When Should a Towline Be Retired?

Chafe protection and twist and how to recognize their impact

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ABSTRACT

Over the past few years the Towing industry has invested in new and more effective Tug designs to enhance methods of Towing. What has become apparent is the connection between ship and tug, the tow line, is of primary importance in regards to operational safety. In recent years the industry has seen an expanding global acceptance of high-performance synthetic tow lines. This has created a need to better understand and improve synthetic tow line performance characteristics and retirement criteria. Following on from the paper given at ITS Singapore 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 will take a closer look at how these standards can best be implemented.

It has been documented that the abrasive and demanding environment that is inherent in towing applications is typically the most dominant strength reduction mechanism. In response to this there have been significant advances and product innovation aimed at protecting synthetic lines against abrasion. This paper will evaluate the comparative differences in residual strength and general line condition between lines returned from field service having been used with a range of different levels of protection. Also, this paper will raise 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;

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

Each of these issues will be 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.

MINIMIZING ABRASION DAMAGE

While synthetic ropes made from high modulus polyethylene (HMPE) have become common in towing application, there are still several methods that can be utilized to increase the value that tug operators may see from the use of such lines. To some, the obvious advantages of these towlines (light weight, flexibility, high strength, buoyancy, etc) aren’t always enough to eliminate the inherent concerns that exist when using a synthetic line in such a potentially abrasive and demanding environment.

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 potential product improvements thru 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 the tension member 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 localized 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 - Typical Pendant location during ship assist

Figure 1 shows a typical ship assist operation. As can be seen, a specific portion of the towing pendant will typically come into contact with the deck hardware on board the customer's vessel. This deck hardware is likely not ideal for use of synthetic ropes. In turn this is the most common location of failures – both in the field and during residual strength testing in the lab. 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 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 6,500 hp tractor tug. After approximately 1,300 assist jobs the line was retired and returned to the factory for testing and inspection. By visual inspection it is apparent the benefits that the chafe protection provide. Figure 3 shows the protected end of the line and Figure 4 shows the typical wear on the unprotected end of the line, both internal and external.

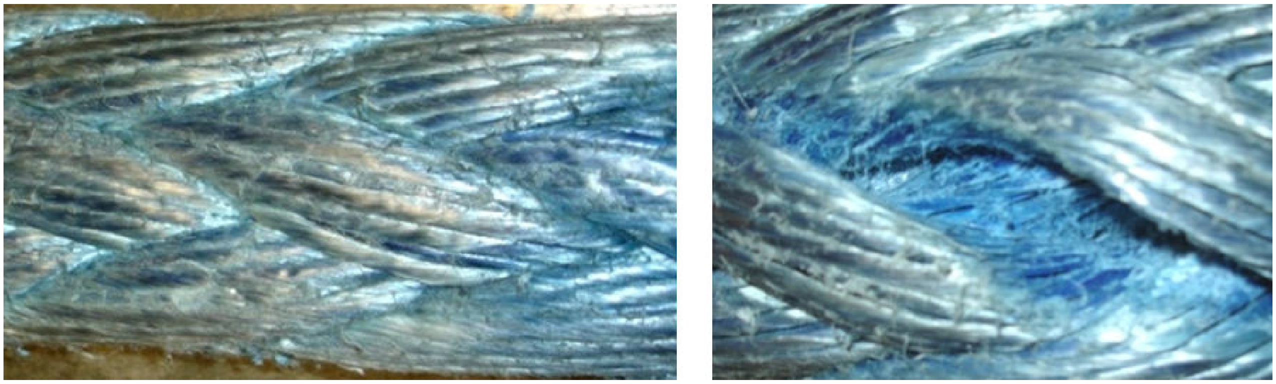

Figure 3 - Protected portion of pendant

Figure 4 - Unprotected portion of pendant

While the protected end of the pendant showed little sign of serious damage and had a predicted residual strength of 65-75%, when tested the pendant broke at a load of 51% of the new rope minimum breaking strength and broke in the most severely damaged area.

There are two significant concerns regarding the use of chafe gear to increase the safety and service life of synthetic towlines; First, recognition of what surfaces, in a vessels typical operations, will produce the most consistent and severe abrasion. Second, utilizing chafe gear that reliably protects those portions of the towline that will likely contact those surfaces on a consistent basis. In doing so, 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%.

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

Figure 5 - Fused yarns, should be inspected further

If the yarns and strands can be manipulated by hand and loosened to the fiber level, back to their original condition, the line has not suffered significant damage. However, if the yarns and strands have been permanently fused together this 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 increasing life expectancy of ropes in all towing applications. Recent efforts to directly combat the negative impact of abrasion have led to the development of an improved proprietary coating that has been trialed and proven in the field with very promising results.

The plot in Figure 5 shows a combination of two residual strength models for HMPE towing pendants. As reported at ITS 2008 in Singapore, the blue line is a representation of the predicted residual strength of a “standard” 12-strand HMPE towing pendant throughout its service life [1]. 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 (yarn-on-yarn and strand-on-strand) abrasion, 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% (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 6 shows the internal condition of a typical 12-strand HMPE towing pendant after several months in service. Notice the wear/fuzzing that has started on the yarn level. Comparing this with the 12-strand pendants with the improved coating there is a significant reduction in yarn-on-yarn damage as shown in Figure 7.

Figure 7 - Internal wear on standard 12-strand pendant

Figure 8 - Internal wear on 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 twisting synthetic towlines can have on strength, and therefore, safety. Figure 10 shows the results of scaled testing that represents the expected strength reduction for HMPE lines when twist is imparted in lines under tension.

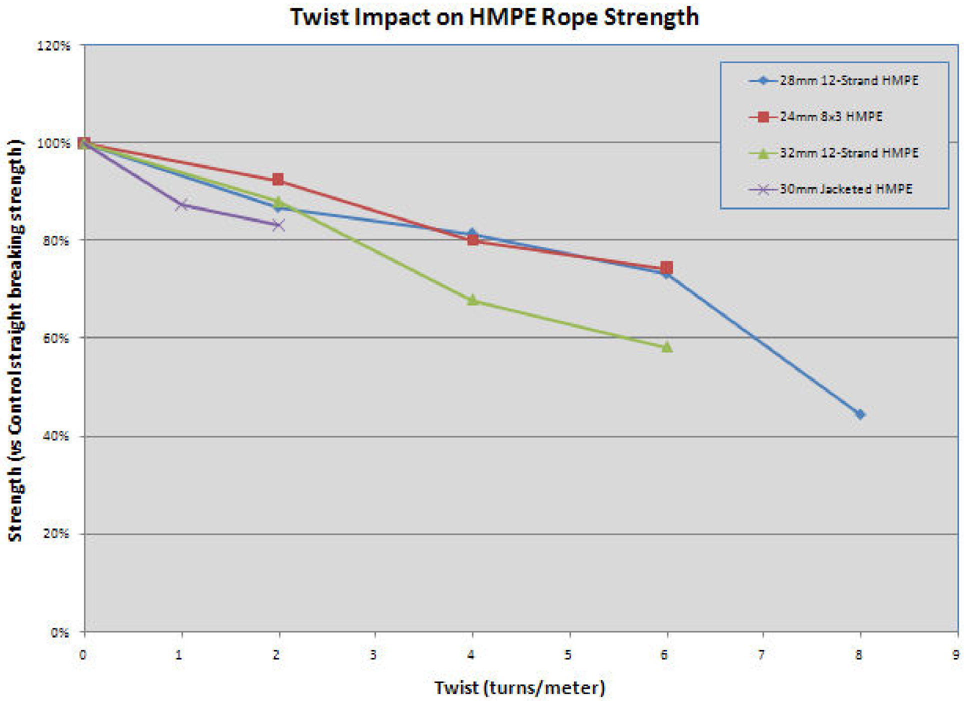

Figure 9 - Twist impact on HMPE rope strength.

It should be noted that while the strength reduction is significant (10–30% for a potentially realistic amount of twist in a typical towline) it isn't necessarily a predictive tool. The strength reduction caused by twist and abrasion are not strictly additive 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 permanently imparted 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 that crew members are aware of the impact it can have so that measures can be taken to prevent permanent twist build up. This can be accomplished by removing twist as lines are taken up after each job/service period.

Figure 10 - Twist imparted in 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 to 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 swivel used to attach the mainline to the messenger line limits the amount of twist that will transfer the from the messenger line into the mainline regardless of how the line is handled by crew members.

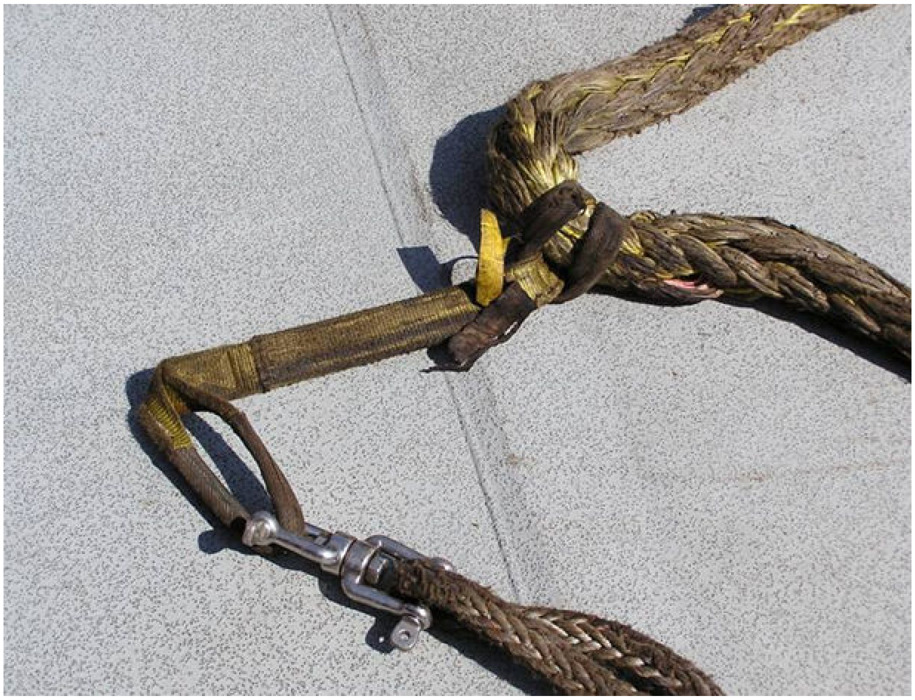

Figure 6 - Tagline swivel

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 good reference points for tug operators to establish a program for tracking a towline's condition and making safe decisions about how they use those lines. Some of the notable documentations are;

1. *OCIMF Mooring Equipment Guidelines (MEG), Appendix D*
2. *Fiber Rope Inspection and Retirement Criteria, CI-2001-04*
3. *The Handbook of Fibre Rope Technology, Chapter 9*

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 customized 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 program 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 most efficiently and properly conducted in close coordination with the rope manufacturer and/or third party testing facilities.

The final critical element to make a full long-term inspection and retirement program successful is the proper documentation of information by the vessel captain and crew. With the advent of modern winch technology there is the opportunity 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 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 – Theoretical 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 by 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 will allow for increased safety by improving subjective decisions about a rope's condition
- Formal, iterative residual strength and retirement programs should be established to provide safer working conditions as well as increase the cost effectiveness by increasing the service life of the line
- Users should work directly with rope manufactures when possible to establish the appropriate inspection and retirement guidelines and methods.

References

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

[2] Fiber Rope Inspection and Retirement Guides, Tension Technologies International, 2008

[3] Oil Companies International Marine Forum, *Mooring Equipment Guidelines*, 3rd Edition

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

[5] McCorkle, E., R. Chou, D. Stenvers, P. Smeets, M. Vlasblom, and E. Grootendorst. "Abrasion and residual strength of fiber tuglines." *ITS 2004: The 18th International Tug and Salvage Convention,* paper tw2, day 2 (May 2004).