Inherent safer design

Design

Inherently safer design (KIDS) evaluation are Important for Identifying fundamental process improvements that can eliminate hazards or reduce the consequences of plant accidents. They are typically performed at the earliest stages of process design, where changes are most cost-effective. As the detailed design comes into focus, inherently safer options are rarely revisited because the designer's emphasis has shifted.

Although fundamental changes during later design phases are more difficult, hey may still be opportunities to entertain new ideas of inherently safer design. Thus, engineers should continue to look for new mechanisms to improve plant safety throughout the design process. Process Safety Risk Management Strategies Chemical process safety measures or process safety risk management strategies are 1. Inherent Eliminate or modify the hazard and/or risk by changing the process to use materials and conditions that are Nostradamus or much less hazardous and/or employing one of four strategies of substitution, minimization, moderation, simplification. . Passive Minimize the hazard by process and equipment design features which reduce either the frequency (likelihood) or consequences of the hazard without the active functioning of any device. 3. Active Manage risk using process control systems, Safety Instrumented System (SIS), safety interlocks and mitigation system such as emergency shutdown systems to detect and correct process deviations. These may prevent an incident or reduce the consequences of the incident. 4.

Procedural Using operating procedures, administrative checks, safety rules, emergency response and management systems to manage the risk. Elements of Inherent Safer Design (SD) Inherent safety is usually divided into

different elements. There is no standardized list, but the following four elements are representative. The preferred order in which they should be addressed is shown below. 1. Substitute 2. Minimize (Intensification) 3. Moderate (Attenuation, Limitation of Effects) 4.

Simplify (Error Tolerance) The use of inherent safety principles not only improves safety, it is likely to reduce capital costs and the investment that has to be made in activities such as training and operating procedures. Substitute The next step in addressing inherent safety is, where possible, to replace a hazardous material with one that is less hazardous. Thus the consequences of a release are fundamentally less dangerous. For example, water-based additive solutions are likely to be safer than hydrocarbon-based solutions because the latter are flammable.

Minimize philosophy comes in part from the Opal tragedy. The facility stored large quantities of the intermediate compound Methyl Assassinate that created the toxic cloud. Had the facility been designed so as to greatly reduce this inventory - a technically seeable solution - then the consequences of the event would have been much less severe. In general, it is often found that the use of continuous reaction rather than batch processes will help minimize the amount of hazardous material that is present. Moderate Moderation (attenuation) accepts that a certain condition exists but aims to reduce its impact.

In the case of the pump that is transferring liquid from one tank to another it may be that the greatest risk occurs if the pump is blocked in while running and achieves dead-head pressure. In such a case the risk can be moderated

by using a lower pressure pump curve. Simplify The final step in achieving Inherent Safety is to reduce unnecessary complexity, make operating errors less likely and that are more forgiving of any errors that are made. CASE STUDY: OPAL DISASTER Opal disaster, also known as Opal gas tragedy is a gas leak incident in India.

This incident is considered the worst industrial disaster in the world. It occurred at the night of 2-3 December 1984 in the pesticide plant of Union carbide India limited (CULL) in Opal, Madhya Pradesh, India. It happened when about 40-45 tons of extremely toxic MICE gas released to the atmosphere. Union Carbide Corporation (USC) built the CULL factory in Opal to produce the pesticide Seven using the MICE as an intermediate material. MICE production unit was added at 1979 to produce it on side rather than importing it. Figure 1: Location of Opal in India highly flammable.

Its boiling point is -? chic. It has a highly active volatile reaction with water. If water comes in contact with MICE a run-away reaction starts which increases the reaction temperature, as a result the reaction rate increases more and more. At a certain temperature the MICE molecules start to combine with their selves with enervating more heat. Figure 2: Health effect by inhalation of MICE On the night of December 23, 1984, a dangerous chemical reaction occurred in the Union Carbide factory when a large amount of water got into the MICE storage tank # 610.

This release was due to a runaway exothermic reaction involving MICE and water, which led to a major increase in the temperature inside the tank to over CHIC (40000. This forced the emergency venting of pressure from the

MICE holding tank, releasing a large volume of toxic gases. The reaction was sped up by the presence of iron from corroding non-stainless steel pipelines. A large amount, about 40 tons of Methyl Assassinate (MICE), poured out of the tank for nearly two hours and escaped into the air, spreading within eight kilometers downwind, over the city of nearly a million people.

Sources say that there were a lot of reasons because of which the incident occurred, but nobody knows for sure what exactly happened. One of the biggest questions raised against Union Carbide was regarding the safety systems in place, in case a disaster such was this was to occur. After detailed investigations it was found that the 'six' safety protocols in place were al non-functional at the time of the accident. Below is a list of the six safety systems that failed: 1. Run Off Tank: Already contained MICE 2.

Mandatory Refrigeration for MICE Unit: Shut down for 3 months to save money 3. Flare Tower: It was disconnected volume of gas 5. Water Curtain: Not functional because it was designed with inadequate height Figure 3: The main factors that contribute to the disaster Before After Figure 4: Opal before and after the disaster As mentioned earlier inherent safety is an approach to accident prevention by substituting, minimizing, moderating and simplifying a hazard. Substitution MICE is a highly toxic chemical that was an intermediate in the production of Carbonyl.

If the concept of substitution was applied here, Union Carbide could have used alternative chemicals or even an alternative reaction to manufacture Carbonyl. This would have made the process inherently safer because hazards levels would be lower as compared to before. Another application of

the substitution principle involves knowledge about the exothermic nature of the reaction between MICE and water. Since, it was known that MICE and water reacted violently to form a toxic gas, Union Carbide should have used substances other than water for cleaning purposes, as well for safety systems such as water curtains.

Minimization Another big problem with the accident was the presence of tanks on-site containing large amounts of toxic MICE. This is a recipe for disaster because in the event of an incident a huge amount of toxic chemical would be exposed to the environment around. Hence, an alternative approach would be to implement the concept of minimization, which would require a reduction in the amount of unwanted MICE being stored on-site. If only a small amount of the hazard is present, the consequences old also be reduced greatly.

Moderation Moderation of the storage conditions (temperature) would have been enabled by the standard procedures required, the MICE was actually at ambient temperature - obviously much closer to its boiling point of 39. 1 co. With the contaminant presence leading to an exothermic reaction and elevated MICE temperature and vapor generation, it is not clear how pressure might have effectively moderated. However, a 90% reduction in the operating pressure involved would have resulted in a 60% decrease in the *ICE-hazard distance. *DOD-Chemical Exposure Index estimates the hazard distance for chemical exposure based on the emergency response planning guideline (ERP) values for the particular material released). Applying the concept of moderation to the scenario at hand, Union carbide should have built the factor far away from an urban city. This would have led to fewer

fatalities once the toxic gas began to spread. By constructing the factor right next to a big city, Union Carbide put the lives of nearly a million people in Jeopardy.

Another application of the moderation concept would have been to install dikes or bounds of mom form to make sure a toxic gas release didn't get released into the surrounding atmosphere. Simplification Lastly, by employing the idea of simplification, Union carbide should have designed a reactor which could sustain the maximum pressure or temperature during a runaway reaction. This would eliminate the need for multiple safety systems that need maintenance round-the-clock. The Opal facility relied on end-of-pipe monitoring and control systems attached to the storage vessels, the reliability of which required they be in a good working order.

Reliance on such systems can create a dual problem: the safeguards may not available when needed, and their existence may provide a false sense of security for process operators who may ignore initial warning signs, such as pressure increase. CONCLUSION As summary, no matter how many secondary safety measures or safety systems are present during an accident such as this, the best and most successful risk mitigation process would be to make the process and its auxiliary components inherently safer, thereby removing any chance of such a disaster of from happening.

The overall safety of a process relies on various layers of protection. The first and most important part of this safety blanket is inherent safety. Inherent safety can greatly help reduce the risks associated with a certain hazard because it deals with reducing the hazard itself, rather than controlling the

consequences resulting from the hazard. Is of utmost importance that we incorporate the concept of inherent safety into our designs. In order to apply these concepts, one has to understand the underlying principles of inherent safety namely: Substitution, Minimization, Moderation and Simplification.

By successfully understanding and applying the principles of inherent safety, we can reduce the occurrences of huge chemical disasters such as Opal that greatly impacted the way we perceive safety today. We also need to look back at those disasters, and learn from our mistakes, because there a lot to learn from what happened in the past.