ADDING INTELLIGENCE TO HEALTH & SAFETY

Rolling out leading safety indicator based risk management in Energy, Engineering & Construction, Mining and Manufacturing industries.

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Abstract

Process and asset safety are important business processes in industries such as mining, Oil & Gas, and other natural resources. Traditionally Health, Safety and Environment (HSE) operations within these industries rely upon review of processes, tool talks, training, and other process-led mechanisms to manage safety. There is an array of technologies ranging from sensors, SCADA systems, Plant Monitoring Systems, but it is only in the last couple of years that companies have started to invest in systems that can generate insight on safety performance and process safety readiness.

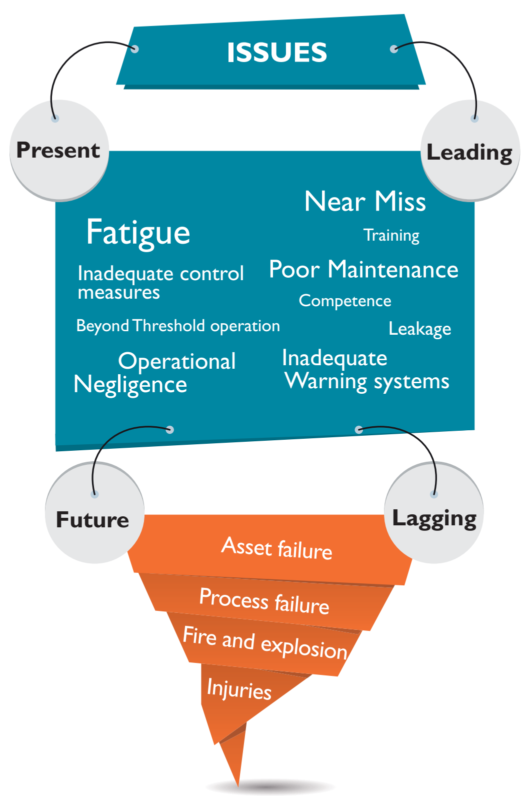
Introduction

The Texas refinery incident in the US in March 2005 was a wakeup call to the Oil and Gas industry because it questioned the sense of managing status quo.

The Baker panel report states that "The passing of time without a process incident is not necessarily an indication that all is well and may contribute to a dangerous and growing sense of complacency."

Since current systems in place largely track historical KPI indicators via lagging indicators such as LTIFR, DART (Days Away/Restricted or Transfer Rate), production loss, work stoppage etc. , the Baker panel report and associated studies by OSHA and other regulatory bodies have recommended a new mode of managing safety based on a term "Proactive or Predictive Risk Management".

For this, companies have to list the contributing factors that lead to injuries, fatalities, work stoppage, spills and releases and create a new set of KPIs called leading indicators. Instead of doing root cause analysis on "What went wrong", studies now recommend that companies measure contributing factors that lead to lesser safety or more accidents.



1.0 What is a Next Generation HSE Risk Management System?

In the context of 'Baker panel report', and incidents such as Texas refinery and Gulf of Mexico, a next generation HSE risk management system could consist of a process and system that can manage insights into competence, operational, process safety, environmental safety, occupational safety risks on a continuous basis, so as to reduce risk as part of ongoing operations. With growing use of advanced analytics, a HSE risk management solution should also be capable of incorporating statistical and analytical abilities into the information that it processes.

2.0 Starting the Journey to a Next-Generation Risk Management System

To begin the journey into a next-generation risk management process, enterprises have to understand their maturity in IT, Process, Technology and Data to move forward on implementing a next-generation risk management system.

- HSE (Health, Safety and Environment) IT maturity – The degree to which automation has been achieved in HSE processes using IT
- Risk Process maturity – The degree to which standardized processes are in place for management of risk
- Technology maturity – The degree to which processes and safety systems have been automated using IT, sensors and other data collection platforms
- Data maturity – The maturity of data model about operations and safety existing currently

2.1 Maturity Assessment of Current HSE Processes

As a next step, enterprises should develop a roadmap for achieving maturity in HSE risk management. Assessment of maturity can begin with a questionnaire such as the one given here.

2.1.1 Identifying the As-Is

- How many leading indicator KPIs are you measuring today?
- Do you have a robust IT system with defined data models?
- Do you have data that measures the effectiveness of a process?
- Do you have data about EXTERNAL factors such as company's regulatory compliance, reputation in market, shareholder value?
- Do you have access to data about INTERNAL factors such as lower production, lower employee morale, lower efficiency, higher costs?

2.1.2 Defining the To-Be

- How many organizational units need a proactive next generation risk management system?
- What is the organizational unit for risk measurement – business unit, plant, geography?
- Out of the KPIs, selected, how many KPIs can be driven by data collected from existing systems, and how much more of IT automation may be needed?
- How many KPIs use subjective sources of data such as opinions, suggestions, and survey scores?

2.1.3 Identifying the Challenges

- Who would be responsible for the given risk control area? Responsibility for data collection, responsibility for mitigating this risk, and targets)
- What is the governance process for managing higher risk areas ?

2.1.4 Identifying the Opportunities

- What are the mechanisms available to reduce the given risk (either though process improvement or through implementation of technology or both)
- Have you listed a set of business use cases, and the benefits of measuring different types of operational risk ?

Depending on answers to the above questions, the journey towards a comprehensive next generation Risk management system begins. The next step involves assessing list of risk variables required for current operations.

2.2 Selection of Leading Risk Variables

Within every process or sub-process in a risk intensive industry, there are multiple levels of safety performance indicators. The study done by the International Oil & Gas producers "Report No. 456, November 2011" [5], recommends a 4–tier KPI approach. The approach in this report outlines a mechanism for a leading risk based risk management method.

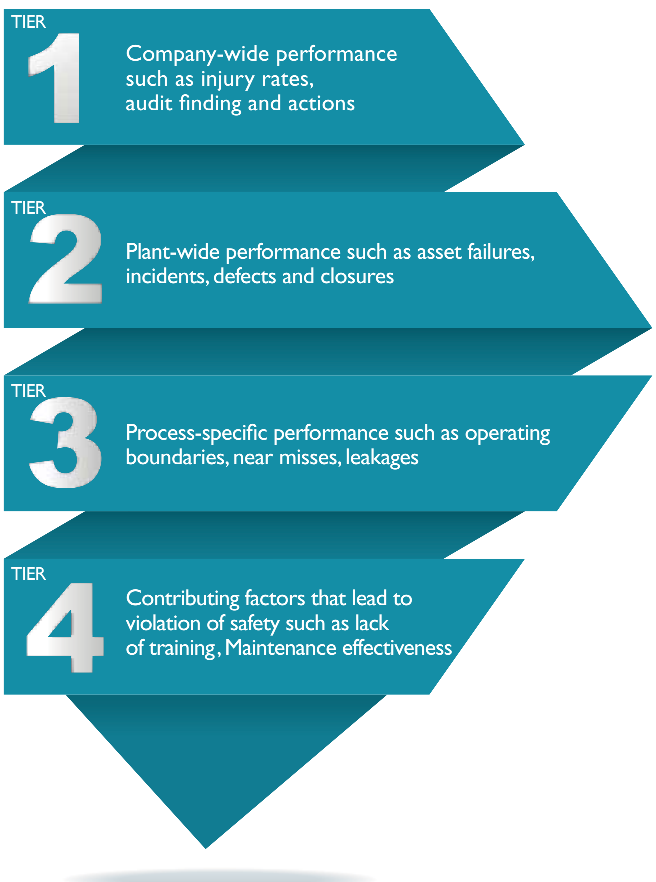


Fig 2: Tiered KPI as per Oil & Gas producers Journal, Report 456

These leading risk KPIs can be classified into buckets based on the level of complexity, and accuracy with which KPIs could be measured. Based on available transactional data systems such as ERP or enterprise HSE packaged applications, these KPI buckets could face different degree of complexity of implementation.

- Process effectiveness
  - Competency levels
  - Asset maintenance effectiveness
  - Inspection completion
  - Outstanding AZOP actions
- Degree of bad outcome
  - Total injuries
  - Near miss intensity
  - Days away from work
  - Number of LOPC events
- Real-time process safety
  - Number of times pressure relief valves operated
  - Environmental thresholds breached
  - Number of critical alarms
- Cultural factors
  - Fatigue at work
  - Overtime in shifts
  - Data quality
  - Action item completion duration

The buckets above also represent causative or contributing factors that lead to incidents, accidents. Once the list of risk variables is documented, the next step is to prioritize these risk variables based on three factors – Cost of measuring risk, Speed of risk variable and accuracy of the KPI.

2.3 Prioritizing KPI Selection Based on Cost, Speed and Accuracy

Each KPI set as bucketed above has different difficulty levels and costs associated with collecting them. For some KPIs, data is available, and the cost of measuring them would be cheap. In other cases, data may not be available, but technology to collect these data would be relatively cheaper.

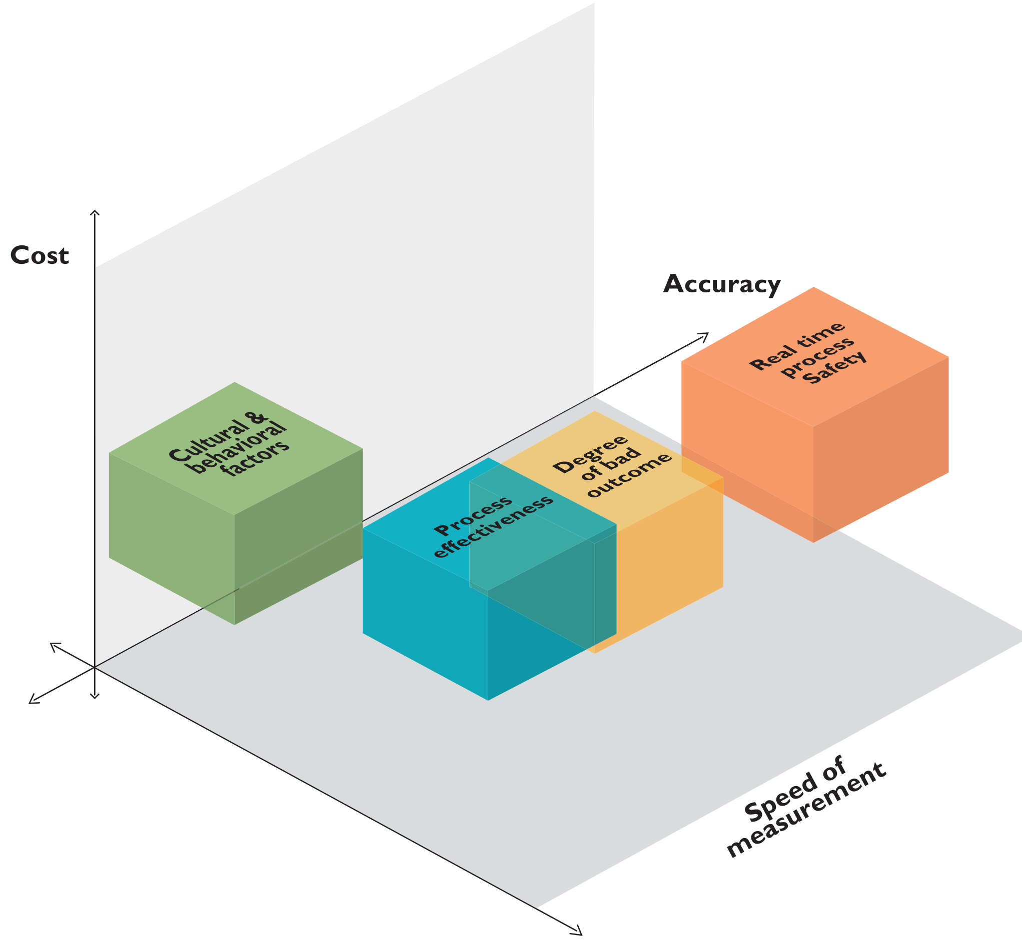


Fig 3: Cost-Accuracy-Speed comparison between risk variable types

The chart above shows a relative cost, accuracy, and speed of measurement of the KPI buckets. KPIs based on real hard data, often provide the most accurate description of risk, but are tough to collect, and cost more to collect and analyze. On the other hand, cultural factors are easy to collect, but often pose difficult challenge of data quality.

In a predictive risk management system, it is important to accelerate speed of measurement, so that insights are available on time before a Black Swan (low probability, high consequence) event arises.

2.4 Defining Relations Between Risk KPIs

While implementing a risk management system, it is important to capture the interdependence between risks, and how they are correlated.

For example, poor maintenance of critical equipment can result from reduced asset maintenance costs, and can also result in loss of containment incidents and these could further result in increased injuries at work place. But, we cannot conclude that reducing asset maintenance costs would increase injuries.

So enterprise risk management solution need modules that allow a risk manager to setup measurements that can highlight the relationship and dependence between leading indicators, and risk variables.

2.5 Managing Uncertainty of Risk

Risk management systems also need to design for the delay in propagation of risks. This is required, since the data collection process is based on total lead time between the onset of a risk, and incidence of an event.

For example, if a person operating particular equipment is not trained on the job, then given unfortunate but cohesive conditions, an accident or incident could happen on the job. The propagation delay between the level of training of operator, and accidents here could be in order of weeks or months. In another example, if the temperature of boiler or pressure of superheated steam goes up, then a LOPC (Loss of Primary Containment) incident could occur. The propagation delay between the leading indicator and the lagging indicator in this case could be in minutes or hours, depending on the process and equipment.

The table below shows the degree of uncertainty between the onset of risk and the incidence of a lagging indicator.

- In the table below, the risk due to temperature of distillate must be solved using more real-time data systems such as Sensor or M2M systems, as lead time from onset of risk to insight is in the order of minutes.
- In case of competency of personnel, a general risk register or action tracking system or a business process management system can be used to manage the process between onset and incidence of risk.

Leading risk	Lagging variable	Transmission delay
Temperature of distillate	Pressure valve release	Minutes to Hours
Skill level of personnel	Process Incidents with injuries	Now to many months
Inspection completion levels	Pipe leakages	Months to Years

Table 1: Propagation delay of leading variables

2.6 Right Scoping the Risk Variables

Implementing a risk management system at a corporate level can help in creating a seamless risk management culture, but measurements taken at a central level can get hidden due to averaging across different organizational units. Risk measurement should be done at reasonable organizational granularity such as process oriented units, or units at each geo level.

Similar processes – The leading indicator is picked from similar process as the lagging indicator. For example, Visibility levels in a mine could be linked to increase in vehicle accidents in the same mine and not to falls and trips due to poor visibility in the warehouse.

Similar geography – A relationship between Level of training to injuries at say APAC and Europe geo level may not yield the right results, as sample data extends across countries where the degree of awareness, regulatory strength, and availability of certified skills etc. may differ from country to country.

Similar organizational control – The effect of a leading indicator may vary depending on the organizational culture or management culture. In fact, the very purpose of leading indicators is to assess the effectiveness of risk management across different organizational units.

The following table shows that a process safety risk indicator needs to be measured and managed at a process or sub-process level. While incident action item completion can be centrally managed by a corporate risk management team, the indicators could be averaged across most business units, without risk of losing the quality of insight.

Leading risk	Lagging variable	Alignment of scope
Temperature of distillate	Pressure valve release	To be measured at plant or factory level only
Skill level of personnel	Process Incidents with injuries	To be measured at plant or factory level. Insights will be obscured if measured at organizational level.
Inspection completion levels	Pipe leakages	Could be measured at any organizational level but more effective at plant level
Calibration completion	Equipment malfunction	Could be measured at any organizational level but more effective at plant level
Incident Action item completion	Accidents or injuries	Could be measured at any organizational level.
Absenteeism of critical plant personnel	Accidents or injuries	To be measured at plant or factory level only.

Table 2: Examples of Scope of leading risk variables

3.0 Implementing a Risk Management System – Critical Features Needed

To implement a risk management system, a due diligence method insisting on the following size steps could be adopted.

- Identify process landscape and desired goals or outcome from business stakeholders
- Map a list of leading and lagging risk variables
- Define the relationships between risk variables
- Test the hypothesis, and arrive at a optimized relationship set
- Measure the correlation between risk variables on an ongoing basis to detect weaknesses in process, quality of data
- Measure interdependence between similar risks to study probability of risk propagation
- Intervene on time into risk stages to prevent Black Swan events

3.1 Leading and Lagging Indicator Correlation Analysis

Once the 7 steps are setup, a basic system should be in place which can measure the correlation between risk variables. Here are some of the hypotheses on how risks are related.

- Increasing intensity, duration or frequency and efficiency of training improves safety
- Increasing number of safety inspections, is likely to increase safety
- Reducing lead time of closing corrective or preventive maintenance requests on assets is likely to reduce chances of LOPC incidents or asset related near misses or injuries

In reality, however, correlation between these parameters is subject to many other contributing factors.

- Are the processes effective?
- Is there issue in data collection?
- Is the leading process really helping improve safety or is it ceremonial and is no inherent value in improving safety?

The methodology of correlation is useful to arrive at a tighter set of KPIs, and a more effective process. This would help the business case justification of setting up an elaborate system for collecting and managing leading indicator KPIs.

There are a number of experimental methods to measure correlation of indicators, and one such method is the Pearson's co-efficient. This method offers a numerical means to determine the following

- Is there a correlation between a leading and lagging variable?
- What is the level of correlation across time?
- Is the leading and lagging variable directly or inversely correlated?
- Is there a data quality issue in collecting these variables?

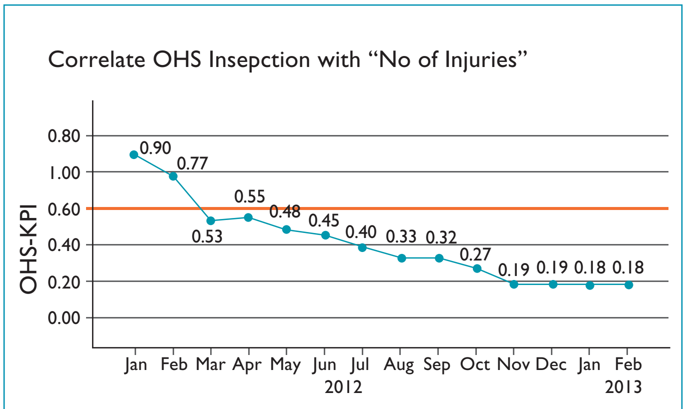


Fig 4: Pearson's product-moment correlation done for no. of Occupational health & safety Inspections versus Injuries within process

The graph here shows the correlation between number of OHS inspections and number of injuries. Unusual changes in correlation such as one in the data in January, February and March can provide insights.

These methods help unravel data errors, and long term correlation of risk variables. This analysis helps in

- Identifying control methods to reduce the risks
- prioritizing control and management of leading indicators
- Replacing human judgment with data driven decision making

Some examples are:

- Correlation of no. of safety meetings/toolbox talks to injuries or days away from work (leading to lagging)
- Correlation of incomplete preventive maintenance to actual corrective maintenance orders issued (Leading to leading comparison)
- Correlation of incomplete safety inspections/ safety reviews/Risk assessments to no. of incidents reported (Leading to lagging comparison)

3.2 Identifying 'Black Swan' Risks

Black Swan risks are low probability but high consequence events which are described with help of the Swiss cheese model. In this model, each slice of cheese represents a barrier of protection and has a set of holes which represents weaknesses in each layer. As per this model, accidents occur when multiple smaller risks line up in such a way that a risk can propagate through each of the barriers. For example, if the number of corrosion faults increase, and number of preventive maintenance inspections drop, and number of process excursions increase at the same time, a cumulative risk would signal unacceptable levels of risk, which increase chances of a catastrophic accident or event.

Fig 5: Combinatorial risk involving four different leading variables selected for a process (Ore Extraction) in a particular mine site (Mine site 1)

The above chart shows how cumulative risk increases with increase in individual risk scores of barrier KPI's. Logically, it means that more than one functional area has become risky due to complacence, or process inefficiency, and combination of inefficiencies could result in a much larger issue such as catastrophic event, or full process shutdown. Management action can focus on defusing the situation based on data collected.

3.3 Bayesian Belief Networks

Further to the above, a truly predictive risk management solution can be built based on its capability to alert management on operations or areas, where Black Swan risk levels are beyond reasonable levels.

The merit of a next generation system would need to come from the ability to precisely calculate probability of risk propagation within connected risks, using available data. For example, within process industries, enough experience is there to get data on how long and whether a pipe corrosion due to salty crude oil input would lead to a leak in that pipe. If such data is available, calculation of probability of risk of accident or an LOPC incident could be calculated.

Current Bayesian Belief models are based on expert opinion, and also provide fixed estimates of risks. If these models are connected to real data, estimates on these risks can be continuously re-evaluated, making risk management more proactive and predictive.

4.0 Insights Generated from Such Analysis

Risk management systems such as these can help HSE risk managers manage their risk portfolio, and control risks within a reasonable boundary.

4.1 It can help identify whether two indicators- logically related or not - are statistically correlated in operational areas. For e.g. In a particular process there might be very little positive correlation between preventive maintenance not done on time and corrective maintenance orders generated even though it is logically related. This can help managers to identify weak spots in the process.

4.2 It can help identify whether the effort put in managing a particular KPI is actually showing results. This can be achieved if a negative correlation is seen between a leading indicator which shows performance improvements and a lagging indicator like no. of injuries. E.g. If no. of injuries is falling with an increase in number of risk assessments then a negative correlation is seen. Ideal performance evaluation criteria would be to pursue a correlation closer to a score of -1

4.3 It can help identify whether there was unusual or extraordinary event within the business. Data will show disruptions in correlation, if there is a sudden increase or decrease -well beyond those routinely recorded- in the value of a given variable/indicator.

4.4 It can help identify accumulation of risk within a process in multiple areas, which can result in a larger catastrophic event. Measurement of cumulative value shows sudden or gradual deterioration of plant compliance to process, and gives sufficient lead time to management to act and defuse the situation.

4.5 It can provide internal or external benchmarks of safety performance to a given operation. Over a period of time, once sufficient data is gathered, the performance of a process in each area can be benchmarked with peers, and processes can be improved through internal exchange of best practices

5.0 Real-Life Use-cases for EHS Safety Monitoring

In many real life catastrophic incidents, a risk measurement system would be an ideal solution to the problem. In most incidents and accidents across process industries such as oil & gas and mining, a set of patterns are visible. The patterns are summarized here, but do not represent an exhaustive list.

Typical HAZOP/HAZID studies should capture these scenarios. So, any project that sets up leading variable risk studies can use such a repository to setup a leading risk performance system.

- Key alarm and alert system not in working condition
- Critical to operation personnel going on leave or being absent from work, resulting in operations being left to inexperienced hands
- Overriding fault conditions during operation of plant, to avoid stoppages
- Outdated equipment with lack of modern alert or fault indication systems
- More than a critical mass of personnel are either temporary staff, or new to the plant
- Shift handover done orally, and not taken seriously.
- Personnel with repeated history of poor judgment or performance at work
- External factors such as weather, visibility

Conclusion

In our experimental setup, an analytical model was setup to create a series of leading indicator KPIs in Asset risk, Occupational Health and Safety, Competence-led risk, and an aggregate risk scenario model was created to show aggregation of risk within a process boundary.
Using such a system, it is possible to manage operational risk of process industries like refining, oil extraction, and natural resource mining industries. Some of the use cases of risk management in process industries would be

- Making sure workers absent from work do not affect process operations
- Making sure critical process equipment is in working state
- Making sure employees are not impacted due to exposure of organic chemicals, heat, dust and chemical vapors
- Making sure that data collected through all IT systems like Incident management, Sensor systems, and SCADA systems is put to good use in generating insights on a regular basis

Using the above approach enterprises can roll out an effective, future proof health and safety risk management system, and benefit from the savings in asset maintenance, workers compensation premiums reduction, better employee morale, and reduced losses due to work stoppages and productivity losses.

References

1 International Association of Oil & Gas Producers, Safety performance Indicators 2009, 2010, 2011: Journal Report No. 439, 455, 2011s

2 Workplace safety & Insurance Board and Canadian Manufacturers & Exporters, Ontario Division "Business results through Health and Safety"

3 International Association of Oil & gas Producers, "Asset Integrity: The key to managing major incident risks", Report No. 415

4 International Association of Oil & gas Producers, "Cognitive issues associated with process safety and environmental indicators", Report No. 460

5 International Association of Oil & gas Producers, "Process safety: Recommended Practice on key Performance Indicators ", Report No. 456

6 Martin Sedgwick & Steven Stewart "Experience with developing Process Safety KPIs within Scottish Power" 2010

7 American Bureau of Shipping "Safety culture and leading indicators of safety", 2012

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