



# Sierra Chemical Co. High Explosives Accident

Mustang, Nevada January 7, 1998

On January 7, 1998, two massive explosions just seconds apart destroyed the Sierra Chemical Company's Kean Canyon explosives manufacturing plant ten miles east of Reno, Nevada, killing four workers and injuring six others. The initial explosion occurred in a room where workers made "boosters" — small explosive devices used in the mining industry to detonate larger explosives. A second, more powerful blast destroyed a building used for drying explosives, leaving a 40-by-60-foot crater that was up to six feet deep.

The two explosions destroyed buildings, blew down walls, and hurled debris as far as a thousand yards. Of the 11 Sierra employees who were at the site when the accident occurred, only one escaped without injury. The explosions killed all four workers who were in or near Booster Room 2, the production room where the first blast occurred. In nearby Booster Room 1, one worker was blown 14 feet by the force of that initial blast. He and four others were trapped as the room collapsed, but all survived.

The explosions had the force of a magnitude 2.0 earthquake and were felt some 20 miles away from the plant. Fearing further blasts, firefighters did not attempt to extinguish fires at the site, and the flames burned for more than a day. Sierra Chemical estimated that in all, 47,000 pounds of explosives were consumed during the accident. The facility was never rebuilt.

## MIXER BLADE LIKELY DETONATED EXPLOSIVE

Producing boosters involved melting, mixing, blending, and pouring trinitrotoluene (TNT) and other raw materials into cardboard cylinders. The work was performed inside Booster Rooms 1 and 2, which were located in two adjoining buildings. In a separate building the chemical pentaerythritol tetranitrate (PETN) was dried before being transferred to the booster production buildings. PETN is one of the strongest high explosives known, and due to its instability it is transported wet.

Although there were no surviving eyewitnesses in Booster Room 2, the CSB used seismic evidence and other techniques to reconstruct what happened on the morning of January 7. Booster Room 2 had housed four large freestanding mixing pots, where explosive materials were melted and blended. The day before the accident a worker had departed early, leaving 50 to 100 pounds of melted base material in the bottom of one of the mixing pots. The base material consisted of TNT and other high explosives.

The worker apparently believed that another operator would use the leftover base material later that afternoon. Instead, the material remained in the pot and solidified over-

night as outside temperatures fell below freezing. The next morning the worker returned to Booster Room 2. He probably assumed that the pot had been emptied, and without checking its contents he turned on the motor

to the agitator blades, setting off the initial explosion.

Using metallurgical analysis, CSB investigators determined that the heavy mixer blade had probably become embedded in the hardened explosive. Investigators theorized that as the blade started to turn, it either struck or pinched the explosive material, causing it to detonate. Another possibility is that the explosive contained a foreign metal object, which initiated the blast by scraping along the inside of the pot. Indeed, survivors reported that Sierra's raw materials — which were purchased as demilitarized munitions from the U.S. Department of Defense — frequently contained foreign metal objects like nuts and bolts. Because the reclaimed explosives were not screened prior to use, metal objects commonly found their way into the mixing pots.

The shock wave from the initial blast detonated several thousand pounds of explosives stored inside the booster room. Heavy debris from this explosion likely rained down onto the PETN drying building 220 feet away, piercing the roof or skylight and initiating an even larger secondary explosion, the CSB concluded.

## INADEQUATE SAFETY CONTROLS AND OVERSIGHT

The U.S. Occupational Safety and Health Administration (OSHA) requires that explosives manufacturers like Sierra

## LANGUAGE BARRIERS TO SAFETY

The majority of workers at the Kean Canyon plant spoke only Spanish, but the plant had no operational policies or procedures in that language. Among the employees, only the production supervisor and three other operators were bilingual. Although the plant's generic OSHA training program included a few Spanish videos, material safety data sheets (MSDSs) identifying the hazards of the explosives were only provided in English. Likewise, safety training sessions and tests were developed and conducted in English and then translated by one of the bilingual personnel. Sierra's reliance upon informal translation created opportunities for error and miscommunication.



Sierra Chemical facility burns after massive explosions.

Chemical follow the Process Safety Management (PSM) standard, which mandates a variety of safety systems for hazardous chemical operations. But the CSB's investigation revealed a lack of adherence to various process safety principles at Sierra Chemical. No workers from the Kean Canyon plant were involved in conducting the company's process hazard analysis for the booster operation, and the scope of that analysis did not extend to Booster Room 2. Plant managers did not understand the hazards of the materials in use — incorrectly believing that they were almost impossible to detonate without using a blasting cap. Raw materials, equipment, and work procedures were altered without an analysis of the hazards of these changes.

Enforcing federal workplace safety rules was the responsibility of Nevada state authorities. However, Nevada workplace safety inspectors in the Reno office had little formal training in explosives, and the state's most recent safety inspection of the Kean Canyon plant (in 1996) had focused on industrial hygiene. Local fire inspectors also lacked relevant training and expertise. Although Nevada had experienced a massive explosion at a rocket fuel plant almost a decade earlier, by 1998 the state still had not identified businesses at risk for catastrophic accidents or established inspection priorities.

#### WORK PRACTICES RISKED DETONATION

Workers in both booster rooms used practices that have long been recognized as hazardous at military explosives facilities. Workers regularly used metal tools, including steel hammers and rods, to break up rejected explosive boosters or to clear out pipes and valves that were blocked with explosives — despite the hazard of an accidental detonation.

None of the operators at Kean Canyon recalled seeing any written operating procedures. Without written procedures, training was conducted in an informal, on-the-job manner, relying upon physical demonstration and word of mouth. Work procedures varied among different operators. For example, CSB's interviews showed that while the normal practice was to check the mixing pots for residual material before starting the motors, not all workers did so.

#### PLANT DESIGN, CONSTRUCTION FLAWED

The CSB noted that explosives producers should ensure that there are safe distances between buildings to prevent an accidental explosion from propagating. The structures at Sierra Chemical were built on separate terraces cut into the slope of a bowl-shaped desert canyon, but they were located too close to each other. Although the terraced design afforded some protection from horizontal ballistic fragments, the buildings remained vulnerable to falling debris.

Based on guidelines from the Institute of Makers of Explosives, the two booster rooms should have been located at least 245 to 295 feet from the PETN drying building. The actual distances ranged from 185 to 220 feet. The two booster rooms should have been sited at least 490 feet apart, but the actual distance between them was just 80 feet.

Department of Defense guidelines cited by the CSB recommend that explosive operations be separated from extraneous work activities by at least 1,250 feet. But at Sierra the production buildings had multiple uses, including unrelated mixing, packaging, and administrative operations. In fact, one of the workers killed was involved in non-explosive-related activities outside Booster Room 2.

Building construction was also deficient. For example, the PETN building should not have had a skylight, which could be penetrated by explosion debris. The production buildings should not have been constructed from concrete blocks, which can fragment in an explosion to form potentially lethal projectiles.

#### RECOMMENDATIONS

On September 23, 1998, the CSB issued a number of safety recommendations to prevent similar accidents in the future.

##### To Sierra Chemical:

The CSB recommended that Sierra Chemical and other explosives manufacturers ensure that their process safety programs include comprehensive hazard analyses, specific written operating procedures, management of change (MOC) procedures, periodic audits, and appropriate safety training and certification for workers and managers. Operating procedures and hazard information should be communicated in languages understood by the workforce.

##### To the Nevada Occupational Safety and Health Enforcement Section:

The CSB recommended that Nevada increase the frequency of safety inspections for explosives manufacturing facilities.

##### To the Institute of Makers of Explosives (IME):

The Board called on the IME, which is a safety association of the U.S. and Canadian commercial explosives industry, to develop guidelines for training workers and for screening reclaimed explosives.

##### To the U.S. Department of Defense:

The Board recommended that the defense department develop a program to ensure that reclaimed munitions are free of hazardous foreign materials and also communicate with industry and government agencies about the lessons learned from past explosives accidents.

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#### NOTICE:

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