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# Learning from the Bhopal disaster to improve process safety management in Singapore

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## ABSTRACT

The Singapore process industry is mainly made up of chemical and energy companies such as Mitsui Chemicals, Clariant, Exxon Mobil, Shell, Sumitomo, Petrochemical Corporation of Singapore and Infineum. Majority of these companies are located on Jurong Island, southwest of Singapore. Jurong Island houses nearly 100 leading petroleum, petrochemicals and specialty chemicals companies and the total investment is about S\$42 billion in total. With a land surface area of only 716 km<sup>2</sup> and a high concentration of process plants, the Singapore government places strong emphasis on safety and risk management. In this paper, four process industry veterans from the government, academic and private sectors were interviewed. Through the interviews, the authors sought to understand the veterans' perspectives on lessons that the Singapore process industry should learn from the Bhopal disaster. The veterans expanded their thoughts beyond the Bhopal disaster and provided many insights and suggestions critical to process safety management in Singapore and other countries. A systemic model of process safety management was derived from the interviews and key elements of operational process safety management were identified. In addition, a research agenda was identified based on the inputs from the veterans.

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## 1. Introduction

The Bhopal disaster, which happened on the night of 2–3 December 1984, is the worst industrial accident in recent history (Abbasi and Abbasi, 2005), resulting in thousands of deaths and hundreds of thousands of ill-health. The disaster was a result of complex socio-technological factors which had been studied by many (e.g. Casey and Casey, 1993; Meshkati, 1991; Peterson, 2009) and the process industry in many countries responded with new safety initiatives and regulations.

In response to global trends in process safety management, the recommended practice on process safety management was established in Singapore in 1993 by the former

Ministry of Labour (Go, 2010). The recommended practice was heavily influenced by the United State OSHA's 29 CFR part 1910.119 and API RP 750, with the aim to "eliminate or mitigate the consequences of large accidental releases involving hazardous substances" (Go, 2010). Subsequently, the recommended practice was developed into the Code of Practice on Safety Management System for the Chemical industry (2001). With the enactment of the Workplace Safety and Health Act (2005) in 2006, a new Singapore Standard, SS506 Occupational Safety and Health (OSH) Management System – Part 3: requirements for the chemical industry was established. Currently, quantitative risk analysis of new process plants is required by regulatory agencies such as the National Environment Agency (NEA), Ministry of Manpower (MOM),

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Singapore Civil Defence Force (SCDF) and Singapore Police Force (SPF).

While the Singapore government and the process industry have implemented many measures to prevent major process accidents, the 30th anniversary of the Bhopal disaster is a timely reminder of the potential severity of process incidents. Thus, this paper aims to use the Bhopal disaster as a platform to identify the key factors affecting process safety and suggest a research agenda to improve process safety in Singapore. It is likely that the identified factors and the proposed research agenda will also be useful to the process industry in other countries.

## 2. Process industry in Singapore

The process industry in Singapore makes up one-third of the manufacturing sector with high growth potential (Ministry of Manpower, 2010). From 2000 to 2009, there was an increase from 61 to 95 chemical companies and the total assets grew from US\$17 billion to US\$25 billion. The sector accounts for a workforce of more than 100,000 workers. It is a cornerstone of Singapore's economic strategy, with at least another S\$5 billion worth of investment over the next few years in Jurong Island and Tuas. The Singapore process industry comprises mainly multi-national chemical and energy companies. Many of the companies are located on the Jurong Island, home to nearly 100 leading petroleum, petrochemicals and specialty chemicals companies, amounting to a total investment of S\$42 billion. With a land surface area of only 716 km<sup>2</sup> and a high concentration of process plants, there is a strong emphasis on safety and risk management on the Jurong Island.

## 3. Summary of causes of Bhopal disaster

Factors leading to the Bhopal disaster have been discussed extensively elsewhere, such as by Shrivastava (1987), Meshkati (1989) and Peterson (2009). These factors include corporate negligence, such that corrective actions were not taken to address earlier accidents. In addition, there were also operational lapses, such as the failure to follow safety and operational procedures in the flushing of the MIC line and faulty, inadequate, or non-operational process equipment. Manpower was also cut due to economic reasons, a problem exacerbated by the replacement of experienced staff with less-skilled employees. In terms of responding to the accident and mitigating its impact, the plant's safety systems, such as the flare tower and the water curtain, were either not operational or did not have sufficient capacity. Emergency response planning and public health infrastructure in the vicinity of the densely populated Bhopal area were also lacking, which could have otherwise minimized the number of people in the community affected by the disaster.

## 4. Research method

This study taps into the expert knowledge and experience of four process and safety veterans in Singapore so as to identify the critical learning points that Singapore should learn from the Bhopal disaster. All of them have more than 25 years of experience in process safety-related work with varied backgrounds in academia, industry, regulatory and training and consultancy services. The brief profiles of the four experts are summarized in Table 1.

**Table 1 – Brief profile of experts interviewed.**

Interviewee no.	Years of relevant experience	Selected experience
1	>33	<ul style="list-style-type: none"> <li>• Currently the Technical advisor to private equity managers, investment banks and fund managers, where he assesses technical, operational, safety and environmental protection issues.</li> <li>• Significant experience in operations, safety and project management at a multi-national oil and gas refinery, involved in the development and implementation of safety programmes and processes, in both line and support functions.</li> </ul>
2	>25	<ul style="list-style-type: none"> <li>• Currently the Health, Safety and Environment Manager of a major oil and gas company in Singapore.</li> <li>• Heavily involved in process industry associations and national level workplace safety and health committees.</li> <li>• Significant experience in areas of process technology and operations, health and safety programme development and implementation, including driving process safety management programme</li> </ul>
3	>35	<ul style="list-style-type: none"> <li>• Currently an academia with a focus on safety, health and environment research and teaching.</li> <li>• Significant experience as an auditor and consultant in a wide range of industries, including the chemical industry.</li> <li>• Heavily involved in workplace safety and health standards setting in Singapore.</li> </ul>
4	About 40	<ul style="list-style-type: none"> <li>• Currently the CEO of a safety and health consultancy in Singapore.</li> <li>• Heavily involved in a national level safety association.</li> <li>• Worked in a range of senior management positions in a safety and health regulatory agency in Singapore; was responsible for enforcement, training and promotion of safety and health.</li> </ul>

Prior to each interview, the expert was given a summary of the causes and lessons learnt from the Bhopal disaster that the authors have prepared. In addition, they also received a summary sheet that spells out the aim of the study and

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