opposite approach is often taken: Study the latest disaster to learn what uniquely went wrong to cause it. If this approach is taken, there is no hope of learning from mistakes and instituting remedial measures that are likely to prevent the next disaster. Thus, AN explosions must be treated like other chemical industry disasters: Achieve safety improvements by identifying the common thread leading to failures. When this is done, the database reveals that 100 percent of the disasters have been caused by uncontrolled fire. Not a single incident has been located to date of an AN fertilizer explosion in storage or transport that was not caused by an uncontrolled fire.

### The West, Texas, Disaster

On April 17, 2013, a significant portion of the town of West, Texas, exploded. This resulted in the deaths of 15 people, mostly volunteer firefighters, and over 200 individuals injured.<sup>[7]</sup> Three schools were damaged, resulting in two of them needing to be demolished. The explosion also destroyed a nearby nursing home, an apartment complex, and 142 private homes,<sup>[8]</sup> with some structures being damaged more than 2,000 feet (600 meters) away.

At 7:29 pm, a policeman on patrol in a park called the county emergency services dispatcher to report a fire at the West Fertilizer Company. A civilian independently called in a report at 7:32, and at that time, the fire department was dispatched to the scene. The first engine arrived on scene at 7:39 pm, followed shortly by several other units. Upon arriving, the volunteer fire department was confronted by a fully involved structure fire, with the closest fire hydrant located more than 1,475 feet (450 meters) away and having poor water pressure. A massive explosion was recorded at 7:51 pm, shortly after the firefighters had set up and started applying water to the fire. The explosion occurred 19 minutes after the first notification, 16 minutes after dispatch, and only 11 minutes after the arrival of the first engine.

Photo 1 shows an overview of the fertilizer facility and its destruction. The AN was stored in the building at the center bottom of the photo, with the explosion originating in the vicinity of the main storage bin, located toward the left end of the structure. The building where the AN was stored was built of wood and had no fire-resistive construction features. The site had a burglar alarm system and some hand-held fire extinguishers, but no sprinklers and no smoke detectors. Furthermore, the fertilizer was stored in wood bins, which had become AN-impregnated over time. Adjacent to the main AN bin was an elevator pit — even though pits, drains, and similar features are a known hazard for AN storage<sup>[9]</sup> due to their potential role in creating confinement for a detonation.

After the explosion, physical investigation of fire debris was not useful because not only was the building demolished, but also a sizable crater was created where the main AN bin used to be. Nonetheless, investigative efforts concluded that it was not likely caused by use of smoking materials, spontaneous

combustion, or incendiarism.<sup>[10]</sup> What could not be excluded was the possibility of electrical wiring failure. In fact, prior inspections had indicated that the wiring system was in poor condition, largely attributable to the corrosive nature of AN stockpiles.

However, some three years after the incident, the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) issued a press release concluding that the fire had to be incendiary, since all possible non-incendiary fire causes had been excluded.<sup>[11]</sup> This prompted a stern editorial<sup>[12]</sup> in a fire safety journal pointing out that the ATF was basing its determination on negative corpus, defined as “the process of determining the ignition source for a fire by eliminating all ignition sources found, known, or believed to have been present in the area of origin, and then claiming such methodology is proof of an ignition source for which there is no supporting evidence of its existence.” The use of negative corpus is specifically prohibited in the guide to proper fire investigation procedures.<sup>[13]</sup> Also, such a logic-defying pronouncement was especially unfortunate in view of its effect on the families of the victims, as well as the townspeople of West in general.

### Codes and Regulations

The West Fertilizer Company facility was located at the city limits of West, and the building itself was outside the city proper. However, the city had neither a building code nor a fire code. This is common in rural areas of the United States. In fact, the State of Texas explicitly prohibits sparsely populated counties from adopting a fire code,<sup>[14]</sup> although West was not in one of these counties.

U.S. building and fire codes that regulate the storage of AN do so indirectly. Instead, they adopt by reference NFPA 400,<sup>[15]</sup> the Hazardous Materials Code, to provide details. At the time of the West disaster, the pertinent edition was 2013; subsequent to the disaster, NFPA responded by updating the code to a 2016 edition. The 2013 edition was seriously flawed in mandating very few safety requirements, allowing the grandfathering of existing non-compliant facilities and allowing the local code official to accept deviations and omissions.<sup>[5]</sup>

The 2016 edition improved the document and tightened up the requirements. However, even the 2016 edition would not have prevented the West disaster.<sup>[16]</sup> While the level of fire safety at the West facility was extremely inadequate, storing AN in a facility of this kind had been the norm in the U.S. In the aftermath of this disaster, over 1,300 AN storage facilities were identified in the U.S. alone.<sup>[17]</sup> Most of these facilities are old and not significantly different from the West facility in their construction aspects. As a result, an uncontrolled fire in any other such facility would entail a comparably serious risk of a detonation disaster.

### Failsafe Safety Measures

In many occupancies, while fire risks can be managed and reduced, the potential for an uncontrolled fire cannot be categorically ruled out. This is because fires need fuel and an oxidizer for combustion, and, in most cases, neither one of these can be assuredly precluded. For example, homes require mattresses, sofas, and other highly combustible goods, while offices are typically places where large quantities of paper need to be stored. But AN storage facilities are an exception to this generality. The AN itself is an oxidizer, not a fuel. To store and handle AN fertilizer, very minimal combustibles are needed, an amount not sufficient for propagating a fire. Required materials might include wire insulation, a powered loader, and very little else. AN storage facilities have been built as concrete domes with no potential for uncontrolled fire, but such construction has been rare. Still, by their existence, it is shown that an AN facility can be built where an uncontrolled fire is a physical improbability.

In principle, such construction alone would suffice to eliminate any hazard. But because the incremental cost is small, it is prudent to require that these facilities also contain a central-station monitored fire alarm system and an automatic sprinkler system. It is also prudent to prohibit pits, drains, and other features that can provide detonation confinement; again, this is a low-cost safety measure. Finally, it is prudent to require that AN storages not be located in propinquity to other explosible materials, although this would rarely be an issue. Thus, to summarize, robust assurance against fire, and therefore, against explosion of AN storages, can be obtained by requiring:<sup>[18]</sup>

- Storage of AN only in detached, noncombustible buildings and noncombustible bins, with only extremely limited combustible items of any kind (e.g., electric wire insulation) allowed
- An automatic fire sprinkler system in full conformance to NFPA 13
- A fire or smoke alarm system monitored by a central station.
- Prohibition against pits, drains, and other features where molten AN could collect
- Prohibition of siting AN facilities in propinquity to storages of other substances susceptible to exploding

Details describing the role of industry and government in this process have been published.<sup>[19]</sup>

### What is Not Required

NFPA 400-2016<sup>[15]</sup> and the U.S. Chemical Safety Board<sup>[7]</sup> state that important safety strategies for AN storage facilities include (1) the establishment of setback (buffer zone) requirements and (2) plans and provisions for the evacuation of nearby individuals.

However, this is an unsound view,<sup>[20,21]</sup> because it fails to

consider the safety of first responders. If any evacuation is needed, it is very likely (as was the case at West) that there will be some occupants who are not able to self-evacuate. This includes persons who are disabled, incompetent, or impaired of sight or hearing. The only way that evacuations can be reliably accomplished is by a door-to-door canvas, which should be accomplished by first responders. If civilians are located where they might be injured or killed by the effects of explosion, first responders have to place themselves in that same endangered environment. Furthermore, the process may be greatly protracted, since in emergencies, erroneous reports often circulate concerning occupants located at places which searches later reveal are unoccupied.

Setback requirements are inappropriate for similar reasons as is reliance on evacuations. If safety measures for the facility and the product are such that explosions are precluded, then setback provisions do nothing useful. If explosions are not precluded, then a potential exists for causing lethalties among first responders, even if setbacks are mandated. This, again, is because there may be a need for first responders to enter the facility in search of people needing rescue or assistance. For a facility that is precluded

from exploding, zero setback is fully sufficient, while if it can explode, no practicable setback distance will eliminate the danger.

Evacuations and setback regulations are weak safety measures — and yet, possibly, the only available one for unexpected disasters of an unknown nature that cannot be precluded. Such weak measures are inappropriate when strong safety measures are known which would preclude explosions.

### **Actions to Promote Safety**

Companies that store AN fertilizer are most commonly small, local establishments, and this was true at West also. As such, they cannot be expected to have expertise in hazardous chemicals explosion safety. Federal government agencies do have expertise in this area, but their efforts have been inadequate, and there are no clear signs of improvement.<sup>[20]</sup> This leaves the product manufacturers as entities that could completely change the AN safety environment. Two actions would suffice:

(1) Change from producing AN to producing calcium ammonium nitrate (CAN).<sup>[5]</sup> The latter is in use or mandated in a number of countries, but not in the U.S. It constitutes a similar product which, while still explosible, is so difficult to detonate that

not a single accidental explosion has been reported of CAN in storage or transport.

(2) Withhold from selling product to distributors that have not been inspected and found to operate a fire-safe facility. ▲



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