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Simultaneously Improving Safety Awareness, Safety Attitudes and Business Results – A Case Study

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ABSTRACT

"The first duty of business is surviving, and the guiding principle of business economics is not the maximization of profit, it is the avoidance of loss." **Peter Drucker**

Achieving acceptable business results is a priority for all facilities (industrial, chemical, process, etc). Based on this premise, a facility with poor economic performance will also be more likely to under-invest in safety activities. That said, reaching economic goals while maintaining satisfactory safety levels can sometimes be a challenge. This paper describes techniques that were used to evaluate risks at a facility, focusing on major accidents.

It was discovered that there was an inherent cost in *not* implementing certain recommendations since the cost of personnel exposure, repair, clean-up, replacement, business interruption, etc. far exceeded the cost of implementing the measure. Overall, the facility reduced the personnel risk from major accidents by an estimated 95%. Not coincidentally, their combined safety capital costs and expected losses dropped by 90% from the same measures. The process graphically demonstrated to plant management the positive economic benefits of improving their safety systems. This in turn resulted in a major improvement in safety awareness and attitudes by operators and management alike.

1. INTRODUCTION

A major accident in a unit on a chemical processing facility, in March 2001, resulted in fatalities and in the unit being down for an extended period while repairs and modifications were made to the unit.

The accident rattled the confidence of plant management and staff. There was a realization that after several years of very low incident rates, complacency had set in due to excellent key performance indicator. The complacency lead to actions and behaviors that did not result in as safe a working environment as desired. Many of the plant personnel were concerned about working on the unit and with bringing the plant back into production safely.

The unit produced a unique and very profitable product and, although the company had significant quantities of the product in storage, the demand from all the clients could not be supplied for the whole period of the outage. The company did try to obtain product from other sources for their clients, but this was not as successful as they would have liked.

The Company had several issues to focus on which included:

1. Ensuring the plant was safe to operate once it was repaired.
2. Rebuilding the confidence of the plant personnel (operators, maintenance staff, etc.) in the safety of the unit.
3. Ensuring a more robust and reliable production that minimizes unplanned outages.
4. Rebuilding the confidence of clients in the security if their supply.

While the unit was down the plant undertook significant safety-focused work to identify hazards, and implement measures to mitigate and manage those hazards. They also redesigned several sections of the unit to avoid a repetition of the accident. With the heavy involvement of plant personnel, the work was undertaken to improve the overall safety and succeeded in rebuilding the personnel's confidence in the unit.

The Company also undertook measures to keep their clients informed during the outage period and to rebuild their confidence in the security of supply of their raw material. One element of their actions included the assessment and minimization of the risk of a long-term unit outage resulting in loss of supply to their clients.

The company contracted DNV for two phasesof work:

<u>Phase 1 – Internal Safety Assurance</u>

- To identify hazards in the design of the plant and in the way it was previously operated.
- To develop recommendations for changes to plant design and operating practices to minimize the risks of the hazards.
- To assist in implementing the recommendations.
- Auditing the implementation program to ensure the recommendations had been implemented and would achieve their risk management objectives.

<u>Phase 2 – External Production Assurance</u>

- Assess their long-term outage risks.

- Develop actions to reduce the long-term outage risks.
- Put the actions into a prioritized program of work for implementation, to ensure they implement the most cost effective actions with produce the greatest risk reduction benefits first.
- Develop an "External Assurance Statement" which they could share with the clients to rebuild their confidence.

It should be noted that Phase 1 was completed prior to restarting the plant, and Phase 2 took place once the plant had been restarted. The paper briefly describes the two phases of work and then summarizes the key conclusions.

2. PHASE 1 – INTERNAL SAFETY ASSURANCE

2.1 Study Scope

This study looked at the unit and its operation from receipt of raw material to production of the end product. It excluded the redesign of the equipment that failed (allowing another project team to focus on this activity), but it did consider the new equipment's operation.

2.2 Study Approach

The safety assurance work was undertaken in three primary steps:

- Hazard Identification.
- Implementation of Recommendations.
- Audit of Implementation Program.

The Hazard Identification (HAZID) step used an initial bow-tie session to identify high level risks for the unit followed by a team brainstorming around an FMEA / SWIFT study of the equipment and operating procedures and practices. As hazards were identified their risk was assessed using a risk matrix and recommendations were developed. Based on the ranking the recommendations were split into those two groups:

- Those identified as addressing high risk hazards that must be implemented prior to restart.
- Those that could be implemented after restart.

The HAZID techniques were applied in a standard manner and are not described here. It should, however, be noted that the team was heavily loaded with plant operators and maintenance staff (as well as a plant engineer and technical experts). This bias, in addition to ensuring knowledgeable people undertook the assessment, was key to the rebuilding of the confidence of the unit's personnel. It facilitated:

- Learning with respect to the hazards of their unit, (i.e. generation of knowledge).

- Discussion on hazards among the units personnel as a whole. The personnel on the HAZID team spoke with their colleagues and got their input to the hazards and recommendations.
- Buy-in to the recommendations and increased confidence in the safety of the unit. They knew that all high risk hazards were addressed as they prioritized the recommendations.

Plans were then developed to implement the recommendations. Note that the plan ensured that all high risk hazards were to be addressed prior to restart. It was found that some recommendations could not (for practical reasons) be implemented prior to restart (e.g. because the time for delivery of a new equipment item was longer than the planned time to restart. In these cases alternative short term measures were developed to manage the risks of the hazards. Only after the plant was confident that the hazards were being managed did they accept the plan.

The client was resource constrained, and DNV assisted with the implementation of recommendations to help ensure that they were completed prior to restart.

Prior to restart DNV personnel, independent from the implementation assistance, undertook an audit of the implementation work. This audit reviewed the implementation of all the recommendations targeted at the high risk hazards (and hence scheduled for completion prior to restart). It verified that:

- Recommendations had been implemented by visual confirmation for new equipment installed, interview confirmation of training / learning with operators, etc.
- Where recommendations had been modified, for say practicality reasons, that they still managed the risks of the targeted hazards.
- Where it had not been possible to implement a recommendation prior to restart that alternative effective risk management measures were in place and would be maintained until the longer term solution could be implemented.
- There was a plan in place with a reasonable / practical time schedule to implement all the recommendations from the Safety Assurance Assessment.

2.3 Results

The outcome of the safety assurance work was:

- An intrinsically safer unit.
- Improved operating procedures and practices.
- A work force that was more knowledgeable in the hazards of the unit and how to manage them.
- Unit personnel confident in the safety of their unit.
- Plant management willing to restart the unit, as they knew they could operate safely.

It should be noted that had the audit concluded the recommendations were not fully implemented, then the plant management would have not have allowed the unit to restarted on schedule.

3. PHASE 2 – EXTERNAL PRODUCTION ASSURANCE

3.1 Study Scope

The External Assurance Assessment was limited to events that would directly impact the site where the unit is located. Loss of supply due to events that impact, for example, delivery of the product to the clients was dealt with via other elements of the Company's actions.

A "Long-term Outage Event" was defined as an event that would result in loss of production for more that 60 to 90 days. Normal storage of product would enable supply to clients for 60 to 90 days at current demand levels. Included in that definition was safety hazards to personnel that would cause serious injury or death.

3.2 Study Approach

The assessment undertaken was broken down into a series of tasks and included significant involvement by the company's business and plant personnel. The tasks are shown in Figure 1.

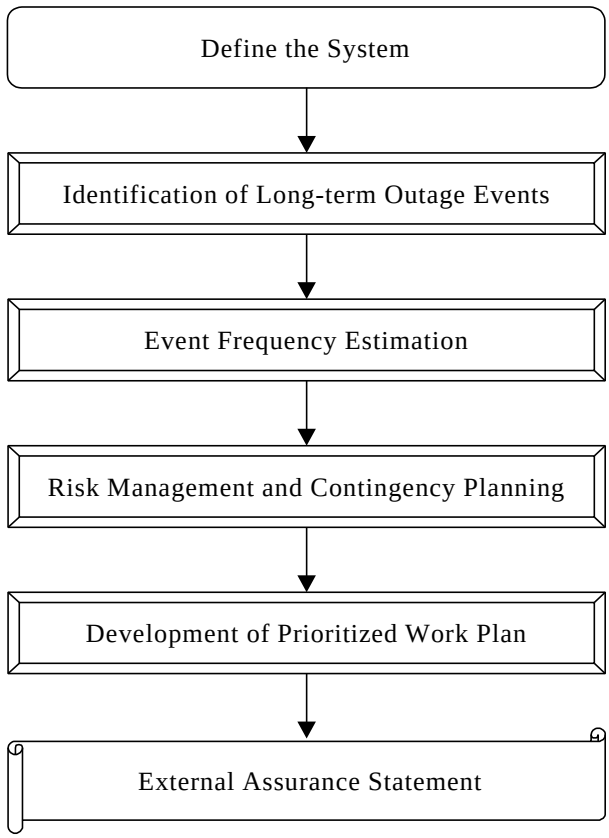

Figure 1 Assessment Approach

3.2.1 Identification of Long-term Outage Events

The first major task was the identification of long duration outage events. This was achieved through a series of Hazard Identification (HAZID) sessions. The purpose of the HAZID sessions was to identify events (failures, accidents, etc.) that would keep the Unit down for an extended period. Types of events considered were:

- Failures of major equipment or other equipment in the unit with long replacement times.
- Failures that had the potential of causing serious injuries or fatalities to plant personnel.
- Process hazards, e.g. fires and explosions, that could damage all or part of the unit, also events that jeopardize the safety of personnel.
- Reasonably probable weather events or other acts of God (e.g. earthquakes, plane crashes, tornadoes, floods, and lightening strikes).
- Utility (internal and external) failures.
- Other events, if any (e.g. labor issues, malicious damage, etc.).

It is important to note that individual personnel safety hazards, process safety hazards, and general industrial hazards (such as scaffolding collapse, vessel and confined space entry hazards, electrocutions, falls, chemical inhalation or exposures from routine handling and routine process tasks) were not the focus of the discussion. These hazards were explicitly covered in a previous Safety Assessment, (DNV, 2001). However, incidents resulting in fatalities or serious injury that could also result in a long duration outage were discussed.

This task was run as three HAZID sessions:

- Equipment failures in the unit or utilities.
- Process events in the unit or utilities.
- External and other event.

The outputs of this task were:

- A list of Long-term Outage Events.
- A list of current safeguards which mitigate against Long-term Outage Events.
- A list of initial ideas to mitigate the risks of the Long-tern Outage Events identified.

3.2.2 Event Frequency Estimation

The objective of this task was to estimate the frequency of the Long-term Outage Events. This was to facilitate the prioritization of the events for the Action Development brainstorming and the Risk Management and Contingency Planning task.

DNV collected data from available sources such as industry databases, DNV's internal library, and the internet to estimate the event frequencies. The data was reviewed with the Company's personnel and where possible, frequency data based on the unit's and the company's experience was incorporated into the analysis.

Frequency calculations were made to reflect specifics of the plant design and how it is operated. This was achieved in discussion with plant personnel, in particular with personnel with knowledge and experience in the design and operation of the unit.

The output of this task was an estimated frequency for each of the Long-term Outage Events.

3.2.3 Risk Management and Contingency Planning

This task was made up of two parts:

1. Risk Reduction Brainstorming.
2. Cost Benefit Analysis (CBA), and recommendation acceptance decisions.

The Risk Reduction Brainstorming meeting included the Company's plant, business and technology personnel and was facilitated and recorded by DNV.

In order of likelihood of occurrence, each Long-term Outage Event was reviewed and measures to manage (mitigate and reduce) their risk were developed. The brainstorming was structured according to a risk management hierarchy of:

1. Avoidance.
2. Prevention.
3. Detection.
4. Control.
5. Mitigation.
6. Corrective Response.

There were many types of measures developed. They included changes in equipment, changes in spare parts strategies, duplication of supply sources, operating changes, etc. For each event and its potential risk reduction measures, the following were estimated:

- The financial impact of the event (e.g. production losses, equipment damage and repair costs, personnel safety and environmental costs, etc.).
- The way in which the measure would reduce the risk and its potential effectiveness.
- The cost of implementing the measure (capital, one off expense and ongoing operating costs).
- How long it would take to implement (or get up and running) the measure.
- Who / what resources would be involved in and responsible for implementing the measure.

After the meeting the Cost Benefit Analysis was undertaken. The risk reduction and the cost effectiveness (i.e. the Return On Investment (ROI)) of each risk mitigation measure was evaluated. The analysis had many interactive complexities to account for; in many cases there was more than one measure mitigating an event, and there were several measures that mitigated more than one event. The risk reduction effects of the measures and cost benefit calculations were setup to account for these complexities.
The outputs of this task were:

- A list of potential risks management measures.
- The risk reduction achieved and the cost of each measure.
- The cost effectiveness of each measure.

3.2.4 Development of Prioritized Work Plan

The Company's plant and business personnel reviewed the list of potential measures to decide which to implement. In their decision making, they took into account the risk reduction effectiveness and cost effectiveness (ROI) of the measures. The Company decided to implement 58 out of the 66 potential measures identified. All practical measures which produce a ROI, along with several which did not, were implemented.

It was not expected that the Company would take forward all the measure developed in the brainstorming. Some measures were different approaches to mitigating the same event, hence once one was implemented the second was redundant. Others produced such minimal risk mitigation that their costs were clearly not justified.

Having determined the measures to implement, a plan was developed that prioritized each measure for resourcing according to their cost effectiveness. In this way the site was able to achieve the most significant risk reductions as early as possible.

3.3 Results

The measures chosen reduce the risk and likelihood of a Long-term Outage Event by more than 90%. They produce a ROI of the 10 to 1, i.e. the reduction in risk is ten times the value of the implementation costs. It is worthwhile to note that the quantified risk calculations took into account hazards posed to personnel by the events identified during the HAZID sessions.

Table 1 Results for Long-term Outage Events

	Current	Future
Likelihood as a % of current	100%	5.3%
% reduction in likelihood	-	92%
Risk	2,390M	174M
Risk as a % current risk	100%	7.3%
Risk reduction	-	2,125M
% reduction in risk	-	93%
Annualizes cost	-	227M

Note that these numbers are presented to show the order of achievement and action commitment. They should mot be treated as absolute and the units are changed from the original assessment.

Figure 2 shows the cost and risk reduction impact of the plan. As can be seen:

- The majority of the risk assessment is achieved within the first 2 years
- The major costs are incurred in the first year and are almost balanced out by the risk reduction achieved in that year.
- There is a ROI achieved in the second (and subsequent) year(s)

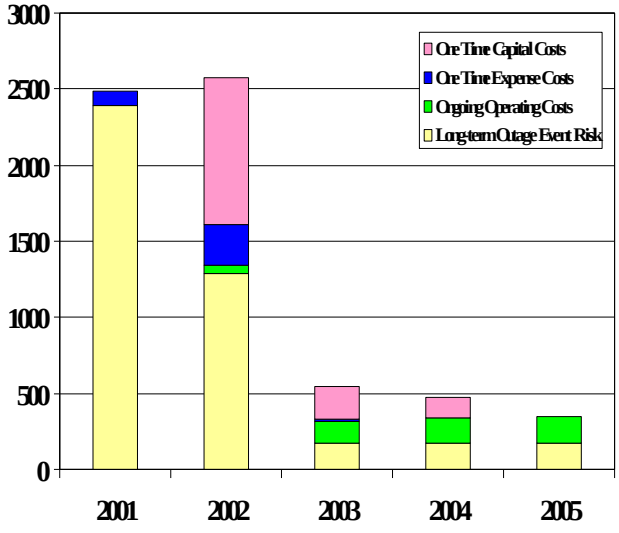

Figure 2 Risk and Investment by Year (for Initial Plan)

A significant portion of the Long-term Outage Events were mechanical integrity/ major hazard incidents. Their outcomes would potentially cause fatalities or serious injuries. The measures implemented, along with the measure from the initial safety studies have helped improve the safety of the facility.

It was also recognized that many of the measures implemented would improve the ease of operating the plant and hence reduce the number of stressful occurrences the plant personnel have to deal with. This reduction in stressful incidents was also seen as producing a safer work environment (although these additional benefits were not accounted for in the analysis).

Based on the work and the Company's written commitment to the plan DNV issued an External Assurance Statement. The Company has shown this statement to their clients to demonstrate that they have / are taking action to minimize the risk of a long-term outage at this unit. This has helped assure their clients of their commitment to, and ability to, reliably supply their unique product.

4. CONCLUSION

In conclusion it can be seen that the Safety Assurance and External Assurance Assessments have positively and cost effectively improved the plant safety level and business reliability for the company. Specifically they:

- Resulted in a unit with an intrinsically safer design.

- Improved operating procedures and practices.
- A work force that was more knowledgeable in the hazards of the unit and how to manage them.
- Unit personnel and plant management confident in the safety of their unit.
- Enhancing the reliability and robustness of production
- Enhancing the confidence of their clients in their ability to provide a secure supply of their unique product. The clients are therefore unlikely to seek alternative substitute products. Hence the Company's business is more robust.
- The Company is able to use the statement as part of their market and sales processes to help ensure new clients assess them as a secure source of their product.
- The site personnel are confident in their ability to supply.

The plant safety has been improved. and the company's business has been positively impacted.

Other key outcomes of the study were:

- The involvement of the units personnel in the work was key in increasing knowledge and confidence.
- The Safety Assurance Audit helped ensure recommendations were implemented within the required time schedule and gave the plant management the verification they needed to commit to restarting the unit.
- Techniques used in safety assessments can be used to aid business improvements.

5. ACKNOWLEDGEMENT

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