



Inherently Safer Design (ISD) Success Stories in Existing Plants

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- 22 years with Monsanto
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Agenda

- Inherently Safer Design (ISD) – Not a New Concept!
- The Regulatory Case for ISD
- ISD – Not Just for the Design Phase!
- ISD Success Stories in Existing Plants
- ISD Implementation
- Opportunities and Challenges with Inherent Safety



Image Source: <https://www.linkedin.com/pulse/beware-phrase-new-improved-greg-coticchia-mba-pc/>

ISD – It's Not a New Concept!

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- ISD has been around since prehistoric times - building on high ground for protection, for example



Le Moustier *Homo neanderthalensis* by Charles R. Knight

ISD – Not a New Concept!

- In more recent times, Alfred Nobel's invention of dynamite revolutionized the mining industry, by moderating the effects of nitroglycerin through absorption on diatomaceous earth.

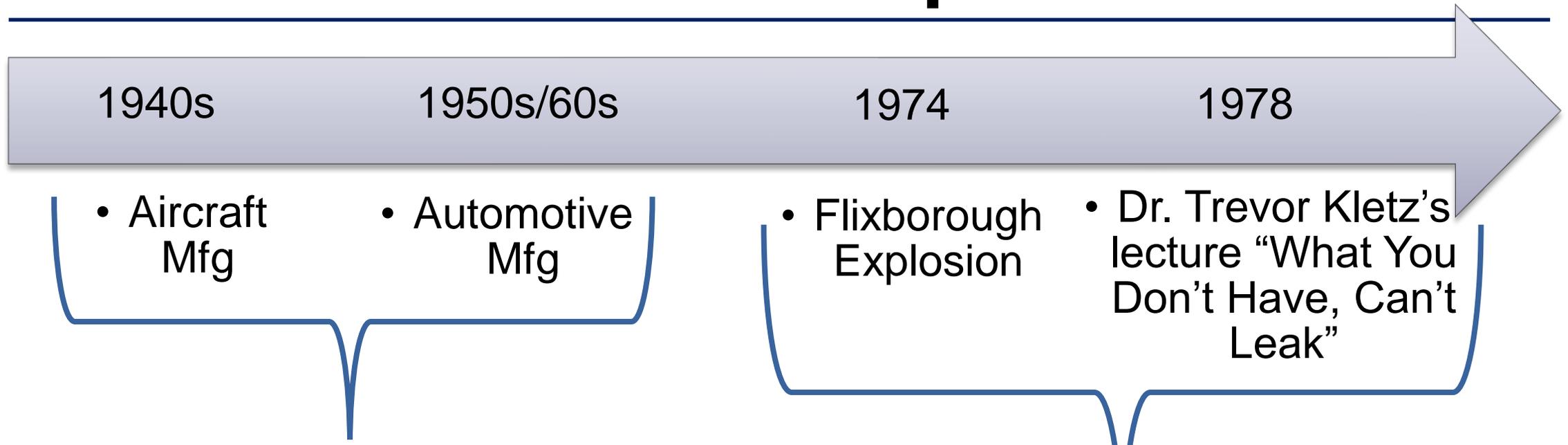


Image Source:
<https://www.britannica.com/biography/Alfred-Nobel>



Image Source: <https://www.etsy.com/listing/206753988/vintage-dupont-dynamite-crate-replica>

ISD – Not a New Concept!



- Aircraft Mfg

- Automotive Mfg

- Flixborough Explosion

- Dr. Trevor Kletz's lecture "What You Don't Have, Can't Leak"

Value Engineering

Application of minimization, simplification, and substitution

First clear and concise discussion of ISD concepts in the process industries

Applying ISD concepts to chemical processes has been shown to reduce risk of process safety incidents and the costs of manufacturing, while improving operability.



ISD – It's Not Just for the Design Phase!

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- Perception is NOT reality!
 - Although the “D” in ISD denotes “design”, the application of ISD is not, and should not, be limited to the design phase
 - Applicable to all phases of the life cycle

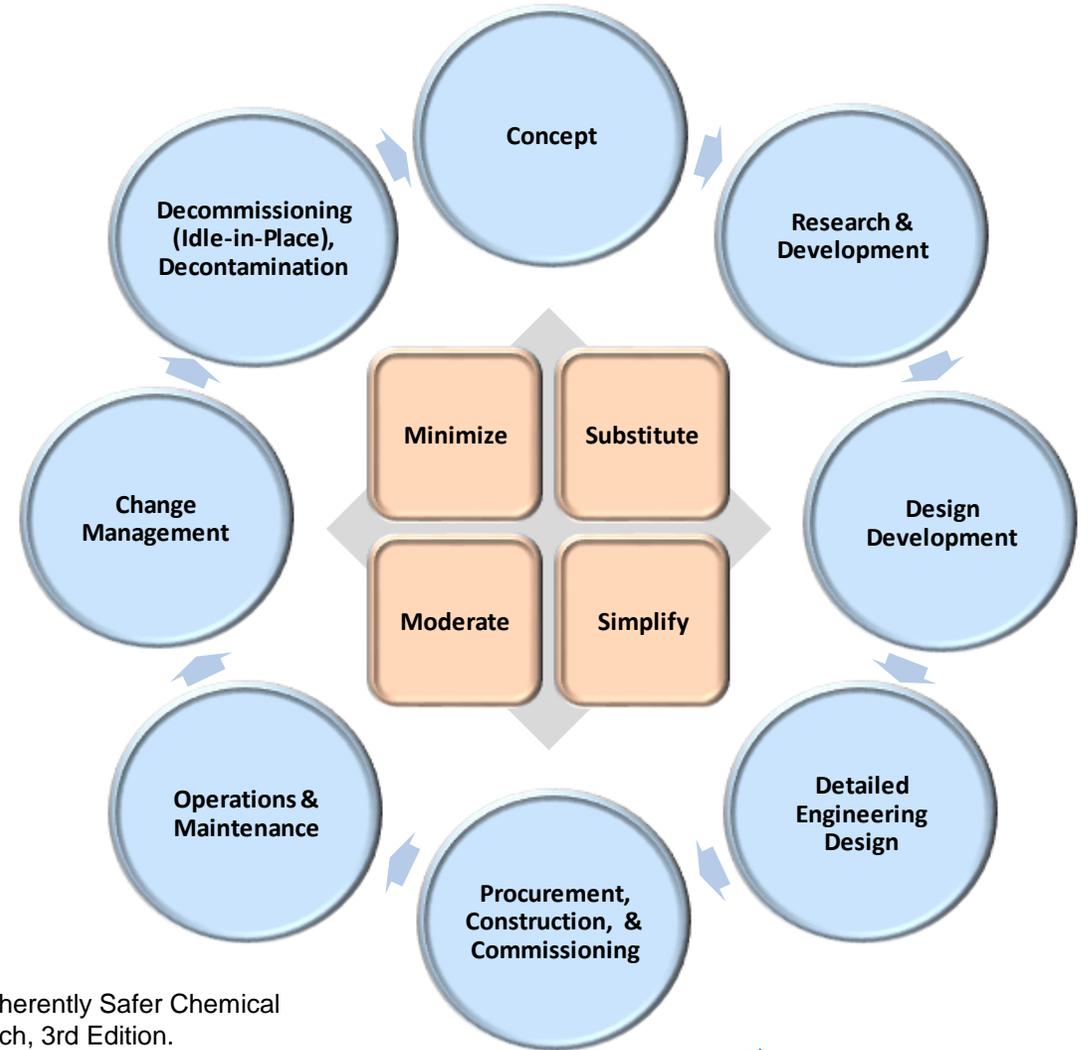


Image Source: Guidelines for Inherently Safer Chemical Processes: A Life Cycle Approach, 3rd Edition.

ISD – It's Not Just For the Design Phase

- As plants and processes start up and operate, ISD provides the tools for incorporating technological and methodological improvements
 - Hazardous inventories can be **minimized**
 - SOPs can be **simplified**
 - Reaction conditions can be **moderated**
 - Hazardous raw materials can be **substituted**



ISD – It's Not Just For the Design Phase

- Even during decommissioning, ISD techniques can be applied:
 - **Moderate** - Mechanical/electrical isolation
 - **Minimize** – Deinventory equipment
 - **Simplify** – Document status of equipment



Image Source: <https://deepsouthcrane.com/news/facilitating-a-refinery-column-placement-in-tight-confines>



ISD Success Stories in Existing Plants

ISD Success Stories in Existing Plants

- ISD Techniques have been applied to numerous existing plants
- Some applications are considered “low hanging fruit”
- Others are more complicated, less straightforward
- Let’s review some examples for each ISD technique

ISD Success Stories in Existing Plants

Substitution

- A classic example (and considered low hanging fruit) – using bleach vs. gaseous chlorine for water disinfection - implemented at numerous sites
- Accidental release much less likely to release chlorine into the atmosphere



Image Source: <https://shop.clorox.com/products/clorox-disinfecting-bleach>

ISD Success Stories in Existing Plants

Substitution

- Anhydrous ammonia to aqua ammonia for WWTP and NOx reduction systems – more low hanging fruit!
- Potential to use existing storage tank
- Accidental releases much less hazardous



Image Source: <https://www.amazon.com/KIK19703575033-Purebright-All-purpose-Cleaner-Ammonia/dp/B00FT4UGS8>

ISD Success Stories in Existing Plants

Substitution

- Painted structural steel to galvanized steel
- Minor increase in installed cost, much lower maintenance costs as well as increased asset protection



Image Source: <https://tampasteel.com/what-is-galvanized-metal/>

ISD Success Stories in Existing Plants

Substitution

Sealed pumps to seal-less pumps



Image Source: <https://magnatexpumps.com/stainless-steel-centrifugal-pump-maxp.php>

Carbon steel piping to higher alloy piping to eliminate corrosion

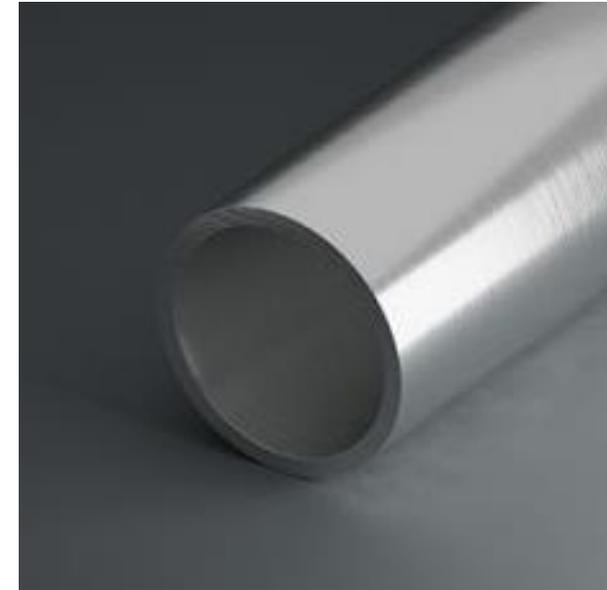


Image Source: <https://store.metalsnet.com/exotics/c276-hastelloy-tubing/>

ISD Success Stories in Existing Plants

Simplification

Unique fittings for nitrogen vs. air



Image Source: <https://www.grainger.com/product/AIR-SYSTEMS-INTERNATIONAL-Hansen-Fitting-For-14A075-25CD44>

Different size flanges on relief valves



Image Source: <https://www.control-specialties.com/kunkle-600njg01-1-1-2-safety-valve.html>

Index pipe sleeves and dip pipes to ensure correct orientation

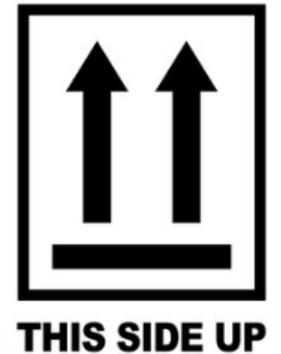


Image Source: <https://www.amazon.com/Reliance-9006178-005-52-Inch-Dip-Tube/>

ISD Success Stories in Existing Plants

Simplification

- Simplified operating instructions
 - Standardized format
 - Information mapping
 - Conciseness
 - Appropriate level of detail



ISD Success Stories in Existing Plants

Moderation

Limit shutoff pressure of pumps below piping MAWP



Sample coolers vs. heat resistant PPE



Control room outside of blast zone vs. blast-resistant buildings



Image Source: <https://www.chemworld.com/Boiler-Sample-Cooler-p>

ISD Success Stories in Existing Plants

Moderation

Blast walls around reactive systems



Image Source: <https://www.tmi2001.com/blog/what-is-a-blast-mat/>

Quiet, climate-controlled operator shelters to promote close monitoring of processes in noisy or extreme environments



Image Source: <https://www.grainger.com/product/PORTA-KING-Modular-Wall-Enclosure-8-ft-18C735>

ISD Success Stories in Existing Plants

Minimization

Minimize the amount of process alarms



Image Source: <https://www.se.com/us/en/work/products/featured-products/>

Install self-cleaning filters where possible, or design systems to eliminate them entirely



Image Source: <https://damnfilters.com/products/4705-0010-messer-oem-replacement-dust-collector-filter>

ISD Success Stories in Existing Plants

Minimization

Install heating and cooling sources on same electrical buss; if cooling is lost, heating will also be lost



Provide access platforms to promote equipment inspection, calibration, and maintenance

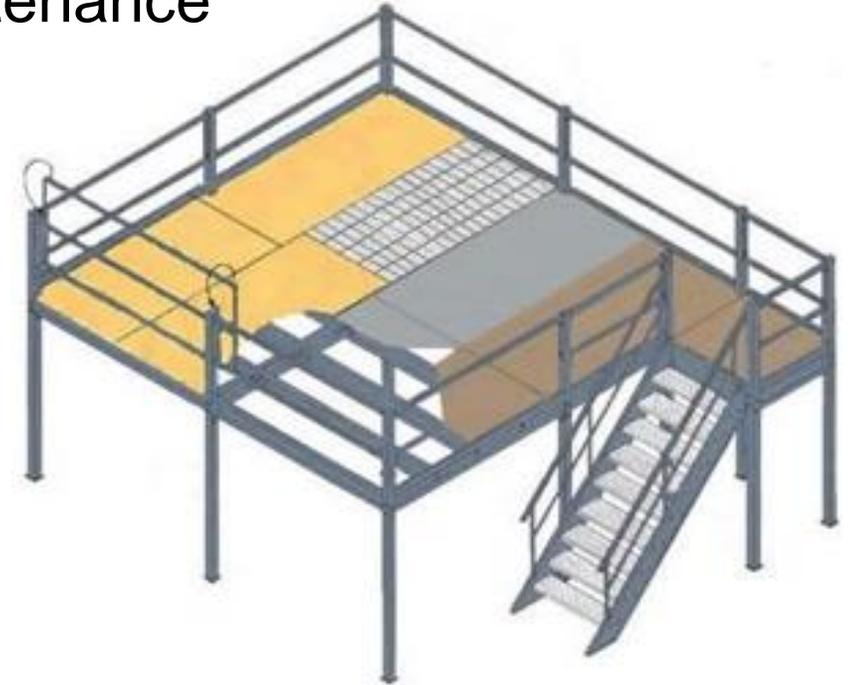


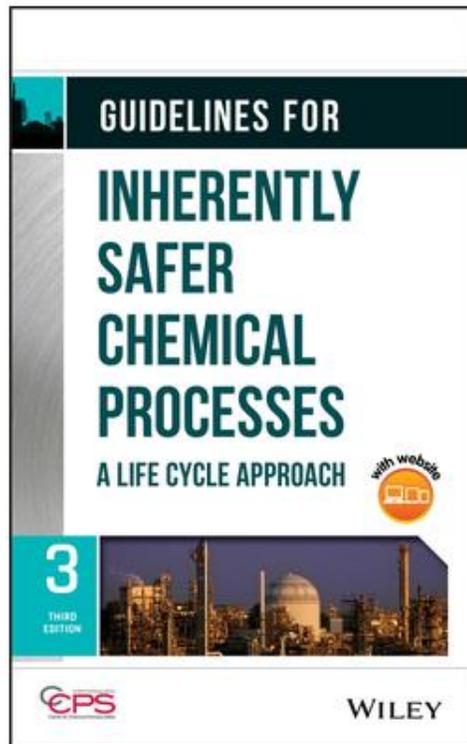
Image Source: <https://shop.fsindustries.com/product/m0848-c-8-x48-mezzanine-black-bar-grating-deck/68745>

got isd?

ISD Implementation Guide

ISD Implementation Guide

- Checklists are an effective tool!
- Example checklists can be found in the CCPS book, *Guidelines for Inherently Safer Chemical Processes: A Life Cycle Approach, 3rd Edition*.



No.	Inherently Safer Design Alternatives	Applicable (Y/N)?	Opportunities/Applications
3.0	MODERATE		
3.3.5	<ul style="list-style-type: none"> Operating at lower pressure to limit potential release rate 		
3.3.6	<ul style="list-style-type: none"> Operating at lower temperature to prevent run away reactions or material failure 		
3.4	Is it possible to use less concentrated hazardous raw materials to reduce the hazard potential? By using:		
3.4.1	<ul style="list-style-type: none"> Aqueous ammonia instead of anhydrous 		
3.4.2	<ul style="list-style-type: none"> Aqueous HCl instead of anhydrous 		
3.4.3	<ul style="list-style-type: none"> Sulfuric acid instead of oleum 		
3.4.4	<ul style="list-style-type: none"> Dilute nitric acid instead of concentrated fuming nitric acid 		
3.4.5	<ul style="list-style-type: none"> Wet benzoyl peroxide instead of dry 		
3.5	Is it possible to use larger particle size/reduce dust (to minimize potential for dust explosions)?		

Image Source: Guidelines for Inherently Safer Chemical Processes: A Life Cycle Approach, 3rd Edition.



Opportunities and Challenges with Inherent Safety

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Opportunities

- There are many success stories from industry where ISD concepts were applied to existing operations/facilities, which resulted in:
 - Safety improvements
 - Improvements in process operability and cost performance

Challenges

- Both industry and policymakers have challenges and opportunities to develop programs for broad adoption of ISD
- While ISD efficacy is generally accepted, implementation and regulation is not straightforward

Thank you!

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 - Alyse Keller
 - Dave Moore
 - CCPS Peer Reviewers!

Questions?

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