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REPORT

Petroleum Safety Authority

Petroleumstilsynet

Identification of activities with risk of accidents during decommissioning and removal of installations

This report is the English translation of the 2020 report with the title:

Identifisering av aktiviteter med fare for ulykke ved avslutning og fjerning av installasjoner

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Content

Appendix

Abbreviations

AFFF	Aqueous Film Forming Foam
HAZID	Hazard identification – systematic method for assessing risk in an activity or operation
HAZOP	Hazard operability analysis – systematic method for assessing risk in design
HVAC	Heating, Ventilation and Air Conditioning
HSEQ	Health, Safety, Environment, and Quality
NGO	Non-Governmental Voluntary Organization, including business and trade Associations
NDT	Non-Destructive Testing
PPE	Personal Protective Equipment
RATs	Rope Access Technician
SIMOPs	Simultaneous Operations
SJA	Safe Job Analysis
WP	Work Permit

1 Summary

This report is prepared by Acona on an assignment to Petroleum Safety Authority Norway to provide an overview of activities involving risk of danger or accidents in removal projects. This is done by identifying risk elements and risk reducing measures related to cessation of production and removal of the topsides on bottom fixed oil and gas installations for the three most common removal methods used in the Norwegian continental shelf (NCS).

The description follows the natural phases of the removal project starting with the final years of the operations phase ending up with the removal of the topsides. Final disposal of the topsides and removal of the substructure is not a part of this report.

The report also gives an overview of some of the incidents resulting in personal injury or having the potential for personal injury.

Uncertainty on choice of removal method in the planning phase may have negative effects on the following phases. Many installations are left without activity in many years awaiting removal. The report therefore includes considerations on the extent of maintenance in the period awaiting start of the removal activities.

The report is structured so that it may act as a reference for planning and follow-up in the different phases of new removal projects.

2 Description of Work

2.1 What is covered in this report

It is expected that the scope of removal activities will remain high for many years to come. The Petroleum Safety Authority has requested Acona to investigate certain aspects of these operations. The purpose of this work has been to identify activities with hazards and accident risks, risk elements, risk-reducing measures, and safety considerations related to the decommissioning of fields and the removal of topsides on fixed installations.

We have examined the following:

- Which removal methods are most relevant on the Norwegian Continental Shelf (NCS) – a brief overview.
- Which phases/activities are involved in a removal project.
- Which hazard and risk elements, as well as risk-reducing measures, characterize the different phases.
- Which areas of expertise are involved in the activities.
- Differences and similarities between the various removal methods.
- Examples from actual incidents are used for illustration.

The focus has been on the period up until the topside is removed from the substructure.

Risks related to securing, removing remaining equipment in the substructure, and further maintenance are not covered by this report.

Petroleum Safety Authority's incident statistics have been reviewed in this study. Additionally, key individuals who have worked on the removal of Ekofisk, Frigg, Valhall, and Yme have provided input to the report. A working meeting was held with AF Offshore Decom, where Jøran Baann and Erik Flodman offered valuable insights based on their extensive experience with the removal of installations no longer in use in the Norwegian, British, Dutch, and German sectors.

Svein Otto Vik has taken all the photographs included in this report.

3 Background

3.1 Active installations

There are approximately 70 fixed installations on the Norwegian Continental Shelf (NCS) today. The table below, based on information from the Norwegian Petroleum Directorate's fact pages (August 2020), shows those that, according to the Directorate's definition, are active. Many of these platforms have exceeded their original lifespan but are still in use. Some have had their lifespan extended due to increased resources, while others will be decommissioned in the near future. This indicates that removal activities will continue for many years to come.

Table 3.1 Fixed installations that are active on the Norwegian Continental Shelf (Source NPD – fact pages)

Name	Type/function	Water depth (m)	Start-up year	Lifespan (years)	End date in relation to lifetime
EKOFISK BS3	JACKET TRIPOD -	72	1974	20	1994
EKOFISK C	JACKET 12 LEGS - DRILLING - OIL PRODUCER	77	1974	20	1994
EKOFISK B	JACKET 12 LEGS - DRILLING - OIL PRODUCER - PROCESSING - WELLHEAD	74	1974	20	1994
ELDFISK A	JACKET 12 LEGS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER	71	1979	20	1999
ELDFISK B	JACKET 12 LEGS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER	71	1979	20	1999
ELDFISK B-FL	JACKET TRIPOD - FLARE STACK	70	1979	20	1999
ELDFISK FTP	JACKET 8 LEGS - PROCESSING	77	1979	20	1999
VALHALL Q	JACKET 4 LEGS - QUARTER	74	1981	20	2001
VALHALL DP	JACKET 8 LEGS - DRILLING	74	1981	20	2001
ULA DP	JACKET 4 LEGS - DRILLING	71	1986	20	2006
ULA PP	JACKET 4 LEGS - PROCESSING	71	1986	20	2006
ULA QP	JACKET 4 LEGS - QUARTER	71	1986	20	2006
EKOFISK K	JACKET 8 LEGS - DRILLING - QUARTER - WATER INJECTION	74	1987	20	2007
STATFJORD A	CONDEEP 3 SHAFTS - DRILLING - PROCESSING - QUARTER - STORAGE	145	1979	30	2009
VESLEFRIKK A	JACKET 4 LEGS - DRILLING	174	1989	20	2009
STATFJORD B	CONDEEP 4 SHAFTS - DRILLING - PROCESSING - QUARTER - STORAGE	145	1982	30	2012
EMBLA	JACKET 4 LEGS - ACCOMMODATION - OIL PRODUCER - PROCESSING - WELLHEAD	70	1993	20	2013
BRAGE	JACKET 8 LEGS - DRILLING - PROCESSING - QUARTER	136	1993	20	2013
STATFJORD C	CONDEEP 4 SHAFTS - DRILLING - PROCESSING - QUARTER - STORAGE	145	1985	30	2015
DRAUPNER S	JACKET 4 LEGS - QUARTER - RISER	70	1985	30	2015
HEIMDAL	JACKET 8 LEGS - DISTRIBUTION - DRILLING - OIL PRODUCER - PROCESSING - QUARTER - WELLHEAD	120	1985	30	2015
GULLFAKS A	CONDEEP 4 SHAFTS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER - STORAGE	133	1986	30	2016
OSEBERG C	JACKET 8 LEGS - DRILLING - PROCESSING - QUARTER	108	1991	25	2016
TAMBAR	JACKET TRIPOD - WELLHEAD	70	2001	15	2016
GULLFAKS B	CONDEEP 4 SHAFTS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER - STORAGE	141	1988	30	2018
OSEBERG ØST	JACKET 4 LEGS - DRILLING - PROCESSING - QUARTER	157	1999	20	2019
GULLFAKS C	CONDEEP 4 SHAFTS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER - STORAGE	216	1990	30	2020
ELDFISK E	JACKET 4 LEGS - WATER INJECTION	72	2000	20	2020
DRAUGEN	CONDEEP MONOSHAFT - DRILLING - PROCESSING - QUARTER - STORAGE	252	1993	30	2023
EKOFISK X	JACKET 4 LEGS - DRILLING	77	1997	30	2027
EKOFISK X-BS	JACKET TRIPOD -	76	1997	30	2027
SLEIPNER B	JACKET 4 LEGS - WELLHEAD	108	1997	30	2027
OSEBERG A	CONDEEP 4 SHAFTS - DRILLING - PROCESSING - QUARTER	109	1988	40	2028
OSEBERG B	JACKET 8 LEGS - DRILLING	108	1988	40	2028
EKOFISK J	JACKET 8 LEGS - OIL PRODUCER - PROCESSING	77	1998	30	2028
RINGHORNE	JACKET 4 LEGS - DRILLING - PROCESSING - QUARTER	129	2003	25	2028
VALHALL WP	JACKET 4 LEGS - WELLHEAD	74	1996	33	2029
KVITEBJØRN	JACKET 4 LEGS - DRILLING - PROCESSING - QUARTER	190	2004	25	2029
OSEBERG SØR	JACKET 6 LEGS - DRILLING - PROCESSING - QUARTER	101	2000	30	2030
HEIMDAL HRP	JACKET 4 LEGS - RISER	120	2000	30	2030
OSEBERG D	JACKET 4 LEGS - PROCESSING	109	2000	30	2030
VALHALL FLANKE SØR	JACKET 4 LEGS - WELLHEAD	67	2003	30	2033
GRANE	JACKET 8 LEGS - DRILLING - OIL PRODUCER - PROCESSING - QUARTER	127	2003	30	2033
VALHALL FLANKE NORD	JACKET 4 LEGS - WELLHEAD	69	2004	30	2034
VALHALL IP	JACKET 4 LEGS - DRILLING - WATER INJECTION	74	2004	30	2034
GUDRUN	JACKET 4 LEGS - GAS PRODUCER - OIL PRODUCER - QUARTER - SEPARATION - WELLHEAD	109	2014	20	2034
EKOFISK M	JACKET 4 LEGS - OIL PRODUCER - PROCESSING - WELLHEAD	78	2005	30	2035
EKOFISK M-BS	JACKET TRIPOD -	78	2005	30	2035
VALEMON	JACKET 4 LEGS - PROCESSING - QUARTER - WELLHEAD	133	2015	25	2040
IVAR AASEN	JACKET 4 LEGS - PROCESSING - QUARTER - WELLHEAD	113	2016	25	2041
SLEIPNER FL	JACKET TRIPOD - FLARE STACK	83	1993	50	2043
SLEIPNER A	CONDEEP 4 SHAFTS - DRILLING - PROCESSING - QUARTER	83	1993	50	2043
SLEIPNER R	JACKET 4 LEGS - RISER	83	1993	50	2043
OSEBERG H	JACKET 4 LEGS - GAS PRODUCER - OIL PRODUCER - WELLHEAD	107	2018	25	2043
VALHALL FLANKE VEST	JACKET 4 LEGS - GAS INJECTION - GAS PRODUCER - OIL PRODUCER - WATER INJECTION	69	2019	25	2044
DRAUPNER E	JACKET 4 LEGS - RISER	69	1995	50	2045
EDVARD GRIEG	JACKET 4 LEGS - PROCESSING - QUARTER - WELLHEAD	109	2015	30	2045
SLEIPNER T	JACKET 6 LEGS - PROCESSING	83	1997	50	2047
GINA KROG	JACKET 4 LEGS - PROCESSING - QUARTER - WELLHEAD	116	2017	30	2047
VALHALL PH	JACKET 4 LEGS - PROCESSING - QUARTER	74	2013	40	2053
EKOFISK L-BS	JACKET 4 LEGS -	79	2013	40	2053
EKOFISK Z	JACKET 4 LEGS - PROCESSING - WELLHEAD	79	2013	40	2053
EKOFISK L	JACKET 4 LEGS - ACCOMMODATION	79	2014	40	2054
TROLL A	CONDEEP 4 SHAFTS - DRILLING - PROCESSING - QUARTER	302	1996	70	2066
JOHAN SVERDRUP DP	JACKET 8 LEGS - DRILLING	113	2018	50	2068
JOHAN SVERDRUP LQ	JACKET 4 LEGS - ACCOMMODATION - QUARTER	113	2019	50	2069
JOHAN SVERDRUP P1	JACKET 8 LEGS - DISTRIBUTION - PROCESSING - SEPARATION	113	2019	50	2069
JOHAN SVERDRUP RP	JACKET 8 LEGS - EXPORT POINT - GAS EXPORT - RISER - UMBILICAL SUPPORT	115	2019	50	2069
ELDFISK S	JACKET 8 LEGS - PROCESSING - QUARTER	72	2015		
ELDFISK S-BS	JACKET 4 LEGS -	72	2015		

3.2 Decommissioned installations

Table 3.2 shows a selection of fixed platforms in and outside of the Norwegian Continental Shelf (NCS) that have either been removed or decommissioned pending removal. Smaller platforms, such as flare towers with bridge connections to nearby platforms, are not included in this table.

Table 3-2 Fixed Platforms That Have Been Removed or Decommissioned Pending Removal (Source Acona)

Platform name	Waterdepth (approx m.)	Year Installed/Start-Up	Year removed Topsides/Substructures	Comments
Albuskjell A	71	1979	2013/ 2013	
Albuskjell F	71	1979	2010/ 2011	
COD	73	1977	2012/ 2013	
Edda	71	1979	2011/ 2012	
Ekofisk 2/4 A	74	1974	2020/2020	
Ekofisk 2/4 D	75	1974	2011/ 2012	
Ekofisk 2/4 FTP	77	1974	2018/	The substructure has not been removed
Ekofisk 2/4 G	77	1982	2016/	The substructure has not been removed
Ekofisk 2/4 H	77	1979	Decommissioned	
Ekofisk 2/4 P		1974	2009/ 2010	
Ekofisk 2/4 Q	77	1973	2014/	The substructure has not been removed
Ekofisk 2/4 R	77	1977	2009/ 2010	
Ekofisk 2/4 S	77	1986	2001/ 2014	
Ekofisk 2/4 T	77	1974	2007	The concrete structure has not been removed
Ekofisk 2/4 W	77	1972/1989	2011/2011	
Frigg DP1	97	1974	2009	
Frigg DP2	98	1978	2007/ 2008	
Frigg TCP2	102	1978	2007	The substructure has not been removed
Frøy	119	1995	2002/ 2002	
HOD	72	1990	Decommissioned	
Huldra	125	2001	2019	
Nord Øst Frigg	102	1984	1996	
Odin	103	1984	1996/ 1997	
TOR	70	1978	Decommissioned	
Valhall D	75	1981	Decommissioned	
Valhall PCP	75	1982	Decommissioned	
Valhall QP	74	1981	2019/	The substructure has not been removed
Yme MOPUS topside	93	2011	2016	
Foreign Sector:				
B11	33	1977	2015	
Booster 36/22	81	1975	2009/ 2010	
Booster 37/4	85	1975	2009/ 2010	
Frigg CDP1	98	1976	2009	The concrete structure has not been removed
Frigg Flammetårn	102	1975	1996	
Frigg QP	102	1977	2008/ 2009	
Frigg TP1	102	1977	2009	The concrete structure has not been removed
H7	41	1977	2013	

3.3 Unwanted incidents on decommissioned platforms

A significant number of installations have already been removed. Reporting from these projects indicates many unwanted incidents, particularly related to dropped objects/crane operations and personal injuries.

The figure shows statistics for a total of 123 incidents reported on a selection of decommissioned installations from 2000 to 2018.

Occupational accidents are the largest single category, while dropped objects and incidents related to cranes and lifting operations together constitute a substantial portion of the reported incidents.

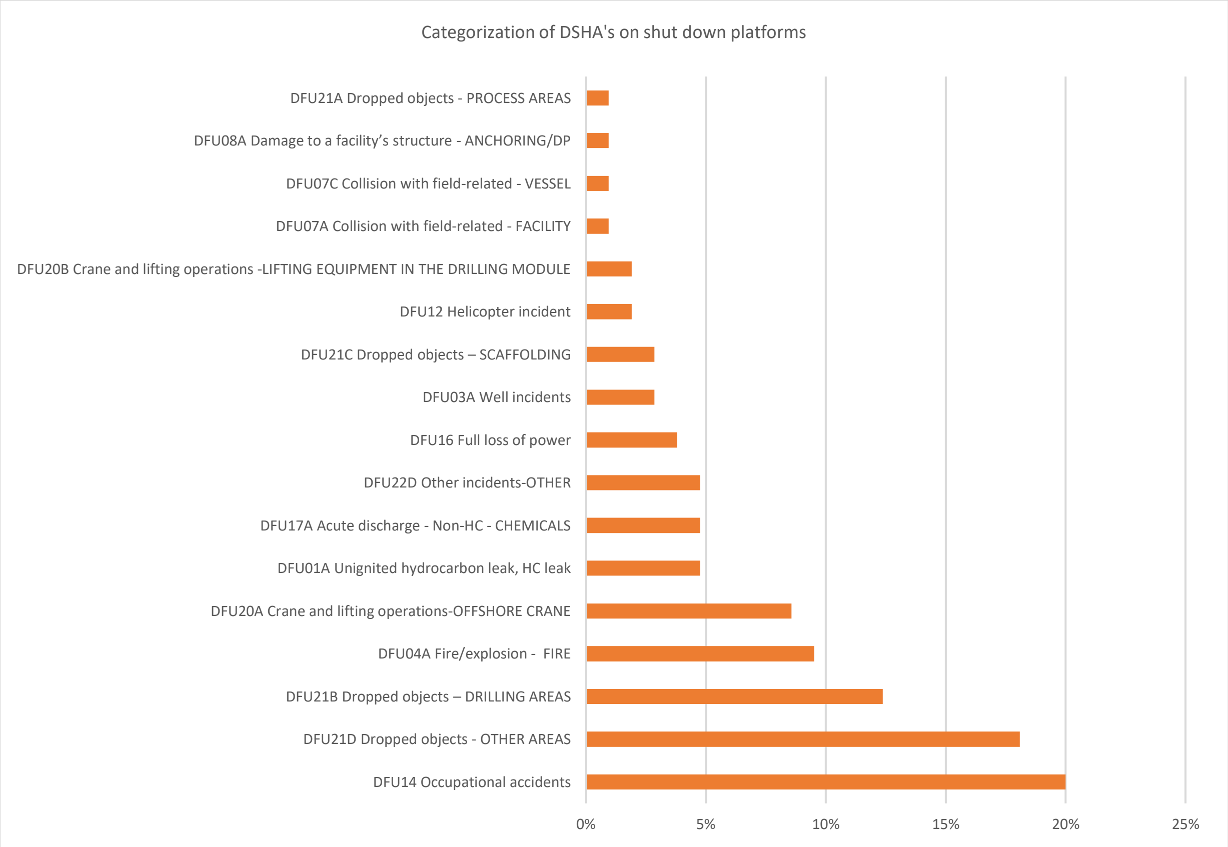

Figure 3.1 Reported DSHAs (Defined situations of hazards and accidents) Related to Platform Decommissioning (Source Petroleum Safety Authority)

4 Removal methods

In Norway today, there are primarily three methods, or a combination of these, used for the removal of topside structures on fixed oil and gas platforms:

- Piece small removal
- Heavy lift method / Reverse installation
- Single lift method

Piece small removal

Piece small removal involves cutting the platform's topside into smaller pieces while the platform is still offshore. The cutting is mainly performed with an excavator equipped with a hydraulic shear, combined with hot cutting. Water jet cutting and diamond wire may also be used. Examples of platforms removed Piece small include:

- CDP 1 on the Frigg field
- DP2 on the Frigg field
- Ekofisk Tank

The piece small method is unlikely to be competitive as a standalone removal method in the future due to the high number of man-hours offshore. However, elements of the piece small method will still be part of the heavy lift and single lift methods.

Heavy lift method / Reverse installation

The heavy lift method involves reversing the sequence of module installation. The modules are separated from each other and lifted away one by one. In some cases, not all modules are separated, and multiple modules can be lifted in one lift, as was done on Ekofisk. Examples of platforms removed using the heavy lift method include:

- Ekofisk I platforms (9 units)
- Odin
- Frigg TCP2

Single lift method

With these methods, the topside is detached from the steel and concrete substructure and the entire topside is lifted off in one lift and transported to shore. Examples of platforms removed using this method include:

- Frøy
- Yme
- Valhall QP

- Frigg QP
- Ekofisk 2/4G, 2/4S

Combination of Piece small and Reverse installation

- Frigg DP2
- Ekofisk FTP

Each of these methods has its own challenges and requires different preparation work. Similarities and differences will be addressed in the following chapters.

5 Overall timeline for a removal project

The main phases of a removal project can be illustrated as follows:

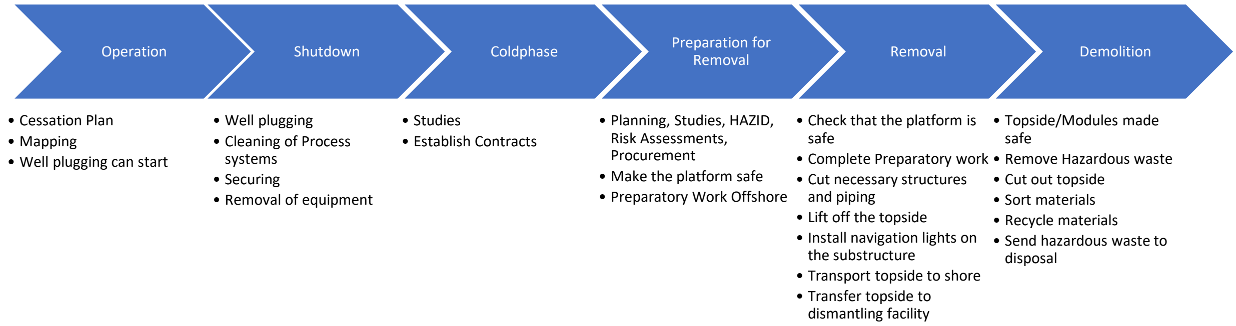

Figure 5.1: Main Phases in a Removal Project (source Acona)

The following chapters will discuss these phases in more detail, focusing on:

- Purpose of activity/phase
- Typical scope
- Who is involved
- Risk elements
- Risk-reducing measures
- Relevant events and conditions

The report mainly covers the period up to the point where the topside has been removed from the substructure.

6 Operational phase – shutdown planning

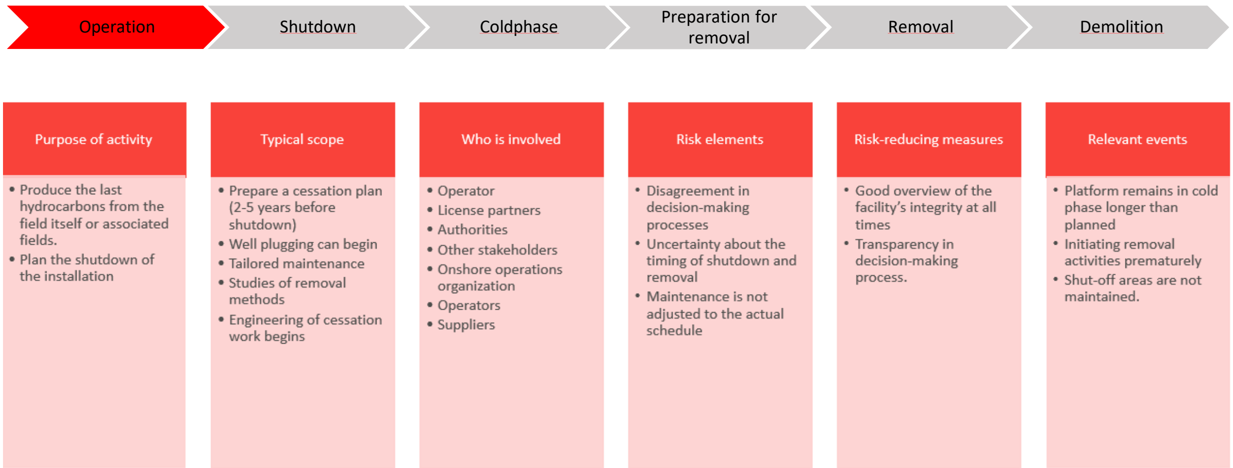

Figure 6.1: Key elements in the Operational phase (Source Acona)

At the end of a field's life cycle, planning for shutdown and removal begins. There are many considerations in this phase. One goal is to keep production running as long as possible to maximize resource utilization. Another goal is to reduce operational costs to avoid unnecessary maintenance and upgrades while still ensuring safe operation. Even after the end date for production is set, the timing of the actual removal activities is often unclear. There are several examples of installations that have remained shut down for years after they were taken out of service.

6.1 Preparation for shutdown

In this phase, alternative removal methods are evaluated. Activities may include:

- Well plugging may begin.
- Studies of removal methods are conducted.
- Design of decommissioning/shutdown work begins.
- Maintenance program is adjusted to end date.

6.2 Cessation plan

According to the Petroleum Act, a Cessation plan must be prepared 2 to 5 years before the production permit expires or the use of a facility ceases.

The Cessation plan should include a **Disposal plan** and an **Impact assessment**. The disposal plan should describe the technical and economic aspects of the decommissioning project. The purpose of the impact assessment is to ensure that environmental, social, and natural resource considerations are included in the planning process alongside technical, economic, and safety aspects. It should also assess possible positive and negative effects on the environment, natural resources, and society resulting from the cessation, as well as preventive and mitigating measures. Importantly, it should provide a description of the evaluated and recommended disposal alternatives.

6.3 Legal and regulatory requirements for the cessation plan

For clarity, reference is made to the current legal and regulatory requirements related to the decommissioning plan. An overview follows:

- The Cessation plan must be prepared according to the Petroleum Activities Act § 5-1, before a permit under § 3-3 or § 4-3 expires or is relinquished, or when the use of a facility finally ceases. The plan should include proposals for continued production or shutdown of production and disposal of facilities. Disposal options may include continued use in petroleum activities, other uses, complete or partial removal, or abandonment.
  - It should be submitted no earlier than 5 years, but no later than 2 years before the expiration or relinquishment of the production permit, or the final cessation of the facility.
  - It is possible to apply for an exemption from submitting the Cessation plan no later than two years before the expected date.
- Regulations to the Petroleum Activities Act, Chapter 6 " Cessation of Petroleum Activities": The Cessation plan may include proposals for the disposal of multiple facilities and must consist of a disposal section and an impact assessment. The Cessation plan should be sent to the Ministry and the Ministry of Labour and Social Affairs, with copies to the Norwegian Petroleum Directorate and the Petroleum Safety Authority.
- Framework Regulations § 30 on Cessation plan.
- Management Regulations § 25 on consent for certain activities.

6.4 Who is involved

In this phase, the following stakeholders are involved in the planning and decision-making processes:

- Operator
- License partners
- Authorities
- Onshore operations organization
- Suppliers
- Other operators
- Other stakeholders (NGOs)

An overview of the authorities involved in the various phases is shown in Figure 3.1.

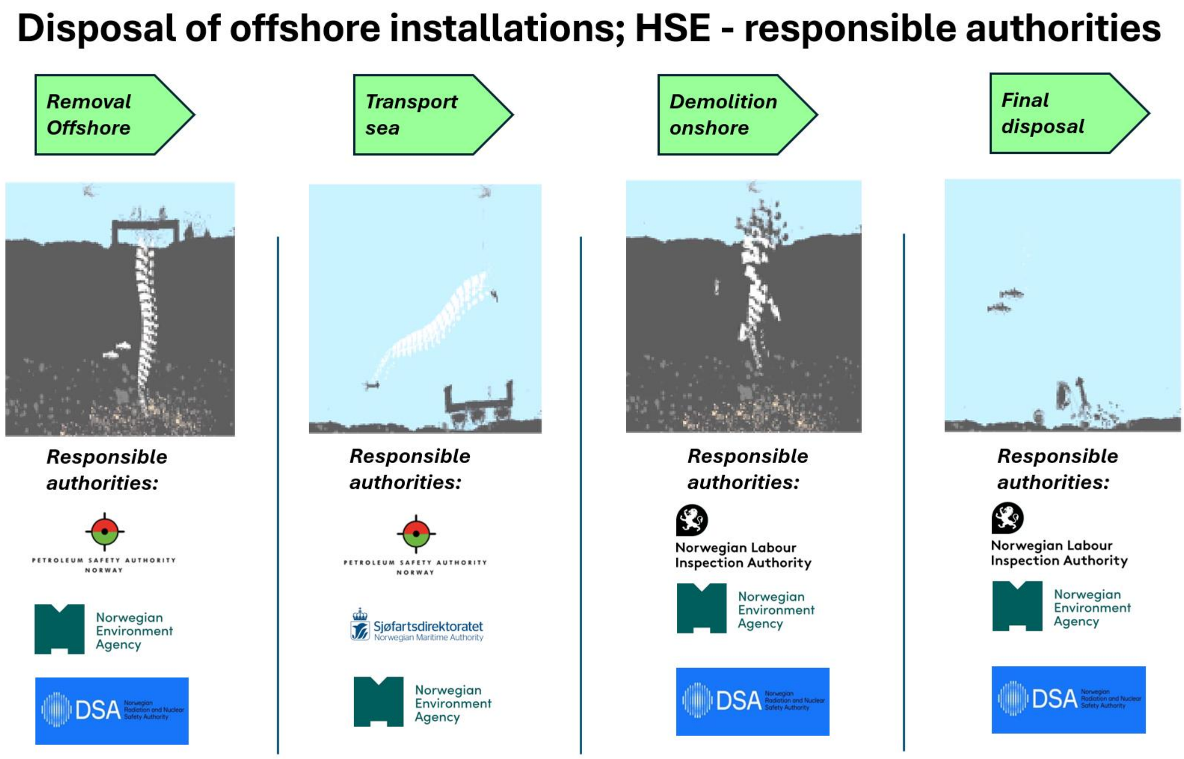

Figure 6.2: Involved Authorities in Decommissioning Projects (Source: IKM Acona)

6.5 Risk elements

Recommended removal solution can be straight forward depending on the complexity of the facility. For large concrete platforms where the substructure remains, there are many stakeholders involved. Authorities from other countries must be consulted, NGOs will provide input, and the process to reach a final solution can be lengthy.

Changes in oil prices or surprises from the reservoir can affect how long profitable production is possible. Requests from other fields for services such as processing or export may extend the economic life of the facility. This often involves uncertainty, as it depends on decisions in other licenses and the outcome of negotiations. Within a production license, different licensees holders may have varying opinions on when it is appropriate to spend money on plugging and securing wells and physically removing installations. This means that both the start and duration of the cold phase can be uncertain in the final stage of a field's life. This uncertainty can negatively impact facility integrity if maintenance is not performed or if systems are decommissioned too early.

6.6 Risk-reducing measures

It is crucial to have a clear overview of the facility's condition and integrity in order to compensate for any changes in plans. Additionally, maintaining a good and transparent decision-making process regarding the future of the installation is essential, so that all parties responsible for safety have sufficient information to implement the appropriate measures.

6.7 Relevant events

Decisions made in the final part of the operational phase can impact what happens in later phases:

- The platform may remain in the cold phase longer than planned.
- Decommissioning activities may start prematurely.
- The market may change.
- The platform and shut-down areas may not be maintained.

7 Shutdown and preparation

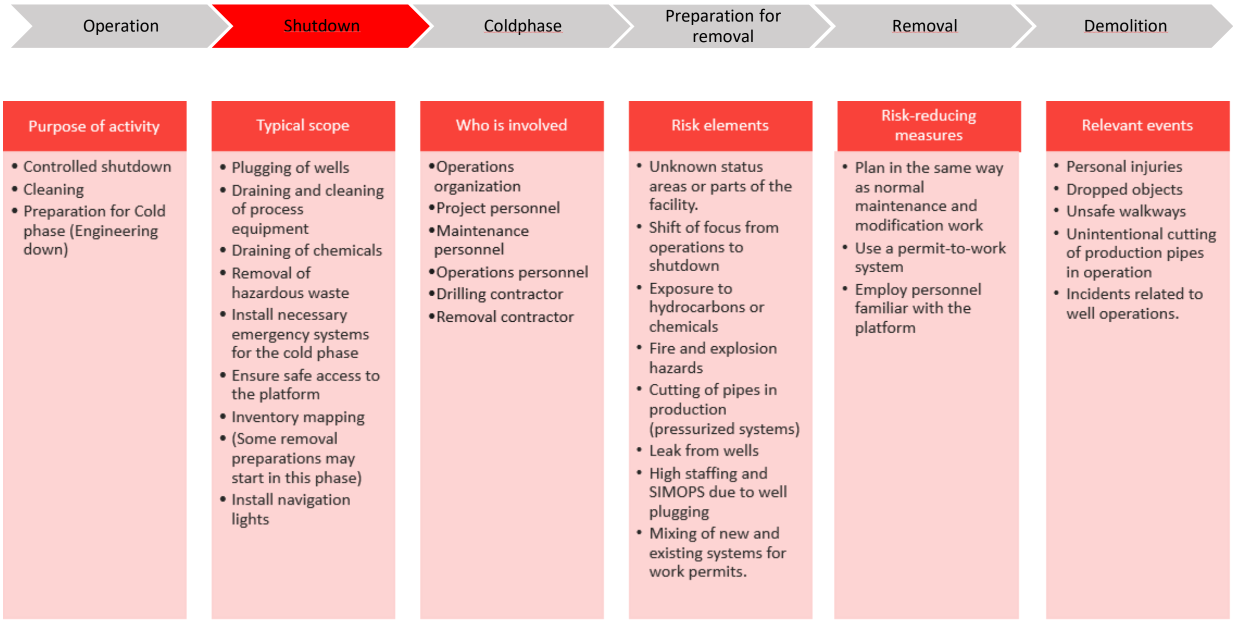

Figure 7.1: Key Elements in the Shutdown Phase (Source Acona)

Planning for shutdown begins well in advance of the actual shutdown. Some shutdown tasks may be carried out while the platform is still in operation or simultaneously with well plugging.

When the use of the platforms ceases, a carefully planned and controlled shutdown and cleaning (engineering down) of the platform systems is initiated. For an installation with platform wells, the last wells are plugged, and the casing is cut and removed. Sometimes, the casings are removed in conjunction with the removal of the topside.

There is varying practice regarding how much inventory and equipment is removed from the platform during this phase because the cost of removing equipment often exceeds its value. Work in this phase is typically carried out by the operator’s maintenance contractors who are familiar with the platform and its systems. Therefore, shutdown tasks follow the same routines as regular maintenance and modification work on the platforms.

During this phase, engineering, planning, job card preparation, and risk assessments for the tasks are conducted.

7.1 Typical scope

- Plugging of Wells (ongoing).
- Shutdown of process system, isolation, draining, and cleaning of process systems with water.
- Energy sources such as pressure valves are set to open positions to prevent pressure buildup.
- Removal of chemicals.
- Drainage of refrigerant gases from freezing and HVAC systems.
- Removal of AFFF chemicals from firefighting equipment.
- Removal of loose objects and other exposed equipment that could fall.
- Cleaning, shutting down, and sealing of biological toilets and sewage systems.
- Emptying of oil separators (sea sump) of oil residues.
- Cleaning of export pipelines.
- Draining of oil from rotating equipment and motors and emptying of diesel day tanks.
- Draining and flushing of diesel systems with water.
- Opening, draining, and providing natural ventilation for tanks.
- Removal of batteries and grounding of cables.
- Removal of hazardous waste.
- Cleaning and emptying the platform of inventory.
- Installation of temporary generators for use during the cold phase.
- Establishment of diesel storage for cold phase maintenance.
- Deactivation of safety systems after all wells are plugged and the platform is cold. These systems include:
  - Firewater
  - Fire and gas monitoring
  - Rescue equipment
  - Medical equipment, first aid
  - Shutdown of power supply
- Drainage and flushing of helicopter fuel systems with water.
- Ensuring safe future access to the platform, including certified helicopter deck.

Environmental inventory mapping is conducted at the end of this phase to give the operator an overview of the products, hydrocarbons, and hazardous waste still present on the platform.

Some systems may still be active, such as:

- Navigation lights powered by temporary electricity from a nearby platform, or by solar panels/wind turbines and batteries.
- Cranes may be maintained and kept operational in anticipation of the removal campaign.
- Fire and gas monitoring of cranes if they are still operational.

- In some cases, lights may be installed on escape routes.

Preparations for the actual removal may sometimes begin in this phase. The advantage is that the platform is warm, the living quarters are operational, cranes, electricity, water, and air are still available, and walkways are maintained and safe to use. An example of this is the Gyda platform, where preparatory work is carried out in parallel with the shutdown and well plugging. The actual removal of the topside is planned shortly after the last well is plugged.

7.2 Who is involved

In this phase, the following stakeholders are involved in planning, decision-making, and execution processes:

- Operations organization
- Project personnel
- Maintenance personnel
- Operational staff
- Decommissioning contractor
- Drilling contractor

7.3 Risk elements

In this phase, there is a high manning level on the platform, and the focus shifts from operations to shut down. Key risk elements are:

- SIMOPS
- Unknown status of areas or parts of the facility
- Exposure to hydrocarbons or chemicals
- Cutting of pressurized systems
- Leaks from wells
- Mixing of new and existing permit systems
- Dropped objects

7.4 Risk-reducing measures

In this phase, it is important to plan in the same way as for routine maintenance and modification work.

The Labor Inspection Authority requires coordination of HSE (Health, Safety, and Environment) work when multiple entities work in shared areas and use shared resources or equipment such as cranes, elevators, and scaffolding. In such cases, there should be a main contractor responsible for coordinating health, safety, and environmental efforts on the site.

A single permit-to-work system must be used.

Personnel familiar with the platform should be employed.

7.5 Relevant incidents

Despite thorough planning and preparation, the following incidents have been recorded in this phase:

- Personal injuries
- Dropped objects
- Unsafe walkways
- Cutting of gas pipes that are still in production
- Breach of barriers

8 Cold phase

Purpose of activity	Typical scope	Who is involved	Risk elements	Risk-reducing measures	Relevant events
• Waiting phase before removal can take place.	• Limited and necessary maintenance. • Extensive maintenance depending on the timing of removal. • Planning of removal.	• Maintenance personnel from the operator. • Survey personnel	• This phase can last for several years. • Loss of structural integrity. • Degradation of the facility, attachments, wall panels, cable trays, etc. • Unsafe walkways. • Helicopter transport • Failure of navigation lights.	• Reduce the time the facility is in cold phase. • Proactive maintenance. • Remove or secure equipment that may later pose a hazard, e.g., due to corrosion. • Remote monitoring of navigation lights.	• Dropped objects. • Personal injury. • Technical issues with helicopter. • Failure of navigation lights, empty batteries.

Figure 8-1 Key Elements of the Cold phase (Source Acona)

8.1 Purpose of the activity

The cold phase is the period between the platform shutdown and the start of preparations for removal. This period can last from a few months to several years (10-20 years).

8.2 Typical scope

To keep costs down, only minimal maintenance work is performed, which includes:

- Maintenance of navigation lights.
- Maintaining walkways to navigation lights.
- Removal of loose objects over walkways.
- Inspection of main structures.
- Maintaining certification of the helicopter deck.
- Possible operation and maintenance of cranes.

During the cold phase, planning for platform removal begins. Relevant removal studies are conducted, platform documentation and drawings are collected, and HSEQ procedures are established. Contractors are pre-qualified for the removal job, and tender documents are prepared, and the tendering process is carried out.

In the tender phase, pre-qualified contractors perform inspections offshore on the cold platforms.

8.3 Who is involved

In this phase, only the operator's maintenance personnel and, if needed, survey personnel visit the platform.

8.4 Risk elements

Typical risk elements are:

- Loss of structural integrity.
- Degradation of the facility, including fastenings, wall cladding plates, cable trays, etc.
- Unsafe walkways.
- Helicopter transport, with unmanned helicopter deck.
- Power failures for navigation lights, including empty batteries.
- Dropped objects.

8.5 Risk-reducing measures

The duration the platform is in the cold phase is crucial for its condition at removal stage. The length of this phase is often unclear, and the scope of necessary maintenance during this phase will also depend on the removal method, which may not always be decided at this stage.

Risk-Reducing Measures:

- Reduce the duration of the cold phase.
- Preventive maintenance*.
- Remove or secure equipment that may become hazardous due to corrosion.
- Remote monitoring of navigation lights, empty batteries, and malfunctioning wind turbines.

8.6 Relevant incidents

Some reported incidents from this phase are:

- Dropped objects, wall cladding plates, structure insulation, etc.
- People stepping through gratings on walkways.
- Breach of barriers.
- Technical issues with helicopters.
- Navigation light failure.

** Leaving a platform in the cold phase with limited maintenance for an extended period (several years) introduces additional safety aspects for personnel who need to visit the platform. Appendix A addresses maintenance considerations for this phase.*

9 Removal planning

Operation → Shutdown → Coldphase → **Preparation for removal** → Removal → Demolition

Purpose of activity	Typical scope	Who is involved	Risk elements	Risk-reducing measures	Relevant events
• Planning of the actual removal • Preparatory work	• Planning • Offshore inspections • Detailed engineering • Assessment of major accident risk • HAZIDs • Risk analyses • SIMOPs assessments • Safe job analyses • HAZOPs	• Operator's operations organization • Operator's removal and project organization • Removal contractor with their subcontractors • Demolition contractor • Operator's safety service • Marine warranty surveyors • Third-party verification	• Dropped objects during inspection • Lack of respect for barriers during inspections • Incomplete or incorrect platform information for engineering • Lack of platform knowledge within the operator • Inexperienced contractors • Lack of competence and culture for removal among contractors • Poor preparation for those performing the actual removal.	• Conduct a safe job analysis before the survey • Clear lines of responsibility • Early identification of risks • Involvement of operations personnel in the engineering phase. • Follow-up with suppliers • Thorough preparations before inspection trips • Focus on the work environment • Training and qualifications • Implement risk prevention measures	• Dropped objects • Unsafe walkways

Figure 9-1 Main elements involved in design for removal (Source Acona)

9.1 The purpose of the activities

In this phase, the selected contractor begins detailed design work, conducts offshore investigations, and performs necessary structural analyses to document the demolition method.

HAZIDs are carried out early in the design phase, and work packages are prepared. HSE assessments and analyses are conducted, with both the operator and contractor contributing with their specialists. Risk assessments are performed at the work package level.

Work plans are reviewed in detail to identify SIMOPs.

9.2 Design Phase

- The contractor prepares project documentation, procedures, and plans.
- Conduct HAZIDs.
- Develop work packages.
- Perform structural and lifting analyses.
- Conduct risk assessments at the job package level.
- Perform SIMOPs analyses.
- Conduct HAZOPs.
- Conduct emergency preparedness analyses.

- Establish offshore removal manuals.
- Specify equipment.
- Purchase and rent tools and temporary auxiliary equipment.

9.3 Who is involved

The operator's maintenance organization is responsible for the platform during this phase.
The removal project organization is established both at the operator and the removal contractor.
The contractor's engineering team is put in place.
The operator's operations organization, both onshore and offshore, as well as the safety delegate, are involved from the project kick-off meeting, during offshore inspections, and in risk reviews.
A contract is signed with an insurance company-approved Marine Warranty Surveyor, who reviews all relevant documents.
An independent third party reviews all structural analyses.

9.4 Risk elements

In this phase, there is relatively little activity on the platform, but during inspections and maintenance, risk elements such as dropped objects, insufficiently secured areas, and unsafe walkways will always be present.

In the design phase, it is crucial to be aware of and account for the risk elements that may arise during the actual demolition work and to implement risk-reducing measures in all project documentation and job cards.

Risk elements that must be focused on include:

- Dropped objects
- Manual handling
- Inadequate management of barriers
- Simultaneous operations (SIMOPS)
- Lack of work permits coordination
- Cutting and burning
- Lifting operations

9.5 Risk-reducing measures

Clear responsibilities

It is important that roles and responsibilities are clearly described in project procedures and job cards, with clear communication lines established. Foremen play a important role in offshore execution, so it is essential to use experienced foremen with detailed knowledge of all ongoing work and to establish clear communication lines.

Early risk identification

Risk identification and elimination should start early in the design phase so that risk-reducing measures can be implemented in design documents and job cards.

Involvement of Operational personnel in design phase

Personnel familiar with the platform from the operation phase should be involved early in the design phase to support project engineers.

Supplier follow-up

It has proven useful to hold safety meetings with management and key personnel from all supplier companies involved in the decommissioning projects. Close, risk-based monitoring of contractors throughout the project is also necessary.

Preparation before departure

Conduct thorough reviews of work and safety expectations with personnel before each offshore trip. For inspections and maintenance campaigns, it is necessary to conduct safety job analyses.

Focus on work environment

Ensure that working environment groups are established among workers. The contractor should have a program that continuously assesses and prepares the working environment.

Procedures

Establish necessary and effective work procedures.

Training and qualifications

Use qualified personnel with fundamental HSEQ knowledge, experience, and a culture of demolition work, as well as understanding of the tasks to be performed. Contractor personnel should be familiar with and trained in relevant risk elements. Conduct safety awareness training and training programs to identify potential hazards.

Risk-Preventive Measures

- Training

- Familiarization with the project
- Audits
- HAZIDs
- Risk analyses at the job card level
- Safety Job Analyses (SJA)
- SIMOPS
- HAZOPs
- Readiness reviews before work starts offshore
- Involve leading vessel personnel in HAZIDs, HAZOPs, tabletop exercises, and emergency drills
- Simulate lifting operations with key personnel
- Toolbox talks
- Thorough inspection of structures before lifting

9.6 Major accident risk

The risk of major accidents is thoroughly analysed in the initial phases. This is done by a team with extensive experience in demolition work.

Major accident risk elements identified in connection with demolition and removal work include:

- Helicopter crashes, personnel transport.
- Collision with passing vessels.
- Collision with supply boats and the platform
- Gas explosion from gas leaks from neighbouring platforms.
- Collision due to failures in the dynamic positioning system of lifting vessels. Crane accidents, many heavy lifts.
- Lifting over pressurized and producing pipelines

When risk elements are analysed and managed appropriately, experience shows that the risks of major accidents are significantly reduced.

It is also crucial that changes to procedures and job cards follow an established change management process and are properly documented.

10 Preparations for removal – regardless of method

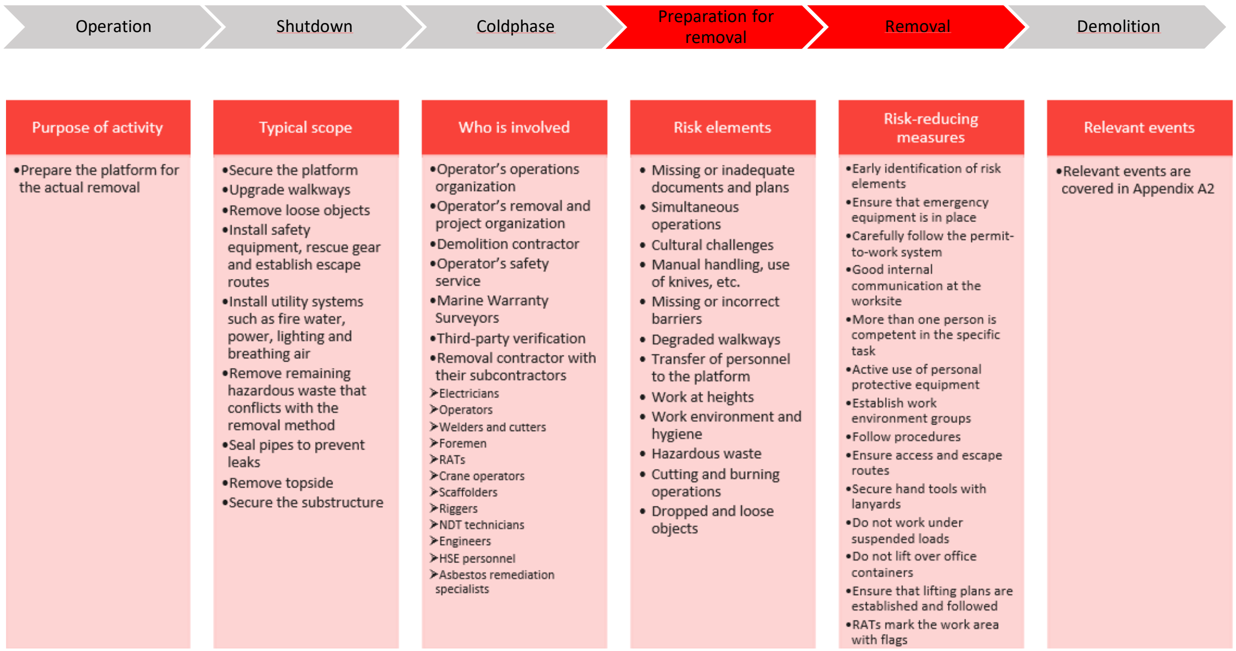

Figure 10-1 Main elements involved in preparation for removal (Source Acona)

10.1 The purpose of the activities

In this phase, the removal contractor begins preparations for the removal. The platform is upgraded to ensure it is safe for access before the actual removal work begins.

10.2 Typical scope

When the platform or parts of it are declared safe, the utility systems such as firefighting water, power, lighting, and air are installed. Once these systems are in place and approved, the actual demolition work can begin.

All removal methods require the platform to be cleaned, but the extent of cleaning varies by method:

- Piece small method requires very thorough cleaning since all pipes, tanks, etc., are cut into small pieces on-site offshore, and any spills could affect the air and sea.
- Heavy lift method requires a high degree of cleaning of pipes and ventilation ducts, as these are cut between modules.
- Single lift method requires less cleaning, as this can be done when the topside structure arrives at the onshore dismantling facility.

All methods require that the platforms are safe to access, but the extent of areas that need to be secured varies by method. Piece small and heavy lift methods need access to most of the platform, while single lift methods might manage with limited access.

All methods require crane assistance, either from an existing platform crane, a temporarily installed crane on the platform, or a crane vessel.

Activities performed for all methods in this phase include:

- Securing the platform.
- Repairing walkways and stairs.
- Removing loose items that could fall.
- Removing any items that could be dislodged by crane wires.
- Installing safety equipment, rescue gear, and escape equipment.
- Installing utility systems such as water, air, power, and lighting.
- Removing any remaining hazardous waste that could conflict with the removal method or result in environmental spills.
- Verifying that all pipes and tanks are cleaned.
- Sealing open pipes to prevent leaks.
- The demolition contractor performs their own environmental assessment.

10.3 Who is involved

In this phase, there is close collaboration between the operator's project organization and the removal contractor.

The removal contractor mobilizes their offshore organization, which may consist of:

- HSE personnel
- Asbestos removal specialists
- Firewatchers
- Burners
- Electricians
- Foremen
- Helpers
- Engineers
- Rope Access Technicians (RATs)
- Crane operators
- Equipment operators
- Mechanics
- NDT (Non-Destructive Testing) technicians
- Operators

- Plate workers
- Riggers
- Scaffolders
- Welders
- Excavator operators

Operator personnel may sometimes participate in monitoring the demolition work.
The demolition contractor performs their environmental assessment during this period.

10.4 Risk elements – regardless of method

Several of the risk elements listed below are relevant to varying degrees for all removal methods.

Work at heights or over open water:

- Dropped objects.
- Work at heights for rope access technicians and scaffolders.

Work environment and hygiene:

- Lack of use of personal protective equipment (PPE).
- Incorrect use of PPE.
- Inadequate or poor lighting at the worksite.
- Smoke, gas, and dust from cutting, welding, and grinding on painted surfaces (health hazards).
- Failure to use fresh air breathing masks.
- Poorly designed barriers.
- High noise levels associated with burning welds (carbon arc burning).
- Unknown types of hazardous substances in pipes, ventilation ducts, and paints.
- Release of hazardous waste not identified during initial assessment and cleaning.
- Ceramic fibers and asbestos in flanges, insulation, cables, walls, ceilings, and floors.
- Exhaust fumes from heavy lift vessels during preparation and demolition work.
- Poor housekeeping at the worksite.
- Vibration injuries from hand tools.

Environmental hazardous materials and waste:

- Risk of releasing environmental hazardous waste into the external environment.
- Hydrocarbon emissions during cleaning and transport.
- Unknown types of hazardous waste in paint, pipes, and ventilation systems.
- Emissions of heavy metals and hydrocarbons.

Degraded Walkways:

- Corroded and unsafe walkways.
- Corroded and unsafe stairs and ladders.
- Corroded and unsafe deck plates.

Documentation and Plans:

- Lack of, or poor "As-Built" documentation.
- Poor quality of reports from offshore inspections.
- Poor quality of the contractor’s procedures.
- Lack of up-to-date information on escape routes and placement of first aid equipment on the platform.
- Missing emergency plans.
- Transfer of personnel to the platform.

Dropped and loose objects:

- Loose wall panels drop without warning.
- Corroded cable trays.
- Forgotten items on scaffolding or structures.
- Cutting pipes on the wrong side of support structures.
- Cutting unstable piping systems.
- Objects being pulled down by crane wires.
- Unsecured hand tools.
- Scaffolding tubes dropped during manual handling.
- Lifting operations over personnel or personnel walking under lifts.

Cultural Challenges:

- Language barriers.
- Improper use of personal protective equipment (PPE).
- Different nationalities among workers.
- Lack of experience with, and cultural understanding of demolition work.

Cutting Operations:

- Cutting of pipes containing mercury and radioactive materials.
- Cutting of pressurized systems.
- Fire hazard if cutting torches are used on flammable materials.
- Risk of fire and explosions if cutting torches are used on process systems with residual hydrocarbons.

- Burn injuries to access technicians when cutting rusty steel.

Lack of capacity or unstable structures:

- The condition of the structures to be removed is unknown and lacks documentation.

Barriers:

- Insufficient or poorly constructed barriers (can blow away, easily overlooked).
- Barriers with "open back doors".
- Ignoring weather conditions when setting up barriers, leading to exposure of workers outside the barriers to smoke, gas, and dust.
- Lack of control and ownership of barriers.
- Lack of respect for barriers, barriers not being removed after use.
- Breach of the barriers.

Personnel transfer to the platform:

- Difficult access to the platform via helicopter, gangway, or basket transport.

Simultaneous operations:

- Unclear procedures and job cards.
- Failure to follow job card sequence.
- Lack of communication between foremen.
- Poor shifts start-up meetings at the worksite.

Lifting operations:

- Failure of old cranes, and lack of crane modifications documentation.
- Lack of available spare parts for cranes.
- Failure to use certified load carriers.
- Loads under tension, wire breaks.
- Numerous crane operations.
- Use of uncertified lifting equipment.

Hand injuries:

- Manual handling of scrap steel.
- Use of knives.

10.5 Risk-reducing measures – regardless of the method

Risk elements are identified early in the design phase, as described in sections 9.2 and 9.5. To eliminate risk elements during the demolition work itself, it is important to closely follow the work permit system (WP) and focus on the following risk-reducing measures:

- Establish systems that carefully control the issuing and return of work permits.
- Plan and manage simultaneous activities (SIMOPS).
- The work sites must be thoroughly inspected, all safety measures must be implemented, and it must be verified that no simultaneous operations (SIMOPS) are ongoing before work permits are signed and issued.
- The contents of the work permits must be understood.
- "Toolbox" talks should be held before the work starts.
- Review or conduct safe job analyses.
- Good internal communication at the work site.
- More than one person is qualified for the specific task.
- Active management of barriers.
- Establish a system for active control and management of barriers.
- Ensure that necessary barriers are in place before work begins, both above and below the work area.
- Consider wind direction when setting up barriers.

Work environment and protective equipment

- Ensure that the work site has sufficient lighting.
- Establish procedures for the use of hand tools.
- Limit the use of knives. Use "vibration-free" tools.
- Ensure the availability and correct use of personal protective equipment.
- Secure hand tools with safety lanyards.
- Maintain good housekeeping at the work site. Hang cables and hoses on S-hooks and use ramps over cables and hoses on the deck.
- Ensure that emergency equipment is in place.

Chemicals

- Avoid the use of chemicals as much as possible.
- Environmentally harmful chemicals should be replaced with eco-friendly products.
- Follow procedures for handling environmentally hazardous liquids and spills.

Secure access and escape routes

- Secure safe access to the platform.
- Repair and secure walkways and escape routes.
- Escape routes should be clearly marked.
- Walkways and escape routes must have sufficient lighting.
- Ensure there are always two escape routes, even after modules or walkways are removed.
- Ensure escape routes are not blocked.
- Escape plans must always be updated and placed at strategic locations on the platform.

Dropped objects

- Remove all loose objects from structures and beams.
- Do not store loose objects on scaffolding.
- Install toe boards on scaffolding to prevent falling objects.
- Remove loose wall panels.
- Ensure the work object is in a stable position before and after the work.
- Clean the area after work to ensure nothing is left behind that could fall.
- Do not work under suspended loads or other items that could fall.
- Do not walk under suspended loads.
- Do not lift over workers or office containers.
- Secure tools and materials to prevent them from falling.
- Secure hand tools with safety lanyards.

Crane and lifting operations

- Rope access technician must mark the area they are working in with flags so that the crane operator/flagman is aware of them.
- Cranes and lifting equipment must be regularly inspected and maintained.
- Transport equipment in approved load carriers instead of manual transport.
- Do not lift over personnel or office containers.

Avoid manual work at heights whenever possible; use mobile lifts instead of scaffolding.
Perform NDT testing of structural steel at lifting points, including old welds.

10.6 Relevant Incidents

Relevant incidents reported are covered in Appendix B.

11 Piece small removal

Operation	Shutdown	Coldphase	Preparation for removal	Removal	Demolition

Purpose of activity	Typical scope	Who is involved	Risk elements	Risk-reducing measures	Relevant events
• Prepare the platform for removal • Removal of the topside, piece by piece	•Install excavators with hydraulic shears •Through cleaning of the platform to prevent spills into the external environment •Cutting up the structures with an excavator combined with burning •Lift containers with scrap to the transport vessel •Lift larger sections to the lifting vessel	•Contractor's demolition personnel, see section 10.3 and excavator operators	•Use of larger construction machinery •Small areas with potential for machine-human interaction •Insufficient capacity to support heavy machinery •Unstable structural elements and unintended collapse as the structure is cut •Many crane lifts between the platform and the transport vessel •Release of hazardous waste that has not been previously identified, steel pieces that "fly" when the excavator cuts steel structures.	•Ensure that all systems are thoroughly cleaned before cutting begins •Establish procedures for the removal of dust, rust, paint flakes, etc. – "clean up" to prevent the release of hazardous waste •Removal of combustible materials before hot work begins •Ensure that procedures for handling hazardous liquids and spills are established •Establish approved lifting plans.	• Dropped objects • Personal injuries during burning • Incorrect use of equipment • Pinch injuries • Crane incidents • Missing lifting plans

Figure 11-1 Main elements related to preparation for removal and removal using piece small method (Source Acona)

11.1 Preparation offshore – Piece small removal

The Piece small removal method involves cutting up the platform's topside into smaller pieces while it is still offshore. This cutting is primarily performed using an excavator fitted with hydraulic shears in combination with hot cutting methods, though water jet cutting, and diamond wire cutting may also be used.

This demolition method requires that all platform systems are thoroughly cleaned to prevent any discharge of environmentally hazardous waste into the sea, and all flammable materials must be removed before any hot work begins.

The cleaning and securing of the platform are carried out by a team of specialists, including experts in process systems, high-pressure cleaning, asbestos removal, and rope access technician. Asbestos and ceramic fibres must be safely removed to prevent their release during the cutting of the structures, thereby avoiding the risk of contaminating large areas of the platform.

11.2 Removal – piece small method

Piece small removal requires extensive logistics, including the transportation of heavy construction equipment offshore and its installation on the platform.

Once walkways are secured and hazardous waste and loose items are removed, the actual dismantling can begin. Excavators equipped with shears are placed on the platform and start cutting the structure from the top down.

It is essential that the module structures have sufficient capacity to safely support the excavators. It may be necessary to reinforce the module roofs with reinforced steel plates (driving elements) for the support of excavators.

Adequate deck space is required for the operation of the excavators and for the storage of containers used for sorting and transporting materials.

Access to cranes is also required, which may include platform cranes, temporarily installed cranes, or crane vessels, to lift containers to and from transport vessels.

The platform is cut into manageable pieces, which are sorted and sent to shore in containers using supply vessels or on the deck of removal vessels. The size and weight of the structural pieces, which can be up to 20 tons, depend on crane capacity and transport methods.

This removal method necessitates frequent trips of transport vessels.

11.3 Personnel involved

In addition to the personnel mentioned in section 10.3, there will be excavator operators who cut up the platform.

11.4 Risk elements – Piece small removal method

Risk elements applicable to all removal methods are described in section 10.4. Specific risk elements for the Piece small method may include:

- Many crane lifts between platform and transport vessel.
- Installation of heavy construction equipment on module roofs/decks.
- Lifting larger structural elements with unknown centers of gravity.
- Lack of Lifting plans.
- Steel debris flying from shears of cutting machines.
- Failure to Use approved load carriers (including slings).
- Collision between transport vessels and platform.
- Cutting operations during Piece small operations generate dust, rust, and paint flakes accumulating on the deck. This debris may contain PCBs, heavy metals, asbestos, etc., and must be continuously removed to prevent environmental contamination.
- Insufficient structural capacity to support heavy excavators.
- Unstable structural elements and unintentional collapse as structures are cut.
- High workload and extensive manual labour offshore increase the risk of incidents.

- Both excavators and burners operating simultaneously in small areas.

11.5 Risk-reducing-measures – Piece small removal method

Specific risk-reducing measures for the Piece small removal method may include:

- Ensure that procedures for handling environmental hazardous liquids and spills are followed.
- RATs should mark the area they are working in with flags to alert crane operators/flagmen.
- Regular maintenance of cranes and lifting equipment, including replacing worn out parts.
- Ensure that the work object is in a stable position before and after a cut.
- Continuous collection and removal of debris from the deck.
- Ensure that lifting plans are established.

12 Heavy lifts – reverse installation

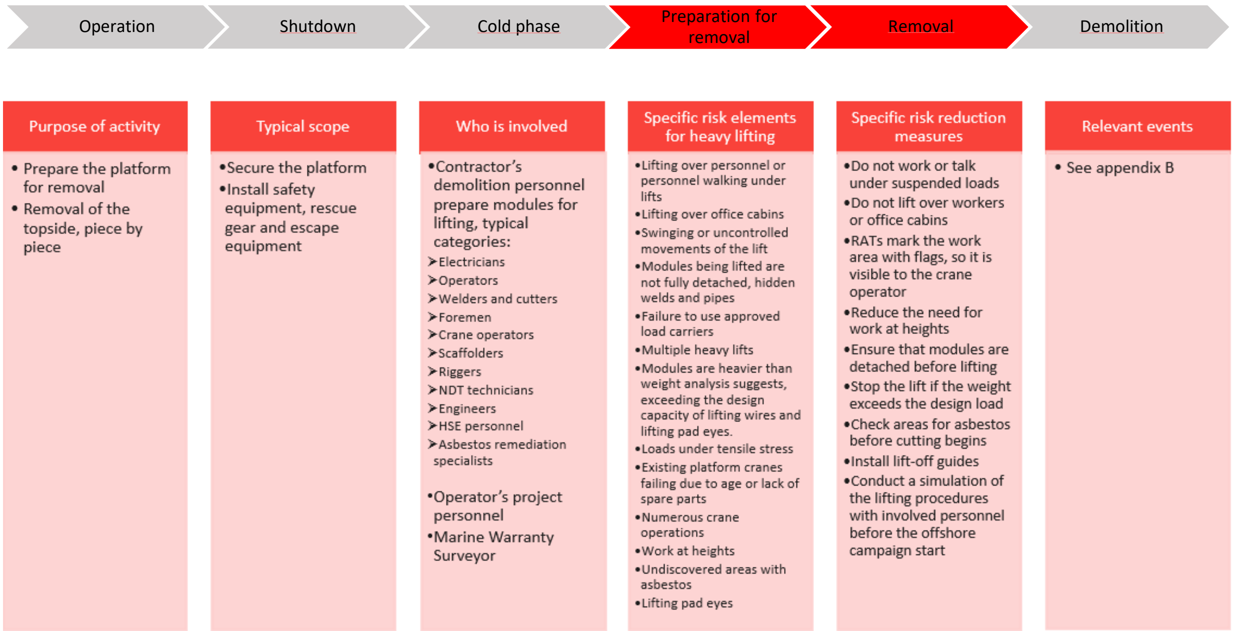

Figure 12-1 Key Elements for Preparation and Removal Using the Heavy Lift Method (Source Acona)

12.1 Preparation for removal – heavy lift method

Reverse installation involves removing the modules from the topside in the reverse order of their original installation.

This method requires extensive structural analysis to verify that the modules can indeed be lifted off as they were installed. It is not uncommon for modules and structural elements to have been modified over the years without proper documentation.

This removal method necessitates that personnel have access to most areas of the topside to disassemble the modules. Therefore, extensive upgrades to walkways, decks, and stairs are required, and loose items must be removed to facilitate safe and effective removal.

Photo by Svein Otto Berge Vik

Photo 12-1 Module Removal using the Heavy lift method – Reverse installation

12.2 Removal – heavy lift method

Modules are separated by cutting openings in the wall panels, floors, and ceilings around the entire module. All pipes, cables, ventilation ducts, and structures, etc., that run between the modules are cut so that each module is free.

Asbestos in the cutting zones between modules or in the lifting points must be removed in a safe manner.

Pipes are sniffed and, if necessary, drained before cutting, and then plugged to prevent leaks.

New lifting pad eyes are installed if the original ones are removed, which is often the case.

Cutting with oxyfuel is the most common method for cutting structures and pipes, but other cutting methods such as water jet cutting, mechanical sawing, and diamond wire cutting are also used.

Water jet cutting is an effective method for removing paint from steel structures and pipes to prevent toxic smoke on the platform during cutting.

Welds connecting the modules to each other or to the deck frame are burned away using oxygen or plasma torches.

The heavy lift removal method requires a lot of work at height, either from scaffolding, mobile lifts/platforms, or by using RATs.

The method also requires extensive welding of new lifting pad eyes.

Modules are lifted from the platform and placed on the deck of a lifting vessel or onto transport barges where they are secured for sea transport.

12.3 Personnel involved

The personnel involved are listed in Section 10.3

12.4 Risk elements – Heavy lift method

Risk elements applicable to all removal methods are described in Section 10.4. Specific risk elements for the heavy lift method can include:

Cranes:

- Uncertain center of gravity for the module and lift.
- Uncertain weight of the module and lift.
- Modules/lifts heavier than calculated weight, exceeding the calculated maximum crane hook load.
- Swinging and uncontrolled movements during the lift.
- Lifting over personnel or personnel walking under hanging loads.
- Modules not completely loose as there may be hidden welds and pipes.
- Crane lifting wire and tugger lines dislog equipment on platform topside causing dropped objects.

Vessels:

- Short distance from the lifting vessel to the platform.
- Collision with the platform when positioning the lifting vessel.
- Failure of the lifting vessel's dynamic positioning system.
- Transfer of modules to transport barges and securing in adverse weather conditions.

Structure:

- Laminations (undetected) in structural steel at lifting points.

Work Environment:

- Exhaust fumes from the crane vessel.

12.5 Risk-reducing measures – Heavy lift method

Specific risk-reducing measures for the Heavy lift method:

Ensure that there are always 2 escape routes, even after a module is removed.

Crane Operations:

- Do not work under hanging loads or other items that could fall.
- Do not lift over people working below.
- Do not lift over office containers.
- RATs must mark the area they are working in with flags so that crane operators/flagmen are aware of them.
- Transport equipment using approved load carriers instead of manual transport.

Work Area:

- Clean the work area after work is completed to ensure nothing is left that could fall.

Work Environment:

- Use hand tools correctly, including the use of safety lanyards.
- Use "vibration-free" tools.
- Plan and manage simultaneous operations (SIMOPS).
- Avoid manual work at height if possible; use mobile lifts instead of scaffolding.

Structure:

- Perform NDT testing of structural steel at lifting points, including old welds.

13 Single lift method

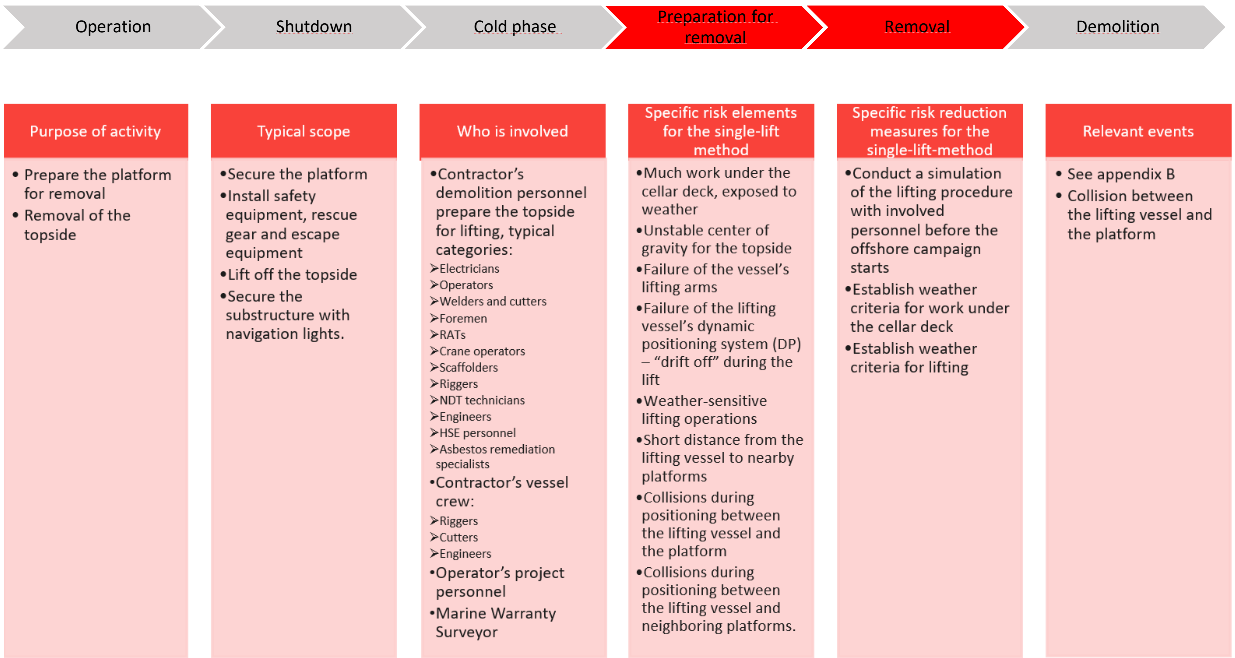

Figure 13-1 Key elements for preparation and removal using the Single lift method (Source Acona)

13.1 Preparation offshore – Single lift method

For the single lift method, extensive structural analyses are required to verify that the deck frame/overhead structure has sufficient capacity to be lifted, transported, and potentially transferred from the vessel to a barge and then to the demolition facility.

Cleaning work for the single lift method is less extensive, and the number of hours needed for preparation on the platform is less than for the previous two methods.

Today, we primarily think of Allseas' Pioneering Spirit when it comes to single lift vessels, but Heerema's Sleipnir and Thialf, and Saipem's S-7000 can also remove and have removed lighter topsides in a single lift.

For the single lift method using the Pioneering Spirit, preparation work involves clearing the underside of pipes, walkways, stairs, structural elements, etc., that could interfere with the vessel's lifting arms. Extensive scaffolding under the lower deck is required for access.

The deck structure or steel legs may need to be reinforced to establish new lifting points. This requires substantial rigging and welding before the topside can be cut loose from the substructure.

The Pioneering Spirit positions and attaches its lifting arms to the lifting points under the lower deck. Once all lifting arms are attached, the topside is lifted from the substructure in a single lift within a few seconds (the Valhall QP quick lift took 9 seconds).

Photo by Svein Otto Berge Vik

Photo 13-1 Single Lift Removal - Positioning of PS

Photo by Svein Otto Berge Vik

Photo 13-2 Single Lift Removal - Lifting Arms Placed Under the Topside

If Sleipnir, Thialf, or S-7000 is to remove the topside in a single lift, it is required to establish new lifting points in the substructure. Holes must be cut through the modules to install the lifting wires. The advantage of this method is that the preparatory work is done above deck.

In some cases, lighter topsides were installed as a single lift using a heavy lift vessel. In these cases, the original lifting points can be reused if they still exist.

Preparatory work includes installing new lifting points, cutting holes in modules for lifting wires, asbestos removal if asbestos conflicts with the work, and detaching the topside from the substructure.

Heavy lift vessels lift the topside in a single lift after the crane's/cranes' rigging is attached to the lifting points on the platform topside.

13.2 Removal – single lift method

With this method, normally only limited access to areas on the platform is required.

For the single lift method, many of the same risk elements as those for the heavy lift method are present, but the scope of offshore work is smaller, and the duration is significantly shorter for the single lift method. The number of heavy lifts is also reduced to a few lifts (platform topside, bridge, and possibly flare boom).

For Pioneering Spirit, most of the preparation work is carried out on and under the platform's cellar deck. If S-7000, Thialf, or Sleipnir is used, these vessels need access to larger areas of the topside to install new lifting points.

For lighter topsides that were installed as a single lift, the original lifting points may possibly be reused, making the preparation work less extensive.

13.3 Personnel involved

When the lifting vessel arrives at the platform, in practice, all preparation work is completed.

In some cases, riggers may be sent to the platform to rig the lifting wires if, for example, Thialf, Sleipnir, or S-7000 is used.

If the lift is carried out with Pioneering Spirit, there is no need for personnel on the platform. All work related to the lift is managed from the bridge of Pioneering Spirit.

A Marine Warranty Surveyor will be present to ensure that the lift proceeds as prescribed.

13.4 Risk elements – Single-lift method

Risk elements valid for all removal methods are outlined in Section 9.4. Specific risk elements for the single-lift method can include:

- Extensive work under the deck where workers are exposed to weather conditions.
- Weather-sensitive lifting operations.
- Uncertain Center of Gravity of the platform topside.
- Failure in one or more of the lifting arms (PS).
- Short distance from the lifting vessel to the platform.
- Short distance from the lifting vessel to nearby platforms.
- Failure in the vessel's dynamic positioning system (DP) during positioning and/or lifting ("drift off").
- Collision between the lifting vessel and the platform during vessel positioning.
- Collision between the lifting vessel and adjacent platforms during vessel positioning.

13.5 Risk-reducing measures – Single-lift method

Specific risk-reducing measures for the single-lift method:

- Comprehensive structural analyses for the entire platform.
- NDT of lifting points as well as old and new welds.
- Conduct lift procedure simulations with all involved personnel; hold a workshop before the offshore campaign starts.
- Establish weather criteria for all stages of the operation.

14 Secure substructure

Operation | Shutdown | Cold phase | Preparation for removal | **Removal** | Demolition

After the platform topside has been removed, the substructure can be left temporarily, removed entirely, or partially. Steel structures are often removed completely, but larger concrete structures may remain on site. If the substructure is left behind, it must be secured with navigation lights.

In all cases, the remaining substructure must be secured temporarily or permanently after the topside has been removed. In the Norwegian continental shelf (NCS), all steel substructures, with a few exceptions, have so far been removed as part of the platform decommissioning. Equinor's Eko S steel substructure and bridge support remained in place for several years before being removed. AkerBP's Eko G and Valhall QP steel substructures are still in place with temporary navigation lights.

Risks related to securing, removing remaining equipment in the substructure, and further maintenance are not covered by this report. As seen from the impact assessment related to the decommissioning plan for the Statfjord field, there are some safety challenges related to removing equipment in concrete shafts. It can be challenging to remove all equipment safely, so the decision on what to do involves a trade-off between costs and safety versus environmental benefit.

15 Recommended reading

This report is not a literature review, but there is plenty of relevant literature available for those interested in delving deeper into the subject on a general basis.

Various methods for the removal of substructures are discussed, for example, in the comprehensive report *"Decommissioning and Disposal of Decommissioned Units"* prepared by Dr. techn. Olav Olsen AS in 2018.

Impact assessments for the decommissioning and final disposal of many different installations are available online. These provide a good overview of the considerations made during the planning phase. Notable examples include Statfjord A, Valhall DP and PCP, and Knarr.

The impact assessment related to the decommissioning plans for Statfjord A includes considerations regarding concrete substructures that remain after the removal of the deck facilities.

OSPAR has produced an *"Offshore Installation Inventory"* that provides an overview of installations in the North Sea. They also publish materials that can guide future decommissioning projects.

OD have "fact pages" that offer up-to-date information on the status of installations on the Norwegian continental shelf (NCS).

Appendix A Maintenance considerations

A1.1 Maintenance considerations

Leaving a platform in a cold phase with limited maintenance for several years introduces several safety concerns for personnel who need to board the platform. Experiences from Frigg, Ekofisk, and Valhall show that corrosion and deterioration increase each year the platform remains without maintenance.

The main risks for personnel on these platforms are:

- Potential dropped objects, such as:
  - Loose wall panels
  - Passive fire protection materials that detach from walls and fall
  - Corroded cable trays
  - Exhaust pipes with significant corrosion
  - Large floodlights and other heavy equipment with rusted mounts
- Unsafe Walkways and Stairs due to rusted supports and grating. Handrails with corroded attachments (which may fall upon contact) provide a false sense of security.

Picture by Svein Otto Berge Vik

Image: Passive Fire Protection Material Fallen Down

Picture by Svein Otto Berge Vik

Loose Wall Panels and Corroded Walkways

A1.1 Risk-Reducing Measures

Measures to be implemented during cold phase

- Replace rusted grating on walkways with composite grating.
- Remove potential dropped objects from areas around walkways.
- Remove loose wall panels near walkways.
- Remove loose wind barriers that could detach and strike standby vessels or neighbouring platforms in strong winds.
- Remove or secure large exhaust pipes, which are often heavily corroded and can easily become falling objects.
- Repair passive fire protection to prevent asbestos insulation from spreading on the platform or undertake controlled removal of asbestos.

Picture by Svein Otto Berge Vik

Passive fire protection containing asbestos has been removed.

A1.2 Preventive and comprehensive maintenance in cold phase

The cold phase of a platform can last for an extended period before the final decommissioning project begins. Preventive maintenance involves undertaking extensive maintenance tasks and removing elements that, based on experience, may eventually pose safety risks.

Key activities that can be included in a preventive maintenance program are:

- Replace metal grating on walkways with composite grating to ensure safe access around the platform.
- Remove air coolers located on the platform roof.
- Remove turbine and generator exhausts from the roof and outside of modules.
- Remove equipment with corroded mounting and support structures.
- Remove flare tips.
- Remove corroded cable trays over walkways.
- Remove loose wall panels.
- Identify and remove objects that could become falling hazards in the future.
- Repair damaged passive fire protection containing asbestos.

Even with extensive maintenance campaigns, annual maintenance must still be carried out to ensure safe access to the platform for inspection crew.

A1.3 Considerations on the effectiveness of preventive maintenance

Preventive maintenance during the cold phase can appear to be an unnecessary expense if the decommissioning method has not yet been chosen, as each method has different access requirements on the platform.

Single Lift Method (SLT):

- This method involves lifting the entire topside in one lift.
- If using Pioneering Spirit (PS), the lifting points are located below the deck, so access to the entire platform is not required. In this case, preventive maintenance might be deemed unnecessary and a waste of resources.
- If S-7000, Thialf, or Sleipnir are used, access to the topside will be needed to install new lifting points and cut holes for lifting wires.

Heavy Lift Method (HLT), Reversed Installation:

- This method requires access to most areas of the platform to prepare modules for lifting. Modules need to be separated, welds removed, pipes cut, and new lifting padeyes welded in. Preventive maintenance in this scenario can help reduce the preparation work (Make Safe) required for this method.

Piece small Removal Method:

- This method require that the platform is secure enough for excavators to be safely placed on the platform topside. It does not require personnel to access the entire platform as long as all systems have been properly cleaned in previous phases.

Appendix B Events related to preparation and removal of topside on oil and gas installations

Operators take risk management seriously and have invested substantial resources to reduce risks associated with decommissioning, aiming for zero incidents. Nevertheless, incidents can still occur. Below is a list of types of incidents recorded during the preparation for and removal of platform topsides in the Norwegian continental shelf (NCS) over the past 15-20 years:

- Dropped objects
- Lifting operations
- Hand and cutting Injuries
- Burns during hot cutting
- Fires
- Inadequate barricades, insufficient or poor handling of barricades
- Simultaneous Operations (SIMOPS)
- Smoke and exhaust
- Incorrect cutting of pipes
- Asbestos
- Crane wire incidents
- Cutting of hydraulic hoses
- Cutting of oil risers
- Corroded walkway grating
- Installation of steel wires on cranes
- Lack of testing procedures for fire water systems
- Cutting in pressurized systems
- Design flaws
- Equipment failures
- Cutting of live electrical cables
- Debris in eyes
- Tripping/spraining Ankles
- Incorrect use of equipment
- Vessel collision with the platform

B1.1 Dropped objects

Dropped objects are among the top ten most common incidents during platform removal operations. It is important to map out simultaneous operations before signing off on a work permit and assess the risk of dropped objects. Forgotten items, inadequate securing of tools, manual handling, equipment failure, communication breakdowns, insufficient toolbox talks, and crane operations are among the causes of dropped objects.

Types of incidents recorded include:

- An aluminium scaffold plank fell during lifting due to improper use of manual lifting equipment.
- Scaffold pipes fell during the construction/dismantling of scaffolding.
- Hand tools fell due to missing safety lanyards.
- Wooden planks fell during assembly within the barricaded area.
- An antenna was dislodged by the crane wire of a heavy lift vessel with no barricading.
- A weather sensor was dislodged by the crane wire of a heavy lift vessel with no barricading.
- A spotlight was dislodged by the guide wire (tugger wire) of a crane on a heavy lift vessel with no barricading.
- A hoist frame collapsed during lifting due to design flaws and lack of quality assurance.
- The crane's lifting yoke detached scaffolding handrails on top of a module, causing the rails to fall within the barricaded area.
- A crane whip wire broke during placement of the crane boom the cradle, with the result that the overhaul ball fell on top of an office container, reason: unverified crane modifications, the area was barricaded.
- A steel support fell during burning and damaged a telescopic truck; the area was barricaded.
- Containers stacked two in high fell during handling with a forklift; the area was barricaded.

B1.2 Hand injuries

Due to several hand injuries, it is recommended to handle pipes and scrap material using machinery as much as possible. Rules are also introduced regarding the size and height of assembly areas. Some operators have implemented a general ban on the use of knives.

Types of recorded incidents include:

- Pinch injuries from manual handling of pipes.
- Cut injuries from knife use.
- Amputated finger from using a chamfering machine during pipe cutting.
- Cut on the hand from an angle grinder.
- Amputated parts of a finger due to a pinch injury while installing a hoist.

B1.3 Corroded grating in modules and walkways

Walkway grates are often very corroded or completely missing. Therefore, the first tasks in demolition work will be to replace defective walkway grating. Areas where personnel are not supposed to enter are secured with barriers.

Despite these measures, there have been incidents where personnel have stepped through defective walkway grating.

Types of recorded incidents:

- A person partially stepped through a grating – the person ignored the barrier.
- A person partially stepped through a grating – the secured area had an "open backdoor."
- A person stepped completely through a grating – new gratings covered the area partially, but the person stepped outside the new grating and fell.
- A person partially stepped through a grating – the area was not barricaded.

B1.4 Fire Injuries on personnel

Much of the cutting work is performed by RATs, who often work in challenging and inflexible positions. Cutting on old, rusted structures generates a lot of sparks. The work position of those hanging from ropes and cutting makes it difficult to remove sparks that get behind protective gear. The neck, shoulders, feet, and hands are particularly vulnerable. Initially, the PPE for burners was not adapted for this work. Significant efforts have since been made to adapt PPE for burners, including proper gaiters, neck protection between helmets and jackets, and the use of appropriate gloves.

Types of recorded incidents:

- Burn injury to the foot – a spark found its way into the climber's shoe while he was hanging from a rope and cutting pipes with an oxy-fuel torch.
- Burn injury to the upper body – a spark from the oxy-fuel torch entered through the collar opening of the jacket.
- Burn injury to the hand – incorrect type of gloves used.

B1.5 Fires and explosions

Much of the decommissioning work involves burning, making it crucial to have a good understanding of what needs to be cut and what other materials are in the area. It is also important to know what is hidden behind walls and under the deck where cutting is taking place. Decommissioning procedures now require that before cutting into pipes in enclosed structures, holes must be drilled and sniffed for gases and hydrocarbons. Sniffing should also be done during the process in case gas develops from deposits in pipes that are being heated.

Types of recorded incidents:

- Hot cutting of deck plates – a fire occurred because the diesel tank's extent covered several modules, not shown on the drawing.
- Insulation in the crane house was heated and ignited during the cutting of steel on the outside of the crane house.
- Hot cutting of pipes without checking the contents beforehand – in several cases, liquid leaked out and ignited.
- Hot cutting of an open oil riser – the heat from the cutting torch vaporized the oil layer inside the riser, which then ignited and exploded.
- During hot cutting of a closed ball valve, the gas trapped inside the valve exploded.
- During hot cutting of platform legs, smaller explosions or fires have occurred due to gases and oil accumulating inside the platform legs.

B1.6 Cutting of pipes and structures

Cutting of pipes and pipe supports has, in several cases, resulted in dropped objects due to poor communication between work teams and unclear job card sequences. Before cutting into pipes, a complete overview of the entire length of the pipe, the location of pipe supports, the weight of the pipe, etc., should be obtained (sometimes pipes can be filled with sand/oil mixtures, significantly increasing the weight).

Types of recorded incidents:

- A pipe that ran between several modules was being worked on at multiple locations simultaneously under different job cards. When the pipe support was cut in one module, the pipe twisted and fell.
- Miscommunication/language barriers resulted in the wrong pipe being cut, causing it to fall.
- Incomplete lifting instructions and incorrect use of lifting straps resulted in a large pipe falling, and the area was not cordoned off.

B1.7 Other Incidents

- Smoke from cutting operations requires large areas to be cordoned off and/or ventilated with fans.
- Exhaust from lifting vessels can be irritating and harmful both to the demolition work and personnel on nearby platforms.
- Lack of securing of asbestos insulation, which was scattered around the platform, resulted in a major cleanup campaign before the demolition could begin.

- During the installation of a new wire on the crane, the retraction mechanism slipped, and the wire hit the crane house.
- The temporary fire water system was not tested and did not provide sufficient pressure to the highest point; during a fire, there was inadequate water supply.
- A hydraulic hose containing oil, placed alongside insulated cables, was cut along with the cables, posing potential risks for personal injury and environmental discharge.
- Poor housekeeping and cleaning led to tripping and ankle sprains

B1.8 Barriers

Lack of, inadequately sized, or incorrectly placed barriers are always a challenge. Therefore, inspecting barriers is crucial to ensure their effectiveness and compliance. It is important that barriers are large enough to protect personnel and are removed as soon as the task is completed. Barriers should also maintain safety in case of concurrent operations in the area.