CABLE MANUFACTURING & ASSEMBLY CO. INC.

DESIGN GUIDE

Control Cables

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 Control Cables DESIGN GUIDE

Push-Pull and Pull-Pull Controls Design Guide

There are many common, everyday applications that use efficient and reliable CMA controls. These applications include automotive seat releases, lawn mower throttle controls, and airplane seat back controls. Some uses of controls are obvious and visible, while others are not. Simple and lightweight controls for dependable, remote activation of throttles, gas springs, mechanisms, or electromechanical devices, etc., can use either push-pull or pull-pull type products.

Push-Pull Controls

Solid core controls are used in applications that require the transmission of forces in both the push and pull mode of operation. The vast majority of these products use various combinations of conduit styles and solid wire cores in their construction.

In some cases, stiffer, small diameter cables can be used for push-pull applications, providing the push load is very light and the combination of cable and conduit is carefully considered. Solid wire cores can be formed on the ends to eliminate the need to apply separate fittings or terminations. Bend radii should be large and routing must be simple in order to avoid a permanent set in the core wire. All push-pull controls have a larger capacity in the pull (or tension) mode than in the push (or compression) mode.

Pull-Pull Controls

Flexible core controls are used in applications that require the transmission of forces in tension only. In general, more flexible conduit and a cable core is used for greater freedom in routing and smaller bend radii in restricted installations feature an integral return spring to keep a specified load on the cable and to return the cable or mechanism to its original position after activation. Controls with cable cores permit the use of most standard fittings allowing a very wide range of mounting and retaining options.

Push-Pull/Pull-Pull Control Design Factors

Applications—Analysis and review of the proposed control function will determine what type of product can be used for a given application. Consideration and definition of potential system variables, such as load, routing, friction, stretch, set, effects of bends on length, temperature, environment, and exposure to containments, will aid in the design of an acceptable control. In general, pull-pull controls are lighter in weight and more flexible that push-pull controls, however, this is a function of the application and load requirements.

Load Factors

Push-Pull—Working loads should be specified as the highest in the pull or tension mode, with the push or compression mode specified at 50% or less of the pull mode. Lower working loads in the push function minimize the tendency of the core to displace the conduit and, more importantly, reduces the potential for the unsupported core outside of the conduit to kink, bend, or distort.

NOTE: The final specifications should be based on the travel core material column strength and the type of use. Consult CMA's Engineering department for additional information.

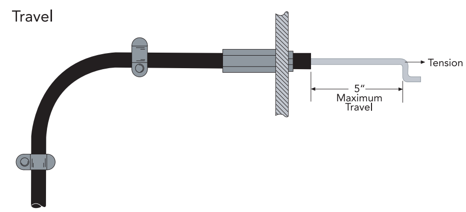
Pull-Pull—Maximum working loads should be specified based on the minimum breaking strength of the cable with a safety factor, and the resistance of the type of conduit selected to resist deflection and compressive forces when a load is applied to the core. Extremely high loads and high life cycles can cause the cable to stretch and wear through the liner of the conduit. The conduit and retained in its routed position for proper function.

Travel

Push-Pull—It is recommended for most light-and medium – duty applications that travel should be limited to 5" maximum. This minimizes possible loss of input versus output, and potential for the core to buckle. In very small diameter core situations, a smaller travel should be used to minimize the possibility of buckling. Each application should be analyzed to compare travel and the applied load to determine if core buckling could occur.

Pull-Pull—Travel of cable cores can usually be specified to suit the application. If the control and core are subject to a hostile environment that could affect the core, a minimum stroke should be specified to limit the exposure of the cable outside the conduit.

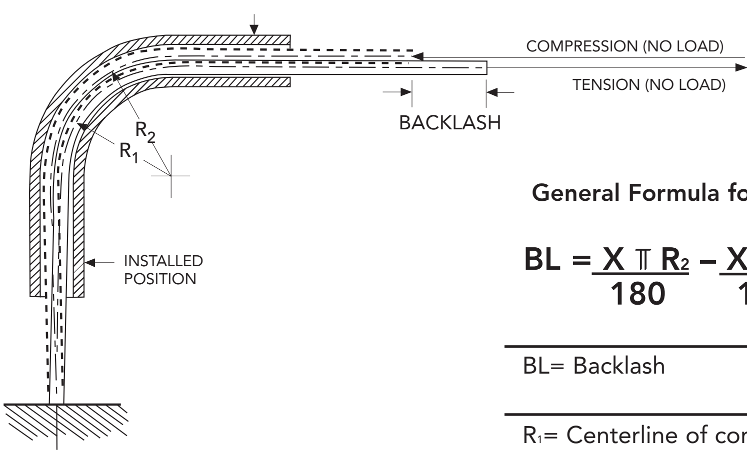
NOTE: Travel and design length of the core is affected by the total number of degrees of bend in the actual routed installation. The type of conduit, core and clearance between the O.D. of the core and I.D. of the conduit can increase or decrease the travel length of the core member. It is highly recommended that a prototype be installed in the system to confirm correct design length and travel.



Lost Motion

Push-Pull—Consideration must be given to the fact that all push-pull controls are subject to the loss of motion between the input and the output ends when a load is applied to the system. Total lost motion of the control consists of backlash and deflection.

Backlash— is the lost motion caused by the clearance between the core diameter and the inside diameter of the conduit. It is present in both the push and pull modes of operation. Backlash is directly proportional to the total degrees of bend in the installed routing and the clearance between the O.D. of the core and the I.D. of the conduit. It can be calculated as shown below:



General Formula for Backlash

$$BL = \frac{X \pi R_2}{180} - \frac{X \pi R_1}{180}$$

BL= Backlash

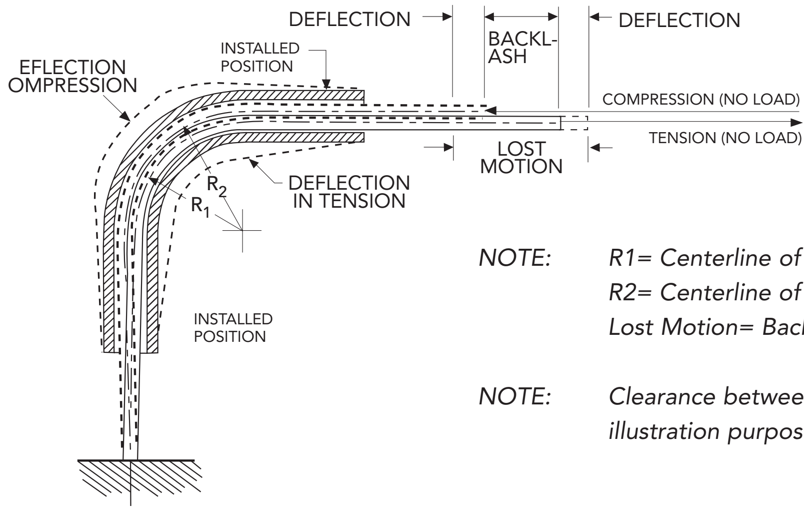
R_1= Centerline of core in tension (No load)

R_2= Centerline of core in compression (No load)

(R_1+ Clearance – Difference between nominal conduit I.D. and nominal core Dia.)

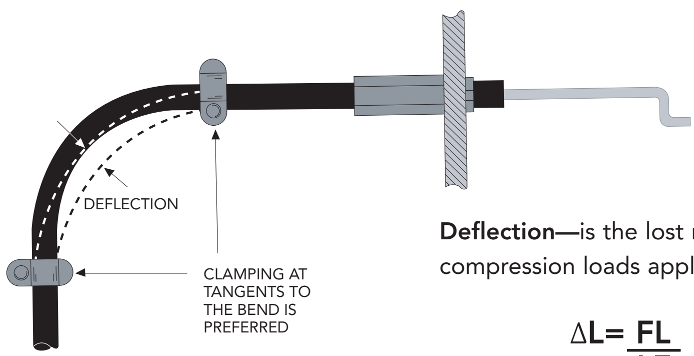
X= Degree of bend (Total degrees)

NOTE: *R1= Centerline of core in tension (No Load)*
R2= Centerline of core in compression (No Load)



NOTE: *R1= Centerline of core in tension (Working Load)*
R2= Centerline of core in compression (Working Load)
Lost Motion= Backlash + Deflection

NOTE: *Clearance between core O.D. and conduit I.D. is exaggerated for illustration purposes.*



Deflection—is the lost motion from elastic strain resulting from tension or compression loads applied to the control. It can be calculated as follows:

$$\Delta L = \frac{FL}{AE}$$

Where
ΔL = Deflection
F = Average force or 1/2 output load + 1/2 input force
L = Length of active inner core
A = Cross sectional area of core
E = Modulus of elasticity of core

NOTE: *Actual deflection of a control in compression may vary from the value calculated based on the potential for buckling and the column strength of the core and conduit.*

The total amount of lost motion increases with higher loads, more bends and increased length of the control. It can be overcome by designing over-travel into the system at either the input or output ends, or both.

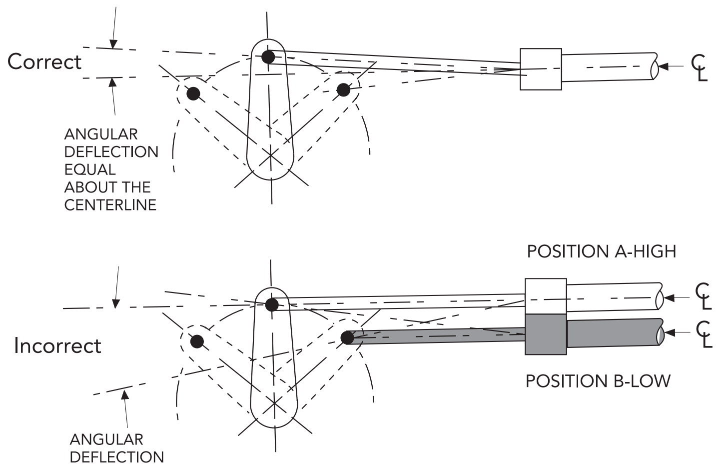
All consideration of lost motion must include the assumption that the control will be securely mounted on either end, and the conduit is firmly held on its routed position.

Pull-Pull—Lost motion is also present in pull-pull controls. Backlash is minimized since most pull-pull controls function under tension. The length of the travel in any cable control will be affected by routing. The required travel for actuation should be added or subtracted to the amount of travel lost or gained in the routed positions In some cases, this can be calculated; in others, samples installed in the system are more accurate in determining core length.

However, these controls are subject to the same deflection factors as push-pull controls. Deflection should also be calculated and used as a design factor.

Alignment and Installation

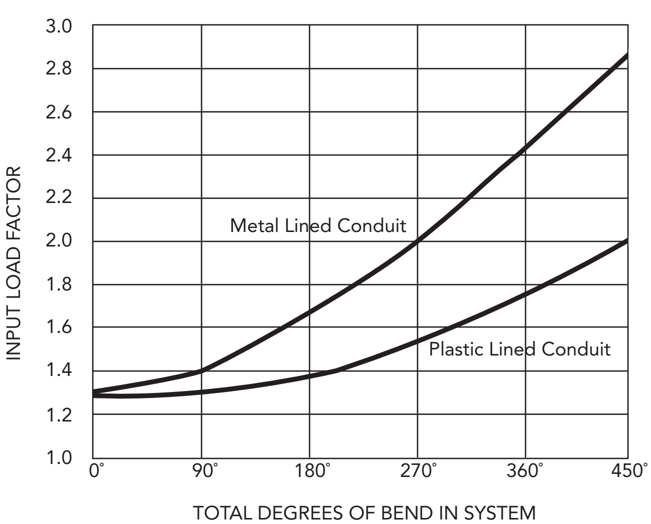
Correct mounting and careful alignment of the cable control and core can maximize efficiency, decreasing working loads and increase cycle life. All controls should be securely mounted and installed to keep cable or core travel in a straight line to the load or device being actuated. In cases where a lever arm is being moved, mount the control to minimize angular deflection of the core, as illustrated. Specify a fitting or assembly detail that will allow rotation at the mounting point.



Efficiency

Push-Pull—The conduit and core selection, as well as the number of bends in the system, combined with the relative friction between the core and the conduit, determine the efficiency of the control. Depending on the materials selected, bends should be kept within a 2" to 10" minimum radius. Recommended minimum bend radii can be estimated by multiplying the core diameter "D" x 100.

Efficiency is reduced by the friction created by bends in the system. This can be calculated using the graph and formula below:



Total Degrees of Bend in System

I= P x F

I= Input Load (Actual)
P= Output Load (Working)
F= Input Load Factor (from Graph)
P/I x 100= % Efficiency

NOTE: The information contained on the graph is for the general design guidelines only. All push-pull controls should be tested and evaluated in the actual use to determine suitability for a given application.

Pull-Pull—Cable cores can create greater friction in either a lined or underlined conduit, and therefore, cable construction should be considered. Most cable controls use 1 x 19 cable, since it has the smoothest outside diameter, and is more flexible than a solid core. For applications requiring more flexibility, 7 x 7 cable can be specified. However, if higher loads are involved, efficiency is reduced and the liner can be subjected to undue wear and damage.

Lubrication

Lubrication is not recommended for most applications. Lubricants can decrease the efficiency of lined conduit and only offer minimal improvements in unlined conduit. Most lubricants tend to collect dirt, dust, etc., that can build up on the core and decrease its efficiency. Special combinations of swaged cable and conduit with liners of very low coefficient of friction are available. Consult CMA Sales and Engineering for further details.

Shuttle Molded Cable Contols

All design considerations for push-pull controls also apply to molded cable controls. Additional design factors do affect the design of these products. They include the molded conduit fittings, conduit selection, assembly functions and dimensions.

Recognition of these factors, combined with a practical design for the application, will result in a successful, reliable and cost-effective assembly.

Shuttle Molded Conduit Fittings

Accepted industry standards for molded part design should be utilized in the design and development of a custom molded fitting. In general, the following should be considered:

1. Determine the type of assembly option desired; i.e., snap in place, push in place, retained with fastener, etc.

2. The wall thickness should be as consistent as possible to minimize potential warpage or excessive shrinkage.

3. The design should permit a minimum of 1/2" length of conduit to be molded within the part. Using notched or serrated conduit with 1/2" minimum length results in a minimum of 35 lbs. pull-off.

4. The design should allow for a straight "open and close" of the mold.
   NOTE: Our Engineering personnel will evaluate your custom conduit fitting and make recommendations regarding its moldability.

5. The fittings must be designed to allow the insertion of a support pin into the inside diameter of the conduit.

Materials

Material selection should be based on temperature, strength and flexibility requirements. Almost any commercially available thermoplastic resin can be shuttle molded. Typical production parts are molded from the following resins.

Material	Properties	Typical Uses
Polypropylene	Low cost, flexibility, low strength and lower temperature ranges	Handles and bushings
Acetal	Moderate cost, good strength, lower impact, moderate stiffness and temperature ranges	Standard fittings, ferrules, bushings and flags
Nylon 6	Some flexibility, good impact resistance and higher temperature ranges	Conduit fittings, ferrules and bushings
Nylon6/6 Glass Reinforced	Higher stiffness, good strength and higher temperature ranges	Bushings, levers, brackets and handles

NOTE: Standard colors for these materials are black or natural. Custom colors are available at additional cost.

Select the material based on the application, with the following criteria considered:

- Environmental and operating temperature ranges and extremes
- Axial and side loaded requirements
- Exposure to chemicals or containments
- Assembly method to mating part or mounting surface
- Actual part function.

Conduit and Core Selection

The size and type of the core (cable or wire) and selection of the conduit is determined by the application.

The majority of applications utilize braided, reinforced conduits. It is also possible to shuttle mold conduit fittings on a flat wire Bowden, as well as long lay conduit (consult CMA Engineering for further information). Braided conduit is coated with either polypropylene (relatively stiff) or nylon (more flexible and heat resistant). Refer to the chart on conduit constructions on page 8 to aid in selection of the appropriate material to meet your needs.

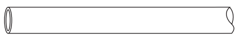
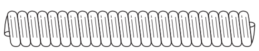
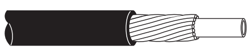
All conduit and core combinations should include a reasonable clearance between the inner I.D. and the core O.D. For most light and medium duty pull-pull applications, a clearance of .015 to .025 between the conduit I.D. and the cable O.D. is recommended.*

**NOTE: Decreasing the clearance to minimize the effects of lost motion can result in dramatically higher operational efforts.*

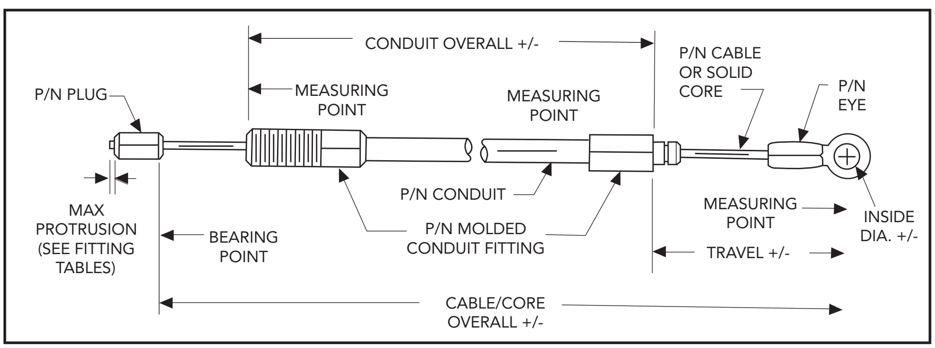
Characteristic	Material	Greatest →			Least
Corrosion Resistance	Wire or Cable	Type 302/304 Stainless Steel, Cadmium Plated Music Wire		Copperized Steel Galvanized Steel	Bright Music Wire Oil Temp. Spring Steel
Flexibility	Wire	Small Diameter			Large Diameter
	Cable	7 x 19	7 x 7	1 x 19	1 x 7
Efficiency	Wire	302/304 Stainless Steel			Hard Drawn Galvanized
	Cable	1 x 19	7 x 19	7 x 7	1 x 7
Compression Loads	Wire	Large Diameter			Small Diameter
	Cable	1 x 7	1 x 19	7 x 7	7 x 19
Tensile Loads	Wire	Large Diameter Wire			Small Diameter
	Cable	1 x 19	1 x 7	7 x 19	7 x 7

*Based on a comparison of the same diameter cable made from the same wire material.

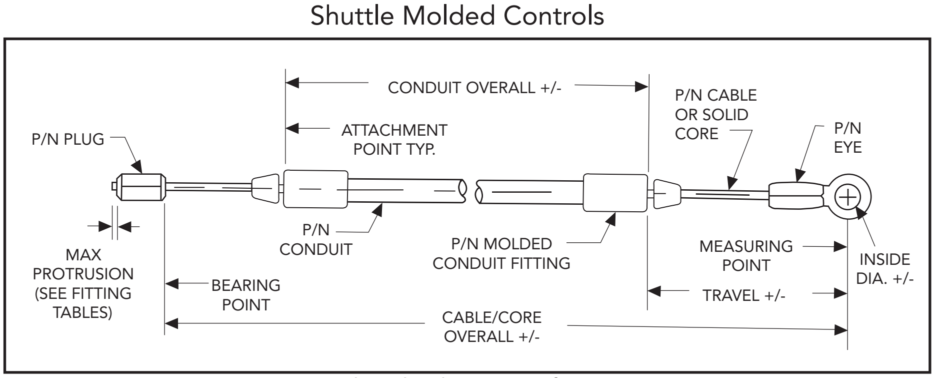
Conduit Selection and Description

	Cost Factor Rating	Conduit Type	Features	Typical Uses
	1	Tubing	Lightweight, very flexible. assemblies, vent controls.	Light duty seat release
	2	Braided Reinforced	Lightweight with liner braid for stiffness & minimal crush resistance	Seat latch, window mechanism, release assemblies, gas spring controls.
	3	Bowden	Good flexibility, good compressive strength, good crush resistance.	Medium-duty lower efficiency throttle controls, PTO controls.
	4	Flat Wire Bowden w/Liner	Fairly flexible, high efficiency, good compressive strength, good crush resistance.	Remote latch, deck and push-pull controls.
	5	Long Lay	Relatively stiff, high compressive strength, good crush resistance.	Clutch cables, brake cables, heavy-duty push-pull controls, marine throttles, shift control cables.

Push-Pull/Pull-Pull Controls



Shuttle Molded Controls



Note: For length tolerances, refer to page 16.

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
2-5 ft.	.060/1.52	.125/3.18	.188/4.8
5-10 ft.	.188/4.8	.375/9.53	.500/12.7
10-20 ft.	.375/9.53	.500/12.7	.750/19.0
20-40 ft.	.500/12.7	.750/79.0	1.00/25.4
40-50 ft.	.750/19.0	1.00/25.4	2.00/50.8
>50 ft.	DICTATED BY APPLICATION CONTACT CMA		

*NOTE: Tolerances tighter than shown are sometimes attainable at additional cost.
Contact CMA Engineering for additional information.*

NOTE: When dimensioning your finished drawing it is recommended that you specify the conduit overall with the cable/core overall OR the conduit overall and the travel.

Additional specifications, which should be added to your assembly drawing.

1. Holding strength of cable/core end fittings to be---lbs. (N) min.
2. Holding strength of conduit end fittings to be ---lbs. (N) min.
3. Max working load in pull mode to be ---lbs. (N).
4. Max working load in push mode to be ---lbs. (N). (Solid Core Assemblies)

Shuttle Molding

The process permits the molding of almost any type of thermoplastic component directly to the surface of conduit, cable or wire. Shuttle molding is done with a vertical injection molding press that utilizes a shuttle or table that moves back and forth in front of the injection nozzle. The upper half of the molds mounted to either side of the shuttle table. With the press closed and in the molding cycle, one lower-half mold is positioned to either the right or left of the head. This permits the operator to remove completed parts and to reload cut lengths of serrated conduit in preparation for another molding cycle. The process offers the following advantages:

- More cost-effective than assembled steel or plastic components.
- Manufactured and assembled in one operation.
- Better pull-off strength than conventional assembly techniques.
- More design flexibility than metal conduit fittings and flags.

Tooling

All molds are made using standard injection mold tool steels. All cavity inserts and cores are hardened to specification, to reduce wear and insure tool life. Most shuttle molds are made in 1, 2, 4 and 8-cavity configurations. The number of cavities is dictated by:

- Part size.
- Monthly or annual production volume requirements.
- Piece part vs. tooling cost analysis.
- Complexity of the part design.

Custom designed conduit fittings can be prototyped using a "soft" single cavity and core pin inserts in our prototype mold base. Prototype tooling can prove the design concept and aid in final specifications for the cable control system. Made for low volume (500-1,000 pieces), these tools are the best way to test a design and get a program going.

CMA's extensive selection of tooling for conduit, cable, fittings, as well as standard molded conduit fittings, offer you many solutions for your cable control needs.

Our Engineering personnel can offer suggestions and design assistance early in your cable control project. Call us with your requirements.

Cable Controls and Remote Actuation Products

CMA offers the widest selection of products available for a multitude of remote actuation requirements. Cable controls offer lightweight, reliable and cost effective solutions for the remote actuation of latches, releases and locking gas springs. These products are being used in many markets that include furniture, physical fitness equipment, recreational vehicles, transportation and specialty seating, medical furniture and equipment and custom OEM products.

CMA will assist you in the design and specification of the best assembly for each application. Where it is required and the volume justifies, we will assist in the design of custom components unique and proprietary to your requirements.