



The Pressure Vessel Explosion at Bayer Chemical Plant

An Online Continuing Education Course for Engineers

Course Number: H-2007

Credit: 2 Hours / 2 PDH / 2 CPD

Engineering Ethics: Pressure Vessel Explosion at Bayer Chemical Plant

PROLOGUE

The Methomyl unit had been in one of its periodic shutdowns and the company took the opportunity to replace the residue treater tank and install a new control system. The staff was anxious to return to production. The unit moved towards a full restart, beginning methomyl synthesis and crystallization. A variety of problems plagued the restart and solvent was used at a rapid rate; it became increasingly important to restart the residue treater and initiate solvent recovery.

The outside operator started the recirculation pump around 6:14 p.m. The control board operator bypassed the automatic safety system, operating the controls manually. As the flasher bottoms entered the tank, the pressure began to rise steadily. Around 10:21 p.m. the recirculation flow abruptly dropped to zero and the temperature in the tank rapidly approached the safe operating limit.

A few minutes later the high-pressure alarm sounded in the control room. Suspecting a blockage in the vent line, the board operator sent two outside operators to check the system. An explosion occurred as they approached. One died at the scene, the other died 41 days later in a hospital burn unit.

INTRODUCTION

The explosion occurred in a 4,500-gallon pressure vessel at the Bayer CropScience (Bayer) facility in Institute, West Virginia on August 28, 2008. The facility was about 10 miles west of Charleston, WV and adjacent to the West Virginia State University (WVSU) campus, the state's only historically black college.

On the fatal night, the operators failed to pre-fill the residue treater vessel with solvent or pre-heat it to the minimum operating temperature, as required by the Standard Operating Procedures (SOP). The result was a runaway decomposition reaction of methomyl. The gas overwhelmed the emergency vent system and the vessel exploded. About 2,200 gallons of solvents and insecticide residues erupted from it and were immediately ignited by severed electrical cables or sparks from debris hitting the concrete, creating a 100-foot fireball¹.

Debris was thrown hundreds of feet. The treater was torn apart and the explosion ripped out piping, electrical conduit and a steel support column. The unit control building and other structures were damaged.

A 6,700 gallon methyl isocyanate (MIC) “day tank” about 70 feet away was hit by debris, but didn’t sustain damage. It remained shielded from the heat of the conflagration by a steel blanket.

The energy released by the explosion was estimated to be equivalent of 17 pounds of TNT. The blast was heard by residents 10 miles away² and broke windows and cracked walls and ceilings in residences and businesses up to seven miles away³.

Local emergency response officials were hampered in their efforts to respond to the blast by inadequate emergency communication from the facility’s personnel. Bayer staff refused to respond to requests for information from local officials for more than an hour.⁴ Acting on their own and fearing that toxic chemicals had been released, local officials later closed Interstate 64, U.S. 60 and State Route 25. Students at WVSU and more than 40,000 residents in five communities were instructed to shelter in place.⁵

The fire burned for about four hours, battled by Bayer’s fire brigade and local fire departments. In addition to the two operator fatalities, six volunteer firefighters and two contractors were treated for possible toxic chemical exposure.

The chemicals released included methomyl, methyl isobutyl ketone (MIBK), hexane, and MIC, the flammable and highly toxic gas responsible for the Bhopal disaster in India that killed an estimated 8,000 people and injured more than 500,000. The night of the Institute explosion, the MIC air monitoring devices that were to monitor the Methomyl-Larvin unit were not operational. Two fence line monitors were operational, but were located downwind about 800 feet from the explosion site and were only designed to monitor carbon monoxide, hydrogen sulfide, flammable gas and oxygen.⁶



Equipment destruction along the trajectory of the residue treater vessel; the deformed shell of the vessel is visible at the center of the photograph. (Source: CSB.)

The incident was investigated by the United States Congress, the Chemical Safety Board (CSB) and the Occupational and Safety and Health Administration (OSHA).

OSHA later issued \$143,000 in fines for 15 violations⁷, citing “Poorly planned operating procedures, flawed emergency systems and faulty employee training.”⁸

COURSE OBJECTIVE

This course will examine the engineering aspects of the disaster and the lessons learned from it that engineers can apply in their professional practice.

THE CAUSES OF THE DISASTER

The causes of the incident were:⁹

1. Bayer did not apply standard Pre-startup Safety Review (PSSR) and turnover practices to the methomyl control system redesign project. The equipment was not tested and calibrated before the unit was restarted.
2. Operations personnel were inadequately trained to operate the methomyl unit with the new distributed control system (DCS).

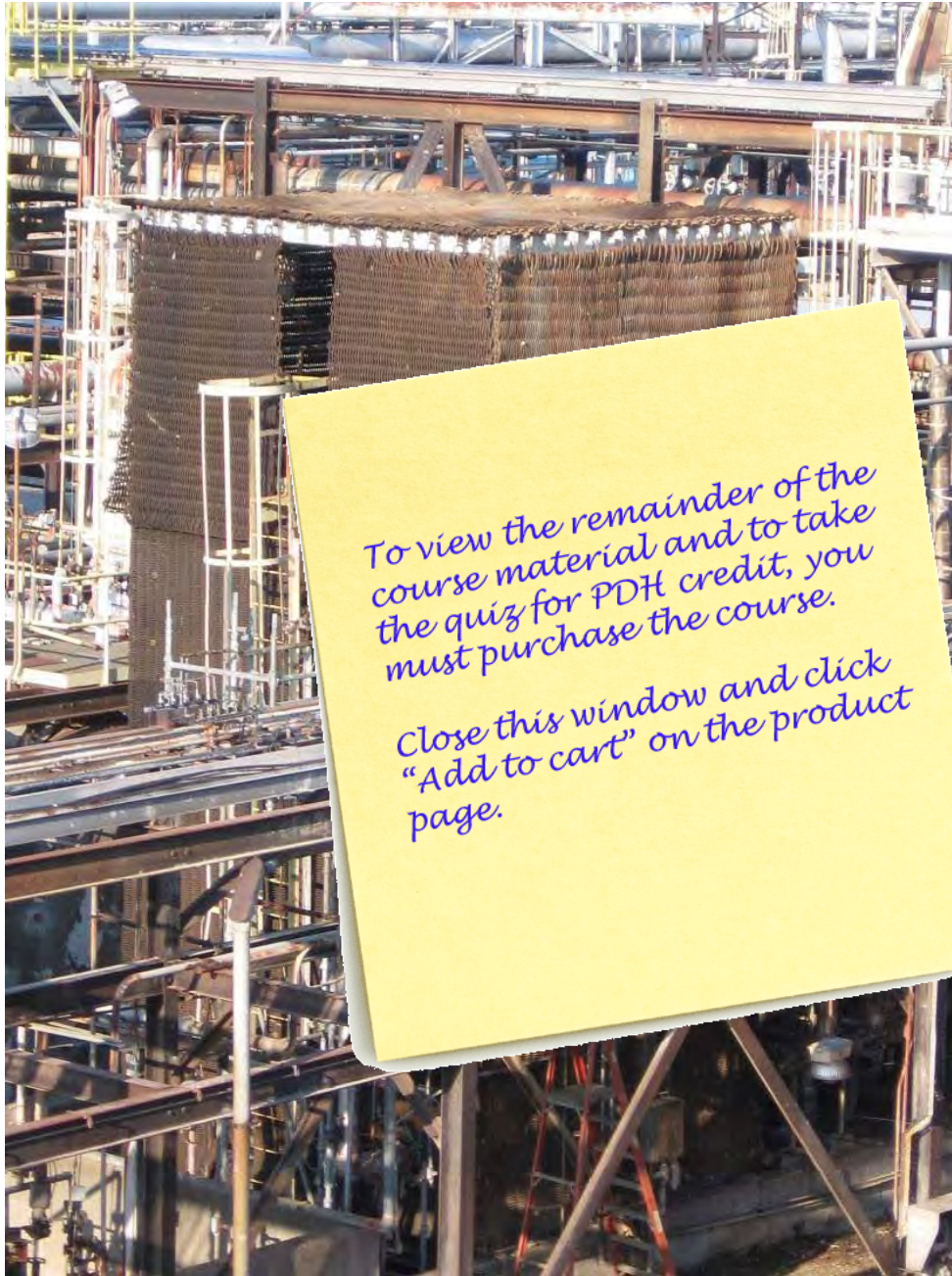
3. Malfunctioning equipment and the inadequate DCS checkout prevented the operators from achieving correct operating conditions in the crystallizers and solvent recovery equipment.
4. The out-of-specification methomyl-solvent mixture was fed to the residue treater before the residue treater was pre-filled with solvent and heated to the minimum safe operating temperature.
5. The incoming process stream normally generated an exothermic decomposition reaction, but methomyl that had not crystallized due to equipment problems greatly increased the methomyl concentration in the residue treater, which led to a runaway reaction that overwhelmed the relief system and over-pressurized the residue treater.

The 2008 explosion spurred 2009 hearings by the U.S. House of Representatives Committee on Energy and Commerce, which asked CSB to develop recommendations for Bayer and state and federal regulators to “reduce the dangers posed by on-site storage of MIC.”¹⁰

There was considerable public anger at inadequacies in the facility’s emergency response in the hours after the explosion. The CSB report also found fault with the company’s emergency response, air monitoring and response to regulatory oversight. The controversies and these issues are outside of the scope of this course, which is focused on the engineering aspects of the disaster and the technical factors that contributed to the incident. These include problems with design, maintenance, procedures, hazard analysis, and training.



The explosion ripped out piping, electrical conduit and damaged structures in the facility. (Source: CSB Report.)



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MIC day tank shield blanket structure. (Source: CSB.)