Final Report:
Definition for Inherently Safer Technology in Production, Transportation, Storage, and Use

Prepared by:

Center for Chemical Process Safety
The American Institute of Chemical Engineers

For

Chemical Security Analysis Center
Science & Technology Directorate
U.S. Department of Homeland Security

July 2010

Homeland Security

Science & Technology

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U.S. Department of Homeland Security
Aberdeen Proving Ground, MD 21010-5424

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13. ABSTRACT (Maximum 200 words)
At the request of the United States (U.S.) Department of Homeland Security (DHS) Chemical Security Analysis Center (CSAC), the Center for Chemical Process Safety (CCPS), a directorate of the American Institute of Chemical Engineers (AIChE), has completed a project to provide a technically based definition of inherently safer technology (IST). CSAC requested that an independent technical organization review the literature and common practice related to design of inherently safer processes, and lead a process to develop a technically-based definition of IST. CCPS reviewed available literature and convened a series of workshops of process safety experts to develop a definition of IST. Along with the definition is included brief discussion of the concepts contained in the definition. As the definition is intended to be concise, CCPS believes that it is important to read the discussion (Appendix B) in conjunction with the definition because this additional information is critical for a full understanding of the IST.

14. KEY WORDS: American Institute of Chemical Engineers (AIChE); Center for Chemical Process Safety (CCPS); elimination of hazards; Global Congress on Process Safety; Kletz; hazardous materials; inherently safer design (ISD); inherently safer technology/inherently safer design (IST/ISD); management of security risks; Occupational Safety & Health Administration (OSHA); Occupational Safety & Health Administration Process Safety Management (OSHA/PSM); safer design (SD); U.S. Environmental Protection Agency (EPA); U.S. Environmental Protection Agency Risk Management Program (EPA/RMP).	15. NUMBER OF PAGES 54 16. PRICE CODE

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EXECUTIVE SUMMARY

At the request of the Chemical Security Analysis Center (CSAC), Science and Technology Directorate, U.S. Department of Homeland Security (DHS), the Center for Chemical Process Safety (CCPS), a directorate of the American Institute of Chemical Engineers (AIChE), has completed a project to provide a technically based definition of inherently safer technology (IST). CSAC requested that an independent technical organization review the literature and common practice related to design of Inherently Safer Processes, and lead a process to develop a technically-based definition of IST. CCPS reviewed available literature and convened a series of workshops of process safety experts to develop a definition of IST. Along with the definition is included brief discussion of the concepts contained in the definition. The definition follows, is repeated in **Appendix A** while **Appendix B** provides additional discussion. As the definition is intended to be concise, CCPS believes it is important to include the discussion in conjunction with the definition for clarification and insight to help chemical engineers and others to develop a full understanding of the concept of inherently safer technology.

INHERENTLY SAFER TECHNOLOGY DEFINITION

Inherently Safer Technology (IST), also known as Inherently Safer Design (ISD), permanently eliminates or reduces hazards to avoid or reduce the consequences of incidents. IST is a philosophy, applied to the design and operation life cycle, including manufacture, transport, storage, use, and disposal. IST is an iterative process that considers such options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm. Overall safe design and operation options cover a spectrum from inherent through passive, active and procedural risk management strategies. There is no clear boundary between IST and other strategies.

- **ISTs are relative:** A technology can only be described as inherently safer when compared to a different technology, including a description of the hazard or set of hazards being considered, their location, and the potentially affected population. A technology may be inherently safer than another with respect to some hazards but inherently less safe with respect to others, and may not be safe enough to meet societal expectations.
- **ISTs are based on an informed decision process:** Because an option may be inherently safer with regard to some hazards and inherently less safe with regard to others, decisions about the optimum strategy for managing risks from all hazards are required. The decision process must consider the entire life cycle, the full spectrum of hazards and risks, and the potential for transfer of risk from one impacted population to another. Technical and economic feasibility of options must also be considered.

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Final Report: Definition for Inherently Safer Technology in Production, Transportation, Storage and Use

1.0 INTRODUCTION

At the request of the Chemical Security Analysis Center (CSAC), Science and Technology Directorate, U.S. Department of Homeland Security (DHS), the Center for Chemical Process Safety (CCPS),a directorate of the American Institute of Chemical Engineers (AIChE), has completed a project to provide a technically-based definition of inherently safer technology (IST), also known as inherently safer design (ISD) but hereafter referred to as IST. CSAC requested that an independent technical organization review the literature and common practice related to design Inherently Safer Processes, and lead a process to develop a technically-based definition of inherently safer technology (IST). CSAC requested that the definition consider the full life cycle of the chemical enterprise, including use and manufacturing, storage, and transportation. CSAC requested a definition that is broad enough to encompass the full supply chain and recognize the possibility that improvement in safety in one dimension of process or supply chain may lead to degradation of safety in another dimension.

1.1 Purpose

The purpose of this project is to develop a definition of "inherently safer technology" (IST) which meets the following criteria:

- Integrated – considers the full life cycle and all security considerations of the process or product;
- Applicable to a broad definition of "technology";
- Consider the full range of hazards of concern associated with a process or product; and
- Be useful in a risk/economic/benefit context.

The IST definition is **not**:

- A specific technical solution;
- Offered in the context of any single specific hazard; nor is it
- A decision on appropriate technology, however it should facilitate processes for making technical decisions.

1.2 Relevant Past Efforts

The concept of IST is not really new, and it is not limited to the process industries. Technologists have always recognized the value of eliminating or reducing hazards associated with any activity. Applying IST without calling it by that name, they simply considered it to be good design. In reaction to a major explosion in Flixborough, England (June 1974), Trevor Kletz questioned the need for such large quantities of flammable or toxic materials in a manufacturing plant, as well as the need for processing at elevated temperature and pressure. Kletz suggested that the process industries should re-direct efforts toward elimination of hazards where feasible by 1) reducing the quantity of hazardous material; 2) using less hazardous materials; and 3) developing technology that operates at less severe conditions rather than devoting extensive resources for safety systems and procedures to manage risks. Kletz first advanced this proposal at the annual Jubilee Lecture of the Society of the Chemical Industry. His proposal was subsequently published as a journal article entitled "What you don't have, can't leak." [1]

Since 1974, the concept of IST has been further developed. Some specific references used in this project include the following:

- CCPS book *Inherently Safer Chemical Processes: A Life Cycle Approach* (1st Edition, 1996 [2], and 2nd Edition, 2009 [3]): IST is a concept, an approach to safety that focuses on eliminating or reducing the hazards associated with a set of conditions.
- Contra Costa County, California Industrial Safety Ordinance: Inherently safer systems (ISS) means Inherently safer design strategies as discussed in the 1996 Center for Chemical Process Safety Publication "Inherently Safer Chemical Processes" and means feasible alternative equipment, processes, materials, layouts, and procedures meant to eliminate, minimize, or reduce the risk of a major chemical accident or release by modifying a process rather than adding external layers of protection (discussed in *Inherently Safer Chemical Processes: A Life Cycle Approach*, 2nd Edition, 2009, Section10.2.1, pp. 229-235). http://cchealth.org/groups/hazmat/pdf/iso/2006_iso_official_code_complete.pdf (accessed July 15, 2010).[4]
- Johnson, Robert: "Inherently safer designs permanently and inseparably reduce or eliminate process hazards that must be contained and controlled to avoid accidents." (unpublished presentation)[5]
- Kletz, Trevor: *Process Plants: A Handbook for Inherently Safer Design*. Bristol, PA, Taylor and Francis, 1998.5: The essence of the inherently safer approach to plant design is the avoidance of hazards rather than their control by adding protective equipment.[6]
- Kletz, Trevor: "An [inherently safer] IS design is one that avoids hazards instead of controlling them, particularly by reducing the amount of hazardous material or the number of hazardous operations." (personal communication in February 2010.)[7]

1.3 Relevance of the Project

For a number of years, IST has received increasing attention as an important component of process safety management systems, and has also been considered a potentially valuable tool in managing security risks for hazardous material handling operations of all types. IST has been incorporated into process safety management regulations in the state of New Jersey and in Contra Costa County, California. [3] Both the Occupational Safety & Health Administration Process Safety Management (OSHA PSM) regulation and the U.S. Environmental Protection Agency Risk Management Program (EPA RMP) regulation encourage inherently safer processes implicitly by setting a threshold for regulatory applicability in terms of chemical inventory.

For a number of years, going back to the early 1990s with an EPA proposal to include technical options analysis as a part of the risk management program under the Clean Air Act, there have been proposals in the U.S. Congress to incorporate IST concepts, sometimes specifically and sometimes using other names or descriptions, into both process safety management and chemical-processing facility security regulations. To date these proposals have not been adopted into regulations, but they continue to be considered in the current session of U.S. Congress. One obstacle to incorporating IST into regulations, either for process safety or for chemical facility security, is the lack of a consensus in defining exactly what "IST" means.

When previously published definitions are compared, they are found to incorporate similar elements. . What is lacking is a definition that unifies the concepts of IST with the fact that any multi-dimensional process includes many facets that are connected and interrelated. Any single chemical process or product may be considered to be a part of a complex ecology with interactions throughout the rest of industry and the global economy. A change to a single aspect of this interconnected system to accomplish a single objective, even one which appears to be highly desirable, may have unanticipated consequences which may be undesirable. Implementation of IST will necessarily require a full evaluation of the entire process and everything related to it.

A primary area of concern to DHS is the potential for intentional release of toxic chemicals caused by a domestic terrorist attack. The very nature of these chemicals poses numerous safety and security issues along the entire supply chain. It has been postulated that application of IST principles may provide an improvement in the overall security of the U.S. chemical industry and the risk it poses. This is a matter of debate and while parties on both sides of the issue believe that IST can play a role, there is no agreement on the level of improvement in security that can be accrued. There are specific examples of IST applications in the literature but no systematic IST methodology for guiding its evaluation or implementation.

2.0 PROJECT PROCEDURE

2.1 Process

While IST was originally conceived as an engineering design philosophy, in recent years the term IST has become politically charged. The CCPS project was intended to bring IST back into the technical realm by assembling a committee of highly respected experts to evaluate the many IST concepts being discussed in the technical and political arenas. The goal is to bring together the many concepts being discussed into a consensus definition.

The CCPS project committee focused on classifying and organizing IST concepts into a draft definition, without initially passing value judgments on any of the components. This initial draft definition was developed at the first of two workshops where concepts of IST as well as all previously published definitions were presented and discussed by the participants. The definition that came out of this initial workshop was used as the basis for a second workshop with an even broader participation, where it was further modified based upon input from the participants. This third draft definition was presented at the Global Congress on Process Safety in San Antonio, Texas (March 22, 2010) for comment by any attendees. Feedback from that presentation was incorporated into the final definition reported here (see **Appendix F**).

2.2 Project Steps and Timeline

2.2.1 Initial Definition Workshop – February 3, 2010

The CCPS project team initially met with DHS CSAC personnel at an all-day workshop held in Linthicum, Maryland on February 3, 2010. **Appendix D** lists the agenda, the participants, and a summary of the key concepts from the workshop.

Team members reviewed the project proposal and DHS outlined its requirements for the project. The team then held an open discussion to review key concepts from the resources and publications available to team members, and concepts derived from their own personal experience with process safety management in general and consideration of IST options in particular. From this discussion, several initial key concepts were developed for consideration and further elaboration into the definition.

Some important issues related to the form of the definition arose during this discussion. The group determined that the “definition” should be concise while retaining the essential features required for understanding the IST concepts. The definition should also avoid the use of examples for purposes of defining IST. To better explain the concepts, the definition would be accompanied by a more extensive, discussion section (**Appendix B**) which could elaborate on the concepts included in the definition, and which would incorporate illustrative examples where appropriate.

Based on comments and discussions during the workshop, a draft definition was developed, and later circulated through the CCPS project team and DHS representatives. After several iterations, the CCPS staff developed a modified draft definition for discussion at a teleconference of the CCPS project team on February 18, 2010. Following the teleconference, additional clarifications were made to the draft definition and it was modified further by CCPS staff. The draft (**Appendix E**) was used as the basis for discussion at a workshop in Houston, Texas, on February 25, 2010. This workshop provided additional opportunities for expert feedback and input from a broader range of process safety experts.

2.2.2 Second Definition Workshop – IST Draft Definition and Discussion – February 25, 2010

Attendance at the Houston, Texas workshop was open to individuals who could demonstrate they have practiced inherently safer process and system design, regardless of industry or whether practiced as an engineer, chemist, operator, manager, or other position. The workshop was announced on the CCPS web site, and by an email to the CCPS Technical Steering Committee. Other individuals whom the CCPS determined were potentially important contributors to the project were specifically invited by CCPS. The draft definition was also sent to Trevor Kletz, who was unable to attend but later submitted comments via email.

Attendees were given a copy of the draft definition to review the day before the workshop. During the workshop, extensive interactive discussion occurred. Attendees were invited to submit comments, suggest concepts that might be missing, or those that might be consolidated or eliminated to keep the definition short, and also to identify the strengths and weaknesses of the candidate definition. Paper feedback forms were collected for review by CCPS. Attendees were not asked to agree on the definition, but rather to provide their perspective on what was missing, superfluous, or at variance with their own concept of IST. All comments were collected and compiled in a spreadsheet after the workshop, and used as a basis for revising the definition.

Participants provided over 150 written comments as summarized in **Appendix E**, ranging from very detailed and specific editorial comments on wording parts of the definition, to significant suggestions to revise the organization and content of the definition. In some cases, specific wording was suggested for parts of the definition. CCPS Staff carefully considered this feedback in revising the definition. It was not possible to incorporate all feedback for many reasons—some suggestions were in conflict with each other, while others were deemed inappropriate because they were too detailed for a high level, short definition. However, all comments were evaluated and considered. As a result of the workshop, CCPS was able to significantly shorten the definition and combine a number of concepts from the initial draft to make the definition simpler, while retaining the essential components of a good IST definition.

The CCPS project team reviewed the modified definition at a teleconference on March 15, resulting in additional simplification and clarification. The result was a final draft definition presented to the process safety community at the Global Congress on Process Safety, in San Antonio, Texas on March 22, 2010 (**Appendix F**).

2.2.3 Third Definition Workshop – Final IST Draft and Discussion Presented at the Global Congress on Process Safety – March 22, 2010

CCPS presented the final draft definition on the first day of the Global Congress, held in San Antonio, Texas, at two IST technical sessions that were open to all meeting registrants (**Appendix F**). Written copies of this final draft definition were made available to attendees along with comment and feedback forms. These sessions concluded with an IST panel discussion lead by session speakers and other people involved in the IST definition project. CCPS received limited feedback from this comment opportunity (primarily minor wording and punctuation changes), which indicates that attendees at these Global Congress IST sessions consider the draft definition fundamentally sound and accurate.

The final draft definition was sent to Dr. Trevor Kletz, who endorsed the draft definition in the following response:

> "The final version of the definition is far better than I expected. I feared it would end up like many (most?) company mission statements and safety policies, which are written in semi-legal language. As a result, few people read them and they have little or no effect. I think those members of the Senate that have been pressing for compulsory adoption of [inherently safer] IS designs may now have a better understanding of the strengths and limitations of the technique. If so, [then it] is a great achievement… ." (personal communication March 16 2010)

2.3 Project Deliverable

The product deliverables are the definition of IST, a discussion of the definition (Appendix B), and this final report.

3.0 KEY FINDINGS

3.1 Final Definition

The project produced a short, scientific definition of IST, as follows:

INHERENTLY SAFER TECHNOLOGY DEFINITION

Inherently Safer Technology (IST), also known as Inherently Safer Design (ISD), permanently eliminates or reduces hazards to avoid or reduce the consequences of incidents. IST is a philosophy, applied to the design and operation life cycle, including manufacture, transport, storage, use, and disposal. IST is an iterative process that considers such options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm. Overall safe design and operation options cover a spectrum from inherent through passive, active and procedural risk management strategies. There is no clear boundary between IST and other strategies.

- **ISTs are relative:** A technology can only be described as inherently safer when compared to a different technology, including a description of the hazard or set of hazards being considered, their location, and the potentially affected population. A technology may be inherently safer than another with respect to some hazards but inherently less safe with respect to others, and may not be safe enough to meet societal expectations.
- **ISTs are based on an informed decision process:** Because an option may be inherently safer with regard to some hazards and inherently less safe with regard to others, decisions about the optimum strategy for managing risks from all hazards are required. The decision process must consider the entire life cycle, the full spectrum of hazards and risks, and the potential for transfer of risk from one impacted population to another. Technical and economic feasibility of options must also be considered.

3.2 Major Issues

Because the IST definition is intended to be short, it necessarily leaves out many clarifications and discussions which are important to a full understanding of IST. The CCPS project team, and participants in the various workshops, believed that additional clarification and discussion of the definition was appropriate. This discussion is found in **Appendix B**. It is essential to read this discussion to fully understand and appreciate the role IST might play as a tool for improved security and safety across the entire hazardous material supply chain. The discussion incorporates most of the key points discussed in the IST definition workshops. Principally:

- IST is a philosophy focusing on eliminating or reducing hazards.
- IST is applicable through the entire life cycle and footprint of any system that manufactures, transports, stores, or uses hazardous materials or hazardous processing conditions.
- While IST applies throughout the life cycle, the greatest opportunities to implement IST significantly arise early in the cycle.
- A material, process, or technology can only be described as "inherently safer" when compared to a different material, process, or technology; and, the hazard or set of hazards which were considered must be specified.
- IST options can be dependent on location and release scenarios.
- There is currently no consensus on either a quantification method for IST or a scientific assessment method for evaluation of IST options.
- IST is a part of an iterative decision-making process for risk reduction and choice, ongoing through the technology life cycle of a technology.
- It is unlikely that any technology will be "inherently safer" with respect to *all* hazards, and other approaches will always be required to manage the full range of hazards and risks.
- IST can be categorized as:
    - **First Order** – Completely eliminates a particular hazard. Note that this does not say anything about the impact on other hazards, which may be increased, decreased, or remain unaffected by the change.
    - **Second Order** – Reduces the magnitude of a hazard, or makes a potential accident associated with a hazard less likely to occur, or less severe, by means of equipment and process design but not through add-on safety devices.
    - **Layers of Protection –** When *all* of the multiple hazards associated with any technology are considered, layers of protection will always be required as a part of the total risk management program. These layers may be made more reliable and robust through the application of principles of inherent safety.
- Decisions on overall risk management strategy need to consider potential conflicts and tradeoffs among:
    - Hazards;
    - Likelihood of failure;
    - Consequences to all potentially exposed populations and
    - Other important risk considerations such as
        - environmental impact;
        - impact on risk in other locations or sectors of the overall economy;
          process and product supply chain and life cycle;
        - technical feasibility;
        - economic viability; and
        - regulatory requirements.

3.3 Utility of the Definition

This definition focuses on understanding the nature of IST, and what needs to be considered in evaluating whether or not IST is appropriate for management of security risks associated with hazardous material facilities of all types. It also provides some high level guidance to assist in identifying opportunities for IST. However, the more extensive and detailed information and checklists available in published literature are more appropriate for use by technical staff (engineers and chemists) and management for identification of IST opportunities for a specific facility. The definition summarizes a very complex technical philosophy in a short and concise statement to make IST understandable to a broad, non-technical audience. However, actual identification of potential IST options, and evaluation of whether or not they make sense to implement at a specific facility requires a more extensive understanding of the technology involved than this definition provides.

3.4 Limitations and Possible Future Work

This project and definition **does not** address a number of important issues in IST, including:

- **Specific methodologies for engineers and managers to identify IST alternatives.** This is a field which continues to be developed, and the current status of techniques and procedures is best summarized in Chapter 8 of the 2nd (2009) Edition of the CCPS book *Inherently Safer Chemical Processes: A Life Cycle Approach*. [3]
- **Methods for measuring the IST characteristics of alternative technologies.** *Inherently Safer Chemical Processes: A Life Cycle Approach*, 2nd Edition[3] (Section 9.7, pp. 223-225) summarizes some research on this topic but there continues to be no consensus on how to measure IST. A primary issue is that any "single number" quantification of IST will necessarily incorporate some kind of weighting factors to combine the potential consequences of different types of hazards (for example, fires, explosions, acute toxicity, chronic toxicity, environmental hazards, etc.). An alternative might be to separately rank the IST characteristics of different options and then use decision analysis techniques to evaluate options in a specific situation.

4.0 REFERENCES

1.0 Kletz, T.A. "What you don't have, can't leak." *Chemistry and Industry*, 6 May 1978, pp 287-292.

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3.0 Center for Chemical Process Safety (CCPS). *Inherently Safer Chemical Processes: A Life Cycle Approach*, 2nd Edition. American Institute of Chemical Engineers, New York and John Wiley & Sons, Hoboken, NJ. 2009

4.0 Contra Costa County, California Industrial Safety Ordinance: Inherently safer systems (ISS) http://cchealth.org/groups/hazmat/pdf/iso/2006_iso_official_code_complete.pdf (accessed July 15, 2010).

5.0 Johnson, Robert: "Inherently safer designs permanently and inseparably reduce or eliminate process hazards that must be contained and controlled to avoid accidents." (unpublished presentation)

6.0 Kletz, T. A. *Process Plants: A Handbook for Inherently Safer Design*. Bristol, PA, Taylor and Francis, 1998.

7.0 Kletz, Trevor: "An [inherently safer] IS design is one that avoids hazards instead of controlling them, particularly by reducing the amount of hazardous material or the number of hazardous operations." (Personal communication in February 2010.)

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APPENDICES

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APPENDIX B: FINAL DISCUSSION ON INHERENTLY SAFER TECHNOLOGY

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APPENDIX D: INITIAL DEFINITION WORKSHOP – FEBRUARY 3, 2010

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APPENDIX A: FINAL DEFINITION FOR INHERENTLY SAFER TECHNOLOGY/INHERENTLY SAFER DESIGN

Below is the final technically based definition of inherently safer technology/inherently safer design (IST/ISD). **Appendix B** provides additional discussion to enable the reader a full understanding of IST.

INHERENTLY SAFER TECHNOLOGY DEFINITION

Inherently Safer Technology (IST), also known as Inherently Safer Design (ISD), permanently eliminates or reduces hazards to avoid or reduce the consequences of incidents. IST is a philosophy, applied to the design and operation life cycle, including manufacture, transport, storage, use, and disposal. IST is an iterative process that considers such options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm. Overall, safe design and operation options cover a spectrum from inherent through passive, active and procedural risk management strategies. There is no clear boundary between IST and other strategies.

- **ISTs are relative:** A technology can only be described as inherently safer when compared to a different technology, including a description of the hazard or set of hazards being considered, their location, and the potentially affected population. A technology may be inherently safer than another with respect to some hazards but inherently less safe with respect to others, and may not be safe enough to meet societal expectations.
- **ISTs are based on an informed decision process:** Because an option may be inherently safer with regard to some hazards and inherently less safe with regard to others, decisions about the optimum strategy for managing risks from all hazards are required. The decision process must consider the entire life cycle, the full spectrum of hazards and risks, and the potential for transfer of risk from one impacted population to another. Technical and economic feasibility of options must also be considered.

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APPENDIX B: FINAL DISCUSSION ON DRAFT DEFINITION OF INHERENTLY SAFER TECHNOLOGY

Inherently safer technology/inherently safer design (IST/ISD) is a philosophy—an approach to safety that focuses on eliminating or reducing the hazards associated with a set of conditions. It is applicable through the entire life cycle and footprint of any system that manufactures, transports, stores, or uses hazardous materials or hazardous processing conditions. IST permanently and inseparably reduces or eliminates process hazards that must be contained and controlled to avoid incidents, rather than controlling those hazards by added-on protective equipment. While IST applies throughout the life cycle of a process, plant, or material, the greatest opportunities for significant IST benefits are early in the life cycle, before the technology becomes deeply integrated into the infrastructure of an industry from raw material suppliers through final product users, and before major investments in plant and equipment are made.

A material, process, or technology can only be described as "inherently safer" when compared to a different material, process, or technology. This description must include the definition of the particular hazard or set of hazards that were considered in making the comparison. Thus, it is *not* appropriate to describe a technology as inherently safer than an alternate technology, with no further description. An appropriate description would be, for example, that the first technology is inherently safer than the alternate technology with respect to the hazards of acute toxicity and flammability of the vapor. Note that this statement makes no judgment about the relative inherent safety characteristics of other possible hazards – the first technology *may be inherently less safe* than the alternate technology with respect to other hazards such as chemical reactivity, chronic toxicity, or potential for hazardous decomposition.

IST options can be location and release scenario dependent, and different potentially exposed populations may not agree on the relative inherent safety characteristics of the same set of options. For example, two options for handling a toxic gas might be receiving the material in ten, 1-ton cylinders or one, 10-ton truckloads. To a population several miles from the site, the 1-ton cylinders would be inherently safer because the maximum potential release size is smaller and less likely to expose them to a hazardous concentration of the gas. However, operators, who would now have to connect and disconnect 10 cylinders for every 10 tons of material used, instead of a single truck, would consider the truck shipments to be inherently safer. Thus, evaluation of IST options can be quite complex, and dependent on the local environment. There is currently no consensus on either a quantification method for IST or a scientific assessment method for evaluation of IST options.

Inherently safer design is a part of an iterative decision-making process for risk reduction. It is ongoing and continuous throughout the life cycle of a technology, from initial conception through commercialization, operation, and, when obsolete, shutdown and demolition. It should consider the entire footprint of the process—raw material sources and supply, impact on supply technologies, transportation, and impact on downstream users and their technologies, and ultimate material disposition. Evaluation of IST options for a particular plant, product, or other system must consider the overall effects of all other impacted systems—it is essential to understand the impact that a change in one technology will have on hazards and risks elsewhere in society. In particular, it is important to identify all such impacts and to make informed decisions on the best overall way to manage risk throughout society.

Risk reduction criteria will be determined by the nature of the hazards or threats, and will require consideration of conflicts among multiple hazards and threats. Tools for understanding societal expectations for risk management include national and local government regulations and other legal requirements, consensus codes and standards developed by technical and trade associations, and internal corporate standards and requirements. The potential hazard of a major release resulting from an accident, as well as security or vulnerability concerns such as theft of materials, contamination of products, and degradation of infrastructure, must be considered. Hazard identification, risk assessment, and security vulnerability analysis tools are used to identify and characterize risk. Risk can be reduced by many methods, including inherently safer design, but those methods must include the full spectrum of risk reduction approaches (passive, active, and procedural risk management systems). This is particularly true when considering the need to manage multiple hazards and risks—it is unlikely that any technology will be "inherently safer" with respect to *all* hazards, and other approaches will always be required to manage the full range of hazards and risks. Ultimately, society must decide which hazards and risks it wants to manage primarily with inherently safer design approaches, and which hazards and risks will be managed with other approaches (active, passive, and procedural).

The inseparability of IST from the overall objective of the safe design and operation of hazardous material manufacturing, transportation, storage, and use is apparent when considering chemical security. An IST with respect to catastrophic release hazard from a fixed manufacturing plant may conflict with methods to minimize other hazards, such as theft or diversion of materials, contamination of product, or degradation of infrastructure. It may not address other hazards at all, or, it may create new hazards.

The CCPS book *Inherently Safer Chemical Processes: A Life Cycle Approach* describes several levels of inherently safer design. [1]

> "**First Order** inherently safer design refers to the identification of alternatives that completely eliminate a particular hazard. Note that, as discussed above, this does not say anything about the impact on other hazards, which may be increased, decreased, or remain unaffected by the change. An example would be using a water based paint to paint a room in your house instead of flammable solvent based paint, eliminating the hazard of exposure to low levels of potentially toxic solvents, and fire hazards associated with flammable solvent.
>
> **Second Order** inherently safer design reduces the magnitude of a hazard, or makes an accident associated with a hazard less likely to occur, by the design of the equipment, and not through add-on safety devices. Again, this does not say anything about the impact of the change on other hazards, which may be increased, decreased, or remains unaffected. As an example of reducing the magnitude of a hazard, explosives such as TNT can be made in small continuous reactors containing a few gallons of material rather than large batch reactors containing thousands of gallons of material. As an example of inherently making a hazard less likely to result in an accident, if adding too much raw material to a vessel can cause a runaway reaction, this can be made inherently less likely by installing a feed tank that holds the exact amount of raw material required, and no more.
>
> **Layers of Protection** include risk management equipment and management systems often categorized as Passive, Active, and Procedural. These layers include risk management features such as containment dikes to manage spills and leaks (passive), safety alarms and shutdown systems (active), and safety procedures and operator actions (procedural). When you consider *all* of the multiple hazards associated with any technology, it is unlikely that it will ever be possible to manage all of them inherently, and layers of protection will always be required as a part of the total risk management program. Inherently safer design concepts can be used to make these layers of protection inherently more reliable and robust."

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1 Center for Chemical Process Safety (CCPS). *Inherently Safer Processes: A Life Cycle Approach.* 2nd Edition, American Institute of Chemical Engineers/John Wiley & Sons, Inc., Hoboken, NJ, 2009, pp. 15-16.

Decisions on the appropriate overall risk management strategy will be a function of, and will consider potential conflicts and tradeoffs with:

- Hazards;
- Likelihood of failure;
- Consequences to all potentially exposed populations;
- Other important risk considerations such as environmental impact;
- Impact on risk in other locations or sectors of the overall economy;
- Process and product supply chain and life cycle, including distribution considerations and final user considerations such as consumer expectations or government regulations regarding product quality;
- Technical feasibility – may be location specific;
- Economic viability – may be location specific; and
- Regulatory requirements – may be location specific.

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APPENDIX C: CCPS PROJECT PROPOSAL SUBMITTED OCTOBER 13, 2009

C.1 SUMMARY OF NEED

The Center for Chemical Process Safety (CCPS), a directorate of the American Institute of Chemical Engineers (AIChE), a 501 (c) (3) not for profit educational organization, is pleased to submit this proposal to the U.S. Department of Homeland Security (DHS) Chemical Security Analysis Center (CSAC).

The CSAC statement of work is attached to this proposal for reference. CSAC is requesting an independent technical organization to review the literature and common practices related to design of Inherently Safer Processes, and lead a process to develop a technically-based definition of Inherently Safer Technology (IST).

CSAC desires that the definition span the full life cycle of the chemical enterprise, including use and manufacturing, storage, and transportation. It is CSAC's view that the various current definitions available in the literature, including those of CCPS, Trevor Kletz, and others have inconsistencies. CSAC further believes that existing definitions are not broad enough to address the full supply chain and do not go far enough to help resolve the classic challenge posed by IST, such as tradeoffs where improvement in safety in one dimension of process or supply chain may lead to degradation of safety in another dimension.

C.2 PROPOSED APPROACH

CCPS proposes a 5-step process to address this challenge.

Step 1: Scoping

While IST was originally conceived as an engineering design philosophy, in recent years the term IST has become politically charged. CCPS will seek to bring IST back into the technical realm by assembling a committee of highly respected experts to evaluate the many IST concepts being discussed in the technical and political arena. The goal of this scoping meeting is to pull together the many concepts being discussed into 3-6 alternative definitions, which would be the deliverable of this step. The committee would strive to focus solely on classifying and organizing the definitions, without initially passing value judgments on any of the alternatives. An idea synthesis process will be used, similar to that used by the CCPS Planning Committee to survey current needs and trends in process safety to generate project proposals for selection by CCPS members. Additionally, the subcommittee will propose criteria by which the alternatives will be evaluated.

CCPS proposes that the scoping committee be led by Mr. Peter N. Lodal of Eastman Chemical. Mr. Lodal is a Fellow of AIChE and of CCPS and is the current chair of the CCPS Engineering Design subcommittee. Mr. Lodal's time will be donated by Eastman Chemical to this project, but reimbursement of his travel, food, and lodging has been requested. The committee membership will also include the following technical leaders from the CCPS community, or others with similar attributes, to represent chemical, refining, and pharmaceutical manufacturing, large and small companies, and experts serving these industries as listed in **Table C-1**:

Table C-1. Proposed Scoping Committee Participants

PARTICIPANT	ORGANIZATION
Kathy Anderson	Vertellus
Scott Berger	CCPS
Paul Butler	CCPS
Eric Freiburger	NOVA Chemicals
Cheryl Grounds	BP
Dennis Hendershot	CCPS
Greg Housell	Pfizer
Shakeel Kadri	Air Products
Neil Maxson	Neil Maxson
Jack McCavit	CCPS
Steve Meszaros	Wyeth
Cathy Pincus	ExxonMobil
Jatin Shah	Baker Risk
Kenan Stevick	Dow Chemical
Karen Tancredi	DuPont
Scott Wallace	Olin

NOTE: This is a *proposed* participant list—substitutions may have been made to actual participants.

CCPS also wishes to incorporate the thinking of Trevor Kletz, considered by many to be the father of the Inherently Safer Process design philosophy. If it were not possible for Dr. Kletz to travel to the committee meetings, his input would be included by tele- or web-conferencing, or offline discussions.

Step 2: Workshop on the definition of inherently safer technologies

Once 3-6 candidate definitions and criteria to evaluate them have been drafted, they will be presented at a workshop so that attendees can review these definitions and criteria. We will not ask the workshop attendees to decide between the definitions, but rather to identify the strengths and weaknesses of each candidate. Likewise, we will not ask the attendees to agree on the criteria, but rather to identify criteria that are missing or superfluous.

Attendance at the workshop will be open to any individual who can demonstrate that they have practiced inherently safer process and system design, regardless of industry or whether practiced as an engineer, chemist, operator, manager, or other position. Labor and activist participants will be welcome, but only to the extent they have actually practiced inherently safer processes. Because some attendees may need financial assistance in order to attend, a process will be developed by which invitations are extended and, if appropriate, travel stipends awarded from grant.

Step 3: Finalizing Definitions

Following the workshop, the CCPS committee will review the input received and proceed to evaluate the candidate definitions, ultimately narrowing them down to a single recommended definition.

Step 4: Presenting Recommendations for Comment

CCPS plans to formally present its recommendations at the Global Congress on Process Safety, and simultaneously publish the recommendations on its website for public comment. Since many key stakeholders attend this conference, it will be a convenient opportunity to gather them together. In order to ensure that key viewpoints are represented during the presentation at the Global Congress on Process Safety, CCPS will invite individuals who represent diverse viewpoints but do not normally attend the Global Congress to attend. A process will developed by which invitations are extended and, if appropriate, registration fees and travel stipends awarded from grant funds to enable such individuals to attend.

Step 5: Finalizing the Recommendation

The CCPS committee will review comments provided at the Global Congress and via other formats and thereafter finalize the definition. If comments were provided by a person who wishes a formal response explaining how their comment was addressed, such a response will be given. This final meeting (or set of meetings) will be held by tele- and web-conference. The single definition, along with the rationale supporting the choice of this definition, will be reported to CSAC in a final report.

C.3 PERSONNEL

CCPS proposes that the project be supported by the following permanent and part-time staff.

Project Manager: Scott Berger, CCPS Executive Director

Scott Berger joined the staff of AIChE in 2001 and has served as the CCPS Director and Executive Director since then. In this capacity, he has facilitated more than 40 projects leading to the publication of CCPS Guideline or Concept Series books, other publications, or training materials related to process safety. Over this period, industrial participation in CCPS activities grew from 65 to over 120 member companies. Prior to joining AIChE, he worked at Owens Corning for 5 years in various leadership roles promoting safer and greener manufacturing processes, management systems, and products. He started is career at Rohm and Haas, where for 18 years he worked in process development and engineering, with a focus on pollution prevention and inherently safer processes. Scott holds a BS and MS from Massachusetts Institute of Technology.

Expert Advisor: Dennis Hendershot, CCPS Staff Consultant

Dennis Hendershot joined the CCPS staff as a part-time staff consultant upon his retirement from Rohm and Haas in 2005. Dennis led two important CCPS projects, the revision of “Inherently Safer Processes,” the CCPS authoritative text on the subject, and “Guidelines for Safety Risk Criteria.” During this same period, Dennis served on the Baker Panel investigating process safety culture within the BP organization following the major vapor cloud explosion in March 2005. Prior to 2005, Dennis worked at Rohm and Haas for 35 years, more than half of which as Rohm and Haas’ leading expert on process safety, hazard and risk analysis, and inherently safer processes. Dennis holds a BS from Lehigh University and an MBA from University of Pennsylvania.

Project Facilitator: Paul Butler, CCPS Technical Manager

Paul Butler joined the AIChE staff as CCPS Technical Manager in 2008. Prior to joining CCPS, Paul worked at Buckman Laboratories for 35 years, more than half of which serving as the Director of Process Safety. In this role, Paul deployed process safety principles and management systems throughout Buckman's worldwide sites. Paul holds a BS from Virginia Tech.

C.4 TIMING AND COST

Table C-2 lists the proposed schedule, dates, and funding for this project. It is assumed the final workshop will be held at the Global Congress on Process Safety on March 22-24, 2010. If a more compressed time schedule is required, the schedule may be changed.

Table C-2. Proposed Schedule and Funding

SCHEDULE	DATE
Awarding of grant	November 1, 2009
Organize scoping meeting	November 1 – November 15, 2009
Hold scoping meeting	November 15 – December 15, 2009
Summarize scoping meeting	December 16, 2009 – January 15, 2010
Organize Workshop	December 1, 2009 – January 15, 2010
Hold Workshop	January 15 – January 31, 2010
Report Recommendation	March 22-24, 2010
Final comments accepted	April 15, 2010
Final report	May 1, 2010
Requested funding: $59,695	

C.5 STATEMENT OF WORK

Prepare a final definition of Inherently Safer Technology in Production, Transportation, Storage and Use

The Chemical Security Analysis Center (CSAC), part of the U.S. Department of Homeland Security (DHS) Directorate of Science and Technology (S&T) is seeking sources to provide a definition of inherently safer technology (IST).

A primary area of concern to the U.S. Department of Homeland Security (DHS) is the potential for intentional release of toxic chemicals caused by a domestic terrorist attack. The very nature of these chemicals poses numerous safety and security issues along the entire supply chain. It is believed that application of principles of inherently safer technology (IST) will provide a significant improvement in the overall safety of the U.S. chemical industry. Even though this view is widely held, there is no consensus on a definition of IST beyond its basic philosophical tenets. There are specific examples of IST applications in the literature but no systematic IST methodology, which can guide its implementation.

In order to provide such guidance, CSAC is seeking a contractor to provide a definition of IST. This definition should address in some manner the basic tenets of IST as applied to production such as:

1. Minimization of toxic material usage;
2. Substitution or use less hazardous materials for toxic materials;
3. Attenuate reaction conditions; and
4. Simplification of process design to minimize human error or equipment failure.

However, because of the concerns of risk shift/transfer to other sectors, this definition should also capture IST issues related to the other components of the chemical supply chain:

1. Transportation,
2. Storage, and
3. Use.

This definition should provide a basis on which the safety of alternate manufacturing, use, transportation, or storage modes of a particular compound can be compared and quantified. This comparison should allow for the selection of the safest process.

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APPENDIX D: INITIAL DEFINITION WORKSHOP – FEBRUARY 3, 2010

D.1 WORKSHOP AGENDA

The Initial Inherently Safer Technology Definition Workshop was held in Baltimore, Maryland on February 3, 2010. The agenda is listed in **Table D-1**.

Table D-1. Agenda

TIME	TOPIC	LEADER
7:30	Breakfast	All
8:00	Summary of agenda – how the day will work	Shawn Bowen
8:15	Introductions	All
8:30	Introductory comments Objectives and deliverables Overall process	George Famini Scott Berger
9:00	Ground rules	Shawn Bowen
9:05	Explanation of definition	Dennis Hendershot
9:20	Pause to write comments	All
9:30	Feedback on “Comparative”	Dennis Hendershot
10:00	Break	All
10:15	Feedback on “specific”	Dennis Hendershot
10:45	Feedback on “value judgment”	Dennis Hendershot
11:15	Feedback on “not absolute”	Dennis Hendershot
11:45	Lunch	All
1:00	Feedback on title and introductory paragraph	Dennis Hendershot
1:30	General feedback	Dennis Hendershot
2:30	Review, summarize, and next steps	Scott Berger
3:00	Close	

D.2 PARTICIPANTS

The Initial Inherently Safer Technology Definition Workshop (February 3, 2010) participants are listed in **Table D-2**.

Table D-2. Workshop Participants

PARTICIPANTS	ORGANIZATION
Scott Berger	CCPS
Shawn Bowen	DHS-CSAC
Dan Crowl	Michigan Tech University
George Emmett	DHS-CSAC
George Famini	DHS-CSAC
Eric Freiburger	Praxair
Cheryl Grounds	BP
Dennis Hendershot	CCPS
Iclal Atay	New Jersey DEP
Peter Lodal	Eastman
Jack McCavit	CCPS Emeritus
Adolpho Negron	US DHS CSAC
Pat Scenefeldt	ExxonMobil
Kenan Stevick	Dow
Karne Tancredi	DuPont
Scott Wallace	Olin

D.3 SUMMARY

Below are the key concepts summary of the Initial Inherently Safer Technology Definition Workshop (February 2, 2010):

- Overview of project and clarifications
- Criteria – how do we know definition fits purpose
- Review “gold book” definition
- Brainstorming
    - How do we extend IST to life cycle steps?
    - Definitions for each life cycle step
    - Also, what IST is not
    - Reconciling the life cycle definitions with each other
    - How does IST apply to vulnerability?
    - Definition for IST related to vulnerability
    - Reconciliation the security definition with the prior
- Preparation for February 25 workshop – how to make sure we get input that clarifies rather than blurs?
- Preparation for March 22 workshop – how to structure.

APPENDIX E: SECOND DEFINITION WORKSHOP – IST DRAFT AND DISCUSSION – FEBRUARY 25, 2010

E.1 AGENDA

The Initial Draft Inherently Safer Technology Definition and Discussion Workshop was held in Houston, Texas on February 25, 2010. The agenda is listed in **Table E-1**.

Table E-1. Agenda

TIME	TOPIC	LEADER
7:30	Breakfast	All
8:00	Summary of agenda – how the day will work	Shawn Bowen
8:15	Introductions	All
8:30	Introductory comments Objectives and deliverables Overall process	George Famini Scott Berger
9:00	Ground rules	Shawn Bowen
9:05	Explanation of definition	Dennis Hendershot
9:20	Pause to write comments	All
9:30	Feedback on “Comparative”	Dennis Hendershot
10:00	Break	All
10:15	Feedback on “specific”	Dennis Hendershot
10:45	Feedback on “value judgment”	Dennis Hendershot
11:15	Feedback on “not absolute”	Dennis Hendershot
11:45	Lunch	All
1:00	Feedback on title and introductory paragraph	Dennis Hendershot
1:30	General feedback	Dennis Hendershot
2:30	Review, summarize, and next steps	Scott Berger
3:00	Close	

E.2 PARTICIPANTS

Participants at the Initial Draft Inherently Safer Technology Definition and Discussion Workshop (February 25, 2010) are listed in **Table E-2**.

Table E-2. Workshop Participants

PARTICIPANT	ORGANIZATION
Kathy Anderson	Vertellus
Steve Arendt	ABSG Consulting
Iclal Atay	NJDEP
Scott Berger	CCPS
Shawn Bowen	DHS-CSAC
Carl Brown	KBR / Univ. Houston
Alber Candello	University of Houston
Kenneth Carlson	Occidental
Jack Chosnek	Independent
Jim Cooper	NPRA
Vic Edwards	Aker Solutions
George Emmett	DHS-CSAC
George Famini	DHS-CSAC
Brad Fuller	AcuTech
Cheryl Grounds	BP
Dennis Hendershot	CCPS
Charles Jones	Solvay-Solexis
Michael Kennedy	SOCMA
Greg Kiihne	BASF
George King	Huntsman
Allen Lasater	Koch
Peter Lodal	Eastman
Sa, Mannan	Texas A&M
John Miles	Occidental
Shawn Moshiri	Chevron
Tim Overton	BP
Cathy Pincus	ExxonMobil
Robin Pitblado	DNV
Mike Sawyer	Apex Safety
Randall Sawyer	Contra Costa County
Roxy Schneider	CCPS
Steve Selk	DHS
Terry Smith	PPG
Karne Tancredi	DuPont
Kevin Walker	Chevron
Scott Wallace	Olin
Nohemi Zerbi	DHS

E.3 SUMMARY

Participants provided over 150 written comments as summarized below, ranging from very detailed and specific editorial comments on wording of parts of the definition, to significant suggestions to revise the organization and content of the definition. In some cases, specific wording was suggested for parts of the definition. This feedback was carefully considered by CCPS Staff in revising the definition. It was not possible to incorporate all feedback for many reasons because some suggestions were in conflict with each other, while others were deemed inappropriate because they were too detailed for a high level, short definition. However, all comments were evaluated and considered. As a result of the workshop, CCPS was able to significantly shorten the definition and combine a number of concepts from the initial draft to make the definition simpler, while retaining the essential components of a good IST definition.

Inherently safer technology (IST), also known as inherently safer design (ISD), is a design philosophy or strategy integral to the broader objective of safer design (SD). Inherently safer technology permanently and inseparably reduces or eliminates process hazards to avoid accidents, rather than controlling those hazards by added-on protective equipment.

Inherently safer technology reduces risk through a hierarchy of approaches, starting with eliminating hazards, then reducing hazards, substituting less hazardous materials, using less hazardous process conditions, and designing processes to reduce the possibility or consequences of human error or mechanical failure. As we progress through this hierarchy, we gradually transition from IST to SD, and that is why IST cannot be separated from SD. Some important characteristics of IST include:

- **Relative**: A technology, material, or process can only be described as "inherently safer" when compared to a different technology, material, or process.
- **Specific**: It is not possible to describe Technology A as "inherently safer" than Technology B without describing the hazard or set of hazards being considered. It is possible for a technology, material, or process to be inherently safer than another technology, material, or process with respect to some hazards and inherently less safe with respect to others.
- **Value judgment**: The potential of an option to be inherently safer with regard to some hazards and inherently less safe with regard to others may require value judgments about the optimum strategy for managing risks arising from all hazards. Some hazards may be managed inherently, while others may require other safety management approaches.
- **Not absolute**: It is fundamentally possible for one technology to be inherently safer than another, while still not safe enough to meet societal expectations.

Inherently Safer Technology – Discussion

Inherently safer design is a concept and philosophy - an approach to safety that focuses on eliminating or reducing the hazards associated with a set of conditions. An inherently safer design permanently and inseparably reduces or eliminates process hazards that must be contained and controlled to avoid accidents, rather than controlling those hazards by added-on protective equipment. A material, process, or technology can only be described as "inherently safer" when compared to a different material, process, or technology, and this description must include the definition of the particular hazard or set of hazards which were considered in making the comparison. Thus, it is *not* appropriate to describe Material A as "inherently safer" than Material B with no further description. An appropriate description would be "Material A is inherently safer than Material B with respect to the hazard of acute toxicity of the vapor, and the hazard of flammability of the vapor." Note that this statement makes no judgment about the relative inherent safety characteristics of other possible hazards – Material A may be inherently less safe than Material B with respect to other hazards such as chemical reactivity, chronic toxicity, or potential for hazardous decomposition.

Inherently safer technology (IST), also known as inherently safer design (ISD), permanently eliminates or reduces hazards to avoid or reduce the consequences of incidents. IST is a philosophy, applied to the design and operation life cycle, including manufacture, transport, storage, use, and disposal. IST is an iterative process that considers options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm. Overall safe design and operation options cover a spectrum from inherent through passive, active and procedural risk management strategies. There is no clear boundary between IST and other strategies.

Inherently safer design is a part of an iterative decision-making process for risk reduction. It is ongoing and continuous throughout the life cycle of a material or process, from initial conception through commercialization, operation, and, when obsolete, shutdown and demolition. It should consider the entire footprint of the process – raw material sources and supply, impact on supply technologies, transportation, the impact on downstream users and their technologies, and ultimate material disposition. Risk reduction criteria will be determined by the nature of the hazards or threats, and will likely require some consideration of conflicts among multiple hazards and threats. Important considerations in prioritizing efforts include the threshold of a major accident hazard (public health impact – PHI), as well as security or vulnerability (including definition of the threat, which must include factors such as theft/diversion, and intentional release). Hazard and risk assessment tools are used to identify and characterize risk. Risk can be reduced by many methods, including inherently safer design, but methods must include the full spectrum of risk reduction approaches (passive, active, and procedural risk management systems). This is particularly true when considering the need to manage multiple hazards and risks – it is unlikely that any technology will be "inherently safer" with respect to *all* hazards, and other approaches will always be required to manage the full range of hazards and risks. Ultimately we must decide which hazards and risks we want to manage primarily with inherently safer design approaches, and which hazards and risks will be managed with other approaches (active, passive, procedural). The inseparability of IST from SD is apparent when considering chemical security. An Inherently Safer Technology with respect to catastrophic release hazard may conflict with, or may not address other hazards, such as theft/diversion of materials, contamination of product, or degradation of infrastructure, or may create new security hazards.

The CCPS book *Inherently Safer Chemical Processes: A Life Cycle Approach* describes several levels of inherently safer design.[2]

> "**First Order** inherently safer design refers to the identification of alternatives that completely eliminate a particular hazard. Note that, as discussed above, this does not say anything about the impact on other hazards, which may be increased, decreased, or remain unaffected by the change. An example would be using a water based paint to paint a room in your house instead of flammable solvent based paint, eliminating the hazard of exposure to low levels of potentially toxic solvents, and fire hazards associated with flammable solvent.
>
> **Second Order** inherently safer design reduces the magnitude of a hazard, or makes an accident associated with a hazard less likely to occur, by the design of the equipment, and not through add-on safety devices. Again, this does not say anything about the impact of the change on other hazards, which may be increased, decreased, or remains unaffected.

2 Center for Chemical Process Safety (CCPS). *Inherently Safer Processes: A Life Cycle Approach.* 2nd Edition, American Institute of Chemical Engineers/John Wiley & Sons, Inc., Hoboken, NJ, 2009, pp. 15-16.

As an example of reducing the magnitude of a hazard, explosives such as TNT can be made in small continuous reactors containing a few gallons of material rather than large batch reactors containing thousands of gallons of material. As an example of inherently making a hazard less likely to result in an accident, if adding too much raw material to a vessel can cause a runaway reaction, this can be made inherently less likely by installing a feed tank that holds the exact amount of raw material required, and no more.

Layers of Protection include risk management equipment and management systems often categorized as Passive, Active, and Procedural. These layers include risk management features such as containment dikes to manage spills and leaks (passive), safety alarms and shutdown systems (active), and safety procedures and operator actions (procedural). When you consider *all* of the multiple hazards associated with any technology, it is unlikely that it will ever be possible to manage all of them inherently, and layers of protection will always be required as a part of the total risk management program. Inherently safer design concepts can be used to make these layers of protection inherently more reliable and robust."

Decisions on the appropriate overall risk management strategy will be a function of, and will consider potential conflicts and tradeoffs with:

- hazards;
- material selection;
- process and product supply chain and life cycle, including distribution considerations and final user considerations;
- technical feasibility – may be location specific;
- economic viability – may be location specific; and
- environmental impact.

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APPENDIX F: THIRD DEFINITION WORKSHOP – FINAL IST DRAFT DEFINITION AND DISCUSSION PRESENTED AT THE GLOBAL CONGRESS ON PROCESS SAFETY – MARCH 22, 2010

F.1 AGENDA

The Final Draft Definition and Discussion of Inherently Safer Technology were presented at the Global Congress on Process Safety, which was held in San Antonio, Texas on March 22, 2010. The agenda for the Global Congress is listed in **Table F-1**.

Table F-1. Agenda for Global Congress on Process Safety: Topical 1 Sessions

Topical 1: Global Congress on Process Safety* 12th Process Plant Safety Symposium (PPSS) 25th Center for Chemical Process Safety International Conference (CCPS) 44th Annual Loss Prevention Symposium (LPS)	
Monday, March 22, 2010	
8:00 AM-9:20 AM	
	Topical 1: Global Congress on Process Safety (#6) - T1C07 Opening Plenary Session - Sherman Glass, President of Exxon-Mobil Worldwide Refining and Supply Co.
10:00 AM-11:30 AM	
	Topical 1: Global Congress on Process Safety (#20) - T1C00 Fires, Explosions and Reactive Chemicals (Part I) Topical 1: Global Congress on Process Safety **(#21) - T1B04 Inherently Safer Design/Inherently Safer Technologies (Part I)** Topical 1: Global Congress on Process Safety (#22) - T1B00 LOPA Bloopers and Outtakes Topical 1: Global Congress on Process Safety (#23) - T1A02 Management of Change - the Most Difficult PSM Challenge
1:30 PM-5:00 PM	
	Topical 1: Global Congress on Process Safety (#26) - T1B02 Case Histories of Risk Assessment and Problem Solving Topical 1: Global Congress on Process Safety (#27) - T1C05 Fires, Explosions and Reactive Chemicals (Part II) Topical 1: Global Congress on Process Safety **(#28) - T1B07 Inherently Safer Design/Inherently Safer Technologies (Part II)** Topical 1: Global Congress on Process Safety (#29) - T1A01 Layer of Protection Analysis (LOPA) - Case Studies and Experiences

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/T1.html (accessed July 6, 2010).

F.2 CONFERENCE SESSIONS

The Initial Inherently Safer Technology Definition and Discussion agenda and abstracts of the sessions held at the Global Congress on Process Safety have been modified and are located in **Table F-2** though **Table F-6**.

Table F-2. Agenda for Inherently Safer Design/Inherently Safer Technologies: Topical 1, Session 21, Part I

Inherently Safer Design/Inherently Safer Technologies (Part I)* Monday, March 22, 2010: 10:00 AM Room 101 A/B (Convention Center)
Dennis C. Hendershot, Process Safety, Bethlehem, PA
Inherent safety (IS) is the modern term for eliminating hazards rather than accepting and managing them. Engineering is the traditional realization of this concept, as its core function is the application of science, technology, and mathematics to develop and implement practical solutions that are safe and efficient. Currently there is much interest across industry, academia, advocacy groups and governments in mandating IS to achieve process safety and security goals. There is much debate as to what comprises IS, how and when it is best applied, who/how to judge this creative process, how and whether it differs from traditional engineering, and what role it should have in the chemical industry to achieve process safety and security goals. This session will present three papers of realistic scenarios and case histories that demonstrate various perspectives and views of IS and its application. A facilitated panel discussion exploring the proper role of IS and audience questions session will follow the presentations.
Sponsor: 25th Center for Chemical Process Safety International Conference (CCPS)
Chair: Eric Freiburger Email: Eric_Freiburger@Praxair.com
Co-Chair: Cheryl Grounds
10:00 AM (21a) Overview of IST Dennis C. Hendershot
10:30 AM (21b) The DHS Chemical Facility Anti-Terrorism Standards – A Risk-Based Approach to Chemical Facility Security Larry Stanton
11:30 AM (21c) IST Trade-Offs Jatin Shah

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/Session13520.html (accessed July 6, 2010).

Table F-3. Abstracts for Inherently Safer Design/Inherently Safer Technologies:
Topical 1, Sessions 21a-21c, Part I*

Overview of IST **Topical 1, Session 21a** **Monday, March 22, 2010: 10:00 AM** **Room 101 A/B (Convention Center)**
Dennis C. Hendershot, Process Safety, Bethlehem, PA
Inherently Safer Design (ISD) is a holistic approach to making the development, manufacturing, and use of chemicals safer. Over time, there have been many developments on the concept of inherent safety; however, currently there is a growing fixation on only one element of ISD: substitution. This paper will present an overview of ISD and its elements of minimize, substitute, moderate, and simplify. In addition, the life cycle of a process will be explained in context of ISD to further explain the most effective use of ISD as well as other risk mitigation methods and strategies.
The DHS Chemical Facility Anti-Terrorism Standards – **A Risk-Based Approach to Chemical Facility Security** **Topical 1, Session 21b** **Monday, March 22, 2010: 10:30 AM** **Room 101 A/B (Convention Center)**
Larry Stanton, Infrastructure Security Compliance Division, Department of Homeland Security, Washington, DC
In October 2006, Congress granted DHS authority to regulate security at high-risk chemical facilities. The resulting program, CFATS, (1) prioritizes facilities that possess chemicals of interest to terrorists due to the release, sabotage or diversion hazards they present; (2) identifies the types of security performance measures that address these risks; and (3) adapts to different types of facilities, ranging from manufacturing plants to universities, hospitals and warehouses across various industries. The risk-based approach drives facilities to consider adoption of a range of risk-reduction measures, including inherently safer technologies, to achieve compliance with the standards.
IST Trade-Offs **Topical 1, Session 21c** **Monday, March 22, 2010: 11:00 AM** **Room 101 A/B (Convention Center)**
Jatin Shah, Baker Engineering and Risk Consultants, Inc., Chicago, IL
Inherently Safer Technologies should be a key consideration in any companies risk management effort. Often we are faced with making a choice between an inherently safer option and one that is more hazardous but provides better benefits. With proper safeguards and controls it is possible to manage the risk of the more hazardous option to levels that are comparable or even lower than the inherently safer option. It may cost more and involve a greater amount of oversight but the benefits may still outweigh the costs. This paper presents three examples to illustrate the trade-offs that one should evaluate in deciding which option is the best for a given situation: 1. Comparison between travel by Automobile and Airplane 2. Comparison of HF vs. MHF (HF with additive)Transport 3. Comparison of HF Alkylation risk reduction options with Sulfuric Alkylation While inherently safer technological options should be considered they may not always be the appropriate option to select, since it may require sacrificing desired benefits that an alternative option can provide at comparable or lower risk.

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/T1.html (accessed July 6, 2010).

Table F-4. Agenda for Inherently Safer Design/Inherently Safer Technologies: Topical 1, Session 28, Part II

Inherently Safer Design/Inherently Safer Technologies (Part II)* Monday, March 22, 2010: 1:30 PM Room 101 A/B (Convention Center)
Inherent safety (IS) is the modern term for eliminating hazards rather than accepting and managing them. Engineering is the traditional realization of this concept, as its core function is the application of science, technology, and mathematics to develop and implement practical solutions that are safe and efficient. Currently there is much interest across industry, academia, advocacy groups and governments in mandating IS to achieve process safety and security goals. There is much debate as to what comprises IS, how and when it is best applied, who/how to judge this creative process, how and whether it differs from traditional engineering, and what role it should have in the chemical industry to achieve process safety and security goals. This session will present three papers of realistic scenarios and case histories that demonstrate various perspectives and views of IS and its application. A facilitated panel discussion exploring the proper role of IS and audience questions session will follow the presentations.
Sponsor: 25th Center for Chemical Process Safety International Conference (CCPS)
Chair: Eric Freiburger Email: Eric_Freiburger@Praxair.com
Co-Chair: Cheryl Grounds
1:30 PM (28a) Federal View of IST From the CSB Perspective John Bresland
2:00 PM (28b) ACC Philosophy On the Appropriate Application of Inherently Safer Principles Peter N. Lodal and Laurie A. Miller
2:3 PM (28c) Applying Inherently Safer Systems – Contra Costa County's Experience Randall Sawyer
3:00 PM Break
3:30 PM Panel Discussion

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/Session 13520.html (accessed July 6, 2010).

Table F-5. Abstracts for Inherently Safer Design/Inherently Safer Technologies: Topical 1, Sessions 28a-28b, Part II

Federal View of IST From the CSB Perspective **Topical 1, Session 28a** **Monday, March 22, 2010: 1:30 PM** **Room 101 A/B (Convention Center)**
John Bresland, United States Chemical Safety Board, Washington, DC
The CSB is an independent federal agency charged with investigating industrial chemical accidents. Headquartered in Washington, DC, the agency's board members are appointed by the President and confirmed by the Senate. The CSB conducts root because investigations of chemical accidents at fixed industrial facilities. Root causes are usually deficiencies in safety management systems, but can be any factor that would have prevented the accident if that factor had not occurred. Other accident causes often involve equipment failures, human errors, unforeseen chemical reactions or other hazards. The agency does not issue fines or citations, but does make recommendations to plants, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), industry organizations, and labor groups. Congress designed the CSB to be non-regulatory and independent of other agencies so that its investigations might, where appropriate, review the effectiveness of regulations and regulatory enforcement. The CSB's investigations and mission gives it a unique perspective of IST that crosses legislation, regulations, industry, trade groups, unions, and public boundaries. The CSB Chair will present this perspective.
ACC Philosophy On the Appropriate Application of Inherently Safer Principles **Topical 1, Session 28b** **Monday, March 22, 2010: 2:00 PM** **Room 101 A/B (Convention Center)**
Peter N. Lodal, Plant Protection Technical Services, Eastman Chemical Company, Kingsport, TN **Laurie A. Miller**, American Chemistry Council, Arlington, VA
As part of its Responsible Care® Process Safety Code, the American Chemistry Council (ACC) has long supported the concepts of Inherently Safer Chemical Processes. In this paper, the authors will describe the ACC philosophy around the appropriate application of Inherently Safer Principles, including a discussion on the avoidance of risk-shifting, and the proper use of economic criteria in the risk decision making process. A number of examples from actual case histories will be included to illustrate the ACC approach.

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/Session 14748.html (accessed July 6, 2010).

Table F-6. Abstracts for Inherently Safer Design/Inherently Safer Technologies:
Topical 1, Sessions 28c-28d, Part II (cont)

Applying Inherently Safer Systems – Contra Costa County's Experience **Topical 1, Session 28c** **Monday, March 22, 2010: 2:30 PM** **Room 101 A/B (Convention Center)**
Randall Sawyer, Contra Costa Health Services, Martinez, CA
During the 1990's, many process safety accidents occurred in Contra Costa County. Some of the impact of these accidents included the following: • Six people died and two others were seriously injured in three separate accidents • Over 20,000 people sought medical attention after one release and over 1,200 went to a medical clinic that was established after another accident • Millions of dollars in equipment damage and lost production. The community and the County's Board of Supervisors were greatly concerned about the accidents and the trend of the accidents. In January 1999, the County's Board of Supervisors passed the Industrial Safety Ordinance. The ordinance expands on the California Accidental Release Prevention Program and the U. S. EPA's Risk Management Program and includes a requirement that covered facilities consider inherently safer systems. This paper and presentation will discuss the experience of implementing inherently safer systems in Contra Costa County. This discussion will include the history on why the County's Industrial Safety Ordinance, which includes the requirement for implementing inherently safer systems, was passed; a definition of inherently safer systems and when inherently safer systems are to be applied; the initial problems with implementing inherently safer systems by the covered facilities; clarification of what is meant by inherently safer systems and when to consider inherently safer systems; auditing for inherently safer system implementation and results; examples of when inherently safer systems have been successfully applied; and the impact of the implementation of inherently safer systems.
Panel Discussion **Topical 1, Session 28d** **Monday, March 22, 2010: 3:30 PM** **Room 101 A/B (Convention Center)**
Abstract: File Not Uploaded

* Adapted from the AIChE Website: http://aiche.confex.com/aiche/s10/webprogram/Session 14748.html (accessed July 6, 2010).

F.3 PARTICIPANTS

The DHS/CSAC/CCPS project participants listed in **Table F.2** were present when the final draft definition of and discussion on inherently safer technology (IST) was presented at the Global Congress (March 22, 2010).

Table F-7. DHS/CSAC/CCPS IST Definition Project Participants at the Global Congress

PARTICIPANTS	ORGANIZATION
Kathy Anderson	Vertellus
Steve Arendt	ABSG Consulting
Iclal Atay	NJDEP
Scott Berger	CCPS
Dan Crowl	Michigan Tech University
Vic Edwards	Aker Solutions
George Emmett	DHS-CSAC
George Famini	DHS-CSAC
Brad Fuller	AcuTech
Cheryl Grounds	BP
Dennis Hendershot	CCPS
George King	Huntsman
Peter Lodal	Eastman
Jack McCavit	CCPS Emeritus
Sam Mannan	Texas A&M
Shawn Moshiri	Chevron
Tim Overton	BP
Cathy Pincus	ExxonMobil
Robin Pitblado	DNV
Randall Sawyer	Contra Costa County, CA
Roxy Schneider	CCPS
Steve Selk	DHS
Jatin Shah	Baker Engineering and Risk Conslutants, Inc. Chicago, IL
Larry Stanton	Infrastructure Security Compliance Division, DHS, Washington, DC
Kenan Stevick	Dow
Karen Tancredit	DuPont

F.4 SUMMARY

Inherently Safer Technology – Final Draft Discussion

Inherently safer technology (IST) is a philosophy - an approach to safety that focuses on eliminating or reducing the hazards associated with a set of conditions. IST is applicable through the entire life cycle and footprint of any system which manufactures, transports, stores, or uses hazardous materials or hazardous processing conditions. IST permanently and inseparably reduces or eliminates process hazards that must be contained and controlled to avoid incidents, rather than controlling those hazards by added-on protective equipment. While IST applies throughout the life cycle of a process, plant, or material, the greatest opportunities for significant IST benefits are early in the life cycle, before the technology becomes deeply integrated into the technology infrastructure of an industry from raw material suppliers through final product users, and before major investments in plant and equipment are made.

A material, process, or technology can only be described as "inherently safer" when compared to a different material, process, or technology. This description must include the definition of the particular hazard or set of hazards which were considered in making the comparison. Thus, it is *not* appropriate to describe a technology as inherently safer than an alternate technology, with no further description. An appropriate description would be, for example, that the first technology is inherently safer than the alternate technology with respect to the hazard of acute toxicity of the vapor, and the hazard of flammability of the vapor. Note that this statement makes no judgment about the relative inherent safety characteristics of other possible hazards – the first technology may be inherently less safe than the alternate technology with respect to other hazards such as chemical reactivity, chronic toxicity, or potential for hazardous decomposition.

IST options can be location and release scenario dependent, and different potentially exposed populations may not agree on the relative inherently safety characteristics of the same set of options. For example, two options for handling a toxic gas might be receiving the material in 1-ton cylinders or 10-ton truck loads. To a population several miles from the site, the 1 ton cylinders would be inherently safer because the maximum potential release size is smaller and less likely to expose them to a hazardous concentration of the gas. But, operators who would now have to connect and disconnect 10 cylinders for every 10 tons of material used, instead of a single truck, would consider the truck shipments to be inherently safer. Thus, evaluation of IST options can be quite complex, and dependent on the local environment. There is currently no consensus on a quantification method for IST, and there is no scientific assessment for evaluation of IST options.

Inherently safer design is a part of an iterative decision-making process for risk reduction. It is ongoing and continuous throughout the life cycle of a technology, from initial conception through commercialization, operation, and, when obsolete, shutdown and demolition. It should consider the entire footprint of the process – raw material sources and supply, impact on supply technologies, transportation, and impact on downstream users and their technologies, and ultimate material disposition. Evaluation of IST options for a particular plant, product, or other system must consider the overall effects of all other impacted systems – it is essential to understand the impact that a change in one technology will have on hazards and risks elsewhere in society. In particular, it is important to identify all such impacts and to make informed decisions on the best overall way to manage risk throughout society.

Risk reduction criteria will be determined by the nature of the hazards or threats, and will require consideration of conflicts among multiple hazards and threats. Tools for understanding societal expectations for risk management include national and local government regulations and other legal requirements, consensus codes and standards developed by various technical and trade associations, and internal corporate standards and requirements. The threshold of a major accident hazard of a major release, as well as security or vulnerability concerns such as theft of materials, contamination of products, and degradation of infrastructure must be considered. Hazard identification, risk assessment, and security vulnerability analysis tools are used to identify and characterize risk. Risk can be reduced by many methods, including inherently safer design, but methods must include the full spectrum of risk reduction approaches (passive, active, and procedural risk management systems). This is particularly true when considering the need to manage multiple hazards and risks – it is unlikely that any technology will be "inherently safer" with respect to *all* hazards, and other approaches will always be required to manage the full range of hazards and risks. Ultimately we must decide which hazards and risks we want to manage primarily with inherently safer design approaches, and which hazards and risks will be managed with other approaches (active, passive, procedural).

The inseparability of IST from the overall objective of the safe design and operation of hazardous material manufacturing, transportation, storage, and use is apparent when considering chemical security. An IST with respect to catastrophic release hazard from a fixed manufacturing plant may conflict with, or may not address other hazards, such as theft or diversion of materials, contamination of product, or degradation of infrastructure, or may create new security hazards.

The CCPS book *Inherently Safer Chemical Processes: A Life Cycle Approach* describes several levels of inherently safer design.[3]

> "**First Order** inherently safer design refers to the identification of alternatives that completely eliminate a particular hazard. Note that, as discussed above, this does not say anything about the impact on other hazards, which may be increased, decreased, or remain unaffected by the change. An example would be using a water based paint to paint a room in your house instead of flammable solvent based paint, eliminating the hazard of exposure to low levels of potentially toxic solvents, and fire hazards associated with flammable solvent.
>
> **Second Order** inherently safer design reduces the magnitude of a hazard, or makes an accident associated with a hazard less likely to occur, by the design of the equipment, and not through add-on safety devices. Again, this does not say anything about the impact of the change on other hazards, which may be increased, decreased, or remain unaffected. As an example of reducing the magnitude of a hazard, explosives such as TNT can be made in small continuous reactors containing a few gallons of material rather than large batch reactors containing thousands of gallons of material. As an example of inherently making a hazard less likely to result in an accident, if adding too much raw material to a vessel can cause a runaway reaction, this can be made inherently less likely by installing a feed tank that holds the exact amount of raw material required, and no more.
>
> **Layers of Protection** include risk management equipment and management systems often categorized as Passive, Active, and Procedural. These layers include risk management features such as containment dikes to manage spills and leaks (passive), safety alarms and shutdown systems (active), and safety procedures and operator actions (procedural). When you consider *all* of the multiple hazards associated with any technology, it is unlikely that it will ever be possible to manage all of them inherently, and layers of protection will always be required as a part of the total risk management program. Inherently safer design concepts can be used to make these layers of protection inherently more reliable and robust."

Decisions on the appropriate overall risk management strategy will be a function of, and will consider potential conflicts and tradeoffs with:

- Hazards
- Likelihood of failure
- Consequences to all potentially exposed populations
- Other important risk considerations such as environmental impact
- Impact on risk in other locations or sectors of the overall economy

3 Center for Chemical Process Safety (CCPS). *Inherently Safer Processes: A Life Cycle Approach.* 2nd Edition, American Institute of Chemical Engineers/John Wiley & Sons, Inc., Hoboken, NJ, 2009, pp. 15-16.

- Process and product supply chain and life cycle, including distribution considerations and final user considerations
- Technical feasibility – may be location specific
- Economic viability – may be location specific
- Regulatory requirements – may be location specific.

FINAL DRAFT DEFINTION FOR INHERENTLY SAFER TECHNOLOGY

Inherently Safer Technology (IST), also known as Inherently Safer Design (ISD), permanently eliminates or reduces hazards to avoid or reduce the consequences of incidents. IST is a philosophy, applied to the design and operation life cycle, including manufacture, transport, storage, use, and disposal. IST is an iterative process that considers such options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm. Overall safe design and operation options cover a spectrum from inherent through passive, active and procedural risk management strategies. There is no clear boundary between IST and other strategies.

- **ISTs are relative:** A technology can only be described as inherently safer when compared to a different technology, including a description of the hazard or set of hazards being considered, their location, and the potentially affected population. A technology may be inherently safer than another with respect to some hazards but inherently less safe with respect to others, and may not be safe enough to meet societal expectations.
- **ISTs are based on an informed decision process:** Because an option may be inherently safer with regard to some hazards and inherently less safe with regard to others, decisions about the optimum strategy for managing risks from all hazards are required. The decision process must consider the entire life cycle, the full spectrum of hazards and risks, and the potential for transfer of risk from one impacted population to another. Technical and economic feasibility of options must also be considered.

APPENDIX G: NOMENCLATURE

Table G-1. ABBREVIATIONS AND ACRONYMS

ABBREVIATION / ACRONYM	DEFINITION
AIChE	American Institute of Chemical Engineers
CCPS	Center for Chemical Process Safety, formed by AIChE in March 25, 1985 to develop process safety information, including guidelines and resources.
CSAC	Chemical Security Analysis Center
DHS	U.S. Department of Homeland Security
DHS/CSAC/CCPS	U.S. Department of Homeland Security/ Chemical Security Analysis Center/ Center for Chemical Process Safety
EPA	U.S. Environmental Protection Agency
EPA RMP	U.S. Environmental Protection Agency Risk Management Program
ISD	Inherently safer design
IST	Inherently safer technology
IST/ISD	Inherently safer technology/inherently safer design
ISS	Inherently safer systems or inherently safer design strategies
OSHA PSM	Occupational Safety & Health Administration Process Safety Management
SD	safer design
U.S.	United States

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APPENDIX H: ABOUT CCPS

Just after midnight on December 3, 1984, water contamination of a tank of methyl isocyanate in Bhopal, India initiated a series of events that led to a catastrophic toxic release, killing more than 3000 residents and injuring over 100,000.

In February 1985, leaders from 17 of the leading chemical and petroleum companies asked the American Institute of Chemical Engineers (AIChE) to lead a collaborative global effort to eliminate catastrophic process incidents by:

- ADVANCING state-of-the-art process safety technology and management practices,
- SERVING as a premier resource for information on process safety,
- FOSTERING process safety in engineering and science education, and
- PROMOTING process safety as a key industry value.

On March 25, 1985, AIChE formed the Center for Chemical Process Safety (CCPS) with charter member companies. In the years that followed, CCPS has been the world leader in every area of process safety information, with over 60 guideline and resource books in print, and an ever-growing web knowledge base. CCPS membership now exceeds 100 companies, headquartered in more than 15 companies in four continents and operating in every part of the world.

To contact or to learn more about the CCPS the following information has been provided:

- View the CCPS book catalog: www.wiley.com/go/ccps
- Learn about CCPS membership: www.aiche.org/CCPS/Corporate/index.aspx
- Browse the CCPS Web Knowledge Base:
  www.aiche.org/CCPS/Resources/KnowledgeBase/overview.aspx
- Attend CCPS events: www.aiche.org/CCPS/Conferences/index.aspx
- Contact CCPS: ccps@aiche.org or +1.646.495.1372.

Homeland Security

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