

THE REGULATION OF INHERENT SAFETY

David A. Moore, PE
President and CEO, AcuTech Consulting Group, Chemetica, Inc., 1948 Sutter Street, San Francisco, CA 94115, dmoore@acutech-consulting.com

INTRODUCTION

Inherent Safety is a worthwhile process risk management strategy to employ, and efforts to implement inherently safer strategies should be given first priority, as is feasible. But regulating the use of inherent safety is proving to be challenging as evidenced by the experiences to date of industrial companies who are under inherently safer requirements as part of the Contra Costa County, California, Industrial Safety Ordinance (ISO)[1,2]. This paper will outline those requirements and explain how the inherently safer requirements were adopted as part of an overall strategy of ISO programs that act in concert to address risk to the community and workers and the issues in achieving compliance.

Inherent safety is gaining momentum in the United States in the minds of the regulators at the Federal, State, and Local Government levels. Inherently safer systems (ISS) requirements of the Contra Costa County, California, Industrial Safety Ordinance (ISO) are a significant new regulation that should be closely monitored by industry[1,2]. While the concept of Inherent Safety has been in the vocabulary of process safety engineers for twenty years, it is only a newly appreciated issue in process safety management. Inherent safety is not widely practiced in an explicit manner in the United States at this time. This is the first process safety regulation in the United States that we are aware of that requires facilities to justify their consideration of inherently safer systems.

Companies in any industry or location should be familiar with the concepts, and concerned with the progress being made in addressing the underlying concerns of the County in enacting the ordinance, the intent of the inherently safer systems requirements, and the merits of any additional requirements. Given that inherent safety is a rather subjective concept, it makes the matter a difficult one to understand.

The ordinance references the definition of inherent safety published by the Center for Chemical Process Safety (CCPS) in its book "*Inherently Safer Chemical Processes: A Life Cycle Approac*h[3]". This is significant in that industry guidance is being held as a standard by which companies need to operate.

The intent of this paper is to provide further explanation of the concept of Inherently Safer Systems, to explain the regulatory requirements, to assess their effectiveness, and to make suggestions on how to improve the regulation of Inherently Safer Systems (ISS).

BACKGROUND ON THE ISO

According to the County[4], the Contra Costa County Board of Supervisors passed the Industrial Safety Ordinance because of concerns of the accidents that have occurred at the oil refineries and chemical plants in the County. The effective date of the Industrial Safety Ordinance was January 15, 1999. The ordinance applies to oil refineries or chemical plants that were required to submit a Risk Management Plan to the U.S. EPA and are a program

level 3 regulated stationary source as defined by the California Accidental Release Prevention (CalARP) Program. The goals of the ordinance include:

1. To reduce the number of incidents being experienced in the County at the covered stationary sources;
2. To reduce the overall catastrophic risk from the facilities, especially to the public and workers.

It is no doubt believed that by encouraging inherently safer systems be considered, that substantial improvements could be made in realizing the goals mentioned above. Part of the ISO requirements is the need for the regulated stationary sources to consider inherently safer systems when evaluating the recommendations from process hazard analyses for existing processes and to consider inherently safer systems in the development and analysis of mitigation items resulting from a review of new processes and facilities. Contra Costa Health Services completed and issued a Contra Costa County Safety Program Guidance Document on January 15, 2000[4]. This document included a definition of inherent safety and some rules for implementation of the ordinance.

Facilities that are subject to this ordinance are, in total, subject to four safety regulatory programs designed to reduce the potential of an accidental release from a regulated stationary source that could impact the surrounding community[4]. The four programs are the Process Safety Management (PSM) Program administered by Cal/OSHA, the federal Accidental Release Prevention Program administered by the EPA (RMP), the California Accidental Release Prevention Program administered by Health Services (CalARP), and the Industrial Safety Ordinance (ISO) administered by Health Services. All of the above regulations require the identification and analysis of hazards, and meeting these regulations requires a significant effort.

A key difference between the PSM, RMP, and CalARP programs and the ISO program, however, is that the regulated stationary sources are required to consider inherently safer practices for all PHA action items under the current Industrial Safety Ordinance. This requirement is unique and is the topic of this paper. Note that the other three regulations imply that inherently safer systems should be employed, but are non-specific in this requirement.

CURRENT REQUIREMENT OF THE ISO FOR INHERENT SAFETY

The current Industrial Safety Ordinance requires facilities to consider inherently safer systems in the development and analysis of mitigation items resulting from a process hazard analysis and in the design and review of new processes and facilities. The Industrial Safety Ordinance defines inherently safer systems as follows:

"Inherently Safer Systems" means Inherently Safer Design Strategies as discussed in the 1996 Center for Chemical Process Safety Publication (CCPS) "Inherently Safer Chemical Processes"[5] and means Feasible alternative equipment, processes, materials, lay-outs, 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. Examples include, but are not limited to, substitution of materials with lower vapor

pressure, lower flammability, or lower toxicity; isolation of hazardous processes; and use of processes which operate at lower temperatures and/or pressures." County Ordinance Chapter 450-8, §45—8014(g).

SUMMARY OF PROPOSED AMENDMENTS

The Board of Supervisors and the CCHS are analyzing the merits of changing the ordinance or at least updating the Program Guidance Document. A newly proposed guidance document for the ordinance may allow a broader application of inherent safety, and may require that ISS be considered for all new, modified, or existing facilities in a more comprehensive way than just to consider the outcomes of PHA action items. That guidance was in draft form at the time of the development of this paper (September, 2002).

This guidance was felt to be necessary since the first few years of the application of inherently safer systems proved to be a frustration for regulators and industry alike. Industry felt that meeting the intent of the regulation was unrealistic for existing facilities, particularly from an economic standpoint. They felt risks were adequately addressed by strategies other than inherent safety. Regulators seemed to feel that industry didn't take the requirements of the regulation seriously and hadn't made substantial progress in the area of inherent safety. They felt that the continued incidents at the facilities were evidence that inherently safer strategy they had expected was necessary.

This dilemma resulted in a several proposals to stiffen the regulations. There are three amendments being considered by the Board of Supervisors for the Industrial Safety Ordinance. One proposal, the Gerber amendment, which was proposed by one of the County Board of Supervisors, would effectively give the authority for the County Health Services Department to mandate the exact technology and ISS design employed when a company rejects a recommendation from a PHA to implement an ISS proposed change.

The crux of it is that while it is already required to implement the most inherently safer strategy, it appears that CCHS and possibly the Supervisors have doubts that industry is taking the principle to heart. Actually much has been done to implement ISS where possible. Of course not every PHA action item is an opportunity for Inherently Safer Systems (many times various layers of protection are required and are reasonable solutions). This has the potential to force very expensive and significant changes in the name of inherent safety.

Another proposal from the CCC Health Services Department suggests that the Industrial Safety Ordinance be amended in the way inherently safer systems are considered. Based on the way the existing ordinance is written, the reduction of existing hazards at the stationary sources is claimed to be 'minor if any at all' and only a portion of each of the processes is considered using the existing ordinance. Health Services is proposing two changes to the ordinance:

1. That a separate study of existing processes to consider inherently safer systems be performed.
2. That the definition of inherently safer systems as defined by the ordinance be amended to emphasize the inherent and passive layer of protection. The inherent layer considers ways of reducing hazards, while the passive, active, and procedural layers look at ways

of reducing the risks. The amendment proposed by Health Services will look at reducing the hazards at existing process, not just reducing the risk, and will look at the complete processes, instead of only portions of the processes.

BACKGROUND ON INHERENT SAFETY

The history of inherent safety as a documented strategy for loss prevention is rather recent, but the concept is very old. "On December 14, 1977, Trevor Kletz presented the annual Jubilee Lecture to the Society of Chemical Industry in Widnes, England. His topic was "What you don't have, can't leak," and this lecture was the first clear and concise discussion of the concept of inherently safer chemical processes and plants.

Safety professionals agree that this is a good 'way of thinking', and is a best practice in process safety management. The Center for Chemical Process Safety of the American Institute of Chemical Engineers (CCPS) published the book referenced by ISO in 1996 to promote the concept[3]. Inherently Safer Systems is a philosophy that is encouraged in the industry to focus engineers and managers on reducing or eliminating a hazard within a chemical process as a goal as it is feasible. No absolute ground rules exist for accomplishing this – it is a philosophy.

At this time in industry, while it is appreciated, it is not prescribed in any other U.S. process safety regulation we are aware of nor is it widely practiced in a formal, documented way by industry throughout the world. Most companies would recognize it as a philosophy, and would encourage its use where possible.

The ISS method employs four key inherently safer strategies:

1. Minimizing,
2. Substituting,
3. Moderating, and
4. Simplifying

Each of these strategies can accomplish hazard reduction or elimination.[4]

"Hazard is defined as a physical or chemical characteristic that has the potential for causing harm to people, the environment, or property."[3] The concept is based on the belief that if one can eliminate or moderate the hazard, not only is the risk reduced, it may be possible to remove the risk altogether from consideration. Alternatively, an inherently safer system would make the hazard less likely to be realized and less intense if there is an accident.

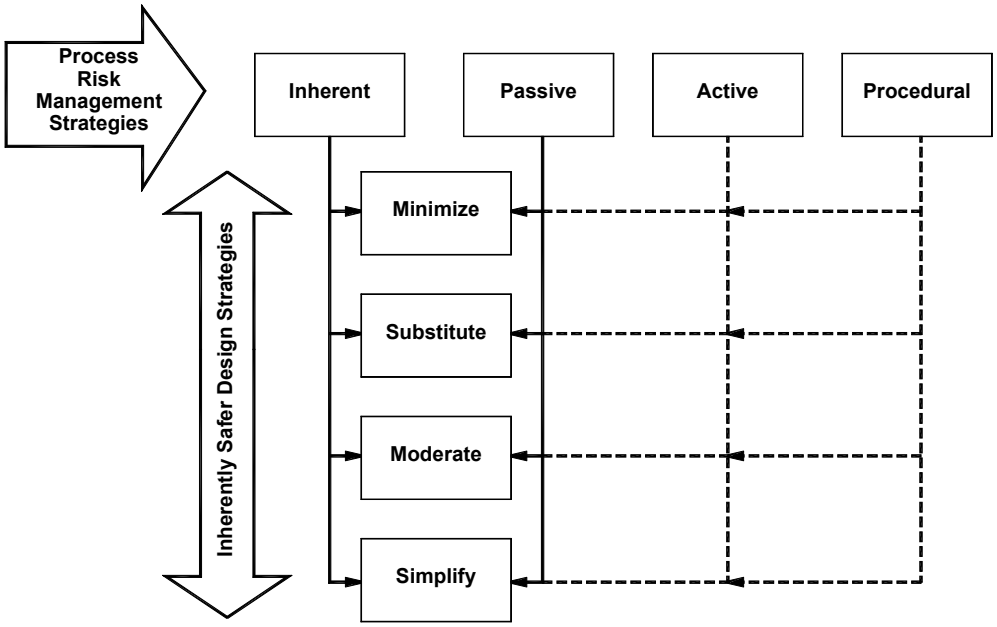
LAYERS OF PROTECTION AND OVERALL PROCESS RISK MANAGEMENT STRATEGY

Similarly, though, CCPS has published several other publications that sanction the use of other process risk management strategies of Layers of Protection and the use of all four process risk management strategies. In fact, these two concepts are described in the same textbook on inherent safety[6]. The layers of protection concept is that every hazard needs to have a series of layers of prevention, detection, and mitigation systems to either assist in prevention of the incident or in reducing the potential impacts of any event. Key to the concept is the idea of reducing the risk of the chain of events from initiation of an incident to prevention of or reduction of the hazardous outcome.

CCPS also describes four categories of risk reduction strategies:

1. Inherent
2. Passive
3. Active
4. Procedural

These strategies are illustrated in Figure 1.



Source: Fig 2.2, CCPS Concept Book *"Inherently Safer Chemical Processes"*[5]

Figure 1. Process risk management strategies

Figure 2 illustrates the matrix AcuTech developed with abbreviations to illustrate the broad application of inherent safety across all four inherent safety strategies and across all four process risk management strategies. The abbreviations are documented in the worksheet for each inherently safer systems study that is done as a means of ensuring the broad application of strategies is implemented. First preference is given to those in the Inherent column, followed by Passive and then Active and Procedural, due to the degree of reliability of each strategy.

All safety professionals agree that layers of protection (Figure 3) and the four process risk management strategies are necessary and advisable strategies, too, and represent another best practice for process safety management. Inherent safety and layers of protection/process risk management strategies are not opposing strategies – they are complementary strategies in an overall scheme to reduce risk. In fact, the strategies cannot be taken out of context and be effective.

Inherently Safer Systems Matrix				
Inherent Safer Design Strategies	Process Risk Management Strategies			
	Inherent (1)	Passive (2)	Active (3)	Procedural (4)
Minimize	MIN1	MIN2	MIN3	MIN4
Substitute	SUB1	SUB2	SUB3	SUB4
Moderate	MOD1	MOD2	MOD3	MOD4
Simplify	SIM1	SIM2	SIM3	SIM4

Figure 2. Process risk management strategies vs. inherently safer strategies

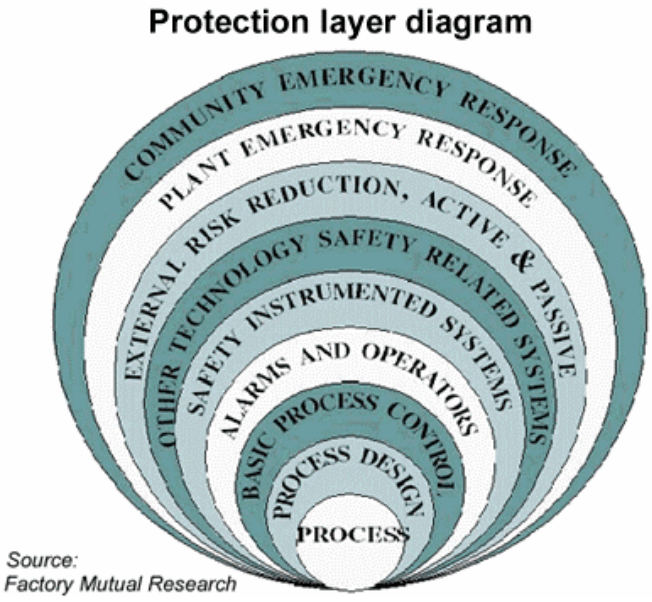


Figure 3. Layers of protection concept

CCHS also recognizes these four strategies in their broad definition of inherently safer systems in their newly drafted ISO guidance, and has encouraged stationary sources to employ all four strategies in an overall risk reduction framework.

OPPORTUNITIES FOR ISS AND LAYERS OF PROTECTION

CCPS states that there are three stages of an accident sequence, the initiation, the propagation, and the termination stages. "Inherently Safer Strategies (and Layers of Protection) can impact the accident process at any of the three stages. The most effective strategies will prevent initiation of the accident. Inherently safer design can also reduce the potential for propagating an accident, or provide an early termination of the accident sequence before there are major impacts on people, property, or the environment"[3]. This description by CCPS says that safety professionals believe that there are many opportunities to employ inherent safety – not only to eliminate a hazard but also to moderate an accident sequence in different ways that, in effect, lowers the risk.

The CCPS book Inherently Safer Chemical Process6 considers the implementation of inherently safer systems over the lifetime of the chemical process. To accomplish this the authors of the book took a broader meaning where the inherent level (the most strict definition of inherent safety) is a subset of their definition, which also include passive, active, and procedural levels. The passive, active, and procedural levels do not reduce or eliminate the hazard, but does reduce the likelihood of a release by reducing the risks.

In other words, inherent safety can be interpreted either narrowly or broadly. "The narrowest interpretation that could be argued from the wording of the ISO definition would be that an ISS reduces the underlying hazard that must be contained and controlled for a Major Chemical accident or Release to be avoided. The broadest interpretation that could be argued from the wording of the ISO definition would be that an ISS reduces the risk of a Major Chemical Accident or Release by reducing the underlying hazard that must be contained and controlled or by improving layer(s) of protection in a way that is permanent and inseparable and not easily weakened or removed from the system. It should be noted that systems that do not address Major Chemical Accidents or Releases, as defined in the ISO, would not qualify for Inherently Safer Systems per the ISO definition."[5]

In either the broad or narrow interpretation case, if the company takes action to employ an inherently safer system, the overall risk is likely to be reduced and the workers, the company, the public, and environment all benefit. The real issue in the end is whether the risk has been reduced sufficiently to a level that is as low as is reasonably practicable. This issue is ultimately more important than whether a company happened to employ an inherently safer system in every PHA action item case or not.

The book explains the dilemma faced by the County ISO regulation on pages 10–11[6]– "There is much discussion about whether or not a particular safety feature in a chemical process is "inherent". Such discussions may arise in part because different people are viewing the process at different levels of resolution, ranging from a global view of the entire process to a very detailed view of specific features of the process. The definition of hazards (an inherent physical or chemical characteristic that has the potential for causing harm to people, the environment, or property) can be applied at any level of resolution."

Based on a review of PHAs and the recommendations associated with them from industry over the past two years, it is clear that this dilemma mentioned in the CCPS book is occurring. In other words, the PHA teams made many decisions that any ordinary company would have made when presented with similar hazards. In some cases, particularly for new processes or for the restart of a crude unit, the PHA teams made many inherently safer decisions. For the most part, the majority of the recommendations involved improving or adding onto layers of protection since the team did not see an opportunity to employ inherently safer systems above existing examples of ISS, and so it was prudent to reduce the risk or improve on the integrity of an existing layer of protection.

This should be encouraged, not criticized. In the end, the reduction of risk is the goal, while it is desirable to eliminate or reduce the hazard itself if possible as a first strategy. The CCPS book explains this concept on page 11 - "For purposes of this text, any improvement in a layer of protection which is permanent and inseparable, and not easily weakened or removed from the system, is considered to be a process safety improvement in an inherently safer direction." This broad definition is not only a move in the right direction; it is a commonplace approach in industry throughout the world and a prudent approach to follow.

BENEFITS AND DRAWBACKS OF ISS

The benefits of employing the inherently safer strategy is that, hopefully, every decision that is made to design, build, operate, and maintain a process attempts to employ an inherently safer system than the original concept or existing process operation. This could result in lower overall risk, since the original hazards may be eliminated or greatly reduced. But it could be that the mere application of an inherently safer solution does not guarantee a safer process. In fact, it is recognized that any change to a process may result in other undesirable effects, even if the change was in the best interest of safety.

Also, an inherently safer change alone does not necessarily constitute a safer plant. If by employing layers of protection the risk can be sufficiently reduced or if it can be reduced to a greater degree than if one or more inherently safer strategies are employed, layers of protection may be a preferred strategy. Even if an inherently safer strategy is employed, the hazard still may be present, and so it may be desirable or necessary to employ layers of protection in addition.

It may be possible to equate the risk of an accidental release to one that has been treated by an inherently safer system if various layers of protection are employed. The concern is that the layers may be unreliable and certainly may be expensive to provide. But the risk could, indeed, be lower with a process employing various layers of protection.

Risk is defined as a measure of economic loss, human injury, or environmental damage in terms of both the incident likelihood and the magnitude of the loss, injury, or damage.[3] The real goal of the ISO is to reduce risk, particularly to the community.

This process works well for existing plants, but in many situations the hazard is not eliminated or reduced. It can be more applicable to new processes or conceptual designs.

LESSONS LEARNED OF THE ISO PROGRAM FOR ISS

In conclusion, depending on the definition of ISS, there were many examples of inherently safer solutions being employed. If the definition is limited to the strictest definition of inherent safety, then only a few of the PHA action items had employed the most inherent strategy for risk reduction. However, other strategies employed resulted in more 'inherently safe' processes since passive, active, and procedural recommendations addressed more inherent approaches.

Lessons learned from the past three years have included:

- Companies found ISS to be economically and technically difficult if not infeasible to accomplish, particularly for existing processes;
- There are different perspectives on what is reasonable and what is feasible when it comes to decisions on the need for implementing ISS;
- The guidance provided to ensure that ISS was being considered consistently and fully was not informative enough, so there was some confusion and an education gap;
- An annual report of the application of ISS showed that the majority of PHA action items did not involve application of ISS (at least not first inherent principles of ISS);
- The public and regulators tend to be impressed with the principles of inherent safety and have high expectations of risk reduction by the approaches;
- The public and regulators often mistrust industry if wholesale technology changes and other first principles of inherent safety aren't applied to achieve major risk reduction;
- This is created by a difference in perception of risk by the public and industry and a misunderstanding or lack of appreciation of the costs of such changes;
- Industry often looks at inherent safety as only the first principles rather than a wider use of the concepts, so this exacerbates the problem;
- Application of inherent safety at only the most purely inherent level (first principles) is often at odds with practical and cost effective risk reduction, especially for existing construction;
- A broader application of inherent safety across all four strategies of process risk management is more practical and may result in novel risk reduction ideas;
- Any move in an inherently safer direction is likely to be a good risk reduction move, so this should be encouraged;
- Inherent Safety is best applied by those knowledgeable of the process with proper training;
- Guidance/training is needed for a team to know how to do this effectively;
- We recommend that ISS be considered as an integral part of the PHA process for efficiency and since it is more widely applied.

CONCLUSIONS

Inherent Safety is a newly appreciated issue in process safety management, and this is the first process safety regulation in the United States that we are aware of that requires facilities to justify their consideration of inherently safer systems. As such, it is important to understand the progress being made in addressing the underlying concerns of the County in

enacting the ordinance, the intent of the inherently safer systems requirements, and the merits of any additional requirements. Given that inherent safety is a rather subjective concept, it makes the matter a difficult one to understand, implement, and regulate.

AcuTech does not recommend that the narrowest view of inherent safety be the only one encouraged. Also, AcuTech recommends that inherent safety is integrated into process hazard analysis (PHA) studies to allow for a broader perspective and a day-to-day effort, rather than only a special study once in a while.

AcuTech believes the best approach is to allow those most knowledgeable of the process to justify their design and operating decisions, as the current ordinance requires, rather than to give the regulator the authority to mandate a particular technology against the will of the industrial company. Inherent Safety must be exercised to the fullest, but there are practical bounds on its application.

The Contra Costa County ISO is on the cutting edge of process safety with inherently safer system requirements. It is likely that other regulations may model themselves after this or similar ones and require inherent safety. Already the City of Richmond, California, has adopted the CCC ISO regulation.

Since the terrorist attacks on the United States in September, 2001, there has been a flurry of regulations for homeland security. The proposed U.S. Senate Bill S.1602 "Chemical Security Act of 2001" lists inherent safety requirements as a requirement. This could have very significant consequences if this is emphasized over other strategies for risk reduction from intentional releases. Inherent safety is being focused on as the leading solution for limiting the risk of terrorist acts on chemical facilities by some regulators and environmental groups.

Companies should begin to apply this voluntarily to gain the benefits and prepare for the future business environment.

REFERENCES

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