

The Quest for Quality

An overview of design and compliance requirements
in docking & mooring equipment



Introduction

When it comes to docking and mooring equipment, the market has become plentiful and varied. While this is beneficial from a competitive and purchaser choice perspective, there are a number of reasons why low cost products are often of inferior quality too.

These reasons range from poor quality materials, to a lack of standardized, robust product testing, to flaws in the design and manufacturing process. There is an urgent need to raise specification and compliance standards across the market, to guarantee that quality is engineered across all docking and mooring solutions, and that the market for such mission critical equipment does not become commoditized.

Compliance is a critical aspect in guaranteeing this quality. Across class, structural integrity, hazardous area, electrical safety, and commercial: there is a lot to consider.

Ultimately, compliance removes product variability, which mitigates risk.

This issues briefing is a straightforward overview of the subject of low cost, low quality mooring systems. It highlights the key market issues and the critical standards and regulations that must be enforced and adhered to during docking and mooring system development.

IN THIS ISSUES BRIEFING, YOU WILL LEARN:

- 3 WHY THE MOORING OPERATION IS SO HIGH RISK

- 4 WHY PRODUCT QUALITY IS CRITICAL TO REDUCING RISK AND IMPROVING SAFETY

- 6 WHY PRODUCT CHOICE AND VARIATION CAN NEGATIVELY IMPACT SAFETY

- 8 HOW TO ENSURE QUALITY THROUGH COMPLIANCE

- 10 HOW QUALITY CAN IMPROVE THE EFFICIENCY AND RELIABILITY OF THE MOORING OPERATION

- 10 WHICH REGULATIONS AND STANDARDS TO CONSIDER WHEN SPECIFYING AND PURCHASING MOORING EQUIPMENT

Mitigating risk in the mooring system

The mooring operation is high risk. The UK P&I Club reports that in the UK in the last 20 years, 58% of injuries occurred during mooring and 26% were due to equipment failure. The Australian Maritime Safety Authority (AMSA) found that of 227 reported incidents between 2010 and 2014, 62% were related to design shortfalls or equipment failures, and 51% of the identified design and equipment safety factors were the result of a parted mooring line.

Clearly, poorly designed, poorly considered or low quality products can result in significant risk to personnel and operations.

The Hierarchy of Controls

The Hierarchy of Controls is a model commonly used to demonstrate the effectiveness of risk mitigation. It clearly shows that the most effective way to control risk is to eliminate hazards.

AMSA cites this model as an effective reminder for ensuring mooring safety: always trying to eliminate hazards where possible. Ensuring equipment quality from the start plays an important role in eliminating hazards.

Quality should be an important factor in the decision making process when buying mooring equipment. Quality measures the degree of product conformity with a set of agreed elements, including material specification and integrity, size and functionality.



*Centers for Disease Control and Prevention (CDC), Controls for Noise Exposure

Traceability also has to be ensured throughout this process.

In a global market, customers are faced with a choice between numerous suppliers. While this is beneficial from a competitive point of view and, theoretically, in terms of customers receiving best value for money, it is difficult to determine whether the item in question is of acceptable quality or not.

Low cost suppliers are out there, but low cost offerings are of inferior quality. Poor quality materials may be used and products may not be tested in a robust, standardized way throughout the manufacturing process.

Mooring fittings are critical to the operation of a terminal. Failure of any component can have a significant impact on the safety of personnel, port infrastructure and vessels. The cost to human life and assets can be catastrophic.

It is mission and safety critical to engineer consistent quality in docking and mooring equipment. Variability can lead to lack of compliance, which in turn can compromise safety.

Mooring fitting selection

In engineering a reliable mooring solution, there are three different selection criteria that have to be taken into account: design life, design philosophy and product quality.

Design life and design philosophy

Design life is specified by the asset owner in line with the structural design life of the wider berth and facility. Typically, mooring fittings are designed for a minimum of 25 years. This design life takes into account a number of factors. The main contributing factors for mooring fittings are dynamic loading and corrosion allowance, and experienced suppliers should be able to build in appropriate functionality to accommodate these parameters over the desired design life. For example, a weld free cast design provides superior resistance to the fatigue associated with dynamic loading, as it is free from the stress concentration points associated with welded joints.

Once the design life is specified, the design codes that the mooring fitting has to adhere to should be considered, and the customer should verify design philosophy and procedure.

Design philosophy is as specified in industry standards:

- OCIMF: Mooring Equipment Guidelines
- BS6349-4: Code of Practice for design of fendering and mooring systems
- MOTEMS: Marine Oil Terminal Engineering and Maintenance standards

These standards specify how a mooring fitting is designed (e.g. the loading conditions and the safety factors used). Best industry practice mandates deeper analysis than industry standards specify. All loading cases should be considered and the mooring fitting should be designed to the worst loading condition.

The design of any steel structure must conform to international steel design codes, including:

- AS3990: Mechanical equipment steel work
- AS4100: Steel Structures

Or other local standards specific to design of steel structures

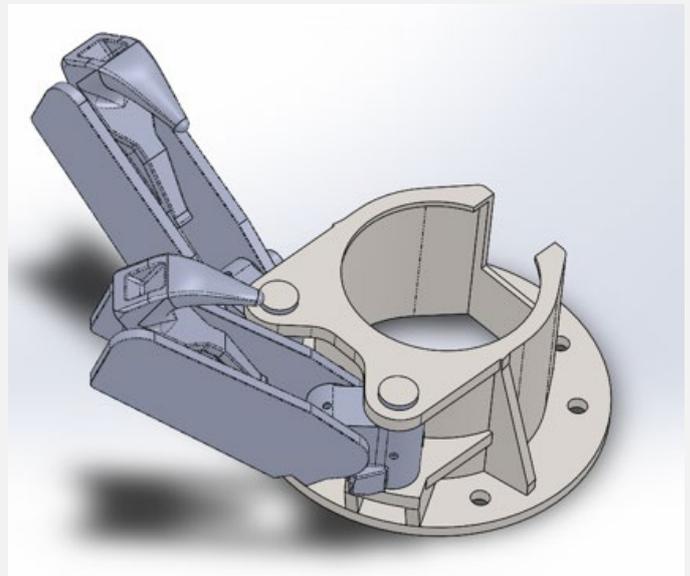
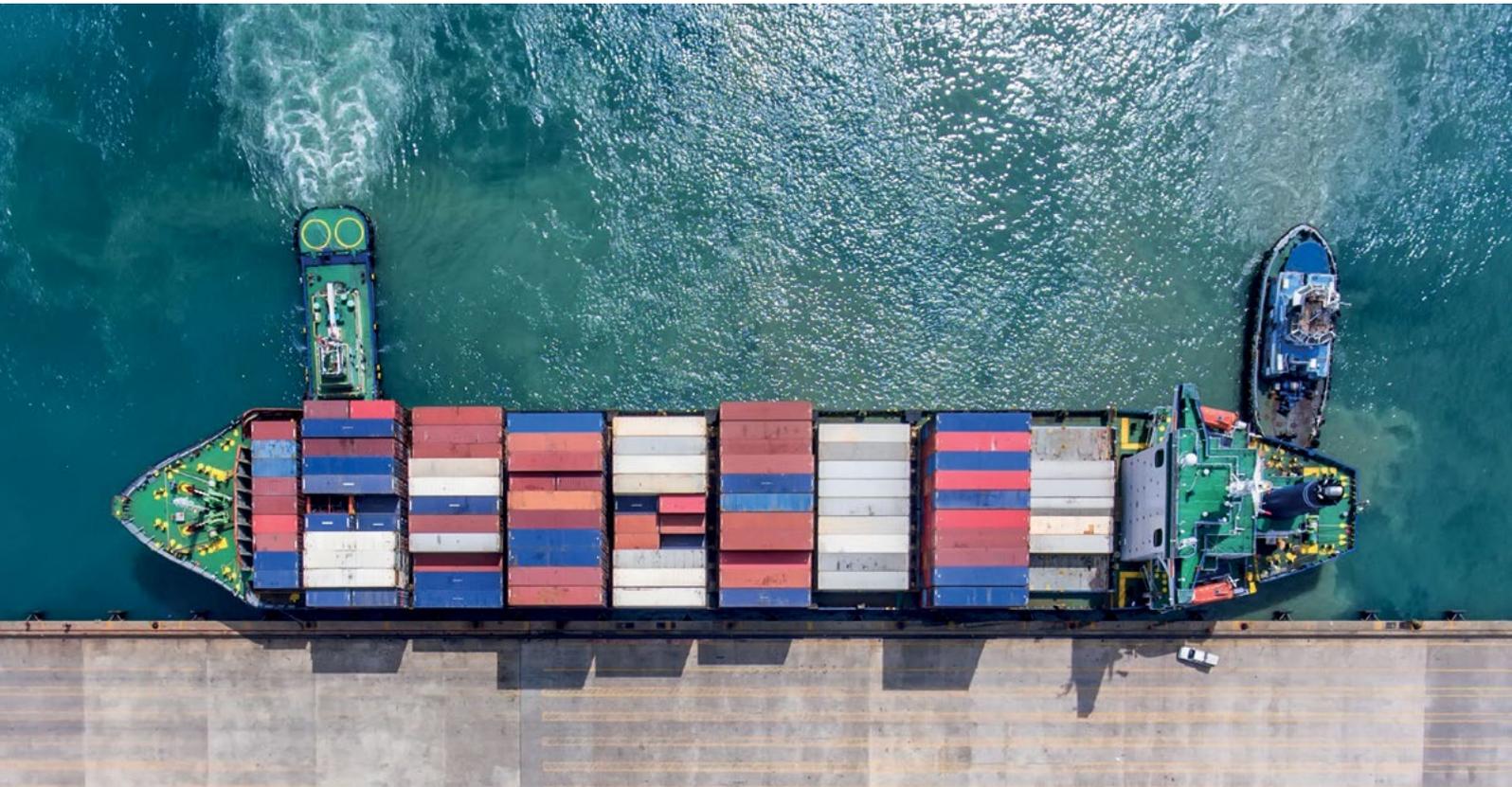


Fig. 1. Designing to worst loading condition



Engineering quality to reduce risk

ISO 9001 accreditation provides a certain level of confidence in accredited suppliers. However, practical experience shows that this alone does not guarantee product quality. Understanding a supplier's unique quality system will be instrumental in ensuring the quality of purchased products.

Quality is defined as:

"...the degree to which a set of inherent characteristics fulfils requirement."

In this context, it is assumed that product requirements have already been agreed between the buyer and the vendor.

When specifying or purchasing a high quality mooring system, there are a number of design, manufacturing and testing considerations that suppliers should be able to demonstrate. They should be able to prove the degree of conformance of the product to agreed requirements from the following points of view:

- **Material specification:** Typically, material grade and composition will be agreed to in the contract. A standard is specified where material mechanical properties and chemical composition are. Each component's material should be selected according to design codes. The customer should be aware of which codes and standards the product is designed to, in order to request design calculations and verify materials selected.
- **Material integrity:** Depending on the manufacturing method whether the material is machined, formed, cast or fabricated, correct manufacturing procedures complying with international standards must be followed. The manufacturing procedures should be detailed in the post contract award documentation.
- **Size:** The product dimensions and weight are an important factor of conformance. Failing to meet the specified requirements can render the product obsolete.
- **Functionality and design:** The product must be fit for the purpose for which it's intended to be used.

Building traceability throughout the process

Traceability is an essential part of quality assurance. All components must be traceable to source material, and each component must have a unique identifier assigned to it.

This identifier can then be traced to a sample. The sample should be tested to ensure it achieves the minimum requirements. While this will theoretically ensure full traceability, it is important to monitor how the sample that gets tested is traced to the source material. One way to address this issue is to employ a third party to witness material cutting and testing of samples.

The problem with current methods of testing and traceability lie in the fact that suppliers can all too easily mislead buyers when it comes to compliance certification, as the traceability process is not robust. While test coupons are submitted to be tested by purchasers, they are not necessarily taken from the mother material used in the manufacture of the product itself.

Best practice, to ensure genuine traceability, dictates third party witnessing to eliminate the risk of false or misrepresented certification. This is a straightforward practice that should be adopted by the industry as a whole. It's all too easy to prove compliance on paper but quality can only really be qualified when there is total assurance that the material being tested is the material used in the product.

Customers need to be able to guarantee that they are buying what has been tested, by ensuring that the materials tested come from the mother material, and that an independent third party witnesses the tests.

CASE IN POINT

Working with a leading owner and operator in the LNG application space, Trelleborg became aware of the low importance placed on the mooring system, which was to be procured by the shipyard as part of the build.

The shipyard viewed the mooring system as commodity equipment, with the main selection criteria being cost. However, while Trelleborg was offering a best practice solution, tailored for the application and fully compliant with applicable Class requirements, a competitor was offering a solution – at a lower price – that compromised functionality and did not comply with Class recommendations.

Trelleborg worked closely with the vessel owner to explore and explain the value of ensuring Class certification, to guarantee the safety and longevity of the project. Despite requiring the most initial outlay, the solution Trelleborg provided will deliver additional value over the course of its lifecycle, in the form of longer design life, lower total cost of ownership, less down time due to inherent quality and seamless integration of the system.



Designing for safety

Certain key considerations must be taken into account when designing a quick release hook.

Hook profile design

- A hook profile with adequate radius will prolong the life of the hawser to its full potential and eliminate premature snapping of lines due to extreme bending radius on the hook profile.
- Adequate rake angle will prevent lines from slipping at high angles especially at high tides or when mooring big vessels.

Hook release mechanism design

- Concealed levers to protect against inadvertent release or hair trigger, which can be life threatening.

Capstan design

- Hawser retrieval is one of the highest risk operations. One aspect of risk is getting the operator's hands caught in the rope while the capstan is running. The use of braked motor lessens the risk to minimum levels as the motor will stop as soon as the operator's foot is taken off the switch or if the emergency stop is activated. The use of non braked motors has significant consequences.

Load Monitoring with Alarm Light & Siren

- The load monitoring function is an essential safety feature that provides an early warning to the operator if the load on the mooring fitting goes outside its optimum levels. Whether the line is over tensioned or has become slack, a distinct alarm should be triggered to prompt the operator to take appropriate action.

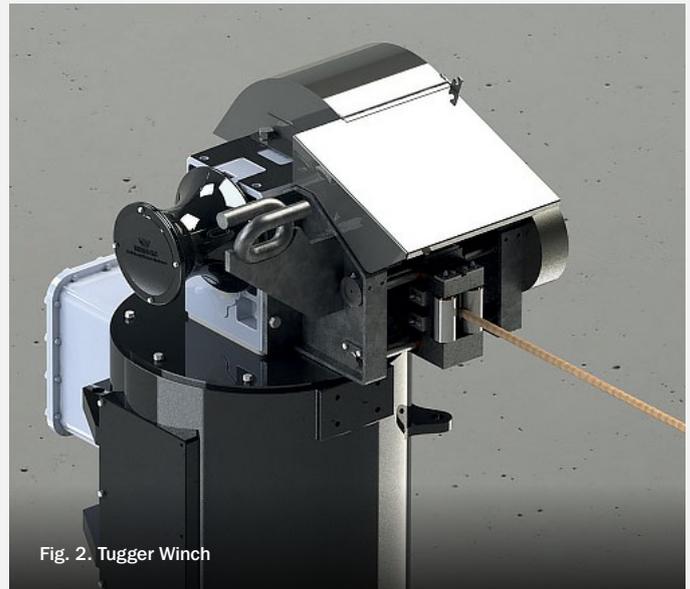


Fig. 2. Tugger Winch

- The use of poorly maintained or damaged heaving lines can result in breakages, endangering mooring crews or jetty personnel operating within the snap-back zone. As an alternative to the traditional capstan, the heaving line is retrieved and spooled onto the enclosed drum of the "tugger winch".

This enables the jetty owner / operators to control maintenance, providing increased safety and efficiency of mooring operations.



Comprehensive compliance assures quality



Fig. 3. Moored freight vessel

Comprehensive compliance assures quality

Compliance is the key to ensuring product consistency, and with it, quality. There are a number of categories of compliance that must be considered. This document outlines them, to offer an overview of the provisions specifiers and purchasers of docking and mooring systems should be demanding from their suppliers.

Unfortunately, some suppliers do not comply with all relevant regulations. These are the areas specifiers should be considering, and interrogating suppliers about.

Structural compliance

Some low quality vendors cut corners by providing substandard materials that do not actually fulfill specification requirements. While the samples tested may comply, the actual material supplied might not. In other cases, vendors – while offering the correct quality of material – might not carry out all the

necessary testing and quality assurance checks that a best practice supply requires.

Suppliers should have a quality management system integrated into their supply chain, with check points at critical junctions to ensure quality and traceability. Specifiers and buyers should be provided with evidence of this as and when requested.

To ensure compliance with material specifications, the following should be conducted for all products:

- Mechanical and chemical testing of samples by the manufacturer
- Mechanical and chemical testing of samples by an internationally recognized third party
- Random mechanical and chemical testing of samples from parent material

Hazardous area and electrical compliance

- In hazardous areas, using the wrong equipment significantly increases the risk of explosions that could cause loss of life and damage to assets and reputations.
- Equipment must be correctly marked for use in hazardous areas:
 - If marked with the symbol “X”, the certificate contains essential information for the installation, use and maintenance of the equipment
 - If marked with the symbol “U”, it is not intended to be used alone and requires additional consideration when incorporated into electrical equipment or systems for use in explosive atmospheres

To reduce ignition risks, it's important to work with OEMs that have a proven track record on hazardous area product design and relevant manufacturing capabilities.

Suppliers must be able to demonstrate proof of compliance with hazardous schemes through their own hazardous certified products and prove they are permitted to assemble equipment inside explosion proof enclosures as part of hazardous schemes, for example, OD203 of the IECEx.

Equipment must be designed, manufactured and installed to meet local and/or international hazardous standards to avoid the ignition of the explosive atmosphere.

- International: IECEx 60079 standards
- Europe: EN60079 standards (to meet ATEX Directive 2014/34/EU)
- United States: National Electrical Code (NFPA 70 & 60079 standards)
- Canada: Canadian Electrical Code (CSA C22.1 & 60079 standards)
- Russia: Ex EAC certification and Technical Regulations 012/2011 of the Eurasian Customs Union (TR CU 012)

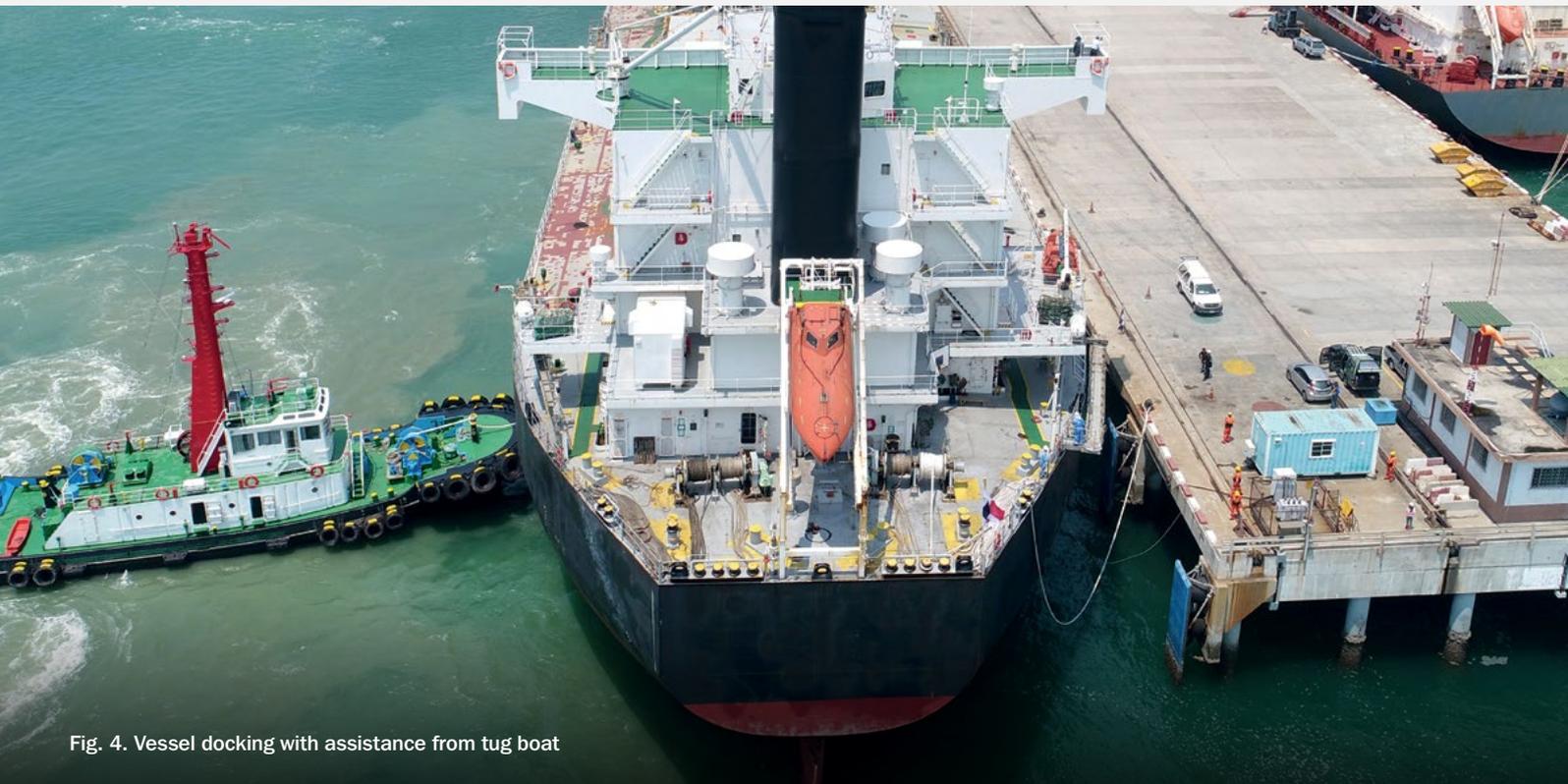


Fig. 4. Vessel docking with assistance from tug boat

Class compliance

Quick Release Hooks and other mooring fittings used on board of vessels for offshore applications in tandem, spread or ship-to-ship mooring, are required to comply with stringent design and quality requirements to ensure the structural integrity of the ship is met. These are applicable for FPSOs/FSOs, FLNG and FSRUs/FSUs and any offshore facility.

Trelleborg mooring fittings for offshore applications are designed in compliance with:

- OCIMF Mooring Equipment Guidelines MEG-3
- IMO MSC / 1175 (Guidance on Ship Towing and Mooring)
- Classification Societies Rules as applicable including:
 - DNV-GL
 - American Bureau of Shipping (ABS)
 - Bureau Veritas (BV)
 - Registro Italiano Navale (RINA)
 - Lloyds

The mooring system will be provided with a “Product Certificate” issued by the relevant classification society as assigned by the ship owner. The Product Certificate covers the following compliance requirements:

- Design survey conducted: The mooring fitting, its support structure holding down bolts and foundation plate must satisfy the design rules of the classification society.

The design is then assessed by the classification society. When approved a “Design Verification” document is issued to demonstrate compliance.

- Manufacturing survey: A surveyor deputed by the classification society inspects each manufacturing step to ensure compliance with class rules from material testing and traceability points of view. These inspection activities are:
 - Witness plate cutting
 - Sample stamping
 - Witness sample testing
 - Welding qualification
 - Witness welding testing
 - Casting or forgings process witness and sample cutting
 - Witness sample testing for castings or forgings

Each inspection activity is documented by a “Statement of Fact” issued by the surveyor. At the conclusion of this step, a “Manufacturing Survey” document is issued detailing the inspection activities in accordance with class rules and as specified in the design verification document.

- Hook proof load and calibration witness: A surveyor deputed by the classification society witnesses the proof load of each mooring fitting to the nominated proof load and the calibration process to the safe working load. A “Proof Load and calibration Certificate” is then issued to document this step. The proof load can calibration certificate is also a statement of fact.



- **Manufacturing Documentation Records (MDR) review:** In this step, all documents issued above are compiled together and reviewed by the classification society to ensure full compliance. Any of the documents issued in the previous steps does not demonstrate compliance on its own. Only a “Product Certificate” does that once all records have been checked by the surveyor.

Commercial compliance

Commercial compliance is not often a consideration of the specifier. However, it’s important that the reassurance and back up provided by a well-established supplier is thought through, in order to best protect the investment made and ensure any warranties or long term contracts will be honored. Where the docking and mooring package is part of a larger contract, the supplier should ensure adherence to end user requirements including defect liability period, handover and warranty.

Claire-Julie Frélaut, Head of Hydrodynamic & Mooring Section, BUREAU VERITAS, explains: “The mooring system of an offshore unit plays an important role in the safety of the unit itself and of the on-board staff. To avoid the risk of failure of the mooring system, it is important to check that the overall mooring design complies with rules from an IACS Classification Society. The Classification Society will supervise the design process step by step and the whole design of the mooring system will be reviewed by independent analysis and the installation of the system will be surveyed.

“It should be kept in mind that the system is ensured to be only as strong as its weakest component of the line. Therefore it is very important to confirm that all components of the mooring system are certified by an appropriate company that will check the material used, the methodology of production, the strength of the components and also the skill and accreditation of the staff involved in the production process. A safe mooring system starts with good quality mooring equipment.”



Trelleborg Marine Systems has over 40 years' experience designing and manufacturing leading edge docking and mooring solutions for varied applications and projects all over the world. We work closely with industry bodies to evolve and maintain best practice standards to ensure the safety, reliability and performance of our docking and mooring portfolio.

For more in depth information and a technical look at overcoming the issues raised by this whitepaper, click [here](#) to watch our webinar.



Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way.

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