

Understanding Precursors to Major Accident Hazard Events Using Safety Critical Task Analysis

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Although the importance of human failures in causing accidents is well known in the Oil & Gas industry, historically the focus has been less on human failures than on technical failures in major accident hazards (MAH).

In order to address this disparity, TOTAL Exploration & Production (E&P) UK (TEPUK) has developed a process to manage the risk of human error across their assets. This is primarily for mature tasks and activities i.e. things that are currently done and have been for some time, as well as new tasks and activities from projects and modifications. This involves developing a robust process to select specific activities where Major Accident Hazard (MAH) scenarios had been identified from the various safety studies. Progress at first has been slow but by developing sound foundations the company has started to show significant benefits in managing human failures within MAH scenarios.

This paper describes progress to date across TEPUK and details how the process has gained momentum by providing dedicated resources to support the assessment process and to facilitate updates to site procedures. This work involves both operators and maintenance technicians in the analysis and site walk- and-talk through of the task. The process has identified safety related risks that were not previously recognised and significant environmental risks, operational risks (equipment damage, process upsets etc) and potential downtime of plant. A key benefit of employee involvement is that employees are actively involved in human error analysis in their day-to-day activities and recognise where human error is critical as well as the true value of maintaining the key recovery systems such as hose registers, locked open/locked closed process, line walks etc.

The challenges along the way include the following points;

- Organisations need to be 'intelligent customers' (ONR Guide 2013)
- A clear and agreed strategy and common methodology as a prerequisite
- Focus on major risks (different to industry approach)
- Closing the loop (from MAH scenarios linked to procedures and through to training & competency)
- Integrating human factors into the business, ensuring that the workforce and management have sufficient knowledge of Human and Organisational Factors (HOF)
- Involving (i.e. beyond 'engagement') the employees (in every aspect of the human factors work-scope; awareness, ownership and accountability)
- Fully integrating the human factors agenda into projects and modifications

This process is very much work in progress however foundations have been developed to streamline the process. A large number of employees are now involved in human factors work-scopes through training, analysis and updates to procedures. TEPUK's focus is to continue addressing high risk tasks which could lead to a MAH across operational sites until these have been fully understood and measures implemented to mitigate issues identified. Only then will there be progress on safety critical task analysis which are identified as medium or low risk.

Keywords: Major Accident Hazards, Safety Critical Task Analysis, Human Error Analysis, Human Factors Procedures.

Introduction and Background

Safety critical task analysis (SCTA) is relatively well known but the practical and effective implementation of the process on an operational site is not as well understood. This paper will give an example of the how Total E&P UK Limited (TEPUK) has approached this issue as well as present some of the benefits and outcomes through our current implementation programme. This paper also describes the strategy adopted by TEPUK to address human failures resulting in MAH events to manage the risk of human error identified in onshore and offshore operating assets.

A TEPUK Human and Organisational Factors (HOF) Strategy has subsequently been developed that enables a consistent approach across all our operational sites whilst meeting the requirements of Total Group Company Rules and the UK Regulator. This strategy focuses on the management of process safety activities and identification of potential interventions in the management of major accident hazards rather than the traditional occupational safety approach to managing human error. This new approach is in addition to occupational safety discipline human factors programmes already implemented across the Company.

For our current project portfolio and modification activities, SCTA was carried out during design as part of the Human Factors Integration Plan (HFIP). This was developed and implemented via the project engineering contractors, continued through handover and now into the operational phase. This process is documented in the company HOF strategy and aligns with guidance provided by OGP 454 (2011).

It was realised from the onset that knowledge of HOF and the application of the new HOF Strategy required some additional training and awareness across the business. An in-house training course was already timetabled within Total E&P but it was a general awareness course for multi-disciplines applied across the entire E&P Affiliate. For us to succeed in implementing this new HOF approach, this course was updated with specific UK site based examples, linked to UK legislative requirements, to the Oil and Gas Industry Step Change for Safety processes and includes best practice and lessons learned from major incidents such as Texas City and Buncefield. This training course is accompanied by a shorter awareness course delivered on site to operator/technicians.

This paper seeks to present practical examples that can be used by other organisations to address human error issues in their management of major accident hazards.

Methodology & Planning - How are we implementing change?

TEPUK has one onshore gas plant at St Fergus built in 1970s with another being commissioned this year on Shetland. Our offshore operational sites are situated in the Northern North Sea, North Alwyn and Dunbar installations and in the Central Graben Area, Elgin-Franklin Complex, Franklin platform and our newly installed West Franklin well head platform (WHP) which came on production in January 2015.

For simplicity, we decided to focus our initial efforts at the St Fergus Gas Plant. The operational team were already aware of the need to improve how we managed human factors, integrating systems into the control of work processes and systems. So this was chosen as our ‘pilot’ site. With hindsight, it may have been easier to integrate this strategy into the project stages of the new gas plant at Shetland. Resources at St Fergus were fully engaged in plant modifications, summer shutdown planning and viewed this additional work requirement as something ‘others’ would do, i.e. HF consultants.

TEPUKs new Head of Safety Engineering saw a need to focus more on HOF in process safety. The TEPUK safety engineering team was a highly competent technical team with little experience of how to implement a new HOF strategy. To ensure this work did not fall at the first base, an experienced human factors engineer was embedded in the safety engineering team rather than the occupational safety department. The role of this Lead Human Factor Engineer was to develop the HOF strategy and establish an environment where it could be successfully implemented across all TEPUKs operational sites. Having the full support of senior management, the HOF strategy was raised in profile and communicated across the company through the implementation of the Company annual SHEQ&I plan. After a further round of convincing, a specific site based HF engineer with the credibility of working at St Fergus for more than 30 years, was established. This has since been identified as a crucial turning point in site based by-in and subsequent ownership of the HOF strategy and associated processes.

The HOF methodology described in the strategy document was to comply with the guidance produced by the HSE in their Roadmap (HSE 2005) for safety critical task analysis (SCTA). This is illustrated in Figure 1. A number of in-house company procedures were developed to ensure implementation of the HOF strategy was consistent across all sites in the future. Although relatively simple, the HSE Roadmap did not have the optimum lay-out nor did it provide the detail TEPUK was looking for to improve the understanding of site based personnel during the implementation phase. As a result, TEPUK produced a more intuitive process flow chart to provide clarity, to add detail where necessary and an explanation of what was required to implement TEPUKs HOF strategy.

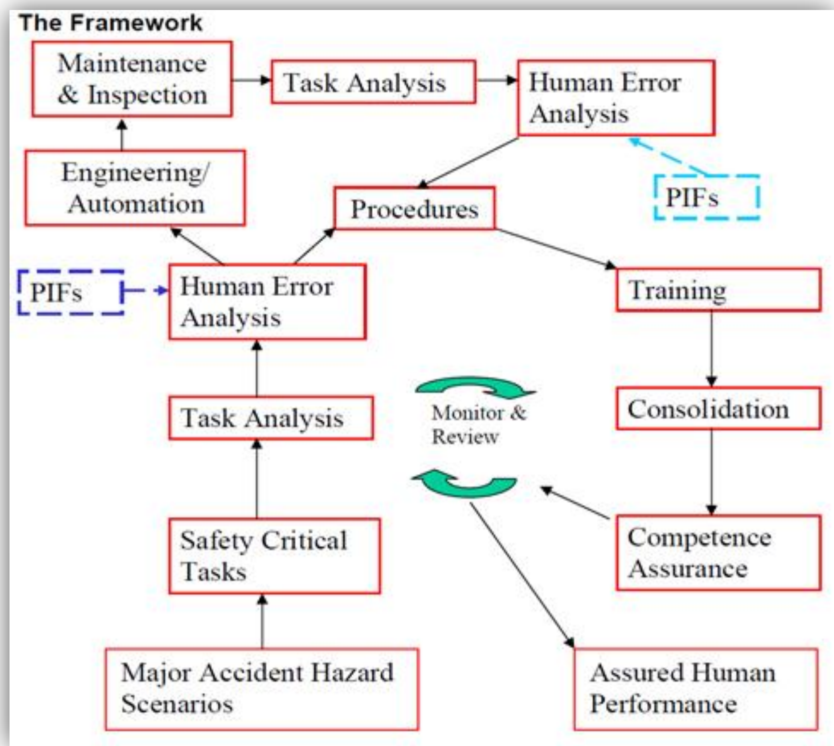

Figure 1: HSE Roadmap

The first step in the HSE Roadmap process, as illustrated in Figure 1, was to identify MAH scenarios where HOF's influence these events or influence the performance of safety critical barriers. Initially, this was thought to be straight forward. However studying the guidance and application of the roadmap process, we found our definitions and detail of MAH scenarios were not clear from a human error point of view and were open to interpretation.

In order to identify MAH scenarios in a robust and consistent manner, TEPUK held a series of workshops over a period of 6 months. These workshops included safety engineers with experience of major accident hazard scenario identification to develop and test the proposed methodology assuring ourselves it was appropriate for the Company.

The output of the workshops influenced the HOF strategy and formed part of the overall safety critical task analysis process. The following is a summary of the process adopted, with detailed illustrations, see Figure 2 and Figure 3.

Safety Critical Task Analysis (SCTA) Process

The SCTA process was divided into two manageable phases. The initial Phase 1 (steps 1.1 – 1.9) focused on information gathering to assure all the MAH scenarios from a human error point of view had been identified and a list of safety critical tasks compiled, categorised by their impact on prevention, control and mitigation barriers.

Phase 2 (steps 2.1 – 2.8) concentrated on education and improvement in understanding of HOF which then allowed the screening of safety critical tasks affecting each prevention, mitigation or control barrier and subsequent human task/event analysis to take place. The outcome of these two phases was a knowledgeable workforce with the capability to identify safety critical tasks related to MAH prevention, control and mitigation barriers in their routine and non-routine operational activities.

Phase 1: Information gathering and safety critical task (SCT) identification (refer to Figure 2)

- Steps 1.1 – 1.4: Collation and Interrogation of MAH Information

A review of existing MAH related information and identification of gaps in this initial MAH list were the goal in these initial steps. To assure ourselves that the list of MAH scenarios identified were correct, a series of workshops were held at St Fergus to identify major accident hazards across all designated plant areas on the operational site. These workshops involved relevant stakeholders, mainly operations and maintenance personnel supported by safety engineering reviewing the information in the site COMAH Report and corresponding safety studies, specifically the QRA and site HAZOP, the process controls in place and relevant reported incidents. The output from these workshops resembled a "bow-tie diagram" where the hazard initiating events (involving human error) that impacted prevention, control and mitigation barriers were identified for a defined list of MAH scenarios. These workshops were valuable as engineers with intimate site knowledge attended; a crucial step in identifying incorrect assumptions and gaps.

❖ Steps 1.5 – 1.9: Reviewing and Categorising Safety Critical Tasks

The proceeding steps involved a collation of information from the workshops, a review of site based operational procedures and task based work instructions. On first pass, a number of these procedures and work instructions clearly defined the specific tasks needed to complete work scopes. When interrogated further, a number of safety critical tasks were either not recognised or were missing from this information. Also, various assumptions were made about the boundaries of job types, e.g. further analysis found that Control Room Operators had a range of tasks that involved more critical operations outside the control room than initially thought. Tasks omissions were identified and added to the screening process and subsequent analysis.

The large number of safety critical tasks identified required some form of prioritisation. The workshops were used to map and then categorise the tasks identified as having a higher, a medium or a lower potential impact to MAH prevention, control and mitigation barriers and to their Performance Standards. With finite resources, the focus of the next stage of analysis had to be on those tasks deemed to be higher impact tasks. This simple task prioritisation process was similar to the approach taken by Hill et al (2009) when they looked at human failure in the assessment of MAH risk. In their work, Hill et al set the following rule-set for SCTA;

- **High:** Human Failure Analysis is required.
- **Medium:** Human Failure Analysis is recommended
- **Low:** Human Failure Analysis is not required

However in TEPUK, all tasks identified as being safety critical regardless of their degree of impact, were subject to a human failure analysis in the planned programme of work.

The following illustration provides detail of the specific steps taken during Phase 1.

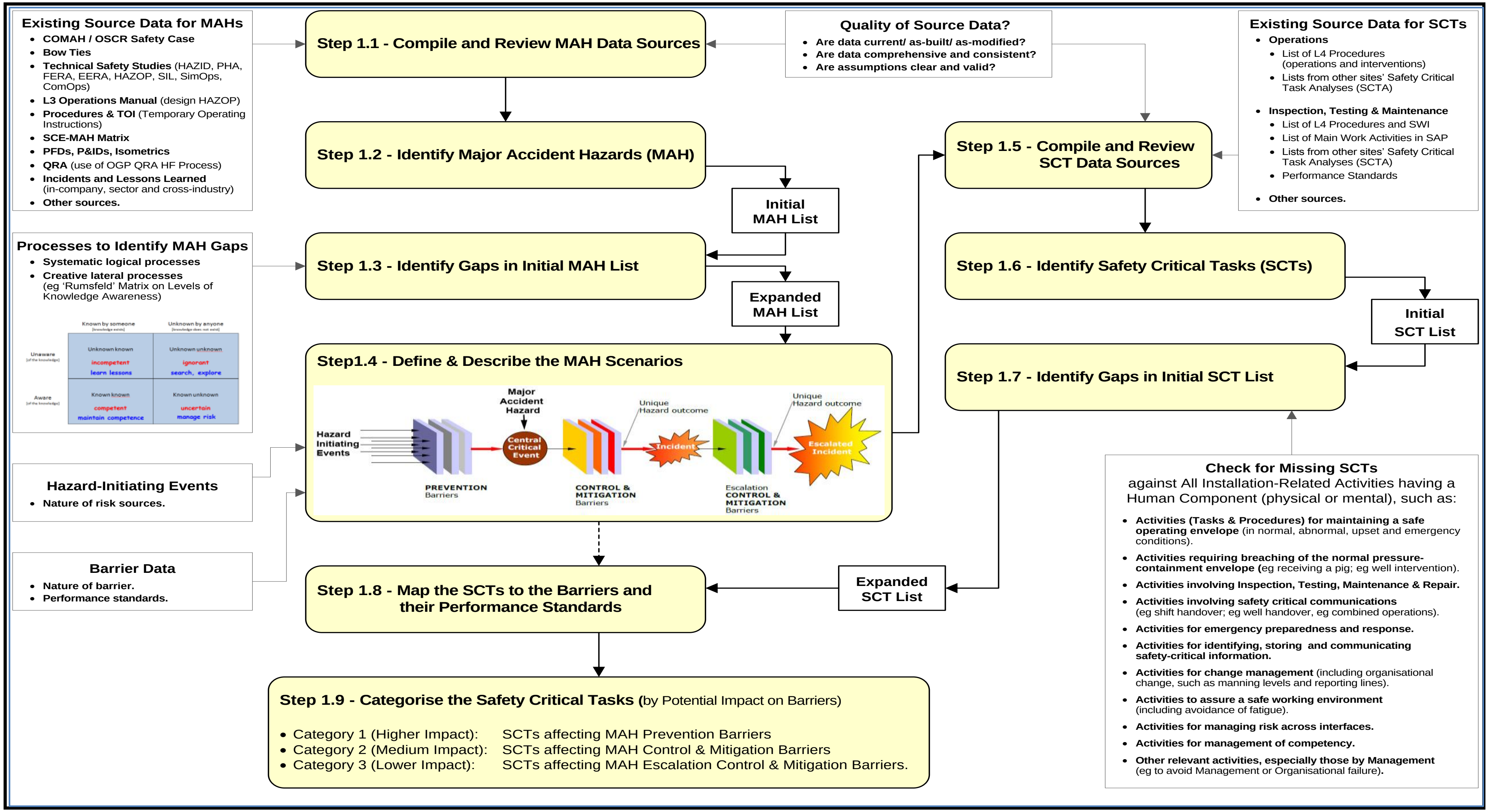

Figure 2: TEPUKs stepped approach to MAH Scenario Screening

Phase 2: Safety Critical Task Analysis and Human Error Analysis (refer to Figures 3 and 4)

To develop a culture where the workforce is constantly aware of the possibility of human failure, TEPUK developed the SCTA process as illustrated in Figure 3. This phase of work involved tasks analysis and human error analysis following standard industry practice as described in Offshore Technology Report – (OTO 1999 092).

The Phase 2 'Old' process describes our initial attempt at implementing a series of steps from a screening workshop, a task analysis and human error analysis workshop that included a HOF briefing, a practical walk through of the operational plant and subsequent revision of relevant procedures. This process was labour intensive, costly and had a significant resource impact on the operational site.

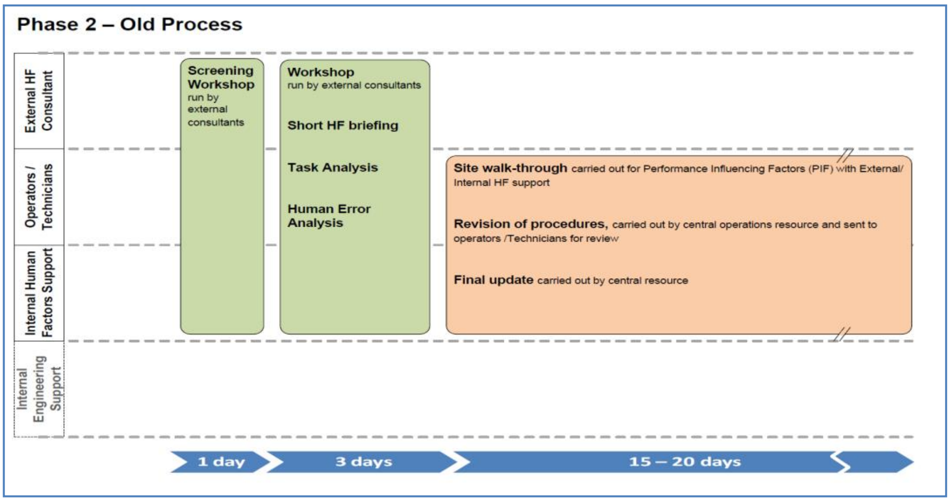

Figure 3: 'Old' Process for Safety Critical Task Analysis

The use of HF consultants in this phase of work was essential to help us understand and clarify the steps we needed to take. As we progressed through these workshops, our increased knowledge of the process led us to revise our approach and implement the 'New' process for SCTA as described in Figure 4.

The use of a simple software programme removed a tedious amount of administration allowing more efficient use of time. This was spent reviewing tasks in more detail with Operators, Engineers and Technicians. The emphasis moved to an increase in employee involvement instead of relying on external consultants and human factor specialists to drive results.

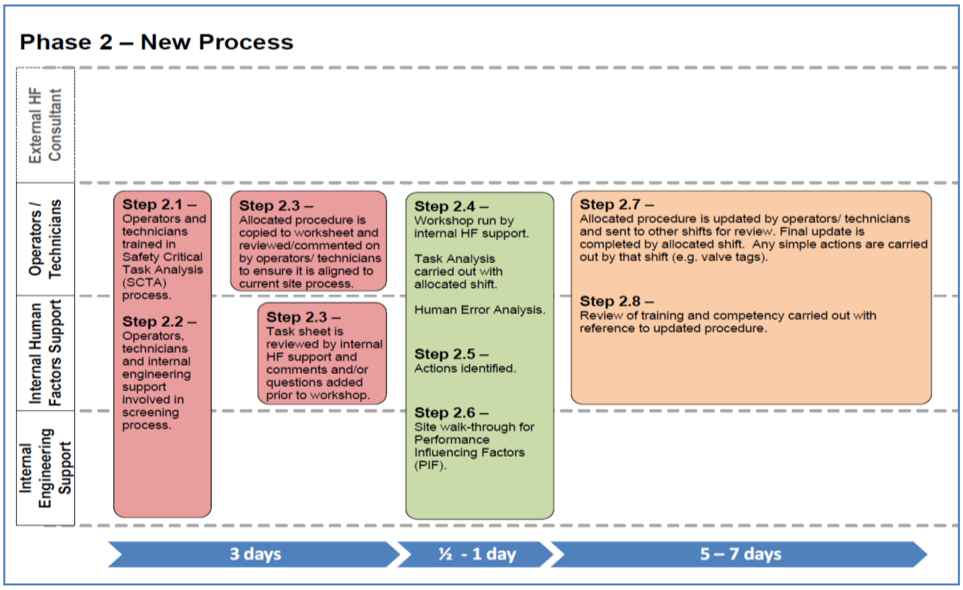

Figure 4: 'New' Process for Safety Critical Task Analysis

One of the incentives for moving to the new SCTA process was a time saving of 50%. Instead of taking 24 days (in total) to deliver results, the new process was delivering results in 11 days. This was primarily down to cutting out a number of steps which involved sending data to an external HF consultant for initial review, then resending information to the consultant for additional categorisation, post workshops. The change occurred as site based operators, engineers and technicians, having a more comprehensive understanding of how the plant processes, were in a better place to judge task criticality.

❖ STEP 2.1: Training and Awareness

We learned from Phase 1 that instead of diving straight into workshops, we needed an audience who were comfortable with HOF terminology and methodology. The 2 day TEPUK HOF course facilitated by an external consultant and TEPUKs Lead Human Factors Engineer was found to be essential if we were to be successful at obtaining supervisor buy-in. Not everyone was available for this length of time away from their busy schedules, so a 2-3 hr awareness session at site was introduced. These awareness sessions communicated the intent of the HOF strategy across the site very quickly, allowing everyone to 'speak' about HOF with a degree of understanding.

❖ STEP 2.2 – 2.3: Screening and Alignment Process

During the more detailed screening process, site personnel identified around 50 procedures in the management system that were no longer required having been superseded by other procedures or drafted for specific one off situations e.g. shutdowns. This reduction in processes allowed the team to focus on those that had a high impact without being over-faced with a barrage of low value information. Each plant shift was asked to look at one high impact task for each shift cycle. The appointment of a site based Senior Operator as the Human Factors Supervisor proved to be another turning point in motivating shifts to review their systems and processes. Using a HEA spreadsheet, the shift reviewed the task activities in a procedure to align with current good practice. The information produced was then reviewed by the Human Factors Supervisor and Engineer to identify anomalies prior to commencing the task and human error analysis.

❖ STEP 2.4 – 2.6: Human Task Analysis (HTA) / Human Error Analysis (HEA) Process

During the HEA process, the team identify and document potential MAH scenarios from human error and existing recovery methods and mitigations. If these recovery methods and mitigations were deemed to be weak then actions were raised in the HEA for follow up.

The actions from HEA were followed up in number of ways depending on severity;

- Where significant risk was found from human error, specific safety studies were required, e.g. HAZOP;
- Where procedural controls were required, **stop/hold points** were added at the specific step in the procedure that highlighted the MAH effect and risk control measures necessary. A counter signature was required by an independent person (Supervisor / Operator) to acknowledge the work team had correctly completed the task activities up till that point, before being allowed to proceed.
- Where an occupational safety hazard was found, a **SHEQ&I note** was added to the procedure to explain the hazard and risk control measure at that specific point in the task.
- Where the consequences of human error involved possible equipment damage, production downtime or business interruption, a note explaining the potential impact was added to the procedure.

Confirmation of the accuracy of the HEA was carried out. Cognisance of Brazier (2013) "the best way to do this is when the task is being performed" was the preferred method however this was not always timely, so a site walk through of the task, involving the shift that was involved in the analysis, was carried out. In both cases, the team was required to bear in mind Performance Influencing Factors (PIF) as detailed by Brazier, A (2003). The HSE also describe PIFs as:-

"Performance Influencing Factors (PIFs) are the characteristics of the job, the individual and the organisation that influence human performance. Optimising PIFs will reduce the likelihood of all types of human failure".

A checklist for the PIFs was developed after reviewing the HSE guidance to ensure a consistent approach was taken by the various shifts, when walking through the tasks on site. This also helped in documenting key findings.

❖ STEP 2.7 – 2.8: Procedure Revision and Competency Reassessment

The procedure being updated looked quite different to the original (post HEA) once the stop/hold points and SHEQ&I notes were embedded and signature boxes highlighted. A review of any additional training and competency requirements were carried out to provide a clear link with the safety critical task. This was another measure to ensure human error was minimised in these key processes.

Results to date: What have we learned?

The implementation of the TEPUK HOF strategy is progressing well across both our onshore and offshore operational sites. It does however rely on a large number of resources. Spreading the work load across shifts has been key to its effectiveness as it is no longer seen to be as intrusive. This change in workforce attitude came once they were comfortable with what was expected of them, their increased understanding of the value of the work, specifically in processes which had become custom and practice but had evolved to include fundamental errors. These fundamental errors could lead to MAHs, to occupational injuries, to production loss and ultimately business impact. Without the detailed screening of tasks, front line operators or their supervisors had not been fully aware of the issues relating to these MAH scenarios.

The safety critical task screening process has evolved over a number of separate workshops. This iterative process has significant value, although the first few workshops proved to be hard going. For St Fergus Gas Plant, the shift teams identified a total of 131 operational activities (in detailed procedures) associated with safety critical tasks affecting the MAH barriers. After the screening process, the categorisation in Table 1 was achieved. Contrary to our initial belief only 33% of the processes were categorised as having a high human error impact on our barriers.

Category 1 (High)	43
Category 2 (Med)	52
Category 3 (Low)	36
Totals	131

Table 1 – Results from safety critical task screening

To address all 131 processes, TEPUK has implemented a longer term work programme. Whilst it would be beneficial to tackle these as quickly as possible, we needed to take into account essential work scopes at site, e.g. summer shut downs, etc. Figure 5 shows an overview of the steps and expected completion of the programme.

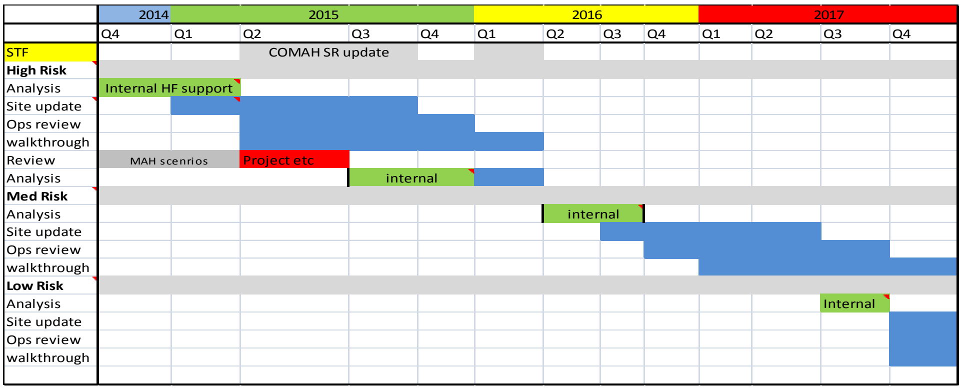

Figure 5: High level summary of the HOF implementation programme at St Fergus Gas Plant

While conducting the HEA it became apparent that a number of key recovery systems were critical as mitigation for potential human error in routine and non-routine activities. By understanding the consequences of human error in our MAH scenarios operators/technicians had a better appreciation of the importance of these recovery systems. The main recovery systems currently highlighted as important at site are:-

- Locked Open/Locked Closed (LO/LC) Register
- Flange Management
- Line Walking
- The Role of Supervision
- Control of Work System (as linked to safety critical tasks)

Once reviewed, an audit and assurance protocol was developed for these systems to assure they remain fit for purposes. They have also been included in the site audit programme to ensure they are maintained and applied consistently across the shifts. The periodicity of audits is linked to the impact these recovery systems have on the potential for MAH scenarios to occur and forms part of the overall management of risk reduction.

Key learning points are;

- ❖ Organisations need to be intelligent customers
  - Provide relevant training and awareness to a broad section of the workforce before implementing a HOF strategy. Thereafter, use the knowledge the workforce has to ensure successful implementation. The use of HF consultants was essential but as the workforce gained confidence through increased knowledge, less reliance on them resulted in greater workforce ownership and cost savings.

    Note: Consultants used prior to the employment of the TEPUK HF Engineer attempted to introduce SCTA but due to their lack of specialism in HOF, this was unsuccessful and costly.
- ❖ Have a clear HOF strategy and a common methodology for implementation
  - Over the past 5 years or so, a number of external consultants were used to help address human factors issues. With no common process to guide and inform their work scopes, what they were asked to develop was not consistent across the all TEPUK assets.
  - For the Safety Critical Task Analysis process to be successful, the process must have clear linkage to activities on site.
- ❖ Focus on the Major Accident Hazards
  - The real value from this HOF strategy is obtained through the screening and categorisation of the hundreds of activities related to their affect on MAH prevention, control and mitigation barriers. These are described as critical barriers by Kirwan (1992).
- ❖ Close the loop (from MAH scenarios right through to training & competency)
  - Detailed documentation is needed to manage higher impact tasks and must fully align with the actions identified in the HEA. The link to training and competency for that task is essential to 'close the loop'.
- ❖ Actively involve the workforce
  - Previous HOF work was restricted to desk top studies due to lack of access to site based personnel. Whilst informative, these were largely ineffective in understanding how tasks were actually carried out at site.

HOF Strategy Implementation Outcomes

This process has produced valuable results and a number of benefits not initially foreseen:-

- Identification of possible MAH scenarios (including environmental events) that could be realised due to a single operator error;
- Reduction in the number of procedures in conjunction with a reduction in non value adding content and ambiguous statements;
- A clear common understanding of the high criticality tasks within the context of the HOF strategy;
- Streamlining of processes leading to a reduction in production downtime due to errors or removal of operator checks having little if any value.
- Identification of possible process upsets, equipment damage and subsequent business continuity issues as a result of human error in order that suitable mitigation can be put in place to minimise impact;
- Provision of clear audit and assurance priorities with emphasis on high criticality tasks and recovery processes;

- Renewed focus on service and equipment vendors who are contracted to carry out safety critical tasks on TEPUKs operational sites.

Conclusions

It is too early in the implementation of TEPUKs HOF strategy to say how successful this work has been. However, the initial outcomes at St Fergus Gas Plant have been sufficiently positive to attract the support of TEPUKs Senior Management. If St Fergus can be classed as a 'pilot' for this work, then the engagement and motivation of the workforce to implement value adding improvements throughout routine and non-routine operational activities, has encouraged our other sites to take notice. A direct outcome is that plans are in place this year to roll out the HOF strategy and implementation of the SCTA process across our Northern North Sea offshore assets (North Alwyn and Dunbar). TEPUKs new gas plant in Shetland has already bought into the strategy and has begun to implement it throughout the remaining project stages prior to handover to our operations teams.

A large number of employees have attended HOF training and awareness sessions and more are planned throughout this year. The sustainability of this training may need to be reviewed, as relying on in-house personnel to deliver training packages can be jeopardised due to low availability, them moving to a different position in the organisation or in fact, leaving the company.

Until the identified high criticality tasks have been adequately controlled, progress on those tasks identified as medium and lower safety critical risk will be slow, i.e. over a few years not a few months. The appointment of a site based HF Supervisor at St Fergus has made a considerable different to the attitude of people on site, so we are hopeful that we can be more proactive and condense this 4 year programme somewhat.

This whole process is very much work in progress but the foundations for success have been implemented. We have developed the strategy based on good industry practice from work previously carried out by the HSE, by recognised HF consultants (e.g. Brazier, A, 2003; Kirwan, 1995) and from experienced operational personnel within our organisation. The key to continued success for us is establishing ownership of the HOF strategy at each site and embedding good HOF practice into our routine and non-routine activities. If we can continue to attract interest from the workforce in this work, we can influence the HSE culture, so HOF thinking specifically targeted at major accident hazard recognition becomes habitual; an aspirational but achievable goal.

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