Rope Selection, Procurement and Usage

Guidance produced by the British Tugowners Association

Acknowledgements & Disclaimer

This product has been produced by members of the British Tugowners Association, as a discrete part of the UK Chamber of Shipping.

Special thanks are extended to the three rope manufacturer Associate Members of the British Tugowners Association for their support, guidance and use of their materials in this document.

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Introduction & Purpose

It may be argued that the tow rope is the single most important piece of equipment in the industry. it provides the essential connection between the assisting and assisted vessel, enabling safe operations.

All too often when a tow rope parts or breaks, the assumed solution is that the rope was not large enough or did not have a high enough Minimum Breaking Load.

Whilst this may be correct in the occasional occurrence, this is not the right answer in the main. The importance of proper rope selection, handling, inspection, and retirement cannot be overstated.

Maximising the safety and service life of the rope begins with selecting the right one, managing its proper function through optimising its handling and the towing system, and retiring from use at the appropriate time.

Tow ropes have developed to become more than simply a line, it is more akin to a towing system. Selecting the right rope for each part of the towing system is not a one size fits all proposition. Each component should be considered independently, and how they relate together – pendant, mainline, and backer.

Overall, this guidance sets out to answer these simple questions:

"How does an operator purchase a rope that does the job required of it?"

"What does success look like for the procurement process?"

"What does an unsuccessful towing system look like?"

In answering these questions, the guidance provides information relating to various aspects of rope procurement, usage, and maintenance throughout its life cycle to give consistent and reliable service. The guidance will assist in the selection of an appropriate rope/towing system for operations and provide a framework of best practice in terms of rope management embracing handling, storage, maintenance, inspection, and retirement.

Measuring Real Value

Indirect Costs The importance of selecting the correct ropes and understanding the potential risks of failures is imperative to minimise indirect costs if an operator needs to replace ropes early.

The aim is to ensure that the most suitable tow rope is selected for the operation, therefore reducing the likelihood of a failure, and to reduce medium to long term cost by increasing service life.

- **Risk to crew safety:** both onboard the tug and towed vessel, fibres such as Polyesters and Polyamides have a high level of elongation / stretch so can recoil back with extreme force and due to the weight of these ropes they have the potential to cause damage or severe injury, modern fibres such as HMPE (Dyneema®) have minimum elongation but can still recoil or whip round under certain conditions. If the rope is damaged, in poor condition, or incorrectly selected so not suitable for the tug or operation then the likelihood of a rope parting will increase.
- **Repair and Maintenance costs to the rope:** Each time the rope is damaged or parts, it will cost money to put it right, from equipment, crew time to repair it or management time to arrange a contractor to repair the rope.
- **Repair and Maintenance costs to the tug:** If the tug is damaged by a recoiling rope or ends up in a propeller the costs can be considerable.
- **Tug down time:** If the rope requires, repairing, re-splicing, or changing the tug cannot work until the rope is ready to be used again. Depending on the operations set up it can take a number of hours to take off the old rope and land it ashore, then load and fit the new rope, this procedure will often require a number of hands to safely complete it. A tug without a tow rope is little use and does not earn any money.
- **Damage to company reputation and image:** Having to report that a tow rope has parted or that a tug is out of service can mean letting customers down and require investigations by Port Authorities.
- **Management and Administration time:** When a rope parts, reports should be written, questions are asked, orders for new ropes placed and arrangements made for disposal and delivery.
- **Environmental impact:** Every time a rope is replaced the old rope must be disposed of. Presently there is limited recycling potential so if the tow ropes service life can be increased then fewer ropes will require disposal during a tug's life.

Cost Per Tow

One method for calculating real value is to use cost per tow (CPT). Calculating cost per tow can act as an indicator tool for operators, and rope manufacturers to estimate the service life of a rope and assist in determining the best line for specific types of operation.

Cost per tow can be used for all parts of the towing system, not just the mainline.

It is important to note that cost per tow will not be consistent across vessels and should not be assumed.

Simple CPT Calculator

This can be calculated by dividing the original purchase price of the tow line by number of tows before the line was retired or failed.

CPT = Original Price / Number of jobs completed

For example, £40,000 / 2,000 jobs = £20 per towing operation.

Detailed CPT Calculator

The BTA has devised a more comprehensive and detailed cost per tow calculator which is included as **Annex B** for experimental use and is briefly illustrated below.

Base number of jobs per rope = 4,000

	A	B	A x B	C	D	C x D
Job Type	**Average Tonnes**	**Time (mins)**	**Multiplier**	**% rope life**	**No. of jobs per year**	**% rope life No. of jobs per year**
Standard job	70	20	1400	0.00025	70	0.0175
1st alternative	70	20	1400	0.00025	70	0.0175
2nd alternative	35	90	3150	0.0005625	225	0.1265625
3rd alternative	35	30	1050	0.0001875	225	0.0421875
Totals				**0.00125**	**590**	**0.20375**

This technique requires the following data points:

- Average tonnes pull during job
- Time used in minutes
- Number of jobs per year expected/historic
- Expected life cycle of the rope (eg 4,000)
- Expected cost of the rope (eg £50,000)

(CxD) / D	E	((CxD) / D) x E
Multiplier	**Rope Cost (£)**	**Cost per Job/Tow (£)**
0.00034534	50,000	17.27

Introduction

Often in the towage industry it is not the Master who directly purchases the tow rope for the tug. More commonplace is the procurement department to go out for tender from rope manufacturers on behalf of the tugs, subject to requirement criteria.

The specification of a tow rope for a vessel should be the culmination of a dialog between operator and vendor. With this dialog the rope vendor will have been able to appraise all the relevant aspects of a tugs expected work and specified a rope that is fit for purpose without overspecification.

The BTA has defined the following as information that should be provided to the procurement department so an informed discussion with the rope manufacturer regarding the best suitability when purchasing a new tow rope can be had.

The list starts from a first principles approach for operations which, for well-established operators or those with long standing relationships with rope manufacturers information may be considered overly simplistic or "obvious", this is intentional so that any preconceived ideas and historic habit is mitigated.

The tables which can also be found in **Annex C** should be completed by the Master or another competent person with the relevant knowledge.

Source: Image courtesy of John Bateson - Shetland Islands Council Towage.

a) Tug Vessel Considerations

Explanatory notes:

- The physical aspects of a tug constitute the foundation of any rope selection.
- Straightforward characteristics such as Bollard Pull, and Steering Force will place firm limits on selection.
- An objective appraisal of condition will help present a more holistic submission to potential vendors.

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Bollard Pull		Number in tonnes
Steering force		Number in tonnes
Propulsion		ASD, Voith Schneider, Rotor, Tractor, Conventional etc.
Drum Specification		Size of Drum (diameter & depth of cheek plates)
Winch Type		Rend & Recover, other etc.
Winch & Staple Location		Location of winch & staple relative to Tug. (fore/aft)
Tug Age		In years (Sub 5, 5-15, 15+)
Tug Condition		Qualitative view

b) Operational Considerations

Explanatory notes:

- Picking the right rope is about more than just the physical characteristics of the tug.
- It is important to provide potential vendors with information about the work the tug is expected to undertake.
- There are times when the precise nature of operations is uncertain, however the more information that can be provided will enable potential vendors to propose ropes and arrangements that are best suited to the operation without over specification.
- Specific operational circumstances can provide vendors greater detail for optimal selection, including:
    - What is the typical condition of the fairleads on assisted vessels?
        - Vessels with commonly badly corroded fairleads may lead operators to request protective sheaving or similar.
    - When working in confined areas, high freeboards on assisted vessels creates a steep angle between the fairlead and the tug pivot point, which can lead to large increases in weight on the tow line.

Source: Image courtesy of Felix Rowe, Fowey Harbour Commissioners.

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Nature of the tow		Stern, CLF, Bow/Bow, Escort, Barge, Push/pull, etc. Indicate all that apply
Static Load		For Escort towing, either Passive or Active. Quantitative in tonnes
Company Safety Factor		Quantitative ratio
Expected use of winch if/when escorting		Auto tension or 'on the brake' Indicate which applies (will be specific to operator/Class rules)
Line buoyancy		Sinking or Floating Line Desired
Expected types of assisted vessels		Cargo ships, naval ships, barges, rigs, plant, etc. Indicate all that apply
Expected freeboard of assisted vessels		High (10m+) Medium (5-10m) Low (sub 5m) Indicate all that apply
Expected complications on mooring decks of assisted vessels		Qualitative free text to include: • Known awkward arrangements • Average condition of fairleads on assisted vessels
Expected width of bitts on assisted vessels		Quantitative in metres. Note, some larger vessels bitts' are too large for the standard 2m eye.
Are lines expected to be connected to emergency towage bracket?		Indicate which is most likely to apply
Expected Safe Working Loads of bits and fairleads on assisted vessels		Quantitative in tonnes

c) Environmental Considerations

Explanatory notes:

As well as understanding the physical characteristics of the tug and the kind of work it will engage in, it is necessary to consider the environment it will work in. For example, a tug engaged in coastal work around the islands of Scotland will inevitably require different hardware to one that only ever works in a sheltered harbour.

There will be uncertainty over the precise environmental conditions a tug is expected to work in. Nevertheless, the more accurate picture that can be provided to a vendor the better the vendor will be equipped to recommend the correct ropes and arrangement without overspecification.

It may be that company procedures place limits on operating conditions. This information is relevant to the section of the correct equipment and HSEQ/Operations Department Operating Parameters should be referred to.

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Nature of the tow		Stern, CLF, Bow/Bow, Escort, Barge, Push/pull, etc. Indicate all that apply
Nature of waters during operation		E.g., river, harbour, sheltered, coastal, sea. Indicate all that apply.
Expected combined wave height		Quantitative height in metres
Expected wind speeds		Quantitative speed in kts or mph
Prevailing wind direction		
Expected tides/current affecting towage		Strength in kts or mph and direction
Operational limits		Do stop work orders exist above certain wind speeds?

Abnormalities and other specific information:

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Any other operational abnormalities		Free text qualitative (operation, environment, assisted vessels deck complications, expected hazards, criteria required by port, etc.)

Rope Strength

Rope tensile strength is one of the characteristics most utilised for selecting rope products. In general, it is important to match a rope's strength to the requirements of the application. Often requirements may be stipulated by regulatory and certification bodies or safety requirements.

While there is a tendency to select ropes with the highest tensile strength possible, care should be taken to assure other performance properties are not scarified, or weak points inadvertently introduced.

Working Loads & Safety Factor

Working loads are the loads that a rope is subjected to under expected or typical working conditions. For rope in good condition, with appropriate splices, and under normal service conditions, working loads are based on a percentage of the breaking strength of new and unused rope.

Working loads, often called **working load limits (WLL)** are calculated by dividing the rope **minimum breaking load (MBL)** by the required safety factor (sf)

WLL = MBL / sf

Safety Factor recommendations vary according to company safety practices and policies, being determined by regulatory standards, best practices, or safety and design criteria.

Operator Examples:

Svitzer set the strength (Minimum Breaking Load or MBL) of the towline is to be a minimum 2.5 times the Bollard-Pull, however it is recommended 3 times the Bollard-Pull (BP) or Maximum Achievable Towline Force (Escort notation tugs) of the tug, whichever is higher.

Boluda Towage use a Safety Factor of 3+ for their tugs up to 90t bollard pull, for their tugs with 95t bollad pull, the safety factor decreases to 2.9 due to rope availability limitations.

Purpose

Tow rope certificates vary considerably from manufacturer to manufacturer and between retailers and resellers. Such variety can lead to a lack of clarity and confusion of the rope purchased and not facilitate rope comparison.

The BTA membership in collaboration with tow rope manufacturers have comprised the following list of data variables which it expects to see on a tow rope certificate. Noting that individual manufacturers wish to retain stylistic control, the BTA suggests harmonisation of tow rope certificates rather than standardisation.

The BTA recommends purchasers request the below information be included on rope certification, detailed using the terminology and measures below.

Information expected for inclusion on a new tow rope certificate

#NUMBER	DATA VALUE	GUIDANCE
1	Product/Brand Name	May be different from the original manufactured product name, i.e. sold by a 3rd party (distributor, agent, fabricator) and renamed / rebranded – the issue then is that it may be difficult to establish the original data or specification of the rope.
2	Original Product Name	To differentiate it from the brand or trade name.
3	Fibre Material	Polyester, Polyamide, HMPE, UHMPE, etc. - Not trade or brand name Be aware that some manufacturers have been known to mix their fibres/materials.
4	Strength	Minimum Breaking Load (MBL) Measured in Metric Tonnes. ISO 2307 most common standard and measured un-spliced strength.
5	Size (diameter in mm)	- Should be the finished diameter of the rope under no tension (includes jacket). - ISO 2307 states diameter is measured under pre-tension (nominal value for open weave loose construction). - Includes jacket if part of the finished/ manufactured rope, but not additional anti-chafe protection added to parts or all of rope. - Regional variation in size measurement, inches in US, mm in Europe. Circumference also used in some parts globally.

#NUMBER	DATA VALUE	GUIDANCE
6	Construction	8 strand, 12 strand, jacketed, unjacketed etc.
7	Colour	Base & fleck
8	Length	Finish overall length of the rope in metres. (OAL)
9	Weight	1) Weight (kg per metre) of unjacketed finished product 2) Weight of the finished product (OAL including jacket/splices/eyes etc as sold)
10	Type of splice	Lankhorst A3 etc.
11	Spliced Strength	ISO 2037 stipulates 90% of MBL. Mean Break Force Mean Break Strength
12	General Description of Rope	Spliced Eyes included (Yes or No) Size of eyes Description of additional protection, hardware or anti-chafing
13	Buoyancy	Specific Gravity/Relative Density
14	Date of Manufacture	
15	Identification Number	Unique number specific to the finished rope. Not shared amongst ropes from the batch. Some pennants found to have same ID number which if distributed to different tugs, can lead to different tugs to have the same certificate number. Leads to loss of traceability. - Local ID number possible solution. Production batch to have same # which is printed on tracer inside rope, date of production, etc. Individual ropes/stretchers have individual and unique certificate # which routes back to original production batch.

Explanatory notes:

It should be recognised that the rope is more than the sum of the individually listed characteristics above.

Information which should be included accompanying a rope through its working life as changes occur. **A rope history log** will provide a significant part of this information if kept up to date.

To ensure appropriate and adequate space for annotations, the BTA recommends the inclusion of a table on the rear of the certificate for such information and signatures.

Rope manufacturers, suppliers and Classification Societies are increasingly providing rope certificates in digital format with the ability to note annotations. However, for the purpose of safety and security, information provided on original certificate should be 'protected/locked' by the supplier to prevent amendments to the original characteristics. Annotations should only be allowed to add notes during the life of the rope, and not amend or delete original information or earlier annotations.

Rope Repackaging & Reselling

There are large numbers of repacked ropes available in the industry to which operator and procurement personnel should be aware. Ropes of the same size and MBL can have vastly differing characteristics. It's important to understand these characteristics. Purchasers are strongly recommended to ask for the original certificate with an original trade name.

Recertified and Reissued Certificates

# NUMBER	DATA VALUE	GUIDANCE
1	Annotations	Good practice for additional information to be included as annotations during the ropes service. Each entry should be signed and dated. Examples include: i) Date brought into service. ii) Tugs name – if rope moved to new vessel iii) Position in use (Port/Starboard) (FWD/STN) iv) Rope damaged, repaired, re-spliced. a. If re-spliced new length should be noted v) Relocated or Transferred. a. Moved to different winch. b. Put in stores as spare vi) Restrictions (Limit of X no of jobs, no longer to be used for escort etc.)
2	Re-issuing of certificates	Replacement certificates, these are allowed as e-copies and are dependent on the individual manufacturer/rigger. Charge often levelled for service and marked "COPY"

An example Rope Certificate with harmonised information

A Strong Rope Company Ltd.

Manufacturer and purveyor of quality ropes since 1999

We hereby certify that we have delivered:

Date: 18 February 2021
To: UK Towage Co., Southampton, SO31 1DU, UK
Purchase Order Number: 09758101

# No.	Data Value	
1	Product/Brand Name	Strong Rope 3
2	Original Product Name	Dyneema® SK75
3	Fibre Material	HMPE
4	Strength (MBL)	130 metric tonnes (unspliced)
5	Size (diameter in mm)	40mm
6	Construction	12 strand braided
7	Colour	White & Red
8	Length	80m LOA
9	Weight	1) 2.1 kg per meter 2) 180kg
10	Type of splice	Eye
11	Spliced Strength	117 metric tonnes
12	General Description of Rope	1.8m protected eye
13	Buoyancy	0.98 (floating)
14	Date of Manufacture	18/12/2020
15	Identification Number	#72346239

Signed by:

XXXXXXX
18 February 2021

An example Rope Certificate with harmonised information

Record of Alterations and Annotations

Date	Alternation Carried Out	Signature
25/3/2021	4 metres cropped at drum end and respliced, replaced back on drum of ASD Heave	*Marcus Smith*

Rope Traceability and Records

Record keeping is essential for the safe use of mooring and towing ropes. It is not uncommon for crews to move between vessels and it is very likely that at some point a Master will be asked to perform a tow using a rope they are not familiar with.

When this occurs, it is necessary for the Master to understand the life of that rope, informing their understanding when making their inspections. This information should be readily available and easily linked to the rope it describes. There are many methodologies for maintaining this information. Some operators mark their certificates, some keep an online log, some maintain a rope register. BTA member Serco's use of a rope register is detailed as a case study overleaf.

As well as keeping readily accessible records of a ropes life it is necessary to be able to easily link those records to the specific rope they refer to. Keeping track of the colourings of the rope may not be enough.

Rigid identification tags can sometimes be found in use. These bring with them concerns of damage to the rope should they become caught between the rope and some part of the assisted vessel or tug. They are also highly susceptible to being damaged themselves and thus becoming lost.

Some manufacturers' ropes carry a unique Product Information Code (PIC), which is printed on a tape inside the rope and on the protective barrier in the eye. It corresponds with the factory certificate number for each rope, providing an effective way of managing rope use and maintenance.

More recently Radio Frequency Identification (RFID) tags have entered service with some manufacturers. These eliminate the hazards of rigid id tags and can be embedded in the rope. However specialised equipment is required to read these tags that may not be readily available onboard.

Whichever method of identifying ropes is put into practice, the ropes in use, and in storage, should be clearly identifiable with their characteristics and life easily traceable.

Member Case Study

Serco's Rope Register and Maintenance Regime

When required by the tug, a Stores Order is raised by the vessel's Master and sent to the procurement department to obtain quotes. The Stores Order contains specification of the tug, previous towlines, type of work and operational characteristics.

Following consultation with the Tug Master, ropes are ordered and delivered to the port with accompanying certification.

Ropes are delivered to the respective vessel with certification and either utilised immediately or stored in the hold. The original certificate remains on board the vessel with the rope, whilst the Marine Superintendent keeps an electronic copy for record keeping and as a back-up.

When the rope is required on the vessel, it is laid onto the designated drum under tension.

Ropes are used as required ensuring they sit correctly on the drum on completion of moves ensuring there are no buries.

Usage is annotated on a sheet after every move and aggregated at month's end for audit purposes.

As the Serco tugs primarily move naval vessels which are generally of light tonnage the wear on the ropes tend to be relatively minimal. As a rule, Serco typically look to retire a rope at approximately 2,000 moves unless issues are found during regular inspections.

Any renewal of splices is conducted by approved riggers, and annotations are the made on the certification upon completion of the splice.

Maintenance routine for the ropes have been entered into the planned maintenance management system which requires ship crew inspection every six months. This requires complete removal from drum with the crew inspecting the rope for any defects/damage by opening the strands to check for internal damage and by flexing the ropes to remove any tension.

Serco also endeavours to get periodic inspections by the Rope Supplier to give further assurance the ropes remain fit for purpose.

serco

OPS 411.1 Rope Register Issue 2. August 2017

Complete In Full For All New Ropes inc. Towlines & When Applicable Changes Made		
Vessel	SD BOUNTIFUL	
Base	PORTSMOUTH	
Rope Details		**Comments**
Where Rope Used	FWD WINCH	
Supplier	Rigging Ltd	
Rope Type	DYNEEMA	
Construction	12 X 1 STRAND BRAIDED	
Diameter	40 MM	
Length	40 M	
MBL	130T	
Certificate No.	ORDER NO XXXXX	
Date in service	FROM BUILD 2009	
Date End for Ended		
Date 1st Crop & # jobs	1/05/2018 AT 1200 JOBS	12 M CROPPED fr DRUM END
Date 2nd Crop # jobs		
Date Taken Out of Service		
No. of Jobs (Towlines only)	1312 as of Oct 2019	Record of jobs done for each update in the rope Details Section
Destructive Load Test Result		If applicable

Email this register at each update in the Rope Details section to your Operations Team

Ref: 411.1
Version: 2.0.0
Issue Date: August 2017

Serco Internal

Preparations

New ropes are generally supplied to the vessel either on a reel or as a coil. It is imperative that ropes are spooled on the drum of a winch without any twist in the rope. A twist in the rope, in combination with a high load on the rope (once put to work), may lead to reduced service life.

The coil delivery should be uncoiled and laid out flat on a debris free surface to avoid incorporating foreign objects in the outer surface. A drum delivery should be used if the vessel has the capability of supporting and allowing the drum to turn whilst winding onto the intended winch.

On the winch

Winching the rope on to the drum should be done under a certain back tension. The rope should be secured to the drum face plate either using a weak lashing or compression plate before running it onto the drum. Each turn on the drum forms a single layer with no overlaps before a second layer is started.

Appropriate back tension can be reached by first running the rope in a figure of eight on two bollards, before it goes onto the drum. Once loaded as above the eye should be put round a secure shore bollard and the rope run off the winch to the start of the last layer. The vessel should then winch the vessel towards the bollard at a low rate, building the layers back using the weight of the vessel to incorporate stretch and tension as it is reloaded prior to first use.

This is advisable to avoid loose or slack turns and the possibility of burying the lead off the drum below its layer and reducing compression and fibre damage that may result.

Smooth path for the rope

Source: Image courtesy of Samson Ropes ©

Prior to loading any new line, time should be allowed to remove the redundant one from the drum and inspect the structure that becomes exposed. Remedial action may be required in the form of light flattening / grinding of any rough or sharp surfaces of the drum, rust removal and groove flattening from slippage of the rope on the drum.

If the towing lead has not been in regular use this may require polishing. When switching from wire to rope allow an extended period to rectify grooves and rough surfaces cut into leads from the wire. Finally inspect the figure of eight bollard intended for initial loading for the running surface and flatten also.

Conventional Splicing

At the end of a rope, an eye can be formed by turning the rope back onto itself and splicing the rope back into the rope itself. This is an old technique, well accepted throughout the world. Many people are still able to make a splice into a simple laid rope. Fewer people nowadays are familiar with the eight or twelve strand plaited constructions. Only a few have the skills to make a good splice in parallel laid cores with an over braided jacket.

The splicing technique involves tucking strands back into the construction several times. No adhesive or other means of holding the strands in place are applied. The splice will hold if done properly. But the holding power of the splice depends on the material (coefficient of friction) and the construction of the rope.

In the conventional splice, one should reckon with a 10% loss of strength in the Minimum Breaking Load (MBL) of the rope (in accordance with ISO 2307). Despite careful splicing, the strands, and thus the fibres, are displaced throughout the splice area. At the end of the splice, the strands will return to their normal position. However, this transition point will be the weakest point in the rope. If a rope is pulled to destruction in a straight line, it should break at this point.

Manufacturers recommend splicing as the preferred rope termination method. Knots can decrease a rope's strength by as much as 60%.

Eye Splices

The standard eye splice cannot be pulled out under tension. However, some splice methods can be pulled out by hand when the line is in a relaxed state. To prevent such tampering, it is recommended that lock stitching be applied to the throat of the splice.

Lock stitching may also prove advantageous on some splices to prevent no-load opening due to mishandling.

Knots

Knots reduce rope strength; they are also a convenient way to terminate a rope for attachment to other hardware/equipment. The strength loss is a result of the tight bends that occur in the knot. It is vital that the reduction in strength when using knots is considered when determining the size and strength of a rope to be used.

Connections

If ropes need **to be connected**, several options are available

A **special link** can be used, but this has the disadvantage of being a heavy metal unit in the rope, which makes rope handling more difficult.

Source: Image courtesy of Lankhorst Ropes © .

A **soft shackle** can be used that has a matched MBL to the two joined ropes, this is a light option but needs to be fitted on protected eyes to minimise chance of cutting into the joined ropes due to smaller diameter.

Source: images courtesy of Lankhorst Ropes ©.

A **spectacle splice** can be made, basically splicing one eye through another eye. This is a good connection, but any replacement ropes need to be spliced on board the vessel. Types of splice do vary depending on the rope design / manufacture.

Source: Image courtesy of Samson Ropes ©

A **cow hitch** can be considered if one length is short and easy to handle like a pennant. The cow hitch in practice can be difficult to get the knot out. A soft round sling tied on the top of each eye can help to separate them.

Source: Image courtesy of Samson Ropes ©

Rope Safety

In any application, persons should be warned against the serious dangers of standing near a rope under tension. Should the rope part, it may recoil with considerable force and speed. All rope handling should be done in accordance with the **Code of Safe Working Practices, in particular Section 26.5 Towing.**

The maritime industry has experienced several serious accidents and near misses with tugs' tow ropes and associated equipment. Even an experienced tug crew can be caught-out during towing as it is not uncommon for a tow rope to suddenly become taut, surge or jump without warning. A messenger line also has the potential to cause serious injury when under tension.

A clear deck policy should be enforced. Once it has been confirmed that the rope has been secured to the assisted vessel, the crewmember is to vacate the deck prior to weight being taken on the tow. The crewmember should report to the bridge when they are inside the accommodation and external doors are secure.

Tug crews should be aware that at any time during the operation, from making fast to letting go, ropes should be treated with extreme caution.

Snap Back

At any time when a tow rope or messenger line is under tension there is potential for the rope to fail. Rope failure may occur for various reasons, should it occur the rope will not necessarily travel in a straight line and the energy it recoils with may be unpredictable, this is called snap-back.

Snap-back zones on vessels are not always effective, can provide false sense of security and should be treated with distinct caution.

If the tow rope's fibres have elongation (stretch), such as Nylon or Polyester, then the risk of hazardous recoil is far greater. These fibres are typically heavier, so the combination of the increased velocity and weight can inflict considerable damage on a tug and its crew.

Modern fibres, such has HMPE/Dyneema have very limited stretch and are lightweight, however under certain conditions such rope still have the potential to snap back and cause damage or injury.

If HMPE/Dyneema ropes are connected to a Nylon or Polyester sections which have stretch characteristics, the risk of it snap back increases.

To help prevent ropes failing and reducing the risk of them recoiling, ropes and equipment used for towing should be of the correct size and strength, adequately maintained and inspected before use.

Lesson	**A clear deck policy should be operated, and crew must never stand near a rope under tension**

The use of rope for any purpose subjects it to varying levels and modes of tension, bending, friction, and mechanical damage; as well as a wide range of environmental variables such as temperature, chemical exposure etc.

Regardless of use, as fibre rope is exposed to particular conditions it will begin to suffer some level of degradation. Maximising rope performance and safety involves selecting the correct rope, using optimal handling during its use, and retiring it from service before it creates a dangerous situation.

The cost of replacing a rope is extremely small when compared to the physical damage or injury to personnel a worn-out rope can cause.

Factors Affecting Rope Usage

1) Elongation (Elasticity)

The elastic property of a rope is sometimes undervalued during the selection of a towing line configuration. The elastic elongation properties of ropes on board is extremely important to the durability of the towing line as well as vessel equipment e.g. winches.

If a tug is connected to a large cargo vessel, up to 10 times its own length, wind and waves/ currents will induce different movements in the two vessels. Consequently, the changing distance between the two vessels is absorbed by the elasticity of the connecting line. Some modern rend and recover winches also add mechanical elasticity into the towing system by compensating for movement and loads.

Elongation comes in three different forms:

I. Construction/structural elongation

During rope manufacture, the tension on the rope is only a few percent of the Minimum Breaking Load (MBL). There remains 'air' between the yarns and strands. During the first few times a rope is put to work (stretched), 'air' is squeezed out and the yarns and strands set themselves. This is called structural elongation. The rope has 'bedded in'.

II. Elastic elongation

Elastic elongation is the flexibility of the yarns and this absorbs the energy put into the rope. Once the rope has been released, the rope will come back to its original length.

III. Plastic elongation

Plastic elongation is a hazardous phenomenon. When yarns are over-loaded (the elongation is more than the yarns can withstand), the structure of the yarns will change. Deformation occurs inside the yarns. As a result, the strength of the yarns will drop instantly, and the rope will not return to its original length. Over stretching can occur either throughout a rope or in a single place. For example, at a sharp bend in a fairlead, bollard or other devices.

The overstretched rope (or the part of the rope overstretched) must be rejected! Plastic elongation may be identified by a reduction in the rope diameter at this point.

The table below shows the elongation characteristics and specific gravities of commonly used fibre types:

GENERIC FIBRE TYPE	NYLON	POLYESTER	POLYPROPYLENE	HMPE
Elongation (1)	15 – 28%	12 – 18%	18 – 22%	3.6%
Specific Gravity (2)	1.14	1.38	0.91	0.98

1. Elongation refers to the percent of fibre elongation at break.
2. Specific gravity is the mass density (g/cm3). Water has a specific gravity of 1. Specific gravity below 1 indicates floating line.

2) Temperature

High and low temperatures can influence rope performance. Ambient temperatures conditions should be well understood and within design limits.

Generally, extremely cold temperatures will not have a negative impact on rope performance. However, moisture and subsequent freezing will impact a rope's handling and flexibility with no known negative long-term impact on rope life. High temperatures can reduce a rope's strength and fatigue resistance. If temperatures exceed limits, special care should be taken to ensure the rope is fit-for-purpose.

High temperatures can also be more localised phenomenon as a result of the rope moving through equipment in the system, where heat is generated by friction. In order to minimise this heat generation, ropes with appropriate coefficient of friction (i.e. grip) should be based on the needs of the system/application.

High temperatures can be generated when checking rope on hardware or running them over stuck or non-rolling sheaves or rollers. Each rope's construction and fibre type will yield a different coefficient of friction in a new or used state. It is important to understand the operation demand and take into account the size of rope, construction and fibre type to minimise localised heat build up due to rope/hardware friction.

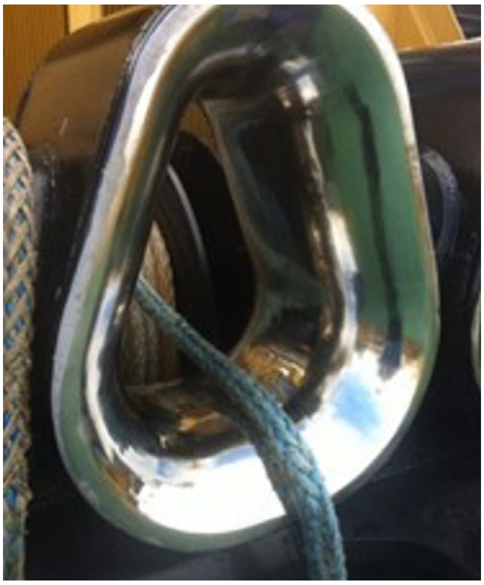
Lesson	**Never let ropes under tension rub together or move relative to one another. With enough heat build-up, the fibres can melt, causing the rope to fail unexpectedly; similar to being cut with a knife**

3) Strength Degradation from Sunlight (UV)

Prolonged exposure of synthetic ropes to ultraviolet (UV) radiation from sunlight and other sources may cause varying degrees of strength degradation. Many manufacturers offer products with coatings, fibres and other attributes to combat such effects, however the best way to avoid UV degradation is to limit exposure.

4) Sharp Cutting Edges and Abrasive Surfaces

Source: images courtesy of Lankhorst Ropes ©.



Tow lines should not be exposed to sharp edges and surfaces such as steel-wire gouge marks or metal burrs (on equipment such as winch drums, sheaves, shackles, thimbles, wire slings etc). When replacing winch lines, care must be taken to ensure the rope is not coming into contact with hardware that has been scored or chewed by previously used wire lines.

When replacing steel-wire rope, in most cases it will be necessary to repair surface conditions of sheaves, shackles, thimbles, and other equipment that may contact the rope. Other surfaces should be carefully examined and dressed as necessary.

The surface condition of the fairleads and deck fittings of assisted vessels can have a significant impact on towline and its lifespan. Bad corrosion or abrasive surfaces will degrade the towline and protective sheaving can be considered.

5) Compression

Compressing the rope will damage the yarns, causing a weak point in the rope. Compression is caused by pressure on the rope from the side. For example, a fork lift truck running over the rope on the quay, a cross point of the two ropes (or the same rope), when the rope makes a short bend over the railing of the vessel and in a fairlead or rollers that are too small in combination with a high load on the rope. On a low D/d ratio (see Glossary), the inside yarns are squeezed, and the outside yarns are over stretched.

6) Dynamic loading

Mooring ropes and towing ropes are subject to dynamic loading - an ever-changing load on the rope due to movement of the vessel. The maximum loading should always stay below the designed maximum which, as a rule of thumb, should never exceed the 50% of the Minimum Breaking Load of the rope. Dynamic loading will cause fatigue in the yarns that will eventually result in loss of strength. This is impossible to detect from outside the rope.

Insight into the fatigue performance of ropes may be provided by the Thousand Cycle Load Level (TCLL) value – an accelerated fatigue testing method developed by the Oil Companies International Marine Forum (OCIMF). TCLL expresses the maximum percentage of the nominal breaking strength that a rope can be cycle loaded 1,000 times, tested under strict conditions. Put simply, the TCLL value expresses the rope's resistance to tension-tension fatigue. The higher the TCLL value, the greater the resistance to high loads or tension-tension fatigue.

Operators should be aware that the TCLL value is simply an indicator and should be caveated as the test is done under strict test conditions and not necessarily representative of the real world use. This value should not be relied upon to determine the life left in a rope.

7) Glossy or Glazed Areas

Glossy or glazed areas are signs of heat damage with more strength loss than the amount of melted fibre indicates. Fibres adjacent to the melted areas probably damaged from excessive heat even though they appear normal. It is reasonable to assume that the melted fibre has damaged an equal amount of adjacent un-melted fibre.

8) Discoloration

With use, all ropes get dirty. Look out for areas of discoloration that could be caused by chemical contamination. Determine the cause of the discoloration and replace the rope if brittle or stiff.

9) Inconsistent Diameter

Inspect for flat areas, bumps or lumps. This can indicate core or internal damage from overloading or shock loads and is usually sufficient reason to replace the rope.

10) Inconsistent Texture

Inconsistent texture or stiff area can indicate excessive dirt or grit embedded in the rope or shock load damage and is usually reason to replace the rope.

11) Fatigue

Fatigue occurs when a material is subjected to repeated loading and unloading. A new synthetic rope has a specific Minimum Breaking Load (MBL). When the ropes are first put to use, they tend to increase in strength a little. This is due to elongation during a mooring or a pull, which can be compared to a stretching process. The increase is not substantial.

Once the rope has reached its full strength, it will work at this level. In time the yarns will gradually start losing their strength, due to tension-tension fatigue. The ABF (actual breaking force) of the rope will decline and, eventually, the rope will break under a 'normal' load.

12) End for Ending

Most manufacturers recommend that every line should be rotated (also called end-for-ending) on a periodic basis. This will vary high stress and wear points and extend useful life. Operators will have their policy on 'end-for-ending' which will be highly dependent upon the nature of service, frequency or use, ability to perform the end-for-end process, and other factors. Regardless of end-for-end timing, a visual inspection should also be performed during the rope re-installation.

Maintenance and rope tests for the duration of the lifespan of a standard tow rope

The average lifespan of a main tow rope is estimated to be approximately 2,000 jobs per operating length. This can feasibly be extended to 4,000 jobs, if the practice of end-for-ending is used. Such a practice is dependent on each company's tow line profile.

If the rope length is less than 150m and does not utilise a grommet or stretcher this may not be a practical option.

If however, the main line is used in conjunction with a grommet or stretcher, or both, then it can often last 4,000 or more jobs with the bulk of wear and corresponding damage failures predominately being experienced in the latter 2 components of stretcher / grommet.

Residual Strength Test

It is a good idea for residual strength tests to be conducted. Maintenance of the rope comes down to correct usage and storage and ensuring that all equipment/hardware the rope encounters is well maintained.

A good practice when end for ending the main line is to cut the spliced eye off the worked section at an approximate length 7.5m, for submission to the manufacturer for destructive testing. If this is performed a notation should be made to the certificate for the rope in use, stating the reduction in overall length.

The manufacturer will then complete a visual inspection of the sample and fit the sample to a test rig to test the residual strength left in the 'worked section' of the tow line. An example of the rig and end point state is shown below.

Before Pull to Breaking Force

After Testing

Source: images courtesy of Lankhorst Ropes ©.

Final Residual Strength Test

The next test to be considered is performed after replacing a tow rope in line with that company's operating guide that governs the replacement of a line.

This test is commonly known as a 'Final Residual Strength' test. The procedure is like the residual strength test, but a visual inspection is cursory. A key figure on this test will be the Actual Breaking Strain.

Knowing this figure for the retired rope along with number of jobs, operating history, repairs, and any previous residual strength test will be key to technical and operational departments. It can then be used for assessing the validity of the current practice that governs the replacement of their tow lines under there guidelines.

The un-planned residual strength test is as a result of a failure in service and any corresponding investigation.

In this case it is common for either the complete line to be tested / inspected or as a minimum a substantial section incorporating any failed area within the rope. In this case a test sling preparation will be used and tested to break load.

The manufacturer will then produce a report with results of the break test, visual inspection, interpretation guideline of their report and supporting technical information and experiences.

Example of Residual Test Report

Test report(s) must show relationship with the specific sample tested. The location of the failure must be determined. Based on a proper visual inspection the main deterioration mode or failure mode in case of an investigation may be determined.

Typical failure zones of residual strength test slings:

(pink)	**Apex of Eye**	• damaged apex of eye due to original connection method used (cow-hitch/ shackle etc.) • D/d impact
(orange)	**Base of Splice**	• unbalanced splice • included angle eye too large (eye length/ test bed pin diameter combination to be checked)
(blue)	**Splice**	• unbalanced splice • poor rope condition used to form the splice
(purple)	**End of Splice**	• typical failure area in a used fibre rope test sling
(green)	**Clear Rope**	• between the splices is the ideal failure area indicating perfectly balanced splices not affecting the result.

Source: Lankhorst Ropes Inspection and Retirement guide

Finally, the tests above can be applied to a grommet (continual loop) and a stretcher in a similar manner, however the availability to 'end for end' is not practical for these parts of a tow line make up.

A good example of line management with a continual loop grommet is to rotate the working section that is used on the ship bollards (approximately 1m) every 100 jobs. Therefore, with a 20m Grommet a 10m length loop would give you a working time, utilising a commonly used level of 2000 jobs before replacement.

Ropes across mooring and towing systems are continually evolving and improving in safety standards and new developments and solutions will periodically enter the industry.

Inspection and Retirement Checklist

One frequently asked question is, **"When should I retire my rope?"**, the most obvious answer is **"before it breaks".**

Any rope that has been in use for any period will show normal wear and tear. Some characteristics of the used rope will not reduce strength while others will. Below are defined the normal conditions that should be inspected on a regular basis. Manufacturers issue their own guidance, inspection and retirement regimes which should be referenced and adhered to in collaboration with this.

If upon inspection any of below types of damage are found, one should consider the following before deciding to repair or retire the rope:

- The length of the rope
- The time it has been in service
- The type of work it does
- Where the damage is
- The extent of the damage

In general, it is recommended to:

• Repair the rope if the observed damage is in localised areas

• Retire the rope if the damage is over extended areas

• Inspect for pulled strands

• Inspect for internal abrasion

• Compare surface yarns with internal yarns.

Types of Damage (images courtesy of Samson Ropes©)

1) Pulled Strand

ACTION: Not Permanent – Repair

What	• Strand pulled away from the rest of the rope • Is not cut or otherwise damaged
Cause	• Snagging on equipment or surfaces
Corrective Action	• Work back into the rope • Check for areas where snagging may occur and remedy where possible

2) Compression

ACTION: Not Permanent – Repair

What	• Visible sheen • Stiffness reduced by flexing the rope • Not to be confused with melting • Often seen on winch drums
Cause	• Fibre moulding itself to the contact surface under the radial load
Corrective Action	• Flex the rope to remove compression

3) Melted or Glazed Fibre

ACTION: Repair or Retire

What	• Fused fibres • Visibly charred and melted fibres, yarns, and/or strands • Extreme stiffness • Unchanged by flexing
Cause	• Exposure to excessive heat, shock load, or sustained high load
Corrective Action	• If possible, remove affected section and re-splice with a standard end-for-end splice. If re-splicing not possible, retire the rope.

4) Cut Strands

ACTION: Repair or Retire

What	• 12-strands: two or more cut strands in proximity • 8-strands/3-strands: One or more cut strands	
Cause	• Abrasion • Shap edges and surfaces	
Corrective Action	• If possible, remove affected section and re-splice with a standard end-for-end splice. If re-splicing not possible, retire the rope. • Check for areas where snagging may occur and remedy where possible	

5) Discoloration

ACTION: Repair or Retire

What	• Fused fibres • Brittle fibres • Stiffness
Cause	• Chemical contamination
Corrective Action	• If possible, remove affected section and re-splice with a standard end-for-end splice. If re-splicing not possible, retire the rope.

6) Inconsistent Diameter

ACTION: Repair or Retire

What	• Flat areas • Lumps and bumps
Cause	• Broken internal strands • Shock loading
Corrective Action	• If possible, remove affected section and re-splice with a standard end-for-end splice. If re-splicing not possible, retire the rope.

7) Abrasion

ACTION: Repair or Retire

What	• Broken filaments and yarns
Cause	• Abrasion • Sharp edges and surfaces • Broken internal strands
Corrective Action	• Consult abrasion images and rate internal/ external abrasion level of rope. • Evaluate rope on its most damaged section. - Minimal strength loss (continue use) - Significant strength loss (consult manufacturer) - Severe strength loss (retire rope) - Check for areas where snagging may occur and remedy where possible

Understanding Abrasion

There are two types of abrasion.

1) Internal Abrasion: caused by the relative movement of the internal and external yarns

2) External Abrasion: caused by contact with external surfaces

An unprotected rope moving over a rough surface, such as a poorly maintained chock can be subjected to both. Upon inspection, it is easy to see that the external strands are abraded by a rough surface: often, fibres can be left behind on the surface that caused the abrasion, and the surface of the rope readily shows abraded yarns.

The same rough surfaces can also cause internal abrasion due to the movement of the internal strands relative to each other. When the rope's surface strands pass over rough surfaces, they are slowed relative to the strands next to them, causing friction. Heat is created from friction – and heat is one of the greatest threats to synthetic ropes.

As a general rule for braided rope, when there is 25% or more wear from abrasion, or the fibre is broken or worn away, the rope should be retired from service. For double braided ropes, 50% wear on the cover is the retirement point, and with 3-strand ropes, 10% or more wear is accepted as the retirement point.

Source: image courtesy of Samson Ropes ©.

Rope Recycling and Disposal

The majority of tow ropes will be manufactured from some form of plastic. Marine plastic is a significant threat to life in the ocean and the whole planet. The shipping and maritime industries have a responsibility to be proactive in reducing environmental footprint.

The UK Chamber of Shipping and British Tugowners Association have a goal of ZERO pollution from ships to sea from plastic and are committed to continuously minimising the generation of shipborne garbage. The industry is and must remain vigilant to the significant threat that single use plastic poses.

The safe disposal of ropes in the appropriate Port Reception Facilities at ports is imperative. Under no circumstances should ropes be disposed of at sea, as this would be an illegal discharge in contravention of MARPOL.

Where possible recycling of rope into other polymer-based products should be sought and encouraged. It is recognised across the shipping industry that much more research and development of meaningful solutions for unusable ropes needs to be done. Some manufacturers provide service whereby ropes returned for testing and deemed unusable are repurposed and recycled.

Source: image courtesy of Boluda Crew of RT Ambition.

Annex A: Glossary

Abrasion, External
From the outside where the rope has been in contact with other surfaces. When this happened under high tension, the abrasion can severely damage part of the rope. If yarns or even strands have been broken or worn away, an equal part of the strength of the rope has been lost.

Abrasion, Internal
Occurs when the ropes move through a fairlead, bollard, sheave of when the ropes are cyclically tensioned. The repositioning of the rope in the curved area makes the strands move against each other.

Abrasion Resistance
The ability of a fibre or rope tow withstand wear and rupture doe to motion against other fibres of rope components (internal abrasion) or a contact surface (external abrasion).

Chemical resistance
The chemical resistance depends on the basic material of the rope and the chemicals it is contaminated with. All synthetic materials are sensitive to some extent to several chemicals. Caution is therefore recommended at all times. Normal detergents will not affect the quality of the rope.

Critical Temperature
The temperature at which the properties of the fibre begin to deteriorate.

Design Factor
A factor that is used to calculate the recommended working load dividing the minimum breaking strength of the rope by the design factor.

Dynamic Load
Any rapidly applied force that increases the load on a rope significantly above the normal static load.

Elongation
Elongation properties of synthetic ropes are primarily driven by the elastic properties of the fibre type acting as the primary strength member. Modern synthetic fibres have significantly lower elastic elongation (higher modulus) when compared to traditional synthetic fibres.

Ropes with higher elastic elongation are typically used to provide a form of energy absorption in a system, while ropes with relatively low elongation, i.e. ropes made from HMPE fibre, provide increased position control and less stored energy at a given load.

Eye Splice

To form an eye at rope ending, the rope is turned into a loop. The loop is laid in such way that from the crouch of the formed eye, the returning rope has sufficient length to make the splice. This length is unravelled, and the loose strands are tucked into the construction of the upcoming rope.

The length of the eye is the distance between the crouch of the eye and the inside of the top of the eye. Within certain limits, this can be made as per customers' request. The length of the splice depends on the construction of the rope and the coefficient of friction of the yarns that form the rope. According to ISO2307:2005 this way of splicing brings a loss of strength in the rope up to 10% of the original minimum breaking strength of the rope.

Floating

The specific gravity indicates whether a rope will float or sink. The floatability of a rope depends on the yarns used in the rope. In general: polypropylene, polyethylene and Dyneema yarns are floating. The ropes made from these yarns, or a combination of these yarns, will be floating ropes. Aramid, polyester and polyamide (Nylon) are non-floating. If a rope is made from a mix of floating and non-floating yarns, the floatability of the rope depends the relative combination of the yarns. A floating rope has a specific gravity of, for instance, 0.98. This means that, in this case, 2% will be above the water line, 98% will be below – just like an iceberg. This is in fresh water, in salty waters the floatability improves by about 2%.

Grommet

An eyelet placed in a hole to protect or insulate a rope or cable passed through it or to reinforce the hole.

HMPE

High Modulus Polyethylene (HMPE) is a fibre which a high strength to weight ratio and low stretch characteristics but limited resistance to high temperatures. The fibres have good abrasion resistance and tension-tension fatigue life. HMPE is resistant to axial compression and has a low coefficient of friction. It is susceptible to creep and creep rupture under certain conditions. Lines made of 100% HMPE will float, however if jacketed, HMPE ropes can have a higher density and may sink. This depends on the diameter and jacket material. HMPE is known by the tradenames Spectra and Dyneema.

ISO 2307 Fibre ropes — Determination of certain physical and mechanical properties

ISO 2307: 2019 is a document produced by the ISO (the International Organization for Standardization) which specifies, for ropes of different kinds, a method of determining each of the following characteristics: linear density; diameter; lay length; braid pitch; elongation; breaking force. The document further provides a method for measuring water repellence, lubrication and finish content.

Jacket
The jacket is an extra layer on a rope braided over the core. A non-load bearing jacket does not contribute to the strength of the rope. A load bearing jacket is part of the strength of the rope.

LDBF – Line Design Braking Force
The minimum force that a new, dry, spliced mooring line will break at when tested.

MBL – Minimum Breaking Load
The minimum breaking load describes the maximum force under straight pull a free length of rope can be exposed to until it breaks.

MEG 4
The Oil Companies International Marine Forum (OCIMF) has introduced new guidelines for the safe mooring of tankers and gas carriers at terminals. Mooring Equipment Guidelines Edition 4, MEG4.

Pendant/Pennant
A short length of synthetic rope attached to the end of a line to provide increased elasticity and ease of handling.

Plaited
A rope structure consisting of an equal number of strands twisted to the right and left and braided together such that pairs of strands of opposite twist alternately overlay one another. Plaited ropes do not kink.

Protection
A loose cover can be put on the rope in an area where excessive abrasion might be expected. These covers are usually made from high performance yarns with a high abrasion resistance.

Specific Gravity
The buoyancy of a rope.

Specific gravity < 1.0 = floating
Specific gravity > 1.0 = non-floating

(In salty water the transition from floating to non-floating is approximately 1.02)

Splice
The joining of two ends of yarn, strand or cordage by intertwining or inserting these ends into the body of the product.

Tail End (Pennant)
A short length of synthetic rope attached to the end of a line to provide increased elasticity and ease of handling.

Tension-Tension Fatigue

Fatigue caused by cyclic axial loading at a given mean load, load amplitude and frequency.

Twisted

A twisted construction is several strands parallel laid into a rope construction. Twisted ropes may kink.

Water Absorption

Traditionally, ropes were made from natural yarns, for example sisal or hemp, and water molecules would penetrate the molecule structure of the material. Of the synthetic fibre materials, nylon behaves in the same way. Nylon becomes heavier when soaked in water and loses strength. If the vessel sails into freezing weather, the water molecules turn into ice crystals and can cause permanent damage to the rope.

If a rope is floating in water for some time, water will lie between the strands and the yarns. This however, will do no harm to the product. It will result in extra weight when pulled from the water, but the water will run out of the rope by itself - this will be accelerated when a force is put on the rope.

Illustrative Cost per Tow Calculator (beta)

Note: this Calculator is offered for towage operators and rope manufacturers to try out and test as theoretical means of calculating Cost Per Tow.

The BTA provides no guarantee of accuracy or applicability for all operations or operators, but hopes that through experimentation and testing a more detailed and insightful CPT calculator can be developed.

ILLUSTRATIVE COST PER TOW CALCULATOR

Base Number of Jobs per Rope 4000

	A	B	A x B	C	D	C x D			
Job Type	**Average Tonne**	**Minutes**	**Multiplier**	**% Rope Life**	**Number of Jobs per Year**	**% Rope Life x No. of Jobs**	**Multiplier**	**Rope Cost**	**Cost Per Job**
1. Standard Job	70	20	1400	0.00025	70	0.0175			
2. 1st Alternative Job	70	20	1400	0.00025	70	0.0175			
3. 2nd Alternative Job	35	90	3150	0.0005625	225	0.1265625			
4. 3rd Alternative Job	35	30	1050	0.0001875	225	0.0421875			
		Totals		**0.00125**	**590**	**0.20375**	**0.0003453**	**50000.00**	**17.27**

Data required:

Average Tonnes Pull During Job
Time Used in Minutes
Number of Jobs per Year as a Comparitor
Base Number of Jobs per Rope (eg 4,000)
Expected Cost of Rope (eg £50,000)

Process:

All variable figures are in RED - Base Numer of Jobs per Rope, Average Tonnes, Time Used, Number of Jobs per Year, Expected Rope Costs
Job Type 1 **MUST** be the standard job so the multiplier will be correct for any other job types. For example, routine berthing operation
Choose your other job type(s), for example routine sailing, escort in, escort out
Enter 0 for any job types no applicable
Final figure is Average Cost per Tow for One Rope in a system

For the full beta excel calculator please use the contact form at www.britishtug.com

Tug Vessel Considerations

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Bollard Pull		Number in tonnes
Steering force		Number in tonnes
Propulsion		ASD, Voith Schneider, Rotor, Tractor, Conventional etc.
Drum Specification		Size of Drum (diameter & depth of cheek plates)
Winch Type		Rend & Recover, other etc.
Winch & Staple Location		Location of winch & staple relative to Tug. (fore/aft)
Tug Age		In years (Sub 5, 5-15, 15+)
Tug Condition		Qualitative view

Operational Considerations

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES (SELECT ALL THAT APPLY)
Nature of the tow		Stern, CLF, Bow/Bow, Escort, Barge, Push/pull, etc. Indicate all that apply
Static Load		For Escort towing, either Passive or Active. Quantitative in tonnes
Company Safety Factor		Quantitative ratio
Expected use of winch if/when escorting		Auto tension or 'on the brake Indicate which applies (will be specific to operator/Class rules)
Line buoyancy		Sinking or Floating Line Desired
Expected types of assisted vessels		Cargo ships, naval ships, barges, rigs, plant, etc Indicate all that apply
Expected freeboard of assisted vessels		High (10m+) Medium (5-10m) Low (sub 5m) Indicate all that apply
Expected complications on mooring decks of assisted vessels		Qualitative free text to include: - Known awkward arrangements. - Average condition of fairleads on assisted vessels
Expected width of bitts on assisted vessels		Quantitative in metres. Note, some larger vessels bitts are too large for the standard 2m eye.
Are lines expected to be connected to emergency towage bracket?		Indicate which is most likely to apply
Expected Safe Working Loads of bits and fairleads on assisted vessels		Quantitative in tonnes

Environmental Considerations

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Nature of waters during operation		E.g., river, harbour, sheltered, coastal, sea. Indicate all that apply.
Expected combined wave height		Quantitative height in metres
Expected wind speeds		Quantitative speed in kts or mph
Prevailing wind direction		
Expected tides/ current affecting towage		Strength in kts or mph and direction
Operational limits		Do stop work orders exist above certain wind speeds?

Abnormalities and other specific information

CHARACTERISTICS	FOR COMPLETION	GUIDANCE NOTES
Any other operational abnormalities		Free text qualitative (operation, environment, assisted vessels deck complications, expected hazards, criteria required by port, etc.)