



THE TENSION CONTROL SPECIALISTS

INSTRUCTION MANUAL



Ribbon-Filament Transducer

Model RFA

DOC 801-0784 R4

Dover Flexo Electronics
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U.S.A.

FOR ASSISTANCE:

TECHNICAL SERVICE - Installations, Start-Up, Troubleshooting, Repairs, Field Service or Returns. **Call (603) 332-6150 and ask for Technical Support or email us at: techsupport@dfc.com**

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SAFETY



This label indicates: “Read The Manual”

Make sure you read and understand all instructions and safety precautions listed in this manual before installing or operating your Model RFA Tension Transducer. If you have any questions concerning the operation of your device or the information in this manual, please contact us.

Email: techsupport@dfc.com

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- **Observe all warning labels.**
- **Never remove warning labels.**



WARNING: During installation care should be taken not to drop the Model RFA transducer, handle the unit with care, sudden jolts or drops can damage its components and serious injury could result.



WARNING: If this equipment is not connected or operated in the manner specified, the operating safety of this unit or of connected equipment cannot be guaranteed.



WARNING: Do not connect a standard excitation (5V) tension transducer to a DFE amplifier with the Extended Range (XRE) option enabled (10V), the transducer may be damaged.

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DOCUMENT CONVENTIONS

NOTICE **NOTES** - Highlight important concepts, decisions you must make, or the implications of those decisions.



CAUTIONS - Tell you when equipment may be damaged if the procedure is not followed properly.



WARNINGS - Tell you when people may be injured, or equipment may be damaged if the procedure is not followed properly.

Numbered lists indicate tasks that should be carried out in sequence:

1. First do this
2. Then do this

1 GENERAL DESCRIPTION

The Model RFA "Ribbon-Filament" Tension Transducer is an electro-mechanical device that converts ribbon, web, or filament tension into a DC voltage proportional to tension. The voltage is amplified in external electronic circuitry such as a DFE Tension Amplifier, Indicator or Closed-Loop Controller which is calibrated to output and/or display actual tension. The tension reading is expressed in pounds, ounces, grams, kilograms, newtons, or any other desirable units. It can also be supplied to a regulator circuit to control tension automatically.

The RFA Tension Transducer is typically used in applications where the machine has only one side frame and the idler wheels are cantilevered. The information in this section will help give a clear understanding of the RFA Tension Transducer system - how it works and how it's used.

1.1 CONSTRUCTION AND MECHANICAL OPERATION (SEE FIGURE 1)

The standard RFA Transducer wheels are manufactured of aluminum to be lightweight and of low inertia, and the ribbon wheels and filament wheels are given a hard coat anodized surface finish to be durable. The bearings are standard deep-groove ball type with shields to discourage entry of contaminants. Custom wheel geometries and/or finishes are available including those made by the customer to be mounted on the adapter wheel, subject to specific DFE engineering approval.

Inside the transducer is a single beam having two parallel cantilevered webs with strain gages mounted on each. When tension is applied, the beam deflects a small amount, causing an electrical output from the strain gages which is directly proportional to the filament tension.

The bore of the housing acts as a mechanical stop, preventing damage to the beam and gages from accidental overloads. The stop is functional through 360 degrees, so the overload condition may occur from any direction, not just the load direction. In all cases, the beam is prevented from deflecting far enough to cause any damage.

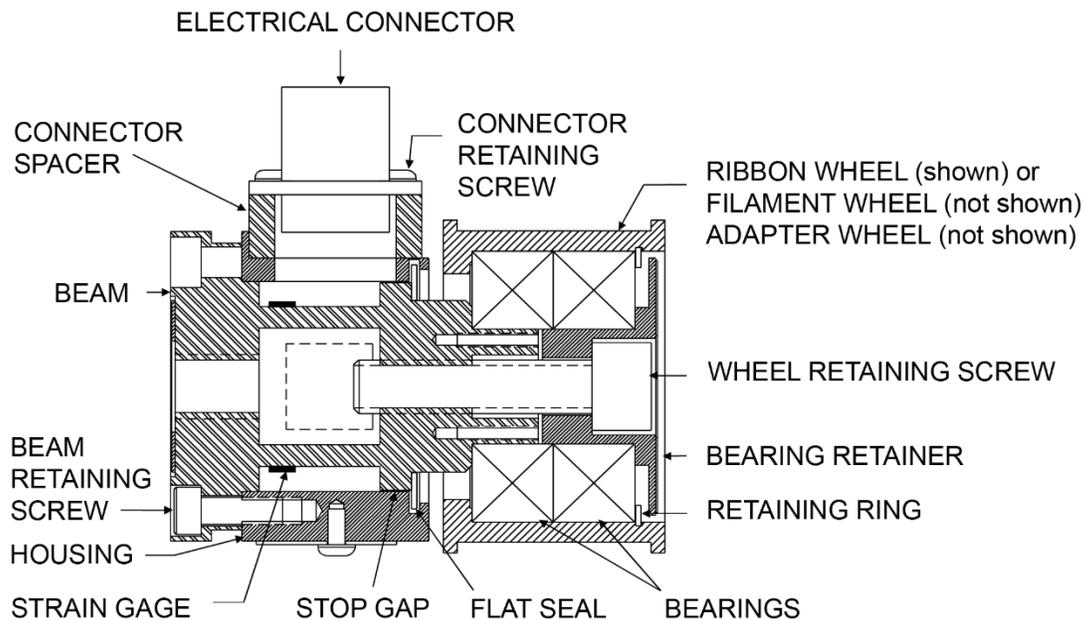


Figure 1 - CUT-AWAY VIEW OF RFA TRANSDUCER

1.2 SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

Excitation Voltage: 5 VDC max (Std), 10 VDC max (XR Option)

Output: 100 mV/V, nominal

Strain Gages: Semiconductor, 100 ohms nominal resistance

Repeatability: +/- 1/4% FS

Linearity and Hysteresis Combined: +/- 1/2% FS

Temperature Range: -10° F to +200° F (-23° C to +93° C)

Temperature Coefficient: 0.02% per degree F, typical (0.01% per degree C, typical)

Electrical Connector: MIL Spec - PT02E10-6P

Electrical Connections:

Pin A (White): Signal Output (-)

Pin B (Black): Excitation (+)

Pin C (Red): Excitation (-)

Pin D (Green): Signal Output (+)

Pin E (Blue): Excitation (-)

Pin F (Brown): Excitation (+)

Mating Electrical Connector:

MIL Spec (Standard) - 6 socket, female, PT06E10-6S

MECHANICAL SPECIFICATIONS

Materials: 303 stainless steel and 7075-T6 aluminum, black anodized hard coat wheel finish.

Maximum Overload Capacity: Four times the load rating.

Deflection: .005" typical (0.127 mm typical)

Standard Connector Position:

S, FL styles - 6 o'clock

PB style - Rear with reference to force direction

Load Ratings: 10, 25, 50, 100, 150 (45, 111, 222, 445, 670 N)

NOTICE Note: The information below is only applicable if a DFE Wheel or shaft assembly is used.

Break-Away Torque: 0.25 in-oz (18 gram-cm) typical

Basic Dynamic Load Rating of Bearings: 4300 lbs (19120 N)

Wheel Weights:

Filament 0.49 lbs (222 g)

Ribbon 0.45 lbs (204 g)

Adapter 0.65 lbs (295 g)

1.3 STANDARD FEATURES

Dual Cantilever Beam: Provides high strength and accuracy at low tension.

Stainless Steel and Aluminum Construction: Excellent durability and corrosion resistance.

Compact Size: For easy mounting--even in small spaces.

1.4 CONFIGURATION CHOICES

These are explanations of standard choices of various configurations that were specified for your application.

Mounting Styles: Screw or Bolt mount (S) uses a single bolt to mount to machine frame. Pillow Block bracket (PB) uses a right-angle bracket to mount onto the machine frame. Flange mount (FL) uses a

four-bolt flange mounted onto the machine frame which can be rotated to any position for precise orientation.

Load Ratings: 10, 25, 50, 100, 150 lbs (45, 111, 222, 445, 670 N)

DFE Wheel Types: Ribbon Wheel (specify width of 1 to 4 inches), Filament Wheel, Adapter Wheel (hub for custom applications).

Connector Positions:

S, FL: 1:30, 3:00, 4:30, 6:00 (std.), 7:30, 9:00, 10:30, 12:00.

PB: Rear (std.), 1:30, 3:00, 9:00, 10:30, 12:00 with reference to force direction.

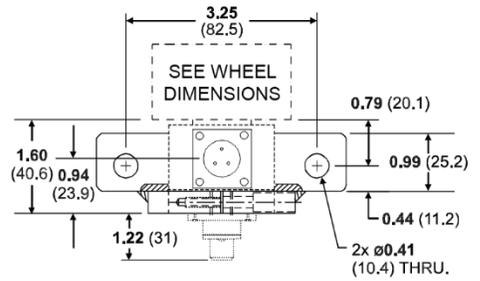
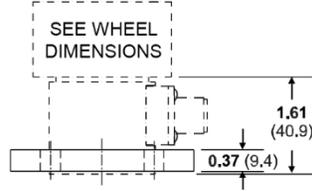
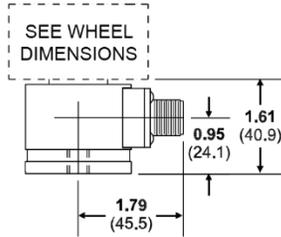
1.5 OPTIONS

Extended Range (XR): Accepts 10V excitation from a supported amplifier, indicator, or controller with (XRE) option.

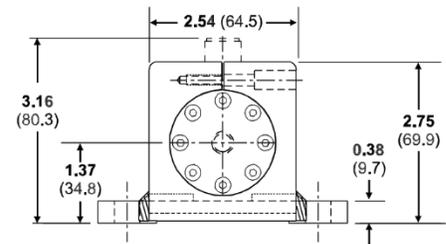
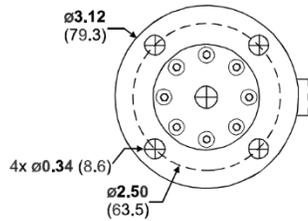
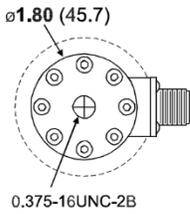
Metric Mounting Screw (MMS): Metric mounting thread for S type transducers.

2 INSTALLATION

2.1 DIMENSIONS



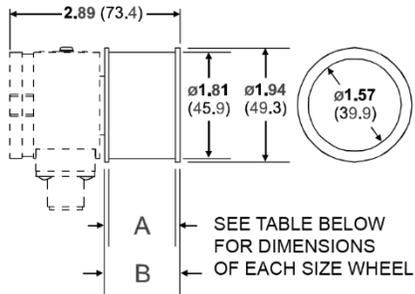
**OPTIONAL MOUNTING STYLE PB
with REAR CONNECTOR**



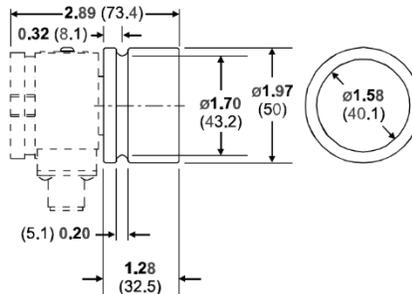
STANDARD MOUNTING STYLES S

**STANDARD MOUNTING STYLES FL
Flange may be rotated**

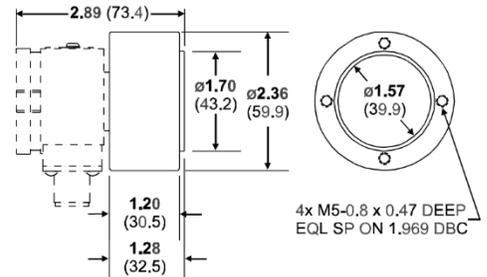
OPTIONAL MOUNTING STYLE PB



RIBBON WHEEL



FILAMENT WHEEL



ADAPTER WHEEL

		RIBBON WHEEL SIZES			
		1	2	3	4
A	in.	1.13	2.13	3.13	4.13
	mm	28.7	54.1	79.5	104.9
B	in.	1.28	2.28	3.28	4.28
	mm	32.5	57.9	83.3	108.7

Figure 2 – DIMENSIONS

2.2 PRE-INSTALLATION REQUIREMENTS

NOTICE **Note:** No brakes, clutches, belts, chains, or gears should be attached to the transducer wheel. It cannot be a nip roll or be in contact with a nip wheel. **Nothing must contact the wheel except the ribbon or filament.**

1. TENSION ZONE

The transducer must be located in the tension zone which is to be monitored or controlled. The beginning or end of any tension zone is always at a nip (driven or braked), unwind shaft, rewind shaft, or drag bar. Any element in the filament path that can change tension is at one end of a tension zone.

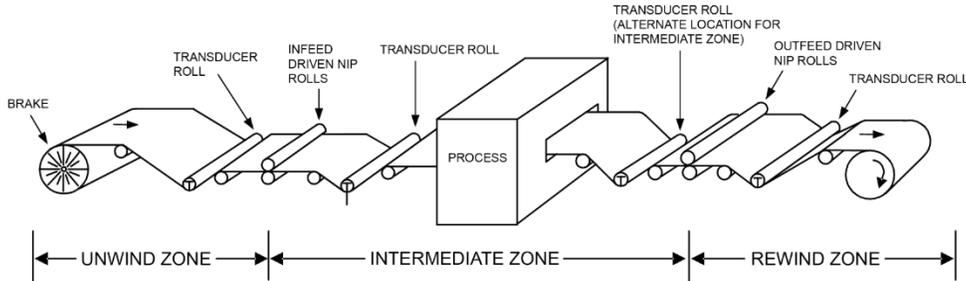


Figure 3 - TENSION ZONES

2. WRAP ANGLE

The web or filament must always contact the transducer wheel in the same way. The wrap angle must not change as the unwind or rewind reel diameter changes. Therefore, there must be at least one idler wheel between the transducer and the unwind or rewind shaft. If the machine has more than one web path, be sure to choose a location that is wrapped the same for each. Otherwise, it will be necessary to install an additional idler roll or transducer, or dual calibration circuitry, or all three. If the wrap angle is allowed to change, the transducer output will change with angle as well as tension, and accuracy will be reduced.

3. MOUNTING SURFACE

The structure on which the transducers are mounted must be very stable and strong. Any movement of the structure may be sensed by the transducers and may cause inaccurate tension readings. The surfaces must also be smooth and flat so the transducers can be properly aligned during installation. The RFA Transducer is sold in three different mounting styles and attached to the machine frame by one of three methods: A single bolt (S) through the back of the unit, a four-bolt flange (FL), or a pillow-block type bracket (PB).

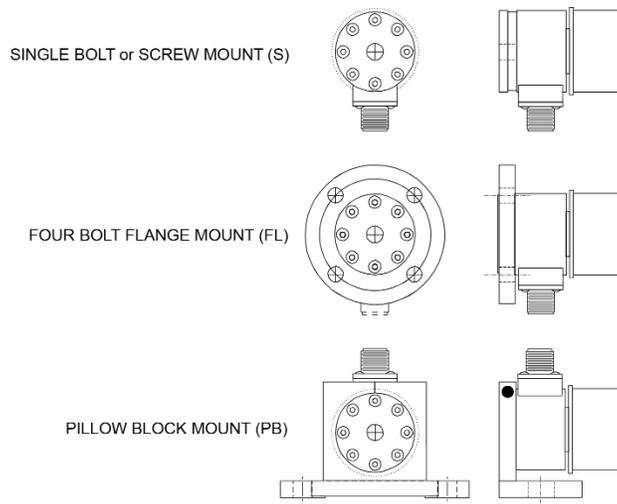


Figure 4 – RFA MOUNTING STYLES

2.3 INSTALLATION

Model RFA Tension Transducers are very easy to install. Follow the simple steps below.

1. ORIENT THE TRANSDUCER (see Figure 5)

The transducer must be turned so the Tension Force arrow (or the notch on the rear edge of the beam) points in the same direction as the Tension Force.

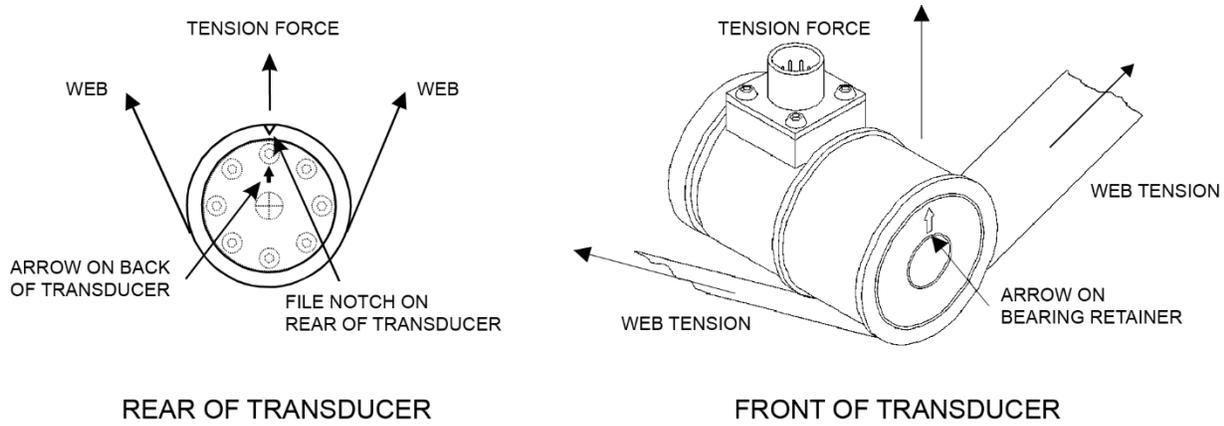


Figure 5 - TENSION FORCE DIRECTION

If you are installing an "S" or "FL," style transducer, adjust the transducer on the machine frame by hand (do not use a wrench) so the arrow (or notch) will bisect the wrap angle.

If you are installing a "PB" bracket style transducer, the transducer is already assembled with the force direction orientation specified when purchased. It can be aligned more accurately by loosening the clamp bolt on top of the bracket and turning the transducer by hand (pry the top of the bracket open with a screwdriver if necessary). Re-tighten the clamp bolt.

2. INSTALL AND TIGHTEN MOUNTING FASTENERS

With the transducer properly oriented with respect to its tension force, install mounting fasteners and tighten to secure the transducer in place.



WARNING: During installation care should be taken not to drop the RFA Transducer, handle the unit with care, sudden jolts or drops can damage its components and serious injury could result.

3. CONNECT TRANSDUCER TO ELECTRONICS

Make your connections to your electronics by plugging in the cables, being careful to align the connectors properly - never force them together. Tighten the connectors to properly seat the pins.



CAUTION: If a non-standard DFE wheel or shaft assembly is used, make certain that it does not bottom-out on the transducer, as this will interfere with the proper function of the transducer and possibly cause damage to the unit.

2.4 ELECTRICAL OPERATION

The Model RFA Transducer is used singularly. Web tension exerts a force on the roll/wheel which is transmitted to the cantilever beam. Four semiconductor strain gages are mounted on the beam, two on the top and two on the bottom. As force is applied and the beam deflects, the top gages are stretched, and the bottom gages are compressed. This increases the electrical resistance of the top gages and decreases the resistance of the bottom gages. The gages are electrically connected in a Wheatstone bridge configuration. The output from the bridge is the sum of the output from sets of gages.

RIBBON FILAMENT (RFA) TRANSDUCERS

THE TENSION (T) AND COMPRESSION (C) STRAIN GAGES ARE CONNECTED IN A BRIDGE CONFIGURATION. AS THE BEAMS BEND SLIGHTLY UNDER WEB TENSION, THE GAGE RESISTANCES CHANGE PRODUCING AN OUTPUT SIGNAL WHICH IS DIRECTLY PROPORTIONAL TO THE WEB TENSION.

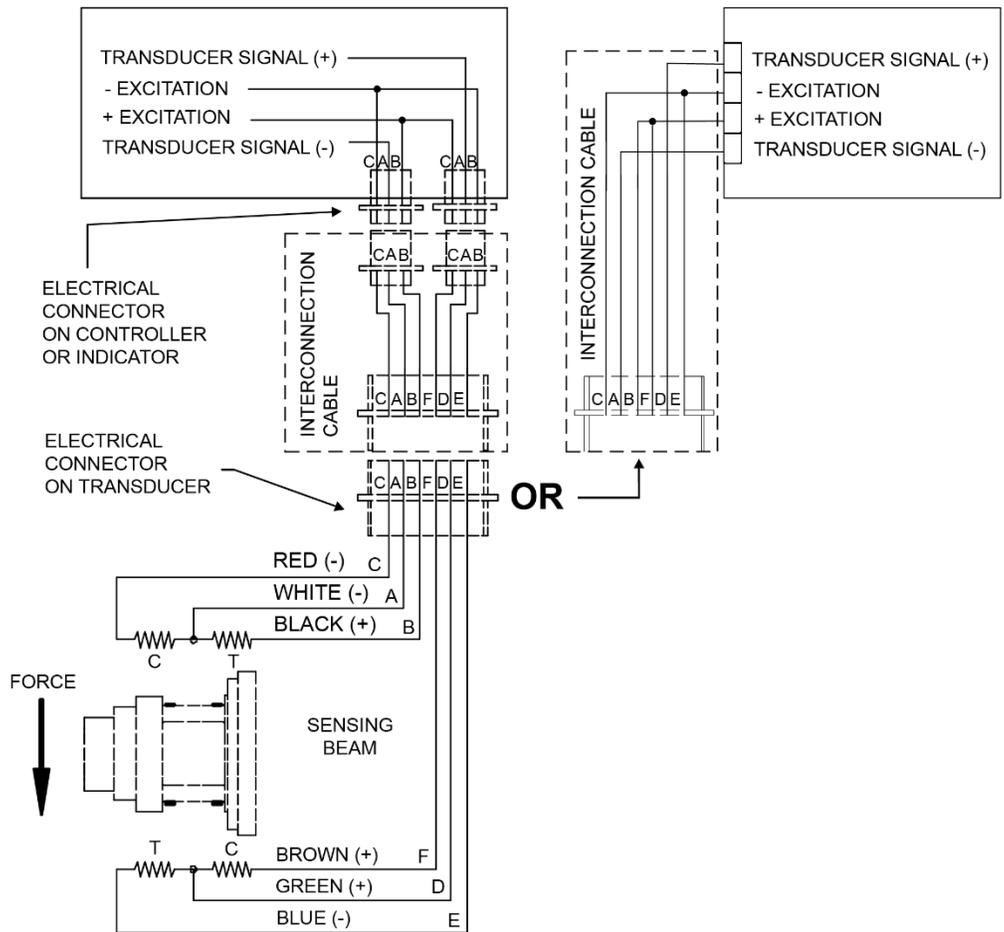


Figure 6 - MODEL RFA TRANSDUCER WIRING

The physical location of the strain gages, on opposite sides of the beam, ensures that each gage experiences the same temperature variations. This, and the Wheatstone bridge configuration, provides automatic temperature compensation and a stable output.

The strain gages used in the RFA transducer are high output semiconductor devices with up to 33 times greater output than the less expensive foil gages used in some budget transducers. Therefore, the signal amplifier used with these RFA transducers is a very stable, low-gain design. An added benefit of the high output is inherent immunity to electrical noise.

3 CALIBRATION AND SETUP

3.1 INTRODUCTION

No physical calibration adjustments are required with the RFA Transducer. Follow the electronic calibration steps listed in the manual of the Tension Controller, Indicator or Amplifier being used with the device. Some general calibration instructions are listed below for reference.

3.2 ZERO THE TENSION METER

1. With no weight on the idler roll and power connected to the devices, press the *Quik-Cal*[™] **Zero** button on the supported amplifier or indicator. If using a touchscreen indicator or controller, press the **Zero** command at the touchscreen menu prompt.

3.3 CALIBRATE THE TENSION METER

1. See Figure 7. Pass the rope over the Transducer wheel / pulley in the same path as the web follows. Tie the end in the machine at least one idler roll beyond the Transducer. Pass the other end by at least one idler roll before the Transducer. Be sure the rope does not pass over any driven rolls, braked rolls, or dead bars (this will cause in-accurate calibration). Attach the weight to the free end of the rope and let it hang without touching anything.
2. **Wait for the weight to stop swinging.**
3. Press the **Calibrate** button on supported *Quik-Cal*[™] amplifiers and indicators or press the **Calibrate** command at the touchscreen menu prompt.
4. This concludes the calibration procedure.

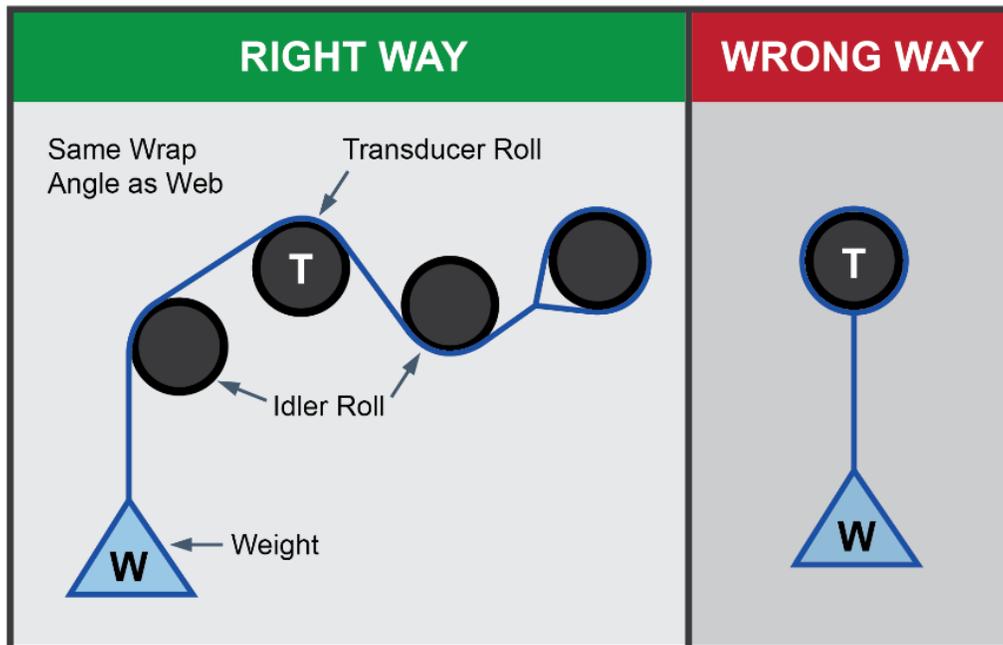


Figure 7 – WEB PATH

4 CARE AND MAINTENANCE

Your Dover Flexo RFA Tension Transducer has been manufactured of quality materials. With proper application and installation your transducer should be relatively maintenance free and long lasting. Any changes in your application which affect the dynamics of your equipment such as web speed, net force, material, etc. could possibly require upgrading of load rating or wheel change. Contact Dover for specific information and engineering assistance.

4.1 BEARING LIFE

The bearings in the RFA Transducer will turn continuously in normal operation. They have been selected to give a long service life under typical operating conditions if properly maintained with lubrication. Use the formula below to find the L_{10} life, in hours, for your application.

To find the radial load (P) for your application, use the appropriate sizing formula in Appendix A, substituting 2 for the 4 to eliminate the oversizing factor.

RPM = 3.82 x line speed in feet per minute/diameter of transducer wheel in inches
(RPM = 318.3 x line speed in meters per minute/diameter of transducer wheel in millimeters)

BEARING SPECIFICATIONS		
Bearing Type	Rated Load (C)	Maximum Speed (RPM)
Ball	4,300 lbs (19,120 N)	20,000

LIFE CALCULATION FORMULAS (where P is radial load as described above)

$L_{10} = (16667 / \text{RPM}) \times (C / P)^3$, for ball bearings

An L_{10} life of 20,000 to 30,000 hours is usually considered satisfactory for web process machinery such as printing presses, coaters, etc.

4.2 DISASSEMBLY AND REASSEMBLY - TOOLS REQUIRED

SCREW SIZE	HEX SOCKET SIZE	LOCATION OF USE
M4 - 0.7	3mm	Beam
M8 - 1.25	6mm	Bearing Retainer

1. Right-angle Allen wrenches.
2. A small flat blade screwdriver.

4.3 CHANGING THE BEARING(S) AND/OR WHEEL

1. Remove the single M8 cap screw holding the wheel, bearings, retainer, and spacer (if any) onto the beam.
2. Remove the wheel, bearings, and bearing retainer from the beam. If the hardware does not separate easily, it may be carefully pried apart by putting flat blade screwdrivers between the wheel and housing and prying equally on opposite sides of the assembly so as not to distort the beam.
3. Remove the bearing retainer, retaining ring and bearings from the wheel.
4. Reassemble the unit with new bearings, new wheel, or both by following the preceding steps in reverse order.

5 TROUBLESHOOTING

This is a list of problems which could occur during initial start-up or afterwards. The probable causes are listed with the *most likely one first* and the *least likely one last*.

1. TRANSDUCER WHEEL SHAKES, VIBRATES, or BOUNCES

1. Wheel is not balanced.
2. Transducer is not securely mounted.
3. Wheel is turning at its natural frequency. Call our **Technical Service Department** for analysis of operating conditions and solution to problem.
4. Transducer beam is vibrating sympathetically with a vibrating machine frame.

2. CANNOT ADJUST TENSION OUTPUT DEVICE¹ / DISPLAY TO READ ZERO WHEN RIBBON / FILAMENT IS SLACK

1. Failure in the tension indicator circuit. Refer to tension indicator/controller manual.
2. A strain gage has failed. To verify: Unplug the transducer cable and use an ohmmeter to measure the resistance of the gages at the connector on the transducer. Measure between pins A, B, and A, C. Also measure between pins D, E and D, F. In each case the resistance should be about 100 ohms. Measure the resistance between any pin and the housing of the transducer. The meter should read infinite resistance. Apply an appropriate force to the wheel by hand or by using a line and a weight, in the direction of the tension force and maintain it while again measuring between pins A, B and A, C. Repeat while measuring between pins D, E and D, F. The resistance should be only a few ohms different from before.
3. Wheel greater than 95% load rating $W \cos(A)$.

3. TENSION OUTPUT DEVICE¹ / DISPLAY READS BACKWARDS

1. Transducer connected to Legacy Electronics². Signal wires are reversed, or transducer is installed backwards with force arrow pointing in opposite direction.

4. TENSION OUTPUT DEVICE¹ / DISPLAY PEGS HIGH OR LOW

1. Meter is not electrically adjusted to zero. Refer to tension indicator/controller manual.
2. Transducer cable has broken wire, poor connection, or short circuit.
3. Strain gage failure. Perform test in 5.2.2 above.
4. Failure in the tension amplifier circuit of the indicator/controller.

5. TENSION OUTPUT DEVICE¹ / DISPLAY DOES NOT READ ZERO WHEN WEB IS SLACK AND READING DRIFTS WITH TIME

1. Meter is not calibrated. See Section 3.
2. Transducer cable has a broken wire, poor connection, ground, or short circuit.
3. A strain gage is cracked. Perform the test in 5.2.2 above.

6. TENSION OUTPUT DEVICE¹ / DISPLAY DOES NOT READ THE SAME EACH TIME THE SAME FORCE IS APPLIED (poor repeatability)

1. Extreme build-up of dirt, ink, adhesive, grease, or other foreign material inside end of transducer causing interference with beam movement.
2. Transducer cable has a broken wire, poor connection, ground, or short circuit.
3. Strain gage failure. See 5.2.2 above.

7. TENSION OUTPUT DEVICE¹ / DISPLAY READING DOES NOT CHANGE WHEN FORCE IS APPLIED TO WHEEL, METER READS ZERO

1. Meter is not calibrated. See Section 3.

2. Extreme build-up of dirt, ink, adhesive, grease, or other foreign material inside end of transducer causing interference with beam movement.
3. Transducer cable has broken wire, poor connection, ground, or short circuit.
4. Transducer cables connected incorrectly, or to wrong transducers.
5. Failure of tension amplifier circuit in controller/indicator.
6. Unit not turned on.

8. TENSION OUTPUT DEVICE¹ / DISPLAY READING BOUNCES

1. Web tension is fluctuating because of machine speed fluctuations, worn bearings, chattering unwind brake, flat spot in unwind or rewind roll, machine vibration, etc.
2. Transducer is not securely mounted.
3. Tension controller damping requires adjustment. See controller Instruction Manual for procedure.
4. Failure in the tension amplifier circuit of the controller/indicator.

Note¹: Tension output devices such as amplifiers, display indicators and closed-loop controllers

Note²: Legacy electronics that precede *Quik-Cal*[™] digital calibration technology

APPENDIX A: SELECTION OF LOAD RATING

Following is the procedure used to calculate the load rating for the transducer(s) for your application. The correct transducer load rating was determined by maximum ribbon (or filament) tension, wrap angle, and wheel weight. If you change any part of your application or plan to move your transducers to another application, please follow the steps below to reconfigure. As always please feel free to contact one of our Applications Engineers for assistance.

The RFA Tension Transducer is available with five standard load ratings ranging from 10 lbs to 150 lbs (45N to 670N). Choose the appropriate wrap configuration from the following diagrams. Then compute the Net Force using the formula below the diagram.

SELECTION PROCEDURE

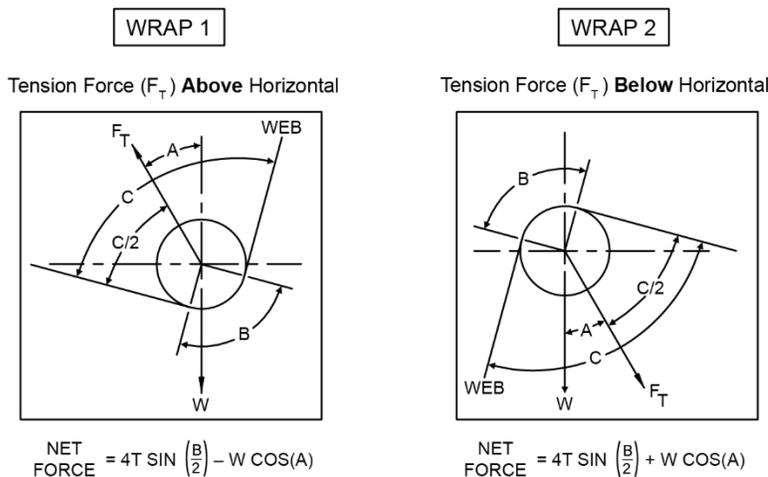
The correct load rating is found in four simple steps:

1. OBTAIN DATA TO PLUG INTO THE SELECTION FORMULA

1. Estimate the maximum web (or filament) tension. Use the Typical Tensions table in Appendix B as a guide if necessary.
2. Determine the wrap angle and tension force direction.

2. COMPUTE NET FORCE USING THE SELECTION FORMULA

Refer to the formulas above. Compute the Net Force, using the formula below the correct wrap diagram.



ANGLE	SINE	COSINE
0°	0.000	1.000
5°	0.087	0.996
10°	0.174	0.985
15°	0.259	0.966
20°	0.342	0.940
25°	0.423	0.906
30°	0.500	0.866
35°	0.574	0.819
40°	0.643	0.766
45°	0.707	0.707
50°	0.766	0.643
55°	0.819	0.574
60°	0.866	0.500
65°	0.906	0.423
70°	0.940	0.342
75°	0.966	0.259
80°	0.985	0.174
85°	0.996	0.087
90°	1.000	0.000

W = Wheel Weight (See Note Below)
B = Wrap angle = $180^\circ - C^\circ$

T = Maximum Web Tension
A = Angle Between Tension Force (F_T) and Vertical

Figure 8 - NET FORCE CALCULATION

Wheel Weights:

Standard filament wheel is 0.49 lb (222 grams) including bearings and fasteners.
 Standard ribbon wheel is 0.45 lb (204 grams) including bearings and fasteners.
 Standard adapter wheel is 0.65 lb (295 grams) including bearings and fasteners.

Weight of customer supplied wheel must be provided and is subject to DFE engineering approval.

Note: These sizing formulas contain an oversizing factor of 2X tension to account for tension surges.

3. SELECT THE LOAD RATING

Use the table below to select the correct load rating. In some cases, the load rating *may be less than the computed Net Force*. This is acceptable because the Net Force formula contains an oversizing factor of 2. Therefore, the actual force exerted on the transducer will not exceed its rating if the transducer is chosen according to the following chart.

LOAD RATING CHART			
NET FORCE		LOAD RATING	
lbs	(N)	lbs	(N)
Up to 13	(Up to 58)	10	(45)
14 - 32	(62 - 142)	25	(111)
33 - 63	(147 - 280)	50	(222)
63 - 125	(285 - 556)	100	(445)
126 - 187	(561 - 832)	150	(670)

4. COMPARE LOAD RATING WITH EFFECTIVE TRANSDUCER WHEEL WEIGHT

NOTICE **Note:** The following applies only to non-standard wheels or other hardware used in place of the wheel.

Sometimes a wheel is so heavy that its weight uses up most of the operating range of the transducer. When this happens, it may not be possible to adjust the tension indicating meter to read zero when tension is zero because the adjustment range of the electronic circuit has been exceeded. To find out if the wheel is too heavy, compare the load rating with the effective weight of the wheel as follows: The effective wheel weight is the " $W \cos(A)$ " term in the formula. If $W \cos(A)$ is more than 95% of the load rating chosen, the tension meter will probably not be adjustable to zero. If this is the case, one or more of the following changes must be made to reduce $W \cos(A)$ to less than 95% of the load rating:

1. Reduce the transducer wheel weight,
2. Increase angle (A),
3. Use the next higher load rating (this is the least desirable choice because it reduces transducer signal output).

APPENDIX B: TYPICAL TENSIONS FOR VARIOUS MATERIALS

TYPICAL TENSIONS FOR WEB MATERIALS			
ACETATE	0.5 lb. per mil per inch of width		
FOIL	Aluminum	0.5 lb. per mil per inch of width	
	Copper	0.5 lb.	"
CELLOPHANE		0.75 lb.	"
NYLON		0.25 lb.	"
PAPER	15 lb *	0.4 lb. per inch of width	
	20 lb	0.5 lb.	"
	30 lb	0.75 lb.	"
	40 lb	1.25 lb.	"
	60 lb	2.0 lb.	"
	80 lb	3.0 lb.	"
	100 lb	4.0 lb.	"
* based on 3000 sq. ft. ream			
PAPERBOARD	8pt	3.0 lb. per inch of width	
	12pt	4.0 lb.	"
	15pt	4.5 lb.	"
	20pt	5.5 lb.	"
	25pt	6.5 lb.	"
	30pt	8.0 lb.	"
POLYETHYLENE	0.12 lb. per mil per inch of width		
POLYESTER (Mylar)	0.75 lb "		
POLYPROPYLENE	0.25 lb. "		
POLYSTYRENE	1.0 lb. "		
RUBBER	GAUGE	AT 25% STRETCH	AT 50% STRETCH
	10 mil	1.75	3.68
	12 mil	1.10	2.03
	16.5 mil	4.09	8.17
	26 mil	2.47	4.97
SARAN	.15 lb. per mil per inch of width		
STEEL	GAUGE - INS	UNWIND-PSI	REWIND-PSI
	.001 -.005	1000	4000
	.006 -.025	850	3500
	.026 -.040	750	3000
	.041 -.055	650	2600
	.058 -.070	550	2200
	.071 -.090	450	1800
	.091 -.120	450	1400
	.121 -.140	400	1200
	.141 -.165	400	1000
	.166 -.200	400	900
	.201 -.275	400	800
	.276 -.380	300	700
VINYL	0.05 lb. per mil per inch of width		

*** For laminated webs, sum the tension for the individual webs and add 0.1 lb per inch width.

TERMS AND CONDITIONS OF SALE AND SHIPMENT

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