HID Inspection Guide Offshore

Inspection of Maritime Integrity (Loss of Stability & Position)

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Summary
This guidance outlines an approach to the inspection of a dutyholder’s management arrangements for Maritime Integrity on a floating installation.

Introduction
Maritime Integrity applies to all floating installations. Maritime Integrity is about staying upright and afloat, maintaining position and installation motions within operational limits; and includes safe practice in all marine operations.

Maritime Integrity has been split into 5 main topic areas as listed in the Appendices. A maritime integrity inspection should include all of the applicable appendices for a given floating installation.

An overall score for the maritime integrity inspection is assigned by following the process for ‘Performance Assessment’ described in this section.

Action
The aim of this Operational Guide (OG) is to provide information and guidance to offshore inspectors to support the delivery of consistent and effective offshore
Maritime Integrity inspections. It does this by highlighting key areas essential to an effective process, so that these can be covered during inspections, providing a framework for inspectors to judge compliance, assign performance ratings, and decide what enforcement action to take should they find legislative breaches. In doing so, it complements HSE’s [Enforcement Policy Statement](#) (EPS) and [Enforcement Management Model](#) (EMM).

Success criteria (fundamental requirements) are listed under the inspection topics (see appendices); these cover the key issues that inspectors should consider when carrying-out inspections against each core intervention issue. In some instances, not all of the success criteria will apply so inspectors should make a judgement regarding which of these are relevant in each case. If the relevant success criteria cannot be met, inspectors should assess how serious the consequences of failure to comply could be. This guidance document will help in their decision making in terms of the performance ratings that they assign and the enforcement action they take (if any) based on the findings of the inspection.

**Background**

**HSE Legislation**

Existing international and flag authority marine legislation, and classification society rules, regulations, and standards are useful reference material in determining the standard expected. However, these are not directly enforceable under HSE legislation. The following HSE legislation is found to be particularly relevant for inspections of maritime integrity:

- **DCR Reg 4** – General duty to ensure integrity of installation.
- **DCR Reg 5** – Design of installation to withstand reasonably foreseeable forces and damage.
- **DCR Reg 7** – Operation of installation to be within defined limits.
- **DCR Reg 8** – Maintenance of integrity with periodic assessments and remedial work.

- **PFEER Reg 5** – Assessment of major accident precursors (e.g. flooding; collision)
- **PFEER Reg 6** – Preparation for emergencies; and general marine competencies
- **PFEER Reg 8** – Emergency response plan; including marine incidents
- **PFEER Reg 10** – Detection of incidents (e.g. bilge alarms; tank gauges)
- **PFEER Reg 12** – Control of emergencies, including remote operation of plant
- **PFEER Reg 19** – Suitability and condition of plant, maintenance of marine SCE.

- **PUWER Reg 4** – Suitability of work equipment – includes marine equipment
- **PUWER Reg 5** – Maintenance of work equipment
- **PUWER Reg 7** – Specific risks – control and competency during maintenance
- **PUWER Reg 11** – Dangerous parts of machinery – adequate protection from rotating shafts

- **SCR Reg 21** – Continuing effect of verification schemes
**Organisation**

**Targeting**
Inspectors should undertake Maritime Integrity inspections as part of the agreed ED offshore intervention plan, when intelligence indicates intervention is necessary or when investigation due to incident is required.

The inspection may be carried out at any floating installation (including jack-up units). Where maritime integrity issues are identified it is essential to ensure that duty holders are robust in their assessment of the implications for their other installations.

**Timing**
Inspections should be planned within the timescales set out by ED divisional management.

**Resources**
Resource for the undertaking of Maritime Integrity interventions will come from discipline specialist inspectors and Inspection Management Team inspectors as appropriate.

**Recording & Reporting**
The operator's performance ratings should be entered on the Inspection Rating Form (IRF) tab of the relevant installation Intervention Plan Service Order. Findings should be recorded in the normal post inspection report and letter.

**Performance assessment**
When inspecting Maritime Integrity there are two areas to be considered as follows;

a) Do the risk control measures implemented lead to compliance with the relevant legislation? This decision will be made in the same way as for other inspection topics by comparing the standard of control achieved against the relevant benchmarks and applying the principles of EMM.

b) The inspection will then reach a conclusion on how well the dutyholder is managing Maritime Integrity. This should be recorded using the assessment criteria listed below.

The following descriptors will be used to assist in determining the appropriate risk gap score for the dutyholder.

a) **Unacceptable (Score 60)** - The management of maritime integrity is grossly deficient in a number or areas.

b) **Very Poor (Score 50)** - A number of deficiencies in meeting minimum legal requirements for maritime integrity have been identified. The management system has failed to address these deficiencies.

c) **Poor (Score 40)** - There is a system in place for managing maritime integrity and this is being followed. However, there are numerous examples where the system has not resulted in the implementation of effective control measures.
d) **Broadly Compliant (Score 30)** - There is a system in place for managing maritime integrity. It has been fully implemented; and most issues considered have resulted in appropriate control measures.

e) **Fully Compliant (Score 20)** - There is a system that has been fully implemented and is effective in identifying appropriate control measures for all relevant aspects of maritime integrity.

f) **Exemplary (Score 10)** - Meets the fully compliant standard but with evidence of class leading systems in complex areas such as the inspection and monitoring of difficult to access areas of mooring systems and hull structure.

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### EMM RISK GAP

<table>
<thead>
<tr>
<th>Topic Performance Score</th>
<th>EXTREME</th>
<th>SUBSTANTIAL</th>
<th>MODERATE</th>
<th>NOMINAL</th>
<th>NONE</th>
<th>NONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable</td>
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<td>50</td>
<td>40</td>
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<td>Broadly Compliant</td>
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<td>Fully Compliant</td>
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<td>Exemplary</td>
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Unacceptably far below relevant minimum legal requirements.

Most success criteria are not met.

Degree of non-compliance extreme and widespread.

Failure to recognise issues, their significance, and to demonstrate adequate commitment to take remedial action.

Substantially below the relevant minimum legal requirements.

Many success criteria are not fully met.

Degree of non-compliance substantial.

Failures not recognised, with limited commitment to take remedial action.

Significantly below the relevant minimum legal requirements.

Several success criteria are not fully met.

Degree of non-compliance significant.

Limited recognition of the essential relevant components of effective health and safety management, but demonstrate commitment to take remedial action.

Meets most of the relevant minimum legal requirements.

Most success criteria are fully met.

Degree of non-compliance minor and easily remedied.

Management recognise essential relevant components of effective health and safety management, and commitment to improve standards.

Meets the relevant minimum legal requirements.

All success criteria are fully met.

Management competent and able to demonstrate adequate identification of the principal risks, implementation of the necessary control measures, confirmation that these are used effectively; and subject to review.

Exceeds the relevant minimal legal requirements.

All success criteria are fully met.

Management competent, enthusiastic, and proactive in devising and implementing effective safety management system to ‘good practice’ or above standard. Actively seek to further improve standards.

### EMM INITIAL ENFORCEMENT EXPECTATION

<table>
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<tr>
<th>Prosecution / Enforcement Notice</th>
<th>Enforcement Notice / Letter</th>
<th>Letter / Verbal warning</th>
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<th>None</th>
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<tbody>
<tr>
<td>Prosecution / Enforcement Notice</td>
<td>Enforcement Notice / Letter</td>
<td>Letter / Verbal warning</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

The overall performance rating for marine integrity will be obtained from a combination of each of the applicable areas of maritime integrity as listed in Appendix 1 to Appendix 5.

Sample checklist examples are given in each Appendix. A number of typical opening questions, together with typical ‘good’ and ‘poor’ resultant findings from an inspection are given. The inspector will then use professional judgment to determine the overall risk ranking for maritime integrity for the installation.
Further References

Offshore Information Sheets

OIS 4/2013 Offshore installation moorings

OIS 1/2012 Effective implementation of offshore verification requirements

OIS 4/2011 Flooding risk to machinery spaces of floating offshore installations: Guidelines on inspection of ship side valves; flood detection and control; inspection and training

OIS 2/2010 Reducing the risks of hazardous accumulations of flammable/toxic gases in tanks and voids adjacent to cargo tanks on FPSO and FSU installations

OIS 8/2009 Oil mist hazards on dual fuel diesel engines

OIS 6/2007 Jack-up (self-elevating) installations: floating damage stability survivability

HSE Safety Bulletins

OSD 1-2013 Warning to offshore industry on blocking of data communications in dynamic positioning systems

HID 2-2012 Warning to offshore industry on possible failure of fire resistant composite deck gratings

OSD 5-2010 Assessment of the adequacy of venting arrangements for cargo oil tanks on FPSO and FSU installations

Contacts

ED Offshore: ED4.3
Appendices

Appendix 1: Stability and Ballast Systems.
Appendix 2: Watertight Integrity.
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Appendix 5: FPSO Cargo Tank Operations and Offloading.
Appendix 1: Stability and Ballast Systems.

Load Management & Stability Control

The stability of a floating installation, whether monohull (surface units), semi submersible (column stabilised units), jack up (self elevating units) or other design is of the utmost importance. A lack of basic understanding of stability and the control of stability can and has led to major maritime disasters.

The standard of performance required by the HSE for both Intact and Damaged stability is defined in detail in RR 387. Other Codes may have been used in the installation design. These include IMO Load Line, Intact Stability, and SOLAS requirements; IMO MODU Code; MARPOL; and SPS Code. The Safety Case and Marine Operations Manual should show which code is the limiting case. This is usually expressed in terms of a ‘maximum allowable KG’, (Vertical Centre of Gravity).

The Marine Operations Manual (refer to RR 387) is a document containing information about stability, loading, and ballast systems of the installation. This will normally be approved by a Classification or Flag Authority. Where installations are not classed, it is expected that stability information is approved by a competent authority as part of the verification process. Limits to deck loading, and restrictions on tank loadings will be defined in the Operations Manual, (typically be to avoid excessive shear forces, bending moments, torsional stress, or to limit the effects of flooding).

In essence a floating vessel with good intact stability will quickly return to its upright condition after it has been heeled to one side by wind or wave action. Loss of stability of the installation is interpreted as damage to watertight hull structure, or an unplanned change in the floating stability of the installation, and is defined as a ‘major accident’ in Regulation 2 of the Offshore Installations (Safety Case) Regulations 2005 (SCR).

The stability of the installation is under the control of the Marine Supervisor, or Ballast Control Operator. Routine operations will include daily checks on load distribution, in particular the movement of deck cargo. Daily checks will be kept and recorded in the marine log.

A load or stability computer will be installed and the hull tank contents, such as ballast, fuel oil, freshwater or drill water will usually be automatically uploaded to the stability programme. Marine personnel will need to input manually changes to deck loads such as deck containers, BOP movements, drill pipe and tubulars and other variables. This system does not directly control stability, but is a tool to determine the installation stability.

The Loading computer/stability programme will also display additional information depending upon the vessel type, for example Torsional stress on a semi submersible and Bending moments and Shear forces on a ship shaped vessel.

A new installation is assigned a lightweight. Over time modifications to the structure and equipment changes will have an effect on the lightweight of the installation. Weight changes should be accurately recorded and a Record of Lightweight change kept which is scrutinised and approved by third parties. Where there is an overall change greater than 2% of lightweight, or doubt about the lightweight and centre of gravity, then this should be
recalculated, which may be by means of an inclining test or an alternative in service monitoring system.

The control of stability is Safety Critical and as such a system must be in place which will enable the stability of the installation to be calculated under all conditions, including total loss of power. This may either take the form of maintaining an additional copy of the stability software available to undertake the calculations on a laptop computer or an entirely manual system utilising a paper based system. Stability software is normally type approved by a Classification Society. Where the installation is also classed the stability results are confirmed for accuracy on the installation computer system. In any event the maritime staff must be able and competent to calculate the stability under all conditions, including total loss of power.

**Ballast System**

**Main Ballast System**

The Ballast system is safety critical and is used to control the stability, whether intact or damaged, by moving sea water to or from various locations in the structure in order to bring the vessel to a safe and level trim as well as to keep the structural loading (shear forces, bending moments, torsional stresses, etc) within permissible limits. The movement of the water to, from or between ballast tanks and the sea uses the dedicated ballast system. Ballast arrangements may be by gravity for intake from sea, and by pump for discharge overboard. The ballast system will be displayed on a mimic panel and/or a computer monitor, the tank contents, the open/closed status of all valves, pipelines and pump parameters will be clearly indicated. Manually selected switch operations will determine the movement of the ballast water to and from the ballast tanks. The operation of each switch normally energising a solenoid which will in turn direct high pressure hydraulic oil to the selected ballast valve actuator. It is normal for the ballast tank valves to fail to the closed position thus reducing the risk of ballast transfer in the event of power failure. Ballast sea chest valves are to fail closed on loss of power. Non-return valves on overboard discharges should be in the correct orientation and adequately inspected to verify their integrity.

The ballast system is controlled from more than one location, for example from either the engine control room or the pilot house/Bridge. One of the control stations shall be within the temporary refuge. The means of switching from one control station to the other must be clear and unambiguous. Where the Ballast suction comes from Main Sea water crossovers the ships side valves should have a remote direct operation which should be regularly tested.

Typically the ballast system will be used in normal operation; to move a semi submersible between transit, operational and survival drafts; to compensate for the increase or decrease in draft in a monohull FPSO as the crude oil is either loaded or discharged; and to empty or fill the pre load tanks in a jack up on arrival at a new location.

In an emergency situation the ballast system will be used to bring the vessel to a safe and level trim as soon as possible. The ballast system is also used to compensate for the loss of buoyancy brought about by damage to the installation.
Secondary or Emergency Ballast System.

In a number of semi submersible designs the pump rooms are at the aft end of the pontoons. This arrangement can lead to a situation where the ballast pumps in the aft pump rooms are unable to draw suction on the forward ballast tanks when the vessel is “down by the head”. A means of deballasting the forward tanks is therefore required and may take the form of dedicated secondary deballasting pumps, powered from the emergency switchboard, installed in the forward columns adjacent to the forward ballast tanks.

Alternative arrangements may take the form of bilge eductors drawing from the forward tanks. Pressurising the forward tanks by means of the rig air system thus creating an artificial suction head on the pumps drawing from the affected tanks is not regarded as safe practice.

Emergency Bilge Arrangements, (sometimes referred to as Bilge Injection).

In the event of flooding of a machinery space, which exceeds the capacity of the bilge pumps, the largest capacity pump in the machinery space (usually ballast or a sea-water cooling pump) must be able to draw directly from the machinery space bilges and thus extract water from the flooded spaces at an enhanced rate. The emergency bilge suction will be fitted with non-return valves to prevent the ballast system from flooding water into the bilges and should be clearly identified.

Competence

The offshore marine positions will need to be able to demonstrate their marine competence by reference to recognised and approved competence training schemes.

In 2005 the International Association of Drilling Contractors, IADC, launched an accreditation for the suppliers of marine ballast and stability training course providers, in line with the International Maritime Organisation, IMO, resolution A.891.

For semi submersible installations this will typically require, the Stability courses 1, 2 and 3 to be completed. Stability 3 including extensive damage control training on a ballast simulator. There should be a minimum of 2 persons on board with stability training appropriate to the type of vessel.

Dedicated maritime personnel would ideally include the OIM and an offshore Marine Supervisor, who reports directly to the OIM, both with a maritime background, and Ballast Control Operators. There should be a dedicated onshore marine superintendent who can be contacted at all times by the maritime personnel on the vessel.

Permanently moored installations in UKCS, such as an FSU or FPSO are considered to be fixed installations, and do not require international marine ‘Flag State’ certification. The maritime competence requirements are largely down to the Duty Holder and will be found in the Safety Case.

Jack ups or self elevating units are different again in that it is usual for the maritime roles, which are only needed when moving station, to be brought on board as and when
required. There is always the risk that the maritime roles will not be readily available in the event of an emergency move.

In any event the Duty Holder should be able to list the maritime competences required for a specific installation and demonstrate that the correct competences are in place, the competences should reflect as a minimum STCW. The training matrix should be up to date and reflect the actual status of the maritime competences.

**Emergency Operation**

Arrangements should be in place to ensure that the vessel can be brought to a safe and level trim in the event of a main power failure. One or more ballast pumps and the complete ballast system should be operable from the Emergency switchboard powered by the Emergency generator in such a power failure event. In addition the stability software should be available on a separate electronic storage medium which can then be loaded on a laptop and the stability calculated manually.

Alternative manual operation of the ballast system solenoids and valves should be available for use in the event of failure of all or part of the system. The maritime staff should be fully conversant with the entire system in both normal and emergency modes of operation. In such an event, where it is necessary to use the various manual controls it is vital that adequate fixed or mobile communications are available and operable at each and every location where the manual controls are installed. The various manual control stations should be readily accessible, be in a safe location and the equipment to be operated manually should be clearly labelled.

More modern vessels ensure that emergency control stations, such as the solenoid valve racks are positioned above the final water plane after damage. That is after damage to the vessel the control stations are above the damaged waterline and are readily accessible.

It is not unusual to find older vessels with solenoid racks installed in pump rooms below the damaged waterplane. This should be challenged in thorough reviews of safety case; the opportunity to raise such racks to above damage waterplane should be taken at class society special periodic surveys.

**Emergency Exercises**

Damage control exercises which necessitate the use of the stability and ballast system in emergency conditions should be carried out at regular intervals. The exercises should be as realistic as possible and reflect a variety of scenarios. Records should be retained on board of the frequency and type of exercises undertaken together with the exercise feedback and any lessons learned.

The majority of stability and ballast system emergency scenarios are foreseeable and as such emergency plans can be created and retained in relevant locations. These may, for example, include instructions to the BCRO as to what valves to close in the event of a flooding incident or the required procedure to follow in the event of a vessel collision.
(In light of the imminent ratification of the IMO Ballast Water Management Convention each installation should have in place an approved Water Management Plan).
## Appendix 1 – Stability and Ballast System - Example questions and findings demonstrating good and poor practice

<table>
<thead>
<tr>
<th>Issue</th>
<th>Good practice</th>
<th>Poor practice</th>
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<tbody>
<tr>
<td><strong>Load Management and Stability Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. <strong>Is the Marine Operations Manual containing approved information on stability and damage control available, up to date and in use?</strong></td>
<td>The Marine Operations Manual on board is of the most recent Revision, is readily to hand and is used frequently. A copy was found in the office of the OIM and in the ballast control room.</td>
<td>It took some time to locate the Marine Operations Manual, it is of a different revision to that on shore and was not being used frequently, if at all. There was only one copy on board.</td>
</tr>
<tr>
<td>2. <strong>Is the computer software used approved and up to date? Is it possible to simulate damage and evaluate stability?</strong></td>
<td>The computer stability software in use reflects the most recent updates and has the capability to simulate damage scenarios. The maritime staff demonstrated their ability to simulate a number of damage conditions.</td>
<td>It was not known if the computer stability software in use included any updates. It was not possible to simulate damage scenarios and the maritime staff were unaware if the stability software could be upgraded to include such a capability.</td>
</tr>
<tr>
<td>3. <strong>Are there independent means of calculating load conditions in the event of main system failure (preferably laptop with sufficient battery back-up)</strong></td>
<td>A laptop computer was maintained in a fully charged condition and the approved stability programme was available on a dedicated portable disc, the maritime personnel were capable of inputting data manually as required. In addition each individual of the maritime staff was required to undertake full manual calculations of the stability on paper based stability sheets on a bimonthly basis.</td>
<td>There was no means of carrying out the stability calculations in the event of total power failure and no copy of the stability programme was maintained on a portable disc. The maritime staff did not have the capability to undertake full manual calculations as they were not required to undertake paper based exercises.</td>
</tr>
<tr>
<td>4. <strong>What records of lightweight change are kept, and who reviews and approves these?</strong></td>
<td>A copy of the lightweight changes was maintained in the office of the OIM, it was up to date, was regularly reviewed by the Class Surveyor and a check around the installation found that all weight changes were recorded accurately. The marine supervisor was responsible for maintaining the document and a copy was maintained in the office of the rig manager on shore.</td>
<td>It was apparent that weight changes had been made to the vessel over time, no documents could be found to demonstrate adequate recording. It was not known who was responsible and it could not be proved that Class had been made aware of any weight changes.</td>
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<tr>
<td>5. <strong>Have any incidents of unusual vessel motion occurred which gave concern as to stability (e.g. unexpected heel or trim, change in roll period)</strong></td>
<td>The maritime staff on board were fully satisfied that the stability programme in use accurately reflected the floating installation motions and behaviour. They were unaware of any unusual or untoward vessel motions.</td>
<td>Concerns were expressed on board as to the stability programme and its ability to accurately reflect vessel motions. These concerns had been noted and passed to the onshore office but to date no action had been taken to check the accuracy of the stability programme. Particular concerns were raised as to the programme responses when tank contents were low.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
<td>Poor practice</td>
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<tr>
<td><strong>Ballast System</strong></td>
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<td>There was no note of the ballast system being an SCE, the performance standards were unknown and the maritime staff were unaware of any pass/fail criteria. Reference to the Class documentation found a number of ballast system comments requiring action on the Duty Holder were in place but had not been actioned.</td>
</tr>
<tr>
<td>6. Is the ballast system defined as a Safety Critical Element and are the Performance Standards for the ballast system suitable and specific to the vessel? Are the pass/fail criteria clear and auditable?</td>
<td>The ballast system was noted as being an SCE and a review of the performance standards found that they were clear and unambiguous. The pass/fail criteria were simple to comprehend and easy to demonstrate. An audit trail was in place and a review of the Class documentation found that a number of the performance standards had recently been checked and found acceptable.</td>
<td>Although it was understood that the vessel could go “down by the head” it was thought that the systems in place would be adequate to return the vessel to a level trim. This had never been proven and could not be tested. The condition of the ballast pumps was suspect and the suction they were capable of drawing unknown. There were no plans in place to rectify the situation.</td>
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<tr>
<td>7. If the installation is a semi submersible and is of the design where the pump rooms are mounted aft in the pontoons, what secondary deballasting system or emergency system is in place to deballast the forward tanks when the vessel is “down by the head”?</td>
<td>The inability to deballast the forward tanks in the event of being “down by the head” was understood. A secondary deballasting system was in place where dedicated submersible pumps were permanently installed in the two largest forward tanks. These were independent of the main ballast system and were powered from the emergency switchboard. They were regularly tested.</td>
<td>One of the ballast pumps in each of the machinery spaces was fitted with an emergency bilge suction and these were designed to be utilised in the event of flooding. However, in one of the pump rooms that particular pump was inoperable through breakdown and although the necessary parts had been ordered for some time they were not expected in the near future. Discussions with the onshore office had not resulted in any improvement to the situation. There was no other alternative emergency means of draining the bilges. The emergency system had not been tested recently.</td>
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<tr>
<td>8. In the event of a machinery space flooding incident which exceeds the capacity of the bilge pumps, what arrangements are in place to utilise the greater capacity of the sea water lift or ballast pumps to assist in draining the space?</td>
<td>In each machinery space one of the main ballast pumps could be powered from the emergency switchboard and was fitted with an emergency bilge suction. The emergency bilge suction were fitted with non-return valves to prevent water flowing back into the bilges from the ballast system. The systems were tested regularly when the opportunity arose and performed well.</td>
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<tr>
<td>9. Are there two or more locations (one of which is within the temporary refuge) where the ballast and associated systems may be operated from? How is control transferred from one location to the other and how is this confirmed?</td>
<td>The ballast and associated systems can be operated from either the engine control room or the pilot house. There is a positive switching arrangement in place which requires control to be passed from the control room in operation to the control room which is going to be used. It is not possible for any control room to demand control without it being passed to it. The system was regularly checked and tested and worked well.</td>
<td>The ballast and associated systems could either be operated from the ballast control room or the pilot house. It was possible to operate the systems without control being passed from one control station to the other. This had led to confusion in the past and in one instance had resulted in a noticeable list. There were no plans to rectify the situation.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
<td>Poor practice</td>
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<td>Incorrect loading of ballast can create excessive bending moments or shear forces in a monohull design and excessive torsion in a semi submersible design. What ballast loading and discharge plans are in place to prevent such an eventuality and are they followed?</td>
<td>Ballast loading and discharge plans were in place and were always followed, it was understood that deviations from the plans could lead to excessive bending moments and/or shear forces on the vessel structure. The stability programme was used to confirm that the loadings and discharges were within strict parameters. In the event that deviations were required, for example where a tank was open for inspection, then the loading and discharge requirements were modified and simulated on the stability programme. The tank contents were regularly manually checked to confirm that the, automatically updated, stability computer data was correct.</td>
<td>It was thought that the vessel design was sufficiently robust such that ballast loading and discharge could be varied at will. No ballast loading and discharge plans were in place and there was no knowledge of there having been any. Reference was not made to the stability computer as it was assumed that, in the event of incorrect loading or discharge, the stability computer would alarm in time and warn the operatives. The tank contents were not manually checked and therefore the accuracy of the data being automatically input to the stability computer was not known.</td>
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### Competence

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<thead>
<tr>
<th>Issue</th>
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<th>Poor practice</th>
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<tbody>
<tr>
<td>In the event that a major maritime integrity concern has to be resolved is there a clear contact individual on shore who is responsible for maritime matters, does that individual come from a suitable maritime background?</td>
<td>There is a dedicated maritime point of contact onshore, he comes from a marine background and is supportive of the offshore maritime work force. The marine supervisor is able to contact him direct in the event that he needs to do so.</td>
<td>The marine personnel on board can only contact the office via the OIM and the OIM does not come from a marine background. There is no one single point of contact onshore and frequently marine concerns are passed around the office before eventual action. Consequently everything takes longer to resolve.</td>
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<td>What competency standards does the Duty Holder require of the maritime staff and how do the actual competency standards in place compare with these? Is there a training matrix on board and does the training matrix accurately reflect the courses and training undertaken and due for each of the maritime staff</td>
<td>The Duty Holder, (of a semi submersible), requires the maritime staff to have completed stability I, II and III, Stability III being the ballast simulator. Checks with the marine individuals confirmed that this was the case and all were up to date. The training matrix was sighted, was readily available and was found to accurately reflect the training situation, it also listed the due dates for refresher courses.</td>
<td>The maritime staff were unclear as to what the Duty Holder required of them and in some cases could not demonstrate attendance at any marine related course. One of the individuals spoken to used to be a crane driver but had fancied a role inside during the winter months. The training matrix was seen as an onshore document and no copy could be found on board. There were no clear plans to change the system.</td>
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<tr>
<td>What importance is placed upon the need for dedicated maritime staff, is there an offshore maritime supervisor, does he report directly to the OIM and is the OIM from a maritime background? Is there a clear demarcation between the work of the maritime personnel and other areas, for example production.</td>
<td>The offshore floating production company had been created as an offshoot of the original shipping company and, as such, the maritime area was seen as of vital importance. A defined maritime section was in place led by a marine supervisor. The marine supervisor reported directly to the OIM, who also had marine experience and both had direct access to a dedicated marine individual onshore. The work of the marine section was seen as playing second fiddle to the all important drilling work, the marine section was manned by individuals with little or no marine experience. The OIM was an ex toolpusher who had little time for the maritime personnel and their concerns. It was not unusual for the marine section to be requested to assist with drilling related work.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
<td>Poor practice</td>
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<td>14.</td>
<td><strong>Does the ballast control room operator fully understand the complexities of the marine related systems?</strong> If he is new to the installation has he had the opportunity to work with a more experienced personnel until he was deemed competent?</td>
<td>It was understood that occasionally a BCRO would have had little experience of stability and related concerns. The Duty Holder had in place adequate training schemes which ensured that new individuals were not given sole responsibility of ballast control until they had spent some time with an experienced individual. They would only be allowed sole control once the experienced individual was satisfied with their work. It was also ensured that they undertook the approved competence scheme.</td>
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<td>15.</td>
<td><strong>Crew changes combined with possible individual sickness or absence may make it more difficult for the Duty Holder to always put in place sufficient maritime personnel. Are there always adequate numbers of maritime personnel on board or, in certain circumstances, is there a shortfall and is this perceived as having an impact on safety?</strong></td>
<td>It was seen as foreseeable that there would be times when there was a possible shortfall in marine personnel, however, the company had in place adequate numbers of experienced individuals who could be brought in as and when required. The possible reduction in marine staffing was perceived as having an impact upon safety.</td>
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<td><strong>Emergency Operation</strong></td>
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<td>16.</td>
<td><strong>In the event of a main power failure is it possible to operate the ballast system from an alternative source of supply? (normally only one ballast pump in each pump room will be powered from the emergency switchboard)</strong></td>
<td>It was confirmed that the ballast system could be operated in full, although at a slower rate of transfer, from the emergency switchboard. One ballast pump in each pumproom being powered from the emergency switchboard. The emergency lighting and communications allowing for remote and local valve control. The system was regularly tested.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
<td>Poor practice</td>
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<td>17.</td>
<td>There may be a need to immediately isolate the ballast mimic panel/VDU monitor and therefore the entire ballast system, for example when electrical faults create unplanned opening and closing of valves. Is there one emergency shutoff switch adjacent to the panel/VDU which would cause complete isolation and is the purpose and position of the switch known to all relevant individuals? It is usual for the ballast valves to move to the closed position in the event of power failure.</td>
<td>The maritime staff could immediately demonstrate their knowledge of the location and purpose of the emergency isolation switch. It was positioned adjacent to the mimic panel/(VDU) and was safely covered to prevent inadvertent operation. The operation of the switch was regularly tested and recorded. The majority of the ballast valves moved to the closed position on power failure, safely isolating the tanks.</td>
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<tr>
<td>18.</td>
<td>Partial ballast control system failure will require the system to be operated from alternative positions such as the solenoid racks or at the ballast valves themselves. It is necessary to ensure that each location has adequate information and clear communication with the control room. Does each of the secondary locations have adequate information and do they have clear communication with the control room?</td>
<td>The position of each alternative location was well understood and each location was well lit and had the necessary piping diagrams safely at hand. The ballast valves could be manually operated at the valves themselves and the necessary manual tools were readily available. The drawings indicated clearly the specific valves and valve numbers and each solenoid within the solenoid panels was clearly marked and related to the drawings. It was also clear as to which way each solenoid had to be moved to either open or close the respective valve. Communications were good at all the alternative locations and were regularly tested.</td>
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<td>19.</td>
<td>Are any of the ballast valves indicating incorrectly on the panel/VDU and are all the tank levels indicators working correctly? Are these faults repaired rapidly and are there spares for the system still available?</td>
<td>It was noted that all the valve indications were correct and that each tank level gauge was indicating clearly. Any faults were rapidly repaired and spares were readily available. A review of the maintenance log demonstrated that the panel was well maintained.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
<td>Poor practice</td>
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<td>20. Are emergency exercises simulating ballast system failures regularly carried out, particularly those utilising emergency hand pump operations, are the exercises recorded and any lessons learned taken note of?</td>
<td>Emergency exercises were logged and comments made as necessary. Ballast system exercises were carried out at regular intervals and the scenarios selected varied. Consequently personnel understood the arrangements and were well aware of the need to maintain clear drawings, valve and solenoid marking and each alternative location had good lighting and communication.</td>
<td>No record of regular ballast system emergency exercises could be found. Discussions indicated that this was thought to be unnecessary as the system worked well. Personnel struggled to complete a simple exercise where it was required to open a selected valve from an alternative location.</td>
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<tr>
<td>21 In the event of an unintentional heel or damage scenario is assistance from onshore available?</td>
<td>A stability model is maintained onshore with a competent person available on call 24x7 who can offer assistance in case of an unintentional heel/damage scenario. The stability model is updated on a regular basis with updated lightship weight and centre of gravity. The naval architect is familiar with the unit and trained in emergency response.</td>
<td>No stability model or competent person available onshore to support decision making offshore. It is not known whether the existing spreadsheet in the office correctly reflects the lightship scenario.</td>
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</table>
Appendix 2: Watertight Integrity.

Watertight Integrity

A floating installation consists of individual compartments many of which are designed to be watertight. Damage or flooding in a watertight compartment should be contained and should not be capable of migrating to an adjacent compartment. The majority of watertight compartments, of necessity, will be below water level. However, in the event of damage to the installation a number of compartments that were above the water line at normal operational draft may well be below the water line after damage. Therefore those compartments will also have to be maintained watertight as they will contribute to the vessel buoyancy and mitigate against any further flooding.

Watertight integrity should be maintained in specific compartments to meet intact and damaged stability criteria and for other compartments that may need to be protected against water ingress for operational and safety reasons (e.g. accommodation spaces, control rooms, spaces containing safety equipment etc.).

Reference in this and subsequent sections should be made to guidance in RR387 and in Offshore Information Sheet 4/2011.

Bilge System

Intact and damaged stability is controlled by means of the ballast system transferring water between dedicated ballast tanks and the sea. The bilge system is essentially only used to remove water that has collected, for a variety of reasons, in spaces which are not dedicated ballast tanks and transfer that water to the sea. Typically bilge water is extracted from machinery spaces, void spaces, column bracings, thruster rooms, pump rooms and similar normally dry spaces. The water that has collected in these spaces being the result of condensation, valve and pump gland leakage, spillage and drainage. Invariably the majority of the bilge water will be contaminated with oil and consequently the bilge water is typically pumped into a storage tank and then via an oily water separator, into the sea.

The water and oil extracted from each of the bilge suctions returns to the bilge pumps via the bilge main. Normally there are two or more bilge pumps in two or more machinery spaces and one of these in each space will be powered from the emergency switchboard. The bilge pumps are started and stopped remotely from the control room or rooms and in addition the bilge suction valves at the majority of locations will be remote operated. It is not unusual for a number of locations, which normally do not need bilge extraction, to be fitted with local manual control of the valves only. For example void spaces higher up in the columns of semi submersibles may only be fitted with manual valves. For areas considered to be at a higher risk of flooding, for example machinery spaces, it is not unusual to have a number of bilge wells draining the space, each fitted with a bilge alarm. As bilge alarms are the primary means of detecting leakage it is frequently necessary to have an additional high/high bilge alarm giving warning of rapid and excessive flooding.

Each bilge suction consists of a well into which the bilge water drains and the well is normally protected by a cover to prevent the ingress of material which could block the extraction pipe work. The bilge valve is connected to the well and each bilge suction is fitted in with a non-return valve to prevent the flow of water from the system back into the
well. Normally each bilge well is fitted with a float switch or a probe which alarms in the control room when the well is full, the alarm usually consisting of both a light and an audible alarm. The control room operator will acknowledge the alarm, which mutes the audible alarm but leaves the alarm light on, then starts the bilge pump and opens the required valve to drain the bilge well. When the level drops in the bilge well the float will drop and the alarm light will go off. Sometimes a bilge pump will be arranged to automatically start and run, the lights and audible alarms will operate as normal. However, there is a danger that the alarm will be muted but the pump continues to run unnoticed due to excessive flooding, even though the light is on. The practise of operating a bilge pump automatically is not recommended.

Bilge System Testing

The bilge valve status will be displayed clearly in the control room or rooms and it is vital that each alarm and light is operational. Bilge alarms should be tested regularly and at least weekly. Selected bilge floats are manually lifted and the display light and audible alarm are confirmed as operational. The buoyancy of float should be confirmed at suitable intervals and any automatically starting pump should also be checked. Probe type bilge alarms should have self-checking arrangements to ensure that no fault exists on the detecting circuit. Oily discharges to sea should be recorded in the vessel's oil record book.

Emergency Bilge Suction

In addition to the bilge system there is normally an emergency bilge arrangement drawing from the largest machinery space, the space most vulnerable to flooding. This takes the form of a bilge suction connected directly to one of the largest pumps, normally either a ballast or sea water lift pump. This pump will be arranged to draw large quantities of water from the emergency suction and will be powered from the emergency switchboard. The purpose of this arrangement is to remove water from the machinery space at a rapid rate in the event of flooding. There should be instructions available, local to the equipment, to enable the emergency bilge suction to be lined up to the pump, the system should be regularly tested.

Watertight doors and hatches

Access to all watertight spaces is required for personnel in order to allow inspection and maintenance. These spaces include ballast tanks only accessible from a pump room or a thruster room accessible from the adjacent engine room. In the case of dedicated tanks, for example those in the pontoons of a semi submersible or low down in the hull of a monohull then access will simply be by means of a watertight bolted hatch. Although care must be taken to ensure that the status of a particular bolted hatch into a tank is known a status light is not required. When the tank is vacated and personnel are temporarily not present then the hatch should be replaced and at least some of the bolts made tight in order to maintain watertight integrity. Ballast tanks on many semi-subss can only be accessed at transit draft and at sheltered inshore locations.

Access along the length of a semi submersible pontoon or monohull from machinery space to thruster room or pump room will be by means of a powered watertight door. Normal operation allows for local control only at each door but emergency operation ensures that each watertight door closes automatically after it is opened. In both local and emergency control arrangements it is possible for individuals to open each watertight door and safely
pass through although in the emergency condition it may be necessary to hold the opening handle or switch in the open position until the door is fully open and safe passage through has been achieved. It is normal for an audible alarm to sound locally and a light to flash in noisy environments adjacent to any watertight door that is in motion.

The status of all watertight doors will be displayed clearly in each control room as will the status of the local/emergency controls in place at the time. Testing of the doors and alarms should be regularly undertaken.

Remotely controlled watertight doors will have a stored hydraulic charge to operate doors in the event of loss of power, and a manual hand pump arrangement for use when stored pressure in the accumulator is depleted. There should be routine checks on watertight doors and other penetrations to ensure their ongoing integrity.

Regular vertical access may sometimes be required via a watertight hatch, for example through a column in a semi submersible to the pump room or propulsion room. In this case the watertight hatch will be alarmed as with the watertight doors and the status of the hatch will be displayed in the control room or rooms. It may not be remotely operable but will only be used when personnel require access to the lower levels. The individuals should always be in contact with the control room and they can thus be warned of the need to exit the spaces and close the hatch after they are clear.

A number of manually operated hatches and doors will be marked stating that they should “always be closed when afloat”, it should be confirmed that this is in fact the case.

**Watertight Space Ventilation System**

Of necessity the majority of spaces which are fitted with bilge extraction, and particularly those containing machinery and which are below the water line, will contain cool damp air. Without ventilation the machinery and pipe work as well as the structure of the affected spaces will soon corrode. In order to minimise the corrosion within these spaces they are connected to a ventilation system which in many cases will not only extract the cool damp air but also supply dehumidified air to the spaces. The ventilation system also assists in maintaining a safe atmosphere in the spaces.

Where there are a number of machinery spaces adjacent to one another, such as engine rooms, thruster rooms and pump rooms, the ventilation system may be common to them all, thus reducing the number of separate ventilation runs from the main deck. The danger of commoning up the ventilation system in this way is that the ventilation system pipe work itself would allow flooding from one space to an adjacent space if no controls were in place.

Therefore each individual space, which is required to remain watertight, will be fitted with isolation valves on the ventilation system pipe work suctions and discharges. In the event of a flooding incident the individual ventilation isolation valves will be closed ensuring that each space remains watertight and no flooding occurs in the space adjacent to the flooded space, the valves are safety critical.

As with the bilge system a ventilation valve status panel will clearly display in the control room or rooms, the open/closed status of each ventilation valve being shown by a light.
Again it is important to ensure that each ventilation valve is operable and the status displayed clearly on the panel. Testing should be carried out at regular intervals.

**Shipside Penetrations**

The machinery spaces of floating installations tend to be largely below sea level to ensure that the pumps within the machinery space have a positive head for pumping purposes. There will be a large number of penetrations through the hull of the vessel within each machinery space each acting as either a suction from the sea or a discharge to the sea connecting to typically, fire, ballast, bilge and cooling water systems. Additionally other penetrations will be installed for sewage systems and other drainage arrangements. Many of the discharge valves will be non-return valves, to prevent sea water from returning back into the system.

The shipside forms part of the watertight structure of the entire floating installation and, as such, each and every shipside penetration should be fitted with a valve to allow the penetration to be closed as and when required. If all the shipside valves were closed then the hull of the ship enclosing the machinery space would be fully watertight and there would be no risk of seawater encroaching into the enclosed machinery space. The shipside valves are Safety Critical Elements and should be recorded as such.

It is not unusual for a major piece of equipment forming part of a sea water system to fail, either through corrosion, erosion or accidental damage. Pipe spools, strainers and pumps have all been known to fail and the immediate effect is to allow the ingress of sea water from the sea into the affected machinery space via the respective shipside valves. The failure of a component within a major sea water system may lead to a massive and uncontrolled flow of water into the space.

Although machinery spaces are fitted with normal and emergency bilge extraction systems it has been found that the total bilge and emergency bilge extraction capability may be exceeded by the possible flooding rate into the machinery space via a failed component. In this case the only way to prevent total flooding of the machinery space up to the damaged water plane is to close the relevant shipside valves and prevent further flow of water into the space. A totally flooded machinery space will put out of action many systems including those which are Safety Critical. For example, ballast, bilge and inert gas generation and power generation sea water cooling.

It is therefore of great importance that maritime personnel are fully aware of the size and location of all the shipside valves. It is of equal importance that they are able to clearly demonstrate that each shipside valve is fully operable, will close fully and will isolate the system from the sea as and when required.

As the machinery spaces are generally unmanned it is necessary to ensure that each shipside valve, that isolates a system considered to be of sufficient diameter to pose a risk of flooding, is remotely operable. The remote operation may be directly from the control room or from a separate location above any damage water plane. Thus in the event of flooding remote closure of selected valves is always possible. Remote operation of all major shipside valves plus CCTV in the machinery space displaying in the control room gives the maximum opportunity to catch any flooding quickly before it becomes a major problem.
Where maritime personnel show a full knowledge of the size and location of all shipside valves, can demonstrate that all valves are operable and will isolate the necessary systems and that the larger valves may be closed from a remote location above the damage water plane then the risk of flooding is minimised. This is particularly the case where CCTV is installed and the bilge system is regularly tested.

**External Openings**

The requirements for watertight and weathertight openings depend on the distance of the opening from the damaged waterplane. Refer to RR387 for further information.

Of necessity openings at main deck level have to be protected from water ingress. For this reason air pipes leading to ballast, fuel and other tanks should be fitted with an anti-flooding device and ventilators, ventilation intakes and outlets that may be used during operation of the unit, while afloat, should incorporate a self-acting anti-flooding device.

Chain locker openings should either be fitted with a means of closure to prevent water ingress or it should be assumed, within the intact and damaged stability calculations, that the chain lockers will be flooded.

Doors and hatches allowing access to spaces within the vessel should either be weathertight, where the hatch or door is above any damaged water plane, or watertight where the hatch or door may be submerged after damage.

All of the above closing appliances should be able to withstand wave impact loads.

Any other external opening leading to spaces, the buoyancy of which is included to meet stability requirements, should be fitted with a weathertight-closing appliance that complies with applicable load-line requirements.

**Penetrations Outwith Design**

Over time offshore personnel will adapt the working environment to suit their way of working and to make life simpler. Sometimes this includes accidental but detrimental modifications to the structure which reduce the watertight integrity of the unit. A semi-submersible design may incorporate main deck level box girders which form part of the buoyancy after damage and these should be maintained watertight. It is not unusual to find that one or more penetrations have been cut or burnt in the deck of these spaces, to aid in the drainage of water which collects on the deck for some reason, the space is no longer watertight.

Any poorly maintained penetration within a watertight bulkhead or deck can allow water to pass through from one space to the next. Typical examples are cable ways that have been modified, pipes passing through a bulkhead which have been changed over time or corroded ventilation runs. Maritime personnel should check that all the watertight boundaries are in fact watertight.
### Bilge and emergency bilge arrangements

<table>
<thead>
<tr>
<th>Issue</th>
<th>Good practice</th>
<th>Poor practice</th>
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<tbody>
<tr>
<td>1. Are the bilge system arrangements clearly displayed within the control room or rooms? Are all of the valve status indication lights operable?</td>
<td>The bilge system was clearly displayed, each pump, pipe run and valve was shown, the system was easy to understand. Each of the bilge valve status lights was operable and spares were available as necessary. All the lights on the panel could be illuminated by the press of one button to check if they had failed. This check was regularly carried out.</td>
<td>Although the bilge system was displayed it was not very clear and a number of valve status lights had failed. This did not cause concern as it was a common occurrence, it was thought that there may be spare bulbs somewhere. If there was a button to check if the indication lights had failed its location was not known and consequently no checks had been carried out.</td>
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<td>2. How is it confirmed that the bilge valve floats and alarms are operable? Is any automatically starting pump checked?</td>
<td>All the main machinery space bilge valves including the high/high bilge valve were checked daily. The floats were manually lifted and the alarms both audible and illuminating confirmed as operable. A number of floats were tested as watertight by filling the bilge wells with water. One of the bilge pumps could be arranged to run on “auto” but the preference was to only use the manual start/stop function.</td>
<td>Sometimes, when an individual was in a machinery space he would test a bilge valve by lifting a float. This was not a daily occurrence and it was not known if all valves and floats had been tested. It was thought that the motorman did it although this was not checked. One of the bilge pumps could be run on “auto” and this was used all the time as it saved the CRO from starting and stopping the bilge pump each time the alarm went.</td>
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<td>3. Is it known how many different methods there are of extracting water from the bilges of the main machinery space?</td>
<td>The information was readily available and known to the control room personnel. The main machinery space had two independent bilge pumps, one of which was powered from the emergency switchboard and also a portable bilge pump. In addition one of the main ballast pumps was fitted with an emergency bilge suction and was powered from the emergency switchboard. Also the sea water cooling pumps could be connected to an eductor system as an additional means of bilge extraction.</td>
<td>No one was very sure but it was thought that there were two bilge pumps in the machinery space. A check with the electrician confirmed this was the case and that one was powered from the emergency switchboard. Although the bilge system display showed an emergency bilge suction on a ballast pump it had never been considered. No one knew if there was a portable bilge pump available and if there was an eductor system there were no records of it being used.</td>
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<td>4. Has the emergency bilge suction been tested?</td>
<td>It was common practice to check the operation of the emergency bilge suction which was connected to a ballast pump. However, as it was understood that the ballast pump system did not pass through the oily water separator it could only be tested when there was clean water in the bilges. It was found to be very effective. It had also been checked when powered from the emergency switchboard.</td>
<td>There was no record of the emergency bilge suction being tested but the maritime personnel were happy to give it a go, even though the bilges in the main machinery space appeared to be heavily contaminated with oil and the vessel was alongside in Invergordon. They tried to demonstrate that the relevant ballast pump could be powered from the emergency switchboard but were unsuccessful.</td>
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<tr>
<td>Issue</td>
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<td>5.</td>
<td><strong>A number of bilge valves will be solely manual in operation, is the location of these valves known and are they confirmed as operable?</strong></td>
<td>It was known that there were a number of manual valves within the bilge system but the location of all was not clear. A drawing was found that showed the locations and it was noted that a number had not been tested for some time. On attempting to test them a number were difficult to find and when they were found two or three were seized up and thus inoperable. No thought was given to accessing void spaces in heavy weather.</td>
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**Watertight doors, hatches and space ventilation system**

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<th>6.</th>
<th><strong>Are the panel lights/alarms indicating the status of all watertight doors and hatches operable? Are the doors, hatches and associated lights and alarms tested, both under local and emergency control?</strong></th>
<th>Most of the lights were operable and spares were being awaited. Dedicated testing was not regularly carried out as individuals passed through most of the doors on a daily basis, and no problems had been reported. Emergency control was believed to have been tested last trip but no records could be found.</th>
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<td>The mimic panel clearly indicated the status of each door and hatch, all lights were operable. The status indication was checked daily and those doors, which could be operated both locally and under emergency control were confirmed as operable under both local and emergency control whenever an individual passed through and on a weekly basis.</td>
<td>No procedure was readily to hand. It was not thought necessary to bolt a hatch back on during a break as no problems had been noted and, anyway, they would not be gone very long.</td>
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<td>7.</td>
<td><strong>There may be a need to enter a normally watertight space for some reason, via a manual bolted hatch. Is there a procedure in place to ensure that the watertight integrity is maintained when there are no personnel present, e.g. during a coffee break?</strong></td>
<td>A number of doors and hatches were marked to remain closed when afloat but the notices were showing signs of corrosion. One notice could not be seen when the door to which it applied was left open. The control room door was often left open on sunny days in order to cool the control room as the air conditioning was inadequate.</td>
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<td>A procedure was sighted and this was followed. In the event that it would be difficult to replace a door during a coffee break, for example because there were temporary lighting cables in place, then an individual would remain at the location until other personnel returned.</td>
<td>A number of doors and hatches were marked to remain closed when afloat but the notices were showing signs of corrosion. One notice could not be seen when the door to which it applied was left open. The control room door was often left open on sunny days in order to cool the control room as the air conditioning was inadequate.</td>
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<td>8.</td>
<td><strong>A number of hatches and doors will be clearly marked, indicating that they should remain in the closed condition when afloat. Are all such doors and hatches maintained closed, except for access when the installation is afloat?</strong></td>
<td>Those doors and hatches that were required to remain closed while afloat were clearly marked and well maintained. It was apparent that the doors and hatches were kept closed at all times except for access.</td>
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<tr>
<td></td>
<td>Those doors and hatches that were required to remain closed while afloat were clearly marked and well maintained. It was apparent that the doors and hatches were kept closed at all times except for access.</td>
<td>A number of doors and hatches were marked to remain closed when afloat but the notices were showing signs of corrosion. One notice could not be seen when the door to which it applied was left open. The control room door was often left open on sunny days in order to cool the control room as the air conditioning was inadequate.</td>
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<tr>
<td>9.</td>
<td><strong>The status of the watertight space ventilation valves will be displayed on a mimic panel in the control room. Are the panel lights/alarms indicating the status of all vent valves operable? Are the ventilation valves and associated lights and alarms tested regularly?</strong></td>
<td>The watertight space ventilation valve status was displayed on a panel. The panel was hidden behind other equipment and obviously not well maintained nor referred to at regular intervals. No records of vent valve testing could be found.</td>
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<td></td>
<td>The watertight space ventilation valve status was clearly displayed on a mimic panel. They were tested on a weekly basis and the time to move from open to close was recorded.</td>
<td>The watertight space ventilation valve status was displayed on a panel. The panel was hidden behind other equipment and obviously not well maintained nor referred to at regular intervals. No records of vent valve testing could be found.</td>
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<tr>
<td>Issue</td>
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<td>Poor practice</td>
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<tr>
<td>10. Is the location of each watertight space ventilation valve known? Has it been confirmed that the mimic panel accurately reflects the correct arrangement?</td>
<td>It was common practice for any new maritime individual to follow the system and check the location of each and every vent valve. It had been confirmed that the mimic accurately reflected the arrangements in place.</td>
<td>It was assumed that the mimic reflected the arrangements in place although no one had checked that this was the case. A walk round with a CRO found that not only was the mimic inaccurate but one valve was not in place. In effect two of the watertight spaces were in communication and it would not have been possible to isolate one space from the other in the event of flooding.</td>
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</table>

**Shipside Penetrations**

| 11. There will be a large number of shipside valves in the various machinery spaces of the vessel. Are the maritime personnel aware of the location and diameter of each and every penetration? The larger the penetration the greater the risk of flooding. How is it demonstrated that each valve will close and isolate each respective system? | A list of the locations and diameters of each shipside penetration was readily available in the control room. Those valves which were considered to be of such a size to cause concern in the event of flooding were highlighted. Modifications, where necessary, had been made to the relevant piping system to enable it to be proved that each valve of concern was operable and demonstrated clear isolation. | The total number, location and diameter of each shipside penetration valve was not known and had never been considered. It was thought that the important valves would be remotely operable. It was not possible to check if each large valve was operable and would isolate correctly as the piping arrangements had not been modified to allow for the necessary checks. |

| 12. Is the total capability of the bilge extraction system, including emergency bilge extraction, in a given space known? How does this compare with the worst case flooding from a large diameter sea water system? | The number, size and total capacity of the bilge extraction in each machinery space was known and had been compared to the worst case flooding event. It was known that if either of two of the largest piping systems failed then the bilge capacity alone would not be able to prevent flooding of the space up to the damage waterplane. Therefore it was understood that the respective shipside valves would need to be rapidly closed. | The total capacity of the bilge extraction capability in each machinery space was not known. It was assumed that it would be enough. No study had been done on the relative flooding rates from the largest piping systems. It was thought that closing the shipside valves would be adequate as most of them were remote operated. |

<p>| 13. Can each of the shipside valves, which are large and therefore considered to be of major risk in a flooding situation, be closed from above the damage waterplane? Are these regularly tested? | It was understood that the largest valves could all be closed from above the damage waterplane. The major valves were all remote operated from the control room and the operation was regularly tested. A number of valves could only be closed manually from outside the control room but the closing mechanism was well maintained and regularly tested. | Most of the largest valves could be closed remotely from the control room, a number had to be operated manually from outside the control room. A check confirmed that the majority of manual control stations were above the damage water plane although one was found to be below the damage water plane. It was found that the closing mechanisms of the manual valves were in poor condition and it was difficult to close the valves and in one case impossible without extensive maintenance being carried out. |</p>
<table>
<thead>
<tr>
<th>Issue</th>
<th>Good practice</th>
<th>Poor practice</th>
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<tbody>
<tr>
<td>14.</td>
<td>It is vital that rapid and clear indications of flooding in a machinery space are indicated in the control room. How is the CRO made aware of such a scenario?</td>
<td>In addition to the machinery space bilge alarms and high/high alarms a zoom, pan and tilt, CCTV system was fitted. This displayed in the control room and, in the event of a flooding incident, indicated clearly both the location and extent of the flooding. The CRO could therefore rapidly close the necessary valves.</td>
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<tr>
<td>15.</td>
<td>The majority of flooding incidents are foreseeable and the action to be taken for each event determined in advance. What procedures are in place for flooding events and are these procedures tested in emergency exercises?</td>
<td>Many possible flooding incidents had been considered by the marine personnel and the procedures for dealing with them determined. A manual was available in the control room which listed clearly the actions to be taken in the event of an incident. The procedures were used as the basis of some of the emergency exercises.</td>
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**External openings and penetrations outwith design**

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<tr>
<th>Issue</th>
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<td>16.</td>
<td>Ventilator openings at main deck level should be fitted with self acting anti-flooding devices. Is this the case and when were they last checked and tested?</td>
<td>It was recognised that each vent opening at main deck level had to be self closing in the event of being submerged, either through wave action or vessel damage. Each vent was checked to confirm that it was self closing and the devices were maintained as part of the planned maintenance regime.</td>
</tr>
<tr>
<td>17.</td>
<td>The chain lockers are open to the elements at main deck level. They can either be left open, in which case they must be assumed flooded in the damage stability calculations, or can be closed off. If they are to be closed off this may be either by manual means or by some mechanical device. How are the chain locker openings taken into account from a flooding view point and is this arrangement reflected in the stability calculations? Is the closing arrangement consistently applied?</td>
<td>Mechanical devices had been fitted at one time but were found unreliable and they were no longer used. Now the deck openings to the chain lockers were closed off manually with temporary cement bags. If this arrangement failed for any reason it was understood that the chain lockers had to be considered as flooded within the stability calculations and this eventuality had been simulated on the stability computer.</td>
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<td>18.</td>
<td>Watertight and weathertight doors and hatches will be so designated because of their location. Is there a drawing showing the designation of each watertight or weathertight door or hatch? Has it been confirmed that the doors are in fact as designated?</td>
<td>A recent revision of a series of drawings showing the location and designation of each watertight and weathertight door and hatch was readily available. The doors and hatches had been confirmed as being as shown in the drawings.</td>
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<tr>
<td>Issue</td>
<td>Good practice</td>
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<td>19. It is not unusual to find watertight spaces where, over time, individuals have cut or burnt holes in the watertight deck or bulkhead. Have all the watertight spaces been checked for this possibility?</td>
<td>The installation had recently changed ownership and the new marine staff appreciated the risk to watertight integrity of holes in decks and bulkheads. Each space had been checked and one or two minor repairs found necessary. All individuals had been made aware of the dangers and a weekly walk round inspection confirmed that no further watertight spaces had been breached in this way.</td>
<td>The risk was not appreciated and some individuals did not realise that parts of the deck structure at main deck level had to be watertight and aided in the residual buoyancy in the event of damage. An inspection found that a hole had been burnt in the deck of the welding shop to allow water to drain to the sea, thus breaching the watertight integrity. It was not usual to carry out an inspection of these areas.</td>
</tr>
<tr>
<td>20. Cable ways and pipe penetrations through watertight boundaries are regularly disturbed when maintenance is being undertaken. Has it been confirmed that each cableway and pipe penetration has been made fully watertight following any such maintenance?</td>
<td>Recent extensive work had been carried out both in dock and on location and the risk to watertight integrity was known. After the work was finished an inspection by the marine staff had found that a number of cableways and one pipe penetration had to be made good. They were now satisfied that each space designated as watertight was now watertight.</td>
<td>It was not common practise to check if cableways and pipe penetrations had been disturbed, it was assumed that those working on them would know what to do. A check around the installation found a number of cableways clearly non-watertight and one bulkhead pipe penetration open to both watertight spaces. Personnel were surprised at the findings.</td>
</tr>
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Appendix 3: Mooring Systems.

Loss of Position

Loss of position of a floating installation can easily lead to collision with an adjacent installation, or to the release of hydrocarbons from fractured drilling or well operations risers. Hence, loss of position is clearly a hazard ‘with the potential to cause a major accident’ and requires evaluation within the safety case. The mooring system, equipment and arrangements are consequently, SCE, Safety Critical Elements.

Breakage of a mooring line is an incident that is reportable under the Offshore Installation and Wells (Design and Construction, etc) Regulations 1996 [DCR]. A single line failure should not lead to a loss of position outside of allowable limits. Multiple line failure however remains a possibility. Loss of position outside of defined operational limits is reportable under RIDDOR.

Mooring System Design

HSE expects that the mooring system will be designed, constructed, operated, and maintained in accordance with recognised standards to meet the metocean conditions that prevail in the area of operation. Offshore Information Sheet 4/2013 gives guidance on what HSE regards as good practice. In essence, the preferred standard is ISO 19901-7 including aspects of the Annex B.2 requirements. Where this is not achieved in full, as may be the case for a number of existing installations, it is expected that a risk assessment is made of the alternative standard that is proposed. Standards that are recognised as current industry practice include API RP 2SK; DNV-OS-E301; NMD 998; and Lloyd's Rules for classification of a floating offshore installation at a fixed location.

The particular mooring type has characteristics that require to be investigated to develop a mooring inspection plan that is appropriate for the expected life of the mooring. Further guidance is available in O&GUK Mooring Integrity Guidance. FPSO mooring types include fully weather-vaning systems (which require no heading assist; heading control systems that require thrusters to maintain a chosen heading; and thruster-assisted systems where thrusters are used directly to limit mooring tensions in the prevailing weather).

Mooring Lines

The mooring lines will either be formed from chain, wire or fibre ropes. Sometimes, for specific purposes, the mooring lines will consist of combinations of the above. In that event the connections between the different types or diameters of mooring line should be considered as possible points of weakness. Sub-surface buoys may also be used to support sections of the mooring line.

An integrity management system needs to be in place as described in HSE Offshore Information Sheet 4/2013 and O&GUK Mooring Integrity Guidance. Further information and guidance (although not so recent) is available in HSE report RR444. The integrity management system should include assessment of deterioration mechanisms (typically wear, corrosion and fatigue); inspection scope; and suggested discard criteria. Further information that can be gathered that assists the assessment of mooring system...
performance includes data from tension monitoring systems; line break detection systems; chain refreshment programmes to limit wear at fairleads

Mooring Chains

Mooring chains will be stud-less or stud link and manufactured as part of an automated process that provides for greater consistency. Associated with the chain type will be an ‘R’ or ‘K’ number, R3, R3S, R4, R5, and R6. The ‘R’ number relates to the material properties, particularly its ultimate strength, yield, impact, proof and ultimate breaking strength. Also associated with the type of chain will be its diameter ‘D’, where ‘D’ is the bar stock diameter from which the chain is formed.

Mooring discard criteria will be based upon loss of diameter, evidence of fatigue cracking, gross deformation and stud looseness in the case of studded chain. For chains that are recovered to the surface for inspection the condition can be assessed by specialist companies. However, for some FPSO's where the chain cannot be easily recovered in situ diameter measurements can still be taken using ROV’s. API RP 2I and DNV-OS-E302 give further guidance on the inspection requirements for mooring chain.

Studded chains tend to be used when there may be a need to retrieve the chains back into a chain locker. The studs reduce the risk of the chains “knotting up” within the chain lockers. Hence most MOUs have studded-chain.

Mooring Wire / Fibre Ropes

For wire and fibre ropes there will be a construction specification typically in accordance with DNV-OS-E303 (fibre ropes) or DNV-OS-E304 (wire ropes), together with the ropes minimum breaking strength, axial stiffness, cross sectional area and class of galvanisation in the case of wire rope.

Used wire rope discard criteria should be in accordance with API RP 2I ; DNV-OS-304; ISO 4309:2010 or by following O&GUK Mooring Integrity Guidelines principles. Inspection needs to look at distributed and grouped broken wires, broken wires at the rope terminations, utilisation of fatigue life, internal and external corrosion and gross deformation such as bird caging etc.

Defining discard criteria for fibre rope is much more difficult and has in the past been based upon testing of insert pieces. Due to the difficulties associated with recovery and testing of inserts and due to the relatively good long term behaviour of fibre ropes, any marked loss of diameter, abrasion, wear, cuts to the fibre will require specialist advice and could be grounds for replacement. Guidance is available in DNV-OS-E303; ABS Guidance Notes for Fibre Ropes for Offshore Moorings; and API-RP-2SM: Guidance for synthetic ropes. Factors for consideration are protection from sand ingress; sheathing of rope; end terminations and protection from mechanical damage; creep of rope; tension monitoring; excursion measurement and defined limits.
Types of Mooring Systems

For the purposes of this inspection guide, mooring systems have been divided into three types: Mobile Offshore Units (MOU) and Floating Production Units (FPU), also including the cylindrical Sevan units; Weather-Vaning FPSO; and Active Heading Control FPSO.

MOU includes the semi-sub drilling units (MODU). Flotels are a special type of MOU, which by their nature are working in close proximity to other installations, and often for a prolonged period of time – both of which are factors influencing the design and inspection requirements for the mooring system.

An FPU is typically a converted semi-sub MODU design. The mooring system will be similar to that for the MOU. However, the essential difference is that the moorings are required to function as a permanent mooring system. The Sevan FPSO has similarities to the FPU in that no turret is required to allow changes of heading of the production installation. The addition of storage inevitably increases displacement and mooring strength requirements.

Passive controlled units will not have heading control. Moorings will usually be directly attached to the mooring spider below the turret, the turret will be closer to the bow of the vessel, and mooring winches will not be fitted. On these types of FPSO, the moorings cannot be recovered for in air inspection and any degradation occurring will need to be identified and managed through in-water inspection.

Active controlled units will have thrusters to maintain a specific heading into the environment and will typically have individual mooring winches that will allow optimisation of line length to reduce wear at fairleads. This system has the potential to allow for in air inspection, or replacement of damaged mooring line. The turret will be near the centre of the vessel length.

MOU Moorings (Temporary Systems)

MOU moorings are denoted as temporary since the installation will only stay in one location for a matter of months, it will then recover the moorings which will allow for a very general inspection, and redeploy at a different location. Mooring lines will be able to be closely inspected when the unit is dry-docked, usually every 5 years. This increased inspection allows lower corrosion and wear allowances than for permanent moorings. Variations in location and water depth should ensure that individual components (chain links and wire sections) are not constantly subjected to wear due at fairleads, and at touch-down zone.

The moorings will be spread laid rather than grouped and normally each line will terminate in a drag embedment anchor. Tension monitoring will be through load cells and this information should be available in the anchor winch house and from within the CCR. Tension load cells should be calibrated and there should be some assurance that the fairleads run smoothly especially for chain mooring systems. As installations age there is an increased risk of wear in fairlead pockets which may lead to the chain jumping pockets and increasing wear.

For MOU designs there should be an emergency release system to slacken selected mooring lines, for example on one side of the MOU, such that in the event of a well-related
fire or blowout etc., the release can be activated and the stored energy in the catenaries will move the installation off location. It will generally not be possible to test the release system; instead some limited simulated testing may be arranged.

The winch brake maintenance procedures should be inspected for some assurance as to the ultimate holding capacity of the braking system, and procedures as to when winch pawls may be used.

Flotel moorings may well require variation to a regular spread mooring pattern due to adjacent structures and mid-water buoys to support mooring lines over subsea infrastructure and pipelines. Site specific mooring analyses will be prepared to client requirements and should take account of OIS 4/2003 guidance.

The mooring chain is most likely to be of stud link variety and generally of much smaller diameter than chain for permanent mooring system. MOU moorings will be subject to classification requirements including five yearly special periodic surveys, where the entire mooring line is laid out dockside and subject to general visual, dimensional, and MPI survey. Retirement criteria will be based upon stud looseness, fatigue cracking, and loss of cross sectional area.

**Floating Production Units (Semi submersible or Permanent MOU Design)**

FPU Units are typically based on converted MODU designs with the drilling packages removed and replaced with processing facilities. The moorings may have been increased from eight to either 10 or 12 to reflect the permanence of the design. The moorings will run from the chain locker or wire drum to a mooring winch then outboard over a, normally, submerged fairlead through the catenary and onto the seabed. The moorings will typically terminate at suction piles or drag embedment anchors around 2km from the installation. As the moorings are spread around the installation the heading of the FPU will essentially be fixed.

If the installation has individual winches and drag embedment anchors then it will be possible to recover the moorings to either an anchor handler vessel or the installation itself for periodic in air inspection. However, the process of recovering the moorings can impart additional wear and damage through grappling or chasing the chain through the catenary and grounded sections. The periodicity of mooring retrieval should be based on the need; to replace components at the end of their life or, to confirm wear rates as part of the integrity management strategy.

Increased wear points will typically be; at the attachment to the FPU (chain held on the winch, or wire as it is spooled onto the drum), wire or chain passing over the submerged fairlead, and at the touchdown point with the seabed (where intermittent thrashing motion can increase wear). Additional wear can occur around the anchor attachment or throughout the length of the mooring depending on the recovery process. Increased wear can also occur at chain/fibre or chain/wire connections.

**Weather-Vaning FPSO (Passive System, Moorings Directly Connected)**

The mooring is typically connected to the mooring spider underwater; there are no winches to allow for tension optimisation or recovery of the moorings, and once installed the moorings will require in-water inspection to provide assurance that the mooring system
continues to be in an acceptable condition. Further information is available in O&GUK Mooring Integrity Guidelines.

These moorings are typically installed through an underwater trumpet mechanism. The mooring line is installed through the bell mouth, and is orientated into a cruciform through angle orientation guides and is fixed in place by two latches that provide a seating for the uppermost link.

The various wear regions within the trumpet mechanism are not easily inspectable through conventional means, and typically, the full extent of wear can only be determined once the mooring has been removed. Since the costs of removing the mooring chain to check for damage are so large most operators have avoided this, and instead are relying on limited inspection and wear prediction models.

Typically, there is no direct means of tension measurement with this type of mooring system; rather the line departure angle from the trumpet and the trumpet angle itself should indicate any potential imbalance between various line tensions. It is also important that the operator be able to detect a mooring line failure within a reasonable period of time, typically one day, though real time monitoring would be preferable. If the operator depends on the trumpet angle falling to vertical to detect for a failure then this needs to be confirmed as soon as possible.

The turrets used on passively moored FPSO’s are usually assumed to be frictionless such that the heading of the turret does not move as the vessel rotates due to the environment. However, there are cases of appreciable friction occurring that can exacerbate wear of the moorings in the region of the trumpet. It is reasonably practicable to monitor the relative rotation between the turret and the vessel; any friction build up would be detected by an uncharacteristic fast rotation or jerk between the turret, and the vessel itself, potential friction build up might not be detected by simply standing on the turret.

**Active Heading Controlled FPSO (with Mooring Winches)**

These monohull installations will typically have a turret near to the centre of the length of the vessel and will use thrusters to maintain a heading into the prevailing environment. The mooring winches will typically be mounted onto the geo stationary turret and allow for tension adjustments. The winches will also allow for mooring recovery such that the mooring lines can be periodically inspected in air.

Wear points similar to MOU FPU designs will be associated with wire or chain held at the winch, components passing over fairleads and around the touchdown location with the seabed.

The thrusters will control the installation’s heading into the environment, and a turret turning mechanism that pushes and pulls the vessel around the turret may assist this turning moment. Due to the relatively large friction effects that can exist between the turret and the vessel, high frequency wave induced yaw motions may be transferred into the mooring especially around the fairleads that can in turn increase wear. Another problem that has been experienced on at least two North Sea FPSO’s is that, in the event of loss of thruster control the installation’s heading can be driven off by the wind loading causing the turret and moorings to twist up. In extreme cases, and if turret breakout does not occur, the moorings can contact the subsea risers.
There are other systems (STL for example) which are described as dis-connectable systems. Risers are attached to a conical buoy which is then latched into the turret structure. Mooring lines are usually made from wire rope in such systems (to limit the weight that the buoy supports when released). Such systems will not normally have tension measurement. In-water inspection will be required to confirm the condition of the moorings.
### Appendix 3 – Mooring Systems - Example questions and findings demonstrating good and poor practice

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<tr>
<th>Issue</th>
<th>Good practice</th>
<th>Poor practice</th>
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<tr>
<td><strong>Mooring System Design and Construction</strong></td>
<td>The verification scheme clearly showed the mooring system and its components as an SCE. The Performance Standards were realistic and the Assurance Activities had been carried out. The ICP had made a number of small comments and these had been dealt with within a short time.</td>
<td>Only parts of the mooring system were included within the verification scheme. The Performance Standards were vague and only some of the Assurance Activities had been completed, (apparently it had been windy for the last few months). Over the last two years corrective comments had been made by the ICP but no action had been taken on them.</td>
</tr>
<tr>
<td>1. The mooring system and its components are Safety Critical. Does the verification scheme clearly show this? Are the Performance Standards realistic and have the Assurance Activities been undertaken? Has the ICP made any comments?</td>
<td>For those individuals required to operate the mooring system the company has a policy of employing individuals from a marine environment. They are required to demonstrate that they have experience with similar systems. There is in addition in place a company sponsored training programme which ensures that all individuals required to work with the mooring system are conversant with the vessel specific systems. New individuals were required to work under supervision before working alone.</td>
<td>Most of the individuals who were required to work with the mooring system had worked offshore before and had a reasonable idea as to what was required. It was believed that they would soon pick up what was needed. There was no training scheme in place. New starts were not required to work under supervision and soon picked up what was needed. There had been no major problems with the maintenance and operation of the mooring system.</td>
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<tr>
<td>2. The mooring system requires to be operated and maintained effectively. How is it demonstrated that onboard personnel are competent to operate and maintain the mooring system?</td>
<td>Identification of all components of the mooring system was available, (most information was retained onshore). The anchors, mooring chains, permanent and temporary, (kenter link) connectors and shackles were listed and the identification recorded. Also identification information on the fairleads and windlasses was available. An auditable trail was apparent for the mooring system components.</td>
<td>Some information was found on board and some was made available after reference to the onshore offices. It could not be confirmed if the information was up to date and there were doubts expressed as to the accuracy of the information found. It was thought that the necessary documentation was incomplete. There was no auditable trail in place.</td>
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<td>3. Are all the individual components of the mooring system identified and is that information available?</td>
<td>Over the years a number of components had been changed. For example two chains had been replaced due to localised wear taking place. The changes, and the reasons for them were accurately recorded and the information was readily available on board and onshore.</td>
<td>It was thought that the previous operator had changed out one of the mooring lines. However, the information was not readily available as the necessary documentation had not been handed over at the time. This did not give rise to concern on board as no other failures of the mooring lines had occurred to date.</td>
</tr>
<tr>
<td>4. Have any changes been made to the original design and have these changes been recorded?</td>
<td>Records are retained on board of the vessel maximum offsets and heave, pitch and roll motions. These are combined with the mooring line tension records which together give a clear indication that the mooring system still meets with the original design. Maximum limits are approached, but not exceeded.</td>
<td>Although the mooring tensions appeared to be higher than they used to be no mooring lines had failed and the higher tensions were put down to global warming. Records were not retained of vessel maximum offsets and motions. It could not be demonstrated whether the maximum offsets had been exceeded.</td>
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<tr>
<td>5. The mooring system will have been designed for specific environmental conditions over the field life. How is it confirmed that the mooring system still meets with the original design parameters?</td>
<td>Records are retained on board of the vessel maximum offsets and heave, pitch and roll motions. These are combined with the mooring line tension records which together give a clear indication that the mooring system still meets with the original design. Maximum limits are approached, but not exceeded.</td>
<td>Records were not retained of vessel maximum offsets and motions. It could not be demonstrated whether the maximum offsets had been exceeded.</td>
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<td>Issue</td>
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<td><strong>MODU and MOU Temporary and Permanent Mooring Systems</strong></td>
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<td>6.</td>
<td>On a MODU or MOU with a standard mooring system it is necessary to be fully aware of both the mooring line tensions and the distance out to each anchor. How are the tensions and “line out” distances determined and is the system fully operational? How are the tension and line out parameters validated?</td>
<td>Each double mooring winch was fitted with two hydraulic load cells which displayed the mooring line tensions, both in the winch house and in the CCR. Also the line out distance of each mooring line at each winch was displayed locally in the winch house and the CCR. All the displays were functioning, both locally and in the CCR. These were recorded every 12 hours, or more frequently in bad weather. As the vessel went into port or sheltered waters regularly the opportunity was taken to calibrate the load cells and “line out” meters. Records were maintained of the calibration frequency.</td>
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<tr>
<td>7.</td>
<td>The mooring tensions are adjustable and may be used to allow for severe environmental conditions? What is the maximum tension for operating the winches?</td>
<td>The mooring tensions were adjustable and when particularly heavy weather was forecast they were adjusted according to a written procedure, this was common practise. The maximum operating tension of the winches was known and displayed both locally and in the control room. Procedure did not allow this to be exceeded.</td>
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<td>8.</td>
<td>Is there an emergency release facility? If so how is it confirmed as being operational?</td>
<td>There was an emergency release facility, which was considered to be an SCE and it could be operated both locally from the winch house and remote from the winches in the CCR. Stored energy was used to release the respective brake and lock pawl. When the opportunity arose, for example when the mooring line was in the chain locker, the various components of the emergency release mechanism were tested individually in a safe and controlled manner.</td>
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<td>9. The windlasses of a MODU are used extensively as the vessel regularly moves from location to location, running and retrieving mooring lines each time. What is the condition of the windlasses and how is it ensured that these SCE items are well maintained?</td>
<td>The windlasses were maintained as much as possible on location. Where this could not be done arrangements were made to go alongside or into sheltered waters where more extensive repairs and maintenance could be undertaken. It was ensured that operational personnel were always present during the repairs. Records of the work carried out to the SCE mooring system were available on board.</td>
<td>As an accommodation unit the vessel remained on location for many months at a time and the windlasses were consequently not used as extensively or as frequently as a MODU. Personnel had, however, expressed concern as to the overall state of the mooring equipment. The vessel had been alongside a shipyard where repairs were undertaken but operational personnel were not present during the repairs. On being handed back to the operational personnel they were unhappy with the work that had been carried out to the vessel SCE mooring system. Onshore staff were not sympathetic to their concerns.</td>
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<td>10. The mooring system includes windlasses which allow for individual tension adjustment and retrieval. When were the mooring lines last inspected?</td>
<td>Although the MOU was on location for some years the opportunity was taken, during the summer months, to retrieve and inspect one of the mooring lines. The majority of the mooring lines had been inspected over time both visually and by MPI means. All records of these interventions were retained on board and no major concerns had been found.</td>
<td>No mooring lines had been retrieved and inspected during the eight years that the MOU had been on location. No problems with the mooring system had been recorded. It was not known what state the individual mooring lines were in and there was doubt as to whether the mooring windlasses would be capable of handling the mooring lines after eight years.</td>
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**FPSO Passive Mooring System**

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<td>11. Does the turret move freely without any apparent friction between the turret and the vessel? How is this checked and how is minimum friction maintained?</td>
<td>The turret of this passive mooring system moved freely and no build up of friction had been noted. This was regularly checked by comparing the angular position of the turret with fixed points such as an adjacent platform and noting any discrepancies in rotational angle. The turret, its bearings and lubrication system were well maintained and checked.</td>
<td>Although the turret was thought to stick a little this did not give cause for alarm as no damage had been done. The marine staff checked for friction, when they were in the vicinity, by standing on the turret and watching the vessel rotate around it. When checked against the position of a fixed structure near by it was apparent that the turret was sticking frequently. There was no procedure to check this regularly. Any records of the maintenance to the turret, bearings and lubrication system were not available.</td>
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<tr>
<td>Issue</td>
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<tr>
<td>12. <strong>How is the failure of a mooring line detected?</strong></td>
<td>Excursion is monitored and compared with expected values based on prevailing environment conditions. However, it was understood that a failed line would not immediately be detected. Therefore a small “suitcase” ROV was retained on board and, dependant on weather when the opportunity arose, the ROV was launched and the spider area inspected. The findings were recorded as comments in the verification system.</td>
<td>It was understood that no component of the mooring system was visible from the main deck. It was incorrectly thought that the vessel offset and operational envelope would be affected to such an extent that it would immediately be apparent that a line had failed. No alternative means of detecting a failed mooring line was available. No records of any other check on mooring line failure could be found.</td>
</tr>
<tr>
<td>13. <strong>What action is taken in the event of a failed mooring line? Are operations shut down?</strong></td>
<td>A failed mooring line is a serious concern and, in the event that a mooring line did fail, operations would immediately cease. Depending upon which line had failed, the weather conditions then and in the future and compliance with the design parameters, the decision to recommence operations would be made. Procedures were in place for this eventuality. Plans were also in place as to how to change a failed line.</td>
<td>Marine personnel were of the opinion that it was highly unlikely that a mooring line would fail, none had as yet. Even if one did operations would continue as normal, there were after all 12 separate mooring lines. No procedure was in place as to what action to take in the event of a single line failure. No plans were in place as to how to replace the failed mooring line.</td>
</tr>
<tr>
<td>14. <strong>Typically the mooring lines enter the turret spider via a trumpet mechanism. The mooring line wear regions within the trumpet mechanism are not easily inspectable through conventional means, and typically, the full extent of wear can only be determined once the mooring has been removed. How does the Duty Holder inspect and determine the extent of wear within the trumpet mechanisms?</strong></td>
<td>It was well understood that a full inspection of the trumpet area was impossible without removing the mooring line. The company worked with other FPSO and FSU operators to create a wear prediction model and this was used and regularly updated as more information became available. Limited inspection of the trumpet and spider area was also possible using an ROV. In addition the use of divers was being considered assuming that the weather was very good and there was little or no vessel motion.</td>
<td>There was no wear prediction model in place and offshore personnel were unaware that other operators shared information for this purpose. Onshore personnel were aware of this practise but the company did not participate. Reliance for inspection was placed upon the use of an ROV, although the dedicated ROV had been damaged during the last attempt at inspection, and was currently unavailable.</td>
</tr>
<tr>
<td>15. <strong>What standards have been used for the mooring equipment? Is information available either offshore or onshore to demonstrate that appropriate standards have been used for the mooring equipment?</strong></td>
<td>It was recognised that the mooring equipment was designed basically to the Class/ISO standard but had been enhanced during the design stage. Class had been heavily involved in the application and enhancement of the standard. Information was not available on board to demonstrate compliance with the appropriate standard but it was readily to hand in the onshore offices. The information was up to date and reflected inspection and comment by Class.</td>
<td>It was not known what standard was applicable to the mooring equipment of the installation and it was thought that this information would be available in the onshore office. It was stated onshore that the company had only recently taken over operation of the installation and it would appear that some of the information had not yet been handed over. The mooring equipment standard and design was missing and despite efforts to obtain the information it was not as yet available.</td>
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<tr>
<td>16. As thrusters are required to maintain the correct heading how is it ensured that the maritime operational staff have the competence to deal with a situation where there is a sudden thruster control failure?</td>
<td>The risk of thruster failure was understood and had occurred on a similar installation. Following the failure personnel had attended a DP training course. Procedures had now been produced to cover the foreseeable events and emergency exercises were carried out regularly to ensure that the staff were competent to deal with such events.</td>
<td>The thrusters had never failed, or at least there were no records of a failure, they were therefore considered very reliable. No procedures were in place and no emergency exercises had been carried out. When sample control failure events were discussed it was apparent that no one individual knew what action should be taken in such an emergency.</td>
</tr>
<tr>
<td>17. On an FPSO with an “active” mooring system how is it ensured that wear on the mooring line components, in way of the turret is minimised?</td>
<td>It was understood that, due to vessel motions and varying mooring tensions, wear would eventually occur on parts of the mooring line. That is those parts in contact with points on the turret and guiding structures. In order to reduce this to a minimum there was a procedure in place to regularly move each mooring line a short distance by using the winches installed, to either pull in or pay out each line as required. The distances were small and had no effect upon the overall system tensions and offsets. The movements made were recorded and the winches were well maintained.</td>
<td>There was only one winch, centrally positioned at the top of the turret, in good weather and on a slack tide it was originally designed such that the vessel could be rotated around the turret allowing the single winch access to each mooring line in turn. This was designed to both allow for installation and retrieval of the mooring lines and to make adjustments as necessary. No records of the winch being used to move any of the mooring lines could be found and no procedure was in place. It was found that the single centralised winch could not be used as it had seized up. It was eventually replaced at some high cost and time penalty.</td>
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<tr>
<td>18. The thruster mode of control can be manual, automatic, heading control, tension damping or position control. Is the thruster mode of operation clearly defined?</td>
<td>Written procedures, retained in the CCR clearly defined the mode of control to be used. It was understood that if a different mode was selected from that defined then personnel confusion could result. Different modes may occasionally be selected but in each case a written procedure was required and it was ensured that all the relevant personnel were made aware of the change and the implications of it.</td>
<td>A number of different control modes were used, the choice of control mode depending upon the situation at the time. In one case the vessel heading had nearly been lost due to a misunderstanding between personnel during a shift changeover. It was still not thought necessary to clarify the control mode in writing as the individuals had been reprimanded and it would not happen again.</td>
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<td>19. <strong>Given that the installation is going to remain on location for a number of years how is it ensured that the thrusters are maintained and, if necessary, repaired.</strong></td>
<td>It was understood that the thrusters had been deliberately over specified for their role and the vessel should operate successfully with a small reduction in the number of thrusters. In the event of a clear weather window they were designed such that it was possible to remove and replace a thruster on location although this had never been done. As a last resort the vessel design allowed for the ability to disconnect from the moorings and risers and go into sheltered waters. The thrusters could then individually be lowered out of the vessel hull and be removed, repaired and replaced before returning the vessel to the original location and reconnecting. It was noted that personnel operated the thrusters with care.</td>
<td>The thrusters had been used for many years and had given no cause for concern. However, it had been noticed recently that two of them were losing hydraulic oil and were a little more difficult to control. The thrusters could not be removed with the vessel afloat. Although in theory the vessel could be disconnected from the moorings and risers and moved to a dry dock little consideration was being given to this possibility as it was believed that the cost of the operation would be excessive and the vessel may not return to the location. There was no other contingency in place and onshore personnel appeared evasive.</td>
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<tr>
<td>20. <strong>In the event of total thruster failure what consideration has been given to the possibility of the vessel heading being blown off position by the weather? In this event the turret may twist and in the extreme case cause the moorings to impact the risers</strong></td>
<td>A lot of thought has been given to thruster and control failures and emergency exercises were carried out regularly. The spacing of the mooring lines and risers made it extremely unlikely that there would be any contact between them. Also free running of the turret was seen as a high priority and lubrication and maintenance of the turret to vessel interface was regularly undertaken.</td>
<td>The complete loss of thrusters had not been considered and no emergency exercise covered this eventuality. No thought had been given to the possibility of the turret twisting and it was not known what effect this would have on any possible impact between the moorings and risers. Vessel heading had been lost a number of times but had been recovered. The turret lubrication system was covered as part of the planned maintenance system.</td>
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**Appendix 4: Dynamic Positioning Systems.**

**Loss of Position**

The hazard of loss of position of a floating installation can lead to collision with an adjacent installation, or to the release of hydrocarbons from fractured drilling or well operations risers. Hence, loss of position is clearly a hazard ‘with the potential to cause a major accident’ and requires evaluation within a safety case. The Dynamic Positioning (DP) system, equipment and arrangements are consequently, SCE, Safety Critical Elements.

Thruster assisted mooring systems will use equipment based on DP systems for the monitoring of position and the control of thrusters.

**The Dynamic Positioning System**

In its simplest form the DP system consists of a number of power generation units, propulsion units and sensors in combination with a sophisticated management or DP control system. The DP control system taking the information from the sensors and correcting the vessel heading and position by determining where the vessel needs to be and adjusting the direction and power of the thrusters accordingly.

DP Systems and their operations are detailed within IMO MSC/Circ.645 – “Guidelines for Vessel’s with Dynamic Positioning Systems’, 1994”, which provides, and is accepted as, an internationally recognised standard. The International Marine Contractors Association (IMCA) produces a wider range of guidance information on DP systems and their operation.

**DP Control System**

The DP control system which consists of the necessary computers, displays and controls will, depending on the class of DP, be duplicated, (in some cases triplicated), and components will be well segregated.

Separation and segregation of the control stations, the manual and automatic controls, and the control computers is essential as is a well distributed connecting cable work. The aim always being to ensure that effect of the loss of any one critical component or area on position keeping is minimised.

**Power generation units**

For DP2 and 3 installations the Power generation capability should be adequate to ensure that station keeping is maintained following worst case single component failure most likely to be loss of one Main Switch Board. Additionally for DP3 this worst case can include loss of a machinery space through Fire and Flood.

DP1 Installations need not comply with either of these requirements and is thus reserved for only non –safety Critical installations.
It should be noted that DP rules and guidelines require only that DP vessels be able to maintain station following a single failure for long enough to safely terminate the work in progress.

**Propulsion units**

A DP vessel is subjected to environmental forces such as wind, wave, and current and, in order to maintain a certain position, these forces have to be counteracted by the vessel’s thrusters. The total forces must be controllable from zero to full power, and through 360°.

A variety of thruster options are available to generate thrust for station keeping.

1) **Azimuthing thrusters**, (can rotate through the full 360 degrees). The most popular thrusters, applied for transit as well as station keeping for Monohull and Column Stabilized DP units.

2) **Fixed direction thrusters**, which includes both:

   - In line conventional propulsion systems, which are used widely for transit as well as station keeping where they provide thrust in the longitudinal direction on ship shaped DP vessels, (OSV’s, diving support vessels and pipe-laying vessels).
   - Transverse tunnel thrusters which are installed in the bow and/or stern of vessels to provide transverse thrust and forces for yaw manoeuvres.

3) **Hybrid concepts utilizing a combination of azimuth thrusters and fixed-direction thrusters** are also used.

**Sensors**

The sensors used by a DP unit will include a selection of:

1) **Position reference sensors**
2) **Sensors used for environmental monitoring**
3) **Vessel Motion Sensors**
4) **Draught sensors.**

1) **Position Reference Sensors**

   Position reference systems are either Absolute or Relative. An Absolute system gives vessel geographical position. A Relative system gives vessel position in relation to a reference point (e.g. TLP or Spar).

   Typical Absolute system sensors
   DGNSS, Acoustic, Taut wire and Inertial, (combined with Acoustic or DGNSS).

   Typical Relative system sensors.
   Artemis, Laser, Radar, DARPS and Gangway

2) **Environmental monitoring sensors**

   Examples of sensors used to monitor the environment include Doppler weather radar, Doppler current profilers, Riser stroke position (DP MODUs) and Acoustic Doppler Current Profilers (ADCP).
3) Vessel motion sensors
Typically Gyro compasses, Vertical Reference Units (VRU's) and wind sensors.

4) Draught sensors
Sensors used include Transponders, beacons and acoustic BOP’s

**DP Equipment Class**

IMO Marine Safety Committee Circular 645 (MSC 645), ‘Guidelines for Vessel’s with Dynamic Positioning Systems’, 1994, defines three DP equipment classes which are intended to provide different levels of station keeping reliability which can be matched to the consequences of loss of position. The three equipment classes are defined by the effect of failure and the nature of the failures which must be considered.

Class Societies will assign their class notations for DP systems based on these IMO Guidelines and their own requirements.

**IMO Equipment Class Definition.**

**DP Class 1**
Loss of position *may occur* in the event of a single failure.

**DP Class 2**
Loss of position *is not to occur* in the event of a single failure in any active component or system.

Where single failure criteria includes:
Any active component or system (generators, thrusters, switchboards remote controlled valves, etc)

**DP Class 3**
Loss of position *is not to occur* in the event of a single failure in any active or static component or system.

In order to meet the single failure criteria it will normally be necessary to provide:
1) For equipment class 2 - redundancy of all active components.
2) For equipment class 3 - redundancy of all components and physical separation of the components.

As a consequence of the need to meet single failure criteria DP vessels will tend to have well segregated power units, thrusters, sensors and interconnecting cabling.

**Minimum Recommended DP Equipment Class**

The minimum recommended DP equipment Class for various DP applications can be summarised as:

DP Equipment Class 1
ROV Support in open water. Platform supply vessels
DP Equipment Class 2
Drilling, Diving, Pipelay, Umbilical lay, Lifting, Accommodation, Shuttle Offtake Tankers, ROV support in close proximity, Floating Production, Well stimulation and Logistics operations.
Walk to Work (W2W)

DP Equipment Class 3
As for Class 2, but where operator requires to maintain station keeping ability (for long enough to safely terminate the work in progress) following effects of fire or flooding on the DP vessel or installation.

**DP Control Modes for DP Activities**

The DP vessel should be equipped with suitable DP modes and features with due consideration to operational requirements. The following selected DP control modes are relevant to specific DP activities.

**Station keeping**
Vessel maintained in a single geostationary position with excursion circle allowance based upon impact of deployed equipment. E.g. where rigid riser is deployed to sea bed the Vessel excursion allowance may be set to a very small tolerance potentially leading to increased thruster activities and load transients.

**Target Follow**
Enables the DP vessel to follow a moving target and is used, for example, to follow an ROV along a pipeline.

**Heavy Lift**
Takes account of the effects of the load transfer on the mass of the vessel and the additional lateral force.

**External Force Compensation**
Where the measured external force acting on the vessel, which is separate from the environment, is included in the DP calculation. This mode is used to account for pipe tensions in a pipe layer and hawser tension in a shuttle tanker.

**Fire Monitor Compensation**
Used to compensate for the varying forces exerted on vessel from the fire monitors.

**Required Documentation**

The IMO Guidelines require all DP vessels to be subjected to survey and testing in accordance with IMO's specified guidelines. This includes initial and periodic complete survey and testing of all systems and components required to keep position after single failures associated with the vessel’s assigned DP equipment class.

This IMO requirement has been interpreted by the DP community such that the
survey requirement is met by a DP FMEA and the testing requirement by DP FMEA Proving Trials. Accordingly, all DP vessels of DP Class 2 or 3 are required to have Class approved and stamped DP FMEA and DP FMEA Proving Trials documentation.

“An FMEA or Failure Modes and Effects Analysis, is a systematic analysis of systems and sub-systems to a level of detail that identifies all potential failure modes down to the appropriate sub-system level and their consequences. A FMECA is an extension of an FMEA that adds a risk assessment of each failure mode to determine its Criticality”

HSE research report RR195 gives some examples where incidents have demonstrated the need for thorough FMEA’s. This is also implied in HSE Safety Bulletin OSD 1/2013 on data communication within DP control systems.

The DP vessel’s FMEA is the most important “Technical” document in the list of required documents.

The DP Operations Manual is the most important “Operational” document in the list of required documents.

Both the FMEA and Operations Manual are to be made available and retained on board.

The IMO Guidelines require a series of checklists, test procedures and DP operating instructions to be incorporated into one manual. Each Classification Society has its own specific requirements for a DP Operations Manual, each with different requirements for content.

The manual should contain sufficiently detailed instructions and guidance to enable the vessel to be operated in DP and safely execute its intended activities. This will include a clear statement on the DP philosophy for the vessel, the organisation, responsibilities and roles of key DP personnel, training and competency, watch keeping and manning, vessel technical data and layout, vessel DP capabilities, operating limits, operating modes, the planning and preparation of DP operations, DP operating procedures, emergency procedures, DP incident handling and alert systems and vessel specific trials and checklists that apply uniquely to the vessel.

It is key that DP operators are confident that they are working in the ‘safest mode of operation’ for the dynamic positioning system, taking into account the ongoing operations at the time. Further guidance is available in DNV-RP-E307 and DP Guidance from the USA Marine Technology Society.

In addition to the FMEA and DP Operations Manual other important documents, which are also to be retained on board, will include:

DP Capability Plots
DP Footprint Plots
Vessel audit reports and DP audits and inspection reports.
DP Location and Watch keeping checklists, (Bridge and Engine Room)
DP related drills and emergency response drills
DP alarm printer readouts
DP familiarisation and competency Records
Résumés and vessel specific work records of all key DP personnel.
The necessary documents are fully listed and explained in more detail in IMO MSC/Circ.645 and related IMCA documents.

**Competence**

Competence is the acquisition of knowledge, skills and abilities at a level of expertise sufficient to be able to perform in an appropriate work setting. DP vessel operators should operate a structured competence assurance program that is applied to all key DP personnel with special focus on ensuring vessel and task specific competence.

Vessel specific competency should, as a minimum, be demonstrated in the following areas:
- Operational modes
- DP FMEA familiarization
- DP Operations Manual familiarization
- Project/ activity requirements
- Contingency plans, modes and drills.

IMCA and Nautical Institute are the key source of guidance on manning and competency requirements.

**Manning**

The required Bridge, Engineer and Electrical manning levels for DP vessels are quite specific and are detailed within the “Marine Technology Society Dynamic Positioning Committee – DP Operations Guidance Part 1”
## Appendix 4 – Dynamic Positioning Systems - Example questions and findings demonstrating good and poor practice

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<tr>
<th>Issue</th>
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<tr>
<td><strong>Hardware</strong></td>
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<td>1. How is it ensured that there are an adequate number of power units available for the current requirement?</td>
<td>There are four separate engine rooms, each containing two generators, each engine room is well separated from the others. Generally the loss of one engine room does not prevent normal DP operations.</td>
<td>Each of the two engine rooms contains two generators. They are thought to be well separated. The loss of either engine room would prevent the continuation of normal DP operations. It is believed that adequate time would be available to make the ongoing operation safe.</td>
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<tr>
<td>2. Will the failure of any one engine utility system cause more than one engine to fail?</td>
<td>The failure of any one component in a utility system will not cause more than one engine to fail. The four engine rooms, each containing two engines, have dedicated utility systems. For example the sea water cooling system in each engine room has a duty and standby pump, two sea chest suctions and two separate sea water strainers. The pressure differential across the strainers is clearly displayed. The individual sea suctions can be remotely switched.</td>
<td>Each of the two engine rooms has a dedicated fuel system, in the event of the fuel system failing power would be lost in both engines in that engine room. It was not clear if personnel on board were aware that such an arrangement was only allowed for DP Class 1 operations.</td>
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<td>3. What consideration is given to the location of the various sensors?</td>
<td>It was understood that the position of the DGNSS receiver was critical due to the risk of “shadowing”, (and the increasing possibility of Radio Frequency Interference). The wind sensor position was also carefully chosen so as not to be affected by the helicopter downdraught.</td>
<td>Personnel were unaware if the DGNSS receiver took into account the risk of “shadowing” but thought that might explain the partial loss of position experienced recently when the vessel was working adjacent to a large accommodation unit. Nobody knew if allowance had been made for the possibility of helicopter downdraught affecting the wind sensors.</td>
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<td>4. Is there an onboard trainer/simulator and is benefit taken of it?</td>
<td>The DP system arrangement included a simulator and this was frequently made use of for both training and simulation purposes. A particular benefit was that the simulator was used to train individuals new to the particular vessel system. Additionally a new task could be simulated prior to being undertaken for the first time.</td>
<td>It was thought that the DP system did come with a simulator capability but this was not used very often. One or two individuals had been seen to use it but there was no specific company policy requiring it to be used. No training had been undertaken on it as far as was known.</td>
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<td>5. Is there an alarm data logger and how effective is it?</td>
<td>There is a data logger in the system with comprehensive capabilities. It is supported from a UPS and regularly used. It has the capability to record many channels of selected data and store them in long term storage. The graphical display option is frequently utilised by DP personnel.</td>
<td>There is a data logger and it is believed that it was used the last time there was a major problem. It was found to be powered from a UPS and had much more capability than had previously been thought. It was generally not made use of very often and it was not known how many channels of data could be recorded or for how long.</td>
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<td>Is the DP system considered to be Safety Critical? What consideration is given to the effect of unplanned unavailability of equipment?</td>
<td>Equipment relating to station keeping is considered to be Safety Critical and is included within the Planned Maintenance system. Inspection, repair and maintainability over the life cycle of the unit being taken into account. Unplanned unavailability of equipment results in risk assessments being undertaken on current and future operations.</td>
<td>The DP system was considered to be safety critical and reference to some of the equipment could be found in the Planned Maintenance system records, although not all. It was assumed that Inspection, repair and maintainability had been considered in the vessel build specification. Unplanned unavailability of equipment would be considered if and when it took place.</td>
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<tr>
<td>DP rules and guidelines require only that DP vessels be able to maintain station following a single failure for long enough to safely terminate the work in progress. What consideration is given to the “time to terminate” a particular task?</td>
<td>Consideration was given to DP availability and operational capability depending upon the task to be carried out. Generally the more complex the task the greater the termination time. Diving support was listed as being one DP mode of operation where the time to terminate was seen as being particularly important.</td>
<td>Generally the vessel acted in ROV Following operational mode well clear of other installations and time to terminate was not a concern. However, a future task being bid for required more complex operations in close proximity to a fixed installation. No thought had been given to the time to terminate required and neither offshore nor onshore management appeared to have had this under consideration.</td>
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<td>Modifications to the DP system and components are not unusual. What is the extent of testing carried out following a modification?</td>
<td>Any modification to the DP system was seen as requiring testing. The extent of testing was subject to a detailed review prior to the actual testing itself. In some cases parts of the initial FMEA had to be retested in order to fully ensure that the modification had not impacted upon the reliability and operation of the systems in place.</td>
<td>Minor modifications were seen as not requiring a detailed review and retesting of the DP system. It was thought that no modification undertaken had, as yet, resulted in any DP faults. There was no written procedure in place requiring modifications to be reviewed and retested and therefore it was not seen as important.</td>
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<td>General DP modes required for the vessel to undertake its current and possible future tasks should be included. What, if any, control modes of operation are included within the DP system?</td>
<td>It was demonstrated that this shuttle tankers modes of operation included; external force compensation, fast current update, shuttle tanker mode and weather vane mode. Personnel were clear in their understanding of the various modes and appreciated the various benefits of each.</td>
<td>The only role that this vessel had been used for to date was that requiring ROV Follow mode, this had been found to be adequate to date. The vessel had recently changed hands and offshore personnel understood that the future role of the vessel was about to change but did not know what mode of operation was to be used or even if it was available. There was no information onboard listing the available modes of operation which the vessel DP system was capable of.</td>
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<td><strong>The equipment class of the vessel required for a particular operation should be agreed between the owner of the vessel and their respective customer based on a risk analysis of a loss of position. What DP Class is currently being used and how was that determined?</strong></td>
<td>This DP ROV support vessel is Classed with DNV and occasionally operates in close proximity to other installations. In this event DP Class 3 is invariably used, this is referred to by DNV as DYNPOS-AUTRO, DPS-3. When the vessel is operating well clear of other vessels DP Class 2 is applied although DP Class 1 is acceptable in most cases. It is understood that prior to a new location discussions are held between the company, the Class society and the client as to the required DP equipment class.</td>
<td>It was assumed by those on board that discussions had been held with the Class Society and the client prior to the current role as a dive support vessel. The Class Society was Lloyd's Register and the vessel was operating to LR's AA DP Class which was understood to be equivalent to DP Class 2. On being asked as to the expected DP Class for the next task alongside a fixed platform it was assumed that LR's AA would be adequate. It was not clear as to whether the vessel even had DP 3, or LR's AAA, capability.</td>
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**Competence, manning and reporting**

<p>| 11. | Competency is assured by the company requiring that all the vessel DPOs participate in the Nautical Institute scheme. As a demonstration of competency each of the onboard DPOs had their Nautical Institute scheme log books available. IMCA M117 provides the DP sector with detailed guidance on the training and experience of key DP personnel. M117 has been adopted by the IMO and issued as IMO MSC/Circ 738 (1996). M117 recognises the formal training and certification scheme for DPOs administered by the Nautical Institute. The Nautical Institute scheme is universally recognised as the industry standard for formal training and certification of DPOs. | The DPOs had attended a formal training and competency program that had been offered by a recognised equipment supplier. Although the course had been useful and had involved a simulator personnel were of the opinion that the equipment on board did not exactly reflect that used during the training. There were concerns as to whether a situation may arise where the onboard equipment would react in a different manner to that anticipated. A number of personnel were aware of the Nautical Institute scheme and had asked to attend the scheme. The company had declined to send them on the grounds that they had already attended the equipment suppliers course. |
| <strong>DP vessel operators should operate a structured competence assurance program that is applied to all key DP personnel. How is competence assured on your DP vessel?</strong> | <strong>When undertaking critical activities in proximity to surface or sub surface structures what manning levels are required?</strong> | It was stated that in all cases there would be two “unlimited” DPOs on the bridge capable of operating the vessel both in DP and manual control. One of the unlimited DPOs would have a minimum of 3 years experience in DP operations at least 6 months of which had been on sister vessel. Experience and qualification levels were documented and auditable. | Although it was understood the intent was that there should be two “unlimited” DPOs on the bridge where one of them should have 3 years experience in DP operations at least six months of which should have been on this vessel or a sister vessel, this was not often the case. The company was experiencing difficulties obtaining and retaining suitable DPOs in the current employment climate. They were recruiting at the moment and hoped to achieve that intent and put in place adequate documentation with an auditable trail. |</p>
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<td><strong>The vessel should be equipped with the appropriate primary and secondary equipment needed to communicate between all parties whilst carrying out the intended task. How is it ensured that adequate communication exists between all parties?</strong></td>
<td>It was recognised that effective internal and external communications was a key tool in managing risk. A common working language and terminology was in use at all times. Communications included voice, visual (CCTV/lights/displays) and audible means (alarms). The means of communication also included integrated IT systems using wireless network technology. Continuity of communications during foreseeable emergency situations had been taken into account.</td>
<td>Despite the fact that available communications included voice, visual and audible means, communication was considered a problem on this particular vessel due to the different working languages. The DP/marine crew, crane drivers and deckhands spoke different languages and this made it difficult to undertake normal operations but almost impossible to operate under emergency conditions. To complicate matters more the technical terminology was not the same between all parties. The parent company had been made aware of the concerns but had no immediate plans to change the status quo.</td>
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<td>14</td>
<td><strong>DP vessels should be provided with and operate appropriate DP incident reporting, investigation and closing out procedures. Documented records should be kept and be capable of auditing. What is considered to be a DP incident and is it reported and recorded?</strong></td>
<td>It was stated that any reactive change of DP status from GREEN to YELLOW or RED was clearly regarded as a DP incident, and would be reported, recorded and investigated. Reactive YELLOW and RED DP incidents were investigated as soon as practicable after the DP incident and, where relevant, trials were carried out as part of the investigation process. Documented incident records were retained on board.</td>
<td>It was understood that any DP incident should be reported but there was a lack of clarity as to what exactly a DP incident was. There had been a number of minor incidents but they had not resulted in any major problems and consequently had not been reported or recorded. No further action had been taken. Very few incident records were found on board.</td>
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<td>15</td>
<td><strong>DP vessels, on occasion, carry out activities which may be unique to project requirements. Records of these activities including information from Hazards and Risks should be made and kept onboard for future reference. Have any such unique activities taken place and is the relevant information recorded?</strong></td>
<td>During the last Dive Support project, which had been adjacent to a fixed platform, a number of unique activities had been carried out. These activities had resulted in additional hazards and risk assessments having to be taken into account. Details and records of these additional hazards and risk assessments were recorded and retained on board for future reference. A review of the records retained on board found further detailed information describing a number of previous unique activities.</td>
<td>DP personnel, who were relatively new to the vessel, could not recall the vessel undertaking any unique activities in the course of normal working. The DP personnel had managed to operate the vessel in all events so far. The Master did remember that a number of times it had been necessary to take into account unusual hazards and carry out, on the spot, risk assessments. It had not been considered necessary to record those activities as the vessel had achieved its objectives each time. No unique activity records were found and there was no procedure in place to do so.</td>
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<td>16.</td>
<td>FMEAs are a requirement to obtain DP Class 2 and 3 notation. Whilst not stipulated as a class requirement for DP 1 vessels operators are encouraged to subject their DP 1 vessels to the FMEA process. Key DP personnel should have a detailed knowledge of the DP FMEA and should be fully informed about the capabilities and limitations of the vessel’s DP system. Does this DP1 vessel have an FMEA and are the key DP personnel fully informed about the vessel limitations?</td>
<td>Although the vessel is only DP1 it was recognised by the operator that an FMEA would be very useful. Consequently the vessel had undergone a full FMEA and DP operational staff had been involved, as much as possible, in the process. Key personnel were therefore fully informed about the capabilities and limitations of the vessels DP system. The technical documentation linked to the FMEA was retained on board and frequently referenced.</td>
<td>ROV Following in open water was considered to be the only role that this vessel would participate in and, despite encouragement from Class, the owners had made the decision that there was no need for an FMEA. However, a recent change in the parent company structure foresaw that the vessel may need to operate in other roles in the future. In this event an FMEA would be required. It was thought by those on board that the cost, time and resource necessary to obtain the FMEA would be excessive and not entirely necessary. Senior personnel did not appear to be able to demonstrate a full awareness of the vessel capabilities and limitations.</td>
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<td>17.</td>
<td>Annual DP Trials form a series of tests of fault and failure conditions relevant to the DP System. The tests should be designed to prove system redundancy and to demonstrate that the vessel’s DP system remains fit for purpose. Annual DP Trials also provide the opportunities for training of the vessel’s crew and enhancement of their knowledge of failure modes and their effects. When were the last Annual DP Trials carried out, were they satisfactory and were they used as a training opportunity?</td>
<td>The Annual DP Trials were carried out in the Autumn of last year in accordance with Class and the IMO Guidelines. A small number of very minor improvements were made and the DP system was found fully fit for purpose. At the time the opportunity was taken to create a number of unusual failure modes for training purposes and this was found to be highly beneficial. Records of the latest Annual DP Trial and the preceding Annual DP Trials were retained on board and sighted.</td>
<td>Due to the fact that there is currently a heavy demand for DP Drilling MODUs a dispensation is in place which allows the Annual DP Trials to be undertaken over one full year. Quite a lot has been done this year but work demand has been so high that we will not finish all the tests in time. It is hoped that the work load in the next few months will allow us to catch up. No opportunity was taken for training, again due to the heavy work load, however, our DPOs are very experienced. Some records were available but it was unclear as to which Annual DP Trial they referred to.</td>
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<td>18.</td>
<td>The vessel specific DP Operations Manual is the most important operational document in the list of required documents. The requirement for a manual has its origins in IMO “Guidelines for Vessels with Dynamic Positioning Systems”. Each Classification Society has its own specific requirements for a DP Operations Manual. What is the purpose of the DP Operations Manual? What does it contain? Is reference made to it?</td>
<td>It was understood by those on board that the manual should contain sufficiently detailed instruction and guidance to enable the vessel to be operated safely in DP. It contained a series of checklists, test procedures and DP operating instructions and in particular the roles and responsibilities of key DP personnel. The manual was frequently referred to as it contained guidance on what particular configurations of generators and thrusters should be used for specific tasks.</td>
<td>The purpose of the vessel specific DP Operations Manual was seen to be just to satisfy Class requirements. It contained a lot of information about the DP systems. It was not referred to very often, if at all, as the DP personnel were very experienced and could manage the DP systems on their own. Class occasionally asked to view the operations manual and it had then to be pulled down from the shelf and dusted off.</td>
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<td>Issue</td>
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<td>19. In recognizing that exposure to risks manifests itself during vessel operations it is recommended that activities performed by DP vessels should be subject to planning and preparation. What preparation and planning is undertaken prior to a typical activity?</td>
<td>For any activity, whether normal or unique, appropriate measures in place would clearly identify critical tasks/operational phases of the activity and ensure that the vessel was set up in the Safest Mode of Operation and in such a way as to be able to continue to operate following the Worst Case Failure. Planning included the pre-project execution readiness checklist; consideration as to the capabilities of the vessel, both intact and residual capability, following Worst Case Failure; limitations imposed by water depth and; the consequences of a loss of position and/or heading. Records were retained on board of the planning documentation.</td>
<td>The vessel normally only undertook ROV Following duties in open water and had done so for some time. Consequently, it was thought that, there was little need for planning or even detailed discussions. It was understood that in the near future the role of the vessel was likely to change and be involved in more complex operations. No additional training had been put in place and none was foreseen. Onshore management had not been very informative.</td>
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<td>20. The design of the power generation system should take into account: 1) The industrial role of the vessel. 2) The power required to maintain station in the defined environmental limits in both the intact and post worst case failure condition 3) The need to work efficiently in all required power plant configurations. Does the existing power plant demonstrate that the above factors have been taken into account?</td>
<td>The power generation system of this DP3 vessel has operated satisfactorily since build, (other than a small number of minor faults which were all dealt with thoroughly, the tests and checks being recorded). The vessel behaves well under all but the most severe environmental conditions, where it is recognised that we are out of limits. All required power plant configurations work as designed.</td>
<td>It is understood that originally the intended location of this DP2 vessel was in an area of the world with less onerous environmental conditions. However, we have worked in the North Sea over the last few years. Most of the time we handle the environment quite well and we have only lost position once or twice in the last two winters. The owners are looking to find work elsewhere once the current contract expires next January.</td>
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Appendix 5: FPSO Cargo Tank Operations and Offloading.

Introduction

Improvements in offshore technology have accelerated the development of marginal offshore oil fields in North West Europe and worldwide, much of this has been made possible by floating production systems.

The FPSO, Floating Production Storage and Offtake vessel or FSU, Floating Storage Unit monohull vessels, are subject to both Maritime Integrity risks and to the risks associated with the loading, storage and discharge of crude oil. Stability, watertight integrity and position keeping require strict control but in addition, other areas of importance include, for example, the need for safe entry to crude oil and ballast tanks in order to facilitate tank inspection and the particular risks associated with the close proximity of a shuttle tanker during export.

It is critical that any crude oil tank is maintained, at all times, in such a condition as to ensure that there is no possibility of the atmosphere within the tank being allowed to enter the explosive limits. In order to prevent this there is a need for strict control of the inerting systems during loading and discharge. Tank washing, purging and gas freeing will be required where there is a need to prepare a crude oil tank for entry and these must also be carried out in accordance with procedure.

Position keeping

Loss of position of an FSU or FPSO can lead to collision with an adjacent installation, or to the release of hydrocarbons from fractured drilling or well operations risers. Hence, loss of position is clearly a hazard ‘with the potential to cause a major accident’ and requires evaluation within the safety case. The mooring system, equipment and arrangements are consequently, SCE, Safety Critical Elements. The FPSO or FSU will either be passively positioned by weathervaning around a turret positioned forward in the vessel or be actively positioned by utilising thrusters around a turret positioned midway along the length of the vessel.

Further details of the types of mooring and thruster assisted systems are found respectively in Appendix 3 – Mooring systems and Appendix 4 – Dynamic positioning systems.

Stability and Watertight Integrity

An ocean going oil tanker will load and discharge at different physical locations and spend some time in transit between locations, it is not unusual for there to be an interval of some two to three months between loadings. Conversely an FPSO or FSU may be loading continuously and discharging to an offloading shuttle tanker much more frequently, perhaps on a weekly or two weekly basis. It is therefore even more critical that the loading and discharge of the crude oil and ballast tanks is undertaken in accordance with an approved stability plan and strictly adhered to. If a discharge or loading procedure is carried out incorrectly there is a danger that the Bending Moment and/or Shear Force limits of the vessel will be exceeded and also the stability of the vessel may be put at risk.
The stability of the installation is under the control of the Marine Supervisor, or Ballast Control Operator. The load or stability computer will register the hull tank contents, such as ballast, crude oil, fuel oil and fresh water and these will be automatically uploaded to the stability programme. Marine personnel will need to input manually changes to deck loads such as deck containers and other variables. The stability programme will display the current Stability, Bending moments and Shear forces on the vessel.

*Further details on the control of stability are found in Appendix 1 – Stability and Ballast Systems*

The FPSO or FSU consists of individual compartments the majority of which are designed to be watertight. Damage or flooding in a watertight compartment should be contained and fluids should not be capable of migrating to an adjacent compartment. The majority of watertight compartments, of necessity, will be below water level. However, in the event of damage to the installation a number of compartments that were above the water line at normal operational draft may well be below the water line after damage. Therefore those compartments will also have to be maintained watertight as they will contribute to the vessel buoyancy and mitigate against any further flooding.

Watertight integrity should be maintained in specific compartments to meet intact and damaged stability criteria and for other compartments that may need to be protected against water ingress for operational and safety reasons (e.g. accommodation spaces, control rooms, spaces containing safety equipment etc.).

*Further details on the control of watertight integrity are found in Appendix 2 – Watertight Integrity*

**Inert Gas Systems**

Large quantities of crude oil can be stored in the cargo tanks of an FPSO and, depending upon the loading and discharging operations, the tanks will be only partially full for much of the time. During these periods it is necessary to maintain the free space above the crude oil in a safe condition, this is achieved by using the inert gas system to maintain the Oxygen levels so that the atmosphere is substantially below the Lower Explosive limit of the Cargo.

The purpose of the inert gas system is to prevent a flammable gas mixture forming above the oil in the cargo and slop tanks.

Conventional tankers tend use the flue gas from the boiler uptakes due to it being readily available, this flue gas is sufficiently low in O2 to maintain the tank atmosphere in such a condition that combustion will not be supported. 11% O2 is commonly recognised as the percentage below which combustion will not be supported but SOLAS require that the tank atmosphere be kept at a maximum of 8% O2 by volume. On an FPSO it is common to have an IG generator which usually burns diesel to produce exhaust gas which is then treated before being delivered to the tanks by blowers, generally with an O2 content of 5% or less.

During the discharge cycle, where the crude oil will normally be transferred to a shuttle tanker, it is therefore necessary to ensure that the inert gas is supplied to the crude oil tanks at a sufficient rate and quality to ensure that the O2 content of the atmosphere above the crude oil remains below 8% and at a sufficient pressure to prevent air being
drawn into the tanks. Conversely during the loading cycle it will be necessary to vent off
the excess inerted atmosphere above the crude oil in order to prevent a build up in
pressure within the crude oil tank. On those occasions where crude oil is neither being
loaded nor discharged the inert gas system will be used to simply “top up” the atmosphere
above the crude oil to maintain it in a safe condition.

It is quite common place to find that the cargo tank vent system is integrated to a greater
or lesser extent with the IG system. This simplifies and reduces the amount of pipe work
but often restricts the system with regards to operability. The system should be able to
maintain a positive pressure on the tanks at all times, the only exception to this is when the
tanks are being gas freed for entry. This means that individual tanks must be able to be
clearly isolated.

Of necessity the inert gas system is extensive and relatively complex, requiring, for
example, an inert gas generator, pipeline systems, deck seals, pressure/vacuum breakers,
isolation valves and/or blanks. Where there is a need to isolate a tank prior to tank entry
the isolation procedure should be covered by the Permit to Work system. Instances have
taken place where a previously isolated tank was re-instated, the incorrect procedure was
used and, due to the non removal of a blank, caused over pressurisation of the crude oil
tank by inert gas resulting in structural distortion of the bulkhead and expensive repairs off
location.

**Venting**

The vent system is used to allow the tanks to be filled and emptied and to prevent the
cargo tanks from being over or under pressured and hence on an FPSO or FSU it is for
the protection of the structural integrity of the installation. Due to the nature of the tank
contents, a mixture of inert gas and hydrocarbon components, the atmosphere that is
displaced when the tank is being filled will contain a potentially flammable component.
Thus the positioning of the vent outlets is extremely important. The vents should be
positioned with as great a separation distance as practicable from sources of ignition both
by horizontal distance and vertical height.

The demand on the venting system of an FPSO is likely to be high due to the
comparatively low levels of stabilisation of the crude oil achieved by the on board process
plant, (particularly as it is fairly common to heat the crude to drive off the lighter ends as
part of the stabilisation process). The heated crude is discharged into the cargo tanks and
is likely to evolve gas in the tanks. This increases the loading on the vent system and also
increases the amount of hydrocarbon likely to be discharged via the vent system and
hence increases the likelihood of flammable atmospheres being formed in the areas
around the vent outlets.

As the FPSO is essentially fixed in one place, when the weather is calm there is little
motion to assist in the dispersal of vented vapours. A conventional tanker however is on
the move for the majority of its working life and thus tends to create an airflow assisting
dispersal due to its own motion. Essentially the venting system of an FPSO is a critical
system both from a safety and production viewpoint and an FPSO requires additional
consideration when compared to that of a conventional tanker.

**Hydrocarbon Tank Blanketing.**
Venting inert gas contaminated with up to 70% hydrocarbons into the atmosphere has an effect on the environment, risks fires and explosions and wastes hydrocarbon products. One alternative is the hydrocarbon blanketing system which is essentially a closed system, that is, provided the field produces sufficient gas to enable the system to operate. The purpose of the system is to replace the use of inert gas in FPSO tanks by pure hydrocarbon gas as a blanket gas in the cargo tanks, and to recover the off gas. The blanket gas prevents intrusion of oxygen into the cargo tank atmosphere, creating a closed system.

In loading mode, surplus gas from the cargo is recovered and recycled into the process plant by means of a blower/ejector/compressor. In offloading mode, due to the large volumes required, it is probable that an inert gas system will be used to maintain pressure in the cargo tanks. All the hydrocarbons are recovered to the process and emissions into the atmosphere are eliminated during normal operation.

When offloading to a shuttle tanker the system can be connected to the shuttle tanker and both the FPSO and shuttle tanker crude oil tanks protected without loss of hydrocarbons or Volatile Organic Compounds.

The FPSO tanks will still need to be inspected and in order to do so the tanks will need to be gas freed, to enable the gas freeing to take place an inert gas generator will be required. The inert gas will be used to displace the hydrocarbon vapours in the tank while maintaining the oxygen content below the explosive limit of the hydrocarbons prior to purging the tank with air.

**Enclosed Spaces / Tank entry**

Enclosed spaces include, but are not limited to: cargo tanks, double bottoms, fuel tanks, ballast tanks, pump rooms, cofferdams, void spaces and sewage tanks. Many of the casualties that have occurred in enclosed spaces have resulted from people entering an enclosed space without proper supervision or adherence to agreed procedures. In almost every case, the casualty would have been avoided if simple guidance had been followed. The rapid rescue of personnel who have collapsed in an enclosed space presents particular risk.

Prior to entering a tank which has been used for the carriage of crude oil it will be necessary to make sure that the atmosphere is safe for entry. Depending upon the previous contents of the tank it is likely that it will need to go through the Tank Washing process to remove any deposits, if at any time during the tank washing the O2 content exceeds 8% then the tank washing must be stopped until conditions are stable at 8% O2 or below. Following the tank washing process purging of the atmosphere by inert gas must be carried out until the atmosphere can be tested and demonstrated to contain 2% or less of hydrocarbons. This is to ensure that, during the subsequent gas freeing operation, no portion of the tank atmosphere is brought within the flammable range. Extensive gas freeing with fresh air will then enable the tank atmosphere to achieve conditions safe for entry without the tank atmosphere passing through the flammable range.

In order to ensure safety for any tank entry, a risk assessment should be carried out. Gas tests carried out prior to entry into the space should reflect the contaminants that can reasonably be expected to be present within the space, taking into account the previous cargo carried, ventilation of the space, structure of the tank, coatings in the space and any other relevant factors. When preparing for entry into a ballast tank or void space where
cargo vapours may not normally be present, it is prudent to test the space for cargo vapours, oxygen deficiency or toxic gases if the space is adjacent to a cargo or bunker tank.

### Class / Competent authority requirements for tank inspection

Sea going oil tankers are subject to a through-life inspection regime involving periodic surveys which rotate on a five year basis. This includes annual surveys, intermediate surveys (approximately midway between special surveys), special surveys every 5 years (also referred to as class renewal), and docking surveys. The International Association of Class Societies, IACS, document “Requirements concerning Survey and Certification”, contains a comprehensive description of survey requirements and procedures.

An FPSO or FSU may not necessarily be Classed, but the competent authority determined by the owner/operator of the FPSO or FSU will reflect to a large extent the Class requirements for tank inspection. Essentially, as each FPSO or FSU will consist of a large number of tanks and each tank has to be inspected within a five year rotation then it is likely that at least one tank will be going through the Tank Washing, Purging, Gas Freeing and Tank Entry process or recommissioning procedure at any offshore inspection. This is an ideal opportunity to inspect the various relevant safety procedures.

### Attendant vessels

Over 96% of vessel/Installation collisions in the UK sector involve vessels with legitimate business there. Although the majority are low energy collisions, attendant vessels cause about 10 times more moderate/severe collisions than passing vessels. Over time the frequency of such collisions has reduced.

It is estimated that approximately 15% of Installations in the UK sector are likely to experience a collision each year. Although the majority of attendant vessel collisions cause only minor damage, 3% have severe consequences. With the steady progress to larger and more powerful support vessels together with Dynamic Positioning, the potential impact energy and resultant seriousness of the collision increases.

### Offtake tankers

Tanker offtake involves relatively large vessels, carrying hazardous cargo, manoeuvring in a congested oil field. Generally the offtake tanker moors to the FPSO or FSU, and is connected to it by hose. Thereafter, it must maintain station and alignment relative to the other vessel during the cargo transfer operation. Hence, the potential for collision occurs during approach, cargo transfer and departure A high standard of vigilance is required throughout these operations. The vessel positions are maintained either by means of the “Taut Hawser” method, where the offtake/shuttle tanker maintains the hawser under a low load at all times or, more frequently, by Dynamic Positioning where the offtake/shuttle tanker maintains position by use of its DP system.

More particularly reference should be made to the recently reissued, August 2013, Oil and Gas UK, Tandem Loading Guidelines

The first edition of these Guidelines was published by the then United Kingdom Offshore Operators Association (UKOOA) in March 2002. In June 2011, Oil & Gas UK published an updated set of guidelines for tandem loading to help operators of Floating Production Storage and Offloading facilities (FPSO), Floating Storage Units (FSU) and offtake tankers
implement agreed good practice when transferring crude oil between FPSO and shuttle tankers. The August 2013 edition is a further update of these guidelines.

The guidelines include information on, UK Legislation & Oil & Gas UK Risk Reduction Strategy, Safe Operations, Crewing Levels Training & Competency, Management Systems and Incident Reporting. Chapter 4 – Safe Operations, contains the meat of the document and is well worth a read. Additional appendices cover standards, risk evaluation, example checklists and incident report forms.

Further guidance is available from ISGOTT and ISGINTT published by the Oil Companies International Marine Forum (OCIMF)
### Appendix 5 – FPSO Operations - Example questions and findings demonstrating good and poor practice

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<th>Issue</th>
<th>Good practice</th>
<th>Poor practice</th>
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<td><strong>FPSO Maritime Integrity</strong></td>
<td><strong>1. Is the loading/discharge plan readily available? Is the plan strictly adhered to and are records kept of the various loadings and discharges undertaken?</strong></td>
<td>The loading plan was found after some searching and it was assumed by those on board that it was followed. However, as the loading was continuous and the discharges were frequent individuals knew what to do without the plan and had no problems, as yet. No records of specific discharges could be found.</td>
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<td>The loading plan was at hand in the control room and was used throughout the loading and each time a discharge took place. Each individual discharge was recorded and the records were available.</td>
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<td><strong>2. It is not unusual for one or more of the crude oil tanks to be unavailable due to the need for inspection or repair. In this event how is the loading/discharge plan modified and how is it determined if the changes to the plan are acceptable?</strong></td>
<td>The required modification to the loading plan would depend upon which tank or tanks was out of action. This event was not at all unusual and most eventualities had been covered. The new loading and discharge plan would be discussed by the marine staff and then simulated on the stability computer to ensure that the stability, bending moments and shear forces were not out of limits.</td>
<td>If only one tank was out of action then the plan would be modified slightly and personnel would use their experience to judge what action to take. There had been no problem so far. The stability computer had the capability to simulate the new loading plan but there was no record of this having taken place. A discharge plan was simulated on the day and the maritime staff were surprised by the results and decided to modify the current loading plan.</td>
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<td><strong>3. The frequency of loading and discharge of the FPSO/FSU is likely to far exceed the more normal sea going tanker loading and discharging frequency. How is it confirmed that the fatigue life of the main structural members is not exceeded?</strong></td>
<td>It was understood that the frequency of loading would have an effect upon structural members. On behalf of the Duty Holder the competent authority and third party structural engineers had reviewed in detail the loading and discharge frequencies and determined the maximum tank capacities to be used and the necessary frequency of discharge. Regular inspections of the most stressed areas were undertaken when tanks were open for inspection.</td>
<td>The long term effects on the structure of frequent loading and discharges had not been taken into account originally. However, recent inspections had discovered a number of cracks in the bulkheads between the crude oil tanks and ballast tanks, the vessel was over thirty five years old though and some cracks were to be expected. As a temporary measure, the level which the crude oil tanks were filled to before discharge had been reduced. It was thought that studies were being undertaken onshore and the results would be made available soon.</td>
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<td>4. <strong>What controls are in place, within the main crude oil and ballast tanks, to prevent or mitigate against corrosion or the effects of Sulphate Reducing Bacteria, SRB? Have any recent inspections found evidence of corrosion or SRB action?</strong></td>
<td>The ballast tanks were protected by sacrificial anodes and these were regularly checked during inspections. It was known that the crude oil from this field had low levels of H2S and the produced crude was treated during production. Crude oil tanks were checked during inspection and in particular the slop tanks were examined for SRB action. The slop tanks were coated and also protected by sacrificial anodes.</td>
<td>There had been no concern over corrosion or SRB action in any of the tanks as they were all covered by sacrificial anodes and the tanks had to be inspected within every five year period. In addition the slop tanks were coated. However a recent inspection of a slop tank had exposed extensive SRB action, to the extent that the lower hull plates, in a number of locations, showed golf ball sized holes eaten away and in one location the hull had been holed through to the sea. There was as yet no clear plan of action. It was thought that the removal of deposits within the affected tank some years ago may have damaged the tank coating and allowed SRB action to take place in isolated spots.</td>
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<td>5. <strong>Machinery space ship side valves are Safety Critical from the watertight integrity viewpoint. Are the SCE Assurance Activities up to date and has the competent authority verified that this is the case. Can all the shipside valves be tested as watertight when closed?</strong></td>
<td>All substantial shipside valves were listed as Safety Critical. SCE assurance activities were up to date and recorded and the ICP had verified that this was the case. In addition modifications had been made to the pipe work to ensure that all the valves could be tested as watertight when closed.</td>
<td>The majority of shipside valves were considered as being Safety Critical although some shipside valves associated with redundant system were not. (There was no need to use them now!) Those that were listed were up to date with the ICP with reference to assurance activities and verification. However, it was found that a number of large diameter shipside valves associated with redundant systems, (original trading tanker systems) were not regularly checked and could not be proved watertight when closed as the pipe work would not allow for such a check.</td>
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<td><strong>FPSO Inert gas and Venting systems</strong></td>
<td>The inert gas system itself and each individual tank which may be inerted are fitted with sensors which indicate Oxygen levels continuously back in the control room. The system alarms on high Oxygen content if necessary. In addition portable Oxygen sensors are supplied and used as required. Both the main and portable sensor types are classed as safety critical and calibrated regularly.</td>
<td>The inert gas system and each tank are fitted with Oxygen level sensors and these alarm as necessary in the control room. There were thought to be some portable sensors and these were found after some time. No records of sensor calibration could be found on board and although the sensors were listed as being safety critical maintenance records were poor.</td>
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<td>7.</td>
<td>It is important that the correct pressure of inert gas is maintained in each of the inerted tanks as over or under pressure could create dangerous conditions. How is it ensured that the pressure is correct in each inerted tank?</td>
<td>The inert gas and vent systems were integrated and the danger of over or under pressure was recognised. P/V valves were fitted throughout the system. Additionally the pressure of the system and individual tanks was displayed in the control room and alarmed when the pressures were approaching preset limits. The P/V valves and sensors were regularly checked and calibrated.</td>
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<td>8.</td>
<td>The inert gas system is safety critical, is there a written procedure to ensure that the system is consistently used correctly and safely? Is it available? Have any problems occurred with the system and have they been quickly resolved?</td>
<td>A comprehensive written procedure was available and strictly adhered to. This was particularly the case when isolating a tank for inspection or bringing a tank back on line after an inspection. No major problems had occurred as the status of each isolation valve or blank was physically checked against the detailed procedure prior to or following any isolation.</td>
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<td>9.</td>
<td>When loading the crude oil tanks the excess vapour from the tanks is vented and will contain a high proportion of hydrocarbon components. Are the vapours vented to a clear space well away from any likely ignition sources? Have there been any incidents where a gas alarm has been activated by the vapour release and what action was taken?</td>
<td>It was recognised that vented vapours from the crude oil tanks would contain a proportion of hydrocarbons. The new build FPSO had taken this into account in the design and the vents were positioned high and well clear of any possible sources of ignition. As a result of the design no gas alarms had been activated by venting vapours to atmosphere. It was understood that in particular calm weather conditions there was a higher risk of this happening although this had not happened to date.</td>
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<td>10.</td>
<td>The inert gas and venting systems frequently utilise common pipe work systems. Are there adequate drawings, schematics and explanations readily available on board of the inert gas and venting systems? Are they made use of by the offshore personnel and are they understood. Has there been a problem in aligning a specific inverting or venting arrangement?</td>
<td>The inert gas and the vent systems were integrated. As a consequence comprehensive and up to date drawings, schematics and detailed explanations were available and utilised. Personnel always made use of them and they were well understood. There had been a number of times when a specific isolation or reinstatement of a tank had to be rethought due to the complexities of the systems but the information available had been more than adequate to resolve the issue.</td>
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<td><strong>FPSO Enclosed spaces and Tank inspection</strong></td>
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<td>11.</td>
<td>Entry to an enclosed space is required to be covered by a Permit To Work. Are those on board satisfied that the Permit To Work procedure used is adequate? Is it always followed and have there been any incidents?</td>
<td>Enclosed space entry was treated seriously, individuals were only too well aware of the consequences of incorrect procedures. The permit to work procedure was comprehensive and detailed. It was always followed and consequentially there had been no incidents. Enclosed space entry formed part of the training matrix and was strictly kept to, all relevant individuals were found to be up to date with the training.</td>
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<td>12.</td>
<td>Class or the competent authority require that all tanks are inspected within a five year period. Are any tanks being prepared for inspection now and what stage are they at, (tank cleaning, inerting, purging etc.)? Has anything unexpected been found during a tank inspection? Where are the records of the last crude oil tank isolation?</td>
<td>One main crude oil tank was currently isolated and in the process of being fully inerted prior to being purged so as to allow a tank inspection. A second tank had recently been reinstated following inspection and was back in use. Some minor cracking had been found in that tank in one or two of the longitudinal members. The ICP did not have serious concerns as the cracks were not unusual in this form of vessel and plans were in place to undertake repairs in the next summer season. Records relating to the isolation and reinstatement of this tank were available and self explanatory.</td>
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<td>13.</td>
<td>How is it confirmed that the portable gas detectors are accurate and working? What gases are checked for including Oxygen levels and why? Has training been given to the individuals who use the gas detectors?</td>
<td>Sample gases are carried on board to check the calibration and operation of the portable gas detectors. A procedure is in place to calibrate the detectors on a regular basis and records of these checks were to hand. The gases checked for depended upon the location of the tank or enclosed space to be entered. For example, if it was a ballast tank adjacent to a crude oil tank that was to be inspected then hydrocarbon contamination would be checked for. Oxygen levels would also be checked for as it was known that corrosion in a ballast tank would deplete the oxygen levels. The use of gas detectors was included within the enclosed space entry training on the training matrix and personnel were up to date.</td>
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<td><strong>14.</strong> When a tank is open for inspection and repair it is necessary to ensure that there is adequate space for personnel access and exit. This should be the case for normal anticipated operations within the tanks and also for emergency situations. Is this always the case? Have there been any incidents where it was found that access and exit routes were inadequate?</td>
<td>Individuals on board had been made aware of an incident on another FPSO where an injured individual could not be removed from a tank under inspection with the stretcher in the horizontal position from the crude oil tank undertaking structural modifications as vent pipes were partially blocking an exit point. As a consequence personnel on this FPSO ensured that whenever a tank was open for inspection adequate space for stretcher entry and access was allowed for at all times. No incidents had required stretcher access to date.</td>
<td>Personnel had been made aware of the incident on another FPSO but had not fully appreciated the consequences. Sighting of a tank currently open for inspection found that a number of cables and portable ventilation pipes were partially blocking an exit point from the tank. Personnel on board swiftly modified the cable and pipe runs and ensured that there was adequate space for an injured person. It was assumed by those on board that procedures would be modified to reflect this, although no immediate action was being taken.</td>
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<td><strong>15.</strong> When a crude oil tank is to be isolated, opened up for inspection and then recommissioned how is it ensured that the atmosphere in the tank never reaches the explosive limit? What action is taken if the atmosphere in a tank being made ready for inspection approaches the explosive limit?</td>
<td>Strict procedures were adhered to as it was understood that the processes of tank inerting, cleaning, purging and gas freeing needed to be carried out clearly and accurately. Loss of control could result in the atmosphere within the tank approaching the explosive limit. In the event that the atmosphere in any tank being made ready for inspection approached the explosive limit for any reason then all processes would be stopped and reviewed until it was safe to continue.</td>
<td>It was stated that personnel on board were very experienced at making a crude oil tank ready for inspection as they had done it many times. When asked to make the procedure available one was eventually found and it was apparent that it had not seen regular use. A number of personnel had undertaken some relevant training but when they were on leave sometimes there was no one individual trained and suitably conversant with the processes required to make a tank safe for inspection. In the event that a tank being made ready for inspection approached the explosive limit then all actions would be stopped.</td>
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**FPSO Attendant vessels and Offtake tankers.**

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<td><strong>16.</strong> Have there been any incidents where an attendant vessel, (supply boat, anchor handler etc.) made contact with the FPSO/FSU? Was this reported? What action was taken to prevent any reoccurrence? As attendant vessels are becoming larger and more powerful have procedures been modified to take this into account?</td>
<td>There had been an incident recently which was partly due to the fact that the port crane was out of use and a supply boat had to approach the starboard side which was the side most exposed to the weather on the day. The supply boat suffered a DP problem and made slight contact with the vessel hull before control was regained. The incident although small was reported, as all incidents of this type are. The owner of the vessel undertook a thorough investigation and determined the cause of the fault and put in place an approved repair. The company are more than aware that attendant vessels are becoming larger and more powerful and have modified the procedures accordingly.</td>
<td>Over the years a number of incidents have taken place where a supply boat for one reason or another has made contact with the vessel. Only one of these incidents was considered worth reporting to the authorities as quite extensive damage was done to the attendant vessel although very little to the FPSO. It is considered that the existing procedures are adequate and that the fault lies with the poor handling of the supply boats. It has been noticed that over the years the attendant vessels are becoming larger and more powerful. They will just have to take more care while alongside or on the approach.</td>
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<td>17. The owners and operators of the FPSO/FSU will be members of Oil and Gas UK. Is there a copy of the most recent Oil and Gas UK, Tandem Loading Guidelines onboard? Is it frequently referred to and are offshore personnel satisfied that they are in compliance with the Guidelines? How do they demonstrate compliance? In particular how do the company demonstrate that their personnel are competent to offload to an offtake tanker?</td>
<td>A copy of the most recent issue of the Oil and Gas UK tandem loading guidelines was available in the control room, it was frequently referred to and personnel indicated that they did their utmost to comply with the guidelines. The FPSO and the dedicated offloading tanker personnel worked closely together in their efforts to comply with the guidelines. Regular audits of both the FPSO and offloading tanker demonstrated compliance with the guidelines and were available to view. The training matrix included specific training for personnel involved in offloading and competence was demonstrated by means of a competence framework incorporating the training and experience of the relevant personnel.</td>
<td>The FPSO had been on location for many years and had undertaken many offloads without serious mishap. A copy of the tandem loading guidelines was found but was not the most recent issue and had not been made much use of. Personnel assumed that they were in compliance and were satisfied with the way that they were carrying out the offloads. There was a competence framework of sorts in place but work load and personnel shortages made it difficult to fulfil the requirements of the framework. It was emphasised that they had carried out many offloads without major mishap. The company had no intention of changing the way things were done.</td>
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<td>18. Is there only one offtake tanker dedicated to this vessel? Are all offload procedures therefore consistently the same and are they always followed? In the event that a previously unknown offload tanker had to be utilised for any reason, how is it confirmed that the marine crew of the offload tanker are fully conversant with the necessary procedures?</td>
<td>There is only one dedicated offloading tanker for this FPSO. It has worked with this vessel for many years and strict procedures are maintained. Offloads always follow the same procedure. In the event that an unknown tanker had to be used to offload then a number of audits would need to be carried out covering both the procedures required and the competence of the offloading tanker staff.</td>
<td>The field is licensed to three companies and each takes an equal share of operations. This means that each has their own offloading tanker and each tanker has different offloading procedures. This means that it is very difficult for the FPSO offloading personnel to ensure that they are consistently using the right procedure for the right offloading tanker. If another, previously unknown, offloading tanker had to be used it would be very difficult to demonstrate that the FPSO offloading personnel were conversant with any new procedures. The three companies have no current intention to utilise one tanker for all offloadings.</td>
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<td>19. Has there been an incident with an offload tanker where it either contacted the FPSO or came too close? Are you informed of incidents concerning other FPSO/FSU vessels and offtake vessels? Do you always report any incidents?</td>
<td>There was one incident where an offload tanker came too close but it did not make contact. Investigations showed that a DP fault had caused the near contact, the fault was found, rectified, tested on sea trials and audited. We are in regular contact with other FPSO and FSU owners and operators and are made aware of any incidents concerning offtake tankers and FPSO or FSU vessels. Incidents are always reported as a matter of course.</td>
<td>There have been a number of occasions where it was thought that an offtake tanker came too close, but no contact was made so no harm done. We do hear from individuals who have transferred from other FPSO or FSU units to this vessel of other incidents but we maintain no formal contact with other FPSO or FSU owners or operators regarding incident information. If an offtake tanker made contact with us we would report it but if it simply came too close we probably would not bother.</td>
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<td>20.</td>
<td>In the event that the weather worsens during an offtake at which point is the decision made to disconnect the offtake tanker? At which point is the decision made to attempt reconnection? Has there ever been an occasion where production had to shut down as the crude oil tanks were full and offtake was impossible due to the weather?</td>
<td>Strict procedures define the maximum motion at which point the decision is made to disconnect. The decision is, however, in the hands of marine personnel on board both the offtake tanker and the FPSO. Safety is the prime concern. Again reconnection is a joint decision and very much depends upon the two vessel motions. There is no defined point at which reconnection must take place. There has been one occasion where the weather was so bad that the offtake tanker could not make connection for some time. The production rate was reduced until such time as the offtake tanker could eventually safely connect.</td>
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