Journal of Loss Prevention in the Process Industries 49 (2017) 132–138

Contents lists available at ScienceDirect

Journal of Loss Prevention in the Process Industries

journal homepage: www.elsevier.com/locate/jlp

West Fertilizer Company fire and explosion: A summary of the U.S. Chemical Safety and Hazard Investigation Board report

Ronald J. Willey

Department of Chemical Engineering, Northeastern University, Boston, MA 02115, USA

ARTICLE INFO

Article history:
Received 4 January 2017
Received in revised form
11 June 2017
Accepted 12 June 2017
Available online 23 June 2017

Keywords:
Ammonium nitrate explosion
Emergency response coordination

ABSTRACT

Storage of fertilizer grade ammonium nitrate (FGAN) is common worldwide. The material is stable when stored at ambient temperatures. However, ammonium nitrate is explosive when exposed to higher temperatures and/or a shock wave source. The presence of even 0.2% carbon adds to the blast potential. This paper summarizes the key finding of an ammonium nitrate explosion that occurred at a FGAN storage facility on 17 April 2013 in West, Texas, USA. 15 people were killed including12 emergency responders who were fighting a fire that occurred on the property before the explosion. Over 260 were injured. The key lessons learned are reviewed and recommendations are offered below.

1. Introduction

Bulk ammonium nitrate storage occurs worldwide because of its importance as a fertilizer and as a mine explosive. The material is stable when stored at temperatures below 40 °C. Part of the reason is that the initial reaction, transition from ammonium nitrate to ammonia and nitric acid, is endothermic. Fertilizer grade ammonium nitrate (FGAN) is classified as an oxidizer identified by United Nations Hazardous Material Number of UN1942 or UN2067. By its chemical nature, ammonium nitrate [U.S. DOT, 2005; Ammonium Nitrate, 2016), NH_4NO_3 or AN in some abbreviations, has an oxidizing group, NO_3 molecularly adjacent to a reducing group, NH_4. At higher temperatures, ammonium nitrate decomposes very rapidly to various nitrogen oxides (NO_2, NO, and N_2O), nitrogen, oxygen, and water vapor with energy released in the form of localized temperature increase, and in the form of a pressure wave that can exceed 100 bars in over-pressure impulse at the source (Berthelot, 1883, from Davis, 1945)[1]. If carbon is present, the oxygen generated rapidly oxidizes the carbon to the formation of gaseous CO_2. Notable ammonium nitrate explosions include the 1921 explosion in Oppau, Germany (4100 tonnes 561 killed) (Oppau, 1921), the 1947 explosion in Texas City, Texas, USA (2100 tonnes, nearly 600 killed) (Texas City, 1947), the 2001 explosion in Toulouse, France (3000 tonnes, 29 killed) (Toulouse, 2001), and the 2015 explosion in Tianjin (1300 tonnes, 173 killed) (Tianjin, 2015; Sun, 2015).

2. Background

The material summarized below is condensed from an Investigation report issued by the U.S. Chemical Safety Board (U.S. CSB, 2016) in 2016.

The city of West, Texas, USA is located in the central portion of the 2nd largest state in the USA (see Fig. 1). The city of West, Texas is about 120 km south of Dallas, Texas, USA. Its population at the time of accident was approximately 2800 people. An overview of the city is shown in Fig. 2. The red outline area in Fig. 2 is the location of the fertilizer company where the explosion occurred. West Fertilizer Company began business in West, Texas in 1962 with the purpose of supplying fertilizer, grain, and farming supplies to the nearby farming industry. When the facility was first built the surrounding area was essentially composed of fields and open space. As the years passed, buildings such as the West Terrace Apartment Complex, West Rest Haven Nursing Home, West Intermediate School, and West High School were added.

Fig. 3 shows that the storage facility was mainly constructed of wood. The roof was underlain with plywood and had asphalt shingles. All of these materials are combustible and provide sources of carbon. The building lacked a sprinkler system. The primary ammonium nitrate storage bin was constructed of wood framing and plywood sides. Its dimensions were 2.4 m wide, 6 m long, and

E-mail address: r.willey@northeastern.edu.

[1] Calculations done by author, decomposition of 22 kg of AN within a confined 1 m^3 space with surrounding air can create 100 bar overpressure. Typical storage density is above 500 kg/m^3.

http://dx.doi.org/10.1016/j.jlp.2017.06.008
0950-4230/

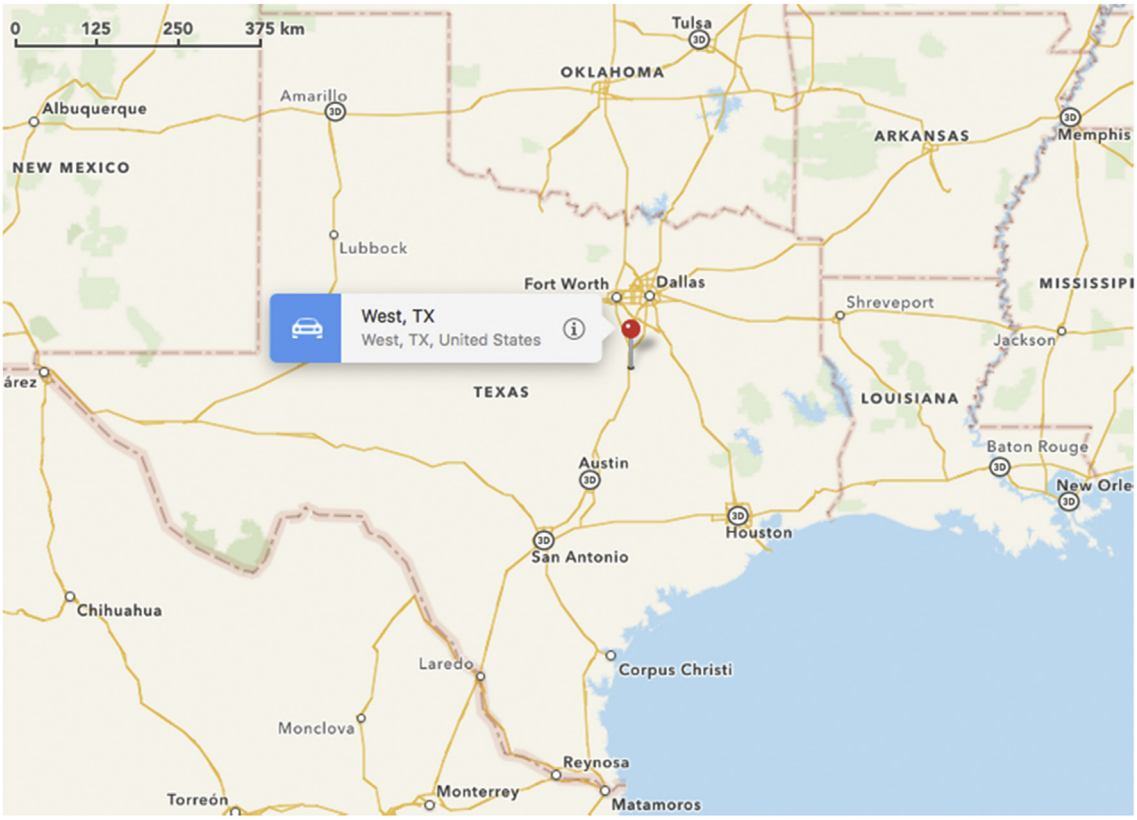

Fig. 1. Location of the city of West, Texas. It is 120 km south of Dallas, Texas, USA.

9 m high. Employees reported that FGAN tends to adsorb moisture and dissolve. Thus, the building was air-conditioned in order to prevent moisture accumulation within.

At the time of the accident, West Fertilizer Company had 36–55 tonnes of fertilizer grade ammonium nitrate stored within a storage building (Item 5 in Fig. 2) and another 91 tonnes stored in a nearby rail car (located below Item 7 in Fig. 2). It is estimated that 30 tonnes of the ammonium nitrate stored within the storage building detonated. The railcar contents did not detonate nor catch on fire.

3. The event

The event began as a fire within the storage building (Fig. 3). At 19:29 on 17 April 2013, citizens began reporting sightings of smoke (Fig. 4). The source was identified as the West Fertilizer Company complex. A police officer responded followed by the West Volunteer Fire Department with two pieces of fire-fighting apparatus. The police officer, recognizing the severity of the fire, began local evacuation of nearby people at a basketball court and playground. He then sealed off traffic access to the complex. The first of three fire engines is reported heading to the complex at 19:37. At 19:51, 14 min after the first signs of smoke, an explosion occurred with a TNT equivalent estimated at 11.4 tonnes.

Shown in Fig. 5 is an overview of the West Fertilizer complex after the explosion. Essentially, the complex was fully destroyed. The overturned FGAN rail car indicates how violent the explosion was. Typically, an overpressure wave of 0.6 bar or better is required to overturn a rail car (NOAA, 2016). Nearby seismic data recorded an event similar to an earthquake of 2.1 on the Richter Scale at 19:50. A 3 m deep by 23 m diameter crater was created below the main FGAN storage bin (Fig. 6 and Fig. 7). 15 people were killed. 350 homes were damaged with 142 homes destroyed beyond repair. Included within the blast wave damage was one nursing home and 3 nearby schools. In May 2016 investigators from the Bureau of Alcohol, Tobacco, Firearms, and Explosives deemed that the initiator fire was intentionally set (Stanglin and Jervis, 2016).

4. Evaluation of scenarios that caused the FGAN to detonate

Although FGAN can detonate, it is a rare event, even when fires are nearby (Davis, 1945; U.S. CSB, 2016). The CSB report forwards two possibilities and three scenarios for the transition to detonation for the ammonium nitrate stockpile. One possibility involves the ammonium nitrate being contaminated from the soot (carbonaceous material) that provides fuel to the oxidizer (FGAN). Fig. 4 demonstrates the transition of the smoke color during the fire with the initial fire showing white smoke (Fig. 4A), transitioning over to a fire with black smoke (Fig. 4B). The presence of black smoke indicates a high level of soot or carbonaceous material from partially burnt wood and asphalt shingles. Some of the carbonaceous particles may have fell on top of the ammonium nitrate stockpile.

Another possibility may have been heat buildup within the storage bin where the ammonium nitrate melted, and then decomposed in a fashion that initiated full decomposition. The heat buildup came from the radiant energy of the surrounding flames. Ammonium nitrate with a carbon source present can exothermically decomposed when the temperature exceeds 180 °C (Dolah et al., 1966). Pure ammonium nitrate's onset temperature is reported at over 300 °C (Davis, 1945; Oxley et al., 1989).

The three detonation scenarios are discussed in the report: **Scenario 1:** Detonation from the top of the FGAN pile; **Scenario 2:** Detonation in heated FGAN along exterior wall exposed to fire; and **Scenario 3:** Detonation in elevator pit that spread to main FGAN