SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2022
ORGANIZATION AND MANAGEMENT SERIES NO. 160

PERMIT TO WORK AND RISK ANALYSIS AS AN ELEMENT OF SAFETY MANAGEMENT SYSTEMS APPLIED ON OIL AND GAS INSTALLATIONS

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Purpose: To present the Permit to Work procedures used as a part of safety management systems applied on offshore oil and gas installations.
Design/methodology/approach: The analysis of Permit to Work systems and the Task Risk Assessments/Safety Job Analysis based on the current international regulations and guidance.
Findings: Permit to Work system is a process requiring continuous development and contribution from all parties involved in the activities carried out on the offshore oil and gas installations.
Research limitations/implications: Legal regulations and guidance only give a framework for development of the Permit to Work System thus there is no uniformity between the systems applied by various oil and gas operators.
Practical implications: International Safety Watchdogs could provide better guidance for development of the Permit to Work Systems. This would allow uniformity between different oil and gas companies.
Social implications: PTW systems allows elimination or at least mitigation of risk associated with potentially dangerous activities carried out on the offshore installations.
Originality/value: Recommendation to uniform Permit to Work Systems and to implement Dynamic Risk Assessment into Permit to Work Systems.

Keywords: Permit to Work System, Task Risk Analysis.

Category of the paper: Viewpoint and Research paper.

1. Introduction

On 6 July 1988 167 men died as a result of an explosion and fire on board the Piper Alpha platform in the UK Sector of the North Sea. A public inquiry into the disaster was held, headed by Lord Cullen, to investigate the cause of the disaster and to make recommendations to prevent a similar occurrence in the future. Lord Cullen issued his report in December 1990 which included 106 recommendations. He concluded that one of the primary causes of the disaster was a failure in one of the key management systems – his report highlighted a number of deficiencies in the operation of the Permit to Work System. One of the most significant causes of the tragedy on Piper Alpha was the breakdown in coordination of hazardous activities. This should have been achieved through the Permit to Work procedures (Booth, Butler, 1992; Guidelines…, 1993; Kyle, 1991). According to study (Okoh, Haugen, 2014), 80 out of 183 major accidents which occurred in XXI century in the US and Europe, maintenance was linked to 80 (44%). The results also show that "lack of barrier maintenance" (50%), "deficient design, organization and resource management" (85%) and "deficient planning/scheduling/ fault diagnosis" (69%) are the most frequent causes in terms of the active accident process, the latent accident process and the work process respectively. Majority of those accidents could be attributed to poor PTW System performance. The petroleum industry handles, stores and processes large quantities of hazardous substances including flammable and toxic materials, so the potential for serious accidents is very high. To prevent such incidents it is vital that there should be effective management of hazards, including the use of safe systems of work with PTW System being the key safety management system. Permit to Work (PTW) is a key part of managing work activities that have inherently higher risks or unique aspects that could lead to a higher level of risk than routine or daily work activities. It is supported by other management policies, procedures and processes to regulate all work activities and to manage risk. When incidents do occur, human factors, such as failure to implement procedures properly, are often a root cause. These failures may in turn be attributable to a lack of training, instruction or understanding of either the purpose or practical application of a Permit to Work Systems (Kyle, 1991; HSG250…, 2005). Number of regulations were introduced in the Offshore Oil and Gas Industry requiring the implementation of Permit to Work Systems for certain specified activities (Kyle, 1991; HSG250…, 2005; Mines Safety and Inspection Act, 1994; Norwegian Oil…; HSG253…). For the floating offshore installations like e.g. Drill Ships, Floating Productions Offloading Storage (FPSO), drilling semisubmersibles etc. apart from Offshore Oil and Gas Industry regulations also International Marine Organization Conventions apply. IMO has established an international standard for the safe management and operation of ships at sea (International Convention…, 2015; The International Safety Management (ISM) Code, 2015; Code of Safe…, 2018) – the International Safety Management Code (ISM) which is partly applicable to the floating oil and gas installations.

2. Permit to Work Systems

A Permit to Work System is an integral part of an offshore installation safety management system and its main function is to manage the wide range of activities which can take place close together in a small space, e.g. drill floor, machinery room or process plant. Permit to Work

Systems form an essential part of the task risk assessment process. When a task is identified an appraisal should be carried out to identify the nature of the task and its associated hazards. Next, the risks associated with the task should be identified together with the necessary controls and precautions to mitigate the risks. The extent of the controls required will depend on the level of risk associated with the task and may include the need for a permit-to-work. A permit to work is not simply permission to carry out an activity. It is a part of a system which determines how the task is to be carried out in a safe manner. It also helps to communicate this to the work party. It should not be regarded as an easy way to mitigate or eliminate hazard or reduce risk. PTW does not make a job safe. That can only be achieved by persons preparing for the work, supervising the work and persons carrying it out. Additionally other precautions may need to be taken – e.g. isolation, or work areas access barriers – and these will need to be identified in the Task Risk Assessment (TRA) before any work is commenced.

The PTW System should ensure that authorized and competent people have thought about foreseeable risks and that such risks are avoided by using suitable precautions. Those carrying out the job should think about and understand what they are doing to carry out their work safely, and take the necessary precautions for which they have been trained and made responsible (Guidelines…, 1993; HSG250…, 2005). A PTW System is a formal written system designed to control certain types of work that are identified as potentially hazardous.

The UK Health and Safety Executive defines a PTW System as a formal and recorded process used to control work which is identified as potentially hazardous, and also a means of communication between site/installation management, plant supervisors and operators and those who carry out the hazardous work (HSG250…, 2005; Jahangiri et al., 2016). The PTW document involves the issuing party and the work party; both parties agree on the conditions, preparations, precautions and limitations. They have to be clearly specified and understood before work begin. The permit records the steps to be taken to prepare the equipment, or work area such as drill floor, process plant etc. for the work, and the safety precautions, safety equipment required on the work site and specific procedures that must be followed to enable the work to be performed in a safe manner. International regulations and guidelines specific for the Oil and Gas Industry provide the following general procedures required for the proper implementation of a PTW System:

- Clear identification of roles and responsibilities.
- Procedure for completing forms, instruction in the issue, use and closure of permits.
- Standardized identification of task, 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.

A 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. The PTW System should have a clear communication between everyone involved, and it should be designed by the company taking into consideration individual site conditions and requirements. Different permit forms may be needed for separate tasks, such as hot work, working at height and confined space entry, so that enough emphasis can be given to the particular hazards present and the precautions required. A Permit to Work shall be used where there is an increased risk to personnel or the environment or the structural integrity of the oil and gas installation is compromised because of work on safety critical elements or where the work involves any of the oil and gas safety systems. Examples are:

- Working at a height.
- Work on safety critical equipment/ systems and or the isolation/ inhabitation of same.
- Work on machinery, which is normally started automatically or from a remote position.
- Work on systems, which contain fluid or gas under pressure.
- Work involving radioactive materials.
- Work on high voltage equipment.
- Work on watertight doors that could risk the integrity of the oil and gas installation.
- Work, which involves entry to enclosed spaces.

3. Risk assessment process

An essential part of the Permit to Work Systems is a task risk assessment process. The extent of the controls implemented by the PTW will depend on the level of identified risk. It is a legislative requirement that a detailed risk assessment of activities performed onboard offshore oil and gas installations is carried out to determine the associated hazards. It is essential to base assessments of each activity on practical knowledge of the tasks, the equipment and the skills required. Such assessments are to be conducted by appropriately experienced persons, who have knowledge of the conditions which could prevail at a specified worksite during a particular activity or combination of activities. By reviewing the various task a job consists of, it can be identified what can go wrong and the necessary safeguards needed to control or mitigate the risk from each stage of the work. This is a risk assessment but when carried out for a particular worksite task, it becomes task specific and is termed a Task Risk Assessment (TRA).

The TRA documents the analysis of a task-based activity focusing on the safety critical aspects and controls and clearly identifies hazards encountered within a job, risk rating (pre- and post-control measures), control measures to reduce and control the risks from each hazard and safety equipment required when doing the job. Where risk cannot be engineered out or reduced by substitution, then suitable control measures (safe systems of work) shall be put in place e.g. permit to work. Where such control measures are implemented, it is essential that they are maintained up-to-date and used properly. The TRA may be used to develop operational procedures (work instructions) to allow work to be conducted in a controlled manner, which eliminates or reduces the risk or alternatively, revalidates existing procedures or instructions.

3.1. Risk Assessment Matrix

The TRA shall be utilised as the basis for job planning and worker briefings during toolbox talk meetings, supported by the Task Evaluation and Toolbox Talk Record. Oil and Gas Industry utilises a Risk Assessment Matrix to carry out qualitative risk assessment of the activities undertaken on offshore oil and gas installations. The three most popular sizes of a risk matrix used by the industry are 3x3, 4x4, 4x5 and 5x5. The Matrix allows individuals, work groups, etc. to determine the risk rating based upon the severity and probability of the hazard or potential hazard associated with the work area or task (ISO 45001, 2021; MIL-STD-882E, 2021; Kovačević et al., 2019). Figure 1 shows risk matrix 5x5 nowadays used by most of oil and gas companies.

HSE RISK MATRIX

		SEVERITY	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
CONSEQUENCES		People	Slight Injury	Minor Injury	Major Injury / Health effects	Single Fatality / Permanent total disability	Multiple Fatalities / Permanent total disability
		Environment	Slight Impact	Minor Impact	Moderate Impact	Major Impact	Massive Impact
		Asset	Slight Damage	Minor Damage	Local Damage	Major Damage	Extensive Damage
		Reputation	Slight Impact	Limited Impact	Considerable Impact	Major National Impact	Major International Impact
LIKELIHOOD	E Almost Certain	Incident has occurred several time in company	E1	E2	E3	E4	E5
	D Likely	Incident has occurred more than once per year in company	D1	D2	D3	D4	D5
	C Possible	Incident has occurred in company or more than once in industry world wide	C1	C2	C3	C4	C5
	B Unlikely	Incident has occurred in industry world wide	B1	B2	B3	B4	B5
	A Remotely likely to happen	Never heard of in industry world wide but could occur	A1	A2	A3	A4	A5

Figure 1. HSE Risk Assessment Matrix. Source: HSG250 - HSE Guidance on permit-to-work systems: A guide for the petroleum, chemical and allied industries.

Such a risk matrix can be used as the starting point for assessment of the activities to be performed, whether by an individual or a dedicated workgroup. Once the requirement to undertake a task has been identified, the task must be subject to an initial assessment using the Risk Matrix. The initial assessment shall include the following steps:

- Determine the severity of conducting the task taking into consideration the potential consequences associated with personnel, asset, operations and environment. This will determine the overall severity rating, i.e. Major, Serious, Moderate, Minor and Negligible.
- Determine the probability that the potential consequences will occur.
- Follow the hazard severity across the line until it dissects with the identified probability rating to give an initial risk rating.

The risk ratings shown on the matrix are colour coded. If the initial risk rating is red or yellow, a full risk assessment shall be conducted. If the initial risk rating is green, only a task evaluation and toolbox talk meeting shall be held, prior to commencement of the task.

Key steps in conducting the risk assessment (with initial risk red or yellow) are:

- When a job is identified, the first action is to carry out an initial appraisal, which will identify the need for any special safety studies or assessments.
- Where a job is more complex and comprises a number of job steps, these shall be broken down into individual steps and assessed separately.
- Hazard identification and risk assessment shall include a visit to the worksite, where practicable.
- Consideration should be given to who might be harmed and how.
- The next stage involves identifying the hazards associated with the task, assessing the initial risk ratings and identifying the controls and precautions required to mitigate those risks.
- The extent of the controls identified will depend upon the level of risk - the higher the risk, the greater the degree of control.
- After identification of controls and precautions, the risk rating shall be re-assessed to provide the residual risk rating – rating after control measures are applied (The Management of Health…, 1999).

Figure 2 presents an example of the flow graph describing the process of issuing the TRA in the electronic Permit to Work System.

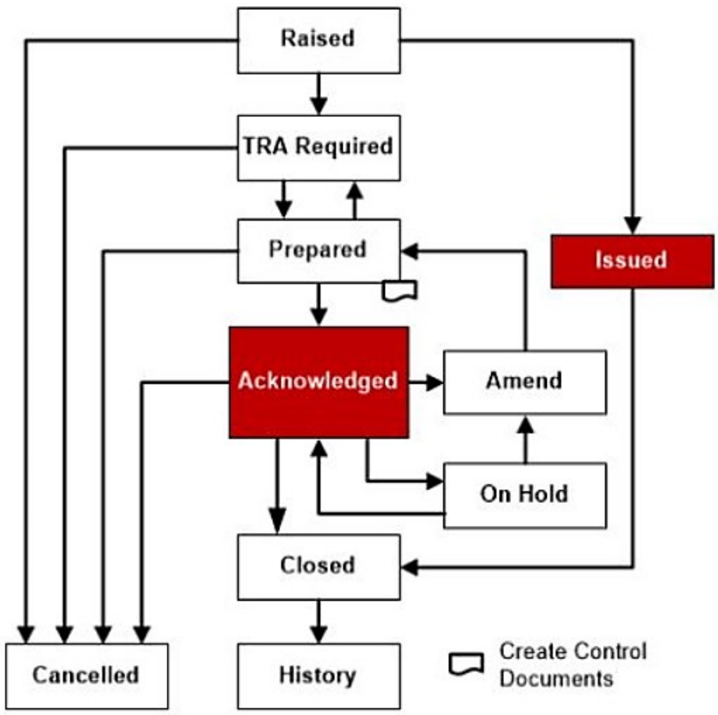

Figure 2. Task Risk Assessment state flow diagram. Source: Engica Q4 user guide.

3.2. Task Evaluation and Toolbox Talk

Task Evaluation (TE) and Toolbox Talk (TBT) Meetings (when initial risk rating is green) should be conducted prior to the commencement of a job, with all members of the workgroup present. Toolbox talk meetings are required, in order to ensure all members have a clear understanding of safety procedures, the job scope and its methodology, individual and collective responsibilities, hazards involved in the activities and control measures required to eliminate or mitigate the risk. All members of the work group should participate. If there is any identified change to the agreed job scope, methodology, worksite or environmental conditions or workgroup members, the job must be stopped and re-assessed. Further toolbox talk should be held prior to re-commencement of the job.

Where a Task Risk Assessment/ Permit to Work is in place, Task evaluation and Toolbox Talk Meetings should also be carried out and additionally the identified hazards/controls should be re-iterated to the workgroup/ individual as part of the toolbox talk.

3.3. Task Risk Assessment for a previously assessed task

Tasks that have previously been risk assessed should not need a new TRA each time they are done, however the TRA should be reviewed and adjusted accordingly prior to commencement of an activity to ensure that the content is applicable to the current workscope, workgroup and worksite. The following points should be considered when conducting a review of an existing TRA:

- Has the work site been revisited by the TRA team?
- Have any of the tasks' steps changed?
- Are there any additional hazards?
- Can the controls be improved?
- Are there any new external influences on the activity?

If, as part of this assessment, it is found that the previous assessment is inadequate and/or not relevant for the task in hand, then a new TRA should be performed.

3.4. Dynamic Risk Review (DRR)

Traditional TRA is about identifying risks in the workplace so that suitable controls can be implemented prior to commencement of the job. TRA limitations, such as its inability to update the risk picture, led to the development of several recent dynamic risk assessment approaches [17]. Dynamic Risk Assessment (DRA) is one of them. It can help people manage additional or unseen risks as they arise. Risk is an evaluation of hazard and likelihood, the only thing that changes is whether you are carrying out the assessment in advance (traditional TRA) or at the time (DRR). Dynamic Risk Assessment can be defined as "The continuous process of identifying hazards, assessing risk, taking action to eliminate or reduce risk in the rapidly changing circumstances of an operational incident."

Dynamic Risk Review (DRR) derives from the Dynamic Risk Assessment process and has been adopted by a growing number of organisations It has also been broadly implemented in the oil and gas sector in recent years. DRR complements the TE/TRA/TBT process and importantly helps workers identify hazards that may arise during the task. The DRR process should be used to assess the risks at the workplace during the task following any planned or unplanned interruptions, when any team members expresses safety concerns, at key stages of the task or whenever requested by work party (Villa et al. 2016).

4. Permit to Work System responsibilities and procedures

International regulations and guidelines related to Permit to Work System (including ISM Code) give only very general framework required to implement the system. Thus there will be many differences between PTW Systems established by offshore operators. The below chapters presents an example of one of the systems used by the international oil and gas company

4.1. Offshore Installation Manager

The Offshore Installation Manager (OIM) has overall responsibility for the function of the Permit to Work System onboard oil and gas installation. The responsibilities include:

- Personnel competence in the company PTW System.
- The planning, issue and return of Permits to Work is properly coordinated.
- A secure method of electrical and mechanical isolation is implemented.
- Adequate time is allowed during shift changes to ensure effective transfer of information relating to Permits to Work.
- The Permit to Work System is regularly monitored for effective implementation.

4.2. Responsible Person/Issuing Authority

Responsible Person (RP)/Issuing Authority is a person designated by the OIM, who has the authority to issue the Permit to Work to the person in charge of the work (Work Group Leader). The Responsible Person responsibility is to ascertain that all practicable steps have been taken to ensure the safety of the installation and the personnel before issuing a Permit to Work:

- The nature of the work is fully understood.
- All the hazards associated with the job are identified.
- All necessary precautions and protection measures as identified in the Task Risk.
- Assessment are detailed and implemented, including isolations, before work begins.
- All people, who may be affected by the work are informed before the work begins, when the work is suspended and when the work is complete.
- Permits to Work for tasks that may interact are cross-referenced.
- Effective arrangements are made for the work site to be examined before work begins, on completion of the work and as appropriate, when work is suspended.
- Sufficient time is spent on shift handover to discuss all ongoing or suspended Permits to Work with the oncoming Work Group Leaders.

4.3. Work Group Leader

Work Group Leader (WGL) is the person in charge of the work. The Work Group Leader is responsible for verifying that all required control measures and precautions (as detailed by the Responsible Person) are in place, prior to commencement of work. The Work Group Leader is specifically responsible to ensure that:

- The work group members have received adequate instruction in the Permit to Work System.
- The job is discussed fully with the person issuing the Permit to Work (Responsible Person).

- The work group are briefed on the details of the Permit to Work and supporting documentation, including any potential hazards and all the precautions that have to be taken through a task evaluation/toolbox talk.
- The precautions and protective measures are in place before the work commences and maintained for the duration of the work activity.
- The Permit to Work supporting documentation is clearly displayed at the worksite.
- The work group members understand that if circumstances change, the work must be stopped and the Work Group Leader informed immediately.
- The work group stays within the limitations set on the Permit to Work.
- In the event of a oil and gas installation emergency alarm, the Permit to Work is returned to the Permit Control Centre (where circumstances allow).
- On completion or suspension of the work, the worksite is left in a safe condition and the Responsible Person is informed accordingly.

4.4. Authorized Gas Tester

Authorized Gas Tester (AGT) – the OIM will appoint persons authorized to carry out gas testing on board. AGT must have the relevant certification to perform such duties and perform testing as per the requirements stipulated on the entry documents for the specific task.

4.5. Permit Coordinator

The OIM is responsible for appointment of the Permit Coordinator. Their main responsibilities is to co-ordinate work activities to ensure potential interactions associated with the work to be carried out are identified and conflicts resolved. Permit coordinator is also the administrator of the PTW System.

4.6. Workgroup

Workgroup Members are individuals working within the Permit to Work System. They will ensure that:

- They have received instruction and have a good understanding of the Permit to Work System.
- They do not start any work requiring a Permit to Work, until it has been properly authorized and issued.
- They receive a briefing from their Work Group Leader on the particular task and they understand the hazards and the precautions taken or precautions/protective measures to be taken.
- They follow the instructions specified on the Permit to Work and associated Task Risk Assessment.

- When they stop work, the site and any equipment they are using is left in a safe condition.
- If they have any doubt or if circumstances change, they must stop work immediately and discuss the matter with their Work Group Leader.
- In the event of an oil and gas installation emergency alarm, they stop work and make the worksite safe.

4.7. Daily Permit to Work Planning Meeting

OIM conducts a daily Permit to Work Planning Meeting with direct involvement of members of the offshore installation management team. The meeting ensures through careful planning, appropriate approval for the work activities, identification of potential conflicts of work, persons in charge of work areas, which may be affected by the work activity, are made aware and can take necessary precautions against possible interaction with other work.

4.8. Worksite Monitoring

Specific Permit to Work monitoring should be carried out to ensure that all procedural requirements, including precautions/protective measures as detailed on Permits to Work, are being complied with. Regular monitoring activities should take place, often on a daily basis.

4.9. Emergency situations

During an emergency all work is to cease. Permits to Work should be returned to the Permit Control Centre for formal suspension and the worksite left in a safe condition. However, where circumstances do not allow return of the Permits to Work to the Permit Control Centre, the worksite must be left in a safe condition. Post emergency situation, whereby normal operations can resume, it is necessary for Work Group Leaders to conduct a re-assessment of all work activities that are subject to Permits to Work. This is to ascertain that conditions have not altered as a result of the emergency and that the Permit to Work, conditions and precautions/ protective measures remain valid.

5. Different types of permits

As it has been mentioned before, regulations and guidelines only give general framework for development of the PTW System. Similar terminology may be used by different offshore companies for types of permits which are fundamentally different. Some of the permits may be called either permits or certificates. The chapter presents types of permits and certificates used by one of the international offshore companies. Figure 3 shows typical permit flow diagram describing the process of issuing a permit (applicable to hot, cold and electrical permits).

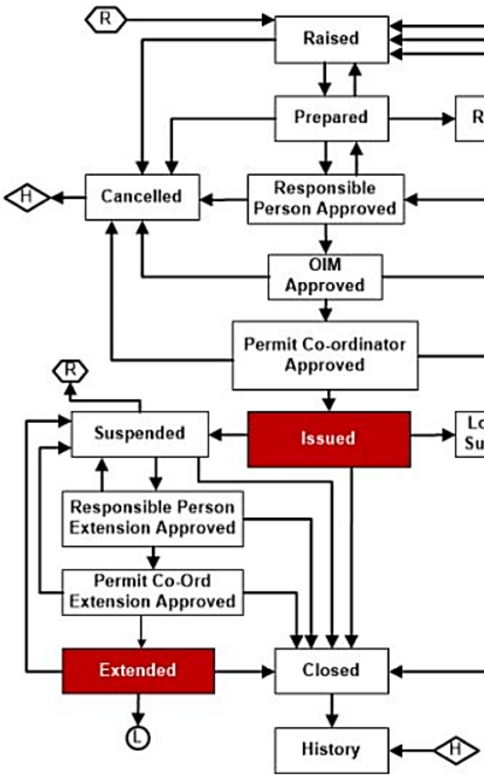

Figure 3. Permit state flow graph. Source: Engica Q4 user guide.

5.1. Hot work permit

Hot work is usually taken to apply to an operation that could include the application of heat, naked flames, welding, cutting, grinding or ignition sources to tanks, vessels, pipelines etc. which may contain or have contained flammable vapor, or in areas where flammable atmospheres may be present. Hot work permits, typically colored red, 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. They are normally used for any welding or flame cutting, for the use of any tools which may produce sparks and for the use of any electrical equipment which is not intrinsically safe or of a suitably protected type.

5.2. Cold work permit

Cold work permits, typically coloured blue, are frequently used to cover a variety of potentially hazardous activities which are not of a type covered by a hot work permit. Cold work permits are issued when there is no reasonable source of ignition, and when all contact with harmful substances has been eliminated or appropriate precautions taken.

The activities for which a cold work permit may be appropriate will vary from site to site but should be clearly defined.

5.3. Electrical work permit

An electrical permit-to-work is primarily a statement that a circuit or item of equipment is safe to work on. A permit should not be issued on equipment that is live. Further guidance on electrical work permits is given in regulations (HSE HSG85, 2013).

5.4. Equipment disjointing certificate/breaking containment permit

This type of certificate is used for any operation that involves disconnecting equipment or pipe work that contains (or has contained) any hazardous or high-pressure fluids or other substances. This type of certificate will normally be used for the insertion of spades into pipe work, and for the removal of such spades. These permits are typically used in the upstream process plants

5.5. Confined spaces entry certificate

Once an area has been classified 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.

5.6. Isolation certificate

Equipment and plant that should be isolated before work is commenced include:

- Machinery – should be isolated from its power supply (electrical, pneumatic or hydraulic) or, if engine driven, the starting system or engine disconnected. Where necessary the equipment should be prevented from moving e.g. from gravity fall of release of pressure, by positive physical means.
- Pressurized systems – of all kinds should be isolated and depressurized.
- Chemical systems – where pipework, vessels or tanks containing fluids or materials which are hot, very cold, flammable, toxic, corrosive, or under pressure, they must be

isolated from their source of supply and drained, purged and decontaminated as necessary.

- Electrical systems – capable of causing a hazard to personnel working on it or of igniting a flammable atmosphere should be isolated, proved dead and earthed.
- Safety and emergency systems – require isolation or inhibition for maintenance. Where the intention is to avoid unnecessary operation of alarms or emergency systems, then inhibition or manual control is to be preferred.

Isolations are the major requirement before working on electrical or mechanical system. Before a PTW can be issued for a task, a risk assessment must be conducted to determine equipment isolation requirements. It is usually used as a means of ensuring that the particular equipment is mechanically and electrically isolated before it is worked on. It is possible that a similarly named certificate may be used for chemical isolation of plant before work is done on it or entry is made. If so, these should be cross-referenced to associated permits. Isolation tags are usually provided as a part of the isolation process. The purpose of these tags is to ensure clear identification of individual isolation in cases of multiple isolation works. The tag number (pre-printed) and lock-out number (to be inserted) is cross-referenced with the isolation certificate number. Figure 4 shows typical flow diagram describing the process of issuing the Isolation Certificate.

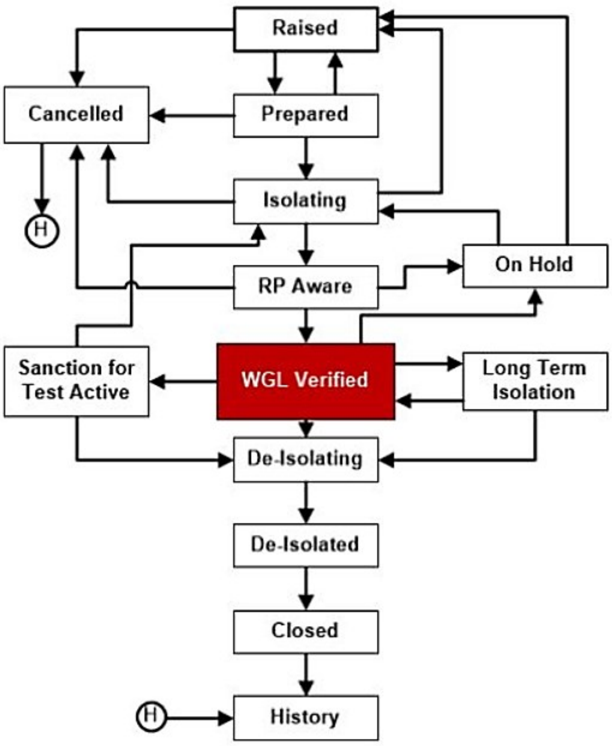

Figure 4. Isolation Certificate state flow graph. Source: Engica Q4 user guide.

5.7. Radiation certificate

Radiation certificates is used often on the drilling rigs, outline necessary control measures to minimise risks of exposure to radioactive sources including site inspection, controls on source exposure, access or containment barriers and radiation monitoring.

5.8. Diving certificate

Diving certificate can be used to control the diving activity itself and to ensure that there are no other activities taking place nearby which create unnecessary additional risks (eg over-side work, live firewater intake pumps). This kind of certificate is used on the offshore construction vessels and when underwater maintenance activities are carried out on the offshore installations

5.9. Working at heights

Some company use separate Working at heights permits which refer to any work-related activity being undertaken at an elevated position, above two metres where there is the potential to fall. Some companies use for this purpose Cold Work permits with associated paperwork. Regulations (The Work at Height Regulations, 2005) established the following guidelines for working at height:

- Ensure workers can get safely to and from where they work at height.
- Do as much work as possible from the ground.
- Make sure you do not overload or overreach when working at height.
- Take precaution when working on or near fragile surface.
- Provide protection from falling objects.
- Consider emergency evacuation and rescue procedures.

6. Development of the electronic Permit to Work Systems

The 21st century advancement in computing introduced electronic systems for managing permits and risks associated with maintenance activities. Transition from paper based system to electronic permitting was led by the oil and gas industry. Major oil industry operators in the North Sea are in the process of transition from paper work PTW System to its electronic versions. It is possible to maintain the same format and content of the paper permits within the electronic system. The electronic PTW system offers a combination of additional features including integration of the PTW System with Computerized Maintenance Management Systems, risk assessment, isolation of hazardous energy, competency management, lessons learned sharing, and continual improvement etc. (Viswanatha et al., 2015).

Paper permitting processes have numerous problems. The disadvantage of paper form of the PTW System is that it can create a "checkbox mentality". Work party often rush through a repetitive, unchanging paperwork process. Quite often permit validation is arbitrary, and may not be strictly followed up. In combination with the repetitive nature of paper permits, this can create the perception that PTW System is just a paperwork exercise. This can cause the Responsible Person and the Work Group Leader to miss the critical details or to make errors that put work party at risk. Permit to work processes, job safety analyses, risk assessments, and conflict management are subject to human error and inconsistency. Paper PTW System creates a high volume of (often redundant) written procedures. These is very time consuming to create, review, and follow. The result is very often paperwork for paperwork's sake. Even worse, it doesn't make the work environment safer or more productive.

By connecting the maintenance, safety and operations workflows, an electronic PTW System can streamline many maintenance repetitive tasks, from tag printing to isolation point validation, through to generating permit requests and issuing permits directly to Work Party. An electronic PTW System reduces the number of duplicates, conflicting, redundant procedures, the time spent on documentation, training etc. Electronic Task Risk Assessments (TRA) and Job Safety Analyses (JSA) provide consistency and standardization. Additionally, the electronic PTW System also allows to examine similar jobs executed in the past. It automatically associates the appropriate hazards and controls based on the information stored in the database. An electronic PTW System also eliminates the element of human error. Conflicts in the work scopes are identified automatically when they occur.

Electronic Permit to Work System also gives a better overview all maintenance activities on board of the offshore installation what is important especially in an emergency situation when all permits are being returned to the permit control center in the same time. It may prove difficult to assess the situation when all the work sites are controlled by the paper system. Electronic system makes it possible to display all the permits on the multimedia board. This allows a better control of the asset, especially in case of the emergency. Figure 5 shows the example of the eSmart electronic permit to work general arrangement dashboard with permits issued for different locations of the oil rig.

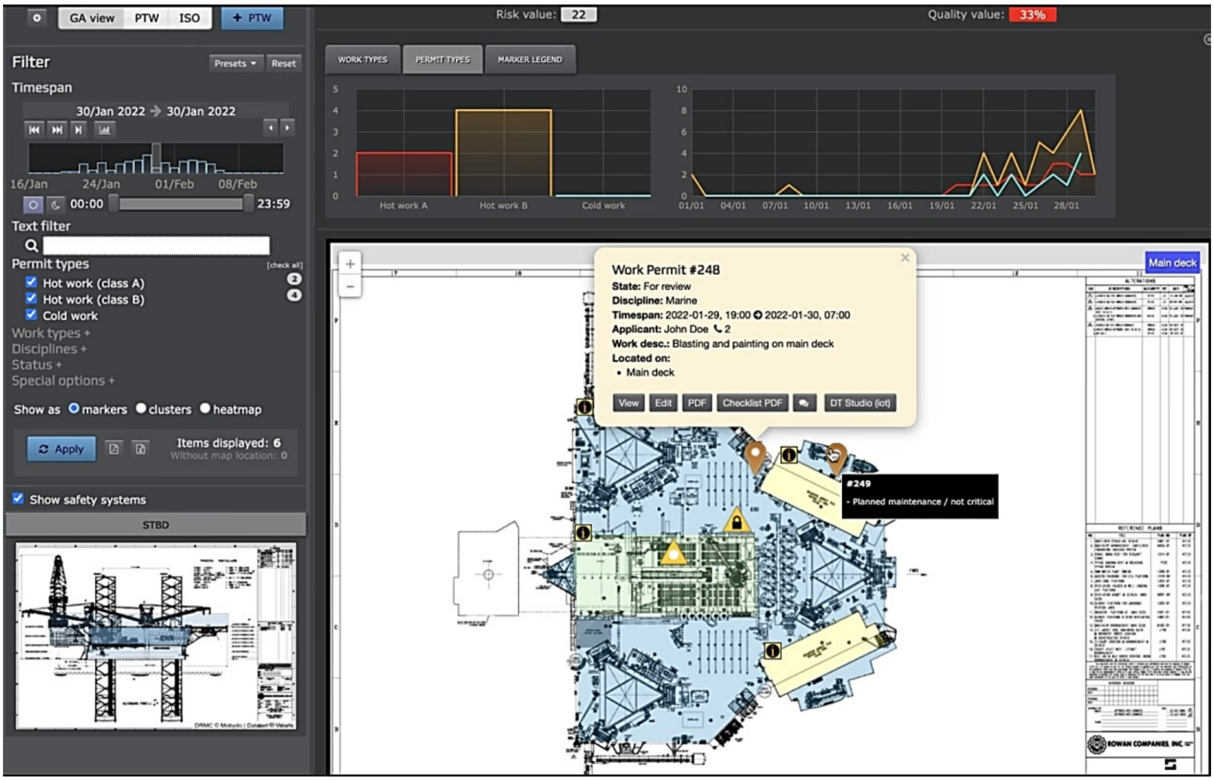

Figure 5. Electronic permit to work general arrangement dashboard. Source: eSmart permit user guide.

Figure 6 and 7 shows the example of the electronic PTW System workflow.

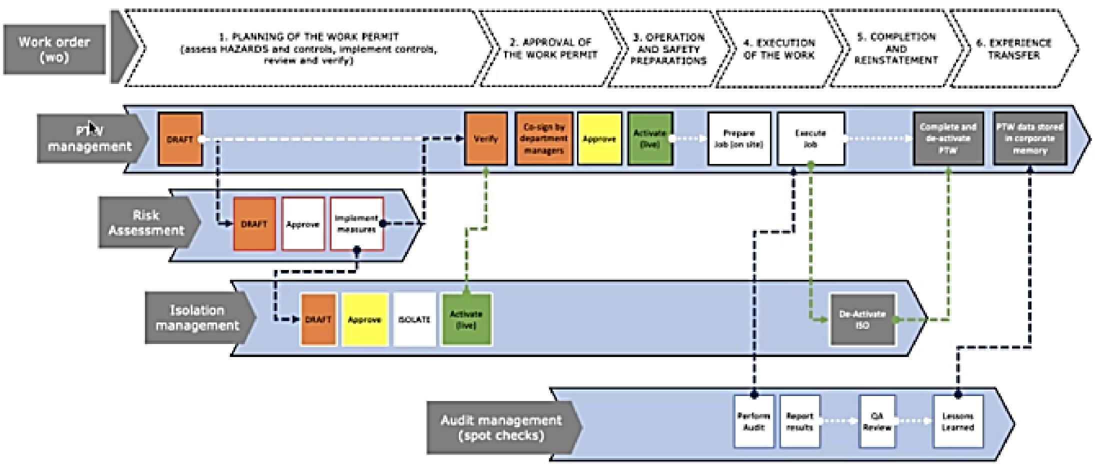

Figure 6. Electronic PTW System workflow. Source: eSmart permit user guide.

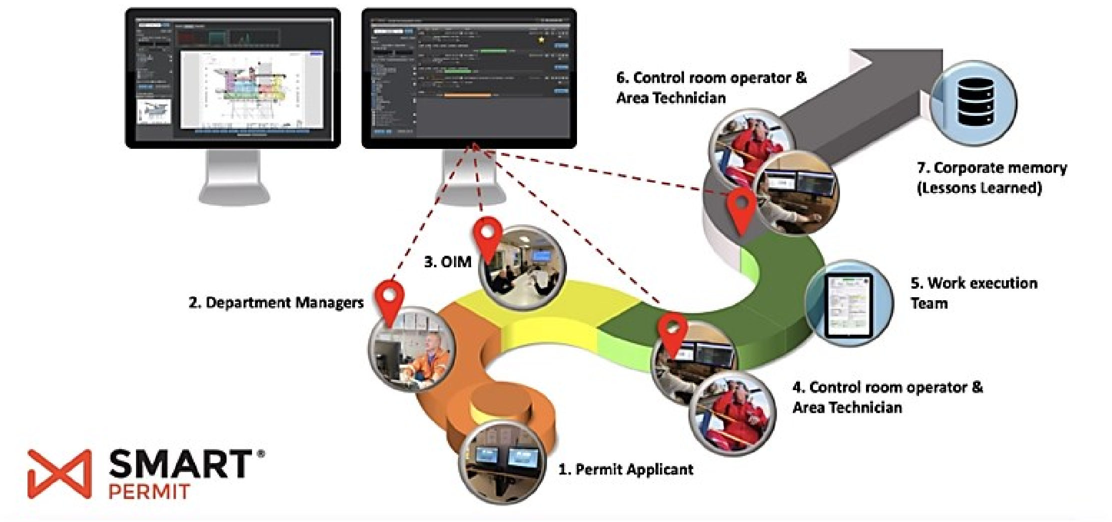

Figure 7. Electronic PTW System workflow. Source: eSmart permit user guide.

Conclusions

1. Permit to work Systems are essential tools in any Safety Management Systems used within upstream installation.
2. Major PTW related accidents have common roots. High proportion of incidents are related to the maintenance errors which could coincide with poor management of PTW Systems.
3. Permit to Work requires contribution from all parties involved in the activities carried out on the offshore oil and gas installations.
4. Better international regulations are required for development of the Permit to Work Systems. This would allow uniformity in PTW between different oil and gas companies. Safety related lessons learnt from all the systems and the companies could be incorporated into one PTW System.
5. Paper permitting processes have numerous problems. Work party often rush through a repetitive, unchanging paperwork process. This can create the perception that PTW system is just a paperwork exercise. The result is very often paperwork for paperwork's sake.
6. An electronic PTW System can streamline many maintenance repetitive tasks by connecting the maintenance, safety and operations. It also allows identification of hazards and assess risks based on similar work executed in the past.

7. Electronic permit to work system gives a better overview all maintenance activities on board of the offshore installation, especially in the emergency situation when it is critical to have a full control of all the maintenance tasks.

Acknowledgments

This research outcome has been achieved under the research project no. 1/S/KE/2022 financed from a subsidy of the Polish Ministry of Educations and Science for activities of Maritime University of Szczecin.

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