FEATURES OF TOVEY ENGINEERING SHEAR WEB FORCE TRANSDUCERS

Shear Web design force transducers have a number of features that make them the best choice for many test measurement and metrology applications. The Shear Web series of force transducers include Model SW General Purpose, Model FR Fatigue Rated, Model SWP High Precision, and Model CS Calibration Standard products. Special features of the designs include:

- Wide Range of Rated forces
- High accuracy performance in typical test environments and unsurpassed accuracy in Metrology applications
- High sensitivity
- True linearity
- Symmetry of tension and compression output
- Low height
- High resistance to extraneous forces
- Excellent rejection of the influences of thermal gradients and thermal transients
- Low barometric pressure change sensitivity
- Low magnetic field sensitivity
- High stiffness, low deflection
- Excellent long-term stability
- Long fatigue life
- Low creep
- Multi-bridge (optional)
- Compression overload protection (optional)
- Wide load ranges for ASTM E74 and ISO 376 requirements

The wide range of rated forces allows the advantages of the shear web design to be utilized for force measurement over ranges from 3 lbf to over 600 Klbf (13 N to 2.6 MN). High accuracy measurements can be routinely achieved by the design in real test environments due to the many design features that reduce response to temperature change, thermal transients and thermal gradients, misalignment, barometric pressure change, and magnetic fields. These features make the measurement engineers life easier in that there need be less concern of performance aberrations due to real world influences not experienced or characterized in the metrology lab. At the same time, many of these same design features provide for enhanced performance in the metrology lab where alignment is seldom perfect, and thus are an aid to the metrologist as well.

The design consists of a center hub connected to an outer ring by means of a number of short shear beams. The outer ring is mounted to a base structure and clamped by high strength screws distributed around the ring. As force is applied to the center hub, the shear beams deflect and the principal shear strain is measured by means of special bonded foil strain gages. The strain gages are wired in a wheatstone bridge configuration.

The cross-section of the beam is designed so that it varies both radially and axially to achieve maximum strain near the center where the strain gage sensor is applied and with lower strains elsewhere in the beam. This results in higher stiffness and enhanced fatigue life since the solder joints are removed from the highest strain area. The strain gages utilized are custom designed and are made from a nickel chromium alloy that can be processed to provide a sensitivity temperature coefficient equal and opposite to the elastic modulus temperature coefficient. Since the compensation is inherent in the strain gage alloy itself, these transducers show little sensitivity to temperature change, temperature gradients, or temperature transients in comparison to other transducer designs in which temperature compensating resistors are required and are often placed remotely from the strain gage sensors. Special wiring techniques result in minimizing sensitivity to magnetic fields.

The nickel chromium strain gages offer a number of advantages over the more typical copper-nickel (Constantan) strain gages. The sensitivity is 10-25% higher, the thermal EMF against copper is much lower so the thermocouple effects at solder joints are significantly reduced, and the fatigue strength is nearly twice as high. Another advantage of the design is that all strain gages operate at the same strain magnitude, which results in 53% more sensitivity than in a column force transducer structure where one-half the strain gages are sensing the Poisson strain which is approximately 30% of the axial strain. Wheatstone bridge circuits are non-linear unless each arm of the bridge experiences the same strain magnitude. Hence the shear web design is inherently linear in contrast to column structures. Another advantage is achieved in symmetry of tension and compression outputs. Column structures decrease cross-sectional area in tension and increase it in compression. This also creates inherent non-linearity that is absent in the shear web design. For applications in which forces vary from tension through compression, this is a significant advantage.

Low height permits installation using minimum space in load frames and test apparatus. The compact design enhances the transducer's ability to withstand high extraneous loads without damage. Special compensation techniques insure that little error is induced by side-loads and moments.

The low height design of shear web type transducers in combination with the location of the shear beams outboard of the center hub results in an unequaled capability to carry side loads, moments, and torque. SW Models are rated to carry side forces or moments of 40% of rated load (where moments are in in-lbf) in conjuction with rated axial load.. SWP, and CS Models are rated for side force or moment of 50% of range. FR Models are rated for side force or moment of 100% of range. Each Tovey Engineering force transducer is checked for extraneous load sensitivity and compensated to minimize this response. The maximum error for the Model SW at the above limits is 0.1%, for SWP, CS and FR Series maximum error is 0.05%. This feature results in the lowest errors due to extraneous forces available. In practice, the ever presence of manufacturing tolerances on machine alignment and fixtures result in negligible errors. In contrast, few column structures can accommodate 10% of rated load as a side load or moment with errors unspecified and typically an order of magnitude larger.

The shear web design is sealed by mean of diaphragms covering the beam area of the flexure. By venting the cavity between the load cell and base, Tovey Engineering transducers are inherently compensated against changes in barometric pressure changes since the same pressure acts on each surface of the transducer. By comparison, column structures generally measure the pressure change quite well.

The short shear beam structure results in a very stiff transducer. Deflections vary from less than 0.001 inch to 0.007 inch, depending on capacity. This results in one of the highest dynamic responses available.

Years of experience have shown that the combination of material selection for the flexure element and the strain gages result in high long-term stability. Tovey Engineering Metrology grade transducers (Model CS) typically change 0.005% in the first year and become more stable with age.

The features of the shear web design result in a structure that enhances fatigue life. Tovey Engineering Model FR Series Fatigue rated transducers are guaranteed for 100 million fully reversed cycles at rated load.

All shear web force transducers have low creep. The SW, SWP, and FR Models have less than 0.03% creep in 20 minutes. CS Models have less than 0.015% creep in 20 minutes.

The structure of the shear web transducers is ideal for multi-bridge requirements. A multi-bridge load transducer is one that has more than one independent measurement circuit built into the body of the transducer. Up to three bridges are available on most of the models.

Compression overload protection is available on much of the shear web product line. This is achieved by controlling the gap between the transducer and the base so that when applied load exceed the rated force, the excess force is shunted into the base. Safe compression overload ranges of 300-500% are available with this option for may of the models.

The shear web design as embodied in CS Model transducers with low creep, low sensitivity to extraneous forces, and good fit to least square polynomial curves provide excellent secondary force calibration standards and field test standards meeting the requirements of ASTM E74 and ISO 376 over wide load ranges. CS models to 100 Klbf are capable of ASTM Class AA force ranges from 10% to rated force and for Class A devices from 2% of range to rated force. At 200 Klbf and higher, the lower load limit is 20% of range for Class AA devices and 4% for Class A.

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