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THE STRONGEST NAME IN ROPE

DEFENDER FUSE™
Alternative Mooring Technology Solution
PER MEG4 SECTION 11

MAY 2023

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INTRODUCTION

When designing mooring systems, Oil Companies International Marine Forum (OCIMF) *Mooring Equipment Guidelines 4th Edition (MEG4)* allows for the adoption of emerging technologies including reduced snap-back solutions. The Samson Defender Fuse™ has been designed and Type approved based on the MBLsd of a vessel in accordance with these guidelines to be used in conjunction with MEG4 aligned mooring systems. This unit is designed to be the leading indicator of an overload event and absorb all energy associated with the mooring system.

MEG4 COMPLIANCE METHODOLOGY

Included in the 2018 publication of MEG4 is a section dedicated to alternative technologies. The introduction of this section provides definitions for alternative and emerging technologies which include those that may be well documented in sectors other than marine tanker mooring in addition to those that are new enough not to have a documented track record in any sector. Inherently, these types of technology offering were not able to have concrete guidelines established for their use within the purview of the sector addressed by OCIMF. However, this inclusion within the MEG4 document illustrates that the intention of the guidelines is not to exclude technologies that are not explicitly noted, but to provide a path towards acceptance in lieu of published regulation.

MEG4 Section 11 provides guidance on the due diligence process which should be pursued when considering adoption of an alternative or emerging technology. This is explicitly broken into five efforts: evaluation, impact, equivalency, formal safety risk assessment, and engagement of stakeholders.

Through development of the Defender Fuse™, Samson followed this path and received 3rd party Type Approval from the American Bureau of Shipping (ABS).

11.2 — Examples of alternative and emerging technologies

At the time of publication, the following alternative and emerging technologies exist for mooring:

- Vacuum mooring.
- Magnetic mooring.
- Shore tensioning systems.
- Tension monitoring systems, e.g. load cells used on winches, bollards, and shackles.
- Mooring tail developments, including condition monitoring and reduced snap-back.
- Mooring line developments, including condition monitoring and reduced snap-back.
- Remote technologies for winch controls.
- Automatic tensioning winches.
- Bollard Non-Destrustive Testing (NDT).

This list is not exhaustive and should not stop new technologies being developed for mooring systems. OCIMF neither endorses or opposed the listed technologies. They may be considered for use following structured due diligence and formal safety risk assessment process.

SOURCE: Mooring Equipment Guidelines (MEG4), Section 11: Figure 11.2, Alternative Mooring Technology.

RECOIL – WHAT IS IT?

It is well understood that a mooring line parting event can pose a significant safety risk, but it may not be obvious why the line would recoil with such dangerous force. The reason is linked to the fact that any mooring line subjected to tension will stretch. This is readily apparent on a small scale with household rubber bands or springs and can be clearly seen at scale with high-stretch mooring tails attached to a vessel that is moving with the swell. As with a rubber band pulled to its breaking point, a stretched line that is released will pull back in the direction of tension — rapidly.

However, it is also true that HMPE, and even steel wire, mooring lines experience a similar if less extreme stretching when subjected to tension. This stretching stores energy within the mooring ropes as the distance between the moving vessel and mooring point increases. If a tensioned line breaks, all of the stretched rope components connected in series are now free to return to their original length and will immediately attempt to. This release of stored energy results in the parted ends recoiling away from the break location as the stretched components rapidly relax.
See Figures 1A–1C.

FIGURE 1A: In any mooring operation situations can arise and create the potential for parted lines.

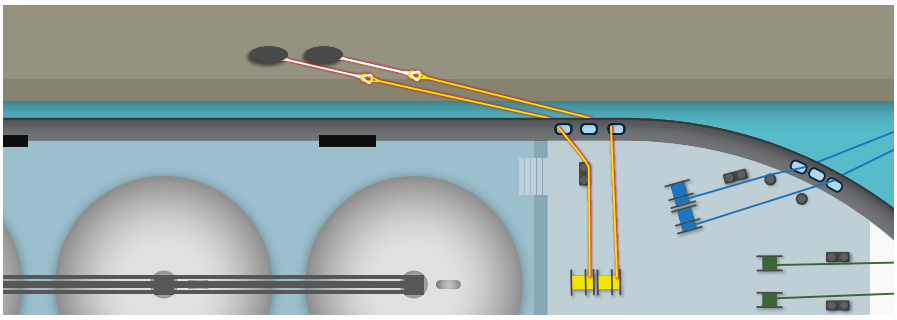


FIGURE 1B: When mooring lines part, the recoiling ends can travel in unpredictable paths putting crew and equipment in danger.

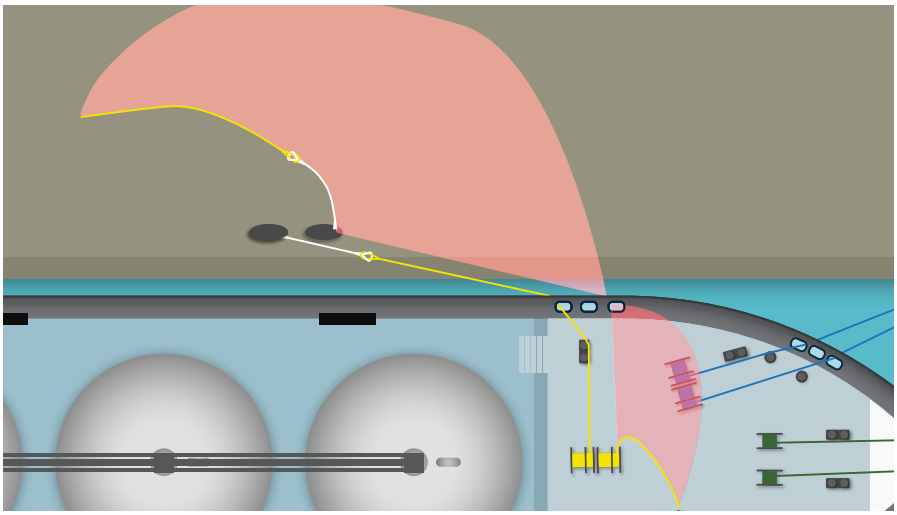
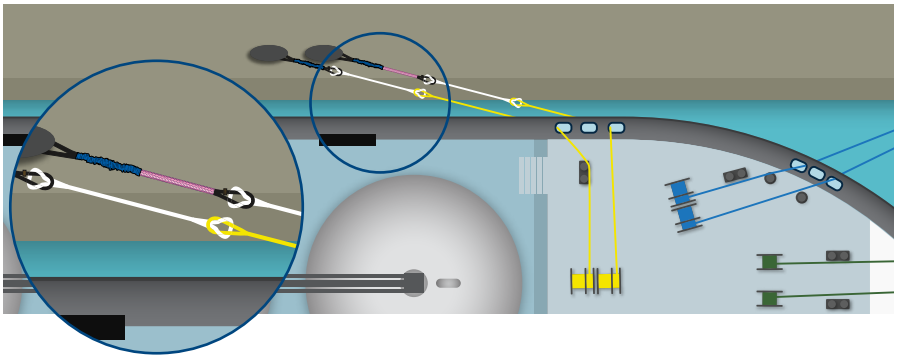
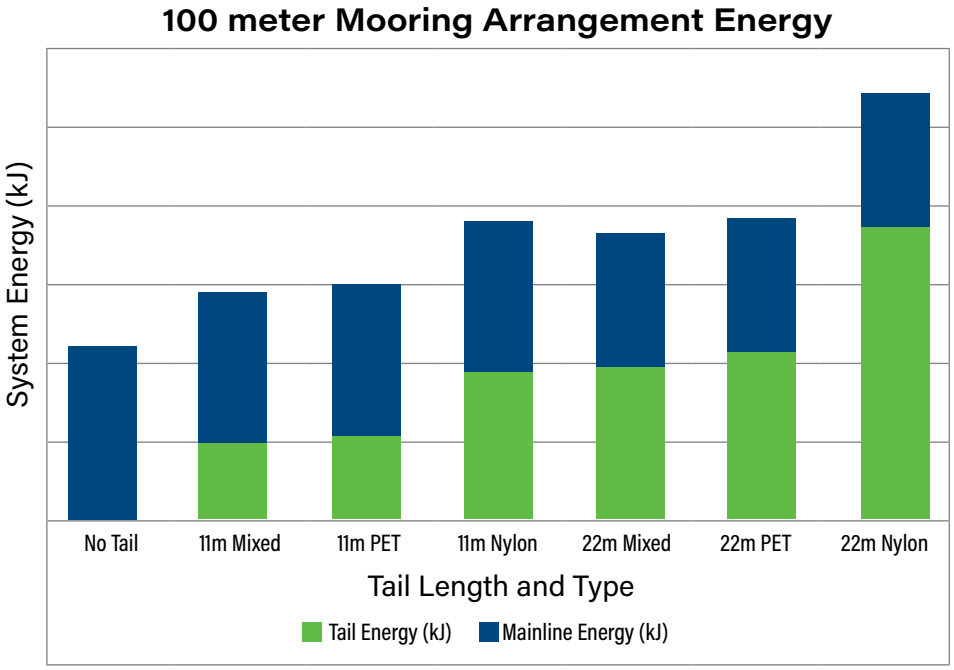


FIGURE 1C: Incorporating Defender Fuse limits the maximum tension that mooring lines experience when overload occurs by deploying to absorb stored energy in the system.



MOORING SYSTEM ENERGY MODEL

Consideration of total system energy of a mooring arrangement, the energy stored in both the mainline and tail, is critical for addressing snap-back. While reduced recoil risk mainline products can be validated by standardized test methods to ensure that they restrain the energy stored within their structure, this approach does not address additional energy from an elastic tail. These relatively short tails are intended to function as a load damper and can contain significantly more energy at a given load than the entire length of a deployed mainline. See Figure 2.



Energy impact dominated by tails in high-performance mooring systems.

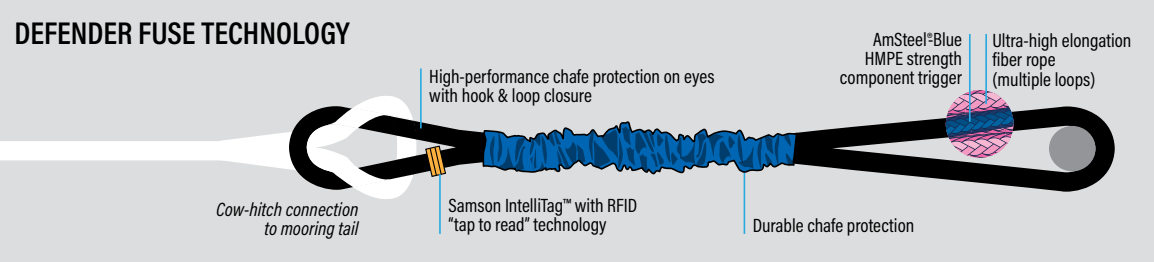
FIGURE 2: Total system energy shared between mainline and tails for a 100 meter deployment length.

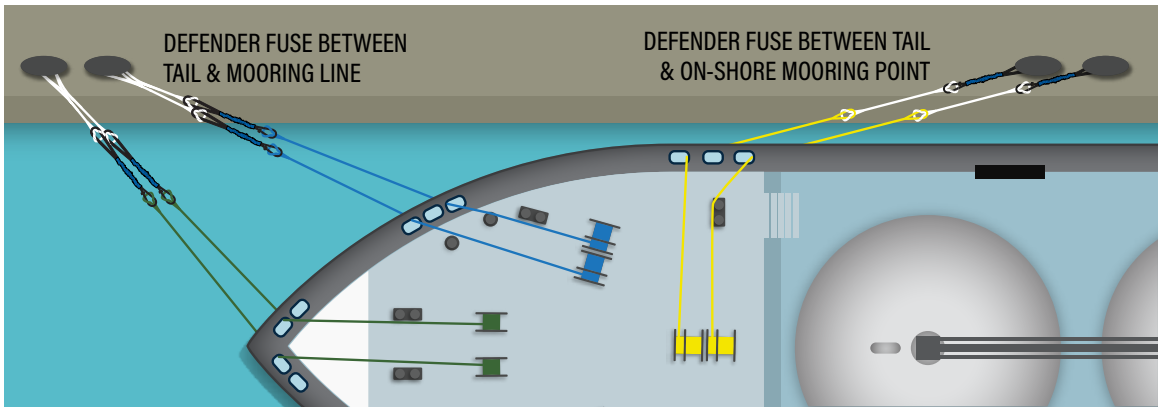
THE DEFENDER FUSE

Samson's Defender Fuse™ is made up of three critical components:

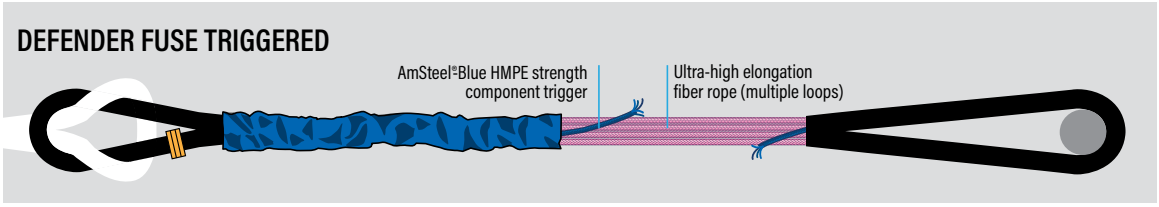
- **CHAFE** outer layer that encapsulates and protects the assembly.
- **TRIGGER** HMPE rope in tension during operation that is designed to deploy at a target load.
- **CATCH** ultra-high elongation material capable of absorbing ALL energy in a mooring line.

The Defender Fuse™ is an assembly intended to be added in series with the mainlines and tails of existing mooring systems. This technology is designed to seamlessly integrate with standard operations and appear visually like an additional tail. During normal conditions, the trigger component will hold the load with a stiffness similar to the HMPE mainlines commonly utilized.





In the event that an overload occurs, this trigger component will deploy, providing an auditory and visually apparent response. The energy stored within the tensioned trigger, mainline, and tail will transfer to the catch component. This specially designed catch material is capable of stretching up to an additional 150% beyond its original length, allowing for all of the energy stored within the stretched mainline and tail to rapidly dissipate without disconnection occurring.



By maintaining connection between the mooring components and allowing them to release all of the energy they stored while stretched, the Defender Fuse™ allows the system to survive an overload event without catastrophic failure of the mainline, tail, or other equipment. This increased length in the overloaded line will share load with other lines in the spread and provide the crew with an opportunity to address the imbalance or operational limit that led to overload without encountering recoiling ends of a broken line or experiencing full disconnection from shore.

FUSE TECHNOLOGY

Due to operational implications around the risks associated with line parting events, the drafters of OCIMF MEG4 highlighted the potential for emerging technologies related to snap-back control explicitly in Section 11. Samson's Defender Fuse™ is one such approach that aims to apply a concept common in other fields, such as electrical circuitry where a fuse is added to the system, to reduce the likelihood of an overload scenario. See Figure 3.

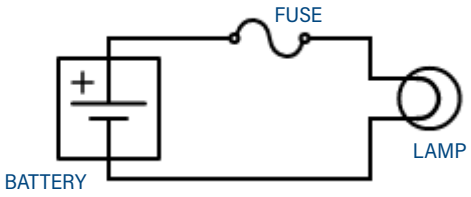
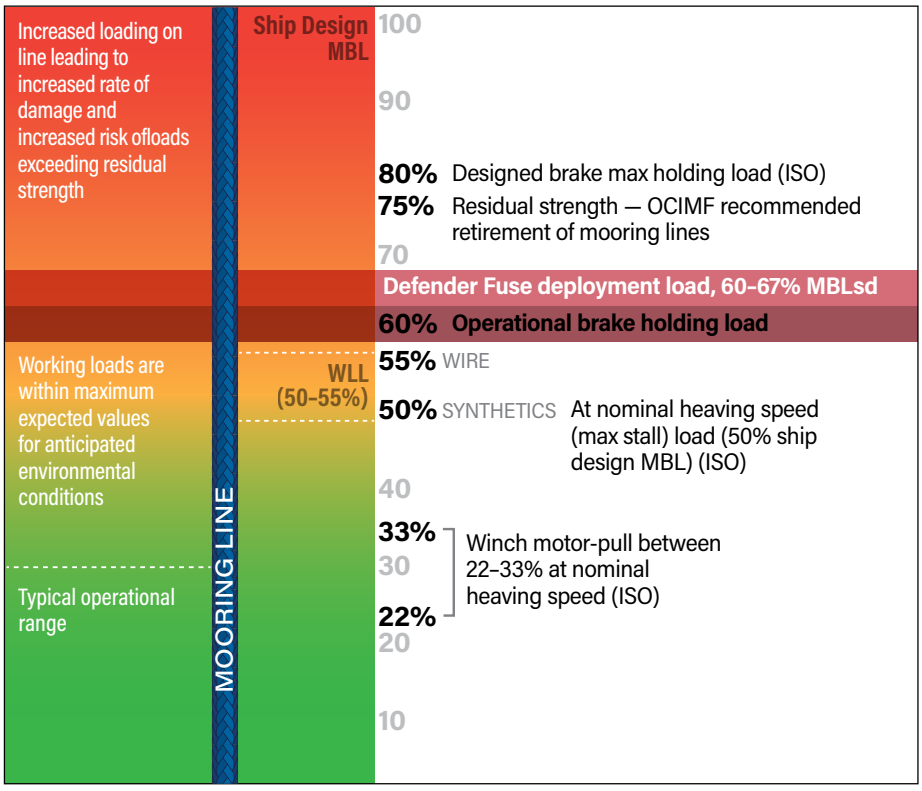


FIGURE 3: Analogous electrical circuit with a battery, lamp, and fuse corresponding to the tension, lines, and Defender Fuse™ of a mooring system, respectively.

By incorporating this technology in series with the existing mooring equipment, a tension reducing response will be activated if a load greater than the designed trigger deployment threshold is observed. The fuse is designed in such a way that the energy included in the full mooring system (mainline and tails) is absorbed during the deployment.

The trigger deployment load has been selected to align with other load control approaches already accepted by the industry, namely the winch brake render setting defined in MEG4 to be set at 60% of the MBLsd. Implementing this additional tension-limited assembly is intended to reduce the risk of mooring line failure events, which continue to occur regardless of mooring winches being outfitted with rendering capabilities. By positioning this fuse outboard of the vessel, the redundant overload protection is optimally positioned to experience overload events that the winch render may be unable to address, due to frictional impacts on observed tension transfer as the mooring line routes around fairleads between the shore and braked winch.

Illustration of operational and limiting values for mooring lines.



SOURCE: Mooring Equipment Guidelines (MEG4), Section 1, Figure 1.4, Illustration of Operational Values and Limiting Values for Mooring Lines.

HUMAN FACTORS

In MEG4 "Section 2 – Human factors", the guidelines focus on reducing crew risk through safety critical task analysis and implementation of improvements. One of the specific items highlighted as a current design challenge is the lack of mooring line load monitoring. This inherent limitation of existing systems can lead to lines becoming overloaded without warning, exceeding design thresholds intended to protect against crew endangerment.

2.3.3.3 Mooring line load monitoring

There is often no facility, either ashore or on board, to monitor mooring line loads during mooring or during the ship's stay alongside the berth, with the consequence that mooring lines can become slack or over-tensioned when unattended. It is recommended that remote load monitoring is included in the mooring design.

SOURCE: Mooring Equipment Guidelines (MEG4), Section 2, Human Factors.

Samson's Defender Fuse is designed specifically to provide a reduced recoil risk while operating with this known limitation of the mooring environment. In the event that an uncontrolled overload scenario not readily apparent to crew on deck results in the mooring line experiencing tensions above the allowed WLL threshold, the Defender Fuse will react, actively relieving strain in the system by adding length. This is intended to provide a release of dangerous energy stored in the mooring line and tail, allowing crew time to address the mooring system and respond to the operational scenario that created the issue.

FORMAL RISK ASSESSMENT

To support vessel operators through this process, Samson has pursued a formal Product Design Assessment and Type Approval with the American Bureau of Shipping (ABS). The process undertaken with ABS included a design failure mode and effect analysis (DFMEA), assessment of development test results, witness of full-scale prototype evaluation, and review of all design model parameters. The robustness of this 3rd Party involvement in validating the performance of the fuse is intended to streamline the adoption process for any vessel ready to adopt this recoil risk reducing technology within the parameters of their specific mooring system.

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Defender Fuse™ RISK ASSESSMENT

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PRODUCT REQUIREMENT	POTENTIAL CAUSE OF FAILURE	POTENTIAL EFFECTS	INITIAL RPN
Energy absorption capability results in recoil containment	Catch damaged by trigger and fails following deployment with all stored energy in the system converted to kinetic recoil.	Recoil occurs when the trigger deploys	
	ACTIONS TAKEN *(highest potential failure items)*		**FINAL RPN**
	Full-scale tests confirm that the sizing of catch components achieve full recoil energy absorption without any occurrence of trigger-damaging catch components.		

PRODUCT REQUIREMENT	POTENTIAL FAILURE MODES	POTENTIAL EFFECTS	INITIAL RPN
Capable of integration with existing mooring equipment	Crushing of catch rope through repeated connection / disconnection leads to premature damage of the catch component.	Operation with Defender Fuse not possible	
		Replacement Defender Fuse required upon inspection	
	ACTIONS TAKEN *(highest potential failure items)*		**FINAL RPN**
	Assembly designed to explicitly accommodate cow-hitch connections and protect critical components to avoid any potential crushing.		

PRODUCT REQUIREMENT	POTENTIAL CAUSE OF FAILURE	POTENTIAL EFFECTS	INITIAL RPN
Trigger deployment at target threshold	Fatigue of trigger leads to reduced break strength and deployment due to loads below WLL.	Winch renders or mainline / tail component fails	
		Operation halted to address deployed fuse and/ or vessel drift occurs	
	ACTIONS TAKEN *(highest potential failure items)*		**FINAL RPN**
	3-year lifetime set based on Tension-Tension testing and calculated fatigue rate of AmSteel®-Blue trigger for typical mooring frequencies.		

PRODUCT REQUIREMENT	POTENTIAL FAILURE MODES	POTENTIAL EFFECTS	INITIAL RPN
Assessment of condition allows for appropriate retirement	Trigger deployment occurs but remains undetected resulting in material yield with low loads applied for remaining component.	Vessel drift or uneven load sharing across mooring lines as catch component yields	
		Continued use leads to damage of trigger and/ or catch components	
	ACTIONS TAKEN *(highest potential failure items)*		**FINAL RPN**
	Create retirement criteria related to the assembly's readily apparent deployment indicator with offset trigger / catch lengths and separated chafe components.		

RISK PRIORITY NUMBER (RPN) SCALE

1–200	201–400	401–600	601–800	801–1000
Very low or no risk	Low or minor risk	Moderate or significant risk	High risk	Very high or catastrophic risk

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USE/RETIREMENT

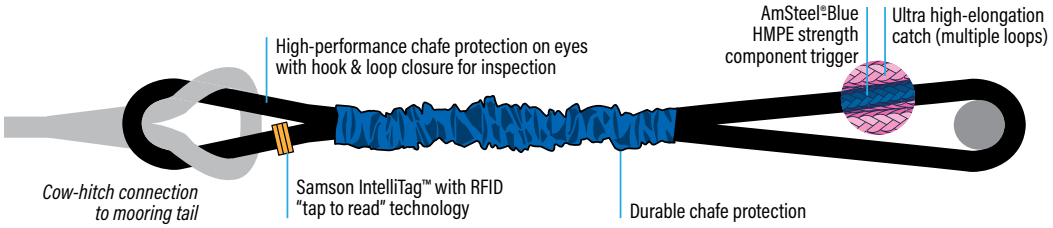
Samson has created a *Defender Fuse Use & Retirement* guide to assist users with the following:

> Selecting the right Defender Fuse option for your system
> Positioning within your current mooring system
> Installation and Retirement best practices

Contact your Samson representative for a Defender Fuse Use & Retirement guide.

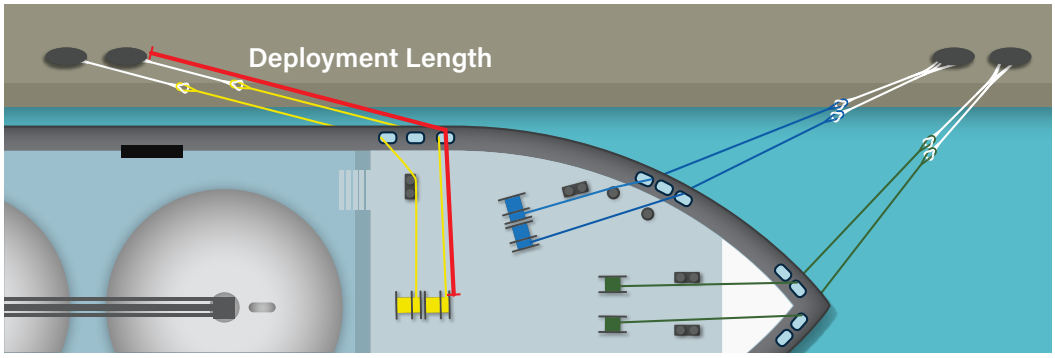
Defender Fuse™ USE & RETIREMENT

DEFENDER FUSE ANATOMY:



SELECTION

Samson's Defender Fuse™ is designed to reduce the risk of recoil in alignment with the MBLsd of the vessel it will be utilized on. The corresponding sizing is based on the amount of energy that can be stored in the mooring configuration and is influenced by the total deployment length, mainline material, and mooring tail specifications.



Defender Fuse™ is designed to reduce the risk of recoil that can result from release of the energy storage in high-performance mooring lines with various mooring tails and total deployment lengths up to 100m. In cases where a Fuse solution is desired in systems where traditional fiber mainlines are employed or in cases where longer deployment lengths are required, contact Samson for recommendations.

Vessel operators select mooring tail designs to reduce peak loads in a mooring system. As tail lengths increase or materials are selected with higher elasticity, the corresponding energy that can be stored in the system similarly increases. As such, the required catch component for a mooring fuse must be scaled appropriately to capture the associated energy. Samson provides two specifications to accommodate these potential mooring configurations, both standard and High Recoil Control (HRC).

- **Defender Fuse™** — energy absorption capability to accommodate up to 11m non-Nylon tails
- **Defender Fuse™ HRC** — energy absorption capability to accommodate up to 22m Nylon tails

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THIRD PARTY TYPE APPROVAL

CERTIFICATE NUMBER	23-2324139-PDA
EFFECTIVE DATE	28-Feb-2023
EXPIRY DATE	27-Feb-2028
ABS TECHNICAL OFFICE	London Engineering Department

CERTIFICATE OF

Product Design Assessment

This is to certify that a representative of this Bureau did, at the request of

SAMSON ROPE TECHNOLOGIES

located at

2090 THORNTON STREET, , FERNDALE, WA, United States, 98248

assess design plans and data for the below listed product. This assessment is a representation by the Bureau as to the degree of compliance the design exhibits with applicable sections of the Rules. This assessment does not waive unit certification or classification procedures required by ABS Rules for products to be installed in ABS classed vessels or facilities. This certificate, by itself, does not reflect that the product is Type Approved. The scope and limitations of this assessment are detailed on the pages attached to this certificate.

Product:	**Rope**
Model:	**Defender Fuse**
Endorsements:	
Tier:	**3 - Type Approved, unit certification not required**

This Product Design Assessment (PDA) Certificate remains valid until 27/Feb/2028 or until the Rules and/or Standards used in the assessment are revised or until there is a design modification warranting design reassessment (whichever occurs first).

Acceptance of product is limited to the "Intended Service" details prescribed in the certificate and as per applicable Rules and Standards.

This Certificate is valid for installation of the listed product on ABS units which exist or are under contract for construction on or previous to the effective date of the ABS Rules and standards applied at the time of PDA issuance. Use of the Product for non-ABS units is subject to agreement between the manufacturer and intended client.

American Bureau Of Shipping

Roderick M.C. Yam,Engineer/Consultant

NOTE: This certificate evidences compliance with one or more of the Rules, Guides, standards or other criteria of ABS or a statutory, industrial or manufacturer's standards. It is issued solely for the use of ABS, its committees, its clients or other authorized entities. Any significant changes to the aforementioned product without approval from ABS will result in this certificate becoming null and void. This certificate is governed by ABS Rules 1-1-A3/5.9 Terms and Conditions of the Request for Product Type Approval and Agreement (2010)

Certificate of Product Design Assessment Rev.3
of 1

Page 1

DEFENDER FUSE CERTIFICATE OF COMPLIANCE

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CERTIFICATE OF COMPLIANCE

It is hereby certified that the products described herein have been produced in accordance with the design, performance and quality standards stated in our Quality Assurance Manual and as cited in the Catalog. In addition, it is certified that the product has been inspected and found to conform to all requirement of the customer's order or to our documentation cited herein.

It is hereby certified that the products described herein have been produced in accordance with the design, performance and quality standards stated in our Quality Assurance Manual and as cited in the Catalog. In addition, it is certified that the product has been inspected and found to conform to all requirement of the customer's order or to our documentation cited herein.

Line Supply Information

Ship Design MBL:	None	**Fiber Type(s):**	HMPE - Polyester - Nylon Blend
Size:	125MT MBLsd	**Vessel MBLsd Range:**	112 MT - 125 MT
Length:	5.0 m	**Nylon Tail Allowed:**	No
Product Code:	80508080160001	**Class 1 Mainline Allowed:**	No
Product Name:	DEFENDER FUSE™		

Performance Attributes

Trigger Deployment Load:	74.8 MT
Unit Weight:	34.9 kg
Max Deployment Length:	100 m
Max Tail Length:	11 m
Test Method:	SRT-104
ABS Type Approval No.:	23-2324139-PDA

Assembly Description: DEFENDER FUSE™ 125MT MBLSD

Sales Order:	D67309	**Customer Name:**	OCEAN PROD RESEARCH CO
Certificate Number:	17038-5-1	**Customer Address:**	19 BUTTS LANE
Date Issued:	January 1, 2001		DIGGS, VA 23045 US

The provided specifications for this product are based on the evaluation and risk assessment methodology published in Section 11 of the Mooring Equipment Guidelines, Fourth Edition (MEG4). The Samson Defender Fuse™ has been designed and Type Approved by the American Bureau of Shipping (ABS) based on vessel MBLsd in accordance with the guidelines and to be used in conjunction with MEG4. All operation, line maintenance, testing and inspection procedures, and discard criteria will be provided upon request. Please contact Samson if more information is needed

Defender Fuse | V.1.0 | 5/11/2023 10:43:06 AM

SAMSON: 2090 Thornton Street, Ferndale, WA 98248 USA

APPENDIX 4

FREQUENTLY ASKED QUESTIONS

What size is the Defender Fuse and will it fit in my system?

Defender Fuse units are sized to specific vessel MBLsd ranges. A Defender Fuse is roughly the size of standard mooring tails allowing it to fit suitably through existing hardware and be connected to mainline or tail components via a standard cow hitch.

What do I do if my MBLsd is between sizes?

Consult Samson! Each Defender Fuse™ design has been carefully scaled for a range of vessel MBLsd to consistently provide a trigger deployment load above the MEG4 allowed WLL and below the mainline / tail retirement threshold. Samson's team will be able to recommend the appropriate solution for your specific vessel(s).

Can my Defender Fuse absorb the energy from tail and mainline?

Yes! The Defender Fuse™ has been intentionally designed to accommodate the energy stored within a high-performance mainline and common high-elasticity tails (i.e., 11 meter / 22 meter long mixed fiber or nylon) up to a total deployment length of 100 meters. If a mooring system is using traditional fiber mainlines, which stretch more than high-performance materials and therefore store more energy, or requires unusually long deployment lengths, consult Samson to ensure a Defender Fuse™ with adequate energy control is supplied.

Other manufacturers provide snap-back protection in their mainlines, what are key considerations?

In any snap-back (reduced recoil) product we should always ask what energy levels the catch material can accommodate as there will be energy stored in both mainlines and tails.

What testing standards were followed?

Evaluation of the Defender Fuse was performed at full scale with comparable energy release applied. While not directly applicable, concepts from CI-1502 test method for High Modulus Reduced Recoil Risk Rope were addressed in the Defender Fuse test program.

Where in the system should I put the Defender Fuse?

The Defender Fuse™ is intended to reduce the recoil risk by experiencing the maximum tensions that a mooring system may be exposed to. As such, it must be positioned in series with the mainline and located between the vessel and mooring point. In systems utilizing both a mainline and tail, this can be achieved by positioning it either between the two or connected to the rope system on one end and directly to the mooring point at the other.

How is Defender Fuse connected to the mooring system?

As is common when connecting a synthetic mainline and tail, the Defender Fuse™ is designed with an eye at both ends to allow for direct connection with a cow-hitch. If used at the end of the mooring line to connect directly to shore, the longer 2-meter eye can accommodate the hooks or bollards typically encountered.

Has cow hitch strength loss been accounted for when the Defender Fuse is installed between the mooring line and pendant using two cow hitches?

Multiple cow hitches will not increase strength loss in the mooring system as the connections at either end of the unit interact independently. Defender Fuse was evaluated between relevant line sizes to ensure no reduction in trigger deployment load. Scale-up tests included multiple cow hitches between components, and the units functioned as designed.

How often should I change out my Defender Fuses?

In the event that an overload is experienced, the Defender Fuse™ must be removed from the system and replaced immediately. If the product does not deploy, it is recommended to remove it prior to achieving 3-years in service.

If the trigger is made of HMPE, why does it need to be replaced every 3-years?

Unlike an HMPE mainline, the entire trigger component of your fuse experiences every load cycle and therefore cannot be end-for-ended in order to extend life. In addition, as it is designed to deploy at a lower load than the mainline it is connected to, each tension cycle experienced is a higher percentage of the material breaking strength, resulting in greater fatigue.

When do I know that the Defender Fuse needs to be replaced?

In addition to replacing after deployment or completion of the service life, a Defender Fuse™ that experiences significant damage must be removed from service. If the cover material is torn and a qualified person can confirm the core components are undamaged, it is possible to repair the unit before returning to use. Any damage to the trigger or catch components inside the protective jacket require retirement.

What happens when it breaks?

In the event that a peak load in the mooring system exceeds the trigger deployment load, the HMPE trigger component in tension will separate, transferring tension to the ultra-high elongation catch component. With energy released by the tail and mainline, the catch component will elongate significantly as it absorbs the corresponding energy. This deployment is an indicator and a warning to take immediate action to address the overload condition. If adequate action is not performed, the catch will continue to stretch and eventually fail, releasing stored energy.

Additional questions?

Contact your Samson representative for assistance.

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