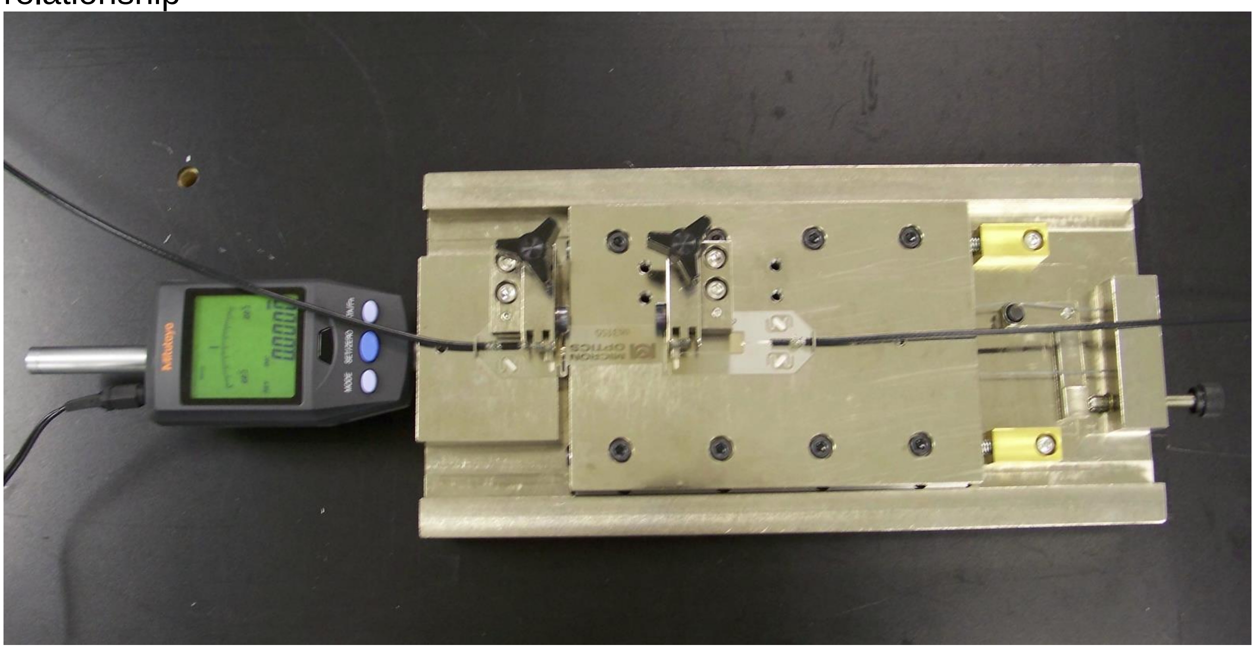
1.0 Gage Factor Tests

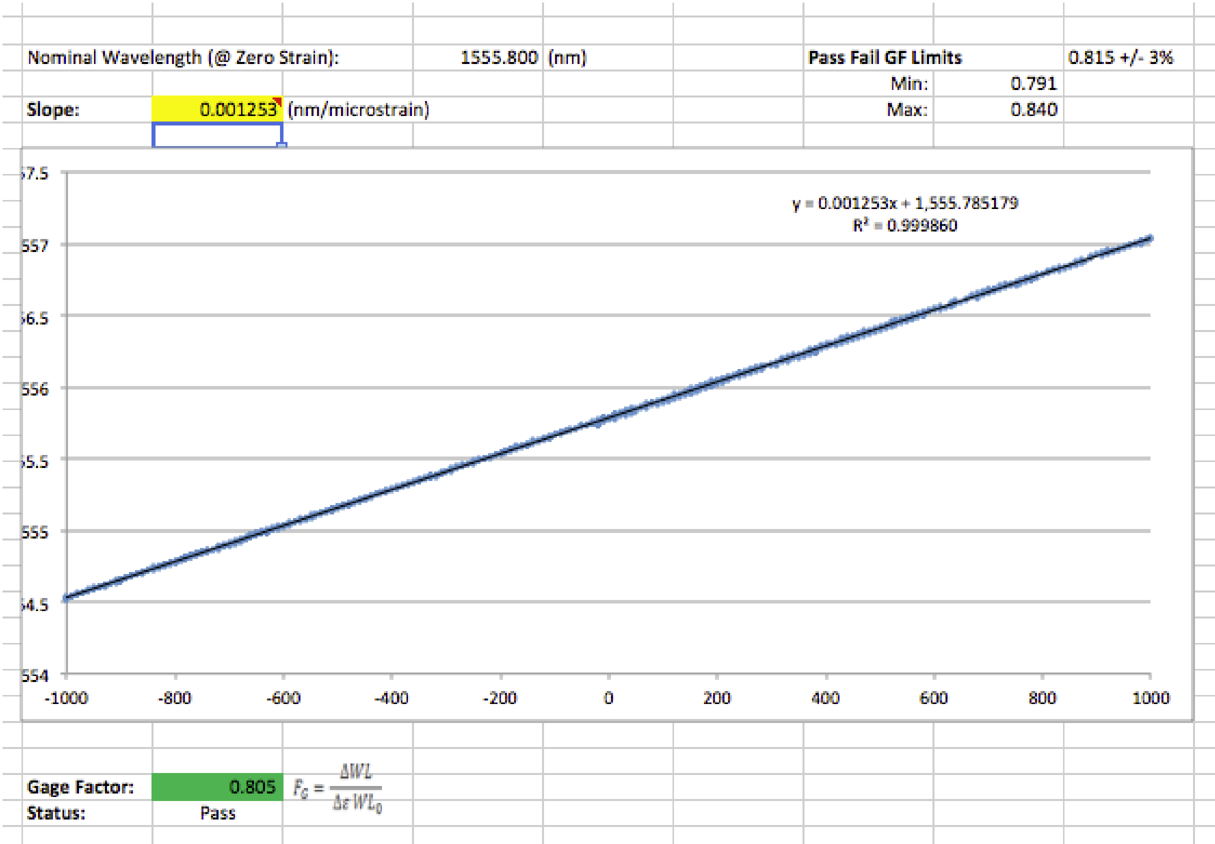
In order to determine the gage factor of the os3155 sensor, the sensor is fixed in place on to a testing station connected to a Mitutoya extensometer. When the length of the testing station expands, this puts tension on the sensor carrier & FBG while the optical sensing interrogator records changes in wavelength.

We convert the displacement measurement into strain (ε= Δin length/initial length), plot the change in wavelength (nm) vs. strain (με), apply a linear fit to the data to determine the slope of the line (nm/microstrain). This slope value * (10^-6 µm/m) / "initial wavelength" equals the gage factor.

1.1. Indicator Slide - shows wavelength to traceable extensometer (total strain) relationship

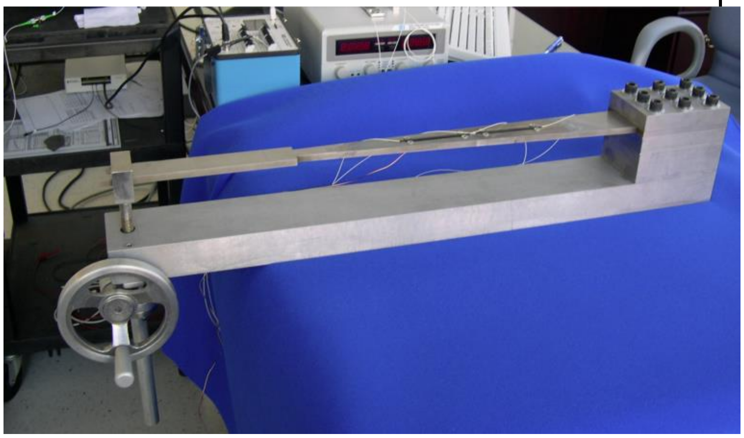


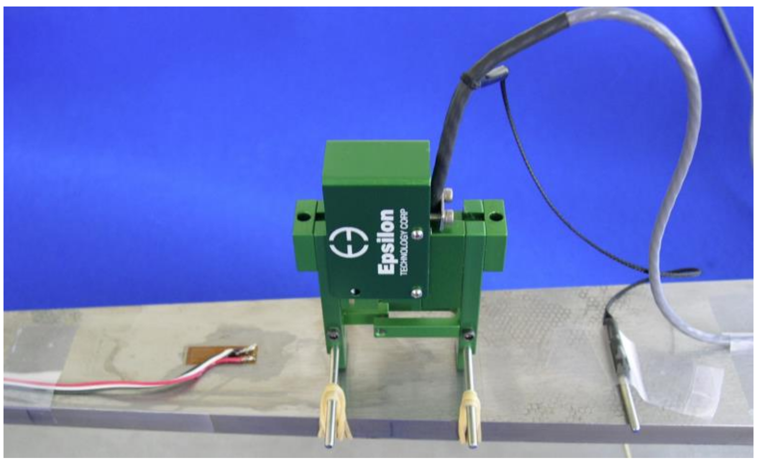
This plot shows the minimum and maximum regression based on historical os3155 calibration data. Every sensor calibration must fall within +/-3% of this range to be fully qualified. The unique gage factor is then reported on an os3155 Sensor Information Sheet to be used in the formula to calculate strain.

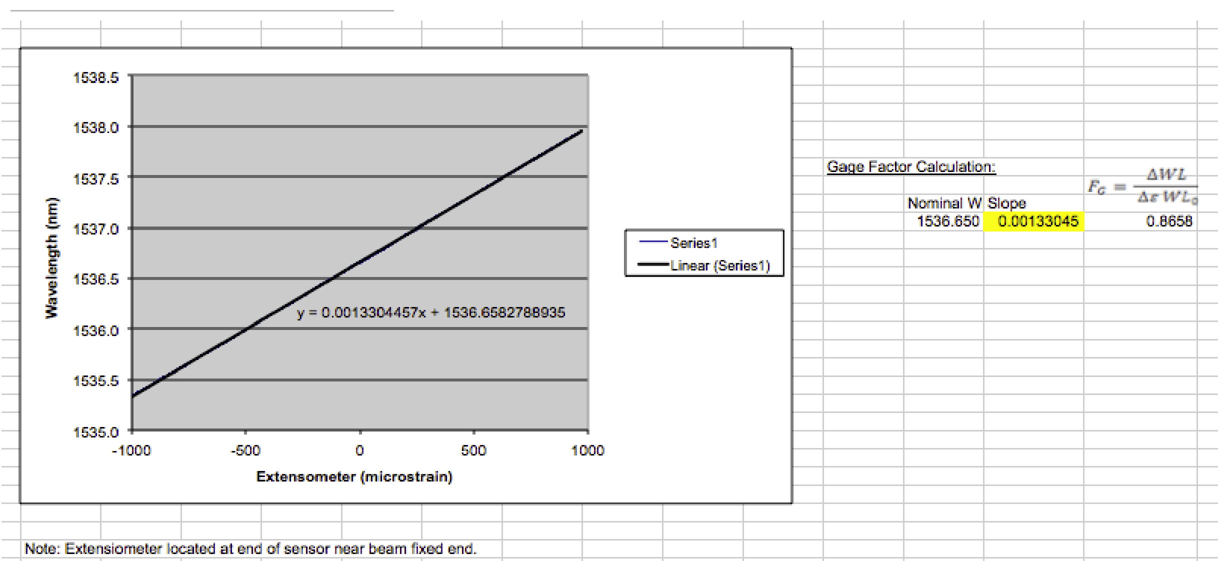


1.2. Constant Stress Beam

This constant stress beam was used for development of our os3155 sensors.





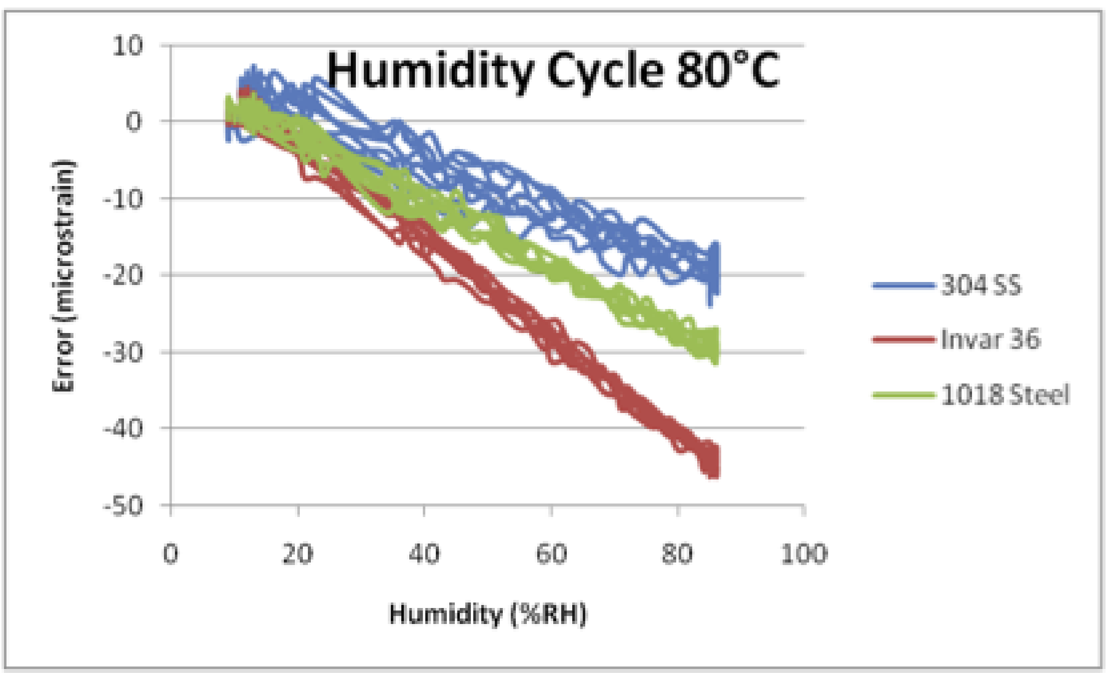


2.0. Humidity

2.1. Humidity Cycling and Sensitivity

The graph below shows the error of temperature compensated strain using the standard formula and published substrate CTE values relative to humidity. The reason for the three different slopes is likely do to temperature variation within the testing chamber. If you look at one of the substrates in isolation you will see the humidity does have some affect on the calculated strain reading; however, this is in a repeatable manner. There is likely a CTE mismatch while comparing the actual response of the substrate to temperature/humidity variation and the published CTE value used in the formula.

Any type of fiber optic sensor should be protected from elements. These os3155 sensors were left exposed in the testing chamber to demonstrate a worst case scenario and confirm the sensor behaves as expected.

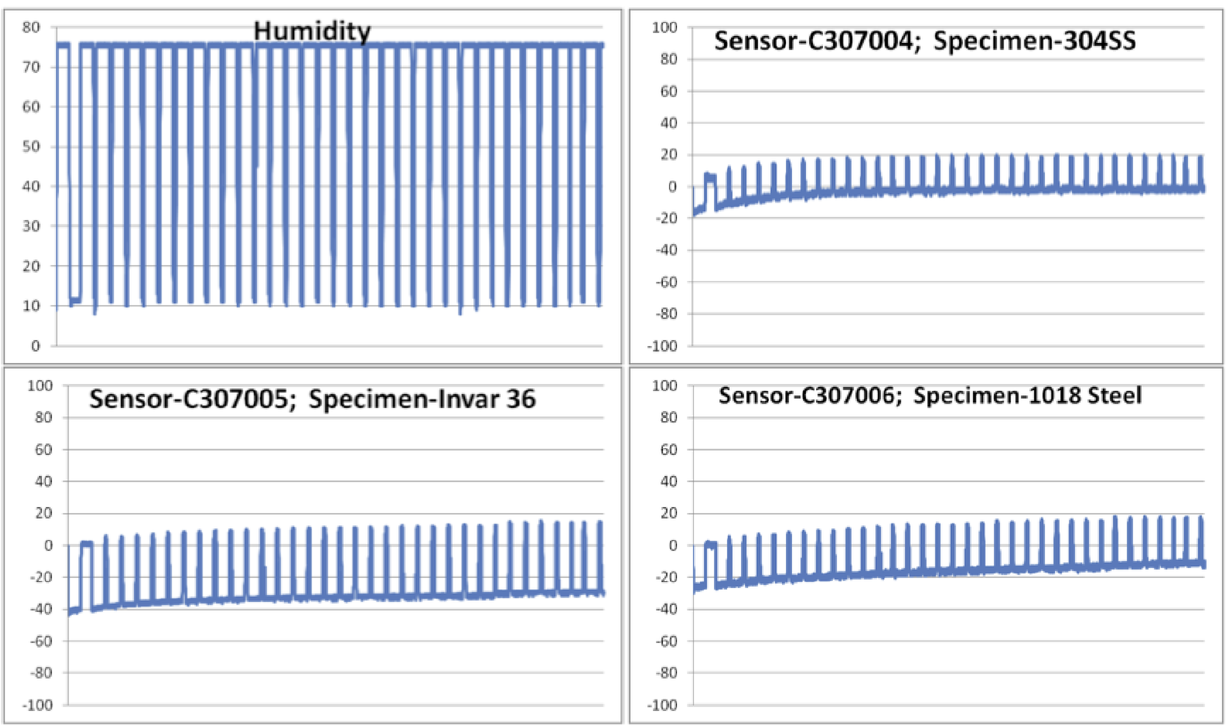


2.2. Long Term Humidity Soak

The graphs below shows a long term humidity soak of the os3155 at 75 degrees Celsius, 75% relative humidity for 44 days. Three sensors were mounted on different materials.

Humidity changes will cause a response to the Polyimide coating protecting the FBG. When the humidity increases it causes the Polyimide to expand exerting compressive forces on the FBG so that the perceived strain reading decreases. Therefore, the lowest readings on the plots are at high humidity.

These charts show that there is limited drift over time during extreme humidity cycling. In typical applications the humidity response is much smaller than what is shown in this extreme test.



3.0. Temperature

The graphs below show the thermally compensated error of three sensors on three materials with vastly different CTEs. Note, there is a glitch in the plot showing a sharp decrease and rapid increase in strain error which is related to an inconsistent temperature change within the testing chamber.

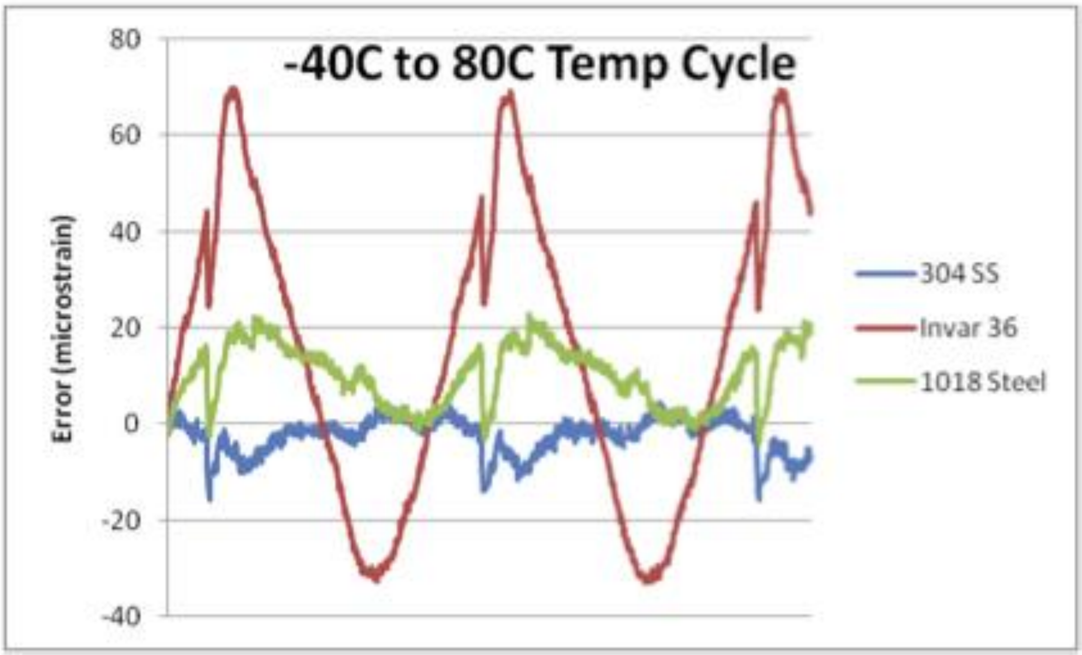
The thermally compensated strain reading with the 304 SS shows ~15µm error using the published CTE value. Most of this error is due to the published CTE value used in the equation which may not perfectly represent the substrate itself.

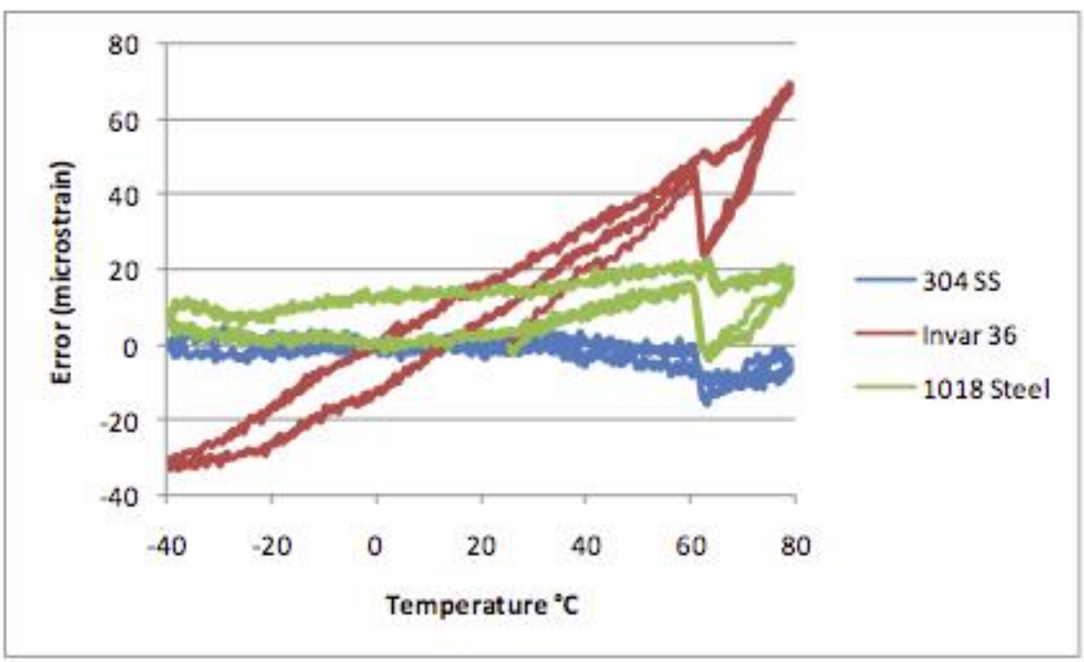
The second graph shows another view of post-processed data with slight modifications to the formula resulting in less thermally compensated strain error over a 120 degree temperature range. In typical applications the compensated strain error could be reduced by fine tuning the material CTE. Please refer to the attached document titled "Five Steps" for more information.

3.1. Temperature Cycling - thermal compensation errors vs substrate type

os3155 Temperature Cycle

Graph shows the error in microstrain due to temperature of three temperature compensated os3155 sensors mounted on different test specimen materials.





3.2. Long Term Temperature Cycling and Drift

The graphs below show the plot of rapid temperature variations from -40 to 80 degrees Celcius with the os3155 mounted on three different substrates. In this accelerated aging test, the temperature is rapidly cycled from -40 to 75 degrees Celsius and the reported strain value is plotted over time. We examined the plot over time to determine how much drift is present in the sensor.

The nominal strain ranges are repeatable during the temperature cycling but there is up to ~30µm drift on some substrates.