Preface of Integrating Safety and Security Management to Protect Chemical Industrial Areas from Domino Effects

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Preface

In recent decades, domino effect accidents in the process industry have raised an increasing concern in scientific, technical, and management domains. Domino effects such as the Buncefield accident in 2005 are characterized by a chain of accidents and may result in extremely severe consequences. The primary event can be an accident, a natural disaster, or an intentional attack. To prevent and mitigate domino effects, growing research on risk assessment and management of domino effects has been conducted in recent decades such as quantitative risk assessment of domino effects and safety barrier management for preventing domino effects. However, little attention has been paid to domino effects triggered by intentional events (intentional domino effects) such as terrorist attacks. This book thus aims to introduce advanced approaches that can model and manage both intentional and unintentional domino effects, developing a safer, securer, and more resilient chemical plant.

Chapter 1 provides a systematic literature review of domino effects in the process industry by classifying the methods used for modeling and managing domino effects, analyzing current research trends, and discussing future research needs. The models are divided into three categories (analytical methods, graphical methods, and simulation methods) and the management strategies are grouped into five types (inherent safety, management of safety barriers, emergency response, cooperative prevention, and security strategies). These approaches and strategies are analyzed and discussed to identify the research gaps and explore future research directions.

Chapter 2 introduces a dynamic graph approach for modeling the spatial-temporal evolution of fire-induced domino effects. The core of this section is the developed Domino Evolution Graph (DEG) model and the Minimum Evolution Time (MET) algorithm for solving the model. A case study is provided to test the model while another case is used to show its application in chemical clusters with a large number of hazardous installations. Compared with previous probabilistic models, the DEG model concerns more physical mechanisms and it is more flexible and visible to model the dynamic escalation process.

Chapter 3 provides a dynamic evolution model of VCE induced domino effects. Past risk assessment methods on VCEs ignore the effects of vapor cloud dispersion and delayed ignitions on the vulnerability of installations. As a result, a Dynamic VCE

Evolution Assessment (DVEA) model is developed based on a dynamic event tree, considering the spatial-temporal evolution of VCEs and the uncertainty of Delayed Ignition Time (DIT). Multiple ignition sources can be considered in this model, addressing the uncertainties of ignition time and ignition positions.

Chapter 4 introduces a dynamic approach, "Dynamic Graph Monte Carlo" (DGMC), for modeling multiple accident scenarios in domino effects. In this chapter, a chemical plant is modeled as a multi-agent system (installations, humans, and ignition sources), and the vulnerabilities of humans exposed to toxic gas, fire, and VCE are considered. Since the spatial-temporal evolution of multiple accident scenarios is addressed, the DGMC model can avoid underestimating domino effect risk, the damage risk of installations and humans.

Chapter 5 introduces an integrated safety and security management framework to tackle both intentional and unintentional domino effects. This framework mainly consists of six steps: chemical plant description, threat and hazard identification, the vulnerability of installations subject to hazards and threats, the vulnerability of installations exposed to domino effects, consequence analysis, risk treatment, and risk reduction. According to this framework, protection strategies encompassing both safety and security can be formulated to reduce domino effect risk.

Chapter 6 provides a cost-benefit management approach for optimizing the investment and allocation of safety and security resources based on the integrated safety and security management framework. A cost-benefit analysis is used to quantify the performance of protection strategies on the prevention and mitigation of domino effects. An optimization algorithm called "PROTOPT" is developed to achieve the most "profitable" protection strategy.

Chapter 7 introduces a resilience concept in domino effect management. A stochastic dynamic method is established to quantify the resistant capability, the mitigation capability, the adaption capability, and the restoration capability of chemical plants, supporting the allocation of safety barriers, security barriers, adaption measures, and restoration measures. Once a domino effect is inevitable, a resilient chemical plant may rapidly restore from the escalation disaster and reduce the losses.

Chapter 8 concludes this book and discusses future research on domino effect management in the process industry.

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