
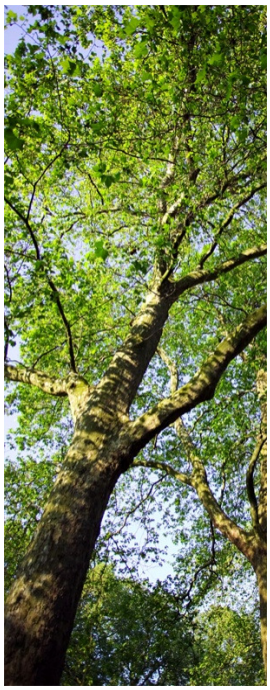


Bligh Bank Offshore Wind Farm

MUMM Project Monitoring: Concluding Report Executive Summary

June 2011
MUMM

Mott MacDonald

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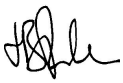
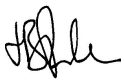

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Content

Executive Summary

Introduction

Belwind has developed and constructed an offshore wind farm of 165 MW capacity (the Project) on the Bligh Bank in the North Sea off the coast of Zeebrugge, Belgium.

As part of the verification team, Mott MacDonald was employed as advisor to the Management Unit of the North Sea Mathematical Models (MUMM) to maintain an overview of quality control (QC) and compliance verification, and to monitor the Health, Safety, Security and Environmental (HSSE) activities undertaken by Belwind and its contractors during the Project construction phase.

This Executive Summary presents a précis of Mott MacDonald's overall conclusions and the key health, safety, environmental and quality compliance and non-conformance issues experienced and overcome during the construction of the Project.

The Project

The Project was developed by Belwind and comprises 55 Vestas V90-3 MW Wind Turbine Generators (WTGs) plus the supporting infrastructure. Construction started in September 2009 and commissioning of all WTGs was completed on 17 December 2010. Installation of strengthening to resolve a technical problem with the grouted connection between Monopile (MP) foundations and Transition Pieces (TP) was completed on 24 March 2011. A total of 1,322,533 man hours were accrued during construction.

The construction team faced particular HSSE challenges. Transportation and installation of MPs over the winter period presented a weather hazard, and, at the time of commissioning, the Project was the furthest offshore wind farm to have been constructed. Incidents at the offshore site therefore risked exacerbation by site inaccessibility and time of transfer to shore for expert medical attention.

In addition, during the construction period it became common knowledge that the industry standard design codes for TP – MP grouted connections, as used for the Project, may not accurately predict the load carrying capacity for the design of offshore wind MP type foundations. The Project team was consequently challenged to identify a certifiable and effective solution whilst construction was taking place (refer to Appendix B).

The Project was completed on time, on budget, and with good QC and HSSE results.

Project verification

A project verification team was established by Belwind to obtain relevant certification and ensure compliance with relevant regulatory and Project standards throughout the construction phase. As part of the verification team, Mott MacDonald acted as advisor to the MUMM. Mott MacDonald maintained an overview of the QC and compliance verification activities undertaken, including the identification and resolution of verification gaps and, was also responsible for monitoring HSSE activities undertaken by Belwind and its contractors and identifying instances of non-compliance with relevant conditions of the Environmental Permit.

The opinion of Mott MacDonald was informed by regular analysis of the following sources of Project QC and HSSE information:

- Monthly construction reports produced by Belwind;
- Discussions with Belwind personnel;
- QHSSE non-conformance / incident reports;
- The Project Audit Inspection Plan;
- Belwind's Lessons Learned database (Lessons Learned); and
- Supporting documentation as requested.

Mott MacDonald reported its findings to the MUMM in six Project Monitoring Reports, issued at regular intervals across the construction period.

Key issues and incidents

An overview of the key HSSE issues experienced during the construction phase is provided in Appendix A, and key QC issues in Appendix B. Tables provided in the appendices include a summary of actions taken to resolve issues, lessons learned for future projects, and Mott MacDonald's verification opinion.

The key HSSE issues considered in detail in Appendix A are:

- The sinking of two MPs during transportation to the offshore site as a result of faulty hydraulic plugs;
- Problems with the implementation and follow-up of safety management system procedures; including particular issues with safety observations and incident reporting, lifting and hoist operations, and tool control;
- Lost Time Incidents (LTIs);
- Vessel collisions, near misses, and non-compliance with harbour regulations, and the transfer of personnel offshore;
- Offshore and onshore spillages;
- Fall arrest safety equipment on TPs;

- The installation of electrical systems in the wind turbines;
- Disposal of non-Project related radioactive cabling; and
- Slippage in the inclination of TPs during storage.

The key QC issues considered in detail in Appendix B are:

- TP connection flange ovality, diameter measurement issues and machined tolerance levels;
- TP paint quality and damages;
- Loops in the infield cable;
- OHVS paint quality; and
- TP – MP grouted connection.

Environmental permit compliance

As part of its duties, Mott MacDonald was required to comment on Project compliance with relevant conditions as contained in the Ministerial Order of 20 February 2008 granting NV Belwind an authorisation for the construction and a licence for the operation of a wind farm on the Bligh Bank in the Belgian sea areas (the Environmental Permit). Relevant conditions and a summary of compliance over the monitoring period are provided in Appendix C.

HSSE verification conclusions

As of 26 April 2011, all HSSE non conformance reports (NCRs) and safety observations related to the construction phase had been closed out to Mott MacDonald's satisfaction except one. An indentation on the top deck of the OHVS required repair following the dropping of a Meteorological Mast. The repair requires favourable weather conditions and is therefore planned for the summer. This is a minor issue and Mott MacDonald is satisfied that the issue has been transferred to the Operation and Maintenance (O&M) phase contractor's snagging list in accordance with standard practice.

It is Mott MacDonald's opinion that the Project remained in compliance with relevant environmental permit conditions throughout the monitoring period in all cases except for Condition 14 (refer to Appendix C), relating to ongoing problems with temporary warning lights (TWLs) during the early installation phase. The malfunction of TWLs was closely monitored by Belwind and occurrences were reported to the relevant authorities, guard vessels stationed to warn off shipping and repairs undertaken promptly. Mott MacDonald is satisfied that Belwind followed due process in this matter.

A breakdown in the communication of NCRs and safety observations between a contractor and Belwind was a source of concern at the onset of the construction phase.

Problems encountered may have hindered the prevention of a number of incidents, including MP sinkings and several LTIs (refer to Appendix A). In response, mitigation was identified and implemented by Belwind. Mott MacDonald believes the actions taken by Belwind were appropriate. The speed and quality of HSSE NCR reporting and documentation over the construction phase improved, bringing it more in line with Mott MacDonald's expectations.

Whilst the LTI key performance indicator (KPI) of a maximum of five LTIs was exceeded (seven LTIs were recorded during the monitoring period), Mott MacDonald believes that the number and severity of recorded incidents represents a good HSSE performance for a project of this scale and nature. Mott MacDonald also notes the bias of incidents towards the Project start up phase (refer to Appendix A), and considers the actions taken by Belwind to improve and monitor HSSE performance across the construction period to have been in accordance with best practice.

Mott MacDonald is also satisfied with Belwind's commitment to identifying key issues and solutions as part of its Lessons Learned (refer to Appendix A).

Overall, it is Mott MacDonald's opinion that Belwind demonstrated a strong commitment to continual improvement and implemented a preventative HSSE approach where possible.

Quality control verification conclusions

As of 26 April 2011, a small number of minor quality observations reported towards the end of construction activities remained open, and were transferred to the contractor's O&M snagging list for closure. This is a standard approach and Mott MacDonald does not have any concerns in this regard.

Mott MacDonald is satisfied that the adopted quality management system (QMS) worked efficiently and was appropriate to the nature and scale of the Project. Throughout the monitoring period no gaps in the Project QC process were identified, other than the failure of a contractor to participate in weekly QHSSE meetings in November 2009. The effectiveness of the QMS is highlighted by the relatively limited number of quality NCRs.

Mott MacDonald considers that the auditing procedures adopted by Belwind were successful. Non-conformances were identified prior to the installation of components. When non conformances were identified they were, in the main, resolved without incurring problematic schedule delay. Where concern was raised regarding the quality of a particular component, such as the TPs (refer to Appendix B), it is Mott MacDonald's

belief that actions taken by Belwind to assert control over the quality process were entirely appropriate.

Belwind has also been proactive in considering quality control improvements through its Lessons Learned (refer to Appendix B).

The grouted connection issue was an industry-wide design problem rather than a QC issue specific to the Project (refer to Appendix B). Nevertheless, Mott MacDonald closely monitored Belwind's response and is fully supportive of its early and decisive approach to establish a workable solution. Whilst it is recognised that the design and installation processes could have run more smoothly, Mott MacDonald is satisfied that due process was followed throughout.

Overall conclusion

Overall, Mott MacDonald is satisfied that the certification and checkings undertaken by Belwind and its advisors and contractors were appropriate to the nature and scale of the Project.

Appendices

Appendix A. Key HSSE Issues

1. Monopile sinkings / transportation plug hydraulics	
Issue	Belwind selected to transfer MPs to the offshore site by flotation, with a watertight seal on MP ends created by installation of temporary hydraulic plugs. During the transportation operation two MPs sank; MP C05 on 24 October 2009, and MP A04 on 7 November 2009. The root cause of these incidents was subsequently attributed to faulty plug hydraulics. Prior to the sinkings a number of minor faults had been identified in respect of plug hydraulics, including failure to release and leakage of hydraulic fluid. In a number of cases hydraulic problems were reported to have led to ingress of sea water during towing. Plug design was also complicit in a number of reported safety incidents related to entanglement and snapping of towing ropes. A breakdown in the incident reporting process between the contractor and Belwind however, meant that Belwind did not receive copies of incident reports relating to faulty plugs until after the second sinking. Of those minor incidents reported in September and October, and forwarded to Belwind following the sinkings, 11 either directly or indirectly identified a problem with plug hydraulics. Commonalities in the plug hydraulic faults being reported were not identified and consequently the problem was not provided due attention until after the first sinking.
Actions taken	Immediately following the sinking of MP C05, the Emergency Response Plan was activated and all necessary authorities were informed. A marker buoy with light was placed at the location and three vessels were placed on guard to prevent any further incidents. The root cause of the incident was investigated and a modification to the installation of the plugs was proposed: • A visual check to verify any rotation of the seal on plugs prior to installation in the MP and completion of necessary adjustments; • A visual check for eccentricity of the plug after installation and prior to pressurisation of the hydraulic system, and completion of necessary adjustments; and • Supervision of the plug installation by the manufacturer's design engineer, who also trained the contractor's supervisor on the correct installation methodology. The new installation methodology was approved by the marine warranty surveyor. The second sinking occurred after adoption of the revised installation methodology. The Licence to tow was subsequently suspended pending re-issue with additional conditions. Following the sinking of MP A04, a further root cause analysis was undertaken and the transportation plugs underwent re-design. Action was also taken to update the Project incident reporting procedures. No further sinkings occurred. Following redesign, none of the safety incidents reported indicated any further material problem with plug hydraulics. The salvage operation to retrieve MP C05 began on 30 October 2009. Following recovery, MP C05 was inspected and subsequently installed offshore. Retrieval of MP A04 was delayed until 15 January 2010 as a result of adverse weather conditions. On recovery, MP A04 was inspected and deformation (marked ovality) to the lower end of the structure was reported. The MP was re-shaped by the manufacturer and tested to ensure that there were no structural or quality implications arising from the initial impact or the re-shaping. It was subsequently installed offshore.
Lessons learned	In response to the MP sinkings, Belwind has identified the following Lessons Learned: • Assess and improve the team's root cause analysis and decision making capability; • Consider more reliable alternative transportation methods for future projects; and • Employ contractual solutions to improve consistency in HSSE observation and incident reporting (refer to Issue 2 in this table).
Verification opinion	The breakdown in communication of known problems with plug hydraulics may have prevented the timely development of an effective preventative solution. As such it is possible that the sinking of the MPs, particularly MP A04, could have been avoided. Despite the second sinking, all actions taken by Belwind were in accordance with due process. It acted appropriately to implement approved safety measures immediately after the incident, and subsequently to identify and rectify causal issues. The incidents were reported to the relevant authorities as per agreed procedures and all necessary certification and approvals were obtained. Mott MacDonald is not aware of any subsequent communication failures with respect to incident reporting and is satisfied that updates to the Project reporting procedures were appropriate to address the issue. Mott MacDonald also notes that flotation is a viable solution to the transportation of MPs offshore, as demonstrated by the absence of incidents following effective resolution of the plug hydraulic problem. Alternative transportation methods, such as transportation onboard lifting vessels, are currently limited by a lack of specialist offshore wind infrastructure.

2. Implementation and follow-up of safety management procedures	
Issue	At the onshore site, in the period September to December 2009, a number of safety incidents were reported including five of the Project's total of seven lost time incidents (LTIs). LTIs were classified as safety incidents that resulted in personnel being absence from work for more than one day. To put this figure into perspective, the Key Performance Indicator (KPI) for the whole construction phase was set at five LTIs. The level of safety performance, as indicated by the incident reports copied to Belwind, was considered below the expectations of the Belwind Project Team HSSE practice remained a key area of concern throughout the construction phase for Belwind and Mott MacDonald.
Actions taken	In November 2009 and in response to the number of safety incidents reported, Belwind conducted an independent audit of the onshore contractor's safety management system and its implementation at the onshore site. The audit found the safety management system employed by the contractor to be appropriate for the works, but that a lack of implementation and follow-up was occurring on the ground. Consequently, the HSSE audit result was unsatisfactory and returned an inventory of 37 items requiring improvement to achieve compliance with Project requirements. In response, the contractor employed additional health and safety staff on site to ensure adequate implementation of its safety system and instigated a renewed focus on safety amongst its workforce. In addition, Belwind placed a fulltime health and safety representative at the onshore site and conducted follow up safety audits to monitor and maintain improvements in safety performance. Work was also undertaken to align the HSSE procedures of contractor teams and Belwind, and to increase the speed of incident reporting to Belwind. The actions taken had a positive impact on the environmental and safety performance at the onshore site and only one further LTI was reported at the onshore site in 2010. Reported safety observations and incidents were closely monitored by Belwind for the remainder of the construction period. Where levels of reporting raised concern for the project management team, action was taken quickly to reduce the risk of escalation in severity or frequency. These ad-hoc interventions included tool box talks to cover particular issues of concern and increasing the number and quality of HSSE supervisors on site. Where it was considered prudent, an increase in supervisory capacity was funded by Belwind.
Lessons learned	To raise the general HSSE performance on site, the following measures are proposed for future projects: • Daily meetings at each site to discuss HSSE issues and upcoming work programme; and • Include an obligation for contractors to provide a dedicated HSSE representative at each site with sufficient authority (i.e. with sufficient seniority to expel workers not wearing proper PPE (personal protective equipment), direct safety discussions, and solve HSSE issues with workers on site). To ensure consistency in safety implementation, Belwind has also identified a suite of contractual measures including a standard reporting matrix in the HSSE masterplan required to be accepted by contractors and sub-contractors, that will state reporting times and levels of incidents to be reported. Key Performance Indicators (KPIs) and non-performance penalties will also be written into contracts.
Verification opinion	The measures adopted had a positive impact on the environmental and safety performance at the onshore site in 2009 and brought it more into line with Mott MacDonald's expectations. The approach taken by Belwind to resolve this issue was appropriate. It is noted that none of the LTIs reported resulted in an absence period of greater than two weeks. However, Mott MacDonald's review of Project safety observations, incidents and root cause analysis' has indicated that a number of incidents were attributed to use of inexperienced or insufficiently trained workers, inadequate HSSE supervision or failure to adequately implement procedures. On this evidence it is Mott MacDonald's opinion that numerous unsafe incidents, LTIs and other minor injuries reported in 2009 and subsequently, may have been preventable. Mott MacDonald is satisfied that Belwind has given due consideration to identifying solutions to these issues for future projects as part of its Lessons Learned.
3. Lift and hoist operations	
Issue	Incidents involving lifting operations were reported on a consistent basis from the start of the Project, at onshore and offshore sites. Many of the reported incidents were of a minor nature although several near misses were recorded and Project components experienced damage on a number of occasions. Safety issues at the onshore site, including lifting and hoist operations, are considered as part of Issue 2 in this table. Mott MacDonald raised concern in July 2010 that a longer term trend in incidents involving lifting

	operations could become established at the offshore site.
Actions taken	Belwind and its contractors worked together to ensure compliance with Project HSSE requirements. Actions included stationing of QHSSE representatives on a number of sites full time, and undertaking a review and update of the lifting procedure. Unsafe lifting issues persisted and, on 25 August 2010, a meteorological mast was dropped by a sub-contractor during attempted installation on the OHVS. The incident investigation found that the lift had taken place with an inadequate lifting plan, insufficient supervision and inexperienced personnel. This incident represented a serious breach of Project HSSE requirements and the project team implemented a lifting ban on the responsible sub-contractor until safe working practices were established at site.
Lessons learned	In addition to those Lessons Learned identified to improve HSSE performance as discussed in Issue 2 in this table, Belwind has identified specific Lessons Learned in relation to lifting operations: • From pre-construction, require contractors to pay particular attention to lifting and hoisting, and to include additional precautions within method statements and risk assessments; • Increase the frequency at which winch training is provided. Rather than once at Project commencement, consider providing on a monthly basis and as a minimum after each crew change; • Request continuity of winching crews to cover a full operation; and • Ensure only trained and experienced personnel undertake winching operations.
Verification opinion	The actions taken by Belwind were responsible and appropriate.
4. Tool control	
Issue	A cluster of knife related incidents occurred at the start of foundation works, and a further cluster of incidents were reported at the start of turbine installation works. The two peaks in reported incidents coincided with the commencement of new construction teams on site. Many of the reported incidents related to the inappropriate use of knives, for example in opening paint cans and cutting tie wraps. The incidents were a manifestation of broader safety implementation issues discussed in Issue 2 in this table.
Actions taken	The issue was noticed by project management on both occasions and appropriate follow up and mitigatory actions were taken. Actions included improved knife issuing controls, tool box talks and improved HSE supervision.
Lessons learned	Refer to Issue 2 in this table.
Verification opinion	It is considered that a number of reported knife injuries could have been prevented if an effective tool and equipment control system had been in place from the start of construction. However, the systems in place were sufficient to identify the problem and follow up actions were proportionate to the level of risk.
5. Vessel collisions and near misses	
Issue	The Project experienced a number of offshore collisions and near misses between vessels, and between vessels and foundation structures. This included a collision between the tug vessel MCS Lenie and Jack-up Barge JB114 during anchor handling operations which resulted in the mast of the MCS Lenie falling onto the bridge. It also includes contact made between JB114 and MP A06 during MP transportation that was reported to the authorities. Analysis undertaken of the relevant incident reports indicates that operations in marginal weather conditions were a contributory factor in most of these incidents. Engine failure and plug design were also cited in a number of instances and the use of unsuitably experienced vessel captains was an ongoing issue.
Actions taken	In most cases, Belwind and its contractor acted to replace the captain of vessels involved in offshore incidents with more experienced personnel. Where necessary, Belwind examined and altered procedures, including anchor handling procedures following the MCS Lenie incident.
Lessons learned	To further reduce the likelihood of incidents on future Projects the following measures have been proposed by Belwind: • Use of a newly developed vessel criteria standard requirement sheet that includes criteria for crew experience and qualifications; and • Consider adoption of a vessel classification standard higher than that of the Maritime and Coastguard Agency (MCA) to ensure vessels can perform well in adverse weather conditions. Options include Det Norske Veritas (DNV), Germanischer Lloyd (GL) or American Bureau of Shipping (ABS) classification.
Verification opinion	Actions taken by Belwind following incidents were appropriate. Additional measures identified for future projects are responsible and entirely appropriate to further improve the safety performance of vessels

	offshore, particularly in adverse weather.
6. Offshore personnel transfers	
Issue	The transfer of personnel to offshore wind turbines using transfer craft carries inherent safety risks. A large number of offshore transfers took place during the course of the Project and a low number of incidents were reported, the most severe being a first aid case. This issue is considered due to the identification of additional safety mitigation in Belwind's Lessons Learned.
Actions taken	The vessel related procedures in place for the Project were sufficient to prevent occurrence of any serious incident.
Lessons learned	Belwind has identified the following actions for subsequent operations, including the Operation and Maintenance (O&M) phase at Bligh Bank, to further reduce risks to personnel during transfer: • To provide a safe distance allowance for personnel transferring to WTGs in the event of sudden vessel movement, transferring vessels are required to have a front bow constructed to maintain a gap of 45 cm to the Transition Piece (TP) ladder; and • Investigation into the WTG boat landing design to allow for even safer transfers.
Verification opinion	Vessel related procedures were adequate and actions identified as part of the Lessons Learned demonstrate a commitment to continuing safety improvement. Belwind has given due consideration to the risk of incidents during transfer of personnel to WTGs.
7. Harbour regulations non-compliance	
Issue	Over the period July to August 2010 Belwind received two complaints from the Zeebrugge Port Authorities in relation to three vessels not complying with harbour regulations by failing to request quay admission. A further complaint was received from a fishing vessel indicating that two further Project vessels had been using excessive speed in the harbour area.
Actions taken	Following these incidents Belwind required its contractor to inform all vessels to comply with harbour regulations and 'Goed Zeemanschap'. No further complaints were received.
Lessons learned	Refer to Issue 5 in this table.
Verification opinion	Actions taken by Belwind were appropriate to remedy the problem.
8. Offshore spillages	
Issue	Four oil spillages were reported at the offshore site. These were: • Spray of approximately 20 litres of hydraulic oil following breakdown of the IHC hydro hammer on the vessel Svanen; • Spill of approximately five litres of hydraulic oil when the hydraulic hose connection broke during exchange of the Temporary Warning Light Frame (TWLF) on MP F3; • Spill of an unconfirmed volume of fuel on the deck of the JB114 during a fuel bunkering operation; and • Leak of approximately 200 litres of oil onto the deck of the JB114 when a nacelle was damaged at location A08.
Actions taken	Contractors followed Shipboard Oil Pollution Emergency Plans (SOPEP) in all cases in accordance with the relevant Project and regulatory standards. Following of SOPEP resulted in minimal release of oil to the marine environment and in most cases all oil was contained on the deck of the relevant vessel.
Lessons learned	Belwind has included a recommendation in its Lessons Learned requiring the offshore fuel bunkering procedure to be approved by Belwind prior to operations.
Verification opinion	Belwind and its contractors took all appropriate measures to address offshore pollution incidents.
9. Onshore spillage	
Issue	The failure of a hydraulic hose on the onshore drilling rig resulted in a loss of hydraulic oil to the ground. Subsequently it was discovered that there had been previous oil spillage under the drill.
Actions taken	Belwind undertook a clean up operation that involved the removal of 60 m^3 of soil. The standard of the clean up operation was high and the post-clean up condition of the site was approved by the site owner.
Lessons learned	For future Projects, Belwind will undertake a complete HSSE inspection of sites prior to commencement of work.
Verification opinion	The evidence of prior leakage suggests this problem had been ongoing and either went unreported or unobserved. As such, the incident may have been preventable. Measures taken by Belwind to improve

	the HSSE performance at the onshore site are discussed in Issue 2 in this table. Mott MacDonald is satisfied that the remedial actions taken by Belwind were in accordance with its expectations.
10. Fall arrest safety system	
Issue	To facilitate safe transfer of personnel to offshore TPs, personnel are attached to a fall arrest safety device. Throughout the monitoring period faults were reported in relation to many of the installed fall arrest systems.
Actions taken	Belwind formed a project team comprising itself, the manufacturer and the Project contractors to investigate the issue and identify a solution. The investigation resulted in a re-design of the fall arrest retrieving line and the new system has since been retrofitted to all boat landings.
Lessons learned	To ensure similar problems are not encountered on future projects, Belwind is continuing its investigation into the design of fall arrest systems to ensure safety during personnel transfers. Participants in the investigation include the leading utilities and contractors in the offshore wind energy business.
Verification opinion	The actions taken by Belwind to rectify the issue were in accordance with Mott MacDonald's expectations.
11. Offshore WTG electrics installation	
Issue	A number of incidents were reported in relation to workers failing to follow Project safety procedures when working on offshore electrical systems. Whilst the workers involved escaped without serious injury, the consequences could have been more severe for the personnel involved.
Actions taken	A root cause analysis was undertaken. The cause was attributed to the use of personnel familiar with installing onshore turbines. In response, the turbine installation contractor undertook additional training for staff on site and introduced more personnel appropriately trained in offshore systems.
Lessons learned	Onshore and offshore turbines have substantively different procedures for the installation of electrics. Use of onshore turbine installers for offshore installation therefore requires careful management and appropriate training and supervision. Whilst Belwind is not directly responsible for managing this issue, it will confirm with the turbine installation contractor that it has considered the issue within its Lessons Learned.
Verification opinion	Belwind and its contractor responded quickly and appropriately to identify the cause and prevent a more serious incident occurring.
12. Radioactive cables	
Issue	In April 2010 a routine scan found radiation to be emanating from a recovered subsea cable at a final disposal site.
Actions taken	Belwind informed the relevant authorities and a dedicated project team was established to handle the incident. The supplier and owner of the cable were contacted to ascertain information about the source of the radioactivity and investigations showed that a transponder installed as part of the cable did contain low levels of radioactive material. Radiation experts AV Controlatom confirmed that the level of radiation emitted from the cable posed no risk to human health. A local disposal company took responsibility for the disposal of the cable and the dismantling operation was overseen by the relevant authorities. The cable is now stored by the local disposal company.
Lessons learned	N/A
Verification opinion	The safety systems in place were sufficient to identify the potential risk and subsequent remedial actions were in accordance with Mott MacDonald's expectations for managing an incident of this nature.
13. Transition Piece storage	
Issue	TPs were stored upright at the onshore storage area prior to transportation offshore. The potential for TPs to fall presented a safety hazard and morning and afternoon measurements of the inclination of the stored TPs were taken. In November 2009, after a period of persistent heavy rainfall at the onshore storage area, results from the morning inclination measurements of the TPs identified that the inclination of two TPs had increased.
Actions taken	Immediately following this observation access to the TP area was cordoned off with high visibility tape and on site personnel were notified of the potential hazard. In addition, the security guard informed personnel arriving on site to remain clear of the restricted area. The cause of the problem was assessed and identified as the washing away of gravel from TP storage foundations during heavy rain. Both inclined TPs were relocated as soon as the weather permitted crane activity, and foundation grit was added to the storage site and levelled.

Lessons learned	Belwind will store TPs on solid ground where possible in future projects and soil pressure will be tested. If no alternative is available other than to store the TPs on made foundations, measures to prevent TPs from falling will be adopted. TP inclination measurement will be carried out as for the Bligh Bank Project.
Verification opinion	The measurement of TP inclination twice per day was prudent and mitigation measures after the event were in accordance with Mott MacDonald's expectations. Belwind's analysis and identified solutions in its Lessons Learned reflect good HSSE management practice.

Appendix B. Key QC Issues

1. Transition Piece connection flange diameters and flatness	
Issue	Measurement of TP connection flange diameters at the manufacturing facility by Belwind found a number of TPs to be slightly outside of the required Project specification for ovality. Belwind also observed inconsistencies in the results of measurements taken by contractors of TP connection flange diameters at the manufacturing facility, and subsequently at the TP storage area. In addition, the flatness (machined tolerance levels) of the connection flange on a number of TPs was slightly outside the required Project tolerance when measured at the harbour site.
Actions taken	Belwind raised the issue of TP flange ovality as a non-conformance. The manufacturer examined the issue and informed Belwind that the ovality issue was due in part to the measurement of TPs in a horizontal position; TPs weigh approximately 160 tonnes, and this weight pressing downwards along the length of the structure would induce ovality. Measurement of TPs in a vertical (as installed) position would result in reduced ovality. Belwind also investigated the TP flange diameter measurement procedure within the manufacturing facility. It found that measurement occurred at different points on each TP and not at a uniform set of fixed points. A new measurement regime was initiated whereby measurements were taken from predetermined bolt locations on the TP to maintain uniformity. Further investigation by Belwind into discrepancy in TP flange measurements performed at the manufacturing facility, and the storage area in Zeebrugge, identified that problems were accentuated by employment of different measuring techniques by the responsible contractors at each location. An independent company was employed to perform measurements. The TPs were re-measured in a vertical position at Belwind's Zeebrugge harbour site. Upright measurements found reduced ovality and the majority of TPs were found to be within the required specification. One TP was returned to the manufacturing facility to address ovality that remained outside allowable limits. Reduced ovality however, was not sufficient to bring the flatness of a number of TP connection flanges within Project specification. Where measurement of flatness at the Zeebrugge harbour site indicated there was an issue, TPs were re-machined to bring the flange flatness within specified limits. Belwind employed a specialist company to assess the potential implications of the remaining ovality on the fatigue of the foundation design. The assessment found that limited ovality should not have a material impact on the structure of the foundations and the WTGs. Investigation by Belwind also identified that the machined tolerance levels (for flange flatness) set by the turbine installation contractor for the Project were unnecessarily stringent and unachievable in practice. No schedule delays were incurred as a result of the ovality issue and where TP ovality remained imperfect it was found that WTG installation could take place without use of excessive force.
Lessons learned	Belwind has considered these issues as part of its Lessons Learned and is implementing the following for future projects: • Design the holes on the WTG tower sea fastening to have enough over dimension to allow for ovality in the WTG tower bottom flanges; • Agree the measurement procedure for TPs, to account for verticality and ovality, in the Quality Assurance and Quality Control (QAQC) plan; • Use a dedicated device to measure effective diameters of bolt holes; • Consider the need to set the tolerances in ovality, verticality and similar to be bigger in the foundation contract than in the WTG contract; • Undertake a prior check of tolerances available in the market; and • Set realistic tolerance criteria for TP flange and tower flange ovality to match industry standards. Actions taken by Belwind to implement Lessons Learned include requesting the turbine installation contractor to examine Project TP flange tolerances and increase to a normal value (+/- 5 mm). It has further been recommended that the turbine installation contractor specifies and describes the measurement method to be used.
Verification opinion	The measures identified and implemented by Belwind were in accordance with Mott MacDonald's expectations.
2. Transition Piece paint quality and damages	
Issue	A number of non conformances were observed by Belwind in relation to the quality of paintwork on the TPs, particularly damage experienced in transit from the manufacturing facility to Zeebrugge.
Actions taken	To ensure the quality of the coating, mainly in the area of the TP to be submerged, a Belwind coating inspector assessed each TP in Zeebrugge prior to the application of the final coat of yellow paint. Subsequent coating activities were closely monitored by Belwind's expert.

Lessons learned	Belwind accepts that damage to paintwork is common when TPs are transported horizontally. For future projects it will therefore try in the first instance to transport the TPs vertically. If that is not possible then it will ensure that the sea fastening is improved to prevent the kind of unnecessary damages experienced on the Project. Belwind does appreciate it is normal that some paint restoration will be required following transportation.
Verification opinion	The measures identified and implemented by Belwind were in accordance with Mott MacDonald's expectations.
3. Cables	
Issue	The cable between WTGs A05 and A06 was found to have three loops in the line following the cable laying process.
Actions taken	Surveys of the loops were undertaken and these have shown that the diameter of the loops is such that the manufacturers specified bending radius for the cable is not exceeded. The manufacturer also confirmed that the looping of the cable will not affect its performance. Belwind has partially buried the loops along the planned line of the cable and protected the entire cable loop with rock armour.
Lessons learned	Belwind has identified the following improvements for future projects: • Infield cables should be surveyed after the first two to six surface layings, requiring special survey methods in order to view any loops/ torques in the cable after surface laying; • The Contractor must provide survey results within 48 hours after completion of the relevant strings, to provide information on the quality of the surface laying crew; and • The required survey method should be stated in the contract; to be executed directly after the first surface layings and submitted to the Project Engineer within 48 hours of completion.
Verification opinion	The measures identified and implemented by Belwind were in accordance with Mott MacDonald's expectations.
4. OHVS paint quality	
Issue	A number of non-conformities were reported regarding the thickness of the paint coating on the joints of the Offshore High Voltage Substation (OHVS) structure.
Actions taken	The issue was investigated by Belwind and the manufacturer and it was concluded that the root cause of the problem was the application of the wrong primers to the structure during painting. As a result of the investigation, the procedure for painting the OHVS structure was reviewed and the final painting of the joints was completed after delivery to the offshore site.
Lessons learned	For future projects, Belwind will include a clear paint specification in its requirements and make sure that all paint inspections are part of the inspection and test plan of the contractor. Belwind will also ensure that all paint issues are resolved prior to installation of any structures offshore.
Verification opinion	The actions taken by Belwind to resolve this issue were appropriate and demonstrated good QC practice.
5. Grouted connection	
Background	As is common in most offshore wind farms, the Bligh Bank Offshore Wind Farm utilises a MP foundation. In order to account for potential verticality of the MP, a TP is lowered over the top of the MP and the annular (ring shaped) space between MP and TP is filled with high strength cementitious grout. This joint is termed a grouted connection. The turbine tower is then bolted to a flange at the top of the TP. Design of the grouted connection is based on established design codes however, recent experience has shown that the design codes may not correctly predict the load carrying capacity of the grouted connection and, at a number of offshore wind farms, a small amount of slippage has occurred.
Issue	During the early Project construction phase it became common knowledge that the industry standard design codes for TP – MP grouted connections were not adequate for the design of the foundations. Compliance with the design codes at other offshore wind farms resulted in TP slippage of up to 40 mm. This is an industry wide design issue potentially affecting all wind farms using a MP foundation and has been the subject of research by DNV and other key industry players.
Actions taken	Once the issue had been brought to its attention, Belwind organised an investigation team to identify a strategy to consider the actions to be taken should the grouted connections show sign of movement. An initial short term strategy comprised gaining knowledge and expertise from other Projects, analysis of raw data on the relative movement between MPs and TPs collected by Belwind, investigation into medium term monitoring options, and identification of preventive measures. Results from the short term strategy then informed a long term solution. On the basis of gathered information, Belwind took the decision to install additional load bearing elements into the existing structure between the MPs and the TPs. The final design involved welding stiffeners to

	the TP wall, and cutting loose the top plate from the existing bracket so as to entirely remove any load transfer to the existing brackets. Any fatigue issues with the levelling bracket welds (that had not been designed for long term load carrying capacity) were thereby avoided. The agreed solution received certification from DNV. Prior to installation of the grouted connection solution, slippage occurred on site at a number of TPs more quickly than had been anticipated. This resulted in steel on steel contact at a number of TPs/MPs. Belwind made an individual assessment of each WTG in order to prioritise bearing works at locations where steel on steel contact had been made, and then where greatest slippage had occurred. WTGs where steel on steel contact was observed were stopped prior to implementation of the solution.
Lessons learned	Various options for preventing re-occurrence of the problem on future Projects are under consideration by Belwind. Identified options include: • Inserting grouting limits (for example air, water and steel temperatures) into the construction contract; • Use of vibration devices during the grouting operation; • Using a conal design for TPs and MPs in order to support the grouting structure and to increase the length of steel on steel contact in case of grout failure; • Use of shear keys; and • Use of a one piece foundation; i.e. a MP with connection flange rather than installation of a TP.
Verification opinion	Mott Macdonald is fully supportive of the actions taken by Belwind to resolve the grouted connection issue and believe they are indicative of a proactive and preventative approach to the management of risk. Belwind followed due process in monitoring TPs for slippage and worked actively to prioritise retrofit for those assessed at greatest risk. Mott MacDonald is also satisfied with the precautionary approach taken to deactivate turbines on identification of steel on steel contact.

Appendix C. Environmental Permit Conditions and Compliance

Condition Number	Condition Summary	Monitoring Period Compliance Summary
2	Each planned modification must be reported to the Board and will be included in the annual work report.	In compliance.
14	During construction, all foundations and structures already finished must have a temporary warning light (at the highest point) for shipping and aviation traffic.	The status of this condition was regularly checked by the site guard vessel and non-conformances were reported to the authority and immediately restored. Additional safety measures were implemented to mitigate any potential safety hazard, including the stationing of guard vessels in the vicinity.
16	All WTGs must be numbered individually at the base of the mast and at the top of the nacelle.	In compliance.
17	All WTGs and transformers must be provided with collection receptacles to prevent liquids from being released in the environment.	In compliance.
29.1	The construction materials and rip-rap must be made of natural materials and must not contain any waste materials or secondary raw materials… the use of slag is prohibited.	In compliance.
31.1	Preventive measures must be taken to avoid causing permanent hearing impairment to sea mammals which could be in the vicinity during pile driving.	In compliance.
31.3	Pile driving activity must not start if sea mammals are observed in the surroundings of the pile driving vessel or pontoon. For this purpose, special lookout must be kept from a half hour before the pile driving work.	In compliance.
31.4	Pile driving must start with a 'ramp-up' procedure: the first pile driving strokes are made with minimal force and the force is gradually increased.	In compliance.
33.1	The lighting of the turbines for the benefit of shipping and aviation traffic must comply with the conditions set by the competent authorities.	In compliance.
33.2	Foghorns, which come into operation automatically in the event of a meteorological visibility of less than 2 sea miles, must be placed on the corner turbines.	In compliance.
34	The holder must maintain the farm on a regular basis.	In compliance, ongoing.
37	The masts must be sawn off up to 2 metres under the seabed… [During decommissioning].	Decommissioning phase.
39	After the operation period of the cables, all pieces that are part of the crossing setup must be removed.	Decommissioning phase.
48	A logbook must be kept in which the following is specified for each turbine: • Date, time and all relevant data of incidents that occur which have an impact of the environment, stating the measures taken; and • The recording of hazardous waste materials, the date of removal of the relevant batch of waste, the quantity and the name of the carrier and the recognised waste processor must also be recorded.	In compliance, ongoing.