Submitted to the

SUBCOMMITTEE ON CYBERSECURITY, INFRASTRUCTURE PROTECTION AND SECURITY TECHNOLOGY
OF THE
COMMITTEE ON HOMELAND SECURITY
UNITED STATES HOUSE OF REPRESENTATIVES

Testimony of

M. Sam Mannan, PhD, PE, CSP
Regents Professor and Director
Holder of T. Michael O'Connor Chair I
Mary Kay O'Connor Process Safety Center
Artie McFerrin Department of Chemical Engineering
MS-3122
Texas A&M University System
College Station, Texas 77843-3122, USA

Phone: (979) 862-3985
e-mail: mannan@tamu.edu
URL: http://process-safety.tamu.edu

On

U.S. Department of Homeland Security's Preventing Chemical Terrorism: Building A Foundation of Security at Our Nation's Chemical Facilities

Friday, February 11, 2011

Introduction

My name is M. Sam Mannan and I hold a BS, MS, and PhD in chemical engineering. I am a registered professional engineer in the states of Louisiana and Texas and I am a certified safety professional. I am a Fellow of the American Institute of Chemical Engineers and a member of the American Society of Safety Engineers, the International Institute of Ammonia Refrigeration, and the National Fire Protection Association. I am Director of the Mary Kay O'Connor Process Safety Center, holder of the T. Michael O'Connor Chair I in Chemical Engineering, and Regents Professor of Chemical Engineering at Texas A&M University. The Center seeks to develop safer processes, equipment, procedures, and management strategies that will minimize losses in the process industry. My area of expertise within the chemical engineering discipline is process safety. I teach process safety engineering both at the undergraduate and graduate level. I also teach continuing education courses on process safety and other specialty process safety courses in the United States and overseas. My research and practice is primarily in the area of process safety and related subjects. The opinions presented in this document represent my personal position on these issues. These opinions are based on my education, experience, research and training.

Chemical security and protection of the chemical infrastructure is of extreme importance to our nation, and I am pleased that the US Congress is continuing to pay attention to issues relating to Chemical Facility Anti-Terrorism. I have provided testimony previously on this subject to the US House of Representatives Subcommittee on Transportation Security and Infrastructure Protection of the Committee on Homeland Security, on December 12, 2007 and the US Senate Homeland Security and Governmental Affairs Committee on March 3, 2010. Since then, I have continued to study various issues related to inherent safety and the implementation of inherent safety. While we have gained additional insight about inherent safety issues, my opinions remain much the same as then.

Background

Hazardous materials can be grouped into three tiers of vulnerability categories. The first category includes the stationary facilities that are members of major industry associations. Even though these facilities have large inventories of hazardous materials and are quite visible, they are the best prepared against attack because of voluntary programs that have been developed and implemented. The second tier of vulnerability category includes smaller and medium-sized facilities that manufacture or use chemicals but may or may not be members of any industry associations. These facilities are less visible, but are also, in general, less prepared and more widely distributed. Finally, the third category of vulnerability includes all hazardous materials that are in transit (by whatever means) throughout the United States. In addition to being present almost anywhere in the United States at any given time, this category also represents high visibility and the highest vulnerability. It could also be argued that this category is the least prepared to deal with intentionally caused catastrophic scenarios.

Some pertinent subjects of interest with regard to attacks on the chemical infrastructure are: active protection measures; passive protection measures; vulnerability analyses, response and recovery plans; and long-term needs and priorities. Active protection measures include increased security, limited access to facilities, and background checks. Examples of passive protection measures include development of exclusion areas and process and engineering measures.

Vulnerability analysis, response, and recovery plans are needed not only to help devise the prevention and protection plans, but also to develop the response and recovery plans. In this respect, it must be mentioned that most of the large, multi-national facilities that are members of major industry associations have voluntarily conducted some form of vulnerability analysis. What is not clear is whether these analyses have been used to integrate planning for response and recovery efforts in coordination with local agencies and the public. One very stark lesson from the 9/11 events is that the "first" first-responders are usually members of the public. Additionally, area- and region-specific vulnerability analysis and assessment of infrastructure availability for response and recovery have not been conducted. Finally, a national vulnerability analysis and assessment of infrastructure availability for response and recovery is a critical need.

Whether natural or man-made, disasters will continue to happen. However, as we have seen with the 9/11 events, hurricanes Katrina and Rita, and chemical incidents such as the Bhopal disaster, planning and response is crucial in being able to reduce the consequences and to recover from the disaster more rapidly. In this regard, it is essential to conduct vulnerability analysis, response, and recovery planning at the following three levels:

- **Plant-specific vulnerability analysis** and assessment of infrastructure availability and preparedness for response and recovery is needed. As mentioned earlier, most of the large multi-national facilities that belong to prominent industry associations have voluntarily conducted some form of vulnerability analysis. What is not clear is whether these analyses have been used to integrate planning for response and recovery efforts in coordination with local agencies and the public.

- **Area- and region-specific vulnerability analysis** and assessment of infrastructure availability for response and recovery should be conducted. Each area- and region-specific analysis should include an assessment and planning for evacuation and shelters.

- **National vulnerability analysis** and assessment of infrastructure availability for response and recovery is critically needed. In doing this national analysis, impact on international issues and criteria should also be considered.

Inherent safety options can be considered; however, it must be understood that determination of inherent safety options is a "***complex process***" and not an "***off-the-shelf technology***". We must be aware of the differences in implementing inherent safety options for

existing plants, as compared to new plants. Also, in some cases, a seemingly clear choice with regard to inherent safety may create some undesired and unintended consequences. Issues such as risk migration, reduction of overall risk, and practical risk reduction should be evaluated whenever an inherent safety option is considered. Such an approach should be based upon the triple-pronged philosophy: evaluation and assessment, prevention and planning, and response and recovery. Planning and preparedness is required for all three areas. Only through a comprehensive, uniform and risk-based approach can we protect the people and communities of our nation as well as protect our nation's critical chemical infrastructure.

Long-term Goals and Priorities

Long-term goals and priorities to prevent and/or reduce the consequences of intentional catastrophic scenarios require clear thinking and hard work. While no one would argue that making hazardous materials less attractive as a target should be a goal that all stakeholders should accept, differences arise in how we realize that goal.

Another long-term goal is to develop technology and know-how with regard to resilient engineered systems and terrorism-resistant plants. In this respect, research and technological advances are needed in many areas, such as bio-chemical detection, sensors, and self-healing materials. Protection of the chemical infrastructure, like many other challenges, requires the commitment and effort of all stakeholders.

I feel very strongly that science should precede regulations and standards. With regard to science and technology investments, many initiatives have been proposed and are being implemented. However, some important additional initiatives that should also be considered are given below:

1. The fact is that the chemical infrastructure and all components including the individual sites, supply, and delivery systems were never built with terrorism in mind. Research must be conducted to determine how we might have designed and built the chemical plants and the infrastructure had we considered these threats. The ultimate goal for such research would be two-pronged. First, determine options for what can be feasibly implemented for existing plants. Second, if necessary, prescribe new standards and procedures for new plants.

2. Research investments should be made on advanced transportation risk assessment methods. Before transportation of any hazardous materials, a transportation risk assessment should be conducted using available information and methodology, as well as time-specific data that may be available.

3. Additional science and technology investments that should be considered are:

    - Development of incident databases and lessons learned. This knowledge base could then be used to improve planning, response capability, and

infrastructure changes. Recent experience in this regard is the improvement in planning and response for the hurricane Rita from lessons learned from the hurricane Katrina.

- Research should be conducted on decision-making, particularly under stress, and how management systems can be improved.

- Research on inherent safety options and technologies. This type of research should be combined with systems life cycle analysis and review of practical risk reduction. In other words, implementation of inherent safety options should not be allowed to create other unintended consequences, risk migration, or risk accumulation. While transportation is outside the scope of the ***Chemical Facility Antiterrorism Standards (CFATS)***, it must be included in vulnerability assessments to avoid transfer of facility risks to transportation risks.

- Basic and fundamental research is also needed on design of resilient engineered systems. For example, if the collapse of the World Trade Center towers could have been extended by any amount of time, additional lives could likely have been saved.

- Basic and fundamental research is also needed on resilient and fail-safe control systems.

- Long-term research is also needed in the area of self-healing materials and biomimetics.

Specific Comments Relevant to *Preventing Chemical Terrorism: Building A Foundation of Security at Our Nation's Chemical Facilities*

With regard to the ***Chemical Facility Antiterrorism Standards***, I have the following specific comments:

1. The US Congress must give the Department of Homeland Security permanent and continuing authority to regulate chemical security in the United States. While many facilities are voluntarily taking appropriate measures, I am concerned that many are not. A regulation that creates a minimum and level playing field is very important.

2. The use of a risk-based approach and risk-tiering in evaluating the vulnerability of any facility is a good approach.

3. The Department of Homeland Security does not currently have appropriate and adequate expertise to implement and enforce inherent safety.

4. With regard to mandated consideration and/or implementation of inherent safety in chemical facility antiterrorism regulations, I have the following comments:

    a. Despite a significant amount of work in the area of inherent safety design and technology, it still remains a very complex task to determine on a case-to-case basis what is an inherently safer technology or approach. In many cases, a seemingly inherent safety approach may result in unintended consequences, risk transfer, and/or risk accumulation.

    b. Based on current know-how and science, there does not exist any widely accepted scientific process by which to require (by legislation or regulation) a mandatory assessment of "inherently safer technology," at a chemical facility. As a result, there are dangers associated with mandating a specific assessment model or requiring an overly burdensome assessment regime.

    c. There are many methods available to the industry for potentially reducing risk and vulnerability. Vulnerability assessments should consider the feasibility of all methods for improving security to determine the method to achieve the optimum balance of cost effectiveness and vulnerability reduction.

    d. As I stated earlier, science should precede regulations. I do not believe that the science currently exists to quantify inherent safety. Regulations or any actions taken as a result of regulations should not create unintended and unwanted consequences. An example in this context is the substitution of hydrogen fluoride (HF) with sulfuric acid (H_2SO_4) for refinery alkylation processes. While it is true that HF is more toxic than H_2SO_4, the amount of H_2SO_4 needed to do the same amount of processing is 100-140 times or more than HF. Thus changing from HF to H_2SO_4 would require large storage facilities and more transportation. In fact, changing from HF to H_2SO_4 may provide more opportunities for a terrorist attack. On the other hand, a well-managed plant with a smaller amount of HF and appropriate safety protective systems may represent a lower overall risk.

    e. An example of risk transfer as well as risk accumulation is the replacement of chlorine with sodium hypochlorite for water treatment processes. The sodium hypochlorite itself is manufactured from chlorine and thus the risk is transferred somewhere else. In fact, if all water treatment is converted to sodium hypochlorite processes, it would lead to risk accumulation where a mega-plant would have to be constructed somewhere with large quantities of chlorine representing a high-value target. Thus, while conversion to sodium hypochlorite may be advisable in some cases, but not in all cases. The determination should be made on a case-by-case basis depending on case-specific information and life cycle risk analysis.

    f. In the case of conversion from chlorine to sodium hypochlorite, there could also be unintended consequences. Sodium hypochlorite is known to be

unstable and can decompose into chlorates which subsequently convert to perchlorates. Depending on the duration and conditions of storage of sodium hypochlorite, the formation of perchlorates can occur. This presents an obstacle when this alternative is introduced as an inherently safer technology than that of chlorine since perchlorates are toxic and have been noted to induce thyroid problems from extended exposure. Moreover, perchlorates have been found in more than 90% of sodium hypochlorite samples, and its concentration is believed to increase with age. Contamination of drinking water during its treatment is the most likely way of entering the human body. However, it has also been found that plants can absorb perchlorates without adverse effects to themselves. The perchlorates are then stored may be passed along in the food chain[1].

A study performed by Orica (an Australian company) found that the number of incidents involving chlorine gas formed by the inadvertent mixing of acid with sodium hypochlorite was larger than those directly from chlorine gas alone[2]. This fact, along with the hazardous properties of the chlorates formed by improper storage of sodium hypochlorite shows that this option cannot be readily listed as an inherently safer alternative for chlorine and that its risks cannot be overlooked.

g. When inherent safety options are considered, we must understand and account for the challenges and difficulties in implementing inherently safer technology and options. The first challenge is simply to measure the degree of inherent safety in a way that allows comparisons of alternative designs, which may or may not increase safety or may simply redistribute the risk. The second is that because inherent safety is an intrinsic feature of the design, it is best implemented early in the design of a process plant, while the US has a huge base of installed process plants and little new construction. Finally, in developing inherently safer technologies, there are significant technical challenges that require research and development efforts. These challenges make regulation of inherent safety very difficult. We believe that a coordinated long-term research and development effort involving government, industry, and academia is essential to develop and implement inherently safer technologies. A similar collaborative approach has shown success in related areas such as green chemistry, energy conservation, and sustainable development.

h. Instead of prescriptive requirements for inherently safer technology and approaches, facilities should be allowed the flexibility of achieving a manageable level of risk using a combination of safety and security options. For example, nuclear facilities have very high hazard materials, but they protect their site and the public with a combination of multiple layers of

[1] http://www.watertechonline.com/news.asp?N_ID=70952
[2] http://www.wioa.org.au/conference_papers/04/paper2.htm

security and safety protective features. All methods of reducing vulnerability should be considered on a case-by-case basis, and the implementation of any one particular method should not take or appear to take precedence over the others.

i. Over the past 15-20 years, and more so after 9/11, consideration of Inherently Safer Technology (IST) options and approaches has effectively become part of industry standards, with the experts and persons with know-how assessing and implementing inherently safer options, without prescriptive regulations that carry risks (both as trumping other tools or potentially shifting risk). A better approach for applying IST in security is by allowing the companies to assess IST as part of their overall safety, security and environmental operations and therefore, cannot be prescriptive. In fact, it seems that the current risk tiering of stationary sources inherently encourages the use of IST. For example, a facility that is in Tier 1 would consider all IST options if they could move the facility to Tier 3 or Tier 4. So, it could be argued that consideration of IST options is part of the market-driven incentive-based approach within the current CFATS legislation. In fact, when facilities use IST approaches to change their tier designation, they should be required to prove that:

- Overall risk has been reduced
- That unintended consequences have not been created
- That risk transfer and/or risk accumulation has not occurred
- That the actions taken or proposed have not just simply resulted in the departure of industry from one area to another

5. Cost-benefit analysis of inherent safety options is another very important and pertinent issue that should be a significant part of any decision making process.

6. Currently there does not exist a generally accepted understanding on the definition of "inherently safer technology." Given that background, if regulations require all plants to be "inherently safe," there might be a tendency to broaden the definition of "inherently safe," so that almost everything fits the definition.

7. Before adopting any regulatory framework requiring the evaluation and/or implementation of inherently safer technology, significant research questions must be answered to reach a universally accepted definition of "inherently safer technology." Research in critical areas such as system reliability and resilience must also provide information to help develop appropriate guidance for facilities, both new and old, regarding methods to assess the costs, benefits, and potential risks of process changes at their facilities and throughout the supply chain and market.

Summary

I applaud the US Congress for providing leadership in this important area of chemical security. It is clear that many companies are taking reasonable and responsible steps in chemical security, including the consideration of inherent safety options. Inherently safer technology is an objective that should continually be pursued, but must always be based upon sound science as well as sound risk assessment and management principles. Mandating the evaluation and/or implementation of inherent safety options must be based on good science. Before such steps can be taken, important issues must be resolved such as a generally accepted understanding on the definition of "inherently safer technology," methods for quantification of inherent safety, and methods for evaluation of inherent safety options. I do not believe that current know-how and science exists to adequately define and quantify any of these issues.

Requirements for inherently safer technology should be based upon good science aimed at making the industry secure, avoid over-regulation, and create a level playing field. US facilities could be at a competitive disadvantage if required to implement unproven technologies simply to meet a regulator's position that such technology is more inherently safe.

I am encouraged by the leadership of Congress and by continued efforts to seek expertise and opinion from all stakeholders.