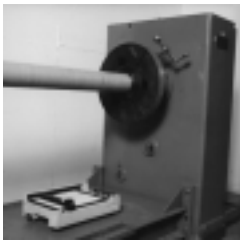
TRUE TUBE ™ COMPOSITE TORQUE TUBES



True-Tube composite tubes are high-strength, lightweight torque tubes for long span drive shafts. These tubes are filament wound carbon or glass fiber construction in an oven cured epoxy matrix. True-Tube composites offer the following advantages over steel tubing.

LONGER SPANS

TrueTube composite tubes have a higher stiffness to weight ratio than steel tubing. That increases the critical speed of the tubing and allows longer spans without center bearings.

LIGHT WEIGHT

TrueTube drive shafts weigh up to 80% less than equivalent steel driveshafts. That means better balance and reduced vibration. Bearing life may be improved by minimizing overhung weight.

DESIGN FLEXIBILITY

TrueTube composite tubes may be custom designed to meet your requirements for torsional stiffness, critical speed or torque capacity. With TrueTube, a designer can tune torsional or lateral critical speeds out of a machine system.

All TrueTube products include an ultraviolet barrier that is wound into the structure of the tube before it is cured. This UV barrier eliminates the need for paints or other protective coatings and results in a smooth, durable finish that other composite tubes don't offer. TrueTube products are cured in an enclosed oven to assure consistent strength and quality. Design data is shown below for standard series tubes. Standard series tubes are designed for maximum length at moderate torques. High torque designs are also available.

MODEL NUMBER	TUBE I.D. INCHES	TUBE O.D. INCHES	SLEEVE O.D. INCHES	RATED TORQUE LB*IN	TUBE WEIGHT (lb./in.)	TORSIONAL STIFFNESS x10^6 LB*IN/RAD	MAX DBSE – INCHES				MAX TUBE LENGTH INCHES
							2000 RPM	1800 RPM	1500 RPM	1000 RPM	
SERIES SL – ALL CARBON CONSTRUCTION											
SL2.0	2.00	2.30	2.40	6,500	0.05	1.26	90	95	104	127	82
SL3.0	3.00	3.25	3.50	12,000	0.08	3.61	110	116	127	155	128
SL4.0	4.00	4.23	4.50	22,000	0.11	8.60	127	134	147	180	145
SL6.0	6.00	6.25	6.63	42,000	0.20	34.4	152	160	175	214	177
SL8.0	8.00	8.25	8.63	63,000	0.24	80.2	180	190	208	255	192
SL10.0	10.00	10.25	10.75	80,000	0.32	155	199	210	230	281	232
SL12.0	12.00	12.25	12.75	100,000	0.38	258	215	227	249	304	232
SERIES SS – CARBON/GLASS CONSTRUCTION											
SS2.0	2.00	2.30	2.40	5,500	0.06	0.97	79	83	91	111	82
SS3.0	3.00	3.25	3.50	10,500	0.08	2.86	97	102	112	137	128
SS4.0	4.00	4.23	4.50	22,000	0.12	7.28	112	118	129	158	145
SS6.0	6.00	6.25	6.63	42,000	0.20	26.4	135	142	155	190	177
SS8.0	8.00	8.25	8.63	58,000	0.28	57.3	151	160	176	216	192
SS10.0	10.00	10.25	10.75	73,000	0.34	115	173	183	200	245	232
SS12.0	12.00	12.25	12.75	88,000	0.42	206	189	199	218	267	232
SERIES LS – ALL GLASS CONSTRUCTION											
LS2.0	2.00	2.30	2.40	5,000	0.07	0.75	66	70	77	94	82
LS3.0	3.00	3.25	3.50	10,000	0.09	2.06	80	84	92	113	128
LS4.0	4.00	4.23	4.50	18,000	0.14	5.04	93	98	107	131	145
LS6.0	6.00	6.25	6.63	39,000	0.23	18.9	110	116	127	155	177
LS8.0	8.00	8.25	8.63	51,000	0.30	43.0	128	135	148	181	192
LS10.0	10.00	10.25	10.75	64,000	0.37	86.0	142	150	164	201	232
LS12.0	12.00	12.25	12.75	77,000	0.46	149	155	163	178	218	232

NOTES: 1) TORQUE RATINGS ARE AT 100% HUMIDITY AND 200 DEG. F.
2) MAX RPM VALUES SHOWN ARE CALCULATED AT 75% OF FIRST CRITICAL SPEED.
3) TORSIONAL STIFFNESS SHOWN IS PER INCH OF TUBE LENGTH.
ACTUAL STIFFNESS = TORSIONAL STIFFNESS/TUBE LENGTH (IN.)

CI on Composites

Official Publication of the SPI Composites Institute *June 1992*

STEEL COULDN'T, COMPOSITES DID

NOTE: Since the publication of this article. ABB has been purchased by CCDI and continues to produce world-class composites.

WHEN STEEL DIDN'T WORK FOR AN ORANGE COUNTY, CALIFORNIA, WASTE DISPOSAL PUMP, DESIGN ENGINEERS USED A COMPOSITE TO SOLVE THE PROBLEM. Steel was originally selected because of its strength, and sewage pumps have to be sturdy. But unfortunately a basic phenomenon of physics offset the strength advantage of steel. All bodies have a natural frequency at which they vibrate when excited. One of the best examples is a tuning fork. When struck it vibrates and produces sound. A similar situation occurs when a deep voiced, resonant opera singer hits a high note and causes the champagne glasses to vibrate and shatter.

In the Orange County pump the steel drive shaft was excited by the motor, the pump itself and everything else attached to the system. So the shaft vibrated excessively, and that's where the trouble came into play. This vibration caused abnormal wear on the pump bearings, and the cost of replacing the worn out bearings was just too high.

The composite drive shaft, however, has a much higher natural frequency than the steel one had. Thus it will not vibrate excessively within the operating range of the pump.

These electric motor drive shaft pumps were replacements for engine/right angle gear drive units. The new pumps are positioned 15 feet below the drive motors, and are connected to the motors by 15 foot vertical drive shafts. Changeover to the new system was completed in the summer of 1990.

Faced with the problem of the vibrating steel shafts, the pump designers deliberated over three alternative solutions:

- Use a larger diameter steel shaft to increase the drive shaft's natural frequency.
- Use a two-piece steel shaft with a second set of bearings.
- Use a light weight, one-piece shaft made of composite material.

APPLICATIONS

This one piece, composite shaft (left) is easily installed and removed for maintenance. The composite drive shaft (right) has functioned without problems since April 1991, so Orange County is installing 23 more.

The larger diameter steel piece was eliminated because the additional weight would make maintenance more difficult and would increase stress on the drive train. The two-piece steel shaft was rejected because of the additional expense that would be incurred for lubricating the additional bearings, and by taking the shaft apart to perform maintenance on the pump or motor.

THE CHOICE - COMPOSITES

So that left the one-piece, lightweight composite drive shaft. It was expected - and in application proven true - that a composite material would provide two basic advantages over steel: a full length (15 foot) drive shaft without the need of a central support, and the absence of vibration that imparts stress on the bearings. In addition, the designers realized that composites' ability to flex and to absorb impact would prove advantageous in the event of earthquake damage, an ever present concern in California.

The use of a composite tube with a universal drive shaft is the first application of this new technology in waste treatment plant operations in California. Orange County (population 2.3 million) maintains one of the biggest sewage treatment systems in the state, consisting of two large treatment plants and 30 lift stations, servicing 825 miles of trunk line sewers.

FURTHER INSTALLATIONS

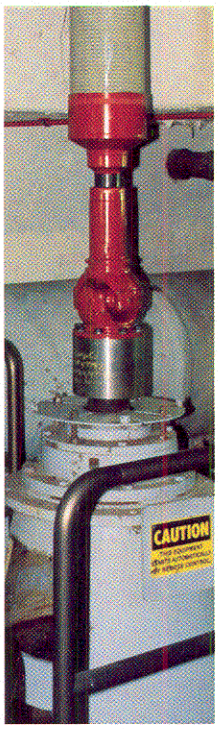
Based on the success of this first composite drive shaft, operating without trouble since April 1991, Orange County plans to install composite drive shafts in 23 of their waste treatment pumping stations. County officials are estimating that the composite drive shaft technology, when completely installed, will save the county six to nine million dollars annually.

The County Sanitation Districts of Orange County (CSDOC) contracted with Johnson Power of North America to develop a universal joint drive shaft featuring a composite tube, and ABB Composites was selected to produce the composite part. ABB formulated a graphite composite material for the 15 foot long shaft. The finished product weighed only 79 pounds, compared to 277 pounds for a steel tube. This lighter weight enables the drive shaft to run through the entire range of pumping speed variations without creating critical speed excitation and the consequent vibration problems.

ABB also drew up the specifications for machining the metal fittings used to connect the composite tube to the universal joints of the drive shaft. Then the finished fittings, manufactured by Johnson Power, were returned to ABB for compression into the composite tube sub-assembly. Compression fittings provide the sturdiest connections and ensure that torque is transmitted properly to the universal joints.

After actual installation in a waste disposal plant, Orange County technicians conducted rigid tests on the new drive shaft. A vibration acceptance analysis measured a speed of 2700 RPM without harmful vibration, well above the recommended 1728 RPM.

In comparison with the steel tube, the lesser mass of the composite successfully eliminated the critical speed excitation problem and cut vibration in half.



ADDITIONAL REASONS

There are a number of other advantages over the steel shaft, too:

- The lighter weight ensures ease of handling. Only two people, using a minimum of support equipment, are required to install or remove the shaft.
- Since the lighter weight of the composite shaft lets the pump operate over the entire range of available speeds, the pump can run at slower speeds when conditions permit, thus conserving energy.
- The composite shaft is resilient, so it can absorb the impact of solid waste objects and then snap back to its original shape, something a metal tube could not do.
- Since the pump thrust bearing is not supporting a heavy steel tube, the cost of replacing worn parts will be cut.
- Thermal expansion will be reduced, thus lessening wear on all moving parts.
- If a pump shaft gets out of balance, which can happen in a heavy use operation, the light weight of the composite tube will provide easier re-balancing.
- Even if a composite shaft breaks, it will be easier to repair than a steel shaft.
- The composite shaft will not rust or corrode, an important attribute in a waste disposal environment.

All in all, very conclusive evidence of a successful composite solution to a key problem.

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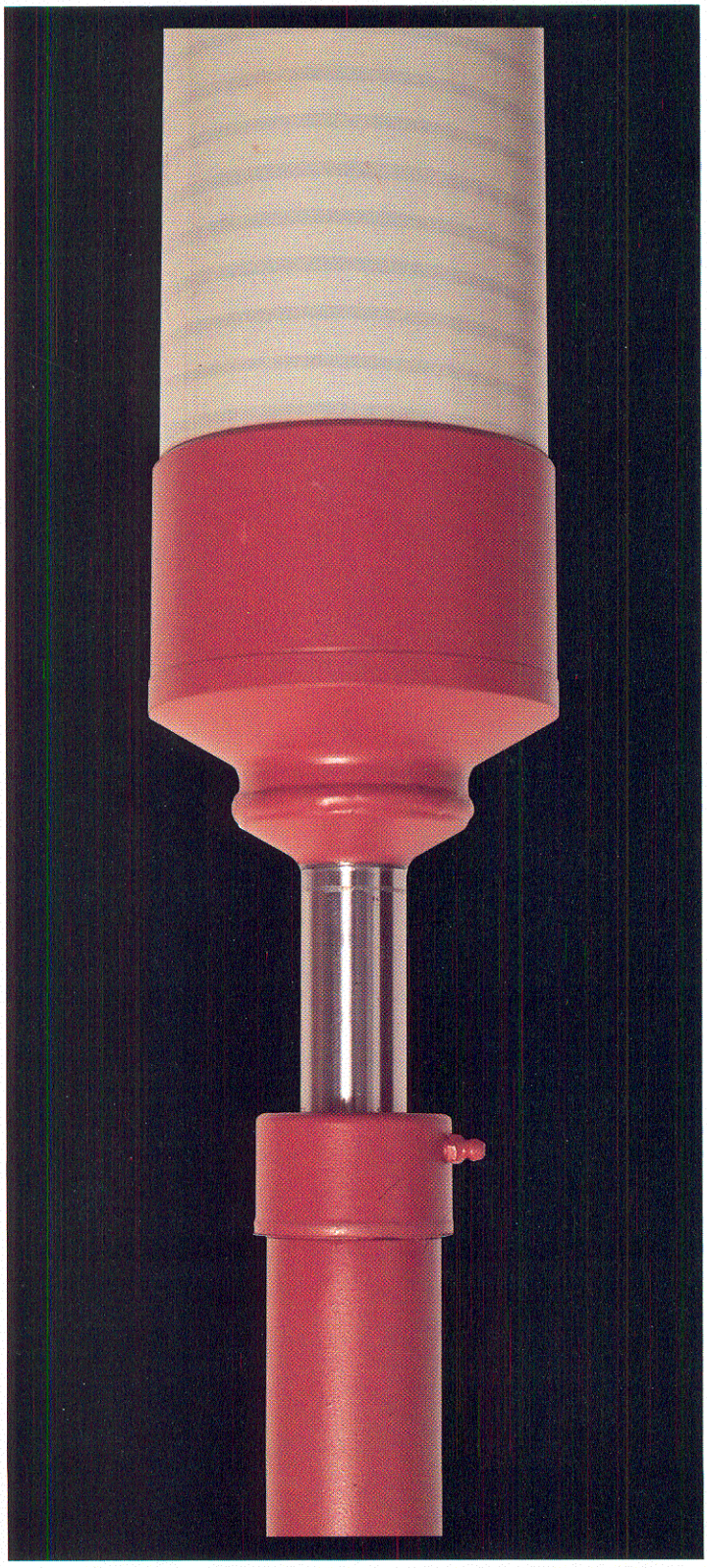
A Turning Point in Drive Shaft Technology

...A Major Innovation in Dry Pit Pumping Applications



Proudly Presenting Ultra Tube... Composite Shafting Assemblies

For years, dry pit pumping systems have been the preferred choice of many consulting engineers and municipalities.

This proven method provides...

.Isolation of expensive motors and controls from potential flooding.
.A cleaner, more accessible facility.
.System can be monitored visually.
.Pumps that will process materials that would clog and destroy submersibles.
.On-site repair for a fraction of the cost of factory required submersible repair.
.Higher horsepower (larger capacity) systems.

Johnson Power is proud to offer UltraTube composite tubing for the following reasons...

.Natural damping characteristics of carbon and glass fibers significantly reduces potential vibration problems.
.The ability to torsionally and laterally tune the system by varying the UltraTube composition.
.Longer lengths spanned in a single section.
.Costly intermediate floors and steady bearing supports can be eliminated in some cases.
.High strength with low weight - reduction in overall mass.
.Maximum power transmission efficiency.

AND, UltraTube intermediate shafting systems are already proven performers in wastewater facilities across America.

If you're specifying new system components for an upcoming project or retrofitting an existing station, call Johnson Power for a no obligation application analysis.

For innovations in drive shaft technology, turn to the industry leader...

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