DEVELOPMENT OF PROCESS SAFETY LEADING INDICATORS FOR MAJOR HAZARD INSTALLATION USING THE CAUSAL REASONING APPROACH

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Most if not all major hazard organisation has sets of lagging and leading indicators to measure their process safety performance, for continuous improvement. The leading indicators are the set of forward looking metrics that indicate the effectiveness of the hardware barriers, key work processes and layers of protection that prevent process safety incidents.

A review of the process safety performance of our oil and gas handling and processing plants showed that we have been recording very good performance on the leading indicators e.g. 96 – 98% percentage compliance with safety critical preventive maintenance. However, the excellent performance on leading indicators has not translated to the expected performance on lagging indicators e.g. number of Tier 1 and Tier 2 Process Safety Events (PSEs). More worrisome is the fact that some of these incidents are "repeat" in nature. This instigated a review of the leading indicators to ensure that we are measuring the right metrics. The result of this review was very revealing. In some instances, the sites could not relate their day to day activities with most of these previous leading indicators. Even where the sites could relate with a few of these leading indicators, it was obvious that the indicators were driving the "wrong behaviour" on the sites.

A full review of the leading indicators was undertaken, the objective being to develop a fit-for-purpose process safety leading indicators that provides the required ownership, visibility and engender early intervention at the sites level, to improve the sites process safety performance. The methodology adopted was to review from causal reasoning approach (vs. defensive reasoning), the past process safety incidents in our organisation, to find out the root causes of the incidents and develop leading indicators to address the identified root causes. A suite of process safety leading indicators was developed, covering production wells and surface facilities and these have been piloted at selected sites, with very good results.

This paper discusses the causal reasoning methodology adopted for the process safety incidents review and the considerations in developing the process safety leading indicators to improve process safety performance at site levels within our organisation.

Keywords: major hazard installation, process safety performance, process safety leading indicators, causal reasoning

INTRODUCTION

Major incidents and near-misses have continued to underscore the need for improvement in process safety performance across major hazard installations. Most if not all Major Hazard organisations have sets of lagging and leading indicators to measure their process safety performance, for continuous improvement. The lagging indicators are a set of metrics showing failures in the plant while leading indicators are the set of forward looking metrics that indicate the effectiveness of the hardware barriers, key work processes and layers of protection that prevent process safety incidents.

We have a suite of leading and lagging indicators across our major hazard installation. The leading indicators were developed from the review of the major accident hazard bowties by identifying the critical elements of the process safety risk control and recovery preparedness barriers (left and right hand side of the bowties) and developing relevant leading indicators. Examples are:

a) Percentage compliance with safety critical preventive maintenance

b) Operations & Maintenance personnel capability gap assessment

c) Total number of unapproved safety critical deviations in the Computerised Maintenance Management System (CMMS)

d) Number of deviation s in place for overdue corrective and preventive maintenance work orders

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METHODOLOGY

A compilation of all the process safety incidents on our sites for the last 10 years (2006 – 2016) was made, highlighting "what happened", "why it happened" and the recommendations. This "Process Safety Incidents LFI (Learning from Incidents) booklet was compiled and reviewed to identify the root causes of the incidents and contributing factors, to address the identified root causes.

The review was of little value for developing the leading indicators because the "why it happened" narratives were from a "defensive reasoning" approach during the incidents investigation. A further review of the incidents from causal reasoning approach was carried out, to identify the root causes of the incidents. A suite of leading indicators was then developed to address the identified root causes and these indicators were piloted at selected sites, with very good results.

The causal reasoning review was carried out with representatives from Engineering, Assets Operations & Maintenance, Corporate Maintenance and Health Safety & Environment.

Defensive vs Causal Reasoning Approach

Our previous process safety incident investigations were based on defensive reasoning, concentrating on "what failed or was missed" to allow the incident to occur. The focus was on "what did not happen" or "what should have happened" e.g. operating procedure was not followed; inadequate risk assessment, lack of training, relief valve certification process was ineffective, etc. It is hindsight based!

Causal reasoning approach focuses on "what has to be true to cause the problem" (what is actually causing the problem. Statements describe what happened and not what didn't happen or what has to be present or true and not what had to be missing or what had to fail. Typical causal factors are working under pressure (fatigue), assumptions on operating envelope of plant. It focuses on reality from the perspective of the individual and shifts focus beyond the individuals involved to the system!

CAUSAL REASONING TO PROCESS SAFETY LEADING INDICATORS

A review of the process safety incidents was undertaken from causal reasoning perspective. For example, on one of the process safety incidents, it was revealed from causal reasoning that the Operators & Maintenance personnel in the field were using Process Engineering Flow Schemes (PEFSs) which have not been updated following engineering upgrades / modification on the plant.

From the review of the process safety incidents, the causal issues were thematically grouped under the following themes, covering surface facilities, pipelines, flowlines and wells

a) Design Integrity

b) Maintenance & Execution Integrity

c) Operating Integrity

d) Process Safety Fundamentals

For each of the causal issues, a leading indicator was identified. On the whole, a total of 20 leading indicators were identified.

Examples of the leading indicators identified are:

- No of red-lined drawings remaining in the field more than 3 months
- Number of items identified during line walk, not in the Asset Register
- Number of dynamic risk assessments carried out in tasks execution
- Number of notifications raised for anomaly in production facility maintenance job routines (MJR)
- No of piping below minimum allowable wall thickness
- Number of day cathodic protection system for a pipeline or flowline is out of service

- Number of missed routine / intelligent pigging of pipelines
- No of wells not Annular Pressure Monitoring-capable

For each of these leading indicators, a Definition Sheet was prepared showing what should be measured and how it will be measured (see Table 1 below).

A pilot of these leading indicators was done across seven production facilities with very good result. It provided a good basis and trend for prompt intervention by Asset Leadership on process safety management across the sites, resulting in over 40% reduction in Tier 1 & 2 PSEs in 2017. The plan is to review these indicators half-yearly and see where alterations and in some cases deletion of the indicators may be required when it is seen that they are no longer providing any useful information or trends.

CONCLUSIONS

A review of previous process safety incidents from causal reasoning perspective provided the lever to develop the fit for purpose suite of leading indicators. It is worthy of note that this initiative delivered a suite of process safety leading indicators which the sites and Operations & Maintenance personnel in the field can fully relate with in their day to day work activities on the sites.

The suite of leading indicators was piloted across seven different sites, with very good results. Following the deployment of these leading indicators, it was seen that the number of Tier 1 & 2 PSEs was reduced by over 40% in 2017.

Indicator Name	**Number of red-lined drawings remaining in the field more than 3 months**
Indicator Details	
Indicator Tier	4
Theme	Operating Integrity
Barrier Type	Critical Process
Description:	
Red-lined drawing shows the modifications done to the design drawings during construction on site. It is usually done by the contractor, and required to be submitted to the Project Engineer for review and preparation of as-built drawings. Such drawings that have not been finalized as "as-built" three (3) months after completion and commissioning of the modification project should be reported for this parameter.	
What is the purpose of this indicator?	
Updated as-built drawings provide better reliability to the operators of the plant for making informed decisions.	
What is the consequence of not having good performance for this indicator?	
Lack of current plant as-built drawing can trigger error enforcing conditions e.g. isolation errors, intervention errors and wrong operator's response to incidents.	
What are the parameters required to measure this indicator?	
Parameter Name	Unit of Measurement
No of red-lined drawings remaining in the field more than 3 months	Number
Calculation	
Indicator Formula: Count of the number of red line drawings yet to be converted to as-built drawings more than 3 months after completion of construction and commissioning Units of Measure: Number Reporting Format: Number of red-lined drawings remaining in the field more than 3 months	
Reporting Details:	
Reporting Frequency: Monthly Time basis for collection: Monthly (snapshot at midnight on the last day of the calendar month)	

Table 1: Example Definition Sheet