



**Kuwait International HSE
Conference & Exhibition**

Title: Role of 'Key Indicators in Process Safety' for Oil & Gas Producers.

Kuwait Regency Hotel

Date: 16.02.2017 (Thursday)

Presentation by,

Engr. Mohammed Al-Ghadban, Ministry of Oil

THE CASE FOR PROCESS SAFETY:

INTRODUCTION:

Process safety is a disciplined framework for managing the integrity of operating systems and processes handling hazardous substances. It is achieved by applying good design principles, engineering, and operating and maintenance practices.

It deals with the prevention and control of events that have the potential to release hazardous materials and energy.

Such incidents can result in toxic exposures, fires or explosions, and could ultimately result in serious incidents including fatalities, injuries, property damage, lost production or environmental damage.

OBJECTIVES:

The last 20 years has seen a surge/increase in process safety experts asking for increasing the scope and application of KPIs, especially the importance of the leading KPIs to prevent process safety events in the Oil and Gas Industry. By understanding the KPIs and how they are used to enhance safety in the processes related to the industry, we intend to add to the emphasis being put on this subject by safety guides the world over.

Industries across the world have achieved remarkable improvement in personal safety in the last two decades. On the other hand, organizations with excellent personal safety have suffered major accidents on devastating scales too. This speaks for separating process safety from personal safety.



THE 4 TIER PROCESS SAFETY APPROACH

The International Association of Oil and Gas Producers (OGP) and the European Chemical Industry Council (CEFIC) have adopted the tier-based approach to process safety.

The tier-based approach is based on the safety pyramid.

The pyramid is divided into four tiers of severity:

- Tier 1: major process safety incidents
- Tier 2: less-severe process safety incidents
- Tier 3: challenges to safety systems
- Tier 4: lack of operating discipline (*e.g.*, unsafe behaviors)

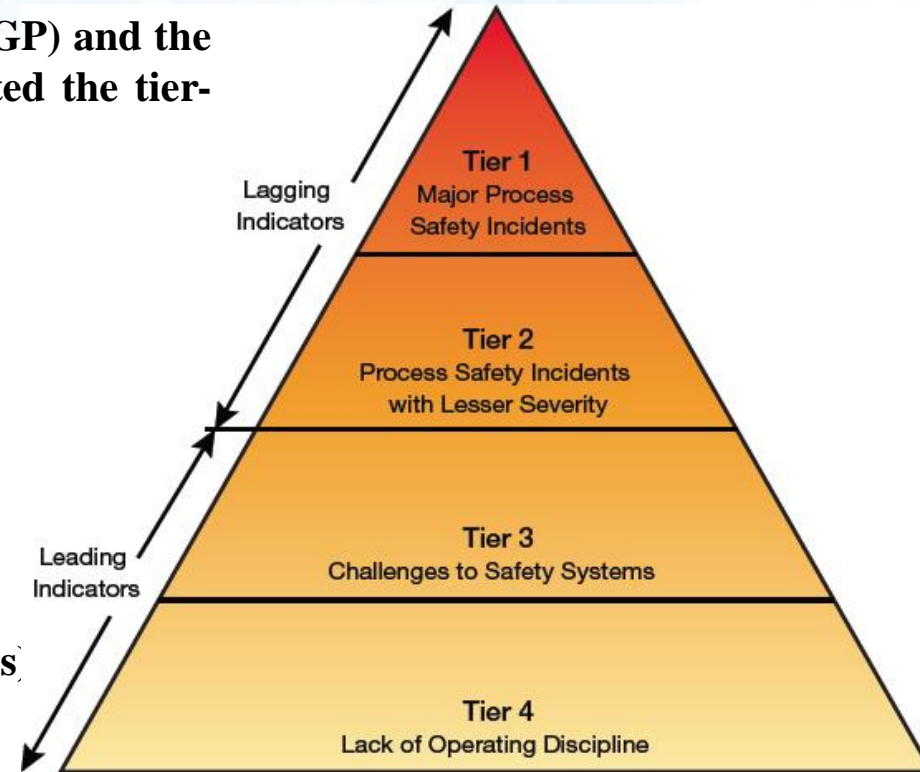


Figure 2. The tier-based approach is based on the safety pyramid.



KEY PROCESS INDICATORS (KPI's)

In the tier model, severity of consequences is maximum at the top of the pyramid and they decrease in severity as we move to the bottom of the pyramid.

- **TIER 1 AND 2 KPIs (KEY PROCESS INDICATORS)**
- Tier 1 and Tier 2 KPIs are considered the LAGGING indicators for process safety.
- These incidents usually occur when multiple layers of protection or prevention in terms of hardware barriers or human barriers have all failed.
- Tier 1 and tier 2 KPIs are very well defined and involve events where there is loss of primary containment (LOPC) that exceeds release thresholds or has involvement of injuries and fires both in upstream or downstream processes.
- Tier 1 and 2 KPIs are used for benchmarking across the industry.
- Satisfactory performance at a bottom line is measured by the lagging tier 1 and 2 KPIs.



THE LEADING INDICATORS

TIER 3 AND 4 KPIS OR THE LEADING INDICATORS:

- **Tier 3 and Tier 4 events** are considered **LEADING** indicators for process safety.
- **Tier 3 and Tier 4 incidents** usually occur more frequently and indicate that a **tier 1 or a tier 2 event** is a possibility about to happen if allowed further without corrective action.
- These events show up as failures or challenges to one or two layers of protection or prevention in terms of hardware or human barriers while other layers continue functioning. when a **tier 3 or a tier 4 incident** happens.
- **Tier 3 and 4 PSIs** are specifically designed to monitor effectiveness of barriers. To be proactive about process safety it makes sense to move down the safety pyramid and use leading indicators to find scope for improvement because a good performance on lead indicators means a good performance on the lagging indicators. Taking care of the smaller lapses or holes or faults will translate into preventing a bigger event.



TIER 1 AND TIER 2 PSEs IN OIL AND GAS

TIER 1 AND TIER 2 PSEs IN OIL AND GAS PRODUCTION:

The Tier 1 and Tier 2 PSEs are limited to drilling and production activities.

It covers all mainstream production operations including:

- Work on production wells under pressure.
- Oil and gas extraction and separation.
- Heavy oil production where it is inseparable from upstream.
- Primary oil processing (water separation, stabilization).
- Primary gas processing (dehydration, liquids separation, sweetening, CO2 removal)
- Floating Storage Units (FSUs) and sub-sea storage units
- Gas processing activities involved with producing gas liquids for sale.
- Secondary liquid separation (i.e., Natural Gas Liquids [NGL] extraction using refrigeration processing) - Liquefied Natural Gas (LNG) and Gas to Liquids (GTL) operations.
- Flow-lines between wells and pipelines between facilities associated with field production operations.
- Oil & gas loading facilities, including land or marine vessels (trucks and ships) when connected to an oil or gas production process
- Pipeline operations (including booster stations) operated by company E&P business.



TIER 3 AND TIER 4 KPI's (H&S) Management System

TIER 3 AND TIER 4 KPI's indicate the health of a safety management system

Measuring and monitoring of tier 3 and tier 4 indicators helps:

- To have early detection of faults and weaknesses or deterioration in safety systems.
- Enables corrective action to be taken to restore effectiveness of the safety system.
- Prevents loss of containment event from occurring.

TIER 3 KPIs examples:

- Measurement of outcome of unplanned and uncontrolled conditions.
- Minor LOPCs below Tier 2 thresholds.
- Containment testing that does not meet acceptable limits.
- Component failures in service.
- Safety relief demands (eg on pressure relief devices)
- Operating limit excursions.
- Safety system demands
- Quality non conformances
- Noncompliance with asset integrity or with standards or audit noncompliance events.
- Corrosion failures.

Tier 3 data represents/identifies impairment or failure of a barrier and so the desirable objective of TIER 3 KPI is 0.



TIER 4 KPIs:

TIER 4 Key Performance Indicator's:

- Help to maintain and improve the integrity, strength or quality of barriers.
- Support management system elements.
- Measures planned activity.
- Performance of operating discipline.
- Safe design and engineering.
- Maintenance inspections and testing.
- Hazard and risk assessments.
- Facility management of change.
- Contractor capability and management.
- Audit improvement actions.
- Safety initiatives.
- Workforce training and development.
- Technical competence assessments.

Tier 4 KPIs support all efforts to understand what is required to reduce **barrier weaknesses or holes**. So, the desirable **objective of Tier 4 KPIs is to achieve 100% COMPLETION**.

Tier 4 KPIs are used by operators, first line supervisors, engineers, and managers at the facility or business level to handle specific hazards with detailed understanding of the plant.

Tier 4 indicators are not used for benchmarking purposes because they are highly facility specific.



Barriers – Process Safety

Barriers may be hard physical barriers/operative barriers or soft human barriers.

As shown in the ‘Swiss Cheese’ diagram hard barriers will block or mitigate the effects of **LOPC** events

HARD BARRIERS typically include:

Preventive controls via design or engineering elements to provide containment systems and automatic control systems.

Escalation controls such as detection, shutdown and blow-down systems

Mitigation controls such as deluge, secondary containment, and automated emergency systems

SOFT BARRIERS typically include:

Management system-related such as procedures and processes

Workforce-related, such as training, competence, behaviour, and culture.

Barriers themselves can be assessed by use of leading and lagging **KPIs**.

Tier 3 KPIs will be more lagging for a barrier and will record the number of failures/near failures of the barrier.

Tier 4 KPIs will be leading indicators and will help to monitor the operations that maintain or strengthen the barrier.

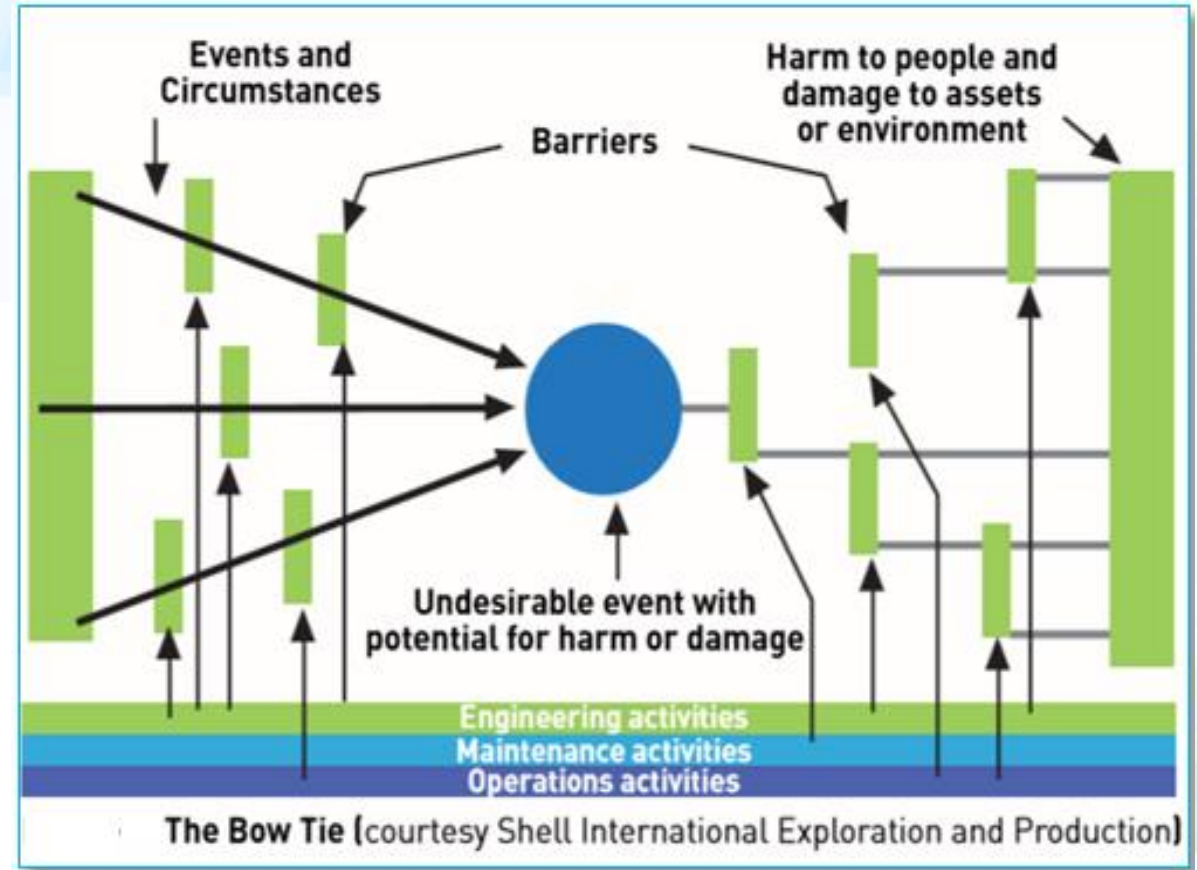


BOW TIE MODEL:

One of the leadership benefits from leading indicators is the clear **LINE OF SIGHT** provided by barrier-based KPIs represented by the bow tie method.

This helps to manage hazards and prevent process safety events, and helps with mitigation measures.

One can select a process, identify the hazards, and project a bow tie model for the hazard and place the barriers that will be preventive in nature on the left and place the mitigative barriers on the right. We can then identify which leading and lagging KPIs to each barrier need to be selected and measured for the process.



Dual Assurance - Leading & Lagging Indicators

To develop performance indicators to control hazards, the concept of “DUAL ASSURANCE” has been provided by HSE (Health and Safety Executive) as explained by the figure below:

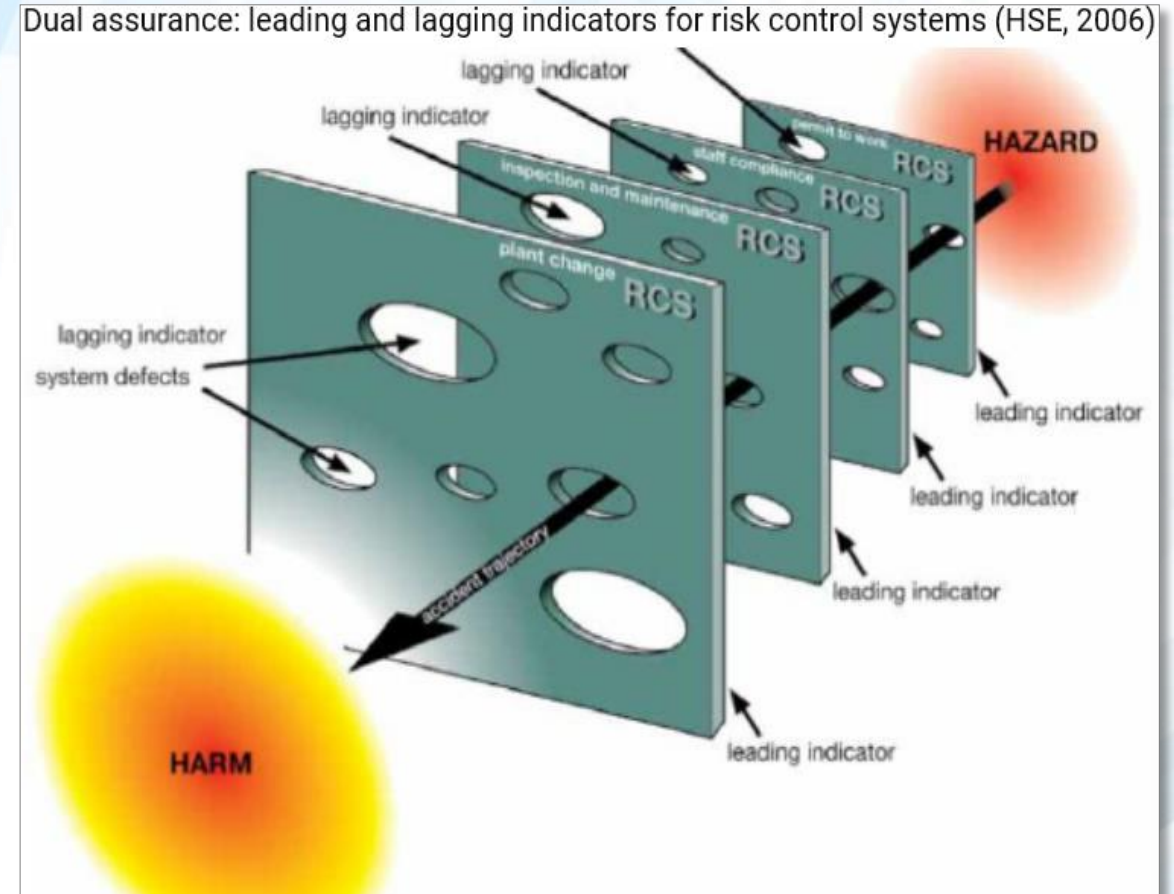
Dual assurance is a composite of both lagging and leading KPIs for every process safety system.

HSE constructed the dual assurance mechanism for risk control system, by adding the two types of indicators to the “Swiss Cheese Model (Reason, 1997).

The barriers here are represented by the cheese slices and they are the leading indicators which will help to prevent an accident (moving along the path of the arrow) from progressing further.

The lagging indicators are represented by the holes in the barriers and they show failure outcomes in terms of process safety.

By relating one leading indicator to one lagging indicator for every important barrier and by assessing their performance we can test whether a given barrier is getting weaker or stronger.



IMPLEMENTATION:

Most companies adopt leading KPIs for:

- Maintenance of mechanical integrity (for eg. a percentage of schedules and data by inspections).
 - Action items follow-up (for eg percentage of action taken by a due date, or by incident investigation, and by audits and inspections).
 - Management of change.
 - Process safety training and competency assessments (by measuring process safety training given and individual competence is then assessed or by correlating lack of training to an incident).
-
- Reviewing the risk profile of any process safety activity helps to select KPIs.
 - Identifying a hazard is the first step of risk assessment to analyze the process safety aspect further.
 - Once the hazard is identified, a bowtie model can be drawn out to identify the barriers or key process safety mitigation measures.
 - KPIs can then be selected for every critical barrier based on real risk by using the dual assurance technique.
 - Analysis of selected KPIs will show emerging trends. KPIs going in an undesirable direction are an indication for positive intervention or resource allocation or reallocation.
 - Comparison of KPIs across different sites in the same enterprise can bring about potential improvement.
 - To develop a system of KPIs resources and processes are needed which involve data collection and reporting and review.
 - Operating staff at the site-specific level should be involved in reporting leading KPIs because they are the ones who work right where the hazards are located.



RECOMMENDATIONS AND CONCLUSIONS:

Selecting and measuring and analyzing KPIs related to process safety in offshore petroleum safety is the proactive thing to do to prevent major incidents. Just focusing on lost time injury frequency rates and similar measures will not help much with major accident prevention.

For offshore drilling, we need to identify specific hazards and risks presented by drilling and associate KPIs to the causes of those hazards. So far, the KPIs for offshore are limited. To highlight such limitations or to highlight the scope for improvement here are a few examples from history:

- Despite of associating indicators to drilling there are other accidents in history which call for a more inclusive scope for KPIs. For Example: The loss of the Kolskaya rig, which was neither related to defined process safety nor was it related to drilling. This rig was operating in the sea of Okhotsk during a fierce winter storm despite of manufacturer's instructions to "not to tow in winter waters". It sank with 53 dead or missing.



- The relevance of KPIs in the Oil and Gas industry itself received a major impetus after the **BP Texas City Refinery disaster of 2005**. Investigation had showed up among other causes that “a focus on occupational safety and not process safety and a defective management of change process” led to the disaster. There has been a call for developing a standard for performance indicators for process safety in the refinery and petrochemical industries involving both leading and lagging indicators and this call is getting more attention since the last 15 to 20 years.
- Making a case for the development of leading KPIs for Oil and Gas Producers, it was stated in a conference 10 years after the Piper Alpha disaster (when the oil producing platform exploded killing 167 people in the North Sea in 1988) that indicators were needed which showed the weak points in safety management systems, that it was necessary to analyze and eliminate the causes of accidents and not just look at symptoms.
- Integration of developing leading and lagging KPIs into the barrier concept provides specific indicators of performance of each barrier or risk control measure.
- The bottom of the safety pyramid are the indicators that are related to the managerial and operational side and they contribute to a safe facility. Developing such KPIs for upstream petroleum safety, especially offshore and in marine environments is considered a work in progress.



- Guidance to development of upstream KPIs needs the understanding and usage of terms related to upstream and marine environments which are challenging very different from those that can be used to describe a facility on land. **For Example:** Loss of primary containment on land means some technicalities on land but will mean very different technicalities in water. The land under water itself, the strata, raises challenges for which sensitive KPIs need to be developed. There is a very vast area of further development considering such issues.



Thank You



2nd Kuwait international HSE Conference & Exhibition (KIHSE 2017) Speakers Engr. Mohammed Al-Ghadban, Ministry of Oil & Nachupally Ram Kumar KPC HSSE Dept.

1/21/2021