

Process FMEA: Preventive Risk Measures for Offshore Wind Farm Projects

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1 The Process Failure Mode and Effects Analysis (P-FMEA)

Operating the P-FMEA

Plan the P-FMEA:

Assure support and resources

Schedule FMEA concept
Arrange the expert workshop(s)

Utilisation of the P-FMEA

Step 1: System Analysis

Step 2: Process Analysis

Step 3: Failure Analysis
Function and Malfunction Analysis

Step 4: Risk Analysis
Occurrence probability (P), severity (S), detection probability (D), Risk Priority Number (RPN)

Step 5: Optimisation
Detection, mitigation, and corrective measures

Follow-up and review:

Follow-up assigned tasks & measures

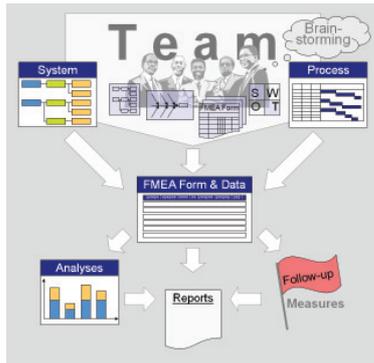
Review & improve the FMEA concept

This poster describes the design of a Process Failure Mode and Effects Analysis (P-FMEA) in order to promote preventive quality and risk management for offshore wind farm projects. The design of this concept study follows the special demands of the client's project management.

As a preventive measure, the (first) FMEA should be set-up at an early project stage to enable the transfer of results into the client's invitation to tender and contracts.

Implementation of the P-FMEA concept

2 The FMEA-Tool



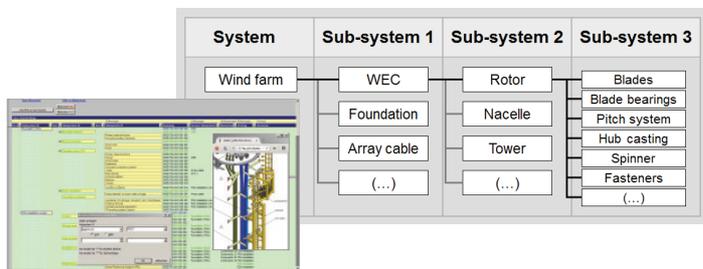
Elements of the FMEA-tool and concept

To manage the data and to guide the FMEA team through a structured process, a macro-based spreadsheet application has been developed.

The FMEA-tool corresponds to the elements of the P-FMEA concept (Fig. left). It facilitates the tracking of agreed actions and preserves the full data set for any subsequent FMEA.

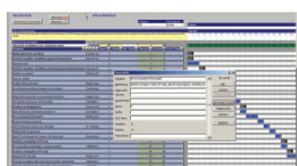
3 The System Analysis (Step 1)

In the course of the system analysis, the complete system (e.g. wind farm) is broken down into sub-systems, which results in a hierarchical tree structure with a distinct defined depth:



Principle of the System Analysis and a screenshot of the FMEA-tool's user interface

4 The Process Analysis (Step 2)



User interface for the Process Analysis

During the course of the process analysis, the main process, e.g. the installation of the wind farm, is broken down into sub-processes. The FMEA-tool helps to illustrate the logical structure (Fig. left).

5 The Failure and Risk Analysis (Step 3 & 4)

An intended process output (function) needs to be described before a respective malfunction can be derived for subsequent analyses:

Process Function and Malfunction Analysis				
Analysis level	Level 0	Level 1	Level 2	Level 3
Example process	Wind farm installation	Foundation installation	Vertical alignment of TP onto monopile	Adjustment of Transition Piece (TP) with hydraulic jacks before permanent stud bolts are set (followed by grouting)
Function of a process (output)	• Save installation • Suitable for 25a operation at defined LCOE (lowest cost of energy)	• Inclination of TP and flange within specification • Fit for purpose in rise time • Suitable to carry loads for 25a	• Ensure TP and flange inclination within specifications	• Counteract any deviation of monopile vertically • Temporary support the TP in vertical position • Enable to fit stud bolts in right position
Potential Malfunction of the process above	• CAPEX (Capital expenditure) increase due to delay and/or need for rectification measures • Increase of LCOE	• Early detection: (before grouting) • Minor delay, repeating vertical alignment of TP • Late detection: (after grouting) • No suitable foundation for WEC-Tower • No certification • Rectification required	• Tiling of TP • Flange dip out of tolerance	• Malfunction A: Machine: Error of vertically measuring instrument, e.g. incorrect factory-calibration • Malfunction B: Human: Incorrect use of instrument or error in reading • Malfunction C: Environmental: Use of instrument outside of accepted operating conditions (e.g. salty atmosphere) • (...)
Two options to correlate the Malfunction Structure (analysis depth)	Potential failure effect	Potential failure	Potential failure cause	Potential failure cause

Exemplified correlation of the Function, Malfunction and the Malfunction Structure

If the 'potential failure' is chosen as starting point for the failure analysis, each identified 'potential failure' is assigned to one (or more) subordinate 'potential failure cause' and to at least one superordinate 'potential failure effect'.

At the expert workshop, a special FMEA Form provides the basis to examine functions, potential malfunctions and to develop preventive measures as well as to quantify risk aspects. Risk Priority Numbers (RPN) are commonly used to prioritise intervention measures on a quantitative and comparative basis. For further information about the RPN scheme please refer to the article published in the proceedings of this conference.

6 The Optimisation (Step 5)

Choice of fields of the FMEA-Form (FMEA-tool)

As part of the optimisation process, the expert-team develops detection, mitigation or corrective measures. Each developed improvement is transformed into a precise task with a set deadline, and an appointed task holder.

The tool's FMEA Form instantly provides an overview of the current situation and the optimised planning for each process (Fig. above). The spreadsheet based tool allows a wide range of further analyses.

7 Results

The proposed P-FMEA concept is a capable method to identify risks, to improve failure detection, and to develop preventive measures.

The concept provides a comprehensive picture as a basis for designing a well matched contractual risk diversification. It is also a recommended method to improve overall risk awareness, as well as to clarify responsibilities and interfaces.

8 References and Annotations

The basic approach of the concept takes its origin from common FMEA concepts as described in: PFEUFER, H.-J. (2002): Fehler-Möglichkeiten- und Einfluss-Analyse (FMEA).- 81 S., Symposion Publishing GmbH (Düsseldorf).

For the illustrations, an English data set is used for example purposes and included purely for illustration only.