

TERMINOLOGY FOR FIBER ROPE Used in Standards and Guidelines

CI 1202-13

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1. SCOPE

Terminology and definitions are important to assure clear communication and understanding among industry members, engineers, re-sellers and consumer/users.

This standard defines the terms that are used in the Cordage Institute standards and in many cases may differ from the same terms used in other areas of the textile industry or other industries.

An attempt has been made to list all terms by the key noun. Thus 'Twill Braid' will be found under 'Braid, twill'. However, other terms are more easily understood if listed with an adjective first; for instance, 'Linear Density', will be found under 'Linear Density' instead of 'Density, Linear'. If a term is defined at another location in the standard an attempt has been made to show it in bold format. Terms may be used as a noun (n.) or a verb (v.) and when multiple uses are possible the abbreviation indicates the way in which the term is used.

2. DEFINITIONS

ABACA FIBER: A vegetable fiber produced from the trunk of the abaca tree (muss textiles). See: Manila

ABRASION RESISTANCE: The ability of a fiber or rope to withstand wear and rupture due to motion against other fibers or rope components (internal abrasion) or a contact surface which can be a portion of the rope itself (external abrasion).

ABSORPTION: A process in which one material takes in another; as the absorption of water by fibers.

ACCESSORY CORD - Small diameter cordage intended for use in a life support system, but not as a primary mainline. (CI-1803)

ADSORPTION: A contact process by which the surface area of fibers, yarns, or fabrics takes on an extremely thin layer of a gas, liquid, or dissolved substance.

ARAMID FIBER (also Para-Aramid): A manufactured high-modulus fiber made from a long-chain synthetic aromatic polyamide in which at least 85% of the amide linkages join two aromatic rings.

BECKER VALUE: A standard measure of the reflectance of abaca fiber, expressed as a dimensionless number, which is used to grade the fiber. The higher the Becker Value the better the uniformity, color and appearance of the fiber. (CI-1308)

BLOCK CREEL: A fabrication method to produce the longest rope length on a designated rope manufacturing machine without splicing or knotting of any of its components.

BRAID: n. A rope or textile structure formed by a braiding process. v. The intertwining of strands in a braiding process to produce a rope structure.

BRAID, DIAMOND: A braid pattern where one strand (or multiple strands) of one direction of rotation about the axis passes over one strand (or multiple strands) in the opposite direction and it in turn passes under the next strand of the opposite direction. Also called a Plain Braid

BRAID, DOUBLE: A rope constructed from an inner hollow braided rope (core) surrounded by another hollow braided rope (cover). Also called Braid-on-Braid, 2 in 1 Braid. (CI-1201, 1306, 1307, 1310, 1311)

BRAID, HOLLOW: A single braided rope having a hollow center. (CI-1201)

BRAID PATTERN: A description of the manner in which the strands of a braided rope are intertwined.

BRAID, PLAIN: See BRAID, DIAMOND

BRAID, SINGLE: A hollow braid consisting of multiple strands which may be braided in a plain or twill pattern. A 12-strand braid is commonly used.

BRAID, SOLID: A cylindrical braid in which each strand alternately passes under and over one or more of the other strands of the rope while all strands are rotating around the axis with the same direction of rotation. On the surface, all strands appear to be parallel to the axis. (CI-1201, 1320, 1321, 1322)

BRAID, TWILL: A braid pattern where one strand (or multiple strands) of one direction of rotation about the axis passes over two strands of the opposite direction and it in turn passes under the next two strands of the opposite direction.

BRAIDER SPLICE: In a braided rope, the continuation of a single interrupted strand (or multiple strand) with another identical strand which is braided from the same carrier. The interrupted and replacement strands are arranged in parallel over some distance and are buried or tucked into the braid so as to secure them into the braid. To maintain maximum strength, the strands should overlap one another for a sufficient distance.

BREAKING FORCE: Also: Breaking Load. The maximum force (or load) applied to a single specimen in a tensile test carried to rupture. It is commonly expressed in pounds-force, newtons, grams-force or kilograms-force. (See Note under Breaking Strength)

BREAKING FORCE, CYCLED: The breaking force of a rope which has been cycled from initial tension to a specific peak cyclic force for specified number of cycles before the break test. (CI-1500)

BREAKING FORCE, UNCYCLED: The breaking force of a rope, which has not been cycled before the break test. (CI-1500)

BREAKING LENGTH: A term for comparing the strength to weight ratio of textile structures from one product to another. The calculated length of a specimen whose weight is equal to the breaking load.

BREAKING STRENGTH: For cordage, the nominal force (or load) that would be expected to break or rupture a single specimen in a tensile test conducted under a specified procedure. On a group of like specimens it may be expressed as an average or as a minimum based on statistical analysis.

Note: Breaking force refers to an external force applied to an individual specimen to produce rupture, whereas breaking strength preferably should be restricted to the characteristic average force required to rupture several specimens of a sample. While the breaking strength is numerically equal to the breaking force for an individual specimen, the average breaking force observed for two or more specimens of a specific sample is referred to or used as the breaking strength of the sample.

BREAKING STRENGTH, MINIMUM (MBS): The lowest permissible break strength for a particular rope product as established by the procedures in CI-2002

BREAKING STRENGTH, MINIMUM: For low stretch and static kernmantle ropes, a value three standard deviations below the mean of the maximum force applied to five or more specimens before failure when tested according to CI 1801. (CI-1801)

BREAKING TENACITY: See: Tenacity Breaking

CARRIER: That part of a braiding or plaiting machine that holds the wound package of yarn, thread, cord, strand or multiple strand and carries this component when the machine is operated.

COMBINATION YARN: In rope manufacturing this term is frequently used to denote a yarn composed of several different materials.. Commonly used to denote a product where polyester fiber is wrapped around a polypropylene yarn.

COMPONENT, RRR DESIGN: A rope component, such as a strand, jacket or core, which by design is intended to stay intact at first break and thus prevent sudden, complete rope failure and inhibit or prevent recoil. (CI-1502)

COMPONENT, LOAD-CARRYING: A rope component, such as a strand or a jacket, which carries a significant portion of the tension in the rope (CI-1502)

COIL: A means of packaging rope, without the use of a reel or spool, by arranging the rope in concentric circles about a common axis to form a cylinder secured with lashings. (CI-1201)

CONDITIONING A process of allowing textile materials (staples, tow, yarns and fabrics) to reach hygroscopic equilibrium with the surrounding atmosphere. Materials may be conditioned in a standard atmosphere (65% RH, 70 degrees F) for testing purposes or in ambient conditions existing in the manufacturing or processing areas.

CORD: A small laid, plaited, or braided item of cordage, usually between 5/32" and 3/8" diameter (4mm and 10mm).

CORDAGE: A collective term for twines, cords and rope made from textile fibers and yarns.

CORE 1: A textile product (yarn, strand, small diameter rope etc.) placed in the center of a rope and serving as a support for the strands around it.

2: Interior (kern) of a Kernmantle rope. Core may be of any continuous construction including parallel strands, twisted strands or braided strands. (CI-2005)

CREEP: See: Deformation Delayed

CYCLE LENGTH: The length along the axis of the rope for a strand to make one revolution around the axis of the rope.

CYCLIC LOADING: Repeated loading of a rope or other structure in service or on a test machine. In cyclic loading tests repeated loading and unloading is conducted between specified minimum and maximum load or elongation limits, or can be performed randomly. Cyclic tests attempt to determine the expected behavior of a rope in use, in particular its changes in elastic response and in breaking strength after a determined number of load or stretch cycles.

Δ LENGTH: The change in length, over a gage length, of a rope during application of tensile force. (CI-1500)

Δ LENGTH, IMMEDIATE: The Δ length from the cycled gage length measured at a particular tension. (CI-1500)

Δ LENGTH, OVERALL: The Δ length from the uncycled gage length measured at a particular tension. (CI-1500)

Δ LENGTH, PERMANENT: The Δ length from the uncycled gage length measured at initial tension after the rope has been tensioned or cycled. (CI-1500)

Δ LENGTH, UNCYCLED: The Δ length from the uncycled length measured at a particular applied force during the first tension cycle. (CI-1500)

DENSITY: The mass per unit volume. See: Linear Density

DENSITY CORRELATION FACTOR: The product of the linear density of the rope and the square of the rope diameter. This factor is used to compare the relative weights of ropes of the same type when establishing the linear densities of the ropes for the rope standard.

DESIGN FACTOR (DF): For cordage, a factor that is used to calculate the recommended working load by dividing the minimum breaking strength of the rope or cord by the design factor. The design factor should be selected only after a professional assessment of risk. (CI-1401, 1905)

DIAMETER, ACTUAL: For life safety rope, the rope size as determined when tested according to CI 1801 or 1805. (CI-1801,1805)

DIAMETER, NOMINAL: Approximate diameter of cordage used for naming or reference purposes.

DYNAMIC LOAD: For cordage. Any rapidly applied force that increases the load on the rope significantly above the normal static load or changes its properties when lifting or suspending a weight.

ELASTICITY: The property of a material by which it tends to recover its original size and shape immediately after removal of the load causing the deformation. For cordage, the measure of the ability to stretch under load and recover fully. See: Deformation, Elastic.

ELASTIC DEFORMATION: See: Stretch, Elastic.

ELONGATION: The ratio of the extension of a rope, under an applied load, to the length of the rope prior to the application of the load expressed as a percentage. (CI-1303)

EXPANDED PTFE: (ePTFE) A strong, microporous version of Polytetrafluoroethylene (PTFE) produced by rapid stretching

EXTENSION: The deformation (change in length) of a rope when a load is applied.

EXTRACTABLE MATTER: Material on or in a fiber, which can be removed by a specific solvent as directed in a specific procedure. (CI-1303)

FIBER: A long, fine, very flexible structure that may be woven, braided, or twisted into fabric, twine, cordage or rope. (CI-1201)

FIBER, MANUFACTURED: A class name for various genera of fibers (including filaments) produced from fiber forming substances, which may be: (1) polymers synthesized from chemical compounds, (2) modified or transformed natural polymers, (3) glasses and (4) carbon.

FIBER, NATURAL: For rope and cordage, a class-name for various genera of vegetable fibers, such as cotton, flax, jute, ramie, sisal and manila (abaca). (CI-1201)

FILAMENT, CONTINUOUS: Manufactured fibers of an indefinite length, which may be converted into filament yarn, staple or tow. (CI-1303)

FILAMENT YARN: A yarn composed of continuous filaments assembled with or without twist.

FILM: A fiber that is extruded in the form of a continuous, flat sheet, having a rectangular cross section, which may or may not be slit into tapes having a smaller width.

FILM, FIBRILLATED: A film formed by the rupturing into fibrils having a random or symmetrical pattern, following orientation and/or embossing of the film.

FINISH, OVERLAY: An oil, emulsion, lubricant or the like applied to a yarn upon completion of textile processing to enhance the performance of the finished product. (CI-1303)

FIRST BREAK: The first separation of at least one load-carrying component in the rope. (CI-1502)

FITTING: A load bearing component that is fitted to the rope or sling. It can be of steel, aluminum, or other material that is compatible with the rated load limit of the rope or sling. (CI -1905)

FORCE: A physical influence exerted on a fiber, yarn, or rope.

FORMING: For stranded ropes, the process of twisting two or more rope yarns together prior to laying, plaiting or braiding into a rope.

GAGE LENGTH: The length between gage marks of the rope at initial tension. (CI-1500)

GAGE LENGTH, CYCLED: The gage length measured after the rope has been loaded and cycled and then returned to initial tension. (CI-1500)

GAGE LENGTH, UNCYCLED: The gage length measured before the first application of load to the rope. (CI-1500)

GAGE MARKS: Marks placed near the ends of a new, uncycled rope in order to perform subsequent change in length measurements. (CI-1500)

HANK: A loose winding of yarn or rope usually of a defined length. (CI-1201)

HARDNESS: For laid and plaited ropes, a relative indication of splicing difficulty expressed as a penetration force determined according to test method CI 1501. (CI-1201, 1203,1303, 1501)

HEAT STABILIZED: A term used to describe a fiber or yarn that has been heat treated to reduce the tendency to shrink or elongate under load at elevated temperature.

HELIX ANGLE: The angle formed by the path of the fiber, yarn or strand and the major axis of the finished product.

HIGH MODULUS POLYETHYLENE (HMPE): A polyolefin fiber produced from an Ultra High Molecular Weight PolyEthylene (UHMWPE) feedstock. Also called extended-chain PE (ECPE) or high performance PE (HPPE).

HIGH TENACITY: Generally an industrial fiber with a tenacity greater than 6 grams/denier or one whose tenacity is significantly greater than that normally found in a particular generic class of fiber. There is no accepted standard for delineating high tenacity. See: Tenacity.

HYSTERISIS: The energy expended, in the form of heat, but not recovered during a complete loading and unloading cycle. It can be measured by determining the area between the loading and unloading graphs of the stress-strain curve.

HYSTERISIS CURVE: A complex stress-strain curve obtained when a specimen is successively loaded and unloaded over a specific range and both the unloading and loading performance is plotted.

IN-SERVICE: A rescue rope is considered to be "in service" if it is available for use in life safety applications. (CI-2005)

INITIAL TENSION: A low tension applied before measuring Δ length. Δ length is then measured from the Initial Length between gage marks at this initial tension.(CI-1500)

INSPECTION, TACTILE: Manipulation of the rope by hand or other means to determine hardness and flexibility. (CI-2001)

INSPECTION, VISUAL: Examination of the exterior or interior of a rope by visual methods, which may include magnification. (CI-2001)

KERNMANTLE: A rope design consisting of two elements: an interior core (kern) and an outer sheath (mantle). The core supports the major portion of the load; and may be of parallel strands, braided strands or braided. The sheath serves primarily to protect the core and also supports a portion of the load. There are three types: static, low stretch and dynamic. (CI-1801, 2005)

KNOTABILITY: For life safety rope, a value used to determine the ability of a life safety rope to hold a knot,

when tested according to CI 1801 or 1805. (CI-1801, 1805)

LAI D ROPES: Ropes made by twisting of three or more strands together with the twist direction opposite that of the strands.

LAY LENGTH: Length along a rope for a complete revolution of a single strand in laid, twisted, braided or plaited rope or cordage.

LIFE SAFETY APPLICATION – An application in which a rope or cord meeting the specifications of CI 1801 and 1804 is mandated, supplied, and/or used in support or protection of a human life. (CI-1803)

LINEAR DENSITY: The mass per unit length of a fiber, yarn or rope. (CI-1201, 1303)

MANILA: Fiber obtained from the leaf stocks of the abaca plant for the production of rope and cordage. See ABACA Fiber. (CI-1201)

MARINE GRADE YARN: A yarn which has been demonstrated to meet the minimum wet yarn on yarn (YoY) abrasion performance criteria given in the relevant guideline, CI-2009, when tested in accordance with CI-1503.”

MARKER: A means of distinguishing one rope from another or one manufacturer from another by the use of yarns, tapes or other markers in a rope, either externally, internally or both. (CI-1201)

MARKER, EXTERNAL: A marker placed on the surface of a rope, in a defined pattern, running the entire length of the rope. (Also referred to as a surface yarn marker) (CI-1201, 1303)

MARKER, INTERNAL: A marker placed inside a rope and running the entire length of the rope. (CI-1201, 1303)

MARKER, TAPE: A continuous, printed tape placed inside a rope, for purposes of providing specific information over the entire length of rope, where the information is repeated at a defined interval. (CI-1201)

MARKER, YARN: The marker yarn is normally a contrasting color of the same fiber used in the rope, however, other fibers can and are used for the marker yarn. The marker yarn may be a single filament, a group of filaments or a twisted yarn and depending on its placement may or may not be incorporated into a structural element of the rope. (CI-1201)

MONOFILAMENT: A yarn consisting of one or more heavy, coarse, continuous filaments produced by the

extrusion of a polymeric material suitable for fiber production.

MULTIFILAMENT: A yarn consisting of many fine continuous filaments produced by the spinning of a polymeric material suitable for fiber production.

MULTIPLIER: A dimensionless, numerical value used to determine the pick count of braided ropes and to overcome the complexity of listing a range of pick counts in a specification for each rope size. (CI-1201)

NYLON (PA): A manufactured fiber in which the fiber-forming substance (polyamide) is characterized by recurring amide groups as an integral part of the polymer chain. The two principal types of nylon fiber used in rope production are type 66 and type 6. The number six in the type designation is indicative of the number of carbon atoms contained in the reactants for the polymerization reaction. (CI-1201, 1303, 1306, 1310, 1312, 1321, 1601, 2003)

NYLON, INDUSTRIAL GRADE: Fibers having an average tenacity between 7.0 and 15.0 grams/denier. (CI-1303)

OVERLOADING: Exceeding the WLL by 2 or more times or loading a rope to more than 50% of its published breaking strength.(CI-2001)

PICK COUNT: In a braided rope, the number of strands rotating in one direction in one cycle length divided by the cycle length. Each multiple Strand with multiple yarns should be counted as one strand. Pick count is normally expressed in picks per inch.

POLYARYLATE FIBER (also Polyester-Arylate, or Liquid Crystal Polymer LCP): A high-modulus fiber made from thermotropic liquid crystal aromatic polyester and produced by melt spinning.

POLYAMIDE: See NYLON

POLYESTER (PET): A manufactured fiber in which the fiber-forming substance (polyester) is characterized by a long chain polymer having 85% by weight of an ester of a substituted aromatic carboxylic acid. The most frequently used acid is terephthalic acid in the presence of ethylene glycol. (CI-1201, 1302A, 1302B, 1304, 1305, 1307, 1311, 1322, 2003, 2009)

POLYESTER, INDUSTRIAL GRADE: Polyester fibers having an average tenacity greater than 7.0 grams/denier. (CI-1304, 1305)

POLYETHYLENE: An olefinic polymer produced from by the polymerization of ethylene gas, and used in the production of manufactured fiber. Polyethylene is similar

to polypropylene in its properties but has a higher specific gravity and a lower melting point. (CI-2003)

POLYMER: A long chain molecule from which man-made fibers are derived; produced by linking together molecular units called monomers.

POLYMERIZATION: A chemical reaction resulting in the formation of a new compound whose molecular weight is a multiple of the reactants; involving a successive addition of a large number of relatively small molecules (monomers) to form the polymer.

POLYOLEFIN: A class of polymer where the long-chain molecules consists of at least 85% by weight of olefin units. Polypropylene and polyethylene are examples of this class of polymer. (CI- 1302A, 1302B, 1620, 1900, 1901, 2003)

POLYPROPYLENE (PP): An olefinic polymer produced by the polymerization of propylene gas, and used in the production of manufactured fiber. Polypropylene may be extruded into a number of fiber forms for use by the rope-maker. (CI-1201, 1301A, 1302A, 1302B, 1320, 2003)

POLY OR PP: An abbreviation used in the industry to denote polypropylene. (CI-1201, 1301A, 1302A, 1302B, 1320, 2003)

PROOF LOAD TEST: A non-destructive load test usually to twice the rated load limit of the rope or sling. (CI-1905)

QUALIFIED PERSON: A person who, by possession of a recognized degree or certificate of professional standing in an applicable field, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.(CI-1905)

RATED LOAD LIMIT (RATED CAPACITY): The load or capacity that must not be exceeded. (CI-1905)

RECOIL: The phenomenon that the broken ends of a tensioned rope draw back rapidly after break. (CI-1502, 1903)

REEL: A spool of large capacity on which rope is wound for storage or shipment. See SPOOL. (CI-1201)

RETIRE: Permanent removal of a rope from service, such that it is no longer used for life safety or other purposes. (CI-2005)

ROPE, 12-STRAND BRAID: A single braided rope produced on a 12-carrier machine where the strands may be intertwined in a twill or plain pattern. (CI-1201, 1305, 1312, 1901)

ROPE, COMPOSITE: A rope manufactured from two or more types of fiber. (CI-1302A, CI-1302B)

ROPE, FIBER: A compact but flexible, torsionally balanced structure produced from strands which are laid, plaited or braided together to produce a product which serves to transmit a tensile force between two points. Generally greater than 3/16" diameter. (CI- 1201)

ROPE, HIGH STRETCH: A life safety rope with an elongation greater than 25% at 10% of the MBS. (CI-1805)

ROPE, LAID: Rope made by twisting three or more strands together with a twist direction opposite to that of the strands. (CI-1805)

ROPE, LIFE SAFETY: A rope, which is mandated, supplied and/or used to support or protect a human life and meets the specifications of the standards CI-1801 and 1805

ROPE LOG: A written record kept separately for each rope. A rope log should contain pertinent information about the rope and conditions under which it was used. (CI-2005)

ROPE, LOW STRETCH: A life safety rope with an elongation greater than 6% and less than 10% at 10% of its minimum breaking strength. (CI-1801)

ROPE, MODERATE STRETCH: A life safety rope with an elongation greater than 10% and less than 25% at 10% of the rope's minimum breaking strength. (CI-1805)

ROPE, PLAITED: An 8-strand rope consisting of two pairs of strands twisted to the right and two pairs of strands twisted to the left and plaited together such that the pairs of strands of opposite twist alternately overlay one another. (CI-1201, 1301, 1302B, 1303, 1304)

ROPE, REDUCED RECOIL RISK (RRR): Rope designed to have a reduced tendency to completely break suddenly and thus catastrophically recoil, as demonstrated in the tests defined in CI 1502.(CI-1502, 1903)

ROPE, STATIC: A life safety rope with a maximum elongation of 6% at 10% of its minimum breaking strength. (CI-1801)

ROUNDSLING: An endless sling composed of a continuous load bearing core made from synthetic yarns, enclosed in a protective synthetic cover, used for general lifting purposes. A roundsling may be of a single-path or multi-path construction. (CI-1905)

ROUNDSLING, MULTI-PATH: A roundsling constructed with more than one load bearing core per sling. (CI-1905)

ROUNDSLING, SINGLE PATH: A roundsling constructed with one load bearing core per sling. (CI-1905)

SAFETY FACTOR: Since a safety factor is not an assurance of safety, the term "design factor" should be used in the selection or design of cordage products. See: Design Factor

SHEATH: Outer cover (mantle) of a Kernmantle rope. (CI-2005)

SHOCK LOADING: Any condition of rapid lifting, sudden shifting of load or arrest of falling load which imparts higher than normal forces on the rope or sling. The dynamic effects often are well in excess of the rated load limit. (CI-1905, 2001)

SINGLES YARN: See: Yarn, Single

SISAL: A strong, white bast fiber produced from the leaves of the Agave plant, and used chiefly for cordage and twine. (CI-1201)

SIZE NUMBER: A nominal designation of rope size, determined from the approximate circumference, measured in inches, calculated as three times the approximate rope diameter. .

SPECIFIC GRAVITY: Ratio of the mass of a material to the mass of an equal volume of water.

SPLICE: The joining of two ends of yarn, strand or cordage by intertwining or inserting these ends into the body of the product.

SPLICE, EYE: An end termination in the form of a loop in a rope, cord or twine to facilitate its testing and/or use regardless of construction. (CI-1303)

SPOOL: A flanged cylinder with an axial hole on which rope is wound for storage or shipment. The spool may be fabricated from wood, metal, plastic, cardboard or a combination thereof. (CI-1201)

STIFFNESS (EA): Stiffness is the slope of a load vs. strain curve. This value is independent of length. EA is commonly used in mechanics as the spring constant multiplied by length. (CI-1500)

STRAIN (ϵ): The ratio of Δ length to the length of rope over a particular gage length. (CI-1500, 1502)

STRAIN, IMMEDIATE ($I \epsilon n\%$): The strain at a specified n percent of break strength expressed as a percent of the cycled gage length. (CI-1500)

STRAIN, OVERALL ($O \epsilon n\%$): The strain at a specified n percent of break strength expressed as a percent of the uncycled gage length. (CI-1500)

STRAIN, OVERALL BREAKING ($OB \epsilon$): The overall strain at breaking of a rope. (CI-1500)

STRAIN, PERMANENT ($P \epsilon$): The strain at initial tension after a rope has been cycled to a specified peak cyclic force for a specified number of cycles, expressed as a percent of the uncycled gage length. (CI-1500)

STRAIN, UNCYCLED ($U \epsilon n\%$): The strain on the first application of tension measured at a particular tension. (CI-1500)

STRAND: The largest individual element used in the final rope making process and obtained by joining and twisting together several yarns or groups of yarns.

STRAND INTERCHANGE: See braider splice. (CI-1201)

STRAND, MULTIPLE: Two or more yarns or strands side by side without being twisted together and braided into a rope from the same carrier.

STRENGTH: The ability to resist force.

STRENGTH, BREAKING: See: Breaking Strength

STRESS-STRAIN CURVE: A graphical representation showing the relationship between the applied force (stress) and the deformation in the direction of the applied force (strain)

STRETCH: For cordage, an increase in length produced as a result of the application of a tensile force.

STRETCH, DELAYED: A time dependent increase in length, while under a continuing load, which may be recoverable or non-recoverable following the removal of the load. Non-recoverable delayed stretch is referred to as creep.

STRETCH, ELASTIC: That portion of stretch, which is recovered immediately after the release of an applied force.

STRETCH, INSTANTANEOUS: That portion of stretch that occurs instantly upon the application of a load or the stretch that occurs instantaneously on the first cycle of a cyclic load.

STRETCH, PERMANENT: That portion of stretch, which is not recovered even after an extended time. A portion of permanent stretch is due to the mechanical realignment of the rope structure.

TENACITY: The tensile stress expressed as the force per unit linear density of the unstrained specimen.

TENACITY, BREAKING: The breaking strength of a specimen in a tensile test carried to rupture and expressed as the force with respect to the linear density of the specimen

TENSILE STRAIN: The relative length deformation exhibited by a specimen subjected to a tensile force. Strain is expressed as a fraction of a nominal gauge length at a reference load. See: Extension.

TENSILE STRENGTH, MINIMUM: See: Breaking Strength Minimum.

TENSILE TEST: A method for measuring the maximum tensile stress of a fiber, yarn, cord or rope when strained to a given point.

TENSION: A force applied along the axis of a material (a fiber, yarn or rope).

TENSION, INITIAL: A low tensile force applied before measuring Δ Length. Δ Length is then measured from the initial length between gage marks at this initial tension. (CI-1500).

TENSION, REFERENCE: A low tension applied while measuring diameter or circumference and the length of the linear density specimen. (CI-1500)

TROUGH CYCLIC FORCE: The lowest force applied during a force cycle. (CI-1500)

TWINE: A textile product normally less than 0.200 inches (5 mm) in diameter generally assembled into a structure that compacts the fiber into a useable structure in various construction forms. (CI-1601)

TWIST: The number of turns about the axis applied to a fiber, yarn, strand or rope over a given length to combine the individual elements into a larger and stronger structure. The direction of rotation about the axis is denoted as "S" (left hand) or "Z" (right hand) twist.

TWISTING: The process of combining two or more parallel, textile elements by controlling the lineal and rotational speeds of the material to produce a specific twist level.

ULTRAVIOLET LIGHT (UV): Sunlight or artificial light just beyond the visible end of the visible spectrum of light,

which can cause damage to some synthetic and natural fibers. (CI-1201)

USE: One or more individual applications during the course of an operation. (CI-2005)

USER: May be an individual, company, organization, department, team, or any other entity using the products discussed herein. (CI-2005)

WORKING LOADS: Limiting load values derived from the minimum breaking strength of a cord or rope divided by the design factor.

WORKING LOAD LIMIT (WLL): The working load that must not be exceeded for a particular application as established by a regulatory or standards setting agency. (CI-1303, 1401)

YARN: A generic term for a continuous collection of textile fibers, filaments or material in a form suitable for intertwining to form a textile structure via any one of a number of textile processes.

YARN, COMBINATION: See: COMBINATION YARN

YARN CONSTRUCTION: A term used to indicate the number of yarns to be combined when producing a strand, cord or rope.

YARN, CONTINUOUS FILAMENT: A yarn produced using filaments of indefinite length and uniform cross section.

YARN, COVER: A yarn positioned on the outer surface of an individual strand or rope, which is generally twisted to give better abrasion resistance.

YARN, SINGLE: The simplest textile structure available for processing into rope, twine or cordage.

YARN, PLIED: A yarn formed by twisting together two or more single yarns in one operation in a direction opposite to the twist direction of the single yarns to produce a balanced structure.

YARN, SPUN: A yarn consisting of fibers of regular and irregular staple length joined together by twist.

YOUNG'S MODULUS: A coefficient of elasticity of a material, expressing the ratio between a stress that acts to change the length of a body and the fractional change in length caused by this force.

▲ WARNING

The use of rope and cordage products has inherent safety risks which are subject to highly variable conditions and which may change over time. Compliance with standards and guidelines of the Cordage Institute does not guarantee safe use under all circumstances, and the Institute disclaims any responsibility for accidents which may occur. If the user has any questions or uncertainties about the proper use of rope or cordage or about safe practices, consult a professional engineer or other qualified individual.

Purpose

This Guideline is provided to help in the selection and safer use of cordage products. Compliance with Cordage Institute Standards and Guidelines does not guarantee safe use under all circumstances, and the Institute disclaims any responsibility for any accidents that may occur.

1. Overview

There are inherent risks in the use of rope and cordage because such products are subject to highly variable conditions that change over time. Therefore, Design Factor selections and Working Load Limits must be calculated with consideration of exposure to risk and actual conditions of use for each application. If in doubt, consult an experienced engineer or other qualified individual regarding the design, application and selection of a rope product.

2. Minimum Breaking Strength

The Minimum Breaking Strength (MBS) is the force that a given rope is required to meet or exceed in a laboratory test when it is new and unused. MBS values are given in Cordage Institute Standards and individual manufacturers' specifications.

3. Working Load / Working Load Limit

The Working Load (WL) is the weight or force applied to rope or cordage in a given application.

The Working Load Limit (WLL) is a guideline for the maximum allowable capacity of a rope product in a particular application and should not be exceeded.

Applied loads higher than a specified WLL can overstress and damage fibers, resulting in premature rope failure. For optimal product performance and the safety of personnel and property, the Working Load of an application should not exceed the WLL.

4. Design Factors

The Design Factor (DF) is the ratio between the minimum breaking strength and working load, (MBS/WL). This value is the margin of safety for an application. For a particular application, the factors affecting rope behavior and the degrees of risk to life, personnel and property must be considered when setting a DF.

Commercial, industrial and "general use" consumers should determine a DF based on actual service conditions and establish operating procedures for a specific application. The consumer must also assess his application and determine any hazards that may exist.

As a rule, the more severe the application, the higher the DF needs to be. Selection of a DF in the general range between 5:1 and 12:1 is recommended. **This specific range of values does not apply to Life Safety ropes and/or rope products designed and manufactured for specific engineered services.** A design factor at the low end of this range should only be selected with expert knowledge of conditions and professional estimate of risk. DF at or above the high end of the range should be used for more severe conditions. When in doubt, always select the highest practical DF, or contact the manufacturer for additional guidance. Engineering assistance may be necessary to determine the service loads and risks and to set the appropriate DF. Expert guidance is strongly suggested when shock loads are possible and/or when the rope is used for lifting purposes.

Considerations in the Selection of a Design Factor

- Select a DF value supported by industry standards, best practices, and/or regulations.
- All components of the system should be considered when determining the DF
- Consider increasing the Design Factor if:
 - Problems have previously been observed in similar applications
 - Injury, death or loss of property may result if rope fails
 - Loads are not accurately known
 - High or continuous dynamic loads are anticipated (See Section 6)
 - Shock loads are anticipated
 - Extensive cyclic loads are likely to occur
 - Tension is on the rope for long periods
 - Knots are used, as knots reduce strength
 - Operators are in training or are not well experienced
 - Operation/use procedures are not well defined and/or controlled.

- Abrasion may occur from exposure to rough surfaces or cutting edges, or by contamination from dirt and grit.

Expert Guidance is Strongly Suggested for the Following Situations

- Rope is used constantly over pulleys or around a small bend.
- Rope is used at elevated temperature that may glaze, weaken or melt the fibers.
- Rope is used in the presence of hazardous chemicals.
- Rope is not new and is of unknown properties and/or prior use.
- Rope is not inspected frequently or adequately.
- Rope will be in service for long periods that may cause strength loss due to fatigue.

CI Guideline 2003 Fibers for Cable, Cordage, Rope and Twine explains some of the effects of elevated temperature and chemicals on synthetic fibers.

5. Calculation of Values

After the WL has been estimated and the DF for an application has been determined, a rope can be selected by calculating the necessary new rope Minimum Breaking Strength. The required MBS is determined by multiplying the Working Load by Design Factor. $WL \times DF = MBS$. For example, an application with a Working Load of 3 tons and a Design Factor of 10 would require rope with $MBS = 3 \times 10 = 30$ tons.

Similarly, the Working Load Limit of a new rope is determined by dividing the Minimum Breaking Strength by the Design Factor for a given application. $MBS \div DF = WLL$. Examples of WLL based on a DF are given in some individual Cordage Institute Standards. The WLL in CI standards are for new ropes with standard terminations.

6. Dynamic Loading

A dynamic load is any load that is not static, such as a live load or a wind load. If not properly taken into account, dynamic loading could shorten the service life of a rope and may even cause failure.

Dynamic load effects are influenced by the stiffness or modulus of the rope and are more severe when using low-stretch rope. Dynamic load effects are more severe on short sections of rope. In extreme dynamic loading cases, the forces sustained by the rope may be two, three or more times the static load.

When an object is moved the force on the rope increases due to acceleration or deceleration. The more rapidly or suddenly such actions occur, the greater the forces. Objects should be moved slowly and smoothly to minimize dynamic effects whenever possible.

When dynamic loading is anticipated, the Design Factor should be calculated based on the dynamic instead of the static load. The advice of a qualified individual should be used in calculating the Design Factor.

7. Recoil/Snapback Safety Warning

When a tensioned rope breaks, an attachment fails, or tension is suddenly released, the energy stored in the rope may cause it to recoil back in unpredictable directions with great force. The recoil may result in injury or death to persons in its path. Persons should never stand under, in line with or in the general path of rope under tension to avoid snapback injuries.

8. Special Applications

The DF ranges can be raised or lowered for applications where field experience has proven successful, where a recognized standard or specification exists, where qualified professionals have made a thorough engineering analysis of all conditions of use and/or a regulatory agency has granted specific permission. In such controlled cases, breaking strength, elongation, energy absorption, and other factors, including operating procedures, must be evaluated during the selection of the Design Factor.

When warning tags are provided by the product manufacturer, they should be attached to each rope per industry or application specific guidelines.

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