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DomPrevPlanning©: User-friendly software for planning domino effects prevention

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Abstract

Chains of accidents, in literature generally referred to as domino effects, knock-on effects, cascade effects or escalation effects occur very infrequently but with disastrous consequences. There exist very few software packages to study such domino accidents in complex industrial areas and to forecast potential catastrophes caused by secondary order (involving a sequence of three installations submitted to two consecutive accidents), tertiary order or even higher order accidents. Moreover, available domino software focuses on risk assessment and on consequence assessment. None of these toolkits specifically addresses the prioritization of installation sequences in an industrial area in order to facilitate objective prevention decisions about domino effects. This paper describes the application of a new computer-automated tool designed to support decision-making on preventive and protective measures to alleviate domino effects in a complex surrounding of chemical installations. Using a holistic approach and thus looking at the entire industrial area as a whole, all sequences of three installations in the area are ranked according to their danger contribution to domino effects. An example of a cluster of chemical plants demonstrates the level of qualitative and quantitative input data required. The example is also used to explain the toolkit results, as well as the surplus value and the benefits for company safety managers and regulators.

Keywords: Domino effects; Escalation accidents; Knock-on effects; Major risk software; Major risk decision support tools

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1. Introduction

Accidents resulting from domino effects in a chemical industrial area are defined as those in which a chemical accident becomes the initiating event of one or more other accidents, increasing the severity of the original accident (Delvosalle, 1996). Some accidents in which domino effects played an important role (Pietersen, 1986; Kletz, 1998; Lees, 1996; Wells, 1997; Khan and Abbasi, 1998) include Mexico City in 1984, Antwerp in 1987 and 1989, Piper Alpha in 1988, Pasadena in 1989 and Vishakhapatnam in 1997.

Domino risk analysis is the process of gathering data and synthesizing information to develop an understanding of the domino risks of a cluster composed of different enterprises and/or a cluster composed of different plants belonging to the same company. The effort needed to develop this understanding varies depending upon the basic information available for comprehending the significance of potential domino accidents (CCPS, 2000).

Only a thorough apprehension of the mechanisms and scenarios leading to such cascade accidents make it possible for safety management to prevent them. Prevention analysis of domino events is a topic of increasing interest for both the industry and regulators due to the fact that the severity of the consequences are exponentially increased if no appropriate preventive measures have been taken. Moreover, they are difficult to predict and to manage effectively. Preventive and protective actions should be based on rational and quantitative information leading to efficient preventive decisions. For this purpose, risk analysis decision support toolkits are available. In general, such major risk decision-support tools calculate the risks for different scenarios associated with a specific installation and produce risk contours, FN-curves[1] and rankings of risk contributors for that single installation (Hirst and Carter, 2002). They try to forecast and assess the probability and the possible adverse impacts of domino effects, employing deterministic models in conjunction with probabilistic analysis. These rather complex-to-use tools generally require extensive knowledge and expertise on the part of the user, such as an understanding of transient interchange of damage load (fire and explosion) between the causing installation and the receiving installation (Bagster and Pitblado, 1991) and mechanics of vessel failure. The available toolkits obviously have some very important advantages, allowing for a very thorough comprehension of highly complex scenarios and generating all possible consequences which could potentially occur on the investigated installation. Often, easy-to-read results in a graphical format are available as well.

However, both the complexity of the data required for assessing escalation events and the level of detail which such toolkits pursue can become a disadvantage for managers who have to decide whether to use them in a company. In chemical enterprises, safety managers are mostly interested in easy-to-handle and user-friendly decision-support tools that provide their users with straightforward information ready for implementation. This paper describes a newly developed computer-aided tool which makes it possible to rank installation chains in a complex installations network using some simple installation input data.

[1] FN-curves express a relationship between the number of fatalities (N) that can follow a major accident, ranging from 1 to some maximum value (N_{max}) and the frequency (F) at which that number of fatalities is reached or exceeded.