Fendering for Tugs

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SYNOPSIS: Tug fenders work harder, for longer and under more extreme conditions than any other fender type. This paper will review the primary fender types in use today as well as the effect that material properties, production methods etc have on performance and service life. Future trends in tug fenders are also discussed, in particular the conflicting requirements for high powered tugs to exert ever lower hull pressures.

1 SAFETY, PERFORMANCE AND PRICE
Fenders are to tugs what tyres are to cars. The best engine and transmission, steering and suspension can all be let down by the wrong choice of tyres. The same is true for tugs – the wrong fender will limit the function of a tug, make it harder to operate and may even affect confidence and safety in difficult situations.

Fenders purchased on the basis of cost alone – and this is surprisingly common practice – may provide small initial savings but the full-life costs borne by the operator will typically be much larger.

2 WHY DO TUGS NEED FENDERS?
Tug fenders perform multiple roles, all of which need to be properly addressed in the specifications, ideally from an operational, performance and material perspective.

2.1 FENDERS ABSORB IMPACTS
When a tug contacts a ship this is a controlled collision and the kinetic energy can only be absorbed in one of three ways – damage to the tug, damage to the ship or elastic deflection of the fender. The energy calculations are quite simple, but selecting fenders with appropriate load-deflection characteristics is more complicated. The fenders have to absorb the impact energy not just square-on but also at angles. How fenders are supported also affects the way they absorb energy, so equally important in the design process is the way fenders are attached.

Figure 2.1a: fender compression (flare).

Figure 2.1b: fender compression (plan).

Bow flares, approach angles and other factors affect which and how many fenders absorb the kinetic energy at contact.

2.2 FENDERS SHOULD BE GENTLE
The thrust of the tug is spread over a finite fender contact area commonly called the hull pressure. Fixed fenders in ports and terminals handling large container ships, gas carriers and the like are commonly designed for 20t/m² or less and these requirements are now appearing in tug specifications.

In contrast, a cylindrical fender will typically exert about 65t/m² (or much higher locally when sacrificial tyres are fitted). Increasing the fender footprint is one seemingly obvious solution, but the demand for more powerful tugs and lower hull pressures is a growing challenge with current fender technology and materials.

Figure 2.2a: PIANC and other design guidelines recommend low hull pressures for dock fenders. Similar values for tugs are being adopted.

<table>
<thead>
<tr>
<th>Vessel type</th>
<th>Hull pressure (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULCC and VLCC</td>
<td>150–250</td>
</tr>
<tr>
<td>Tankers</td>
<td>250–350</td>
</tr>
<tr>
<td>Product and chemical tankers</td>
<td>300–400</td>
</tr>
<tr>
<td>Bulk carriers</td>
<td>150–250</td>
</tr>
<tr>
<td>Post-Panamax container ships</td>
<td>200–300</td>
</tr>
<tr>
<td>Panamax container ships</td>
<td>300–400</td>
</tr>
<tr>
<td>Sub-Panamax container ships</td>
<td>400–500</td>
</tr>
<tr>
<td>General cargo (un-belted)</td>
<td>300–600</td>
</tr>
<tr>
<td>Gas carriers</td>
<td>100–200</td>
</tr>
</tbody>
</table>
2.3 FENDERS MUST BE HARD WEARING
There is constant movement between tug and an abrasive ship hull. Wear rates of the fender depend a lot on the type of rubber (natural, SBR etc), how it is formulated and the quality of processing. Some rubber types have inherently better abrasion resistance. Harder compounds are sometimes more wear resistant but also become more slippery and prone to cuts, tears, brittle failure and fatigue, not to mention higher hull pressures. Soft rubbers will be stickier but can overheat and wear faster in open sea operations.

2.4 FENDERS SHOULD BE LONG LASTING
Making long-lasting rubber compounds that perform well in severe marine environments is a specialist skill best left to polymer chemists. Ozone and ultra-violet light (which cause embrittlement and surface cracking in unprotected rubbers) are both abundant where tugs operate but can be resisted with suitable additives in the rubber. There are thousands of possible formulations that need to balance operating performance with environmental resistance, tensile strength, elongation, hardness, tear and abrasion properties. Rubber specifications are already well covered by established standards used for fixed fenders in ports and harbours, but infrequently adopted or adapted for tug fenders. Third party verification of these properties can also be a low-cost precaution to ensure high quality and long-lasting materials are used.

Figure 2.3a: Abrasion testing is one of several tests that should be routinely carried out on fenders.

Figure 2.4a: Rubber is a complex material. It requires skill and experience to get optimum properties for every application.

3 WHAT TYPES OF TUG FENDER ARE AVAILABLE?
Fenders used on tugs vary in design according to the duty they perform.

Figure 3.0a: Many larger tugs use similar fender layouts.

3.1 CYLINDRICAL FENDERS
Cylindrical fenders are popular on the bow and/or stern of tugs, usually for pushing against flared hulls and in open sea conditions. They are typically fitted into a curved recess, held in place by a combination of longitudinal chain and a series of circumferential chains or straps rebated into grooves. Sacrificial tyres are sometimes fitted over the cylindrical fender although the benefits of reducing wear versus greater maintenance and higher localised hull pressures are questionable.

Cylindrical fenders are usually needed in long lengths and ever-increasing diameters. Production methods, handling and transportation limit single lengths to around 13m in diameter up to 1,000mm – a fender of this size already weighs around 9 tonne. Larger sizes are made by spiggoting two or more lengths together, though joints near the main pushing areas should be avoided where possible. Tight bends in large fenders are another limitation which designers sometimes overlook.
3.2 PUSHING FENDERS

Pushing fenders present a large flat surface that distribute forces and reduce hull pressures and are fitted to bow or stern depending on tug propulsion. Pushing fenders evolved from crude square profiles into sophisticated 'M' and 'W'-shaped cross-sections. These later types provide a more gentle contact face, absorb more energy and eliminate gaps where ropes can snag. M and W fenders can also be fitted around tight radii to give designers more scope with hull form, whilst a simple pin fitting allows quick replacement.

Production tolerances are critical with all fender types but especially for pushing fenders. Inconsistent cross-section shapes make fitting a nightmare and little savings on material are soon lost due to wasted time during installation. Poorly fitting fenders are also more prone to damage and spares can prove nearly impossible to fix without lots of trimming and grinding.
Poor quality extrusions can be difficult and costly to install. Fine extrusion tolerances are achievable even on the largest W-fender sections. Price, quality and performance are closely linked.

3.3 SIDE FENDERS
Side fenders are mostly used during escort duties and when berthing the tug at unfendered docks. These beltings are most commonly a ‘D’-shaped profile fixed between parallel flat bars welded to the hull.
Butt joints can be the most vulnerable part of the side fender and these should ideally be spiggoted to prevent steps that might snag. It is also important to chose the size of the side fender according to application rather than the budget. Fenders that are specified too small for the job will be a waste of money even when made to the highest standards.

Figure 3.3a: D-fenders are commonly used as side beltings. They must be well fixed and large enough for the job.

3.4 TRANSITION FENDERS
Transition fenders are small and often forgotten, yet perform an important service at the interface between pushing and side fenders. They are usually made from solid rubber blocks, hand shaped to make a smooth joint. Whilst a small part of the overall cost of a tug fendering system, transition fenders will pay for themselves quickly by preventing damage to the more vulnerable ends of pushing and side fenders.

4 THE FUTURE OF TUG FENDERS
Current tug fender designs have changed little in the past 20 years. Advances have mainly been incremental with improved materials and production techniques plus some increases in size to cope with the extra power.

To handle the latest generations of container vessels, gas carriers and the like, tugs are now moving well beyond the 100-tonne BP threshold whilst hull pressures drop to sub 20t/m² levels.

Tug designers can still extract a little more from existing fender types with small enhancements to the hull shape, better modelling and prediction of applied loads and transmission. This in turn will call for better fender specifications plus stricter testing protocols to ensure compliance with the owner’s requirements.

High up on the ‘To Do’ list is a new generation of tug fenders, perhaps more modular in design, certainly thicker and softer but without adding weight high on the hull. They should embrace new material technologies such as hybrid urethanes and composite constructions for higher performance and durability.

Proving new tug fender designs will be the biggest challenge since few owners will want to experiment with prototypes. This raises further questions about developing reliable tests and trials, something a manufacturer like Trelleborg cannot do without the active support and involvement of the tug industry.

Last but not least, technologies from allied industries can be introduced. One example is laser docking systems already in common use on oil and gas terminals. Simplified systems could easily be adapted for tugs to allow high precision approaches with better knowledge of speed, range and angle – in any weather, day or night.

Figure 4.0a: Laser.
Laser docking systems are easily adapted for use onboard tugs to give accurate range and closing speed in all weathers.