

DEP SPECIFICATION

DYNAMICALLY POSITIONED (DP) VESSELS FOR CONSTRUCTION, DRILLING/COMPLETIONS/WELL INTERVENTION ACTIVITIES – SELECTION AND OPERATION

DEP 37.90.10.32-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies the types of equipment and minimum performance levels required to conduct operations safely on board a dynamically positioned (DP) vessel.

The requirements in this DEP are applicable to the following activities:

- offshore construction;
- accommodation support;
- DP MODUs, Well intervention and stimulation vessels
- DP offshore supply vessels assisting in specific construction activities.

Vessels shall comply with all applicable Class and Flag State regulations.

NOTE: Although not explicitly within the scope of this DEP, it may also be applied to manage other DP-related activities.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated Jan. 2010; see (1.7) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in exploration and production facilities. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.4 ABBREVIATIONS

ABS	American Bureau of Shipping
AFC	Approved for Construction
AI	Asset Integrity
ASOG	Activity Specific Operational Guidelines
AVR	Automatic Voltage Regulator
BV	Bureau Veritas
DGPS	Differential Global Positioning Satellite system
DNV	Det Norske Veritas
DP	Dynamic Positioning
DPO	DP Operator
ECR	Engine Control Room
ESD	Emergency Shutdown System
FMEA	Failure Modes and Effects Analysis
GPS	Global Positioning (satellite) System
IMO	International Maritime Organisation
IMCA	International Marine Contractors Association
LBL	Long Baseline
Lloyds	Lloyds Register of Shipping
MODU	Mobile Offshore Drilling Unit
OIM	Offshore Installation Manager
SIMOPS	Simultaneous Operations
STCW	Standards Of Training Certification and Watchkeeping
VRU	Vertical Reference Unit
WSOG	Well Specific Operational Guidelines

1.5 DOCUMENT HIERARCHY

In the event of conflicts between Contract documents, AFC Drawings, Specifications and other referenced standards, the following document hierarchy shall apply:

- Contract or agreement (including any approved exceptions);
- AFC Drawings;

- Principal's specifications (including project specific data sheets);
- This DEP.

1.6 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (11).

1.7 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated January 2010. The main change was replacement of "SHALL [AI]" with "SHALL [PS]".

1.8 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.9 DUAL UNITS

**Amended per
Circular 60/12**

Dual units have been incorporated throughout this DEP.

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. GENERAL

2.1 GENERAL REQUIREMENTS

This DEP shall be used for the initial selection and subsequent operation of a DP vessel for activities where DP is the primary means of station keeping.

DP vessels operated or chartered by the Principal, or on the Principal's behalf, shall comply with this DEP. Additionally, project, field, activity or well specific operational guidelines SHALL [PS] be established for each project and implemented during the execution of the work.

2.2 PHILOSOPHY

The philosophy of managing operations on a DP vessel shall be based on gaining a clear understanding of the safest mode of operation for the vessel. A pre-contract verification process shall be initiated to gain this understanding. Upon final selection of the vessel and award of a contract, the Contractor shall develop ASOG or WSOG which shall be used to execute DP operations safely. The Principal shall be engaged in the development/review and approval of this document. For critical operations, the safest mode of operation shall be decided in collaboration with the Contractor and SHALL [PS] be included in the ASOG or WSOG.

The overriding philosophy shall be to:

- 1) understand the worse case failure and significant single point failures (if any) of the DP system;
- 2) determine the configuration for the safest mode of operation;
- 3) undertake Defined Critical Activities with the vessel's DP system, configured for the safest mode of operation;
- 4) ensure that all key DP Personnel on the vessel are brought to the same level of understanding with regard to the ASOG/WSOG;
- 5) have robust contingency plans in place.

2.3 APPLICABLE SPECIFICATIONS

The following specifications/guidelines shall be complied with by the Contractor unless specifically directed otherwise by the Principal:

- IMCA M 103;
- IMO MSC Circular 645;
- IMO MSC Circular 738;
- IMCA 117;
- IMCA 191;
- IMCA 04/04.
- IMCA M 182
- IMCA M 178

NOTE: Not every job requires the use of all the above specifications/guidelines. The Principal shall identify the specifications/guidelines which need not be applied if irrelevant to the job with the Invitation to Tender and Contract documentation.

2.4 DP CLASS

The DP equipment class required for a particular operation shall be based on a risk analysis of the consequences of a loss of position for the specific activity being considered. In certain areas of operation the local government or Coastal State may dictate the minimum class required.

NOTE: DP Drilling MODUs will generally be DP Class 2 or better. If the Principal chooses to use a vessel of a lower DP class, that decision shall be supported by a structured risk analysis. See Appendix 1 for equivalency of class.

2.5 TECHNICAL CAPABILITY

Contractors shall provide necessary documentation for assessment of the technical capability of the DP vessel being proposed. Documentation and evidence shall also be provided to help assess the competence of the Contractor's operational management and personnel.

3. VERIFICATION PROCESS

3.1 GENERAL

The Contractor shall provide the documentation listed in Tables A and B, for the purposes of:

- validating the technical suitability of the vessel for the activity;
- identifying the vessel's configuration for the safest mode of operation;
- understanding the vessel's station keeping capabilities following the worst case failure;
- understanding the general level of compliance with:
 - IMCA M 103 (Feb 1999 and supplement M 161 – two vessel operation)
 - IMO MSC Circular 645
 - relevant DP class requirements
 - any relevant mandatory standards and guidelines applicable in the particular Coastal State
 - IMO MSC Circular 738 (which refers to IMCA M 117 as an acceptable standard).

Principal specific requirements may be more stringent than the IMCA and IMO guidelines.

A formal submittal of the following shall be required as part of the Contractor's proposal. Documents specified in Table A shall be subjected to a detailed review. The outcome of this review, along with the submittals specified in Table B, shall be used in audits.

3.2 DOCUMENTATION FOR DETAILED REVIEW

Table A Documentation for Detailed Review

No.	Document	Remarks
1	Vessel's Class Notation and Copy of Certificate	
2	FMEA of DP System	FMEA requirements in Section 3.1. FMEA SHALL [PS] have clear statement on Vessel's Safest Mode of Operation in DP (Power Generation/Power Distribution/Auxiliaries)
3	FMEA of ESD system where applicable	May be part of DP system FMEA
4	FMEA Proving Trials Results	
5	Annual Trial Results	
6	Power System discrimination and selectivity study, protective device calibration/testing documentation and vessel's bus tie philosophy Power Management Functional Description if not adequately covered in FMEA documentation.	Power System Study SHALL [PS] be sufficiently detailed and provide a clear understanding of the safe mode configuration for the vessel. The Principal may accept closed bus tie operations if this Study shows this to be the safe mode. The Principal reserves the right to specify Open Bus for critical operations. See also 4.5 for further clarification of use of open/closed bus ties
7	DP Capability Plots	Capability plots should include the condition following worst-case failure. Capability plots should include current conditions of 1.0 kn, 1.5 kn and 2.0 kn Drilling Rigs- Capability plots shall include the condition following worst case failure and generated for contracted environmental limits.(Operational and Standing by)
8	Results of Capability proving tests for intact condition and worst case failure	Procedure in Appendix 2
9	Results of tests that show generators and thrusters can produce full power upon worst case failure	Procedure in Appendix 2
10	Philosophy for carrying out critical DP operations in proximity of sub sea or surface hazards	Includes methodology for risk assessments and contingency planning (examples to be provided)
11	Service reports concerning the DP system (last three years)	
12	Details of any DP related modifications since last FMEA	
13	Details of any acoustic noise tests conducted on the vessel	For determination of suitability of Acoustic Position Reference System
14	Audit Results (last three years) of Vessel and DP inspection	Include close-out reports
15	DP Operations Manual	Vessel Specific DP Operations Manual, not the Manufacturer's DP manual

No.	Document	Remarks
16	DP Incident reports (last three years) including close-out reports	Advisory, yellow alert and red alert levels
17	Details of spare capacity and interface for additional position reference sensors	
18	Details of Logging/Data Capture Capability	
19	Examples of ASOG/WSOG that vessel has used in the past	Example in Appendix 3
20	Details of Software QA methodology, Quality plan and modification management for key systems e.g. DP control system, power management system, variable frequency drives etc	
21	For vessel performing lifts on DP, i.e., lifting using vessel's gear and setting where loads can be restrained – details of DP control system proportional gains for fore/aft, port/stbd and heading along with description and settings for any heavy lift modes	Instability of the DP control system can be caused when the load is restrained by the setting guides. Procedures and or DP control system features need to be in place to avoid this.

- NOTES:
1. When this DEP is used for DP Drilling and Intervention Vessels the riser analysis SHALL [PS] be required for detailed review.
 2. Vessels carrying out lifting/setting operations on DP SHALL [PS] assess the potential for instability in the DP control system (heavy lift mode instability issues).
 3. Power system interconnections and redundancy, Automatic switching systems
Where Systems rely on diode paralleling or automatic switching, protections shall be in place to limit faults within design failure intent.
 4. Where redundancy concepts rely on interswitching mechanisms, reliability and effectiveness of such systems shall be documented. (Trials/Technical qualification process)
 5. Qualifications of DP operators shall be in accordance with Nautical Institute DP operator certification requirements. DP CLASS 2 and 3 vessels shall be manned by operators with a unlimited Nautical Institute Certificate. Limited Nautical Institute DP certificates may be acceptable on DP 1 vessels.

3.3 DOCUMENTATION REQUIRED AS BASIS FOR AUDIT

Table B Documentation Required for Basis for Audit

No.	Document	Remarks
1	Field Arrival/mobilization Trials Procedures	
2	DP watch keeping check lists	DP control position and ECR
3	Details of DP related emergency drills (black-out recovery, and any others as identified in FMEA)	
4	Maintenance schedules covering operational period of equipment such as diesels, generators, auxiliaries and thrusters	
5	DP/ECR manning and operator shift pattern.	

	Clear depiction of roles and responsibilities and tasks that are to be carried out by DP Operators	
6	Résumés of all key DP personnel on vessel	To include copies of relevant certification and record of DP hours
7	Examples of lessons learned workshop or tool box talks pertaining to DP operations	Alternative means may be used to disseminate information and provide ongoing training
8	DP watchkeeping log books	

4. REQUIREMENTS

4.1 MANNING

Vessel shall comply with the Statutory requirements. Additionally, for DP operations manning shall be in accordance with the following.

4.1.1 Bridge Crew

Operation	Minimum Bridge Crew per shift	Minimum Experience
When within 500 m (550 yds) zone of surface facilities and/or undertaking critical activities in proximity to surface or sub surface structures	2 unlimited DPOs on the bridge capable of operating the vessel with DP experience	Unlimited DPO with a minimum of 3 years experience on a vessel engaged in similar operations. At least 6 months to have been on the subject or sister vessel. Experience level should be documented and may at the request of the principal be demonstrated.
NOTE: The Master shall not be considered as one of the required unlimited DPOs for meeting the manning requirements.		

4.1.2 Engineer

A licensed engineer (STCW 95 Compliant) shall be on watch and shall have at least 6 months experience on similar equipment and operations.

4.1.3 Electrician

An electrician shall be present and shall have appropriate high-voltage training/certification if applicable. The electrician should have at least 6 months experience on similar equipment and operations.

4.2 FMEA / PROVING TRIALS AND ANNUAL TRIALS

FMEA/proving trials and Annual Trials submitted should comply with the following minimum requirements:

- FMEA SHALL [PS] define the safest mode of operation, the worst case failures, significant single-point failures, hidden failures and mal operation in the summary.
- FMEA shall be updated after any major modifications and proving trials have been conducted.

- FMEAs should have been reviewed and updated once every five years (even if no major modifications have been carried out). Proving trials (if necessary) or comprehensive Annual trials should be conducted following this review. This review should incorporate lessons learned within the industry and from failures and incidents on board the vessel (see Guidance Note 1).
- FMEA Proving Trials shall address all known and identified failure modes.
- Failure modes that are known and are unable to be tested due to practical limitations, shall be clearly identified in the FMEA document. Alternate means of demonstrating adequate barriers against these failures shall be clearly described
- Periodic FMEA testing should be scheduled for high-risk FMEA issues (e.g. black-out recovery).
- Annual trials are adequate and have been conducted in the past 15 months and were witnessed by an independent party (see Guidance Note 2).
- Action items from FMEA, proving trials, annual trials, audits and incidents have been or are in the process of being closed out. Closing out of action items shall be well documented and auditable.
- FMEA Documents should have vessel-specific:
 - details of governor failure modes;
 - details of AVR failure modes;
 - details of power protective and power management functions
 - details of main switchboard control power failure modes;
 - details of position reference system processing provided by the DP control system;
 - details of gyro compass and VRU system processing provided by the DP control system
 - details of DP control system's consequence analysis feature;
 - DP control system Input/Output Schedule;
 - details of Networks;
 - single-line diagram for satellite based position references;
 - single-line diagram for hydro-acoustic position references;
 - single-line diagram(s) for other position reference systems (e.g. Taut Wire, Laser based etc.);
 - details of ESD system where applicable – see Guidance Note 3.
 - details of communications and alerting systems provided for the DP operator and their redundancy (systems and power supply).

Some FMEAs may not contain all the above information. In such cases the requested information should be supplied as separate documents in sufficient detail with clear identification of the content.

Guidance Note 1: It is recognised that some companies monitor and manage changes through a structured management of change process. It is expected that such process will trigger review of FMEA if warranted. Due diligence dictates, that a process be established within the contractor's organisation to ensure that the FMEAs are reviewed. The review shall be carried out:

- when changes are implemented
- once every five years

Where no changes are implemented it is expected that the review still be undertaken to verify:

- that no changes have occurred that would warrant a review/revision of the FMEA

- that known incidents within industry or from the vessel cannot manifest themselves.

Evidence of this review shall be provided by a competent person accountable for DP operations within the contractor's organisation.

Guidance Note 2: Trials performed on a continual basis for MODU's, per IMCA 191 guidelines, may be considered as an alternative to annual trials.

Guidance Note 3: The ESD system SHALL [PS] be evaluated as follows:

- Detailed cause and effect matrix
- Split along lines of vessel's DP redundancy concept
- Failure modes of ESD system
- Protection against inadvertent operation

It shall be recognized that most vessel's ESD will be in compliance with MODU code, where activation of a single ESD activation can cascade and result in a complete blackout. Inadvertent activation could result in unacceptable consequences. Due consideration is to be given to authorized overriding/bypassing the level that will result in a complete blackout.

4.3 POSITION REFERENCE SYSTEMS

A suitable suite of position reference systems shall be agreed between the Principal and Contractor. The following points shall be considered and evaluated:

- Number of independent position reference systems required (normally three).
- Choice of Reference Systems including absolute and/or relative.
- Water depth of operation (for acoustics and taut wire).
- Area of operation (e.g. sensitivity of GPS to scintillation).
- Multiple DGPS of the same type shall not be considered as redundant. Redundancy of multiple DGPS systems should be achieved by diversity (for example using different DGPS suppliers). The vessel's DP system should be capable of accepting raw GPS signals without the differential update.
- Multiple acoustics shall not be considered as redundant unless they operate on different principles and cause no interference.
- Acoustic systems shall be suited for the water depth in which operations are carried out and shall be capable of being used in conjunction with other position reference systems potential for interference from other DP vessels in the area shall be taken into account and appropriate mitigating measures will need to be in place. See guidance note.
- For critical operations involving coupled body motions, both absolute and relative position reference systems are required. Field conditions dictate which systems are used. In general a mix of absolute and relative systems should not be used for coupled body motions unless:
 - the DP system has a Relative Positioning Mode;
 - field conditions and trials prove that the vessel is capable of maintaining position in this mode and carrying out the intended work;
 - the intended operation is of short duration when vessels are coupled (not exceeding 1 h).

Each position reference system shall use its standard interface to connect the DP control system. 'Pseudo' interfacing and/or any intermediate processor(s) (such as a survey system) should not normally be used, unless there are special project requirements. In that case an FMEA and test procedure shall be provided for the particular set-up.

Survey systems fitted on the vessel are not to share control of position reference systems used by the DP control system.

Additionally, the DP Controller should have at least one free spare interface to connect project specific position reference system(s).

Guidance Note: Where acoustic systems are deemed necessary as a position reference for critical operations, LBL is recommended for water depths exceeding 700 m (765 yds).

Where survey systems share commonality with position reference sensors used for DP, any changes in Survey systems shall be covered by an update of the relevant DP FMEA sections (including proving trials)

See table in Appendix 4

4.4 GYRO COMPASSES AND VRUS

4.4.1 Gyro Compass

In general the industry requirements are for vessels DP CLASS 2 and above to have three gyro compasses interfaced to the DP control system. Certain class societies have permitted two gyros..

This DEP requires three gyros for vessels DP CLASS 2 and above. For vessels engaged in diving operations this requirement shall not be varianced unless it is approved by the Principal's Technical Authority 1 and accompanied by a structured detailed risk assessment.

Guidance note * – two gyros can be considered for non diving related operations provided that

- a third independent accurate heading read out can be provided at the DP position.
- Information is provided to show that the gyro rejection logic of the DP control system includes rejection on the basis of gyro drift and sudden apparent jump in heading
- And consequence of loss of position is not severe

4.4.2 VRUs

Where position reference information is actively corrected by VRU data, there shall be at least three VRUs. Any deviations to this shall be subject to a structured risk assessment and there shall be evidence that a lack of three VRUs does not introduce the risk of loss of position.

4.5 OPEN AND CLOSED BUS TIE OPERATIONS

Default position is for vessels to be operated with one or more open bus ties.

Closed bus tie operations may be considered for non-critical operations if it can be demonstrated that closed bus tie operation is capable of preventing a black-out under the following fault conditions:

- any single generator or Voltage Regulator (AVR) fault;
- any single equipment failure or fault;
- any single diesel or diesel speed control fault;
- any single switchboard fault;
- any single shared systems fault (e.g. control power or fuel);

and if

- closed bus tie operation is inherently safer.

Guidance Note: Closed bus tie operations may be considered when effective protective and blackout recovery measures have been implemented and tested. Examples of effective protection against common mode failure such as advanced generator protection and quick trip of the bus ties, Example of effective blackout recovery measures such as precharging DC links on thruster drives, transformer pre magnetising, etc.

4.6 DATA LOGGING, ALARMS AND SCREEN CAPTURE

Vessels should be provided with a separate data logging system.

The purpose of such a system is to aid in understanding the real causes of failures and provide faster diagnosis and recovery following a failure.

The system should at least have:

- the ability to capture and store in electronic media key parameters of a DP system (including key power plant data) for a minimum period of 30 days;
- a means of analyzing data and depicting it in a usable format (graphs/reports);
- a means of providing hard copies in colour;
- the capability to read logged data using off-the-shelf commercially available software and in the Windows environment;
- a data logger processor connected to a UPS;
- the capability to print DP control system screens to a colour printer connected to a UPS;
- alarm printers for hard copying alarms for the DP control system computers (the printing of these alarms shall not require any operator intervention).

4.7 STATUS ALARM SYSTEM AND COMMUNICATIONS

The status alarm system and DP related communications should have:

- visual and audible status alarm indication for yellow and red alarms at DP control position, ECR, the work area and the area where the work is controlled;
- alarms manually initiated from the DP console;

Guidance Note: It is recognised that some Contractors have implemented automatic initiation of these alarms notwithstanding the above; vessels shall have manual means for initiation of status alarms.

- alarms logged on the DP alarm printers;
- alarms operational in a black-out;
- alarms recorded on the data logging computers;
- accessible redundant means of direct communications between the DP console and ECR, work area and the area where work is controlled from.

One means of communication for the above shall be hands-free and still be operational during a black-out.

4.8 DOCUMENTATION

Documentation submitted in accordance with Tables A and B shall be reviewed in order to gain an understanding of:

- effective incident reporting, investigation and close-out;
- adequacy of DP related drills conducted on board the vessel;
- accuracy of vessel's capability plots and proving tests;
- assessment of system reliability and outstanding issues from the service reports
- confirmation that the capability plots cover the worst case failure(s) identified
- confirmation that the consequence analysis feature covers the worst case failure(s) identified;

Guidance Note: Consequence analysis is a requirement of class however certain classification societies do not clearly specify that it needs to cover worst case failure.