National Aeronautics and Space Administration








Dust to Dust:

Imperial Sugar Company Dust Explosion

Leadership ViTS Meeting

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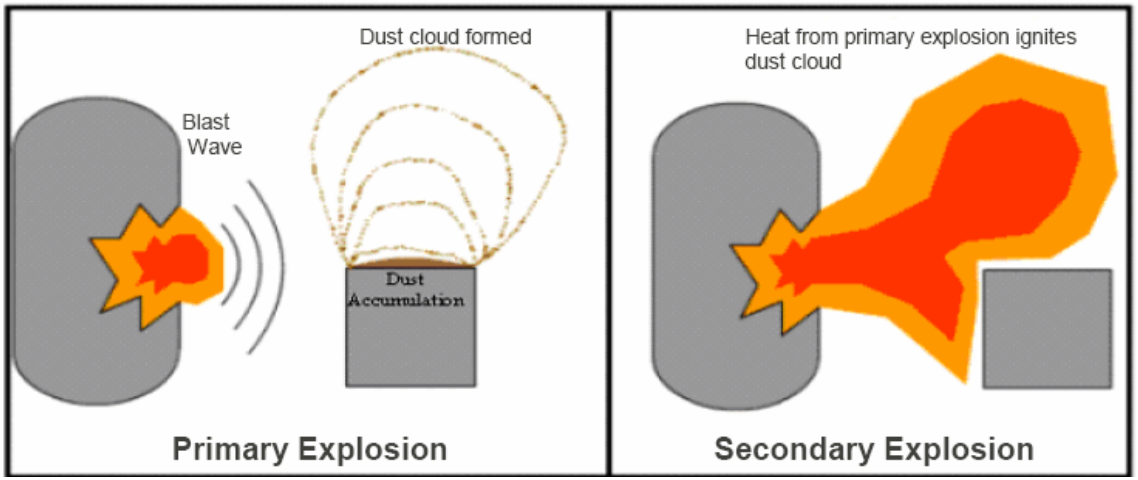
THE MISHAP

On February 7, 2008, a series of violent explosions devastated a sugar refinery in Port Wentworth, Georgia. Workers inside had little time to escape as pressure waves heaved concrete floors, blasted brick walls, and collapsed stairwells. Combustible sugar dust, along with sugar that had spilled from packing and processing machinery, fueled fires that burned up to seven days after the initial blast. The explosions claimed the lives of 14 workers and critically injured 36 others. The blaze ravaged storehouses, packaging buildings, and processing areas that had been operating for more than eighty years. The U.S. Chemical Safety Board deemed it the most devastating dust explosion in decades.

Combustible Dust Explosions

•When products such as wood, rubber, plastics, chemicals, metals, and food products pass through machinery, they generate fine dust particles that become explosive when dispersed in a confined space.
•An explosion that takes place in an unvented enclosure can quickly become catastrophic, especially if combustible dust has accumulated in other areas of the facility.
•Shockwaves from the initial explosion can dislodge accumulated dust, and the fireball can ignite it, triggering a chain reaction of secondary explosions.
•Secondary explosions can be more powerful and destructive than primary explosions because of the increased concentration and quantity of airborne particles.



Mechanism behind a propagating combustible dust explosion (Credit: OSHA)

BACKGROUND

Imperial Sugar Company

•Port Wentworth sugar plant was built in 1917 and had operated for more than 80 years without a major incident.
•Facility converted raw sugar into granulated sugar, then packaged it or refined it into specialty sugar products.
•Process used hammer mills, conveyor belts, and bucket elevators – all of which caused sugar dust to disperse into the air and spill onto the floor.
•The depth of the spilled sugar ranged from several inches in some places to several feet in others. Sugar dust that dispersed into the air settled upon horizontal structures such as light fixtures and beams.
•Dust collection equipment was undersized, outdated, and ineffective.

Silo Tunnel Modifications

•Three 100-foot tall silos stored granulated sugar until it was ready to move to the 4-story packaging or refining buildings adjacent to the storehouses.
•Sugar left the storage silos via chutes positioned at each silo's base. The chutes channeled the sugar onto a conveyor belt that ran through a tunnel beneath the silos (tunnel dimensions were 10 feet wide x 130 feet long).
•Every so often, clumps of sugar would clog the chutes, causing sugar to spill onto the floor and sugar dust to disperse into the tunnel.
•Early in 2007, Imperial Sugar decided to enclose the conveyor belt with steel panels to eliminate the possibility of contaminating the sugar with falling debris or foreign objects.
•The enclosure did not have an associated ventilation or dust collection system.
•Sugar dust that once dispersed into the tunnel was now trapped in a space one tenth the tunnel's size.



Computer model of the conveyor beneath the storage silos depicting tunnel, clogged chutes, and steel enclosure (Credit: CSB)

WHAT HAPPENED?

Scenes of devastation followed the explosions at Imperial Sugar's facility in Port Wentworth, GA.

Primary and Secondary Explosions

•Close to 7:15 p.m. on February 7, 2008, a massive explosion tore the enclosure in the silo tunnel apart.

•In adjacent buildings, rafters and pipes upon which inches of sugar dust rested shook violently.

•Sugar dust dislodged from these surfaces and rained into the air below. As the initial fireball shot through the tunnel and vented into adjacent buildings, it ignited the falling dust, causing a chain of violent secondary explosions.

•As walls, floors, beams, and conduits collapsed, the dust that had accumulated on top of them poured downward, refueling and intensifying an inferno that already raged below.

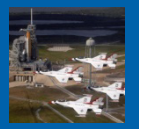
•Security cameras at facilities two miles from the site recorded massive fireballs erupting from the refinery for as long as fifteen minutes following the initial blast.

•The packing buildings burned for four days before firefighters could fully extinguish the flames. Fires in the storage silos reached 4000° F and continued burning one week after the primary explosion.

•Eight workers died on the scene, and six more perished at a regional burn unit. Thirty-six workers suffered critical burns and injuries.









PROBABLE CAUSE

CSB Investigators reported that on February 7, 2008, one of the silo chutes became clogged, causing a backup on the conveyor and releasing excessive amounts of dust into the enclosure. Something ignited the sugar dust, but because the damage to the tunnel, enclosure, and conveyor was so extensive, investigators could not point to a single ignition source with certainty. Based upon tests and upon worker reports that overheated ball bearings had been a recurring problem at the plant, CSB concluded that the hot surface from an overheated bearing most likely ignited the sugar dust inside the enclosure, initiating the explosive chain reaction.

UNDERLYING ISSUES

Inadequate Employee Training and Emergency Preparedness

•Imperial Sugar required its workers to undergo annual safety training, but CSB's review of more than 10,000 pages of training materials failed to reveal anything on the topic of hazardous dust despite the fact that Material Safety Data Sheets (MSDS) on sugar warned of sugar dust's combustible nature.

•Employees at Imperial Sugar may have allowed dust to accumulate to extreme levels because they were unaware of the combustion hazards such accumulations entailed.

•Emergency plans called for employees to use the intercom system in the event of a crisis, but the refinery and packing buildings (where the explosions took place) did not have intercoms. Workers in those areas had to rely on radios and cell phones for emergency alerts.

•Training programs did not include evacuation drills or work-location specific training, and workers unfamiliar with escape routes faced great difficulty when evacuating.

Normalization of Deviance

•Although employees and contractors may not have been aware of combustible dust's insidious hazards, correspondence dated as early as 1961 shows that Imperial Sugar's management was cognizant of the danger.

•Over decades of operation, the Port Wentworth refinery experienced dozens of small fires caused by overheated bearings that were fueled by combustible dust, but none of them caused fatalities, serious injuries, or catastrophic damage.

•Since none of the incidents ever led to a major catastrophe, it became easier for the organization to keep accepting lower standards until the lowered standards became the normal practice. As per CSB, Imperial Sugar's managers allowed complacency to rob them of the swift action that likely would have prevented the disaster.

FOR FUTURE NASA MISSIONS

- The explosion at Imperial Sugar took place in part because plant operators were uninformed of the risks at the facility and because they were vastly unprepared to deal with an emergency.
- As a part of emergency preparation, it is important to consider "process safety." Specific processes could benefit from scenario-driven hazard analysis. In making a "case for safety," operators show how hazards within a process can be managed effectively.
- Consider the ways in which day-to-day decisions affect safety barriers and controls – ensure that past choices have not increased safety or technical risk to an unacceptable level.

- Combustible dust does not pose as prominent a threat at NASA as it does in certain industries, but explosions need not be fueled by combustible dust to become catastrophic.
- Equally hazardous dangers lie in hundreds of chemicals and reactive materials handled at NASA Centers every day, including solid and liquid rocket propellants, ethylene oxide, or anhydrous ammonia.
- Given such hazards, good housekeeping, strict maintenance practices, and ignition risk identification and mitigation are paramount in preventing combustible liquids, compressed gasses, and dozens of other unstable and reactive materials from initiating a disaster.

Employees at Imperial Sugar Company's Port Wentworth facility allowed sugar dust to accumulate to extreme levels. Here, machinery, support structures, and floors are covered with inches of sugar dust.