

Intended for
Oljedirektoratet Norway

Document type
Summary Report

Date
March, 2016

Ramboll ref.
1140000528/ROGC-Z-RA-000027

UNMANNED WELLHEAD PLATFORMS - UWHP SUMMARY REPORT



Revision **1**
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Description **Issued for external use**

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0. ABSTRACT

In order to identify cost- and production-effective development concepts with the same functionality and robustness as subsea developments, the Norwegian Petroleum Directorate has initiated a study to evaluate different unmanned wellhead platform concepts.

Ramboll has performed a high level mapping of types of unmanned wellhead platforms installed worldwide and a more detailed assessment of the unmanned wellhead platforms installed in the North Sea.

Based on the characteristics of the platforms, they can be grouped into 5 types. Each type has been assessed with respect to complexity, operational features, well intervention, methods of access, manning frequency, man-hours on board and operational experience.

A review of and a comparison between the regulatory framework in Norway and neighbouring countries have been performed to evaluate, whether the regulations and guidelines support the development concepts of unmanned wellhead platforms.

The overall conclusion was that unmanned wellhead platforms can be cost- and production-effective development concepts in the more shallow part of the Norwegian Continental Shelf and that the regulatory framework is open to the concept.

However, in order to avoid discussions and individual interpretations of the regulatory framework, it is suggested to develop a guideline and/or a NORSOK standard for unmanned wellhead platforms.

1. INTRODUCTION

An unmanned wellhead platform (UWHP) is a development concept under consideration in several licenses on the Norwegian shelf. The main driver is to identify a cost- and production-efficient solution offering similar functionality and robustness as a subsea development.

Historically, UWHPs have been designed in different variations; from simple dry wellhead installations to more advanced installations with processing equipment, shelter and helicopter deck etc. The installations are accessed via helicopter, boat or walk-to-work (W2W) bridges.

In the light of the increasing interest in unmanned installations for field development on the Norwegian continental shelf, the Norwegian Petroleum directorate wishes to gain an understanding of the various conceptual UWHP solutions. From a governmental point of view, it is considered important to gather knowledge about the opportunities as well as the limitations, including the potential risks related with such development solutions.

This summary report includes résumés and conclusions of the main topics within:

- Different types of unmanned platforms and the location of these platforms
- The norms, codes and standards used in- and outside Norway
- Experience as well as operation & maintenance philosophies
- Generic design data for unmanned platforms

Further details are described in the sub-reports, ref. /5/, /6/, /7/, /8/, /9/ and /10/.

2. ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
ALS	Accidental Limit State
API	American Petroleum Institute
BAT	Best Available Technology
CAPEX	Capital Expenditure
CCTV	Central Controlled TV, Closed Circuit TV
CT	Coiled Tubing
DEA	Danish Energy Authority
ESD	Emergency Shutdown
F&G	Fire and Gas
FRB	Fast Rescue Boat
GoM	Gulf of Mexico
HSE	Health, Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
LTI	Lost Time Injury
ME	Middle East
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NCS	Norwegian Continental Shelf
NNMI	Normally Not Manned Installation
NORSOK	Norsk Sökkels Konkuranseposisjon
O&M	Operation and Maintenance
OPEX	Operational Expenditures
OSR	Offshore Service Rig
PDO	Plan for Development and Operation
POB	Personnel On Board
PSA	Petroleum Safety Authority (Norway)
PTW	Permit To Work
RBI	Risk Based Inspection
RCM	Reliability Centred Maintenance
SCADA	Supervisory Control and Data Acquisition
SCE	Safety Critical Elements
STAR	Slim Tripod adapted for Rig (platform)
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
UK	United Kingdom
US	United States
UWHP	Unmanned Wellhead Platform
W2W	Walk-to-work

3. DIFFERENT TYPES OF PLATFORMS

This section describes the different variants or types of unmanned wellhead platforms used in the North Sea area.

3.1 Main types

Based on reviews of different types of unmanned wellhead platforms, these have been divided into five groups or types. A very short summarisation of the five types is given in Table 3-1.






Type 0	Type 1	Type 2	Type 3	Type 4
 <p>Complex platform with helideck and fire water system and various process equipment. Crane. Automated to allow remote operation for typically 1-5 weeks.</p>	 <p>Simple platform with helideck. Typically, 2-12 wells. Crane. No fire water. Test separator or multiphase metering. Designed to operate unmanned for periods of 2 – 3 weeks at a time.</p>	 <p>Simple platform without helideck. Typically, 2-10 wells, however, up to 30 wells have been seen. Crane. No fire water. No process facilities. Designed to operate unmanned for periods of 3 – 5 weeks.</p>	 <p>Minimalistic platform. Typically, 2-12 wells. No crane, no fire water, no process facilities. Designed to operate unmanned for periods of 6 months to 2 years.</p>	 <p>Super minimalistic platform. Typically, only one well (max. two) on one small deck. Well connected directly to pipeline. Lift gas may be included.</p>

Table 3-1: Overview of UWHPs

3.2 Access methods

The different potential access methods to unmanned wellhead platforms in the North Sea area are listed below:

- Helicopter access
- Access by Fast Rescue Boat (FRB)
- Access by walk-to-work (W2W) bridge on a support vessel. Based on a hydraulically controlled bridge
- Access from boat using a Z-step access system, a compensating step-up platform system
- Heli-hoisting
- Access from Offshore Service Rig (OSR), a jack-up service rig.

Traditionally, access by helicopter has been the preferred method of access in the Norwegian part of the North Sea. In other parts of the North Sea, boat access has been widely used.

Partly initiated by the offshore wind industry, alternative access methods allowing safe and comfortable access to the installations have been developed. A typical example is the walk-to-work (W2W) bridge. The W2W bridges can become the future method of access to unmanned wellhead platforms in the Norwegian part of the North Sea, provided that there is a sufficient availability of vessels with W2W bridges installed.

3.3 Installation methods

The different installation methods and their applications are shown in Table 3-2.

Method	Launch	Crane barge lifting	Jack-up drilling rig	Self-floating	Wind energy sector, jack-up crane barge
Application	Large jackets with a weight >12,000 tonnes Typically, in up to 140 m water depth	Jackets within crane barge capacity of max. 12,000 tonnes Typically, in up to 140 m water depth	Mono-tower jackets up to 1,000 tonnes Max water depth of 90 m	Suction-pile jackets Water depth up to 100 m	Jackets up to 1,200 tonnes Max. 65 m water depth

Table 3-2: Installation methods

3.4 Type 0 platforms

The concepts for type 0 platforms are very much the same as for manned installations - but on a smaller scale. The platform is designed for frequent manning and if necessary the crew may stay overnight for periods of time.

The main characteristics and features of the type 0 platforms are:

- The platform is equipped with a helideck, and the primary evacuation is by helicopter
- Secondary means of escape are a Totally Enclosed Motor Propelled Survival Craft (TEMPSC).
- The tertiary means of escape are by life rafts
- The platform is designed for both coiled tubing (CT) and wireline operations
- The platform has a crane sized for coiled tubing equipment (50-60 tonnes)
- The platform is equipped with fixed fire water deluge systems
- Gas-based firefighting systems are provided in the electrical rooms
- Fire water/foam coverage of the helideck is provided from the fixed fire water system
- The electrical equipment room and the shelter for personnel are under HVAC control
- There are both fixed fire and fixed gas detectors on the installation
- There are separate wellhead control systems, Emergency Shutdown systems (ESD systems), Fire & Gas Systems (F&G systems) as well as Supervisory Control and Data Acquisition systems (SCADA systems)
- Remote shutdown can be initiated from the host. Locally initiated shutdowns may require local reset.

The philosophy for the firefighting system is to protect both the platform and the staff on-board. Only if a fire cannot be brought under control, a controlled evacuation including mustering will be initiated.

3.5 Type 1 platforms

The platform is designed for manning by helicopter during daytime, but the platform is also equipped with an emergency shelter to be used in case sudden bad weather makes a return to the host platform impossible.

The main characteristics and features of the type 1 platforms are:

- The platform is equipped with a helideck, and the primary evacuation is by helicopter
- Secondary means of escape are a Totally Enclosed Motor Propelled Survival Craft (TEMPSC)
- Tertiary means of escape are life rafts
- The platform may be designed for both coiled tubing (CT) and wireline operations or only for wireline operations
- The platform has a crane sized for well intervention equipment (10-50 tonnes)
- Fire water/foam coverage of the helideck is provided from water/foam tanks pressurised by nitrogen
- Firefighting of small fires is based on the use of hand-held extinguishers
- During drilling operation, fire water can be provided from the drilling rig
- The emergency shelter for personnel is provided with HVAC, when the facility is manned
- There are both fixed fire and fixed gas detectors on the installation
- There are separate wellhead control systems, whereas ESD systems, F&G systems as well as SCADA systems are integrated into one common logic solver or computer
- Remote shutdown can be initiated from the host. Locally initiated shutdowns may require local reset.

The basic firefighting philosophy for this type of platform is only to neutralise smaller fires using hand-held extinguishers, and otherwise there is focus on fast and efficient evacuation and escape in case of any major fire events.

3.6 Type 2 platforms

The platform is designed for manning by a Fast Rescue Boat (FRB) launched from a standby vessel during daytime and in calm weather. The standby vessel will stay at the platform, when manned, and will also act as a crew facility.

The main characteristics and features of the type 2 platforms are:

- Primary evacuation is performed by the FRB
- Secondary means of escape are life rafts
- The platform may be designed for light wireline operations
- The platform has a small crane (1-2 tonnes)
- Firefighting of small fires is based on the use of hand-held extinguishers
- During drilling operation, fire water can be provided from the drilling rig
- There are no overnight facilities on the platform
- There are fixed fire detection based on fusible plug loops and hand-held gas detectors, when the facility is manned
- Wellhead control, ESD systems, F&G systems as well as SCADA systems are integrated into one common logic solver or computer
- Remote shutdown can be initiated from the host. Locally initiated shutdowns may require local reset.

The basic firefighting philosophy for this type of platform is only to neutralise smaller fires using hand-held extinguishers, and otherwise there is focus on fast and efficient evacuation and escape in case of any major fire events.

3.7 Type 3 platforms

The concept for the type 3 platform is based on the use of inherent safety principles, noble materials and equipment with documented reliability. The consequence is therefore that visiting frequency is very low. The primary method of access is by walk to work bridges from a standby vessel. During the entire operation or manning period the vessel will be connected to the installation also acting as the crew facility. Access by FRB will only be in exceptional cases.

There will typically be a Closed Circuit TV (CCTV) to monitor the platform, and not least the CCTV will be used, if a remotely controlled re-setting after a shutdown is required (i.e. resetting without manning the installation).

The main characteristics and features of the type 3 platforms are:

- The primary evacuation takes place via the W2W bridge
- Secondary means of evacuation are by the FRB or by the standby vessel (if manned by FRB, this is the primary means of evacuation)
- Tertiary means of evacuation are a life raft and suitable access to the sea (if manned by FRB, this is the secondary means of evacuation)
- All well intervention operations require the presence of an offshore support rig (OSR)
- No platform crane, all lifting is based on a cargo transfer system from the standby vessel or the OSR
- Firefighting of small fires are based on the use of hand-held extinguishers
- During drilling operations, fire water can be provided from the drilling rig
- There is no shelter on the facility
- There is fixed fire detection based on fusible plug loops and hand-held gas detectors, when the facility is manned
- Wellhead control, ESD systems, F&G systems as well as SCADA systems are integrated into one common logic solver or computer
- Remote shutdown can be initiated from the host

The basic firefighting philosophy for this type of platform is only to neutralise smaller fires using hand-held extinguishers, and otherwise there is focus on fast and efficient evacuation and escape in case of any major fire events.

3.8 Type 4 platforms

The type 4 platform is a super-minimalistic facility with one to two wells. This type of UWHP is mainly known from the US Gulf of Mexico (GoM), however, a few are installed in the Dutch sector of the North Sea.

The platform is very small, and escape is directly back to the FRB, which brought the visiting crew on board. There are no other lifesaving appliances on board.

The platform is equipped with a fusible plug loop (pressurised by hydraulics or lift gas) as the only means of fire detection. The basic philosophy is that there is focus on a fast escape in case of any fire event.

4. LOCATION OF PLATFORMS

This section summarises the different global oil and gas areas, in which unmanned platforms have been installed.

Country/Area	Total no. of platforms	No. of unmanned platforms	%	Range of water depth for unmanned platforms (m)
Norway	99	5	5	70-125
UK	590	148	25	20-150
Denmark	54	14	26	35-70
Holland	156	47	30	20-55
Abu Dhabi/ME	375	200	53	20-70
Far East	400*	50*	12*	20-110
GoM, US	>4000	>1000	25*	20-180
GoM, Mexico	1000*	100*	10*	30-160
Africa	200*	20*	10*	20-60

Table 4-1: Location of unmanned platforms

*approximation

Compared to other parts of the world, very few unmanned wellhead platforms are installed on the Norwegian continental shelf. Out of 99 platforms (including 20 floaters), the percentage of unmanned platforms is 5% corresponding to the following 5 unmanned platforms:

- **Tambar** (70 m water depth)
- **Embla** (75 m water depth)
- **Hod** (72 m water depth)
- **Sleipner Vest** (110 m water depth)
- **Huldra** (125 m water depth)

The main reasons for the current low number of UWHPs on the Norwegian continental shelf is the size of the fields, the distance to infrastructure, the water depth and the regulatory requirements in Norway.

In Denmark, unmanned platforms have been installed since the early 1980ies. The first two being 4-legged type 0 UWHPs, since 1989 eight type 2 UWHPs, and since 2003 four type 1 UWHPs have been installed. They are all situated in the shallow waters of the Danish part of the North Sea in water depths from 37 m to 70 m.

The Dutch continental shelf is situated in the relatively shallow southern part of the North Sea, which means that none of the platforms are located in water depths of more than 40-50 m. Approximately 30% of the 156 Dutch platforms are unmanned.

In the UK sector of the North Sea, operators have made use of unmanned platforms since the mid 1980ies. The majority is located in the southern part, some in the central part and only a few in the northern part of the North Sea.

Around 25% of all platforms in the US Gulf of Mexico are unmanned. The nature of these platforms are very simple structures - often holding only one well per platform.

The Persian Gulf is relatively shallow with a water depth of maximum 80 metres, and oil companies often have a central platform complex and then rings of wellhead towers (unmanned) around these central complexes.

More detailed information about the location of unmanned platforms can be found in the sub-report, ref /6/.

5. OPERATION AND MAINTENANCE PHILOSOPHIES

This section describes the operation and maintenance philosophies for unmanned platforms.

5.1 General

The Operation and Maintenance (O&M) philosophy shall stipulate the goals for the operation and maintenance of the UWHP.

The philosophy shall be supported by strategies for the operation and maintenance, i.e. which tasks shall be carried out to reach which goal, and also the strategies behind the tasks must be outlined.

More detailed information about the operation and maintenance philosophies for unmanned platforms can be found in the sub-report, ref. /9/.

5.2 Design aspects

For the UWHPs, the main issue is that O&M activities shall be designed out of the equation, wherever possible in order to minimise the manning frequency and the hours spent on board. Equipment and systems shall be kept at a minimum, and equipment requiring periodic inspection or re-certification shall to the extent possible be avoided.

Focus should be on using noble materials to considerably reduce the need for Risk-Based Inspections (RBI), furthermore focus shall be on specification and procurement of equipment with proven reliability and high Mean Time Between Failure (MTBF) (and as far as possible a short Mean Time To Repair (MTTR)).

Equipment requiring periodic inspections (fire extinguishers, inflatable life rafts, etc.) can be brought to the installation, when needed.

Generally and not least, for the installations with very rare visits and very short maintenance campaigns, equipment shall to the extent possible be of a modular design. This is to support the philosophy that no repairs take place on the platform, but instead a complete module (e.g. a complete actuator) is simply replaced.

5.3 Operation and maintenance philosophy

The philosophy must, depending on the type of UWHP, define:

- The design lifetime of the platform
- How the platform shall be operated
- Requirements for pigging and the pigging frequency
- Logistics of daily consumables such as chemicals, power, hydraulics, etc.
- Production and injection figures including goals as regards regularity and uptime
- How often may the platform be visited / maximum manning hours per year
- How are well service operations planned to be carried out
- Whether the platform is to be in operation during visits, or whether it is assumed to be shut down (or maybe only shut down in case intrusive maintenance is to be performed on hydrocarbon-containing systems)
- How should the platform be manned (helicopter, FRB, W2W bridge, etc.)
- Is the manning by a crew from the host or by a specialist team from shore

5.4 Operation and maintenance strategy

The strategies shall address:

- The level of automation (needs for remote monitoring and control) including needs for condition monitoring and preventive maintenance
- Necessary operations (on a task level), which can be performed remotely, and which require manning (including “remote resets”)
- Which integrity tests need to be performed - and how often - on well-related valves and can such tests be carried out remotely
- Which well service operations need manning
- Manning strategy including team background, skills and competencies
- Should manning be a crew from the host or a specialist team mobilised from shore?
- Outline of the “Permit-to-Work” (PTW) system (controlled from host)
- Dedicated strategies for %-scheduled maintenance, application of RCM and RBI, planned preventive maintenance, Safety Critical Element (SCE) checks against performance standards, mandatory tests/inspections/re-certifications, fabric maintenance including preservations, etc.
- Strategy for spares, tools, workshops and consumables being used during manning – for example container solutions on the OSR or W2W vessel.
- Campaign strategy.

The O&M strategy will depend very much on the mechanical handling strategy being developed for the platform.

Campaigns and the majority of the required manned operations for the operation and maintenance of the UWHP should take place during the summer time.

5.5 Philosophy and strategy Type 0 platform

The Type 0 UWHP was designed with an operation and maintenance philosophy very similar to manned installations. A large amount of unscheduled maintenance is accepted and executed on this type of platform. Typically, there is a 40% to 60% distribution between scheduled and unscheduled maintenance.

Since these installations are equipped with a helideck, the operation and maintenance activities are based on the easy availability of helicopters. The typical manning frequency is in the range from once a week to almost daily, as continuous unmanned operation is actually not allowed for some of the traditional designs and equipment.

The consequence is that these UWHPs are visited very often, and the duration of the visits may be disproportionate to the task to be performed.

This type of platform has a pedestal crane, which is used in the mechanical handling on board, and which also allows chemicals, consumables, spares, tools etc. to be taken on board from the supply boat. Furthermore, some platforms have a crane sized to take coiled tubing equipment on board.

All operation and maintenance work is to the extent possible performed, while the platform is operating.

5.6 Philosophy and strategy Type 1 platform

The operation and maintenance activities are reduced as much as possible by keeping the amount of equipment at a minimum, by avoiding equipment needing periodic inspections or re-certifications and by selecting reliable equipment with proven records.

The Type 1 platform will normally be manned by helicopter, and therefore some breakdowns can be accepted due to the easy access. In addition, certain operations need manning, such as bunkering of fresh water or diesel and replacement of chemical tanks. The typical manning frequency is in the range of once every 2-4 weeks.

Elements of Reliability Centred Maintenance (RCM) and Risk-Based Inspection (RBI) are typically introduced in the maintenance strategy. Also, elements of condition monitoring and preventive maintenance are part of the strategy. The typical number of man-hours on the facility is in the range of 5,000-6,000 hours per year.

This type of platform has a pedestal crane, which is utilised in the mechanical handling on board, and which also allows chemicals, consumables, spares, tools etc. to be taken on board from the supply boat. A few platforms have a crane sized to take coiled tubing equipment on board, however, it is more likely that coiled tubing operations are only performed, if a drilling rig or an OSR is present at the platform.

In order to optimise the use of hours on board, all maintenance work is to the extent possible planned to be performed, when the platform is manned due to operational requirements and vice versa.

5.7 Philosophy and strategy Type 2 platform

The operation and maintenance activities are reduced as much as possible by keeping the amount of equipment at a minimum, by avoiding equipment needing periodic inspections or re-certifications and by selecting reliable equipment with proven records.

Planned major maintenance work is scheduled to take place during the summer period to ease the manning using an FRB or other access methods from the sea. The typical manning frequency is in the range of once every 3-5 weeks.

Elements of RCM and RBI are typically introduced in the maintenance strategy. Also elements of condition monitoring and predictive maintenance are part of the strategy. The typical number man-hours on the facility is in the range of 1,500-3,000 hours per year.

This type of platform has a pedestal crane, which is utilised in the mechanical handling on board, and which also allows chemicals, consumables, spares, tools etc. to be taken on board from the supply boat, and some platforms have a crane sized to take wireline equipment on board.

Coiled tubing operations can usually only be performed, if a drilling rig or an OSR is present at the platform.

In order to optimise the use of hours on board, all maintenance work is to the extent possible planned to be performed, when the platform is manned due to operational requirements and vice versa.

5.8 Philosophy and strategy Type 3 platform

The operation and maintenance activities are designed for the platform and are reduced to a minimum, and equipment and systems are selected to optimise the production uptime and to extend the maintenance intervals.

Planned major maintenance work is scheduled to take place during the summer period (if possible) to ease the manning using a W2W system or other access methods from the sea. The theoretical manning frequency is in the range of once every 6-24 months.

Elements of RCM and elements of condition monitoring and preventive maintenance are part of the strategy. The use of noble materials minimises the RBI requirements. All maintenance work will be carried out in campaigns once every 6 months or every 2 years - depending on the operator's philosophy. Typically, the campaign will be executed, when the platform is shut down. The theoretical number of man-hours on the facility is below 500 hours per year.

The Type 3 platform does not have a crane. Lifting operations inside the platform can (maybe) take place within some limitations, if portable lifting equipment is brought on board via a W2W bridge. Otherwise, lifting operations to and from the platform will rely on an external crane (drilling rig, OSR or combined W2W/crane).

Well service operations, such as wireline operations and more heavy operations, can only take place, when an OSR or a drilling rig is present.

5.9 Philosophy and strategy Type 4 platform

The operation and maintenance activities for this type of installation are reduced to an absolute minimum and often refer to the API recommendation for testing and inspection.

The systems on these installations are also reduced to a minimum. Some breakdowns are expected and will be handled as the installation is visited. All maintenance work is to the extent possible performed, when the platform is manned due to operational requirements. As these facilities are typically located in shallow water close to shore, where access by FRB is relatively easy, the designs have not necessarily been optimised to reduce the number of visits, the typical visit frequency is relatively high - in the range of twice a week to every second week.

The platform may have a small davit for lifting a valve internally on the platform.

Otherwise, all major operations involving lifting and moving items will require an OSR or a drilling rig to be present.

6. EXPERIENCE WITH UNMANNED PLATFORMS

This section gives an overview of the operation and maintenance experience gained primarily from the Danish part of the North Sea.

More detailed information about the experience with unmanned platforms can be found in the sub-report, ref. /8/.

6.1 Introduction

Generally, there are good experiences with the UWHPs. Types 2 and 3 have very a high availability (uptime) - in the range of 95% - 99.5% - and the number of hours spent by personnel carrying out operation and maintenance is very low. For the new Type 2 platforms with few wells, this was in the range of 567 to 713 man-hours per year.

In addition, the UWHPs have proven to be very safe, and in the Danish part of the North Sea, no Lost Time Injuries (LTIs) have been reported.

Please note that the maintenance activities mentioned in this section do not include any well service activities.

6.2 Documented experience

Documented experience from the past regarding maintenance is very limited in the literature. In the present study, only 3 references (/2/, /3/ and /4/) were identified. These are all from Denmark and are published in the 1990ties.

The early data presented in Table 6-1 is based on data for three type 2 platforms over a three-year period. The data excludes well service activities and solely covers the topside.

Uptime	98% - 99.5%
Scheduled maintenance:	2 – 434 hours/year
Unscheduled maintenance:	0 – 345 hours/year

Table 6-1: Early maintenance data

The data in Table 6-1 is based on relatively new facilities with only 1-3 wells. For more mature installations with 10 wells, the estimated scheduled and unscheduled yearly maintenance hours on the installation are shown in Table 6-2. The data is based on own experience and recent interviews with owners.

Type 1:	5000 – 6000
Type 2:	1500 – 3000
Type 3:	< 500

Table 6-2: Maintenance hours (scheduled and unscheduled) – yearly (one installation)

6.3 General highlights of experiences

Highlights of experiences, as outlined in the following sections, are:

- Uptime is reduced in the more complex types of UWHPs (Types 0 or 1) compared to Types 2, 3 and 4
- Visit frequency and hours spent on the platforms are higher on Types 0 and 1 than on Types 2, 3 and 4.
- It is beneficial to reduce the F&G and fire water systems to an absolute minimum
- Generally, equipment is minimised (no redundancy), but focus is on procuring highly reliable equipment with high MTBF
- Using noble materials and special surface treatment systems reduces the need for surface treatment to about zero during the lifetime
- The automation level must be balanced. The number of instruments and signals shall be kept as low as possible. On the other hand, operations needing human intervention (example: drain tank with manually controlled drain pump) shall be limited to a minimum
- The use of electro-hydraulic cranes is not recommended on installations with diesel generators, as the diesel engine will be sized for the major user: the crane. Therefore, for the majority of the time, the engine will run on a very low utilisation, which causes problems for diesel engines
- Extended design control checks and verifications are required to avoid any design errors. It is extremely expensive to rectify such design errors on an unmanned installation
- Extended commissioning checks are required
- Diesel engines cause downtime, and therefore cable supply from the host platform is preferred
- Hydraulic systems also cause downtime and regular maintenance. They cannot be avoided, but focus must be on improving them and also to improve the skills of personnel working with hydraulic systems and fittings
- Operational faults count very high. It is extremely important that the visiting crew is familiar with the installation

It is important to have teams or at least job leaders, who are well acquainted with the installation. Having an expert team onshore dedicated to the UWHPs could be one way of ensuring this. Such a team could be mobilised to carry out all operation and maintenance work - not just on one UWHP - but on all the similar UWHPs owned by the company.

All disciplines shall have full focus on the manning, operation and maintenance strategy throughout the development project of an UWHP. In many development projects, there is a tendency to add «nice-to-have» equipment and systems, because it is possible, or because this is done in conventional development projects. Some of these are HSE-initiated elements, which do not really add any value, but which require a higher manning frequency, since the safety equipment has to be checked regularly. This must be avoided.

6.4 Summary and recommendation

The overall experience shows that the amount of equipment and systems should be minimised and only highly reliable equipment and noble materials should be used, which will reduce Capital Expenditure (CAPEX) as well as Operational Expenditures (OPEX).

The above points towards the simple UWHP type 2, 3 or 4 being the preferred concepts, however, other important factors need to be considered, such as:

- Distance to the host facility
- Production rates and number of wells
- Major rotating equipment on board, such as downhole pumps, booster compressors, transfer pumps
- Reservoir complexity as well as types and frequency of well interventions
- Need for operator interventions and maintenance requirements

So for some fields, the more complex type 0 or 1 could be the optimum concept.

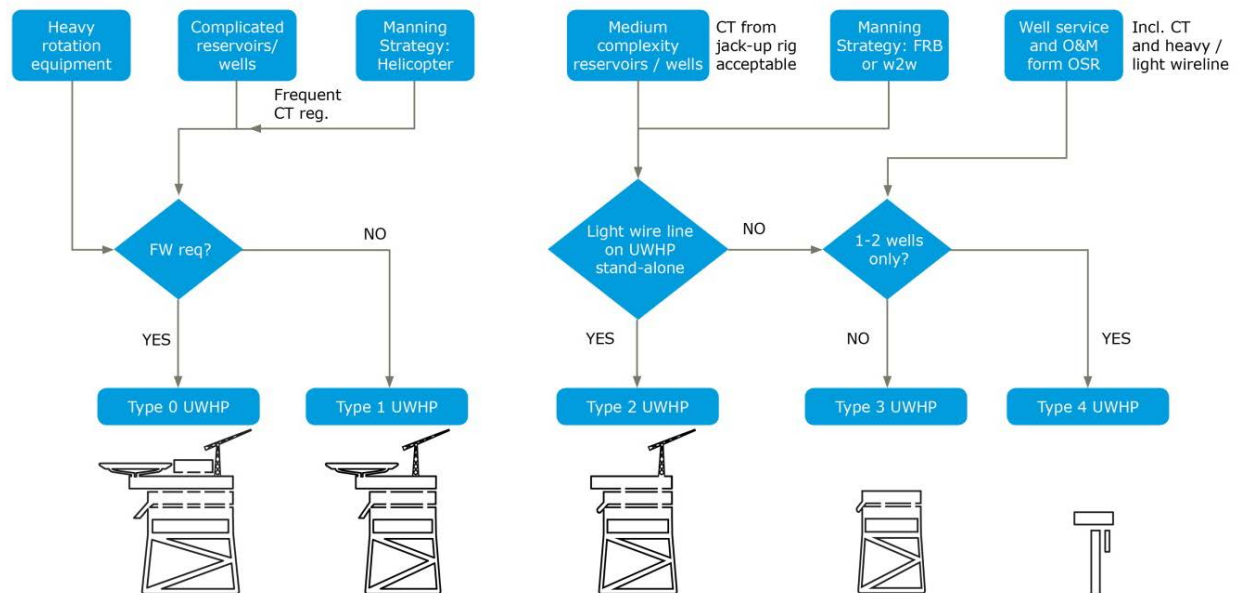


Figure 6-1: The right type of UWHP for the job is essential

7. REGULATIONS

This section describes the relevant laws, rules and regulations in Norway and adjacent continental shelves. Furthermore, the current regulatory framework in Norway has been assessed for the implementation of projects related to unmanned platforms.

Regulations from the following countries have been considered:

- Norway
- Denmark
- United Kingdom
- The Netherlands
- Germany

7.1 Overview of Norwegian regulations for the design of UWHPs

Norwegian laws and regulations relevant to offshore activities have immense focus on the safety and health of people and the protection of the environment. Petroleum Safety Authority (PSA) regulations in Norway emphasise on following the same overall principles to manage the risks towards health, safety, environment and the assets, regardless of whether the facilities are manned or unmanned;

- Facilities shall be based on the most robust and simple solutions as possible (Facility regulation)
- Prudence and caution in planning and implementation of the activities (Framework HSE regulation / Facility regulation)
- Use of both technical, operational and organisational barriers (Framework HSE regulation)
- Application of inherently safer design (Framework HSE regulation)
- Application of As Low As Reasonably Practicable (ALARP) principle (Framework HSE regulation / Facility regulation)
- Application of Best Available Technology (BAT) (Framework HSE regulation / Facility regulation)
- Application of barriers against hazards in the form of detection, prevention, mitigation and emergency response (Management regulation)
- Provision of independency between barriers (Management regulation)
- Single failure does not result in unacceptable consequences (Facility regulation)
- Allocating performance requirements on the barriers and follow-up on the requirements in the operational phase (Facility regulation)

For unmanned facilities, simpler solutions may be chosen provided that these solutions can be proven satisfactory through special assessments, ref. Facility regulation section 6.

Guidelines to the PSA regulations provide references to specific NORSOK and international standards as recognised sources for design methods to meet the requirements in the regulations. The purpose of the guidelines is to demonstrate, how provisions in the regulations can be met; however, the guidelines are not legally binding.

The present NORSOK standards have limited references and prescriptive requirements with respect to the design of unmanned platforms. NORSOK S-001 has some specific requirements related to the design of safety systems for the Normally Not Manned Installation (NNMI), and N-001 has some less strict requirements for Accidental Limit State (ALS) and partial factors for the structural design with conditions as stated in the standard.

The withdrawn NORSOK standard S-DP-001, Rev. 1, December 1994, had two informative annexes; B1 and B2 that covered Type A and Type B of Normally Not Manned Installations (NNMI), but these annexes were removed in Revision 2.

7.2 Comparison with other regulations in North Sea area

The purpose of reviewing the offshore legislations from other parts of the North Sea Continental Shelf and performing a comparison with Norway's offshore legislation was to find out, to which degree they are the same or differ with respect to design and operation of unmanned platforms.

The conclusion from the review is that the Norwegian offshore legislation provides a solid and comprehensive framework for the design and operation of offshore platforms in the Norwegian Continental Shelf (NCS). In its current form, the regulation is significantly less prescriptive than in earlier editions but has extensive prescriptive requirements in its guidelines, which further refer to relevant standards.

If the PSA Facility regulation requirements and the NORSOK "S" series related to technical safety and HSE are used as the starting point for the design of minimum unmanned offshore platforms, the first challenge is to establish, which functions are mandatory on board the minimum unmanned platform, which equipment/barriers can be brought on board during actual visits and which functions can be avoided, if the risks covered by the safety function are not actually present.

The legislation in Denmark, the UK and the Netherlands has more references to the design of unmanned platforms. The Safety Case regime in Denmark and the UK provides the flexibility that duty holders take the responsibility of demonstrating that their plan to develop a field by installing an unmanned platform meets the legislation's goal-setting requirements.

Table 7-1 indicates the similarities and differences between legislation in Norway and the adjacent continental shelves. Germany does not have any specific offshore regulations and is consequently not included in the table.

	Norway	Denmark	UK	Netherlands
Type of legislation – Is it goal-setting or prescriptive?	Goal-setting and prescriptive	Goal-setting and prescriptive	Mainly Goal-setting	Goal-setting and prescriptive
Does the legislation require submission of Safety Case?	No (Note 1)	Yes	Yes	Yes
Does the legislation have references to unmanned platforms?	Yes (Note 2)	Yes (Note 3)	Yes (Note 4)	Yes (Note 5)
Does the legislation promote the ALARP principle?	Yes (Note 6)	Yes	Yes	Yes

Table 7-1: Comparison of legislation in Norway and adjacent continental shelves

Notes:

1. Norwegian legislation requires the preparation of a "Plan for Development and Operation" (PDO) of a petroleum deposit. There is a considerable similarity between the documentation for a PDO and a Safety Case, but Norwegian legislation does not lay down a safety case regime
2. The term used in Norwegian legislation is "simpler facility" with and without "accommodation"
3. The term used in Danish legislation is "not permanently manned offshore installation"
4. The term used in UK legislation is "normally unattended installation"
5. The term used in Dutch legislation is "unmanned mining installation"
6. Norwegian legislation does not exactly use the term ALARP, but it requires that the risk shall be further reduced to the extent possible

By comparing the design requirements for simple unmanned platforms in the withdrawn NORSOK standard S-DP-001 and the Danish Energy Agency's guidelines with the design requirements in the PSA Facility regulation, it might easily be interpreted that UWHP concepts based on minimum and cost-effective solutions will be in non-compliance with parts of the PSA Facility regulation. Nevertheless, the facility regulation section 6 states that simpler solutions may be chosen for such facilities provided that these solutions can be proven satisfactory through special assessments.

The current NORSOK standards also fall short as regards providing any coherent set of minimum requirements for such platforms.

However, in principle, the guidelines and the NORSOK standards are only one way of fulfilling regulations. Alternative solutions may be chosen, provided that the operator can demonstrate that these are safe and fulfil the detailed requirements in the regulations.

7.3 Conclusion and recommendations

In Norway, due to the early discovery of several large-sized hydrocarbon deposits in the NCS, manned platforms in the form of large integrated production platforms or complexes were favoured as the most cost-effective concepts for the development of offshore fields for years (e.g. Ekofisk, Statfjord and Troll). Accordingly, the development of regulations adapted the form compatible to such concepts. As a result, the regulations at that time and later updates have had very limited explicit references to the unmanned platforms. The same applies for the development of NORSOK standards. Because of that, the development of any minimum unmanned platforms in Norway quickly gets entangled in the requirements from regulations and standards, which were originally intended for the protection of health, safety, environment and assets on large manned platforms.

To close the gap, the best feasible short-term solution is to develop a guideline or a NORSOK standard that provides an approach to the design of the unmanned platforms for NCS. The approach can either be detailed prescriptive requirements at the level found in the withdrawn NORSOK standard S-DP-001 or according to a risk-based approach, where the burden and the responsibility that the residual risk is ALARP is on the duty holder. Providing that a new standard is developed, the PSA Facility regulation has to be amended accordingly to provide specific references to the new developed NORSOK standard.

More detailed information about regulations can be found in the sub-report, ref. /7/.

8. GENERIC DESIGN BASIS

This section provides an overview of the design data, which shall be clarified before issuing a tender for the design or the construction of an unmanned wellhead platform, UWHP.

Most operators have their own standard list of content for a specific design basis, however, the content will more or less cover the following main items:

- System design
- General design data
- General design regulations and standards
- Topside disciplines
- Structures
- Battery limit and interface.

More detailed information about a set of generic design basis data for unmanned platforms can be found in the sub-report, ref. /10/.

8.1 System design

This section includes information about the overall set-up of the UWHP, the connecting pipelines and the host facility, i.e. an overview of the entire architecture.

The general project description can in most cases also be used in the Scope of Work for a consultant and or contractor, who is assigned to design and or construct the platform.

8.2 General design data

This section includes information about the general design data to be used as basis for most of the disciplines. The content will e.g. be information about the type of platform, the number of People on Board (POB), water depth, design life, helideck and or boat landing, number of well slots, producers and injectors, pigging requirements etc.

8.3 General design regulations and standards

This section includes information about definition, of which regulations, norms, codes and standards as well as relevant European Directives and internal company technical standards and procedures are to be used as basis for the design. Furthermore, a definition of which 3rd party verification is required, e.g. "Certificate of Compliance" for the platform part and a similar approval from a recognised Marine Warranty Surveyor for the weighting prior to load out.

8.4 Topside disciplines

This section includes information about the different topside disciplines i.e.:

- Health, Safety and Environment (HSE) / Technical Safety
- Process
- Piping and layout
- Mechanical and material handling
- Material technology
- Electrical
- Instrumentation
- Telecom
- Operation
- Maintenance (including well service requirements and strategy)
- Weight control
- Structure.

as well as necessary information about the following:

- Reservoir (fluid composition, pressure and temperature)
- Drilling (wellbay area, well spacing, elevations)
- Pipeline (interfaces, dimensions, pressure and temperature)
- Marine operation (load and sail out, installation).

References are made to attachment 6 for further details.

8.5 Battery limit and interfaces

This section includes information about the battery limit and the interfaces to e.g. the pipelines, risers, drilling rig and well intervention, well growth and well spacing etc.

8.6 Special cost considerations

The selection of the relevant type of unmanned platform depends on many factors. The main selection criteria for example depend on the field size, the depletion philosophy, the number of wells, the water depth, the operation and maintenance strategy, the well intervention requirements, the distance to the host, the required utilities (umbilical versus installation on the platform) and the access requirements (helideck versus boat landing).

In section 8.7 and 8.8, the requirement for an umbilical and methods of access are discussed.

8.7 Umbilical versus installations at the platform

The most cost-effective solution for the unmanned wellhead platform may be to supply the electrical power, chemicals for injection, communication and hydraulic power from a nearby host via an umbilical. The installation of an umbilical will eliminate the need to install power generation, chemical tote tanks and pumps etc. on the unmanned wellhead platform.

However, the installation of a standard umbilical with, e.g. 10 kV electrical power, 24 fibre-optical communication cables and 3 tubes for chemicals as well as the pulling head, hang-off, flanges and J-tubes has a certain cost. While the alternative, the installation of, e.g. a power generation module providing 2 times 75 kVA incl. a bunker station, diesel oil storage as well as a hydraulic power pack, chemical tote tanks and line of sight communication at the platform most likely has a lower cost.

By including the operation and maintenance costs in the equation, the umbilical solution will, however, most likely be the most cost-effective solution, see Figure 8-1.

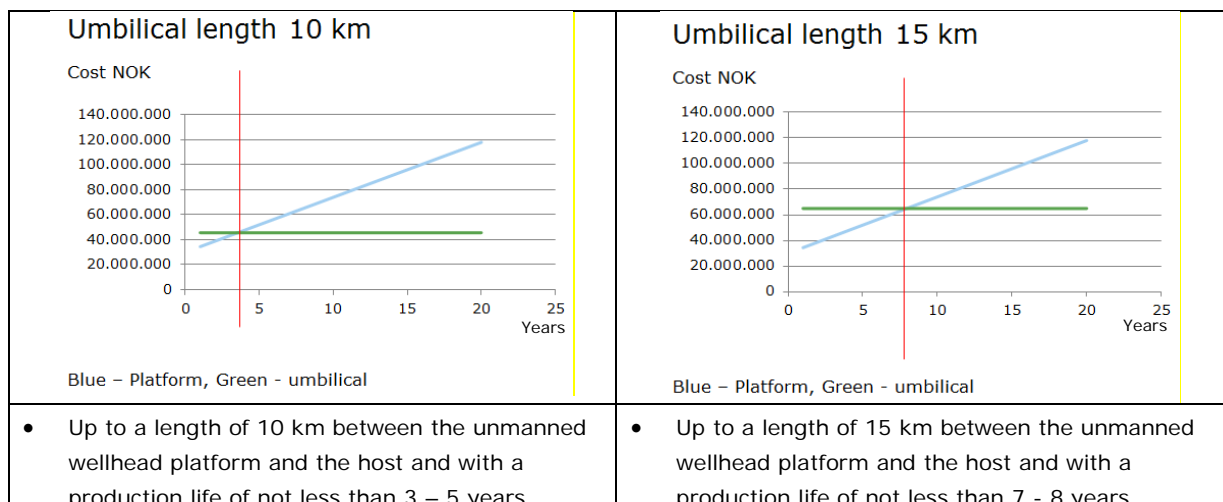


Figure 8-1: Costs of umbilical solutions

The new trend is to use an umbilical to supply all the utilities from a host platform, where the operation and maintenance activities are more cost-effective than on an unmanned platform. Furthermore, this solution is the most safe approach, as the visits and the maintenance work on the unmanned platform are limited.

8.8 Helideck versus boat landing

The most cost-effective platform type is the one without a helideck, as the helideck requires some sort of accommodation/emergency shelter, and the present legislation in Norway also requires that fire water pump(s) (a NORSOK requirement) are installed on platforms with helidecks.

The first unmanned platform built in Denmark was without a helideck (Maersk Oil), however, later some unmanned platforms were built with a helideck (DONG E&P) in order to obtain a higher availability.

The new trend is to use a telescopic gangway (walk-to-work system), e.g. from Ampelmann or similar, in order to avoid the boat landing and the access limitations due to wave heights.

	
<p>Ampelmann type E offshore gangway The picture is from the Internet: http://www.ampelmann.nl/products/.</p>	<p>Uptime 23.4 m AMC gangway accessing the Trianel Borkum West wind turbines and substation The picture is from the Internet: http://www.uptime.no/.</p>

Figure 8-2: Examples of gangway access methods

9. CONCLUSION

The overall conclusion of the study is that unmanned wellhead platforms can be cost- and production-effective development concepts for the more shallow part of the Norwegian Continental Shelf.

Although, the type 3 minimalistic platform seems to be the preferred concept, there are some factors, which need to be considered. As the concept is based on access by W2W bridges on a standby vessel or an offshore support rig, there should preferably be several UWHPs of this type in an area in order to distribute the operating costs of having OSRs or W2W vessels in the area on more facilities, as the alternative would be to accept that the mobilisation time could be fairly long.

For more complex reservoirs with frequent well intervention operations, the type 0 or 1 platforms may be the preferred concepts.

With respect to the regulatory framework, the PSA regulations focus is on preventive measures, i.e. inherent safe design, application of ALARP and BAT principles, simple and robust design as well as prudence and caution in planning and implementation of activities. These are all factors, which support the concept of unmanned wellhead platforms.

Whereas the underlying guidelines and NORSOK standards have more focus on mitigation measures requiring more systems, equipment and maintenance, and therefore do not support the concept of unmanned wellhead platforms, and most UWHP concepts will be non-compliant with the guidelines and the NORSOK standards.

But in principle, the underlying guidelines and NORSOK standards are only one way of fulfilling regulations. Alternative solutions may be chosen, provided that the operator can demonstrate that these are safe and fulfil the detailed requirements in the regulations.

However, to avoid discussions and individual interpretations of the regulatory framework, it is suggested to develop a guideline and/or a NORSOK standard that provides an approach to the design of unmanned platforms for NCS. The approach can either be detailed prescriptive requirements at the level found in the withdrawn NORSOK standard S-DP-001 or a more risk-based approach, where the burden and the responsibility that the residual risk is ALARP is on the duty holder. In parallel to the development of such a NORSOK standard, the PSA Facility regulation also has to be amended to provide specific references to the new developed NORSOK standard.

10. REFERENCES

/1/	Danish Energy Authority (DEA) Guidelines, Chapter two, Unmanned Installations, 2008 (outdated)
/2/	T. Kristensen, Mærsk Olie og Gas AS, Production Experience from an unmanned satellite platform (STAR Concept), Gas processors Association, European Chapter, 11th Continental Meeting, 1994, Helsingør, 25 – 27 May 1994
/3/	Hans Henrik Kristensen, Mærsk Olie og Gas AS, not dated (about 1993), Operating Experience with STAR platforms
/4/	ISC Bulletin No. 31, March 1993, Not Normally Manned Platforms, Bent Lyngberg and Lars Dam Rasmussen
/5/	Ramboll report ROGC-Z-RA-000031, Different types of unmanned platforms
/6/	Ramboll report ROGC-Z-RA-000028, Location of unmanned platforms
/7/	Ramboll report ROGC-Z-RA-000029, Review of regulations
/8/	Ramboll report ROGC-Z-RA-000032, Experience with unmanned platforms
/9/	Ramboll report ROGC-Z-RA-000033, Operation and maintenance for unmanned platforms
/10/	Ramboll report ROGC-Z-RA-000030, Generic design basis data for unmanned platforms