



Date: May 28, 2008

Bend & Flexibility Report

Objective: Determine the relative flexibility of different possible outer jacket materials including ETFE, PFA and TPU. The stiffness of these materials is quantified by subjecting all three materials to the same physical test, the details of which are below.

Material Details

TPU – Pellethane 2363-90AE Thermoplastic Polyurethane Elastomer
Hardness Shore A: 90A
OD: 0.087"
ID: 0.027"
Thickness: 0.025"

ETFE – Ethylene Tetrafluoroethylene
Hardness Shore D: 63D – 72D
OD: 0.125"
ID: 0.062"
Wall Thickness: 0.031"

PFA – Teflon Perfluoroalkoxy
Hardness Shore D: 60D
OD: 0.125"
ID: 0.062"
Wall Thickness: 0.031"

Preparation

Standard STFOC was fed into the PFA and ETFE tubing. This was done so that the PFA and ETFE would have the same configuration as the TPU cable in stock. Our TPU cable configuration is such that the outer layer of TPU is extruded onto STFOC of 0.027" in diameter. Therefore to account for any affect the LCP may have on flexibility, the PFA and ETFE were configured as such.



Due to the coiling of the tubing and cable during shipment and storage, there is a memory bend to the cable and tubing. The samples were taped down straight on a work bench in an attempt to eliminate the bending. This is shown in Figure 1.

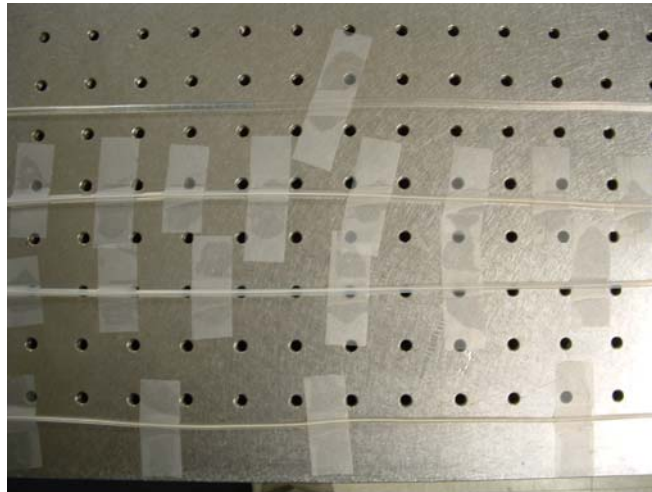


Figure 1. Straightening of Cable

The samples were left in this set-up overnight for approximately 16 hours. When they were released from this position they still had a bend as shown in Figure 2.

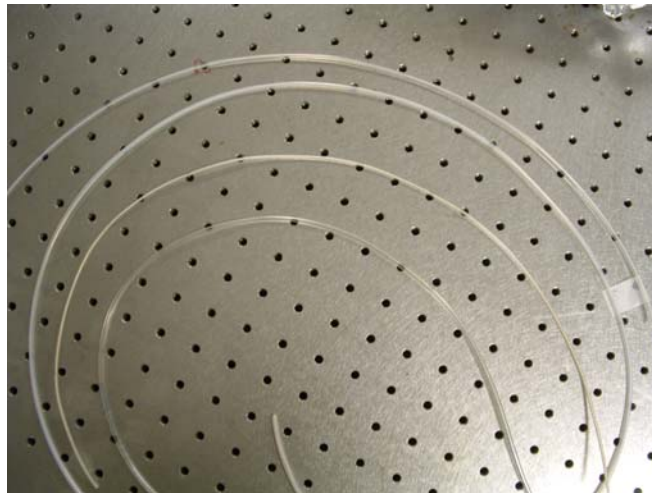


Figure 2. Memory Bend Remains



Test Set-up

The samples were marked at 10" from one end. See Figure 3.

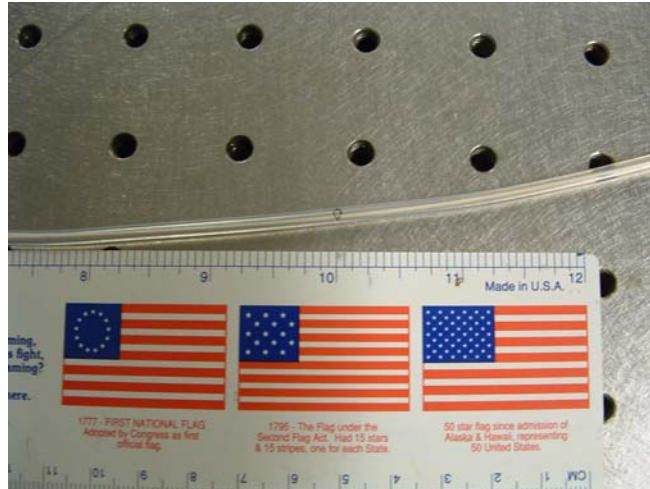


Figure 3. Marking Cable

The samples were then fastened to the bench with exactly 10" hanging over the edge. The samples were configured in such a way that the curl was in a vertical direction as shown in Figure 4.

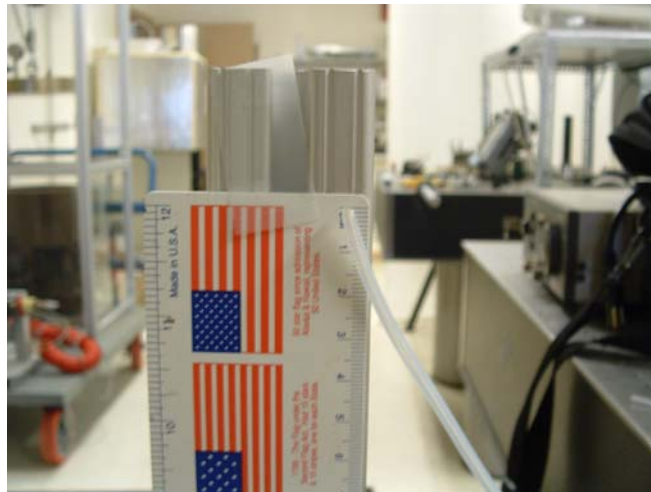


Figure 4. Initial Set-up Zero Weight



Figure 4 shows the ETFE tubing with STFOC cable. This was used as the standard due to it possessing the most curl. Therefore as a benchmark, the initial unweighted position of the ETFE sample was set to 0mm on the ruler as shown. After this measurement was recorded, a weight was placed on the very end of the sample and the weighted vertical position was noted as shown in Figure 5.

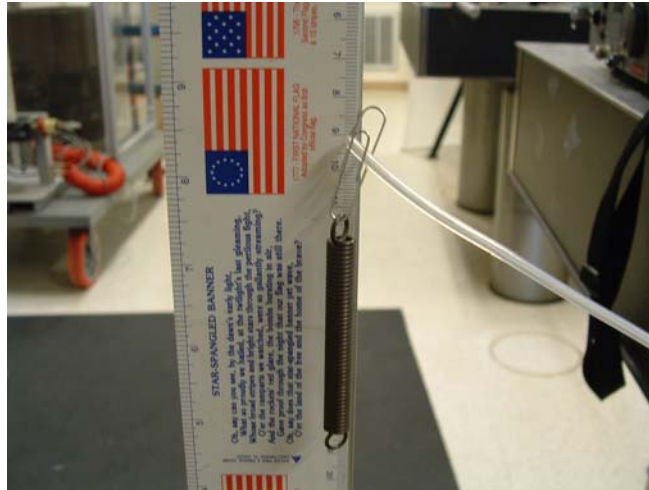


Figure 5. Measurement Under Load

The weight consisted of a paper clip and a spring from our workshop. This combination was chosen because of its ease to fasten to the end of the sample and because of its precise weight. The paper clip weights 0.5g and the spring weights 9.5g for a total weight of 10.0g.

Relative flexibility will be inversely proportional to the distance between the initial unweighted measurement and the measurement with 10.0g attached. For example, the ETFE sample had an initial measurement of 0mm and an under load measurement of 9.0mm for a delta of 9.0mm. A more flexible material will have a delta greater than 9.0mm and less flexible materials will have a delta of less than 9.0mm.

PFA, which feels more flexible, is shown in its under load position in Figure 6. Results are tabulated in Table 1 below.

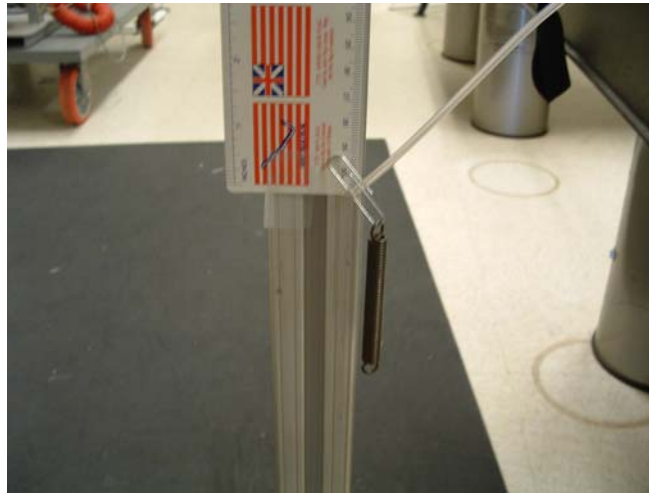


Figure 6. PFA Tubing Under Load

Table 1. Flexibility Measurement Results

Material	Initial Measurement	Under Load Measurement	Measurement Delta
ETFE	0mm	9.0mm	9.0mm
PFA	9.2mm	29.8mm	20.6mm
TPU	0mm	38.5mm	38.5mm

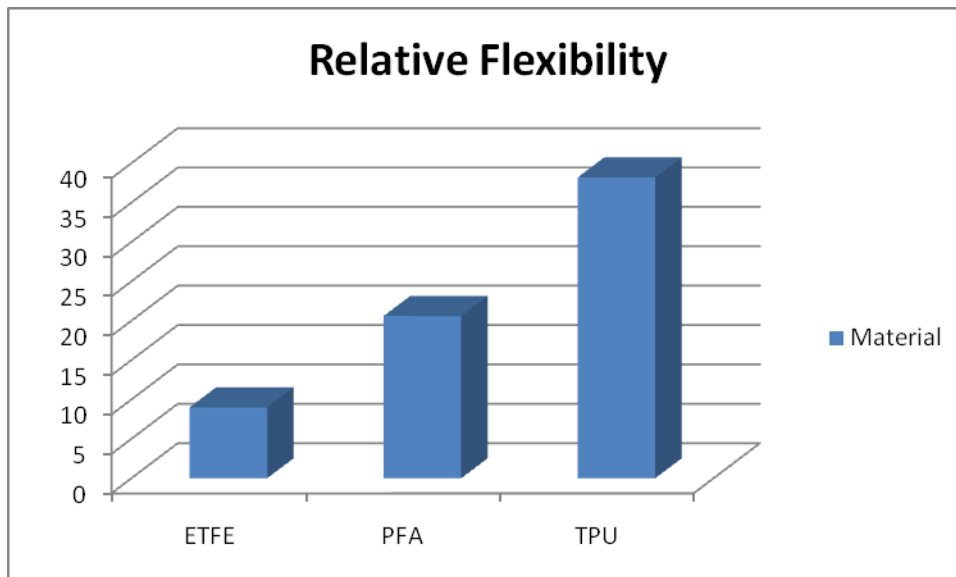


Figure 7. Graphical Representation of Relative Flexibility



Conclusion

The measurements confirm what can easily be measured in a qualitative way by hand. The TPU, which appears more flexible to the touch is much more so. The ETFE which feels the most stiff bent the least of our samples.

The verification of this data will help when determining which polymer might be used for extruding over cable in applications where flexibility, bend radius and non-kink properties are important.

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