SWR & WINCHES

• WHAT IS THE STEEL WIRE ROPE-SWR?
• GRADE OF SWR
• HOW TO DETERMAINE THE CAPACITY OF SWR
• SAFETY FACTOR OF SWR
• AUSTRALIAN STANDRADS SWR & WINCHES
• WINCHES & SHEAVES
What is the Steel Wire Rope (SWR)?

• I hope that at the end of this presentation we will be able to determine a proper definition for SWR!

• Now, I would like to ask everybody to imagine the world we are living in without the SWR!

• Can you imagine all the town and cities, high rise buildings, bridges and roads, cars, mining and construction machinery, airplanes, space shuttles and space station, dentistry, hospitals, etc. without SWR?

• The world we know and live in wouldn't exist without SWR.
What or better say how much do we know about SWR?

What did we learn about SWR at schools, universities and other institutions?

ANSWER is simple: NOT MUCH OR NOTHING!

Is it correct if we asked a dogman or a crane operator what is the capacity of a 16 mm SWR sling that they would give us a straight answer and advise that it is $8d^2=2000$ [kg]. However, if we asked an engineer the same question he or she would not be able to answer the question. The best they would do is ask for a SWR certificate and again try and guess in answering what should have been a simple question.
Here is an example
Example continued
Questions

1. Is this SWR with WLL off 1500 good to safely lift the load?
2. What is the value of pull force F at the lifting of the load G?
HOW TO MAKE THE **SWR**

http://www.youtube.com/watch?v=By8K5mKSwDA
http://www.youtube.com/watch?v=eDVf71xd2cQ
HOW TO MAKE THE

http://www.youtube.com/watch?v=eDVf71xd2cQ
THE SWR

TESTING:
http://www.you
HOW TO SELECT THE SWR

• FIRSTLY USE APPROPRAITE STANDARDS TO CLASIFY SWR
• DETARIMEN THE SWR CAPACITY
• FLEET ANGLE–WINCH DRUM-SHEAVE-ANCHOR POINT
• WINCH DRUM AND SHEAVE DESIGN
• SWR LENGTH

AUSTRALIAN STANDRADS
ISO STANDARDS
EN-STANDARDS
BS-STANDARDS
AMERICAN STANDARDS
HOW TO SELECT THE SWR

AUSTRALIAN STANDARDS

- AS-1418-1,...,19
- AS-2550-1,...,19
- AS-2759 Steel wire rope — Use, operation and maintenance
- AS-3596 Steel wire ropes — Product specification
- AS-1666-1 Wire-rope slings/Part 1: Product specification
- AS-1735-1...18 Lifts, Escalators and moving walk;
HOW TO SELECT THE **SWR**

AUSTRALIAN STANDRADS

- AS-1418-1,...19
- AS-2550-1,...19
- AS-2759 Steel wire rope — Use, operation and maintenance
- AS-3596 Steel wire ropes — Product specification
- AS-1666-1 Wire-rope slings/Part 1: Product specification
### HOW TO SELECT THE SWR & WINCH

- **SWR GRADE**

<table>
<thead>
<tr>
<th>Rope grade</th>
<th>Range of wire tensile strength grades (N/mm², MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1570</td>
<td>1370 to 1770</td>
</tr>
<tr>
<td>1770</td>
<td>1570 to 1960</td>
</tr>
<tr>
<td>1960</td>
<td>1770 to 2160</td>
</tr>
<tr>
<td>2160</td>
<td>1960 to 2160</td>
</tr>
</tbody>
</table>
• ROPE CLASS AND CONSTRUCTION
  • ROPE CLASS IS A GROUPING OF ROPES OF SIMILAR PROPERTIES AND PHYSICAL CHARACTERISTICS;
  • ROPE CONSTRUCTION REFERS TO DETAIL AND ARRANGEMENT OF THE VARIOUS ELEMENTS OF THE SWR.

• FACTORS, AREAS, MASSES AND BRAKING FORCES
  • FILL FACTOR (f) \( f = \frac{A}{A_u} \)

  \( A \)-nominal metallic cross sectional areas of all the wires in the rope;

  \( A_u \)-circumscribe area
HOW TO SELECT THE **SWR & WINCH**

- FACTORS, AREAS, MASSES AND BRAKING FORCES
  - MEASURED ROPE LENGTH MASS $M_m$
    - $M_m$ is determined by weighing and is expressed in kilograms per 100 m
FACTORS, AREAS, MASSES AND BRAKING FORCES

- Minimum braking force factor $K$

$K$ is an empirical factor used in the determination of minimum braking force of a rope and obtained from product fill factor $f$ factor for the class or construction, spinning loss factor $k$ for the rope class or construction and $(\pi/4)$

$$K = (\pi/4) \times f \times k$$
## HOW TO SELECT THE SWR & WINCH

### CALCULATION OF MINIMUM BREAKING FORCE FOR ROPES LISTED IN THE TABLES OF APPENDIX C

<table>
<thead>
<tr>
<th>Class</th>
<th>Minimum breaking force factor (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 × 7 with fibre core (see Table C1)</td>
<td>0.332</td>
</tr>
<tr>
<td>6 × 7 with steel core (see Table C2)</td>
<td>0.359</td>
</tr>
<tr>
<td>6 × 24FC with fibre core (see Table C3)</td>
<td>0.286</td>
</tr>
<tr>
<td>6 × 37M with fibre core (see Table C4)</td>
<td>0.295</td>
</tr>
<tr>
<td>6 × 19M with fibre core (see Table C5)</td>
<td>0.307</td>
</tr>
<tr>
<td>6 × 19 with steel core (see Table C6)</td>
<td>0.356</td>
</tr>
<tr>
<td>6 × 19M with steel core (see Table C7)</td>
<td>0.332</td>
</tr>
<tr>
<td>6 × 36 with fibre core (see Table C8)</td>
<td>0.33</td>
</tr>
<tr>
<td>6 × 36 with steel core (see Table C9)</td>
<td>0.356</td>
</tr>
<tr>
<td>8 × 19 with steel core (see Table C12)</td>
<td>0.356</td>
</tr>
<tr>
<td>8 × 36 with steel core (see Table C13)</td>
<td>0.356</td>
</tr>
<tr>
<td>18 × 7 (see Table C15)</td>
<td>0.238</td>
</tr>
<tr>
<td>34(M) × 7 (see Table C16)</td>
<td>0.318</td>
</tr>
<tr>
<td>35(W) × 7 (see Table C17)</td>
<td>0.360 (rope grade ≤1960)</td>
</tr>
<tr>
<td>35(W) × 7 (see Table C17)</td>
<td>0.350 (rope grade &gt;1960)</td>
</tr>
</tbody>
</table>
HOW TO SELECT THE **SWR & WINCH**

- Minimum Braking Force $F_{\text{min}}$
  - Minimum braking force $F_{\text{min}}$ is a specific value, expressed in kN, below which the measured braking force $F_{\text{m}}$ is not allowed to fall in a prescribed braking force test

\[ F_{\text{min}} = \left( d^2 \times Rr \times K \right)/1000 \, [\text{kN}] \]

- $d$ – nominal rope diameter
- $Rr$ – rope grade
- $K$ – braking force factor
HOW TO SELECT THE **SWR & WINCH**

- Calculated Minimum Braking Force \(F_{c.min}\)
  - The Calculated minimum braking force \(F_{c.min}\) is based on the nominal wire sizes, wire tensile strength grades and spinning loss factor for the rope class or construction as given in manufacturer’s rope design.

- Measured Braking Force \(F_m\)
  - The measured braking force \(F_m\) is obtain using a prescribe method. (see Section 6/ AS3569)
• Measured Aggregated Braking Force $F_{e.m}$
  
  • The measured aggregated braking force $F_{e.m}$ is the sum of the measured braking forces of all the individual wires taken from roper.

• Spinning loss factor $k$

  • The spinning loss factor $k$ is the ratio between either the calculated minimum aggregated braking force $F_{e.c.min}$ and calculated minimum braking force $F_{c.min}$ of the rope or the specific minimum aggregated braking force $F_{e.min}$ and specified minimum braking force $F_{min}$ of the rope, as determined from rope maker’s design.
• Calculated minimum aggregated braking force $F_{e.c.m}$

• The calculated minimum aggregated braking force $F_{e.c.m}$ is calculated from the sum of the products of cross-sectional area (based on nominal wire diameter) and tensile strength grade of each wire in the rope as per manufacturer’s specification.
SAFETY FACTOR SF

WHAT IS “SAFETY”?
SAFETY FACTOR SF

SAFETY IS ABSENCE OF DANGER!
SAFETY FACTOR SF

HOW DO WE MEASURE THE APSENCE OFF DANGER?
SAFETY FACTOR SF

- WHAT IS “SAFETY”?  
- SAFETY IS ABSENCE OFF DANGER!  
- HOW DO WE MEASURE THE ABSENCE OFF DANGER?

- THE FIRST ATTEMPT IS TO DEFINE THE SAFETY FACTORS!  
- THE STORY OFF THE SAFETY FACTOR IS A STORY OF TRIAL AND ERROR.  
- LONG PERIOD WITHOUT ACCIDENT ENCOURAGE THE ENGINEERS TO LOWER SAFETY FACTORS.  
- SUDDEN FAILURE OFF STRUCTURE-SWR, ON THE OTHER HAND, WOULD TELL THE ENGINEER THAT THEY HAD TO INCREASE THE “ABSENCE OF DANGER” BY RAISING SAFETY FACTOR TO ACCOUNT FOR UNKNOWN STRESS OR STRESS CONCENTRATION.
THE SAFETY FACTOR CAN BE KNOWN AS THE

“FACTOR OFF IGNORANCE”
THE SWR

- INCIDENTS:

http://www.youtube.com/watch?v=4OOg7vL3rNY
Rope safety factor = minimum breaking force $F_{\text{min}}$/ nominal rope tensile force $S$
In 1847, the Dee bridge in the UK, designed by the famous engineer Robert Stephenson, collapsed under the weight of a railway train only eight months after its completion. A jury analysed the failure and found that the safety factor had been as low as 1.6. The jury decided that the safety factor for future bridges built in the UK should not be less than 6.
The Brooklyn Bridge

John Roebling, the designer of the East River Suspension Bridge, today better known as the Brooklyn Bridge, was not the only one of the leading bridge builders of his time. He was also the first manufacturer of wire rope on the American continent.
The suspension ropes on the Brooklyn Bridge were also designed with a safety factor of 6. During the time the bridge was being built, John Roebling died, and his son Washington Roebling continued his work.

After the stone towers were completed in 1877, the main cables were spun in place. Wire by wire was pulled over the pylons so that it could adopt its natural catenary, and then it was bundled with the other wires. This procedure, invented by John Roebling, allowed the wires inside the bend to be shorter and the wires outside the bend to be longer than those in the center, guaranteeing a uniform stress distribution over the cable cross section.
Before installation, every steel wire was tested by an independent observer, and wires with insufficient strength were rejected.

In 1878, Washington Roebling noticed that the pile of rejected wire, which should be slightly growing each week, had actually almost disappeared. He started a secret investigation and found that all the rejected wires had been worked into the main cables anyway!
Consequently SF was reduced to 5.

During construction the owner decided to add railway tracks!

SF was reduced again to 4.

Roebling decided the bridge was still "safe" and modified it as requested.
Time has proved him correct:

Heavy railroad trains crossed the bridge for more than 50 years, and after more than 120 years of heavy daily traffic the main cables of the Brooklyn Bridge are still in place.
### TABLE 7.3.4.2
CLASS OF UTILIZATION OF MECHANISMS

<table>
<thead>
<tr>
<th>Class of utilization</th>
<th>Total duration of use $H$</th>
<th>Description of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>$H \leq 200$</td>
<td>Infrequent use</td>
</tr>
<tr>
<td>$T_1$</td>
<td>$200 &lt; H \leq 400$</td>
<td></td>
</tr>
<tr>
<td>$T_2$</td>
<td>$400 &lt; H \leq 800$</td>
<td></td>
</tr>
<tr>
<td>$T_3$</td>
<td>$800 &lt; H \leq 1600$</td>
<td></td>
</tr>
<tr>
<td>$T_4$</td>
<td>$1600 &lt; H \leq 3200$</td>
<td>Fairly frequent use</td>
</tr>
<tr>
<td>$T_5$</td>
<td>$3200 &lt; H \leq 6300$</td>
<td>Frequent use</td>
</tr>
<tr>
<td>$T_6$</td>
<td>$6300 &lt; H \leq 12500$</td>
<td>Very frequent use</td>
</tr>
<tr>
<td>$T_7$</td>
<td>$12500 &lt; H \leq 25000$</td>
<td></td>
</tr>
<tr>
<td>$T_8$</td>
<td>$25000 &lt; H \leq 50000$</td>
<td>Continuous or near continuous use</td>
</tr>
<tr>
<td>$T_9$</td>
<td>$50000 &lt; H \leq 100000$</td>
<td></td>
</tr>
<tr>
<td>$T_{10}$</td>
<td>$100000 &lt; H$</td>
<td></td>
</tr>
</tbody>
</table>
Safety factor of **SWR**

### Nominal Load Spectrum Factor and State of Loading for Crane Mechanisms

<table>
<thead>
<tr>
<th>Nominal load spectrum factor ((K_m))</th>
<th>State of loading</th>
<th>Description of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125</td>
<td>(L1)—Very light</td>
<td>Mechanisms subjected very rarely to the maximum load and, normally, to very light loads</td>
</tr>
<tr>
<td>0.25</td>
<td>(L2)—Light</td>
<td>Mechanisms subjected fairly frequently to the maximum load but, normally, to rather light loads</td>
</tr>
<tr>
<td>0.50</td>
<td>(L3)—Medium</td>
<td>Mechanisms subjected frequently to the maximum load and, normally, to loads of moderate magnitude</td>
</tr>
<tr>
<td>1.00</td>
<td>(L4)—Heavy</td>
<td>Mechanisms subjected with high frequency to the maximum load</td>
</tr>
</tbody>
</table>
Safety factor of SWR

7.3.4.4 Group classification

The group classification for the various combinations of class of utilization and state of loading shall be as given in Table 7.3.4.4.

NOTE: The application of group classification to specific types of crane mechanisms is covered in the appropriate parts of AS 1418.

<table>
<thead>
<tr>
<th>State of loading</th>
<th>Nominal load spectrum factor ($K_m$)</th>
<th>Class of utilization</th>
<th>Group classification of crane mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1—Light</td>
<td>0.125</td>
<td>$T_0$</td>
<td>$T_1$</td>
</tr>
<tr>
<td>L2—Moderate</td>
<td>0.25</td>
<td>$T_0$</td>
<td>$T_1$</td>
</tr>
<tr>
<td>L3—Heavy</td>
<td>0.50</td>
<td>$T_0$</td>
<td>$T_1$</td>
</tr>
<tr>
<td>L4—Very heavy</td>
<td>1.00</td>
<td>$T_0$</td>
<td>$T_1$</td>
</tr>
</tbody>
</table>

NOTE: Where class utilization calculations give a crane mechanisms group classification of greater than M8, as indicated by an asterisk (*), the mechanism shall be designed for the required rated life.
## Safety factor of SWR

### Minimum Coefficient of Utilization ($Z_p$) for Other Than Reeved Systems

<table>
<thead>
<tr>
<th>Classification of mechanism</th>
<th>Minimum coefficient of utilization ($Z_p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>2.5</td>
</tr>
<tr>
<td>M2</td>
<td>2.5</td>
</tr>
<tr>
<td>M3</td>
<td>3.0</td>
</tr>
<tr>
<td>M4</td>
<td>3.5</td>
</tr>
<tr>
<td>M5</td>
<td>4.0</td>
</tr>
<tr>
<td>M6</td>
<td>4.5</td>
</tr>
<tr>
<td>M7</td>
<td>5.0</td>
</tr>
<tr>
<td>M8</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Safety factor of SWR

- Rope coefficient (C)

- \( C = \frac{Z_p}{y \cdot f \cdot R_0 \cdot (\pi/4)} \cdot (1/2) \) OR

- \( C = \left( \frac{Z_p}{K' \cdot R_0} \right)^{1/2} \)

**K’** - the empirical factor of minimum breaking load of a given rope construction as provided by the rope supplier;

**R_0** - the minimum tensile strength of the wire used in the rope, in megapascals;

**Z_p** - the minimum practical coefficient of utilization

**f** - the filling factor (factor dependent on rope construction)

**y** - loss factor \( y = \frac{R_{1\text{min}}}{R_1} \)

**R_{1\text{min.}}** - the minimum braking strength of rope wires;

**R_1** - the calculated braking strength of the rope.
Safety factor of **SWR**

**CALCULATION OF MINIMUM ROPE DIAMETER** ($d_{\text{min}}$)

- $d_{\text{min}} = C \cdot (SR)^{1/2}$

$F_R$ - the maximum wire rope tension, in newtons, which is obtained by considering the following factors:

- (a) Rated capacity of the appliance;
- (b) Mass of the pulley block or other lifting attachments that increase rope tension;
- (c) Mechanical advantage of rope reeving;
- (d) Efficiency of the rope reeving;
- (e) The mass of the suspended length of the hoist rope, which shall be included when the load handled is more than 5m below the slewing mechanism of the lifting appliance;
- (f) Load due to acceleration (and retardation) of the load on the hook, if in excess of 10% of the vertical load;
- (g) Included angle of the rope at the upper hoisted position, if the rope angle is greater than 22.5°.
Safety factor of \textbf{SWR}

- CALCULATION OF MINIMUM ROPE DIAMETER \((d_{\text{min}})\)

- Prof Feyrer from university of Stuttgart - formula to predict the service life of wire ropes in reeving system with sufficient accuracy.

\[
\log N = b_0 + [b_1 + b_4 \times \log (D/d)] \times [\log (S \times d_0/d^2 \times S_0) - 0.4 \times \log (R_0/1770)] + b_2 \times \log (D/d) + b_3 \times \log (d/d_0) + 1/[b_5 + \log (d/d_0)]
\]

- \(N\)-indicate number of bending cycles;
- \(d\)-the nominal rope diameter in [mm];
- \(D\)-the diameter off the sheave [mm];
- \(S\)-the rope line pull in [N];
- \(L\)-the length of the most heavily strained rope zone in [mm];
- \(R_0\)-the nominal tensile strength of wire in [N/mm^2]
Safety factor of **SWR**

- MINIMUM WIRE ROPE BRAKING LOAD ($F_0$)

\[ F_0 = F_R \times Z_P \]

- $Z_P$ - the minimum practical coefficient of utilization
5.17.5 Design
The rope groove of a sheave shall be an arc of minimum radius 0.525 times the nominal diameter of the rope and shall be tangential with sides flared with an included angle of 35° symmetrical about the centre-line of the groove. The groove shall be smoothly finished and free from surface defects liable to damage the rope. The edge between grooves shall be rounded.

NOTE: For guidance on groove profiles for wire rope sheaves, see Appendix J.

7.17.2 Diameter of sheave
The diameter of each sheave shall comply with Clause 7.18.

7.17.4 Sheave guard
Where there is a possibility of the rope being dislodged from the sheave, for example, when the rope is not continuously under load, the sheave shall be provided with means to retain the rope in the groove.

Where required, sheave enclosures shall protect personnel from injury and protect the sheaves from falling debris and similar. Such sheave enclosures shall not prevent the wound condition of the wire rope on the sheave from being viewed.

7.18 DRUM AND SHEAVE DIAMETERS
The diameter of each drum and sheave shall be measured at the pitch diameter of the groove and, except where specified otherwise in the appropriate part of AS 1418, shall be not less than the value specified in Table 7.18, as appropriate, to the following equation:

NOTES:
1 For guidance on groove profiles for wire rope sheaves, see Appendix J.
2 For guidance on groove profiles for rope drums, see Appendix K.

\[
\begin{align*}
D_k & \geq \frac{d}{n_{\text{min}}} \\
D_k & \geq \frac{d_{\text{min}}}{n_{\text{min}}} \\
D_k & \geq \frac{d_{\text{min}}}{n_{\text{min}}}
\end{align*}
\]

where:
- \(D_k\) = pitch diameter of drum
- \(n_{\text{min}}\) = minimum ratio for drum
- \(d\) = nominal diameter of rope
- \(d_{\text{min}}\) = minimum design diameter of rope
- \(D_s\) = pitch diameter of sheave
- \(n_{\text{min}}\) = minimum ratio for sheave
- \(D_e\) = pitch diameter of rope equalizer sheave
- \(n_{\text{min}}\) = minimum ratio for rope equalizer sheave

Where a deflection sheave tensionometer is fitted, it shall be fitted only to the running section of the rope. Where the included angle of the deflected rope is not less than 160°, the ratio of deflection the sheave diameter to the rope diameter shall be not less than 3.
### HOW TO SELECT THE SWR & WINCH

#### RATIOS OF DRUM AND SHEAVE PITCH DIAMETERS TO ROPE DIAMETER

<table>
<thead>
<tr>
<th>Classification of mechanism</th>
<th>Minimum ratio of drum and sheave pitch diameter to steel wire rope diameter ((D_{id}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drums</td>
</tr>
<tr>
<td></td>
<td>((h_d))</td>
</tr>
<tr>
<td>M1</td>
<td>11.2</td>
</tr>
<tr>
<td>M2</td>
<td>12.5</td>
</tr>
<tr>
<td>M3</td>
<td>14.0</td>
</tr>
<tr>
<td>M4</td>
<td>16.0</td>
</tr>
<tr>
<td>M5</td>
<td>18.0</td>
</tr>
<tr>
<td>M6</td>
<td>20.0</td>
</tr>
<tr>
<td>M7</td>
<td>22.4</td>
</tr>
<tr>
<td>M8</td>
<td>25.0</td>
</tr>
</tbody>
</table>
HOW TO SELECT THE **SWR & WINCH**
HOW TO SELECT THE SWR & WINCH

(b) Flange of drum welded to bearing block
HOW TO SELECT THE SWR & WINCH

(c) Drum with gearwheel fitted to flange
HOW TO SELECT THE SWR & WINCH

(d) Drum with stiffener
7.19.3 Diameter of drum
The diameter of the drum shall comply with Clause 7.18.

7.19.4 Actual thickness of drum shell
The thickness of the drum shall, with due allowance for manufacturing allowance and inaccuracies, e.g., machining, core shift in casting and out-of-roundness in rolling, be not less than the value calculated in accordance with Clause 7.19.5.

A detailed method of stress analysis of a crane drum in accordance with Appendix L may be used in lieu of Clause 7.19.5.

The thickness of the drum shell shall be not less than 5 mm for grey iron drums or not less than 3 mm for drums of material other than grey cast iron.

7.19.5 Theoretical thickness of drum shell (abbreviated method)
The minimum theoretical thickness of the drum shell shall be calculated by the following equation:

\[ T_D = \left( T_{DB}^2 + T_{DB} T_{DC} + T_{DC}^2 \right)^{1/2} \]  

\[ \ldots 7.19.5 \]
HOW TO SELECT THE **SWR & WINCH**

\[
T_D = \text{minimum theoretical thickness of the drum shell measured, for a grooved drum, to the root of the rope groove, in millimetres}
\]

\[
\geq 5 \text{ mm for grey cast iron drums (see Clause 7.19.4)}
\]

\[
\geq 3 \text{ mm for drums of material other than grey cast iron (see Clause 7.19.4)}
\]

\[
T_{DB} = \text{minimum theoretical thickness of drum shell allowing only for beam-bending stresses, in millimetres}
\]

\[
= 1250 \frac{M}{D_{DM}^2 F_b}
\]

\[
T_{DC} = \text{minimum theoretical thickness of drum shell allowing only for compressive stresses, in millimetres}
\]

\[
= \frac{1000 K_{RL} P_{RS}}{p F_t} - 0.15d \quad \text{(for grooved drums)}
\]

\[
= \frac{1000 K_{RL} P_{RS}}{p F_c} \quad \text{(for ungrooved drums)}
\]
**HOW TO SELECT THE SWR & WINCH**

\[
M = \text{bending moment due to beam action of unfactored, i.e. static, rope load (P_{R,3}), in newton metres}
\]

\[
F_b = \text{permissible bending stress, in megapascals}
\]

\[
= 0.185 \text{ times the tensile strength for grey cast iron}
\]

\[
= 0.20 \text{ times the tensile strength for nodular graphite cast iron with elongation less than 12 percent}
\]

\[
= 0.67 \text{ times the yield stress for materials with elongation not less than 12 percent}
\]

\[
D_{DM} = \text{mean diameter of drum shell, in millimetres}
\]

\[
= D_{DN} - T_D
\]

\[
D_{DN} = \text{nominal diameter of drum shell}
\]

\[
= \text{for grooved drums, the diameter measured between the roots of the rope groove, in millimetres}
\]
HOW TO SELECT THE **SWR & WINCH**

$$K_{RL} = \text{rope layer factor and rigidity constant of drum shell}$$
- $= 1.0$ for single layer
- $= 1.3$ for two layers of rope with wire-rope core (WRC) or wire-strand core (WSC)
- $= 1.4$ for two layers of rope with fibre core (FC)
- $= 1.5$ for three layers of rope with WRC or WSC
- $= 1.6$ for three layers of rope with FC
- $= 1.6$ for more than three layers of rope with WRC or WSC
- $= 1.8$ for more than three layers of rope with FC

$$P_{Rs} = \text{maximum unfactored, i.e. static, rope load, in kilonewtons}$$

$$p = \text{pitch of rope coils, in millimetres}$$

$$F_c = \text{permissible compressive stress (see Table 7.19.5), in megapascals}$$

$$d = \text{nominal diameter of rope, in millimetres}$$
# HOW TO SELECT THE SWR & WINCH

TABLE  7.19.5
PERMISSIBLE COMpressive STRESS

<table>
<thead>
<tr>
<th>Material</th>
<th>Standard number</th>
<th>Grade</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤250</td>
<td>&gt;250, ≤500</td>
<td>&gt;500, ≤750</td>
<td>&gt;750</td>
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<tr>
<td>Grey cast iron</td>
<td>AS 1830</td>
<td></td>
<td></td>
<td>77</td>
<td>88</td>
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<tr>
<td>Nodular graphite cast iron</td>
<td>AS 1831</td>
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<td>Cast steel</td>
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<tr>
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</table>
HOW TO SELECT THE SWR & WINCH
HOW TO SELECT THE SWR & WINCH

REEVED SYSTEMS—ALLOWANCE FOR FRICTIONAL EFFECTS
(Normative)

Frictional resistance in a reeved system results in an increase in rope tension. This resistance is caused by bearing or journal friction and by internal friction induced in the rope by its flexing and unloading as it passes over each sheave.

Where a number of parts of rope support a load, the sum of the tension in each part is equal to the force applied by the load to the reeved system. When the system is stationary, the tension in each part is equal; when the system is in motion, half the parts have tension greater and half the parts have tension less than the average tension.

The value of maximum rope tension ($P_{\text{max}}$) in a reeved system may be calculated by the following equation:

$$P_{\text{max}} = \frac{(1 + \mu)^{N_{\text{s}}}}{1 + (1 + \mu)^{N_{\text{s}}} + (1 + \mu)^{2N_{\text{s}}} + \ldots + (1 + \mu)^{N_{\text{s}}}} P_{\text{L}} \quad \ldots (1)$$

where

- $P_{\text{max}}$ = maximum rope tension, in kilonewtons
- $\mu$ = friction allowance
- $N_{\text{s}}$ = number of falls of rope supporting $P_{\text{L}}$
- $N_{\text{L}}$ = number of deflection sheaves
- $P_{\text{L}}$ = load applied to the reeved system, in kilonewtons

The friction allowance depends on type, arrangement and method of lubrication of the sheave bearings, and the flexibility of the rope.

Where the number of falls is large, the inherent flexibility of the rope system and the lower speed of motion lowers impact and other dynamic effects and consequently the increase in rope tension is allowed to be absorbed into the load factor. Where the reeved system has more than 10 parts of rope supporting the load, frictional effects become of such significance that they cannot be disregarded.

Clause 7.16 requires allowance to be made for frictional effects. Where the system has more than 10 parts of rope supporting the load, frictional effects shall be considered.

The following example has been included in this Appendix to clarify the method of making such allowance.

Example:
Calculate the maximum rope tension ($P_{\text{max}}$) in the reeved system shown in Figure G.1.

DATA:

- $P_{\text{L}} = 100 \times 9.81$ kN
- $N_{\text{s}} = 12$
- $N_{\text{L}} = 3$
- $\mu = 0.02$ (assumed)

Applying the formula (1) with the given data:

$$P_{\text{max}} = \frac{(1 + 0.02)^{12}}{1 + (1 + 0.02)^{12} + (1 + 0.02)^{2\times12} + \ldots + (1 + 0.02)^{12}} 100 \times 9.81$$

After calculations:

$$P_{\text{max}} = 120 \text{ kN}$$
HOW TO SELECT THE SWR & WINCH
HOW TO SELECT THE **SWR & WINCH**
D = Nominal Rope Dia
R = Radius of Rope (D/2)

Groove Diameter
Rope Diameter

1.5 Rope Diam'

Sheave Groove with too much Clearance
Sheave Groove with too little Clearance
Sheave Groove with correct Clearance
APPLICATIONS
APPLICATIONS

[Image of workers on a power line]

PRTO60
Pera
APPLICATIONS
APPLICATIONS
APPLICATIONS
APPLICATIONS
What is the Steel Wire Rope (SWR)?

THE SWR IS MECHANISM
OR
THE SWR IS MACHINE ELEMENT
Answers:

2 - What is the value of pull force:

\[ F = 3G \]
Answers:

F > 3G
WLL = 1500
G = 500
\( \nu = \frac{WLL}{G} \)
\( \nu = 3 \)

THE ROPE DOESN’T HAVE CAPACITY TO LIFT THE LOAD SAFELY
WHAT DID WE LEARN FROM THE PREVIOUS EXAMPLE:

• THE SAFETY FACTOR OF THE SWR IS NOT ONLY DATA FOR DETERMINING THE REQUIRED CAPACITY OF THE SWR;

• IS IT POSSIBLE IN REAL LIFE TO HAVE THE SCENARIOS AS SHOWN IN THE EXAMPLE?

• THE SAFETY FACTOR RECOMMENDATION OF THE SWR IN MANY STANDARDS AND CALCULATIONS IS LESS THAN 3 !!!!
ADVICE

- Avoid dynamic loads (easier said than done);
- Don’t modify anything without consulting a qualified and competent engineer/designer;
- Inspect SWR frequently;
- Inspect SWR in the right place:
  - in the most fatigue zones;
  - at load pick up points;
  - at equalizer sheave;
  - on the drum;
- Inspect rope end connections;
- Measure the grooves of sheaves & drums;
- Keep an inspection Log Book.

- **APPROPRIATE DESIGN, WORK HAZARDS AND RISK ASSESSMENT IS REQUIRED.**
- **DO NOT USE THE SWR IF YOU DO NOT KNOW 100% ALL THE HAZARDS, RELATED RISKS, CONDITION AND CAPACITY OFF THE SWR.**
Every wire rope will fail if it is not taken out of service in time.
ADVICE

DO NOT EVER FEEL SAFE
THANK YOU