Testimony[1]
of the
Synthetic Organic Chemical Manufacturers Association

Submitted to the

Senate Committee on Environment & Public Works

On

Inherently Safer Technology

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I. **Introductory Comments:** **What is *Inherently Safer Technology*?**

Inherently Safer Technology (IST) is a philosophy that began in the late 1970's. Its goal is to use traditional engineering, chemistry, and other scientific concepts to reduce the risks associated with chemical processing. Since its inception, IST has been ingrained as a normal part of the research and development (R&D) process development and manufacturing discipline in the chemical industry for many years.

Few terms in chemistry are as misunderstood as "inherently safer technology." While ostensibly self-explanatory, the term as used in chemistry and engineering is not as easily understood by non-scientists. IST is a conceptual framework that covers chemical processing procedures, equipment, protection, and, when feasible, the use of safer substances. Many non-scientists have been led to believe that the only road to inherent safety is by way of reducing the amount of hazardous chemicals used in manufacturing and processing. IST, however, is limited by the laws of physics; a simple reduction in the use of hazardous chemicals is often not possible or may only result in the redistribution of risk, without actually reducing it.

II. **The Unique Nature and Role of the Batch and Specialty Chemical Manufacturing Sector**

Specialty chemicals are essential ingredients and building blocks for the manufacture of almost everything made in the United States. Specialty chemicals perform very specific functions, based largely on their molecular structures, which give them unique physical and chemical properties. Without these substances, nylon would not be strong enough to use for seatbelts, medicine would revert back to what it was in the 1800s, and our armed forces would not have the equipment and supplies necessary to defend our country.

Because of their complex chemistries and narrowly focused applications, specialty chemicals are typically produced batch-by-batch in reaction vessels. Batch processes are very different from the 24 hours a day, 7 days a week continuous operations that produce commodity chemicals. Since continuous processes employ continuous feeds and yields, the production volume is usually far greater than for batch processes. The main difference, however, is that a batch process, which incorporates the chemical reaction (and yields the desired product), has a distinct beginning and end for each batch. As a result, the products that are stored onsite also change on a continual basis.

In addition to differences in processing and variable production schedules, another distinct feature among specialty chemical producers is the variability of risk at production and storage sites. Batch producers are necessarily flexible and they can make many different products during any given production year. Their business is driven by customer demand, and many chemicals are made on short notice. As a result, the types and quantities of chemicals onsite at a batch manufacturing facility often change from week to week or even day to day, leading to similarly frequent changes in the risk profile of the facility. This ever-changing risk profile can be a challenge for risk managers, but it also provides opportunities to continually review the chemistries for novel and safer approaches. Conveniently, it also makes it that much harder for a potential terrorist to know what chemicals are on site and in what quantities at any one time. The inherent variability of batch manufacturing can actually make these sites less attractive as a target of terrorists.

SOCMA is the leading trade association representing specialty and batch chemical producers. Approximately 90 percent of SOCMA's members are small businesses, according to Small Business Administration definitions. While commodity chemicals make up most of the production volume in the global marketplace, specialty chemicals make up most of the diversity (the number of different chemicals) in commerce. As a condition of membership to SOCMA, chemical companies must subscribe to our environmental and security management system, called ChemStewards®. This selfimposed program requires companies to develop systematic approaches to environmental and chemical risk management.

III. <u>The Concepts and Principles of IST and Pollution Prevention</u>

Inherently safer technology is a chemical engineering philosophy that was launched by the industry in the late 70's. Its goal is to use traditional engineering, chemistry and other scientific concepts to reduce the risks associated with chemical processing. Risk and safety are often used in the same context, but the two actually have an inverse relationship: as risk is reduced, safety is increased. Since its inception, IST has been ingrained as a normal part of the engineering discipline in the chemical industry.

Pollution Prevention is a general philosophy that is broader in scope than IST and also got its start in the late 70's, when scientists and policy analysts in the U.S. and Europe saw the economic benefits of reducing pollution earlier in a chemical's life cycle, and not focusing only on disposal. P2 uses traditional engineering, chemistry and other scientific concepts to reduce the risks associated with the use of chemicals. While P2 may appear ill-defined, the principles upon which its concepts are founded are common throughout most environmental management system approaches.

The philosophies behind IST, P2 and most other environmental management systems are very similar. Each calls for systematically using engineering, chemistry and other scientific concepts to achieve the same ultimate goal of risk reduction. The main difference between IST and P2 is the scope of activities each is intended to cover. IST is mainly focused on chemical processing. P2, on the other hand, is very broad in scope and intended to go beyond chemical manufacturing and be applied to downstream uses of chemicals as well. If the scope of P2 was limited to chemical processing, it would very closely resemble the IST approach to risk reduction. The language may be different, but the principles and concepts are essentially the same.

IV. Using IST and P2 to Make Business Decisions

The costs associated with handling materials classified as hazardous have increased substantially over the past 20 years. The economic incentives for reducing the use of hazardous chemicals include reduced likelihood of accidents among laboratory and processing workers, cheaper transportation and disposal costs, discounted insurance rates and fewer regulatory requirements. Obviously, it is in a chemical company's best financial interest to handle less hazardous substances; it helps reduce costs, which helps maximize profits. The concept of risk reduction, practiced through IST, P2 and other environmental management systems, is an important feature of the business model employed by chemical producers. The same principle applies for those who use, store or distribute chemicals, so in many ways IST is built into the chemical supply chain.

In commercial chemistry, costs are minimized by getting the best yield from raw materials, reducing the amount of waste from a particular reaction and by not having to pay additional costs associated with the handling of substances classified as hazardous. IST and P2 are employed from the very beginning, during R&D, when scientists study a particular chemical reaction, or series of reactions, to determine the best ways to maximize the yield. The scientists look at all raw materials, as well as the resulting products, including unintentional by-products and potential waste streams.

The next phase in R&D is typically the pilot phase, which attempts to replicate the bench-scale results at a slightly larger scale. The process (i.e., chemical reaction and necessary equipment) is again reviewed in detail and tweaked accordingly. The R&D phase may continue and include trial usage at the customer's site, to check product performance, ensure that the product can be used safely and make sure that there are no unaccounted risks. IST and P2 do not stop at the R&D phase, however. This approach is also applied when full-scale production begins, to double-check findings from earlier studies. If changes are made at some point in the future, the review process is conducted all over again to see what impacts the changes will make.

IST and P2 approaches are based on fundamental, long-standing engineering and chemistry principles. The concepts associated with IST and P2 work because they identify opportunities to maximize yields, reduce wastes and reduce risk, which, in turn, reduces cost and maximizes profit—the most powerful driver in business. Even if the conditions in the market place change, such as new regulations or restrictions, the fundamental driver for business decision-making will continue to be the maximization of profit. IST and P2 use fundamental engineering and chemistry principles that fit well into the chemicals business model.

V. <u>Chemistry, IST and the Laws of Physics</u>

Despite their fundamental importance, IST and P2 are two of the most misunderstood concepts in commercial chemistry. While it seems self-explanatory, the terms as used in chemistry and engineering may be misleading to non-scientists. Many non-scientists have been led to believe that the only way to ensure safe chemical manufacturing or achieve pollution prevention is by reducing the amount of hazardous substances used in chemical manufacturing and processing. Application of IST and P2, however, follow basic, scientific principles and are bound by the laws of physics; a simple reduction in the use of hazardous chemicals is rarely possible within the confines of a particular chemical reaction or process. When such reductions are possible, they often result in the transfer of risk to other points in a chemical process or the supply chain, without actually reducing it. To place the current IST and P2 debate in context, this discussion will begin with an illustration of the limitations of substitution in the field of chemistry, then move to an explanation of why reducing a hazard in a process does not necessarily reduce the overall risk.

Like IST and P2, chemistry is also bound by the laws of physics. These physical laws place restrictions on what can and cannot be done when trying to make a chemical. For instance, a molecule (i.e., a chemical) is made up of atoms (e.g., sodium, carbon, chlorine, etc.) that are in specific locations or positions on the molecule. In organic chemistry, the goal is to take the atoms from one molecule and move them to locations on another, different molecule so that the target molecule takes on a specific function or behavior.

The laws of physics dictate if, how and when those atoms can be moved. To achieve certain critical structural changes, reactive chemicals must be used, and many are by their very nature hazardous, e.g., toxic, flammable, etc. In light of these constraints, scientists seeking to achieve certain chemical changes are often left with few alternatives. Where hazardous chemicals are used, they are highly regulated by EPA, OSHA, DOT and others, and appropriately managed by chemists in universities, government and industry. The fact of the matter is that scientists usually cannot produce the materials that make our standard of living possible without using very specific chemicals. Making medicine is a good example.

Often, it takes multiple steps to make medicine. Each step in the process carefully moves atoms from one molecule to locations on another molecule. Eventually, the scientist will obtain the desired chemical that performs a precise medicinal function. The movement of these atoms, from one molecule to another, is a chemical reaction and can only take place using certain materials. The chlorine atom, for instance, when it is located on a specific part of a molecule, allows these steps to take place. One common misconception, though, is that any chlorine atom will do. That is not the case. Chlorine atoms take on different behaviors, or physical properties, depending on the atoms to which they are attached.

Table salt consists of the sodium (Na) and chlorine (Cl) atoms, which make up the chemical sodium chloride (NaCl). The chlorine atom used to make medicine, on the other hand, often comes from phosgene ($COCl_2$) or phosphorous trichloride (PCl_3). Phosgene, for example, has one carbon atom bonded to one oxygen atom and two chlorine atoms, giving the chlorine atoms very specific characteristics. The sodium atom that is attached to the chlorine atom in table salt, however, gives the chlorine a different nature. The very specific nature of the chlorine atom in phosgene is critical to its fundamental role in pharmaceutical manufacturing and minimizes the formation of potentially toxic by-products that would otherwise contaminate the medicine. By contrast, to use the chlorine in table salt in the drug manufacturing process would require the application of electrical energy to the salt, resulting in the formation of chlorine gas, which is corrosive and poisonous by inhalation. At that point, it is no longer table salt; it has been converted into a compound (chlorine) with similar hazards to the phosgene and achieving that conversion required the introduction of additional risks. The complex chemistry associated with making medicine has well-defined physical boundaries and requires the use of reactive chemicals. That is why, generally, medicine is not made from table salt.

IST is a conceptual and often complex framework that covers procedures, equipment, protection and, when feasible, the use of less hazardous chemicals. Its premise is that if a particular *hazard* can be reduced, the *overall risk* associated with a chemical process will also be reduced. In its simplicity, it is an elegant concept; however, reality is not always that simple. A reduction in hazard will reduce overall risk if, and only if, that hazard is not displaced to another time or location, or does not magnify another hazard. If the hazard is displaced, then the risk will be transferred or increased, not reduced. Here are several examples of how seemingly simple reductions in hazard may affect overall risk:

> <u>Reducing the amount of a chemical stored on site</u>
> A manufacturing plant is considering a reduction in the volume of a particular chemical stored on site. The chemical is used to manufacture a hazardous precursor to a critical nylon additive, which is sold to another company and used to make seat belts stronger. Because it is a critical component for nylon strength, and seatbelt production cannot be disrupted, the production schedule cannot change. If the amount stored on site is reduced, the only way to maintain the production schedule is to increase the number of shipments to the site. This leads to more deliveries (an increase in transportation risk), more transfers of chemical from one container to another (an increase in transfer risk) and, since there is now a greater chance that production could be disrupted by a late shipment, there

is an increase in economic risk. This analysis only accounts for the risk to the manufacturer and does not include the risk to the customer making the seat belts or those using seat belts.

Substituting Sodium Hypochlorite for Chlorine

Some people point to the Blue Plains water treatment plant in Washington, DC, as a prime example of how easy it is to substitute sodium hypochlorite solution for chlorine gas as a wastewater disinfectant. Unfortunately, several important facts are usually missing from these explanations. First, the conversion was not an overnight process; in fact, the substitution began prior to September 11 and included costly retrofitting to the plant to accommodate the substitution. Second, the District of Columbia is in a different situation financially than other municipalities, in that it often receives federal funding to make such expensive changes possible. Also, it takes a large amount of sodium hypochlorite to achieve the same sanitizing effects as chlorine. But the most important fact that is missing from this story is that it takes chlorine to make sodium hypochlorite. The facilities producing the hypochlorite must now use and store vast quantities of chlorine in very few locations to keep up with the increased demand. There are only a handful of sodium hypochlorite producers in the United States, which means that more and more chlorine will have to be concentrated in a few locations to keep up with demand. The ultimate result of this is a huge increase in risk at chemical facilities that produce hypochlorite and, since water treatment plants typically use 1-ton cylinders, a somewhat modest reduction in overall risk.

In science, risk is dependent on the circumstances and surroundings of a hazard. A simple reduction in hazard will not necessarily result in a reduction of overall risk. IST decisions, therefore, are and should be based on overall risk, not simply on inherent hazards.

VI. IST: An Environmental and Safety Concept

As noted earlier, the philosophical movement of IST was born in the chemical industry during the late 70's and is routinely practiced by chemical engineers. It can be argued that this approach, along with the concept of P2, led to the establishment of environmental management systems, which provide a systematic way to manage environmental, health and safety risks. At no time during the evolution of IST were the founders thinking about applications in chemical site security. In fact, practitioners of IST, i.e., chemical engineers, to this day consider IST an environmental, health and safety approach.

Only recently have some people sought to connect the concept of IST to security; and, those proponents are typically not engineers, nor are they practitioners of IST. In fact, most do not have the technical background to fully grasp the concepts and principles that make up IST.

To SOCMA's knowledge, only one study has been conducted to try connect the concept of IST to security. In April of 2006, the Center for American Progress published a report, *Preventing Toxic Terrorism, How Some Chemical Facilities are Removing Danger to American Communities*, which claims that 284 chemical facilities have substituted hazardous materials for less hazardous products. It is easy to misinterpret this report. Just the title alone is misleading, because it uses the term "chemical facilities," when, in fact, approximately 90 percent of the study facilities are related to utilities, not chemical plants. Most of the facilities in the study are related to water treatment (about 75 percent), agriculture (almost 10 percent) and electricity (about 5 percent). Out of the 16 manufacturers that responded, only 6 were in the chemical or allied products industries. Most of those 6 make formulations, which are mixtures of chemicals, but those companies do not actually produce the chemicals. The IST methods applied were as follows:

- 3 moved operations or storage to another location

- 1 changed from rail shipments to pipeline distribution
- 1, a chemical wholesaler, provide no explanation of what was done
- Only 1 company actually implemented IST; but, in reality, it was an engineering and process change more than a chemical substitution

This study has little to do with chemistry or chemical manufacturing. It primarily concerns the substitution of products used by water and electricity providers, and farmers, all of which are critical infrastructure.

In most cases presented in the report, chlorine was substituted with sodium hypochlorite solution. As was previously pointed out, it takes chlorine to make hypochlorite bleach; therefore, the few bleach manufacturers will have to have much more chlorine on hand, concentrated in very few places, to keep up with the ever-increasing demand for hypochlorite solution. This not only transfers the risk, but concentrates it and magnifies it—due to more chlorine being needed at the bleach manufacturing sites. Also, commercial grade hypochlorite solutions present very well-known risks as well.

The prefix “hypo” indicates that the compound has as much chlorine as is physically possible and needs a specific substance to prevent the chlorine gas from being released out of the hypochlorite solution. Hypochlorites by their very nature are unstable compounds, which is why we do not see a dry form of sodium hypochlorite, and will release copious amounts of chlorine gas under easy-to-achieve conditions. I would argue that there are more incidents involving the release of chlorine from hypochlorites than releases from actual chlorine vessels, such as rail cars and cylinders.

The only example in the report of IST being used at an actual chemical facility was the substitution of oleum with sulfur trioxide. Oleum, also known as fuming sulfuric acid, is simply sulfuric acid with an excess of sulfur trioxide added. The sulfur trioxide is the chemical consumed in the process, and is much more dangerous than the sulfuric acid. The company chose to manufacture and consume the sulfur trioxide on-site, rather than having it delivered in concentrated sulfuric acid. This is an excellent example of IST, because the transportation and transfer risks were reduced, and waste was minimized. These changes will probably pay for themselves and reduce overall costs for the company in the long run. In the context of security, however, is there a significant amount of risk reduction? It could be argued that the answer is no. Although oleum releases sulfur trioxide fumes, it does so at a rate that is much slower than a release of pure sulfur trioxide from a pressurized cylinder or rail car. Because of the slow release of sulfur trioxide gas from the oleum, a release would be fairly easy to control compared to a release of liquefied or pressurized sulfur trioxide.

VII. Conclusion

In essence, the concepts and principles that make up IST and P2 are the same. Like P2, IST uses chemistry and engineering principles to enhance safety and reduce risk. Because chemistry and engineering must follow the laws of physics, significant risk reduction is very difficult to achieve, without transferring the risk to something—or someone—else.

Congress already created a law to ensure that full consideration is given to the same concepts and principles that make up IST: The Pollution Prevention Act. There are also components of IST built into the EPA's Risk Management Program, under the Clean Air Act, and the Process Safety Management regulations at OSHA. IST is an environmental, health and safety approach, not a panacea for security.

Scientists support the concept of using inherently safer technologies whenever possible for more than economic reasons. They have a big motivating factor: their own safety. Scientists spend hours each day in laboratories and manufacturing facilities that use and produce chemicals. It is difficult to imagine that any scientist would not want to work under the safest conditions possible.

With all of these economic and safety incentives in place, the question becomes: Why do chemical companies still use hazardous materials? The simple fact is that the laws of physics are a much larger determining factor in selecting process materials than anything else. No federal program mandating IST or P2 will change how these processes are run in any significant way. Instead, such a program would result in government micromanagement of the decision-making process at individual facilities, would impose burdensome paperwork requirements on the regulated community, would duplicate certain key requirements of other federal and state regulatory programs, could slow chemical production activities, and could lead to manufacturers moving production overseas. Forcing implementation of IST and P2 could be quite costly. As the cost of doing business in the U.S. increases, manufacturers will seek opportunities to relocate to lower-cost regions, taking much needed manufacturing jobs with them.