Using Human Factors risk analyses to develop risk-informed competence standards

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Competence management within the process industries has traditionally centred around role-specific training and development pathways. Individuals progress through training programmes designed to equip them with capabilities commensurate to the operational and managerial roles to which they are exposed during their career.

It is important for industry to maintain consistent training standards with an appropriate focus on general process management and process safety. However, it is becoming increasingly apparent that competence management systems which focus solely on generic or role-specific training may be failing to equip candidates with task-specific knowledge and understanding which is essential for safe process control.

The UK Health and Safety Executive promote the integration of Human Factors (HF) within safety management systems by means of the HSE Human Factors Roadmap. The Roadmap outlines the importance of linking HF risk assessment activities to tasks with the potential to either initiate major hazard events or enable recovery from, or mitigation of, those events should they occur. If applied properly, a thorough approach to HF risk assessment provides improved verification of process control and process safeguarding. However, insights gained from such work also provide the opportunity to identify task-specific knowledge and capabilities which are vital for process safety. Identifying training needs in this way ensures that competence standards, which have a basis in HF risk analyses, are more directly linked to the control of the specific MAH tasks which operators face on a daily basis. This paper describes a process for using HF risk analyses to identify task-specific knowledge and skill demonstrations which can form the basis of competence standards for safety-critical activities.

Traditional views on competence management

Competence management is a complex issue for the process sector. Maintaining the competence of a workforce which is exposed to a wide and varied set of processes and hazards is challenging, this can be further complicated for multi-site operators who must manage not only the hazards encountered on different facilities, but may have to do so under the umbrella of group or corporate standards and procedures.

Traditional approaches to competence management within the major hazards sector focus on the development of role-specific competence standards which, where possible, align to company-wide training and development pathways. For example, the COGENT model for training and development refers to competence standards being influenced by the task-specific, role and company-wide (i.e. group policy) knowledge that operators need to progress within an organisation. Reference is also made to the importance of aligning competence against nationally recognised occupational qualifications.

In terms of development of the competence standard COGENT outlines how safety-critical tasks should act as a basis to ‘determine the practical, technical and behavioural skills, the organisational and legislative knowledge, and the level of expertise to perform the task competently’ (Cogent, 2012). However, while the guidance refers to safety-critical tasks, there is little explanation as to how these tasks should be used and assessed to identify training needs. An example (illustrative) training matrix provided within the Cogent publication presents, what appear to be, a series of very general role competencies. (See Figure 1)

An example of a competency /role matrix based on Cogent Gold Standards	Process Operator Chemicals	Process Technician Chemicals	First Line Supervisor Chemicals
TECHNICAL			
Process Operations			
the individual can work safely to...			
prepare to start up a process	√	√	
start up a process	√	√	
monitor and maintain a process	√		
complete/shutdown a process	√	√	
control and monitor a process and resolve problems		√	
additionally an operator can...			
handover the process	√		
maintain product quality	√		
clean and prepare items of plant and equipment	√		
support the maintenance activities on the plant and equipment	√		
manage materials into and between production stages and separate & dispose of by-products and waste as appropriate	√		
additionally a technician can...			
respond to process problems		√	
plan to and maintain product quality		√	
support the maintenance activities on the plant and equipment		√	
handover the process		√	

Figure 1 – Screenshot of an illustrative training matrix published by COGENT[1]

[1] Guidelines for competency management systems for COMAH sites (2012) – Example of a competency/role matrix based on Cogent Gold standards. Screenshot (P.43)

Figure 1 illustrates the type of tasks that could form the basis of a training and development programme: - ‘Prepare to start-up a process’, ‘start-up a process’, ‘handover a process’, ‘clean and prepare items of plant and equipment’. These are obviously general categories of task which would be tailored to the processes and equipment for a particular operational site. However, this screenshot outlines the relatively high level of detail advocated by the Cogent approach to competence management.

From a management perspective, it is important to have some categorisation of role-specific competence requirements such as this (I.e. a site must know that an individual in control of a process can undertake each of these operations successfully). However, from a human factors perspective, the reliability of higher-level competence standards such as this is questionable. In particular, it is uncertain whether this approach captures many of the task-specific features of process control which may be associated with MAH events.

It is the experience of the authors of this paper that many major accident hazard sites implement competence management systems which are heavily driven by such matrix approaches to training and development. Such systems involve the development of training matrices which outline the operational tasks, site instructions and operational policies which are specific to the various job roles within the organisation. The matrices are then used to track operators’ training and development. Often confirmation that training has been successful is the basic verification that an operator has successfully carried out the various activities within the matrix a prescribed number of times. Occasionally there will be additional theory testing associated with these operational tasks. However, in many cases, it is unclear how such testing has been developed, whether it focuses on areas which are critical to MAH control and whether the assessment and verification process is task-specific.

Therefore, a multi-site operator may have a competence matrix for operational staff which includes, for example, ‘Pigging and pig-removal’. This training may cover the general principles of pigging operations which are common to several operational facilities, however it will not detail the specific operational differences associated with pig trap systems on different sites and it may not test whether a candidate understands the key safety-critical features of the specific pig trap(s) on their site.

Matrix-based training such as this offers the potential to verify an operator’s exposure to operational tasks. However, unless a reliable method is used to develop training standards, and tailor generic standards to align with local site facilities and processes, then this approach to competence management may not verify in any detail an operator’s awareness and understanding of site-specific tasks, hazards and equipment to which they are exposed on a daily basis.

This presents one of the problems with traditional approaches to competence management. While it is important that operators can safely control a process (I.e. they can competently undertake the types of activities that Cogent outline in Figure 1), it is equally important that operators understand site specific hazards, risks and safeguards and that there are systems in place to verify and maintain that understanding. It would seem that traditional approaches to competence management place too much emphasis on the former at the expense of the latter.

In some respects, it is understandable how such a situation arises. Process industries are complex, managed by means of a multitude of tasks, procedures and company policies and standards. From a corporate perspective there is a potentially overwhelming wealth of information which can be used for site-specific training and development. The development of generic training standards utilising company training matrices is one means to overcome this hurdle.

However, the advent of greater incorporation of human factors (HF) within process safety management presents an opportunity to redress this balance. Human factors analyses, which focus on process control from the perspective of the operator, examine controls and safeguarding differently to traditional engineering approaches. The focus is on the operator’s interaction with the process and, in particular, their knowledge, understanding and capabilities. This can bring new and improved insights regarding process safety which, if incorporated into to the development of competence standards, can help ensure that training is better tailored to reflect the day-to-day realities of process control.

HSE guidance for development of competence standards

Between 2012 and 2015 the UK Health and Safety Executive (HSE) carried out a targeted competence management inspection campaign for COMAH operators. This was driven by an Operational Delivery Guide for this topic (HSE, 2011). The aim of this work was to verify how coherently competence was being managed by MAH operators. While the inspection campaign which this guide was intended to support has now ended, the principles of the guide remain relevant.

The HSE delivery guide outlines the expectation that competence management systems will be focused on verifying task-specific knowledge and capabilities and that procedures would be central to the process for developing competence standards.

Essentially the HSE expectations for competence management are:

1. Competence standards exist for safety-critical tasks and these are informed by relevant findings of risk assessment activities.
2. Operators have the requisite level of knowledge regarding MAH processes and controls.
3. Operating procedures for safety-critical tasks are available, accurate (i.e. reflect the true realities of the task) and there is evidence that they are being followed.

4. Plant and equipment design facilitates adherence with the operating procedures.

This approach to inspecting competence standards, which focused on risk assessment, procedures and plant and equipment design aligns closely with HSE guidance on the integration of Human factors within MAH process management. This guidance is described in section 3 below. Section 4 of this paper outlines the use of this approach as framework for the development of competence standards.

HSE approach to HF integration – achieving risk informed competence standards

The HSE roadmap[2] presented in Figure 2 introduces how human factors can be integrated into the process safety risk analysis process.

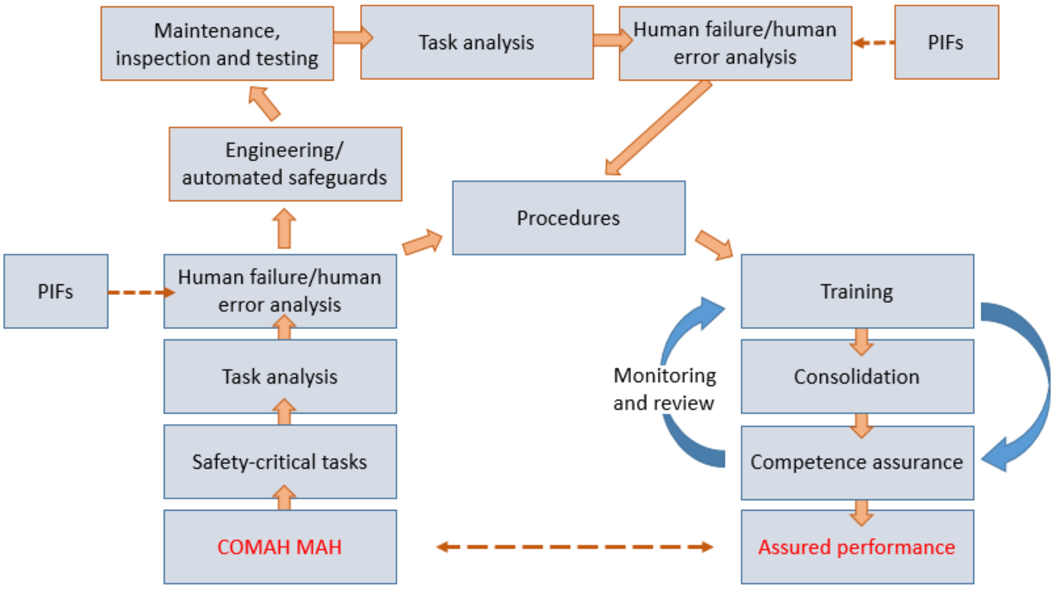

Figure 2: HSE human factors roadmap

The roadmap outlines a systematic process whereby HF risk analysis activities stem from site COMAH Major Accident Hazards. If the HF roadmap is followed to completion, competence management represents the final phase of a logical process of risk analysis which has been focused on the key site hazards (I.e. the site MAH scenarios). It is therefore worthwhile briefly introducing the key stages of the roadmap and explain how competence management fits into this model of HF integration.

Identification of safety-critical tasks

The starting point for this process is a full review of a COMAH site's Major Accident Hazard (MAH) scenarios for the purposes of compiling a safety-critical task list for that facility (See, Energy Institute, 2011). This list (which is likely to comprise operational, maintenance and emergency response tasks) forms the basis of the subsequent HF review work, where the tasks which have been identified are prioritised for the subsequent programme of task and human error analysis.

Task and human error/human failure analysis

The first step in the HF review process is to carry out task and failure analysis of the safety-critical task identified for review. There are a variety of task and failure analysis methodologies available. However, the methods which have been utilised as part of this work are Hierarchical Task Analysis (Kirwin and Ainsworth, 1992) and the SHERPA failure analysis methodology (Systematic Human Error Reduction and Prediction Approach) (Embrey, 1986).

HTA ensures that a full and complete representation of the safety-critical task is achieved. This is a process whereby the detail of any existing approaches to task completion are verified and, if necessary, challenged. Once established, the HTA is then subject to predictive human error / failure analysis by means of the SHERPA methodology. This allows for the proactive identification of foreseeable human errors which may adversely affect MAH control.

A significant component of this analysis process is the identification of Performance Influencing Factors (described as PIFs in the HSE HF roadmap diagram at Figure 2). These are features of the task which may positively or negatively influence successful task performance. For example, common PIFs often identified on COMAH establishments are poor or absent

[2] http://www.hse.gov.uk/humanfactors/resources/hf-roadmap.pdf. NOTE: This roadmap model has recently been updated by the HSE. The link to procedures and competence has been retained, however the new framework places more emphasis on the implementation of engineered safeguards to address potential human error. However, at time of writing this paper (and at the time when the HSE competence management Inspectors' guide was an inspection priority) the previous roadmap approach was that which was advocated by the HSE. Whilst the emphasis has changed slightly, this model remains relevant to HF integration in the process sectors. The revised roadmap can be found at http://www.hse.gov.uk/comah/guidance/hf-delivery-guide.pdf.

valve and equipment labelling (which may contribute to operators failing to locate critical equipment, or operating the wrong equipment in error), time pressure and distractions (which may result in critical task steps being unintentionally overlooked), environmental factors such as poor lighting (which may affect how reliably instrumentation in the field is perceived), poor plant design and layout (which may restrict access to critical process equipment) or lack of operator knowledge, understanding and awareness (which may result in mistakes). The list of potential PIFs is wide and varied depending on the task, the operating context and the individual site conditions. Underlying management and/or organisational priorities can also influence how tasks and processes are carried out and often this alone can have significant bearing on task success.

The fundamental aim of the HF risk analysis process (I.e. task and error analysis) is to identify and rectify factors which may be increasing the likelihood of human failure. Often potential weaknesses in process control / safeguarding are identified and this analysis process presents the opportunity to present recommendations for improvement. Where they are practicable, engineering solutions should always be prioritised.

As can be seem from Figure 2, where task and error analysis has identified the presence of engineered controls, the tasks and procedures associated with the maintenance, inspecting and testing of such safeguards should be subject to an equally rigorous programme of task and error analysis.

HF roadmap – risk informed procedures

HSE expectations for HF integration go further than simply undertaking task and error analysis. The original HF roadmap establishes a link between the aforementioned HF risk analysis activities, procedures and competence standard development. If, during the HF analysis process, task analysis has been carried out with an appropriate degree of rigour, this can effectively translate into a revised operating procedure for the task. HTA has been used to develop a complete and logically structured representation of the task. This detail is, in effect, the written description of the task and can form the basis of any revised procedure. Finding the correct level of procedural support for the demands of different operational tasks can be a complex issue. However, the outputs of the HTA do at least provide this opportunity. (Embrey and Marshall, 2016).

HF roadmap - competence standards

The final link in the HF roadmap is development of competence standards and the ongoing maintenance and verification of operator competence. If undertaken correctly, significant time and effort is likely to have been committed to the HF risk analysis process. Insights are often gained during this work which highlight weaknesses in current operator training and development (I.e. gaps in process knowledge and understanding) or have the potential to improve training programmes (I.e. provide new insights regarding process control which could be used to augment training packages). A more complete explanation of the process of using and developing this information is provided in section 4 below.

Using the risk analysis process to develop risk-informed training standards

HF risk analysis – composition of the review team and information transfer

Ideally the review team would comprise a facilitator (with in-depth expertise and understanding of the HF analysis methodology), at least one front line operator or task expert (with extensive experience and understanding of the task under review), a process safety practitioner with background understanding of relevant process controls and process capabilities) and a member of the site safety/compliance team (who should be integral to site risk analysis activities and any decisions made on the findings/outcomes of such work).

One of the key benefits of the HF risk analysis process is that each of these individuals often provide different insights regarding process control. For example, front line task experts can often clarify the correct method of task completion and/or describe problems associated with the task (I.e. performance influencing factors), while process experts/members of safety or compliance teams can assist in any judgements relating to the consequences of task failure, explain the purpose and function of current safeguards and/or comment on the viability of proposed additional safeguards.

This team composition and the subsequent sharing of information can often identify gaps in the knowledge of the respective parties. For example, an operator may be unfamiliar with the purpose or function of a particular process safeguard and this knowledge gap is closed due to the input of the engineer or safety expert. Likewise, the engineer/safety expert may have previously been unfamiliar with certain operational challenges associated with undertaking a task in a previously prescribed manner which is clarified by the operator. Often it is this exchange of knowledge which adds important substance to the task review process. It is frequently found that the knowledge which is elicited during these sessions is not formally documented, rather it is tacit or held 'in the heads' of the experienced operators / engineers participating in the review. This may be knowledge which has developed over many years of plant experience (for example awareness of which valves do not fully close during an isolation, understanding of how a process column functions during an upset).

Often, such insights are only formally shared when questions relating to process control are explored during the task and failure analysis sessions. This therefore presents the perfect opportunity to capture these insights or make records of any identified gaps in current knowledge and understanding. The following case study provides an example of how such insights are identified and how this information can be used as the basis of competence standards.

Case study of the process

The following example follows the development of part of a competence standard using the HF risk analysis process. The safety-critical task in question is the connection of a jetty unloading arm for a ship-shore LNG transfer.

The first stage of the process was to carry out a full hierarchical task analysis of the task. This provided a complete (step-by-step) representation of the task. The top level of this analysis is shown below.

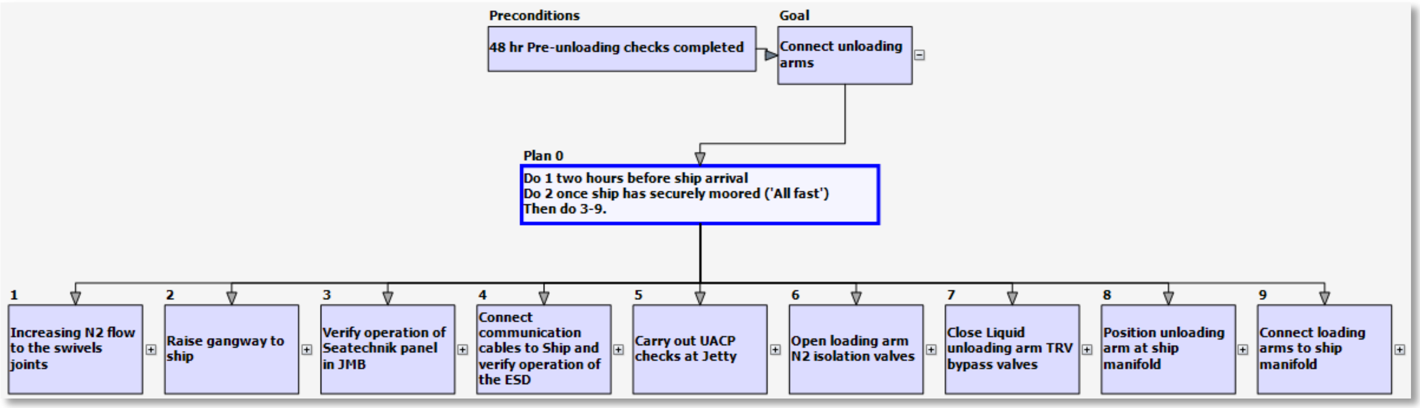

Figure 3 – Top level of HTA

The second stage was to carry out proactive human failure/error analysis. This involved examining each step of the task analysis in closer detail, with a focus on the steps with potential MAH outcomes. The first subtask in the HTA was broken down to the discrete steps as indicted in figure 4 below.

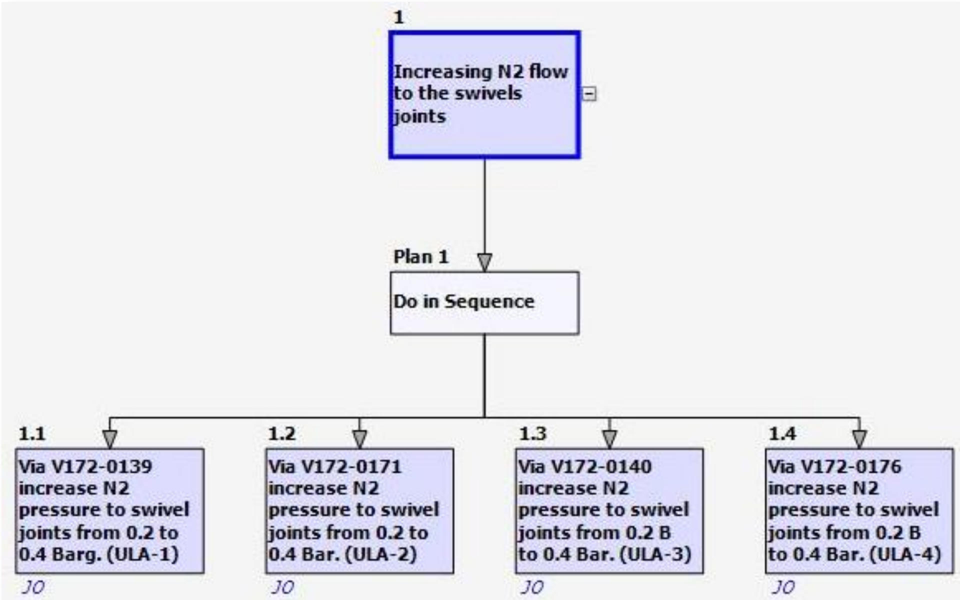

Figure 4 – Breakdown of 1st HTA subtask

Sub steps 1.1-1.4 are identical in their detail, they simply require the jetty operator to separately increase the flow of purge gas (Nitrogen) to each of the four jetty unloading arms. The review team considered this potentially MAH-critical as the act of increasing N2 pressure raises the warm N2 flow across the swivel joints and removes any built-up moisture within the swivel joint. If this is not done, when LNG is subsequently introduced into the unloading arm during the ship-shore transfer, any excess moisture at the joint could potentially freeze.

The review team considered this to be potentially critical as any ice build-up at the swivel joint could restrict movement of the joint (which is meant to articulate freely to accommodate the movement of the ship in the tide) and potentially cause damage to the joint. The very worst case outcome associated with freezing of the joint was considered to be serious damage of the unloading arm with potential loss of containment (LOC) LNG.

This issue was therefore discussed in greater detail when carrying out the human failure/error analysis. The full output of this section of the analysis is shown below (Figure 5).

ID	Description	Failure Mode	Error Description	Consequence Type	Existing Risk Control Measures / Recovery	Performance Influencing Factors	Risk Reduction Measures
1.1	Via V172-0139 increase N2 pressure to swivel joints from 0.2 to 0.4 Barg. (ULA-1)	ACT9 Action omitted	Fail to increase N2 flow to ULA-1	Possible MAH Potential failure to purge all retained moisture from ULA swivel joint. Possible freezing of joint and line damage. Ultimate worst case is LOC LNG	There is a permanent N2 flow which should prevent moisture ingress. (However, may not suitably remove any significant moisture build-up.)	+ve: N2 gauge is clear and accessible -ve: Operation of N2 valves for all ULAs is time consuming. -ve: Evidence that some operators do not understand the process safety reasons for this increase in N2 pressure.	Examine ULA N2 pressurisation. Ensure Ops are given sufficient time for this task. Revisit training and assessment - ensure all operators understand why N2 pressure is increased (even by this relatively minor pressure rise).
		ACT10 Action incomplete	Fail to fully increase N2 pressure to 0.4 Barg.	As above			

Figure 5 - Screenshot of risk analysis of MAH-critical task step

The review team described an emerging issue associated with this task step. The team described a number of instances where LNG offloads had taken place where it was later found that N2 pressure had not been raised prior to the transfer. Follow-up of these events found that the operators responsible for these omissions had simply failed to appreciate the importance of this pressure increase. Operators recognised that there was already N2 flow across the swivel joints (an existing N2 pressure of 0.2 Barg) and, despite the procedure clearly indicating the requirement for an increase in pressure to 0.4 Barg, they assumed that given the pressure rise was only minimal (0.2 Barg increase) that it was a 'nice to have' rather than an essential preparatory step in the unloading arm connection task. One contributory feature (an important performance influencing factor) was that it took additional time for a jetty operator to increase the N2 pressure for each unloading arm, and therefore, several operators had stopped routinely performing this step.

Therefore, the HF review found that the combination of a time-consuming series of steps and a lack of process understanding has contributed to the (frequent) omission of four safety-critical task steps.

This finding prompted greater investigation into operator training. There was no individual competence standard for this task, rather operators responsible for jetty operations receive training in a number of general principles associated with jetty operations. Competence assessment was managed by means of multiple choice question sets and some high-level question and answer sessions with an assessor. (It should be noted that the assessor may not be a jetty specialist so may themselves be unaware of some of these less obvious critical task features.)

The existing competence standard did include a multiple choice question which required candidates to state what N2 pressure an unloading arm should be raised to prior to LNG offload. However, there was no clarification within the training programme as to *why* the N2 pressure increase is important. Operators simply had to learn the answer to the question. Training and assessment was not focused on proving understanding of the process safety implications of this critical task step, it was instead more focused on confirming people were able to undertake the task[3].

During discussion with the review team it became apparent that the reason for the doubling of N2 pressure from 0.2-0.4 Barg is that, even though this is a very small pressure rise, the doubling in pressure doubles the warm N2 flow over the swivel joint. It is this doubling of flow which is critical in the removal of any excess moisture. It was apparent that operators routinely violating these procedural instructions had insufficient knowledge of the function of the process to determine why this is so critical.

This prompted the development of a provisional task-specific competence standard for this procedure. The HF review had exposed a specific (critical) shortcoming in process knowledge and understanding. The task experts participating in the review clarified the importance of the task step and provided justification (the process safety reasons) as to why it must be carried out in this way. This information contributed to the development of the competence standard. See Figure 6.

[3] NOTE: This was a feature of the Longford gas plant explosion, where operator training was focused on candidates learning the answers to questions to ensure that assessments would be passed rather than the competence assessment being used to verify process knowledge. (Hopkins, 2000.)

Action	Step	Notes and key points	Training and competence requirements		
			Knowledge demonstration	Skill demonstration	Core competence
1. Increase N2 flow to the swivel joints	1.1. Via V172-0139 increase N2 pressure to swivel joints from 0.2 B to 0.4 Barg. (ULA-1)	Possible MAH - Possible freezing of ULA swivel joint. Potential mechanical failure of joint and ultimate LOC LNG. There should be visible increase in flow. This is a liquid unloading arm	Candidate understands the importance of this (minimal) pressure rise to 0.4 Barg. **Reason:** By doubling the pressure (to 0.4 Barg) you are in fact doubling the flow which increases the volume of warm N2 passing across the swivel joints. This will decrease the moisture content, preventing freezing of the joint and maintaining safe articulation of the joint. Although this may seem like a small pressure increase it is essential.	Candidate is observed successfully controlling the opening rate of this valve to achieve the adequate increase in flow rate.	
	1.2. Via V172-0171 increase N2 pressure to swivel joints from 0.2 to 0.4 Bar. (ULA-2)	See 1.1 This is a liquid unloading arm			
	1.3. Via V172-0140 increase N2 pressure to swivel joints from 0.2 B to 0.4 Bar. (ULA-3)	See 1.1 This is the Liquid/ vapour hybrid unloading arm			
	1.4. Via V172-0176 increase N2 pressure to swivel joints from 0.2 B to 0.4 Bar. (ULA-3)	See 1.1 This is the vapour return arm			

Figure 6 – Example task-specific competence standard for connecting of jetty unloading arms

As can be seen from figure 6 the structure of this document mirrors that of the task analysis (which formed the first stage of this analysis process). The document also incorporates all of the relevant risk analysis information which was gathered during the human failure/error analysis.

However, the main feature of this document is the information which populates the 'Training and competence requirements' columns. This is where insights gained from the human failure/error analysis can be recorded and used as the basis for the competence standard. The standard itself comprises three columns: *Knowledge demonstration*, *Skill demonstration* and *Core Competence.* This is based on the recognition that there are potentially three separate inputs into any MAH task-specific competence standard.

The *Knowledge demonstration* is an opportunity to record any specific process, hazard and/or safeguarding knowledge and understanding that a candidate must demonstrate to prove their competence for this task. Ideally the standard should outline the specific knowledge demonstration and provide a clear description of the specific knowledge which is required. This ensures that there is consistency to the training and assessment process – i.e. the same level of knowledge and understanding is verified for all prospective candidates regardless of which trainer performs the assessment. (Consistency of assessment can be a major issue if there are a number of different assessors with varying knowledge, expectations and standards.)

The *Skill demonstration* provides an opportunity to record any specific expectations which must be witnessed in relation to how a candidate physically performs the task. For example, the human failure /error analysis might indicate that it is important that a particular task step is performed correctly (E.g. Carefully cracking open a valve at a high pressure-low pressure interface). This enables a record to be made within the competence standard to ensure that anyone being trained and assessed for this task is physically observed carrying out that step correctly. The skill demonstration helps to ensure that operators not only have the requisite knowledge necessary to undertake the task, but that their physical capability to carry out safety-critical task steps has also been verified. In the case of the above example, an important skill demonstration was that the candidate is physically observed controlling the valve to achieve the correct rate of N2 flow.

Finally, the *Core competence* column allows for a record to be made of any site or company generic training which must be assured as part of this safety critical task. This would be general skills, activities or knowledge which applies to many site tasks/operations including the specific task under examination. Example generic site tasks may be atmospheric testing, making utility connections, making and breaking flanges, venting cavity valves. Such core competencies are expected to be trained and assessed separately as part of general operator training and development. The maintenance of operator competence for such core tasks would be managed separately to any ongoing or periodic retraining and assessment for the specific safety-critical task in question[4].

[4] There is no core competence associated with this task step. However, later in the task there is a requirement for the operator to undertake an O2 test of the unloading arm (prior to the introduction of LNG). This activity to carry out O2 testing was recorded as a core competence for this task (I.e. it is assured by means of general operator training and assessment separate to any specific training for this task).

Conclusions

The HF risk analysis process provides a number of valuable insights and outcomes. Firstly, task analysis ensures a complete and accurate understanding of the task and provides the basis for revised (and improved) operating procedures. Secondly, failure analysis identifies how and where safety-critical tasks can be vulnerable to human error and provides the opportunity to verify the reliability of current process controls, or propose additional safeguarding measures. Finally, the entire process provides the opportunity to identify whether the current approach to competence management is truly training operators to understand and control MAH risks appropriately.

Assuming task and error analysis is carried out with an appropriate degree of rigour it should quickly become apparent whether the current approach to training and development is suitable. Where deficiencies exist, human failure/ error analysis should uncover shortcomings in process knowledge and understanding and/or the capability of the workforce to undertake tasks safely. Once these insights have been achieved is a relatively quick process to develop revised competence standards.

Once developed, these competence standards can be used in two ways. If the task merits a standalone standard due to its length, complexity or importance then this document can, in itself, form the basis of that standard. However, if the task is part of wider set of operations for a job role or process area, then the insights gained from this analysis can be used to augment the more general training and assessment programme for that role or process area. If this activity is repeated for other safety-critical tasks associated with that role or process this will ensure that the full package of training for that role/process area is appropriately risk informed.

Therefore, this process can either form the basis of new competence standards where none already exist or can be used to bolster existing (possibly more general) standards by closing any gaps where task-specific knowledge or capability assessment may be absent.

An emerging problem within the process sector is the issue of an ageing workforce where individuals with significant levels of experience are approaching retirement. When this generation leave the industry, years of accumulated (tacit) knowledge leaves with them. This methodology offers an efficient mechanism for gathering, recording and transferring this knowledge to new generations of the workforce

This method of developing risk informed competence standards which are intrinsically linked to key site hazards provides the opportunity to maximise the investment of resources committed to HF risk analysis activities, maximise the insights gained during the process and demonstrate the rigour and continuity of the process of intelligent HF integration.

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