

Inherently Safer Principles

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Figure 1. Reactor sampling before applying ISD *

Alkylation is a chemical reaction where an alkyl group is transferred to a molecule. A plant catalytic alkylation reactor produced a mixture of three compounds (ortho, meta, and para isomers). The product composition is a critical specification that needs to be monitored. Sampling was done twice a day (once per shift) at the reactor outlet. The sample was hot and contained hazardous materials. The sampling process had resulted in first aid incidents.

Engineers looked at the statistical quality control data for that sample. The results were consistent. They did not vary much if the raw material quality and reactor temperature and pressure were maintained. The plant applied inherently safer design (ISD) to that operation. Reactor sampling was reduced from twice a day to once a week (ISD – Minimize). They also instituted a practice to take additional samples when there were process upsets, changes in raw material quality, or when there was a replacement of the catalyst. This resulted in waste reduction, cost reduction, and minimized the exposure to hazardous materials for personnel who took the samples and analyzed them. At the same time, they did not compromise the product quality.



Did You Know?

ISD strategies include:

- Minimize/Eliminate—Eliminate hazardous material or activity. Reduce inventory of hazardous materials or energy.
- Substitute—Replace a hazardous material or process with an alternative that reduces or eliminates the hazard
- Moderate—Use dangerous materials in a less dangerous form or under less severe conditions.
- Simplify—Designing processes, equipment, and procedures to eliminate unnecessary complexity.
- ISD is not just for design. ISD principles are applicable across the life cycle of a chemical process. A process or a procedure can be simplified, a hazardous material may be eliminated or replaced with safer material anytime from pilot plant to production.

What Can You Do?

- When you participate in an activity that results in the identification of hazards and safeguards – a Process Hazard Analysis (PHA), incident investigation, pre-startup safety review, job safety analysis (JSA), a plant safety review, look for opportunities to apply ISD principles to eliminate or reduce hazards. Rather than immediately looking for safeguards.
- Ensure that any ISD options identified are reviewed using your plant Management of Change (MOC) procedures before implementing them. Any change, even one which is intended to eliminate or reduce hazards, has the potential to introduce new hazards or increase the magnitude of other existing hazards.
- Reference: Ganeshmani N. Inherently safer design: Success stories. *Process Saf Prog.* 2025; 1-7. doi:10.1002/prs.70007

Inherently safer – eliminating hazards rather than managing them!

Prinsip Keselamatan Inheren

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Gambar 1. Pengambilan sampel reaktor sebelum menerapkan ISD (*Inherently Safer Design*)

Alkilasi adalah reaksi kimia di mana suatu gugus alkil dipindahkan ke sebuah molekul. Sebuah reaktor alkilasi katalitik di pabrik menghasilkan campuran tiga senyawa (isomer orto, meta, dan para). Komposisi produk merupakan spesifikasi kritikal yang perlu diperhatikan. Pengambilan sampel dilakukan dua kali sehari (sekali per shift) pada keluaran reaktor. Sampel tersebut bersuhu tinggi dan mengandung bahan berbahaya. Proses pengambilan sampel ini telah menyebabkan terjadinya insiden pertolongan pertama.

Para insinyur meninjau data pengendalian mutu statistik dari sampel tersebut. Hasilnya konsisten dan tidak banyak variasi selama kualitas bahan baku, suhu dan tekanan reaktor dijaga. Pabrik kemudian menerapkan prinsip *Inherently Safer Design (ISD)* pada operasi tersebut. Pengambilan sampel reaktor dikurangi dari dua kali sehari menjadi satu kali seminggu (*ISD – Minimize*). Selain itu, diterapkan praktik pengambilan sampel tambahan apabila terjadi gangguan proses, perubahan kualitas bahan baku, atau saat dilakukan penggantian katalis. Hal ini menghasilkan pengurangan limbah dan biaya, serta meminimalkan paparan bahan berbahaya terhadap personel yang mengambil dan menganalisis sampel. Pada saat yang sama, kualitas produk tetap terjaga.



Tahukah Anda ?

Strategi ISD meliputi:

- Minimalkan / Hilangkan - Hilangkan bahan atau aktivitas berbahaya. Kurangi inventaris bahan berbahaya atau energi.
- Substitusi - Gantikan bahan atau proses berbahaya dengan alternatif yang mengurangi atau menghilangkan bahaya tersebut.
- Memoderasi - Gunakan bahan berbahaya dalam bentuk yang tidak terlalu berbahaya atau di bawah kondisi yang tidak menimbulkan dampak bahaya.
- Menyederhanakan - Merancang proses, peralatan, dan prosedur untuk menghilangkan kompleksitas yang tidak perlu.
- ISD bukan hanya untuk desain. Prinsip ISD dapat diterapkan di seluruh siklus hidup suatu proses kimia. Proses atau prosedur dapat disederhanakan, bahan berbahaya dapat dihilangkan atau digantikan dengan bahan yang lebih aman kapan saja, mulai dari pilot plant hingga produksi.

Apa yang Dapat Anda Lakukan?

- Ketika Anda berpartisipasi dalam suatu kegiatan yang menghasilkan identifikasi bahaya dan *safeguard* - seperti *Process Hazard Analysis (PHA)*, investigasi insiden, *pre-startup safety review*, *job safety analysis (JSA)*, atau *plant safety review* - carilah peluang untuk menerapkan prinsip *Inherently Safer Design (ISD)* untuk menghilangkan atau mengurangi bahaya. Pertimbangkan dahulu bagaimana bahaya tersebut dapat dihilangkan atau diminimalkan melalui penerapan prinsip *Inherently Safer Design (ISD)*, daripada langsung mencari *safeguard* untuk bahaya terkait.
- Pastikan bahwa setiap opsi *Inherently Safer Design (ISD)* yang diidentifikasi sudah ditinjau menggunakan prosedur *Management of Change (MOC)* di pabrik Anda sebelum diterapkan. Setiap perubahan, bahkan yang bertujuan untuk menghilangkan atau mengurangi bahaya, memiliki potensi untuk menimbulkan bahaya baru atau meningkatkan tingkat keparahan bahaya lain yang sudah ada.
- Sumber: Ganeshmani N. *Inherently safer design: Success stories. Process Saf Prog.* 2025; 1-7. doi:10.1002/prs.70007

***Inherently safer* – menghilangkan bahaya, bukan sekadar mengelolanya!**