

DESIGN FOR SAFETY TOWARDS VISION ZERO

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Singapore Chemical Industry Council, SCIC



Process Innovation Asia-Pacific Conference

Design for Safety towards Vision Zero

1. Lessons Learnt from Examples / Incidents
2. Facts: MNC versus SME on Process Facility
3. Fundamentals of Design for Safety
4. Design for Safety Professionals

Strive for Operations Excellence and Sustainability

1. Lessons Learnt from Examples / Incidents



Air-con repairman dangles outside 12th storey HDB flat **without harness, risks life for few hundred dollars**

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1. Lessons Learnt from Examples / Incidents



You don't want get out on the **wrong side!**



You don't want landing on the **wrong step** when get out of room!

1. Lessons Learnt from Examples / Incidents

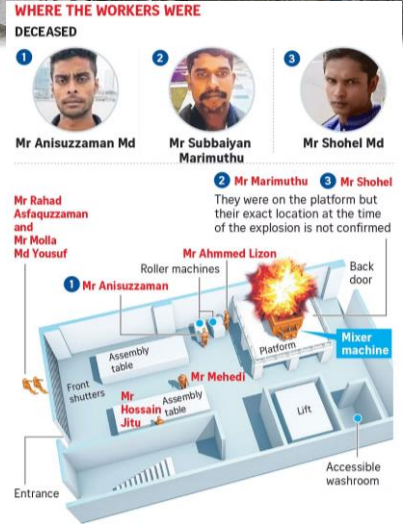


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1. Lessons Learnt from Examples / Incidents



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✓ Tuas dust explosion incident – 24 February 2021

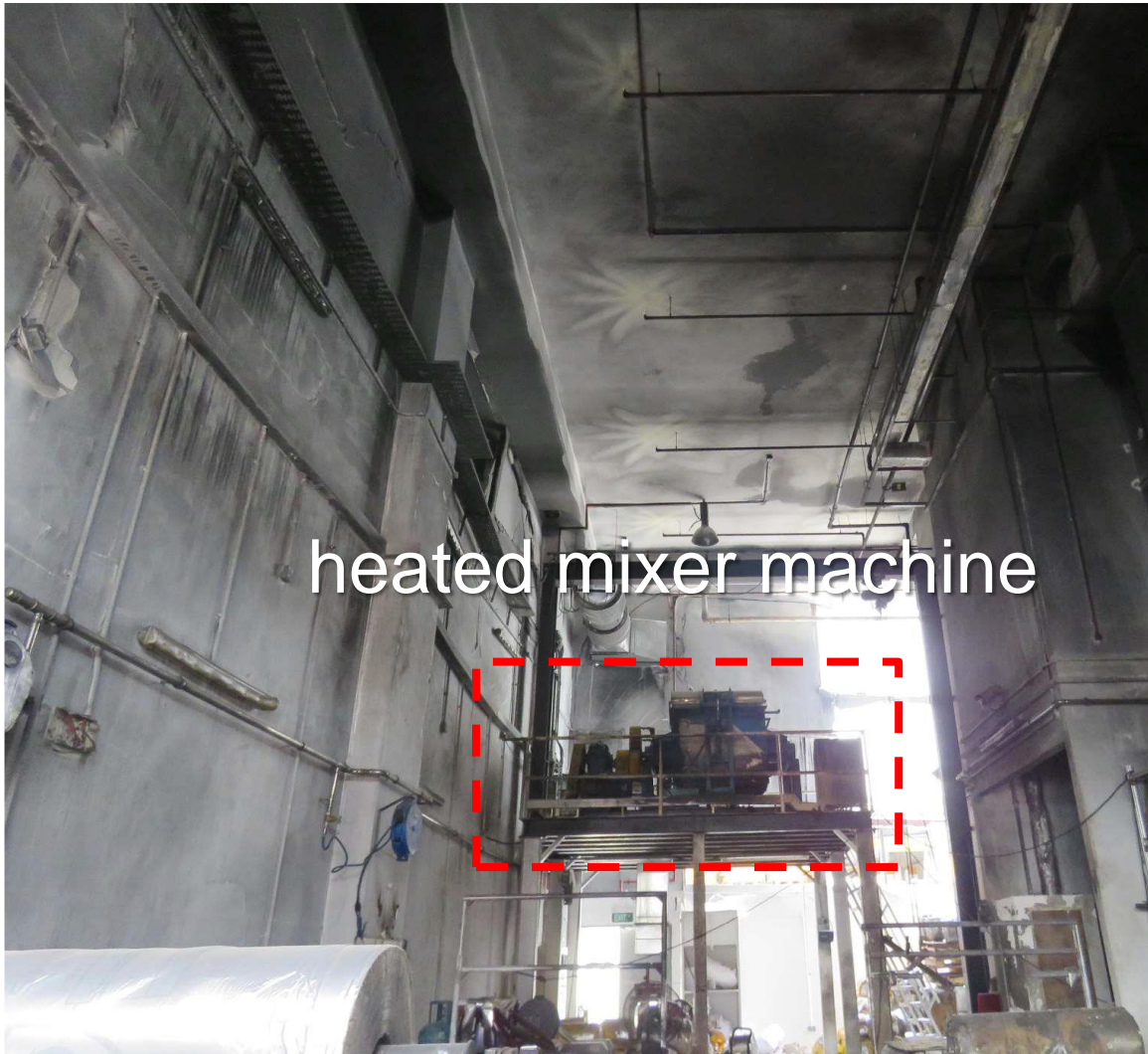
Inadequate Design Considerations

→ Mixer Machine Operated in Unsafe Manner

- No proper investigation when machine showed signs of failure and risk to safety and health (e.g., oil leaks and instances of fire; simply “repair” as “solution”)
- The causes were not established for corrective measures
- Operations continued despite many Red Flags

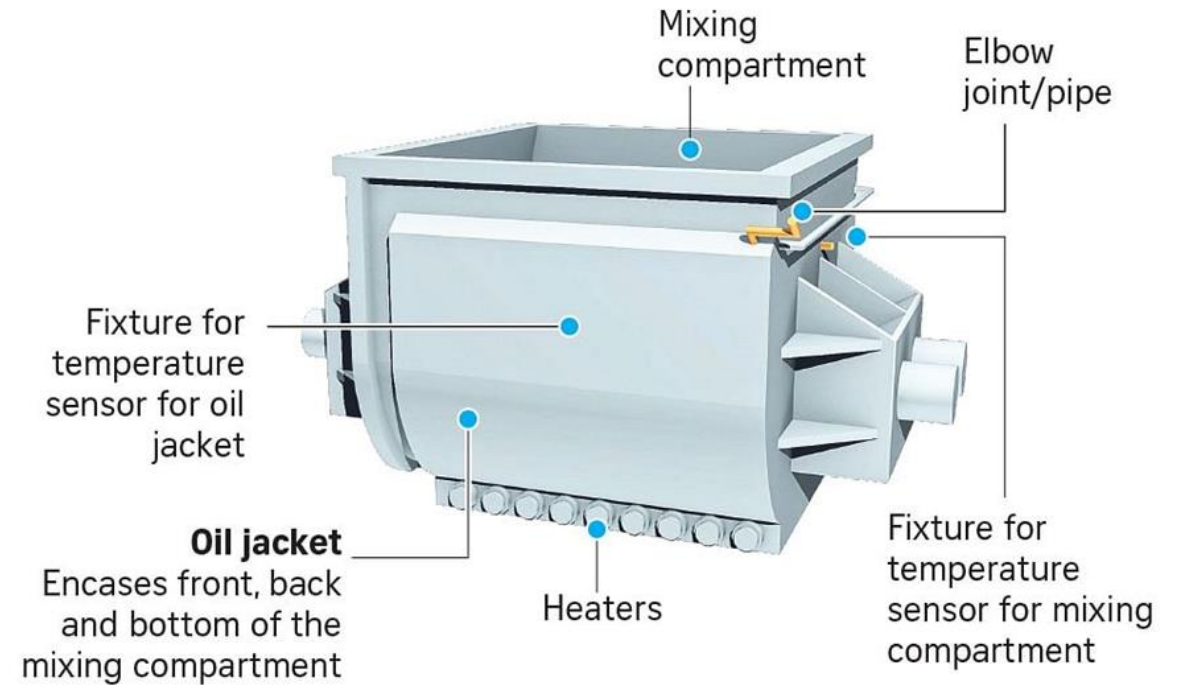
**No proper engineering → Make-shift combination → Shoddy assembly →
Lack knowledge of entire process & operations → Unsafe operations ...**

1. Lessons Learnt from Examples / Incidents



The mixer machine that exploded

The machine – which features a mixing container surrounded by a heated jacket of oil – is used to create a clay-like material used for fire protection in buildings.



Poor safety competence, especially process safety, despite many red flags

↖ Temperature sensor not sensing oil temperature inside jacket

↷ Mixer machine oil jacket was operated as a closed system

↻ Insufficient thermic oil in mixer machine's jacket

1 Temperature sensor was not inserted to oil jacket to monitor (and “control”) within safe limits, i.e. below oil boiling point so as to minimise oil vapour generation in jacket. The only one temperature sensor used at mixer chamber is not representative of oil temperature

2 Mixer machine oil jacket vent line was sealed / plug to “minimise” thermic oil loss without a safety relief valve. This is a deviation (wrong modification) from original equipment manufacturer design without risk assessment

3 There was no proper means to ascertain minimum thermic oil level required before commencement of operations. Insufficient oil level / without submerging heater elements not only resulted in inefficient heating of oil, but also overheating of heaters

Poor safety competence, especially process safety, despite many red flags

1 Temperature sensor not sensing oil temperature inside jacket

2 Mixer machine oil jacket was operated as a closed system

3 Insufficient thermic oil in mixer machine's jacket

1 Temperature sensor was not inserted to oil jacket to monitor temperature (to be maintained within safe limits, i.e. below oil boiling point so as to minimise thermic oil loss) within safe limits. The only one temperature sensor used at mixer machine was used to monitor temperature

2 Mixer machine was modified to "minimise" thermic oil loss with a modification (wrong modification) from original design without risk assessment

3 The proper means to ascertain minimum thermic oil level required before commencement of operations. Insufficient oil level / without submerging heater elements not only resulted in inefficient heating of oil, but also overheating of heaters

Strictly, there were violations of multiple Process Safety elements!

1. Lessons Learnt from Examples / Incidents

Importance of Design for Safety!



Safe design is an important part of risk management

Help prevent accidents and injuries from occurring

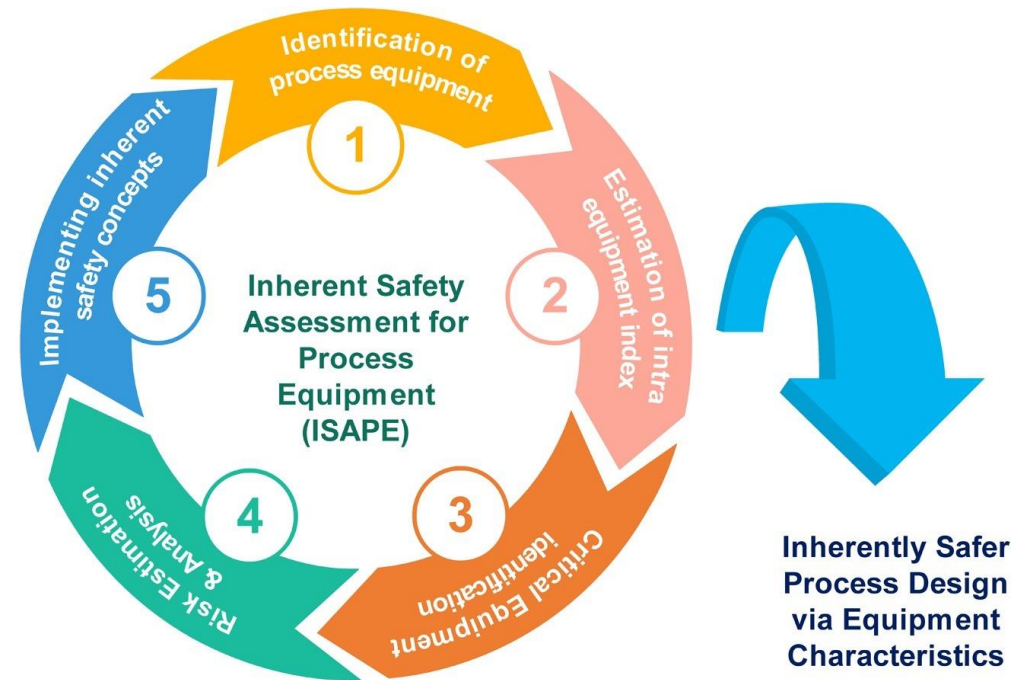
Incorporate features that protect people and property from harm

2. Facts: MNC versus SME on Process Facility

Safe design and operation of process facilities that manufacturing products involving the use of hazardous materials such as fuels and chemicals

→ require process safety design considerations to minimise risks to health and safety throughout lifecycle of product being designed

Inherent Safety Assessment for Process Equipment



Source: ScienceDirect

It can be challenging for Small and Medium Enterprises (SME) to certify their equipment to the machinery safety standard → **seek professional support**

3. Fundamentals of Design for Safety

Process Safety Design Considerations

- ❖ Identify hazards and risks – PHA: **HAZOP**, etc.
- ❖ Singapore laws: regulations – WSH: DfS Regulations 2015, Construction Regulations 2007, Risk Management Regulations; WSH guidelines on Design for Safety
- ❖ Process safety management



Source: SafetyCulture

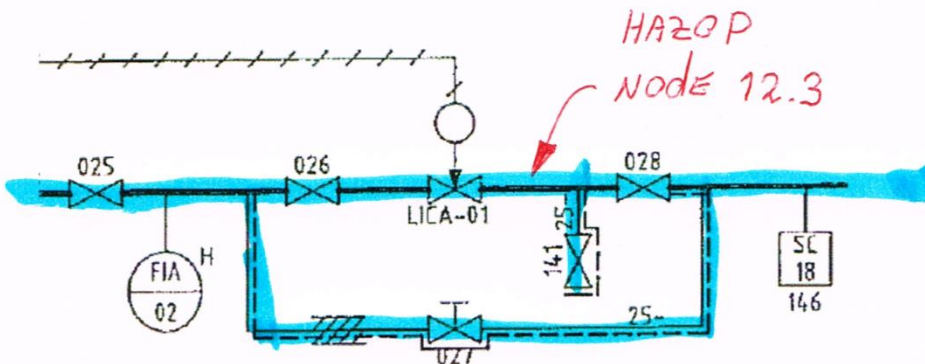
3. Fundamentals of Design for Safety

HAZOP Study Process



- 1 Build a HAZOP team
- 2 Identify processes, P&ID, and HAZOP nodes
- 3 Define the parameters, determine deviations, and select guide words
- 4 Identify controls and establish safety monitoring
- 5 Communicate HAZOP results and improve processes

Source: SafetyCulture



Severity escalation (S) ↑	[1]	4	3	2	1	AC	4: "Critical Risk"	
	[2]	3	2	1	AC	AC	3: "High Risk"	
	[3]	2	1	AC	AC	NSR	2: "Medium Risk"	
	[4]	1	AC	AC	NSR	NSR	1: "Low Risk"	
	[5]	AC	AC	NSR	NSR	NSR	AC: "Acceptable"	
		[1]	[2]	[3]	[4]	[5]	NSR: "No special risk"	
		← Likelihood escalation (L)						

The integration of HAZOP study with risk-matrix and the analytical-hierarchy process for identifying critical control-points and prioritizing risks in industry

Source: ScienceDirect

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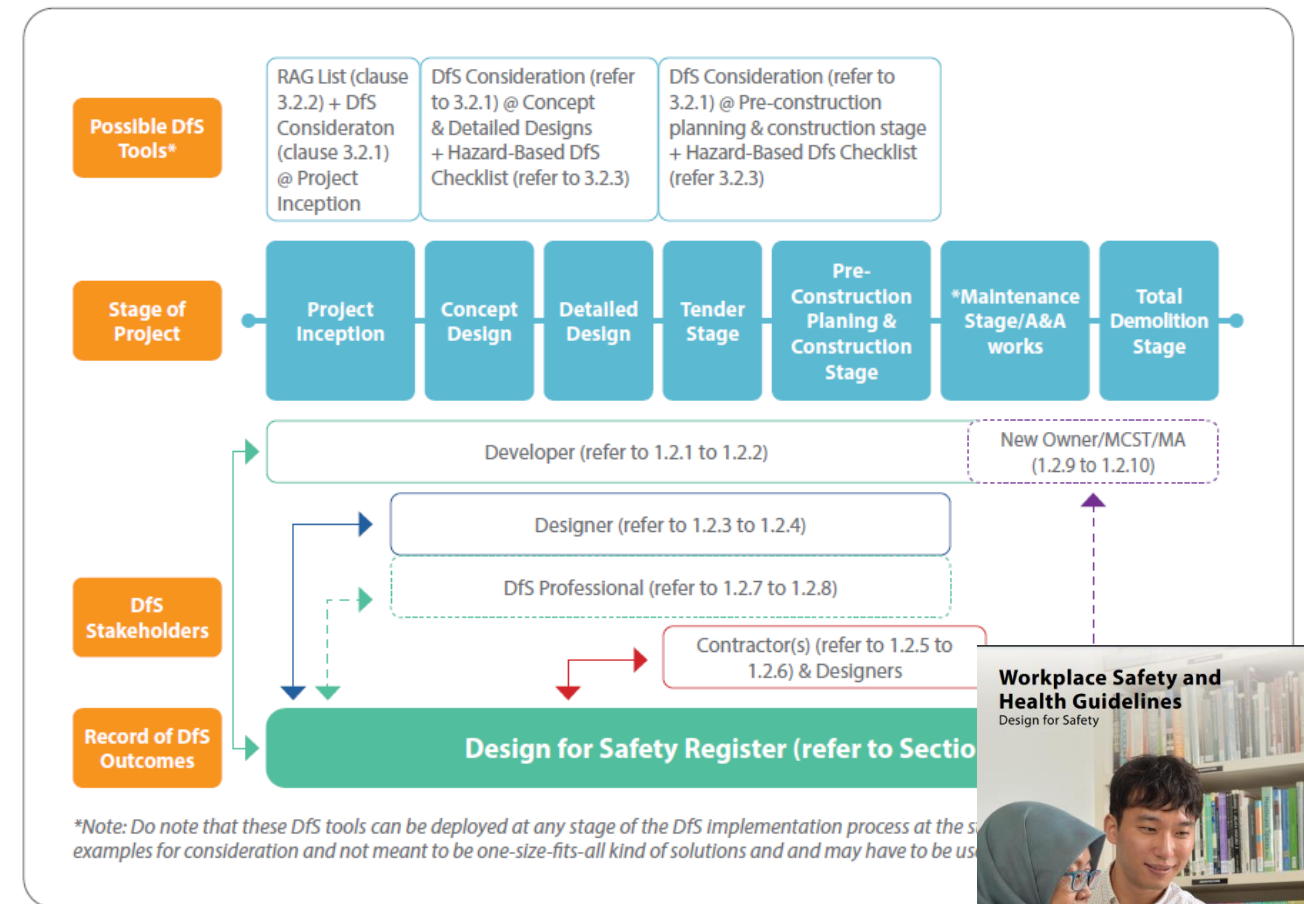


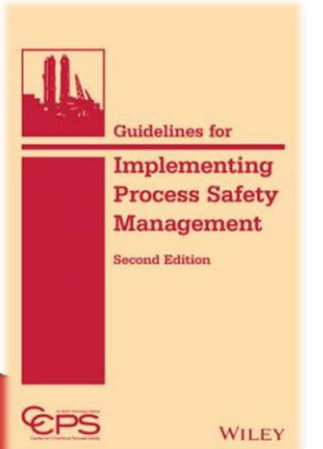
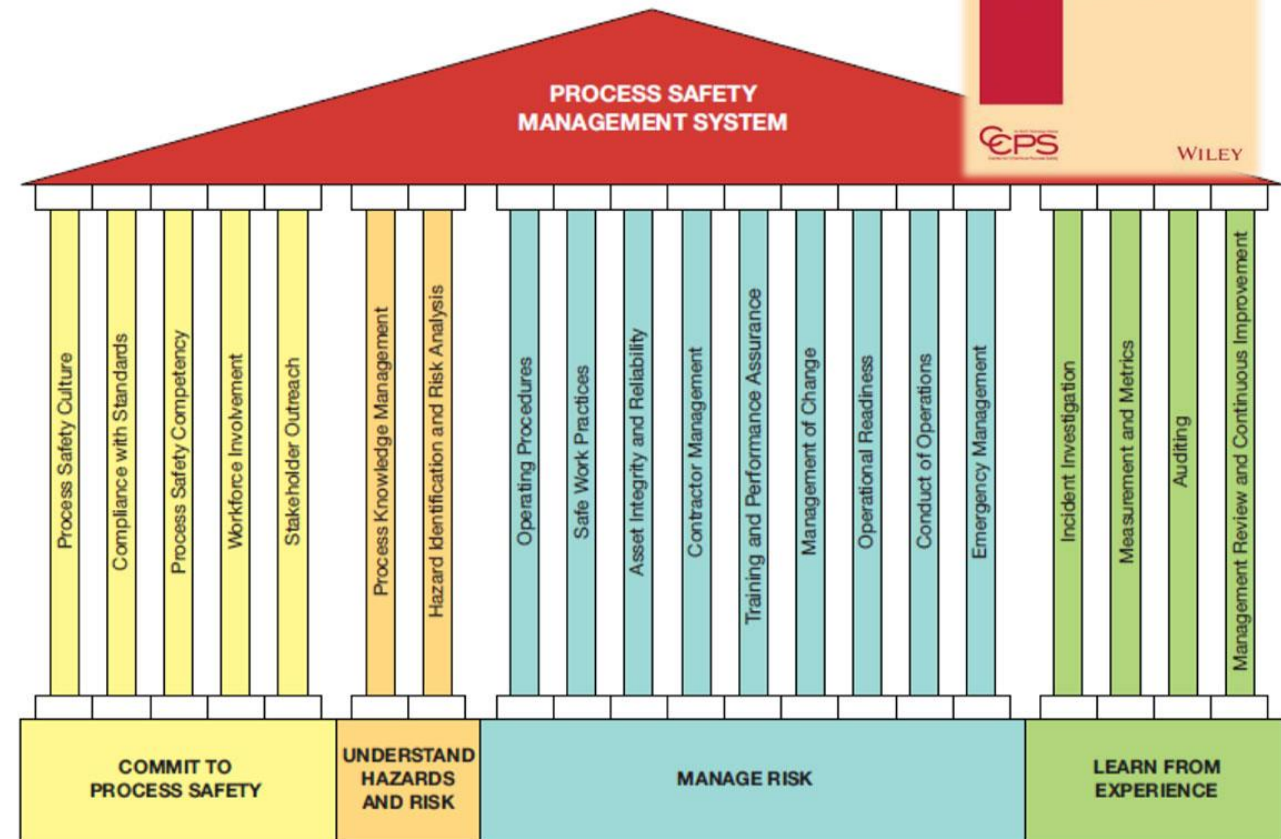
Figure 2: Sample DfS process for a typical construction project (New Build).

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Process Safety Design Considerations

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- ❖ **Process safety management**

CCPS Risk-Based Process Safety Management System



4. Design for Safety Professionals



Design for Safety (DfS) Professionals:

- ✓ Convene DfS Review Meetings
- ✓ Keep an updated copy of DfS Register
- ✓ Provide all relevant information on each foreseeable risk identified and its mitigation

Safe Design of Process Facilities

- ✓ Basic engineering – process design
- ✓ HAZOP Study based on Process & Instrument Diagram
- ✓ Convene identified risk mitigation measure meetings to improve inherent design including process equipment
- ✓ Detailed engineering including 3-D model for facility operability
- ✓ Post construction site checks
- ✓ Pre-start-up safety review before commissioning of facility

4. Design for Safety Professionals

Safe use of machineries and combustible dust:

- ✓ Additional standards for manufacturers, suppliers and users of industrial machineries and combustible dust
- ➔ From **December 2024**, MOM will require companies to comply with additional standards based on the recommendations of the Tuas Explosion Inquiry Committee

<https://www.mom.gov.sg/workplace-safety-and-health/safe-measures/sectoral-level/safe-use-of-machineries-and-combustible-dust>

Legal duties on manufacturers and suppliers of industrial machines

- ✓ This will be expanded to cover more types of industrial machines, equipment and hazardous substances to ensure that they are safe when used

Label and notify usage of all combustible dusts for prescribed amounts:

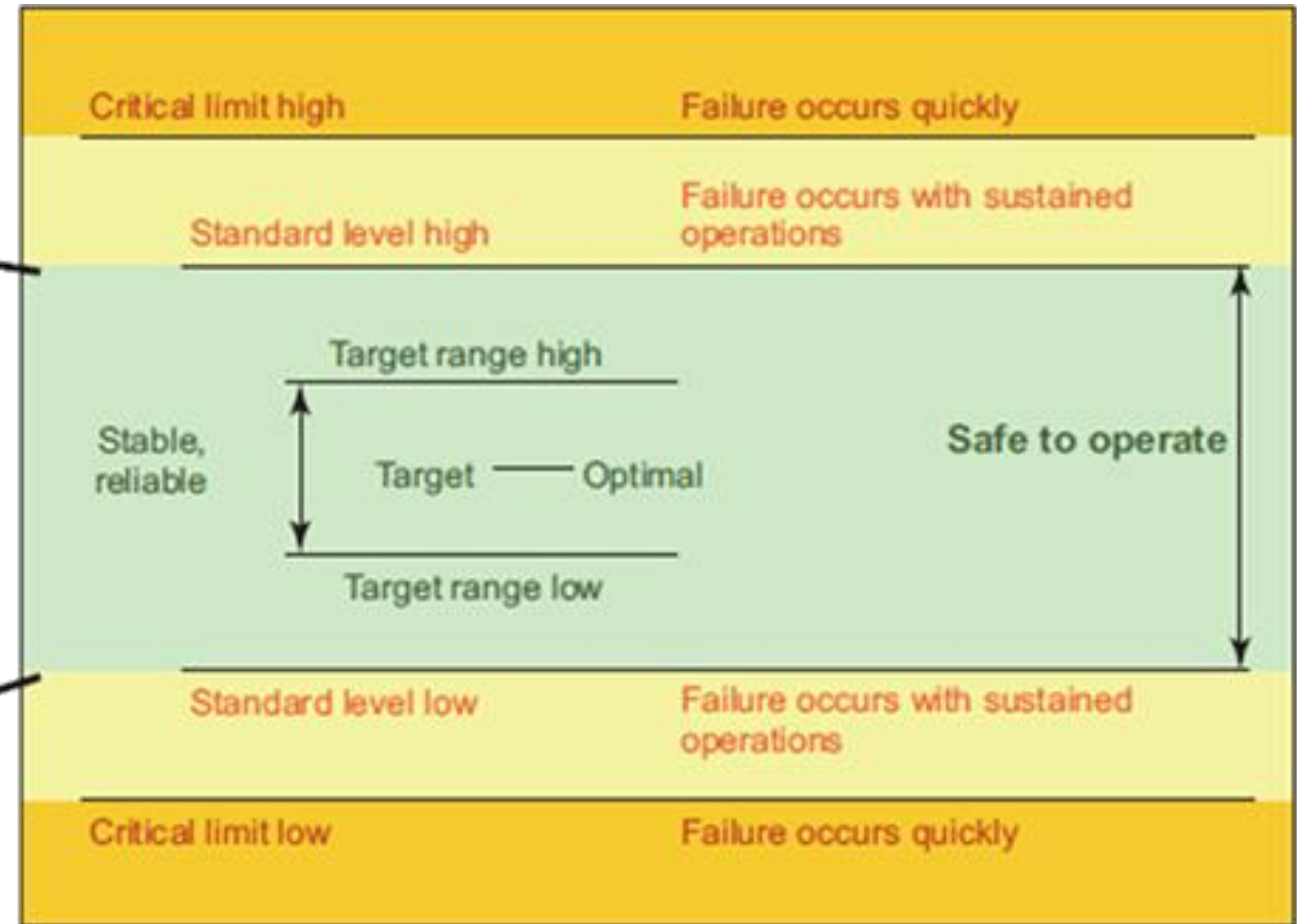
- ✓ Labelling requirements will be expanded to organic combustible dust
- ✓ Users of combustible dusts must notify MOM and their building owners or landlords

4. Design for Safety Professionals

Design for Safety (DfS)

Integrity Operating Windows (IOWs)

Process Safety Management System (PSM)



<https://becht.com/becht-blog/entry/integration-of-integrity-operating-windows-into-process-safety-management/>

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