



Photo by Bill Tomkins

# Morton International Explosion

Paterson, New Jersey April 8, 1998

To workers at the Morton International chemical plant in Paterson the evening of April 8, the gathering noise “sounded like a train rumbling through.”

The 2,000-gallon chemical reactor shook as the internal temperature rose ever higher. Nearly four decades old, the kettle was nine feet tall with carbon-steel walls an inch thick. Inside were thousands of pounds of reacting chemicals.

Minutes earlier, everything had appeared to be normal. At 7:40 p.m., workers turned on the steam supply to the kettle, beginning what they assumed would be a routine six- to eight-hour production run of Automate Yellow 96, a dye used to tint petroleum fuel products. But the lead operator watched with concern as the kettle temperature began to climb precipitously, reaching 212°F less than half an hour later, at 8:05 p.m. A vigorous heat-producing reaction was underway, and it was warming the kettle much faster than steam alone would do.

## WHAT IS A RUNAWAY REACTION?

Many industrially useful reactions are heat-producing or “exothermic.” A runaway can occur when a chemical reaction produces heat more rapidly than it can be removed from the system. Excess heating further accelerates the reaction, causing the temperature to skyrocket. Components of the mixture may then boil violently or decompose to form gases, and the resulting pressure may cause a vessel rupture or explosion. Generally the larger a reaction vessel is, the more difficult it is to cool effectively, and the greater the risk of a runaway. Even reactions that require heating for initiation are frequently exothermic and may be susceptible to a runaway. Runaway reactions have been responsible for a number of catastrophic chemicals accidents, including those in Seveso, Italy (1976); Bhopal, India (1984); and Lodi, New Jersey (1995).

To control the reaction, the lead operator decided to cut off the steam and turn on the cooling water. A couple of minutes later, the kettle began to vibrate ominously as it surpassed the intended maximum processing temperature of 300°F. Liquid and gas began venting from the top of the kettle, as the internal pressure built. Unknown to the workers, the chemicals inside the kettle would begin to decompose at 380°F. That would initiate an even more violent runaway reaction that could rip the steel vessel apart.

Moments later, as the temperature rocketed past 380°F, the rumbling grew louder still. Workers began rushing for the exits.

At about 8:18 p.m., the Morton plant shook as accumulated pressure blew off the 18-inch metal hatch that was clamped to the top of the kettle. The kettle was lifted from its moorings and driven into the floor below. A fiery stream of gas and liquid erupted through the roof of the building, raining down chemicals onto the surrounding community.

Residents in a 100 city-block area were confined to their homes, voluntarily sheltering in place for up to three hours while officials evaluated health risks. Firefighters and workers in neighboring businesses reported throat, eye, and skin irritations consistent with chemical exposure.

Meanwhile, the last two fleeing workers had been caught by the blast and were knocked down a flight of stairs before collapsing to the ground. In all, nine workers were injured, including two with severe burns. As one of the injured said later at a public meeting of the U.S. Chemical Safety Board, “The pressure was so much on me, I couldn’t move. It had pinned me against the wall. It seemed like forever.”

## ANALYSIS OF PROCESS HAZARDS WAS DEFICIENT

The CSB investigation found that Morton had not adequately evaluated or controlled the hazards of the Yellow 96 production process. Neither the preliminary assessment conducted in 1990 nor a subsequent hazard analysis five years later considered the possibility of a runaway chemical reaction – one of the most common reactive hazards. As a result, the production kettle was not provided with sufficient cooling capacity or adequate emergency shutdown or venting systems. Morton’s analyses never considered possible scenarios – such as excessive heat input or inadequate cooling – that could trigger a runaway reaction.



**PROCESS CHANGES EXACERBATED RISKS**

CSB investigators found that two critical decisions had increased the chances of a runaway reaction in the Yellow 96 process.

Company researchers had originally called for controlling the process by introducing one of the raw materials stepwise in four equal portions. But in 1990, Paterson managers adopted a new procedure whereby the full amount of the chemical would be added to the reactor at the outset. With all the reactive chemicals massed in the kettle, a runaway reaction would become much harder to prevent or control.

Similarly, a 1996 decision to increase the kettle size and the batch volume made it harder for operators to cool the reaction mixture effectively. The percentage of temperature overruns rose significantly after the scale-up.

The CSB investigation found that Morton had not provided operators with adequate instruction to manage the Yellow 96 process safely. For example, operators were directed to inject small shots of steam to raise the kettle temperature in 4-5°F increments, but they were not told how much steam to let in or for how long. Nor did operators have a way to measure how much steam or cooling water was actually reaching the kettle. Workers had to rely largely on their own personal experience and intuition in trying to control the process.

**OPERATORS LACKED NEEDED SAFETY INFORMATION**

Under these conditions, it was very difficult to keep the temperature of the Yellow 96 reaction within the narrow safe operating range. Temperature-control problems occurred in eight of the 32 previous batches, according to operator notes.

Supervisors and operators in Paterson were unaware of the potential for a runaway chemical reaction, despite cautionary statements in early corporate research reports. Years before the incident, company researchers had noted possible hazards in the Yellow 96 reaction and recommended testing to design emergency venting equipment and an emergency shutdown system. This information never found its way to Paterson personnel responsible for the safety of the Yellow 96 production process.

Absent any knowledge of the hazard, Paterson operating procedures did not discuss how to avoid or recover from temperature deviations nor did they warn of the consequences if the kettle overheated.

**DANGER SIGNS WENT UNHEEDED**

Morton could still have corrected safety problems in the process by launching investigations into any of the eight prior instances when process temperatures exceeded the normal range.

Process and design changes resulting from such investigations could have prevented the 1998 explosion. Although investigating near-miss events and other safety incidents is a recognized good practice, no investigations were conducted in this case.

**KEY RECOMMENDATIONS**

After analyzing the root causes of the Morton incident, the U.S. Chemical Safety Board on August 16, 2000, made a number of safety recommendations to reduce the risks of similar incidents at Morton and elsewhere.

**To Morton International:**

The Board recommended that the Morton Paterson plant revalidate its analyses of the hazards of all reactive chemical processes. The Board also requested that the plant revise operating procedures and training, install any needed pressure relief and emergency shutdown equipment, and establish a program to investigate any unsafe process deviations in the future. The Board also called for revision of Morton's Yellow 96 Material Safety Data Sheet (MSDS) to include more accurate information on the chemical's reactive nature.

The Board further recommended that parent corporation Morton International, now a Rohm and Haas subsidiary, establish a program to share reactive chemical safety information more widely within the company.

**To OSHA and EPA:**

The Board recommended that the U.S. Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) issue joint guidelines on the management of reactive process hazards. The Board also called on the two agencies to cooperate with CSB in a special investigation on reactive hazards.

**NOTICE:**

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