ATLAS NOTE

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Determination of the force required to compress an elastomeric connector

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Abstract

We present a calibration of an FC22 load cell using a linear regression on data obtained by compressing the cell with lead weights. This was used to determine the forces required to compress two types of elastomeric connectors.

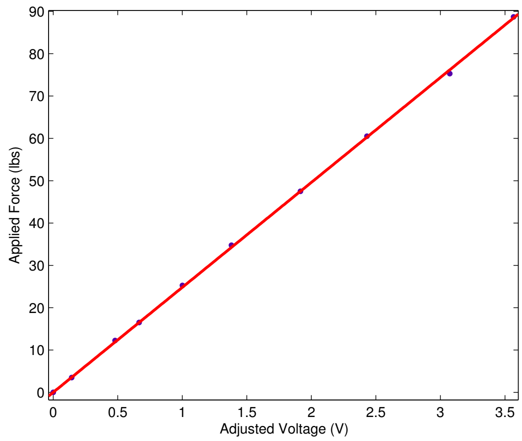

Figure 1: Linear fit to the measured load cell compression data showing applied force versus the cell adjusted voltage, $V - 0.5$ (see text).

1 Introduction

This note details how we determine the force required to compress various elastomeric connectors to a height of 6 mm. In Sect. 2, we describe the sensor and calibration which was later used to measure the desired forces, while the force measurements and elastomeric connectors themselves are discussed in Sect. 3.

2 Load Cell Calibration

To gather data, we use a Measurement Specialties FC22 compression load cell. This cell, when powered with 5V, outputs a voltage proportional to the amount of force being applied to it. As the correspondence between output voltage and applied force provided by the makers of the cell is inaccurate, we calibrate this correlation using some premeasured weights. A collection of lead blocks are weighed and placed on a plate which compresses the load cell sensor. We measure the voltage produced by the cell at a range of applied weights, twice for each weight. The measurements are not identical in both trials, but differ by up to 0.01V. With this data, we find that the amount of force being applied, F in pounds, is given by:

$$F = 24.8(V - 0.5),$$

where the constant of proportionality is 24.8 ± 0.15. This linear regression along with our measured values can be seen in Fig. 1. The metal plate which holds the weights in our setup slides on three posts which allow for wobble in the plate. The posts of the setup can be seen in Fig. 2. This may explain, in part, that we could not obtain the same values exactly when the same weight was applied multiple times.

3 Elastomeric Connector Compression

We test the elastomeric connectors after calibrating the load cell, applying the force necessary to compress a connector to 6 mm and measuring the voltage output by the cell, which can then be converted into force. The connectors used are Z-wrap connectors made by the Z-axis Connector Company. We test both the Z-wrap 314 connectors, which we will call elliptical, and the Z-wrap 305 connectors, which we will call rectangular. Information about each type of connector can be found in Figs. 3 and 4. These names

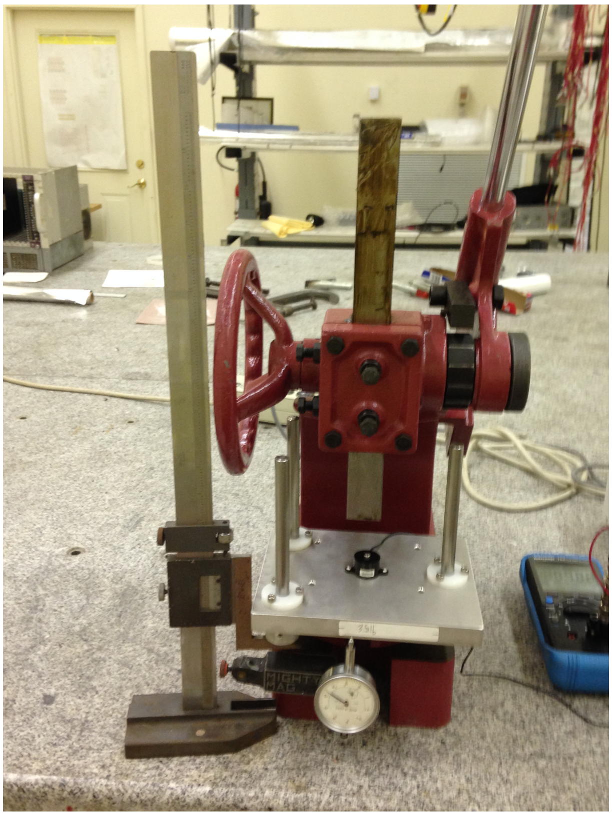

Figure 2: The press used for elastomeric connector compression. The black cylinder is the load cell, and the metal stage with posts was used for calibration.

are due to the shape of the silicone core around which the conductors are wrapped. The connectors, which are 6.5±0.15 mm high according to factory specifications, will be used in the NSW upgrade of the ATLAS experiment. They are used to connect the readout strips of micromega detectors to the front-end (FE) board used to process the micromega signal. To establish electrical contact, the connectors must be compressed to 6 mm. Our scope is to measure the force needed to compress a connector from 6.5 to 6 mm.

To apply the force, we use the mechanical press shown in Fig. 2, and the entire setup can be seen in Fig. 5. We use ABS holders for the elastomeric connectors machined to a height of 6 mm. These holders can be seen in Fig. 6. The attached micrometer is zeroed when only the empty holder is between the metal plates in the setup shown in Fig. 7. A connector is then placed into the holder and between the metal plates in the setup. After the connector is inserted, the press is tightened until the micrometer returns to its zero point, indicating that the connector has been compressed to 6 mm in height, matching that of the holder. Additionally, the starting height of all connectors was measured to within 0.02 mm using a micrometer. As stated above, the factory designated height range for the connectors is 6.5±0.15 mm for both types. We find that the average elliptical connector height is 6.43 mm and that the average rectangular connector height is 6.42 mm. This information can be seen in Fig. 8, and it falls in the expected range.

This procedure is carried out twice for each of twenty two elliptical connectors. The results for both trials are averaged and plotted in the histograms seen in Fig. 8. We also performed the procedure once for each of fourteen rectangular connectors. The results were plotted in the histograms seen in Fig. 9.

The average force needed to compress an elliptical elastomeric connector to 6 mm is 14.1 lbs. The average force needed to compress a rectangular elastomeric connector to 6 mm is 17.8 lbs.

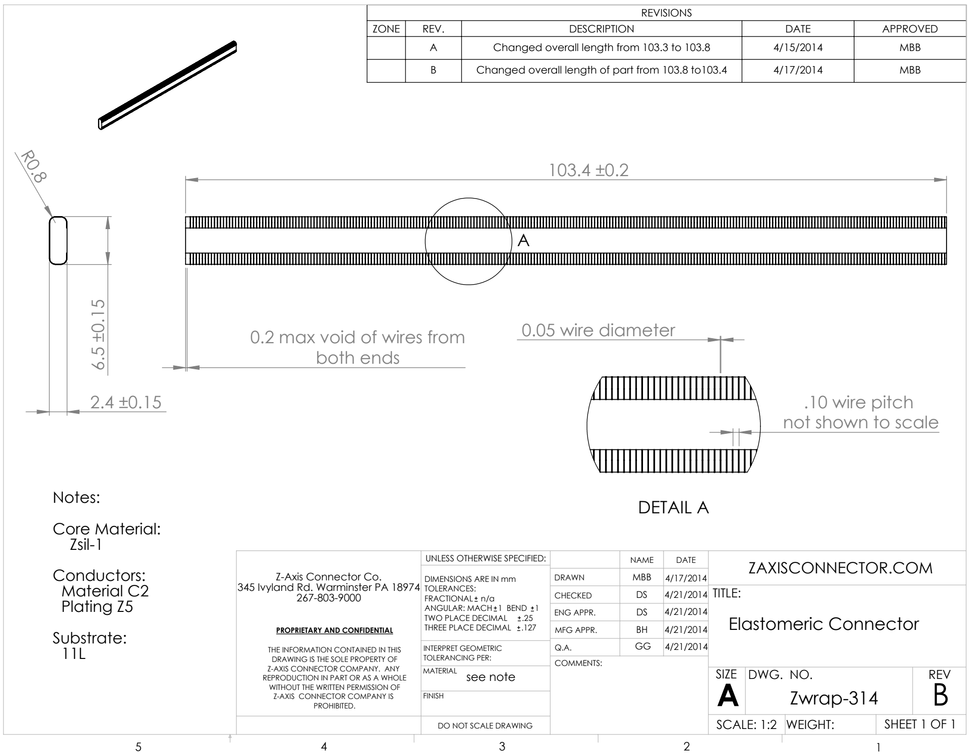

Figure 3: Schematic of an elliptical elastomeric connector.

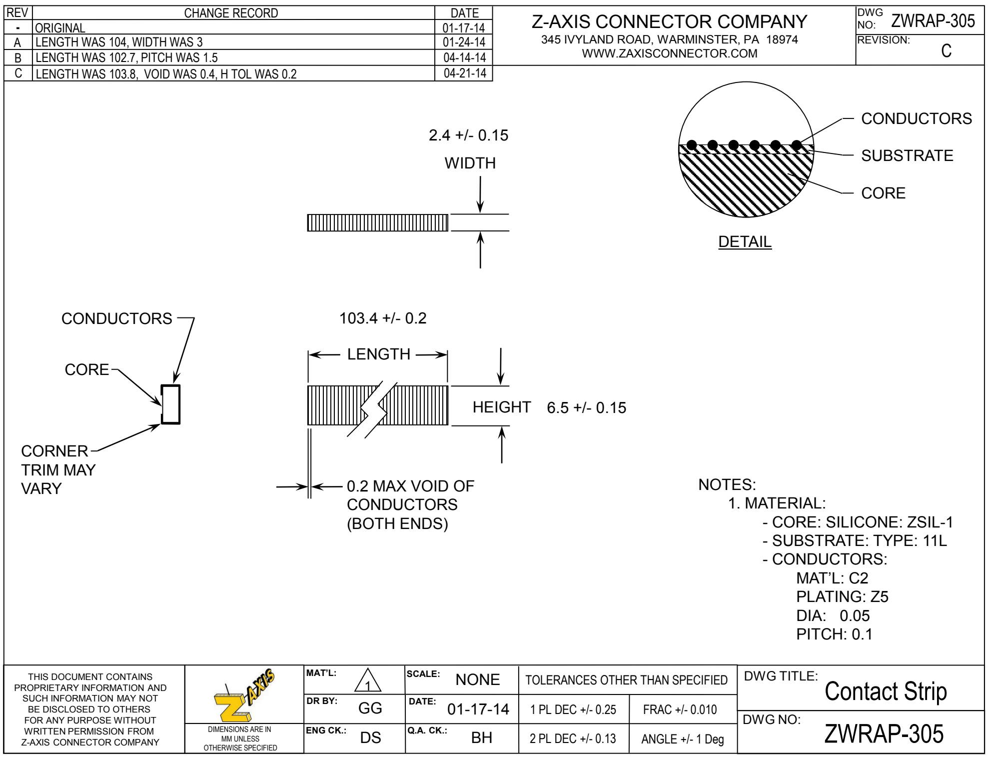

Figure 4: Schematic of a rectangular elastomeric connector.

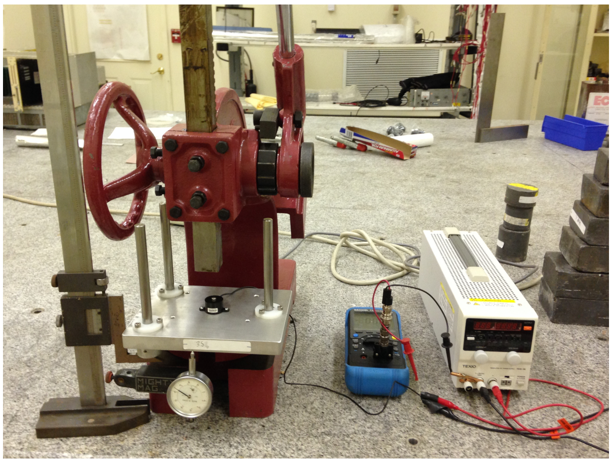

Figure 5: The complete setup for elastomeric connector compression, described in Sect. 3.

Figure 6: The 6 mm high holders used during compression of the connectors.

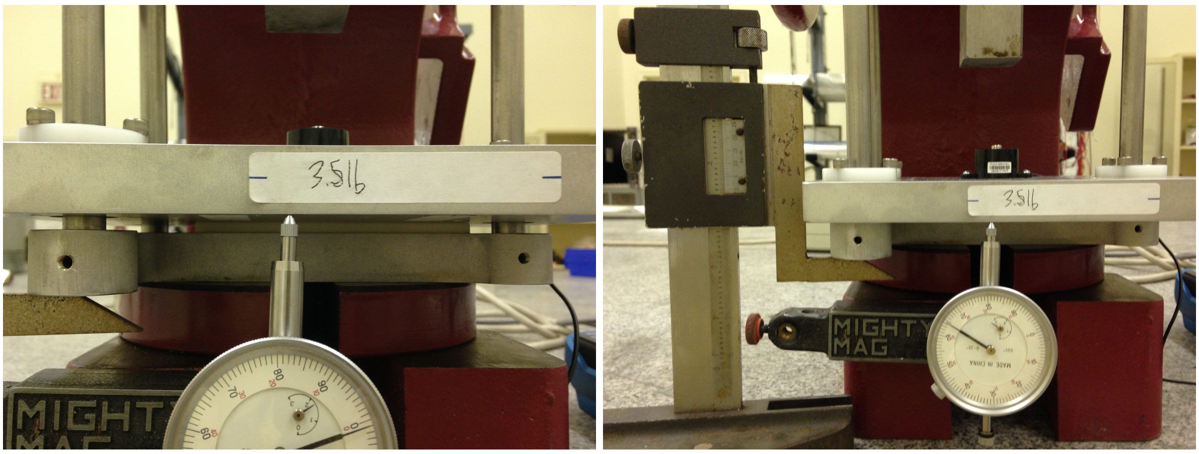

Figure 7: The compression setup with a holder before zeroing (left) and without a holder (right).

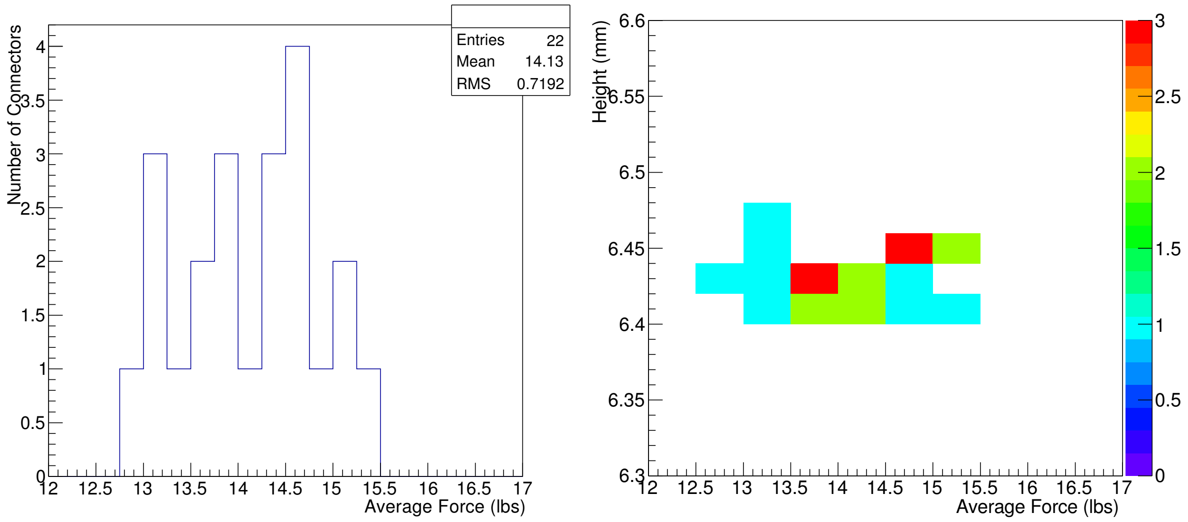

Figure 8: The histogram on the left shows the force measured for each of the 22 elliptical connectors, and the right shows height of the connector versus the average force measurement.

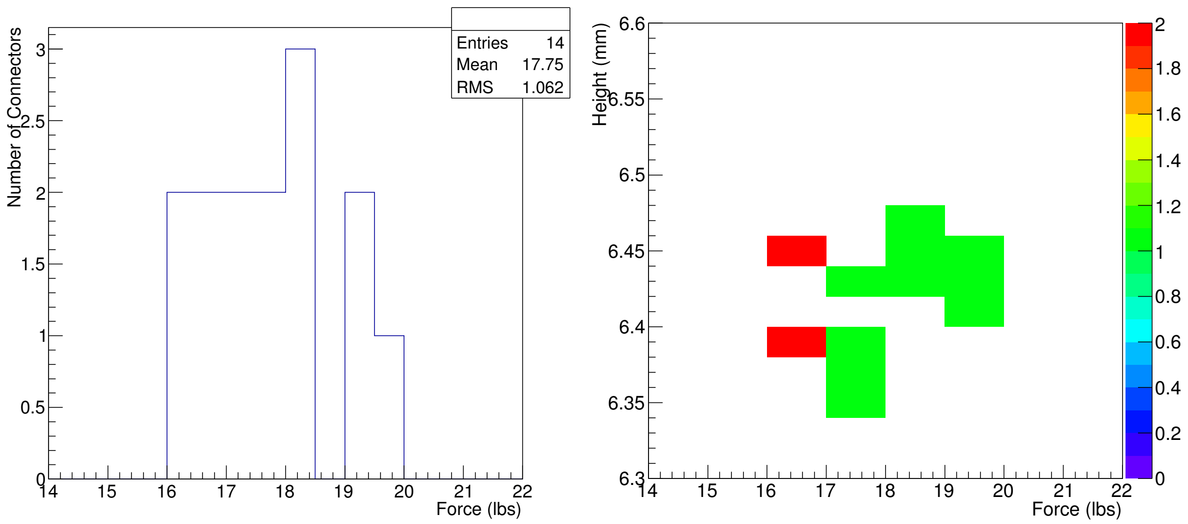

Figure 9: The histogram on the left shows the force measured for each of the 14 rectangular connectors, and the right shows height of the connector versus the average force measurement.

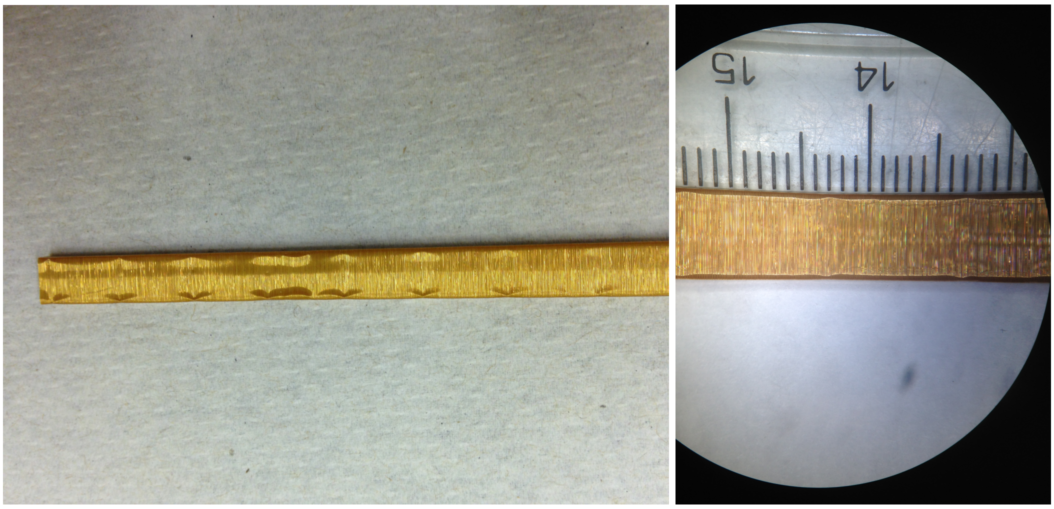

Figure 10: Visible deformities can be seen with no magnification (left) and under a microscope with a ruler measuring in centimeters (right).

The data given above is subject to some systematic error. First, as noted in Sect. 2, the force applied to the load cell by our metal plate is subject to be skewed, leading to possible errors in our calibration and in measuring the force applied to the connectors. While we attempt to minimize this error by averaging multiple measurements, there is likely still some deviation. Secondly, we observe multiple techniques for applying pressure to the load cell, which give slightly varying results. That being said, all methods give results within 1.2 lbs.

After compressing some of the elastomeric connectors, visible deformities developed which can be seen in Fig. 10. The deformities match the ribbed nature of the inside of the ABS holder. The deformed connectors were examined with a microscope, and no wires were seen to be broken. This means that the deformity should not affect performance of the connector. It appears that the silicone core and the wires forming the connector simply changed shape while the pressure was applied.

4 Conclusion

Using our calibration of the load cell, we determine that the average force needed to compress an elliptical elastomeric connector to a height of 6 mm is 14.1 lbs. Similarly for a rectangular connector, the average force required is 17.8 lbs. Since 6.7 mm is approximately the upper end of the height range expected to be produced according to Z-axis Connector Company specifications, this would require a compression of 70% larger. Then the upper bounds on the compression force required are 24.0 and 30.3 lbs, for elliptical and rectangular connectors respectively.