The Domino Effect
Assessing Chain-of-Event Consequences
in the Context of COMAH

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Preventing harmful releases—and reducing the adverse consequences of those that do occur—is a shared goal of industry and regulatory bodies. In order to avoid and mitigate, however, companies must be aware of their risks and how a release can snowball, producing the domino effect. The chain of cause and effect, as well as what to do about it, is staggeringly complex. Addressing it is obligatory under the Control of Major Accidents and Hazards Regulations 2015.

From an industrial safety point-of-view, the domino effect refers to the cumulative consequences of a chain of events set in motion by some initial occurrence, often a chemical release. The metaphor suggests a rapid sequence of collapse, extensive and relentless—a vivid symbol of failure to prevent or contain damage. Clearly, it is a situation that operators in the chemical and process industries strive to avoid and one that regulatory bodies target. The European Union's Seveso Directive produced the Control of Major Accidents and Hazards (COMAH) Regulations 2015, which is applicable throughout Europe. The directive requires, among other things, that organisations consider the domino effect in their reports.

It is useful to start with an example of the domino effect that many people overlook. ATEX (Appareils destinés à être utilisés en ATmosphères Explosives) applies in the EU (DSEAR, or Dangerous Substances and Explosive Atmospheres, is the UK equivalent). It provides for the use of certified equipment to minimise the chance of ignition in the event of a flammable gas release. Note that ATEX does not eliminate completely the risk of ignition, it just makes it much less likely. If a gas release does ignite despite precautionary measures, then an actual fire occurs. If another ATEX point leaks gas nearby, the fire becomes larger, potentially igniting the next release, and so on. This is a domino effect, where a small fire develops into a larger fire.

In the context of COMAH, a company's task is to assess, on one hand, how a sequence of events would affect its own people and premises, and on the other, how it could affect the surrounding area and industries. Not only do potential damages need to be considered, but also how they can be prevented or mitigated (see figure 1, page 3). This means first identifying what kinds of releases are possible and following their consequences as they branch off and eventually cease, and then devising feasible means of stopping them. It "...requires multidisciplinary knowledge and know-how, an adequate mindset, eye for detail and for the big picture, a short-term as well as a long-term vision, thorough collaboration efforts, a generalistic perspective with specialist knowledge, and so on. Different domains need to be dealt with in relation to domino effects: technological issues, procedural requirements, and human factor topics."[1]

1 As G. Reniers and Robby Faes observe in their chapter on managing domino effects in Domino Effects in the Process Industries (2013): https://www.sciencedirect.com/topics/engineering/domino-effect

Figure 1. Impact levels of a domino effect.

Given this complexity, having a general framework to apply to the process is indispensable (see figure 2, page 4). Both severity and duration play a role. The worst combination is, of course, severe damages that persist and grow over an extended period of time. Fortunately, not every damaging release is long-lasting, and some that continue to affect the environment for years could be less severe in their effects. Occupying this middle ground are, for example, chlorine gas releases, which can cause considerable harm but typically do not endure more than a couple of days, and lead particles, whose effects are not as destructive, but which may remain in mud and riverbeds for years. The least worrisome are releases that are neither particularly hazardous nor long-lasting.

Another factor to consider is the extent of the impact in terms of distance from the initial release. Can consequences be limited to the factory's premises, and if not, how far is their reach? Within that area of impact, the first priority is to address clear risks to human beings, with a 1 in 1 million[2] chance of fatality as a point of reference. The nature of the release–liquid, gas or solid–can lead to a wider or narrower area of impact because of the characteristics of each. For example, waterborne releases, because they spread easily and are difficult to control, should be considered first of the three, followed by releases transmitted through the air. This is because harmful gases are subject to dilution in the environment and therefore tend to dissipate more quickly than liquids. Finally, solids, such as dust, should be assessed.

As mentioned above, COMAH reporting requires companies to include prevention and mitigation strategies alongside the description of cascading events. New technologies are expanding the options in this arena, which includes containment

2 Often companies choose a target of 1 in 10 million to be sure of achieving 1 in 1 million.

solutions. This generally takes the form of treatment facilities where a release can be captured and 'deactivated' before it is able to spread, arresting the domino effect. Older plants may benefit from retrofitting with more recent technologies, and where additions or new construction is planned, prevention and mitigation of harmful releases should play a major role in layout, materials and more.

The purpose here has been to call attention to the complexity of the domino effect–only one of many topics to be included in COMAH reporting–and to point out key features that can help companies initiate their analysis. In the end, these chain reactions and strategies to prevent or mitigate them demand expertise in multiple areas and an eye for both the proverbial forest and the trees. Having an objective, trusted advisor at your side with experience, expert resources and a thorough knowledge of COMAH regulations can help identify blind spots and provide a fresh perspective where needed. At DEKRA, we specialise in offering our clients the support they need, not only to meet requirements, but to thrive while helping build a safer world.

Figure 2. Factors influencing chain-of-event consequences.

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Clive de Salis is Principal Process Safety Specialist and consultant in process design safety, critical instrumentation and hazards. He writes both the IEC62443 series of standards on Cyber security and the IEC61508 series, which includes IEC61511 on SIL, rated systems. His main areas of expertise are process risk assessment, including HAZOP, with extensive experience in the design and installation of safety systems and determination of safety integrity levels. His recent experience includes expert witness selected by barristers and solicitors for dust explosions.

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