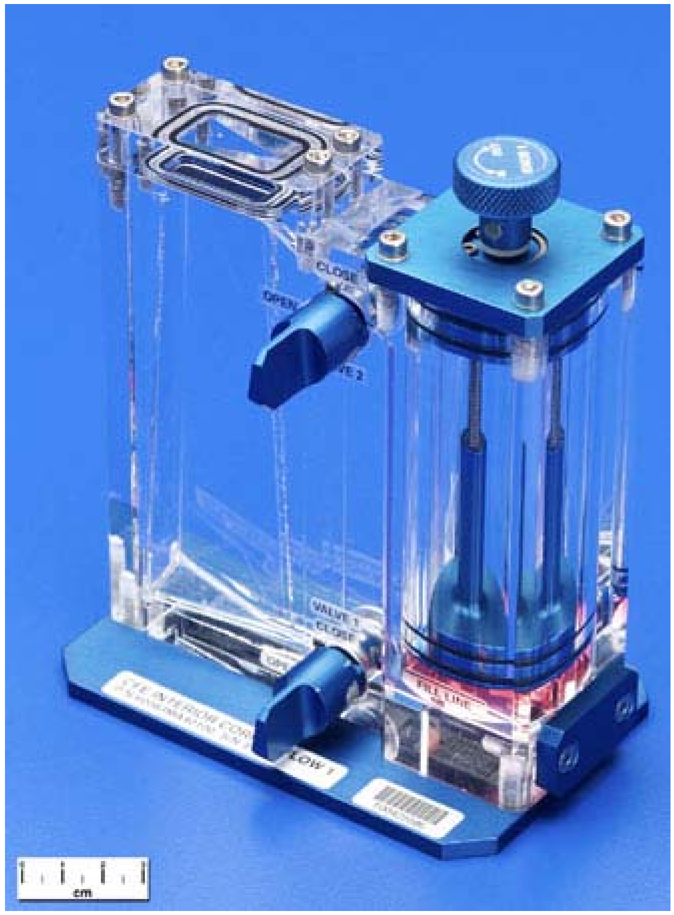
# Integrity of Polymethylmethacrylate (PMMA) Chemically Welded Joints Examined

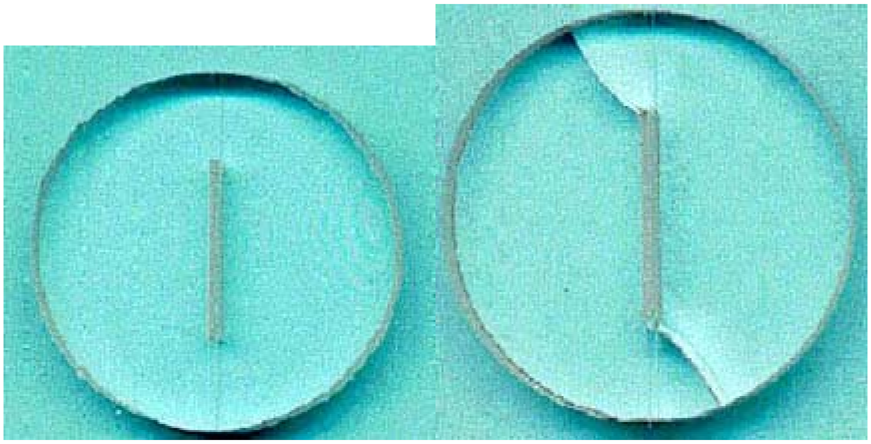
NASA Glenn Research Center's Capillary Flow Experiments (CFE) program is developing experiment payloads to explore fluid interfaces in microgravity on the International Space Station. The information to be gained from the CFE is relevant to the design of fluid-bearing systems in which capillary forces predominate, for example in the passive positioning of liquids in spacecraft fuel tanks. To achieve the science goals of CFE, Glenn researchers constructed several types of experiment vessels (ref. 1). One type of vessel, known as the interior corner flow (ICF), will be used to determine important transients for low-gravity liquid management in a two-phase system. Each vessel has a cylindrical fluid reservoir connected to each end of the test chamber by internal transport tubes, each with a quarter-turn shutoff valve (see the following photograph). These multipiece vessels are made from polymethylmethacrylate (PMMA) because of its excellent optical properties (i.e., the fluids can be observed easily in the vessel). Because of the complexity of certain vessels, the test chamber had to be manufactured in pieces and welded chemically. Some past experience with adhesive bonded plastic showed that the experiment fluid degraded the adhesive to the point of failure. Therefore, it was necessary to see if the fluid also degraded the chemically welded PMMA joints.




*Interior corner flow vessel for CFE experiment.*

In response to these concerns, a joint CFE-Glenn program was conducted to investigate the effect of silicone oil on the strength of the bonded PMMA. A number of different tests were conducted to assess the joint strength. These included tests on the PMMA parent material, tests on welded PMMA, and notched samples of both welded and unwelded PMMA. In addition, samples were aged in either air or silicone oil for up to 8 weeks to investigate any potential deleterious effects of the environment.

The results showed that neither parent material nor welded structures were degraded by long-term exposures in air or silicone oil. Notched samples lowered the strength and failure strain of the materials, and these decreases were predictable from fracture mechanics. Also, biaxial stress states from the notch did not adversely affect the weld joint. This was verified by using Brazilian disks to examine both mode-I and mode-II cracks (see the following photographs). These tests indicated that the crack prefers to follow a mode-I type path rather than following the weld, suggesting that the weld has nearly parent material properties. A fracture analysis was performed on the ICF vessel using the actual dimensions and proof pressure. This analysis showed that there was a factor of 3 margin of safety for the worse-case conditions.



*Brazilian-disk, welded samples. Left: Weld line in the pretest state. Right: Kinked crack from a mode-II test.*

# Reference

1. Weislogel, M., et al.: The Capillary Flow Experiments: Handheld Fluids Experiments for International Space Station. AIAA-2004-1148, 2004.

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