

PROJECT MANAGEMENT APPROACH FOR HVDC TOPSIDE: RISK ASSESSMENT ANALYSIS OF SPOOL MANUFACTURING PROCESS

Lavinia CRETU

"Dunarea de Jos" University of Galati,
Faculty of Mechanical Engineering, Galati,
111 Domneasca Street, 800201, Romania
E-mail: lavinia.cretu@ugal.com

Carmen GASPAROTTI

"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati,
47 Domneasca Street, 800008, Romania,
E-mail: carmen.gasparotti@ugal.ro

ABSTRACT

This paper aims to present how the risk assessment is conducted and to explore the main risks that could potentially disrupt the production flow of piping spool fabrication. From a management perspective, risk assessment may act as a foundation for a successful project. However, if it is not solid, consequences appear. For complex projects, such as HVDC topside, the operational team must be aware of the effects of risks that occur, and before any measures are implemented, the team must be capable of anticipating them. As a starting point, through a brainstorming session, it was assessed using a qualitative analysis of the risks, the probability of occurrence, and the impact they could produce. The process is associated with a variety of risks, from small ones (for instance, human errors that can be corrected) to larger ones (quality defects, contaminated materials, timeline constraints, non-compliance with standards, and safety risks). The paper also includes strategies of mitigation and associated actions. Moreover, in this paper are included methods proposed for further in-depth analysis.

Keywords: pipe spool fabrication, risk severity, mitigation, awareness.

1. INTRODUCTION

Considering the current context where the offshore industry is progressing across the world, Aker Solution has built two of the most impressive energy converter platforms in collaboration with Siemens Energy and

Scottish Power Renewables. It is noteworthy that Aker is recognized for delivering structures that operate in the most complex environments.



Figure 1 EA3 HVDC topside lifted into place [1]

The core of this paper is the topside built in Romania for the East Anglia Three converter platform. While the topside provides the setting, the analysis is centered on the critical importance of the pipe spool fabrication, which will be detailed in the following sections.

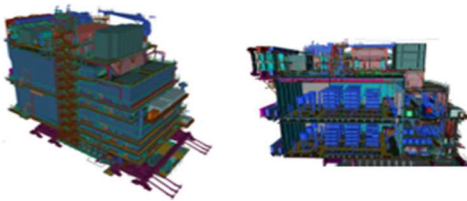


Figure 2 EA3 Topside [2]

As part of the building sequence, the topside was transported to Stord, Norway, for the installation of the HVDC (High-Voltage, Direct-Current) equipment. According to Figure 1, the jacket foundation of the HVDC offshore converter station is now fixed to the seabed and the topside is installed in the North Sea, located 69 km off the Suffolk coast.

As indicated in Figure 3, the converter platform, part of the East Anglia Three Hub, with the capacity of 1.400 MW, representing just a part of the total capacity of the Hub (3.100 MW), will be capable of producing clean energy to power the equivalent of more than 1.3 million homes.

HVDC system consists of two converter stations: offshore, power generated by wind turbines (up to 100 wind turbines, each reaching a height of 247m, with a rotor diameter of 230m) via an inter-array cable system (up to four subsea export cables are considered for transmitting electricity from offshore to the shore), and onshore, connected to the distribution grid.

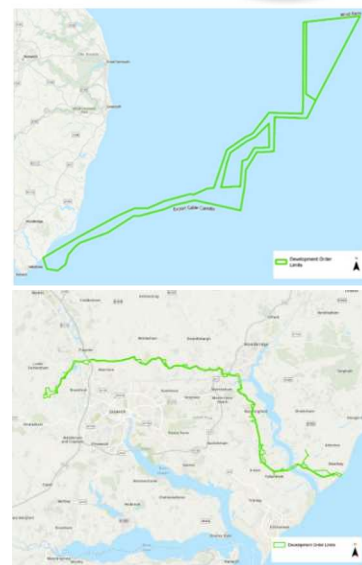


Figure 3 EA3 windfarm project [3]

According to Siemens CEO Marc Becker, the UK aims to reach Net Zero (removing CO₂ in equal quantities as they produce). The UK government fully recognizes the importance of renewable

energy and considers it to be on par with oil and gas [4].

East Anglia Three offshore wind farm is undoubtedly one of the largest wind farms across the world and will begin to operate at the end of 2026.

Generally, a project is subjected to daily challenges and companies to various risks. Managing the flow of production for these massive projects, particularly spool manufacturing, requires having the capability to anticipate any risks that could potentially compromise the integrity of the final product.

The procedures are slightly different when it comes to structures that are intended to operate in the open seas. It is essential to comply with rigorous standards and to perform with a higher degree of precision regarding the use of specialized materials (stainless steel, duplex stainless steel, super duplex stainless steel, and titanium, known for their exceptional corrosion resistance).

Manufacturing of spools involves a series of sequential phases as shown in Figure 4.

The process begins with receiving and processing documentation, followed by cutting, beveling, and welding, in accordance with the Welding Procedure Specification (WPS).

Quality inspections are carried out as per Norsok standards for acceptable oxidation levels, and following this step, NDT (Non-Destructive Testing) methods and 3D measurements are applied to verify the weld seam integrity.

A wide range of potential risks must be carefully anticipated. For instance, NDT procedures, particularly Radiographic Testing, must be executed under rigorous safety measures as the exposure to radiation can be harmful to people.

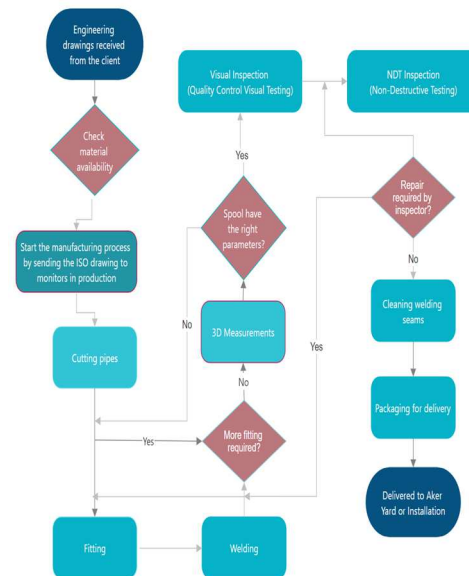


Figure 4 Production Flow Chart
(process sequence of spool fabrication)

Before delivery, the final phases are cleaning welding seams and packing the pipes to protect them from environmental factors during storage and transportation.

Throughout all these phases, efficient monitoring is the key to achieving a seamless workflow and delivering the quality expected.

Risks can be numerous, especially in a process where activities are interdependent. Risk management is used in various companies to identify, assess, and analyze risks, taking into consideration that the methods do not eliminate the risk exposure, their goal is to create an environment for making the right, well-informed decisions, and minimizing the negative impact [5].

2. RESEARCH METHODOLOGY

This paper uses a general methodology as a working tool for improving

risk management, which involves three stages: risk identification, assessment, and management [6], [7].

The risk identification process is the first step, through which all possible sources of risk are discovered, to eliminate or reduce the probability and the impact they could produce.

Risk assessment involves assessing the impact of risk materialization, combined with the assessment of the probability of its materialization, to determine risk exposure. Some risks require a qualitative estimate, while others require a quantitative estimate. As an assessment tool, various probability scales can be used, generated by the experience of those working in Risk Management (Figure 5).

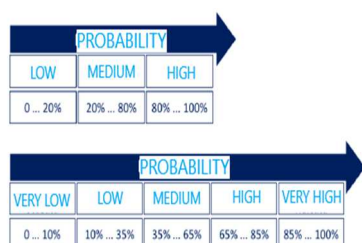


Figure 5 Probability scale

Regarding the impact assessment, it is done both qualitatively and quantitatively. Even if quantitative estimates are more appreciated and relevant, in the end, the unitary image of the identified risks is given by a qualitative assessment, built also on the basis of the quantitative estimate.

Types of qualitative scales regarding impact are the three-step scale and the five-step scale (Figure 6).

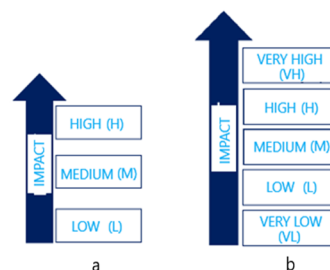


Figure 6 Qualitative scales relating to impact (a. three-step scale; b. five-step scale)

Risk exposure is a probabilistic concept, directly related to the probability of risk materialization, having significance only before the risk occurs. Risk exposure operates with an implicit hierarchy of identified risks.

Risk exposure is a combination of probability and impact, being a two-dimensional, matrix-type indicator.

Out of the various methods used for qualitative analysis of the risk, the brainstorming method was chosen. This heuristic method, created by A.F. Osborn, encourages team participation to identify the main factors that cause the risks [8].

The matrix type 5x5 places the risks on a coordinate system where one axis shows the values of probability of occurrence (or likelihood) and, the other one, the impact (or consequence), on a scale from 1-5.

Regarding the third stage of risk management, this is achieved using various risk response strategies, which are, actually, measures taken to reduce the probability of the risk occurring and the impact it could have on the results if the risk were to materialize.

Risks are identified where it is perceived that there are consequences on the achievement of objectives, and measures can be taken to solve the problems.

3. RESULTS AND DISCUSSIONS

In this regard, is necessary to evaluate or determine the priority of the risk [9]. Taking this into consideration, the priority lies in the severity of the risk and the right measures must be taken promptly.

The severity may be considered as being the consequence of a risk, for instance a safety risk, a potential bottleneck that slows down the production cycle, or other aspects that could compromise the overall project.

IMO describes the risks as being “the combination of the frequency and the severity of the consequence” (MSC Circ 1023/MEPC Circ 392) [10].

Based on the observations and the brainstorming conducted, the risk criteria is described through the impact and the likelihood as mentioned in the previous section. Table 1 shows the percentages for probability of occurrence, while Table 2 indicates how the risk rating is calculated, based on Probability Rating (PR) multiplied by the Impact Rating (IR).

Risk is assessed using five categories of risk rating:

- Risk rating 1: Rare, the possibility to occurrence is nearly small
- Risk rating 2: Unlikely, seldom occurring
- Risk rating 3: Possible, subject to occurrence
- Risk rating 4: Likely, more possible to occur
- Risk rating 5: Almost certain, expected to occur

The percentages are estimated as follows:

Table 1 Probability of occurrence

Risk Rating	Probability	% Occurrence
1	Rare	< 5%
2	Unlikely	5-20%
3	Possible	21-50%
4	Likely	51-70%
5	Almost certain	> 70%

Table 2 Probability and Impact

Risk No.	Treat / Opportunity	Probability	% Occurrence	PR	Impact	IR	Risk Rating (P x I)
Risk 1	T	Possible	21-50%	3	Major	4	12
Risk 2	T	Likely	51-70%	4	Major	4	16
Risk 3	T	Rare	< 5%	1	Catastrophic	5	5
Risk 4	T	Rare	< 5%	1	Major	4	4
Risk 5	T	Possible	21-50%	3	Major	4	12
Risk 6	T	Likely	51-70%	4	Major	4	16
Risk 7	T	Likely	51-70%	4	Major	4	16

After placing the risks, the so-called risk matrix map presented in Table 3 highlights in colors the risk levels (the overall risk rating) in the following manner:

- Low Risk, from 1-3
- Medium Risk, from 4-9
- High Risk, from 10-16
- Severe Risk, from 17-25

In both business practice and project management, this type of matrix is used to monitor risk dynamics regularly [5]

Table 3 Risk matrix type 5x5

Probability		Impact				
		Insignificant	Minor	Moderate	Major	Catastrophic
		1	2	3	4	5
Rare	1	1 - Low	2 - Low	3 - Low	4 - Medium	5 - Medium
Unlikely	2	2 - Low	4 - Medium	6 - Medium	8 - Medium	10 - High
Possible	3	3 - Low	6 - Medium	9 - Medium	12 - High	15 - High
Likely	4	4 - Medium	8 - Medium	12 - High	16 - High	20 - Severe
Almost certain	5	5 - Medium	10 - High	15 - High	20 - Severe	25 - Severe

Table 4 shows the risk descriptions along with the actions and corresponding strategies. Risk response is characterized by the following practices or strategies: avoidance, mitigation, acceptance, transferring, and contingency planning.

Table 4 Risk actions and strategy

Risk no.	Risk Description	Response/Action	Risk Strategy	Current Rating	Target Rating
Risk 1	Process Risk: Manufacturing defects	Provide training to ensure that workforce is qualified to use techniques or procedures properly	Mitigation	High	Low
Risk 2	Schedule Risk: Delays in material procurement	Maintain strong relationship with suppliers; measures must be taken to avoid the disruption of the workflow; allocate a time buffer for unforeseen situations	Mitigation	High	Low
Risk 3	Safety Risk: Accidents at workplace	Add strict safety protocols and provide safety training regularly; frequent safety audits to monitor if the rules are followed; regular maintenance of equipment	Contingency Plan	Medium	Low
Risk 4	Environmental Risk: Pollution	Comply with standards and regulations; reduce the impact of pollution by implementing methods for an eco-friendly process	Contingency Plan	Medium	Low
Risk 5	Reputational Risk: Quality issues	Regular inspections to consolidate quality assurance awareness	Mitigation	High	Low
Risk 6	Planning Risk: Unclear scope which contributes to exceeding project deadlines	Rigorous monitoring of planning and production cycle; timely address the issues encountered for a better clarity	Transfer	High	Low
Risk 7	Delivery Risk: Subcontractors impact project timelines	Monitoring progress closely and maintain open communication to avoid delays	Transfer	High	Low

Regarding this study, the identified risks range from Medium to High, as shown in Table 4. These risks must be managed appropriately and closely monitored to ensure the mitigation actions are properly implemented and the impact is being reduced. The risk response chosen is the following:

- Mitigation (to reduce the probability and the impact of the risks);
- Transferring the risk to other parties by contractual agreement (suppliers, subcontractors, stakeholders, outsourcing providers);
- Contingency planning (a plan developed with contingency reserves in the budget).

For the sake of clarity, the outsourcing providers are, for instance, third-party safety auditors, inspectors, Quality Assurance auditors (QA), Logistics and Supply Chain providers, and training laboratories.

Figure 7 presents visually how different risk response strategies can be applied for each of the seven risks identified in the analyzed HVDC case, along with the corresponding actions to be implemented.

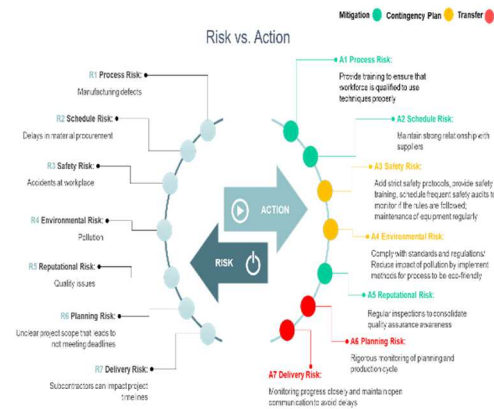


Figure 7 Risk response strategies

Although multiple techniques can be applied, for this paper has been adopted the estimating technique based on probability and impact. For a more comprehensive examination, the root-cause analysis can be used for mapping the risks and finding the fundamental cause. This technique requires the willingness of management to address the root cause, instead of adopting workarounds [8].

Another technique for deepening the assessments of risks is the post-project analysis (so-called Lessons Learned) to prevent making the same mistakes or missing opportunities. In addition, it can serve as a database and can be a good indicator to leverage previous experiences [8]

CONCLUSIONS

Based on the above analysis, can be concluded the following:

- Operational team must be involved in the assessment process, they may have a different view of the risks and they will face the consequences of the decisions made by the management team.

- The risks must be systematically monitored and the assessments must be reviewed regularly. A risk assessment can be considered just a "snapshot". The organization, the working practices, and technology are constantly changing, and other subsequent hazards can be omitted.

- Leaders must consistently provide support to ensure adaptation to changing project dynamics to avoid risk exposure.

- The result of risk management must be communicated and understood by all parties involved.

REFERENCES

- [1] ScottishPower Renewables' first-ever offshore innovative HVDC station lifted into place, 2025. Accessed: October. 23, 2025. [Online]. Available at: <https://www.scottishpowerrenewables.com/w/scottishpower-renewables-first-ever-offshore-with-innovative-hvdc-station-lifted-into-place>.
- [2] Cretu, L. "Project Management Approach for HVDC Offshore Converter Platform: A Comprehensive Analysis of Spool Manufacturing Process". Master thesis. 2024.
- [3] Pamela Lague, Siemens Gamesa bags East Anglia 3 wind turbine contract, Enlit platform, 2023 Accessed: October. 23, 2025. [Online]. Available at: <https://www.enlit.world/library/siemens-gamesa-bags-east-anglia-3-wind-turbine-contract>.
- [4] Biljana Maljugin, Marija Matotek Andelic, Srdana Taborosi Zrenjanin, Risk analysis and risk management in business, XII International Symposium on Engineering Management and Competitiveness Serbia, 2022 (EMC 2022).
- [5] Anna Korombel, Piotr Tworek, Qualitative risk analysis as a stage of risk management in investment projects: Advantages and disadvantages of selected methods-theoretical approach, Jun. 2011, Journal Of Interdisciplinary Research.
- [6] Daryanto, Maulana, M. A. and Kurniawan, F. "Operational Risk Assessment Of Ship To Ship Transfer In The FSRU Lampung Using Risk Matrix Method". IOP Conference Series: Earth and Environmental Science, Volume 557, 2nd Maritime Safety International Conference (MASTIC) 18-Jul-2020, Surabaya, Indonesia.
- [7] Siswoyo, B., Fadillah, A., Pratama, P. and Irvana, R. "Risk Assessment for Ship Safety Development in Surabaya Western Access Channel". In: Maritime Safety International Conference 2018. DOI: 10.23977/mastic.024.
- [8] IOP Publishing, Operational Risk Assessment Of Ship To Ship Transfer In The FSRU Lampung Using Risk Matrix Method, IOP Conference Series: Earth and Environmental Science.
- [9] IACS, A Guide to Risk Assessment in Ship Operations, 2004. Accessed: November 1, 2025. [Online]. Available at: https://www.panamashipregistry.com/wp-content/uploads/2019/07/A-Guide_to_Risk_Assessment_in_Ship_Ops.pdf.
- [10] Revised guidelines for formal safety assessment (FSA) for use in the IMO rule-making process. Accessed: November 1, 2025. [Online]. Available at: [https://www.wcdn.imo.org/localresources/en/OurWork/HumanElement/Documents/MS-C-MEPC.2-Circ.12-Rev.2-2020-Revised-Guidelines-For-Formal-Safety-Assessment-For-Use-In-The-IMO-Rule-Making-Process-\(Secretariat\).pdf](https://www.wcdn.imo.org/localresources/en/OurWork/HumanElement/Documents/MS-C-MEPC.2-Circ.12-Rev.2-2020-Revised-Guidelines-For-Formal-Safety-Assessment-For-Use-In-The-IMO-Rule-Making-Process-(Secretariat).pdf)

Paper received on November 1st, 2025

