Off-Axis Loads - Guide To Calculating Side Loads | FUTEK

Guide to Calculating Extraneous Loads

FUTEK Advanced Sensor Technology strongly believes in providing all of our customers with reliable data that helps them in determining the right product for their application. We provide this "Extraneous Loads & Coefficients Guide" in order to help determine the adequacy of the sensor in the presence of loads and moments that are not in the intended direction of the sensor.

Note: In this document all forces, regardless of the load cell's capacity, are in lb. (pounds mass), and all the moments, regardless of capacity, are in in-lb (inch-pounds).

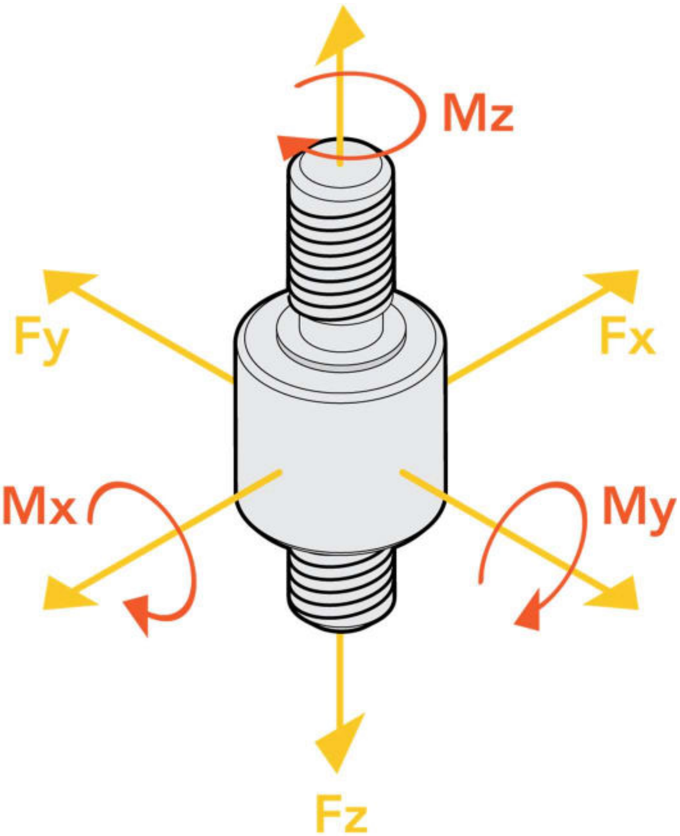

Figure 1: Definition of All Loads & Moments Applied

The forces depicted in Figure 1 may be characterized as following:

Loads (Fx, Fy, Fz [lbs]). Defined as a load along each respective axis, these forces are applied by the customer during or after installation. The direction of each load is indicated on the specification sheet of each load cell model.

Moments (Mx, My, Mz [in-lb]). Moments (torques) are forces that cause the structure to either bend or rotate. To label the axes correctly on each of FUTEK's sensors, please refer to the individual sensor's sheets of each specific model.

Most of the time, the project designer should have a good idea what forces and/or moments will be acting on the sensor. Using this information, FUTEK utilizes an combined stress equation to determine whether or not a sensor is suitable for the application.

Calculating the External Loads

There are four easy steps in determining if the external loads are acceptable on the load cell:

1. Find the Extraneous Loads Sheets for the desired load cell
2. Determine the extraneous forces and moments that will be acting on the sensor
3. Select the extraneous load coefficients provided by the table for the sensor's capacity
4. Lastly solve the basic equation for the combined stress due to all the loads from step 2. Your calculated combined stress should be equal to or less that the chosen σ_{max} from step 3. If you exceed the allowable stress value, a higher capacity model should be chosen.

The basic equation for combined stress is the following:

$\sigma_{max} \geq (A)|Fx| + (B)|Fy| + (C)|Fz| + (D)|Mx| + (E)|My| + (F)|Mz|$

A, B, C, D, E, F are the coefficients (step 3) determined by FUTEK's engineers. The units of A, B, and C are provided in psi/lbf, whereas the units of D, E, and F are provided in psi/in-lb. The resulting answer from the equation above has units of psi.

Example

We are looking to see if we can use a 500 lb capacity LCM300 inline load cell for an application. The load cell will experience 300 lb downwards force in the Fz direction, a force of 25 lb in the Fx direction, a 2.5 lb force in the Fy direction, and a moment of 1 in-lb about the z-axis.

To calculate if the combined forces and moments will allow the 500 lb capacity to be used in this application, we need to refer to the External Load Document of the specific load cell.

Table 1: Extraneous Load Coefficient LCM300

CAPACITY (lb)	A	B	C	D	E	F
25	1200	1200	560	3500	3500	1040
50	3500	3500	870	8955	8955	7225
100	3336	3336	530	9050	9050	8345
250	770	770	220	1955	1955	1380
► 500	665	665	150	1420	1420	1250
1000	475	475	86	1405	1405	1190

We first need to obtain the off axis coefficients (A,B,C,D,E,F) for the desired capacity. We then place the coefficients and forces in the combined stress equation.

Note that the equation requires the absolute value of the forces or moments. For example, although the main force in the Fz direction is applied in the negative direction (-300 lb), the force should be entered as 300 lb in the equation (i.e. $|-300|=300$).

$\sigma \geq (A)|Fx| + (B)|Fy| + (C)|Fz| + (D)|Mx| + (E)|My| + (F)|Mz|$
$\sigma \geq 665\times|25|+665\times|2.5|+150\times|-300|+1420\times|0|+1420\times|0|+1250\times|1|$
$\sigma \geq 3325+1662.5+45000+0+0+1250$
$\sigma \geq 64537.5$ psi

Next we need to look at the maximum stress (σ_{max}) that the structure is able to handle.

Table 2: Maximum Stresses on the Structure

PARAMETER	VALUE σ_{max}
Material	17-4PH S.S.
Static Load (=60% Y.S.)	87,000
Fatigue (Non Reversing Loads)	78,000

Table 2: Maximum Stresses on the Structure

Fatigue (Full Reversing Loads)	62,000*

All the stresses on the structure should be less than or equal to the maximum stress (σ_{max}), depending on the how the load cell is being loaded.

$\sigma_{max} \geq \sigma$

In our example we see that extraneous loads are acceptable for if they are static or non-reversing. If these loads are fully reversing, the structure might yield, thus a higher capacity unit should be selected. It should be noted that the fully reversing maximum stress condition is determined so that the structure lasts for at least 10 to 20 million cycles. If the load cell needs to last more than 100 million cycles the maximum fatigue stress for a reversing load should be under $\sigma_{max} \times 0.75$ (46,500 psi in our case). In this case, if we wanted the load cell to last infinite life under fatigue fully reversing conditions, we will need to look for a larger load capacity.

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