Date: May 30, 2008

Temperature Discoloration Test
Bare SMF-28e vs. SMF-28e coated with LCP

Objective: Subject bare SMF-28e and STFOC cable with SMF-28e fiber inside to 205°C for various lengths of time. Observe the discoloration of the fiber as a function of duration at elevated temperature and as the bare fiber compares to LCP coated cable. Determine if the LCP provides thermal protection to the SMF-28e acrylate coating.

Duration Comparison

As suspected, when the bare fibers were exposed to elevated temperatures of 205°C for extended time, there is a discoloration of the outer buffer as the acrylate burns. The time durations chosen were 1 hour, 2, hours, 3 hours, and 6 hours. As can be seen in Figure 1, the longer the amount of time in the oven the darker the fiber became. Fibers are shown 1 hour to 6 hours from left to right.

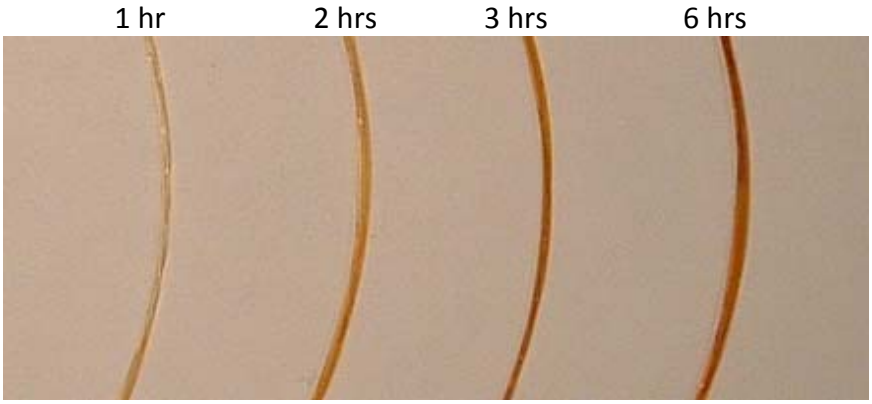

Figure 1. Bare Fibers After Baking

STFOC cables were subjected to the same temperatures at the same time and after the lengths of cable were removed from the oven, the LCP jacket was removed to reveal the bare SMF-28e underneath. As shown in Figure 2, while the fiber did darken somewhat with time, it appears to have leveled off at the 2 hours mark. The cable that remained in the oven for 6 hours did not appear any darker than the cable that remained only for 2 hours. Also, there is a noticeable difference in between the levels of darkening in the bare fiber to the with cable protection.

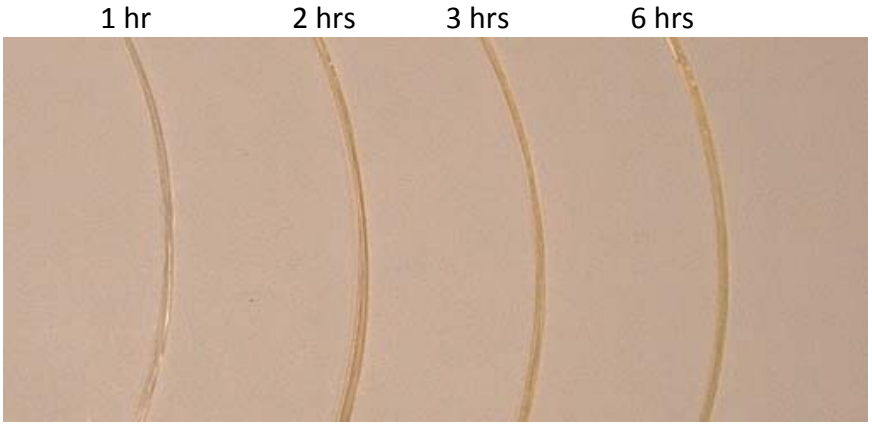

Figure 2. STFOC Fibers After Baking / After Stripping LCP Coating

Bare Fiber vs. LCP Coated STFOC Comparison

Below we have side-by-side comparisons of the bare fiber and the fiber that was in the oven in cable form. Samples were removed at 1 hour, 2 hours, 3 hours and 6 hours.

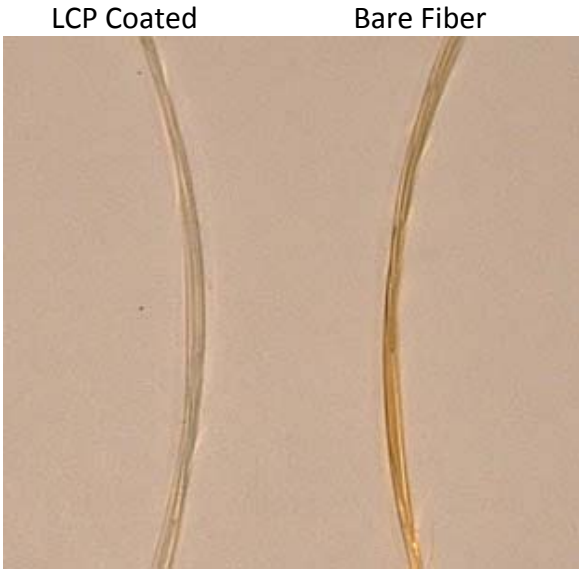

Figure 3. 1 Hour

LCP Coated Bare Fiber

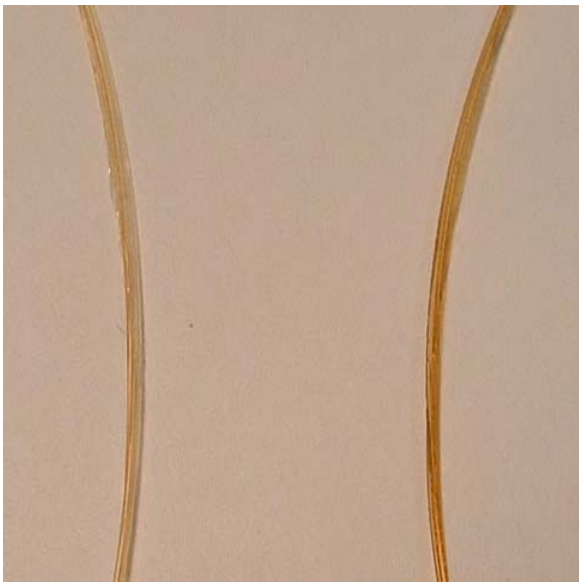

Figure 4. 2 Hours

LCP Coated Bare Fiber

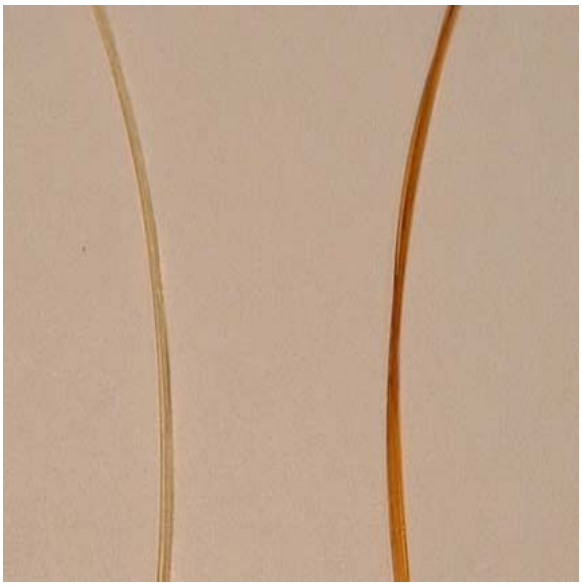

Figure 5. 3 Hours

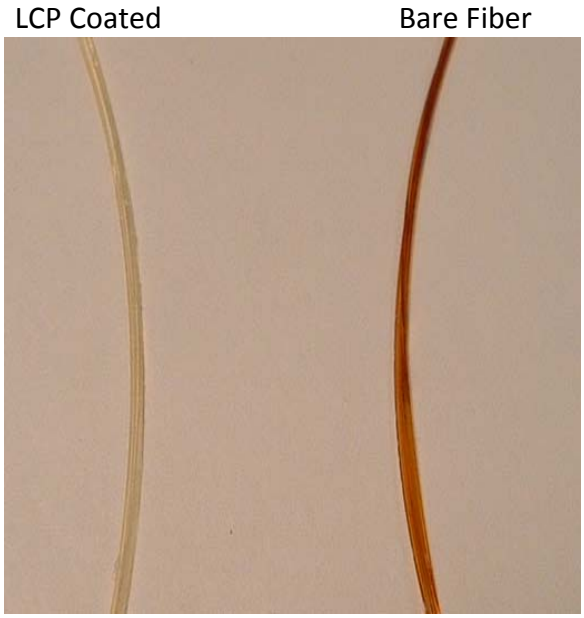

Figure 6. 6 Hours

Clearly in each case the fiber that was protected with LCP has had significantly less damage and has burned (darkened) to a much lesser degree. The protection is in large part due to the permeability of the LCP. LCP has low permeability and will thus limit the burning of the acrylate coating. This theory is supported by the observation that at the ends of the STFOC cables, the fiber had darkened noticeably. The closer to the end of the cable, the darker the fiber. This is shown below in Figure 7. As one moves from the left side of the fiber (further from tip of cable) to the right side of the fiber (closer to the tip of the cable) the cable become increasingly darker.

Figure 7. Darkening of Tips of Cable

Extended Bake

As mentioned above, during the first test of 1 hour, 2 hours, 3 hours and 6 hours bake, the LCP coated fibers that were in the oven for 3 and 6 hours did not appear to have any further appreciable discoloration of the fiber. The bare fiber, however, will get continually darker until almost black at 24 hours.

To further examine this, LCP coated fiber was baked at 205°C for 24 hours and the results are shown below in Figure 8. The fibers subjected to 2 hours, 6 hours and 24 hours all appear to have darkened a similar amount and past the 2 hour mark, the LCP jacketing is protecting the bare fiber from burning further. One theory is that due to the low permeability of the LCP, the fiber discolors only until the oxygen that may exist within the confines of the cable. After the existing oxygen is exhausted the fiber will burn no further.

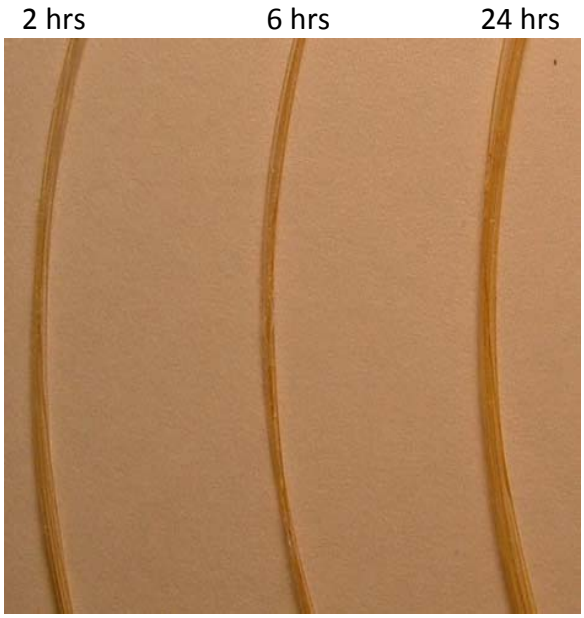

Figure 8. Results of 24 Hours Test

Summary

LCP jacketing will protect standard off-the-shelf SMF-28e from burning like bare fiber will during exposure to high temperature – in this experiment, 205°C. While the acrylate will darken somewhat in STFOC, it appears that there is a limit to this discoloration and past that point, no further discoloration will occur. To observe the effects of this discoloration on fiber performance we will perform an extended test measuring the cable/fiber loss while exposed to high temperatures for long periods of time. By protecting the fiber, STFOC will allow standard off-the-shelf fibers to be used in harsh environments where they previously could not. Because of this, use of expensive high performance fibers such as polyimide coated fibers may become unnecessary and users of fiber optics in harsh/high temp environments may be able to significantly reduce their cabling expenditures. Please see *Extended High Temp Loss Test.*