Strain Measurement Errors

A Micro-Measurements strain gage is an inherently precise measurement device easily capable of resolving one part in a million or more. That capability is primarily due to the exacting standards and controls under which every strain gage is manufactured. Yet, the titles of many Micro-Measurements technical publications make reference to errors. These numerous references should not, however, be viewed as a lack of confidence in the intrinsic accuracy of the strain gage itself. The principal errors cited in these publications arise from the way in which the strain gage is installed and the strain measurement made by the user. Indeed, these publications are made available to our strain gage customers because we believe that only by thoroughly understanding the error sources associated with the use of a measurement device can the user hope to achieve optimal measurement accuracy.

- Local Sources
- Strain Sensing Sources
- Gage Resistance Sources
- Interface Sources
- Instrument Sources
- Error Corrections

LOCAL SOURCES

Strain at the molecular level is related to the relative spacing between atoms. The strain gage, of course, has finite stiffness and may locally reinforce the test part to which it is bonded. This reinforcement is ordinarily significant only for test materials with low elastic moduli such as plastics, and for thin specimens (Tech Note TN-505, Strain Gage Selection Criteria, Procedures, Recommendations).

The strain in the test part can also be affected by heat from the strain gage. If the excitation voltage is too high relative to the heat dissipation characteristics of the material, large changes in temperatures in both the test part and the strain gage can adversely affect the accuracy of the strain measurement. As a result of these, a certain amount of error and uncertainty can be introduced at the very beginning of the measurement process (Tech Note TN-502, Optimizing Strain Gage Excitation Levels).

STRAIN SENSING SOURCES

At the next level, strain in the test part may not be completely transmitted to the grid of the gage if the adhesive bond is faulty (series of Instruction Bulletins and Tech Tips). Similarly, the desired strain does not get transmitted to the grid if the gage is mislocated or misoriented on the test part (Tech Note TN-511, Errors Due to Misalignment of Strain Gages).

GAGE RESISTANCE SOURCES

On the third level, resistance changes in the grid may be caused by effects other than strain along its axis. This occurs when the temperature changes significantly during testing. The gage resistance will then be modified by the thermal output characteristics of the gage (Tech Note TN-504, Strain Gage Thermal Output and Gage Factor Variation with Temperature). Strain gages undergoing cyclic loading may experience fatigue-induced resistance changes unrelated to strain (Tech Note TN-508, Fatigue Characteristics of Micro-Measurements Strain Gages). Additionally, the gage resistance can be altered, to a small degree, by the strain perpendicular to the gage axis; i.e., by the transverse sensitivity of the gage to strain (Tech Note TN-509, Errors Due to Transverse Sensitivity in Strain Gages).

INTERFACE SOURCES

Errors introduced into the circuitry between the gage and instrument are at the fourth level in the measurement. Signal attenuation due to lead wires is perhaps the most common error in strain measurement (Tech Tip TT-612, The Three-Wire Quarter-Bridge Circuit). Another interfacial error in quarter-bridge and certain other half- and full-bridge circuits is caused by the non linear output of the Wheatstone bridge circuit (Tech Note TN-507, Errors Due to Wheatstone Bridge Non linearity). Thermocouple effects and changes in contact resistance at circuit connections can also produce errors at this stage. Additionally, noise from external electrical and magnetic sources may find their way into the measurement system (Tech Note TN-501, Noise Control in Strain Gage Measurements).

INSTRUMENT SOURCES

Fifth-level errors are those that occur within the instrument itself. With a properly calibrated instrument, and one designed specifically for strain gage measurements, these errors should be negligible unless the instrument is actually malfunctioning. This latter condition would normally be evident from the erratic behaviour of the instrument, or from anomalous calibration data (Tech Note TN-514, Shunt Calibration of Strain Gage Instrumentation).

ERROR CORRECTIONS

It should be obvious that to obtain consistently accurate strain data, one must be familiar with all the potential error sources at each stage of the measurement process. Judgment is required to ascertain which -- if any -- errors may be of significant magnitude in any particular measurement. Additionally, it is necessary to "design" the measurement system to suit the situation. This involves selecting components, establishing procedures, incorporating corrections, etc., to eliminate or minimize the errors to an acceptable level of uncertainty in the measurement data.

The obvious route to minimizing uncertainty in strain gage measurements is the attainment of knowledge and skills in the use of gages. Much of this knowledge is incorporated into the software supplied with our Strain Smart Data Systems.

Beyond the above, the strain gage user has, by telephone, facsimile, and email, instant access to the expertise of the Micro-Measurements Applications Engineering Department. The Applications Engineering staff has many years of experience with strain gages, and has counselled gage users on virtually every imaginable type of installation. They are readily available to assist you with your efforts in controlling errors in strain measurement.