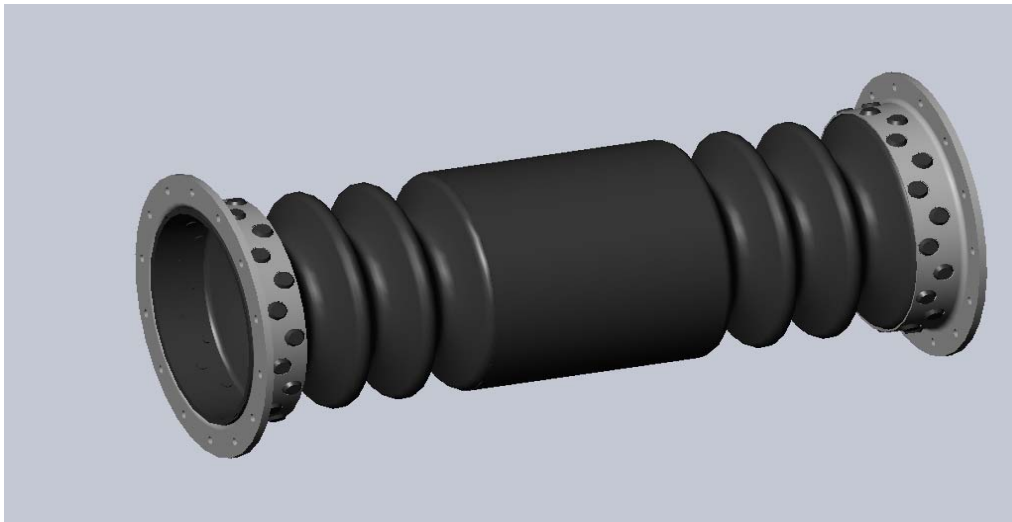


## LTI Industrial Drive Shafts

### Highlights:

- Outstanding performance evolved from a helicopter heritage
- 100% fully integral carbon fiber epoxy construction. No flex element corrosion concerns
- One piece construction. No need to re-balance – ever!
- Lengths up to 14' (4.3m)
- Lightest solution in the world! No more struggling with cranes. LTI shafts are typically 50 -75% lighter than all competing technology (including those with carbon fiber spacing tubes)
- Highly engineered solutions incorporate industry leading torque density, motion accommodation and zero-growth spacing tubes. As part of a paradigm shift in flexible drive trains LTI has incorporated a Coefficient of Thermal Expansion (CTE) close to zero such that even 14 ft long drive shafts do not unacceptably load flex elements under thermal load
- LTI flex shafts are maintenance free and constant velocity<sup>1</sup>

The drive shaft transmits power from the output shaft of the prime mover to the input shaft of the driven machine. LTI industrial drive shafts are highly corrosion resistant, lightweight for easy installation, tolerate ambient temperatures to 275 degrees, and are well balanced for high speed operation. Transmitting full system power over significant distances LTI shafts also accommodate parallel offset of the end faces due to structural movement of the infrastructure (including thermal growth) and imperfect installation. This parallel offset or lateral deformation results in an equal and opposite bending moment / rotation in the flex elements at each end with consequential high cycle fatigue considerations. The material solution comprising LTI flex elements handles this cyclic stress better than any other material and therefore allows best-in-class motion accommodation.



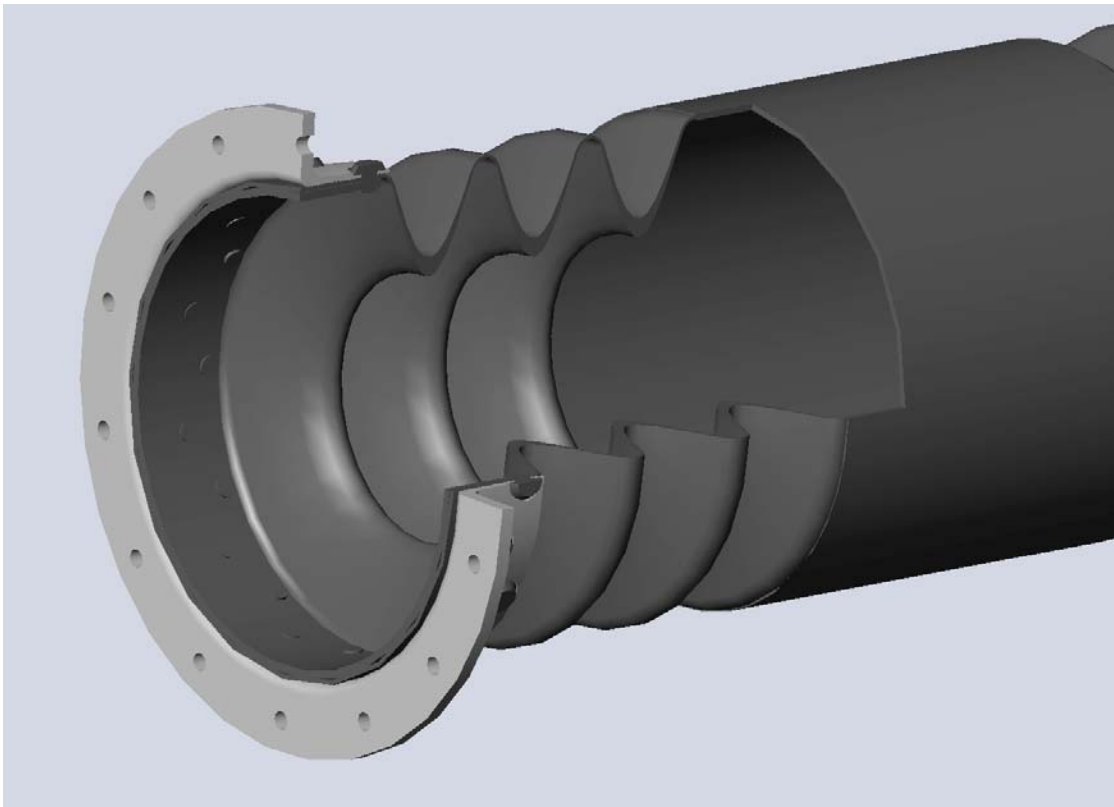
## Weight

*No cranes, reduced part count, no need to re-balance – ever! Designed to provide infinite fatigue life*

The LTI family of highly engineered industrial flex-shafts builds the flex elements integrally into the shaft without the additional split-lines and fasteners usually required. This feature removes the prospect of losing shaft balance where these large numbers of parts traditionally came together. Additionally, the LTI integral solution improves shaft reliability and provides for very large weight saving - much of which comes from the obsolescence of the lumped masses where bolted split lines used to be – even the longest and highest power LTI shaft can be installed by hand without the need for cranes.

## Resonance

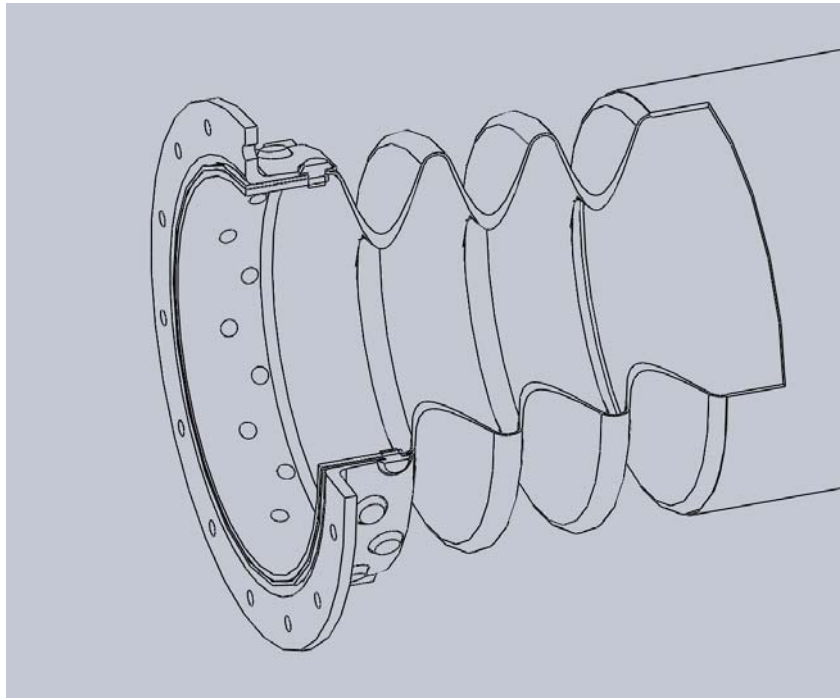
LTI flex-shafts allow high operational speeds below resonance in bending for two reasons: First, the extremely low mass per unit length of the spacing tube and secondly the ability to make the spacing tube the same diameter as the flex elements. This important difference arises because of the avoidance of bolted split lines between flex elements and spacing tube such that socket / wrench access to nuts and bolts is no longer required at this location. Conventional, assembled, shaft/coupling solutions usually design for sub-critical operation below the ‘whirling’ or 1<sup>st</sup> bending natural frequency but very often must pass through the 1<sup>st</sup> axial natural frequency to reach operational speed. LTI integral composite drive shafts are typically sub-critical for each of axial, torsional and bending resonance.



## Torque & Misalignment

LTI industrial drive shafts are competitive with all competing technology in torque density. Torsional buckling thresholds are more than 100% above operational torque limits for most sizes. The LTI Industrial series are IN400, IN500, IN600, IN800, etc., increasing in size through IN2600 – these designations emanating from initial tooling sizes of 4 inch through 26 inch diameters. Shaft selection may be dictated by required torque or by bending natural frequency when the shaft is long. Axial motion and torque limits are constants for each series while parallel offsets possible, weight, and natural frequencies are functions of the length required. Almost all non-aerospace applications of flexible drive shafts require power transmission while the end faces are forcibly misaligned but still parallel to each other. The enforced lateral translation of the end face results in a fully reversed bending fatigue cycle occurring once per shaft revolution with equal and opposite bending rotations at each end of the shaft and an associated constant shear force. Historical practice with conventional technology has been to provide a limit angle permissible at each end and to use the spacing tube length to calculate the resulting allowable parallel offset. LTI's line of highly engineered, fully integral flex shafts provides the allowable offset directly.

It should be noted that while LTI composite flex shafts are capable of larger misalignments than other constant velocity<sup>1</sup> couplings this is usually not the best design solution because of a phenomenon referred to as geometrical non-linearity. Essentially this means that some of the torque transmitted by the rotating spacing tube is converted to bending in the flex elements at each end and for high torques this can result in early, quasi-static, failure of the flex elements in any technology. Differentiation between technologies is found in weight, natural frequencies, part-count, reliability, torque density, and cost.



Series	Axial Stiffness	Bending Stiffness	Axial Motion Limit	Torque Continuous Operating	Torque Peak Overload	Torque Momentary	Max. Shaft Diameter (C)
	Lbf/in	In.lbf/rad	in	In.lbf	In.lbf	In.lbf	in

<b>IN400</b>	3190	5,400	0.04	15,000	18,750	22,500	4.148
<b>IN500</b>	2950	7,750	0.05	25,933	32,416	38,900	5.154
<b>IN600</b>	2,850	10,700	0.06	41,000	51,250	61,500	6.16
<b>IN800</b>	2,750	18,750	0.08	85,500	106,875	128,250	8.172
<b>IN1000</b>	2,850	29,750	0.10	153,333	191,666	230,000	10.184
<b>IN1400</b>	3050	63,000	0.14	377,333	471,666	566,000	14.208
<b>IN1800</b>	3370	114,500	0.18	750,667	938,334	1,126,000	18.232
<b>IN2200</b>	3700	187,500	0.22	1,309,667	1,637,084	1,964,500	22.256
<b>IN2600</b>	4050	287,500	0.26	2,092,000	2,615,000	3,138,000	26.28

**Table 1 Industrial Drive Shaft Properties Independent of Length**

- High maintenance gear couplings, universal joints and others where sliding contact exists between separable parts result in both wear / lubrication requirements and non-constant velocity. LTI's diaphragm type flex elements are both maintenance free and constant velocity (rpm in = rpm out).

