

INVESTIGATION OF LARGE-MAGNITUDE INCIDENTS: BHOPAL AS A CASE STUDY

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Presented At
The Institution of Chemical Engineers Conference On
Preventing Major Chemical Accidents

London, England

May 1988

ABSTRACT

The investigation of large-magnitude incidents is fraught with difficulties and the process of establishing the primary cause of an incident often requires an understanding of human nature in addition to the necessary technical and engineering skills. The salient non-technical features that are common to the investigation of large-magnitude events are discussed in general. The investigation of the Bhopal disaster is discussed as a specific case study in light of these salient features. The results of the overall investigation are discussed and it is demonstrated that the commonly-held view that water-washing of a certain header caused the disaster is physically impossible. Evidence is presented which indicates that direct water entry into the methyl isocyanate storage tank was the likely initiating cause of the Bhopal disaster.

I. INTRODUCTION

In the aftermath of a major accident or incident in the chemical industry, it is common practice to ascertain the cause of the event through an investigation. If the magnitude of the incident is very large in terms of its impact on people, property, or the environment, it is not uncommon to assemble several teams of investigators to seek the cause of the incident independently. In the United States, a large-magnitude event may be investigated by the company that owns the facility, the insurance group that provides the liability coverage, federal investigators (e.g., OSHA, EPA), and state and local regulatory agencies. When several investigations are being conducted concurrently, in spite of the differing interests that are represented by each investigating team, cooperation and fact-sharing generally occurs among the investigating teams. This cooperative spirit was evident to some extent, for example, in the investigation of the LPG disaster in 1984 in Mexico City¹.

Given the significant amount of damage that is typically associated with a large-magnitude event, coverage by the news media is both extensive and exhaustive, especially if a number of fatalities have occurred. The news media represent yet another group of separate investigators and tend to focus on the human interest aspects of the tragedy. In addition, often with little hard information available, they actively speculate on the cause of the event in an attempt to "scoop" the story; that is, to be the first to report the cause to the world at large. In recent years, the news media with their surfeit of investigative reporters have become a predictable presence at the site of an incident.

Although no two major disasters are the same, our involvement in the investigation of more than a dozen events of significant magnitude has led us to believe that there are certain salient features that are common to most investigations. They include:

1. **Media Pressure** - In the immediate aftermath of a large-magnitude incident, both non-technical and technically trained reporters converge on the site, looking for quick "answers" to the question of what caused the event.

Most reporters are responsible, restrained, and unbiased in their reporting. However, a fringe group usually appears on-site that is more interested in developing causation theories, which seem to have great public appeal, regardless of their veracity.

In the case of the disaster at Bhopal in 1984, the cause célèbre was the "missing slip-blind" during a water-washing operation. An assertion was made that failure to insert a slip-blind prior to water-washing of some filters ultimately led to water entering the MIC tank and starting a reaction. This assertion proved to be false, as will be demonstrated later in this paper.

The difficulty with these incorrect causation theories is that, because the public and the media have a short attention span, the theories can become the conventionally accepted versions of what occurred. When a technical investigation discloses the actual cause much later, there may be less coverage, because the event is "old news" by then.

2. **Psychological Issues** - It has also been our experience that those people associated with a large-magnitude incident seem to evince an internal need to put some psychological distance between themselves and the incident. For example, there are those who feel -- in hindsight -- that even though they were not responsible for the event, they could have done more to reduce the magnitude of the event. And there are those who just wish it had not occurred on "their watch". There are also occasions when persons on duty distort and omit major facts to establish a reduced responsibility for the event. There is substantial evidence that such distortions and omissions occurred in Bhopal.
3. **Eyewitness Accounts** - When eyewitnesses are questioned about a major accident or incident, they tend to reveal only those facts that they personally consider important and pertinent. Thus, a good investigator must draw people out, using a line of questioning which elicits all pertinent facts. We have found that an eyewitness is most likely to be forthcoming and helpful if he or she is questioned immediately after the event. Once a story is told, whether accurate or inaccurate, it tends to harden. Further, where a deliberate distortion occurs, with the passage of time, the persons involved tend to coordinate their stories better. This puts a substantial premium on talking to persons involved quickly. In the Bhopal situation, the Union Carbide investigation team was blocked from doing this by the Indian Government for over a year. As a result, Union Carbide was unable to uncover the ultimate cause of the event until 1986.
4. **Contradictory Accounts** - When faced with contradictory statements from various

witnesses, an investigator has to weigh various accounts and then judge which account is likely to be correct, discarding the false account. This may require gaining an understanding of the probable motives of those persons who, knowingly or unknowingly, provided the incorrect accounts. It is also often possible to assess the accounts against known or technically established facts, to determine their accuracy. We encountered numerous cases of directly contradictory accounts of various situations that transpired during the Bhopal incident from those who were present during the event.

5. **Time Perception** - Although witnesses in a traumatic incident often recall the sequence of events with remarkable clarity, their perceptions of time during the actual incident sometimes differ. Therefore, when establishing the true chronology, witnesses' time perception must be evaluated against objective evidence. In the case of the Bhopal investigation, piecing together the correct chronology required that perceptions of time among different witnesses be accounted for in a consistent manner.

The above list of features is by no means complete. However, it does identify some significant issues that are manifest in incident investigations, and which should be considered by investigators of large-magnitude incidents. The very presence of these issues makes an incident investigation more than a purely technical exercise. In many ways, one can liken the investigation to attempting to correctly piece together a complex jigsaw puzzle, with the added challenge of having several pieces that are hidden, others yet to be discovered, and several extraneous pieces that do not belong in the completed puzzle at all and have to be discarded. To add to the investigator's difficulties, the "puzzle" has to result in a clear picture, even though assembled in a background of human tragedy and suffering, media attention, and a general aura of suspicion and hostility towards the plant and company investigation teams.

The above factors are those which we have identified in our investigation of large-magnitude incidents, and many of these factors played a role in the investigation of the Bhopal incident. The following sections will give a brief background of the investigation, elaborate upon some of the factors which were encountered and resolved during the investigation, and present some of the evidence and the conclusions of the investigation.

II. BHOPAL INVESTIGATION

BACKGROUND

To the best of our knowledge, two separate major detailed technical investigations of the Bhopal event were authorized. One investigation², sponsored by the Government of India (GOI), was conducted by a staff of scientists and engineers from the Council of Scientific and Industrial Research (CSIR), and it included other experts as well. A second investigation³, sponsored by the Union Carbide Corporation (UCC)*, was conducted by scientists and engineers from UCC, Union Carbide India Limited (UCIL), outside experts, and attorneys. The two investigations went forward entirely independent of one another. (The Indian Central Bureau of Investigation (CBI) also conducted its own investigation.)

In addition to these major investigations, dozens of opinions, purportedly based on investigations of the incident, were offered by various newspapers, magazines, television and radio commentators, authors, organizations, consultants, and politicians. Such accounts generally proved

to be quite flawed and incomplete.

Union Carbide investigators were at the site of the incident at Bhopal within days of the event to provide assistance and to conduct an investigation, but found that the plant had been sealed and placed under the control of the CBI. The cause of the incident was not then apparent. The methyl isocyanate (MIC) production unit had been shut down six weeks prior to the incident and the storage tank (Tank 610) had been isolated at that time; all that was known was that the pressure had risen in Tank 610 during the third shift on a Sunday night, December 2-3, 1984, and that MIC had been released into the atmosphere. It was unknown whether the release had been triggered by the entry of a contaminant, water, or some other agent.

The search for the cause of the incident at that point was, however, a secondary consideration; a second tank (Tank 611) containing some 20 tons of MIC remained, and the first order of business was to assist in its safe disposal.

It was determined that the safest route would be to process the MIC and SEVIN carbaryl pesticide, which was then done promptly. The processing of this tank of MIC was conducted jointly by UCIL and the CSIR, with the assistance of UCC's technical team, in an activity labeled Operation Faith by the Indian Government.

Following the safe disposal of the remaining MIC in December of 1984, the UCC investigation team attempted to begin its investigation. However, the legal skirmishes had commenced in both the United States and India and the CBI essentially maintained complete control over the records of the MIC unit. Although the investigation team was permitted to see copies of records in the period immediately following the event, it was allowed to do so only by specifically requesting a copy of a particular record or document.

*The author of this paper and the organization he represents were a part of this investigation team. Thus, if the team was unaware that a particular document existed, the document would never come to its attention, even though it might have a significant bearing on the outcome of the investigation.

Moreover, the CBI prohibited interviews with the plant's employees. The team submitted to the CBI a list of 193 plant employees whom it wanted to interview, but permission was refused. The CBI would only authorize discussions with the Plant Manager and the MIC Production Superintendent, neither of whom was on duty the night of the incident. In fact, the CBI was conducting a criminal investigation into the incident, and it contended that attempts by Union Carbide's investigating team to formally interview the workers would constitute "tampering with evidence" in the criminal investigation.

The problem of access to information was further magnified by this threat of criminal prosecution by the Indian government, Union Carbide's Chairman, Warren Anderson, who went to Bhopal to offer assistance and relief immediately after the incident, was placed under arrest upon his arrival in the city, and seven UCIL officers and employees were also arrested. This posture, in addition to physically preventing an investigation by Union Carbide, created an atmosphere of fear of criminal sanctions among the plant workers. Such an atmosphere, together with the sheer magnitude of the disaster, made witnesses even more defensive and uncommunicative than is usually the case in such investigations.

Further, the CBI conducted its criminal investigation into the incident using aggressive tactics. We believe this treatment played a major role in the development of a "cover-up" by plant employees. As noted earlier, there is a reflexive tendency among plant workers everywhere to

attempt to divorce themselves from the events surrounding any incident and to distort or omit facts to serve their own purposes. This is especially so where the investigation is criminal in nature. In addition, once an eye-witness has taken a defensive position under aggressive questioning by police making a criminal investigation, it becomes, as a practical matter, nearly impossible for the witness to later change that position to state the actual facts.

The team was permitted access to samples of the tank residue, and, after several months of extensive analysis of the residue of Tank 610, including more than 500 experiments, the UCC investigation team issued its report in March 1985³. The team concluded that the incident was caused when 1,000 to 2,000 pounds of water entered the tank. After subsequent experimentation and more extensive sampling much later, the amount of water was determined to be even greater. This large quantity of water reacted with the MIC in the tank, causing its temperature to rise to over 100°C, leading to a vigorous exothermic trimerization of MIC, resulting in rapid rises in temperature and pressure, and ultimately causing the major release. The incident occurred, despite the fact that the system had been designed and operated to keep out even small amounts of water, and the fact that no water had ever entered the tanks during the five years the plant had been in operation. Moreover, it was clear upon subsequent sampling and analysis that no water had entered either of the other two MIC storage tanks.

Because the MIC production facility had been shut down for over a month prior to the incident, and for a variety of other reasons that will be discussed, the investigation team concluded that direct entry of the water -- that is, by a direct connection to the tank rather than through the plant's piping system -- was likely. However, because the team had not been permitted to interview the plant employees and did not have full access to the records, it was unable to develop this theory further at that time.

The CSIR publicly issued its report² in December of 1985, approximately one year after the incident. The CSIR report also concluded that the event was caused by the entry of a large quantity of water into Tank 610. The CBI has not, to date, issued a public report of the findings of its own investigation.

LITIGATION

For more than a year, the CBI continued to prohibit interviews with the plant's employees. In the interim, a new aspect to the investigation developed. The Indian Government filed a civil suit against Union Carbide Corporation in the United States, asserting that the Government was the sole representative of the Bhopal victims. Thus, the Government acted as the plaintiff in a civil case with an interest in proving Union Carbide Corporation to be liable, yet, in its institutional role, it continued to exercise complete control of access to the sources of proof, restricting Union Carbide's ability to learn the truth, and fostering a version of the facts which supported its own litigation interest.

The Government's position as a party to the civil suit ultimately provided certain benefits to Union Carbide's investigation. In December 1985, a U.S. magistrate⁴ ordered the Indian Government to turn over copies of certain of the plant's records that had been seized, and these then became available for analysis by Union Carbide for the first time. Moreover, while it was before the U.S. court seeking information from Union Carbide, the Indian Government could not, as a practical matter, continue to restrict access to plant employees, which enabled Union Carbide to finally begin interviews. Despite having been denied access to the evidence for more than a year and despite being viewed with a great deal of hostility and suspicion, Union Carbide investigators

conducted a thorough review of the incident which included detailed interviews with virtually all of the relevant plant employees.

INTERVIEWS

Union Carbide employees and representatives began to interview the plant's employees in January 1986. Many people spoke openly and willingly. However, the team anticipated that there would be problems in interviewing the plant's employees, and the team therefore was assisted by a person familiar with most of the employees. This proved advantageous because the team found that many would speak to him, even if they were unwilling to speak to the entire team. It also proved beneficial in assessing the credibility of each individual.

Language also loomed as a potential problem, although ultimately it did not prove to be troublesome. Although all operators spoke English, many were more comfortable speaking Hindi. Several members of the team were fluent in Hindi and, by translating each question and answer, the interviews progressed smoothly.

However, the team did encounter some problems in locating the involved employees and persuading them to talk about a traumatic incident that had occurred a year and a half earlier. The Bhopal plant had been shut down since the incident, and the employees, by and large, had sought other employment. Many of the former operators and other employees had departed Bhopal without leaving any forwarding addresses, and it took weeks of questioning former landlords and neighbors to determine their whereabouts. Several had relocated as far away as Nepal and remote areas of India. This required lengthy journeys -- in one case, only to find the wrong individual with the same name. Careful advance preparation was therefore necessary.

Many of the former MIC operators were later employed by the State Government as plant safety inspectors. Some of those who had been most directly involved refused to talk to the team and eluded many attempts. Because politeness is an Indian trait, in fact, some would make appointments for interviews, but then disappear just prior to the appointment. Once found, however, the customary politeness proved to be an advantage, and the investigators learned it was wise to nurse the obligatory cup of tea for hours to prolong the interview in order to obtain bits and pieces of new information.

Although the Indian Government has continued to refuse access to the original plant records, copies of some of them were produced in the civil suit, and the investigators were able to analyze them and use their content in the interviews.

The investigators conducted well over 70 interviews over the course of a year and a half. The significant aspects and findings of this investigation are presented in what follows. To better understand the findings, however, a basic understanding of the plant's layout and operation is necessary.

III. BHOPAL PLANT LAYOUT AND OPERATION

The plant layout is shown in [Figure 1](#). Methyl isocyanate (MIC) was produced at the Bhopal

