Incident

SAFETY MEMO

April 25th, 2022 – Bioethanol Alcohol Storage Tanks

Introduction

Bioethanol is a liquid alcohol produced using biomaterial feedstock. First generation bioethanol is produced using cereals and sugar beets, while second generation bioethanol uses non-food sources like forestry residue and lignocellulosic biomass through hydrolysis, fermentation, and distillation. Liquid bioethanol is flammable, and its vapors are highly explosive. Therefore, operators must consider safe storage and handling methodologies in the design. This safety memo summarizes bioethanol alcohol storage hazards and reviews a real-world example of the risks of bioethanol.

Bioethanol Storage

Bioethanol becomes hazardous during the distillation process and increases with product storage. Bioethanol is typically stored in large volume tanks at the distillery site. For such tanks the research data identifying the hazardous phenomena for the storage of flammable liquids are[1]:

- Fire which represents 36% of accidents.
- Explosion which represents 18% of accidents.
- Environmental pollution in 75% of accidents.
- Injuries in 32% and deaths in 2% of accidents.

Case Study - Consecutive Explosions of Bioethanol Alcohol Storage Tanks[2]

About ten years ago, a major explosion occurred on a bioethanol production site causing significant material damage and substantial operating losses. The fire required the intervention of 90 firefighters to prevent the spread and allow it to be extinguished.

Figure 1 – Typical Bioethanol Storage Tanks

What Happened?

Following a cleaning operation of one of the bioethanol tanks, a strong exothermic reaction took place between an excess of oxidant, potassium permanganate (KMnO4), and an aqueous solution of ethanol at 96%. The exothermic reaction then ignited the bioethanol vapors trapped within the storage tank. The vapors created an explosive atmospheric condition (ATEX) which resulted in the consecutive tank explosions (Figure 2). The storage facility lacked the appropriate engineering control measures to prevent, detect, and raise the alarm for such accidents.

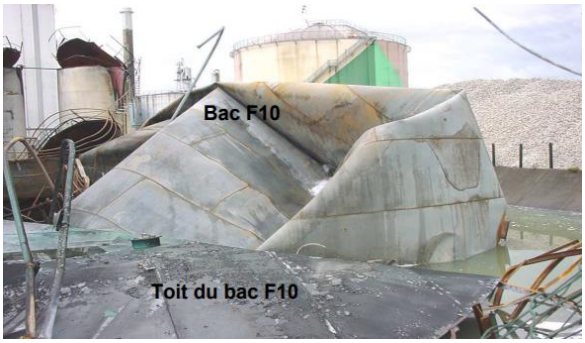

Figure 2 – Bioethanol Storage Tanks After Explosion

What Actions Were Taken?

Following the accident, the operator implemented these engineering controls:

- Establish or improve the assistance agreement between operators and consider the different types of foam concentrate used by the neighbouring sites
- Enhanced fire detection and alarm system.
- Installed tank ring sprinklers and misting screens.
- Installed bioethanol detectors and alarm system.
- Installed misting screens between retention basins.
- Reconstructed tanks with vented roofs.
- Inertization of the tanks with nitrogen
- Elimination of solid permanganate and replacement with diluted liquid permanganate after validation of the process

Lessons Learned

This accident highlights the importance of engineering controls to address hazards presented by a process. With bioethanol storage tanks, engineering controls can prevent significant damage, operational losses, and operator injury or death. Emphasis should be placed on increasing operator awareness outside of the danger zone, via remote monitoring and alarming capabilities. Additional emphasis should be placed on automated fire suppression systems.

[1] Aria. Accidentologie associée aux liquides inflammables de catégories 2 et 3. Retrieved from https://www.aria.developpement-durable.gouv.fr/synthese/syntheses/accidentologies-csprt/accidentologie-associee-aux-liquides-inflammables-de-categories-2-et-3/

[2] Lessons learnt from industrial accidents. (June 11, 2002). French Ministry of the Environment. Retrieved from https://www.impel.eu/wp-content/uploads/2016/06/accidents_Bordeaux_2002_en.pdf

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