

## Improvement of Process Safety Monitoring of a Major Hazard Facility through Implementations of Effective Key Performance Indicators

Ameer Hamza, Process Safety Engineer, Syed Salwat Hosain Rizvi, Safety Manager, Engro Polymers & Chemicals Ltd, Port Qasim Road, Eastern Zone Bin Qasim Town, Karachi, Pakistan

At a petrochemical site, the most important aspect related to process safety is to gauge your safety management system performance through a set of key components usually called as indicators. There are basically two types of key performance indicators: i) Leading Indicator ii) Lagging Indicators. API-754 provides a complete set of guidelines on indicators based on TIER classification of incidents. There can be multiple aspects covered as indicators such as failures of safety systems, activation of safety instrument systems or failure of PSVs or rupture disks. We at Engro Polymers & Chemicals felt the need of improving our process safety monitoring to capture key process safety risks of the facility more appropriately so we aligned our process safety KPIs with API-RP-754 guidelines for gauging our site's process safety performance. Apart from adopting guidelines from API-RP-754 we also identified some other key indicators which had a direct link with the process safety performance of the facility, these included monitoring of vulnerable equipment on which any modification has been done temporarily based on inspection recommendations etc. Highlighting such events/issues for enhancing management focus on the key process safety parameters of the plant is the main feature of these new key performance indicators that we achieved through this transition

### Introduction

Process safety is always a challenging aspect for the industries having highly flammable or toxic chemicals at site. Development of management systems is one aspect of driving the processes as per standards but more important is to maintain the compliance of structural practices & keep intact the measures of process safety management system to minimize the possibilities of any major incident.

Previously, at EPCL, we were using self-developed process safety leading indicators in which multiple process safety aspects were not covered properly. The previous set of KPIs were unable to reflect the actual process safety performance of the plant which was evident from the fact the KPIs score remained satisfactory against number of process safety issues that plant was facing. Safety performance indicators must raise a flag on concerning areas before occurrence of any incident which is the true purpose of indicators. We had reliability issues at site like multiple leakages, safety systems failures and non-compliances to management systems which our process safety LI's were unable to reflect in a compelling manner.

Dealing with a Petrochemical plant having toxic and flammable inventories requires stringent controls which led us to redesign our process safety KPIs. With API derived indicators, we were able to draw management's attention towards the key focus areas of plant which were critical for improvement of process safety performance of site for avoiding major accident hazards. The set of indicators we developed are based on our experience of excessive LOPC incidents faced due to integrity issues, practices and the scenarios provided by API-754 for gauging system's effectiveness.

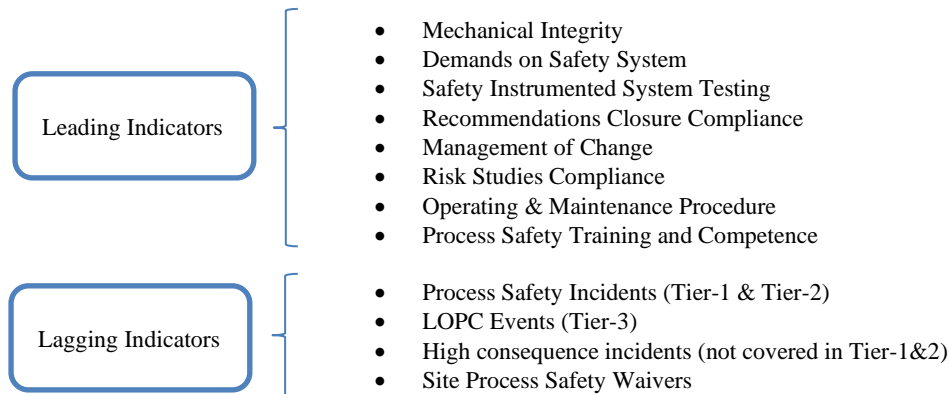
### Process Safety Indicators

#### Key Components

Many industries follow their own set of parameters to monitor the effectiveness of their procedures as per their industry's requirements. Some sectors put more focus on occupational safety and personnel safety related violations/incidents whereas industries like chemicals, petrochemical and oil & gas sectors give high preference to their process safety items along with occupational safety & environmental concerns. API provides guidance for some important process safety indicators for refining and petrochemical units through RP-754. API classifies process safety indicators into four tiers of leading and lagging indicators. Tier-1 and 2 are the lagging indicators whereas Tiers 3 and 4 act as leading indicators to Tier 1 & 2. Tier-3 & 4 represents challenges to the preventive and mitigative barriers that progresses towards the path to harm but is stopped short of a Tier 1 or Tier 2 consequence. These are site specific, and industries incorporate these to improve their systems. As a general API defines these indicators as

- Tier-1 & 2 Indicators – Process Safety Events (T-1/2 PSE)
- Tier-3 Indicator – Challenges to Safety Systems
- Tier-4 Indicator – Operating Discipline and Management System Performance

EPCL adopted API guidelines to develop set of indicators as per the site requirements which are as follows:



## Lagging Indicators

### Process Safety Incidents (Tier-1 & 2)

Any unplanned or uncontrolled release of a process service or material including non-toxic and non-flammable materials that results in serious injury/fatality or fire having significant asset damage or public evacuation is termed as process safety incident. EPCL follows the Tier categorization for the classification of process safety incidents as per the guidelines of API-754. The difference between Tier-1 & Tier-2 is based on the severity of the incident. Any process safety incident occurred at site following under these two categories shows the safety barrier systems weakness and should be reflected in process safety performance. The debit for both incidents in KPIs must be different depending on their severity.

### LOPC Events (Tier-3)

LOPC events not falling under Tier-1 or 2 categories cannot be left unrecognized. These incidents often lead to catastrophic events. These may include dropwise leakages of toxic or flammable material which have high consequence if not attended timely. EPCL track such leakages for proper investigation to avoid any major accident hazard. These leakages must be part of process safety KPIs as such events intend to highlight weak node of process and gaps in mechanical integrity practices.

### High consequence incidents (not covered in Tier-1&2)

There might be such incidents occur at sites which ideally do not fall under Tier-1 or 2 categories as per the consequences defined in API for these two, but they can carry potential to any harm or result in major accidental hazard. For example, in oil & gas sectors, a fire incident in operating area has a potential to escalate considering hydrocarbon in the process lines. This might have no impact on plant assets or people but have potential consequence of any major loss.

### Waivers or Exceptions

Industries generally follow a practice to have waivers on the system or protocols that are not possible to fulfil for a specific time or activity. Simple example is to have a waiver on preventive maintenance of any single PSV on live circuit. Since for its PM you must shut down your whole plant, so people often take waivers for delaying such activities on the basis of administrative controls, past experiences etc. by reviewing it properly through safety aspects. In other words, waiver is an exception taken from management to bypass safety management system guidelines. If we reconsider the previously mentioned example again, it is a major concerning area in context of process safety. PSVs is a key safety system that must be kept healthy by conducting its required PMs on frequent basis as per standard practices and guidelines.

All such waivers that have direct impact on process safety of plant that might include PMs of safety switches/interlocks, inspection of critical vessels, bypassing PSM guidelines etc. are the vulnerable aspects of safety management system. All such on going waivers must be reflected in process safety KPIs since it is a risk that the site carries to continue production.

## Leading Indicators

### Mechanical Integrity

MI is the most critical component of process safety KPIs. The purpose of this indicator is to highlight all integrity related compliance items for focus.

**Temporary Repairs:** Process plants often need to have a temporary repair based on the condition of the operation. Temporary repairs are done to keep the system operations with mechanical reinforcement but on the same side to maintain the integrity and health of TR is also inevitable. Compliance to temporary repairs field health check should be reflected in the performance indicators. Similarly, all the temporary repairs installed to any process piping or equipment itself is a vulnerable part of the system that must be resolved or replaced through permanent solution such as replacement of

vulnerable equipment or line with the new one. All such temporary installation possesses a hazard on high operating line or equipment that should be followed-up for removal. Number of TRs installed on critical services must be tracked through MI KPIs and should be treated as a process safety threat

**Inspection Recommendations:** Flags are raised often by the inspections team for degradation of metallurgy on critical circuits or equipment. These highlighted parts must be reflected in performance standards as these can cause ultimate hazard if not taken-up properly. Such weak nodes must be manifested in the integrity KPIs.

**Safe Operating Limits:** Operating an equipment under its safe operating limit (SOL) is one of the most important concepts provided by API. System should not exceed its SOL during normal operation as operating above SOL can degrade the system efficiency, mechanical integrity and compromise the safety factor. If system breaches its SOL i.e. a tank operating at its High-High limit so these need to be reported, tracked and reflected in site performance LI's.

**Preventive Maintenance Compliance:** To keep the site reliability at a safer end, each industry develops a preventive maintenance plan for its essential & hazardous systems/equipment. These PMs compliance has a huge share in keeping a site reliable and up to the mark on safety scale. Any noncompliance to these activities specially on safety critical items like PSV or ESDs should be discouraged and subsequently highlighted to the higher management for stewardship

### **Safety Instrumentation Systems Testing & Demand on Safety Systems**

**Instrumentation Testing:** Safety instrumented systems need to be tested at frequent intervals to verify the proper functionality of defence layers. These testing enables us to gauge the reliability of safety instrumented functions. The compliance of these testing and the ultimate outcome must be a part of leading indicators. Whenever there is a failure during testing of safety layers, it should be logged, properly investigated and subsequently shown in site safety performance

**Activation of Safety Systems:** Frequent activations of a safety system such as demand on PSVs due to high pressure episode during plant operation or any interlock actuation due to parameters disturbance etc reflects the uncertainties in plant operation. In other words, the recurrent abnormalities and demands on safety system may lead to a hazardous state followed by any incident. All SIS or mechanical safety system actuations & failures need to be included in performance indicators as per the guidelines of API-754. EPCL managed to put more focus on such events after incorporation of this indicator in LI's.

### **Recommendations Closure Compliance**

Effectiveness of safety management system is also often assessed by looking at the importance given to the site safety recommendations. Source of recommendations can be any risk study like Quantitative Risk Studies, Fire Risk Assessments, Process Hazard Analysis, Layer of Protection Assessment or Critical Incident Investigations etc. Follow-up of these recommendations and to ensure the closure of the items generated against any study must be derived from the higher management and any non-compliance of this must be stewarded in site safety committee. Recommendations closure compliance is an essential site safety performance gauging parameter for industries

### **Management of Change**

Management of change concept is often used in industries to carry out any modification or addition in operating areas. A group of technical and safety individuals sit together to review every aspect of new installation or modification before execution. Management of change protocols compliance means to have a proper MOC approval for execution, the modifications executed are as per the MOC document etc. A compliance check audits to be conducted frequently and any discrepancy must be reported for action. MOC protocols compliance must be included in leading indicators to put more focus on key safety management elements

### **Safety Risk Studies Compliance**

Safety studies like PHAs, QRA, FEHA, LOPA etc are conducted to assess the site associated hazards. Petrochemical and Oil & gas sectors do not compromise on the risk studies as these assessments help to evaluate the major risks and their preventive control measures available & required. With time, several modifications or changes arise in operating equipment/circuits that possess undue hazard which might not be visible with naked eye. Detailed hazard evaluations must be conducted on frequent basis to keep the site on safer end. EPCL have developed a calendar for PHAs and other risk studies to carry out a review of operating area nodes on fixed intervals like 5 or 10 years. By adding compliance of these studies to safety performance indicators enabled EPCL to emphasis on these essential & critical exercises.

### **Operating & Maintenance Procedure**

All plant critical procedures must be kept evergreen as these serve to be the guidelines for daily based activities. Such procedures include emergency handling procedures, operating procedures, safety critical equipment defeat procedures, maintenance activity procedures etc that must be updated and revised on frequent intervals. API suggests incorporating the compliances of all critical procedure's revision in KPIs. The best approach to achieve this is to select the critical procedures and define a frequency of revision for them. Tracking of these revisions must be done through LI's

### **Process Safety Training & Competence**

While working on a petrochemical plant, the competency & knowledge of people related to the site associated hazards must be gauged through a set of parameters. To maintain a definite knowledge level of individuals for process safety, the fulfilment the requirements of safety trainings and exercise must be taken in account. EPCL included the emergency

response exercise compliance & PSM skill certification renewal compliance as a leading indicator to retain a degree of competency required for the job.

## Conclusion

Improving process safety performance of major hazard facilities is a continuous struggle, the advisory functions and execution functions handling hazardous facilities must keep on looking into opportunities to improve the process safety practices minimizing the possibilities of major accidents. KPIs serve as the tool for site management to ensure this continuous focus is maintained in the most appropriate manner. While setting KPIs for safety system, always adopt the following approach:

- KPIs must drive process safety performance improvement
- Implementation of the performance indicators should be easy & practicable
- The performance should be reflected on statistical scale through set of parameters

For EPCL, alignment of previously used KPIs with API-RP-754 is one of the examples of the good focus, commitment for improving the reliability and process safety performance of its assets. But the important part is the continuous calibration of KPIs with actual site performance and key focus areas. Safety advisory function must keep a close watch on the site conditions and must keep calibrating the KPIs in a manner that must depict the actual process safety performance of the plant because only with continued focus reliable and safe plant operations especially for major hazard facilities can be achieved. Other than this, one more important aspect is 'learning by other mistakes', so the safety advisory functions must also network with renowned institutions to implement the learnings and improvements of other similar industries at their facilities.

## Advantages

Implementation of these KPI's impacted the overall process safety culture of site. The major benefits EPCL has extracted from the execution of these indicators are:

- Due focus on critical process safety incidents based on Tier categorization
- Underlining site integrity issues and quick rectification
- Strong follow-up & monitoring of process safety & risk studies items compliance
- Process safety risk identification on early stages

Just like EPCL, petrochemical and refineries need to switch their course towards risk-based framework for the prevention of major accidental hazard at sites. These key performance indicators play a vital role in establishment & improvement of a process safety culture in any organization and help to lead a sector towards operational excellence.

## References

1- ANSI/API Recommended Practice 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries (Second Edition, APRIL 2016)