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## **Enhancing Safety Through strengthening Human Barrier**

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### **Abstract**

It is a well-known fact that up to 80 % of industrial incidents are caused wholly or partly by human actions. “Machines on its own does not cause any Incidents but human intervention does” is the well know based on incident investigations. To reduce the Incidents and its consequence, it is imperative to have knowledge, know-how, authority & controls be given to all front line personnel making them a reliable and competent barrier.

Based on the learnings from events, it was observed that for every incident there are several factors which had contributed to the event. Outcome of the findings suggest enhancing the robustness of preventive measures and this was the top priority within KOC – It includes workforce involvement through Competency Enhancement, further enabling them to identify the underlying hazards and follow the company procedures and standards. The process is chalked on a routine basis as a Plan Do Check Act (PDCA) activity to improve the inherent human reflexes. This plan/campaign was audited periodically to ensure that workforce can be included as a barrier.

It was observed that PDCA where planning was based on the inspection & Audit gaps identified. The gaps suggested the diversity of training and awareness session required and competency enhancement at various levels to ensure that personnel act as a critical barrier reducing the human error. It is imperative to suggest that unfamiliarity/skill & knowledge, planning (time shortage or hasting up) and understanding the hazards present along with supervision and feedback stood out as the top human factors which weakens the Human Barrier. The various sessions had motivated the frontline workforce to voice upon the concerns to their superiors for ensuring a safer operation prevail in the oil field. Further the Human factors play a significant role and this is to be given priority at all levels to include safety behavior and safety culture. The Human factor along with the feedback forms the base of the safety pyramid. It was also observed from the quarterly trends which focused on developing a significant improvement in the safety integrated policy concept for enhancing safety through strengthening human barrier.

The concept of Human and Human factors being a reliable barrier in the past has not been given significant weightage in design and operation. The idea of this paper is to showcase the approach where the reliability has increased and can consider personnel as a barrier and ensure a reliability operation/ activity. Workforce with a significant support can transform into efficient preventive and mitigative barrier.

**Keywords:** Human Barrier, Workforce Safety, Natural Safety, Culture Enhancement

### **Introduction**

Safe and sustainable operability have been a key challenge in all process industries where time, material and resources (including human resources) are evaluated on a monetary base line inputs. The foundation for newer technology and associated complex equipment is to ensure better efficiency and operating margins. Considering the number of controls, inherent safe design and safeguards, included in the modern technology/equipment, it is still observed that the incidents tend to rise in the organization. Further the modern incidents are powerful to wipe out the facility and to the extent of determining the sustenance of the organization.

When discussing process safety, it is of the general opinion that the operability and process upsets are the key to understand process safety aspects and that the personnel involved are included under umbrella of occupational (personal) safety. The key understanding is that the entire operations is being operated and managed by personnel working in the frontline. Also it is imperative to note from the process safety incidents that “Machines on its own does not cause any Incident but human intervention does”. As a result, it is important that we understand the significant contribution by the front line workforce and to ensure how they can manage to become a reliable barrier in the process safety.

It is also required that an organization develops tailor made programs to ensure that workforce is significantly on-guard to assimilate the hazards associated in the activities performed, the process involved and evaluate risks with all the available tools and mitigate in a timely manner to avoid incidents – appropriate risk management.

### **Concept of Human Barrier**

The Risk Based Process Safety approach by CCPS defines the twenty (20) Elements classified under the Four (4) Pillars of Process Safety. On evaluating each of the element, on both macro level and micro level, it is evident and clear that human activity/ human element presents as the key input driver. It is vital that due weightage is given for each of the element’s underlying knowledge to ensure that there is a robustness built into the system.

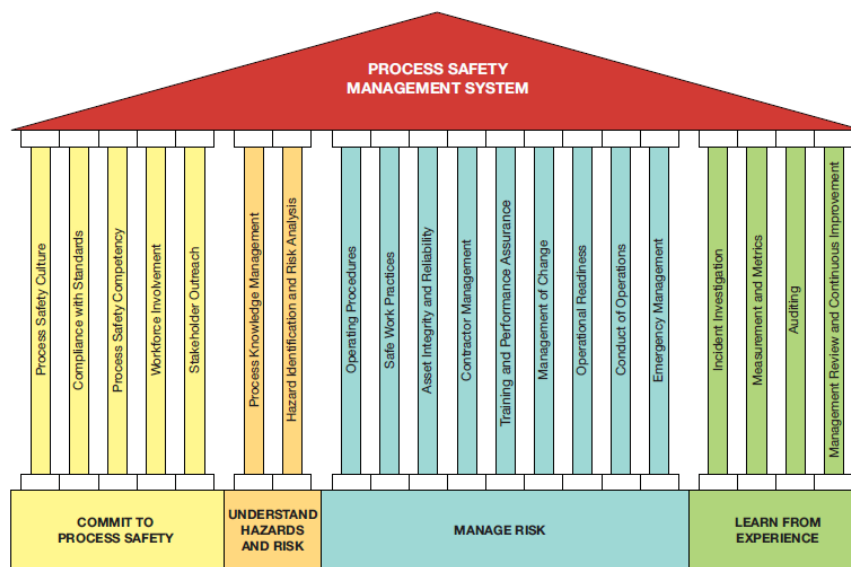


Figure 1 Pillars (Foundational Blocks) and associated Elements that constitute a sturdy RBPS Management System Pillars (CCPS)

The Process Safety Elements as well as, working personnel at all levels have revealed that, every sane human being in general is committed to self -safety- generally known as naturally safe, however the degree of commitment varies. The commitment is motivated by several methods - many analysis and theories have been developed on that subject. The knowledge (procedural & practical, risk evaluation), training (regular, critical and emergency) and act to work appropriately in a timely manner ensures that the robustness is built into the Universal Process Safety System.

“Human Barrier of Process Safety” comprises of the overall thought process and logical response of personnel to handle and contribute across the Process Safety Elements.

As part of company PHA requirements (possible technical safety studies such as HAZID, HAZOP, SIL, FMEA, etc.), Simulations (SIF, Model reviews, QRA’s, F&G Mapping etc.), knowledge levels along with safer and reliable systems are developed, it can be stated that the Engineering has emerged competitively over time considering that the engineering decisions is resourced and well aided. As a result, this area of concern where human functional impact and critical decision making, under the time bound circumstances is moved towards the operations and maintenance phase.

The workforce at the site, interacting with the machines/equipment and reviewing the process on minute to minute scenario, are to take well informed step and are considered as the “Front Line Human Barrier”.

### Process Safety and Barrier Management – A Hierarchical Approach

It is the top of the pyramid in process safety pyramid or top event in case we refer to the bow tie model that is to be avoided.

As the hierarchy suggests, the process safety incident is the top of the Process Safety Metric Pyramid (Figure 2) - the top being Major process safety incident and second level is the process safety incident with lesser severity. Understanding the process safety pyramid, it is evident that

incident is a culmination of failure of the Layer of Protection concept with a lesser significance. Also, the near miss incident is a forewarning of process safety (near- miss) incidents. These near miss incidents could be due to process upset/ failure or improper guideline or procedure or unsafe behavior resulting into near miss incidents. However, the bottom most part of the pyramid is generally considered the unsafe behavior, acts or insufficient operating discipline which is to be considered as process safety near miss incident at par with respective level.

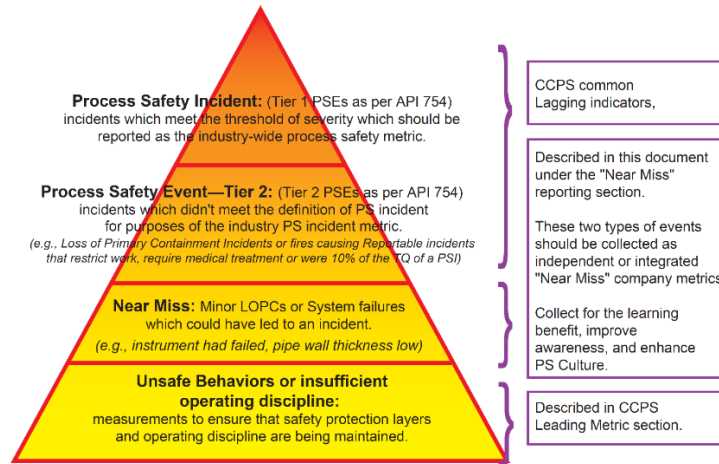


Figure 2 Process Safety Metric Pyramid (CCPS)

To elucidate the same in a swiss cheese model or using the bow-tie, the hazards are contained by multiple protective barriers and it is certain that any barrier may have weakness or holes, when all these holes are aligning the hazard passes through the barrier resulting in the potential for adverse consequences. Barrier may be physically engineered in the design of the system; however, the behavior control depends on the people, especially the front line workforce. The holes can be latent/ incipient or actively opened by the people.

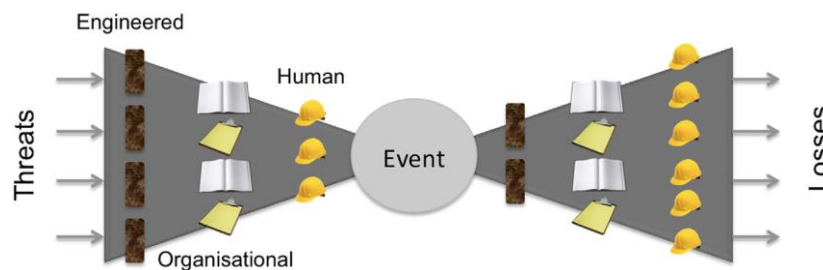


Figure 3 Conceptual bowtie showing the relationship between threats, events and losses and different types of Generic Controls (McLeod, R.W)

As the process safety pyramid (Ref: Figure 2 Process Safety Metric Pyramid ) is explained above, failure of protection layers is directly or indirectly responsible under the personnel working in the field. The actual safety and operability of the facility and/or field falls in the hands of the operational and maintenance workforce. In other words, organizations shall implement the management of leading indicators because appropriate interpretation of the leading indicators matters in the process safety management.

This idea of having a robust front line human barrier is important. Stressing on this, Kuwait Oil Company management has established a robust management system that includes reporting of

leading indicators such as near miss, hazardous condition and in-house developed behavioral safety tool- SOC (Safety Observation and Conversation) and mechanism to implement the corrective actions from the leading indicators. This systems ensure that all unsafe conditions are reported for a quick rectification and enhancement in the respective systems.

Besides the leading indicators, the lagging indicators are also documented in the management systems and they are reviewed and investigated as per procedures.

It is from the leading and lagging indicators, a continual improvement is ensured through updating manuals, procedures and learning from incidents (leading & lagging). The Quarterly Performance Review (QPR) of the HSSE is conducted to see how the indicators are performing and evaluating the safety triangle bottom. Also to understand the performance of frontline workforce in terms of reporting the hazardous condition observed and to review the number of conditions corrected. This tracking is to ensure that the observed hazardous conditions does not lead to incidents. Also during the review, analysis of the number of SOC reported, wherein how many worked was intervened to correct the behavior/ activity is also included.

Based on the leading indicators & lagging indicators of the past, a detailed program was conceived to strengthen the front line workforce personnel who act as a human barrier of controlling the risk and consequence. For the emergency response, a realistic training based on the NORSOK - CRIOP (Crisis Intervention and Operability) was imparted to the front line operation and maintenance workers as it defines the hierarchy during emergency operations.

#### **Plan Do Check Act (PDCA) Program on Human Barriers**

It is observed across all process industries that an incident has a direct correlation where some of the final signals/checks were either missed or critical signals not addressed at the right stage to avoid the accident or negate the consequence. The goal is to ensure that such scenarios are addressed and that workforce personnel are prepared for such contingencies within the organization.

Within KOC, to understand the gaps available in the frontline workforce, initially a course discussion with operational & maintenance frontline workforce was undertaken to understand that there is a gap existing – This is important a detailed protocol may not lead into appropriate responses. This is then followed by a streamlined audit by developing a specific audit protocol – this is to be done with the task of operational teams. The protocol focused on the following: Knowledge (Procedures), Practical Response during scenario, Behavior and Cultural Impact, Management support (Expectation).

Inside KOC, the HSSE Management System Framework Guide suggest the utilization of Plan Do Check Act guideline at its core, is to encourage and facilitate continual improvement on all its HSSE parameters. The below KOC HSSE Quality model shows the 13 HSSE elements used in KOC and how they are interlined to each other. Each of the element has a set of guidelines and procedure including the process safety procedures.



Figure 4 KOC HSSE Quality Model and Relationship to Elements

The Planned Program: The commitment of the leadership had suggested to identify the process safety/ human barrier gaps. These requirements have been identified based on the Audits/inspections, following which a Performance Indicator system was developed. The performance indicator included all the leading indicators identified by the frontline workforce, identifying process safety hazards, suggesting the management of change with justification of how it can support maintenance and operations, Trainings and awareness session required on the Process Safety risk assessment (including behavioral aspects) and Training and awareness session related to Operational and Maintenance activities and Emergency Response readiness.

The Worked out Program: A clear strategy consisting of bridging the gap was developed by creating a modular training package for each of the target group considering the diversity and training needs. During the training and awareness session, the frontline workforce was mooted to voice their concerns and brainstorming of the cases of incidents in the process industry was discussed. Also included topic was “What Can Be Done Better for Their Facility”. The session took feedback and reciprocated it to the management at the end of every quarter along with additional training needs identified during the sessions.

The training aspect shall start with identification of the hazard, critical signs and signal from the unit/equipment. The key for accident prevention evaluation is the key to understand the prevailing hazard and how it had started to take shape. The overall theme of the awareness session was “Any unfamiliarity/ skill for not identifying a hazard senses disaster”. This was also included by showing and discussion various incidents from within the company and the industry.

It was also made clear to the frontline workforce that however robust the design and engineering is, and capability of the equipment, it is not all information has been included on your control panel or included in the operational manual or based on a risk based maintenance program. As a result, the operators and maintenance personnel who are looking at the facility, and listening to the physical response of the equipment, a balanced approach has to be taken on the total operations and inform the concerned team for their expert evaluation of the scenario. It was

emphasized that taking support of including different subject expert opinion is the best way to utilize the company knowledge resources to enhance the better operability of the plant.

For example, considering some of the older plants, there shall be several generation difference units and controllers which are to interact. The awareness session included that the field operator shall also be in a position to distinguish between the hardware and software issues as it is always important to ensure the maximum utilization of the equipment/ facility. This is first line of evaluation and identification. The awareness session shall be followed up as an incremental part of the training. The training focused on how to identify the Leading Process Safety Indicators, and how operational intervention is required or as to when the Maintenance activities would be more advised to make it an advantage.

The advantage of an awareness session shall always mean that there is a recap of the earlier session as well as to include an incremental information to the participants. Further the competency enhancement at various levels is conducted to ensure that field personnel act as a critical barrier reducing the human error.

Similar to a STOP system, KOC had included Safety Observation and Conversation system where every working aspect is included and peer review is done to ensure that the job is done in the safest manner. It is different when it comes to emergency response and management where CRIOP based training is imparted. Right from identification and stopping the process requires many inputs and quick decision making capabilities. The functional administrative capability of evaluating and decision making of the front line workforce be enhanced by periodically conducting a CRIOP based discussion coaching and facility/ field based action response training.

The Evaluation of the Program: Competition session between teams were conducted with frontline supervisors and their team to come with ideas “What Can Be Done Better for Their Facility” and this helped in the supervisor gain confidence on his/her team and how the other team defends on not having it in place. These session made teams more competent and number of Management of Change (MoC) had resulted in the event/ competition. They were further evaluated on technical merits – this was scored on the performance on the program.

During the competition and during the program, it was recommended to check on motivation of the frontline workers and also with supervisor evaluations – this is done on observing and feedback and response to interactions. This concept of the motivation, support from the management, supervisor evaluation and positive support is combined and described as Human Barrier Maintenance – when evaluating the human barrier, it is important that the last line is well connected and well informed of the decision to be made. The performance indicators developed act as evaluation of the program. The program was reviewed every first week of every month and during the management meetings the results were discussed.

Review of the program: Reports were generated on both monthly and quarterly basis. The monthly report was on the indicators identified the base line requirement and on the new requirements identified based on the training/awareness session conducted. Quarterly reports were generated to review the performance of the program on overall basis. The modular training planned and its basis was suggested to the top management by showing the performance and scope of coverage.

The feedback from the management was discussed in the following awareness sessions to encourage the frontline workforce personnel. A two way feedback from the management to the frontline workforce and the workforce perception to the senior management, resulted in an increase of mutual trustworthiness. Further the program was a welcome on all fronts to enhance the reliability of the frontline workforce as a human barrier.

### Result and Inferences

The results have been satisfactory as the frontline personnel were involved in the discussion on procedural control and operability issues after implementation of the program. It was made clear that barrier management in the process safety management has been assigned as Key Performance Indicators. API RP-754, Process safety performance indicators for the refining and petrochemical industry and KOC internal guidelines and procedures for process safety management (under KOC HSSE Management System) are considered in identifying the leading and lagging performance indicators.

Inclusion of the operation and maintenance workforce and involving at all stages as well as conducting CRIOP based discussion has been beneficial for the frontline workforce as well as for the management as a reliable barrier is been formed. It is to be clearly noted that this barrier is a last line of contingency and cannot be included for operational planning of emergencies.

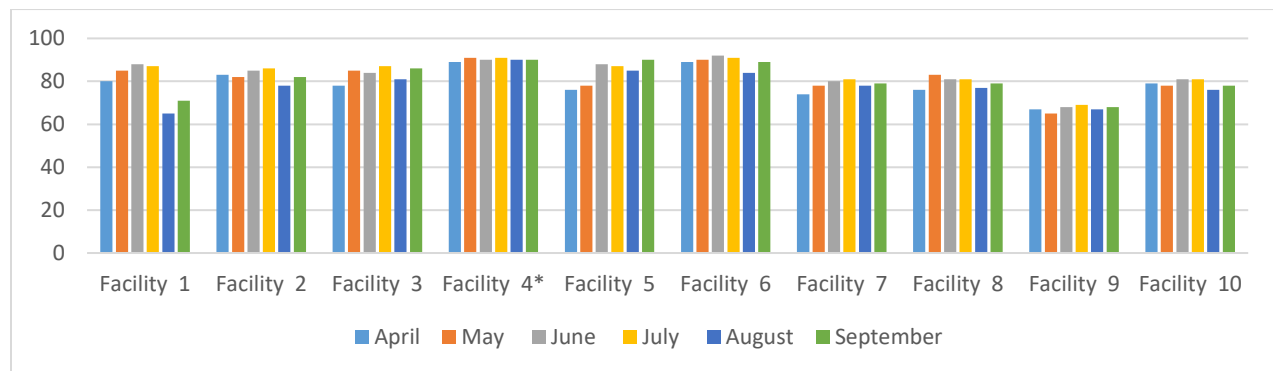


Figure 5: KPI Performance - Human Barrier & Emergency Response Evaluation

The training/ awareness session for this program include the following as indicators for evaluation:

- Leading indicators
- Process Safety Hazards
- Trainings and awareness session – Process/ Behavior/ Occupation Safety/ Guidelines/ Standards
- Training and awareness session related to Operational and Maintenance – MoC/ Procedure
- Emergency Response readiness

Scoring was predominantly based on the training and awareness session conducted. The objective is to train and evaluate rather than evaluate on an overall aspect. As there was a fresh inclusion of new frontline workforce and considering the partial staff rotation in August as a result, most of the scoring had dropped a little in the month of August. It was observed that Facility 4 had no rotation of staff and as a result the scoring on the parameters were maintained.

As described in the Hierarchical approach (Refer Section Process Safety and Barrier Management – A Hierarchical Approach), all kinds of barriers shall be audited and focused to enhance and



ensure program is on track to reach the goal. The Key Performance Indicators for operational and maintenance workforce shall include operating the equipment in critical efficiency zone to ensure optimum production is maintained in the highly volatile crude market besides adhering to HSE standards and procedures.

It is to note that however, adept they are with facility procedures and protocols, a constant training and encouragement with support for management (Human Barrier Maintenance) is required to ensure that they are able to deliver the knowledge received.

The maximum visibility of process safety management (including barrier management) is achieved by the adequate awareness and incorporating the risk mitigation measure into the system by design and by following the HSEMS standards & procedures of the company. Further training and behavior based vision on the risk, consequence of the various hazards which have been identified during the various studies would support and ensure clarity.

### **Conclusions**

The operational & maintenance personnel act as the most important line of control in the Safety Management Program (both Process Safety as well as Occupational Safety) and for its implementation. The core concept is to continually develop the frontline personnel and enhance their competence in responding to any process safety deviations in a safe and sustainable manner to avert incidents.

The program is generally an ongoing and continuous in nature. It is important to have a compatible digital concept for better tracking of the continual improvement in case of workforce spread across different area for such programs - considering the size of the organization by virtue of the changes in workforce, locations and complexity.

It is important that the frontline personnel are considered as a barrier and are included right during design, startup and commissioning and all Management of Change (MoC) activities. They shall also be trained for appropriate response during operating and maintenance (operational phase) for managing the safety critical elements only to suggest the holes of the Swiss-cheese model can be shrunk / barrier in the bowtie can be strengthened by creating a better control, by the strong knowledgeable and capable workforce who act as a barrier by holding the risk and not escalating it further.

The human barrier act in a most significant manner and work wonders within the safe operating framework defined. Further, the operational and maintenance workforce along with a comprehensive system to report hazardous conditions, near miss items, and safety observations in the field supports in strengthening the preventive barrier and support the overall all safety in the industry.

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The Authors are basically from the Conventional Oil background along with experience from several projects on process safety management and barrier management. This journey where many man hours have been invested to enhance and develop the frontline of workforce by making them a reliable human barrier and in their view it has been a very humbling journey.

The authors also, acknowledge the other teams in the organization who had supported them in this program.

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