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When Should a Towline Be Retired? Chafe protection and twist and how to recognise their impact

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SYNOPSIS

For the past few years, the towing industry has invested in new and more effective tug designs to enhance methods of towing. Consequently, what has become apparent is that the connection between ship and tug, the towline, is of primary importance with regard to operational safety. The industry has recently seen an expanding global acceptance of high-performance synthetic towlines. This has created a need to better understand and improve synthetic towline performance characteristics and retirement criteria.

Following up on Crump et al[1], this paper tries to answer the question: When should the towline be retired? Several published standards and guidelines describe methods for inspection and retirement criteria, and this paper takes a closer look at how these standards can best be implemented.[2]

It has been documented that the abrasive and demanding environment that is inherent in towing applications is typically the most dominant strength reduction mechanism.[1] In response to this, there have been significant advances and product innovations aimed at protecting synthetic lines against abrasion. This paper evaluates the comparative differences in residual strength and general condition of lines returned from field service after having been used with a range of different protection levels. This paper also raises awareness of the harmful impact of twisting braided towlines and the importance of protecting against twist build-up.

INTRODUCTION

There are several important factors to maintaining safe working conditions of synthetic towlines. Most critically, these factors include:

- Minimising abrasion damage, both external and internal to the rope;
- Preventing permanent twist from developing in the line;
- Defining consistent inspection requirements to help eliminate subjective differences and personal opinion from dictating retirement criteria.

Each of these issues is discussed in detail. This information is intended to act as a reference guide that can be used to establish inspection and retirement criteria, as well as safe operating procedures for tugs servicing in ship assist and escort applications.

MINIMISING ABRASION DAMAGE

While synthetic ropes made from high modulus polyethylene (HMPE) have become common in towing applications, to some the obvious advantages of these towlines (lightweight, flexibility, high strength, buoyancy, etc) are not always enough to eliminate the inherent concerns that exist when using a synthetic line in such a potentially abrasive and demanding environment. Hence, there are several methods developed to increase their value.

The threat of abrasion in such environments can be greatly mitigated through several mechanisms. Here we will focus on two: the proper use of chafe protection and the potential product improvements through the use of selective coatings.

Chafe protection – defining value

While HMPE towing lines are extremely durable against abrasive surfaces, their service life can be greatly extended by protecting them from contact with rough surfaces – particularly while under tension. Chafe gear can provide this benefit, but without the proper use of such protection, it may be difficult to gain the full value of these products. Since most towing applications create localised abrasion points on the line, strategic positioning of chafe gear should always be used to create the most beneficial use of the products.

Figure 1 shows a typical ship-assist operation. As can be seen, a specific portion of the towing pendant comes into contact with the deck hardware on board the customer's vessel. This deck hardware is not ideal when using synthetic ropes. In turn, this is the most common location of failures – both in the field and in lab simulation studies. In different applications, other portions of the line may be exposed to specific abrasion. Because of this, care should be taken to install chafe gear in the appropriate locations.

Figure 1: Typical pendant location during ship assist.

Figure 2 shows two typical towlines with a length of braided chafe gear along a section of the line (as well as within the spliced eye).

Figure 2: Towlines with eye and body braided chafe gear.

This configuration of chafe gear was used on a towing pendant installed on a 6,500hp omni-directional tug. After approximately 1,300 ship assists, the line was retired and returned for inspection and testing. The visual inspection proved the benefits of chafe protection. *Figure 3* shows the protected end of the line, with minimal effects of abrasion. *Figure 4* shows the typical wear on the unprotected end of the line, both internal and external.

Figure 3: The protected portion of the pendant.

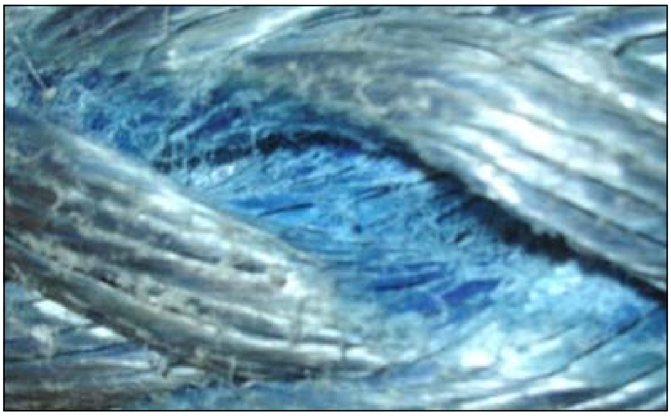

Figure 4: An unprotected portion of the pendant.

While the protected end of the pendant showed little sign of serious damage and had a predicted residual strength of 65–75 per cent, when tested, the pendant broke at a load of 51 per cent of the new-rope minimum breaking strength, and broke in the most severely damaged area. From this, it should be noted that severe localised abrasion is a serious concern in all towing applications and can create a weak link in a rope that may otherwise be in good condition.

There are two significant concerns regarding the use of chafe gear to increase the safety and service life of synthetic towlines. Firstly, recognition of what surfaces in a vessel's typical operations will produce the most consistent and severe abrasion. Secondly, utilising chafe gear reliably protects those portions of the towline that will most likely contact those surfaces on a consistent basis. In so doing, both the internal and external integrity of the rope are protected. This allows operators to increase their operating residual strength by as much as 15–20 per cent, which could allow for an increased service life based on operating safety requirements.

An important note with regard to inspecting the internal condition of HMPE towlines: melting and fibre fusing can sometimes appear to be much more severe than it actually is. When HMPE towlines are severely overloaded, the strand-on-strand compression can cause the fibres and yarns to fuse together as a result of the internal heat and pressure that develop. However, high loads from typical use can create fibre compression with a similar appearance. Figure 5 shows the condition of an overloaded line with yarn and fibre fusing.

Figure 5: Fused yarns. This line should be inspected further.

If the yarns and strands can be manipulated by hand and loosened to the fibre level, back to their original condition, the line has not suffered significant damage. However, if the yarns and strands have been permanently fused together it is a sign of severe damage and this section of the line should be repaired or replaced.

Coatings: improving operational safety through product innovation

With the industry-wide experience that has been gained over the past several years, there is a growing need for increased life expectancy of ropes in all towing applications. Recent efforts to combat the negative impact of abrasion have led to the development of an improved proprietary coating that has been tested and proven in the field, with very promising results.

The plot in *Figure 6* shows a combination of two residual strength models for HMPE towing pendants. As reported in Ref 1, the black line is a representation of the predicted residual strength of a "standard" 12-strand HMPE towing pendant throughout its service life. The yellow line is a preliminary model for the residual strength of 12-strand HMPE pendants coated with the new coating technology.

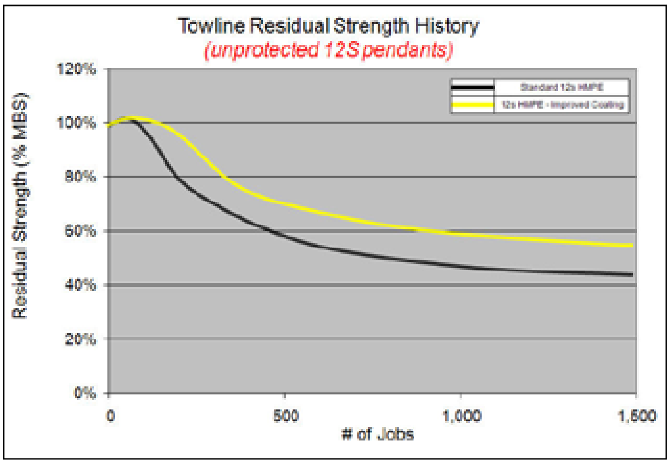

Figure 6: Residual strength model comparison.

By greatly reducing the degradation caused by internal abrasion (yarn-on-yarn and strand-on-strand), this new coating has allowed these towing pendants to operate at a higher safety factor by increasing their residual strength by as much as 15 per cent after approximately 400-800 jobs (over previously tested pendants on similar applications/vessels) This improvement allows not only increased operating safety, but also the shift in the curve shows that the line could remain in service for a longer period of time before reaching the same residual strength.

Figure 7(a) shows the internal condition of a typical 12-strand HMPE towing pendant after several months in service. Notice the wear or fuzzy appearance that has started on the yarn level, and compare it with the 12-strand pendant treated with the improved coating in *Figure 7(b)*. There is a significant reduction in yarn-on-yarn damage on the treated pendant.

Figure 7(a): Internal wear on a standard 12-strand pendant.

Figure 7(b): Reduced internal wear on a 12-strand pendant with improved coating.

IMPACT OF TWIST ON TOWLINE STRENGTH

While abrasion is the primary deterioration mechanism of towline strength, operators should have a high awareness of the negative effects that twisting synthetic towlines can have on strength and, therefore, safety. Figure 8 shows the results of scaled testing that represents the expected reduced strength for HMPE lines when twist is imparted in lines under tension.

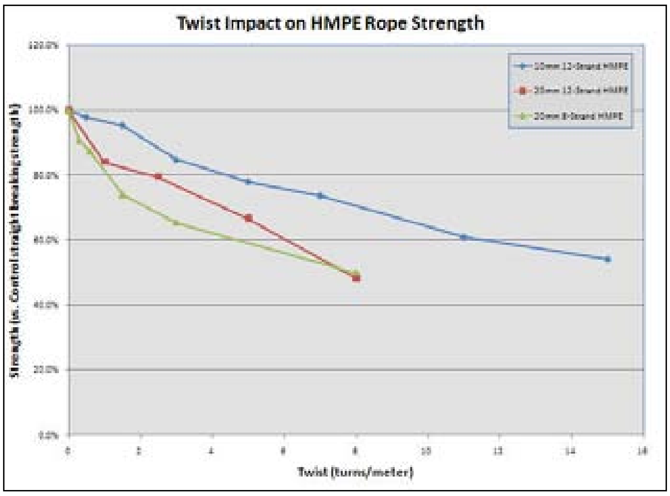

Figure 8: Twist impact on HMPE rope strength.

It should be noted that, while the strength reduction is significant (10–30 per cent for a potentially realistic amount of twist in a typical towline), it is not necessarily a predictive tool. The strength reduction caused by twist and abrasion are not strictly cumulative and a more extensive study would be required to determine the real-life strength reduction that could be expected with several different levels of twist and abrasion damage.

Figure 9 shows a pendant that has a moderate amount of twist (approximately two turns per metre) permanently introduced into it from operational influences. The lines in the photo show how the braid pattern has been twisted (strand crowns should run parallel with the axis of the rope). This issue can often be quite difficult to notice in the field, which makes it critical for crew members to be aware of the impact this can have so that preventive measures can be put in place to prevent permanent twist build-up. This can be accomplished by removing twist as lines are taken up after each job/service period.

Figure 9: Twist introduced in an HMPE pendant.

While the most important step that can be taken to prevent twist from becoming permanent is operator awareness, other mechanisms can be used to prevent twist from being induced by outside influences such as handling by crew members on the client vessels. One such method is shown in Figure 10. The tagline swivel used to attach the mainline to the messenger line limits the amount of twist transferred from the messenger line to the mainline, regardless of how the line is handled by crew members.

Figure 10: Tagline swivel.

DEVELOPING RETIREMENT GUIDELINES

Increasing safety by implementing objective inspection guidelines

Throughout the marine industry, there are several publications in the form of standards and guidelines that can act as useful reference points for tug operators to establish a programme for tracking a towline's condition and making safe decisions about how they use those lines. Some of the notable references are:

- Oil Companies International Marine Forum (OCIMF) *Mooring Equipment Guidelines* (MEG), Appendix D 3;
- *Fiber Rope Inspection and Retirement Criteria*, CI-2001-04 4; and
- *The Handbook of Fibre Rope Technology*, Chapter 9.5.

All of these publications go into some detail regarding the impact that several methods of damage can have on a rope's remaining strength and how that impact can be estimated in a non-destructive manner. Understanding these recommendations is an important step in the development of a customised inspection guideline. The images above in *Figures 3, 4, 6, 7* and *9* can be used as reference for inspection of HMPE ropes to supplement the images in any inspection guideline.

After establishing a safe retirement plan based on subjective visual inspections, a retirement programme should begin to quantify the typical strength-deterioration model. This process should be an iterative one that allows the operator to balance safety and cost-effectiveness by progressively determining how long lines can be expected to operate at a given safety factor. This type of process is conducted most efficiently and properly in close coordination with the rope manufacturer and/or third-party-testing facilities.

The final critical element to a successful, full, long-term inspection and retirement programme is the proper documentation of information by the vessel captain and crew. With the advent of modern winch technology, the opportunity exists to track and record line tension throughout the life of a given towline. If this option is not available, the proper information can still be easily documented.

An example of some of the basic information is listed in *Table 1 (see below)*. In order to accurately compare data as the process evolves, as well as limit the amount of subjective information required to qualify the data, it is important that such information is not lost in the process.

								Service		
Vessel Name	Line Size (Dia)	New Line MBS (kg)	Chafe Protection	Vessel BP (tonnes)	Typical Service	Winch Type	Vessel Drive-Type	Jobs	Hours	Months

Table 1: Towline history tracking log.

CONCLUSIONS

- While abrasion and twist are both significant threats to the life of any synthetic towline, their harmful impact can be reduced through the proper use of chafe gear and operational diligence;
- Product improvements can provide an added measure of safety in towing operations;
- Abrasion damage, both internal and external, can be reduced through the use of improved coating technologies;
- Knowledge of proper inspection techniques allows for increased safety by improving subjective decisions about a rope's condition;
- Formal, iterative residual strength determination and retirement programmes should be established to provide safer working conditions as well as increasing cost-effectiveness by extending the service life of the line;
- Users should work directly with rope manufacturers when possible to establish the appropriate inspection and retirement guidelines and methods.

REFERENCES

[1] *Abrasion and Fibre Fatigue in High Performance Synthetic Ropes for Ship Escort and Berthing*, T Crump, K Volpenhein, D Sherman and R Chou, ITS 2008: The 20th International Tug and Salvage Convention, Day 3, Paper No. 4 (May 2008).

[2] *Fiber Rope Inspection and Retirement Guides*, J Flory and HA McKenna, Proceedings of MTS/IEEE, Oceans08, Quebec City (2008).

[3] *Mooring Equipment Guidelines,* 3rd Edition, Oil Companies International Marine Forum, Witherby Seamanship International (2008).

[4] *Fiber Rope Inspection and Retirement Criteria* (2004), Cordage Institute CI 2001-04

[5] *Handbook of Fibre Rope Technology*, HA McKenna, JWS Hearle and N O'Hear, CRC Press (2004).