



University of
Stavanger

Faculty of Science and Technology

MASTER'S THESIS

Study program/ Specialization: Risk Management	Spring semester, 2015 Open access
Writer: Shambu Jayakumar (Writer's signature)
Faculty supervisor: Prof. JAYANTHA.P.LIYANAGE, PhD External supervisor(s): Mr. MIKAL DAHLE	
Thesis title: Safety integrity under demanding conditions: A study on Permit-to-Work (PTW) systems in the Marine-Subsea sector	
Credits (ECTS): 30 pts	
Key words: Safety integrity Permit to work Marine operations	Pages: + enclosure: Stavanger, Date/year

Abstract

Last few years has seen evaluation of the oil and gas industry into innovative subsea solution and technological leap leading to the subsea factory. Taking this into perspective the marine subsea industry is one of the most developing sectors involving many stakeholders with a wide range of background to perform various operations. These operations bring together marine operators, ship owners, subsea asset owners/asset operators, subsea equipment manufacturers, various subcontractors, yards, etc., to work together under demanding conditions. Due to high-risk nature of oil & gas business, such operations constitute various critical features requiring specific measures to reduce unwanted events and risk exposure. The permit to work (PTW) system is such a critical measure, which is an integral part of a safe working structure that can help to manage the wide range of activities taking place simultaneously. Risk assessment and risk mitigation, which are core elements for the PTW system, are key contributors for safe execution of jobs. A comprehensive PTW system should not only determine how the work can be carried out safely but also should envisage human factors involved in operations.

In addition to generic features that are relevant to normal PTW systems, there are specific needs to account for the nuances of the marine subsea industry. This is to increase the safety as well as efficiency of operations especially under demanding conditions in terms of time, cost, and safety. Years of experiences have begun to question if PTW systems should be applied to all activities since current practices have a considerable potential to lead to many confusions among stakeholders weakening the overall effectiveness. This would require a closer analysis of the current PTW systems and practices to ensure safety integrity as well as to establish an effective work interface between stakeholders.

This thesis assesses the state of current PTW system in the marine subsea industry and present the lesson learnt from previous projects and suggest best practices and potential improvements for a seamless interface and expectations.

Acknowledgement

“The most rewarding things you do in life are often the ones that look like they cannot be done.” –

Arnold Palmer

..So does this one.

The journey of completing the second master thesis has been challenging, interesting and sometimes, it did look like it cannot be done. The journey becomes all the more special when I remember all the advice, attention, care that I received from all the special people around me to manage the juggling act between academic, professional and personal life.

The pillar stone in academics has been my Professor and mentor Prof. J P Liyanage, who believed in me and has made this possible. His advices have influenced me greatly and always helped to place the bar one notch higher each time. In him I found a role model who is not only academically brilliant but also a hard working gentleman with great passion for his work.

I would like to thank my supervisor and Engineering manager Mr. Mikal Dahle and my discipline supervisor Mrs. Janne Octavia Vatne who have been a great source of inspiration in both professional and personal life. They have encouraged and supported me in all my endeavours for the last five years.

I would like to thank Mr. Atle Vik, Captain Bjorn Fjallsbak, and Mr. Tony Rutherford for helping me with this research and also standing by me in some of the toughest professional challenges.

I would like to thank my wife, Janaki who stood by me during the lows and highs. Special thanks to her for coming up with some fantastic ideas whenever I am stuck. I do not know how to thank my 10 month old daughter, Gowri, whose smile brings most refreshing feeling after long days and tired nights.

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Abbreviation

Capex	Capital expenditure
DnV	Det norske veritas
DSV	Diving support vessel
HSE	Health safety and environment
HSE	Health and safety executive
HSEQ	Health, safety, environment and quality
IA	Issuing authority
IMR	Inspection maintenance and repair
IOR	Improved oil recovery
IT	Information technology
ITS	Integrated template structure
JRA	Job risk assessment
LPG	Liquefied petroleum gas
MEG	Mono ethylene glycol
MPV	Multipurpose vessel
NCS	Norwegian continental shelf
NCS	Norwegian continental shelf
ObsROV	Observation class remotely operated vehicle
OCM	Offshore construction manager
OPEX	Operating expenditure
OSV	Offshore support vessel
PA	Personnel announcement
PCM	Pre commissioning manager
PTW	Permit to work
RFO	Ready for operation
ROV	Remotely operated vehicle
SIMOP	Simultaneous operations
WAH	Working at height
WP	Work permit
WROV	Work class remotely operated vehicle

PART ONE: INTRODUCTION

1. Introduction

Marine subsea industry is one of the most developing sectors involving many stakeholders with a wide range of background to perform various operations. These operations bring together marine operators, ship owners, subsea asset owners/asset operators, various subcontractors, yards, etc., to work together under demanding conditions. Due to high-risk nature of oil & gas business, such operations constitute various critical features requiring specific measures to reduce unwanted events and risk exposure.

If oil were blood, then production platforms would be the heart that pumps the blood through its veins (Liyanage, 2008). In the past couple of years these ‘hearts’ are moving more subsea. There is a wide spectrum of marine operations ongoing with highly specialised state of the art vessels. To continue with the analogy- marine operators would be the doctors, keeping the hearts running. It could vary from a smaller IMR inspection vessel to state of the art saturation diving vessel where the divers have similar condition to astronauts. OLF (2006) concluded with the term Integrated Operations to describe the new collaboration, decision engineered revolution in the NCS which would lead to seamless integration between the various stakeholders.

The permit to work (PTW) system is one such critical measure, which is an integral part of a safe working structure that can help to manage the wide range of activities taking place simultaneously. Risk assessment and risk mitigation, which are core elements for the PTW system, are key contributors to safe execution of jobs. The process in the permit to work system needs to be flexible, yet, robust enough to meet the requirements of all various types of operations. Also the implementation and integration of these system should be as seem less as possible.

A comprehensive PTW system should not only determine how the work can be carried out safely but also should envisage human factors involved in operations. There is need for a holistic integrated system which provides standardised approach inclusive of all the aspects of the operation. This system should be in line with the industry regulations and best practices.

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In addition to generic features that are relevant to normal PTW systems, there are specific needs to account for the nuances of the marine subsea industry. This is to increase the safety as well as efficiency of operations especially under demanding conditions in terms of time, cost, and safety. Years of experiences have begun to question if PTW systems should be applied to all activities since current practices have a considerable potential to lead to many confusions among stakeholders weakening the overall effectiveness.

It should include hazard identification and mitigation, controlling of hazardous operation, lock out tag out isolations, subsystem govern activities including confined space entries, lifting, working at height, hot works etc. The process should be able to lead the operators step by step through the procedures, while highlighting the risks involved and aid them in enhancing control of the job and thereby excluding the risk.

Another aspect that is usually forgotten is that the Permit system covering the marine operation should not only cover the special or critical operation but also should be capable of covering the planned maintenance programs. When the vessel is operational in sea she is highly mobile specialised operational unit but in a dock, during a large maintenance period, she goes into what could be described as a large process plant mode. The system should have features that would cover the work during the major maintenance and modification works such as in a yard or in dry dock. An integrated approach for the PTW should be able to interconnect and achieve synergy between the various elements of the PTW system.

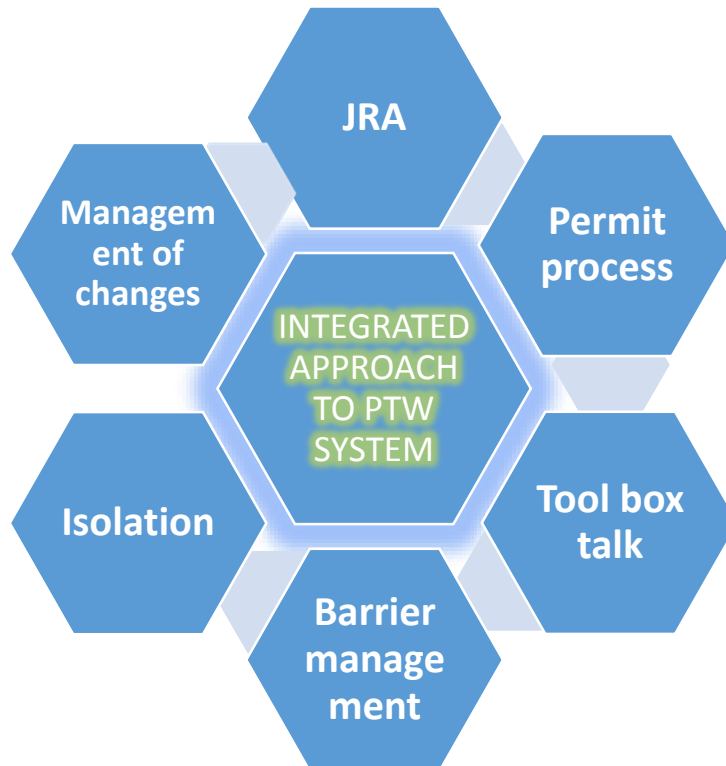


Figure 1 Building blocks of an integrated PTW system.

With so many aspects to cover, the marine subsea industry seems to be following different individual systems which are not following similar standards. They are different depending on which company is implementing them. A Marine operator owned system is very different from a ship owner owned system even when the work performed is same. This leads to confusion in the process.

Objectives, scope, methodology and delimitation

The Main objectives of this thesis can be described briefly

- To study the state of the permit system in the marine subsea industry. Expectations and reality
- Comparative study between various permit systems
- Suggestion for improvement – in order to facilitate an integrated operations between the various stakeholders

It is very evident that there are differences in the understanding and approach to the PTW system by each party involved in the same operation. There are already very obvious mismatches in expectations but more significantly these differences in the understanding could lead to catastrophes.

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Scope and structure: The scope of the thesis is to study the permit to work system in the marine subsea industry in detail.

The first section cover features of a general permit to work system- studying them with relevant regulations and guidelines. They are general guidelines which are applicable for all work sites.

The second section of this report we are going into the specifics of subsea industry. As mentioned earlier different stakeholders have different approach to PTW system. In this section we will study the features of permit system followed by the main players in the industry – marine operator, ship owner, yards

Third section is a comparative study of the various features in different permit system studied in section

The fourth and final section is suggestion for improvement. It describes the changes that are proposed by the industry expert and experience feedback from previous projects. At the very end there is section on need for further action from industry to ensure an integrated approach.

Methodology: For developing this report is outcome of going through permit system/regulations of various shipping companies, Marine operators and onshore/offshore EPCI contractors from Norway, UK, Middle East, Asia and Australia. Suggestion were drawn from the interviews with various vessel owners/superintends, Captains, master mariners, chief engineers, maritime experts, ship yards , engineering directors in the oil and gas industry. Some of the suggestion are also drawn from personnel experience in similar projects.

Limitations: There are 6 major marine operators in the NCS alone and there are numerous ship owners and yards which leads to many potential permutations and combinations. Each of these alliance will lead to new system of operation. The case studies discussed in detail are typical examples of systems used. But it might be missing certain features that could be available in other similar regimes. Also the suggestion made in the report are subjective judgements. While developing a new system, there is need to consider the unique feature of the operation which needs to be tailor made. These system needs to be developed by collective discussions and agreement but the suggestion mentioned in this report can be used as guidelines for deliberations.

2. Features of the general PTW system

A permit to work system is a formal recorded process used to control work which is identified as potentially hazardous. It is also a means for communication between the management, supervisors and operators with the work team in the hazardous area. (HSE, 2005). A generic PTW system should include

- Clear identification of roles and responsibilities
- Procedures for completing forms, instructions in the issue, use and closure of permits
- standardised identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures along with the modes of communicating
- facilitate the flow of information between the various parties involved in the job
- monitoring and auditing to ensure that the system works as intended

The permit system could be paper based or electronic and is devised by each company to meet specific requirements. There are permits which vary vastly in processes, procedure, terminology and system. Even in the marine subsea industry each of the stakeholders has their own unique system which varies from one another. In this thesis the case studies will look at some of the permit systems in detail and will be able to identify the differences.

Specifically they need to cover a wide range of scope – from construction to operations. While the vessel being built or during a large vessel modification scope the permit system will be valid for construction, pre commissioning, commissioning and start-up of the new systems installed on the ship. While the vessel is operational in the sea the risk management systems should be able to cover all operations on the ship including subsea operations. Which all activities will fall under PTW system would depend on categorisation of job in the particular PTW system.

A. Guidelines and regulations for permit to work system

There are various guidelines and regulations that aid in the development, establishment and maintenance of a rigid permit to work system. For the fixed and floating production installation in the Norwegian continental shelf, '*Norwegian Oil and Gas Recommended Guidelines for Common model for work permits (WP)*' was established by Norwegian oil and gas association that included a working committee from the major oil and gas operators. This thesis will try to initiate the discussion covering the permit system for the marine subsea industry.

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In the UK, the *HSG250 Guidance on permit-to-work systems - A guide for the petroleum, chemical and allied industries* was established by health and safety executives. This give general guidelines to the petroleum industry in general.

International association of oil and gas producers OGP issued, *Guideline to PTW system* in 1993. This was developed by representatives from global oil and gas companies. This was in the wake of Lord Cullen report which investigated the fatal piper alpha incident of July 1988.

For confined space entries there are guideline from worksafeBC, Canada. They were established in 1917 and give advice in the marine industry in general *Shipping –safety guidelines*

In Australia the permit to work system has been influenced heavily by the mining industry. Lots of references are made to *Mines Safety and Inspection Act 1994 (WA)* and *Mines Safety and Inspection Regulations 1995*. Other regulations include *Occupational Safety and Health Act 1984 (WA)* and *Occupational Safety and Health Regulations 1996 (WA)*.

B. Major elements in PTW system

The guideline mentions some main element that should be included in the PTW system. They are described in the sections below

i. Roles and responsibility

Roles and responsibilities have to be defined and described for all scope of work with no possibility for ambiguity. It is a common practice in South East Asia and Australia that all procedures start with definition of roles and responsibilities. When it comes to PTW systems -it is usual for a large work site to have a Permit to Work Systems Manager who will be a part of the HSEQ team and will be the owner of the PTW system on site. He will be in charge of describing the roles and responsibility for the site. He will be liaising closely with the Construction manager who will appoint trained competent personnel for each role. In the case of a construction vessel this role is shared by the captain and offshore construction manager (OCM). See below some of the roles and responsibilities described as standard practices around the world

Roles	Responsibilities
Construction Manager	The Construction Manager is responsible for the management of the permit to work system for the construction scope of work.
Pre-commissioning Manager (PCM)	The Pre-Commissioning Manager is responsible for the management of the permit to work system for the pre-commissioning scope of work.

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Issuing authority	<p>Issuing Authorities are responsible for:</p> <ul style="list-style-type: none"> • Reviewing the JRAs for the job • Approving job risk assessments and allocating a unique JRA number. • Ensure correct issue, suspension and cancellation of Work Permits. • Reviewing that work can proceed safely with no significant impact to/and from SIMOPS • Participating in job risk assessments as required. • Reviewing all active ICCs, permits and associated documentation is available for review. • ensuring that the PIC has a detailed understanding of the task, the work location and the equipment to be worked on. • Verifying that the PIC is aware of responsibilities in case of an emergency at worksite. • Reviewing that a detailed handover takes place when responsibility is transferred to oncoming Issuing Authorities at shift change including the status of all Work Permit and isolations under their control. • Maintaining an Extended Period Isolations Register.
Contractor Site Manager	<p>The senior management person on site for each contractor is responsible for the appointment and managing the competence of their respective Permit Receivers.</p>
The Permit coordinator	<p>The Permit coordinator is responsible for daily coordination of the Permits, maintenance of a PTW register to ensure all Permits are recorded and tracked.</p>
Responsible engineer	<p>The person appointed to be in charge of a specific area of authorization who is responsible for reviewing and ensuring that the requirements are complied with by the people performing the work. Responsible Person is responsible for:</p> <ul style="list-style-type: none"> • verifying that all work carried out by personnel under their control is covered by the appropriate level of documentation/control

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	<ul style="list-style-type: none"> • verifying that an appropriately detailed risk assessment is carried out for the task ongoing • verifying that all precautions specified on the JRA are put in place in the work site • verifying that the work described in the Work Permit is properly completed or ensuring that the work is left in a safe condition when the work is stopping. Ensuring that the area is clean • to be a part of detailed safety briefing with the PIC during the Work Permit planning stage and ensure that all hazards have been identified and controls can be put in place to mitigate them • ensuring that the PIC has a detailed understanding of the task, the work location and the equipment to be worked on • Reviewing that the PIC is completely aware of any expected actions/responsibilities to be adopted in the event of an emergency • verifying that the worksite inspections are carried out before, during and after the performance of each task
<p>Chief engineer/System Supervisor</p>	<p>He is the final authority on the systems from a technical point of view</p>
<p>Work team</p>	<p>Personnel who carry out work described on a Permit to Work under the direction of the Person in Charge. They are responsible for:</p> <ul style="list-style-type: none"> • To take part actively and be proactive in understanding a suitable toolbox talk by the PIC before starting work and signing the toolbox talk form to acknowledge this. • Reporting all worksite problems to the PIC as soon as possible • Performing work under the terms and conditions specified for the safe execution of an assigned work activity at all times. • Alerting the PIC as soon as possible on identifying where the conditions specified in the Work Permit / Toolbox talk are or cannot be followed

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Person in charge	<p>The person actually carrying out the work, or leading the work party. PIC's are responsible for:</p> <ul style="list-style-type: none"> • Being fully conversant with the work and associated precautions described in the task plan and JRA • Carrying out the safe execution of assigned work activities and is responsible for the work team • Briefing and performing toolbox talk to all the workforce under their control about the potential hazards, precautions and conditions applicable to the work • verifying the Work Permit, JRA and any associated documentation is approved by the Responsible Person before starting the task and that the approved Work Permit is displayed at the worksite, where practicable. • verifying the worksite is left in a safe and tidy condition at the suspension or completion of work activities. • Returning the Work Permit and closing out to the Issuing Authority after completion of the job or by the end of permit period
Area authority	Person in control of the location where work is to be carried out
Site checker	Person carrying out checks as detailed on the permit. Mostly onshore activity
Isolation authorities	The person responsible for mechanical and electrical Isolations being applied prior to invasive work or removed once it is safe to do so.
Gas tester	Suitably trained and competent individuals to test for the presence of flammable vapors, toxic gases and oxygen within confined spaces.

Table 1 Roles and responsibilities - generic

ii. Procedures relevant to the PTW system

There are various procedures that need to be followed for the proper implementation of the permit to work system on board the vessel. It is important to understand the various steps in the process and how they influence the system. The exact sequence could differ from one site to the other based on the needs and requirements. But it will be safe to say that all the major aspects will be covered before the work onsite is completed.

The Permit system starts with the planning for the job including preparation of the procedures and work plans. It will extend to risk assessment and JRA relevant for the job. These processes may not seem very complicated but when there is large scope of work each item will need to be done planned and organised

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carefully. In beginning of 2014 there was a major modification work for one of the major construction vessel in the North Sea. There were 80 work plans that were completely different and had to be executed safely as quickly as possible. To have proper risk assessment of such a big scope itself is a massive task. If there we spend even one hour on each work pack for risk assessment – there is need for 10 days to cover just the risk assessment part of the work. This shows the importance of everyone involved in the job to understand and plan for having sufficient risk assessment and control measures. Even the engineers involved in the early planning stage should be having this in mind as combining the work plans will help in efficient implementation of the PTW system. There are various tasks that will be a part of the routine list in the vessel and need not be covered in the PTW system. While granting a permit the Issuing authority must take into consideration, location of activity, tasks to be undertaken. Other work in area, mitigation measures in place and rescue plans before granting the exception.

Experiences have begun to question if PTW systems should be applied to all activities since current practices have a considerable potential to lead to many confusions among stakeholders weakening the overall effectiveness. There has been certain scopes of work that should be covered on PTW

- Non-production work (e.g. maintenance, repair, inspection, testing, alteration, construction, dismantling, adaptation, modification, cleaning etc.);
- Non-routine operations
- Jobs where two or more individuals or groups need to co-ordinate activities to complete the job safely;
- Jobs where there is a transfer of work and responsibilities from one group to another.

(HSE,2005)

Some of the systems are now going electronic and paper free. There should be an interface between these electronic versions with paper system so that authorization can be made from anywhere on the vessel/site. It should be noted that accessing to networks from inside the tank or confined spaces might not be possible. Solution could be for using paper copies and then feeding them online later on but that would hinder parallel permit validation process. In 2013 a construction vessel operating in the Norwegian sector tried to phase in a completely paperless operation with all procedures and system fed into iPad but the system failed to meet the lofty goals because of accessibility issues. This is very relevant considering the fact the connectivity in the North Sea is supposedly much better than some of the other operational area around the world and accessibility will be an issue in the open seas. This will also be applicable

There can be multiple copies of the permit made. This will obviously depend on the type of permit system used but it's important that all the relevant personnel take care of the permits and handle them as is required. The permits must be stored even after the work is complete for audit purposes.

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Validation and checking the permits are critical element of the PTW system. It would again differ from one system to another. Permit interactions are very important to identify and they are to be handled very carefully by the issuing authority. On a marine operation side of business there are certain areas that will take priority over any planned maintenance work

1. dive system when divers are in water
2. cranes during deployment or recovery
3. thrusters (DP systems) when ship near an installation

No permit should be given out for any work that will influence these. Also there can be a system which will highlight and warn the issuing authority if any work will indirectly affect these system as a knock on effect

Permits running across shifts: Handovers are critical links in a safe system. There should be clearly understandable handover system should be in place. Handover regime should cover all the permit controlled work ongoing and the work should be stopped at a shift in a stage where it can be easily communicated and understood by the incoming group.

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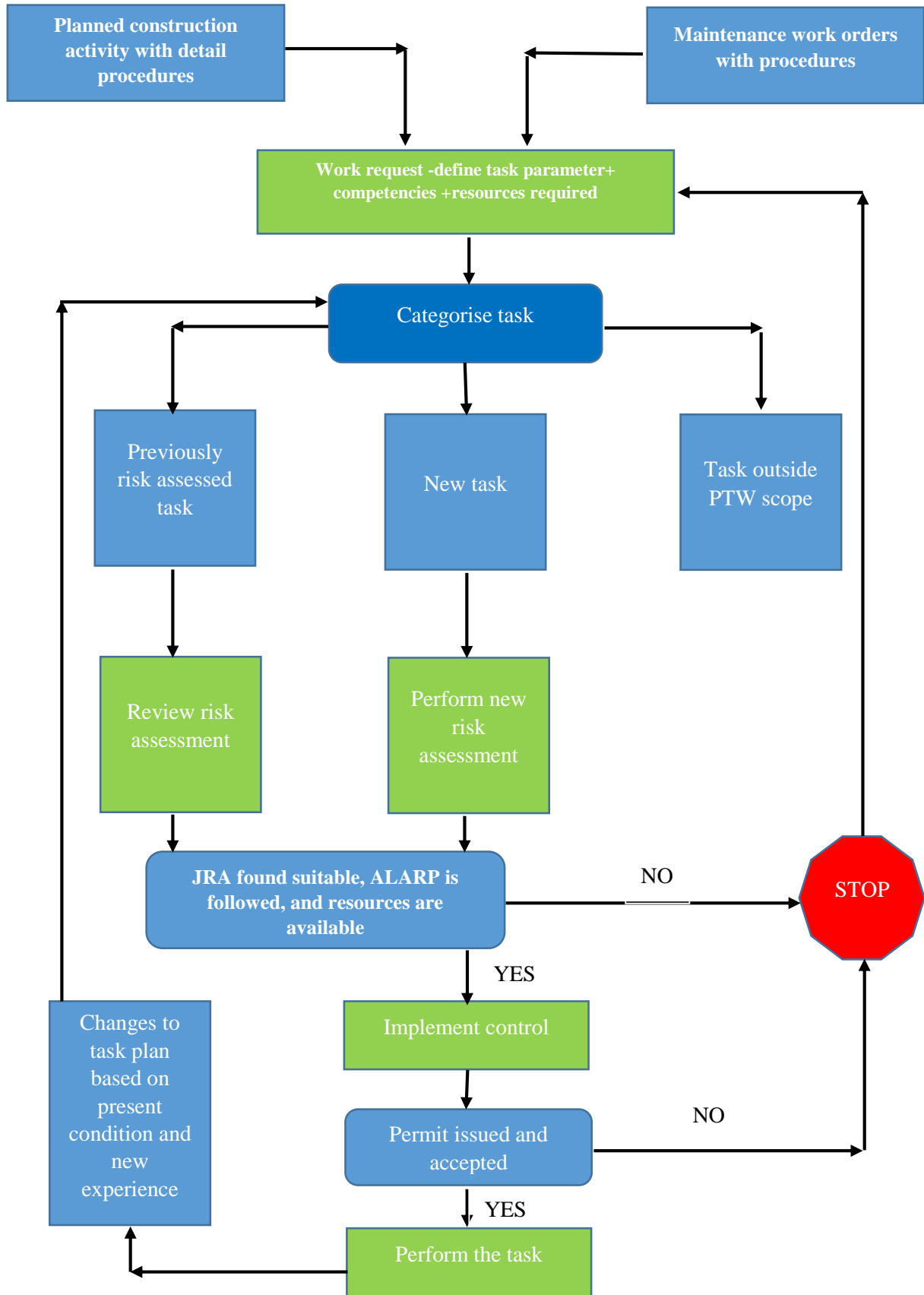


Figure 2 Flowchart for a generic permit to work system

iii. Display for the permits:

Lord Cullen report after the Piper alpha says Copies of all issued permits should be displayed at a convenient location and in a systematic arrangement such that process operating staff can readily see and check which equipment is under maintenance and not available for operation. (Piper alpha, Lord Cullen report)

It has been noted on ship yards and mobilizations bases across the world that this is not a practice that is being strictly followed. There are multiple of reasons:

Mobilizations for marine operations are very time bound and ship could potentially berth any of the quay side. The quality, training and system vary immensely from one yard to the other. Average mobilization time for a ship in the quay side is 3 days where there will be a large group of subcontractors joining the vessel and it is very difficult to train them to higher standards within the short duration of time.

iv. Tool box talk:

Tool box talk is carried out with work party by the PIC where the full work party discusses the following as minimum

1. it will be attended by all the members of the work party
2. plans for the work is explained in detail by the PIC
3. procedures are reviewed in detail
4. responsibilities for each and every one is identified
5. hazards are identified and barriers are discussed and identified
6. Access and egress for the work location. Placement for key emergency items and systems such as first aid kit, fire extinguishers, radios etc.
7. isolation needed for the job
8. simops in the location of the worksite
9. equipment and tools to be used for the job
10. each person with sign the tool box talk form with date and time where they acknowledge that they understand the roles and responsibility
11. there has to be a culture of openness and transparency during such meetings
12. tool box talks need to be topped up every time a new member is joining the team

v. Closing a permit

On completion of the work, the Permit Receiver shall indicate that the work is complete by signing off the permit and returning the permit to the Permit Issuer. The PTW is only considered closed when signed off by the Permit Issuer. The Permit Issuer or delegate will visit the site, confirming that the work site

has been left in a safe and acceptable condition. The permit is then retained by the Permit Issuer and passed to the PTW Coordinator for record keeping.

C. Types of permits and certificates

There are various types of permits and certificates that are relevant to most worksites. Below are a list of various permits that is used in various industries.

i. Hot work permit

Hot work permit is required for all work involving ignition source i.e. naked flames, welding, flame cutting, grinding, the use of heat shrink blowers etc. Hot work is usually taken to apply to an operation that could include the application of heat in areas where flammable atmospheres may be present. Hot work permits, typical are more generally applied to any type of work which involves actual or potential sources of ignition and which is done in an area where there may be a risk of fire or explosion, or which involves the emission of toxic fumes from the application of heat.(HSE, 2005)

A cold work permit is usually applicable in onshore facilities but they are very rarely used in marine subsea industry. Work on any equipment and or pipe work that has been formally handed over to Pre-commissioning following the issuance of a (MC) Mechanical Completion certificate. A cold work permit is required for all electrical/mechanical run checks onshore.

ii. Confined space entry

Once an area has been determined as a Confined Space a Confined Space Entry Permit is required for all entry or work to be conducted in a confined space.

Confined space entry certificates (unless detailed on a hot work or cold work permit) are used to specify the precautions to be taken to eliminate exposure to dangerous fumes or to an oxygen-depleted atmosphere before a person is permitted to enter a confined space. The certificate should confirm that the space is free from dangerous fumes or asphyxiating gases. It should also recognise the possibility of fumes desorbing from residues, oxygen depletion of the atmosphere as a result of oxidation, or the ingress of airborne contaminants from adjacent sources. The certificate should specify the precautions to be taken to protect the enclosed atmosphere against these hazards, e.g. by forced ventilation, physical isolation or by the provision of personal protective equipment including breathing apparatus. (HSE, 2005)

The confined space entry, the task/s to be undertaken within the space must be risk assessed by a competent person/s before work associated with the confined space is carried out.

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Notice of energization

An NOE is required prior to the energisation of any part of an electrical system, inclusive of all electrical commissioning activities above fifty volts.

Radiation work certificate

A Radiation Work Certificate is required for any work that involves the use of radioactive sources or x-ray machines for Non Destructive Testing (NDT). There is need to take radioactive material offshore especially when there is hyperbaric welding (underwater welding) and the x-rays are used for NDT. Skandi Arctic (DSV) had to take radioactive source during hyperbaric welding in the Stadfjord C worksite. There were special areas designated on the deck to store the radioactive source.

iii. Working at height certificate:

Working at height is identified as one of critical operation as it has been the cause of many fatalities.

There are certain basic guidelines to guide the working at height. There has to be permits in place when personnel undertake any of the following activities:

- Work is being performed at heights over energised (live) plant
- The use of a fall arrest system is required then working above 2m, where protection is not provided by a permanent structure or scaffold with equivalent protection (i.e. mid rail, top rail [900-1200mm] and toe board)

The UK health and safety executive in their working at height guidelines says:

- do as much work as possible from the ground
- ensure workers can get safely to and from where they work at height
- ensure equipment is suitable, stable and strong enough for the job, maintained and checked regularly
- make sure you don't overload or overreach when working at height;
- take precautions when working on or near fragile surfaces
- provide protection from falling objects
- Consider your emergency evacuation and rescue procedures. (HSE,2014)

The graph shows that the WAH risk involved in the marine industry is higher than other high risk industry (construction industry). So there are further stricter regimes in the marine industry (details are mentioned in the case studies).

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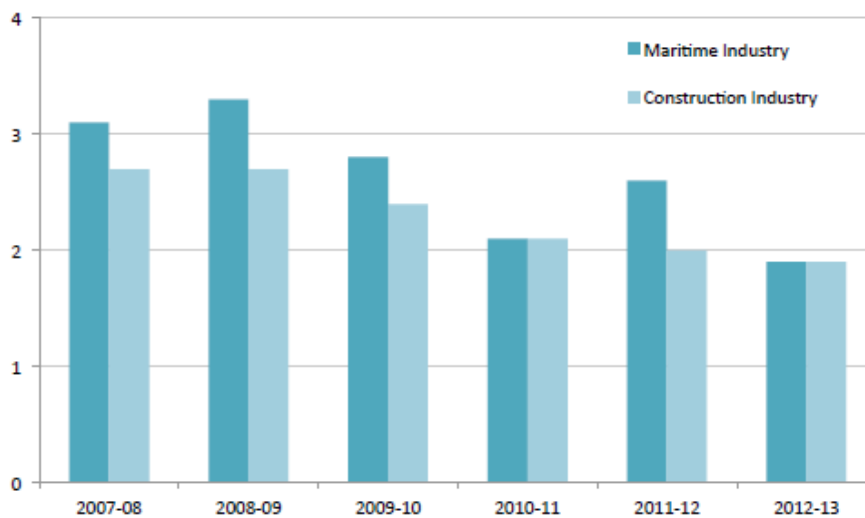


Figure 3 Incident rate (serious claims per 1000 employees) for marine sector (source: SWA)

Removal of Platform, Grating, Handrail or Stair Treads Certificate

A Removal of Platform, Grating, Handrail or Stair Treads Certificate is required for the removal replacement and/or alteration of all platform, grid mesh or checker plate, handrail or stair tread once it has been installed, inspected and opened for access.

iv. Electrical permit / Isolation confirmation certificates

Isolations form the major requirement prior to working on electrical or mechanical system. Before a permit to work can be issued for a task, a risk assessment must be conducted to determine equipment isolation requirements. Wherever isolations are required an isolation confirmation certificate (ICC) is required. The ICC combines on one document a record of all isolations required to perform the work in safety.

The equipment may require isolations from:

- Sources of electricity
- Process fluids and pressure
- Mechanical drives
- Control systems

The ICC ensures that the isolations are applied and documented in a thorough and systematic manner. The Permit shown on the Permit Register on the ICC may be signed as close against the ICC by the PTW Coordinator, upon sighting the actual Permit as having been closed by the Permit Issuer.

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i. Lock out and tag out procedure

Any Authorised Person who is required to work on any equipment, which is energised or has the potential to be energised, shall obtain the appropriate permit / certificate from the TPO Permit Issuer and work in accordance with the applicable Work Method Statements. The permit / certificate will describe all equipment to be isolated and define the exact boundaries of the isolation including valves and blinds. This is done using P&ID / Electrical Drawings etc. Prior to de-isolation signed approval will need to be obtained from issuing authority.

Where there are other personnel or work groups working on an isolated system, this shall be appropriately identified on the Isolation Certificate, stating PTW numbers and type.

Extended Period Isolations (EPI) will be controlled using the section on the Isolation Certificate, detailing the reason for the extended period isolation. The Permit Issuer will sign this section on initial placement of this as an EPI, review monthly and sign acknowledgement, with justification of the isolation still being in place.

A register attached to the ICC is available to allow for isolations to be de-isolated and then isolated or a boundary isolation to be changed. This allows for testing etc. on equipment within the boundary isolation. Under tis register keys must be authorised to be released and then signed out by those requiring the de-isolation. Once the task is complete and the isolation re-established, the keys are then signed back in by all parties

PART TWO: DETAILED STUDY OF TYPICAL PTW SYSTEMS

3. Case study 1. Marine operator PTW work system

Marine operators are the main installation or intervention stakeholder who is responsible for subsea intervention. They are in charge of the main operations related to the subsea asset. They could be operating in their own vessel or could hire in a third party vessel from a ship owner. Marine operators will have their own PTW system integrated into the vessel if the vessel belongs to them. When it is a third party vessel the permit system will depend on the agreement/contract between the marine operator and ship owners. Marine operator PTW routines are followed usually if the ship is on a long term charter with the operator. There are examples in the NCS when two different types of PTW systems are being used in two different vessels between the same marine operator and ship owner.

Marine operators have invested substantial time and resources in the development of the safe permit to work system, based on the present regulations and guidelines. This section will go through the main features of the PTW system followed by some of the marine operators.

A. Roles and responsibilities

In the permit system the roles and responsibilities on the vessel are clearly identified with the hierarchy of approval. There is training matrix which is verified vs the required competency matrix to ensure that the personnel are suitably trained for the responsibilities they are supposed to perform. There is usually an onshore coordinator who maintains the competency matrix and ensure that personnel get adequate training when due.

Another key feature of this system is that most of the training, especially for the work party members are done online. This is saving much time and resources and has been a big success in the North Sea sector.

Roles	Responsibilities
Captain/ vessel master	The captain of the ship has the final authority on the vessel. He has the overall responsibility for the safety of personnel and operations onboard. He also ensures the competences of people for doing the job.
Construction Manager	The Construction Manager is responsible for the management of the permit to work system for the construction scope of work. On a third party vessel

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	OCM will be the responsible for ensuring the company policy are followed. There is usually a bridging document showing the responsibility sharing between OCM and captain.
Issuing authority/bridge	Issuing authority is usually the chief officer who is responsible for reviewing and approving of JRA, ensuring the validity and correctness of the work permit, along with suspension of relevant work permits when applicable. They are verifying the isolation certificates for the job.
Responsible engineer	The Vessel master/offshore construction manager appoints a Responsible Person for a specific location. He is responsible to ensure that the work in the allocated location is carried out under the correct regimes. Vessel master maintains a list of competent persons who can act as area responsible.
HSE coordinator	Vessel HSE coordinator is an offshore position with lots different scopes to perform. <ul style="list-style-type: none"> • Ensure the JRA are suitable and numbered correctly • Ensure that the company policies are implemented properly • Assist the OCM in the implementation company philosophy • Have site inspection to ensure that the PTW system ae implemented correctly
Chief engineer/System Supervisor	Technical expert –refers to a person identified as the technical expert on the area on the machinery that is going to be worked upon. Before a planned maintenance is to be carried out , the responsible person discusses with Chief engineer/ System supervisor to let him know about the details for the work that is needed to be performed and associated risk or supervisory considerations needed. Usually there is chief engineer on the vessel who is the expert on the vessel system and there are system supervisors for each main systems in the vessel.
Work team	Personnel who are actually performing the work onsite. They are led by Person in charge who is the leader for the work party and is responsible for the safety of operations. They participate in tool box talk which will be held by the person in charge.
Person in charge	The leader for the work party and is responsible for the safety of operations. They participate in tool box talk which will be held by the person in charge.

Isolation authorities	Isolation authorities, appointed by the vessel master, competent to approve electrical, mechanical or instrument isolations. Also they ensure that the proposed isolations does not have any impact anywhere else. For the electrical items on the vessel it will be the vessel electrician.
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Table 2 Roles and responsibilities - cases study 1

B. Planning and categorization of work onboard

For any operation there are various stages from planning to execution and subsequently to completion. It is important that an integrated PTW system can address all the various stages of the operation. An integrated approach ensures that no main items are missed/overlooked due to human misjudgement. Also it serves not only as a checklist, but also as a planning tool when properly utilised.

i. Planning

Planning for an operation could be ongoing for many days, months or even years but it's important that brief description of the work and reference to relevant procedures are added to the permit so that the work team can refer to the job when they are needed.

Operations in the marine subsea industry should have an operational procedure which covers methodology, roles and responsibilities mentioned in it. A good procedure will also mention in the beginning the tools needed, operation to be completed prior to start up, potential hazards involved, technician operators needed etc. identified and listed in the beginning of the method statement. This procedure should be mentioned in the permit for reference.

As a part of the daily planning of operations on the vessel a planning meeting is held every day where responsible engineers and area responsible present the scope for next 24 hours. It can be seen as a permit/ planning meeting where various scopes are presented. The vessel masters, offshore managers who are looking at the scopes are able to see the simops and priorities the work activities. Certain scopes can be given priority over others in case of simops. It also can be used as a schedule updating meeting where the live schedule can be studied and updated in detail. This is particularly valid in the case of major reconstruction work in the ship.

Main steps in planning of an offshore operation is

- Definition of the scope of work
- A detailed work statement showing clearly the methodology
- Schedule the work for planning and allocation of resources

The work could possibly fall under

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1. Work requiring a work permit
2. Work falling under 'routine jobs
3. New jobs IA can decide on the permit requirements

ii. Work requiring a work permit

A Permit will be required where any work is needed for any operations, where there could be potential hazards to personnel involved, safety of plant and environment.

- Non-production work (e.g. maintenance, repair, inspection, testing, alteration, construction, dismantling, adaptation, modification, cleaning etc.)
- Non-routine operations
- Jobs where two or more individuals or groups need to co-ordinate activities to complete the job safely
- Jobs where there is a transfer of work and responsibilities from one group to another. (HSE,2005)

The section below shows the specific jobs that are listed in marine operators system that would cover the main scopes of operations a vessel capable of subsea interventions are able to carry out. These jobs could mostly covered by a combination of the permit system available on the vessel and the permit system on field in which they are operating.

Specific jobs	Details
Working in confined spaces	Confined spaces contribute to one of major risks on a vessel. It's very important from the marine operators' side that the confined areas on the vessel are clearly marked. Rescue and emergency system are clearly marked and labelled ready for use. Procedures for confined space entry including guards are closely followed.
Working on / overriding safety systems	Caution should be taken in case of working or overriding safety system. The systems need to be controlled properly with detailed risk assessment prior to operations. It also very important that the close out report of such maintenance or modifications is clearly mapped documented and understood.
Hot work involved	Hot work include cutting, burning, welding. It is necessarily introducing a spark in the area and control measures have to be in place. An example

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	would be no weldable areas on the deck. Example: Direct welding on top fuel tanks should not allowed in any circumstances unless the tanks are properly vented, cleaned and air tested. There should clear marking of non weldable areas on the deck.
Involving diving	Work where divers are involved and to include both saturation diving and air diving.
Involving heavy lift	There should be permit while doing heavy lifting. There are usually critical tasks with many parties involved-Deck crew, crane drivers, engineers, bridge (maintaining the trim of the vessel).
Involving subsea intervention	Intervention work involving the ROV or divers on subsea asset will need permit authorization and certificates from the asset operators. This could also include trenching , dredging etc.
Involving energy isolations	Could be involving the electrical – generators, switch boards, PLC systems. Care should be given not only to high voltage connections but also to low voltage connections as lots of incidents are reported while working on latter system.
Pipe/cable laying	Permit will be needed when we are laying cables or pipelines from the hip to the seabed. There will be substantial work on the deck including rotating reels, tensioners, hold back arrangements etc. that would need the area to be barrier off limits. Also there is substantial work on the sea bed.
Working over the side of the vessel	Permit is needed when work is performed by the side of the vessel. Life vest have to worn at all times and fast rescue craft (FRC) needs to be on standby in case of any eventualities.
Work involving unfamiliar equipment's / systems and procedures	Detailed Risk assessment needed prior to operation of a new equipment onboard the vessel. These are covered by the permit.

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Tasks involving dangerous substances	There could be various dangerous substances that are taken onboard for the project specific requirements. An example is radioactive substance taken onboard for X-raying of the welds in underwater subsea hyperbaric welding. Special transportation boxes are used and special areas are demarcated on the vessel.
SIMOPS / environmental factors could possess a threat	If there any activities that could be of concern to the environment, it should be given special consideration. These requirements are very stringent especially in offshore Brazil.
Issuing authorities thinks it is needed	The Bridge could decide if any operation needs to be covered by the PTW system based on the complexity of operations.

Table 3 major subsea intervention operation from ships

iii. Work falling under routine jobs

Non permit operations – the issuing authority can categorize a work that does not fall under hazardous operation or routine activity as a non-permit activity. A non-permit is a low hazardous well understood activity. The risk and protective measures are well understood by the work party. Some activities that are included this list.

See below the list of activities that are listed in the routine operation

Specific jobs	Details
Routine samplings	These routine sampling could be done by marine crew who will be responsible for the sampling for vessel system. Ex: an example for the routine sampling work could be air sampling works for the diving gas for testing the quality of air. This work is performed by dive techs or life support techs.
Mooring of the ship	The mooring of the ships is performed by ABs from the marine crew based on the direct command from the bridge. Usually the captain gives direct commands to the marine crew on radio on the mooring requirements.

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<p>Normal rigging activities</p>	<p>The normal rigging activities are performed by the deck crew under the direct supervision of the deck foreman. ABs are usually in charge of rigging for the provisions coming to the galley or the gangways.</p> <p>If the main deck cranes are used it will be the team of the crane operators, deck riggers and deck foreman. It is usual that the deck foreman will take out a permit for working at height at the start of the shift. There is usually a good practice to have a tool box talk even in case of routine activities.</p>
<p>Normal crane activities</p>	<p>The normal activities include simple lifting which comes in standard shapes and well within the capacity of the crane. This is usual during the mobilization or in the yard.</p> <p>Some standard lifts: standard containers, standard baskets, pallets, small clump weights</p> <p>Special crane operations: heavy lifts, spools, complex shapes like GRP covers, templates, manifolds etc. Deck foreman or crane divers are usually in charge of these.</p>
<p>Galley duties</p>	<p>Galley duties are usually carried out by dedicated galley crew. Main precaution comes in the design and fabrication with fire proofing elements preventing the fire to spread across the board in case of any eventualities.</p>

Table 4 list of routine jobs

Bombay high incident, 2005 – highlighting the importance of incorporating safety culture by EVERYONE on board, including the galley operators

The Mumbai High Field was discovered in 1974 and is located in the Arabian Sea 160km west of the Mumbai coast. It consisted of NA small wellhead platform built 1976, MHF residential platform built 1978, MHN processing platform built 1981, MHW recent additional processing platform.

The complex imported fluids from 11 other satellite wellhead platforms and exported oil to shore via undersea pipelines, as well as processing gas for gas lift operations. The seven-storey high Mumbai High North (MHN) platform had five gas export risers and ten fluid import risers situated outside the platform jacket. In July 2005, a multi-purpose support vessel (MSV) collided with the MHN platform, severing at least one gas riser and causing a massive fire which destroyed the MHN platform within two hours.

Collision

At time of accident on 27 July 2005, the Noble Charlie Yester jack-up was undertaking drilling operations in the field and was positioned over the NA platform. The MSV Samudra Suraksha was working elsewhere in field supporting diving operations when a cook on board the MSV cut off the tips of two fingers. Monsoon conditions onshore had grounded helicopters, so the injured person was to be transferred from the MSV to the MHN by crane lift for medical treatment. While approaching the MHN on the windward side, the MSV experienced problems with its computer-assisted azimuth thrusters so the MSV was brought in stern-first under manual control and the injured person was transferred off the MSV.

At around 1605 hours, strong swells pushed the MSV towards the MHN platform, causing the helideck at the rear of vessel to strike and sever one or more gas export risers on the MHN jacket. The resultant gas leak ignited within a short time. The close proximity of other risers and lack of fire protection caused further riser failure. The subsequent fire engulfed the platforms MHN and MHF, causing the complete destruction of the MHN. The fire also engulfed the MSV Samudra Suraksha, with heat radiation causing severe damage to the NA platform and the Noble Charlie Yester jack-up. Emergency shut-down valves (ESDVs) were in place at each end of the risers, but some risers were up to 12 km long and riser failure caused large amounts of gas to be uncontrollably released. Six divers in saturation chambers on MSV were left behind when the vessel was abandoned. They were rescued 36 hours later. The MSV suffered extensive fire damage and was towed away from scene but later sank on 01 Aug 2005, about 18km off Mumbai coast.

Aftermath

MHN collapsed after around two hours, leaving only the stump of its jacket above sea level. A total of 384 personnel were on board the MHN complex and NCY jack-up at the time of the accident. All installations were abandoned with 362 crew rescued and 22 reported dead (11 fatalities with 11 missing).

Source : http://home.versatel.nl/the_sims/rig/mhn.htm

C. Procedures relevant to PTW system

The system for implementation of PTW in each set up is unique. Even among marine operators there are various formats available.

The key steps of the permit to work procedure from marine operator are shown in the flowchart.

When it comes to the PTW form itself they are divided into various sections as described below. Each of the permit form has three copies. One copy is to be kept with the IA, one with PIC and one with RP. The forms are usually divided into separate sections.

Section 1- carries general info about the permit

For the marine operator system the usually the section 1 will contain the following information that are relevant to the work. This section is completed by the responsible engineer or PIC. They should complete this after onsite inspection.

1. They are uniquely numbered (sometimes renumbered). The importance of the numbering is to have reference to the previous permit that was issued for the same job and aid in tracking the history and progress of work. It also makes filling out of the forms easier as they can be used as reference.
2. Permit could show what kind of work was involved as a tick off box giving a quick overview. This could make it easier for sorting and quick overview of the type of permits. It could save valuable time in case of emergencies and there is no need to isolate certain jobs. Usually on a vessel the permits are sorted by the type of permit and sent to the management on a daily basis to give them a quick overview of the activities on the vessel.
3. Type of work – detailing the type of work will include. Examples would be to specify whether it is a hot work, confined space entry, working at height etc. The permit should be described as precisely as possible.
4. Location of work – the specific location on the vessel should be mentioned on the permit. This has to be as specific as possible. Example: when we have confined space entry into tanks – the tank numbers has to be specified as they are to be checked.
5. Description of the work to be carried out – this could vary from very basic description for a well understood frequently conducted work to very detailed description including drawings and task plans for work that are unique to the vessel. The permit format should have the space to include these details.

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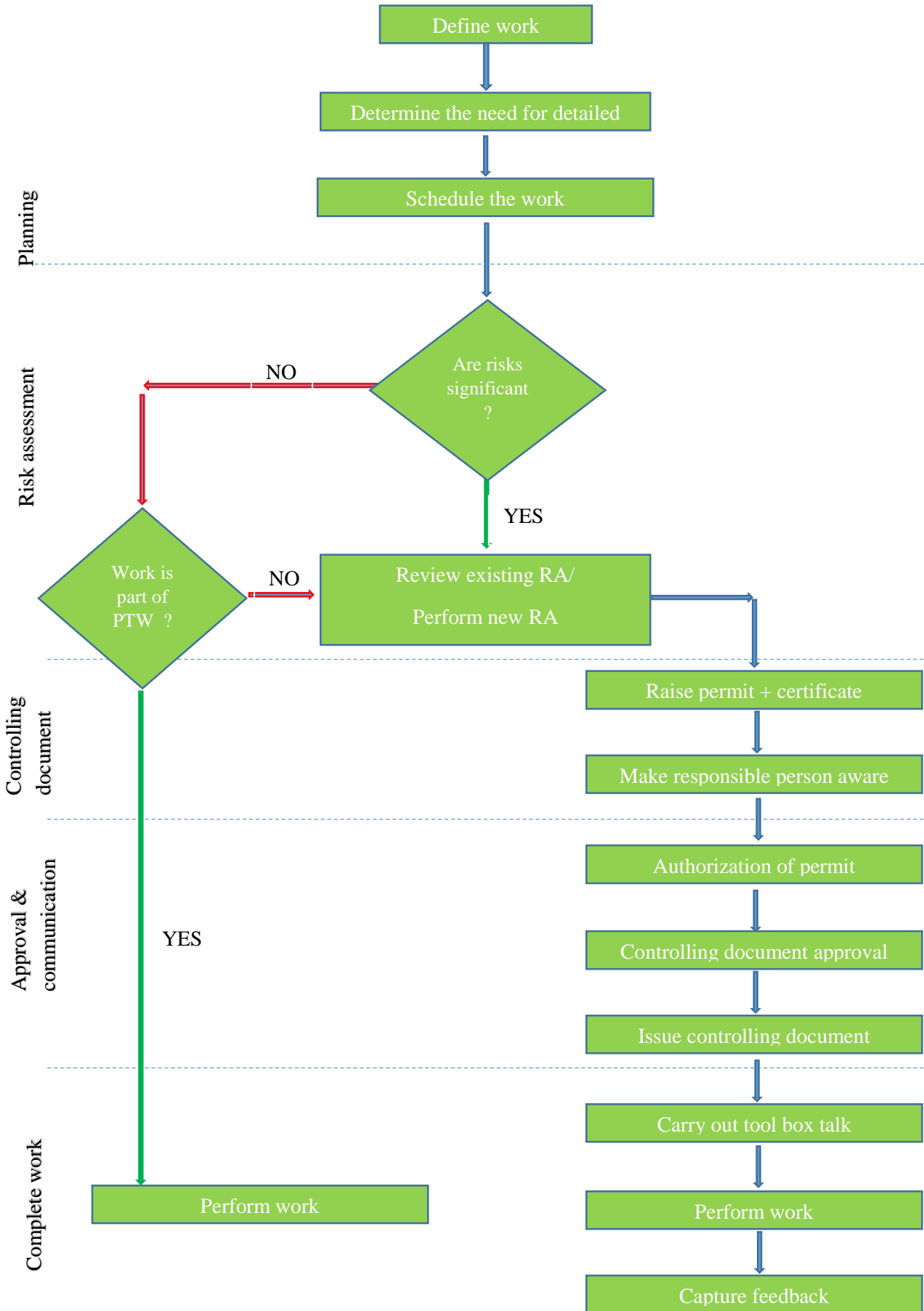


Figure 4 Flowchart showing PTW process for case study 1

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Section 2 – control measures/controlling documents

This section is to be filled up by the responsible person who identifies and include risk control measures to the permit request. This section is to be filled by PIC.

1. References are given to the risk assessments which identify the risks and barriers to meet the ALARP levels. The risk assessment are to be completed by PIC
2. There should be references to the various certificates that are relevant to the operation. some examples of such certificate are
 - a. gas test certificate
 - b. confined space entry certificate
 - c. dive certificate
 - d. isolation certificates

These certificate numbers needs to be cross referenced by the issuing authority

Responsible person can also discuss with the technical expertise and get advice at this point.

Section 3 Permit validation

The PIC and RP submit the permit form to IA after completing section 1 and 2 in the permit planning meeting. Section 3 will be filled by the vessel master/chief engineer during the permit planning meeting and is basically a planning tool. During the planning meeting the vessel master can go through the permit along with the risk assessment with his team. Vessel master will approve this section when they are happy with the risk barriers in place. Section 3 is filled when the permits are send to the vessel master or the issuing authority who will review the permit request and evaluate the condition on the vessel for the planned operation and maintenance activity and ensure that all the precautions are in place for doing the job. In case of the large rebuild or modification for the vessel – the time frame flexibility should be a big time and resource saver.

Section 4 – Permit acceptance

The acceptance of the permit has two step. Step I happen in the issuing authorities' office. This section of the permit is filled, reviewed and signed by the IA after detailed discussion with PIC about the precautions and limitations also considering all the work ongoing in the area and prioritizing them as required. IA signs the permit for approval and PIC signs the permit taking responsibility. Copies of the permit are taken and distributed accordingly.

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Number of copies for the work permit: Usually there are 3 copies for the permit. (Original, copy1 and copy2)

Copy 2 of the work permit is kept at the issuing authority office. They are usually kept in separate pocket separating out the various types. They are segregated into hot work; working at height, gas entry etc. so as to know which permits are present. Original and copy 1 are kept with the PIC and used site verification.

Some vessel has an A1 copy of the vessel drawing in the issuing office. The issuing authority can have color coded magnet dots which could be placed over location of the permit in the drawing.

The validation of the permit can be up to 72 hours and the RP; PIC in the back to back shifts can sign and activate this permit within the mentioned period.

Suggestion for magnetic colors are (these suggestion were presented by the Health safety executives, govt of UK) (HSE, 2005)

PERMIT	COLOUR CODE
Hot work	Red-edged or red
Confined space entry certificate	Green-edged or green
Equipment disjoining certificate /breaking containment permit	Black-edged
Isolation certificate	White
High voltage electrical isolation certificate	Yellow-edged or yellow
Sanction to test certificate	White
Excavation certificate	White
Diving certificate	White (or relevant colour from list above if diver carrying out that type of work)

Table 5 colour coding for permits

Original and copy 1 is taken to the worksite where the PIC will conduct a tool box talk with the work party. All the work party members will sign the tool box signoff sheet.

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Before the work can commence step 2 of the acceptance is completed when the responsible Engineer for the job will inspect the permit, all associated paper work and signs the original and copy 1.

Copy 1 is carried by the RP who will be responsible to ensure that the work is performed according to the systems and procedure for the vessel.

PIC is responsible for the wellbeing and safety of the work party. The work party is required to inform the PIC about any changes in the work. If there is any change in the work condition PIC informs the RP and IA.

By the end of each shift the PIC takes the original copy of the permit to the IA , who will collect all the permits and action according whether the permit needs to be reissued for the following shift or not. If the work is going to continue and permit is approved for the incoming shift the issuing authority and PIC can sign a section of the permit (In both original and copy 2). Next shift PIC will take the original to the work site where he will have the inspection with RP, who will sign the original form.

If there is any suspension for the permit PIC needs to return the original to the IA, where it will be stored with copy 2 till the work can start again. When the work overruns the permit allowed time a new permit has to be raised.

Section 5. After the work is completed

The last section for the form is the work completion section. Once the work is completed the permit needs to be signed by the PIC and RP and they are brought to the IA office where all the 3 copies can be collected together –signed and archived. The close out of work permit is one of the most critical phase especially in maintenance phase and have to be informed to all the relevant parties.

If the work is not completed a separate section could be signed which highlight the need for a follow on permit in future. The archives are part of the audit process where all the work permits could be audited by trained parties.

Even among the marine operators PTW vary from paper hard copy format to completely online systems. The selection is based on the operational requirements. If the vessel is operating in very remote locations then having a completely online system will be difficult. There are also human factors involved including training and competence of manning available on the vessel. If it's a very busy vessel with relatively easy job the vessel could be out in the open sea without a trained software technician.

i. Tool box talk:

Tool box talk is carried out with work party by the PIC where the full work party discusses the following as minimum. Marine operators put special emphasis on tool box talks. They are performed after the permit has been issued by the bridge/issuing authority. The system usually states that there is

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no need for tool box talks prior to operation unless there is new team member in the work team. It includes all the action/discussion point that are mentioned in the general permit system.

ii. Triggers for stopping:

The triggers for stopping the job can be mentioned in the permit papers and should be discussed with the team during the tool box talk.

The job can stopped when there if there is

1. Any changed to permit conditions.
2. Sounding of alarms – then the workers have to make the work place safe before moving the evacuation muster location. The work to start only after clearance is obtained from the issuing authority.
3. If anyone notices a potential hazard or change in condition the Pic is to inform RP and work should carry on only after the clearance is obtained.
4. If the permit is suspended by the PIC – he should return the permit to the RP with a written explanation on why the permit was suspended. The RP will be responsible for checking and evaluating the safety at the site. IA has to verify that the work site is safe for proceeding with operation.

D. Electrical PTW system /Isolation certificates

The permits are usually accompanied by isolation certificates which verify that the workplace has barriers in place between stored energy. They can be mechanical isolation (in case of gases and fluid etc.) or electrical isolation (in case of electrical appliances).

The impact of isolation have to viewed in detail and risk accessed this could be the basis for the priority given for the job.

A good example for this the work done recently on an installation vessel where we had to install new water hydrant system in the back deck to meet the new deck DNV requirements. This was the peak of activities without work going at many places in the vessel. During the risk assessment it was noticed that while tapping into the new existing fire system for adding the new system could lean the emergency safety system will not be operational and the vessel will not be prepared for any incidents. So it was decided to do some trial examples to see how much time would take and how the work could be optimized. More personnel where brought to the vessel and it was decided to do the tap in at 4 location at the same time in order to save time. An all stop was called for other activities reducing the probability for accidents or incidents. The work for the tap in was finished in one and half hours as opposed to initial plan for couple of days.

This was possible because

1. trial runs showed how the work could be modified to be more efficient
2. all missing items /tools / parts where identified well in advance during the trial fit up
3. trial runs showed need for more personnel if work on all 4 location was to happen at same time
4. This work was given priority and all the other works were stopped in order to avoid any chance of disruptions.

Electrical isolation tags

The electrical tags are very strict and could be done with

1. potentially two locks with key for one lock going to IA and key for other lock going to PIA
2. when locking is not possible it could be an idea to remove the fuse and marking clearly not to put the fuse back till permit is valid
3. it is not advisable to use electrical signals to isolate system – there has to be physical disconnection
4. all stored electrical energy in the system should be discharged
5. all isolation should be checked prior to starting of the work
6. Tear off slips from caution notice placed in the work site could be added to the ICC.

Mechanical isolations

1. Isolation valves should be physically locked, if possible, while isolated.
2. Spring loaded valves should not be used for mechanical isolations. It could be removed and blinded. If these are not possible there should be a risk assessment to identify additional control measures.
3. High strength plastic red and white chain instead of red and white tape to be used for barrier because they last longer.
4. Pressure check has to be done just before breaking containment.
5. Highly visible tag which contains details about isolation to be placed with the barrier. color coding can be used for various types of tags.

Extended period isolation:

Extend period isolation is made when the isolation is made for extended period of time often more than the permit times. They are usually done as a part of the maintenance program.

1. They are used when waiting for spare parts.
2. When equipment becomes redundant and there is waiting for repairs / modification or replacement.
3. If equipment has been in extended period isolation then they need to be reviewed and inspected thoroughly before they can be started up again. the reason being that the system could see various changes when left unused for extended periods of time and could lead to unwanted behavior of the system.

Isolation of safety and emergency system- should be carried out under the permit to work system at all times. A detailed risk assessment has to be carried out, covering both personnel and equipment , prior to isolating any of the emergency system.

Safety and emergency system include

1. alarm system
2. safety shut down system
3. fire and gas system
4. firefighting equipment
5. emergency escape equipment

E. Hot work permit

The permit to work system usually has good focus on the hot work permits. The physical dangers of hot work are very evident so there is caution associated with this genre of work. Following works fall under the permit to work system

- Gas or Arc welding
- Gas Cutting
- Burning and Brazing
- Grinding
- Radiography
- Gasoline Fuelled Engines and Equipment
- Work on Electrical Equipment
- Any other possible sources of ignition

There are certain features that applicable to the hot work type of permit

- Special attention is given to area surrounding the work space.
- Underdeck areas are of special importance. No welding is allowed over insulation or fuel tank. Under deck insulations are some of the biggest time consuming challenges for operation in NCS. The insulation is need for class approval before the vessel can sail. To remove the insulation is very labor intensive work with lots of working at height involved. The new generation ships are coming with double skin on deck to allow for direct welding.
- No welding is allowed over fuel tanks till they are gas free and tested.
- There is focus on fire watchers both above and below deck during welding. They need to be wired to the radio channel and should carry extinguishers.
- The fire watchers have to be on watch half an hour after the welding is completed.
- Special protection is needed for equipment, cables and hoses near to the hot work location. Special fire blankets needs to be used.
- Hose and cable management is very important as they cause the majority of slip hazards.
- Good ventilation is needed while working in the enclosed area as the welding leads to toxic gases.
- Proper PPE needs to be worn at all times. Face masks and fire retardant coverall are absolute must. There has been incident in 2015 when the coverall got accidental fire because wrong quality.
- Certified equipment with sufficient safety handles needs to be used. Its common yet unacceptable practice to remove the handles of grinders to ease the usability. There has to be proper management plan for gas bottles for welding gear.
- Deck to be marked clearly of NO WELD ZONES.

F. Permit for confined space entry

Confined space is an enclosed or partially enclosed area with limited ventilation where the atmosphere might become a health hazard. There should be sufficient ventilation at all times including mechanical ventilation fans.

Permit system list as the potential dangers as:

1. Process happening in the area. Example is enclosed area in the ship with marine growth or rust will have very limited oxygen as they are already used up.
2. As result of operation handled earlier before closing the tank. It could be a good idea to maintain a log of activities in the identified enclosed areas on the vessel. On the vessel there could be enclosed spaces like dry tanks for which activity logs can be maintained. They needs to be referred prior to giving out new permits. Also it can help to identify the root cause in case of any incidents.
3. Ingress of gases from areas outside the confined space.

2.1.1.Entry into tanks

When a tank lids needs to be removed a tank lid certificate is to be raised .This is to track all the lids and confined space entries that are ongoing at the vessel. IA keeps an overview of the activities and they could be also marked on the vessel drawings with stickers showing location. These certificates should show the reason for opening and tags has to be marked so that they could be traced from being open to closed and verified.

There should be a confined tank guard entry who is on the radio with the bridge at all times, who will control the entry and exit to the tanks. He will report to the bridge as soon as anyone in entering or exiting the area. He also can make note of the name of the people entering and exiting the area so that they can be tracked in case of any incidents. He is responsible for having all the safety and emergency provisions on standby at the area.

He should inform the bridge in case of any emergency and try to keep eye contact with the person inside the confined space. In case of an emergency he can enter the confined space for rescue only after the full rescue team is on the location.

2.1.2.Gas testing requirements:

All confined space entry will require gas testing prior to starting the operations. This is to verify the quality of atmosphere inside the space. Gas testing is relevant every time it has been identified in a risk assessment.

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The permit system should have a gas certificate frame work which shows the certificate number and mentioning the type of test and type of gases to be covered. IA authority should also mention the frequency of testing depending on the type of job.

G. Working at height

Marine operators usually have very high focus on the working at height procedures. Working at height has been the cause of many fatalities on ships and their effect has been brought to the forefront in recent years.

Working at height in the ship is all the more challenging considering the fact that the vessel will be moving in the sea. This is all the more critical in areas like the North Sea where the sea can get really rough. In 2012, Technip for Åsgard project engineered for a man less deck concept to protect personnel from manual operation during high sea states.

The definition of Working at Height is any work carried out in an area at, above, or below ground level where the potential exists to have a fall likely to cause personal injury.

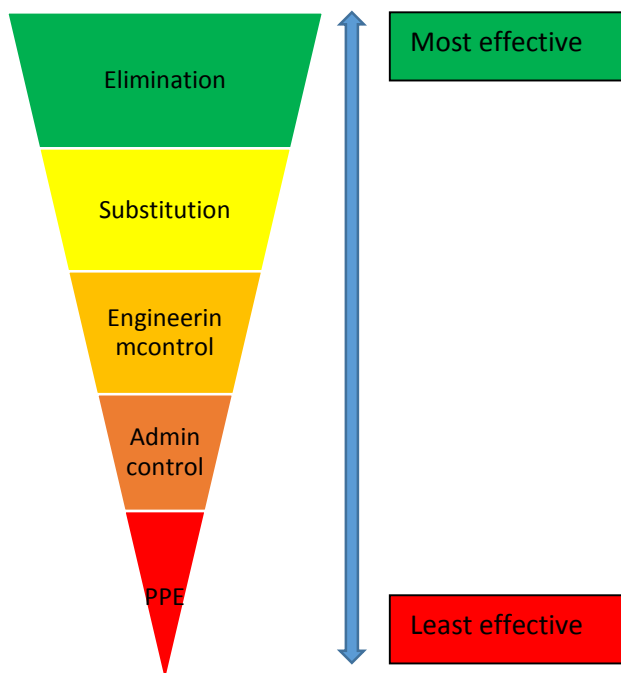


Figure 5 the main guiding principle for hierarchy of safety measures vs WAH

Main features for working at height permits are

- Personnel Working at Height have to be competent, fit and trained for the task. The training has to meet the required level mentioned in the competency matrix.
- Inspection of safety equipment used by third party every year.

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- Through inspection by the user prior to use every time.
- Logging of safety equipment- usually it will be the assistant deck foreman who will be responsible for tracking this.
- Safe access to the work site. Scaffolding are used extensively in NCS. But the quality of equipment's used and skills available vary significantly from yard.
- Provision for emergency rescue. if it is a long duration job there might be an emergency rescue exercise where a dummy is used to see the ease of rescue from the work site. This exercise gives a good idea of clamping points for hoisting personnel down.
- Provide protection from falling objects. It's not allowed work one above another at the same time. Tools falling from the top level to lower level are identified as one of the major causes of injuries.
- The tools needs to have secondary securement when they are working at height-in order to prevent them falling down below.
- Extensive use of anchor points for hooking up and back scratchers for ladders.
- JRAs have to be issued and approved for WAH. For some of the maintenance there could be a generic JRA which needs to be reviewed and approved.
- Before the Work at Height activities start a specific Tool Box Talk, shall be conducted. This needs to be performed beginning of each shift.
- Planning for the work includes identifying the time needed for accessing and identifying the potential for barrier to access.
- The scaffolding should be built in such a way that there is need for minimum starching when on the working platform.

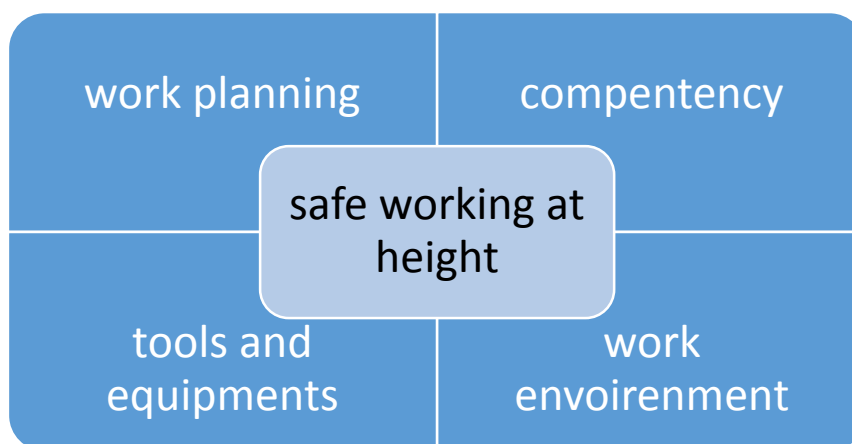


Figure 6 Safety matrix for working height

H. Lifting procedure:

Offshore lifting is a major operation that is ongoing in the subsea industry. Each of the operators have their own safety management system. In an engineered complex lift there are various stages of which certain parts will be covered under the vessel permit to work system.

1. Planning/engineering phase – the task plans are made along with the lift plans and lift rigging sketch. Rigging is ordered based on the lift plans. Some special rigging can take up to 3 weeks of delivery.
2. JRAs performed on board with rigging supervisors, deck foreman, and crane driver, vessel crew to go through the risk associated with the operation and what barriers could be in place. They also discuss what kind of permits will be needed. They are usually
 - a. Working at height – to attach rigging, working on outriggers
 - b. Hot work- if there is cutting of sea fastening needed for releasing from deck
3. After all the permits are sorted out -Prior to operation there will be a tool box talk where everyone is briefed about their roles and responsibilities.
4. The bridge will contact the authorities for deploying the module subsea.
5. The deck foreman will be in charge of the operation and he will be in direct communication with the crane driver for crane movements and bridge for the vessel movements.

Special attention is given

1. Sweeping the module to check there is no loose objects.
2. All the lifting gear to be checked thoroughly and certificates verified prior to use.
3. Never work under suspended loads.
4. Watch for pinched fingers. PPE to be worn at all times.
5. Safety harness and life jackets to be worn when working at height and working above water.
6. Use tag lines as needed.
7. Watch out for simops.
8. Clear the work area of potential trip hazards.
9. Avoid working in the tension line of tag lines.
10. Emergency rescue craft to be on alert.
11. Divers should be asked to return to the bell if it is a major lift.
12. Special attention to be given when the module is passing through the splash zone.

3. Case study 2. Ship owner PTW system

This is a case study of the permit to work system that is used by a ship owner and has some features unique when compared to other permit system.

The PTW system define a Work Permit is not only a permission to carry out a potentially dangerous job but also a system that determines how a job can be performed safely and how to avoid that two separate harmless jobs end together in a hazard. The PTW system is built up with reference to various work scopes. The following tasks require a Work Permit and this procedure is linked to:

1. Work permit - Hot Work (All type of work which can cause sparks, open flame.)
2. Work permit - Electrical System
3. Work permit - Working at Heights/outboard
4. Work permit - Entries into Enclosed/ Confined Spaces
5. Work Permit - Other (General maintenance work, heavy lift, use of dangerous substances, other)
6. Lock Out / Tag Out

In addition a Work Permit is required when work needs to be performed on the emergency system including:

- a. Safeguarding systems: emergency stops, relief valves and associated interlocks, quick closing valves, MOPS
- b. Alarms: general alarm (PA, status lights), manual alarm call points, Sound powered telephones
- c. Fire & gas detection systems
- d. Fire control: firewater main, hydrants, deluges, sprinkler, foam, CO2, dry powder fire extinguishers,
- e. Thrusters/positioning systems
- f. Evacuation and escape: heli-deck, lifeboats, life rafts etc.

A. Roles and responsibilities

In this permit system the roles and responsibilities are described with focus on the ship systems. The roles are very similar to what is described in the marine systems but there are a few new additions.

Roles	Responsibilities
Captain/ vessel master	The Vessel Master has overall responsibility for the implementation of the Work Permit system, and for ensuring that procedures and systems are in place and that personnel are competent to carry out their functions within the

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	<p>Work Permit system. It will still be each seamen's job and responsibility to execute all work in accordance with safe work practice and Good seamanship.</p> <p>Furthermore it is Master responsibility to assure that all work tasks are prioritized looking at the possible SIMOPS.</p>
<p>Issuing authority/ bridge</p>	<p>A role fulfilled by the Chief Officer or 2nd Officer. Issuing Authorities are responsible for:</p> <ul style="list-style-type: none"> • Reviewing detailed risk assessment has been carried out for the task. • Reviewing and approving job risk assessments and allocating a unique JRA number. • Ensure correct issue, suspension and cancellation of all Work Permits. • Reviewing that work can proceed safely with no significant impact to/and from simultaneous operations / adjacent work. • Participating in job risk assessments as required. • Reviewing all active ICCs and associated documentation is available for review. • Reviewing that the PIC has a detailed understanding of the task, the work location and the equipment to be worked on. • Verifying that the PIC is aware of any expected actions/responsibilities to be adopted in the event of an emergency. • Carrying out a detailed safety conversation with the PIC prior to Work Permit issue to ensure the PIC understands the full conditions of the Work Permit. • Reviewing that a detailed handover takes place when responsibility is transferred to oncoming Issuing Authorities at shift change including the status of all Work Permit and isolations under their control. <ul style="list-style-type: none"> • Maintaining an Extended Period Isolations Register.

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Responsible engineer	<p>The person appointed to be in charge of a specific area of authorization who is responsible for reviewing that the requirements are complied with by the people performing the work. Responsible Person is responsible for:</p> <ul style="list-style-type: none">• Reviewing that all work carried out by personnel under their control is covered by the appropriate level of documentation/control.• Reviewing that an appropriately detailed risk assessment is carried out for the task.• Reviewing that all precautions specified on the JRA are put in place.• Reviewing that the work described in the Work Permit is properly completed or ensuring that the work is left in a safe condition if not completed.• Carrying out a detailed safety briefing with the PIC during the Work Permit planning stage to ensure that all hazards have been identified and controls can be put in place to mitigate them.• Reviewing that the PIC has a detailed understanding of the task, the work location and the equipment to be worked on.• Reviewing that the PIC is fully aware of any expected actions/responsibilities to be adopted in the event of an emergency.• Reviewing that the worksite inspections are carried out before, during and after the performance of each task.
Work team	<p>Person(s) who carry out work described on a Permit to Work under the direction of the Person in Charge. They are responsible for:</p> <ul style="list-style-type: none">• Reviewing that they receive and understand a suitable toolbox talk by the PIC before starting work and signing the toolbox talk form to acknowledge this.• Reporting all worksite problems immediately to the PIC.• Working under the terms and conditions specified for the safe execution of an assigned work activity at all times.

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	<ul style="list-style-type: none"> • Alerting the PIC on identifying where the conditions specified in the Work Permit / Toolbox talk are or cannot be followed.
Person in charge	<p>The person actually carrying out the work, or leading the work party. PIC's are responsible for:</p> <ul style="list-style-type: none"> • Being fully conversant with the work and associated precautions. • Carrying out the safe execution of assigned work activities. • Briefing (toolbox talk) the entire workforce under their control in the potential hazards, precautions and conditions applicable to the work. • Reviewing the Work Permit, JRA and any associated documentation is approved by the Responsible Person before starting the task and that the approved Work Permit is displayed at the worksite, where practicable. • Reviewing the worksite is left in a safe and tidy condition at the suspension or completion of work activities. • Returning the Work Permit to the Issuing Authority after completion of the job or by the end of permit period.
Isolation authorities	The person responsible for mechanical and electrical Isolations being applied prior to invasive work or removed once it is safe to do so.
Gas tester	Suitably trained and competent individuals who are authorized by the Vessel Master to test for the presence of flammable vapors, toxic gases and oxygen within confined spaces.

Table 6 Roles and responsibilities - cases study 2

B. Planning and procedures relevant to PTW procedure

This section describes the permit to work process, steps and responsible involved.

The permits are prepared in the bridge by the chief officer or the first mate. The responsible engineer would contact the bridge for a new permit and handover the permit request.

i. Preplanning:

Planning is done by the responsible engineer. He or the person in charge has to produce a job risk assessment JRA on the work plan /procedures developed for the operation. JRA are prepared based on the type of job that is going to be performed. If the job is main operation task with many lots of marine operations it is advisable to have marine engineers to be present in the JRA.

After the JRA is completed a tool box talk is carried out with the full work party where the JRA is presented to the work party. This is done before each shift where Roles and responsibilities of the work party member are also discussed during this tool box talk. The tool box talk usually also contains the check list of all potential hazards and they are addressed by the PIC. All the members sign along with their roles.

The PIC or the RP takes the JRA and the tool box talk forms to the IA office where they are reviewed by the IA authority. It is expected that the person in charge fills draft for the permit to work form. But that may not be the case all the time when the IA will take responsibility for preparing the whole permit. The issuing authorities usually use a draft version or make a draft from a similar previous permit. If it's a completely new work then the A has to populate the whole permit form which takes longer time and usually leads to long ques in the IA office.

For the Person in charge to fill the forms they can access to the online permit system through a password protected gateway where they will be able to fill in the permit forms partially. This has been a big challenge to implement this as there are have been many issues with online accessibility from site and could lead to a standstill if there is no alternate plan. It also has been a challenge to train subcontractor Pic to the required level to fill in the online forms. This is often the case because the vessel will see very many different Pic as she is visiting various quay side or docks.

Another item to evaluate is the human factor element of the subcontractor PICs. They will not take full owner a ship permit to work system and cannot expect to handle the system carefully and is seen difficult to have full control. With these incidents happening frequently the IA on ships are usually reluctant to give complete access to the subcontractor PICs.

IA reviews the permits form along with the other work ongoing identifying any hazops and is approved if they are safe to proceed. The original copy of the permit is signed then by the IA along with the PIC who accepts the responsibility and responsible engineer ensuring the process is implemented correctly.

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Two extra copies of the permit are made – the original is kept in the bridge, copy 1 returned to PIC and copy 2 is given to the responsible engineer. Maximum duration of the permit is 12 hours or when till the PIC is on shift. Before it has become time expired it is possible to Extend a permit to work. The extension certificate can be printed out showing till when the permit is extended to. The appropriate persons sign it. It is copied and the extension cert is attached to the front of the permit.

When the permit is issued the online system will show the permit to be in **green** indicating that the permit is active. By the time the permit runs out it will change the colour to **red**. Once the permit is activated the IA place them in the permits issue display board which sorted into various types of permits.

Issuing authority or chief officer takes rounds to see that the permit system is respected and conditions mentioned in then risk assessment are met and maintained. All permits are automatically suspended in the event of an emergency. The personnel are briefed to stop all work and make the area safe and proceed to emergency stations.

By the end of the shift – the PIC is responsible to ensure that the work is restored to a safe state and the site will be inspected by responsible engineer. If the work is complete IA, Pic and RP will sign out the permit. They will also remove the lock out.

If the work is not completed – the status of the work is discussed by the PIC, RP in their handovers. Before a shift goes off they are required to secure the area and the status of the job is explained to the new team members by PIC during the tool box talk. There is option to extend the permits but they usually new permits are taken out for each new shift.

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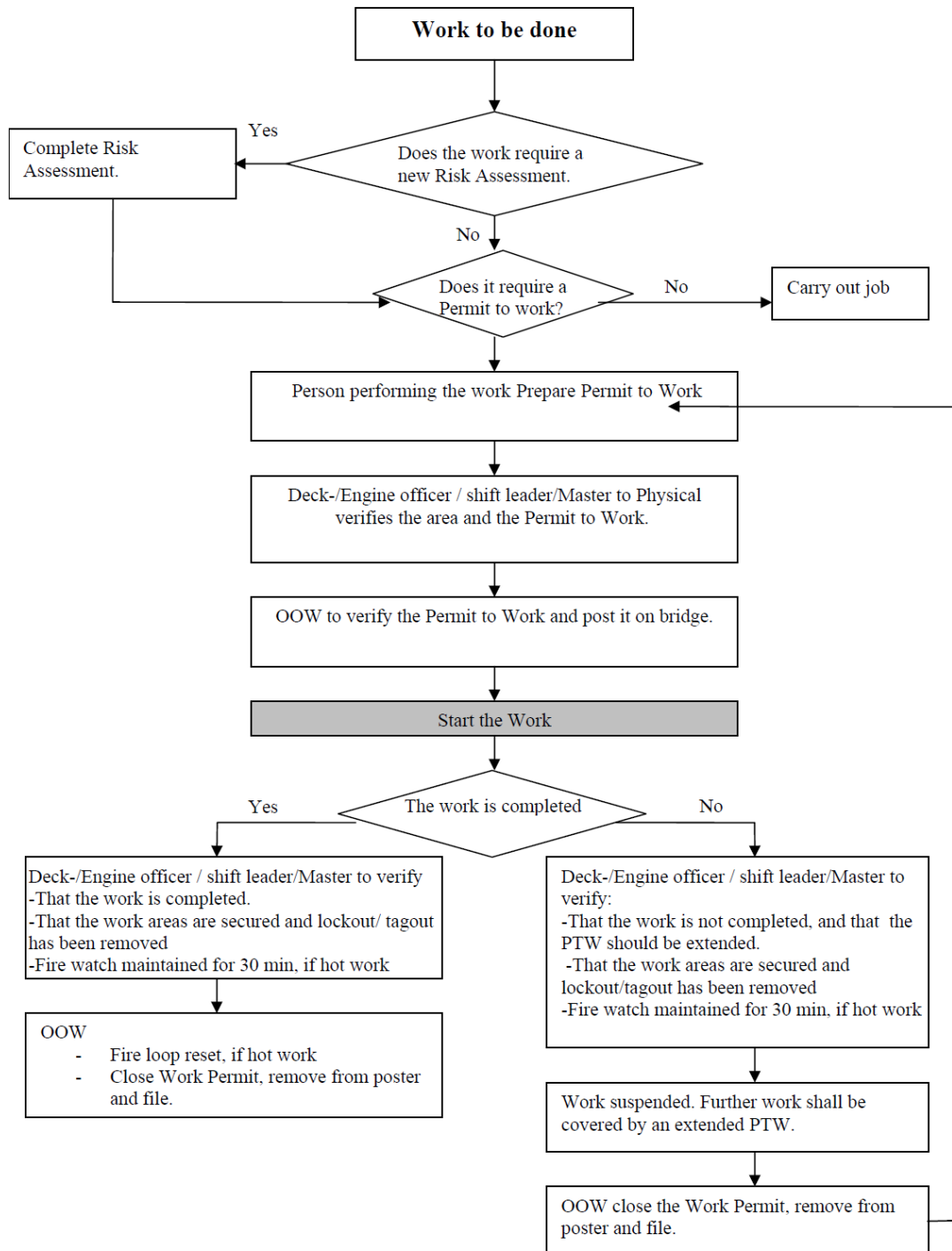


Figure 7 Flowchart showing the PTW process for case study 2

C. Procedures relevant to PTW system

The forms of the permit system are tailor made for the operations relevant to marine operations. There is focus on the marine operations side. There are many features that are missing from the operators system but there could be more emphasis made on the project side of operations. Main sections for the permit forms are:

Section 1- carries general info about the permit

For the ship owner system - section 1 usually will contain the following information that are relevant to the work and are usually filled by the bridge personnel or the issuing authority office. With the IA filling the forms there are some specific advantages and disadvantage

1. Type of work and description of work – detailing the type of work. As the system asks for the issuing authority to fill in the permit format there are some advantages and disadvantages.

Advantages:

- a. Issuing authority will have better understanding of the work to be performed.
- b. There is more control over the permit system.
- c. All the permits will have similar style of application and there is less chances of confusions.

Disadvantages:

- a. Much more time consuming than the marine operator system and there is usually a big waiting line for the permit in the issuing authority office.
2. Location of work – the specific location on the vessel should be mentioned on the permit. This has to be as specific as possible. Example: when we have confined space entry into tanks – the tank numbers has to be specified as they are to be checked.
 3. Work location responsible: this is identified as the personnel who will be responsible for the area of the work.

Section 2 – control measures

This section is also filled in by the issuing authority and includes space for adding the file names for risk assessment, certificates etc. But in this case there were no check boxes for typical certificates which could have served as a reminder for the Issuing authority and could have reduced the chances for human errors.

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Section 3 identification of control measures

Section 3 in this permit system is the control measures that need to be in place for the safe execution of operation. The measures mentioned in the list will depend on the permits that are requested for. They have a reminder for the various items including PPE, precaution equipment required, notifications etc. This basically serves as a check list and is helpful in reducing the human error factors.

1. Personnel protection equipment
 - a. Coverall
 - b. Ear protection
 - c. Face shield
 - d. Gloves
 - e. Hard hat
 - f. Safety shoes
 - g. Safety glass
2. Precaution equipment required
 - a. Barricades
 - b. Fire hose
 - c. Scaffolding
 - d. Ventilation
 - e. Warning posted
 - f. Watchman
3. Notification internal
 - a. Bridge
 - b. Client rep
 - c. Company office
 - d. Crane operator
 - e. ROV supervisor
4. External notification
 - a. Port authority
 - b. Yard
 - c. Stand by vessel

Section 4 – Approval section

In the ship operator Permit system the Issuing authority will sign the permit in section 4 followed by the signature for the person in charge and the responsible person. All the three sign the permit in the IA office. The work can commence as soon the work permit is issued and displayed on the work site.

Section 5 – close out section

Section 5 is the close out section of the permit where the IA, PIC and responsible engineer will sign the closing out of the permit. PIC and RP has to meet in the IA office and sign-out the original form stating that that work is complete or area is returned to safe state. And form is kept in the archives for 12 months after the job is complete.

D. Electrical systems permit to work/isolation certificates

The risks of electrical shock are much greater on board ships than they are ashore because the conditions of wetness, high humidity and high temperature, inducing sweating, reduce the contact resistance of the body. All maintenance Work on High Voltage Systems, above 50 volts, will require a permit to work. Severe and even fatal shocks may be caused at voltages as low as 60V.

Clear legible instructions should be posted in every space containing major switchboards about first aid and treatment. Before any work is done on electrical equipment, fuses should be removed or circuit breakers opened to ensure that all related circuits are dead.

Prior to start up always measure that there are no voltage between the phases, and no voltage between each phase to earth before any work is started. If possible, switches and circuit breakers should be locked open or, alternatively, a 'not to be closed' notice attached.

Where a fuse has been removed, it should be retained by the man working on the equipment until the job is finished. All Electricians shall have their own numbered padlock, controlled under the permit system. This is very important for traceability from the IA office. All tools used for electrical maintenance tasks e.g. screwdrivers, pliers, spanners, should be insulated up to 1000 volts. Tools should not be carried in pockets.

All insulating PPE and approved insulating rubber matting must be maintained in good condition and inspected prior to commencement of the task- this is particularly important during yard stays where there will be groups of workers coming in to various scopes including mechanical fit-up and could leave the mats in a bad state. All procedural requirements for the use of PPE during Electrical Maintenance are to be met. There will be a minimum of two people engaged in the task of Electrical Maintenance on the main switchboard, distribution panels and live feed control boxes. One person will be the designated worker and the other person is assigned as a watchman for the operations as a lookout should a problem arise. The person in attendance should be competent in the treatment of electric shock.

Main switchboards, distribution panels and live feed control boxes must have warning signs indicating the number of people and PPE to be used for servicing the system. The signs are to be in English and

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other languages common to the ship. All main switchboard, distribution panels and live feed control boxes should have insulated mats placed in front of them. If the workspace is hot, the maintenance workers should wear a sweatband to soak up perspiration- it's very much relevant in the warmer areas of operations such as Australia , middle east ,gulf of Mexico , brazil, south east Asia. Slight adjustment are made to PPE to control sweat. Accidents have occurred when workers have wiped their forehead with their sleeve and the wet sleeve has made electrical contact.

Flammable materials should not be left or stored near switchboards. Carbon tetrachloride should not be used for cleaning electrical equipment as the vapours are toxic in nature. Other safer cleaning solvents such as 1:1:1 trichloroethane are available but even with these the area of use should be well ventilated. Solvents should always be used in accordance with manufacturer's instructions only.

While in operation or in testing it might be needed to work near to live system even though its not recommended. Example for such a testing would be DP testing of the vessel where various switch boards are opened and closed in order to see how the DP system is responding to power outs from different sources maximum precaution have to be taken. The working position adopted should be safe and secure to avoid possible fatal contact with live parts arising from a slip or stumble or the movement of the vessel Contact with the deck, particularly if is wet, should be avoided. Footwear, if damp or with metal studs or rivets may give inadequate insulation. The use of a dry insulating mat is necessary at all times. Contact with bare metal should be avoided. A hand-to-hand shock is especially dangerous. To minimise the risk of a second contact should the working hand accidentally touch a live part, one hand should be kept in a behind protecting back whenever practicable.

Jewellery such as wristwatches, metal identity bracelets and rings should be removed. They provide low resistance contacts with the skin. Metal fittings on clothing and footwear are also dangerous.

Meter probes should have only minimum amounts of metal exposed and insulation of both probes should be in good condition. Care should be taken that the probes do not short circuit adjacent connections. In measuring voltages greater than 250V the probe should be attached and removed with the circuit dead.

Lockout and tag out system

Logout and tag out is required wherever there is risk of accidental turn-ons which includes:

1. Maintenance of electrical systems
2. Maintenance of pneumatic systems
3. Maintenance of hydraulic system
4. Maintenance of fuel powered engines

The lockout process involved identifying the energy sources and isolation, all the movable parts to be released or blocked and the tag out should state the reason why the machine is out of operation with responsible person and date. Barriers needs to be in place when before the equipment is started again and tested.

E. Hot work permit to work

All Welding and Gas cutting operations require a “Hot Work Permits”. (The only exception to this rule is if the vessel has a designated welding workshop) Operators should be trained, competent with the equipment to be used and instructed where special precautions need to be taken. Any persons not having specific experience and practice in the safe use of gas or electric welding equipment will not perform the job.

The Permit focuses on the situation of working place mainly on sufficient lighting especially in tanks and other below deck spaces. Where portable lights are needed to provide adequate illumination, they should be clamped or otherwise secured in position, not hand held, with leads kept clear of the working area. Wire and hose management is critical as it is one of the major causes for trips and falls in a mobilisation. They should be placed under wire/hose protection covers or should be coiled up if not in use.

Harmful fumes can be produced during these operations especially from galvanizing, paint etc. Oxygen in the atmosphere can be depleted when using gas cutting equipment. Noxious gases may be produced when welding or cutting. Therefore special care should be taken when welding and cutting in enclosed spaces to provide adequate ventilation. . The effectiveness of the ventilation should be checked at intervals while work is in progress. In confined spaces, breathing apparatus may be required.

Welding and cutting equipment must be inspected by a competent person before use. Protective clothing and equipment should be worn by the operator and as appropriate by those working with him to protect them from particles of hot metal and slag and from accidental burns and to protect their eyes and skin from ultra-violet and heat (infra-red) radiation.

The operator should wear:

- Eye protection. The type of eye protection depends on the task being carried out.
- Welding helmet with suitably coloured transparent eyepiece, eye goggles or a hand held shield may be suitable alternatives in appropriate circumstances.
- Long sleeved natural fibre fire retardant coverall.

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The lack of proper PPE is the major issue on board when it comes to mobilisation when some subcontractor turns up without proper PPE. In some cases they will be coming in from various countries and may not be able to bring their PPE. Ships usually have limited spare PPE and the thermal coveralls needed for the harsh winter. It might be necessary to have the bridge disable the fire alarms in the area. If this becomes necessary all affected personnel must be informed.

Before 'hot work' is begun, a check should be made that there are no combustible solids, liquids or gases, at, below or adjacent to the work area, which may be ignited by heat or sparks from the work. Particular attention should be given to vents from tanks containing combustible fluids. Welding or other hot work should never be undertaken on surfaces covered with grease, oil, paint or other flammable or combustible substances.

When welding is to be done in the vicinity of open hatches, suitable blankets should be erected to prevent sparks dropping down hatchways or ventilators. Port holes or other opening through which sparks may fall, should be closed. Fuel tanks or other spaces that have contained flammable substances should be tested and certified 'gas free' before any repair work begins. The gas tests are to be carried out by a competent person using calibrated meters with proper certificates. When the hot work is completed, the area must be thoroughly inspected and monitored continuously for an additional 30 minutes to check for delayed fire. This includes the deck below the area and opposite sides of any bulkheads where the work took place.

F. Confined space entry

All Entries into Enclosed or Confided Spaces requires a permit to work. All types of tanks, structural voids and other types of enclosed spaces should be regarded as potentially dangerous. Lack of adequate ventilation means that the atmosphere in the enclosed space may not be sufficient to support life because oxygen has been consumed by the rusting of metal, drying of paint etc. Anyone who enters an enclosed space where toxic gas is present or there is a low concentration of oxygen will collapse unconscious very quickly and without warning.

Some areas seen as part of confined space are

- Ballast tanks
- Pits, sumps
- Boilers
- Storage tanks
- Double hulls

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- Fuel tanks
- Holds of boats
- Tank cars
- Pumping stations
- Tank trucks
- Storage bins
- Other similar spaces
- Utility vaults

Before entering ventilate the space mechanically with approved apparatus include blowing fans, fume extractors etc. The workers need to keep them active all the time when the work is ongoing. There has been instance when they have switched off due to the cold air but it's very important to have the ventilation in spite of the cold.

Before anyone enters any enclosed or confined space, gas tests must be carried out to check for the presence of flammable, explosive or toxic gases and also to measure the oxygen content to ensure there is an adequate supply of oxygen. The gas tests are to be carried out by a competent person using calibrated instruments. No one should enter an enclosed space without wearing breathing equipment until the atmosphere has been tested and proved safe. If in doubt about the atmosphere, use breathing apparatus.

The oxygen content of the space must be checked at regular intervals and the Officer in charge of the operation should decide on the actual frequency when giving out the work permit. Ensure oxygen is not used to sweeten an oxygen deficient atmosphere. All valves leading to tanks must be isolated by lockout and tag out before anyone enters the compartment. No fuel driven equipment in enclosed spaces as it might add toxicity to air.

Any person entering a confined space with limited visibility must use safety harness and lifeline where required. The free end of the lifeline should be positioned outside the confined space. This will aid in the evacuation of the person in case of emergency

If during the course of the operation, unforeseen difficulties or hazards develop, the work must be stopped if possible and practicable, so that the situation can be fully re-assessed. Take all the equipment & tools needed for the job when entering the area and maintain a record of equipment's taken in. Prepare adequate approved lighting for the space. The return log must be completed the tools are taken out. Tools left mistakenly in fuel tanks have led to many machinery troubles in the past.

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Anyone entering any potable water tank must wear clean clothing and disinfected footwear, and shall not be suffering from skin infections, diarrhoea or any communicable diseases.

Types of gases that could be present in confined spaces (source – worksafebc, 2008)

<i>Contaminant</i>	<i>What is the MAIN danger?</i>	<i>What does it look/ smell like?</i>
Argon (Ar)	Displaces oxygen May accumulate at bottom	Colourless, odourless
Carbon dioxide (CO ₂)	Displaces oxygen Toxic May accumulate at bottom	Colourless, odourless
Carbon monoxide (CO)	Toxic — asphyxiant (causing suffocation)	Colourless, odourless (NO WARNING)
Chlorine (Cl ₂)	Toxic — lung and eye irritant May accumulate at bottom	Greenish yellow colour; sharp pungent odour
Gasoline vapours	Fire and explosion May accumulate at bottom	Colourless; sweet odour
Hydrogen sulfide (H ₂ S)	Extremely flammable Very toxic — causes lung failure May accumulate at bottom	Colourless; rotten egg odour*
Methane (CH ₄)	Fire and explosion May accumulate at top	Colourless, odourless (NO WARNING)
Nitrogen (N ₂)	Displaces oxygen	Colourless, odourless (NO WARNING)
Nitrogen dioxide (NO ₂)	Toxic — severe lung irritant May accumulate at bottom	Reddish brown; pungent odour
Sulfur dioxide (SO ₂)	Toxic — severe lung irritant May accumulate at bottom	Colourless; rotten, suffocating odour
Oxygen (O ₂)	Low levels — asphyxiant High levels — causes spontaneous combustion, explosion	Colourless, odourless

Table 7 Types of gases that could be present in confined spaces

G. Working at height

The ship owners PTW system has also lots of focus on the working at height. They are well aware of dangers associated and have highlighted that in the procedures. They usually include a variety of works including working on both maintenance and construction work. Some of the areas identified on the ship with frequent working at height are:

- Mast
- Deflectors
- Winches
- Cranes
- Davits

Some of the key features identified in the procedure are

- Safety harness need to worn at all times while WAH. Safety gear to be inspected prior to use every time. The equipment needs to be quarantined properly if found damaged.
- Use of safety net as seem required at the location of job and Minimum working at height when the vessel in sailing as there will be considerable movements.
- While working near the funnel and mast care should be given to reduce the steam emission as much as possible.
- Before working near the transmission aerial attention to ensure that no transmission to be made during course of work.
- Radio scanner to be locked out prior to working near the radar scanner.
- Special consideration to be given while transporting the tools to working height. Tool baskets to be used.
- Use of secondary securing of tools in mandatory while working at height.
- The procedures also mention about maintaining a clear work site at the end of the shift
It is worthwhile to note that most of near misses are occurring with tool left at height at the end of the shift and due to lack of proper clearing out. Some of the companies maintain the log of tools that they are taking up scaffolding. When the work team is coming out they need to sign out their tools.
- Scaffolding to be made according regional regulations for the scaffolding. They needs to be recertified every 14 days /10 days based on the regulation.
- Consideration to be given when scaffolding parts are brought onboard and stored with good housekeeping regimes.
- Vessel crew usually uses a simple scaffolding system which does not need extensive training to build.

4. Case study 3 - Yard

Another significant stakeholder in the marine subsea industry is the yards where the ships are built on worksites when there is substantial maintenance or modification works. According to DNV classification of ships the vessels have to be dry docked every 3 years for inspection of the hull. Operators usually use this period substantially to perform major maintenance and modification operations on the ship.

There are certain yards that have their own permit system which is to be used instead of the permit that is usually run on the vessel. The permit systems on the yards are usually very different from the ships as they need to be flexible to meet system requirements for various clients in the ship yard at the same time. In Dec 2013 in the old Maersk shipyard in Odense, there were 7 ships in 4 different dry docks and quays in the same yard. Each of these ships had different systems which could be very different from each other. Another challenge is the fact that these ships are coming in for a few days and there is immense focus of time efficiency as these ships will be out of contract during the maintenance period with no income to the owners.

It is also safety critical to have a common system as it will give an overview of the activities that are going on in the yard. There needs to be good coordination between the activities going on in the various vessels and the common permit system is a good tool.

In certain yards in Asia the ship is given in full custody of the shipyard and vessel owner can have only one representative on the yard at any time as they are sometimes seen as interfering in the progress.

In this section of the report we will look at a typical example of how a yard sets up a global permit system that is valid for all the ships in the yard.

A. Roles and responsibilities

All subcontractors for the whole package will be reporting to the main yard as the contractor. The subcontractors would include

Roles	Responsibilities
Vessel/site representative	Vessel representative will be from the ship owners side (usually the vessel manager or superintendent) who has good knowledge of the vessel system and work that needs to be done. He is in charge of approving the permit requests. Also he is also approving the time sheets.

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Permit officer	Permit officer in the contractor side who will look at the JRAs and apply for the permit on behalf of the contractor.
Work team	Personnel who are actually performing the work onsite. They are led by Person in charge that is the leader for the work party and is responsible for the safety of operations. They participate in tool box talk which will be held by the person in charge.
Person in charge	The leader for the work party and is responsible for the safety of operations. They participate in tool box talk which will be held by the person in charge.
HSE site rep	He is responsible for <ul style="list-style-type: none">• Ensure the JRA are suitable and numbered correctly• Ensure that the company policies are implemented properly• Have site inspections to make sure that the PTW system is implemented correctly• Point of contact in case of emergency

Table 8 Roles and responsibilities - cases study 3

B. Planning and procedures for permit to work

The planning and the permit to work process in the yard system is different from what is usually followed on the ship. The ship yard system is a separate system that could cover for all the ships in the yard at the same time. It means that all the personnel can work on various ships under same system and there is no confusion and more efficiency in work. This is an online system with unique sectors in the database for each vessel. The vessel representative will be able to edit and modify permits in their respective sectors.

The system of operation in the yard is also very different from other system. Below is a main features and step by step process for the one of yard process

1. The vessel is usually under the umbrella of the main contractor who will project managing a group of subcontractors. The permit system is run by the permit officer in the main contractor.
2. The subcontractors have daily meeting with the contractors where they will discuss the action plan for the next 24 hours. They request for new permits on a daily basis to the permit officer.
3. Permit officer review the permit request along with the risk assessment presented. Permit officer in liaison with the project manager and planner prioritise the work scopes and prepares the permit in the online system and forward it to the vessel superintendent /representative.

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4. Vessel superintendent review all the permits that are have been requested by the contractor and he is the final issuing authority for the permit. He can either reject the permit or approve the permit with comments.
5. Once they are approved, the permit is forwarded to the subcontractor PIC and he prints out and signs on to the permit form along with the risk assessment and perform the tool box talk along with the work party members. These permits will be displayed in the work site.
6. After the work scope is completed they are PIC will close the permit electronically in the database.
7. The permit officer, vessel superintendent, HSE advisors can monitor the permit status online.

PROCESS FLOW CHART

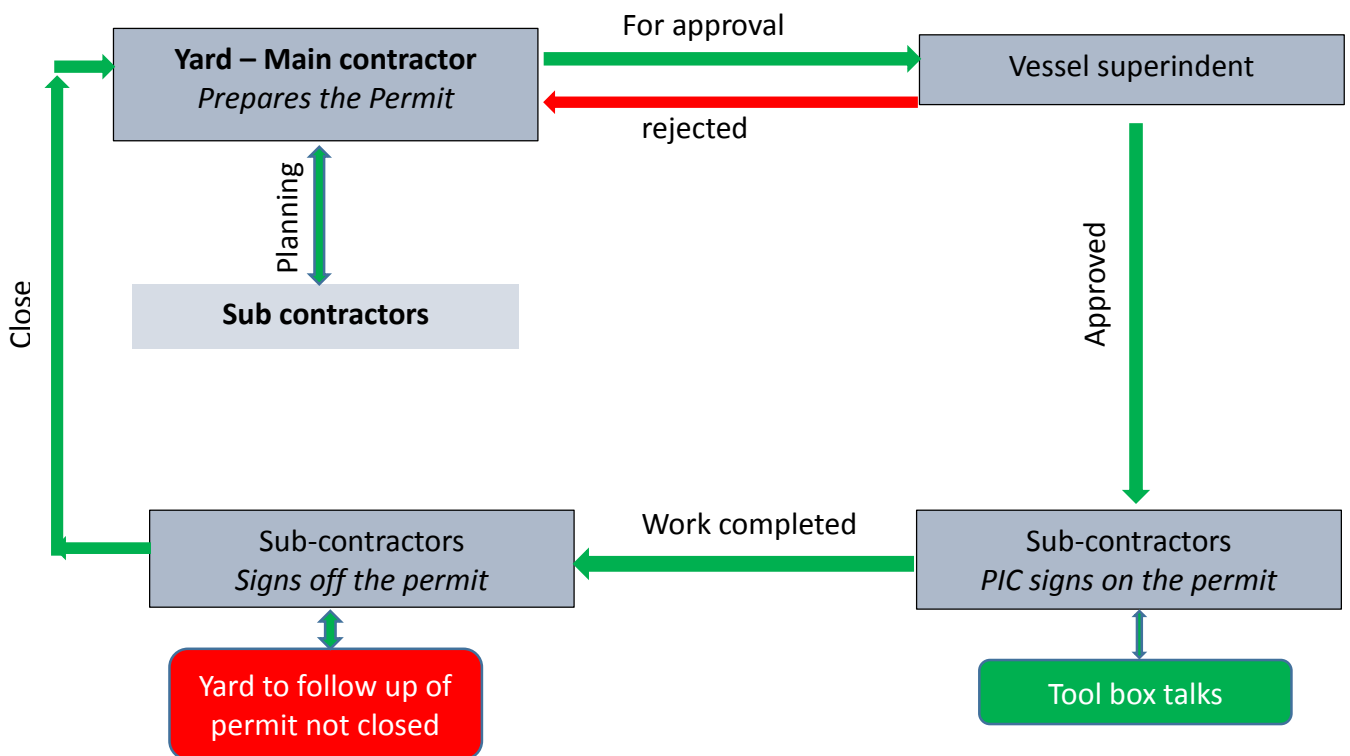


Figure 8 Flowchart showing the PTW process case study 3

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There are many subcontractors who reports to the main contractor who are usually the yard itself. The main subcontractors usually on a ship yard are:

1. welders , fitters, ship builders (unique trade in ship yards)
2. electrical technicians
3. hydraulic technician
4. engine technicians
5. cleaners
6. painters
7. NDT techs
8. Crane drivers and banks men
9. Forklift operators

3rd party survey will also liaise with the main subcontractors to identify suitable timing for inspection and approval.

The permits are prepared by the contractor permit officer after subcontractors informs what are the permits needed for the following day. The permit officer will review the JRA of the subcontractors and follows up with the permit after he has reviewed the process.

Permit officer needs to

1. Have good understanding of the ship and subsystems especially electrical systems which can be complicated.
2. Have good understanding of the scope of work by the subcontractor.
3. Good communication with the planners and project manager to see the sequence of operations.
4. Good communications with the vessel superintend.

There are many pros for having a system run by the main yard contractor. Some of the main pros are:

1. Contractors apply for permit – they have clear understanding of what is planned for the next shift based on the manning plan and progress in the work.
2. There is need for only limited client reps while following the PTW system.
3. There is considerable cost savings for the client as there is need for less number of ship representatives.
4. There is good control provided the permit officer have all the information about the vessel. It is very relevant if the ship was made in the yard or when she has been there before for other modification works.

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5. They are usually more efficient than using a system based on the ship. This is usually because main contractor has better communication their subcontractor.

But there are some cons as well while following this system

1. There are limited supervisors / supervision from personnel who are familiar with the vessel.
2. It could be risky if the contractors do not have all the updated information about the vessel. Usually there are some modification made during the vessel time and they may not be updated regularly.

C. Uniqueness of a ship yard

A yard is very special work location because it is very dynamic work environment with many different types of ships coming in for various kinds of inspection and modification activities. Each of these vessels could be seen as factory space in on standard and very different from one another. Typical types of vessel coming into a yard could be

1. drilling rigs
2. heavy lift vessel
3. major construction vessel
4. Pipe lay barges
5. Bulk carriers
6. oil tankers
7. seismic vessels
8. smaller cargo vessels
9. ferry
10. cruise ships
11. fishing trawlers

By looking at the wide array of types of ships it very clear that there are various types of vessel with wide variance of rules and system in place. It's important that all the workers understand all the relevant system well. Also working team needs to be comfortable with the permit system.

It is also very important to see the infrastructure set up in the yard itself. There are cranes, multi wheeler etc. that needs to be planned and have a safe execution with efficient simops. The online database system will provide with an overview of all the activities that are ongoing and can help in planning a safe operation looking at all the various jobs going on in parallel. The managers and HSE officers can have an overview of all the activities happening in the yard and plan accordingly

Importance of having coordinated activity in the yard

Having common system to control the activities is major tool in safe operation of the entire yard as all the activities could be planned properly and safely. The picture bellows shows the extend modification/repair work that a yard needs to carry out and the complexity of job.

MSC Flaminia is a post panamax container ship with a capacity of dead weight tonnage of 85,823 tons. She is nearly 300 metres (980 ft.) long and 40 metres (130 ft.) wide and was built in 2001 in Daewoo shipyard in Korea. On 14 July 2012,[4] a fire in hold 4 caused an explosion aboard MSC Flaminia while the ship was underway from US, to Antwerp, Belgium, forcing the crew to abandon the ship some 1,000 nautical miles (1,900 km; 1,200 mi) from nearest land in the middle of the Atlantic Ocean. There was extensive damage to ship and 2 fatalities. (Wikipedia). The ship was not granted permission to enter to enter national waters till almost end of 2012.

In end of 2013 she was towed to a yard in Denmark as special environmental systems were needed to clean the ship. There was concern of major toxic elements, which had to be handled very carefully and area had to be barrier off in the yard. But during the same time there were 7 other ships in the same yard. The cleaning activities on the damaged vessel and other operation in the nearby vessels had to be coordinated very well with minimal simops.



Picture showing the vessel in the yard.

Flaminia in the background.

The yellow painted area is the barrier with restricted access.

The block of steel is damaged part of ship

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Picture showing a damaged block from the vessel

There are special containers to store toxic chemicals left inside the vessel after the fire



Picture showing the aerial view of the MSV Flaminia fire damage (taken from another vessel).

100 Te crane (servicing 3 other vessel in the same yard) in the background

D. Types of permits and certificates

The types of permits and certificates in the yard are very similar to the system used by the ship owners. I reckon there is already good co-operation and understanding between the two industries of ship owners and ship yards as the two industries have been working together very closely.

Major difference is the fact that there is more focus on permits needed from the land authorities or commune as the yard has more interactions with the local municipalities than ship owners. Also there is very limited focus on subsea related tasks as the permit system will not be applicable when the vessel is out in the sea.

There is more focus on the roles and responsibilities in the permit in the ship owners system. This is because once the ship is in the sea there is limited personnel availability and each and every person needs to know what is supposed to be done in case of emergency. In the yard there is more flexibility in personnel as more personnel could be mobilised easily.

The PTW system the yard feels more flexible and less stringent – the reason could be that the work party needs to be flexible with lots of different types of system and hence giving room for flexibility.

PART THREE: ANALYSIS

5. PTW Gap Analysis

A. Purpose

The purpose of this section is to highlight any differences in expectation and guidance between marine offshore operator HSEQ procedures and standard ship owner HSEQ standards. In this section YARD system are not included as they are similar to ship owner HSEQ standards.

B. Scope

To review the contents and guidance provided in both the marine offshore standards and shipping procedures and documents. This part mainly focuses on the higher risk procedures which it is felt need to be more robust. In summary, suggestions and recommendations for improvement of systems will be provided to improve alignment and control between the company procedures.

C. Permit to Work-procedures

This section compares the main aspects of the permit system including the planning and the various procedures associated with the permit to work. For this section the yards have a PTW process which could be more comparable to onshore industrial plant.

	General permit system guidelines	Marine operator	Ship owners
1	<p>Roles and responsibilities have to be clearly defined.</p> <p>(As an extension of these roles and responsibilities it's important to understand the qualification for performing each job. Even though it is not explicitly mentioned in the guidelines – it will be very beneficial to list the qualification needed for each role)</p>	<p>Good description with a training matrix describing what training is needed by each person and on what kind of training is needed by each personnel.</p> <p>There are details in the induction process for personnel who will be operating within the PTW system.</p> <p>This clearly identifies the types of work to be completed, the associated documents required to support the various types of PTW and the process to follow to fully apply, monitor and close a PTW task.</p>	<p>Lack of training matrix for personnel involved in the Permit to work process.</p> <p>The procedure states <i>"The Master is responsible that the Work Permit system is understood and followed by all crew on board"</i>.</p> <p>This does not clearly define how the personnel will be made to understand the system.</p> <p>No formal training process in position and no records to show that personnel have reviewed and fully understood the system and their roles within it.</p>

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	General permit system guidelines	Marine operator	Ship owners
		<p>A check point on the familiarization inductions that this presentation has been explained and studied (and familiarization to be signed)</p> <ul style="list-style-type: none"> - For new crew signing on the vessel - For shore workers coming on board for work that require PTW. <p>As an example, only the personnel with level 3 training in system is able to apply for permits and approve permits.</p>	<p>There is no multi-level system for various roles. The general presentation is given to everyone coming on board.</p>
2	The validity period of JRA is not clearly mentioned	<p>Procedure makes it clear that a specific and thorough Job Risk Assessment must be completed with every PTW application.</p> <p>There is clear description on how often they should be reviewed and approved (every year even in case of routine operations).</p>	The renewal period and validity of risk assessment is not mentioned clearly
3	Require inspection of job site – but does not specify the frequency of inspection	There is clear provision for the work site inspection. Permit is valid only after the responsible engineer inspect the site	The inspection is done by the bridge personnel and they are usually limited to spot checks only
4	Checklists are not mentioned in detail.	Quick checklist available for many permits. There could be more added in the future	There are some check lists available in the system. But there could be more added to check details and avoid human errors.
5	Highlights the importance of tool box talks	The tool box talks after the permit is issued from the bridge. Bridge will go through the risk and mark them in the permit and talk leader go through them. The tool box talk is usually held in the work site location.	The tool box talk needs to be performed prior to the permit is issued. All the work party members need to sign the tool box talk form. The signed tool box talk is attached to the permit. Tool box talk rarely happens in the work site

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	General permit system guidelines	Marine operator	Ship owners
6		Tool box forms and talk are separate	The tool box combined together when there is a massive mobilisation
7		New personnel can join the team after the permit is granted provided he goes through the tool box talk. This gives a lot of flexibility of personnel during large operations	All the work party has to be identified and should sign the permit before the permit is given. Not very flexible when there is need for new personnel needs to join. This makes it very rigid and inflexible and does not lead to best utilisation of resources –as personnel could not be used for other scopes other than where he has attended the tool box talk.
		Permit can be valid for more than one shift .There is an efficient system in place to have permits to be valid for more than one shift and the work to be able to continue with new set of work team. Helps to save much time following the permit process	Permits are usually valid for only one shift. The team has to apply for a new permit after each shift. this leads to loss of time and causes frustration.
		Individual RP and PIC can fill the permit form in the online database. Faster process in the IA office	IA authority fills up he form . Leads to long delay in IA office

Table 9 comparison table -PTW procedures

D. Hot work permit

Vessel sees most hot work permit during yard stays in both mobilizations and maintenance /refurbishment periods. The number of hot work permit during operation at sea is very limited. There is usually only one rigger/welder per shift on the vessel – seriously limiting hot work capacity.

The systems controlling the hot work in all the three case studies are very similar. There are some areas with varied focuses and are listed below:

	General permit system guidelines	Marine operators	Ship owners
1	Working conditions to be suitable for job	Working condition aspects needs to be studied in detail and included.	The Permit focus on the situation of working place focusing on sufficient lighting.
2		More details to be given on what kind of atmospheric testing is needed.	The effectiveness of the ventilation to be checked at intervals while work is in progress. In confined spaces, breathing apparatus may be required.
3	Barriers to be in place wherever necessary	Decks marked clearly with No weld zones.	The procedure to include clear marking of the deck with No weld areas.
4	Blankets to be placed to protect equipment from fire	Protection of the hatchways to be included.	There is focus on covering hatchways with fire protection.
5	Blankets to be placed to protect equipment from fire	Good focus on protecting high pressure hoses.	High pressure hoses protection can be added to the checklist.

Table 10 comparison table -Hot work permit

E. Working at Height

When considering the types of tasks that involve working at heights at sea, images of tall masts and deep cargo holds often spring to mind. However, numerous tasks at sea involve working at heights. Falls can occur anywhere on a ship, such as, ladders, gangways, over the side and stairs in machinery spaces. When adding slippery surfaces and ship motion to the equation, the potential for accidents is high. (MSA, 2015)

	General permit system guidelines	Marine operators	Ship owners
1	Roles and responsibilities have to be clearly mentioned. There is not much description on the specification for the rescue team.	Description of responsibilities for each person to be involved in the working at height is added to ensure all roles are clearly defined and can be discussed within the work party. Rescue team composition could be improved	Guidelines are provided regarding roles and responsibilities within the working at height task, issuing authority, supervisor, person working at height, stand by person etc. But more details could be added on the responsibilities. Especially the rescue team. The ship when working at sea will not have access to fire department who will be available for land based organisation
2	Height above which there is need for permit is varying in different parts of the world. Example: In UK regulation says any work where there is potential to injury should be covered by the PTW system. In middle east its specified as 2 m.	Any work or access carried out in an area at, above, or below ground level where the potential exists to have a fall likely to cause personal injury". This removes the limit for work at height and should ensure that consideration is given to any operations which could potentially expose the operator to potential falls leading to injury.	Ship owner policy states a permit to work is required for all tasks that require working at heights above 2 meters.
3	HSE UK specifies the need to challenge the need to work at height	There is a section in the permit system that will challenge the need for WAH (to find alternatives).WAH should be avoided if possible	A section could be added to look into possibilities to reduce work at height and reduction of potential hazards.
4	Not sufficient focus on the checklist	There is working at height planning checklist to be used to ensure no human errors or all practical evaluation are made for the safe operations working at height	The checklist has been recently introduced on the ship system. Wide range implementation is still ongoing

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	General permit system guidelines	Marine operators	Ship owners
5	Training needs to be provided and documented	Training requirements for personnel working at height and being a member of the rescue team needs to be described better – especially considering the wide range of equipment and system and training available in the market today. Roles are better described in this system.	Training requirements for personnel working at height and being a member of the rescue team needs to be described better – especially considering the wide range of equipment and system and training available in the market today
6	*specific to marine industry	Special care to be added while working near the steam outlets like funnel or near mast	Special care already included working near the funnel and mast care should be given to reduce the steam emission as much as possible
7		Need to update the procedure while working near aerials	Special care already in place Before working near the transmission aerials to ensure that no transmission to be made during course of work
8	*specific to marine industry	Lockout of the radar scanner to be added in procedure	Radio scanner to be locked out prior to working near the radar scanner

Table 11 comparison table -WAH

F. Confined Space Entry

A confined space is an enclosed or partially enclosed area that is big enough for a worker to enter. It is not designed for someone to work in regularly, but workers may need to enter the confined space for tasks such as inspection, cleaning, maintenance, and repair. A small opening or a layout with obstructions can make entry and exit difficult and can complicate rescue procedures. (worksafebc.com)

	General permit system guidelines	Marine operators	Ship owners
1	Need for details in the roles and responsibilities	Details on roles and responsibility defined clearly. Needs to identify clearly the rescue team with names on each shift.	Include section of responsibilities for each person to be involved in the Confined Space Entry process to ensure all roles are clearly defined and can be discussed within the work party.
2	Need for monitoring the quality of gas	Requires continuous gas monitoring (it may not be practical to get a third party gas analyser for continuous monitoring as specified- especially when offshore	Mentions about testing the gas before starting the work. Monitoring to be made every 12 hours or under captain's discretion
3	Training specified	Requirement for training clearly specified	Training in confined space is applicable for all ABs seaman on board.
4	Rescue equipment should be in site	Rescue equipment to be placed near the confined space. This needs to be taken into account while ordering the spare kits , especially when it's in yard with many tank entries	More practical approach to placement of emergency equipment. There are dedicated places in the ship with quick reach of all personnel /confined space entry guard
5	Checklist and rescue plan	Confined Space Entry procedure is supported by any additional planning documents or rescue plans.	There can be following attachments to the permit: Method Statement. Job Risk Assessment Rescue plan and checklist. Isolation Confirmation Certificate (ICC). Gas Test Certificate. Confined Space Entry Certificate.

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	General permit system guidelines	Marine operators	Ship owners
6		Update needed on the system to address the valves to the work site	States clearly that the valves leading to the confined space needs to be locked and tagged
7	Gas to be tested regularly	Gas to be tested every 2 hours by third party	The officer in charge to decide the frequency of gas testing needed in the confined space

Table 12 comparison table CSE

G. Electrical/mechanical Isolation

On review of the information contained and the application of the electrical system procedure and isolations it is found that the processes followed by the stakeholders are very similar.

The system is sufficient to control the normal levels of operations with the above listed procedures giving personnel suitable guidance on the expectations for work with electrical systems.

There have been concerns in the past regarding the suitability of the system, but any faults identified and incidents involving electrical systems may have come through a lack of training and understanding of the procedural requirements due to the lack of formal training in the PTW systems. Human factor usually plays a massive role in this case.

H. Importance of competency matrix

The marine operator system has more focus on training and competency tracking. The integrated system includes the tracking of the competency matrix. The PTW guidelines are very clear on the importance of having clear roles and responsibility. Taking this further competency matrix plays a critical part in identifying who can take up the roles.

Personnel available on the ship should have their skills and training to be updated and the authorities should be able to track the skill set available.

PART FOUR: RECOMMENDATIONS FOR IMPROVEMENT

6. Suggestions

Studying the different types permit systems prevalent in the subsea marine industry –it seems that there is need for a more concentrated and joined effort from the various stakeholders and to develop a system that could be used as a general template. There are lots of features that could be adapted from one another and other similar industries such as the onshore oil and gas industry.

It seems to be high time when all the parties come together and address the PTW system and this will be one of the key for a successful integrated operation. Below are list of suggestions for each section.

A. Roles and responsibilities

As the regulation mentions, earlier roles and responsibilities have to be clearly defined with as much details as possible.

It is noted that there are different titles that are being used in the industry loosely depending on the background of the user. They could eventually lead to confusions and if there are different titles they should be grouped together or addressed together in the permit descriptions.

An exclusive list of all the various titles that is used in the industry and what the specific job descriptions for these titles are has been compiled and is given below.

Roles	Responsibilities
Captain/ vessel master	The captain of the ship has the final authority on the vessel. He has the overall responsibility for the safety of personnel and operations onboard. He also ensures the competences of people for doing the job.
Construction Manager	The Construction Manager is responsible for the management of the permit to work system for the construction scope of work. On a third party vessel OCM will be the responsible for ensuring the company policy are followed. There is usually a bridging document showing the responsibility sharing between OCM and captain.

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Issuing authority/ bridge	Issuing authority is usually the chief officer who is responsible for reviewing and approving of JRA, ensuring the validity and correctness of the work permit, along with suspension of relevant work permits when applicable. They are verifying the isolation certificates for the job.
HSE coordinator	<p>Vessel HSE coordinator is an offshore position with lots different scopes to perform.</p> <ul style="list-style-type: none"> • Ensure the JRA are suitable and numbered correctly • Ensure that the company policies are implemented properly • Assist the OCM in the implementation company philosophy • Have site inspection to ensure that the PTW system are implemented correctly
Responsible engineer/ Responsible personnel	The Vessel master/offshore construction manager appoints a Responsible Person/responsible personnel for a specific location/job. He is responsible to ensure that the work in the allocated location is carried out under the correct regimes. Vessel master maintains a list of competent persons who can act as area responsible.
Chief engineer/System Supervisor	Technical expert –refers to a person identified as the technical expert on the area on the machinery that is going to be worked upon. Before a planned maintenance is to be carried out , the responsible person discusses with Chief engineer/ System supervisor to let him know about the details for the work that is needed to be performed and associated risk or supervisory considerations required. Usually there is chief engineer on the vessel who is the expert on the vessel system and there are system supervisors for each main system in the vessel.
Work team	Personnel who are actually performing the work onsite. They are led by Person in charge who is the leader for the work party and is responsible for the safety of operations. They participate in tool box talk which will be held by the person in charge.
Person in charge	<p>The person actually carrying out the work, or leading the work party. PIC's are responsible for:</p> <ul style="list-style-type: none"> • should have completed understanding of the scope • safe execution of assigned work scope

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	<ul style="list-style-type: none"> • Lead the tool box talk with the work party • Coordinate with IA and RP • Ensuring a clean and safe work site • close out of the permit with the bridge at the end of the shift • Ensure a good handover with the back to back team
Isolation authorities	Isolation authorities, appointed by the vessel master, competent to approve electrical, mechanical or instrument isolations. Also they ensure that the proposed isolations do not have any impact anywhere else. For the electrical items on the vessel it will be the vessel electrician.
Gas tester	Suitably trained and competent individuals who are authorized by the Vessel Master to test for the presence of flammable vapours, toxic gases and oxygen within confined spaces.
Permit officer	Permit officer is dedicated to look at the scopes of works, JRAs and apply for the permit. He is also responsible for following up the permit system.

Table 13 Roles and responsibilities - suggestion

B. Planning and categorization of risk

Planning for the implementation of the PTW system and the execution for the job can make the real difference in safe execution. As Tom Landry says ‘Setting a goal is not the main thing, It is deciding how one will go about achieving it.’

The same is relevant in this case where we need to identify how best we can plan and implement the PTW system correctly.

i. Pre audit

The subsea marine industry being so dynamic with so many stakeholders-what previous project example have clearly pointed out is the gap in the expectations of various stake holders when they come together. Of course it might not be possible to have a pre audit every time but they should be employed every time there is possibility.

For the proper implementation of the permit system and to understand and appreciate all the aspects of the permit system for the marine subsea industry would be to have a through audit of the potential quayside or dockside. Personal suggestion would be to have frame agreements with the quay side so that the pre audits, explanation for the scope of work and other audits could be completed up front.

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1. The subcontractors coming on from the quay side should have a good understanding of the permit system. In 2013 when Technip took one of her major chartered vessel to Denmark in a new dry dock, there were many audits and presentations where the expectation on HSE, scope of work and PTW systems were given. It was seen as a major factor in the successful completion of the job because as soon the expensive vessel came in there was no confusion on the permit system and the workers were able to go to work directly.
2. Another major issue that creeps up most of the time is lack of proper PPE. Offshore industry has some of the highest requirements compared to other industry which are relevant and related like the ship building industry. In 2015 there was an incident in one of the North Sea vessel where the subcontractor welder PPE caught fire onboard because the PPE was not completely fire proof. Pre audit checking the PPE is one of the most important item to be audited. Audit of a random worksite in the yard is important and expectations have to be conveyed clearly. There has also been a very positive improvement in the past. Steel done company in Finland has a major success story on this where they performed excellently well with training on the HSE system. This was all the more commendable considering that they had very limited experience in the North Sea oil and gas industry.
3. The subcontractor supervisors should be sent detailed scope of work prior to the ship coming to the quay side so that they can be familiar with the vessel.
4. The subcontractor supervisors should be sent the vessel drawings prior to the ship coming to the quay side so that they can be familiar with the vessel if there is substantial work below deck.

6.1.1.Pre mobilization meeting

While Pre mobilization meetings can ensure that the systems are in place and as expected –it is important to have a pre mobilization meeting with the yard. It's advisable for an engineer from the ship to be available on the quay side prior to the vessel arrival.

1. He should be able to give scope briefing to subcontractor personnel
2. He can update the subcontractor management with vessel ETA and ensure all personnel are ready when the vessel is arriving
3. He can be the interface with the vessel. Arranging and helping out in case there is any issues with
 - a. Pilot for the area
 - b. Ensure there are bollards available for mooring
 - Ensure there is personnel for mooring the vessel
 - Procure any last minute items

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4. More focus should be given in the vessel inductions on the permit system of the vessel and the modes of display.
5. Vessel should prioritize going into ‘mother ports’ where the workers are familiar with the systems from the past projects.

Project teams should have prior meeting and presentation on the work and risk assessments should be done prior to ship arriving at the berth.

C. Procedure relevant to PTW

i. Checklist for each permits

Checklist is one of the features that was present in the marine contractors system. They were found to be suitable and accepted by all the other stakeholders and all agreed that it would help tremendously for reducing the human factor errors in the permit to work system.

The checklist will differ from vessel to vessel based on operational features of the vessel. There are certain features that would remain common for all. These systems have been used extensively in the Middle East onshore sector and have been very successful.

It is worthwhile to note that during the course of this thesis some of the ship owner systems were actually incorporating new checklist into their existing systems.

ii. Request for permits

Permits have to be filled in by PIC (marine operator system) or IA ship owner system. Both have advantages. Personal suggestion is that PIC and IA need to work on the same online platform in case of any major modification work in the ship. There should be good training for the PIC and RP about the vessel layout and on how to fill in the forms so that there are correct requests with similar standards.

If the issuing authorities are doing all the permits it takes a lot of time for permits to come by in case of a large modification work. Here it will be beneficial to have permit officer like what is available in the onshore system. A dedicated permit officer position has proven the worth in on shore industry and in certain ship yards.

iii. Warning system –mapping the dependencies

Update the permit system with dependencies – If a work permit is taken out on one system the software should be able to tell all the affected system so as to give precaution/ warning to the issuing authority for a closer look. This will help immensely to reduce the human factors of judgmental errors or knowledge about the particular system. This could be done in detail in an office environment and should

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be done during the design phase of any system. These dependencies should be identified during the design phase and should be marked in the FMECA.

iv. Including check boxes for certificates

Permit system should have name samples for the type of certificates to be included (ex: diving, isolation etc.). This will help in reducing the human error of not picking up a relevant certificate. In certain permit system, it mentions all the possible certificates and the PIC when requesting the permit ticks of the relevant boxes.

In the permit system more focus should be on marine side of operations and other stake holder should include the feature present in the ship owners system. An example of this would be the need for port notification. In Norway there is need for special permits if we need to do any deployment testing in the fjords, the navy has to be notified and there is need for special permit from the authorities.

v. Validity period for JRAs

JRAs are the starting points for a safe operation and issuing authorities have to look into the JRAs prior to issuing the permit. It is also important to have an updated JRA. It's required to update the JRS every year in the marine operator system. This should be a norm across all the PTW regimes by all the stakeholders to update the JRAs every year. This will ensure updating the risk assessment to meet the latest technological advancements and new methodology of operations.

vi. Display of permit

The display of the permits both in the IA room and work site is very vital for avoiding errors and is part of the emergency response philosophy.

In 2015 NSG added an A0 plotted vessel drawing in the bridge (issuing authority office) so that the IA can look at vessel drawing for quick references. Also unique color magnetic stickers were placed at the location of work on the drawing. They also have a permit showcase where they have sorted the various permits for easy tracking. In case of an emergency in a particular location the IA can identify all the work going on in the location very quickly without going through the entire paperwork. This is a very common practice in the vessel.

It is also important to have a showcase carrying the copies of all the permits which are active. They needs to be sorted according to the kind of permit it is. This will help in identifying the details for any particular permit. The subsea marine industry definitely needs an improvement in the way the permits are displayed in the worksites. The vessel needs to have better systems to display the permit. Most of the time the signed permit just ends up with the PIC as the mechanism of display is not well defined.

vii. Slips trips and falls and working at height

Slips trips and falls contribute to a major proportion of the accident happening at the work place. This is a major concern in the marine subsea industry as well. There are welding hoses and electrical cable that come one the deck during the mobilisation and leads to accidents. The cold winters in North Sea sector results in very icy decks and most of the ships take lots of care to maintain an anti-slippery deck. They include actions like clearing the water, adding salt, using anti slip paints etc.

When it comes to good housekeeping and hose management its essential to drive in the point with the work team to maintain the work place safe. The bigger percentages of accidents happen in the beginning of the shift when the work party is not sure of the trip hazards. In 2014 Technip made a major drive to reduce slip and trips and all work party members were asked to clean the work site and maintain good housekeeping in the last 15 minutes of their shift. There was major improvement when it comes to safety and general tidiness.

When working on scaffolding it will be good to maintain a tool log showing which tools are taken to the top of the scaffolding. They can be logged out when they are brought down. This is a proven method for preventing loose objects when working at height

There could be a section in the permit form for the inspection party to check the tidiness of the work place before the permit is approved.

Need for focus on slips and falls – PTW system could be used as a tool to ensure that there is good housekeeping and hence less chances for injury. **‘No permit to an untidy workplace’**

According data collected by Health and Safety executive, UK, 2014.

- In 2013/2014 STFs were responsible for more than half (57%) of all major/specified and almost three in ten (29%) over seven-day injuries to employees, making up 36% of all reported injuries to employees (RIDDOR).
- 986 thousand working days due to slips & trips

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Injury	Slips & trips	Falls from height	Combined STFs
Fatal	2	19	21
Major/specified	7 742	2 895	10 637
Over-seven-day	13 841	3 038	16 879
Total	21 585	5 952	27 537

Table 14 Reported injuries to employees, 2013/14p (RIDDOR all enforcing authorities)

Major/specified injuries by year	Slips & trips	Falls from height	Combined STFs
2007/08	10 963	3 270	14 233
2008/09	10 504	4 684 ^B	15 188
2009/10	10 676	4 226	14 902
2010/11	9 835	3 957	13 792
2011/12	8 830	3 063	11 893
2012/13	8 647	2 575	11 222
2013/14p	7 742	2 895	10 637

Table 15 Major/specified slip, trip and fall injuries to employees (RIDDOR, 2007/08 to 2013/14p)

Major/specified injuries by season	Slips & trips	Falls from height	Combined STFs
Spring (April to June) (Major)	1 860 (24%)	722 (25%)	2 582 (24%)
Summer (July to September) (Major)	1 860 (24%)	734 (25%)	2 594 (24%)
Autumn (October to December) (Specified)	2 049 (26%)	709 (24%)	2 758 (26%)
Winter (January to March) (Specified)	1 973 (25%)	730 (25%)	2 703 (25%)
Total	7 742	2 895	10 637

Table 16 Major/specified slip, trip and fall injuries to employees by season, 2013/14p (RIDDOR)

It is heartening to know that there is not substantial increase in the number during winter.

viii. Confined space entry

The regulation advises for regular testing of gases in confined spaces. But they are not concrete on the time interval between different testing by 3rd party verification. This is a major point of contention as some of the permit system says the gases needs to be tested every 2 hours and some states the officer has the authority to decide based on the circumstances.

I reckon that it is in best interest to give the authority for the officer in charge to decide with one mandatory test every day. Previous project have shown that this is a practical and safe approach. This is important from a practical point of you as to have a gas testing done at every location every 2 hours on a massive ship will not be possible. This will not be possible in a yard scenario with major modification work. The small personnel gas monitors should be worn at all times.

ix. Duration of permit validation

The duration of permit should be open for subjective judgment of the issuing authority or the vessel master. Some permits should be given for very short duration of time depending on the type of work. For example, if there is work on any of the safety critical items like the interventions on the fire and safety alarms or fire water systems or DP systems. It has to be kept to minimum time and the RP should be responsible for informing the IA about the completion pf the job and isolations have to be restored to normal safe positions in case of the large rebuild or modification for the vessel – the time frame flexibility should be a big time and resource saver. I suggest that in case of the large scopes where duration could be for many months the permits should be valid for 2 weeks and needs to be renewed every 2 weeks.

Pros:

- a. Will increase efficiency and will promote continuity of work if the permits are taken available for 2 weeks. Personnel will be able to continue the work.
- b. Will reduce paper work
- c. RP can concentrate on the actual job rather than in meetings

Cons

- a. The work party, PIC and RP needs to keep a close vigil and ensure that the nature of work has not changed after the permit has been issued.
- b. RP and IA have to be careful about the simops in the area and extra care needs to be taken to ensure that work party is aware of the ongoing activities.

I suggest that a tool box talk prior to each shift where these are covered should be made compulsory. This could be combined in to work party shift handover talk. So that all people associated with the job can meet and discuss the progress of work and challenges to the

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work. Also it can be the forum to discuss about the safety concerns, simops from other group of workers that are doing different scope of work

x. Tool box talk

Tools for tool box talks

Recommendations:

1. All tool box form should have a small description or signs showing the potential hazards which could serve as a reminder for the PIC.
2. The relevant hazard boxes could be ticked off as they are discussed.
3. Tool box talks could be aided by flyers and notice cards which could compile the lessons learnt from past incidents for similar scope of work.
4. There can be sign boards detailing the job and hazards.
5. A tool box to be done at the beginning of each shift. It could be combined with a shift handover which could make it efficient by saving time.

xi. Follow up of permits

Proper follow up of the permit system and the individual permits are vital for the safe execution of job. The regulations in general have not been clear on the level of supervision or follow up needed. Of course it will depend on the type of operation that is going on in the site.

There should be better guidelines on

1. Frequency of site inspection
2. Roles and responsibility on who is going to follow up / inspect the site
3. What kind of testing is needed as a part of inspection (example: frequency of gas testing)

The inspection plan should be aided by an inspection checklist. Inspection checklist are important for the correct inspection plan. This is very common in the PTW system in Middle East onshore sector. Attached is a checklist for scaffolding inspection.

The present permit system does not specify how many permit one person can be in charge of at any particular time. It will be unreasonable to expect one person to follow up many permits. In Australia it is mandatory that the maximum number of permits that a person can be in charge of at any given time is 4.

For following up, the Ship owner system have work location responsible. It's a very positive step for the follow up and should be incorporated in other system as well.

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SCAFFOLDING INSPECTION CHECKLIST		
LOCATION: <input style="width: 100%;" type="text"/>	WORK PERMIT N° <input style="width: 100%;" type="text"/>	
	CHECK	REMARKS
<u>SCAFFOLD BOARDS:</u>		
1. CLEAN AND CLEAR OF DEBRIS		
2. CORRECTLY JOINTED		
3. CORRECTLY LASHED		
<u>SCAFFOLD TUBES:</u>		
1. NOT BENT OR DISTORTED		
2. FREE FROM CORROSION		
3. CORRECTLY FITTED		
<u>SCAFFOLD FITTINGS:</u>		
1. CLEAN AND LUBRICATED		
2. FREE FROM CORROSION		
3. CORRECTLY TIED		
<u>ACCESS</u>		
1. LADDERS FOR ACCESS		
2. FREE ACCESS TO SCAFFOLDS		
<u>LADDERS</u>		
1. LONG ENOUGH		
2. CLEAN AND NO LOOSE OR MISSING RUNGS		
3. CORRECTLY LASHED WITH ROPES		
<u>FOUNDATIONS AND STRUCTURES:</u>		
1. FIRM FOOTING		
2. CORRECTLY ATTACHED TO FIRM STRUCTURE		
3. DESIGNED TO TAKE ACTUAL LOAD		
<u>PREVENT RISKS OF FALLING:</u>		
1. TWO FIXED HANDRAILS		
2. TOEBOARDS FIXED AND SECURED		
<u>SAFETY EQUIPMENT:</u>		
1. SAFETY HARNESS WITH LIFE-LINE		
2. WORKING LIFE VEST		
3. SCAFF-TAG		
INSPECTED BY SAFETY	DATE:	
AUTHORITY:	VISA:	
NOTE: IF ANY MODIFICATIONS OR ABNORMALITY OCCURS THE SCAFFOLD SHOULD BE RE-INSPECTED AGAIN PRIOR TO USE		
Distribution: Yellow – Perf. Authority White – PERMIT OFFICE Blue – On Site Pink - Safety		

Example for the inspection checklist used by a Middle East EPCI contractor

D. Certificate attachments to permit system

Certificates and attachments form the vital cog in the permit to work system in order to ensure that the entire barriers are in place. JRA will identify the risk that are involved with the operation and the also the barriers that are in place to ensure safety of both personnel and equipment. The certificates give accountability to the barrier that is in place. The work party should be able to check the certificates and should be able to work with assurance.

i. Isolation certificates

Isolation certificates for both hydraulic, mechanical and electrical has to be in place prior to intervention. It will be very beneficial to have various attachments to these certificates which could add more information to the certificates.

Attachment for the isolation certificates

As attachment there could be:

1. Isolation tags – showing details for the isolation. Some of the systems have tag numbers with a copy of the tag stored with the IA. This will make it easily traceable. Also in case of an emergency it will be quicker to trace the isolation responsible and get the system back up and running if needed.
2. Caution notices- There can be caution notices attached which give more information to the workers in the area.
3. Electrical disconnection labels- Electrical disconnection labels show the status of the connection with the leads.
4. Marked up engineering and electrical drawings- Marked up engineering drawings are to be attached to the certificates. They shows the modification that going on in the work site,
5. P &ID drawings.
6. Isolation procedure based on the system.

ii. Electrical isolations

Electrical isolation has to in place with padlocks in the switchboard before intervention to the electrical systems onboard. Most of the PTW system uses two padlocks –key to one to be kept with the isolating authority and key to the other one with the PIC so as to ensure that there is no accidental energizing of the circuit.

I suggest numbering the padlocks and keeping a register in the issuing authority's office to identify who is in charge of the isolation padlocks. I have also seen that as soon as isolation authority puts on a lock

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he will add his name and phone number as separate tag so that he could be called in in case of questions or emergencies.

SIDE: Switch off, Isolate, Dump and Earth should be the guide words for the electrical isolations and should be mentioned in the tool box talks.

iii. Confined space

Confined space entry permit seems to be the most sought after and grey area in the marine subsea industry. There has been a lot of confusion ongoing being what is defined as an enclosed space and what is a confined space – with the rules and regulations being so much different for either. The suggestion is to add a confined space determination form.

An example for a confined space determination form is attached below –such forms are used in the onshore industry business.

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Confined Space Determination			
General Details			
Space Name:		Date of Evaluation:	
Space Type:		Assessment Team:	
Vessel/Module:		Register No:	
Work Scope:			
Chemicals:			
Confined Space Determination			
<p>All enclosed or partially enclosed spaces that are not intended or designed primarily for human occupancy must be assessed using the Confined Space Determination Form (assessment tool) before entry or the commencement of any task. Where it is determined as being a confined space a Confined Space Permit is required.</p>			
1. Is the space enclosed or partially enclosed? (Is the design of the space fully or partially enclosed in such a way that atmospheric contaminants (lighter or heavier than air) can accumulate in the space?)	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
2. Is the space intended or designed primarily for other than human occupancy? (What is the primary purpose/design of the space – to work in or to hold/house plant equipment, services etc.) (Note - a person may regularly enter a space to perform work but this does not make the space a normal place of work.)	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
AND – Is the space liable at any time to have?			
a) Low or high oxygen content outside the safe range (19.5% -23.5% by volume)	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
b) Contaminated atmosphere that may cause impairment, loss of consciousness or asphyxiation	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
c) Flammable airborne contaminant that may cause injury from fire or explosion	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
d) Engulfment potential that may cause suffocation or drowning (stored free flowing or rising level of liquid)	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
For the space to be a confined space there must be a yes to 1 and 2, plus a yes to at least one of:- a, b c or d.	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
<p>Therefore, no longer is the physical size, only one way in or out, difficulty of access/egress the key factor, but the potential for an unsafe atmosphere of the space itself, or engulfment, are the major determining factors. There are also many primarily designed workplaces that have a potential unsafe atmosphere but we manage these by controlling the hazard not calling or treating these normal places of work as confined spaces. E.g. Spray painting in a spray painting booth.</p>			
Is this area considered a Confined Space?			Yes <input type="checkbox"/> No <input type="checkbox"/>
<p>If "NO" determined for CSE - TPO HSE Advisor to review and sign.</p> <p>Name: _____ Date: _____</p> <p>Signature: _____</p>			

The vessel has limited rescue team member on each shift. The IA needs to ensure that there are sufficient personnel for rescue from both confined space and working overboard. If there are not sufficient personnel on-board then the permit should not be given at the same time. No confined space entry and working overboard at the same time should be allowed as there is no enough rescue party. A check box could be added for reminding the IA about his worst case manning scenarios.

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Anyone entering any confined potable water tank must wear clean clothing and disinfected footwear, and shall not be suffering from skin infections, diarrhoea or any communicable diseases.

iv. Working at height

Working at height along with slips and trips leads to the most injuries. It should receive more attention considering the extensive motion of the vessel. More focus needs to be given to drive in the safety culture into this particular area – to reduce individual human factors

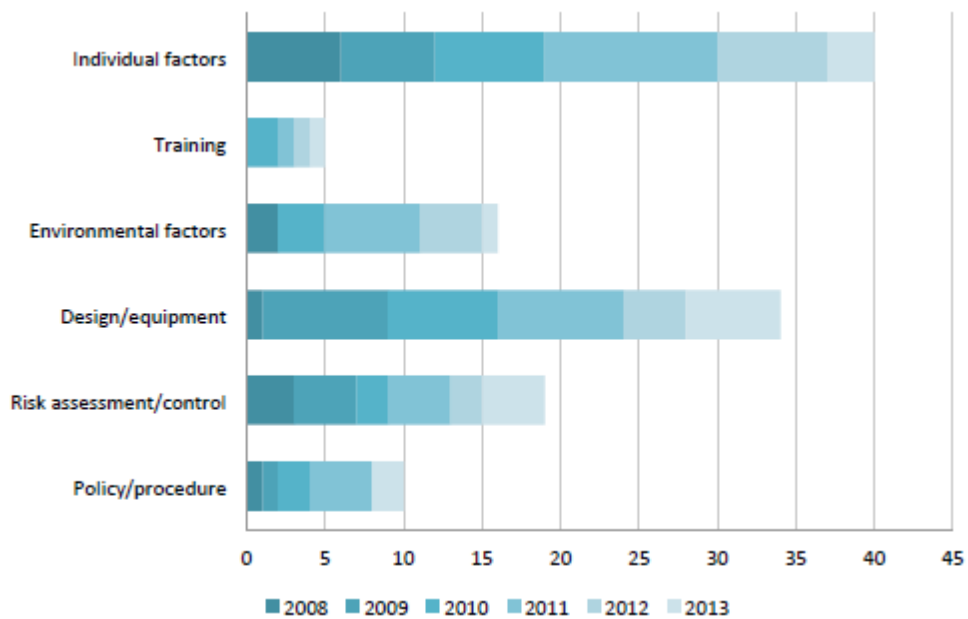


Figure 9 Fig: Number of safety factors identified in falls from height incidents

v. Matrix showing the certificates needed

In some of the Australian onshore industries they have certificate matrix showing what certificates are needed for each permit. It could be a good idea to introduce them in the marine subsea industry as well as to give the PIC and IA a quick overview of the paper work that is required to complete the planned task.

<i>Certificate types</i>	Hot work permit	CSE	Electrical
Radiation certificate		*	
Excavation certificate		*	*
WAH certificate	*	*	*
Isolation certificate	*	*	*
Heavy lift certificate			
Road impact notice	*	*	*
JRA	*	*	*

Table 17 An example for certification matrix (example from onshore work Australia)

E. Recommendations to the stakeholder management

The permit system similar to the HSE systems demands high level transparency. It also calls for a very open arm approach towards each other. The operators for oil and gas topside have very strict and controlled regime where as some of the older yards have not got up to speed on the HSE standards and requirements. A symbiotic attitude could lead to development of all parties involved with a better understanding of each other.

It is time for the all the major players to sit together and set up a standard that could serve as a good template for the marine subsea industry. The oil and gas industry have to take the initiative to iron out the variations and put forward the expectation. There has been some discussion on the cost associated with such an enterprise. This will definitely help to bring down the quality cost and will increase efficiency of operation, leading to savings of millions NOK annually. This is a humble call for the industry to rise and prepare for the interesting challenges that is ahead of us.

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