G+ White paper

Steel fabrication for the offshore wind industry – safety, practices, and opportunities

G+ Global Offshore Wind Health & Safety Organisation

In partnership with

energy institute

STEEL FABRICATION FOR THE OFFSHORE WIND INDUSTRY – SAFETY, PRACTICES, AND OPPORTUNITIES

G+ White paper

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EXECUTIVE SUMMARY

Objectives and methods of the white paper

This White Paper represents the completion of the first phase of a G+ project aiming to better understand the complexities of health and safety in the fabrication of steel structures for current and future offshore wind projects, and how offshore wind developers can better support fabricators in improving health and safety. In this first phase of the project, K2 Management was appointed by G+ to engage its members and the fabricator community to seek their direct feedback on the challenges faced, and to conduct background research on relevant international regulation and guidance. This paper does not offer guidance: it reports on the findings of this first phase of the project and offers an outline of initial recommendations for inclusion in a good practice guidance (GPG) that will be developed in the second phase of the project. This GPG will seek to address the identified challenges, helping to create a common understanding around health and safety objectives between client and fabricators.

What guidance already exists for the industry?

All regions where the most active fabricators are present have requirements for compliance with local health and safety (H&S) legislation. However, the level of regulation and enforcement can vary significantly depending on the region, which can lead to gaps in expectations between project developers and fabrication yard.

ISO standards are seen to offer a suitable, general structure and a framework to support compliance with legislation. ISO 45001:2018 is generally the standard referred to by most of the fabricators' when considering H&S. However, its main focus is on safety management systems and compliance, therefore it does not offer guidance on actual best practice for H&S. It remains the fabricators responsibility to suitably identify the more complex tasks and utilise their experience, knowledge and established practices to make the workplace safe. For parties that wish to gain more assurance over performance, then best practice guidance from the oil and gas industry offers some synergies and an opportunity to ensure some standardisation.

What is the industry's current experience?

Beyond the vast range of quality standards that currently exist for steel structures and offshore applications, it is important to recognise that the extent of the overall fabrication process, which involves many steps and various interfaces requiring handling loads manually or with specific equipment (e.g. lifting, moving, suspending or lowering), as well as the dimensions of the material handled, represents a significant health and safety risk.

Sadly, at the time of writing this paper, fatal and serious incidents are being reported at steel fabrication work for offshore wind projects. Two case studies covered in this paper are used to illustrate significant deviations from what could be considered best practices. Such deviations included, for example: lack of organisation and rigour in the management, lack of monitoring and compliance with the Method Statements, and poor understanding of the challenges faced by employees carrying out the work. Feedback from project developers also evidenced similar issues, pointing out gaps in the H&S culture in the yard, and the weakness or absence of relevant H&S guidance for the fabrication. Direct discussions and engagement with the yard throughout the project appeared to be seen as a key element to enable the appropriate application of the H&S measures.

From the yard's perspective, such early engagement was also seen as a key demand. Dropped objects, slips, trips and falls and the use of tools and equipment are typically the most reported incidents

leading to lost workdays. This is overall similar to the rest of the industry (see e.g. gplusoffshorewind.com), which indicates that lessons could be shared across the industry. However, it is generally felt by fabrication yards that they have only limited ability to provide input in projects, leaving them with very little opportunity to eliminate risk completely. This is particularly true when considering the increasing challenges raised by XXL foundations, as demand for such foundations grows. The genuine interest in further collaboration between G+ and the fabricators should be seen as critical to help improving fabrication safety in the project, exchanging on design requirements and fabrication limitations as early as possible.

What are the key takeaways?

Key recommendations for the next steps
Overall, three key leads were brought out as relevant ways to address some of the most critical challenges. These shall be considered in future best practice guidance: **Integrating fabrication considerations in the design**: Improving H&S in steel fabrication for offshore wind can begin well before the first steel plate is being manufactured. Adopting safe-by-design principles, feeding back lessons learnt in future design, and facilitating fabrication requirements to be considered using fabricators' input at an early stage, are key elements to develop. **Clarifying H&S requirements from the procurement and contractual phase**: The responsibility to ensure a positive and safe working environment is often unclear from the contract set-up, project developers generally feeling that it is that of the fabrication contractors, whilst fabricators feel that the limited H&S consideration in the project design leaves only little mitigation options. Best practices in terms of H&S requirements should be provided, with reference to relevant standards where applicable, to clarify and normalise as much as possible the enforcement of good H&S practices. **Accounting for cultural differences**: Cultural differences between countries and between organisation mindsets (project developer vs. fabrication yard), such as language or reference barriers, difference in leadership behaviours, or differences in trainings, can lead to conflicts, stress and ultimately to H&S incidents. An open communication between the parties, with clear channels and respectful approaches to cultural differences, is essential, and the leadership of the developers is a key aspect to enable it.

1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

Steel is the obvious crucial element in offshore wind projects as it is used in a major part of a wind farm, from the wind turbine generator to its foundation and the plant's substation. It faces challenging conditions, with harsh and irregular loadings, in a corrosive environment. Material strength and durability are therefore critical to support the intended design life of a project, and steel fabrication requirements are typically very strict to ensure that the design achieved meets the project targets.

Although there is a solid basis of guidelines and standards guiding the steel fabrication steps specifically for the offshore wind sector, there is a scarcity of health, safety and environment (HSE) standards that ensure safe working during such fabrication. At the time of writing this White Paper, recent news of a fatal incident occurring at a fabrication yard had been shared across the industry. This was an unfortunate reminder that clear guidelines are necessary to lower the risks, in a demanding and accelerating context for the industry.

This paper attempts to identify the major challenges in H&S during steel fabrication for offshore wind, and to outline initial recommendations for the definition of a set of formal, practical and relevant, good practice guidance that would address the problems identified, creating a common understanding of H&S expectations, with the ultimate goal of preventing injuries and improving H&S performance in steel fabrication for offshore wind.

For clarity, the scope of this study covers from the receipt of steel at the fabrication yard up to loadout. Loadout may include loading onto the transportation vessel and preparing sea fastenings. The study also focused on primary steel fabrication, where primary steel makes up the can sections of monopiles (MPs), transition pieces (TPs) and jacket legs. Conversely, secondary steel is typically that of boat landing or external platforms, and tertiary steel can be considered fittings such as rails or ladders.

The document is organised in four mains sections: following this introduction (Section 1), the current safety performance of fabrication yards, based on a review of different case studies and engagement with the stakeholders, is outlined in Section 2. Existing industry practices and guidance are presented in Section 3. Section 4 then draws conclusions from the afore reviews to identify the key challenges driving the H&S performance in steel fabrication.

This document does not offer guidance: it reports on the findings of this first phase of the project and offers an outline of initial recommendations for inclusion in a GPG that will be developed in the second phase of the project.

1.2 ABBREVIATIONS

Abbreviation	Meaning
ACoP	Approved Code of Practice
ACP	American Clean Power
API	American Petroleum Institute
AWEA	American Wind Energy Association
BAUA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin
BMAS	Bundesministerium für Arbeit und Soziales
BS	British Standard
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CR	client representatives
CW	circumferential weld
DoL	Department of Labor
DimCon	dimensional control
DNV	Det Norske Veritas
DWEA	Danish Working Environment Authority (Arbejdstilsynet)
EI	Energy Institute
ER	emergency response
ETSI	European Telecommunications Standards Institute
GPG	good practice guidance
HiPo	high potential near hit
H&S	health and safety
HSE	Health, Safety and Environment
HSWA	Health and Safety at Work Act 1974
IEC	International Electrotechnical Commission
IOGP	International Association of Oil and Gas Producers
ISO	International Standards Organisation
KPI	key performance indicator
LMRA	last minute risk analysis
LOLER	Lifting Operations and Lifting Equipment Regulations 1998
LW	longitudinal weld
LWD	lost workdays
MP	monopile
MTC	medical treatment case
NLA	Netherlands Labour Authority
NDT	non-destructive testing
NORSOK	Norwegian Shelf's Competitive Position
NSB	National Standards Body

Abbreviation	Meaning
OHS	Occupational Health and Safety
OCRP	Offshore Compliance Recommended Practice
OSHA	Occupational Safety and Health Administration
RAMS	risk assessment method statements
RCA	root-cause-analysis
RFI	request for information
RORO	roll-on, roll-off
RWC	restricted work case
SI	statutory instruments
SPMT	self-propelled module transporter
TP	transition piece
WAH	work at height
WTG	wind turbine generator

2 CURRENT STATUS OF THE INDUSTRY

At the time of writing this White Paper, recent news of a fatal incident occurring at a fabrication yard had been shared across the industry. This was an unfortunate reminder that clear guidelines are necessary to lower the risks, in a demanding and accelerating context for the industry.

In order to better understand how safety risks can be handled, it is critical to first appreciate the current practices in the industry and measure the current requirements and efforts in terms of H&S.

The typical steps followed by fabricators to manufacture primary steel for offshore wind are outlined in 2.1, evidencing the complexity of the process and the resulting H&S risks. Two case studies illustrating past incidents at fabrication yards are then presented (2.2), highlighting some of the key issues that the industry is facing. Finally, in order to capture more accurately these issues at stake, an initial engagement with stakeholders was conducted and is reported in 2.3

2.1 TYPICAL PROCESS FOR FABRICATORS

The flowcharts in Figure 1 and Figure 2 attempt to give the reader an understanding of the typical steps of producing primary steel structures for offshore wind, for TPs and foundations (MPs and jackets) respectively. Those should be considered as generic, high-level processes only, and variations should be expected for each, based on design and project specificities.

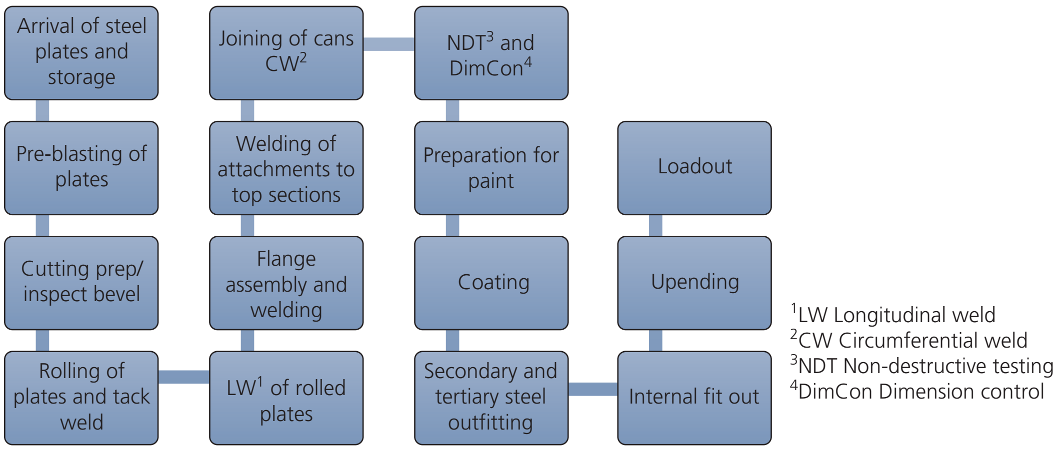


Figure 1: Typical fabrication process for TP

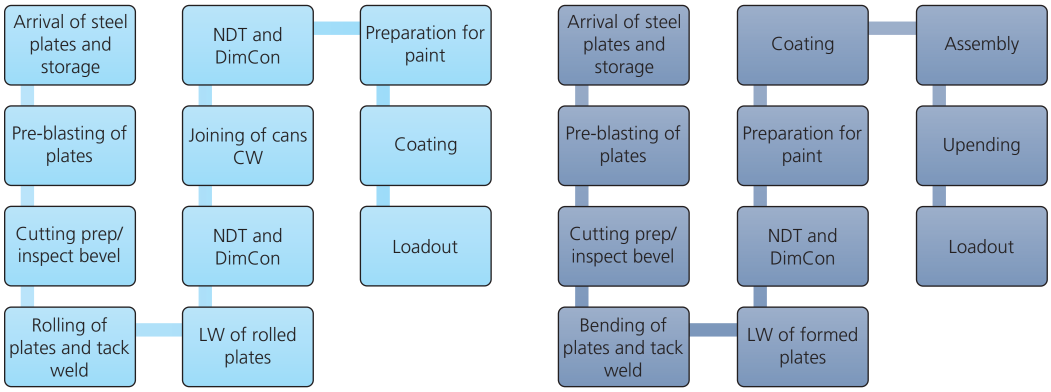


Figure 2: Typical fabrication process for MP (left) and for jacket brace of leg (right)

Although quality standards exist for most of the typical steps to ensure the steel is prepared correctly, it is important to recognise that the extent of the overall process, with many steps and interfaces requiring lifting, moving, work under load etc., as well as the dimensions of the material handled, represents a significant risk of an incident occurring. For jackets in particular, there are many individual components and fit up challenges, requiring multiple lifts and access issues, as well as greater overall final product mass, which can create significant complexity for lifting.

Some fabrication risks are direct consequences of design specificities, and in that sense, the design stage plays a significant role as risk enhancer, or on the contrary, risk mitigator. For example, considering access for specific welds from the design step can have a significant positive impact on the fabrication process and reduce risks , such as when welds are difficult to lay due to position.

Increasing size and weight of steel, in particular due to turbine size demands, can also create variation from what is typically a standardised process and may result in a new method of lifting or moving sections to the next stage. For example, as longer monopiles are designed for more powerful turbines and deeper waters, ever-larger diameters are required. This implies increasing the steel thickness to meet the Diameter (D) to Thickness (t) D/t ratio criteria set by the engineering standards on tubular structures. But thicker plates mean much heavier structures, and the current D/t standards are becoming invalid for XXL foundations. Until recently, design standards and engineering papers would set the D/t ratio to values less than, or equal to, 100. Some more up-to-date standards set the new reference ratio to 120. But even with the 120 ratio, MPs with diameters of 10m and above would become disproportionately heavy (considering a steel grading S355, typically used for its yield strength), and the handling and support of such heavy components throughout fabrication becomes of priority concern. It is critical that these variations or ‘changes’ are managed by the fabricator in consultation with the client.

Finally, it is common that most primary steel fabricators will subcontract smaller components, especially tertiary steel items, but also secondary such as external platforms and boat landings, therefore consideration for receipt of these items must also be considered when planning.

A number of the steps listed in the processes are required to meet quality standards and ensure the steel is prepared correctly for welding or coating; however, it’s important to recognise that each one of these stages requires additional handling of the material and with that an increased likelihood of an incident occurring.

2.2 PRESENTATION OF CASE STUDIES

2.2.1 Case study 1 – transport of TP

This case study describes an incident that occurred at a fabrication yard that was producing TPs for an offshore wind farm project. A fully coated and outfitted TP was being transported from the workshop to port. An incident occurred where the TP was tipped from the Self-Propelled Module Transporter (SPMT), resulting in the full TP lying on the road. There were no injuries occurring from this incident; however, a structure of 300t+ falling from its cradle could have been far more serious.

On investigation of this incident, the root cause was identified as a mechanical failure in one of the valves linked to the suspension field control system of the equipment used. This failure was linked to the breakage during the transport of a Teflon gasket inside the valve. The programmed suspension did not work correctly and caused the equipment to lift abruptly, tilting until the cradles came to rest on the road. This disproportionate tilt caused the TP to roll off the transport cradles. A pre-operation inspection did not detect any visual control anomalies such as hydraulic fluid leaks.

Beyond this root cause, the investigation also identified further safety deviations, that were flagged as requiring action to avoid future accidents. These deviations can be outlined as follows:

- Lack of organisation and rigour in the management and preparation of the Method Statement.
- Lack of monitoring and compliance with the key points of the Method Statements.
- Manoeuvre carried out without checklists, defined roles, and responsibilities.
- Overconfidence due to previous successes, and oversized measures taken for the operation.

2.2.2 Case study 2 – grit blasting

As a requirement of various standards set out by industry, raw steel requires a process called grit blasting, where compressed air and abrasive media are used to remove contaminants from surfaces. It also produces an etched surface, which enhances the adhesion of the coating.

This case study considers an incident that occurred at a fabrication yard that was producing TPs for an offshore wind farm. To perform grit blasting, the worker required access to the TP via a cherry picker. This was common practice for this specific process and was captured within method statements and risk assessments. The grit blast hose would be secured in the cherry picker basket in order to minimise the risk of dropped objects. As the worker stopped work, they released the hose and let it hang free so they could replace the outer lens of their face shield (a common practice due to the lens becoming pitted). When doing so, the worker caught the handle of the hose, and it activated the compressed air and media. The hose was then whipped into the worker's face, resulting in the lens failing and media becoming lodged in their eye.

On investigation, a number of factors were identified as having potentially contributed to the incident, in particular the bypass of the trigger failsafe mechanism (see Figure 3), and the replacement of the face mask visors (see Figure 4).

Figure 3: Typical trigger with safety catch
(image from stock library, exact equipment used during incident may have differed)

Figure 4: Typical design face shield
(image from stock library, exact equipment used during incident may have differed)

The trigger has a built-in safety to prevent accidental activation; this was commonly bypassed by holding down or removing the springs as it was perceived as an ergonomic improvement. The bypass of a failsafe mechanism was not identified or acknowledged by management, despite an inspection that found that all triggers in use had bypassed mechanisms. The removal of this failsafe, or failure to identify it as a stop point, increased the likelihood of an uncontrolled event.

The face visor in use was designed with a three-lens system: the inner lens is glass, held in by a moulded gasket; the middle lens is designed to offer further protection to the inner lens (1 mm polycarbonate), and finally up to 3x disposable outer lens are in place to minimise pitting. On inspection of the face mask, it was noted that the glass had shattered. Interviews across shifts evidenced that, as the disposable visors (and often the middle one as well) were typically pitted quickly, meaning continued stopping of works to replace, the workers would usually double up on the glass to have better visibility and prolonged use without changing. However, this change removed the protection that polycarbonate has against grit and reduced the overall protection to workers.

Overall, the root cause was deemed to be lack of management supervision, and poor understanding of the challenges faced by employees carrying out the work, whereby deviances perceived as time saving and convenient had become accepted, normalised practice amongst the operators of the equipment.

2.3 ENGAGEMENT WITH THE INDUSTRY

In order to further frame the current status of the H&S practices and considerations in the industry regarding steel fabrication and identify the key risk areas for the offshore wind industry, it was important to engage with the relevant industry to get direct feedback. This section presents the outcomes of this engagement, with G+ members (2.3.1) and with the fabricators (2.3.2).

2.3.1 Feedback from G+ members and associates

The engagement with G+ was intended to assess how incidents in yards are viewed, what are the H&S expectations being set, and how sites are currently assessed for their performance. For that purpose, several workshops were held across Q1 2023, and an RFI was circulated among the G+ participants to the workstream (see request for information (RFI) document in Appendix A).

Outcomes from direct discussions

Various workshops with the G+ members took place throughout Q1 2023, to openly discuss the issue and capture, in an open format, the developers' experience. General topics for consideration were tackled and are key elements to understand the industry's current practices, providing relevant ground for preparing future guidelines.

In general, fabricators typically build their H&S management system with a view to meeting the local legal requirements (see also Section 3). Best practice is often seen as being able to demonstrate conformance towards ISO 45001 (see also 2.3.2), as it is generally known that certification to this standard will typically give a strong base for ensuring compliance with local laws and regulations.

However, it is now necessary to consider the external impacts to the supply chain.

The record low strike prices nowadays being agreed, in an electricity price market seeing record highs, was generally felt as a key item of concern. In addition, the current macro-economic situation is seeing inflation soar. In such context, offshore wind projects must agree to long-term prices three to four times lower, and fabricators are seeing increases in the cost of materials and wages. This creates a critical issue from a project supply chain and investment perspective, as offshore wind projects work with razor thin margins, typically leading to a procurement heavily driven by cost, and less focus on H&S concerns.

In addition, recent years have seen the number of offshore wind projects drastically increasing. Fabricators are having to scale up significantly to meet the needs of developers, and the very large demand creates a bottleneck in the supply chain and resources. In turn, this situation typically leads to a procurement heavily driven by availability, potentially further hindering efforts to address H&S concerns. For example, while many welds in fabrication process are automated, qualified welders are still in short supply. Jackets, in particular, require many complex manual welds, but the skill force is inadequate to address the demand, and inadequately qualified workers may end up being deployed on complex tasks, necessarily increasing the risks of incidents.

As the wind turbine generators (WTGs) capacity is growing, foundations are getting bigger and bigger, nowadays reaching dimensions as large as 12-14 mm diameter and 120-140 mm wall thickness, with a gross tonnage of around 3 000 t. Such dimensions pose significant challenges at the fabrication stage that the industry has not had the time yet to fully address. This is a critical risk for fabrication yards for when such projects kick off, with immediate impacts on H&S.

A significant aspect of concern raised was also the difference in H&S culture. When the culture is not cemented into the workplace, contractors are less likely to buy into the culture, and are more at risk of taking shortcuts and straying from process. This is already insufficiently controlled at the direct contractor level, but becomes significantly challenging when the fabricator uses, for example, agencies who provide welders (in the context of shortage of skill force mentioned in a previous paragraph). Similarly, local content requirements only add to the challenges for skilled labour, as new and emerging markets may not be familiar with the more stringent H&S and welding standards.

All those aspects were accounted for when preparing the RFI to the G+ members and the survey questionnaire to the fabricators, in order to best formalise and capture the industry's opinion on these matters.

Feedback to RFI

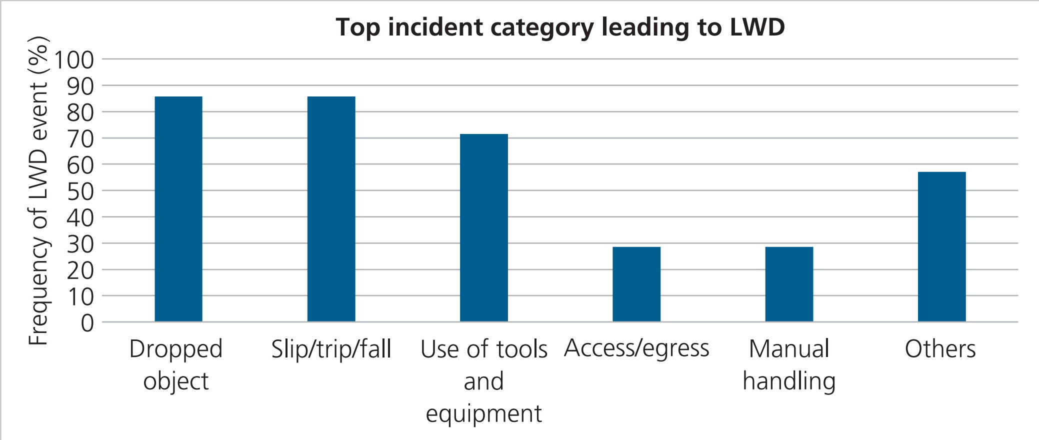
Further to direct discussions, a formal RFI was circulated to the interested G+ members, in order to more precisely capture H&S data and feedback on experience. The RFI consisted of six questions, covering from H&S considerations in the procurement process to lessons learnt.

As members of the G+ organisation, the workstream participants were already all familiar with the main leading and lagging H&S indicators and implementing them on their projects. Leading indicators reported included e.g., number of hazard observations, number of inspections or audits, and number of training hours. Lagging indicators reported included number of fatalities, lost time injury, restricted work cases, medical treatment cases, first aid cases, near miss incidents, environmental incidents, or high potential incidents.

Out of the four respondents, only two seemed to include some H&S considerations in their qualification process: one respondent mentioned that H&S criteria were considered e.g., H&S key performance indicators (KPIs) from the past five years, description of the H&S management system, possible H&S certification (ISO 45001/14001…), example of project H&S plan, or Risk Assessment Method Statements (RAMS). The other mentioned that H&S self-assessment questionnaires were used as a basis for pre-qualification. For the two other respondents, no criteria were presented; one mentioned that the qualification relies largely on already implemented H&S management systems at the fabrication yard, assuming they would be sufficient for the project given the yard's experience. Moreover, it was also mentioned that costs and availabilities were precluding H&S weighting.

Controls seem to be essentially based on contractual H&S requirements and Client Representatives (CRs) with relevant H&S background. The lack of H&S culture in the yard, potentially due to less H&S stringent projects from other clients, and the weakness or absence of relevant H&S guidance for the fabrication was pointed out. Direct discussions and engagement with the yard throughout the project appeared to be seen as a key element to control the appropriate application of the H&S measures.

Despite these controls, incidents and accidents still occur. The top five incident categories for different key indicators were outlined by the respondents, and were very closely aligned with reported data from 2022 G+ Incident Data report G-2022-incident-data-report.pdf (gplusoffshorewind.com) for the offshore wind industry (note: fabrication out-of-scope for G+ reporting). Focusing on incidents that resulted in lost workdays (LWD), dropped objects, slips, trips and falls and the use of tools and equipment appear to be all occurring with some frequency over a project, followed by work at height (WAH) and then jointly access/egress and manual handling (see Figure 5). The similarities between data sets would suggest that the fabrication industry is seeing similar issues to the rest of the industry when delivering offshore projects, and therefore that lessons could be shared, and improvements made in cooperation with each other.



* % is calculated as ratio of incident category leading to LWD over number of projects reported by respondents

Figure 5: Processed response to Q2 of the G+ Member RFI: What are the top 5 incident categories for LWD?

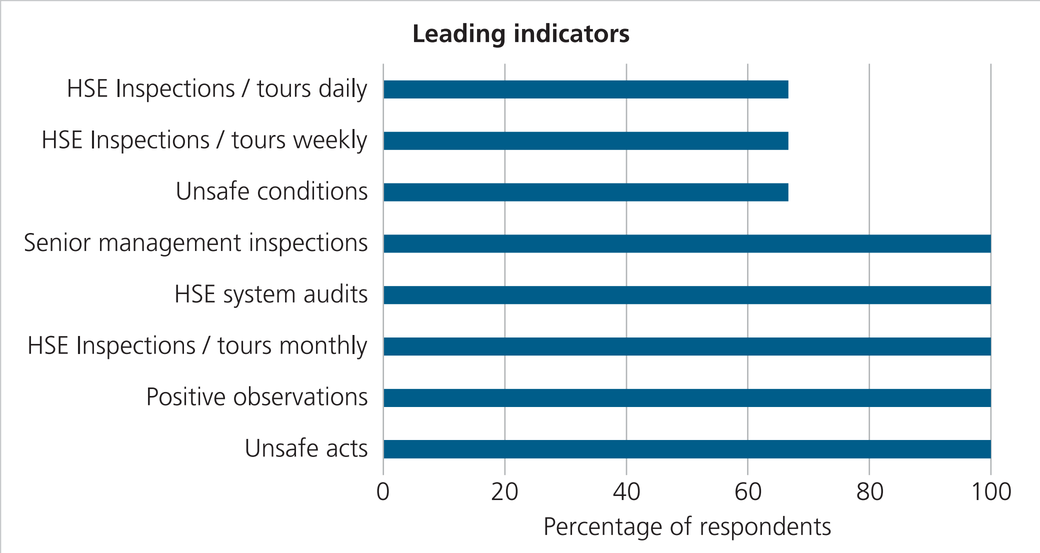
For half of the respondents, mitigation measures for these incidents appeared to be mostly seen as the responsibility of the fabrication yard. Investigations are typically led by the yard, and recommended actions implemented by them as well. For the other two respondents, slightly more detailed measures were mentioned, such as 5M model to verify the assignment of the task or conduct targeted safety campaigns on main source of incidents.

The question on lessons learnt yielded various results on potential causes for incidents, including poor situational awareness in complex projects requiring WAH, manual handling, welding and hot works, site simultaneous operations. Lack of supervision, transient workforce and limited H&S culture from yards were also pointed out. A close follow-up, with qualified CR, was seen as a good way forward, as well as stringent H&S requirements from the contract stage. It was also mentioned that lessons learnt from gravity-based fabrication highlighted the large risk of dropped objects during fabrication; It was suggested that the design should consider these risks and enable containments solutions (e.g., nets).

2.3.2 Feedback from fabricators

The engagement with the relevant industry aimed to assess how, and which, standards and guidelines are being applied, what are the industry practices typically followed, and what incidents are experienced. A short survey was circulated among fabricators, both by email to a selected list, and later by LinkedIn (see LinkedIn post here and survey questions in Appendix B).

When asked about the leading and lagging H&S indicators monitored on projects, the respondents overall confirmed covering most, if not all, the indicators proposed (see Figure 6).



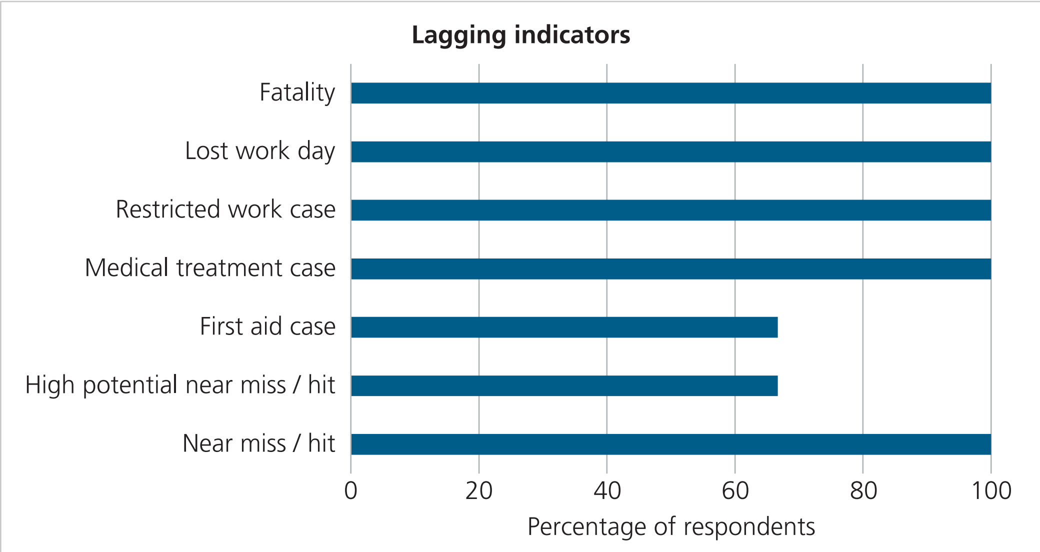


Figure 6: Responses to Q1 and Q2 of the fabricator survey:
What leading and lagging indicators do you monitor from an H&S perspective?

When considering the categories of incident observed, the ranking by frequency was similar for the two types of indicators, with physical hazards as the most frequent, followed by ergonomic and environmental hazards (see Figure 7 for the lagging indicators, from most frequent on top to less frequent at the bottom, noting a similar distribution for the leading ones – see also Appendix C for incident category examples).

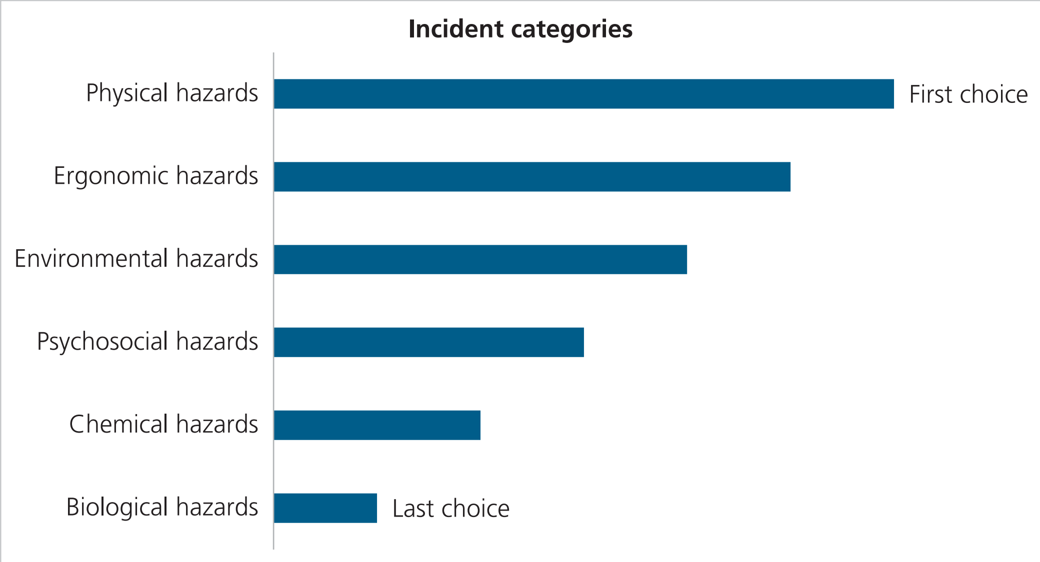


Figure 7: Processed response to Q6 of the fabricator survey:
What are the top incident categories you frequently see from lagging indicators?

Respondents had routines in place to carry out effective Root-Cause-Analysis (RCA), essentially following basic methods such as 5 whys, 8D or fishbones. No respondent confirmed the use of more detailed tools such as Kelvin TOPSET® or Taproot®.

Respondents were also not clear about the standards and guidelines followed during the fabrication process to ensure safe working conditions. The feedback to this question was limited, essentially citing safety objectives (e.g., 'zero incidents') or philosophy ('focus on top risks') rather than formal standards or guidelines describing detailed approaches and methods. Only one respondent listed formal standards, limited to ISO 14001 and ISO 45001.

Despite this, the Employer Requirements were overall deemed very restrictive in terms of H&S requirements (with an average score of 9.3/10). Rather than indicating that employers are demanding in terms of H&S, further statements from respondents seem to indicate that the fabricators feel like the H&S constraints lie mostly on the employer's side, with little margin for manoeuvre for the fabricator. Lessons learnt seemed also relatively limited, apparently due to employers' focus on lagging indicators and general mistrust.

Finally, when looking ahead, a question was asked about the challenges potentially posed by XXL generation of foundations, and how they are addressed. There was a consensus that the safety challenges are indeed very high, and generally underestimated in the industry. The limited margin for input from fabricators in projects was raised again in the responses provided, flagging that this leaves the fabricator with very little opportunity to eliminate risk completely; instead, they are only able to mitigate risks often with less robust controls open to human error and requiring enforcement. Tools such as daily Last Minute Risk Analysis (LMRA) or weekly toolbox talks were mentioned, although it can be assumed that these are already conducted as part of current projects and again form more of the administrative controls.

An additional key outcome of the engagement was the genuine interest in further collaboration between G+ and the fabricators. This is seen as critical to help improving fabrication safety in the project, exchanging on design requirements and fabrication limitations as early as possible.

3 EXISTING INDUSTRY GUIDANCE AND STANDARDS

In this section, relevant laws, regulations, standards and guidance documents relevant to the fabrication of primary steel for the offshore wind industry are reviewed. The lists are not exhaustive and only aim at offering an insight into the minimum requirements for legal compliance.

3.1 LAW, GUIDANCE AND BEST PRACTICE

The laws and regulations considered in this section are specific to some of the main countries steel fabricators operate from.

3.1.1 European directives on safety and health at work

Article 153 of the Treaty on the Functioning of the European Union (EU) gives them the authority to adopt directives in the field of safety and health at work. The Framework Directive, with its wide scope of application, and further directives focusing on specific aspects of safety and health at work are the fundamentals of European safety and health legislation.

Member States are free to adopt stricter rules for the protection of workers when transposing EU directives into national law. Therefore, legislative requirements in the field of safety and health at work vary across EU Member States.

Belgium jurisdiction

In Belgium, health and safety fall within the competence of the Minister for Employment and its administration, the Federal Public Service Employment, Labour and Social Dialogue. The Belgian Focal Point is coordinated and managed by this administration. The Focal Point works in close collaboration with The Directorate-General for Humanisation of Labour, within this administration; the labour inspection 'Supervision of Well-being at Work' is also part of this administration and controls the compliance with occupational safety, health and well-being standards.

Table 1: Overview of relevant acts and regulation – Belgique

Regulatory body	Document
Federale Overheidsdienst Werkgelegenheid, Arbeid en Sociaal Overleg	Act of 4 August 1996 on well-being of workers

Denmark jurisdiction

In Denmark, the Danish Working Environment Authority – Arbejdstilsynet (DWEA) is responsible for ensuring a safe, healthy and constantly improving working environment through effective supervision and appropriate implementation of the health and safety measures. The Authority also drafts orders and instructions, in cooperation with labour market partners.

Table 2: Overview of relevant acts and regulation – Denmark

Regulatory body	Document
Arbejdstilsynet (Danish Working Environment Authority)	Working Environment Act no. 674 of 25 May 2020
Arbejdstilsynet	Executive Order No. 290 of 5 May 1993 on the Conditions at Alternating Places of Work
Arbejdstilsynet	Executive Order No. 1795 of 18 December 2015 on Measures to Protect Workers from the Risks related to Exposure to Carcinogenic Substances and Materials at Work
Arbejdstilsynet	Executive Order No. 1109 of 15 December 1992 on the Use of Work Equipment

Germany jurisdiction

In Germany, offshore wind developers are responsible for the establishment and implementation of the health and safety guidelines. The applicable regulatory framework is based on the German Labour Protection Act – Arbeitsschutzgesetz (ArbSchG) which has been issued by the Federal Ministry for Labour and Social Affairs – Bundesministerium für Arbeit und Soziales (BMAS). The BMAS is supported by advisory committees on occupational health to regularly review and update the German Labour Protection Act if needed. The Federal Institute for Occupational Safety and Health – Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) is BMAS's most important advisory body operating directly under BMAS.

Table 3: Overview of relevant acts and regulation – Germany

Regulatory body	Document
Arbeitsschutzgesetz, ArbSchG	German Occupational Safety and Health Act
Arbeitsschutzgesetz, ArbSchG	Act on the Implementation of Measures of Occupational Safety and Health to Encourage Improvements in the Safety and Health Protection of Workers at Work
Arbeitsschutzgesetz, ArbSchG	Act on Occupational Physicians, Safety Engineers and Other Occupational Safety Specialists
Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAUA)	ASR A2.1 Protection against falls and falling objects, entering hazardous areas
BAUA	TRGS 528 Welding work
Bundesministerium für Arbeit und Soziales (BMAS)	German Labor Protection Act

Netherlands jurisdiction

In the Netherlands, rules derive from the Working Conditions Act (Arbowet), the Working Conditions Decree (Arbobesluit) or the Working Conditions Regulations (Arboregeling). The Netherlands Labour Authority (NLA) is responsible for enforcing the legislation. As part of demonstrating compliance with the acts and decrees, an Arbo (OSH) Catalogue shall be populated, which documents a collection of measures and solutions for working conditions in the relevant industry. The OSH catalogues play an important role regarding enforcement.

Table 4: Overview of relevant acts and regulation – Netherlands

Regulatory body	Document
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions Act, Act of 18 March 1999
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions, Decree of 15 January 1997
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions Regulation Text amended up to 1-9-2016

Spain jurisdiction

Focal Point of the European Agency for Safety and Health at Work in Spain, occupational risks prevention is regulated by the Law 31/95 and its complementary or developing regulations. Public authorities lead the policy in the occupational risks prevention field for the promotion and improvement of working conditions, controlling the activities of the Public Administrations with competences on prevention matters, and the participation of employers and employees in those activities, through their representative organisations.

Table 5: Overview of relevant acts and regulation – Spain

Regulatory body	Document
Head of State	Law 31/1995 of 8 November 1995 on Occupational Risk Prevention (LPRL)
Central Labour and Social Security Inspectorate	Ministry of Labour and Social Economy Ministry of Inclusion, Social Security and Migration
Ministry of Labour and Social Affairs	Regulation of the Services of Prevention

3.1.2 Rest of the world

United Kingdom (UK) jurisdiction

In the UK, the Health and Safety Executive owns a significant amount of primary and secondary legislation. The primary legislation comprises the Acts of Parliament, including the Health and Safety at Work etc Act 1974. The secondary legislation is made up of Statutory Instruments (SIs), often referred to as ‘regulations’. Additionally, there are Approved Codes of Practice (ACoPs) that help describe preferred or recommended methods that can be used (or standards to be met) to comply with regulations and the duties imposed by the Health and Safety at Work etc Act.

Table 6: Overview of relevant acts and regulation – United Kingdom

Regulatory body	Document
Health and Safety Executive	Health and Safety at Work etc (HSWA). 1974
Health and Safety Executive	Management of Health and Safety at Work Regulations (MHSWR) 1999
Health and Safety Executive	Provision of Use of Work Equipment Regulations (PUWER) 1998
Health and Safety Executive	Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)
Health and Safety Executive	Control of Substances Hazardous to Health Regulations 2002 (COSHH)
Health and Safety Executive	The Confined Space Regulations 1997
Health and Safety Executive	Work at Height Regulations 2005

Taiwan (TW) jurisdiction

In Taiwan, The Council of Labor Affairs (CLA) was renamed the Ministry of Labor (MOL) in 2014. This was done based on the need for promoting a healthy and safer workplace.

In parallel, a merger of departments was integrated into the Occupational Safety and Health Administration, OSHA. This was constituted on the same date as the MOL. OSHA is obligated to the formulation and execution of occupational safety and health policies. It comprises four divisions - Planning Division, Occupational Hygiene and Health Division, Occupational Safety Division, and Occupational Accident Labor Protection Division.

Table 7: Overview of relevant acts and regulation – Taiwan

Regulatory body	Document
Ministry of Labor	Occupational Safety and Health Act - imp.1974, Latest amendment: 2019
Ministry of Labor	Enforcement Rules of the Occupational safety and Health Act – imp.1974, Latest amendment: 2020
Ministry of Labor	Labor Inspection Act
Ministry of Labor	Labor Occupational Accident Insurance Protection Act
Taiwan Occupational Safety and Health Regulations (OSHA)	Machinery and Equipment regulations
OSHA	Hazardous substances regulation

United States of America (USA) jurisdiction

In general, the primary regulator for health and safety in the USA is the Occupational Safety and Health Administration (OSHA), within the Department of Labor (DoL), which provides health and safety regulation on a federal level and approves specific state level H&S plans. It should be noted that the USA provides each of the fifty (50) states with a high degree of autonomy, including in the implementation and enforcement of Occupational Health and Safety (OHS) standards. Although OHS regulations are developed and, in the main regulated, by OSHA, each state can opt to develop and enforce its own programme, but these must be at least equal, or equivalent to the federal requirements.

The USA has one primary federal law: the Occupational Safety and Health Act 1970. The Act is organised into four distinct elements; the most notable are those pertaining to construction and general-industry workplaces. It is further separated into several 'parts' and 'sub-parts', each covering a particular compliance topic, such as machine guarding, excavations and hazardous chemicals.

Table 8: Overview of relevant acts and regulation – USA

Regulatory body	Document
Occupational Safety and Health Administration (OSHA)	Occupational Safety and Health Act of 1970
Occupational Safety and Health Administration (OSHA)	29 CFR – 1910 – General Industry; 1915, 1917, 1918 and 1919 – Maritime; 1926 – Construction

3.2 RELEVANT STANDARDS

The main certification bodies producing standards relevant to the fabrication of primary steel for the offshore wind industry are essentially the British Standard Institution (BSI), Det Norske Veritas (DNV), the European Committee for Standardization (CEN), the International Electrotechnical Commission (IEC) and the International Organisation of Standardisation (ISO).

The standards listed in this section are not exhaustive and are commonly found documents referenced within commercial documentation. When considering fabrication of structures for the renewable energy industry, many of the standards focus on ensuring a standardised approach to design and end quality of the product; however, very few have specific focus on physical health and safety.

British Standards (BS)

British Standards (BS) are the standards produced by the BSI Group incorporated under a Royal Charter which is formally designated as the National Standards Body (NSB) for the UK. The BSI Group produces British Standards under the authority of the charter, which lays down as one of the BSI's objectives to: Set up standards of quality for goods and services, and prepare and promote the general adoption of British Standards and schedules in connection therewith and from time to time to revise, alter and amend such standards and schedules as experience and circumstances require.

Table 9: Standard relevant to fabrication – BS

Standard number	Document	Revised date
BS 7121-1	Code of practice for safe use of cranes – Part 1: General	2016

Det Norske Veritas (DNV)

DNV is a Norwegian classification society, the independent expert in assurance and risk management and the world's leading classification society and a recognised advisor for the maritime industry. DNV delivers world-renowned testing, certification and technical advisory services to the energy value chain, including renewables, oil and gas, and energy management.

Table 10: Standard relevant to fabrication – DNV

Standard number	Document	Revised date
DNV-OS-C101	Design of steel structures	2019
DNV-ST-0145	Offshore substation	2020
DNV-ST-0119	Floating wind turbine structures	2021
DNVGL-ST-N001	Marine operations, general	2018
DNV-RP-N101	Risk management in marine and subsea operations	2019
DNV-OS-C401	Fabrication and testing of offshore structures	2021

European Standard (EN)

European Standards (sometimes Euronorm, abbreviated EN, from the German name Europäische Norm ('European Norm') are technical standards which have been ratified by one of the three European standards organizations: European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC), or European Telecommunications Standards Institute (ETSI). All ENs are designed and created by all interested parties through a transparent, and consensual process.

Table 11: Standard relevant to fabrication – EN

Standard number	Document	Revised date
EN 1090-2	Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures	2018

International Electrotechnical Commission (IEC)

IEC is an international standards organisation and recognised as the main body for onshore and offshore wind energy. IEC standards serve as the basis for risk and quality management and are used in testing and certification to verify that manufacturer promises are kept.

Table 12: Standard relevant to fabrication – IEC

Standard number	Document	Revised date
IEC 61400-6	Wind energy generation systems – Part 6: Tower and foundation design requirements	2020

International Organisation of Standardisation (ISO)

ISO is a worldwide federation of national standards bodies, of which there are 165 national standards bodies. The work of preparing International Standards is normally carried out through ISO technical committees. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardisation. ISO standards are cross-referenced across various standards.

Table 13: Standard relevant to fabrication – ISO

Standard number	Document	Revised date
45001:2018	Occupational health and safety management systems.	2018
ISO 31000	Risk management	2018

3.3 OTHER RELEVANT DOCUMENTS

G+ is the global health and safety organisation, bringing together the offshore wind industry to pursue shared goals and outcomes. It is run in partnership with the Energy Institute (EI), which provides the secretariat and supports its work.

Table 14: Standard relevant to fabrication – other regulatory bodies

Regulatory body	Standard number	Document	Revised date
American Clean Power (ACP) Association standards Committee	OCRP Edition 2	ACP Offshore Compliance Recommended Practices (OCRP) Edition 2	2022
American Wind Energy Association (AWEA)	OCRP	AWEA Offshore Compliance Recommended Practice (OCRP)	2012
American Petroleum Institute (API)	API RP 2A	Recommended Practices for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design	2014
International Association of Oil and Gas Producers (IOGP)	577	Fabrication site construction safety recommended practice – Hazardous activities	2018
IOGP	597	Fabrication site construction safety recommended practice – Enabling activities	2018

Regulatory body	Standard number	Document	Revised date
G+ Offshore Wind	GPG	Working at Height in the Offshore Wind Industry Case Study on Reducing Manual Handling and Ergonomics Related Incident in the Offshore Wind Industry Improving Compliance Workshop: Basic Lifting Operations	Various
Lloyds Register	N/A	Code for Lifting Appliances	2020

3.4 SUMMARY

Based on the literature review in this section, it is fair to say that all regions where the most active fabricators are present have requirements for compliance with local legislation. However, depending on the region, the level of regulation varies significantly, which can lead to gaps in the H&S expectations between project developers and fabrication yards.

Regarding standards: ISO standards offer a suitable general structure and a framework for compliance with legislation and is generally the standard referred to by most of the fabricators. However, it remains a general, overarching document, and for more complex tasks with inherent specific hazards, it overall proposes only limited guidance. For parties that wish to gain more assurance over performance, then best practice guidance from the oil and gas industry offers some synergies and an opportunity to ensure some standardisation.

4 CONCLUSION – PRELIMINARY LEADS FOR GUIDANCE

Having assessed the current status of the industry (Section 2) and the existing industry guidance and standards (Section 3), some risk categories can be brought out as key challenges to address in future best practice guidance. This section outlines three initial leads for consideration that, in K2 Management, should be prioritised when building a best practice document.

It is worth noting that fabricators appear keen to engage with the G+ and provide their own experiences. This should be seen critical to help improving fabrication safety in the project, exchanging on design requirements and fabrication limitations as early as possible.

4.1 INTEGRATING FABRICATION CONSIDERATIONS IN THE DESIGN

Improving health and safety in steel fabrication for offshore wind can begin well before the first steel plate is being manufactured. In particular, it was mentioned that lessons learnt should feed into future design and consider making the fabrication phase safer. An example presented was to consider in the design a means to safely implement control measures such as netting. The easier it is to install something, the more likely it is to be used.

From the perspective of the fabricators, concerns were raised around opportunity to provide input into projects. It was flagged that fabricators are often left in a situation where design is not sufficiently considered for production, and fabricators are only able to mitigate risks by applying controls and isolating people from the hazard – which can often add time to the fabrication process.

This becomes even more of a requirement when progressing towards XXL generation of MPs. The size of these foundations exacerbates existing challenges as well as creating new ones in terms of handling, space availability or equipment, and consideration should be given to the fabricators' restrictions in order to ensure a safe fabrication.

In general, it is critical to adopt safe-by-design principles to reduce personnel risks, and every step of the fabrication should be considered in the design to ensure that logistical challenges (e.g., multiple lifts or transportation, loadout capability/capacity (roll-on, roll-off (RORO), onshore crane of vessel crane)) are accounted for. Risk management can be used early in the design process to then emphasise H&S throughout the fabrication process. It is helpful to involve those involved in the fabrication process for their input to better understand fabrication challenges and to actually design for production. Doing so will not only improve safety, but can introduce cost savings and efficiencies.

4.2 CLARIFYING H&S REQUIREMENTS FROM PROCUREMENT AND CONTRACTUAL STAGE

To date, the procurement process has often focused on cost and availability rather than H&S, and only limited criteria and associated weights have been formalised in typical emergency responses (ERs). Although costs and availability are indeed critical factors with direct impact on the feasibility of a project, it should be considered that the lower the sell price, the less chance for capital being made available to focus on H&S. Additionally, focusing on capacity and/or availability does not give reassurance that H&S performance will be acceptable.

Lessons learned have highlighted frequent poor situational awareness, simultaneous operations, lack of supervision and transient workforces, which are typical root causes for incidents that can be critical to the project. Current means of managing contractors is often carried out via the enforcement of contractual H&S requirements and monitored with CRs who have a relevant background. However, the responsibility to ensure a positive and safe working environment is often unclear from the contract set-up, project developers generally feeling that it is that of the fabrication contractors, whilst fabricators feel that the limited H&S consideration in the project design leaves only minimal mitigation options.

Regarding existing guidelines, the majority of guiding documents on fabrication appear to focus on the quality of product and have little influence on safety. The same applies when investigating tools and methods for incident investigation. While there are many tools available, such as Kelvin TOPSET® or Taproot®, none was referred to for conducting detailed RCA. Instead, more simplistic methods such as 5-whys and fishbone diagrams were mentioned. The purpose of identifying the root cause of an incident is essentially to greatly reduce the likelihood of recurrence; however, it is very common that incident reports lack detail and effective corrective and preventative actions, and the event is often repeated. When clarifying H&S requirements during contract set-up, specifying a recognised incident investigation methodology and evidence of training for that model should be considered.

The impact of the procurement and contracting models should be considered, and alternative approaches could be investigated to ensure that H&S performance is suitably accounted for compared to cost and capacity, and that H&S requirements are clearly stated.

4.3 ACCOUNTING FOR CULTURAL DIFFERENCES

In this study, consideration is given to the meaning of culture as the values, beliefs, systems of language, communication, and practices that people share in common and that can be used to define them as a collective. In the context of H&S, this essentially covers the aspects related to risks that are shared within an organisation, and that can be promoted by individual learning on one hand, but even more importantly by senior management, enforcement of realistic practices for handling hazards, continuous organisational learning, and care and concern for hazards shared across the workforce.

Fabrication contractors that responded to the survey were overall unable to clearly state any specific standard for H&S outside of what is legally required of them – and those respondents, for having taken the time to answer the survey, can be considered as already sensitised to H&S issues. It should therefore be considered that, for less developed yards, the lowest level of safety required could be expected.

It is generally recognised that awarding projects to yards that have a limited H&S culture, with limited budget and resource for improving or putting focus on such culture, will typically represent an accrued risk for unplanned events and additional challenges for that project. Changing culture requires acceptance and understanding by those involved as to why change is required, and is a process that typically spans over a much longer time frame than a single project.

An efficient mitigation measure could be to clearly specify H&S requirements from the procurement phase (see also 4.2), so that the H&S aspects are stated contractually, in particular when pre-qualification investigations evidenced significant risks due to lesser H&S culture. Early engagement (e.g., from the design stage – see also 4.1) and support should also be considered, in order to ensure streamlined communication between the parties, in particular in a context where the rapidly changing industry transforms the process requirements.

Finally, the cultural differences between countries and between organisation mindsets (project developer vs. fabrication yard), although positive in many different aspects, can have negative effects impacting H&S: language or reference barriers, difference in leadership behaviours, differences in trainings, miscommunications and poorly inclusive environments/ organisations, can lead to conflicts, stress, and ultimately to H&S incidents. An open communication between the parties, with clear channels and respectful approaches to cultural differences, is essential, and the leadership of the developers is a key aspect of it.

APPENDIX A
REQUEST FOR INFORMATION CIRCULATED TO G+ MEMBERS

REQUEST FOR INFORMATION (RFI)—SAFETY IN STEEL FABRICATION

- From: G+ Steel Fabrication Working Group (with K2 Management support)
- To: G+ members
- Date: 17/02/2023

A.1 PURPOSE

Steel is the obvious crucial element in offshore wind projects. It is used in a major part of a wind farm, from the wind turbine generator to its foundation and the plant's substation. It faces challenging conditions, with harsh and irregular loadings, in a corrosive environment. Material strength and durability are therefore critical to support the intended design life of a project, and steel fabrication requirements are therefore typically very strict to ensure that the design achieved meets the project targets.

Although there is a solid basis of guidelines and standards guiding the steel fabrication steps specifically for the offshore wind sector, there is a severe scarcity of HSE (Health, Safety and Environment) standards that ensure safe working during such fabrication.

In order to fill this gap, G+ has set up a new workstream to investigate how the steel industry can be further integrated into the safety culture of its members, whilst respecting different accountabilities.

This RFI attempts to collect the vast experience of the G+ members in offshore wind development, to identify the major challenges in health, safety and environment (HSE) during steel fabrication, as well as the practices and guidance currently followed in the industry.

The RFI comprises six (6) questions and is anticipated to take about 20 min to answer providing information is available.

Ultimately, and based on the information gathered, the study conducted in this workstream will lead to the provision of recommendations for the definition of a set of formal, practical and relevant, good practice guidance that would address the problems identified, creating a common HSE set of rules to improve H&S in steel fabrication for offshore wind.

This document is organised in three (3) main sections: following this introduction (Section 1); Section 2 presents the list of requested input. You are invited to populate the text boxes with your answers and have an opportunity to add any additional information you would wish to share by adding attachments. Finally, Section 3 stands as additional, optional input request.

A.2 HOUSEKEEPING

It is critical that anonymity of the data collected is guaranteed, in order to avoid comparison between projects or stakeholders. For this purpose, please note the following:

1. Please send your answer to this RFI to G+ Secretariat by clicking on this link here. G+ secretariat shall then collate the data received and anonymise it before sharing the results to K2 Management.
2. Please consider providing comprehensive feedback – the more data are collected, the more anonymity can be guaranteed. A minimum threshold of four answers, with at least two projects each, was defined for sharing the received data with K2 Management.

We would be very grateful to receive your survey response by 10/03/2023. Please note that, in our experience, your input and engagement throughout the workstream study are key factors to the applicability of the outcomes and the success of the workstream, and your input is therefore very much appreciated. If you have any queries or comment regarding this RFI, please do not hesitate to reach out.

A.3 REQUESTED INFORMATION

You are invited to provide information on the following points:

A.4 HEALTH AND SAFETY MONITORING IMPLEMENTED

Please describe what you monitor from an HSE perspective (please consider leading and lagging type indicators). Click or tap here to enter text.

A.5 INCIDENT DATA

Please share the following data, where available (definitions as per latest G+ incident data guidelines):

- Hours worked each year and if inclusive of contractors.
- Lost time incident frequency (LTIF[1]) and total recorded incident rate (TRIR[2]).
- Top 5 incident categories for lost workday injuries (LWD).
- Top 5 incident categories for restricted work case (RWC).
- Top 5 incident categories for medical treatment case (MTC).
- Top 5 incident categories for high potential near hit (HiPos).

Please note that the data will be collated and anonymised, to obtain general statistics over different parameters. Therefore, please consider providing an answer following the format suggested in Table A.2. Any additional information you judge relevant, regarding the data provided, or in the form of e.g., case studies, is also welcome, and can be provided as appendix.

1 LTIF: The number of recordable injuries (fatalities + lost workday injuries) per 1 000 000 hours worked. Hours worked rounded up to the nearest 10 000.

2 TRIR: The number of recordable injuries (fatalities + lost workday injuries + restricted workday injuries + medical treatment injuries) per 1 000 000 hours worked.

Table 14: Incident category examples

Biological	***Chemical***	***Physical hazards***	***Ergonomic hazards***	***Safety hazards***	***Environmental hazards***
Blood and other bodily fluids	Cleaning products	Heights	Poor posture	Trip hazards such as trailing wires and cords, frayed carpets and rugs, and unexpected items on the floor	Extreme Temperatures
Medical waste	Paints and solvents	Loud noises	Frequent lifting, carrying, pushing, pulling and lowering	Slip hazards, such as water or ice on the floor	Extreme Precipitation
Fungi, moulds and yeasts	Pesticides	Radiation	Repetitive movements	Ladders, roofs, scaffolding and high working areas can result in a fall from a height	High levels of pollution
Bacteria and viruses	Glues	High exposure to sunlight or ultraviolet rays	Improperly adjusted workstations and chairs	Unguarded machinery with which an employee can accidentally come into contact	High levels of radiation
Animal and bird droppings	Gases such as acetylene, propane, carbon monoxide and helium	Extreme temperatures	Awkward movements	Damaged tools, equipment or machinery	High levels of noise
Environmental specimens, such as plants or soil	Vapours and fumes	Fires	Frequent physical effort or physical effort for long periods	Modified tools, equipment or machinery	

Table 14: Incident category examples (continued)

Biological	*Chemical*	*Physical hazards*	*Ergonomic hazards*	*Safety hazards*	*Environmental hazards*
Biological toxins and venoms	Flammable materials	Fatigue, stress, overloaded mental health	Excessive vibrations	Electrical hazards that could cause electric shock, burns or fires, including frayed or faulty cords or wires, missing ground pins, incorrect wiring, and overloaded circuits	
Insect bites	Heavy metals, such as aluminium, mercury and lead	Body stressing from repetitive or strenuous work		Areas of poor visibility	
Rubbish, wastewater and sewage	Petroleum products	Confined spaces with poor ventilation or contaminants		Overhead power lines	
SARS-CoV-2 (COVID 19)		Electricity, including electric shock. Vibrations		Falling/ dropped objects	

Table 15: Incident data

Case Description				Incident Rate		Work Process[3]	Top 5 Incident Categories[4]			
Project Identifier[5]	Work Package	Region (Fabricator)	Hours Worked	LTIF	TRIR	Top 5 Work Process breakdowns	LWD	RWC	MTC	HiPos
Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text
Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text
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Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text	Click or tap here to enter text

3 What activity/work process was being carried out at time of incident

4 See Table 14 Incident Category Examples

5 Please consider de-identifying the projects (using e.g., 'Project 1', 'Project 2' instead of the actual project name)

A.6 HSE CONSIDERATIONS DURING PROCUREMENT

Please describe how you weight HSE criteria in your procurement process.

Click or tap here to enter text.

A.7 MITIGATION MEASURES

Please describe what mitigating measures you implement when facing incidents (please consider the top five incidents).

Click or tap here to enter text.

A.8 CONTROLS

Please describe the controls that you implement in your Projects and the ones that are typically defeated (please consider standards, guidelines, contractual requirements).

Click or tap here to enter text.

A.9 LESSONS LEARNT

Please describe what lessons learnt you have drawn to date from your experience.

Click or tap here to enter text.

A.10 AOB

You may provide as attachment any additional information you think relevant for the study. Please also feel free to reach out to followup on any point of interest.

A.11 ADDITIONAL INPUT

In addition to the collection of data through this RFI, K2 Management will also engage with fabrication yards to assess the typical industry practices applied and the critical safety elements with behavioural safety. The engagement with the industry will take place via a short survey to be sent to targeted HSE managers of specific fabricators. The intention is to cover a wide geographical spread, in order to capture potential cultural differences and regional specificities.

The list of entities to be contacted and the survey questions are provided in Appendix B. You are invited to review the contact list and survey questions proposed, and provide comments where applicable, e.g., with additional yards you would wish to include or questions you would wish to amend.

Finally, and in parallel to the collection of data, K2 Management will also review a range of relevant standards and guidelines, as well as any document in the energy and other applicable sector covering safety in steel fabrication. The review will aim at identifying any gap between the industry practices and the guidelines provided in the existing literature, to inform the development of the GPG document to be created in the next phase of the workstream.

A preliminary list of relevant standards and guidelines to be reviewed is provided in Appendix C. You are invited to review the proposed list, and provide comments where applicable, e.g., on their relevancy or on missing documents.

APPENDIX B
ENGAGEMENT WITH FABRICATION YARDS

B.1 List of Targeted Fabrication Yards

- UK:
  - Smulders UK
  - Wiltons Engineering
- Belgium
  - Smulders
- Denmark:
  - Bladt
- Germany:
  - Steelwind
  - EEW
- Netherlands:
  - SIF
  - SPT
- USA:
  - Sparrows Point Steel (In progress)
- Other countries:
  - Navantia/Windar (Spain)
  - Haizea (Spain)
  - Seah (Korea)
  - Dajin (Chinese, but opening a factory in Poland)
  - Century Wind Power (Taiwan)
  - TPC (Taiwan)

B.2 SURVEY QUESTIONS TO STEEL FABRICATORS

Management

Safety in Steel Fabrication

Steel is the obvious crucial element in offshore wind projects. It is used in a major part of a wind farm, from the wind turbine generator to its foundation and the plant's substation. It faces challenging conditions, with harsh and irregular loadings, in a corrosive environment. Material strength and durability are therefore critical to support the intended design life of a project, and steel fabrication requirements are therefore typically very strict to ensure that the design achieved meets the project targets.

Though there is a solid basis of guidelines and standards guiding the steel fabrication steps specifically for the offshore wind sector, there is a severe scarcity of HSE (Health, Safety and Environment) standards that ensure safe working during such fabrication.

This survey attempts to identify the major challenges in HSE during steel fabrication for offshore wind, as well as the practices and guidance currently followed in the industry.

Within the safety in steel fabrication workstream of G+, the survey results with then inform the formalisation of recommendations for the definition of a set of formal, practical and relevant, good practice guidance that would address the problems identified, creating a common HSE set of rules to improve health and safety in steel fabrication for offshore wind.

Please note that your responses will be kept confidential and your company name will not associated to any survey results. It is anticipated that the survey should take approximately 5 minutes or less to complete.

...

* Required

1. What leading indicators do you monitor from an HSE perspective?*

- [ ] Unsate acts
- [ ] Unsafe conditions
- [ ] Positive observations
- [ ] HSE Inspections/tours monthly
- [ ] HSE Inspections/tours weekly
- [ ] HSE Inspections/tours daily
- [ ] HSE system audits
- [ ] Senior management inspections
- [ ] Other

2. What lagging indicators do you monitor from an HSE perspective?*

- [ ] Near Miss/Hit (NM)
- [ ] High potential near miss/hit (HiPo)
- [ ] First Aid Case (FAC)
- [ ] Medical Treatment Case (MTC)
- [ ] Restricted Work Case (RWC)
- [ ] Lost Work Day (LWD)
- [ ] Fatality (FAT)
- [ ] Other

3. What key standards/guidelines/best practice do you follow? Please list*

Enter your answer

4. What are the top incident categories you frequently see from leading indicators*

- Biological hazards
- Chemical hazards
- Physical hazards
- Ergonomic hazards
- Environmental hazards
- Psychosocial hazards

5. What are the top incident categories you frequently see from lagging indicators*

- Biological hazards
- Chemical hazards
- Physical hazards
- Ergonomic hazards
- Environmental hazards
- Psychosocial hazards

6. How restrictive are the Employer Requirements you typically need to adhere to with regards to HSE?*

0	1	2	3	4	5	6	7	8	9	10

No HSE requirements — Very strict requirements

7. What have lessons learnt told you to date and how do you ensure they are implemented into future projects?*

Enter your answer

8. How are you preparing for the XXL generation of foundations and the Health and safety challenges it may pose? *

Enter your answer

9. Would you be available for a follow-up to discuss some of the feedback and provide input to the guidance document being prepared? *

◯ Yes

◯ No

You can print a copy of your answer after you submit

Submit

APPENDIX C
PRELIMINARY LIST OF RELEVANT STANDARDS AND GUIDELINES

This Appendix lists the standards and guidelines identified to date as potentially relevant to guide the health and safety of steel fabrication for offshore wind. It should be noted that the list is not meant to be exhaustive at this stage, should be seen as preliminary only, and is subject to adjustments as the review process progresses.

The list is divided between regulatory documents (Appendix C.1) and standards (Appendix C.2).

C.1 REGULATION DOCUMENTS

C.1.1 UK jurisdiction

Regulatory body	**Document** ***(Key document)***	**Sector**
Health and Safety Executive	Health and Safety at Work etc (HSWA). 1974	Offshore and Onshore
Health and Safety Executive	Management of Health and Safety at Work Regulations (MHSWR) 1999	Offshore and Onshore
Health and Safety Executive	Provision of Use of Work Equipment Regulations (PUWER) 1998	Offshore and Onshore
Health and Safety Executive	Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)	Offshore and Onshore
Health and Safety Executive	Control of Substances Hazardous to Health Regulations 2002 (COSHH)	Offshore and Onshore
Health and Safety Executive	The Confined Space Regulations 1997	Offshore and Onshore
Health and Safety Executive	Work at Height Regulations 2005	Offshore and Onshore

C.1.2 Denmark's jurisdiction

Regulatory body	**Document** ***(Key document)***	**Sector**
Arbejdstilsynet (Danish Working Environment Authority)	Working Environment Act no. 674 of 25 May 2020	Offshore and Onshore
Arbejdstilsynet	Executive Order No. 290 of 5 May 1993 on the Conditions at Alternating Places of Work	Onshore
Arbejdstilsynet	Executive Order No. 1795 of 18 December 2015 on Measures to Protect Workers from the Risks related to Exposure to Carcinogenic Substances and Materials at Work	Onshore
Arbejdstilsynet	Executive Order No. 1109 of 15 December 1992 on the Use of Work Equipment	Onshore

C.1.3 Germany's jurisdiction

Regulatory body	**Document** ***(Key document)***	**Sector**
Arbeitsschutzgesetz, ArbSchG	German occupational safety and health act	Offshore and Onshore
Arbeitsschutzgesetz, ArbSchG	Act on the Implementation of Measures of Occupational Safety and Health to Encourage Improvements in the Safety and Health Protection of Workers at Work	Onshore
Arbeitsschutzgesetz, ArbSchG	Act on Occupational Physicians, Safety Engineers and Other Occupational Safety Specialists	Onshore
Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAUA)	ASR A2.1 Protection against falls and falling objects, entering hazardous areas	Onshore
BAUA	TRGS 528 Welding work	Onshore
Bundesministerium für Arbeit und Soziales (BMAS)	German Labor Protection Act	Offshore and Onshore

C.1.4 Belgium's jurisdiction

Regulatory body	Document *(Key document)*	Sector
Federale Overheidsdienst Werkgelegenheid, Arbeid en Sociaal Overleg	Act of 4 August 1996 on well-being of workers	

C.1.5 Netherlands' jurisdiction

Regulatory Body	Document *(Key Document)*	Sector
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions Act, Act of 18 March 1999	Offshore and Onshore
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions, Decree of 15 January 1997	Offshore and Onshore
Arbeidsomstandighedenbesluit Dutch Working Decree	Working Conditions Regulation Text amended up to 1-9-2016	Offshore and Onshore

C.1.6 USA's jurisdiction

Regulatory body	Document *(Key document)*	Sector
Occupational Safety and Health Administration (OSHA)	Occupational Safety and Health Act of 1970	All sectors, occupational
Occupational Safety and Health Administration (OSHA)	29 CFR – 1910 – General Industry; 1915, 1917, 1918 and 1919 – Maritime; 1926 – Construction	All sectors, occupational

C.2 STANDARDS

C.2.1 British Standards (BS)

Regulatory body	Standard number	Document *(Key document)*	Sector	Revised date
BS	BS 7121-1	Code of practice for safe use of cranes – Part 1: General	Onshore	2016

C.2.2 Det Norske Veritas (DNV)

Regulatory body	**Standard number**	**Document *(Key document)***	**Sector**	**Revised date**
Det Norske Veritas (DNV)	DNV-OS-J126	Design of offshore wind turbine structures	Offshore Wind	2016
DNV	DNV-OS-C101	Design of steel structures	Steel structures	2019
DNV	DNV-ST-0437	Loads and site conditions for wind turbines	Foundation	2016
DNV	DNV-ST-0145	Offshore substation	Substation	2020
DNV	DNV-ST-0119	Floating wind turbine structures	Offshore Wind	2021
DNV	DNVGL-ST-N001	Marine operations, general	Offshore Wind	2018
DNV	DNV-RP-N101	Risk management in marine and subsea operations	Offshore	2019
DNV	DNV-OS-C401	Fabrication and testing of offshore structures	Fabrication	2021

C.2.3 European Standard (EN)

Regulatory body	**Standard number**	**Document *(Key document)***	**Sector**	**Revised date**
EN	EN 1090-2	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures	Fabrication	2018

C.2.4 International Electrotechnical Commission (IEC)

Regulatory body	**Standard number**	**Document *(Key document)***	**Sector**	**Revised date**
IEC	IEC 61400-6	Wind energy generation systems – Part 6: Tower and foundation design requirements	Offshore Wind	2020

C.2.5 International Organisation of Standardisation (ISO)

Regulatory body	Standard number	Document *(Key document)*	Sector	Revised date
ISO	45001:2018	Occupational health and safety management systems.	All	2018
ISO	ISO 31000	Risk management	All	2018

C.2.6 Others

Regulatory body	Standard number	Document *(Key document)*	Sector	Revised date
Lloyds Register	N/A	Code for Lifting Appliances in a Marine Environment	Offshore Wind	2020
NORSOK	S-001	Technical Safety	Offshore, O&G	2020
API	API RP 2A	Recommended Practices for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design	Offshore Platforms	2014
G+	GPG	Working at Height in the Offshore Wind Industry Case Study on Reducing Manual Handling and Ergonomics Related Incident in the Offshore Wind Industry Improving Compliance Workshop: Basic Lifting Operations	Offshore Wind	
American Wind Energy Association (AWEA)	OCRP	AWEA Offshore Compliance Recommended Practice (OCRP)	USA Recommended Practices Offshore wind	2012
American Clean Power (ACP) Association standards Committee	OCRP Edition 2	ACP Offshore Compliance Recommended Practices (OCRP) Edition 2	USA Recommended Practices Offshore wind	

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