

How to Calculate Extraneous Loads

Futek Advanced Sensor Technology, a leading manufacturer of Load, Force, Torque, Pressure Sensors/Transducers, makes a point to provide all of our highly valued customers with reliable data that helps them in determining the right product for the right application. We provide “Extraneous Loads & Coefficients” in order to determine the adequacy of the Sensor in the presence of actual predetermined load(s) and moment(s) application’s by the customer.

As an example, we would like to examine ALL possible loads applied on our In-Line Threaded Tension/Compression Load Cell, The LCM500 Series:

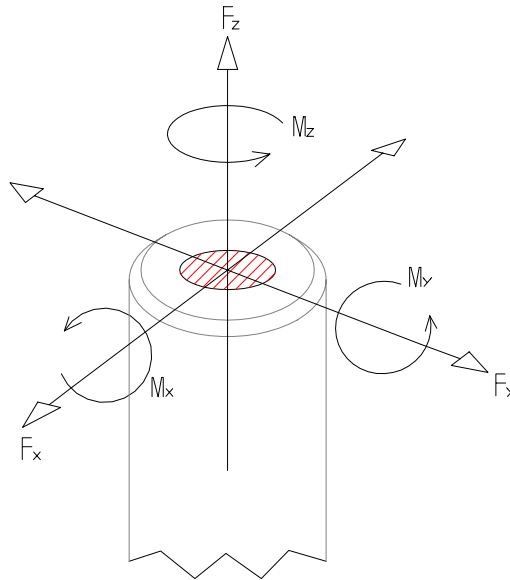


Figure 1: Upper Portion of LCM500 with All Loads/Moments Applied

The forces depicted in **Figure 1** may be characterized by the following:

Axial Loads (F_x , F_y , F_z in *lb*) – Defined as a load along respective axis, these forces are applied by the customer after installation. For Futek load cell example LCM500, the axial load F_z is considered the primary test load, and F_x , F_y are considered shear loads of application.

Moments (M_x , M_y , M_z in *in-lb*) – These forces when applied normal to respective axis cause the body of an object to bend in the same direction. For Futek torque sensor installation M_z is considered the primary measuring moment. On the other hand, for our Futek load cell installation, example LCM500 and all other Futek load cells, these moments about a respective axis characterize an off-axis loading.

Since our customers have a good idea what forces and/or moments will be applied in a particular direction (x, y, z), Futek Advanced Sensor Technology utilizes an extraneous load limit calculation for finding σ_{\max} (σ_{\max} is the maximum allowable stress from the summation of all forces and moments in the given directions and may be calculated by our customers, as you will see later). But first, Futek considers three factors when devising σ_{\max} and they are the following:

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- 1) Material- The material selection of the Futek product, for example, LCM500 utilizes 17-4 P.H. for its high properties and optimum aging treatment.
- 2) Structure- This is primarily focused on the design of the Futek sensor which is meticulously carried out by Futek engineers.
- 3) Capacity- The maximum Force that the Futek sensor is rated at, for example, LCM500 has a capacity range of 2000Lbs to 50,000Lbs.

Table 1 is provided to guide the customer in his or her proper selection of our Futek sensor/transducer, showing values of σ_{max} in a Static or Fatigue environment:

Please note: The () values in the provided table are 75% of Fatigue strength based on $10-20 \times 10^6$ fully reversed cycles and allow for factors that influence fatigue such as surface finish, stress concentrations, size variations, mean stress, corrosion, temperature and other factors in the design of a transducer. For 100×10^6 cycles, or infinite fatigue life, use 75% of values shown for fully reversed or non-reversing loads.

Table 1: Maximum Allowable Stress (σ_{max}) in psi.

Futek Sensor Material	Static Loads (appx. 60% Y.S.)	Non-Reversing Loads *Fatigue*	Full Reversing Loads *Fatigue*
Aluminum 2024-T4 (or T351)	28,000	18,000	15,000
17-4 P.H. Stainless Steel	87,000	78,000	*62,000

Finally, there are four easy steps in determining the load cell that fits the needs of the customer:

- 1) Choose the desired Allowable stress value σ_{max} from **Table 1** by taking Static or Fatigue into consideration.
- 2) Determine the extraneous forces and moments.
- 3) For whichever model chosen based on capacity, select correlating extraneous load coefficients from the table provided by Futek Advanced Sensor Technology. As a suggestion, for load sensors, you should be most concerned with F_z measuring axis for capacity, and M_z measuring axis for torque transducers.
- 4) Now solve the basic equation for the combined stress due to all loads from step 2. It is important to note that your calculated combined stress should be equal to or less that the chosen σ_{max} from step 1. If you exceed the allowable stress value, it is HIGHLY recommended you choose a higher capacity model.

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The basic equation for combined stress is the following:

$$\sigma_{\max} \geq (A)F_x + (B)F_y + (C)F_z + (D)M_x + (E)M_y + (F)M_z$$

Where A, B, C, D, E, F are Coefficients (step 3) determined by Futek Advanced Sensor Technology Engineers.

We will consider the following sample calculation of LCM500 for completeness.

LCM500 Coefficients, Material: S.S. 17-4 P.H. ($\sigma_{\max} = 62,000$ psi)

Table 2: LCM500 Coefficient's per Capacity

Capacity (Lb)	A (F _x)	B (F _y)	C (F _z)	D (M _x)	E (M _y)	F (M _z)
2,000	1,286.54	28.33	28.33	761.97	761.97	647.97
5,000	311.02	311.02	12.98	193.95	193.95	148.64
10,000	185.54	185.54	6.29	71.72	71.72	59.87
20,000	58.70	58.70	3.37	27.36	27.36	2.48
50,000	27.14	27.14	1.53	7.49	7.49	7.83

From **Table 2**, provided by Futek Advanced Sensor Technology, we may see that for the LCM500, a material of 17-4 P.H., Full Reversing Loads are 62,000 psi. All that needs to be chosen is the desired capacity. But first, let us say the customer has the following given data:

Load Applied $F_z = 10,000$ lb

Shear load $F_x = 100$ lb

Lets us choose 50,000 lb capacity since the customer hypothetically wants to be on the safe side and having a higher load at the primary measuring axis F_z . For 50,000 lb capacity, our given coefficients from the table pertinent to our applied loads are:

A = 27.14 B=27.14 C= 1.53 D=7.49 E=7.49 F=7.83

where $\sigma_{\max} = 62,000$ psi.

We are ready for the Maximum allowable Stress equation:

$$\sigma_{\max} \geq (27.14)*(100) + (27.14)*(0) + (1.53)*(10,000) + (7.49)*(0) + (7.49)*(0) + (7.83)*(0)$$

$$\sigma_{\max} \geq (27.14)*(100) + 0 + (1.53)*(10,000) + 0 + 0 + 0 = 2,714 + 15,300 = 18,014 \text{ psi.}$$

$$\sigma_{\max} \geq 18,014 \text{ psi.}$$

$$62,000 \text{ psi.} \geq 18,014 \text{ psi.}$$

Conclusion: Surely, as you may see, if the customer is not particularly concerned with a high factor of safety when applying the loads, it is recommended that he or she may want to choose a LCM500 of lower capacity.

Please refer to the provided Futek Advanced Sensor Technology Transducer table that you have inquired for your Extraneous Loads Calculation