



Case Study: The PEPCON Disaster

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The PEPCON facility before the blasts

Summary of the Disaster

Just before lunchtime on May 4th, 1988, at a facility near Henderson, Nevada, a panicked maintenance crew could be seen dashing away from the site of the *Pacific Engineering Production Company*, also known as PEPCON. Behind them, a moderate but ambitious-looking fire was establishing itself in a large storage lot.

The crew had been repairing a wind-damaged steel-and-fiberglass building when a stray spark from their welder somehow managed to set fire to the structure. The men fetched some nearby water hoses and attempted to douse the flames, but the flourishing fire mocked their efforts, and soon began to fondle the 55-gallon drums stored nearby. With this alarming development, the crew abandoned their hoses and gave up the fight in favor of a hasty departure. The workers knew exactly what was in these barrels, and they didn't wish to be present to observe how it would react to the flames.

At that time, PEPCON was one of the only US producers of the chemical *ammonium perchlorate*, a key ingredient in the rocket fuel used for space shuttle boosters and Titan missiles. This white granular compound is a powerful oxidizer, and its purpose is to accelerate rocket fuel combustion. Also present at the facility were bulk quantities of other hazardous materials used in manufacturing, such as hydrochloric acid and nitric acid.

Over four thousand tons of ammonium perchlorate were in the storage area that day, so the anxiety-stricken workers fled with great enthusiasm. The Challenger explosion fifteen months earlier had prompted NASA to freeze the space shuttle program pending investigation, yet the United States government continued to contract PEPCON at pre-Challenger quantities. Consequently, the containers full of the unused fuel component had slowly accumulated, making the site pregnant with stored energy.

Over the years, the entire facility had become peppered with residue from the ammonium perchlorate. Stiff winds on the day of the maintenance workers' visit conspired against them, and quickly turned a small welding accident into a brilliant orange fireball. As news of the fire spread, most of the employees rushed to evacuate the six buildings, but a man named Roy Westerfield stayed behind and called 911:

Dispatcher: Fire department.

Westerfield: Emergency. We need the fire department, all you can get here. Immediately.

Dispatcher: What's the problem?

Westerfield: Oh, we've got... everything's on fire.



PEPCON site ablaze

At about the same time, the chief of the Clark County Fire Department noticed the column of smoke on the horizon, and ordered his units to go to the location immediately. He and a passenger climbed into his car and raced to the scene ahead of the fire trucks. The intense fireball became visible from about a mile away, belching its column of acrid smoke into the sky.

Soon the pair began to see dozens of fear-stricken PEPCON employees on the roadsides; men and women hurrying away from the burning facility on foot in spite of the mid-day desert heat.

A few minutes later, as the chief neared the cluster of flaming buildings, he and his passenger were blinded by an abrupt flash. The car rocked and windows exploded as the vehicle was slammed by a deafening shock wave. As the explosion's echoes slowly faded, the fire chief stopped the car to assess the situation and tend to a few cuts caused by the hail of broken glass. Moments later a badly damaged vehicle approached from the direction of the plant, and its driver paused alongside the chief just long enough to warn him that the worst of the explosions were probably yet to come. Realizing that the inferno had grown far beyond his department's fire-suppression capabilities, the chief turned his car around and headed back towards Henderson.

The fire engine crews had reached the same dismal conclusion when they observed the explosion during their approach. It was clear that there were serious safety concerns in moving any closer, so the firefighters pulled their trucks off the road about a mile from the disaster-in-progress, and watched the towering flames from afar.

A mile away in another direction, an engineering crew had been performing routine maintenance on a television tower on Black Mountain when they spotted the fire and began filming. About four minutes after the first major explosion, the engineers watched in awe as the PEPCON site completely disappeared in a spectacular burst of energy that dwarfed the initial blast.



The fire at the PEPCON plant following the second explosion

Their vantage point afforded them a perfect view of the compression wave as it recklessly radiated across the desert, mowing down brush and demolishing a marshmallow factory adjacent to PEPCON. Due to the distance the sound of the blast didn't reach them for several seconds... but when it did, it was thunderous.

The Clark County fire chief was still trying to put distance between himself and the facility when the violent detonation struck. The blast wave swept in rapidly from behind and clobbered his wounded car, momentarily smothering him in an avalanche of noise and pressure. When the moment passed, he was astonished to find that the vehicle was still somewhat operational in spite of the significant bruising. He continued his retreat and eventually limped his injured automobile past the columns of idling fire engines, their pulverized windows littering the roadway. By the time he reached town and found his way to the hospital there were already hundreds of people gathered there awaiting treatment. The explosion one and a half miles away had dislodged parts of buildings and shattered windows in town, causing many instances of trauma and lacerations.

On the horizon, a plume of smoke rose 1,000 feet into the sky, and the column was said to be visible from as far as one hundred miles away. Some distant observers reportedly wondered whether this mushroom cloud indicated that the long-running Cold War had finally progressed into the Hot War that Americans feared.

The frenzied inferno at PEPCON finally calmed once the explosions had consumed the majority of the fuel. The cataclysmic blasts had ripped a hole in the ground and ruptured a gas line, but the resulting 200-foot-tall flame was easily starved to death by shutting off the gas feed from a station a mile away. Investigators arrived to survey the damage, and they found utter devastation. PEPCON's six buildings were totally destroyed, and where they had stood was nothing but twisted metal and a fifteen-foot-deep crater. The neighboring marshmallow factory fared no better, having been unable to absorb the incredible pressure wave. Many structures in Henderson also suffered damage, mostly in the form of shattered windows, cracked walls, and doors that were blown from their hinges. Some buildings as far as ten miles away were affected.



Roy Westerfield

Though there were almost 400 injuries reported— both from ground zero and from Henderson residents— surprisingly there were only two deaths. One was a worker confined to a wheelchair who had been unable to exit from the PEPCON building quickly enough. The other was Roy Westerfield, the very man who had made the original 911 call. He had been handicapped by the effects of polio, leaving him unable to walk very well. It is generally believed that he opted to stay behind and alert the authorities, knowing that escape was unlikely.

Further investigation into the event found that the destructive energy from the larger explosion was roughly equivalent to 1,000 tons of TNT, or one kiloton. It caused seismograph needles to

dance as far away as Colorado, where the sensitive equipment measured the distant tremor as a 3.5 on the Richter scale.

PEPCON lawyers responded quickly, attempting pin the blame on Southwest Gas company. The lawyers claimed that the natural gas fire occurred first, subsequently causing the ammonium perchlorate explosions. Three days after the disaster, one of these attorneys claimed, “Nothing ignites ammonium perchlorate. It does not burn. It is not flammable.” Though the compound was not considered to be an extreme explosive threat before the PEPCON disaster, chemists pointed out that the attorney’s grasp of chemistry must be as flimsy as his grasp of ethics. They described the chemical as “unstable and highly flammable.”



Wrecked vehicles displaying the effects of the shockwave of the second explosion

PEPCON had only \$1 million in insurance, a policy which was grossly insufficient to pay for the damage to others’ property. A colossal courtroom battle ensued, involving dozens of insurance companies and over fifty law firms. The outcome of this massive orgy of justice was one million pages of depositions, and a \$71 million settlement which was divided among the victims and their families.

PEPCON never rebuilt the Henderson site. The company changed its name to *Western Electrochemical Co.* and built a new ammonium perchlorate plant in Cedar City, Utah which remains in operation today. But their safety record has certainly improved since the 1988 disaster; to date, there has only been one deadly explosion at the new facility.

Analysis of the Disaster

A series of strategic and tactical problems at the PEPCON chemical plant led to a fire and eventual explosion of ammonium perchlorate, with an equivalent impact on the surrounding area of a 1-kiloton nuclear detonation. The explosion claimed 2 lives, injured around 370, and caused an estimated \$100 million in damages. For this case study in professionalism we will focus on PEPCON's disaster preparation, the response of government agencies, and underlying social and professional factors contributing to the disaster.



Remnants of the PEPCON facility

Ammonium perchlorate is an oxidizer that can be mixed with aluminum and other materials to create a solid propellant. PEPCON was one of two manufacturers of AP in the United States, and supplied AP to NASA for the Space Shuttle. After the Challenger disaster of January 28th, 1986, the Space Shuttle program was grounded while the investigation was ongoing. The provider of solid rocket boosters for NASA, Morton Thiokol, therefore had no need for the propellant. However, the contract PEPCON had with Morton Thiokol to supply AP was not altered, and so PEPCON continued to produce AP and store it on site. By the time of the explosion in 1988, PEPCON had stockpiled over 4,000 tons of AP in various storage containers including aluminum bins and polyethylene drums. Lax housekeeping meant that dust had built up all around the warehouses, despite the danger of fire. Additionally, despite several fires PEPCON had not installed an alarm or a proper fire suppression system in the plant, instead

relying on hoses to douse any flareup. At this time the US government considered AP an oxidizer, not an explosive, and correspondingly had fewer regulations concerning its production and storage.



Each Space Shuttle is loaded with approximately 55 tons of propellant. AP makes up 70% of the fuel.



The second explosion consumed 1,500 tons of AP – almost four times the amount consumed by one Space Shuttle solid rocket booster.

On the day of the disaster, welding work was being performed near an area where AP was stored. Some sparks caught dust near bins of AP, which began to ignite. The dust fire spread to the AP stored in aluminum bins and polyethylene drums, feeding a volatile reaction that quickly got out of hand. A combination of 70% ammonium perchlorate, 15% aluminum, and 15% polyethylene is approximately the formula for a solid rocket booster, making the containers a compounding factor in the explosions. Employees futilely fought the fire with a garden hose and soon enacted the disaster response plan for PEPCON, which essentially stated "flee the facility." Fortunately, all but two PEPCON employees were able to escape the facility; the two that remained were handicapped and unaccounted for in safety protocols. Although fire response teams braved the danger and headed towards the burning plant, they regrouped following an explosion that shattered their windows. Minutes later, over a third of PEPCON's ammonium perchlorate exploded at once, equivalent to a 1-kiloton nuclear explosion. The Kidd Marshmallow plant was obliterated, and the explosion's effects extended 10 miles. Furthermore, a gas main running underneath the plant exploded, burning for over an hour before being turned off.

The PEPCON disaster was precipitated by negligence on the part of PEPCON and its employees, and the response from national agencies was swift. The disaster affected more than just PEPCON, and the national agency response was swift. Other underlying attitudes towards response and readiness also impacted why so much ammonium perchlorate was being stored. Next, the participants and social/professional failures are covered in depth.

Participants

Although the blast caused a variety of damage in a 10 mile radius, only two people were killed. Both were PEPCON employees. One of the employees, Roy Westerfield, stayed behind to call 911. Roy had been handicapped by polio and was not able to make the phone call and escape in time. The other employee killed was also handicapped. Their deaths raised questions regarding the evacuation procedures in place. The U.S Fire Administration, the Federal Emergency Management Agency (FEMA) and the National Fire Data Center released a report citing the need for improvement in the evacuation plans regarding both healthy and handicapped individuals, as well as the need for emergency triage procedures in nearby hospitals. The U.S. Fire Administration, FEMA, and the Department of Energy also released a report that called for better maintenance practices to ensure that AP residue did not build up on buildings and machinery. The report also called for the elimination of fuel sources around the facility and the implementation of ventilation systems, sprinkler systems, fire alarms, and fire-sensing systems. Aside from a sprinkler system in an administrative building, the PEPCON facility did not have these systems prior to the disaster.

The blast also had effects outside of the plant and its employees. The Kidd Marshmallow factory which was just a couple miles away was completely destroyed by the compression waves given off by the blasts. An underground gas line controlled by Southwest Gas Company was ruptured, adding fuel to the fire. Luckily, the company shut the gas off quickly.

Kerr-McGee, the only other producer of AP in the United States, was also located within the blast effect area. Although this could have lead to an even more disastrous explosion, the plant

suffered only minor damages, including shattered windows and cracked walls. While there were no casualties or resulting fires at Kerr-McGee, the threat of what could have happened if the fire spread that far initiated a push for better safety and prevention practices.

Professionalism

There were several human errors in the PEPCON explosion which are specific to this particular case, there are however some things that seems to be related to human psychology, and transcend this particular case. The PEPCON disaster can be understood in terms of the surplus of stored Ammonium Perchlorate, as much as it can be understood in terms of negligence, so why was there so much unnecessary Ammonium Perchlorate?

This can be explained the phenomenon of standardization of deviance, and what we have called survivor overcompensation.

Standardization of Deviance

The phenomena of standardization of deviance is a psychological phenomena that occurs when an individual readjusts its expectations based on a long period of non catastrophic risky behavior. In other words, after a long time of engaging in risky behavior without consequences, an individual is more likely to raise the threshold of what he or she would considers risky. In the case of PEPCON, the company had been inappropriately storing Ammonium Perchlorate for a long period of time. This had not result in any incidents, and so the company kept doing it, inflating dramatically the consequences of a disaster if it was to occur.

Survivor Overcompensation

This is not a phenomena officially found in human psychology literature, but as described below, it has been useful in understanding the reasons behind the PEPCON disaster. Significant research has been done regarding different disorders that follow the surviving of traumatic experiences. Amongst these are PTSD, OCD and others. However, it seems to be the case that

after surviving a traumatic experience, the individual will readjust the threshold of preparedness that he or she originally had. In other words, if an individual has gone through a shortage of food, he or she is more likely to save more food than they would have saved previously. This phenomena, although still unnamed is particularly common amongst war survivors, who have a difficulty disposing things and justify keeping them by arguing that they might need it in the future. In relation to PEPCON disaster, the factory set their standards of production based on the needs of NASA, and after the Challenger disaster, they failed to readjust their production, and kept producing Ammonium Perchlorate based on what they *might* need as opposed to what they actually did.

Conclusions

The May 4, 1988 PEPCON explosion still evokes astonished hindsight. With such vast explosive potential, how could the hazards of welding on such a structure constructed in part with flammable material not have been better assessed? It would be logical to minimize the relevance of this map of causes to an individual's work or project, especially if the individual's work does not involve hazardous material. But the dangers of potentially hazardous material (e.g., ammonium perchlorate, solid propellant, liquid propellant, hydrogen, hypergols) force us to realize things that have never happened before happen all the time.

Planning for failure, like designing for success, sometimes depends upon key assumptions to scope and scale the effort to the resources available. This scoping and scaling can lead to planning for the scenarios considered most likely, instead of worst credible. Coping with the worst credible outcome can easily exceed available resources; engineers should not only plan to prevent the (disastrous) outcome, but also how best to recover lost critical functionality by accessing other resources.

Although the PEPCON disaster could have been even more catastrophic in terms of loss of life, the effect of disasters and emergencies has a resounding impact on the public in close proximity and also those far away.