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# Spring-loaded Winch Band Brakes as Tools to Improve Safety During Mooring Operations on Ships

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ABSTRACT: Some recent accident reports involving large vessels in mooring operations or breaking away from their moorings conclude that brakes of mooring winches do not render before line parts. As the potential loss of life is high, the utmost attention on-board must be paid to minimise this inherent risk. When the load on the mooring lines becomes overloaded beyond the pre-set levels, mooring winches band brakes have the safety function of rendering and allowing the line to shed this load before its potential breaking and the subsequent snap-back. As a preventive measure against breaking, the pre-set level, known as Brake Holding Capacity (BHC), must be below the Minimum Breaking Load (MBL) of the line. In this paper, the authors analyse concerns that can arise from those with conventional screw manually-applied band brakes regarding their BHC reliability. Thus, in order to improve safety, the advantages of the spring-applied band brakes with manual setting and release or with hydraulic release are highlighted. Finally, the paper shows a typical procedure using a hydraulic jack for brake testing the winch of a Liquefied Natural Gas (LNG) ship to fix their BHC in order to hold 60% of the MBL of the mooring line.

## 1 INTRODUCTION

Working with mooring lines entails an inherent risk of accidents [5], notably in case of mooring lines breakage and their subsequent snap-back phenomenon; that is, the sudden release of the stored energy in a tensioned mooring line when it suddenly breaks [13], [10]. A fact that is corroborated in multiple accident reports [1], [3], [4], [8], [9]. One example of their seriousness is reflected in UK P&I (2016) [15] study where, through a statistical analysis data along the last twenty years, it is shown that personal injuries of this type is the seven most frequent cause, but the third expensive per claim, indicating how appalling some of them can become.

In the past (even being normal in small ships nowadays), to moor a ship it was necessary to deploy lines conventionally in warping drums by pulling the tensioned line after taking sufficient turns so that there was enough friction for the rotating drum and then stoppering to allow the free end to attach to the bollards.

Contemporary mooring practice on modern large vessels, as it makes manual handling difficult, demands that all lines are set up on dedicated and self-stowing mooring winches that, on the same driving shaft (forward, in combined windlass-winches also), allows deploying them usually from two or three drums, each one fitted with independent capability to be engaged-disengaged. In most of those ships, the drum is of the split (recommended by ISO, 2012) [6] instead of the undivided type and the brake is of the band type [2], [10], [16] although the disk brakes option has advantages as they are less affected by wear and tear and the line can be reeled paying out irrespective of the top or bottom of the drums; probably due to acquisition and maintenance costs "… few, if any, winch manufacturers offer them as an alternative to band brakes" [10].

A split-type drum comprises a tension section that holds one layer of the mooring line and a storage section that the remainder of the rope is wound onto. They were designed to cope with two disadvantages that undivided drums have:

– To prevent the spooling problem encountered with undivided drum winches due to lines biting into each one when under load (undivided drums have several layers on one drum, whereas split drums have one layer on the tension section), and;
– As on undivided drums all the line required for mooring the ship is stored on a single drum, the layers of the unused line increase the diameter of the drum effectively, thus decreasing the BHC whereas, as split drums operate with only one layer of the mooring line on the tension section, theoretically they can maintain a constant BHC.

Each drum has its respective band brake that lets it hold mooring lines fast on brakes with the winch disengaged, after being previously heaved tight against the rubber fenders with the winch engaged until achieving the desired pretension to use friction in order to reduce the fore and aft movement of the vessel [2], [10].

Brakes have two circular steel bands connected by an articulated joint pin. At the opposite end, the top half is anchored to a pivot point fixed to the deck or bed plate and the bottom half (the free or floating end) is connected to the brake control lever (Fig. 2).

Brass screws or copper rivets attach steel bands to high-grade non-asbestos marine brake linings. Due to the wear and tear in ordinary use of brake linings, when their thickness has reached a certain level they must be replaced as per manufacturer´s operations manual (it usually features a wear indicator to this end), in order to maintain effectiveness of the winch brake by suitable friction between the linings and the rim of the winch drum. The brake linings rely on the coefficient of friction against the brake drum to hold the force on a line. How to tight or release the band brakes depends on their application type, either by means of a simple conventional brake handle (or hand wheel) manual screw or in conjunction with a spring-applied by manual setting and release or by hydraulic release.

As a static device, the prime aim of the band brake is to secure the winch drum and the mooring line spooled and layered on it, holding the line tight when moored.

When the load on the mooring line becomes excessive (overloaded) beyond a predetermined level, the brake has an added safety function of rendering to allow the line to shed its load by releasing the tension in a controlled manner [14]. This serves to prevent a mooring line from breaking and snapping back.

To manage the safety function of the brake effectively, a winch brake test for the winch operator guide should be carried out in order to hold the line correctly with the winch disengaged. However, the load at which the brake renders is also dependent on its actual condition.

At the ship design stage [10], the MBL of the lines is determined taking into account factors such as the ship's size and hull form, the number of mooring lines to be deployed, mooring restraint requirements, the maximum windage and lateral underwater area to cope with wind and tidal conditions respectively. Regarding the windage and underwater area, Oil Companies International Marine Forum -OCIMF- uses standard environmental criteria to this end [10]. Based on the MBL, the mooring winch general requirements and parameters being dealt with in ISO 3730:2012 [6] and ISO 7825:2017 [7] are determined. Regarding the winch brake, their BHC will not be less than 80% of mooring line MBL [6] in the first layer although, through a brake winch test, it should be operationally set to hold 60% of the MBL on the first layer to permit slippage before the line breaks [11].

The mooring set-up on-board should be such that the winch brake should be the weakest link in case of overload followed by the primary line, the synthetic tail if any (MBL for mooring tails should be 25% higher than that of the primary mooring line to which they are attached [10]); and lastly the fixed structures such as the winch foundation and the fairleads. This set-up is the standard and its intention is to minimize the consequences in case of overload.

The drum load of the winch (also called hauling, hoisting or rated load), i.e. the pull that the mooring line can develop at the rated speed on the first layer, should be within 22% to 33% of the MBL of the line [6] assuring adequate force to heave in against environmental forces, but being low enough to prevent the line from overstressing in the stalled condition i.e., the maximum rope tension, in kilonewtons -kN-, is measured at the drum exit when the drum ceases to rotate in the haul direction, the prime mover being set for maximum torque and the rope being wound on the drum in a single layer. The rendering load (maximum rope tension measured at the drum exit when the drum just starts to rotate in the opposite direction to the applied driving torque) will not be more than 50% MBL of the line [6]; therefore, the BHC is always greater than the rendering load. Thus, when occasionally unanticipated changes of load generated by extreme winds, waves or tide cause the brakes to render and the vessel to be at risk of moving off the berth, it is not possible to engage the winch and haul the lines after releasing the brakes in an attempt to put the ship alongside again [11]. Instead, good seamanship in those cases dictates to maintain engines ready for manoeuvring, to require tug assistance, to ballast the ship down to reduce the total forces acting on the ship as the wind gradient is greater than the under keel clearance effect [11] and to disconnect hoses or any other fixed cargo handling system on-board from the harbour.

As most modern large ships are equipped with dedicated mooring winches with split drums fitted out with band brakes, in this paper we analyse how to manage the safety function of the band brake to render before breaking the line and their reliability depending on the type of application. To that end, the methodological approach followed by the authors along this work combines the theoretical background to highlight good seamanship on this subject with empirical evidence on a shipyard obtained by actual cases on board different ships. This strategy allows them to compare the efficiency of distinct winch brake types and to show a real study case carried out on board an LNG carrier, having mooring winches with state-of-the-art technology.

## 2 PERFORMANCE DETERMINANTS OF BAND BRAKES

The load at which the brake renders depends on several factors which, as a whole, determine their performance. The degree to which it has been tightened, their condition and the correct direction to reel the line on the winch drum are examined below.

### 2.1 *The setting of the band brake*

After hauling the line with the winch engaged until it achieves the correct pretension, the degree to which the brake linings has been tightened against the rim of the drum to hold the line with the band brake and the winch disengaged is the primary factor. The tension force generated by the threaded screw spindle engaging into the nut creates a compressive force of the brake band against the rim of the barrel through the brake mechanical linkages [16] which will generate a resistant torque. To this end, the winch operator should have some form of reference guide by a winch brake test to try and ensure constant torque each time the brake is applied (further on we will analyse an example of how it should be carried out).

### 2.2 *The condition of brakes to maintain proper friction*

The actual state of winch brakes affects their friction, so a small change in friction coefficient causes a big change in the BHC of the winch in such a way that, as a rule of thumb, it may be twice [10]. The condition of brake linings, the rim of the drum and a proper maintenance of brake mechanical linkages are very sensitive to changes in friction. The pitting and corrosion reduce the brake's effectiveness as the contact area between the brake lining and the brake drum metal face reduces.

As oil or heavy rust around the brake linings and drum reduce the BHC of the winch, some operators heave the drum engaged for a while with the brake slightly applied in order to burn them off [5], [10]. The same should be made to seating brake linings and smooth them when replaced because they do not have their full coefficient of friction due to their initial rough surface. In both cases, the drum should be turned slowly in order to prevent brake fade (loss of friction) due to the overheating linings.

In order to avoid corrosion problems on the rim of the drum on which the brake lining acts, it is recommendable to make them either of stainless steel or retrofitting the existing ones by machining the drum rim and filling with solder of stainless steel (Fig. 1) or even by welding a stainless steel plate over the existing material.

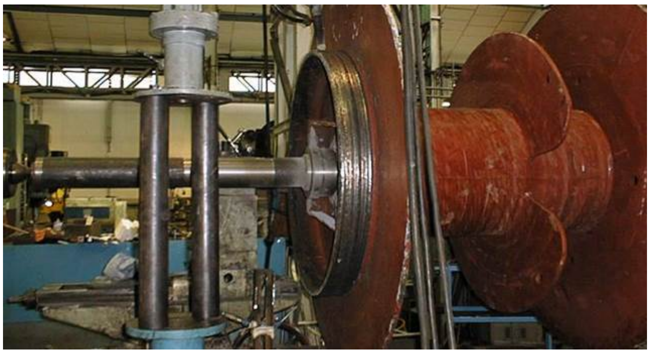

Figure 1. Split drum of a dedicated mooring winch whose rim was retrofitted by filling stainless steel with automatic soldering in Navantia Ship Repairs Fene-Ferrol (Spain).

### 2.3 *The direction of reeling on the winch drum*

The mooring line should be correctly reeled onto the drum; otherwise, a substantially BHC reduction of the winch will occur. To avoid misunderstanding, it should be permanently marked on the drum [5].

The criteria to establish the correct reeling of the line on the drum should be such that, in the pay-out direction, the mooring line pulls against the fixed end of the brake band, closing the gap between the fixed and the floating brake mountings and thus assisting with the operation of the brake [2].

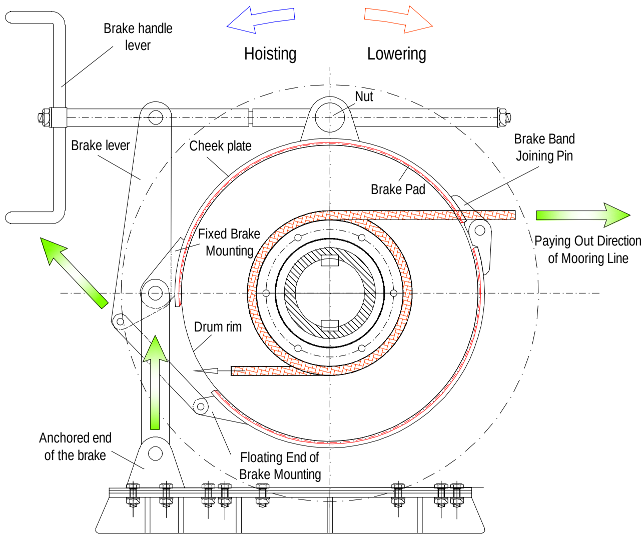


Figure 2. Correct reeling direction of mooring line depending on brake mechanical linkages set-up. In this case, it is achieved when it pays out from the top of the drum.

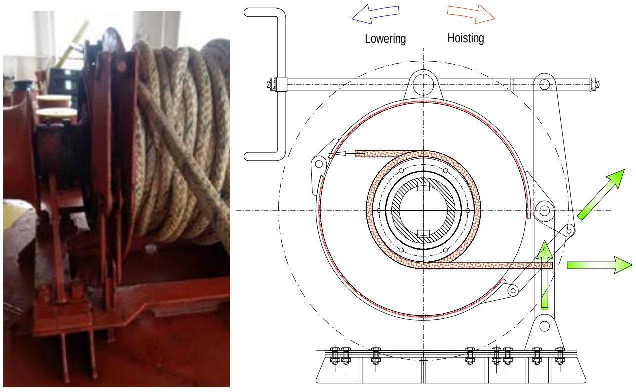


Figure 3. Left: Line being incorrectly reeled onto an undivided drum considering the brake mechanical linkages set-up. Right: Drawing showing how the mooring line should be reeled so that it pays out from the bottom of the drum not from the top.

Fig. 2 shows how the line should be reeled depending on the brake mechanical linkages set-up (the parts that are used to link the band brake parts to each other and to the bed plate). In this case, the line should paid out from the top of the drum. Fig. 3 shows a line incorrectly reeled on an undivided drum and how in this case, as the brake mechanical linkages set-up is different, the line should be reeled so that it pays out from the bottom of the drum instead of from the top. Besides reduction of winch BHC, additional problems may arise when the line is improperly reeled because, as it does not work horizontally to pedestal roller and fairlead, a risk of jumping from the pedestal roller is generated.

## 3 MOORING WINCH WITH CONVENTIONAL SCREW MANUALLY-APPLIED BAND BRAKE

With this type of application, the band brake is tightened or r eleased by manually turning a screw spindle by means of a brake handle (or hand wheel), which is easy to apply (Fig. 4).

As a general rule, the winch operator should turn the brake handle clockwise when tightening. Thus, as a result, it draws the ends of the brake bands together by closing the distance between the nut and the brake lever (decreasing the effective control rod length), which in turn brings the brake lining into contact with the rim´s drum.

In order to achieve the proper torque to hold the line, the brake is applied by tightening the screw with the brake handle until some form of predetermined index mark is in line with an indicator ring fixed on the spindle-rod. Regarding the reliability of this manual band brake application two problems may arise:

1 Due to the wear of linings after some mooring manoeuvres, if we tight the band brake until the predetermined mark is set, the torque applied will be less than the correct BHC of the winch (60% MBL).
2 Under worsening environmental conditions, if an additional load is applied to the attached mooring line, the brake band stretches in the pay-out direction. This reduces the load on the brake controls relieving some of the tension in the threaded rod until it becomes looser in such a way that it could be possible to re-tight the brake when the mooring line is under high load, even if it was set to the correct torque originally. Therefore, with those manually-applied band brakes, once the winch is subjected to a high line load, there is no way to determine the proper brake handle torque required. So, retightening as brake band stretches could be misleading because the operator cannot be aware when he exceeds the maximum BHC threshold and, therefore, the line may part before the brake slips.

It could be possible to set the winches manually with a torque wrench but few owners, if any, use this option.

Figure 4. Conventionally screw manually-applied band brake of Crude Oil Tanker “Tulip”.

## 4 SPRING-APPLIED BAND BRAKES

With band brakes manually operated by just screwing up the brake handle it can be difficult to achieve the required torque consistently in practice so that it accomplishes their safety function. To overcome this uncertainty, some brake designs incorporate a spring-applied device with manual or hydraulic release. The purpose is twofold: to assure a constant BHC of the winch by applying a pulling force of the band brake against the rim of the barrel that can be set up for operator reference and to prevent the risk of overtightening the brake band in case it stretches.

The band brake is spring-applied to hold on the brake using a spring compressed inside a cylinder against a piston that is part of the brake handle-spindle-rod device. To release the brake, the piston that compresses the spring needs to be either manually or hydraulically operated.

The spring design is made of Belleville washers (also known as “disc spring” or “Belleville disc”). The theory behind this spring type [12] goes beyond the content of this paper; suffice it to mention that it is a conical-shaped spring with an open centre (much like a washer) exhibiting low deflections relative to high loads, making it ideal for cushioning heavy loads with short motion. Their load/deflection ratio can be changed by using several Belleville washers stacked to modify the spring constant or the amount of deflection either in series (aligned in opposite directions to increase deflection and lower spring constant) or in parallel (aligned in the same direction to increase load maintaining spring constant) or a combination of the two alignments. The relationship between the load and deflection is non-linear, particularly as load increases; therefore, they are well suited to areas with constant thrust that must stand up against heavy wear, as is in the case of band brakes of mooring winches. The exact configuration depends on the BHC of the mooring winch requirements determined on ship design stage, taking also into account the stroke of the spring regarding their axial compression limits between the band brake on and the releasing conditions. Fig. 5 shows schematically a spring applied band brake formed by Belleville washers where, depending on the manual or hydraulic release, the piston compressing them is displaced axially by the operator turning the brake handle or by the hydraulic pressure acting on the oil chamber respectively.

### 4.1 *Spring-applied brake with manual setting and release*

To apply the brake, the operator should have an indicator ring that may be moved on the spindle-rod device, whose correct position is set up through a brake winch test as a guide to permit slippage before the line breaks (it should be adjusted if required using an Allen key). The degree to which the spring is compressed inside the cylinder by turning the brake handle depends on the holding load of the brake [10]. As the BHC of the winch will not be less than 80% of the mooring line MBL in the first layer, but operationally set up to hold 60% of the MBL, the spring should have some residual compression capability even in the brake-on condition set-up.

To release the brake once the winch is engaged, the operator further decompresses spring against the piston by continuing turning the brake handle anticlockwise. In this way, distance “b” is increased (brake handle-spindle-nut-rod-piston unit moves toward operator) which consequently makes the two half-circular parts of band brakes stop doing contact with the rim of the barrel as a result of the brake mechanical linkages set-up; i.e. the band brake releases. To apply the brake from the released condition, distance “b” decreases as the spindle threads over the nut while the operator turns the brake handle clockwise (Figs. 5 and 6). After an initial compression of the two half-circular parts of band brakes seating the linings to the rim of the barrel, distance “b” stabilizes and the piston begins to compress the spring until the indicator ring is placed in line with the pre-set mark. In this way, the brake can be applied regularly to its correct value because any wear of brake lining and/or elongation in the brake mechanical linkages is fully compensated.

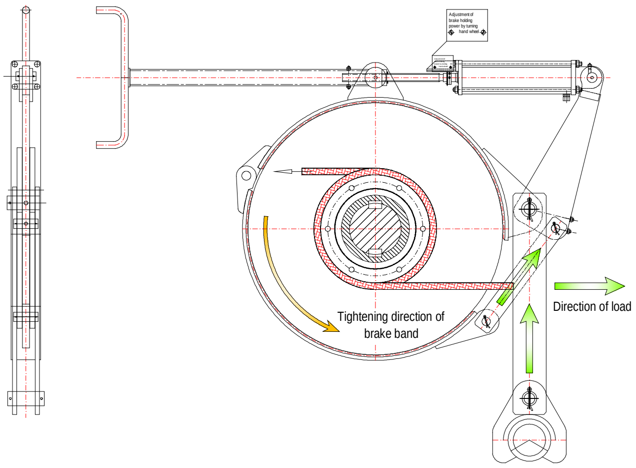


Figure 6. Spring-applied band brake with manual release. Source: TTS Kocks GmBH, Bremen.

Figure 7. Spring-applied band brake with manual release of LNG Tanker “Excelsior”.

### 4.2 *Spring-Applied Brake with Hydraulic Release*

In this case, the brake is released either by a hydraulic hand pump (Figs. 8 and 10) or, if the winch is hydraulically powered, by taking advantage of the main hydraulic pressure that drives it (Fig. 9).

With this band brake application, the operator does not usually need to use the brake handle to apply the brake or release it. Therefore, this design option permits a more reliable pre-setting.

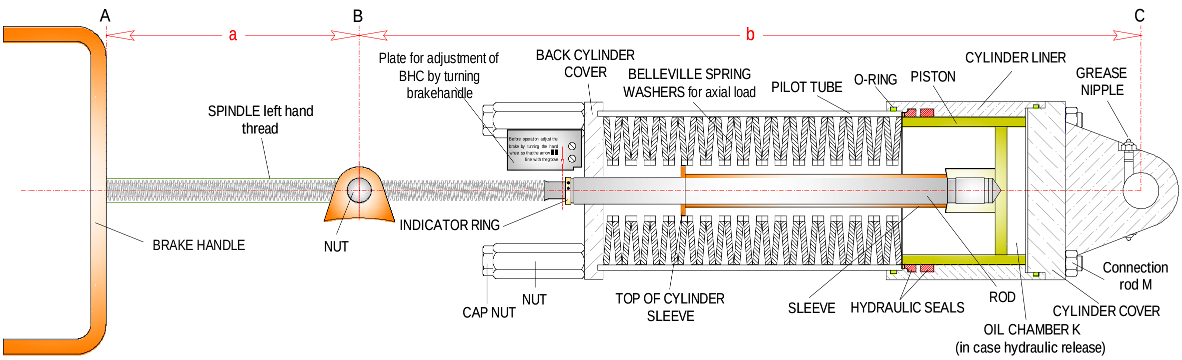


Figure 5. Spring-applied brake (Belleville washers) showing the band brake applied (brake handle-spindle-nut no to scale). In this Fig., the spring is formed by 32 Belleville washers stacked in series. Source: TTS Kocks GmBH, Bremen.

The set-up in the brake on condition to fix 60% of MBL of the line on the first layer by the residual compression of the spring is achieved in the brake winch test by turning the brake handle accordingly in a similar way, as seen for manual release in the previous paragraph. After this set-up, the brake handle should be secured with a seal to prevent tampering (Figs. 8 left and 9 right). However, for an easy visual check, it is also recommendable to follow the indicator ring-index mark on the fixed plate for adjustment method (Fig. 15) seen for manual setting in the previous paragraph [10].

The brake handle only serves:

- To adjust the spring residual compression through the band brake set-up test;
- To turn it clockwise when we apply the brake on after a visual check in case the indicator ring and the fixed mark pre-set are not in line and;
- For emergency, releasing the brake in case of a hydraulic breakdown.

Figure 8. LNG Tanker “British Innovator”: Band brake spring-applied and hydraulically release by hydraulic hand pump.

To apply the brake from the released condition, the hydraulic pressure is relieved from the cylinder oil chamber to the sump tank of the pump by opening the oil return valve (Fig. 10). Thus, according to the brake test set-up, the compressed spring automatically extends until its compressive force is balanced by the resistance of the brake band being pressed against the rim of the barrel (Fig. 5 -distance “b” decreases). Therefore, the spring automatically applies the correct force between the brake band and the rim of the drum at all times, which involves an advantage over manual setting because there are not any requirements for a crew member to re-apply the torque by turning the brake handle to the pre-set mark.

To release the brake, hydraulic pressure is applied on the oil chamber to the other side of the piston (pressure side) after closing the oil return valve by pumping oil from the hydraulic hand pump (Fig. 8) or, when the main hydraulic pressure that drives the winch is used, by acting on the directional control valve to this end (Fig. 9). By doing so, the spring is further compressed until the linings are free from the rim of the barrel (Fig. 5 -distance “b” increases).

Figure 9. Tanker “Florida Voyager”: Band brake spring-applied and hydraulically released by taking advantage of the main hydraulic pressure on winches with hydraulic drives.

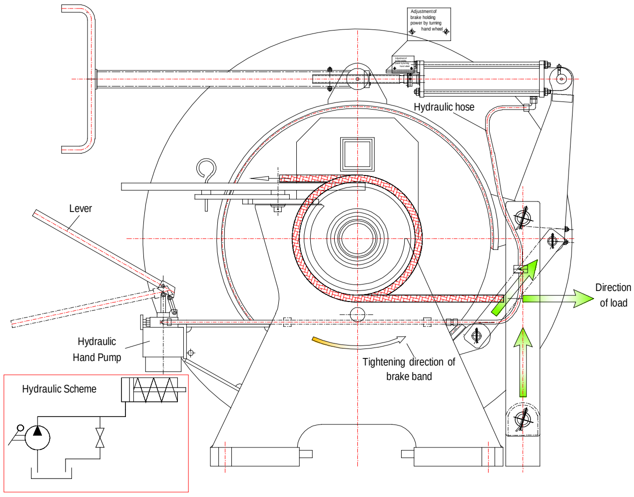


Figure 10. Spring-applied band brake with hydraulic (hand pump) release. Source: TTS Kocks GmBH, Bremen.

## 5 STUDY CASE

### 5.1 *Procedure for band brake testing a mooring winch*

To ensure safe mooring, all mooring winch brakes on-board should be set to release the mooring lines at the correct load. To this end, brakes should be tested individually at regular intervals, not exceeding twelve months and after a retrofit or repair or when a brake slippage or malfunction occur [5], [10].

This test is performed by means of a brake test kit that consists of a hydraulic jack with a pressure gauge and a bracket specifically made to bolt onto the flange of the winch drum with a sliding pin, in order to transfer the jack force to the drum.

In this paragraph, it is described the procedure for a winch brake test in one of the winches supplied with split drum having a band brake spring-applied and manual release (see Figs. 5-7) of the LNG Tanker “Golar Winter” carried out in Navantia Ship Repairs Fene-Ferrol (NW Spain).

To carry out the test, data known, the ones to be computed and their nomenclature (Fig. 11) are as follows:
MBL of wire rope = 124 tons.
F1 BHC (required to hold 60% of MBL) = 74.40 tons.
L1 Distance drum centre - 1st. layer of rope centreline (R+r) = 32.20 cm.

F2 Force exerted by the hydraulic jack (to be computed).
L2 Distance centreline of drum to centreline of hydraulic jack = 85.00 cm.
R Drum radio = 30.00 cm.
r Wire rope radio (1st layer) = 2.20 cm.
A Hydraulic jack effective piston area = 50.27 cm².
P Hydraulic jack slipping pressure in bars (to be computed).

The kit placed on board for use was the hydraulic jack YALE Aluminium mod. AJH-660 (capacity = 60 tons and stroke = 152 mm).

The hydraulic jack fixed to the drum end plate substitutes the pull on the mooring wire (F1) in order to apply a high and known load that simulates the load on the line by means of hydraulic pressure. This pressure is related to the torque applied by the jack on the winch drum as shown in Fig. 11.

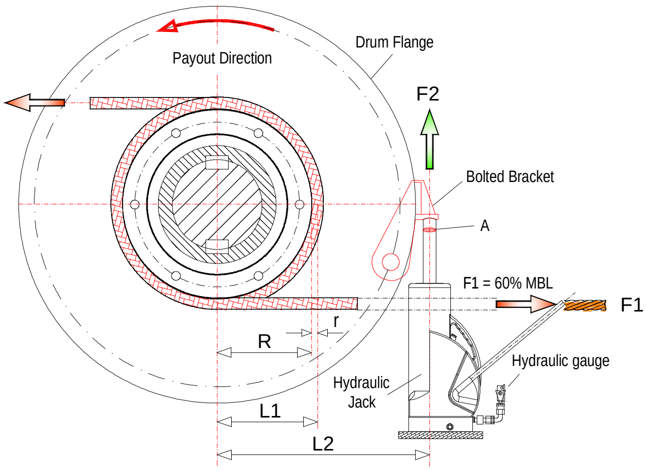


Figure 11. Arrangement for testing the brake in one of the mooring winches of LNG Tanker "Golar Winter".

As we cannot apply a force equivalent to F1 that represents 60% MBL of the line, we need to generate a simulated torque (F2 x L2) equal to the actual torque (F1 x L1) by applying a previously computed hydraulic pressure with the jack. The formulae given below simply compensate for the difference in radius between drum and barrel (first layer) and the jack attack point, referred to the drum centre.

Actual and simulated torque should be the same, so Equation (1) is expressed as follows:

$$F1 \times L1 = F2 \times L2 \quad (1)$$

All data are known except the F2 term, so their value is shown in Equation (2).

$$F2 = \frac{F1 \times L1}{L2} = BHC \times \frac{R + r}{L2} = 74.40 \times 1{,}000 \times \frac{32.20}{85.00} = 28{,}184.47 \text{ kg} \quad (2)$$

Knowing the hydraulic jack effective piston area (A), the normal pressure to the bracket contact area applied by the piston of the jack with F2 force that generates the simulated torque should be computed in bars because the reading in this kit on the pressure gauge (Fig. 15 right) is in those units.

$$P = \frac{F2}{A} = \frac{28{,}184.47 \text{ kg}}{50.27 \text{ cm}^2} = 560.66 \frac{\text{kg}}{\text{cm}^2} \times 0.980665 \frac{\text{bar}}{1 \frac{\text{kg}}{\text{cm}^2}} = 549.82 \text{ bars} \quad (3)$$

### 5.2 *Procedure for setting up and testing the BHC of the winch*

Once the pressure to be applied by the hydraulic jack was computed to simulate a torque equal to the actual torque that, with the wire rope on the first layer of the drum, is generated by a force equal to F1 (60% MBL), the following steps should be carried out:

1 The hydraulic jack should be checked to ensure that there is proper hydraulic oil level and that the pressure gauge is calibrated and certified.
2 The drum flange and/or the split disk (the notched flange that divides the storage from the tension sections of a split drum) must be equipped with a hole to install the bracket. In this test, it was used the hole on the split disk (Fig. 13).
3 There should be enough free space on the split disk to accept the testing gear. To this end, some of the wire was spooled off (Fig. 12 right).
4 The winch drum should be turned to set the hole at 90 degrees to the deck or bedplate in order to position the piston jack subsequently underneath with their supporting surface in horizontal position (Fig. 13 left and centre).
5 The spring is compressed (brake-on) at its maximum value (BHC not less than 80% MBL) by turning the brake handle clockwise accordingly. The winch drive should be disengaged afterwards.
6 Pump up the jack until the computed pressure of 549.8 bars (550 is sufficient for practical purposes) is shown on the pressure gauge assuring that this reading has been stabilised (Fig. 13 right).
7 To find the correct set-up of the winch band brake, we reduce the spring residual compression by turning the brake handle smoothly anticlockwise while watching the pressure gauge reading (Fig. 14 left).
8 When it comes to a slight reduction in pressure gauge reading, the simulated torque which represents a force F1 equal to 60% MBL with the wire on the first layer of the drum is achieved (Fig. 14 right).
9 The indicator ring on the spindle should be adjusted by using an Allen key so that it coincides with the permanent index mark made on the fixed plate for adjustment (Fig. 15).
10 The test is completed.

Regarding the winch drum and its band brake, it is important to notice that it does not matter if the equal torque is generated either by the hydraulic jack or by the pull on the wire line; the reaction will be the same. Therefore, when the jack computed hydraulic pressure is applied, we equate torques, not forces because of unequal lever arms. For this reason, it is not necessary to carry out the test with one layer of wire rope on the tension section of the split drum (the actual condition where the force F1 generates the torque); in fact, in this test the wire rope was spooled on the storage section, therefore with several layers (Fig. 13).

Figure 12. Mooring winch of split drum type dotted with spring-applied band brake with manual release where the brake test was performed. The necessary wire rope was spooled off to have enough free space.

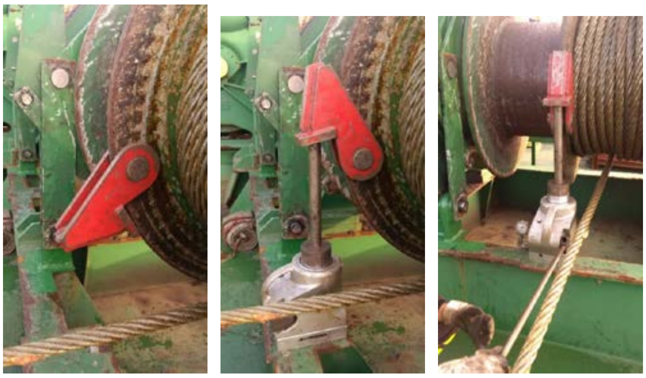

Figure 13. The bracket installed on the split disk (left); the hydraulic jack positioned underneath ready to apply hydraulic pressure (centre) and the operator pumping up pressure with the lever until the pressure gauge reading reaches 549.8 bars (right).

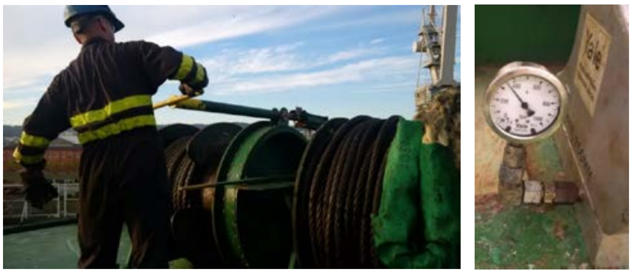

Figure 14. Winch operator turning the brake handle anticlockwise to apply the residual compression on the spring (left) until a slight reduction in the pressure gauge reading is seen (right).

Figure 15. Nut-spindle-rod-cylinder with spring where the indicator ring and the fixed plate for adjustment are shown (left), and indicator ring position adjusted after the test to the permanent mark on the fixed plate (right).

## 6 CONCLUSIONS

Mooring manoeuvres entail an inherent risk that demands the utmost attention on-board to minimise it. Accident reports showing the fact that improper set-up of winch band brakes had been found to contribute to several casualties confirm the need to maximise the performance of this task in mooring operations. On large ships, there is an unstoppable tendency towards using dedicated self-stowing mooring winches of the split drum type fitted out with band brakes instead of warping drums. The brakes of those winches have the safety function of rendering before potential breaking of the lines and their subsequent snap-back, releasing the tension in a controlled manner once it increases to a pre-set maximum force. To this end, the BHC of winches should be set to hold 60% MBL of the line on the first layer.

The three types of winch band brake application were analysed, of which the manually applied is not reliable enough from the safety point of view. The current trend is to use band brakes of the spring-applied type either with manual setting and release or with hydraulic release, because they overcome most drawbacks the manually applied application has. Nevertheless, the hydraulic release seems the best option. This is because, once preset, the spring automatically applies the correct force and the operator does not need to re-apply the torque by the brake handle aside from the fact that, due to wear and tear of the linings, visual check reveals that the indicator ring does not coincide with the fixed mark on the plate for adjustment. Actually, the spring acts as a dynamometer that shows the constant force applied when the indicator ring position is in line with the fixed plate for adjustment after being preset through a winch brake test.

The theory behind and the procedure to carry out a winch brake test to set the BHC of winches has been explained through an actual case. On-board different winches designs can exist, so it is recommendable to make an Excel spreadsheet to compute the pressure the hydraulic jack (taking into account their particulars) needs to apply on each of them.

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