Managing Process Safety in a Decommissioning Project

Michael Green, Paul Franklin and Jennifer Pearce (Atkins Limited – SNC Lavalin). Lee Allford (Energy Institute)

The need for effective management of process safety during decommissioning was highlighted in the structural collapse incident at the Didcot power station that resulted in 4 fatalities. In addition to the tragic loss of life, the fact that the police and HSE launched a joint investigation to consider corporate manslaughter, gross negligence manslaughter and health and safety offences, highlights the gravity of getting it wrong.

This, together with the projected rapid increase in decommissioning activity in the UK over the next decade, particularly offshore, underlines the need to ensure process safety is managed effectively within a decommissioning project.

With support from the Energy Institute and cross-industry involvement from the petrochemical, offshore, bulk storage sectors and the UK Safety Regulator, new guidance has been developed to support those engaged in decommissioning to plan, design and execute their projects so as to manage risk from major accident hazards (Energy Institute, 2019).

This paper presents the key elements of this guidance which provides a roadmap to managing process safety across the lifecycle of a decommissioning project, from initiation through execution. The guidance is set-out according to typical phases of a decommissioning project, providing useful insights into key process safety considerations, objectives, tasks and outputs.

Keywords: Process Safety Management, Decommissioning, Major Hazards, Framework.

Introduction

The number of facilities, both onshore and offshore, that are coming to the end of their viable operating life and are likely to be decommissioned in the coming years is increasing, not only because of their age but also due to inefficient plant, operating costs, changes in technology and more demanding environmental regulations. This will place a greater demand on those involved in the decommission of these facilities, including facility owners and operators, regulators, contractors and others in the decommissioning supply chain. A primary concern for all involved in decommissioning will be to do so safely, and in particular without major accidents occurring with the potential for injuries or fatalities.

There is a legal requirement in high hazard industries to have robust systems in place for managing Major Accident Hazards (MAHs); such as loss of containment, fire, explosion, structural collapse, etc. This applies across the lifecycle of a facility from concept, through design, construction and into long term operation of the facility. However, when it comes to plant decommissioning, plant operators may have less corporate experience and fewer systems in place for managing process safety.

Unlike major investment projects where there is clear potential for value creation, decommissioning will generally involve a significant commitment of capital without, in most cases, adding any revenue value to a company's business. To some extent, decommissioning is largely concerned with managing a company's liabilities and so there may be some pressure to do it at as a low a cost as possible. This can be constraining for those tasked with managing decommissioning projects.

Incidents such as the structural collapse at the Didcot A Power Station in 2016 (see Figure 1), provide a stark reminder that the need for effective management of process safety does not end when the plant stops operating.

Figure 1: Didcot A Power Station Collapse. UK - 2016.

The intention of this paper is to set out a framework for managing process safety within decommissioning projects from the initial scoping studies through to physical decommissioning and dismantling. The paper draws on new industry guidelines commissioned by the Energy Institute for managing process safety in decommissioning projects (Energy Institute, 2019).

Key Process Safety Considerations in Decommissioning

Decommissioning has been described as the process to plan for, gain approval, engineer and execute the cleaning, dismantling, removal and disposal a facility.

Every decommissioning project will have its own specific process safety issues that will require careful consideration throughout the planning, preparation and execution. Among other things, these site-specific issues will be determined by the nature of the materials handled by the plant (e.g. highly toxic chemicals), the plant age and condition (possible structural integrity issues) and location (such as offshore or a site integrated within a larger complex). However, as identified through a series of cross-industry workshops (Energy Institute, 2017) there are a number of common themes that must be addressed in any decommissioning project; these are:

- Project management with a strong focus on process safety.
- The stages of a decommissioning project (from late life operations through to dismantle/demolish and removal).
- Communication with stakeholders.
- Interaction with regulators and compliance with legislation and industry/company standards.
- Determining and managing the hazard profile.
- Managing people.

These themes are addressed further in this paper, along with some issues that are specific to particular industries.

Project management with a strong focus on process safety

As mentioned, effective Project Management has been identified as a key requirement to managing process safety in decommissioning. Moreover, there are specific aspects of project management that process safety professionals and others who have Health, Safety and Environment (HS&E) responsibilities or accountabilities should be mindful of in the planning and execution of the decommissioning project.

The recognised approach to managing risk and ensuring optimum outcomes from a large capital project, such as decommissioning an entire facility, is through planning, designing, and managing the project with an appropriate number of phases and stage gates where necessary, throughout the project lifecycle.

The number of discrete phases in a decommissioning project, and the activities and controls associated with each of those phases may vary according to the size, complexity, location and other factors relating to the facility. In addition, for some decommissioning projects, there may be some potential for optioneering within the initial project phase(s) where options are reviewed and revisited until a well-defined plan emerges which can be sanctioned/approved and carried forward for further development, definition and execution.

As with a major capital development project, for the decommissioning of a major facility there might typically be four recognizable project phases, as shown in Figure 2.

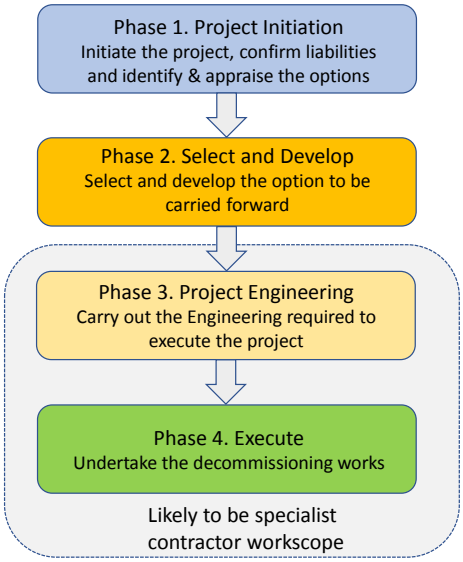

Figure 2: Typical Project Phases

Prior to the commencement of decommissioning, the site operator and/or owner must ensure that an appropriate Safety Plan, with a risk-based approach, is in place to safely manage the engineering and execution work.

A critical factor in safely executing a decommissioning programme for any facility is understanding and managing the condition of the plant to the point it is handed over to the decommissioning contractor. Site operators have a responsibility for ensuring safety during decommissioning of their facility in cooperation and coordination with principal and other contractors, taking account of:

- Provision of relevant information
- Key roles and responsibilities
- The selection of contractors and personnel undertaking the work
- Technical assurance
- The changing hazard profile during the stages of the decommissioning project
- Communication of hazards and risks
- Benefits from learnings from previous decommissioning projects
- Effective Management of Change
- The application, monitoring and review of safe working practices
- Liaison with Regulators and Stakeholders

The following is an overview of the main considerations, objectives, tasks and outputs that could be expected within each of the four notional project phases described above.

Project Initiation Phase

It is widely recognised that the ability to drive good safety performance and outcomes from any project depends upon expectations set and decisions made at the earliest stages of the project. Conversely, attempting to retrospectively improve safety outcomes in projects that were not initially well planned and thought out is increasingly more expensive and disruptive as the project progresses. With this in mind, it is important to ensure that process safety management is a major driver from the initiation phase onwards. The project initiation phase should therefore:

- fully understand the condition of the plant, what it contains and its hazard potential;
- develop an overall project plan that allows for effective HS&E management;
- identify options for decommissioning and carry out an initial assessment of them;
- identify key issues and risks to be managed as the project progresses.

It will be useful to set out an overall hazard management strategy for the project. Although it will be necessary to comply with any prescriptive legal requirements, to ensure effective management of process safety the hazard management strategy should be risk-based. This will require that hazards are well understood through identification and assessment, and that the associated risks are managed proportionately and effectively to reduce them to a level that is As Low As Reasonably Practicable (ALARP). The hazard management strategy may describe, at a high-level, how specific aspects of the project that can influence how major hazards are managed will be approached. As the Project Plan develops in subsequent phases, reference can be made back to the hazard management strategy to ensure it remains consistent, or that there is justification for deviation from it.

The following are some of the main process safety objectives during the project initiation phase. They are not necessarily exhaustive but represent some of the key outcomes required in this phase.

- Identify legislative requirements and company standards for decommissioning that must be complied with;
- Identify the feasible options for decommissioning that can achieve an acceptable safety standard and demonstrate that risks have been managed to a level that is ALARP;
- Ensure that process safety acts as a major driver in the selection and future development of the selected option for decommissioning. Responsibility for ensuring process safety is addressed throughout the project should be assigned to a senior member of the project team;
- Understand the key risk drivers to be managed as the decommissioning project progresses;
- Ensure appropriate early dialogue with the regulator(s) and other key stakeholders who can influence the decommissioning project outcome;
- Generate a comprehensive listing of process safety issues to be carried forward into the next phase of the decommissioning project.

One of the main outputs from this Phase is likely to be a small number of feasible options or a single option, considered in a risk assessment, that can be carried forward for more detailed technical and commercial assessment and development. Other outputs that will feed into subsequent phases will include:

- A clear understanding of the extent of the facility to be decommissioned and interfaces;
- Details of the hazardous inventories;
- A preliminary hazard register;
- A project Safety Plan;
- Hazard management strategy;
- An understanding of the requirements for further process safety study work in subsequent phases.

Select and Develop Phase

The focus of this phase may be to select and develop the technical solution, finalise the general Execution Plan for the project and appoint the decommissioning contractor(s). This phase could be amalgamated with the initiation (or project engineering) phase for simpler projects.

In the Select and Develop phase, the viable options that were identified in the project initiation phase are evaluated in more detail to identify a single preferred option to go forward to the Engineering and Execute phases.

The contracting strategy will be finalised, the procurement process for selecting the contractor(s) established and, at some point prior to the Engineering Phase, the contractor(s) appointed to undertake the decommissioning works.

The following are likely to be among the main process safety objectives of the Select and Develop phase.

- Ensure that Major Accident Hazards (MAHs) are considered in the evaluation, selection and development of decommissioning options;
- Select and optimise the option to ensure risks continue to be managed;
- Ensure that plans are developed for management of the project's HS&E risks including identification of HS&E study requirements, regulatory compliance and conformance with the organisations policies and procedures;
- Generate a comprehensive listing of process safety issues to be carried forward into the next phase of the project;
- Ensure that HS&E considerations are incorporated in the assessment and selection of contractor(s) to undertake the decommissioning;
- Ensure there will be suitable arrangements to manage and positively influence safety culture that may occur through the project due to the changing workforce and organisations involved;
- Ensure that occupational health, hygiene and safety hazards are considered in the selection of the decommissioning option, including the likely change in risk profile throughout the various stages of the decommissioning activity.

Main outputs from this Phase will include:

- The option for decommissioning will have been selected and developed with input from the risk assessment;
- Key findings and actions arising from the HAZID, HAZOP and other studies;
- The outline procedure for isolating and cleaning the plant and removing or containing all hazardous inventories;
- An appointed competent Contractor able to meet HS&E criteria and requirements;
- Updated HS&E Plan and Hazard Register;
- Submitted Regulatory and Permitting Approvals and Notifications;
- Critical items of plant that may have to be recertified, modified, etc.

Project Engineering Phase

All of the engineering work required for the execution of the decommissioning workscope is undertaken in this phase.

At this point in the project, it is likely that a contractor will have been selected and they will be responsible for executing the decommissioning project to completion, with suitable oversight and support from the facility operator. They will most likely be responsible for the detailed engineering required in preparation for the execution of the decommissioning project workscope.

Depending on the complexity of the decommissioning works programme, the engineering work required in this phase might be limited and there may not be any clear demarcation between this and the Execute phase.

Conversely, for major decommissioning projects involving considerable cost and project risk, such as the removal of larger offshore installations, it is possible that an additional engineering ‘define’ phase, akin to Front End Engineering and Design (FEED), will be conducted prior to this more detailed Engineering Phase.

It is worth noting also that some of the early stage decommissioning workscope at site may run in parallel with this phase. For example, the site operations team may have been tasked with isolating and cleaning the plant in readiness for handing the facility over to the decommissioning contractor. Equally, this could be in the contractors workscope as well.

The main process safety objectives during the Project Engineering phase will include:

- Ensure that all necessary HS&E and process safety requirements are in place prior to moving into the Execute phase;
- Ensure that the facility is isolated and cleaned and in a suitable condition prior to commencing decommissioning activities that could involve breaking containment. Note that this could be done in the Execute phase but frequently plants are shutdown and isolated and cleaned by the plant operations team well in advance of the actual decommissioning work commencing on site;
- Ensure plans are in place for managing HS&E and process safety on site during Execution. This will extend to oversight of the contractor(s).
- Confirm that interfaces between parties involved in the decommissioning have been identified and a process has been established to manage them;
- Ensure that Management of Change (MOC) procedures are in place for managing procedural and hardware changes that could arise and have a process safety impact.

Key output from this Phase will be:

- Contractor management plan will have been developed and will be being implemented;
- Approved HS&E plan for the Execute phase;
- Action register from hazard studies such as HAZOPs and HAZIDs, with actions being implemented.
- A detailed plan for managing the degradation and removal of Safety Critical Elements (SCE) or Safety and Environmental Critical Elements (SECEs);
- In some jurisdictions, a resubmitted Safety Case/Safety Report that covers the decommissioning activity.

Execute Phase

This phase covers the execution of the decommissioning works at site and will include many of the stages identified below (see Stages in the Execution Phase). The facility may have been handed over to the Contractor to execute the decommissioning programme and may already have been isolated and cleaned by the facility operations team in readiness for subsequent dismantling, removal and disposal, but it is also possible that the plant isolation and cleaning stages will be within the workscope of the contractor.

The following are some of the main process safety objectives during the Execute phase of the project:

- Ensure that agreed process safety measures are being implemented in full by the contractor throughout the decommissioning programme;
- Ensure that the contractor is implementing its own Safety Management System (SMS) and any other requirements that have been identified and form part of the programme;
- Where changes in the programme, schedule, circumstances arise, the MOC process is being implemented effectively;
- Ensure that arrangements to manage the changing safety culture throughout the execution of the project are planned.

Post Project Review

It is important to capture learnings throughout the project lifecycle and this can be achieved, at least in part, through a post-project review. Although this will cover all aspects of the project and its management, particular focus should be put on the management of process safety, what worked well, where there were incidents and what lessons can be taken forward from them. This should help avoid mistakes being repeated and contribute to future decommissioning projects being executed more safely.

The stages of a decommissioning project

There is merit in defining the stages typically involved in the execution phase, i.e. the main stages of activity running from preparatory work when the facility is still operational through dismantling, removal and reinstatement of the site. The number and nature of these stages will depend on the facility but a typical breakdown for an offshore facility is shown below. It is noted that there is likely to be some overlap between these stages, so each one is not necessarily sequential. Furthermore, the first five of these stages may be undertaken before the contractor is appointed and before the execution phase begins.

Late life operation	As it nears the end of its operational life, the way a facility is maintained and operated may be subject to change to take account of its impending shutdown. For example, maintenance and inspection routines may be changed or even suspended or equipment may be taken out of service, perhaps extending to entire process trains or units.
Run-down	Perhaps a sub-set of ‘Late life operation’ but a planned run down of major spares could occur when the facility is still operational.
Warm suspension	At some point, the facility will cease operating and a period of time may lapse prior to final isolation and cleaning of the plant. Hazardous inventories will still be present, possibly even at pressure. Although the potential severity of some hazards may be reduced during this stage, process related accident hazards could still occur.
Final cleaning and isolation	There will be a process of depressuring and removing or containing all potentially hazardous inventories and materials in the facility, where it is reasonable to do so. An example would be the removal of all hydrocarbon inventories from an oil & gas facility. During this stage, the plant will have been isolated at strategic locations in preparation for future dismantling.
Cold suspension	After the facility has been depressured, isolated and thoroughly cleaned, there could be a period of maintaining it in a safe condition until further decommissioning work is to be undertaken. At this point, the major hazards associated with the process/operation will have been removed, altering the hazard profile of the facility.
Dismantling and disconnection	Equipment across the facility may be physically disconnected from adjacent equipment, utilities, etc. Structures, larger equipment, pipework, etc. will be dismantled in preparation for physical removal

	from the site. This could either be piece-small or piece-large and could extend to entire modules or units being physically disconnected.
Removal and transportation	Where a facility has been dismantled, sections of the facility could be removed from the site to a location where it can either be disposed of or recycled. An example would be the removal of a topsides module or entire topsides from an offshore installation onto a barge and from there to a shore base for subsequent recycling and disposal.
Demolishing	For shore-based facilities that are not planned to be removed in sections, they will most likely be demolished with some sorting and processing of waste being carried out on-site. Prior to demolition work commencing, it is likely that equipment and material that can reasonably be recycled will already have been removed.
Disposal	Those parts of the dismantled or demolished facility that cannot be recycled or reused will ultimately have to be disposed of safely and in an environmentally responsible manner.
Reinstatement of the site	Some degree of decontamination of the site might be necessary. Work may also be required to return the site to its original condition or to a state agreed with the regulating authority.
Surveillance	Depending upon the condition of the site and in particular whether any part of the facilities have been left in place (e.g. pipelines, jacket or gravity base structures, cuttings piles, etc.) then there may be a requirement for ongoing surveillance

It is noted that in some industries, planning and designing for eventual decommissioning begins as early as the concept selection stage for the facility.

Communication with Stakeholders

Early, ongoing and effective engagement with stakeholders with a defined interest in the decommissioning will reduce the potential for problems as the project progresses

The important issue with stakeholders is to engage at the earliest practicable opportunity to exchange information and to ensure, as far as possible, goodwill throughout the decommissioning programme. In the context of managing process safety in decommissioning, key stakeholders are likely to include:

- Plant workforce;
- Others with knowledge of the facility;
- Contractors supporting the decommissioning;
- Communities affected by the activity;
- Corporate management;
- Operator's project team;
- Regulators/local authorities;
- Emergency services;
- Utility and material suppliers;
- Other "connected site" operators;
- Government organisations;
- Pressure groups/NGOs.

These stakeholders could either influence the safe outcome of the decommissioning, be impacted by hazards arising as a result of the decommissioning project activity or both.

When relevant stakeholders have been identified, it will then be helpful to understand these organisations and the means to engage with them. This can be achieved by understanding of how stakeholders are affected or impacted (positively or negatively) by your decommissioning project or who can have influence over it.

Various methods are available for assessing stakeholders, such as those prepared by Oil and Gas UK (OGUK, 2013) or the Association of Project Managers (APM, 2019).

Given the number of stakeholders, their relationship and changing extent to which they need to be engaged throughout the project, some form of stakeholder engagement or relations plan will be necessary. The stakeholder relations plan should be established well in advance of commencing the decommissioning activity. What is important is ensuring that through the process of stakeholder engagement:

- Full use is made of their knowledge and experience in order to understand and better manage potential hazards associated with the decommissioning; and
- They are kept suitably informed of any aspects of the decommissioning programme that could impact their safety or the safety of those they have a responsibility for.

Interaction with Regulators and Compliance

Regulatory authorities will seek assurance that those carrying out decommissioning work will undertake it safely with suitable prevention and mitigation controls to prevent major accident. They may also require prior notification of decommissioning work. The Project Execution Plan and supporting HS&E plan will be key supporting documents in this regard.

In the UK, the Health and Safety Executive, Government Departments, Local Government or Planning Departments may have requirements that will determine the methods that are acceptable for decommissioning as well as requirements for notification. The UK legal requirements for decommissioning work are both implicit and explicit. All decommissioning work should comply with general safe systems or work legislation such as Control of Substances Hazardous to Health, Work at Height Regulations, Lifting Operations and Lifting Equipment Regulations, etc. However, underpinning all UK health and safety legislation is the Health and Safety at Work Act (HSWA) (HSE, 1974) which places a duty on every employer to ensure the health, safety and welfare at work of employees.

Other UK legislation is explicit in its requirements for decommissioning and requires dutyholders to undertake certain activities and notification requirements, these include the Offshore Safety Case Regulations (HSE, 2015/SCR), Control of Major Accident Hazard (COMAH) Regulations (HSE, 2015/COMAH) and the Pipelines Safety Regulations (PSR) (HSE, 2015/PSR).

Of particular note is the Construction (Design and Management) regulations (HSE, 2015/CDM) that require a framework to be in place to manage pre-construction and construction stages of any project. Under CDM, the term ‘Construction’ also applies to work relating to the demolition and removal of a facility.

Industry and Company Guidance

Some larger organisations may have in-house guidance on decommissioning and these should be sought out, referred to and implemented as necessary. All organisations should have guidance documents that, although not necessarily specific to decommissioning, will be applicable at various stages in the decommissioning programme in terms of managing process safety. These might refer to managing process safety and major hazards during Operations and Maintenance, Turn Arounds, Projects and Modifications. These documents will still provide useful guidance that will have relevance to decommissioning.

Although not specific to decommissioning, guidance has been developed for Process Safety Management (Energy Institute, 2010). The guidance is based on a framework comprising 20 elements, with each element setting out expectations of what organisations need to get right in order to meet the intent of each element. Those elements and associated expectations of particular relevance to decommissioning have been identified in the Energy Institute’s guidance on managing process safety in decommissioning (Energy Institute, 2019).

Determining and Managing the Hazard Profile

One of the main challenges in decommissioning is determining and managing the changing risk profile during the various execution stages. This can be due to process changes, making and breaking of containment, contact with hazardous substances and introduction of ignition sources and other hot work. Some of these may have been considered during normal operation and routine maintenance; however, many may not have been and will present new hazards and risks to the operator.

The facility operator will be required to identify the hazards during the decommissioning process and decide who might be harmed and how. For each hazard, the operator should evaluate the risk and determine whether existing precautions are adequate or whether more needs to be done. These assessments should be revisited frequently, given the changing status and conditions at the site, and revised as required.

A particular challenge that may have to be managed is the perception that, following final cleaning, the facility will become a low risk environment. Whilst this might be the case in terms of fire, explosion, toxic and other process fluid related threats, the hazard profile will have changed, with other threats, such as structural integrity, arising from the decommissioning activity.

Generic Process Hazards and Risks

As with the operation stage, the main generic process hazards will include:

- Fire:
- Explosion;
- Release of toxic substances, and
- Releases of corrosive substances.

Whilst one of the main tasks during the decommissioning stage will be to remove the inventory of hazardous materials, decommissioning activities will result in changes in the risk profile, including:

- Mixing of incompatible chemicals;
- Process changes;
- Hazards associated with intermediate chemicals;
- Working near to other live plant and other proximity hazards;
- Work in confined spaces;
- Significantly ageing plant and a greater likelihood of containment failure;
- Simultaneous operations;
- Changing number of personnel, many of them unfamiliar with the site;
- Addition of ignition sources including cutting and welding; and
- Lack of information with regards to condition of plant and any modifications.

In addition to these process hazards, consideration should also be given to other non-process hazards or hazardous conditions. This will include, among others:

- Structural collapse
- Falling from height
- Dropped objects and swinging loads, especially involving heavy lifts
- Mechanical failure
- Electrical hazards
- Loss of or impairment of safety systems

Subsequently, any risk assessment must ensure that these hazards have been clearly identified and assessed at appropriate stages, the necessary precautions have been specified in detail, required safety equipment is available and adequate instruction and information has been given to all relevant personnel.

Risk Assessment Techniques

The following techniques are typical of those that could, and in some circumstances, should be allowed for in the project safety plan. Where appropriate, they should assess all relevant hazards including those that are also present during normal operation; those where the risk level has changed due to the decommissioning activity itself, e.g. number of operations, manning, etc.; those that have changed due to the increase in probability, e.g. increased likelihood of loss of containment, increase in probability of ignition; and specific decommissioning related activities, e.g. demolition, lifting, etc.

Hazard and Operability (HAZOP) Studies – the HAZOP could be used to assess MOC where systems are added or modified due to additional or changing requirements and conditions relating to the process, utilities and other systems. An example would be for the final cleaning of plant or the addition of temporary power systems.

Hazard Identification (HAZID) Workshops – In addition to applying HAZID to specific decommissioning activities with inherent significant hazard potential, it may also be appropriate to undertake one or more HAZID exercises at points in the decommissioning process that could, due to a combination of tasks or cumulation of changes, result in a more significant hazard potential. Guidance has been developed for Creeping Change HAZID (Energy Institute, 2017) that could be applied to effectively in such circumstances.

Simultaneous Operations (SIMOPs) Workshops - Examples of circumstances that would justify a SIMOPs assessment would include:

- If there is an operational plant adjacent to the facility to be decommissioned;
- Some decommissioning tasks will occur when some elements of the plant are still operational. An example of this would be plugging and abandoning some wells offshore when other wells are still producing;
- Where a particular task has higher associated risk, such as heavy lifting operations.

Relevant to SIMOPs in the offshore environment is when two or more installations (or vessels) are operating in close proximity to each other with the potential for hazardous interaction, referred to as Combined Operations (COMOPs). An example of this would be a heavy lift vessel (HLV), accommodation support vessel or other construction support vessel (CSV) being located adjacent to the installation being decommissioned.

Human Factors Assessments – Human factors should be considered throughout the decommissioning process and there may be justification for a Human Factors Integration Plan (HFIP). This would show the HF activities to be carried out at each stage together with details of the approaches and methods to be used. The HFIP should be managed by someone with the requisite competencies. The plan should describe the HF work required and how it will be resourced and delivered. Guidance on managing human and organisational factors specifically for decommissioning has been developed (Energy Institute, 2019).

Task Based Risk Assessment - A task-based risk assessment can be used to identify at an early stage the hazards and risk factors that have the potential to cause harm during specific decommissioning tasks. It allows for an assessment of additional risk reduction measures where necessary and whether there is a case for them to be implemented.

Point of Work Risk Assessment - A point of work risk assessment is undertaken by the personnel carrying out work prior to commencing it. The intention is to identify hazards and risks at the point of work which may have arisen as part of a changing risk profile or not been picked up in previous assessments. It allows personnel to take time to ensure they are appropriately instructed and equipped and if not, to withdraw and ensure that work only commences once the appropriate controls are in place.

Managing People

The four ‘P’s are often cited in reference to process safety management; these being:

- People
- Plant
- Processes
- Performance (monitor and improve the above three)

Regardless of the quality or condition of the plant and processes, if the people using or implementing them are not suitably qualified or experienced, and their performance isn’t being reviewed and assured, it is likely that hazards will not be managed effectively.

Issues that are critical in respect of managing people are:

- Project Organisation: The project team must include personnel with detailed knowledge of the facility and its condition, and they must be retained for the duration of the project or a resourced succession plan put in place;
- Competency: The project team (operator and contractors) have the experience and competencies necessary;
- Training and Awareness: Appropriate training is available to further equip and upskill personnel;
- Monitoring and Improving performance: Measures are in place to monitor performance and intervene and improve, if necessary.
-

In addition, as discussed previously, there must be:

- Effective Communication: Across any interfaces between the facility operator, contractors, external agencies, suppliers, etc.
- Stakeholder engagement: Managed effectively;
- A good process safety culture: Prevalent across the team.

Project Organisation

The project organisation should be clearly defined, bearing in mind it may change with time as the decommissioning progresses through the planning and execution. The structure and organisation of the project team will change when a Contractor is appointed as they will have their own project organisation.

Key roles with associated responsibilities and competencies, must be developed in order that suitable candidates can be considered and appointed. Project teams for a sizeable decommissioning project are likely to include the following roles, especially in the Engineering and Execute phases which will have a significant contribution to managing process safety:

- Professional project manager/lead
- HS&E lead
- QA lead
- Decommissioning engineers
- Operations staff with detailed site knowledge
- Technical experts

There is merit in appointing the project leader well in advance and, if possible, he/she should be dedicated to the decommissioning project. This will be essential for larger projects.

Competency

Whilst it will not be feasible for everyone involved in the project to have prior decommissioning experience, the key roles requiring essential competencies, should be identified. In addition, a proportion of the roles will also require competencies in specific areas of HS&E and process safety, with a subset of those having project safety management skills. These competencies should be defined and applied when assembling the project team.

Training and Awareness

A programme of induction will be required, particularly for contractors and other personnel unfamiliar with the site.

Induction and training will most likely be required for permit to works systems and other procedures. Other requirements for training of the team involved in the decommissioning will depend upon:

- Gaps in competency;
- Specific technologies to be applied that are novel or not widely used;
- Exposure to specific hazards, such as asbestos;
- Demolition contractors experience of process industry hazards.

Monitoring and Improving Performance

Regular review and audit of compliance with safe systems of work at the site will ensure that HS&E and process safety performance is maintained at required levels. An audit programme should be implemented. This can be carried out by personnel from both within the organisation or by personnel independent of the project.

Some Specific Issues Worth Specific Consideration

Decommissioning can result in some specific challenges, many of which will be common to a variety of facilities. Process safety management topics that may be specific to the onshore oil and gas and petrochemical sector are addressed below

Project Plan

Onshore facilities which are the subject of decommissioning and demolition may be of significant age with associated integrity issues. When designed and constructed, the process of decommissioning may not have been explicitly addressed in the design

and there may have been no requirement to compile a health and safety file, as is currently required under the UK CDM regulations. As a consequence, it may be necessary to develop an approach and, in some cases, carry out enabling modifications to the process plant to allow decommissioning activities to proceed. These modifications would need to be risk assessed and managed appropriately through the MOC process. Examples of this include;

- Isolation and separation from common services, such as flare systems. This may require additional isolations to be installed during the shutdowns of adjacent units at an early stage in the planning process.
- Protecting and rerouting live systems.
- Identifying a method of facilitating the unloading and safe disposal of hazardous chemicals in a controlled manner when the design intent was only to receive and consume the chemical.
- Design of temporary support works to facilitate safe demolition of structures.

Documentation

Considerable uncertainties can exist when carrying out a decommissioning project on a site which may have been built many decades ago. Drawings and other documentation may be inaccurate or non-existent and the lack of information may also be compounded by changes of ownership of the asset over its life time. Modifications carried out over the site's life may not have been documented at the time, or the information may have been lost in the intervening period. A lack of accurate records and incomplete information can therefore be anticipated which could result in incorrect assumptions or mistakes being made during engineering or execution. Lack of information may relate to structural details of buildings, routing of underground pipe work or services such as electrical cables, gas supply lines, etc. all of which could represent a significant hazard during decommissioning and demolition work and act as an initiator for a Major Accident Hazard (MAH).

Additional surveys, 3D scans and line walks to reduce uncertainty of plant status prior to decommissioning and demolition may be necessary. These elements of enabling works could take some time and this needs to be allowed for in the overall scheduling of works and started earlier in the project planning phase.

Handover to demolition contractor

It is likely that the process plant will, at a suitable point, be handed over to a demolition contractor. It will be necessary to provide the demolition contractor with assurance that the plant is in a safe condition that will allow the demolition workscope to proceed. This will require:

- Clearly identifying physical disconnections.
- Separation of plant into several sections with defined battery limits, supported by documentation, dependent on the scale of the works.

Other methods successfully employed to reduce the opportunity for error include:

- Positive identification of equipment to be removed via physical marking of plant equipment.
- Create an island to ensure that there are no above or below ground live cables or lines entering the plant to be demolished and prove that an air gap exists.

Interaction with the Regulator and Compliance

In the UK, to comply with the legal requirements laid down in the CDM regulations (HSE, 2015), a written construction/demolition phase plan will be required and it will be necessary to provide 'pre-construction' information such as the location of any hazardous materials (e.g. asbestos) and the presence of any services, particularly underground, that may not be immediately obvious to the contractors carrying out the work on site.

Protective functions

Equipment and procedures exist on a live plant to prevent and reduce the consequences of a loss of containment. The appropriate timing for the removal of each of these process safeguards needs to be established, consistent with the hazard profile identified and the activities taking place. These protective functions include safety related trips, relief valves, fire and gas detection and firefighting provisions - both hardware and procedural. It is not always appropriate to remove the function when the plant stops operating.

For example, in many plants, the pressure envelope is protected through the use of relief valves which are designed to discharge to a flare system. At some point in the decommissioning, process relief valves will no longer be required to provide this protective function. The point at which the relief system associated with the plant can be isolated and decommissioned will need to be established, taking account of the intended duty. Thermal relief may still be required if there could be trapped inventory and activities such as cleaning where heat sources may be introduced which create additional relief cases. It is also possible that exothermic reactions could occur during the decommissioning process thereby providing a further potential heat source.

Uncertainty of plant condition

If a process unit has been in operation for a period of time prior to the decontamination and dismantling task taking place, there could be greater uncertainty on the condition of equipment and line work. Integrity could have deteriorated, and knowledge of the process plant lost due to experienced, long-serving staff having left. Planned maintenance may have reduced significantly in the latter stages of the operating plant's life, increasing the likelihood of integrity concerns. These factors are unlikely to apply to routine maintenance outages. The combination of these factors could increase the likelihood of mechanical failures and structural collapse. Surveys and inspections may be required to reduce uncertainty and allow appropriate risk reduction measures to be incorporated into decommissioning and demolition plans.

Decontamination and Cleaning

It will be necessary to decontaminate and clean equipment, prior to dismantling, to remove hazardous materials and trapped inventories. The equipment to be cleaned may include systems such as closed drains which may not have had to be cleaned internally for previous inspections. The contaminants could present a risk to the safety of people and or the environment. Depending on the process, the contaminants could be present in several forms:

- Solids: Residues, products, pyrophoric scale;
- Liquids: Trapped in piping and equipment low points, bottoms of tanks and vessels;
- Vapours: Volatile chemicals in pipes, storage tanks;
- Aerosols: Suspended in air, this includes powders and dusts.

A thorough risk assessment study is needed for each of the cleaning procedures. It is recommended that such an exercise is planned well in advance to mitigate the effects of the activities on the safety of people and the environment.

Combustibles

Due to the nature of the materials processed in a refinery, pyrophoric scale can be expected in many drums, vessels and pipework including flare lines, and the possibility of its presence and ability to act as an ignition source is a hazard that requires management during the cleaning and decontamination stage.

Although likely to be drained of all fluids, a packed column that is open to the atmosphere can present a combustion hazard, particularly if the process fluid has been flammable or forms combustible fouling products. Column packing, which provides a high surface area to volume ratio, and metal dusts are combustion hazards. As well as hot work, pyrophoric compounds, such as pyrophoric iron (FeS) or other organic dusts or films or exposure to strong oxidisers, may provide ignition sources for column internals. Cleaning column internals as far as possible before exposing packing to oxygen is important to reduce the risk of a packing fire.

SIMOPS and Adjacent Plants

On a refinery or other large petrochemical site there may be a requirement to decommission and or demolish process plant while operations continue on nearby live process plant. The live operating plant may be under the control of either the same operator or another operator on an adjacent site; stakeholder engagement and good communication is essential.

Many of the hazards which will be identified as part of decommissioning and their subsequent management may already have been encountered, perhaps to a lesser extent, when a turnaround takes place on one process plant while other plants nearby continue to operate. A careful consideration of SIMOPS at the planning stage will be the requirement to manage the hazards and interactions; developing a SIMOPS matrix to identify the interactions may be helpful in this respect.

Concerns introduced could include:

- Proximity of live systems to the decommissioning workforce;
- Possible heavy lifts in vicinity of live plant;
- Additional traffic near live plant;
- Work at boundary may interact with an adjacent operating plant;
- Shared utilities such as power and steam;
- Common elements of flare systems;
- Common drain systems;

Conclusions

There can be a mindset that there is little or no major accident hazard risk when a facility is shut-down and decommissioning activities begin; the perception can be that process safety concerns will diminish, and the focus should move towards closer management of occupation safety. The extent of some hazards will undoubtedly change as will the risk profile, however due to the introduction of new hazards, uncertainties with plant status and condition, transient workforce, etc. the focus on process safety management must be maintained.

In terms of managing the full extent of the decommissioning project, it can be beneficial to consider process safety management requirements in broadly similar phases as for a development project. This phased approach will help ensure hazards are identified, assessed and can be managed effectively by the time the project is executed.

Other factors that require careful consideration are:

- Project management with a strong focus on process safety;
- Early identification of key stakeholders and planning for effective communication with them throughout the project;
- Interaction with regulators and ensuring ability to comply with relevant legislation and industry and company standards;
- Managing the hazard profile as the status of the facility changes;
- Managing the people aspects of the project as they pertain to process safety, including organisational factors, contractor selection and involvement, competence and unfamiliarity with the site;
- Ensuring continued access to personnel with critical knowledge of the facility, particularly if the operators personnel are being demobilised, redeployed, etc;
- Accurate information is essential and can be a particular issue for older facilities or where there has been one or more change of ownership.

References

APM, 2019. Stakeholder engagement resources. Association for Project Management. https://www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/resources/

Energy Institute, 2010. Guidance on Managing Human and Organisational Factors in Decommissioning. http://www.energypublishing.org/publication/ei-technical-publications/human-and-organisational-factors/guidance-on-managing-human-and-organisational-factors-in-decommissioning

Energy Institute, 2017. Guidance on applying a creeping change hazard identification (CCHAZID) methodology. First Edition. Energy Institute. May 2017.

Energy Institute, 2017. Technical Workshop Proceedings: Process Safety in Decommissioning Projects. First Edition. March 2017.

Energy Institute, 2019. Guidance on Managing Process Safety in Decommissioning Projects.

HSE, 1974. Health and Safety at Work Act, 1974.

HSE, 2015/CDM. Construction (Design and Management) Regulations 2015. 2015. Guidance on Regulations L153.

HSE, 2015/COMAH. The Control of Major Accident Hazards Regulations 2015. SI 2015/483. UK Health and Safety Executive.

HSE, 2015.PSR. A Guide to the Pipeline Safety Regulations. L82. UK Health and Safety Executive.

The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015. L154. UK Health and Safety Executive.

HSE, 2015/SCR Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015 (SCR 2015) SI 2015/398. UK Health and Safety Executive.

OGUK, 2013. Guidelines on Stakeholder Engagement during Decommissioning Activities, April 2013. Oil & Gas UK.