<u>APPENDICES</u>

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APPENDIX A
UNOLS Rope and Cable Safe Working Standards

Revision 2 09/03/2014

A.0. Introduction

46 CFR 189.35 – "Weight Handling Gear" describes design standards for handling systems aboard inspected oceanographic research vessels. However, this standard does not address Factor of Safety (FS) on the tension members. The purpose of this appendix to the RVSS is to establish safe and effective operating limits for vessels in the UNOLS fleet for tension members loaded beyond traditional shore-side limits.
This standard seeks to define the requirements, which must be adhered to during over-the-side deployments in order to maintain a safe working environment for all personnel aboard. The secondary goal of this standard is to minimize damage to tension members and handling equipment, and the loss of scientific equipment, while still permitting the science objective to be met.
Normal operation beyond the parameters defined in this standard is forbidden. Exceptions to this are an emergency situation declared by the Master or other officer in charge of the vessel as noted in Section A.8.4.

A.1. References

A.1.1. <u>HANDBOOK OF OCEANOGRAPHIC WINCH, WIRE AND CABLE TECHNOLOGY, Third Edition.</u>

A.1.2. <u>Mechanics of Materials, Second Edition, Gere and Timoshenko, 1984</u>

A.1.3. <u>Wires and Cables Deployed Overside of RVS Vessel – Generic Operating Limits, Document Number SE301050, Issue No.: 001, 12/01/00.</u>

A.1.4. <u>Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities, ABS, 2014, Section 17 Handling Systems</u>

A.1.5. <u>UNOLS Wire Pool Wire Maintenance Policy, 2014</u>

A.2. Definitions

A.2.1. <u>Assigned Breaking Load, (ABL)</u>	Will be the lowest of the Nominal Breaking Load and Tested Breaking Load. In practice ABL will be equal to NBL used unless testing shows TBL to be less than NBL. An ABL that is greater than the NBL may never be used. Depending on the intended use of the tension member there may be two ABLs for fixed end and free to rotate conditions.
A.2.2. <u>Auto-Render</u>	The capability of the winch to automatically pay out at a pre-set maximum tension in order to prevent the tension member from exceeding the pre-set tension.
A.2.3. <u>Cable</u>	A woven, flexible tension member with internal conductors or other means of transmitting data such as glass fiber.
A.2.4. <u>“D”</u>	The root diameter of the sheave.
A.2.5. <u>“d”</u>	The outside diameter of the cable or rope.
A.2.6. <u>“d1”</u>	For cable the largest diameter wire in the armor wires. For wire rope the largest of the outer wires.
A.2.7. <u>Dynamic Loads</u>	Loads induced due to vessel motion (heave, roll, pitch, etc.)
A.2.8. <u>Elastic Limit</u>	The elastic limit or yield point of a material is the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed some fraction of the deformation will be permanent and non-reversible. For rope or cable this is the load that causes permanent set, or

	deformation, of the wires. (See Background Information)

A.2.9. <u>Estimated Maximum Tension (EMT)</u>	An estimate of the greatest line tension that will occur during a given deployment. It's calculated using specific properties of the OHS, the science package, and other factors.
A.2.10. <u>Factor of Safety (FS)</u>	Factor of Safety is defined as the ratio of the maximum stress that a structural part of other piece of material can withstand to the maximum stress estimated for it in the use for which it is designed. For the purposes of this standard, FS shall be considered the value selected by the operator. Section A.8 defines the minimum standards that must be met to select specific FS values.
A.2.11. <u>Fixed Ends (FE)</u>	Both ends of the tension member being fixed without the ability to swivel. Most wire rope and cable NBL values are based on FE. An example of a fixed end application is towing a MOCNESS.
A.2.12. <u>Free to Rotate</u>	The end of the tension member is free to rotate either because a swivel is at the end of the tension member or the package at the end of the tension member can rotate freely. Tension members used in free to rotate applications typically have a NBL below the fixed end NBL. An example of a free to rotate application is a lowered CTD package.
A.2.13. <u>"g"- question on def.</u>	The vertical acceleration due to gravity. For normal static loading (no dynamic effect), "g" is equal to 1.0. To take into account dynamic effect due to ship's motion and package drag, the simple static load is multiplied by a factor higher than 1.0. Under ABS standards, normally 1.75 or 2.0 for vertical accelerations is used depending on the application. "g" is applied to the mass of the package and tension member, not the weight. For permanently installed systems, consideration may be given to lesser loads where it can be shown that the maximum expected loads are less than those given above. (Ref A.1.4)
A.2.14. <u>Induced Rotation</u>	Induced rotation occurs when external forces cause torque to be applied to the tension member. An example of an induced rotation situation would be a tow vehicle that spins while being towed but a swivel is not in place to decouple the vehicle from the tension member. This situation could develop if the tail fin of a corer was bent. Induced rotation should never be allowed to occur on a tension member that has not been specifically designed for this purpose.
A.2.15. <u>Nominal Breaking Load (NBL)</u>	Manufacturer's minimum published breaking load for a rope or cable.
A.2.16. <u>Render-and-Recover</u>	A winch's combined ability to auto render, then haul the tension member back when the tension drops to an amount below the pre-set tension. Generally recovery haul back is limited to the point of the initial rendering.

A.2.17. <u>Rope</u>	A woven, flexible tension member with no internal conductors. It may be made from natural fibers, synthetic fibers, or metal.
A.2.18. <u>Safe Working Tension (SWT)</u>	The maximum tension that is allowed to be applied to the tension member during normal operation. SWT = ABL / FS Because there may be two different ABLs (fixed end & free to rotate) there may be two SWTs.
A.2.19. <u>Tension Member</u>	Generic name used to describe a rope or cable in service for over the side work.
A.2.20. <u>Tested Breaking Load (TBL)</u>	The actual load required to pull a tension member to destruction as determined by testing. Depending on the intended use of the tension member testing may need to be done under fixed end and free to rotate conditions.
A.2.21. <u>Transient Loads</u>	Loads induced which are temporary by nature, including the weight of entrained mud, weight of entrained water, pull out loads, drag due to package characteristics and/or winch speed, etc.
A.2.22. <u>“w”</u>	The width of the sheave groove supporting the sides of the tension member.
A.2.23. <u>Winch Owner</u>	The party or their representative who is normally responsible for the operation, inspection, maintenance, and testing of the winch. This could be the vessel operator or the scientific party.

A.3. Limitations

Loading limitations are expressed in terms of Factor of Safety (FS) on Assigned Breaking Load (ABL) in this document.

The limits in this document may not be used where other regulations are applicable, for example, on cargo cranes. In such cases, the shore-side regulations, which apply, must be adhered to. For example, the Occupational Safety and Health Administration (OSHA) generally require a 5.0 FS on cable breaking strength.

This standard assumes that the tension member is properly used for its intended purpose.

A.4. Compliance Dates

This standard went into effect 01 June 2011 with the exception of rollers. The addition of rollers to the requirements in

Table A.8.1 to Table A.8.4 was incorporated into the RVSS as part of Revision 1 to Appendix A. Roller diameter shall meet this requirement as soon as the appropriate equipment modifications can be funded and purchased and no later than 01 June 2015. Additionally as part of Revision 1 to Appendix A, Table 6.1 for operating with a FS of 5.0 or greater has been modified to require sheave and roller diameters “as large as practicable” versus equal or greater than the manufacturer’s recommendations.

A.5. Testing and Preventative Requirements

A.5.1. Testing Program

Cable paths and fairlead arrangements vary widely from ship to ship and change over both the short term (from cruise to cruise) and the life of the vessel. It is impossible to develop a set of standards, which tries to quantify the precise effects on breaking strength, or tension member life, as a result of system design. Instead, each vessel must have a testing program in place, which suits how their tension members are used, and routinely evaluates the status of each. The assumption is that the results of testing will indicate the effect of both the loading and system design on the breaking strength of the tension member.

The testing program followed shall be based on the FS selected by the Owner, which is in turn based on use and the particulars of the handling system employed. The Owner shall have documentation in place specifying the FS for each tension member in use.

Tension member test samples shall 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. Although this may not be the location of maximum loading during operations, this represents a practical means of determining ABL from an operational standpoint.

The initial ABL shall be assigned through testing by the UNOLS Wire Pool before distribution to the fleet. If the initial test results in an ABL less than the NBL, the Wire Pool shall reject the tension member.

If subsequent testing results in a TBL that is greater than or equal to the initial ABL, the initial ABL shall be used by the Vessel Operation for the purposes of this standard.

If subsequent testing results in a TBL that is less than the initial ABL, then the new TBL shall be used in lieu of the initial ABL by the Vessel Operation for the purposes of this standard.

A.5.2. Method of determining (TBL) – Steel Wires and Cables

ASTM A931-96, “Standard Test Method for Tension Testing of Wire Rope and Strand” (Re-approved 2002) shall be used. Tests shall be done with one end of the tension member free to rotate.

The Vessel Operator shall send samples to a UNOLS-accepted test facility (UNOLS Wire Pool at WHOI) for consistency of testing purposes and maintaining statistics. For steel cables and wire rope, the Operation shall send a five-meter (16 ft.) test sample (as described in Section 4.3) terminated on both ends with the fittings normally used in the field. If the field terminations are found to not develop full breaking strength, a test may be conducted using standard poured epoxy resin terminations.

The Vessel Operator shall also provide a copy of the wire history or wire log information with the sample and, as a minimum, this should include the following:

- UNOLS wire identifier, as described in Chapter 7 UNOLS Winch and Wire Handbook, Third Edition
- Winch and system manufacturer.
- Number and/or duration of deployments since last test.
- Maximum tension of each deployment.
- Maximum payout of each deployment.
- Description of wire train: the number of sheaves between winch and water. Sheave material and values of “D” and “w” for each sheave.

Lubrication Log- A log of the lubrication and maintenance on the wire shall be maintained.

A hard copy and/or electronic copy of the TBL test results and ABL will be provided to the Vessel Operator for each sample tested.

A.5.3. Method of determining (TBL) – Synthetic Tension Members

Reserved

A.5.4. Electromagnetic Testing

Reserved

A.5.5. DC Resistance Testing

Reserved

A.5.6. Retirement of Steel Tension Members

Beside obvious physical damage (kinks, bird caging, abrasion, broken strands, excessive corrosion, etc.), a length of tension member shall be removed from service, or cut back so that the unacceptable length is removed, if any of the three following criteria are met:

- If the ABL, with the appropriate FS applied as described above, does not meet future scientific requirements.
- If the ABL deteriorates below 50% of NBL.
- Peak tension over turning sheaves at any time during operations exceeds the Elastic Limit (FS of 1.8 for cable, FS of 1.33 for wire rope).

A.5.7. Retirement – Synthetic Tension Members

Reserved

A.5.8. Lubrication

Appendix A does not directly deal with requirements for tension member lubrication. Lubrication of tension members is detailed in the UNOLS Wire Pool Wire Maintenance Policy (Ref A.1.5). This policy prescribes the application of a lube/corrosion inhibitor at a frequency of no less than once every twelve months while in service and when the tension member is taken out of service.

A.5.9. <u>Fresh Water Wash Down</u>

While understanding that fresh water is limited at sea, an automatic system that washes the tension member on retrieval is highly encouraged since it greatly extends service life. This is expanded upon in the UNOLS Wire Pool Wire Maintenance Policy. The policy dictates for a tension member in use that a wash down occur at the end of every cruise, but at an interval no greater than one month.

A.6. Background Information

A.6.1. <u>Performance Over a Rolling Sheave</u>

When a steel wire rope or cable passes over a rolling sheave, up to a 30% reduction in breaking strength occurs (Ref A.1.1 Section 6.4, Pg. 8-22). For a tension member with a nominal breaking load of 10,000 lbs., this would be a reduction in strength of 3,000 lbs. to an anticipated breaking load of 7,000 lbs. Using a FS of 1.5 in this example, the Safe Working Tension equals 6,667 lbs., just below the reduced strength anticipated. Since all oceanographic tension members pass over at least one sheave, this is the primary argument for not exceeding a FS of 1.5.

A.6.2. <u>Yield Point and Elastic Limit</u>

“Yield Point” is where continued deformation will occur without adding significantly more load. The “Elastic Limit” is considered to be the load, which induces permanent set or deformation. For steel, the “Yield Point” and “Elastic Limit” are essentially the same for all practical purposes. However, these two points may be quite different for other materials such as synthetics and glass fiber. Since wire rope and cables are made of strands and are not solid bars of steel, the precise Yield Point can be hard to determine by testing. A point on the stress-strain curve known as “0.2% Offset Yield” is used instead. The 0.2% Offset Yield for three-strand wire rope can be found in Section 2.2 (pg. 1-5) of Reference A.1.1.

For cables with copper conductors, the yield point generally occurs anywhere from 50-55% of the breaking strength (FS = 1.8) at which point the performance of conductors deteriorates. This is the principle argument for not exceeding a FS of 2.0 for steel cables with copper conductors, the goal being to maintain conductor performance over the life of the cable.

For wire rope, the yield point generally occurs around 75% of the breaking strength (FS = 1.33). This is the other reason for not exceeding a FS of 1.5 on steel wire rope, the goal being to maintain the useful life of the wire rope. This limit matches well with the performance over rolling sheaves above.

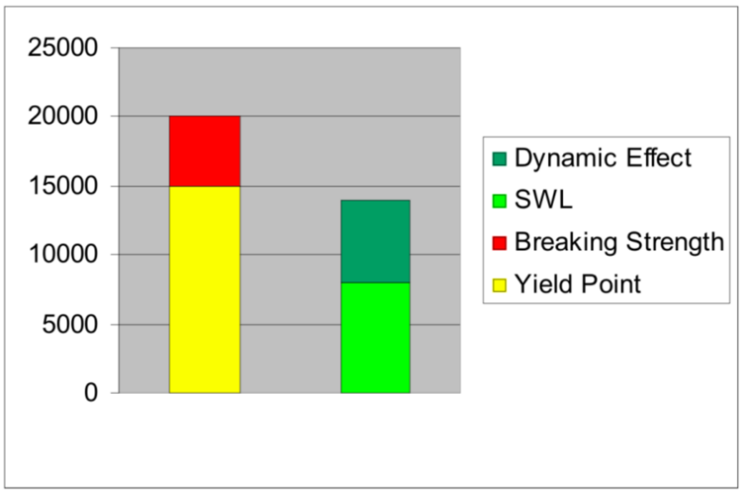
A.6.3. <u>Tension Monitoring Justification</u>

When using low FS in oceanographic research, the capabilities of the tension member monitoring system become critical with respect to capturing and displaying dynamic loads. This standard is divided into four primary sections (

Table A.8.1– Table A.8.4), with each section having increasingly stringent requirements for the monitoring system. If the monitoring system is not capable of reliably capturing peak (or low) dynamic loads, then the chosen FS must keep the tension member below its yield point.

For example, on a tension member with a breaking strength of 20,000 lbs., the approximate yield point would be 20,000 x 0.75 = 15,000 lbs. Using a FS of 2.5, the allowable loading would be 20,000/2.5 = 8,000. If the system is not capable of reliably capturing dynamic effect, then a worst case scenario of 1.75 times static load would have to be assumed (i.e. "g" = 1.75), or 8,000 x 1.75 = 14,000. 14,000 is below the approximate yield strength of 15,000 so the integrity of the tension member would be preserved despite the monitoring system. Figure 1 illustrates this, and is why a FS of 2.5 is used as the lower limit in Table A.8.2.

Figure 1: Tension Member Integrity



When a tension measuring system is not available which forces using a minimal FS of 5.0, EMT calculations must be done based on mass not weight. In general, the weight of the package, entrained water and the cable or rope in air is roughly equal to the mass. Do not use weight in water for the dynamic loading estimates.

A.7. WINCHES AND HANDLING SYSTEM DESIGN

All handling systems and winches, whether portable or permanently installed, must be properly designed to an appropriate standard as described in Appendix B of the RVSS.

A.7.1. <u>Load Limiting Devices</u>

For operations where the weak link itself might be entangled or buried, then Auto-Render shall be the preferred method of strain relief.

A.7.2. <u>Heave Compensation</u>

Heave compensation may not be used as a load limiting device but may be used to minimize the dynamic accelerations during deployments. When using heave compensation it must be realized that most methods work a small section of a tension member over a sheave or sheave train. For this situation it is important to make adjustments so that a different section of the tension member is worked on each deployment or over extended deployments.

A.8. Requirements

A.8.1. Estimated Maximum Tension(EMT)

This is an assessment of the maximum tension that a payload can exert on a tension member during a deployment. The EMT is the sum of static loads (package weight, sample weight, tension member weight), quasi-static loads (drag force), transient loads (pull out forces), and dynamic loads (the effects due to accelerations from heave). Not every deployment will involve every type of load.

The effect the EMT has on a given deployment depends on the monitoring system employed. For cases where there is no monitoring system or a low resolution monitoring system (as described in

Table A.8.1 and Table A.8.2), the EMT for a deployment needs to be equal or less than the SWT of a tension member and the SWT of the OHS (see Appendix B) for a deployment to be allowed. In cases where there is a high resolution monitoring system (as described in Table A.8.3 and Table A.8.4), the EMT without dynamic loads should be less than the tension member SWT and the SWT of the OHS with the provision that should the monitored tension exceed the SWT the deployment will be halted. Section A.9 provides examples of calculating EMT.

A.8.2. Steel Tension Members

Operating tension members with a Factor of Safety (FS) less than 5.0 results in increasingly higher levels of risk to personnel and equipment. To manage the higher risks so that operations stay within a manageable level,

Table A.8.1 to Table A.8.4 were developed. These tables outline the procedures and equipment requirements that must be in place to operate at different ranges of Factor of Safety. It is the operator's discretion at which FS they choose to operate under as long as they meet the requirements for that FS.

The impact that the diameter of sheaves in the wire path have on tension member service life and safety is significant. For higher loads such as those seen when operating with a FS less than 5.0, having adequately sized sheaves is critical. Further study has shown that the diameter of load carrying rollers has an equally critical impact on tension member service life. For this reason Revision 1 to the RVSS Appendix A included load carrying rollers along with sheaves in the requirements of

Table A.8.1 to Table A.8.4. Only load carrying rollers were impacted by Revision 1 to Appendix A. A load carrying roller would be any roller in the wire and cable +path that serves to change the direction of the loaded tension member.
Examples of rollers where the requirements of Appendix A apply:

- Rollers on a level wind whose function is to ensure a small fleet angle to the level wind sheave is maintained. There is the potential for the tension member to come up hard against one of these rollers and change the direction of the tension member when under load.
- Any level wind that only uses rollers without a sheave has the potential for the tension member to come up hard against one of the rollers and change the direction of the tension member when under load.

Examples of rollers where the requirement of Appendix A do not apply:

- Sense rollers such as what are used on an electro-active level wind that senses when a level wind needs to change direction.
- Capture rollers that are there to help keep the tension member in a sheave groove during no load pre and post deployment periods, but that once the tension member is loaded it is not in contact with the capture rollers.

Table A.8.1 Steel Tension Member – Factor of Safety 5.0 or Greater – Minimum Requirements

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 A.8.2 must be used.
	Sea conditions and the resulting ship motion will affect the transient loads created on the tension member.. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
Tension Monitoring	Tension monitoring is not required. If tension monitoring is not available tension should be determined by calculation of EMT, 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 0.75 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 tension members during use
Testing	No routine break testing is required. Tension members shall only be tested every two years to the desired SWT, along with the handling system.
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, lubrication, wire train description, maximum payout 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 tension member 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. If there are configuration changes to controls or to the hardware then the operator qualifications must be refreshed and documented.

Table A.8.2 Steel Tension Member – Factor of Safety From Less Than 5.0 to 2.5 – Minimum Requirements

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 A.8.3 must be used.
	Sea conditions and the resulting ship motion will affect the transient loads created on the tension member.. 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 refresh rate 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, wires and cables 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 SWT 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,maximum payout 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. If there are configuration changes to controls or to the hardware then the operator qualifications must be refreshed and documented.

Table A.8.3 Steel Tension Member – Factor of Safety From Less Than 2.5 to 2.0 – Minimum Requirements

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 A.8.4 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 refresh rate 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, maximum payout 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. If there are configuration changes to controls or to the hardware then the operator qualifications must be refreshed and documented.

Table A.8.4 Wire Rope – Safety Factor From Less Than 2.0 to 1.5 – Minimum Requirements

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 refresh rate 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,maximum payout 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. If there are configuration changes to controls or to the hardware then the operator qualifications must be refreshed and documented.

A.8.3. Synthetic Tension Members

Reserved

A.8.4. Extenuating Circumstances

Ship operators and their seagoing staff must understand that if, by force of circumstance or by the desire to maintain scientific operations while on a cruise, when they do not meet the operating requirements as described in tables 8.1 through 8.4, they are embarking on a potentially dangerous activity. The consequences of this activity could be loss of valuable equipment, damage to the vessel and its fixed equipment, and, in the worst case, injury to personnel. Operators shall develop a procedure on how, and under what circumstances, the vessel will safely continue operations in the event the operating requirements are not met.

A.9. Examples

A.9.1. Safety Factor of 5.0

Examples of where a SF of 5 has to be used because a tension measuring system is not available or the sheave/roller diameters are smaller than required.

Figure 12

A grab is planned on 500m of 0.25" 3x19 wire rope using a FS of 5.0.		
Assigned Breaking Load (Free to Rotate)	6,750	
Factor of Safety	5	
Safe Working Tension = ABL/FS	1,350	
Weight of Grab (in seawater)	175	
Weight of Sample (in seawater)	25	
Weight of wire rope (in seawater) = 0.284 lbs/m x 500m	142	
Static Total		**342**
Quasi-Static Load (drag)		**35**
Pound-mass of Grab (in air)	200	
Pound-mass of Entrained Mud (in air)	50	
Pound-mass of 500m of wire rope (in air) = 0.327 lbs/m x 500m	164	
Total Mass of System	414	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**310**
Transient Load Pull Out Load	100	**100**
Estimated Maximum Tension Pounds-force		**787**
Because the estimated maximum tension of 787 pounds is less than the SWL of 1,350 pounds it is acceptable to proceed with this grab.		

Figure 2

A CTD cast is planned on 500m of 0.322 cable using FS of 5.0.		
Assigned Breaking Load (Free to Rotate)	10,000	

Factor of Safety	5	
Safe Working Tension = ABL/FS	2,000	
Weight of CTD (in seawater)	600	
Weight of Sample (in seawater)	-	
Weight of tension member (in seawater) = 0.474 lbs/m x 500m	237	
Static Total		**837**
Quasi-Static Load (drag)		**300**
Pound-mass of CTD (in air)	1,000	
Pound-mass of Samples (24btls*10liters sea water =240 liters*2.2lb/l)	528	
Pound-mass of 500m of tension member (in air) = 0.573 lbs/m x 500m	287	
Total Mass of System	1,815	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**1,361**
Transient Load		**-**
Estimated Maximum Tension Pounds-force		**2,498**
Because the estimated maximum tension of 2,498 pounds is more than the SWL of 2,000 pounds it is NOT acceptable to proceed with this CTD cast.		
Vessel Operator must either: know the actual dynamic loading on the package (based on location on vessel, drag, weather conditions, etc.) and/or meet the requirements allowing a lower FS described in Section 6 in order to proceed.		

Figure 3

A tow is planned on 1000m of 0.322" cable using a FS of 5.0.		
Assigned Breaking Load (Fixed Ends)	11,600	
Factor of Safety	5	
Safe Working Tension = ABL/FS	2,320	
Weight of Grab (in seawater)	350	
Weight of Sample (in seawater)	-	
Weight of wire rope (in seawater) = 0.474 lbs/m x 1000m	474	
Static Total		**824**
Quasi-Static Load (drag)		**180**
Pound-mass of Grab (in air)	500	
Pound-mass of Entrained Mud (in air)	-	
Pound-mass of 500m of wire rope (in air) = 0.573 lbs/m x 1000m	573	
Total Mass of System	1,073	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**805**
Transient Load Pull Out Load	-	**-**
Estimated Maximum Tension Pounds-force		**1,809**
Because the estimated maximum tension of 1,809 pounds is less than the SWL of 2,320 pounds it is acceptable to proceed with this grab.		

A.9.2. Finding a Factor of Safety for an Operation

An example of estimating the FS requirements that will need to be met for a particular operation.

Figure 4

A piston core is planned on 4000 m of 9/16" wire rope with an ABL of 32,000 lbs. The winch and frame are both rated for 50,000 lbs.		
Weight of corer (in seawater)	2,000	
Weight of Sample (in seawater)	100	
Weight of 4000 m of wire rope (in seawater) = 1.404 lbs/m x 4000m	5,616	
Static Total		**7,716**
Quasi-Static Load (drag)		**300**
Pound-mass of corer (in air)	2,600	
Pound-mass of mud sample (in air)	350	

Pound-mass of 4000m of cable (in air) = 1.614 lbs/m x 4000 m	6,456	
Total Mass of System	9,406	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**7,055**
Transient Load Pull Out Load		**2,000**
Estimated Maximum Tension Pounds-force		**17,071**
FS = Assigned Breaking Load (32,000)/Estimated Maximum Load (17,071)		**1.87**
In order to proceed with this core the requirements in Section 6 for operating at a safety factor (FS) of 1.5 will need to be met.		
Since there is a "substantial risk" of entanglement with this kind of operation, a weak link should be selected by the Vessel Operator to protect the wire rope and personnel.		

Figure53

A 36-bottle CLIVAR CTD cast deploying 6000 meters of .322-diameter cable is planned. The steel cable has a Free to Rotate ABL of 10,000 lbs. The SWT of the handling system is 10,000 lbs. The minimum FS permitted for E.M. cables is 2.0 per Section 8; therefore the maximum tension allowed on the cable is 5,000 lbs.		
Weight of CTD (in seawater)	1,000	
Weight of Sample (in seawater)	-	
Weight of tension member (in seawater) 0.474 lbs/m x 6000m	2,844	
Static Total		**3,844**
Quasi-Static Load (drag)		**500**
Pound-mass of CTD (in air)	1,500	
Pound-mass of Samples (36btls*10liters sea water =360 liters*2.2lb/l)	572	
Pound-mass of 6000m of cable (in air) = 0.573 lbs/m x 6000 m	3,438	
Total Mass of System	5,510	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**4,133**
Transient Load		**-**
Estimated Maximum Tension Pounds-force		**8,477**
FS = Assigned Breaking Load (10,000)/Estimated Maximum Tension (8,477)		**1.18**
6,000-meter deployments with a 36-bottle rosette on 0.322 cable easily falls below a FS of 2.0 and can only be accomplished in very calm weather or with motion compensation. Without good cable monitoring this should be a no-go situation.		
Note: It is clear that deep CTD operations using 0.322 cable in heavy weather or with a large/heavy CTD will easily exceed an FS of 2.0 and easily could go lower than 1.5. This is below the advisable limit for conductor cable because of the increased potential failure of the internal conductors. If FS is reduced to this level, parting of the cable or decreased cable life due to failure of internal conductors should be anticipated. Operators should do everything possible to reduce ship or deployment system movement. Operators can use a motion compensation package,auto render, or slow down the rate of winch operation in order to reduce the dynamic loads. As an alternative, a stronger cable could be considered, however most stronger UNOLS Cables also weigh more – see next example		

Figure 6

A CLIVAR CTD cast deploying 6000 meters of 0.680-diameter coax cable is planned. The steel cable has a Free to Rotate ABL of 37,000 lbs. The SWT of the handling system is 45,000 lbs. The minimum FS permitted for E.M. cables is 2.0 per Section 6; therefore the maximum tension allowed on the cable is 18,500 lbs.

The Vessel Operator has chosen to use a FS of 2.0 on the cable under Section 6 above. The Vessel Operator must either know the actual dynamic loading on the package (based on location on vessel, drag, etc.) and/or monitor cable tensions closely as required in Section 5.0, or use motion compensation to reduce dynamic effect.

Weight of CTD (in seawater)	1,000	
Weight of Sample (in seawater)	-	
Weight of tension member (in seawater) 1.814 lbs/m x 6000m	10,884	
Static Total		**11,884**
Quasi-Static Load (drag)		**500**
Pound-mass of CTD (in air)	1,500	
Pound-mass of Samples (36btls*10liters sea water =360 liters*2.2lb/l)	572	
Pound-mass of 6000m of cable (in air) = 2.271 lbs/m x 6000 m	13,626	
Total Mass of System	15,698	
Dynamic Load (multiply Mass Total by 0.75 for g=1.75)		**11,774**
Transient Load		**-**
Estimated Maximum Tension Pounds-force		**24,158**
FS = Assigned Breaking Load (37,000)/Estimated Maximum Tension (24,158)		**1.53**

6,000 meter deployments with a 36-bottle rosette on 0.680 cable gives a slightly better FS than 0.322 cable for deep casts. An even greater FS can be achieved with 0.681 F.O. cable that has a breaking strength of around 46,000 and is only slightly heavier than 0.680. A 36 place CTD with all bottles full can be handled at a FS of 2.0 in conditions that yield a "g" factor as high as 1.4.

Note: In all circumstances, a full ocean depth CTD cast will require using the procedures contained in Table 6.3 for FS between 2.0 and 2.5 as long as a steel cable is being used due to the weight and mass of the deployed cable. The level of tension monitoring will allow the operator to use actual dynamic loading to make decisions about whether or not to continue a cast.