Process Safety Index

An objective, consistent method for evaluating the balance between Threats and Protection

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Introduction

◇ **BSc(Hons) Chemical & Process Engineering**

◇ Over 30 years' experience of Major Accident Hazard facilities

◇ **Design, Operating & Consulting roles in highly regulated industries including Oil & Gas, Pharmaceuticals, Energy & Chemicals**

◇ Accredited Functional Safety specialist and contributed to the development of international Alarm Management standards (ANSI-ISA 18.02, EEMUA 191 & EEMUA 201)

◇ **IChemE Professional Process Safety Engineer**

◇ IChemE Fellow

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If you can't measure it, you can't manage it…

◇ Process Safety Performance Indicators (**PSPI**) are an effective tool for monitoring and analysing the success of risk control measures both in terms of **Leading** (to provide advance warning of potential events) and **Lagging** (to record and evaluate these events when they occur).

◇ High reliability organisations (**HRO**) utilise these indicators to **improve performance** and **increase engagement**, however with so many indicators to choose from, it is likely that different sites, companies, countries and industries will have **different sets of indicators** and it is therefore more challenging to identify and analyse wider trends in similar applications to maximise shared knowledge.

◇ A good set of performance indicators may indicate that operations are 'safe' but **are they safe enough**?

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Proposition

◇ A standard approach (called the **Process Safety Index**) which is based on established industry principles to **objectively** and **consistently** evaluate the fine balance between Threats and Protection in order to assist duty holders to determine if they have **sufficient** (or indeed excessive) **protection** in a way that can be **anonymously compared** across businesses without revealing sensitive process information.

◇ In simple terms, the Process Safety Index is an arithmetic evaluation of the overall **Protection** against the **Threat**(s) being addressed.
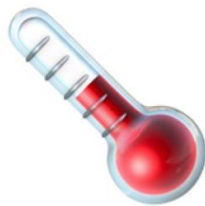
PROPERTIES   PROCESS   PREVENTION   PERFORMANCE
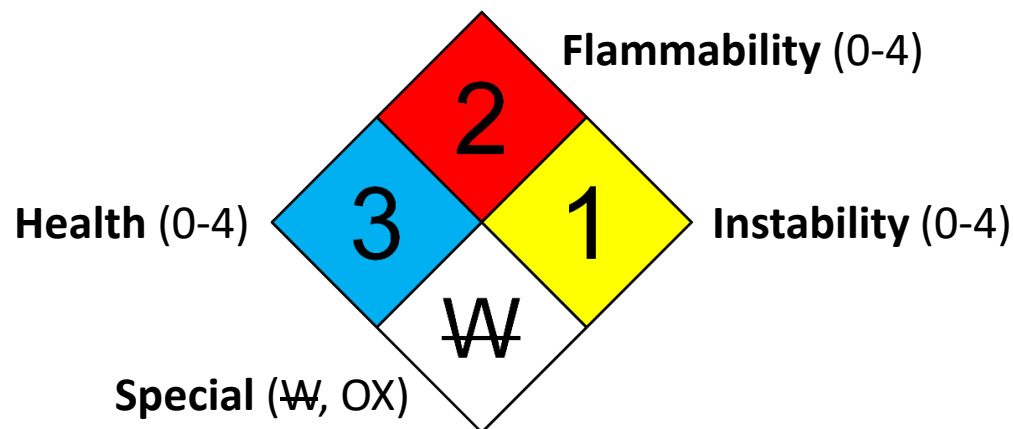
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Threats (Properties + Process)

◇ **Chemicals** & Conditions

- Physical properties and how they are processed/handled

◇ Inspired by **Dow Fire & Explosion Index**

- Material Factors, General & Special Process Hazards

◇ Aligned with **NFPA 704** ("Fire Diamond")   or GHS Classification

Flammability (0-4)

Health (0-4)   **Instability** (0-4)

2

3   1

W̶

Special (W̶, OX)

◇ Process contribution based on:

- **Pressure**   (includes vacuum)
- **Temperature**   (includes cryogenic)
- **Inventory**   (includes regulatory thresholds)
- **Exposure**   (to personnel, to public, to vehicles, to elements & from others)

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Protection (Prevention + Performance)

◇ Leading Indicators (**OSHA PSM**)

1. Process Safety Information
2. Process Hazard Analysis
3. Operating Procedures
4. Training & Employee Participation
5. Mechanical Integrity
6. Management of Change
7. Emergency Planning & Response
8. Compliance Audits

◇ Lagging Indicators (**API 754**)

1. Tier 1   LOPC events of Greater Consequence
2. Tier 2   LOPC events of Lesser Consequence
3. Tier 3   Challenges to Safety Systems
4. Post Event Investigations

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Calculation

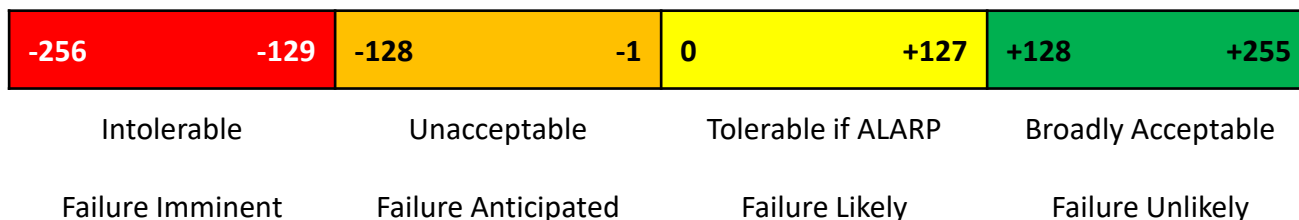◇ Threats = Σ (Properties) × Σ (Process)
- **Properties** (Health, Flammability, Instability & Special)
  - ◇ 0 to 4 Health, Flammability, Instability & 1 to 4 for Special
- **Process** (Pressure, Temperature, Inventory & Exposure)
  - ◇ 1 to 4 each
- Min = 1 & Max = 256

◇ Protection = Σ (Prevention) × Σ (Performance)
- **Prevention** (8 Leading PSPI)
  - ◇ 0 to 4 each
- **Performance** (4 Lagging PSPI)
  - ◇ 0 to 2 each
- Min = 0 & Max = 256

◇ Process Safety Index = **Protection** – **Threats**
- Min = -256 & Max = +255

-256 -129	-128 -1	0 +127	+128 +255
Intolerable	Unacceptable	Tolerable if ALARP	Broadly Acceptable
Failure Imminent	Failure Anticipated	Failure Likely	Failure Unlikely

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Example

Process Safety Index

Threat = 117 Protection = 38 Index = -79

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Calibration

◇ Threats

- Water (as steam) and other **materials can be hazardous at extreme conditions** therefore minimum property value of 1 not 0
- Process values start from 1 (not 0) to ensure that "normal" conditions do not cancel out high property values.

◇ Protection

- High (good) prevention (leading) values with low (bad) performance (lagging) values may indicate that wrong leading indicators are monitored/managed (since events are still occurring)
- Low (bad) prevention values with high (good) performance values may indicate that you've just been lucky (events waiting to happen).
- **Poor leading cannot be compensated by good lagging and vice versa**, hence minimum value for both is (pessimistically) set at 0.

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Applications

◇ Index applied to particular Unit Operation or Major Equipment which can then **aggregate** up the hierarchy.

Enterprise
  ⭦ Region
      ⭦ Site
          ⭦ Area
              ⭦ Unit

◇ Colour coded Block Flow Diagram (similar to OSHA PSM Appendix B)

◇ Management **dashboard** with clear, consistent thresholds for alarm & action

◇ Make visualisation as "**live**" as practical with interface to Process & Maintenance Management Systems

◇ Compare performance within enterprise and across industry – hosted by "**neutral**" body.

◇ Predict future performance (protection **degradation**) – similar to stock prices.
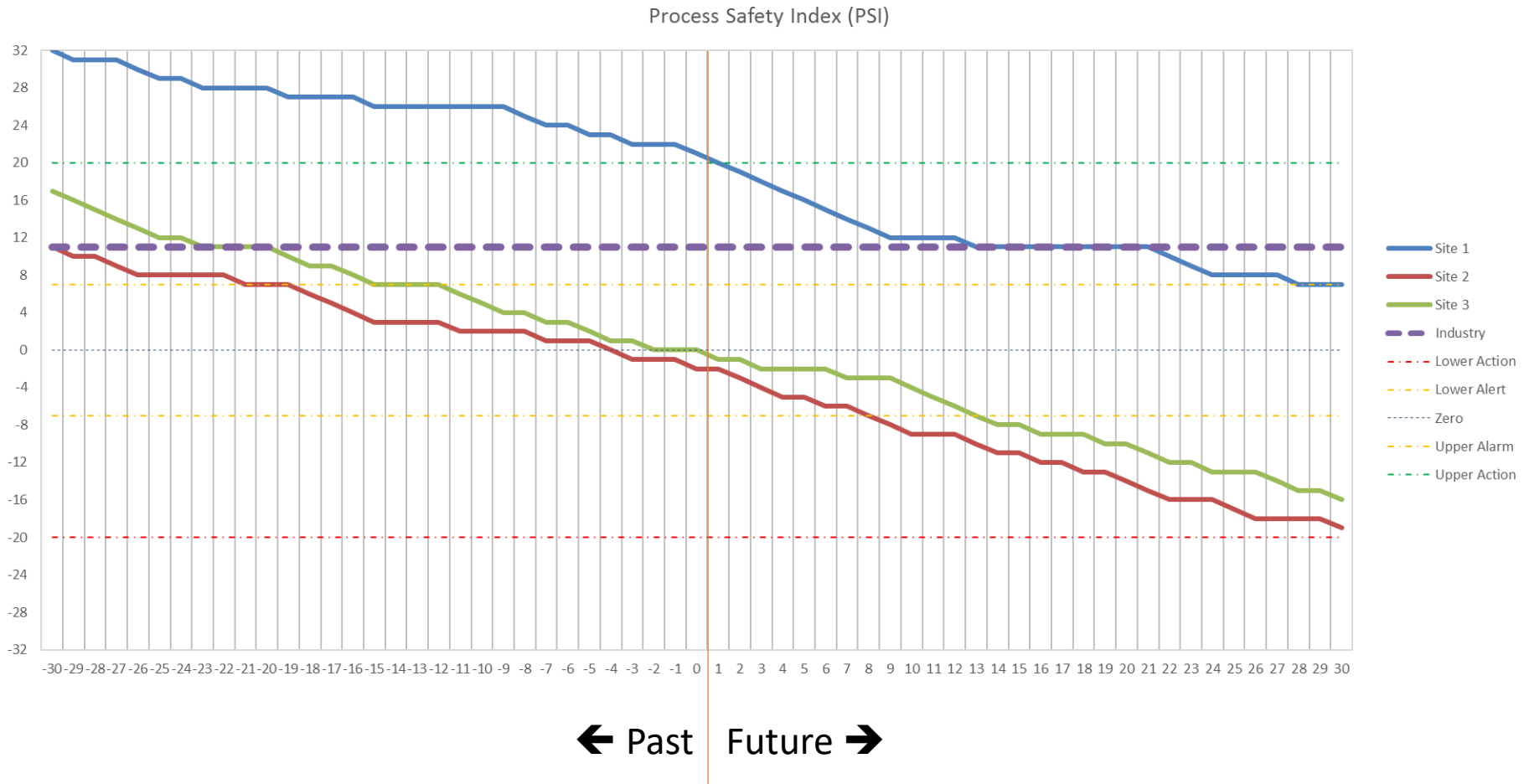
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Visualisation (example)
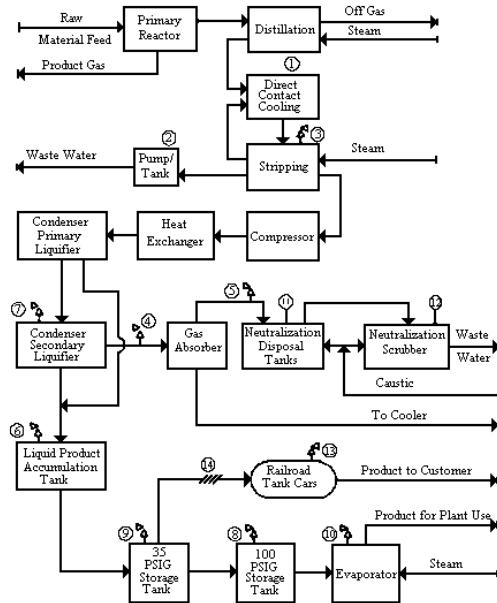
Block Flow Diagram – example from OSHA PSM
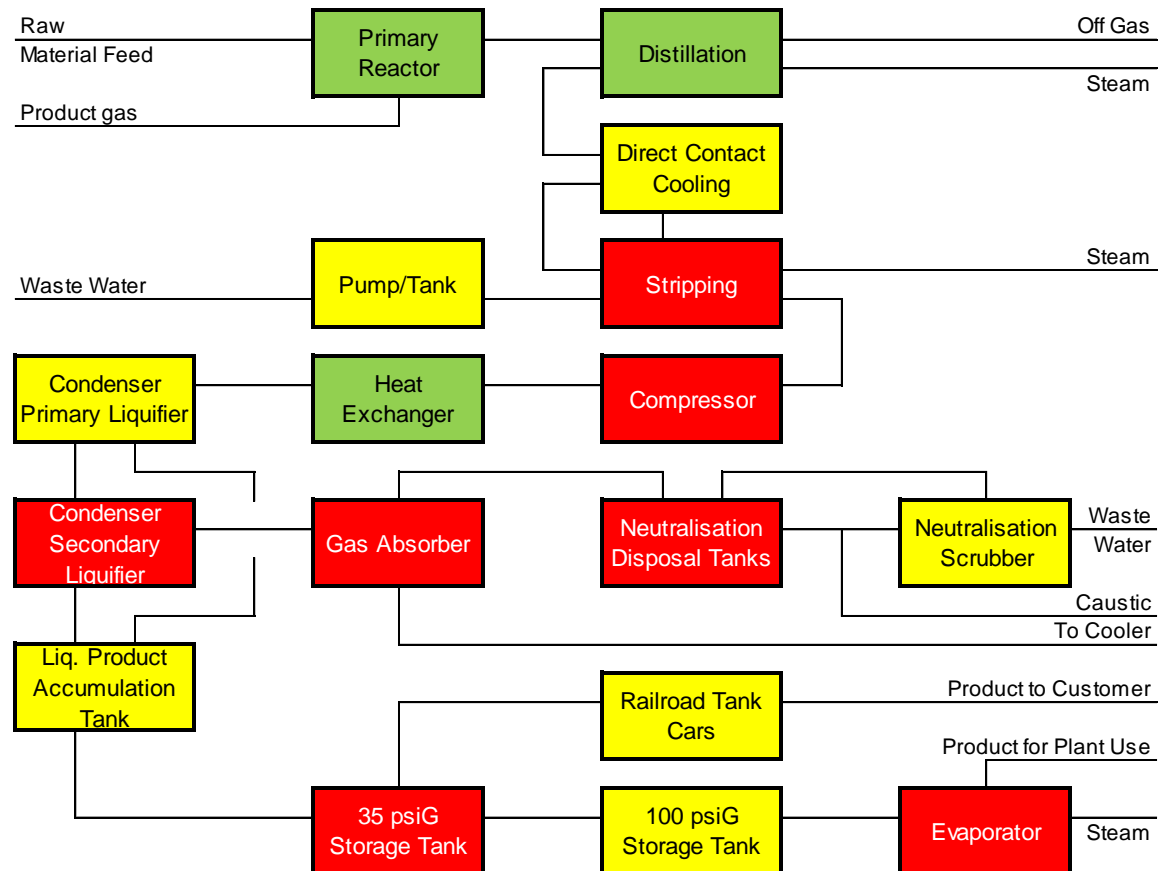
High level (drone view) of the interconnections between major process units/unit operations

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Visualisation (example)

Process Safety Index (PSI)

← Past | Future →

Conclusions

◇ Process Safety Index is similar to Risk where Threat ≈ Consequences & Protection ≈ Likelihood.

  - **Objective rather than Subjective**
  - **Used for conventional Risk Assessments e.g. PHA/HAZOP**

◇ Consistent scoring of process safety threats & protection allows clearer comparison within and between businesses.

  - **Focus on weaker protection measures**

◇ Future performance predictable (within reason) based on anticipated degradation

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Questions

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