



psm the goal is zero harm



Process safety indicators of performance

Francois Holtzhausen



Loss of Containment of Hazardous Substances



While the bear is in the cage, we are safe!



The bear **is out of the cage** when there is a:

- **F**ire
- **E**xplosion
- **R**elease of hazardous chemical (LOPC)

= Process safety incident

= **FER**

Everything we do in process safety is about preventing these incidents



Process safety incident (FER) definition

*An incident that resulted,
or could reasonably have resulted, (near miss)*

- *in a fire, explosion*
- *or an **episodic, unintended** release of a **hazardous chemical** from **primary containment**,*
- *or an **episodic, unintended** release of **pressure energy***

*and where a **chemical process** was involved.*

Notes:

- *This is the Sasol definition but is close to the CCPS definition*
- *The term: “Process safety incident” is used by CCPS to refer to significant incidents only.*



About process safety performance....

A manager wants to impress visitors....

About the site:

- Working with large volumes of flammable solvents
- Daily loading and unloading

About process safety performance:

- No fire in 15 years
- Recordable incident rate is way below average
- Never had a fatality

*Is process safety in
good shape?*



A week later....





Observation

- So although no incident in 15 years is good to hear, one cannot draw any proper conclusions from this statement
- Statistically, there are too few data points

Lesson?

- Counting significant incidents or fatalities is not a good metric of process safety performance!



Lets look at some incident investigation reports for major process safety incidents:



BP Texas City Explosion.

- 15 Fatalities, 170 injured.
- Over US\$ 1 billion in repairs and losses
- Over US\$ 1.6 billion set aside in compensation claims.
- Catastrophic loss of company reputation leading in-part to the replacement of the CEO.
- Fined record US\$ 87 million in Oct 2009 by OSHA.

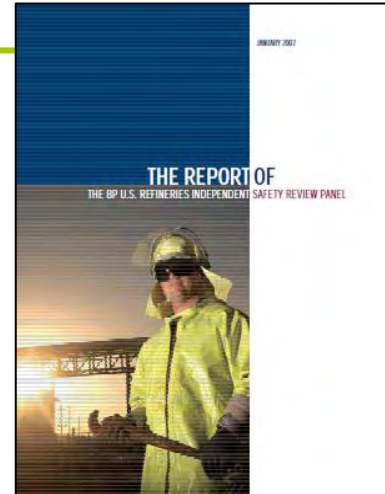




Texas City the aftermath

The Baker Panel Report

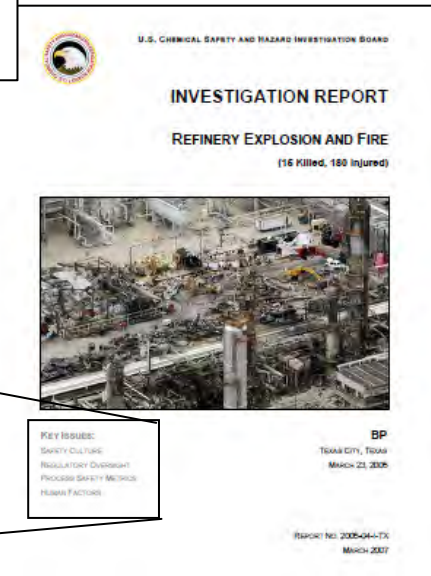
“BP used injury rates to **monitor process safety performance** Gave misleading information and was not effectively monitoring process safety performance.”



U.S. Chemical Safety and Hazard Investigation Board

Lack of **appropriate safety metrics** identified as a key issue.

KEY ISSUES:
SAFETY CULTURE
REGULATORY OVERSIGHT
PROCESS SAFETY METRICS
HUMAN FACTORS





Texas City the latest but not the first!

Longford Gas Plant (1999)

In 1999 gas explosion and subsequent fire at Esso Plant in Australia resulted in large damage plus extensive disruption to gas supplies.

Andrew Hopkins – Lessons for Longford

“Measuring Safety in terms of lost time injuries is inherently problematic.”

BP Grangemouth (2000)

Power distribution failure, MP Steam Failure, FCC Unit Fire – Series of 3 incidents in 2000

Report by UK HSE (2003)

“Companies need to develop KPIs for major hazards **to ensure process safety performance is monitored.**”



How then should process safety performance be measured?



What does the rest of the world do?

- CCPS and EPSC stimulated many debates on this issue during 2008/9
- At last we are seeing some agreement on the definition of significant incidents
- The concept of severity of an incident is an exciting new development



Centre for Chemical Process Safety (CCPS)

- **CCPS** 2006 working group:
 - Proposed standardised industry metrics for reporting company process safety performance
 - To demonstrate overall industry trend in performance
- Supported by the **EPSC** (European Process Safety Centre)

“You don’t improve what you don’t measure!”





CCPS Process Safety Metric Pyramid

Sasol builds

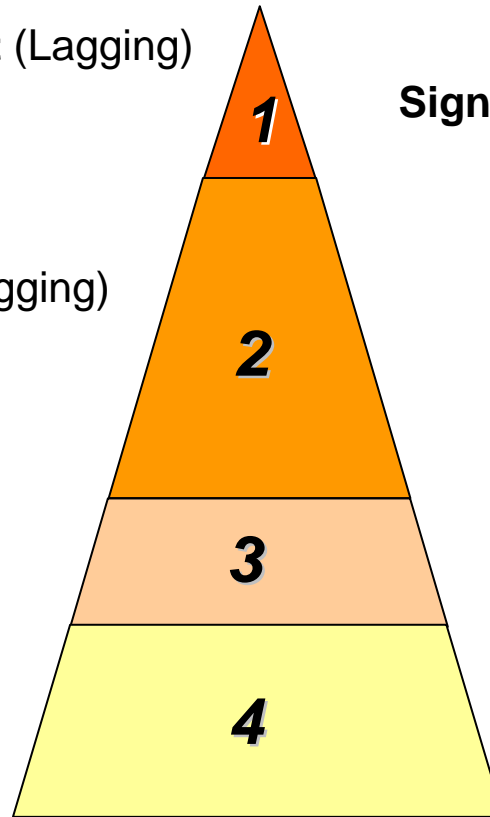
Significant

“Process safety incident” count (Lagging)
Meets threshold of severity
Option of severity score

Other actual incidents count (Lagging)
Doesn't meet severity threshold
“Near miss”??? LOPC

Near miss incidents (Lagging)
A challenge to a safety system
Could have led to an incident

Leading metrics
Effectiveness of preventative systems



“FER”
Severity score applied to all



More general “Near miss” definitions

1. Near Miss Incident (General)

An unplanned sequence of events that could have caused harm or loss if conditions were different or were allowed to progress, but actually did not.

2. Near Miss Incident (Process safety related)

An incident that did not result in an accidental release of a hazardous chemical, fire or explosion, but which could reasonably have, given different circumstances.



CCPS definition of a “Process safety incident” or a “Significant” incident:

If either of the following is true:

- 1. A lost work day case or more serious injury*
- 2. Direct financial loss greater than \$25 000*
- 3. A release of a hazardous chemical greater than the CCPS threshold quantity*



CCPS threshold quantities

					<i>kg</i>
Group	Flammability Packing group	Equivalent NFPA criteria	Flash Point (Closed Cup)	Initial boiling point:	CCPS Threshold
1	Packing Group I	Flammable vapour or gas	-	– ≤ 35°C	500
2	Packing Group II	Flammable liquid	< 23°C	> 35°C	1 000
3	Packing Group III	Combustible liquid	≥ 23°C ≤ 60°C	> 35°C	2 000
<u>Toxic materials:</u>					
	Toxic Inhalation Hazard (TIH) Zone	Inhalation Toxicity			CCPS Threshold
4	Toxic inhalation hazard Zone A	LC50 < or equal to 200 ppm			5
5	Toxic inhalation hazard Zone B	LC50 > 200 ppm and < or equal to 1 000 ppm			25
6	Toxic inhalation hazard Zone C	LC50 >1 000 ppm < than or equal to 3 000 ppm			100
7	Toxic inhalation hazard Zone D	LC50 > 3 000 ppm or < or equal to 5 000 ppm			200

***Packing groups available from MSDS
or CCPS tool and database:***

[Download the Process Safety Incident Evaluation Tool \(v 3.02\)](#)

Or: <http://www.aiche.org/ccps/knowledgebase/measurement.aspx>

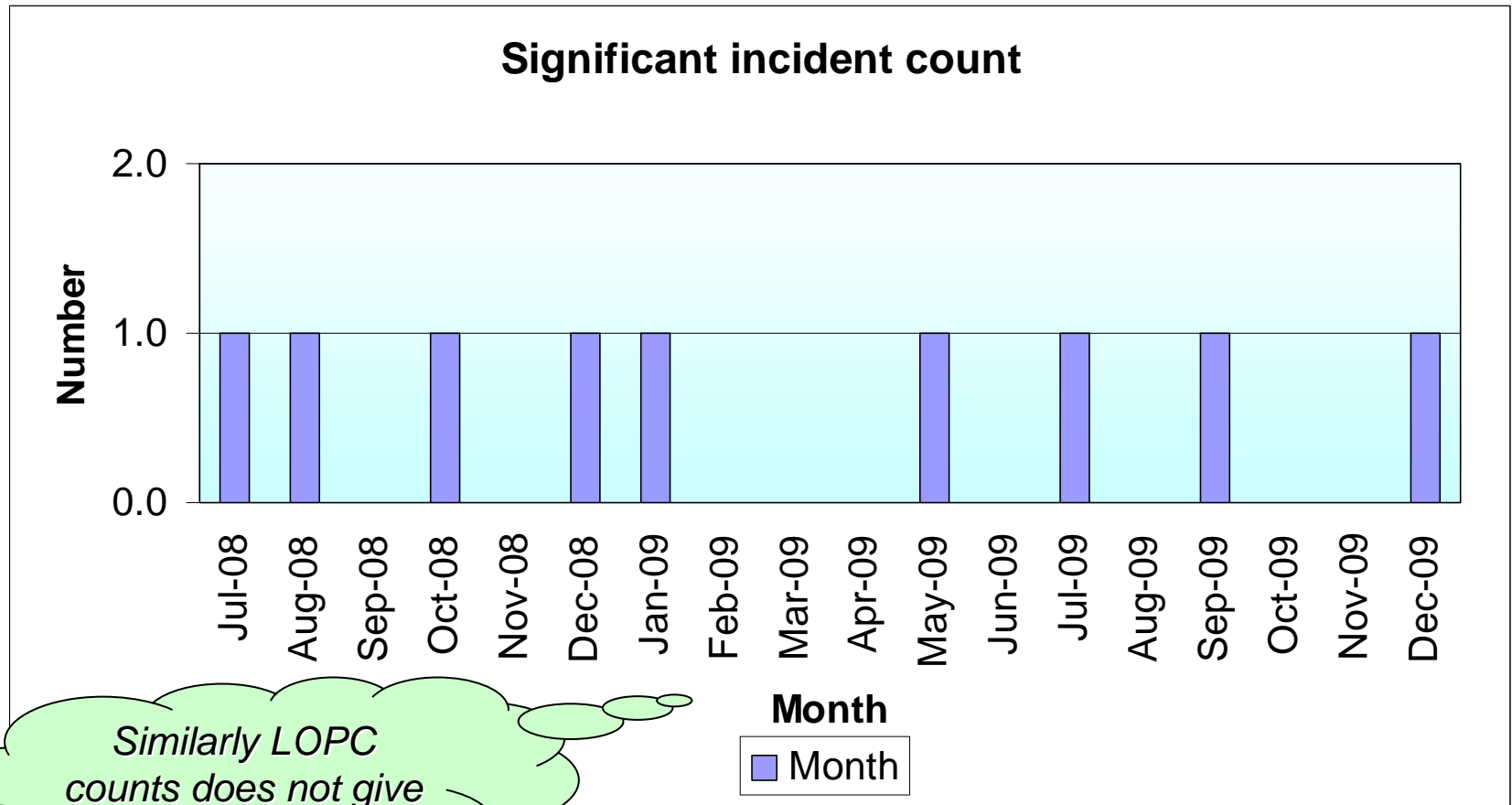


Why the Sasol FER Severity Index???

- Sasol wanted to measure the process safety performance of **smaller units**
 - The CCPS lagging metrics **were not working well** when applied to smaller units
- Needed a **trend** over time for smaller units to see if they are making progress



Is there a trend???



Similarly LOPC counts does not give clear trends

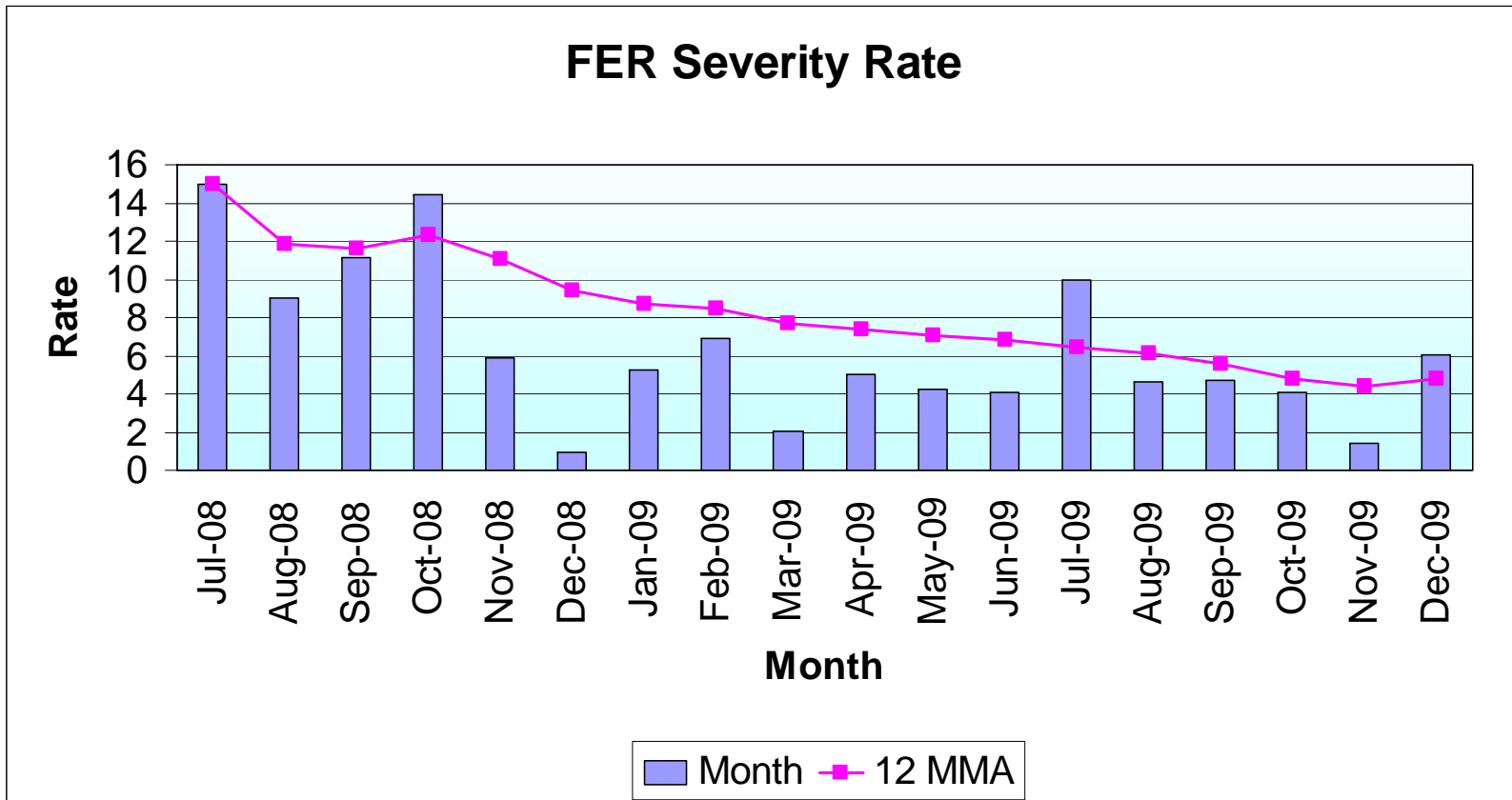


Sasol builds on CCPS metrics:

- Include **all actual incidents** no matter how small in order to get more data. (combining the two top parts of the CCPS metric triangle.)
- Build on the CCPS **concept of incident severity** by calculating a severity score for each incident. There are vast differences in the severity of incidents which is not reflected in an incident count
- Use the CCPS concept of **normalizing using hours worked**
- Sasol developed an **Excel tool** to calculate incident severity, draw graphs and allows root causes to be analysed



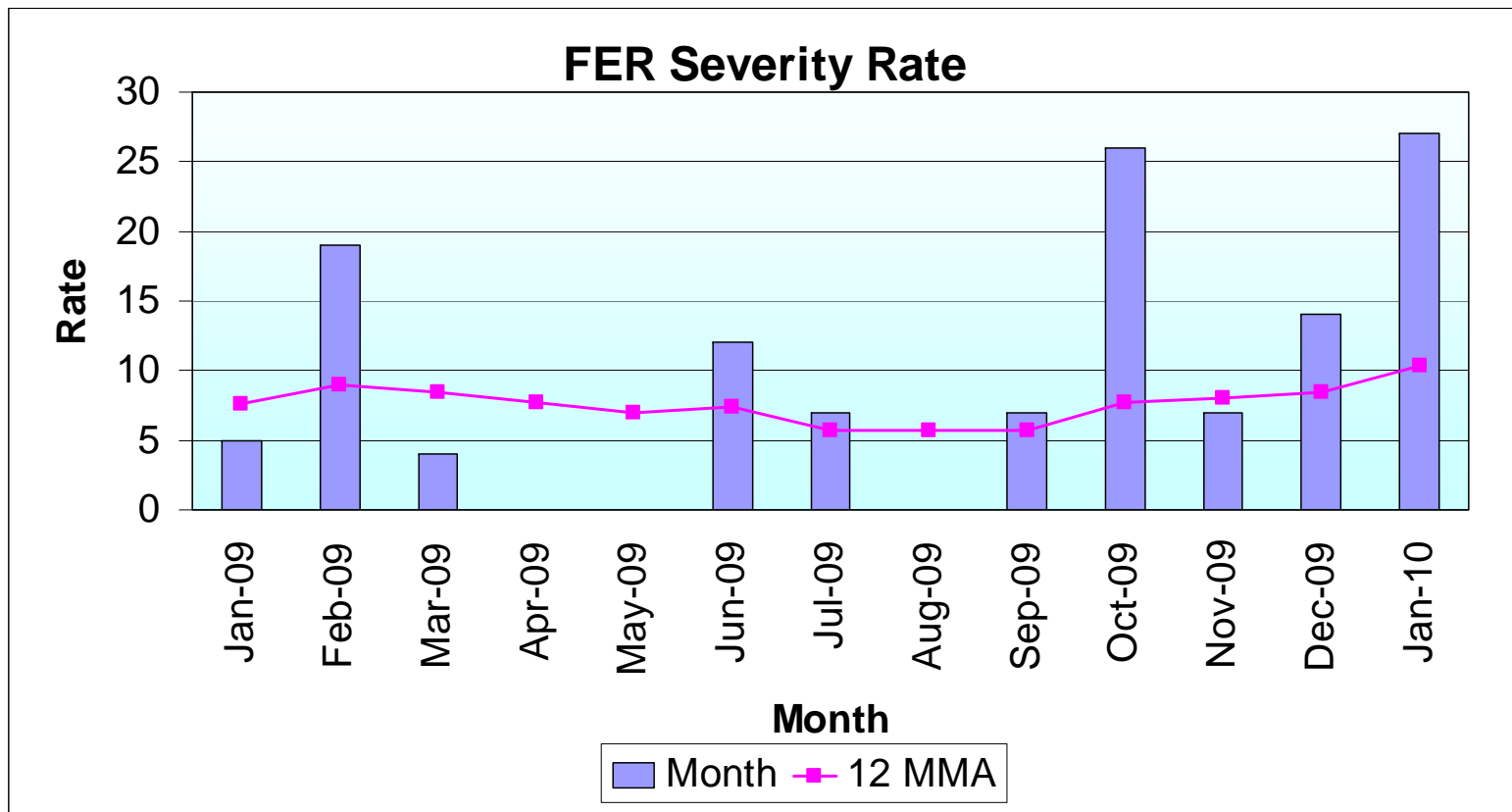
Apply Sasol FER Severity index to previous data:



Whatever they are doing is working!



Another plant: Culture of reporting



Implementation phase: getting the culture for reporting right.



The FER Severity Index will be higher if:

- ***A larger quantity of a more severe chemical is released:***
 - *The actual quantity of the release and hazardous nature of the chemicals involved. (150)*
- ***The actual consequences of the incident are more severe:***
 - *Actual injuries (100)*
 - *Direct financial loss (100)*
 - *Environment, community and company image (100)*
 - *Time taken to stabilise the emergency. (50)*
- ***The potential consequences could have been more severe***
 - *The potential release quantity and hazardous nature of the chemicals involved. (20)*
 - *Number of people that could potentially have been injured. (20)*
- ***Preventative controls in plant design and maintenance failed to prevent the incident.***
 - *Mechanical integrity maintenance strategies failed (50)*
 - *Design preventative controls failed (50)*
- ***Management controls such as procedures and training failed to prevent the incident.***
 - *Management controls failed (50)*
- ***Mitigating equipment in plant design was ineffective to control the fire, explosion or release.***
 - *Design mitigating features failed. (50)*
- ***Maximum score for any incident (sum of all criteria): $740/7.4 = 100$***



Sasol FER tool uses a table for each criteria: e.g. injuries:

Classification	Score
Off-site fatality	100
Multiple on-site fatalities	100
On-site fatality	70
Multiple on-site recordable injuries	70
Serious off-site injury	70
Lost work day case.	40
Medical treatment case. (Including restricted work)	10
First aid case.	5
No injury	0



Automatic incident classification:

Incident classification	FER severity index score (FER-SI)	Incident investigation levels
Major	>45	1
Significant	35 and higher but less than 45	2
Moderate	20 and higher but less than 35	3
Minor	8 and higher but less than 20	4
Insignificant	<8	4

Also Significant if either of the following is true:

- 1. A lost work day case or more serious injury***
- 2. Direct financial loss greater than \$25 000***
- 3. A release of a hazardous chemical greater than the CCPS threshold quantity***



Leading indicators

- These are mostly the metrics you put in place to ensure a management system is working.
- Often it is company specific
 - What is critical to your system and how will you measure it.



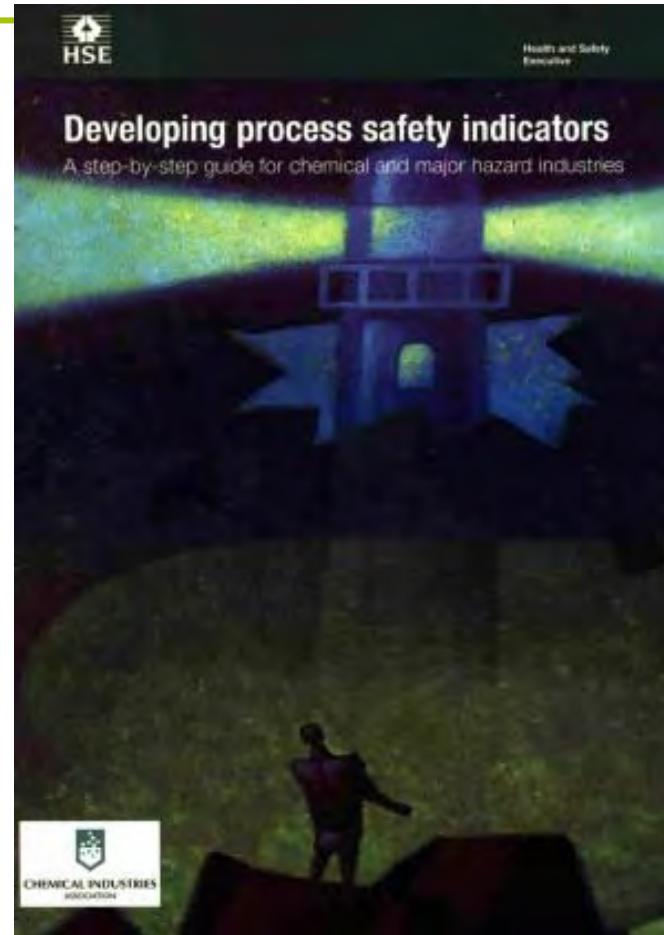
CCPS Suggested Leading Indicators

- **Mechanical Integrity**
 - Inspections done / Inspections due
 - Time safety critical equipment in failed state / Total operating time
- **Action Items Follow-up**
 - No. of overdue action items / Total action items
- **Management of Change**
 - % MOC's satisfying MOC policy
 - % Start-ups with no safety related problems following a change
- **Operator Competency**
 - % operators trained on schedule
- **Challenges to the Safety System**
 - Activations of safety systems and relief valves
 - Deviations outside of operating limits



Approach developed by the UK HSE: HSG 254

- Guidance document: First published in 2006.
- Pre-dates the work done by the CCPS.
- Follows from HSE 2003 report into Grangemouth Refinery incident, UK
- Issued as guidance for companies operating in the UK, in order to demonstrate responsible care.



Link:

<http://www.hse.gov.uk/pubns/books/hsg254.htm>



HSG 254

- Acknowledges that systems deteriorate over time
- Emphasises the concept of dual assurance both active and reactive monitoring
- Follows the “Swiss Cheese” concept. Accidents are the result of failures of barriers. Develop lead and lag indicators for each barrier in safety systems
- Not prescriptive
- Defines a six stage process for a company to develop appropriate metrics

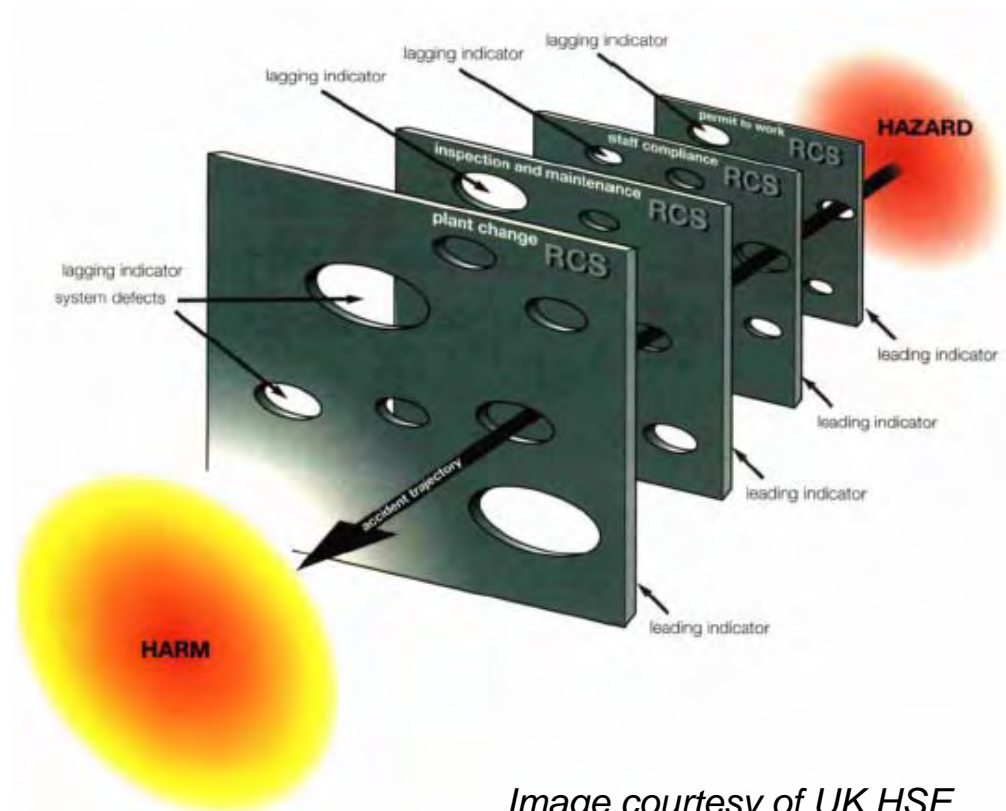


Image courtesy of UK HSE

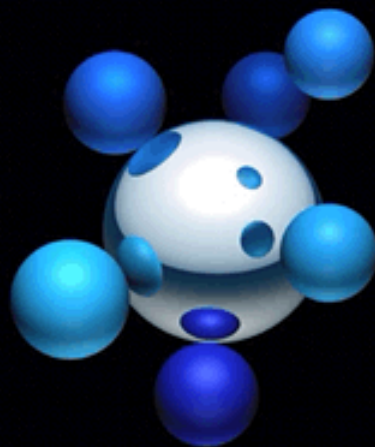


In closing:

Remember:

Primary objective of all these metrics:

- **To measure and assure the process safety performance of your business and its parts.**
- **Your business, your plant!**



SASOL
reaching new frontiers