CABLE MANUFACTURING & ASSEMBLY CO. INC.

DESIGN GUIDE

Cycle-Flex™

10896 Industrial Parkway NW | PO Box 409 | Bolivar, OH 44612-0409 | 800.586.8404 | www.cmacable.com

CABLE MANUFACTURING & ASSEMBLY CO. INC.

Table of Contents

CMA Cycle-Flex™ DESIGN GUIDE

Cycle-Flex Miniature Cable

As the pioneers and industry leaders in miniature cable fabrication and technology, we have engineered many products that have been incorporated in a wide range of demanding applications. As the largest manufacturer of miniature mechanical cable and assemblies, CMA offers a complete selection of standard or custom engineered products designed to suit many needs.

Cycle-Flex is strong, lightweight, flexible and durable with these desirable features and benefits:

Material—Standard Cycle-Flex is made from AISI Type 302-304 high quality stainless steel wire. Special materials are available on a custom order, minimum run basis.
Lubrication—All individual wires and strands are treated with a specially formulated lubricant for extended cable life in flexing applications. Cycle-Flex for medical applications is available unlubricated on special order.
Coating—Cycle-Flex is coated with CMA PC-100 Nylon. This flexible, yet abrasion resistant coating cushions the strands, retains the lubricant and seals out contaminants, which greatly increases cycle life.
Constructions—1 x 7, 1 x 19, 7 x 7 and 7 x 19 are standard and readily available in a wide range of sizes. Special diameters of bare or coated cables, non-standard constructions and custom coatings are available. Consult CMA Sales and Engineering for additional information.
Pre-Stretched Cable—This proprietary process eliminates constructional stretch, and should be used in situations where cable stretch is a factor. Specify pre-stretched cable by adding the suffix "PS" to the Cycle-Flex part number. Please refer to the chart below for the sizes and constructions readily available.

Cable Assembly Design Factors

This design guide has been specifically written to include all pertinent technical information and data needed to properly design and specify a Cycle-Flex miniature cable assembly.

The design recommendations for cable and assemblies are based on CMA's extensive experience and success in design, manufacture and testing of a wide range of products in many markets. Each use and new application is unique, requiring careful analysis and accurate specifications to result in a successful product. Follow this guide and utilize the Application Data Sheet to obtain a timely response and evaluation of your miniature cable project.

Cable Stretch

All cable stretches under an applied load. There are two types of stretch – constructional and elastic. In the majority of cases, where a cable of the correct diameter and construction has been specified, stretch is not a factor in the function of the assembly.

Constructional Stretch

All cable contains small clearances between the individual wires and strands. With the application of the initial load, this clearance is minimized, allowing the cable to "stretch" in length. The amount of the load, type of cable construction, and the length of the assembly all affect the amount of constructional stretch. Cable with more wires in its cross section, as compared to that of less, will stretch more during the application of the same load.

Most cable assemblies are specified with a safety factor greater than the working load. This in many cases may minimize constructional stretch as a design factor.

In applications where stretch is a factor, constructional stretch of a cable assembly can be practically eliminated by "proof loading" it to 60% of the cable's minimum breaking strength. Proof loading can be specified at additional cost. This cost can sometimes be eliminated by proof loading the cable at the time of assembly or duration installation in the product or system. It should be noted that cable stretch will occur, and should be planned for in the cable design and installation procedure.

Elastic Stretch

Elastic stretch is the actual elongation of the individual wires in a strand or cable. It occurs when a cable is subjected to a load that is less than the yield point of the metal. The elongation is approximately proportional to the load applied. When the load is removed from a proof loaded cable it will return to its original length, providing the load has not exceeded the yield point of the metal, causing permanent elongation or failure. The elastic stretch of a cable can be calculated using this formula:

$$ES = \frac{PL}{EA}$$

Where: ES = Elastic Stretch in Inches
P = Pounds Load
L = Length in Inches (of Cable Assembly)
EA = EA Value *(Product of the Metallic Cross Sectional Area and Modulus of Elasticity)*

Note:
1. *The formula is bases on using cable that has been proof loaded to 60% of its breaking strength to remove constructional stretch.*
2. *The EA values listed in the CMA Cable Specifications are conservative and are intended for general information only. The actual EA value of any cable can vary bases on the materials used and the manufactured quality of the cable. Testing a proof loaded cable assembly under the working load is the most accurate way to determine elastic stretch.*

NOTE: Some popular Cycle-Flex cable sizes are available as pre-stretched (proof loaded) bare and coated cable. Proprietary equipment is used to pre-stretch the cable to eliminate constructional stretch. This cable can be specified by using the suffix "PS" after the cable part number.

Cable and Assembly Breaking Strength

The minimum breaking strength of a cable is defined as the minimum tensile strength in pounds or kilograms, and can be found in the Cycle-Flex Miniature Cable Specification Sheet. The minimum breaking strength of a cable assembly should be based on the maximum working load, any potential shock load and a reasonable safety factor. The recommended minimum safety factor specification (minimum breaking working load) is 10:1. In shock or peak load applications, a higher safety factor is recommended. Please consult CMA Sales and Engineering for further information.

Assembly Strength

Most Cycle-Flex applications are subject to relatively light loads, and use coated cable. In cases where fittings are swaged over the coating, please consult CMA Engineering for the recommended minimum holding strength specification for the fittings and cable you have selected.

The holding strength of Cycle-Flex fittings swaged to bare cable should never be specified at or near the minimum breaking strength of the cable!

A minimum holding strength based on 80% of the cable breaking strength should be specified for most assemblies except for ball fittings, which should be specified at 50%.

Realistic holding strength requirements will result in a consistent and cost-effective product, readily manufactured and tested.

Holding Strength/Cable Protrusion

Cable-Flex cable assemblies, in particular, can benefit from cable protrusion on ball, plug, loop and most eye fittings. Allowance of protrusion contributes to reaching the maximum holding strength possible for the cable and fitting selected. The protrusion can be ground flush on ball and plug fittings; however, a lower holding strength must be specified.

Cable Lubrication

All Cycle-Flex cable is lubricated during the manufacture of individual strands and cable. CMA's specifically formulated lubricant enhances the cable's resistance to fatigue in cycling and flexing applications. Lubricated cable, combined with our durable Nylon coating, offers the highest life cycles possible and should always be specified in flexing applications and pulley systems.

Predictable Performance-Life Cycles

The predictable performance of most Cycle-Flex cable assemblies can be estimated by using the formula and chart shown below. By calculating the cable flex load, the estimated cable flex life can be obtained.

NOTE: A cycle is defined as cable travel from point A to point B, 180 degrees and back to point A, over one pulley.

To estimate the life cycle potential of a Cycle-Flex assembly, follow this procedure:

Establish the maximum working load.

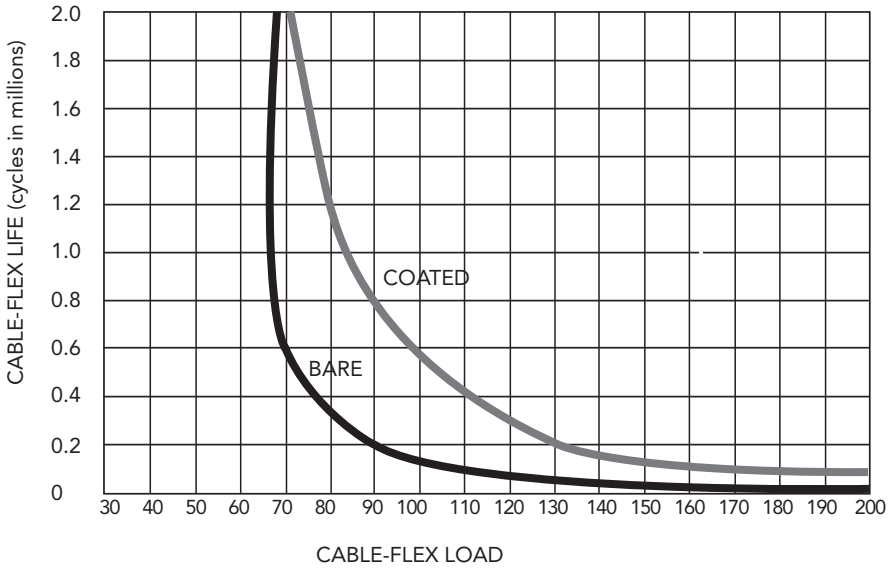
Select a Cycle-Flex cable suitable for the application that has a breaking strength (10) ten times the maximum working or shock load.

Establish the pulley diameter for the cable selected. NOTE: Refer to the Cycle-Flex Miniature Cable Specification Sheet for recommended minimum pulley diameters.

Calculate the cable flex load using the following formula:

$$\text{Cable Flex Load} = \frac{\text{Maximum Working Load}}{\text{"C" Rating (Cable Area)}} + \frac{\text{"F" Rating}}{\text{(Cable Modulus X Wire Diameter)}} \text{ Pulley Diameter}$$

NOTE: The C and F ratings are contained in the Cycle-Flex Miniature Cable Specification Sheet. Identify the CABLE FLEX LIFE by locating the cable flex load value and reading up to the intersection of the curves for bare or coated cable.



CABLE FLEX LIFE can be increased by using larger diameter pulleys, reducing the load, or selecting the most flexible Cycle-Flex cable.

Systems that include additional pulleys, a change of direction in different planes or when the cable reverses itself in the same plane, combined with closely spaced pulleys can all contribute to decreasing the predictable performance by 50% or more. With critical high life cycles requirements, it is recommended that the proposed cable assembly be tested under conditions that accurately represent the end use. Cable selection, fitting requirements and system design can then be analyzed as to their suitability for the application. Consult CMA Sales and Engineering for additional information, design guidance and samples.

Pulley Design Factors

The proper pulley diameter and groove design are critical to the life expectancy of any Cycle-Flex cable and pulley system. The recommended pulley diameter for each Cycle-Flex cable is listed in the Cycle-Flex Miniature Cable Specification Sheet. Using pulleys of smaller diameters than shown will result in reduced cable life and premature failure.

Installation

Cycle-Flex cable and pulley systems require careful and precise installation for maximum cable, pulley and bearing life. Inadequate procedures, the system environment, alignment, lubrication and unnecessary overloading all affect life expectancy.

Proper fleet angle specifications for any pulley, drum or capstan system is essential for proper function and maximum cable life. Please refer to Commercial Design Guide for additional information.

Careful attention to these factors in the design and specification stage of your project will result in a successful Cycle-Flex cable system.

Assembly and Fitting Tolerances

The specification of realistic tolerances is essential to producing cost-effective cable assemblies. In most cases, standard block tolerances for machined parts should not be used for cable fittings and assemblies. The swaged areas of most fittings should be specified as reference dimensions, unless the part of the fitting is critical to the installation and assembly. When they must fit into a mating part, after swaged dimensions can be specified within the tolerances indicated on the charts. Extremely close tolerances on fittings and assembly lengths can add unnecessary cost. The chart below indicates acceptable length tolerance conditions for Cycle-Flex miniature cable assemblies.

Cable-Flex Cable Assembly Tolerances

Assembly Length in Feet	Tight Tol. +/- in./mm	Normal Tol. +/- in./mm	Relaxed Tol. +/- in./mm
0-2 ft.	.030/0.76	.060/1.52	.125/3.18
2-4 ft.	.045/1.14	.093/2.36	.188/4.8
4-8 ft.	.060/1.52	.125/3.18	.250/6.35
8-10 ft.	.093/2.36	.188/4.80	.312/7.92
10-15 ft.	.110/2.79	.250/6.35	.437/11.10
15-20 ft.	.125/3.18	.275/6.99	.500/12.70

A small load is applied to any cable assembly in order to keep it straight and true, permitting accurate measurement. Any special tolerance conditions and/or inspection procedures should be reviewed with CMA Engineering and Quality personnel prior to the drawing release and any quotation request.

Cable Installation and Assembly Procedures

Proper handling and installation of Cycle-Flex cable and cable assemblies is important to obtain maximum cable life and to avoid premature failure. Cable assemblies should never be twisted or the fittings rotated during installation. Twisting and rotation will either unwind or over wind the strands, which can result in cable failure. Care should also be taken to avoid nicking, kinking or bending the cable installation.

Detailing and Specifying Cycle-Flex Cable Assemblies

An engineering drawing or sketch which is complete in terms of specifications and required control dimensions offers a clear picture of the proposal assembly and will result in a more accurate quotation and evaluation of the design. CMA's Engineering Sales Staff and Field Representatives are ready and willing to assist you in this critical design and specification stage of your Cycle-Flex cable assembly.