Lifting operations can often put people at great risk of injury, as well as incurring hefty costs when they go wrong, but Factors of Safety (FOS) for lifting equipment is not an easy issue to summarise, as it is not a unified subject all over the world.

The USA has the ASME B30.9 Chapter 11/API/OSHA codes and regulations, and in Europe the EN 13000 rules and regulations are used, but besides that there are also a number of classification societies such as Lloyd’s, ABS, DNV-GL and others that have their own rules and regulations. This does not make it easy for end-users to identify which safety factors should be applied when using steel or fibre grommets and slings.

Safety factor

A safety factor is the ratio between the work load limit (WLL) and the minimum break load (MBL). Personally, I am a supporter of the Lloyd’s Rules laid down in the Code for Lifting Appliances in a Marine Environment (CLAME), as they make sense to me and they are not too difficult to understand.

CLAME specifies a safety factor of five for steel slings up to a WLL of 25 tonnes. From 25 tonnes up to 160 tonnes the FOS goes down linearly to three, and beyond a WLL of 160 tonnes stays at FOS = 3 (see figure 1).

The reason for a lower FOS for steel slings and steel grommets beyond a WLL of 160 tonnes is that these slings and grommets are used a lot less in daily operations than steel slings and grommets with a WLL of 25 tonnes or less (FOS = 5).

For synthetic or soft slings, a FOS of seven applies, which makes the use of soft slings in the WLL category above 160 tonnes extremely big.
As an example, we can take the WLL = 700 tonnes HMPE (high modulus polyethylene = Dyneema) lifting slings and grommets used by Seaway Heavy Lifting on the Greater Gabbard Windfarm, in which monopiles weighing between 519 tonnes and 676 tonnes were lifted.

The wire ropes used for the lifts were manufactured by Samson in Lafayette, USA, and they had a diameter of 144 mm, with a breakload of 2,331 tonnes, providing ample lift strength to handle the heaviest piles.

The slings and grommets were manufactured by Endenburg in the Netherlands. With a FOS of seven and a 160 tonnes a linear decrease of the FOS should stay at seven, but between 25 tonnes and 676 tonnes were lifted.

The slings and grommets were manufactured by Endenburg in the Netherlands. With a FOS of seven and a diameter of 144 mm, these synthetic slings seem over-compensated for their job, resulting in a debate about reducing the FOS for large capacity synthetic slings and grommets, which to my mind makes sense.

For synthetic slings and grommets with a WLL of less than 25 tonnes, the FOS should stay at seven, but between 25 tonnes and 160 tonnes a linear decrease of the FOS could be justified. The question is, what FOS should be used? The beauty of synthetic slings, and especially the HMPE ones, is that they have the same strength as steel grommets and slings but weigh only one seventh of the steel equivalents, which makes handling and working with them much safer and easier.

**FOS ratings**

Contrary to the recommended safety factors published in the Lloyd’s CLAME, the ASME B30.9 Chapter 11 regulations use a FOS = 5 for all grommets and slings, irrespective of their WLL or the material from which they are fabricated.

The FOS = 5 rating applies for steel as well as synthetic slings and grommets. I find the CLAME rules for steel slings more appropriate (FOS varying from three to five, depending on the WLL), but for synthetic slings the CLAME should be reduced for the large capacity slings and grommets and not stick to FOS = 7. The International Marine Contractors Association (IMCA), has recognised the need for lower safety factors in offshore subsea lifting work and even allows a FOS = 2.25, due to the fact that the steel rigging used in subsea lowering jobs makes up a large part of the available lifting capacity at great depths (requiring long and heavy lifting tackles, if steel wire ropes and rigging are used in deepwater locations).

We should ask ourselves, what are we trying to achieve with safety factors? A safety factor is the ratio between the WLL and MBL. Slings and grommets are all fabricated from steel or synthetic wire ropes. The MBL is calculated by the wire rope manufacturer and depends on the steel quality that has been used and the design of the wire rope. The theoretical calculated MBL is then tested by a breakload test which must always be more than the calculated theoretical value.

The MBL value is the value that is specified in the wire rope catalogue and is the guaranteed breakload value of the wire rope. Depending on which rules the end-user applies, the adequate FOS is selected. If the FOS for a sling with a WLL of 25 tonnes is five, then the MBL of the wire rope is five times the WLL, resulting in an MBL of 125 tonnes. The higher the FOS, the larger the margin of safety.

This does not mean that we can use slings and grommets for a higher load than the certified WLL, as the FOS only protects us from breakage due to wear and tear and sometimes misuse of the slings. A grommet or sling with a certain WLL may never be used for a higher load than the certified WLL and we still need to inspect the slings and grommets for excessive wear and tear and scrap them if they fail the safe-use criteria.

To conclude: select the right sling for the job (based on the expected maximum force in the sling), inspect slings prior to use, remove slings from service if they are not fit for purpose, remember the effect of sling angles on load capacities and finally, properly store slings when they are finished with to avoid damage. It is far from easy to find the correct safety factor for slings and grommets on Google, and even then it will not be the same in every country.

How does an international shipping company deal with this, when its lifting grommets are based on the Lloyd’s CLAME, for example, which agrees on a safety factor of three for slings with a WLL above 160 tonnes, but in the USA, ASME B30.9 11 requires an FOS of five?

**Lifting and spreader beams**

In daily practice, we frequently mix up the terms ‘lifting beams’ and ‘spreaders’. The difference is that a lifting beam is a device that helps guide the lifting slings from the lifting points of the load towards the hook block, whereby a set of shackles are fitted to the lifting beam to connect the slings from the lift points with another set of shackles connecting the slings from the lifting beam to the hook block (see figure 2).

As an example, in lifting a load of 100 tonnes there is a split between the lifting slings above and underneath the lifting beam. The forces in the lifting slings above the lifting beam (when guided under an angle of say 60° to the hook block) are higher (58 tonnes) than the forces in the slings underneath the lifting beam (50 tonnes). See the lefthand side of figure 2.

A spreader can be any beam or pipe structure equipped with flanges to guide the continuous lifting slings or grommets from the lifting points of the load to the hook block. In the spreader beam, no lifting shackles are used except the ones to hold the spreader in
position and absorb the force component of the main lifting slings downwards. The forces in the continuous lifting slings (marked red) are 50 tonnes, and below or above the spreader are the same. Due to the angle of 60° to the horizontal, the force in the blue slings will be around 8 tonnes at 60° and 21 tonnes at 45°.

To make a proper lift beam or spreader design, the compression force in the beam should be as accurate as possible along the neutral axle of the beam. Modulift, in the UK, has a wide range of properly designed lifting/spreader beams that are certified and fulfil that requirement. Due to the link plate connection to the lower slings, they are suitable for a wide range of lifting angles. All lifting gear – such as shackles, slings, grommets and other similar equipment – must have valid test certificates.

According to the Lloyd’s CLAME, the lifting/spreader beams must be tested with a load depending on the WLL of the beam according to the formula: Test Load L = 1.04 * WLL + 9.6 tonnes which means, depending on the WLL, all lifting/spreader beams must be tested with an over-load of 10-100 percent of the WLL. Consequently, a 10-tonne WLL lifting/spreader beam must be tested with 20 tonnes.

Please note, this article is intended for guidance only. While every care has been taken to ensure the accuracy of the contents, no responsibility will be accepted by the publishers for any errors.

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