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

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## 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, the consequences appear. For complex projects, 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.

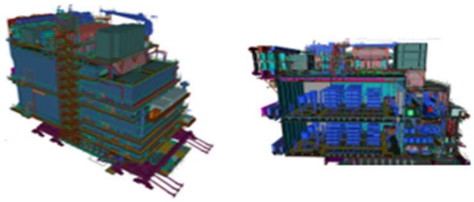

**Figure 2** EA3 Topside [2]

As part of the building sequence, the topside was transported to Stord, Norway, for 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 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 consist in two converter station: 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.

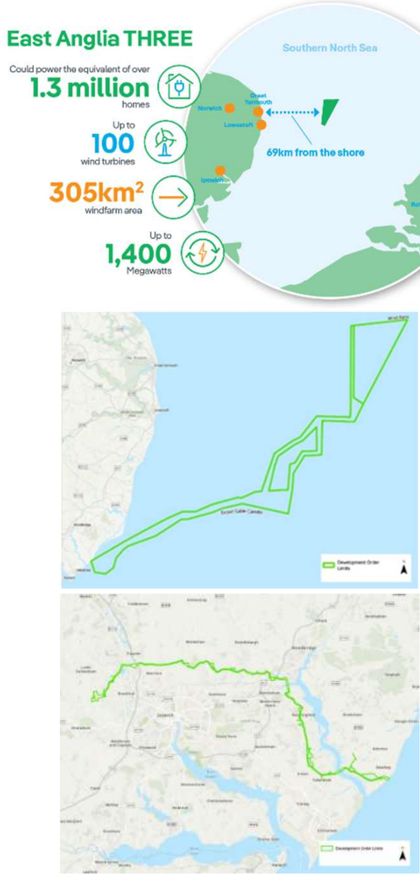


**Figure 3** EA3 windfarm project [3]

According to Siemens CEO Marc Becker, the UK aims to reach Net Zero (removing C02 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.

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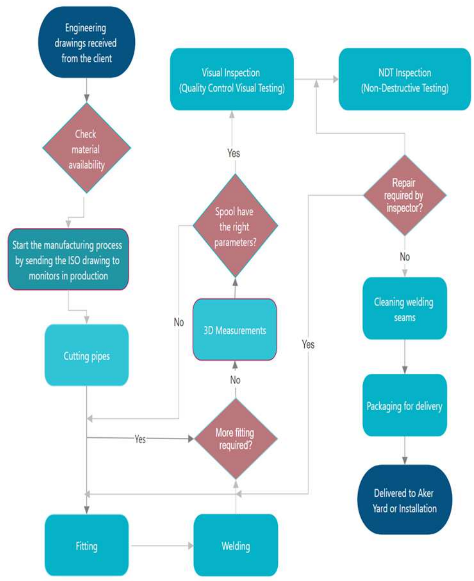


**Figure 4** Production Flow Chart (process sequence of spool fabrication)

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, taking into consideration that the methods do not eliminate the risk exposure, the scope 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).

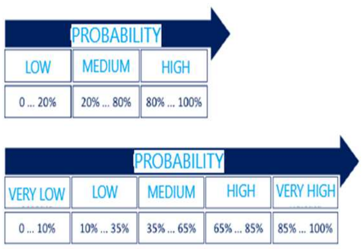


**Figure 5** Probability scale

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).

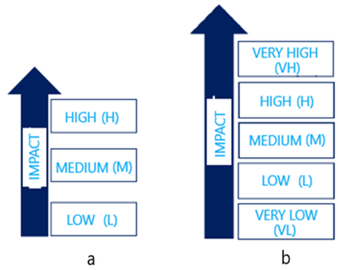


**Figure 6** Qualitative scales relating to impact (a. three-step scale; b. five-step scale)

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

The risk is significant for the company or for the process, within the scope of this paper, being the manufacturing process, only if it has a clear meaning to take the right business decision. 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 slow 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, subjected 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.

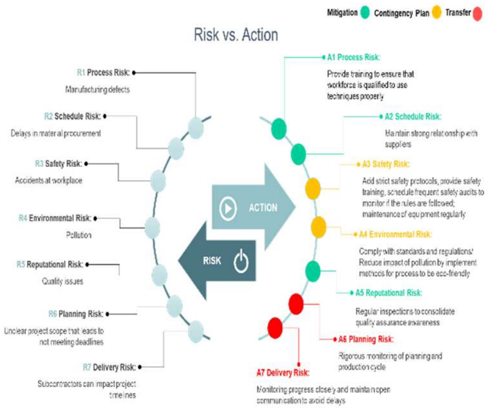


**Figure 7** Risk response strategies

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.

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