DYNAMIC POSITIONING SYSTEMS DURING EMERGENCY OR UNEXPECTED SITUATIONS

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Abstract

The paper presents the consequences for DP systems during emergency or unexpected situations like failure one or more gensets, failure one of propulsion unit, overloading electric system, getting off the course, vessel abandonment of DP work, etc. The design of DP system takes into consideration required the DP system class, the requirements of adequate classification society under supervision the ship is built. It is necessary to fulfil the system redundancy in normal operation states. When failures occur in the vessel systems, it changes the possibility of DP work. There are three DP alert levels: green, yellow and red needed the proper responses. It was prepared required procedures for crew according to ISM Code, IMCA and IMO regulations. For the vessel safety, it is important the training process all crew members, especially one of the navigating officer as DP operator and one of the engineer or electrician. They ought to know their duties during alarms, exercises and real situations, especially in DP operation. The human factor ought to be taken into account as well. The DP operator may directly initiate the loss of vessel position or interact with technical failure events, which then contribute to a loss of vessel position. The important problem to solve is how to avoid emergency situations. It's time for quick and important decisions for further vessel's activity.

Keywords: *DP systems, ships propulsion, failure of marine energetic elements, faults in DP systems*

1. Introduction

The safety and reliability of DP systems depend on many factors but the most important one is how to maintain the station keeping during emergency or unexpected situations. It is high time for quick and important decisions for further vessel's activity.

The first step is made during vessel system design to estimate the risk modelling in DP operation. Most studies on the safety of DP operation have been concentrated on DP technical failures. It is known [1] that the DP loss of position during operation is not rare. There are three modes of loss of position of DP vessels:

- drive-off – means failure onboard of Mobile Offshore Drilling Unit resulting the MODU drives away from the target position. It may involve: false position information, DP control failures, thruster or power transmission failures, operator errors etc.,
- drift-off – means failure on-board of Mobile Offshore Drilling Unit resulting in deficiency of thruster forces (partly or full blackout) in relation to environmental forces,
- force-off – means no failure onboard of Mobile Offshore Drilling Unit but due to sudden environmental forces resulting, the MODU is operating outside its capability envelope [10].

The human factor as the primary or secondary reason of errors is so important that the DP operators ought to pass required training. The DP operator may directly initiate the loss of vessel position or interact with technical failure events, which then contribute to a loss of vessel position. The following factors are considered to have an influence on human actions:

- competence (simulator training, onboard training, certification, operational experience, knowledge about system onboard, duration of work as DP operator),

– attention level (job attitude, external/internal distractions, concentration on work),
– communication and team work (organizational level).

Auto AQD (Emergency Quick Disconnect) is initiating by a driller upon receiving red alarm status from DP operator allows minimizing the effects of loss of vessel position. The time needed for EQD process is the most important factor to carry out the recovery system.

The major elements of DP operations are shown in Fig. 1. It may be seen how the DP operation pyramid is complicated.

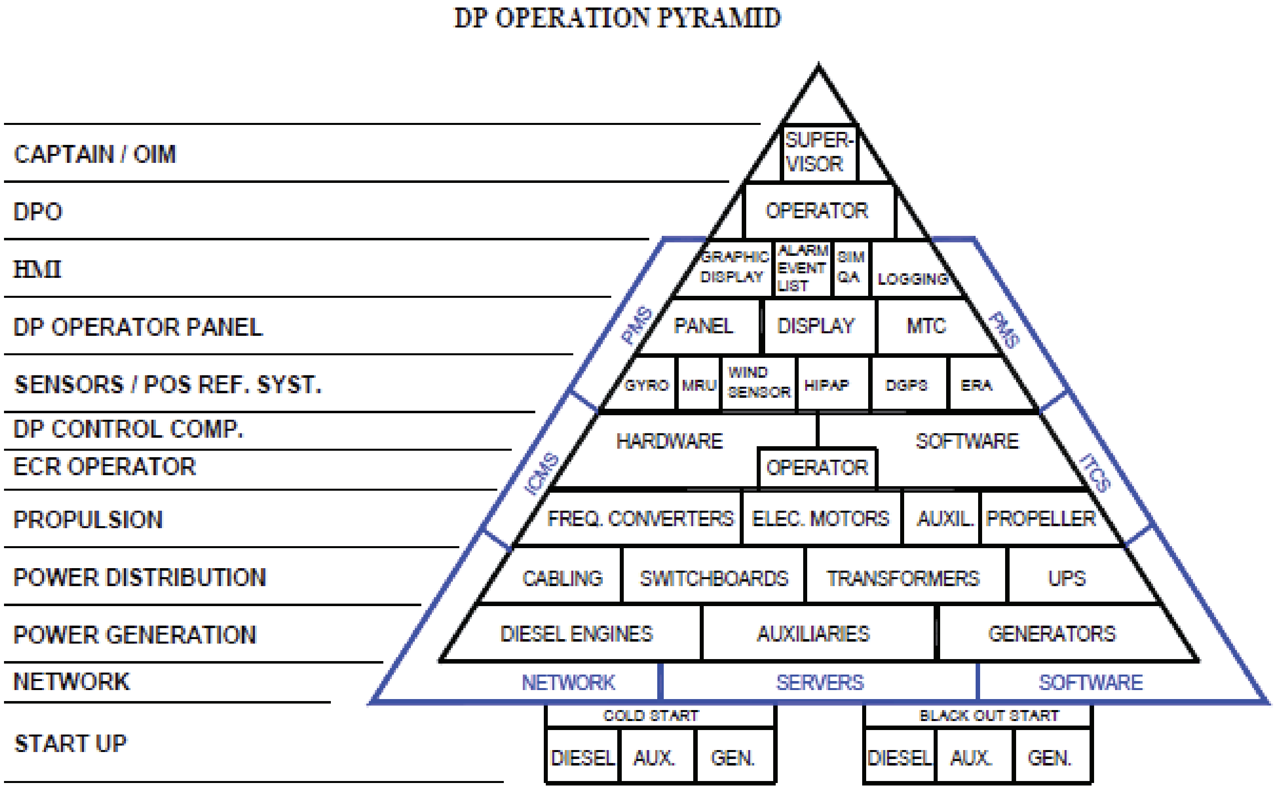

Fig. 1. Major elements in DP operation [10]

The time needed for the EQD process is approximately 30 seconds. The allowable time for DP operator to assess the situation and push the red status alarm (push a button) will be around 40 seconds [10]. During about 70 seconds, the vessel may change the position about 70 m and given a 100% drive-off condition. The human reaction time is very specific to an operational context (situation) and generally is between 10 to 70 seconds.

2. How to avoid emergency situation

The DP class needs redundancy in all systems. This is the simplest way for restricting the emergency situations but somewhere is a limit for the propulsion system complication (Fig. 2 and Fig. 3). The good sense of the thruster number is between 4 to 12 dependently of the thruster type and DP class [7, 8]. It was shown the minimum recommended DP equipment class according to vessel type in Tab. 1.

The power plant may be located in one engine room up to DP class 2. For DP class 3 it is minimum two. For drilling vessels, four engine rooms divided by watertight bulkheads are met. In every engine, room is complete power system from engines, switch boards, control systems to propulsion units. The connections (tiebreakers) among the switchboards are needed to ensure the electrical power for the most number of thrusters in emergency situations [3-5].

The DP control takes advantage of separate Power Management System (PMS).

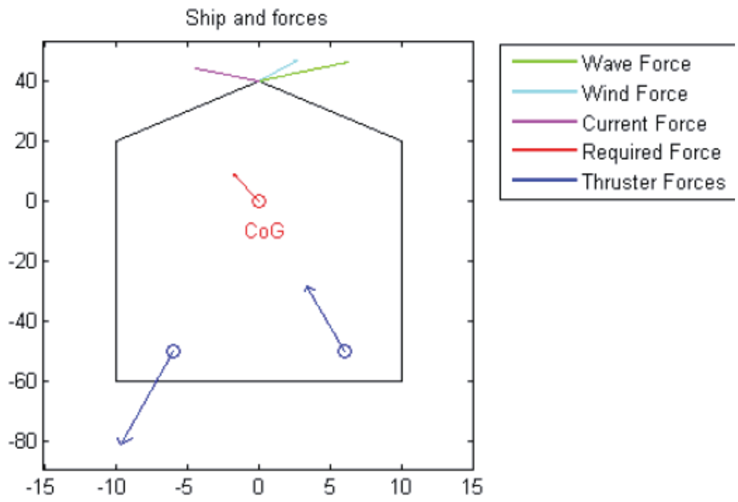

Fig. 2. The propulsion system with 2 thrusters need as a minimum 58.7 MW of total power for required DP capability [11]

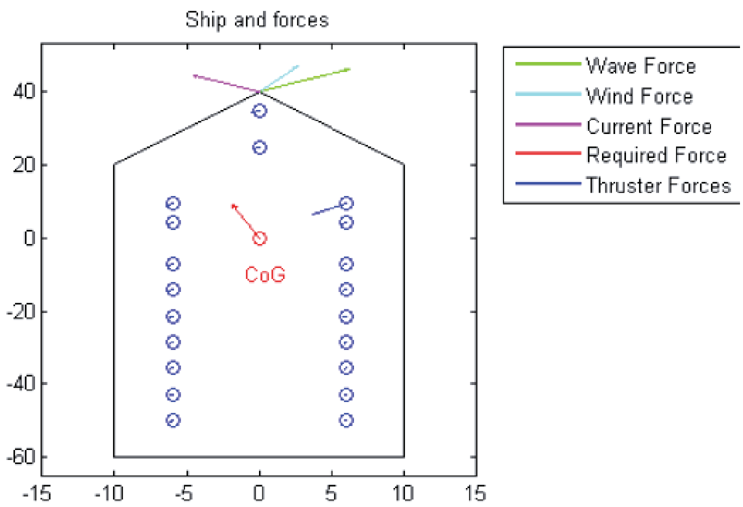

Fig. 3. The propulsion system with 20 thrusters need as a minimum only 12.2 MW of total power for required DP capability [11]

Tab. 1. Minimum recommended DP equipment class according to vessel type [2]

DP vessel type	Recommended DP equipment class
Drilling	3 earlier 2
Diving	2
Pipelay	2
Umbilical Lay	2
Lifting	2
Accommodation	2
Shuttle Offtake	1
ROV support	2 open water 1
Floating production	2
Well stimulating	2
Logistic operations	2

The Power Load Monitoring and Blackout Prevention function performs a dynamic setpoint reduction of the thrusters to prevent blackout (fully or partially) on a power bus or isolated bus section as a consequence of applying too much power to the thrusters (overloading the power system).

This function will only limit thruster commands to avoid a stable power plant overloaded [9, 12, 13]. The DP system requires the following information in order to perform blackout prevention:
– generator power and breaker status,
– bus-tie breaker status,
– thruster breaker status (if more than one for each thruster).

Upon completion of the DP installation, complete performance tests are carried out to the classification society surveyor at sea trial [2, 7]. Testing will typically include the following general steps, during which the correct operation of alarms and displays will be verified:
– position and heading movements in manual control,
– position and heading movements in automatic and mixed control using different combinations of reference systems,
– verification of the mathematical model by deselecting all reference systems while automatically holding heading and position,
– simulation of failures of controllers, gyrocompasses, position reference systems, wind sensors, thruster signals, etc.,
– simulation of failure of normal control power supplies to verify correct operation and duration of UPS supplies,
– verification of power management functions, including pitch limitation,
– endurance testing, i.e. maintaining automatic control at fixed position and heading for an extended period of time [13].

3. Procedure during unexpected situations

The unexpected situations may occur in every moment but the probability is bigger when the DP vessel sails at full load of power system or in heavy environmental conditions. These situations are dangerous for the crew and vessel safety. What unexpected situations are:
– strong quick change of environmental conditions like: squall, blast of wind, swell,
– rolling of a vessel due to necessary quick thrust change during DP operation,
– quick change of vessel heading due to propulsion system failure,
– man fault, etc.

There are no existing prepared procedures because the unexpected situations may be a lot. The experienced crew ought to forecast the abnormal situations during vessel operation and try to prevent them. It is important to keep cool, to think rightly and to try to solve the problem. There are three DP alert levels and responses as follows:
– green alert – normal, no action, operations progress,
– yellow alert – degraded, carry out degraded condition risk assessment,
– red alert – emergency, take whatever action necessary to prevent human injury, avoid collision, make the vessel safe avoid environmental pollution and structural damage [1].

The first action when the yellow alert occurs is to make the vessel safe. The actions will be determined by the specifics of degradation. This may mean:
– cessation of all supply operation,
– movement of the vessel away from the installation to a safe position,
– to take manual control (for example during operation with the hose connected),
– master on the bridge.

All DP incidents ought to be reported (using the DP incident reporting procedure). The records are of enormous help to the industry. Even the least serious incident can be importance in analyses of the incident data. Owners are recommended to participate in DP incident reporting scheme for IMCA (the International Marine Contractors Association).

In Fig. 4. it was shown the drilling platform “West Venture” during operation with the tug assist. The escape routes from platform are by helicopters or vessel’s boats (the boat position is about a hundred meters over the water level).

Fig. 4. Operation in drilling platform "West Venture" [www.marinetalk.com]

4. Operation during emergency situations

The emergency situations occur as a result of:

- an accidentally auto-stop, shut-down, automatic prime mover trip, equipment malfunction or failure,
- short-circuits or overloading in electrical system and next partially or fully blackout,
- fire on a vessel and fire-fighting action,
- hull grounding,
- environment pollution and antipollution action (for example: fuel tanks overflowing),
- hull damage (above or below the water level) and rescue action,
- man overboard and rescue action,
- rescue action at sea another vessel or men,
- abandoning the vessel,
- exposure of drifting sea ice to hull,
- man fault (for example: switching off the important equipment), etc.

Under the circumstances it was prepared required procedures for crew according to ISM Code, like Ship Oil Pollution Emergency Plan (SOPEP) and crew ought to do like it is written in the procedure.

For the vessel safety it is important the training process all crew members. They ought to know their duties during alarms, exercises and real situations.

The red alert is information that the emergency situation occurs. It means that the vessel is unable to maintain the position or imminent threat of collision.

If emergency situation occurs the vessel operation may be restricted or stopped. The emergency situations often need "all hands on board", so every member of crew ought to fulfill his duties promptly as quick as possible.

There are over 20 DP procedures. The list of 24 procedures are enumerating [1], like: arrival checks, communications, approaching to installation, separation distance, selecting a safe work location, escape route, position and heading changes, etc.

The master or navigating officer ought to have:

- required certificates as navigating officer appropriate to class of vessel,
- DP certificate,
- adequate experience on the vessel type,
- adequate experience on the DP control system type and equipment classification,
- knowledge of the vessel's FMEA (Failure Mode and Effects Analysis), together with detailed understanding of the implications of all identified failure modes,
- detailed knowledge of the vessel's DP operation manual and adequate knowledge of the contents of the vendor manuals,
- knowledge of relevant IMCA guidelines including DP incident reporting [1].

Owners should always have on board at least one engineer or electrician who has adequate training to ensure competence and knowledge of the control systems of the vessel. There is a first level of response to a problem on board and a person well qualified to execute recommendations from the vendors when further help is needed.

All the above-mentioned certificates and experiences are necessary for safe vessel operation in the point of view of marine administration for DP operator. The vessel is not only the bridge and navigating officers but a team of men who ought to cooperate. The vessel safety depends on all crew members, sometimes on a man with the lowest rank.

5. Final remarks

Emergency situations may occur in spite of redundancy of DP system elements, the risk modeling in DP operation and prepared required procedures in case of yellow or red alerts. But all the time this is a challenge for the master and his crew to minimize the possible threats to the vessel and men.

The IMCA's guidelines of DP safe operation for OSV (Offshore Supply Vessels) may be used as a guidance and an endeavour to reflect the best industry practice.

The growth in the use of DP systems has been accompanied by the development of internationally recognized rules and standards against which DP vessels are designed, constructed and operated.

The main target is the minimizing the risk and effects when the DP vessels during operation are in emergency or unexpected situations. Due to human factor, the training of DP operators and all members of crew is vital for men and vessel's safety.

It was presented and indicated the importance for DP systems how to survive and to maintain the station keeping during emergency and unexpected situations. Time is the main value. The adequate reaction and the reply ought to be known and clearly performed.

References

[1] *A Guide to DP Electrical Power and Control Systems*, IMCA M206, 2010, www.imca-int.com.

[2] *Dynamic Positioning Systems*, Rules for Classification of Ships, Part 6, Chapter 7, DNV, 2011.

[3] Herdzik, J., *Problems of Propulsion Arrangement Choice of Multi-Mode Ships*, Journal of KONES Powertrain and Transport, Vol. 17, No. 2 pp. 129-135, 2010.

[4] Herdzik, J., *Problemy utrzymania gotowości eksploatacyjnej jednostek pływających z napędem pędnikami aktywnymi*, Logistyka, Nr 2, s. 1619-1624, 2010.

[5] Herdzik, J., *Application Possibilities of Electric Driven Propulsion of Multi-Mode Ships*, Journal of KONES Powertrain and Transport, Vol. 17, No. 1 pp. 163-168, 2010.

[6] Herdzik, J., *Possibilities of Improving Safety and Reliability of Ship Propulsion System During DP Operation*, Journal of KONES Powertrain and Transport, Vol. 19, No. 2. pp. 219-226, 2012.

[7] Herdzik, J., *Challenges of Ship Propulsion Systems During DP Operations*, Journal of KONES Powertrain and Transport, Vol. 19, No. 2, pp. 211-218, 2012.
[8] Herdzik, J., *Verifications of Thrusters Number and Orientation in Ship's Dynamic Positioning Systems*, The International Journal on Marine Navigation and Safety of Sea Transportation, June 2013.
[9] Radan, D., et al., *Reducing Power Load Fluctuations on Ships Using Power Redistribution Control*, Marine Technology, Vol. 45, No. 3, pp. 162-174, 2008.
[10] Verhoeven, H., et al., *Safety of Dynamic positioning Operation on Mobile Offshore Drilling Units*, DP Conference, Houston 2004.
[11] Wills, J., *Dynamic Positioning Simulator. Professional Training Tool*, TU Delft, 2007.
[12] *Kongsberg K-Pos DP Dynamic Positioning System*, Release 7.0, Operator Manual, Kongsberg, Norway 2007.
[13] Munden, A., *Classification of Control and Power Systems for Dynamic Positioning*, Dynamic Positioning Conference, Houston 1997.