Contents lists available at SciVerse ScienceDirect

Process Safety and Environmental Protection

journal homepage: www.elsevier.com/locate/psep

Industrial disasters: Extreme events, extremely rare. Some reflections on the treatment of uncertainties in the assessment of the associated risks

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ABSTRACT

This paper addresses the issue of risk from disasters occurring due to accidents in high-consequence technologies, e.g., nuclear and oil and gas. The focus is on the challenges posed to the representation and treatment of uncertainties in the assessment of such risk, given that the occurrence of such extreme disasters is extremely unlikely, and yet they occur. A general framework of analysis is proposed.

Keywords: Industrial disasters; Rare events; Uncertainty; Risk; Probability; Interval probabilities; Dempster-Shafer theory; Possibility

1. Introduction

In the past 20 years or so, many industries have undergone significant changes. Competitiveness and liberalization has brought considerable advantages in the quality of products and services. On the other hand, processes and systems have seen an increase in the severity and complexity of their operation (energy ratings have increased, pressures, temperatures, flows have increased, storages have been reduced, interdependencies among industries and technologies have been increased, etc.).

The situation depicted above is such that the risk is increased, of large scale accidents with significant losses in both human lives and economic terms. And indeed, a number of industrial accidents have plagued the history of the last century of industrial activities (see Table 1 , elaborated from the information on http://en.wikipedia.org/wiki/Industrial_disasters).

Although the industry has always paid attention to safety, and has a relatively good safety record, we have seen in recent years a growing public concern to safety and protection from industrial (and natural) disasters, perhaps driven by the growing scale and complexity of modern plants. This has brought with it an increased intensity in safety regulation and in the critical scrutiny of the safety procedures.

In this scenario, quantitative risk assessment has emerged as a technical tool in support to the systemic examination of the risk associated to an industrial activity, and to the building of the confidence in the adequacy of the protections thereby installed. Quantitative risk assessment is a science that has been developed in the past 40 years to help understand better the risk associated with accident events. The interest in quantitative risk assessment is witnessing a continuous growth due to the fact that it allows a rational management of hazardous industrial activities through their systemic understanding.

The accident events object of the assessment are typically extreme and at the same time very unlikely. The rarity of these events is such that there is typically very little 'statistical' information associated to their occurrence. The challenge is then to say something about these potentially disastrous accident events based on the little information available, typically in the form of expert judgment supported by indirect physical

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Received 13 December 2010; Received in revised form 16 June 2011; Accepted 24 January 2012

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doi:10.1016/j.psep.2012.01.004

Table 1 – The history of industrial accidents.

Date	Name	Description	Consequences	References
Chemical industry				
1921	Oppau Explosion, Germany	A tower silo storing 4500 tones of a mixture of ammonium sulfate and ammonium nitrate fertilizer exploded at a BASF plant in Oppau	500 deaths, 2000 injuries	–
1932–1968	Minamata Disaster, Minamata Bay, Japan	Was caused by the dumping of mercury compounds. The Chisso Corporation, a fertilizer and later petrochemical company, was found responsible for polluting the bay for 37 years	3000 people suffered various deformities, severe mercury poisoning symptoms or death	–
1947	Texas City Disaster, Texas	At 9:15 am an explosion occurred aboard a docked ship named the Grandcamp. The explosion, and subsequent fires and explosions, is referred to as the worst industrial disaster in America. The blast shattered windows from as far away as 25 mi (40 km). Large steel pieces were thrown more than a mile from the dock. The origin of the explosion was fire in the cargo on board the ship. Detonation of 3200 tons of ammonium nitrate fertilizer aboard the Grandcamp led to further explosions and fires. The fertilizer shipment was to aid the struggling farmers of Europe recovering from World War II. Although this industrial disaster was one of the largest involving ammonium nitrate, many others have been reported including a recent one in North Korea	578 deaths, 3500 injuries	–
1948	BASF's Ludwigshafen explosion, Germany	A chemical tank wagon explosion within the BASF's Ludwigshafen, Germany site	207 fatalities	–
1974	Flixborough disaster, England	An explosion at a chemical plant near the village of Flixborough	28 deaths 36 injuries	–
1976	Seveso disaster, Seveso, Italy	The release of dioxins into the atmosphere and throughout a large section of the Lombard Plain. The disaster lead to the Seveso Directive, which was issued by the European Community and imposed much harsher industrial regulations	3000 pets and farm animals died, 70,000 animals were slaughtered, 193 people suffered from chloracne and other symptoms	–
1984	The Bhopal disaster, India	Is the largest industrial disaster on record. A faulty tank containing poisonous methyl isocyanate leaked at a Union Carbide plant. The disaster caused the region's human and animal populations severe health problems to the present	20,000 deaths 570,000 injuries	Times of India. In Context, Bhopal Disaster.
1988	Auburn, Indiana	Improper mixing of chemicals. The worst confined-space industrial accident in U.S. history	5 deaths	Joseph A. Kinney and William G. Mosley, "Death on the Job," The Multinational Monitor, April 1990, vol. 11, no. 4, citing a report by the National Institute for Occupational Safety and Health.
1989	Phillips Disaster, Pasadena, Texas	Explosion and fire. Registered 3.5 on the Richter scale	23 deaths 314 injuries	–
2001	Toulouse, France	An explosion at the AZF fertilizer factory. Extensive structural damage to nearby neighborhoods	29 deaths 2500 injuries	–