Blocks, Tackles, Cordage, Sailcloth

Toronto Brigantine Grade III

Parts of a Block

1. Hook
2. Inner Strap
3. Outer Strap
4. Pin
5. Swallows
6. Cheeks
7. Sheaves — either plain, roller, or self-lubricating
8. Breach
9. Becket
10. Thimble
11. Shell

Oxford Companion to Ships and the Sea

Types of Blocks

- Single block
- Double block
- Triple block
- Fiddle block
- Snatch block

The complete Rigger’s Apprentice, Brion Toss 1998

Types of Sheaves

Kevlar flat-bottomed wire and rope V-grooved rope semicircular wire and rope notch

The complete Rigger’s Apprentice, Brion Toss 1998
How do Blocks and Tackles Work?

- To lift this 100 lb weight 100 ft you will need to pull 100 ft of line
- There is no mechanical advantage to this

We have added a pulley
- But we are still lifting 100 lbs and pulling 100 ft of line
- No mechanical advantage and we have only changed the direction

We have now added another pulley
- The ring in the ceiling is holding 50 lbs, and the pulley in the ceiling is holding 50 lbs
- So now the weight we are lifting is half, but we have to pull twice as much line to raise it the same amount
- This a 2:1 advantage

We have now added another pulley
- The person pulling is now only has to pull 25 lbs, but they must pull 400 ft of line to raise the object 100 ft
- This a 4:1 advantage
How do you calculate your mechanical advantage?

- In a block and tackle there will be a stationary block that is attached to part of the vessel, and a block attached to a moving object (sail, dory, yard, boom etc).
- When calculating mechanical advantage focus on the moving block
- Count the number of lines entering or exiting a sheave, or attached to a becket

Mechanical Advantage

- Notice A and B are the same block and line arrangement just reversed, but B has a 2:1 advantage and A only has a 1:1. This is the same for C and D with a 3:1 vs 2:1
- When the line you are pulling on is leading from the moving block it is **rove to advantage**, when it leads from the stationary block it is **rove to disadvantage**

Types of Purchases

- Single Whip
- Double Whip
- Double Purchase
- Gun Tackle
- Spanish Burton

Single Whip

- Rove to disadvantage
- 1:1
Double Whip

- Rove to disadvantage
- 2:1

Double Purchase

- Rove to disadvantage
- 4:1

Gun Tackle

- Rove to advantage
- 3:1

Spanish Burton

- Used to move cargo
- 4:1 advantage combined
Combined tackles

- Combined 12:1

Friction

- Friction increases as the number of sheaves increases
- There is roughly a 10% increase in the “weight” of an object per sheave
- If you are lifting the 250lb AP with a double purchase (two double blocks) you would have 4 sheaves, and the extra 10% due to friction would be 25lb per sheave = 100lbs, for a rough total “weight” of 250lb + 100lb = 350lb
- With a 4:1 purchase the weight that the person would have to pull would be roughly 350/4 = 87.5lb

Reeving methods

- Lacing: when blocks are facing the same direction and line is passed from one sheave to the next. Lots of friction produced when chock-a-block, wear on cheeks and line.
- Right-angle reeving: blocks are at right angles, less friction when chock-a-block
- Triple blocks should always have the fall leading from the middle sheave, this prevents the block from tipping with the force of hauling

Types of Rope Fibres

- Traditionally made from manila, hemp, linen, cotton, coir, jute, and sisal.
- Most rope is now made from synthetic fibers such as polypropylene, nylon and dacron.
Types of Rope fibres

• Polypropylene:
  – Stiff, hard to work with, hard on the hands, very little stretch, easily damaged by UV and heat, Floats

• Nylon:
  – Easy to work with, looses shape, easy on the hands, doesn’t float, can stretch up to 40% of its length, weak when wet

• Dacron:
  – Easy to work with, maintains shape, easy on hands, doesn’t float, not as stretchy as nylon

• Roblon:
  – Synthetic material (from Denmark) that looks like natural fiber, used on replica vessels

Rope Making

• Many fibres (A) are twisted together to form yarn (B)
• Many yarns are twisted together to form strands (C)
• Strands are twisted together to form rope (D)
• Rope is twisted together to form cable (E)

Traditional Rope Making

• Rope was made in a rope walk or ropery
• A traditional operational ropery remains in Chatham England. It is 346m (1135 ft) long, and when constructed was the longest brick built building in Europe capable of laying a 1,000 ft (300 m) rope

Laid Line

• Hawser
• Shroud
• Cable
Hawser Laid Line

- Hawser laid line generally consists of three strands twisted together, usually in a right-hand direction.
- Most of the lines used at TBI are Hawser laid.

Shroud Laid

- Ordinarily, a shroud-laid line is composed of four strands twisted together in a right-hand direction around a center strand or core.
- This core is usually of the same material but smaller in diameter than the four strands.
- Shroud-laid line is more pliable and stronger than hawser-laid line.
- Shroud-laid line has a strong tendency to kink.

Cable Laid Line

- Consists of three hawser laid lines twisted together

Braided Line

- Inner core: prevents stretch and provides strength
- Outer braid: prevents damage from abrasion, UV, chemicals
- Made from synthetic materials like nylon, polyester and spectra

http://www.urbanhart.com/shopsite/rope_polyesterind.html
http://redpointropes.com/rope.html
Types of Braided line

• Hollow Braid: has no core, is very flexible but can flatten during use. It is only found in small sized rope.

• Parallel Core: has a braided sheath over a core of straight or lightly twisted yarns – it is very strong.

• Braid on Braid: has a braided core inside a braided sheath - will stretch less and has less flexibility than a hollow braid.

Braided vs Laid

• Compared to braided line, laid line is generally:
  – Not as strong
  – Stretches more (better for mooring lines or anchor lines)
  – Easier to splice
  – Less expensive
  – More traditional look

Rope Strength

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Nylon</th>
<th>Polypropylene</th>
<th>Manila</th>
<th>Sisal</th>
</tr>
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<tbody>
<tr>
<td>1/4&quot;</td>
<td>124</td>
<td>1,485</td>
<td>113</td>
<td>1,130</td>
</tr>
<tr>
<td>5/16&quot;</td>
<td>192</td>
<td>2,250</td>
<td>171</td>
<td>1,710</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>278</td>
<td>3,330</td>
<td>244</td>
<td>2,440</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>525</td>
<td>5,760</td>
<td>420</td>
<td>3,780</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>935</td>
<td>9,360</td>
<td>700</td>
<td>5,600</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>1,420</td>
<td>12,750</td>
<td>1,090</td>
<td>7,650</td>
</tr>
<tr>
<td>1&quot;</td>
<td>2,520</td>
<td>22,500</td>
<td>1,800</td>
<td>12,600</td>
</tr>
<tr>
<td>1.1/2&quot;</td>
<td>5,320</td>
<td>47,700</td>
<td>3,820</td>
<td>26,800</td>
</tr>
<tr>
<td>2&quot;</td>
<td>9,200</td>
<td>82,800</td>
<td>6,700</td>
<td>46,800</td>
</tr>
</tbody>
</table>

For comparison a 5/16 wire rope (6x19) has a 10,540 lb breaking strength. If unsure, figure the working load is 1/10th of the breaking strength.

Comparison of Rope materials

<table>
<thead>
<tr>
<th></th>
<th>Manila</th>
<th>Nylon</th>
<th>Dacron</th>
<th>Polyprop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Strength</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Relative weight</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Elongation</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Relative resistance to impact or shock</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Mildew and Rot resistance</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Acid resistance</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
<tr>
<td>Alkali resistance</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sunlight resistance</td>
<td>Fair</td>
<td>Fair</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Organic solvent resistance</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Melting Point (Degrees F)</td>
<td>380</td>
<td>410</td>
<td>410</td>
<td>300</td>
</tr>
<tr>
<td>Floatability</td>
<td>Only new</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Relative Abrasion Resistance</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

1=lowest, 4=highest

Feeney Wire rope and rigging
Roblon (Spunflex)

- 3 laid line
- Made of fibrillated polypropylene film yarns
- UV stabilized and resistant to acids, alkalis and sunlight
- Colour of hemp, so it has that traditional look
- Used on many traditionally rigged ships and STVs

Knots and Splices and Strength of Rope

- Knot is the weakest part of a line
- Knots with sharp curves like an overhand knot are the weakest knots
- Knots with broad curves are generally stronger

<table>
<thead>
<tr>
<th>Knot Type</th>
<th>% Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Rope</td>
<td>100%</td>
</tr>
<tr>
<td>Anchor or Fisherman's bend</td>
<td>76</td>
</tr>
<tr>
<td>Timber hitch</td>
<td>70-65</td>
</tr>
<tr>
<td>Round turn</td>
<td>70-65</td>
</tr>
<tr>
<td>Two half-hitches</td>
<td>70-65</td>
</tr>
<tr>
<td>Bowline</td>
<td>60</td>
</tr>
<tr>
<td>Clove hitch</td>
<td>60</td>
</tr>
<tr>
<td>Sheet bend</td>
<td>55</td>
</tr>
<tr>
<td>Reef knot</td>
<td>45</td>
</tr>
<tr>
<td>Eye Splice</td>
<td>95-90</td>
</tr>
<tr>
<td>Long Splice</td>
<td>87</td>
</tr>
<tr>
<td>Short Splice</td>
<td>85</td>
</tr>
</tbody>
</table>

Splices

- You should already know how to do the following:
  - Eye splice
  - Back splice
  - Short splice

Long Splice

- Used to join together two lines
- Repair a broken or damaged line
- The diameter of the line does not increase, unlike with a short splice
Long Splice

Wire Rope

• Consists of wires twisted into strands which are twisted into rope
• May contain a core made of fibre or wire rope

http://www.industrialrope.com/class.html

Types of Wire Rope

• Classified by the Lay
  – Regular: strands laid in the opposite direction of the rope, better resistance to crushing, less rotation when ends are not fixed
  – Lang: strands laid in the same direction as the rope, more flexible, better resistance to fatigue and wear

• Both Lang and regular lay have the same breaking strength
• Classified by the number of strands (eg 6) and wires (eg 19) in each strand 6x19,


Wire rope with more small wires is more flexible, but is less resistant to abrasion and corrosion
Splices and Swages

- Advantage of splices is that they can easily be inspected for wear and corrosion
- Swages are the commercial alternative to splices
- If you want a splice you have to do it yourself

Serving

- Protects wire rope and line from wear and chafe
- Protects wire rope from corrosion

Worming and Parceling

- “Worm and parcel with the lay, turn and serve the other way”
- Worming is done with linseed oil soaked marlin
- The worming material is placed between the strands of the wire rope
- Parceling was traditionally done using sailcloth. Now it is often done with cloth tape (hockey tape)
- Worming and parceling provides an even surface for serving

Sail Theory – How a sail works

- Downwind:
  - sail merely traps the wind
  - boat is being pushed forward
Sail Theory – How a sail works

- Upwind: Bernoulli’s Principle
  - Windward side = high pressure
  - Leeward side = low pressure
- Sail is sucked towards the low pressure, pulling the boat forward

TBI Sails

<table>
<thead>
<tr>
<th></th>
<th>Pathfinder</th>
<th>Playfair</th>
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<tbody>
<tr>
<td>Main</td>
<td>Topgun</td>
<td>Topgun</td>
</tr>
<tr>
<td>Main Stays’l</td>
<td>Topgun</td>
<td>Topgun</td>
</tr>
<tr>
<td>Jib</td>
<td>Topgun</td>
<td>Topgun</td>
</tr>
<tr>
<td>Course</td>
<td>Topgun</td>
<td>Oceanus</td>
</tr>
<tr>
<td>Tops’l</td>
<td>Topgun</td>
<td>Oceanus</td>
</tr>
<tr>
<td>Jibtop</td>
<td>Topgun</td>
<td>Topgun</td>
</tr>
<tr>
<td>Fisherman</td>
<td>Dacron</td>
<td>Dacron</td>
</tr>
<tr>
<td>Gaff Tops’l</td>
<td>Destiny</td>
<td>Destiny</td>
</tr>
</tbody>
</table>

Topgun

- Topgun is a Polyester based cloth, originally intended for use as a tarpaulin/sailcover.
- Andy has found it works quite well for what we need.
- Cheaper than the sailcloths actually designed to replicate older materials.
- Although not designed as a sailcloth it possess many of the qualities that TBI requires such as strength and UV resistance.

Oceanus

- Polyester based cloth
- Designed for use as a sailcloth.
- Andy is not a big fan, but feels it works alright for squares
- More expensive than Topgun.
**Dacron**

- Dacron is also polyester based
- Andy does not use it for making many of our sails anymore
- Commonly used in more modern rigs

**Destiny**

- Destiny is a Duradon derivative (another polyester)
- Andy felt would give flatter setting, and it has

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**Sail Cloth Comparison**

<table>
<thead>
<tr>
<th>Sail Cloth</th>
<th>Shape Retention</th>
<th>Strength to Weight</th>
<th>Aesthetic Appeal (colour, feel, smell)</th>
<th>Durability</th>
<th>Ease of Handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Poor</td>
<td>Low</td>
<td>Excellent</td>
<td>Good</td>
<td>Good (poor when wet)</td>
</tr>
<tr>
<td>Flax</td>
<td>Poor</td>
<td>Low</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Duradon</td>
<td>Fair</td>
<td>Med-Low</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Soft Dacron</td>
<td>Good</td>
<td>Med</td>
<td>Good</td>
<td>Good</td>
<td>Good/Excellent</td>
</tr>
<tr>
<td>Firm Dacron</td>
<td>Excellent</td>
<td>Med-High</td>
<td>Poor</td>
<td>Fair</td>
<td>Poor</td>
</tr>
<tr>
<td>Cruising Laminates</td>
<td>Excellent</td>
<td>High</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Racing Laminates</td>
<td>Excellent</td>
<td>Very High</td>
<td>Poor</td>
<td>Poor</td>
<td>Fair</td>
</tr>
</tbody>
</table>

**Characteristics to look for in Sailcloth**

- Strength
- Amount of stretch
- Resistance to UV damage
- Feel of the fabric
- Cost
- Easy to work with
Sail Damage

• Torn sails:
  – Straight tear: sail caught on rigging
  – L-tear: sail caught on rigging
  – Jagged tear: excessive stress
• Worn sails
  – UV damage: becomes brittle
  – Sail becomes thin from chafing

Sail Repair

• Short straight tears can often be repaired by stitching up the hole (or using Sail tape if you are on a Yachty boat)
• Longer tears, jagged tears and L-shaped tears can be stitched but often require a patch over the area to reinforce the sail
• Worn places in a sail can sometimes be repaired with a patch, but if it is extensive then the sail may have to be replaced

Stitches

• Round Stitch: sewing seams
• Herringbone Stitch: repairing tears

Round Stitch

• Used for sewing seams and patches
**Herringbone**

- Stitch is started before the rip
- Stitches are not all at the same distance from the tear

**Sailmaker’s Herringbone**

- Very similar to the basic herringbone, but with an extra locking stitch
- Stronger and fills the hole better than regular herringbone

**Sewing Patches**

1. Cut out the lumpy portion of the damaged area, pin out the sail, and measure the patch dimensions.
2. Cut the patch, fold its hem under, and place it over the damaged area.
3. Pin the patch, make the strike-up marks, and draw the sew-to line around the patch.
4. Staple the patch, pull the pins, and flat stitch the outer edge of the patch to the sail, maintaining alignment of strike-up marks.
5. Turn the sail over and remove the remainder of the damaged cloth. Leave enough cloth for a seam and hem.

6. Fold the hems under, staple, and sew.