ARE WE REALLY LEARNING" A Case study- Still Going Wrong"

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This Presentation which is part of my forthcoming book titled "Are We Really Learning?" whose idea got inspiration from Last ASSP PDC where I got inspiration to go through all global catastrophic incidents. In this book I am working on a new age "Process Safety Management" process - "MLW-CAR-TOWARDS SOCIETAL RISK"

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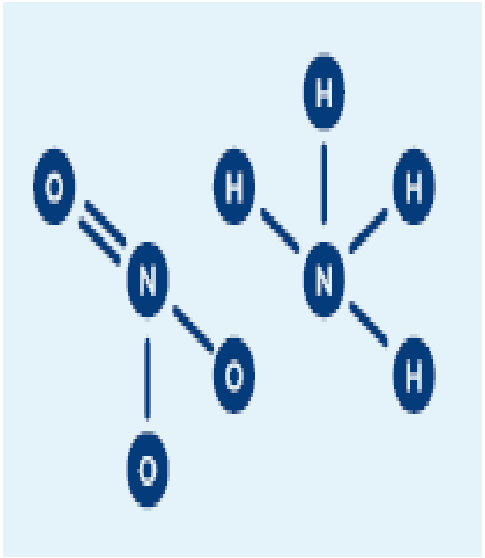
CHEMJIAGANG, CHINA
2019
OPPAU, GERMANY
1921
TIANJIN, CHINA
2013
MIHAILESTI, ROMANIA
2004
JAREZ, FRANCE
2003
WEST, TEXAS, US
2013
TOULOUSE, FRANCE
2001
TEXAS CITY, US
1947
BEIRUT, LEBANON
2020

WHAT IS AMMONIUM NITRATE?



- WHITE CRYSTALINE SOLID INORGANIC CHEMICAL COMPOUND
- PREDOMINANTLY USED AS NITROGEN FERTILIZER
- USED IN EXPLOSIVES MAKING
- POWERFUL OXIDIZER THAR RELEASES HIGH ENERGY WHEN SUBJECTED TO SHOCK OR EXPOSED TO HIGH TEMPERATURES IN A CONFINED AREA.
- HIGHLY HYGROSCOPINC SUBSTANCE WITH NATURE OF ABSORBING MOISTURE FROM NATURE AND FORMS AQUEOUS SOLUTION MAKES IT.
- RISK OF EXPLOSION INCREASES WITH THE COMBINATION OF HEATING, CONTAMINATION AND CONFINING.
- ITS EXPLOSIVE NATURE IS 1000 KILOGRAMS OF IT EQUIVALENT TO 250 KILOGRAMS OF TNT(TRINITORTOULENE) UNDER BULK STORAGE CONDITIONS.

SEPT 21, 1921- OPPAU, GERMANY

- On 21. September 1921 the explosion of an ammonium sulfate nitrate silo in Oppau killed 507 and injured 1917 people.
- 4500 Tons of Ammonium Sulfate Nitrate was stored.
- Ammonium sulfate nitrate is a mixture of 2 salts: ammonium nitrate (explosive) and ammonium sulfate (inert). The explosiveness of the mixed salt is mainly determined by the ratio of these 2 salts. The influence of the mixed salt composition on the sensitivity to detonation impact had been thoroughly investigated before the accident as it was common practice to use small explosive charges to loosen the salt which had solidified during storage in the silo.
- About 20.000 blasting operations were carried out without any notable incident. Experiments conducted after the accident revealed that several physical parameters (particle size, density, water content, homogeneity of crystal structure) also had an influence.
- The introduction of a new drying process for ammonium sulfate nitrate (spray process, “Spritzverfahren”) caused changes in all these parameters resulting in a salt with increased explosiveness.
- In addition a dust-like fine fraction with increased ammonium nitrate content was formed which accumulated at the edge of the silo.

SEPT 21, 1921- OPPAU, GERMANY

NEIGHBOURHOOD DISTRUCTION

- It can be assumed that on the day of the accident at least one of the explosions for loosening the caked salt was carried out in the area of the fine fraction, thus initiating a detonation of this fine fraction and causing the detonation of further fractions with approximately “normal” nitrate content.
- This accident is a strong example for the need of Management of Change (MOC) procedures, which are an integral part of today´s process safety.
- - Lack of care by operators induced by introduction of a new bonus system which was linked to the production quantity
- - Introduction of the new spray process - Deviations from the operating procedures resulting in the addition of wrong amounts of AS (too little) or AN (too high)
- Fine dust in 100 of tons ignored settling down with a thickness of 0.5m has created as dust cloud which lead to the explosion.

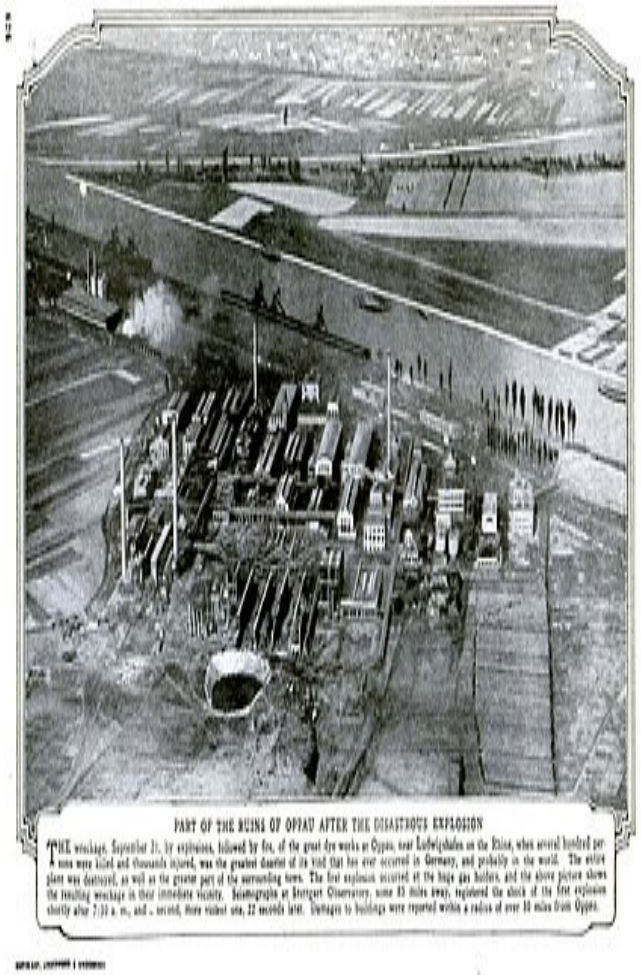
SEPT 21, 1921- OPPAU, GERMANY

NEIGHBOURHOOD DISTRUCTION

SEQUENCE OF EVENTS

- - Introduction of the spray process at the beginning of 1921
- - Accumulation of a fine fraction with AN content > 55 %. This fine fraction is sensitive to detonation impact from Perastralit cartridges.
- - The accumulation of the fine fraction is not noticed since it is located at the edge of the silo and since the main fraction has the required AN/AS ratio.
- - The physical parameters of the main fraction have changed, causing an increased sensitivity to a strong detonation impact
- - The blasting operation on 21.09.1921 for loosening the solidified salt was carried out at least partially in the area of the fine fraction thus initiating a powerful detonation
- - The detonation of the fine fraction acts as booster for further ASN with correct AN/AS ratio, which due to changed physical parameters is able to explode

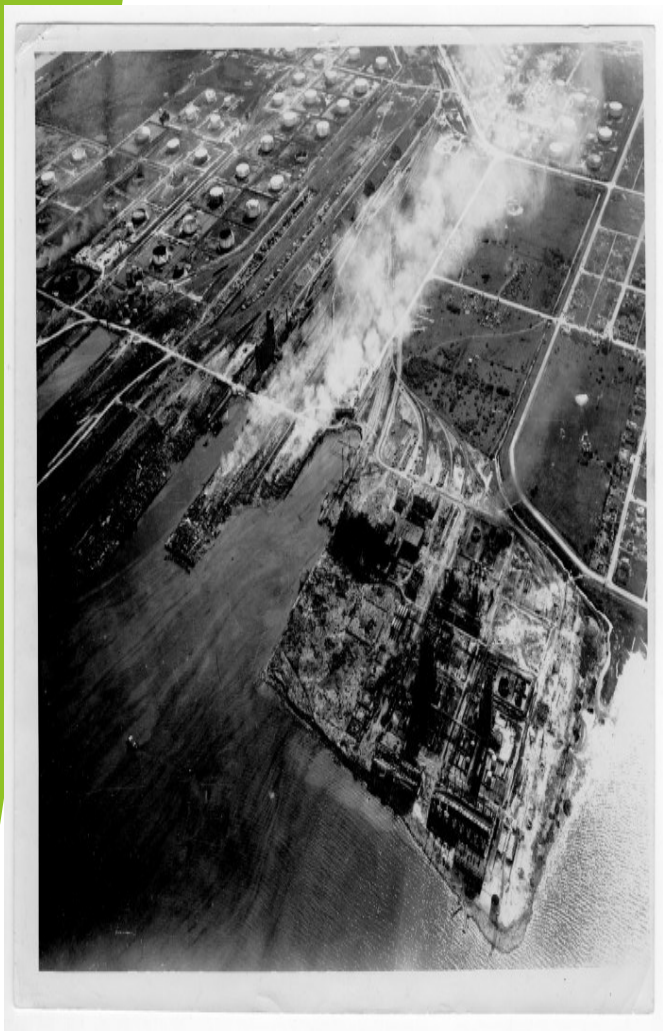
SEPT 21, 1921- OPPAU, GERMANY


PART OF THE RUINS OF OPPAU AFTER THE DISASTROUS EXPLOSION

LESSONS LEARNED FOR SIMILAR OPERATIONS TODAY

- Management of Change: Before implementation of a process change the consequences to process safety must be checked and the safety concept must be updated
- In particular the influence of the process change upon the safety characteristics of the handled materials must be determined
- If a process has an extremely high hazard potential, it must be impossible that one single fault (e.g. a deviation from the correct chemical composition of ASN) can activate this hazard potential

APRIL 16, 1947- TEXAS CITY, USA



SS GRANDCAMP Explosion at Texas Port

- carrying combustible material sisal, cotton and peanuts, small arms ammunition and Ammonium Nitrate bags produced during war time and later to be used as fertilizer.
- Early in the morning fire was caught.
- The ship exploded while fire control measures were being carried out.
- The entire dock area got destroyed along with nearby Monsanto chemical company, smaller companies, wear houses, storage tanks.
- Flying debris prompted more explosions and tidal wave of 13ft(4 Meters) high has swept the dock area, destroyed minimum 1000 residences and buildings.

LESSONS LEARNED

- Always treat any scene with ammonium nitrate, or any other explosive compound, as just that, an explosive device
- First responders do not have the appropriate PPE to protect ourselves from any energetic material.

SEPT 21, 2001- AZF FRANCE

BEFORE EXPLOSION

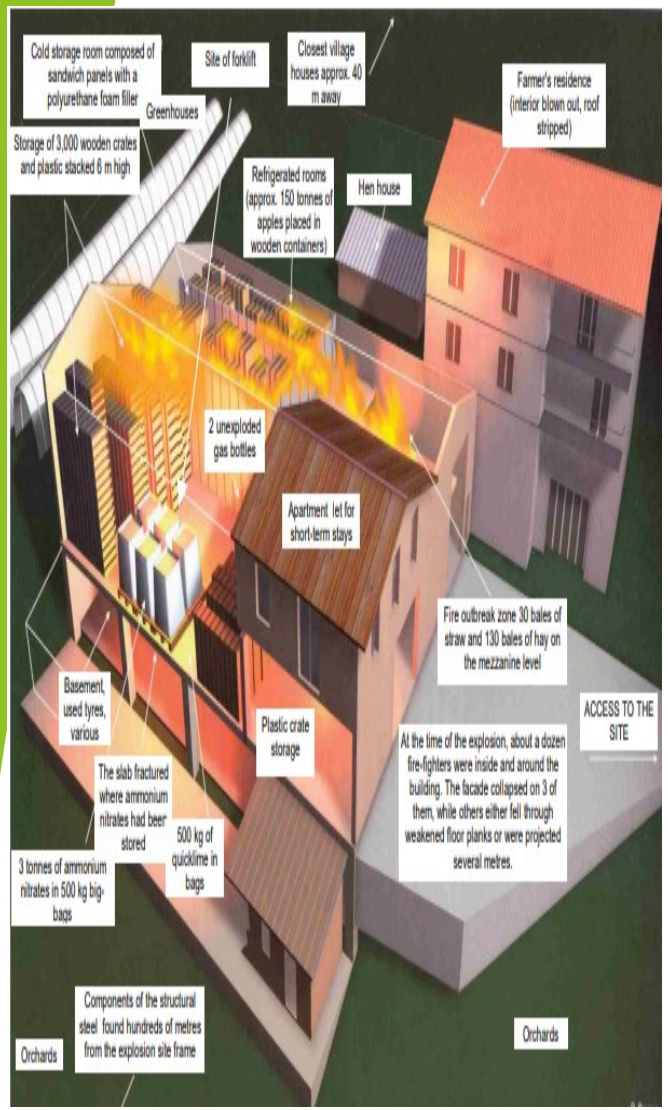
AFTER EXPLOSION

- The explosion occurred in a downgraded ammonium nitrates store, which was authorized for 500 tons and contained approximately 400 tons of product on the day of the explosion. The chemical was stored flat and separated by partitions.
- The TNT equivalent mass of the explosion was estimated by INERIS to be in the range of 20 to 40 tons of TNT.

Lessons Learned:

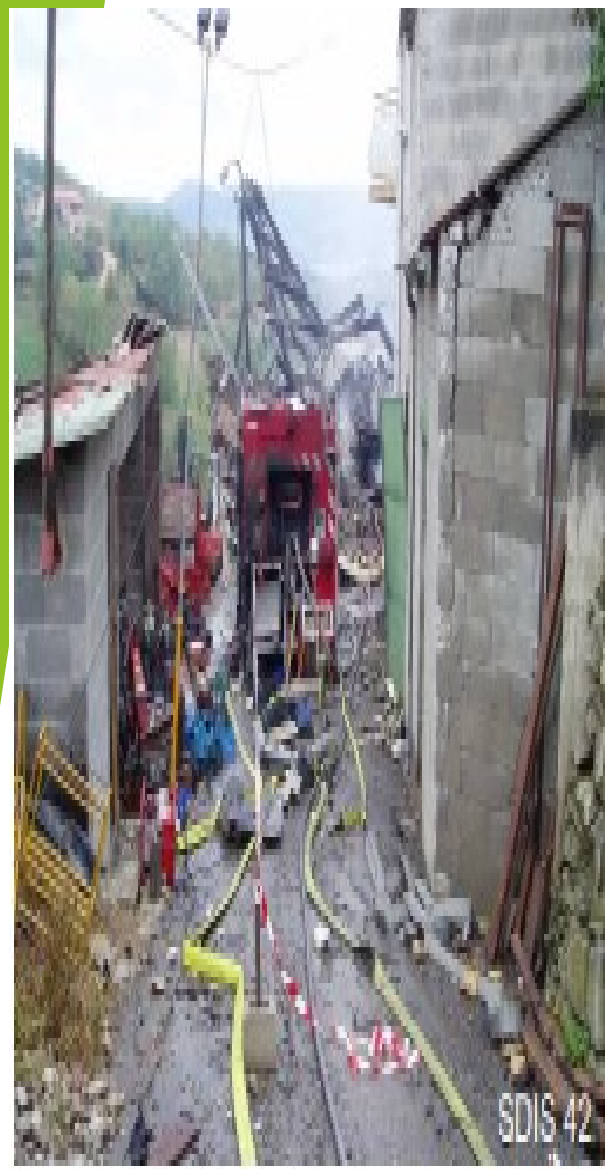
- Redefinition of ammonium nitrate to cover lower percentage composition.
- Necessary to improve quality of hazard studies and their homogeneity between different industrial sites. Studies should specify basic assumptions concerning accident scenarios, external threats and failure of safety systems.
- Reduce the risks posed by hazardous installations via various measures such as double confinement and breaking up stock into smaller amounts.
- Harmonization of regulation requirements for transport of goods in areas such as ports and marshalling yards.
- Defined new land use planning rules that deal with potential hazardous situations.

SEPT 21, 2001- AZF FRANCE



- On Thursday, October 2, 2003, at around 3 pm, a fire broke out inside the barn of the tree farmer at the mezzanine level used to store, among other items, bales of hay and straw. Alerted by his son who had smelled the emanating smoke, the farmer unsuccessfully tried to put out the fire using an extinguisher. Fire-fighters were notified about a farm fire at 4:02 pm. Upon arriving on the scene, at 4:23, they had to battle an extremely violent barn blaze responsible for releasing an impressive plume of smoke. The crew set out to extinguish the main source of combustion, with the aim of saving the house adjoining the barn using 4 variable-rate nozzles, yet the team quickly faced water supply interruptions. The captain called for a "water supply backup" unit at 4:38 pm. The fire-fighting strategy adopted had to be adapted to both the amount of water resources and the fire's progression. Once the house was out of danger, fire-fighters turned to two variable-rate nozzles in order to protect the flat that was still intact on the barn's first floor.
- The human toll of this accident amounted to 26 injuries: 18 fire-fighters, 9 of whom seriously; 3 gendarmes slightly hurt by effects from the blast (temporary hearing loss); these individuals were positioned some 50 m from the explosion site; 5 bystanders with slight injuries, knocked down by the effect of the blast or in some cases hit by hot projectiles.

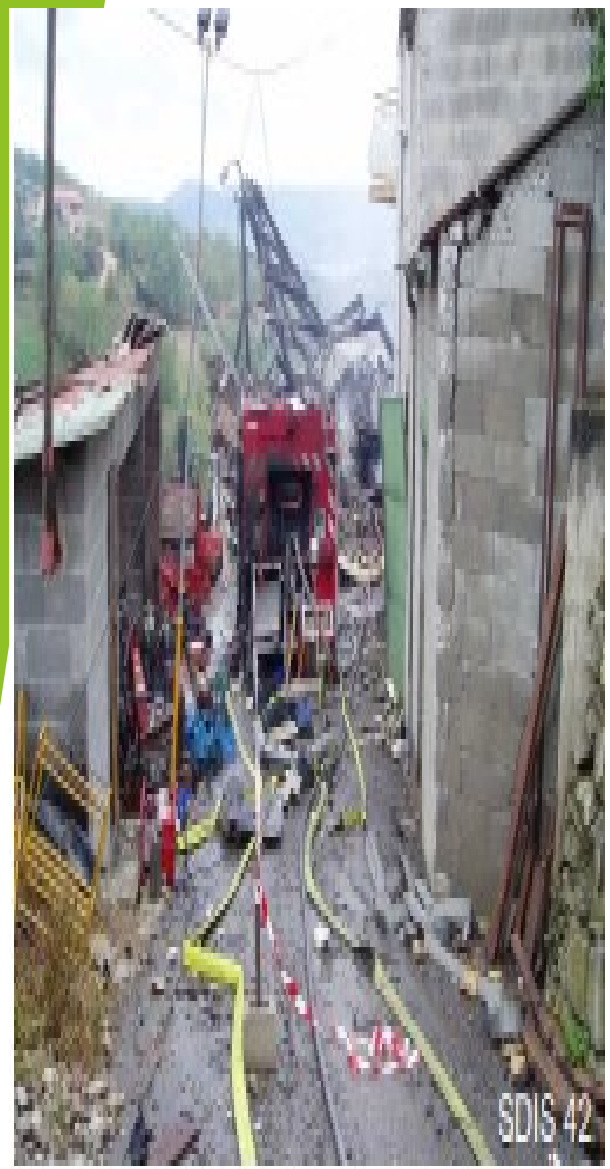
SEPT 21, 2001- AZF FRANCE



LESSONS LEARNED:

- Clean, well ventilated and appropriately signed premises (up-to-date and visible posters of safety guidelines to be followed, in particular "no smoking" signs).
- Ensure electrical circuits and equipment in good working order, compliant with standards and verified on a regular basis;
- Workplace and safety guidelines developed by the farmer, who is also responsible for ensuring that the content is known to and applied by all, including external contractors working onsite, along with regular personnel training sessions, particularly for employees involved in accident prevention.
- Bag storage, intended to reduce the risks of fertiliser contamination by means of incompatible products;
- Fertiliser storage in a barn that contains none of the following: products capable of igniting during a fire: straw, hay, cereals, livestock feed, sawdust, wooden crates, pallets, sulphur, etc. Fertilisers are combustive products that cause fires to grow (fertiliser bags carry the "combustive agent" warning logo).
- products capable of contaminating fertilisers: organic materials, fuel, fuel oil, gasoline, gas, phytosanitary products, and a number of incompatible products (chlorates, copper salts, etc.);
- Prohibition of fertiliser storage in zones with direct access to hot spots, flames, bare light bulbs, electrical wires, heating ducts, welding operations; in the absence of personnel or operating activity, it is recommended to proceed by

SEPT 21, 2001- AZF FRANCE



LESSONS LEARNED:

- Fertilizer storage only within a fire-resistant cell, to the greatest extent possible.
- Vehicle parking at safe distances from fertilisers and proper maintenance of motorized vehicles so as to avoid:
  1. fertiliser contamination by eventual fuel or oil leaks,
  2. vehicle hot spots (engine, exhaust pipe, etc.).
  3. Room equipped with fire-fighting gear (equipment in appropriate quantity and quality for the specific risks encountered, enabling either internal or external response).
- In the event of fire or risk of fire, the farmer must be able to identify products, with the assistance of commercial documentation, as well as indicate to responders the quantity of fertilizers present onsite and their exact storage locations

MAY 24, 2004- MIHALESTI ROMANIA

In the early morning of 24th May 2004 at the entrance of Mihăilesti village a road truck transporting 20 t of ammonium nitrate skidded off the road, overturned in the ditch and slipped several meters. The cabin of the truck caught fire in a few minutes after the impact. The ammonium nitrate was transported in sacks, from which in the moment of the impact some flew off the trailer and many of them got broken releasing the substance on the ground. The driver of the truck reported the accident to the police and tried to extinguish the fire in the cabin. Civilians travelling on the road and local people from the village stopped to help him extinguish the fire, but without success. The fire was spreading due to the strong oxidizers presence. Also two reporters from the Antena 1 station were present filming the event. Later two special fire-fighter trucks arrived and started to prepare the equipment for the intervention, but the explosion took place before they could start to extinguish the fire. The explosion took place approximately after 1 h from the moment of the impact. The Istria seismological station (aprox. 160 km from Mihăilesti) registered two earthquakes, the first at 05:47:44 and a second, much stronger at 05:48:45. The second earthquake was comparable to a 3 MSK earthquake originating from the Vrancea area. The results show the fact that probably two explosions took place consecutively, the second one being much stronger.

MAY 24, 2004- MIHALESTI ROMANIA

The consequences of the accidents were catastrophic: - 18 deaths (fire-fighters, local people, reporters, policemen), 11 injured;

- 150 m of E85 road destroyed; - 16 houses damaged: windows broken or roof damaged; - 6 private cars damaged or destroyed; - 2 fire-fighter trucks heavily damaged; - electrical supply network of Mihailesti village damaged. Heavy pieces from the truck were projected at hundreds of meters, the central axle of the truck weighting 1.5 t being found in the roof of a house at 250 m from the accident.
- Learning from the incident:
- A general conclusion is that both accidental and deliberate accidents will continue to occur unless best practices are implemented in industry and transportation and unless lessons learned from past accidents are applied. Considering the earthquakes measured at Istria station it can be concluded that two explosions took place in the case of Mihăilesti accident. The first explosion was weaker and a lower TNT equivalency could be associated with it. The second explosion was probably a detonation and a high TNT equivalency should be associated. A more detailed analysis of the Mihăilesti explosion is necessary for the determination of TNT equivalencies.

MAY 24, 2013- WEST TEXAS, US

WEST FERTILIZER COMPANY FIRE AND EXPLOSION

(15 Fatalities, More Than 260 Injured)

- On April 17, 2013, a fire and explosion occurred at the West Fertilizer Company (WFC), a fertilizer blending, retail, and distribution facility in West, Texas. The violent detonation fatally injured 12 emergency responders and three members of the public. Local hospitals treated more than 260 injured victims, many of whom required hospital admission. The blast completely destroyed the WFC facility and caused widespread damage to more than 150 offsite buildings
- The explosion happened at about 7:51 pm central daylight time (CDT), approximately 20 minutes after the first signs of a fire were reported to the local 911 emergency response dispatch center. Several local volunteer fire departments responded to the facility, which had a stockpile of between 40 and 60 tons (80,000 to 120,000 pounds) fertilizer grade ammonium nitrate (FGAN), not counting additional FGAN not yet offloaded from a railcar.

leading Indicators Ignored/Violated:

- In 2009 insurer gave a notice to WFC stating they were not renewing the insurance due to lack of compliance with Loss Prevention recommendations based on audits between 2006 to 2009 on automobiles and drivers, storage and application of dry and liquid fertilizers, grain and feed milling and anhydrous ammonia.

MAY 24, 2013- WEST TEXAS, US

3. Exposed 440-Volt Electrical Wiring Identified in 2007 Survey

. Damaged Electrical Cord Identified in 2008 Insurance

.oss control specialist findings:

- A corroded 440-volt wire ran from the pole on the north side of the plant through the bulk fertilizer facility to the anhydrous ammonia tank area on the south side of the facility.
- An aluminum ground wire showed noticeable signs of corrosion from the fertilizer. The loss control specialist noted that the wire could lose its ability to ground, potentially causing shock and fire hazards.
- Several temporary lighting sockets needed to be wired in permanently to reduce the potential for electrical shocks and fire hazards.

➢ Fire fighter fatality causes:

1. Lack of incident command system. 2. Lack of established incident management system. 3. Lack of hazardous materials (HAZMAT) and dangerous goods training. 4. Lack of knowledge and understanding of the detonation hazards of FGAN. 5. Lack of situational awareness and risk assessment knowledge on the scene of an FGAN-related fire. 6. Lack of pre-incident planning at the WFC facility. 7. Limited and conflicting technical guidance on AN.

MAY 24, 2013- WEST TEXAS, US

Lessons Not Learned and Lessons Learned :

- Pre-West-Incident FGAN-Related Fires and Explosions: Lessons Not Learned
- Found that lessons learned from previous firefighter fatalities and emergency responses to FGAN related incidents were not effectively disseminated to firefighters and emergency responders in other communities where FGAN is stored or used.

Technical Findings

1. The presence of combustible materials used for construction of the facility and the fertilizer grade ammonium nitrate (FGAN) storage bins, in addition to the West Fertilizer Company (WFC) practice of storing combustibles near the FGAN pile, contributed to the progression and intensity of the fire and likely resulted in the detonation.
2. The WFC facility did not have a fire detection system to alert emergency responders or an automatic sprinkler system to extinguish the fire at an earlier stage of the incident.
3. On the basis of interviews with eyewitnesses and supporting photographic evidence, the first observed fire and smoke originated in and above the seed room and progressed throughout the northern half of the WFC facility. The radiant heat from the fire, fueled by the structure, flammable building contents, and the asphalt roof shingles, likely heated the surface of the FGAN pile. Contamination from soot, molten asphalt, and molten polyvinyl chloride (PVC) from an overhead conveyer produced a detonable mixture of combustibles and FGAN oxidizers. Increased ventilation generated a brighter and hotter flame, heating the FGAN-fuel mixture on the surface of the pile.

MAY 24, 2013- WEST TEXAS, US

Regulatory Findings .

Occupational Safety and Health Administration (OSHA) efforts to oversee facilities that store and handle FGAN fell short at the time of the incident.

Insurance Findings .

WFC's previous property and liability insurer, which provided insurance to WFC from 2006 through 2009, did not focus on FGAN hazards in its annual insurance inspections because it was not required to do so. However, the insurer did not renew WFC's commercial property policy in 2010 because WFC repeatedly failed to comply with the insurer's safety-related recommendations (e.g., to replace corroded electrical wiring), which were identified in loss control surveys.

Emergency Response Findings.

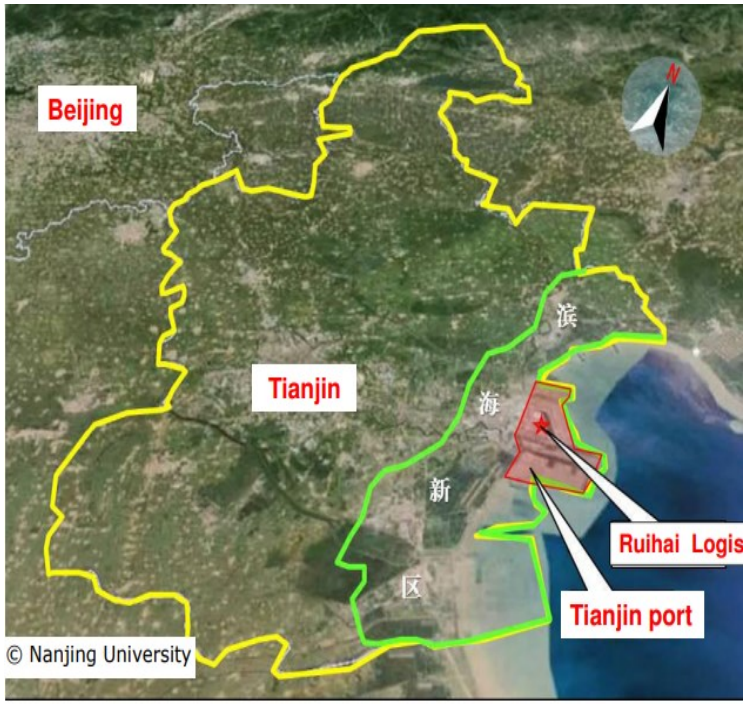
The West Volunteer Fire Department (WVFD) did not conduct pre-incident planning or response training at the WFC facility to address FGAN-related incidents because was no such regulatory requirement. Thus, the firefighters who responded to the WFC fire did not have sufficient information to make an informed decision on how best to respond to the fire at the fertilizer facility.

AUG 12, 2015- TIANJIN CHINA

Series of explosions that killed over one hundred people and injured hundreds of others occurred at a container storage station at the Port of Tianjin on Wednesday, 12 August 2015. The first two explosions occurred within 30 seconds of each other at the facility, which is located in the Binhai New Area of Tianjin, China. The second explosion was far larger and involved the detonation of about 800 tons of ammonium nitrate. Fires caused by the initial explosions continued to burn uncontrolled throughout the weekend, repeatedly causing secondary explosions, with eight additional explosions occurring on Saturday, 15 August.

The cause of the explosions as per later concluded investigation in February 2016 that an overheated container of dry nitrocellulose was the cause of the initial explosion.

AUG 12, 2015- TIANJIN CHINA



- As of 12 September 2015, the official casualty report was 173 deaths, 8 missing, and 797 non-fatal injuries.
- 304 buildings, 12,428 cars and 7,533 containers were badly destroyed.
- Environment damage: 320.6 tons of sodium cyanide and a large amount of other chemicals were dispersed.
- August 12, 22:51:46: fire, 23:34:06 (~45 min later): the first explosion, 23:34:37 (~30 sec later): the second explosion. August 14, 16:40: the fire was extinguished.
- According to the on-site staffs, the video, the trace evidences, and the destruction and displacement characteristics of the containers, the central area of the dangerous goods container storage station was identified as the initial fire point.
- No electrical equipment at the fire site; cable, lighthouse (road lamp) and video surveillance are normally. So we can rule out the possibility of electrical lines and equipment factors causing the fire.
- Meanwhile, no lightning weather; no vehicles. So we can exclude the fire legacy, lightning, vehicles and other external factors.

AUG 12, 2015- TIANJIN CHINA

MARCH 21 2019-CHEMGIANJANG,CHINA

The March 2019 explosion occurred at a local time of 14:48 (06:48 GMT). 78 people were killed, and at least 94 were severely injured, 32 of whom were critically injured.

Around 640 people required hospital treatment and were taken to 16 hospitals.

The injured included children at a local kindergarten. CNEC detected an M_L2.2 artificial earthquake whose epicenter is at 34.331°N 119.724°E. The force of the blast started numerous fires in Yancheng, knocked down several buildings, and reportedly destroyed windows several kilometers away. The fire was reported to have been controlled by 03:00 local time. Considerable damage was caused to nearby factories and offices; the roof of Henglida Chemical Factory, 3 km from the explosion, fell in. At least one of the people killed was in another building destroyed by the blast. Windows are reported to have been blown out up to 6 km away from the explosion, and houses and other buildings were damaged in the nearby village-level administrative divisions including Hai'an Town (Haianju) and Shadang.This explosion was strong enough that it registered on earthquake sensors and could be seen by satellites.The blast created a crater resulting in a magnitude 2.2 seismic shock that took over 900 firefighters to get the fire under control.

AUGUST 04 2020-BEIRUT,LABANON

- The Beirut port Ammonium Nitrate explosion killed 218 people, including nationals of Lebanon, Syria, Egypt, Ethiopia, Bangladesh, Philippines, Pakistan, Palestine, the Netherlands, Canada, Germany, France, Australia, and the United States.
- It wounded 7,000 people, of whom at least 150 acquired a physical disability; caused untold psychological harm; and damaged 77,000 apartments, displacing over 300,000 people.
- At least three children between the ages of 2 and 15 lost their lives. Thirty-one children required hospitalization, 1,000 children were injured, and 80,000 children were left without a home.
- The explosion affected 163 public and private schools and rendered half of Beirut's healthcare centers nonfunctional, and it impacted 56 percent of the private businesses in Beirut.
- There was extensive damage to infrastructure, including transport, energy, water supply and sanitation, and municipal services totaling US$390-475 million in losses. According to the World Bank, the explosion caused an estimated $3.8-4.6 billion in material damage.

AUGUST 04 2020-BEIRUT,LABANON

- It resulted in ammonia gas and nitrogen oxides being released into the air, potentially with toxins from other materials that may have also ignited as a result of the explosion. Ammonia gas and nitrogen oxides are harmful to the environment as well as to the respiratory system.
- Destruction is estimated to have created up to 800,000 tonnes of construction and demolition waste that likely contains hazardous chemicals that can damage health through direct exposure, or soil and water contamination.
- United Nations Development Program (UNDP) has estimated that the cost of cleaning up the environmental degradation from the explosion will be over $100 million.
- Causes and Lessons Learned
- Shear human Negligence(Human Factor) & “No Lessons learned”
- There was extensive damage to infrastructure, including transport, energy, water supply and sanitation, and municipal services totaling US$390-475 million in losses. According to the World Bank, the explosion caused an estimated $3.8-4.6 billion in material damage.

EVOLUTION OF PSM

WHAT WENT WRONG?

1. OPPAU -1921
2. TEXAS CITY 1947

1992- PSM LAUNCH- lessons learned

29 CFR 1910.119

OSHA developed the Process Safety Management (PSM) standard (issued in 1992), which covers the manufacturing of explosives and processes involving threshold quantities of flammable liquids and flammable gasses (10,000 lbs), as well as 137 listed highly hazardous chemicals.

STILL GOING WRONG

1. AZF FRANCE -2001
2. MIHALESTI ROMANIA -2004
3. WEST TEXAS -2013
4. TIANJIN CHINA-2015

5.CHEMGIANJANG,CHINA-2019

”ARE WE REALLY LEARNING? WHY STILL GOING WRONG?”

THANK YOU

YOURS

PRAKASH TATA

Q & A