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LINKFLEX

MASTERFLEX

Benefits of Flexible Shaft

Flexible Shafts are a preferred rotary motion transmission device because they:

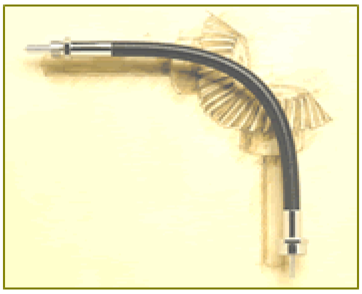
- **Eliminate alignment problems:** Flexible Shafts have no need for the tight tolerances that solid shafts require
- **Provide Greater design freedom :** Limitless possibilities in positioning motor and driven components
- **Have Higher Efficiency:** Flexible Shafts are 85%-95% efficient. Gears, U-Joints Belts and Pulleys give much lower performance due to greater frictional losses
- **Allow large offsets:** Flexible couplings allow only 5 degrees of offset and U-Joints 30 degrees, but with a 40-50% decline in efficiency. Flexible Shafts permit a full 180 degree off-set while maintaining their high efficiency
- **Are Light weight and powerful:** Flexible Shafts have a 3 to 1 weight advantage over other design solutions while transmitting greater power loads
- **Have Lower Installation Cost:** Flexible Shafts install in minutes without special tools or skills. Solid Shafts, Gears, Pulleys, and Universal Joints require precise alignment and skilled mechanics for their installations.
- **Reduce parts cost:** Bearings and housings for Solid Shafts and Gears require precise machining operations. Flexible Shafts eliminate the need for such demanding tolerances and their excessive costs.
- **Are Easy To Install:** Need no special installation tools.
- **Can Be Designed At The Latter Stages Of A Project:** Unlike other rotary motion devices that need to be designed around because of their rigidness, defined configurations, and large mass. Flexible Shafts allow greater design freedom since engineers have only one piece to work on, eliminating complex coordination of multiple pieces
- **Are not affected by vibrations:** Vibrations do not affect flexible Shafts performance.

Versatile Flexible Shafts

Flexible Shafts are often the preferred choice for rotary motion transmission over gear boxes, universal joints, and belts-and-pulleys in industrial and medical fields as well as in consumer items.

FLEXIBLE SHAFTS VS. GEAR BOXES

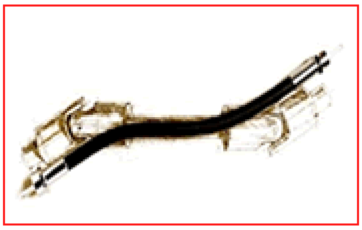
Flexible Shafts are preferred over gear boxes because they:



- are more economical for right angle bends
- are more efficient
- are less noisy
- occupy less space
- are easier to install-need no special skill or special tools
- require looser tolerance
- don't require expensive couplings that gear boxes often need

FLEXIBLE SHAFTS VS. UNIVERSAL JOINTS

Flexible Shafts are preferred over universal joints because they:



- are less expensive
- have fewer components
- are more efficient
- do not require tight mounting tolerances unlike universal joints
- have constant angular velocity
- require minimal maintenance
- make very little noise

Further, universal joints can be off-set only up to 15-20 degrees after which the change in angular velocity becomes objectionable. Flexible Shafts go up to 90 degrees without any discernible change in performance.

In universal joints, more components are needed beyond 20 degree offsets, adding to cost and space requirements.

Flexible Drives

flexible shafts

The truly flexible alternative to couplings and universal joints and shafts

General Product Information

- **Advantages**
- **Basic structure**
- **Load (Torque)**
- **Operating speeds**
- **The use of gearing**
- **Curves in the shaft**
- **Direction of rotation**
- **Installation and care of flexible shafts and casings**
- **Lubrication of flexible shafts**
- **What next?**

A flexible shaft makes it possible to
- ❖ **transmit power**
- ❖ **between two points**
- ❖ **regardless of their relative positions.**

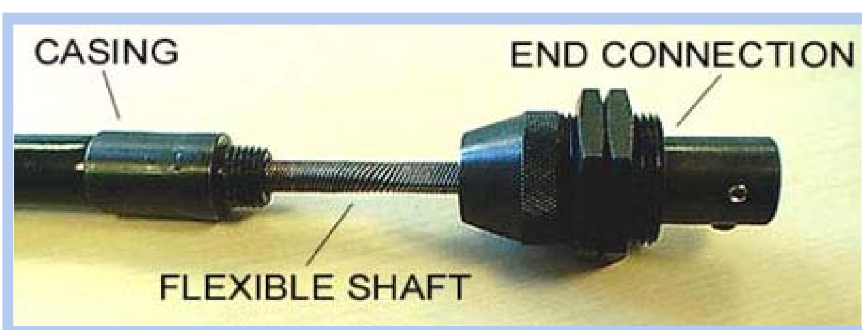
Use flexible shaft to transmit rotary power around a curve!

- ## Advantages

Design freedom	Design your system and place your driving and driven elements in the preferred position.
Design simplicity	No need to spend precious time ensuring tight drive system tolerances. Flexible shaft take up large misalignments by design
Moving parts	Ideal for hand tools or situations which involve constantly changing positions.
Dampens vibration	Tolerates vibration
Reliable	Minimum moving parts ensures reliability through simplicity
Bi-directional	Designed to deal with the most complex design requirements
Safe	Supplied as a self-contained drive the system is fully contained
Simple installation	Flexible to allow installation in the smallest of spaces.

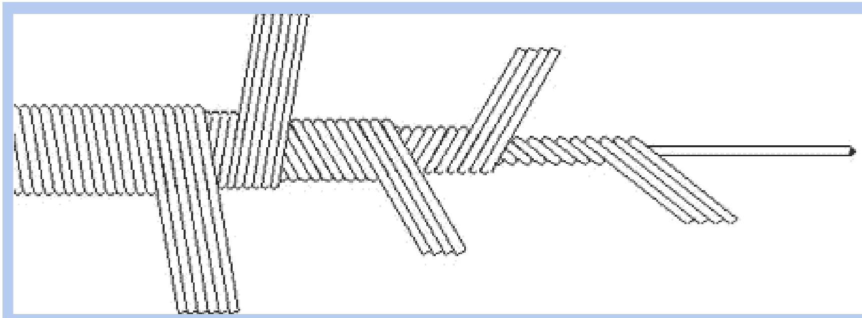
- ## Basic structure

A complete flexible drive will usually be made up of:



- A flexible shaft. This is the part that does the work and transmits the rotary motion.
- A flexible casing. This contains the flexible shaft and prevents excessive twisting under load.
- End connections. These are usually required to connect to the driving (e.g. motor/hand wheel) and driven (e.g. gearbox, valve) elements of the system.

Flexible shaft is built by winding one layer wire over another with a single wire or 'mandrel' in the centre. Successive layers alternate in pitch and direction.



Typical combinations are:

- The shaft only – with machined shaft ends attached or a squared formed onto the end of the shaft.
- The shaft and casing only – as above but with the addition of a casing to restrict shaft twisting.
- A complete flexible drive as described above.

MasterFlex® and LinkFlex® Industrial flexible Industrial shafts incorporate the latest advancements in flexible shaft design and construction and are manufactured using high tensile wires in carbon or stainless steel.

The characteristics of a flexible shaft are determined by the combination of the following factors:

- Grade of wire
- Number of layers
- Size of wire
- Number of wires in each layer
- Built-in tension

Varying the combination of these basic characteristics produces different types of shaft.

At one extreme is a shaft with maximum torsional stiffness, or resistance to twisting under load, giving minimum flexibility; at the other extreme is an

exceptionally flexible shaft which low torsional stiffness.
Between these extremes are many flexible shafts designed to meet our customer's requirements.
Factors that affect the design and application of a flexible shaft are discussed below:

- **Load (Torque)**

The load to be moved is normally expressed as the torque required to move the load.
The torque that a shaft must transmit is the principal factor in shaft selection. The torque requirement should be the maximum anticipated and, where possible, determined by direct measurement.
There is a distinct advantage in operating a flexible shaft at the highest speed conditions will permit, as the higher the speed the lower the torque on the shaft.
Other factors to consider are starting torque, reversing shocks and fluctuating loads all of which may constitute overloads on the shaft.
Where the overload strains on the shaft are not severe the factor of safety will generally be sufficient.
Where these factors are substantially more than normal running torque loads then a shaft capable of carrying these loads must be used.

- **Operating speeds**

Ordinarily, speeds of 1 – 3600 rpm are recommended as being well suited to flexible shaft operation.

Shafts of a larger diameter when run in a curved condition speeds should not exceed 152 surface metres per minute because of the possible excessive heating.

This maximum surface speed for any given shaft may be translated in r.p.m. by using the following formula:

$$\frac{152000}{3.14 \times d} = \text{r.p.m} \quad \text{(Where 'd' is the shaft diameter in mm)}$$

However, there are many applications where speed exceeds this guide and these figures represent a general rule for obtaining the best service life.

- **The use of gearing**

It is common practice, where standard motors are used, to introduce gearing to increase or decrease the ultimate speed of the operated device or tool.
Bearing in mind the desirability of always running a flexible shaft at the highest practical speed, it follows that in every case where gearing is used it should be located so that the flexible shaft operates at the higher speed.
Where gearing is introduced to reduce speed it should be placed at the driven end of the shaft; to increase speed place the gearing at the motor end.

Curves in the shaft

Since the flexible shaft was developed primarily as a means of transmitting power under conditions that make it impossible to use a solid shaft, most applications involve curves.

These applications may be divided into two types:

1. Those in which the shaft operates in a given position and the curve or curves in the shaft remain fixed.
2. Those in which there are relative movement between the driving and the driven elements, and the curvature of the shaft is continually varied.

Each shaft has a recommended minimum operating radius. This is the radius of the smallest curve in which the shaft should be operated. It varies with the type of shaft and the shaft diameter. Figure quoted for MOR includes a suitable safety factor.

A shaft should not be bent in a curve of smaller radius than its recommended minimum. The main consideration with respect to curves is their effect on the torque capacity of a shaft and on its service life. The torque capacity and service life of any given flexible shaft decreases as the radius of the curve is reduced. Therefore in working out an application the rule is to design all curves with the largest possible radius the application will permit.
Where conditions impose more than one curve in the shaft the radius of the smallest curve should be used as the basis for selecting shaft.

Direction of rotation

The pitch of the outer layer of wires determines the direction of rotation in which the shaft will give the best results. The shaft should be rotated in the direction that tends to tighten up its outer layer. When the shaft is operated in the opposite direction the torque capacity is generally reduced by 50%.
However, this reduction in torque capability is less severe in the range of the bi-directional shafts.

Installation and care of flexible shafts and casings

1. Never bend a flexible shaft, or a casing with a shaft inside it, in a radius smaller than the 'minimum operating radius' of the particular shaft.
2. Do not subject the shaft or casing to unnecessary end pull or compression. Excessive tension on shaft or casing may cause permanent damage.
3. When installation is made, check for correct protrusion of shaft fittings to ensure proper engagement with mating parts.
4. After one end of a flexible shaft combination has been attached at the driving or driven end, be sure the shaft rotates freely before attaching the other end. Also, make certain that end fittings are properly engaged at both ends and that the shaft is not cramped in the casing.

5. Keep the flexible shaft and inside of casing free from dirt and grit.
6. Securing the casing with clamps at suitable intervals is desired in all fixed applications.
7. Frequent lubrication of flexible shafts is not always necessary except with large diameter shafts. Steel flexible shafts should always have a thin coating of grease to prevent corrosion.

- **Lubrication of flexible shafts**

Flexible shafts generally require periodic lubrication. The frequency of lubrication depends on the nature of the service. Where the shaft operates for long periods or is subjected to considerable flexing during operation, the lubrication should be more closely supervised.

General lubrication – the following procedure is recommended:

1. Remove the shaft from the casing. Clean both the shaft and inside the casing thoroughly by washing in a degreasing agent.
2. Drain the casing and dry the shaft.
3. Coat the entire shaft lightly with a good grade of grease. Contact our service department if you require details of the grease originally used. Grease as the shaft is assembled into the casing. Do not force grease into the casing with grease guns or pressure lubricators.

We can also supply a range of stainless steel flexible shafts which require, when used in our new flexible drive systems, no grease.

- **What next?**

If you are planning to use a flexible shaft in your application or now realize that our flexible shaft will solve your engineering problem then use the technical data of our **MasterFlex®**.
These drives are standard products that, if not suitable, can be adapted for your application.
If you require a more bespoke solution you can use the performance data quoted for the **MasterFlex®** drives as a guide to typical flexible shaft performance.

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LinkFlex®

Mechanical power transmission made easy

- **Mechanical power transmission made easy**
- **for short lengths**
- **The truly flexible alternative to couplings and universal joints and shafts**

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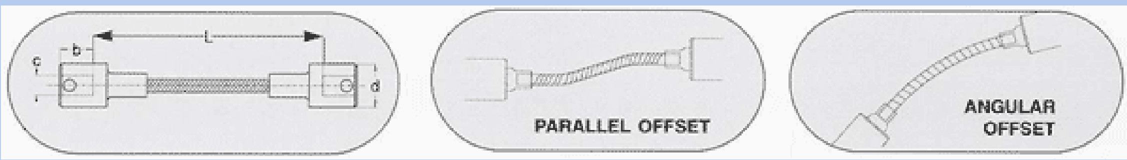
Flexible Drives



Please contact our sales department if you require:

Higher torque figures than those stated... Longer or shorter couplings... Alternative bore sizes or keyways etc... Couplings in Stailess Steel, Non-Magnetic or Non-Ferrous materials.

3mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (cNm)
LF 03010/_	33.00	8.00	3, 4 or 5	12.00	2.05°	0.35	8000	35.30
LF 03020/_	43.00	8.00	3, 4 or 5	12.00	4.00°	1.40	8000	22.60
LF 03030/_	53.00	8.00	3, 4 or 5	12.00	6.10°	3.20	8000	11.90
LF 03040/_	63.00	8.00	3, 4 or 5	12.00	8.15°	5.65	8000	8.50

4mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (cNm)
LF 04020/_	47.00	8.00	4, 5 or 6	12.00	3.75°	1.25	8000	45.20
LF 04030/_	57.00	8.00	4, 5 or 6	12.00	5.50°	3.00	8000	23.70
LF 04040/_	67.00	8.00	4, 5 or 6	12.00	7.50°	5.30	8000	14.10

5mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (Nm)
LF 05020/_	53.00	10.00	4, 5 or 6	14.00	3.25°	1.18	6000	1.36
LF 05030/_	63.00	10.00	4, 5 or 6	14.00	5.00°	2.60	6000	0.78
LF 05040/_	73.00	10.00	4, 5 or 6	14.00	6.70°	4.50	6000	0.64
LF 05050/_	83.00	10.00	4, 5 or 6	14.00	8.40°	7.30	6000	0.40

6mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (Nm)
LF 06030/_	71.00	12.00	5, 6 or 8	16.00	4.30°	2.25	3600	1.99
LF 06040/_	81.00	12.00	5, 6 or 8	16.00	5.70°	4.00	3600	1.45
LF 06050/_	91.00	12.00	5, 6 or 8	16.00	7.16°	6.25	3600	1.00
LF 06075/_	116.00	12.00	5, 6 or 8	16.00	10.50°	13.90	3600	0.43

9.5mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (Nm)
LF 09050/_	101.00	15.00	6, 8 or 10	23.00	7.15°	6.20	3600	4.33
LF 09075/_	126.00	15.00	6, 8 or 10	23.00	10.70°	13.75	3600	2.71
LF 09100/_	151.00	15.00	6, 8 or 10	23.00	14.30°	24.50	3600	1.79
LF 09125/_	176.00	15.00	6, 8 or 10	23.00	17.90°	37.80	3600	1.42

12.7mm Shaft

Part No.	L mm	b mm	c mm	d mm	Max Angular Offset	Max Parallel Offset (mm)	Max Speed (rpm)	Max Torque (Nm)
LF 12050/_	112.00	15.00	8, 9.52 or 10	23.00	4.75°	4.15	3600	15.82
LF 12075/_	137.00	15.00	8, 9.52 or 10	23.00	7.15°	9.25	3600	11.85
LF 12100/_	162.00	15.00	8, 9.52 or 10	23.00	9.50°	16.50	3600	7.90
LF 12125/_	187.00	15.00	8, 9.52 or 10	23.00	11.90°	26.65	3600	6.35

Standard material for all couplings is steel end connectors (En3b) and a steel shaft. End connectors are fitted with an appropriate steel grub screw. Assembly is blacked to offer corrosion resistance.
To order - simply telephone quoting the part number required i.e. LF 03010/030 (/30 = 3.0mm bore) and quantity desired. Preferred sizes of bores are given in the above tables under column 'c'.

NEW – Panel Mounts

An additional option to add versatility to this highly popular product. Permits the simple connection of a panel knob to its controlling element with the minimum of fuss within enclosures. Contact for details.

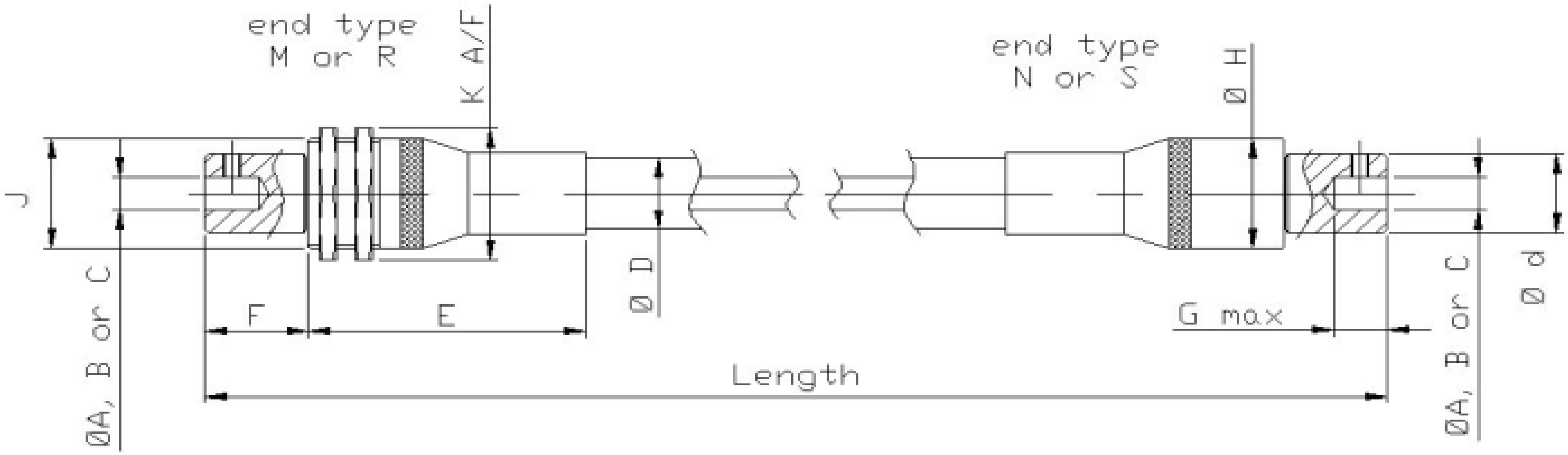
<u>MasterFlex - Performance</u> Characteristics for NORMAL and HIGH DUTY MasterFlex

Shaft Code	Shaft Ø	Direction	Min Operating Rad (mm)	Torsional Deflection (°)		Speed (rpm)		Max Torque (Nm) vs Bend Radius (mm)											
				Wind	Unwind	Normal Duty	High Duty	75	100	125	150	175	200	250	300	350	400	500	600
04	3.80	A & C	75	31.3	75	2000	12000	0.15	0.22	0.29	0.35	0.40	0.44	0.50	0.53	0.55	0.56	0.56	
		B		28	56	200	3000	0.65	1.20	1.50	1.70	1.80	1.85	1.95	2.00	2.03	2.05	2.10	
05	4.75	A & C	100	9.3	36.5	2000	12000		0.26	0.56	0.75	0.87	0.94	1.06	1.17	1.29	1.40	1.60	
		B		7.5	17	200	3000		1.30	1.70	2.05	2.17	2.25	2.34	2.40	2.45	2.50	2.60	
06	6.35	A & C	125	3.5	8.75	8000	8000			0.80	1.05	1.30	1.50	1.87	2.15	2.38	2.57	2.85	
		B		1.5	3.25	200	3000			4.0	5.0	6.0	7.0	8.0	9.0	9.4	9.8	10.5	
08	8.00	A & C	150	0.65	1.25	2000	6000				2.7	3.0	3.6	4.2	4.5	4.75	4.9	5.2	5.5
		B	200	0.5	0.8	200	2000						10.0	12.5	14.4	15.8	16.5	17.6	18.5

Shaft Code	Shaft Ø	Direction	Min Operating Rad (mm)	Torsional Deflection (°)		Speed (rpm)		Max Torque (Nm) vs Bend Radius (mm)											
				Wind	Unwind	Normal Duty	High Duty	200	250	300	350	400	500	600	650	750	800	1000	1500
09	9.52	A & C	200	0.9	2.15	2000	6000	4.5	5.4	6.0	6.5	6.8	7.1	7.2	7.25				
		B		0.3	0.63	200	2000	13.0	17.0	20.0	23.0	24.4	26.0	27.2	28.0				
13	12.7	A & C	250	0.2	0.47	2000	4000		8.0	10.0	12.0	12.5	13.0	13.5	13.7	14.1	14.3	15.0	
		B		0.11	0.20	200	2000		23	32	41	45	49	51	51.5	53	53.5	56	
16	16	A & C	300	0.27	0.23		2000			12.5	14.0	14.7	16.0	17.5	18.0	19.3	20.0	22.5	
		B	350	0.06	0.13		1500			20	28	31.5	36.5	40	41.2	43.8	45	50	
19	19.05	A & C																	
		B	400	0.01	0.01		1500					40	50	60	62.5	65	66.2	70	75

Figures for torsional deflections are in Degrees for a load of 0.1 Nm load at 1 metre along the shaft.

NORMAL DUTY (Oilite Bearings - End Type Codes R & S) MasterFlex - Dimensions



All dimensions in mm

Shaft Ø	Connector Bores (A,B and C)			d	D	E	F	G Max	H	J	K
	A	B	C								
4	4	5	-	12,5	10,5	43	10	8	15	M15 x 1	22
5	5	6	8	15,5	14	50	16	12	18	M18 x 1	24
6	6	8	9	18,5	17	59	17	14	21	M21 x 1	27
8	8	11	12	18,5	17,5	63	23	17	22	M22 x 1.5	30
9	10	14	-	23	22,5	69	25	20	26,5	M26.5 x 1.5	35
13	15	16	-	26	25	84	31	24	29,5	M29.5 x 1.5	36

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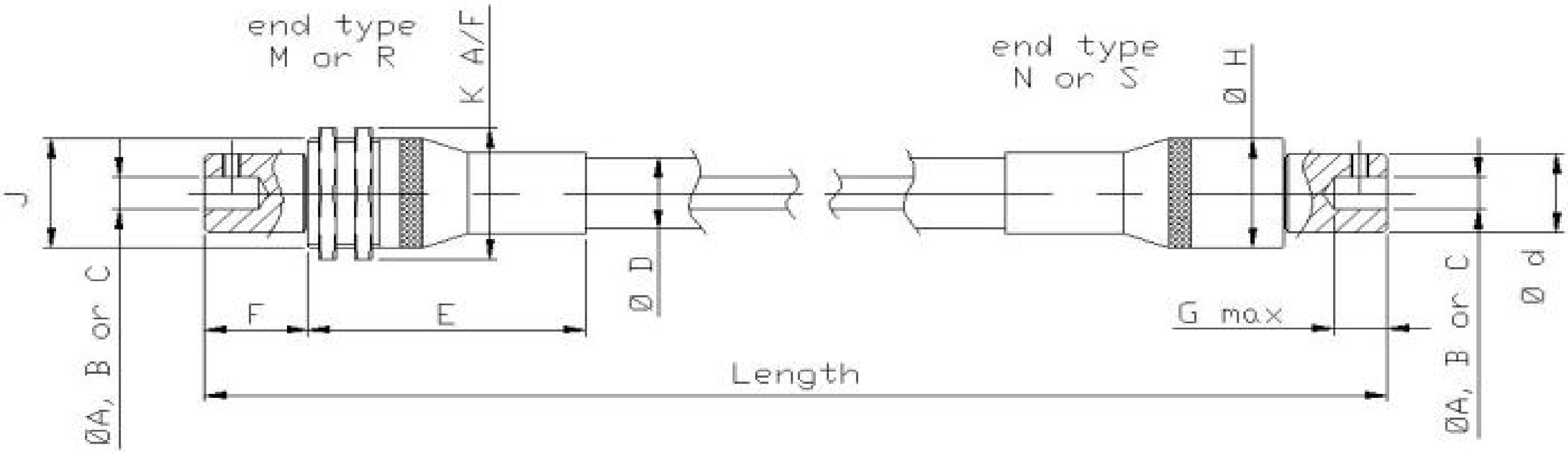
HIGH DUTY Ball Bearing MasterFlex - Dimensions



Dimension Table for **HIGH DUTY (Ball Bearings - End Type Codes M & N)**

All dimensions in mm TBA means : To Be Advised

Shaft Ø	Connector Bores (A,B and C)			d	D	E	F	G Max	H	J	K
	A	B	C								
4	4	5	-	10,75	10,5	48	11	8	18	M18 x 1	24
5	5	6	8	14	14	59	14,5	12	21	M21 x 1	27
6	6	8	9	18	17	66,5	19,5	14	27	M27 x 1	35
8	8	11	12	20,5	17,5	68,5	24	17	30	M30 x 1.5	36
9	10	14	-	24,5	22,5	78,5	25	20	34	M34 x 1.5	41
13	15	16	-	28	25	85,5	26,5	24	38	M38 x 1.5	46
16	16	19,05	20	31	32	108,5	30	25	44	M44 x 1.5	55
19	16	17	20	36,5	31	114	31	25	50	M50 x 1.5	60
25	TBA	TBA	TBA	50	44	155	50	34	74	M74 x 2	84

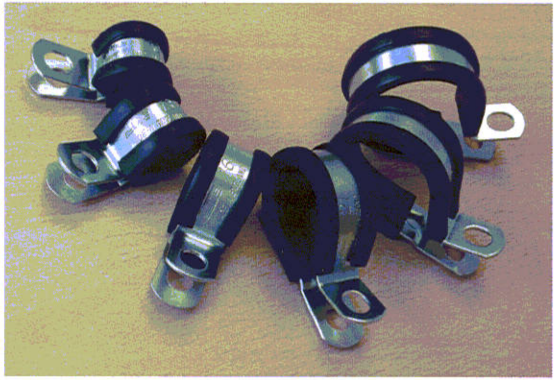
Accessories

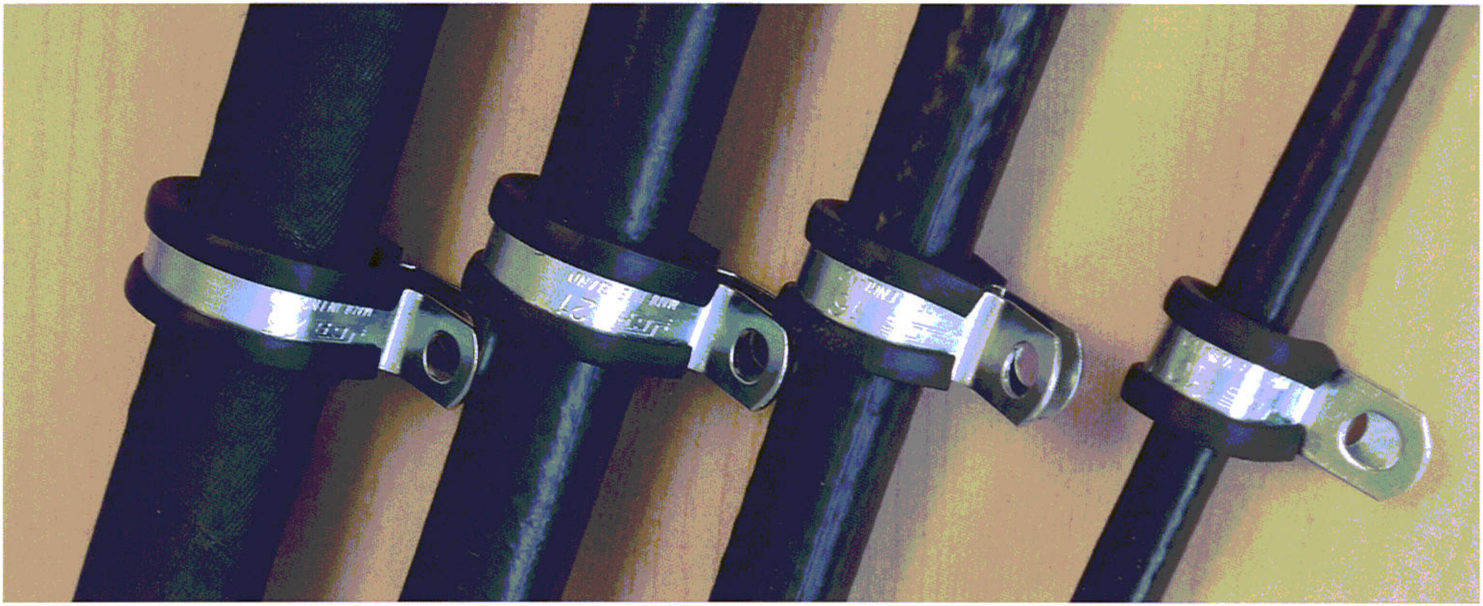
'P' Clips

Used to provide local restraint to structure for long MasterFlex assemblies in areas where differential movement is not required or to restrict to a particular section of shaft.

To suit MasterFlex	MasterFlex Case Ø (mm)	Clip no. (Finish BZP)	Fixing Hole Ø (mm)
M04	10.5	PC0410	6.6
M05	14	PC0513	6.6
M06	17	PC0616	6.6
M08	17.5	PC0816	6.6
M09	22.5	PC0921	6.6
M13	25	PC1325	6.6
M16	32	PC1629	6.6
M19	31	PC1629	6.6

Stainless steel 'P' clips are available on request.





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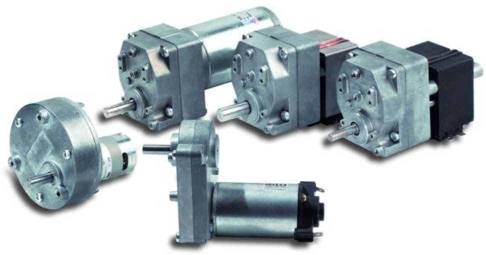

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