Engineering Report
Project 107
TSE SD/SDP-70 DRUM STRENGTH

Revision 6/19/2018

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By

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Introduction

The SD-70 and SDP-70 spoolers are manufactured by TSE International, Inc. They're intended for utility line spooling and tensioning. They were not intended for marine use. They were not designed to meet federal regulations for wet weight handling gear, nor were they intended to meet the specifications of any classifications society. They're also decidedly lightweight when compared to marine winches with same maximum pull (7500 lbf at the drum core).

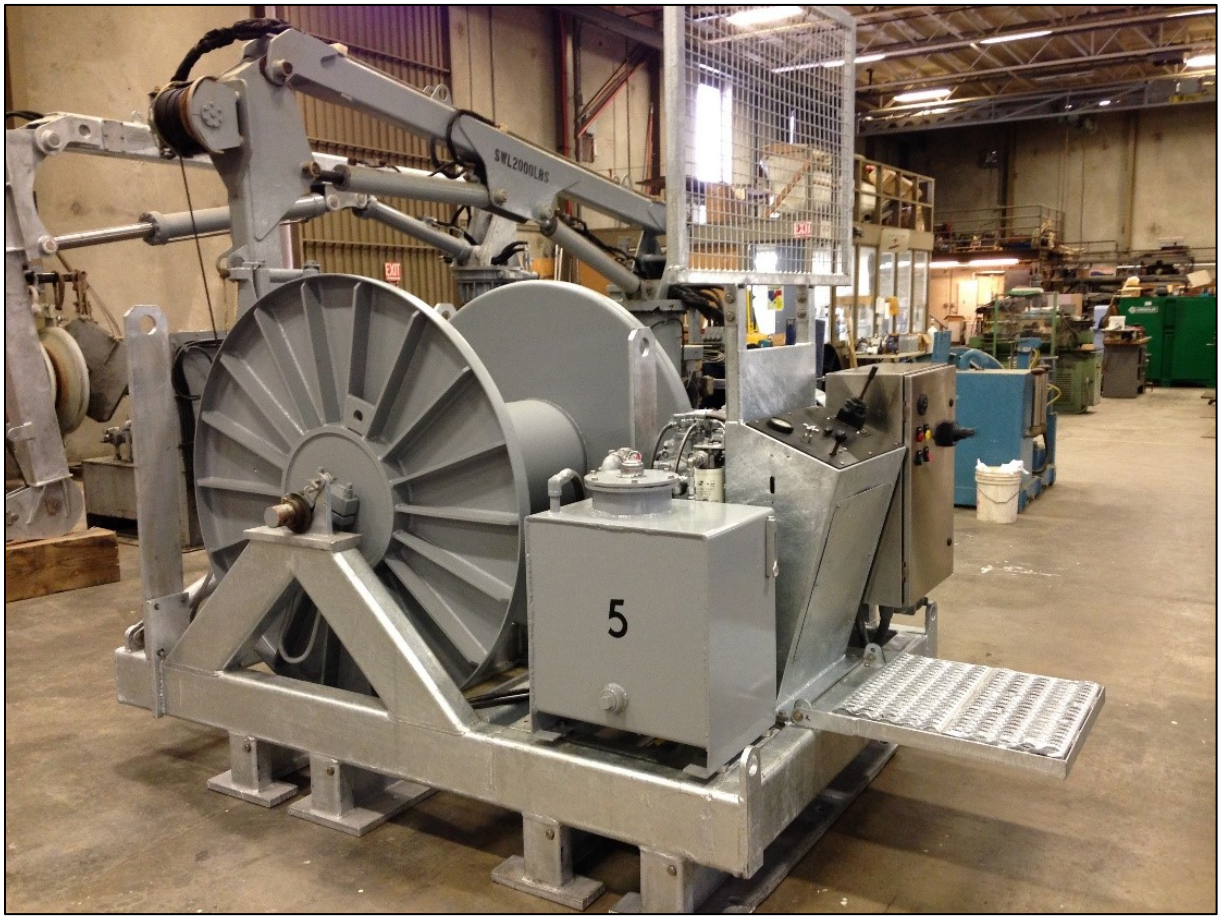

Figure 1: A TSE SDP-70 line tensioning spooler.

The west coast winch pool has four of these spoolers. They're constantly in use--generally for spooling moorings onto or off of the surface of the ocean. The west coast winch pool endorses using them this way because it places a relatively light load on the spooler.

At times these spoolers are also used for hoisting mooring anchors and other loads beneath the surface of the water. The west-coast winch pool hasn't historically endorsed using them this

way because we haven't known the limits of the spoolers in great detail and, because of their nature, these operations can impart loads on the spoolers many times greater than anticipated. To make matters worse, operators have no way of knowing the load on these spoolers because they don't have tension meters.

Our primary concern has been with the drum. Some editions of the SD-70 manual state the spoolers can damage their drums by applying excessive tension to a line. The manuals don't state how much tension, or what other conditions are required for the damage to occur.

Our community needs a portable winch that can safely hoist mooring anchors beneath the surface of the water. One purpose of this project is to better understand the conditions leading to a drum failure. Another purpose is to determine if, or under what conditions the TSE SD-70 spooler could be safely used for this purpose.

Loads and Failure Criteria

The drum was examined in three ways. First, hand calculations were done to determine the stress at which the drum would collapse. Then, a hoist design procedure was used to determine the amount of line tension required to create that stress. A safety factor of 1.5—to drum collapse—was used in these calculations.

Next, hoist design criteria from a DNV standard were used to determine the relative strength of the drum cheeks, and the minimum pitch (see Fig. 2) required to prevent the drum from collapsing under the spooler's power. These calculations assumed an allowable stress as high as 85% of the yield stress.

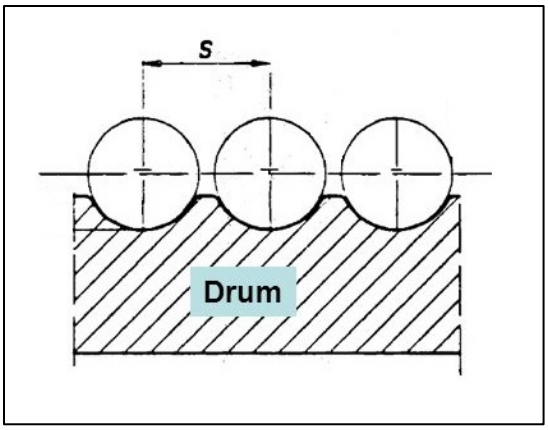

Figure 2: Pitch (s) is the distance between the wraps on a drum.

Shearing of the drum's shaft was examined as well. This calculation assumed failure would occur due to shearing in the narrow space between the drum and drive-side bearing. It used a safety factor of 1.5 to yield.

The shaft and drum materials are an unknown steel. For safety's sake, all calculations assumed them to be (rather weak): ASTM A36.

Approach 1: determining SWT as a function of line diameter

When a winch or hoist possesses a single layer of line it's straightforward to determine the line tension causing the drum to collapse. The same isn't true when there are multiple layers. Upper layers tend to squeeze lower layers into a smaller diameter-- lessening their tension and the pressure they place on the drum by an unknown amount. For this reason testing and/or design procedures based on empirical evidence are required to predict the safe working tension (SWT) on a multi-layer winch drum.

Omer Blodgett's book *Design of Weldments*[1] contains one of these design procedures. It relates minimum drum thickness, drum diameter, and line tension for winches multiple layers of line. It was used to calculate the drum's critical pressure (the pressure on the surface of the drum causing it to collapse) and, because the safe working tension in this procedure depends on line diameter, safe working tension was calculated for many common line diameters[2]:

Line Diameter (in.)	SWT (lbf)
.25	2,012
.38	3,078
.50	4,184
.56	4,757
.62	5,330
.75	6,515
.88	7,740
1.0	9,005

Table 1: SWT vs. Line Diameter as calculated using the procedure found in *Design of Weldments*.

[1] Blodget, Omer. Design of Weldments. Cleveland: The James F. Lincoln Arc Welding Foundation, 1963. 5.3-6 – 5.3-10.

[2] These calculations may be viewed in the spreadsheet *2018-04-09 O. BLODGET CALCULATIONS.xlsx*

These SWTs seem somewhat low. Anecdotal evidence suggests much greater tensions than these can be used without breaking the drum. This discrepancy is probably because this design procedure assumes the line is spooled onto the drum without gaps. Moorings are often spooled with large gaps in between wraps, which places far less pressure on the drum. These results pose another problem as well.

For safety reasons apparatus made to tow or lower items beneath the surface of the water must be able to withstand the breaking strength of their tension members (lines, cables, and wire ropes). According to the manufacturer, the SD/SDP-70 spoolers shouldn't be subjected to line tensions above 20,000 lb. These results suggest a minimum line diameter of .88" is required to prevent the spoolers from damaging themselves. The breaking strength of a typical .88" dia. synthetic line is 90,800 lb.—far too strong to be safely used with these spoolers.

This line of investigation was abandoned because it didn't reveal a safe way to use the SD/SDP-70 spoolers to hoist mooring anchors beneath the surface of the water.

Approach 2: applying DNV standard for certification no. 2.22

DNV standard for certification no. 2.22, *Lifting Appliances,* contains design guidelines for winch drums. They're also based on empirical evidence[3]. Instead of line diameter, the guideline for drum thickness considers minimum line pitch and tension. This relationship was used to form this useful table giving a minimum pitch for various line tensions (SWTs)[4]:

Minimum Line Pitch (in.)	SWT (lbf)
0.3	2000
0.5	4000
0.8	6000
1.0	7500

Table 2: SWT vs. line pitch as calculated using the DNV procedure.

[3] The June 2013 revision was used. Sections 2.2.7 and 2.2.8 contain formulae for calculating drum thickness and flange strength.
[4] These calculations may be viewed in the spreadsheet *2018-04-09 DNV PITCH VS. TENSION.xlsx*

This DNV standard also includes minimum strength requirements for winch drum flanges. Finite element analysis[5] was used to determine if the SD/SDP-70's flanges met these requirements. They did not. They possessed 25% of the suggested strength. One image of the FEA results is below.

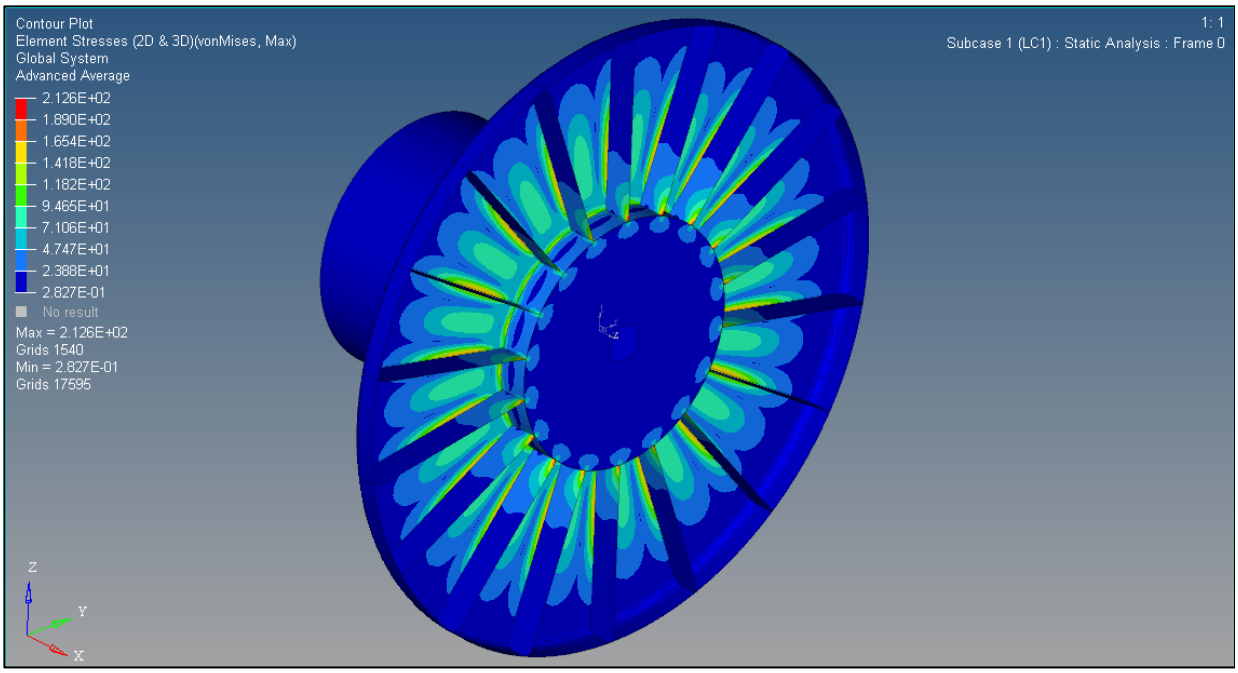

Figure 3: Results for the drum flange FEA. This plot is of Von Mieses stress. Only 25% of DNV's suggested design load was required to reach the allowable stress--85% of the material's yield strength or 212.6 Mpa. The material was assumed to be ASTM A-36 steel.

Conclusion

It's no surprise the SD/SDP-70 drums didn't meet all the requirements in the DNV standard. They were never intended to. The DNV standard was a good tool for assessing the drum nonetheless. It shed enough light on the drum's weaknesses to draft procedures for avoiding them. The SD/SDP-70 spoolers can be used safely to tow or lower objects beneath the surface of the water if these procedures in the recommendations section are observed.

[5] The FEA model and analysis results file *107 TSE SD-70 DRUM STRENGTH.mvw,* can be viewed using Altair HyperWorks software.

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Recommendations

Regardless of the tension member or mooring's construction (steel or synthetic), a deployment's estimated maximum tension (EMT) should be calculated using procedures in the latest revision of RVSS Appendix A including a dynamic factor of 1.75 or more. The EMT must never exceed 7,500 lbf.

Table 2 should be used to determine an appropriate pitch for each operation. An appropriate pitch is one resulting in a SWT greater than or equal to the EMT. When hauling in, operators must use a pitch sufficient to prevent damage to the spooler drum.

When hauling in, to the best of their ability, operators should prevent the tension member or mooring from contacting the drum flanges.

Contact information

If you have any questions regarding the contents of this report, feel free to contact the SIO Winch and Wire Engineer:

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