UNOLS RVSS Appendix A

Safety Factors
Equipment Characteristics
and Maintenance

A course outline
prepared for RVTEC 2013
with funding provided by the
National Science Foundation

By

Aaron E. Davis, PE
SIO Winch and Wire Engineer

1.0 Introduction

1.1 My Aims

I'm often presented with misconceptions regarding the content of UNOLS RVSS Appendix A. My goal is to present a literal interpretation of the requirements set forth in the latest edition (ed. 9 - 03/12/2009) so personnel within the community know, once and for all, what is and is not expected of them. I intend to point out which of its statements are suggestions rather than requirements. I'll also elaborate on the reasons surrounding the requirements in order to bring forth a better understanding of their importance.

1.2 A Note to the Reader/Audience

Presenting the true contents of Appendix A necessitates bringing its shortcomings to light--cases when the text and the intent of the UNOLS Safety Committee clearly differ. In doing this, I'm in no way attempting to poke fun at the document or those who worked to produce it.

In these cases, the Safety Committee has made it clear their intent must be carried out. To facilitate this, this course outline was reviewed by the Safety Committee; the committee's intent was inserted, where appropriate, to make it known. If the intent remains unclear, please contact the Safety Committee for clarification.

As the title page implies, this presentation only encompasses matters pertaining to equipment characteristics, their affect on factor of safety selection, and equipment maintenance considerations. Additional requirements are set forth in Appendix A.

2.0 Purpose

2.1 The Purposes of Appendix A are (§A.2.2):

- "...to maintain a safe working environment for all personnel onboard."
- "...to minimize damage to tension members and handling equipment, and the loss of scientific equipment..."
- "... while still permitting the science objective to be met."

3.0 Application

3.1 Appendix A applies to steel tension members only.

This is *implied* throughout the document. There are sections reserved for synthetic tension members, but they have not been added to date.

3.2 Appendix A applies to ***"...vessels in the UNOLS fleet for tension members loaded beyond traditional shore-side limits."*** (§A.2.1)

As Figure 1 (following page) shows, shore-side limits, or safety factors (FS) typically used on land-based equipment are generally much higher than those we may employ. Notwithstanding the statement in §A.2.1, table 6.1 on p. 119 includes requirements for FS ≥5, and therefore it includes requirements for tension members loaded within traditional shore-side limits as well.

3.3 Appendix A applies to tension members used as components of overboard handling systems.

§A.2.1. makes reference to 46 CFR 189.35 "*Weight Handling Gear*"--the federal regulation pertaining to overboard handling systems on research vessels. §A.2.1 points out that this regulation doesn't address safety factors for tension members. It also states that the purpose of Appendix A is to establish "*...operating limits...for tension members...*" Therefore, §A.2.1 *implies* that Appendix A applies to tension members used as components of overboard handling systems. It isn't, however, specifically stated.

Table D-3.—Approximate design safety factors for wire rope

Type of service	Approximate safety factors
a. Mobile cranes	
Running ropes	3.5
Standing or pendant lines	3.0
b. Overhead and gantry cranes	5.0
c. Overhead hoists (underslung)	5.0
d. Portal, tower, pillar cranes	
Running ropes	3.5
Standing ropes	3.0
e. Hammer head tower cranes	5.0
f. Power passenger and freight elevators	7-12
g. Rope guided workmen hoist	
Hoist ropes	8.9
Guide ropes	7.0
h. Personnel hoists	8-11
i. Derricks	
Guy	3.0
Hoist	3.5
j. Slings	5.0
k. Material hoists	7.0

Figure 1: Some "traditional Shore-side limits" for tension members[1].

[1] Taken from p. 7 of the U.S. Bureau of Reclamation's 2009 Reclamation Safety and Health Standards (RSHS), Appendix D: "Wire Rope." It may be viewed at: http://www.usbr.gov/ssle/safety/RSHS/appD.pdf

3. 4 The limits in Appendix A do not apply when *"... other regulations are applicable."* (§A.2.5)

There are regulations pertaining to tension members for cargo-handling cranes, and for those used to overboard manned submersibles. Therefore, the greater tensions/lower safety factors allowed by Appendix A cannot be applied to tension members on these systems.

3.5 Application Dates

- Excepting those pertaining to rollers, all Appendix A requirements must be complied with by 01 June 2011 (§A.2.7)

- Appendix A requirements pertaining to rollers must be complied with: "*...as soon as the appropriate equipment modifications can be funded and purchased and no later than 01 June 2015.*" (§A.2.7)
  The deadline appears to be the only concrete requirement in §A.2.7. The remainder encourages, but does not require, compliance prior to the deadline. At any rate, the UNOLS Safety Committee does intend for rollers to comply as soon as possible.

4.0 <u>Effects</u>

4.1 Limits for Line Tension

Appendix A places limits on the amount of tension one may place on a wire rope/cable during a deployment.

4.2 Deployment Requirements

Appendix A dictates actions that must occur while a deployment is taking place.

4.3 Administrative Requirements

Appendix A requires certain administrative procedures be carried out to obtain/maintain compliance.

4.4 Maintenance Requirements

Appendix A requires certain maintenance actions be carried out to obtain/maintain compliance.

5.0 The Limit for Line Tension (SWL)

5.1 The Safe Working Load (SWL)

5.1.1 A tension member's safe working load (SWL) is: "*The maximum tension that is allowed to be applied to the tension member...*" (§A.0.21)

5.1.2 It's defined mathematically in §A.0.24 as: SWL = ABL/FS, where ABL is (roughly) the tension member's breaking strength and the safety factor (FS) is the proportion of the breaking strength we're allowed to utilize.

5.1.3 A tension member's breaking strength will differ depending upon whether or not its ends are fixed or free to rotate. A tension member may be assigned two ABLs--one for each condition. Therefore a tension member may have two SWLs as well(§A.0.24).

5.2 The Assigned Breaking Load (ABL)--The 1st Component of the SWL

5.2.1 ABL is what we consider the tension member's breaking load/breaking strength in calculations pertaining to Appendix A.

5.2.2 ABL is arrived at in one of two ways:

- If the tension member is not break tested (FS ≥ 5):
  We consider its breaking strength to be the "*Manufacturer's minimum published breaking load...*" (§A.0.14), which we call the Nominal Breaking Load (NBL). Therefore ABL = NBL if the tension member isn't break tested.

- If the tension member is break tested (FS < 5):
  The tension member's actual breaking load/breaking strength is revealed by a test; we call it the Tested Breaking Load (TBL). TBL is formally defined in §A.0.19 as "*The actual load required to pull a tension member to destruction as determined by testing.*"
  Following the test, we consider the tension member's "breaking strength" (ABL) the lesser of the test result (TBL) and the manufacturer's published minimum breaking strength (NBL).

- A tension member's breaking strength will differ depending upon whether or not its ends are fixed or free to rotate. Therefore, at times, manufacturers will specify two NBL's--one for each condition. In these cases, a tension member may be assigned two ABLs--again, one for each condition (§A.0.20). Unless some feature of the science package prevents the end of the tension member from rotating, the free-to-rotate ABL should be used to calculate the SWL.

5.3 Factor of Safety (FS)--The second component of the SWL

5.3.1 Definition

The definition of FS presented in Appendix A isn't very revealing. §A.0.23 only defines it as "*...Assigned Breaking Load/Safe Working Load.*" A more instructive definition is: the proportion of the tension member's breaking strength that may be utilized safely.

5.3.2 Responsibility for Determination

Who is responsible for determining the factor of safety (FS)?

- §A.3.2 refers to a "*...FS selected by the Owner...*" (emphasis mine). This implies (but doesn't specifically say) that in cases when the owner and operator are not the same entity, the owner must select the FS, and therefore must select the amount of tension to place on the tension member.

- §A.6.1 states that "*It is the Operators discretion at which FS they choose to operate under as long as they meet the requirements for that FS.*" (emphasis mine) Therefore, in cases when the owner and operator are not the same entity, the operator will ultimately determine the FS that will be used during a deployment--regardless of what FS the owner might have selected.

The implication in §A.3.2 is least likely to conflict with the instruction in §A.6.1 if the owner and the owner's equipment meet the requirements for the FS selected by the owner.

5.3.3 Equipment Requirements for FS Selection/Use

These requirements are given in tables 6.1-6.4 (pp 119-122), which are included in the back of this outline for your convenience. They pertain to the diameter of rollers/sheaves, the grooving in sheaves, and acceptable characteristics/use of tension monitoring systems.

5.3.3.1 Minimum Sheave and Roller Diameter (D)

i. For sheaves, the diameter (D) is considered "*The root diameter of the sheave.*" (§A.0.9) Figure 2 (below) illustrates what's meant by root diameter.

ii. For rollers, D is not defined in Appendix A. It seems straightforward to assume it's the roller's outside diameter (OD). (The UNOLS Safety Committee has confirmed that this assumption is correct.)

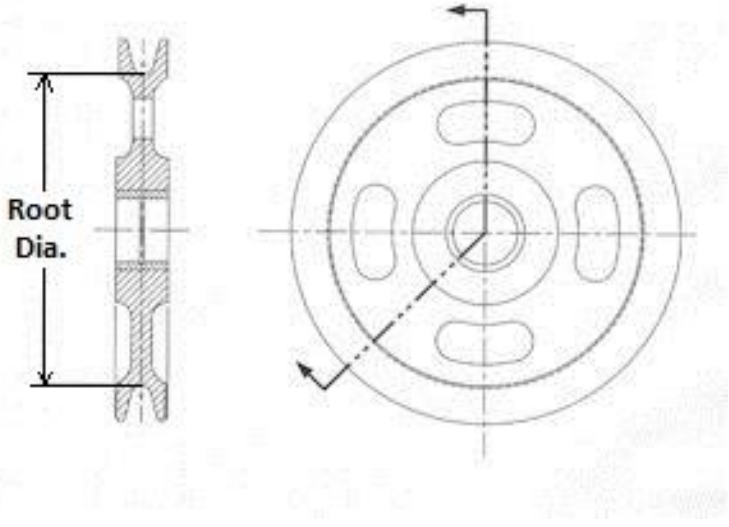

Figure 2: The root diameter of a sheave. It's the sheave's diameter as measured from the bottom of its groove.

iii. To utilize a FS ≥ 5.0, D must be "*...as large as practicable.*" (table 6.1, P. 119)
There is no requirement for sheave size for FS ≥ 5.0 as there's no criteria by which one may determine what's practicable. (Despite this, the UNOLS Safety Committee does intend for sheaves to be as large as possible.)

iv. To utilize FS < 5, D must be the greater of (tables 6.2-6.4 on pp 120-122):

- D≥ 40 x d, where d is defined as "*The outside diameter of the cable or rope.*" (§A.0.10)

- D ≥ 400 x d1, where d1 is defined as "*...the largest diameter armor...or outer wires.*" (§A.0.11)

5.3.3.1 The Importance of Sheave and Roller Diameter (D)

i. Strength reduction due to bending

- Tension members are "bent" when they pass over a sheave/roller.

- This bending loads the tension member unevenly--the wires furthest from the sheave's axis are loaded to a greater degree. Therefore, a tension member passing over a sheave will always break at a lower tension than it would if it were straight.

- This effect is more pronounced on smaller sheaves (see Figure 3 below), and with tension members constructed with "fatter" wires[2]. (We consider a wire "fat" if 400 x d1 > 40 x d, which is why a larger sheave is called for in this case.)

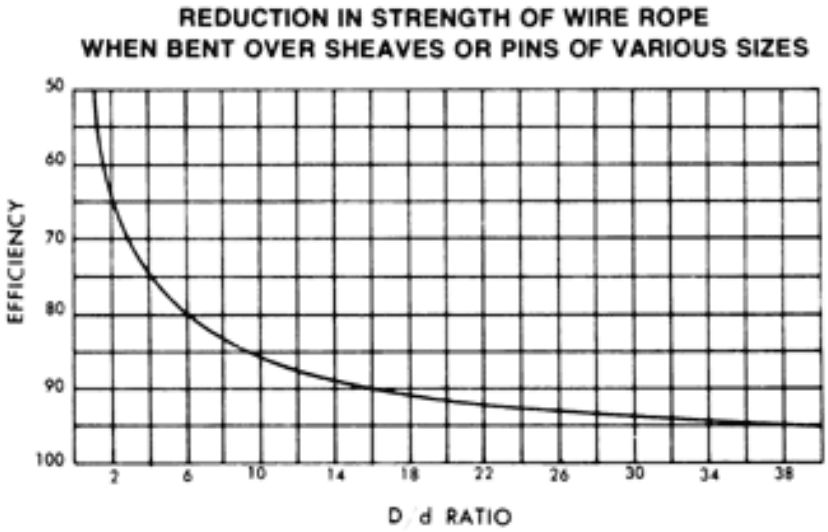

Figure 3: The effect of sheave/roller diameter on wire rope strength. This particular graph pertains to some 6-strand wire rope constructions. Actual efficiencies for 3 x 19 wire rope will differ, but the overall trend is likely similar[3].

ii. Fatigue concerns (service life)

- The service life of a cable or wire rope is dramatically affected by the sheave's diameter (see Figure 4 on the following page).

[2] On p. 32 of the American Steel and Wire Company's 1946 publication "Tiger Brand Wire Rope Engineering Handbook." A digital copy may be obtained online at: http://www.tramway.net/Tiger%20Rope.pdf)
[3] Taken from a website hosted by Unirope®: http://www.unirope.com/wireropeslings/wrs_ddratioeffects.shtml

- General industrial standards call for sheave diameters around D/d = 20. (For example, §7.4.1.1 of the 2004 API Specification 2C, Specification for Offshore Pedestal Mounted Cranes, calls for D/d = 18 for hoist sheaves)

- Standards for applications requiring very high reliability, such as elevator hoist sheaves, call for sheave diameters *starting* at D/d = 40. (For example, ASME A17.1-2004 ¶ 2.24.2.2 requires sheaves used with elevator suspension cables have a diameter of at least D/d = 40)

- Figure 4 (following page) implies that by using D/d = 40 (rather than 20) the service life of our tension members will be increased by:

$$\frac{40 - 12.5}{12.5} \times 100 = 220\%$$

The relationship between sheave diameter and lifespan differs for various wire rope constructions. It's not clear which wire rope constructions Figure 4 applies to, but it's not likely to pertain to those we employ. Nonetheless, this example does demonstrate that a generous sheave size will enable our tension members to last a great deal longer.

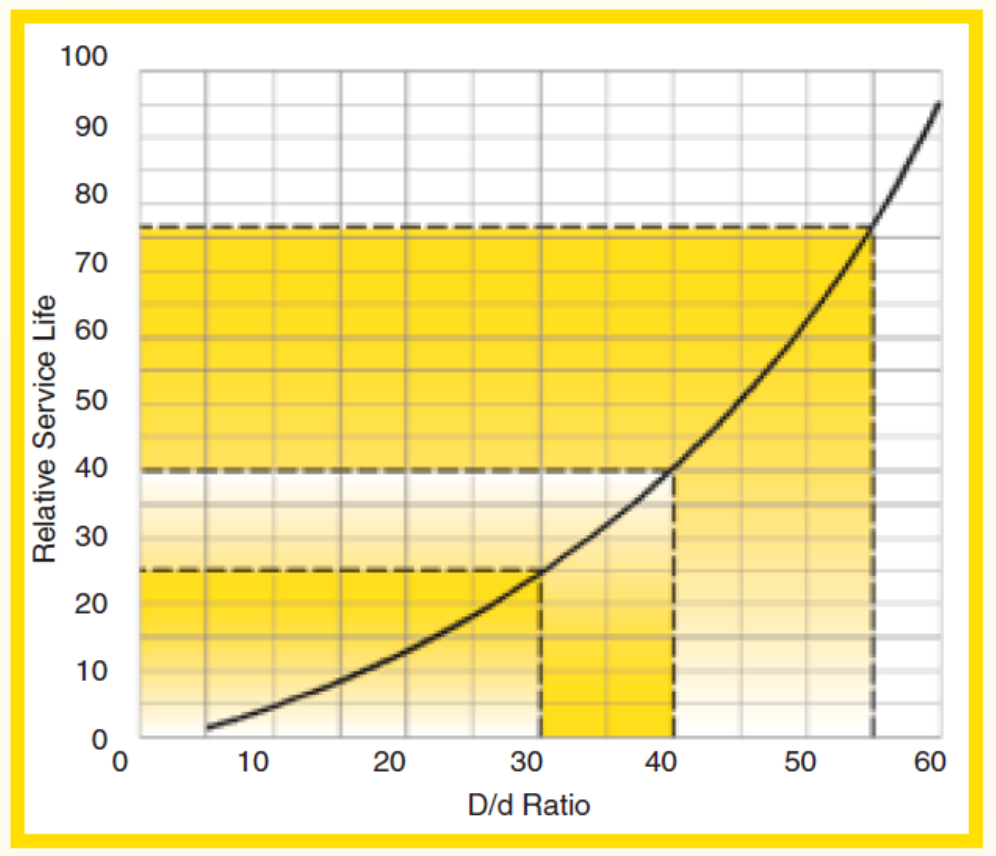

Figure 4: The service life curve developed by the wire rope industry[4]. This curve isn't likely to pertain to the tension members we employ. It's presented to illustrate the general relationship between tension member longevity and sheave diameter.

iii. Permanent Deformation[5]

Even if they do not break, tension members may take on a permanent set (remain forever bent) when loaded over a sheave/roller if D < 200 x d1.

[4] Taken from Bethlehem Elevator Rope® Technical Bulletin 9 by Wire Rope Works, Inc. This publication may be viewed online at:
http://www.wwwrope.com/product_pdfs/EL_TB_09.pdf

[5] On p. 32 of "Tiger Brand Wire Rope Engineering Handbook."

5.3.3.2 The second requirement for sheaves: groove diameter.

i. Groove requirements for FS ≥ 5.0: none specified.

ii. Groove requirements for 2.5 ≤ FS < 5

Appendix A does not elaborate on what "grooving" means. The pertinent groove parameter specified in other publications is the diameter at the root of the groove as shown in Fig. 5 (following page). (This is what the Safety Committee meant by "grooving").

- Minimum size (table 6.2 on p. 120):
  "*Grooving of the sheaves should be as close to "d" as practical...*"
  This seems suggestive (i.e. guidance, but not a requirement). However, the Safety Committee does intend for sheave grooves to be very close to the wire/cable diameter in this case.

- Maximum size:
  Given as "*...and <u>generally</u> no larger than 1.5d.*"
  (emphasis mine) This also seems suggestive (i.e. guidance, but not a requirement). However, the Safety Committee intends for sheave grooves to be no larger than 1.5 x d in this case.

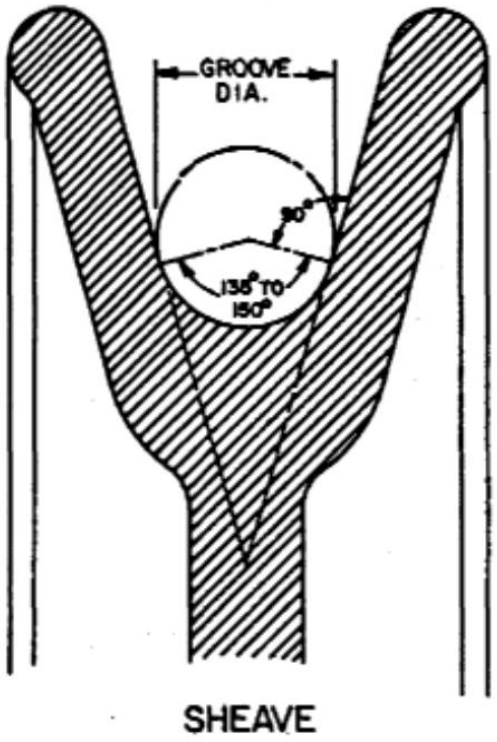

Figure 5: The diameter of a sheave groove[6].

[6] Taken from p. 1-26 of the UNOLS Handbook of Oceanographic Winch, Wire and Cable Technology, 3rd ed. It may be viewed online at: http://www.unols.org/publications/winch_wire_handbook__3rd_ed/01_3x19_wire_rope.pdf

iii. Groove requirements for FS < 2.5

- Minimum size:
  "*Grooving shall be per Ref A.1.1, Chapter 1, and section 11.0...*"
  This is a reference to the Handbook of Oceanographic Winch, Wire, and Cable Technology; the referenced section sets forth sheave groove limits in a table shown here as Figure 6 (following page). This table seems to have caused some confusion: there are not separate criteria for new and used wire. Also, over time, the diameter at the bottom of the groove will tend to get smaller (not larger) over time.

  If the sheave is new, or if the groove is reconditioned, the diameter at the bottom of the groove must exceed the nominal diameter of the wire rope by the amount in the column entitled "New or Remachined Grooves (%)." A new sheave for wire rope with a nominal diameter of 1/8", for example, must have a groove diameter of 1.08 x 0.125", or 0.135". To be clear, this is the maximum groove diameter.

  Once the sheave has been placed into service (or placed back into service in the case of a reconditioned sheave) the diameter at the bottom of the groove must remain in excess of the nominal diameter of the wire rope by the amount in the column entitled "Minimum (%)." A sheave for wire rope with a nominal diameter of 1/8", for example, must retain a groove diameter of at least 1.04 x 0.125", or 0.130". If the groove diameter becomes smaller, the groove must be reconditioned.

Tolerance Groove Diameter Should Exceed Nominal Rope Diameter

Nominal Diameter of Rope in Inches	Minimum (%)	New or Remachined Grooves (%)
0 to 1/8	4	8
Over 1/8 to 3/16	3.5	7
Over 3/16 to 1/4	3	6
Over 1/4	2.5	5

Figure 6: Acceptable sheave groove diameters[7]. The middle column contains the smallest diameter allowed. The right-hand column contain the largest diameter allowed.

iv. One source of confusion regarding groove size:
It's anti-intuitive that some aspect of the groove's cross-section is going to get smaller as it wears. However, the diameter at the root of the groove will get smaller over time. See Figure 7 (following page) for an illustration. This phenomenon is described in the following excerpt, which pertains to grooves in traction heads:

"*New and re-machined grooves on "U" type machines should be 1/32 inch greater than nominal rope diameter. Grooves should be re-machined when worn to less than 1/64 inch larger than nominal rope diameter*."[8]

[7] This table may also be found on p. 1-27 of the UNOLS Handbook of Winch, Wire and Cable Technology, 3rd ed.
[8] P. 65 of the "Tiger Brand Wire Rope Engineering Handbook."

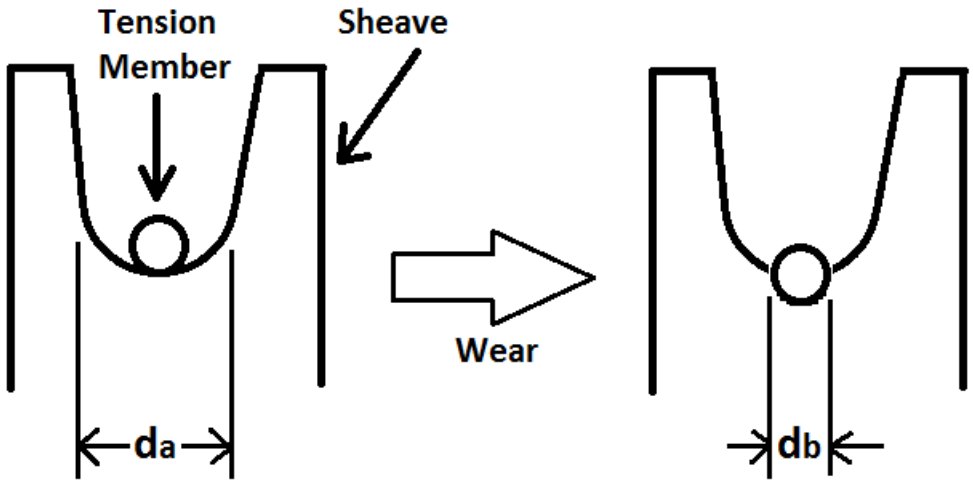

Figure 7: The process by which wear reduces the diameter in the root of a sheave groove. As the tension member wears away at the root of the sheave groove, the root of the sheave groove will take on the shape of the wire, which has a lesser diameter.

5.3.3.3 Why is the groove diameter's size important?

i. A minimum size is required to "*...avoid pinching and binding of the strands, and to permit the rope to adjust itself to the radius of curvature.*"[9]
ii. A maximum size is required as "*...grooves of too large diameter do not properly support the rope, and allow it to become elliptical.*"[10]

5.3.3.4 Tension monitoring system requirements (including alarms)

i. FS ≥ 5.0 -- no requirements

[9] P. 1-25 of the UNOLS Handbook of Winch, Wire and Cable Technology, 3rd ed.
[10] P. 64 of the "Tiger Brand Wire Rope Engineering Handbook."

(There are some requirements listed in the "Tension Monitoring" row of table 6.1, page 119. However, they pertain to calculating the estimated maximum load on the tension member; they don't pertain to monitoring the load.)

ii. Some general requirements for monitoring systems are set forth for FS < 5.0 (Tables 6.2-6.4 pp. 120-122):

- "*Tension must be monitored at the winch operator's station...*"
- "*The system must also be capable of logging tension data...*" Emphasis mine. I have not found any statement in Appendix A that requires you to actually log tension data. The UNOLS Safety Committee does, however, intend for tension data to be logged.
- "*The handling system must be fitted with both audible and visual tension alarms that sound and illuminate...*"
- "*Alarm conditions must automatically be included in the logged data.*"

iii. Additional requirements for 2.5 ≤ FS < 5.0 (Table 6.2)

- The monitor must have "*...a display resolution of at least 3 Hz (every 330mS).*" (The display must refresh 3 times per second).

- Logging capabilities: "capable" of logging at a rate of at least 3 times/sec. (3Hz, or every 330mS). Again, despite the wording, the UNOLS Safety Committee does intend for tension data to be logged.

- Alarm set points: "*...sound and illuminate prior to a FS=2.8 of a wire's Assigned Breaking Load (ABL).*" This means the alarms must be set to activate before the tension reaches an amount equal to ABL ÷ 2.8.

iv. Additional requirements for 2.0 ≤ FS < 2.5 (Table 6.3)

- The monitor must have "*...a display resolution of at least 10 Hz (every 100mS).*" (The display must refresh 10 times per second).

- "*Tension must be continuously monitored using a 'tension trending' graph at the winch operator's station*."

- Logging capabilities: "capable" of logging at a rate of at least 20 times/sec. (20Hz, or every 50mS). Again, despite the wording, the UNOLS Safety Committee does intend for tension data to be logged.

- Alarm set points: "*... sound and illuminate prior to a FS=2.2 of a wire's Assigned Breaking Load (ABL).*" This means the alarms must be set to activate before the tension reaches an amount equal to ABL ÷ 2.2.

v. Additional requirements for 1.5 < FS < 2.0 (note FS is greater than 1.5 always)

- The monitor must have "*...a display resolution of at least 10 Hz (every 100mS).*" (The display must refresh 10 times per second).

- "*Tension must be continuously monitored using a 'tension trending' graph at the winch operator's station.*"

- Logging capabilities: "capable" of logging at a rate of at least 20 times/sec. (20Hz, or every 50mS). Again, despite the wording, the UNOLS Safety Committee does intend for tension data to be logged.

- Alarm set points: "*... sound and illuminate prior to a FS=1.7 of a wire's Assigned Breaking Load (ABL).*" This means the alarms must be set to activate before the tension reaches an amount equal to ABL ÷ 1.7.

5.3.3.5 Why are monitoring requirements important?

i. Without a tension monitoring system we're forced to rely upon data from previous deployments, and/or engineering calculations--mere estimates of tension which may be very inaccurate at times.

ii. As we rely upon a greater proportion of the tension member's breaking strength, or approach tensions very close to that which would otherwise damage the tension member, it becomes increasingly important to monitor the tension accurately, and in real time.

6.0 Maintenance Requirements

6.1 Calibration of the Tension Monitoring System

6.1.1 Calibration requirements for FS ≥ 5 -- none required

6.1.2 Calibration requirements for 5 > FS ≥ 2.5

- Calibrate at least every 6 months

- Calibrate "*...at [a] load equal to the imposed [load] at the selected FS.*" Though it's not clear, the Safety Committee's intent is to require the calibration to be accomplished at the greatest tension in the FS range. Therefore, calibration must take place with the tension member under a tension equal to ABL ÷ 2.5. It's at this tension that the calibration is most critical.
- "*The tension measuring system must be maintained with an accuracy of 4% of the applied load.*" (Emphasis mine. More frequent calibration may be required to maintain this level of accuracy.)

6.1.3 Calibration requirements for 2.5 > FS ≥ 2.0

- Calibrate at least every 6 months

- Calibrate "*...at [a] load equal to the imposed load at the selected FS.*" Though it's not clear, the Safety Committee's intent is to require the calibration to be accomplished at the greatest tension in the FS range. Therefore, calibration must take place with the tension member under a tension equal to ABL ÷ 2.0. It's at this tension that the calibration is most critical.

- "*The tension measuring system must be maintained with an accuracy of 3% of the applied load.*" (More frequent calibration may be required to maintain this level of accuracy.)

6.1.4 Calibration requirements for 2.0 > FS > 1.5

- Calibrate at least every 6 months

- Calibrate "*...at [a] load equal to the imposed at the selected FS.*" Though it's not clear, the Safety Committee's intent is to require the calibration to be accomplished at the greatest tension in the FS range. Therefore, calibration must take place with the tension member under a tension equal to ABL ÷ 1.5. It's at this tension that the calibration is most critical.

- "*The tension measuring system must be maintained with an accuracy of 3% of the applied load.*" (More frequent calibration may be required to maintain this level of accuracy.)

6.2 Wire Rope/Cable Break Tests

6.2.1 General requirements

- Test samples must be "*...a clean 'representative' length from the end that will be put into future use, not simply the end immediately adjacent to the existing termination.*" (§A.3.3)

- Tests must be conducted by the WHOI Wire Pool (§A.3.8)

- Samples must be 5 meters in length and "*...terminated on both ends with the fittings normally used in the field.*" (§A.3.8)
  The WHOI wire pool generally requires longer samples--between 7m and 20m long depending on the wire size and the terminations (if any) on the sample's ends. Though it's not in line with the requirements in this section, the WHOI wire pool does accept and test samples delivered without terminations.

- Samples must be accompanied by the tension member's history/logs. (§A.3.9)

6.2.2 Additional break testing requirements for FS ≥ 5 -- none. Break testing is not required. (Table 6.1)

6.2.3 Additional break testing requirements for 5 > FS ≥ 2.5 (Table 6.2)

- Test at least every 2 years

- Increased to annual testing if ABL decreases by 10% (or cut back and re-test)

6.2.4 Additional break testing requirements for 2.5 > FS ≥ 1.5 (Tables 6.3-6.4)

- Test at least annually

- Increased to bi-annual testing if ABL decreases by 10% (or cut back and re-test)

6.3 Wire Rope/Cable Lubrication

§A.3.16 states: "*As long as these inspection and testing programs are adhered to...*" lubrication is "*...highly encouraged...*" but "*...not expressly required.*"
The testing and inspection programs referred to are those contained in §A.3, which largely pertain to break testing. Some might argue, therefore, that lubrication is required on tension members that don't see this type of testing. This was not, however, the intent of the UNOLS Safety Committee. Lubrication is highly encouraged on all tension members, but not required.

6.4 Wire Rope/Cable Fresh Water Wash Down

Encouraged. Not required. (§A.3.17)

Table 6.1 - Wire Rope or Cable - Factor of Safety 5.0 or greater	
General	Wire Rope or Cable of steel construction may be operated to a nominal FS = 5.0 on the ABL, including transient and dynamic loads, as long as the following precautions in this section are adhered to.
	When the minimum Factor of Safety of 5.0 is reached, the deployment must be halted, or the next level of standards described in Table 6.2 must be used.
	Sea conditions and the resulting ship motion will affect the transient loads created on the wire. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
Tension Monitoring	Tension may be determined by calculation of instrument weight, wire, weight and entrained volume of water, including transient and dynamic loads, as long as the Owner is confident that a FS of 5.0 will not be compromised. If no other precise information is available on package drag and/or vessel accelerations, the Vessel Operator should use the ABS "g" factor of 1.75 as a minimum.
Alarms	None
Sheaves & Load Carrying Rollers	The sheave and roller diameter should be as large as practicable.
Deck Safety	Personnel on deck should follow good safety practices when working in the vicinity of wires and ropes during use
Testing	No routine break testing is required. Wires shall only be tested every two years to the desired SWL, along with the handling system.
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, lubrication, wire train description and maximum loading (as determined by monitoring system or by calculation for each cast) for the full service life of the rope or wire. The wire log shall transfer with the wire if it is removed and placed in storage, or transferred to another winch or Owner.
Winch Operator	The Owner and the Master of the vessel must deem competent, in writing, all winch operators. "Deemed Competent" means that both the Owner and the Captain are confident, given the particulars of the winch and the overall operational scenario (weather conditions, equipment being deployed, etc.), that the Winch Operator has the necessary experience to operate the winch safely.

Table 6.2 - Wire Rope or Cable - Factor of Safety From Less Than 5.0 to 2.5	
General	Wire rope or cable of steel construction may be operated to a nominal FS =2.5 on the ABL, including transient and dynamic loads, as long as the following precautions in this section are adhered to.
	When the minimum Factor of Safety of 2.5 is reached, the deployment must be halted, or the next level of standards described in Table 6.3 must be used.
	Sea conditions and the resulting ship motion will affect the transient loads created on the wire. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
	Motion-compensation may be used to reduce the dynamic loads below the permissible limit and/or to reduce the chances of a "zero load" condition.
Tension Monitoring	Tension must be monitored at the winch operator's station with a display resolution of at least 3 Hz (every 330 mS). The system must also be capable of logging tension data at a minimum frequency of 3 Hz (every 330 mS). The tension measuring system must be calibrated at a minimum of every 6 months at load equal to the imposed at the selected FS. The tension measuring system must be maintained with an accuracy of 4% of the applied load.
Alarms	The handling system shall be fitted with both audible and visual tension alarms that sound and illuminate prior to a FS=2.8 of a wire's Assigned Breaking Load (ABL). Alarm conditions must automatically be included in the logged data.
Sheaves & Load Carrying Rollers	The D/d ratio must be at least 40:1 or 400d1 (whichever is greater) throughout. Grooving of the sheaves should be as close to "d" as practical, and generally no larger than 1.5d.
Deck Safety	The Operator should identify "Danger Zones" around ropes and wires under tension. To the extent possible, given the nature of operations involved, all personnel should be excluded from these zones such that a sudden failure cannot result in injury.
Testing	Wire Samples from the end closest to the termination shall be sent for testing every two (2) years and generally in conjunction with handling system SWL tests. If a 10% decrease in ABL is detected, then the testing shall be increased to annually. Alternately, the Owner may cut back to and re-test a new representative length
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, break tests, lubrication, wire train description and maximum loading (as determined by monitoring system or by calculation for each cast) for the full service life of the rope or wire. The wire log shall transfer with the wire if it is removed and placed in storage, or transferred to another winch or Owner.
Winch Operator	The Winch Owner must certify that all Winch Operators are competent. By "Certified Competent" it is meant that the Owner must have written documentation in place showing that the operator has been through and successfully passed a formal owner/operator developed training program on the winch, handling apparatus, and monitoring system. The system vendor or the Owner, depending on the complexity of the system, may conduct a formal training program. The certification must be renewed annually. The master shall verify certifications and designate the approved winch operators.

Table 6.3 - Wire Rope or Cable - Factor of Safety From Less Than 2.5 to 2.0	
General	Wire rope or cable of steel construction may be operated to a nominal FS =2.0 on the ABL, including transient and dynamic loads, as long as the following precautions in this section are adhered to.
	FOR CABLES -When the minimum Factor of Safety of 2.0 is reached, the deployment must be halted. FOR WIRE ROPE -When the minimum Factor of Safety of 2.0 is reached, the deployment must be halted, or the next level of standards described in Table 6.4 must be used.
	Sea conditions and the resulting ship motion will affect the transient loads created on the wire. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
	Motion-compensation may be used to reduce the dynamic loads below the permissible limit and/or to reduce the chances of a "zero load" condition.
Tension Monitoring	Tension must be monitored at the winch operator's station with a display resolution of at least 10 Hz (every 100mS). The system must also be capable of logging tension data at a minimum frequency of 20 Hz (every 50 mS). Tension must be continuously monitored using a "tension trending" graph at the winch operator's station. The tension measuring system must be calibrated at a minimum of every 6 months at load equal to the imposed load at the selected FS. The tension measuring system must be maintained with an accuracy of 3% of the applied load.
Alarms	The handling system shall be fitted with both audible and visual tension alarms that sound and illuminate prior to a FS=2.2 of a wire's Assigned Breaking Load (ABL). Alarm conditions must automatically be included in the logged data.
Sheaves & Load Carrying Rollers	The D/d ratio must be at least 40:1 or 400d1 (whichever is greater) throughout. Grooving shall be per Ref A.1.1, Chapter 1, and Section 11.0 to provide adequate support.
Deck Safety	The Operator should identify "Danger Zones" around ropes and wires under tension. To the extent possible, given the nature of operations involved, all personnel shall be excluded from these zones such that a sudden failure cannot result in injury. Warning notices should be displayed at points of access indicating the danger. Physical and/or visual barriers should be erected as needed. Existing doors and accesses to the area should be secured when possible
Testing	Wire Samples from the end closest to the termination shall be sent for testing annually. If a 10% decrease in ABL is detected, then the testing shall be increased to every six months. Alternately, the Owner may cut back to and re-test a new representative length.
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, lubrication, wire train description and maximum loading (as determined by monitoring system for each cast) for the full service life of the rope or wire. The wire log shall transfer with the wire if it is removed and placed in storage, or transferred to another winch or Owner.
Winch Operator	The Winch Owner must certify that all Winch Operators are competent. By "Certified Competent" it is meant that the Owner must have written documentation in place showing that the operator has been through and successfully passed a formal owner/operator developed training program on the winch, handling apparatus, and monitoring system. The system vendor or the Owner, depending on the complexity of the system, may conduct a formal training program. The certification must be renewed annually. The master shall verify qualifications and designate the approved winch operators.

Table 6.4 - Wire Rope - Factor of Safety From Less Than 2.0 to 1.5	
General	Wire rope of steel construction may be operated to a nominal FS =1.5 on the ABL, including transient and dynamic loads, as long as the following precautions in this section are adhered to.
	Once a FS = 2.0 is reached a regular check on wire loading shall be performed. This will require halting a deployment at regular intervals (~ 500 m) and conducting a slow haul until the nominal and peak tensions are established and verified. A decision on whether to proceed must then be based upon the limiting value of SF = 1.5. **The deployment must be halted, when the minimum Factor of Safety of 1.5 is reached.**
	Sea conditions and the resulting ship motion will affect the transient loads created on the wire. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
	Motion-compensation may be used to reduce the dynamic loads below the permissible limit and/or to reduce the chances of a "zero load" condition.
Tension Monitoring	Tension must be monitored at the winch operator's station with a display resolution of at least 10 Hz (every 100mS). The system must also be capable of logging tension data at a minimum frequency of 20 Hz (every 50 mS). Tension must be continuously monitored using a "tension trending" graph at the winch operator's station. The tension measuring system must be calibrated at a minimum of every 6 months at load equal to the imposed load at the selected FS. The tension measuring system must be maintained with an accuracy of 3% of the applied load.
Alarms	The handling system shall be fitted with both audible and visual tension alarms that sound and illuminate at prior to a FS=1.7 of a wire's Assigned Breaking Load (ABL). Alarm conditions must automatically be included in the logged data.
Sheaves & Load Carrying Rollers	The D/d ratio must be at least 40:1 or 400d1 (whichever is greater) throughout. Grooving shall be per Ref A.1.1, Chapter 1, and Section 11.0 to provide adequate support.
Deck Safety	The Operator should identify "Danger Zones" around ropes and wires under tension. To the extent possible, given the nature of operations involved, all personnel shall be excluded from these zones such that a sudden failure cannot result in injury. Warning notices should be displayed at points of access indicating the danger. Physical and/or visual barriers should be erected as needed. Existing doors and accesses to the area should be secured when possible
Testing	Wire Samples from the end closest to the termination shall be sent for testing annually. If a 10% decrease in ABL is detected, then the testing shall be increased to every six months. Alternately, the Owner may cut back to and re-test a new representative length.
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, lubrication, wire train description and maximum loading (as determined by monitoring system or by calculation for each cast) for the full service life of the rope or wire. The wire log shall transfer with the wire if it is removed and placed in storage, or transferred to another winch or Owner.
Winch Operator	The Winch Owner must certify that all Winch Operators are competent. By "Certified Competent" it is meant that the Owner must have written documentation in place showing that the operator has been through and successfully passed a formal owner/operator developed training program on the winch, handling apparatus, and monitoring system. The system vendor or the Owner, depending on the complexity of the system, may conduct a formal training program. The certification must be renewed annually. The master shall verify qualifications and designate the approved winch operators.