

Title	Research Report 086: Competence assessment for the hazardous industries
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Executive Summary	<p>BACKGROUND - WHY COMPETENCE ASSESSMENT?</p> <p>Why is competence assessment considered important? Firstly, review of past major incidents (such as the Longford explosion summarised below) indicates that the lack of certain skills or knowledge has led to errors that contributed to the incident. In each case, it had been assumed that an individual with a certain level of experience or training would be competent and/ or that the dissemination of a procedure would be sufficient. In addition, the concern about competence is further increased by the move towards multi-skilling, delayering and downsizing. Staff are increasingly expected to take on a wider range of responsibilities with less supervision. This increases the need to check competence.</p> <p>The Longford explosion</p> <p>The most recent example entails the Esso Gas Plant explosion in Longford, Australia, wherein the loss of oil circulation resulted in the plant getting colder followed by the rupture of a heat exchanger on restart due to cold metal embrittlement. The inquiry concluded that there was ample evidence that operators did not appreciate the dangers of cold metal embrittlement despite being trained about it. The inquiry reports that operators were tested during training modules and that in the event of incorrect answers further coaching was provided. However, after coaching the “re-assessment” comprised asking the operator if they now understood the matter. If the operator indicated they understood the matter it was ticked off. According to operators it took courage to say you did not understand the re-explanation.</p> <p>The Commission found, during questioning, that operators still did not see what was wrong with their answers. In addition, the inquiry found that operators gave answers without actually understanding them. In particular, operators knew the correct answer to a question on the action of a valve was to prevent “thermal damage” but did not know what was meant by thermal damage. They gave the answer thermal damage because that was the answer in the training manual. The assessment tested whether operators could present information received from training back to the assessor, without testing understanding.</p> <p>With the implementation of the Control of Major Accident Hazard Regulations 1999 (COMAH) on April 1st 1999, it is not acceptable to make untested assumptions about staff competence. The Health and Safety Executive (HSE) as part of the COMAH enforcing Competent Authority (others being the Environment Agency and Scottish Environmental Protection Agency) has published guidance that requires “For hazardous events that could lead to a major accident, the safety report should show that risk-reduction measures have been put in place to reduce the risks to as low a level as is reasonably practicable.” This general guidance is made specific to the matter of human performance. HSE Safety Report Assessment (2001) guidelines require that “The safety report should show what measures are in place to ensure adequate performance by human operators, ” Indeed, the HSE asks, in their Human Factors Working Notes for COMAH Safety Report Assessment (HSE 2001), for a competence assurance system that includes the setting of appropriate competence standards, assessment and reassessment. The note also asks that there be a specific link between identified safety critical tasks, roles and responsibilities and a targeted comprehensive management system.</p> <p>Competence assessment is intended to improve accident prevention in the following ways:</p>

- Identify and fill gaps in individual's competencies before they contribute to a major incident;
- The development of standards will provide individuals with a clear view of what competencies they need, and hence should encourage development of competencies;
- The requirement for Duty Holders to set performance standards should prompt them to provide appropriate training and, if incidentally, reveal where unrealistic performance expectations exist for staff;
- Competence assessment may reveal that sub-standard competence is occurring;
- The inclusion of competence assessment within a planned management system should reduce the likelihood of substandard staff performance being overlooked, and indeed help lead to continuous improvement, and;
- The setting of standards and associated assessment of competence should mitigate the pressures arising from organisational change for staff to work beyond their limits.

In addition, a demonstrable process of competence assessment should provide assurance to regulators and other stakeholders that a core aspect of safety case, namely staff competence, is valid. This can be particularly important in the case of older plant, which can fail to meet latterday operability standards and may lack up to date procedures, whose safety is based on the ability of staff to compensate for lower operability standards. It is also an important part of demonstrating the balance between reliance on procedures versus staff competence, i.e. to what extent do tasks need to be proceduralised rather than relying on staff competence?

What is competence assessment?

The question is often asked "What is meant by competence?" Competence is commonly regarded to be the ability to perform the activities within an occupation or function to the standards expected in employment. This definition makes reference to standards. Thus, competence is equated to an ability to perform to the expected standard. Hence, competence assessment entails measuring a person's performance against a standard.

In the context of COMAH competence is the continuing ability of individuals and teams to perform reliably the Major Accident Hazard elements of their roles, responsibilities and tasks, and for this to be demonstrable. Following on from this is the implied need to have a set of competence standards that directly cover the Major Accident Hazard elements of jobs and suitable forms of assessment.

It is also important to note that the definition of competence is outcome-based. It leads to the view that competence assessment entails the collection of sufficient evidence of workplace and / or personal performance to demonstrate that the individual can perform to the specified standard. This definition of competence is important in two respects. Firstly, it highlights the need to recognise the difference between recording a persons experience / training and assessing their competence.

Secondly, this outcome-based view of competence assessment can be compared with the common objectives of selection and recruitment. That is, selection and recruitment processes often aim to predict whether a person has the appropriate underlying characteristics and knowledge for a job. Accordingly they test personality, aspirations, underpinning knowledge and attitudes with the expectation that they will be able to perform competently with the passage of time and appropriate experience and training. Standard selection processes do not necessarily require an individual to be fully competent at the time of appointment. This also highlights the difference between aptitudes and ability, wherein a person

can have an aptitude but may lack the ability to apply it to good effect.

These distinctions are important in the context of COMAH, as it is insufficient to assume that a standard selection process (which often focus on aptitude rather than ability) ensures competence. In addition, in the context of COMAH it is necessary to demonstrate specific aspects of knowledge, such as awareness of operating safety limits, how a process upset may lead to a major incident, what are the major hazards on a site and how may they occur.

Competence assessment as part of competence assurance

Competence assessment should form just one part of a wider competence assurance process, where competence assurance covers the process of training, development of procedures, supervision and other forms of employee assistance. Indeed, the HSE have issued guidance on competence management for the Railways sector (HSE, 2002). This guidance places competence assessment in the context of a competence management system.

Current practice

Review of current practices within and outside the onshore hazardous industries indicates that there is wide variation in the standard of competence assessment. In some cases Duty Holders have developed systematic approaches to competence assessment and even made explicit links between the COMAH safety report risk assessment and competence assessment. In other cases reliance is placed on unstructured on-the-job review.

The most frequent method of competence assessment is that of ‘observational assessment’ by a supervisor or appointed trainer. In some cases the assessment of operators and maintenance staff rely on unstructured peer review, a practice considered as poor by this study. However, in some companies this judgement is guided by the use of validated task descriptions, skill and knowledge inventories, verbal test questions, and guidelines on (for example) the number of times a person needs to correctly perform a task to be deemed competent.

Three of the surveyed onshore companies have used some form of task analysis in order to identify safety critical task and define the correct way of working for use in assessing their staff. Some companies carry out a form of risk assessment to identify safety critical tasks for which they require assurance of staff competence. Assessors can then test a person’s knowledge by asking them how they would carry out a particular task and probe their understanding of (say) the safety function of equipment and key safety procedures. However, two other surveyed onshore companies had no systematic approach for defining tasks.

Also, in the case of safety critical emergency roles, such as control room management of process upsets, there are examples of the application of “advanced” forms of assessment, such as the systematic use of simulator based assessment of decision making and command skills.

Finally, in some cases assessor competence has been addressed by the use of trained assessors.

Lessons from other high hazard sectors

The review of practices in other sectors highlights a number of key points. First, there are examples of competence assessment being managed as part of a cohesive, planned and managed process. In particular, the nuclear sector has developed a process of ensuring Suitably Qualified and Experienced Personnel perform all tasks. A competence – job matrix is used to determine competence requirements for each job against which staff are assessed.

Another example can be found in the aviation sector wherein there is a set of training, experience and assessment requirements for pilot qualification covering initial appointment, progression from one grade to another, transfer between aircraft types and ongoing competence assurance. The range of tasks, experience and knowledge required is laid out in standards.

Finally, the assessment of offshore installation managers, air pilots and submarine commanders provide examples of how to assess the competence of emergency response roles. In particular, these examples entail the use of simulators and exercises based on accident scenarios taken from risk assessments, and the use of behavioural checklists by observers to guide the assessment of performance on “softer” competencies such as delegation, communication, decision making under stress, information acquisition etc.

Comparison of “standard” assessment and safety related competence assessment

In many ways the approach to the assessment of competence in safety critical roles does and should mirror the approach advocated for competence assessment in general. In particular, the concept of collecting evidence of performance, the need to set performance criteria, independent, credible and competent assessors and the use of standards outlining key skills and knowledge are all equally pertinent. However, it is apparent that there are some particular requirements and practices in the context of major accident prevention. These include:

- A need to ensure that the process of competence assessment is managed in a systematic and proactive manner to a standard commensurate with major accident prevention;

High-risk industries tend to place more emphasis on certain methods due to the relative importance of certain types of tasks and the need to provide a particularly high level of competence assurance for safety critical roles. In particular, high-risk industries tend to place more emphasis on:

- The role of risk assessment in identifying competence needs.
- The use of task analysis to identify the skills and knowledge entailed in complex technical tasks;
- The development of techniques, such as the use of behavioural markers to assess “softer” skills such as communication in emergencies;
- Licensing (in the nuclear and aviation sectors) – again reflecting the need for a high level of assurance and very high standards of competence in certain safety critical tasks
- The role of simulators and exercises, due in part to the rareness of emergencies but again reflecting the importance of assessing competence for handling emergencies, process upsets and rare events such as shutdown and start up.
- The need to monitor and maintain competence, in particular recognising the need for skills to be maintained to handle infrequent events and to ensure staff maintain technical skills and knowledge to operate processes and equipment.

Thus, whilst there are many commonalities between “standard” competence assessment and assessment for safety critical tasks, the characteristics of high hazard tasks and the need for a high standard of assessment does mean that specific attention must be awarded to the design of competence assessment for major accident prevention.

Competence assessment advice

In order to develop a process of competence assessment, it is necessary to answer the following points:

- What competencies need to be assessed to ensure that error or sub-standard performance will not contribute to a major accident?
- Are the competence expectations realistic?
- What assessment criteria and competence standards, including what level of performance evidence, are required to ensure risks are As Low As Reasonably Practical?
- What method(s) of assessment are required to acquire evidence of competence?
- What qualifications and experience do assessors need to be credible and competent?
- How often should performance be reassessed, reflecting the level of risk and possibility of skill decay?
- What method(s) of reassessment are needed?

This entire process should be managed proactively as per any aspect of accident prevention.

Identifying safety critical tasks/ jobs

It is envisaged that competence assessment commences with the identification of safety related tasks or jobs using techniques such as risk assessment and task / job analysis. Such an assessment should cover all forms of activity, including normal process operation, process upsets, planned and unplanned maintenance. At this stage the analysis may simply provide a task or activity inventory for which assessment is required in the context of major accident prevention.

Define performance standards

Next, a set of performance standards and assessment criteria are defined. This entails analysing the types of competencies required, describing what comprises adequate performance and defining measurable criteria by which to judge performance. At this stage a more detailed task analysis and / or specification of competences may be required to help develop testable competence standards. The task or competence description should provide a view of:

- The correct way of doing a task (against which a person's performance can be judged), and;
- Key competences (Skills, behaviours and underpinning knowledge).

The task need only be decomposed to a level that enables the production of testable task /competence descriptions.

As befits the task, competence standards tend to cover:

- Skills, such as being able demonstrate an ability to (say) interpret process instrumentation readings, diagnose faults, operate controls, enact a procedure;
- Underpinning knowledge, such as understanding the chemistry of a reaction;
- Safety behaviours and attitudes, such as safety leadership, communication, teamwork.

It is reiterated here that assessment should aim to acquire performance-based evidence that a person can carry out a task, rather than just collate evidence of underpinning knowledge. Thus, standards should denote demonstrable skills and testable definitions of what comprises "competent" performance. Examples of competence assessment criteria are given below.

- Operators involved in emergency response need to successfully carry out an emergency response procedure on three separate accident scenarios selected from the safety case;
- Supervisors must correctly manage an operation, such as removing a hydrocarbon pump, starting from developing the plan of work, specifying a permit to work, instructing staff, monitoring their work, checking pump integrity prior to start up... etc;
- Safety engineers must be able to correctly interpret a piping and instrumentation diagram, identify all (contrived) engineering defects and specify safety devices and engineering modifications as noted in company standards;
- A maintenance technician should be able to recollect all key safety actions required in the isolation of a hydrocarbon pump, its dismantling and restoration.

These may be augmented by “tests” of underpinning knowledge, such as:

- Minimum periods of “observed” experience – taken to be indicative of competent performance;
- Qualifications and training - used as an indication of the level of underpinning knowledge;
- Verbal or written examination of a person’s knowledge and/or attitudes.

Thus, a range of criteria may be devised, each matched to the type of competence (observable skills and behaviours versus underpinning knowledge).

The competence standard may assume or require a certain level of supervision, and hence there may be a scale of competence standards for people of varying competence. This is illustrated by the Institute of Electrical Engineers competency guidelines for use with safety practitioners working on safety related Electrical, Electronic and Programmable Electronic Systems. The standards of competence are graduated for supervised practitioners, practitioners and experts.

It is common practice to use national qualifications as a means of demonstrating skills and knowledge. Whilst this is entirely reasonable it is important to:

- Ensure that the national qualifications cover the specific skills and knowledge required by the site’s processes, equipment and activities, including site specific safety matters;
- Recognise that NVQs by their nature are limited to assessment of on the job performance and hence may not cover infrequent safety critical activities, such as emergency response, process upsets, infrequent maintenance activities etc;
- Ensure that the form of assessment and level of performance evidence collated matches the safety criticality of the processes, equipment and activities.

It is pertinent to note that in some case studies the implementation of NVQs is guided by inhouse assessment of the specific skills and knowledge associated with the site’s processes, equipment and activities. In addition, it should be noted that some organisations have felt that their assessment process has been “NVQ driven” rather than driven by their range of activities. Finally, as NVQs are designed to cover all aspects of task performance, they may include tasks and activities that have relatively little bearing on major accident prevention. Hence, whilst NVQs may assist with the demonstration of safety related competences, major accident prevention may not by itself require completion of the entire NVQ syllabus.

Select assessment method

Once the task and type of competences are understood, an appropriate assessment method can be identified. The method of assessment should provide a valid and

reliable measure of the type of competence in question, such that two different assessors would give similar results. Ideally the reliability of the assessment process would be monitored by review of actual performance, i.e. does the standard of staff performance accord with the results of competence assessment. If sub-standard performance is observed, in contrast to acceptable assessment results, the validity and reliability of the assessment process should be reviewed. In summary;

- Physical / sensory-motor competences can be demonstrated by practical “show me” assessments wherein people either complete the real task or a component of it, such as driving a road tanker to demonstrate steering skills.
- The ability to carry out a prescribed procedure of work can, usually, be demonstrated by a “show me” test wherein you attempt to complete the task.
- Cognitive skills, such as the ability to (say) assimilate process control information from a VDU and thereafter interpret it might be demonstrated by the candidate talking through the interpretation of displayed information. However, such verbalisation may interfere with some cognitive skills whilst it may not be possible to verbalise other cognitive skills, such as mental arithmetic. In these cases post task debriefing of candidates may be appropriate.
- Whilst satisfactory completion of a task that requires the use of knowledge, such as fault diagnosis, may be indicative of underpinning knowledge, it is possible that the correct action was by luck. Accordingly, knowledge tends to be assessed through verbal or written questioning.
- Whilst psychometric personality tests may provide a prediction of interpersonal, team management and safety behaviours, observation of actual behaviour in the real or simulated work setting using behavioural observation tends to provide a more valid measure.

Assessor competence

Assessors should be competent in the process of competence assessment and have adequate knowledge and experience of the tasks being assessed. The level of expertise in assessment should be matched to the form of assessment and the need for the assessor to be credible in the eyes of the candidate. For example, in-house coaching on how to complete assessments may be adequate for “on the job observation” of simple operation tasks, but completion of NVQ units D32/33 may be needed for (say) assessment of more complex operational tasks. In the case of behavioural competences such as team coordination and communication assessors may need to be trained on what comprises “good performance”, what are the behavioural markers and how to gauge performance against these markers.

Ongoing assessment

Finally, ongoing “competence checking” needs are determined by consideration of how competencies may decay over time and the safety criticality of the task. More frequent assessment tends to be required for higher risk tasks and tasks wherein skills may decay sooner. All persons tend to be assessed at least annually in the form of a performance appraisal based on line management observations. People involved in complex safety critical tasks, such as process managers or control room operators, may be appraised more formally every 1 to 3 years. The highest risk tasks may be assessed every six months.

There are a number of considerations regarding the form of reassessment to apply. In the case of infrequent tasks, such as emergency response or response to a process upset, normal day to day work may not provide any opportunities for performance to be demonstrated. In such a case, it may be necessary to set tasks, run simulations or exercises. On the other hand, day-to-day work may provide a

valid indication of performance in the case of routine frequent task, such as road tanker driving. However, there is an additional array of sources of evidence of performance available once a person is in post. These can include:

- Standard SHE audits can cover the performance of safety critical tasks, specifically the level of adherence to safe practices and individual performance;
- The contribution of individual competence to an incident can be assessed as part of the incident analysis process;
- Many companies use behavioural observation schemes that can provide observations of safety related behaviour that can be used as the basis of one to one coaching.
- Peer review: On the job performance can be monitored and appraised by line managers, but this does need to be formalised and systematic.

The latter sources of evidence may compliment more formal forms of assessment.

Responding to sub-standard performance

It is clearly important to have a pre-planned response to the identification of sub-standard performance to enable the company to act purposefully on the results of competence assessment. The response to sub-standard performance tends to vary according to the purpose of the assessment and the safety criticality of the task.

In the case of selection, promotion and recruitment decisions the discovery of sub-standard performance tends not to pose a significant “policy” problem, in that people are simply not appointed to the position and /or are required to undergo further training / experience. Once a person is in post, the discovery of sub-standard performance tends to pose a more difficult challenge. First, it is important to check whether the sub-standard performance arises from omissions in training, supervision or other factors such as inadequate procedures or equipment. If the sub-standard performance is attributed to the individual, there are at least three common responses, namely retraining staff, increasing the level of supervision and placing limits on the scope of an individual’s role and responsibilities. In the case of the most safety critical roles, it is likely that a person will be required to demonstrate competence, perhaps by undergoing reassessment, before they are re-authorised to take on their normal duties again, especially if they normally work unsupervised or are a key decision-maker such as a process supervisor.

Advice on implementation

The following advice on the practical implementation of the ideas in this report was solicited from COMAH Duty Holders during three seminars at which this report was presented.

Given that there are potentially a large number of safety critical jobs and tasks on a COMAH site it is advised that:

- The development of competence assessment arrangements is prioritised by ranking jobs/activities in terms of their safety criticality, and;
- A gap analysis is completed to establish which jobs/tasks are least well assessed, with further work focused on the highest risk jobs/tasks that are least well assessed.

The results of risk assessments completed for other purposes and the listing of major accident scenarios within Safety Reports could be used to guide this prioritisation.

As regards the development of standards and assessment methods it was suggested that Duty Holders could first explore whether:

- More use could be made of existing national vocational standards?
- Current operating procedures could be used in assessing individual competence?
- Assessment could be integrated into COMAH emergency exercises?

As regards the management of competence assessment, advice includes:

- Developing a matrix of jobs and key competencies;
- Create a (computerised or paper) log of assessment of individuals;
- Integrate the audit of competence assessment into the wider safety management audit process.

Conclusion

Organisations operating high-hazard plant recognise that major accident prevention is predicated upon the experience, commitment and competence of their staff, including their contractors. The COMAH regulations and the lessons learnt from major incidents indicate that it is not enough to assume that exposure to training and experience assures competence. There are already examples of good practice in the development and application of competence standards and systematic assessment methods. This study provides a summary of these practices in a sufficiently general way that the diverse range of sites regulated under COMAH can apply.

The main report provides a set of advice, checklists and examples for use by Duty Holders.

Industry feedback on the report

The advice in this report has been scrutinised in detail by six COMAH duty holders and presented for review at three seminars of about 150 individuals in total from COMAH duty holders, representing refineries, chemicals, explosives, gas, power generation, storage and other operations. The advice and checklists in this report take account of their feedback. Additional advice has been provided on implementation, whether tasks or jobs should be the starting point of standards setting, terminology was clarified, the definition of competency was elaborated and advice on where competence assessment fits into wider competence assurance has been provided.

Duty Holders thought that the ideas in the report provide a systematic and demonstrable way of assessing competence, and that implementation of the advice would be an improvement on most Duty Holders current practices. It was stated that “The Assessment guidance is very good”.

Many delegates could identify some examples of good practice in their firms although only a few delegates indicated that their firms consistently followed the advice as a whole. It was also indicated that the advice is consistent with “standard” competence assessment arrangements and hence should be compatible with current industry practice. As stated by one delegate, they were reassured that in some cases “Naturally occurring evidence is acceptable evidence” of competence.

The strengths identified by Duty Holders included:

- The advice can be used generically across industry;
- The advice contains good definitions;
- The approach encourages the analysis of tasks;

- The approach could be audited and is very demonstrable :
 - The approach is more systematic than what firms do at the moment;
 - The approach ties up with NVQs;
 - Very useful, black and white and straightforward
- The main areas of debate comprised the level of resources required to fully implement competence assessment and how to assure the competence of contractors. As regards the resource requirements, it was noted that a programme of competence assessment could be implemented over a number of years, with higher risk jobs prioritised. It was recognised by delegates that the competence of contractors (completing safety critical work) is of equal importance as staff competence. However, researchers and delegates agreed that further thought needs to be given to how best to implement competence assessment amongst contractors.

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