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Creep Test Results on D0 RunIIB Stave

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1. Abstract

The D0 RunIIb final design stave has been tested to verify its response to long term loading (creep). Two stave mockups have been investigated. Mechanical stave #3 has been under continuous loading for 8 weeks. The maximum deflection was 3.6 μm, with 80% of the total sag reached after the first two weeks. Mechanical stave #2, despite the denomination, has been assembled successively with improved gluing assembly process and tested for six weeks. No creep mechanism has been observed in this surveyed mockup.

2. Creep test results

Two staves were tested: mechanical stave #3 and mechanical stave #2. While the stave numbering was dictated by the chronological order in which the stave cores had been built, the structural members (channels) were glued on stave #3 before stave #2. Hence, while stave #3 can still be seen as a “work in progress”, stave #2 features a state of the art channels-to-core glue joint.

For the creep test, staves were simply supported in a way analogous to what was done for the deflection tests [1]. Four sapphire bearings glued on carbon fiber plates simulated the stave bulkhead supports. These plates were mounted on two aluminum blocks interconnected by two 1” OD tubes. The whole supporting structure was glued onto the CMM granite table. Six cylindrical steel pieces were placed at the center of each silicon sensor to simulate a quasi-distributed mass of 151.63gr total. The actual stave mockup mass is 118.36gr. Figure 1 shows the test setup.

During the whole test, the temperature in the clean room remained approximately constant (71.5 ±1.2 °F), while the relative humidity ranged between 31 and 45%.

For each stave, the reference system was set at the beginning of the experiment. A 3×34 data grid (three lines of abscissa Y=±6 and Y=0) was measured to check the strain in the silicon sensor region. As results from the first test showed 80% of the total strain had occurred in the first two weeks, data for the second stave were taken more frequently in the first fourteen days.

Figure 2 shows a typical data chart. The solid lines represents the strain the silicon sensor underwent from the beginning of the test to the given day along the three different abscissas (blue is the sensor centerline, red and green 6 mm off from the center). The dotted line corresponds to the fourth order polynomial that best fitted all the points measured on the sensor. Small particles of dust seem to have been the cause of the two relatively large peaks at ~200mm (green line) and at ~400mm (blue line).

A summarize of the sag the two mockups exhibited can be seen in Figure 3 and Figure 4 for stave #3 and stave #2 respectively. There, the maximum deflection obtained from the interpolated curves is charted versus time (days). Stave #3 seems to exhibit some creep behaviour during the first four weeks. However it must be said that the overall strain, over a period of eight weeks, was 3.6μm and this value is comparable with the accuracy of the coordinate measuring machine (CMM). Stave #2 reveals no signs of creep phenomenon and the oscillation the curves in Figure 4 exhibit around the zero strain axis clearly indicates data were dominated by measurement errors.

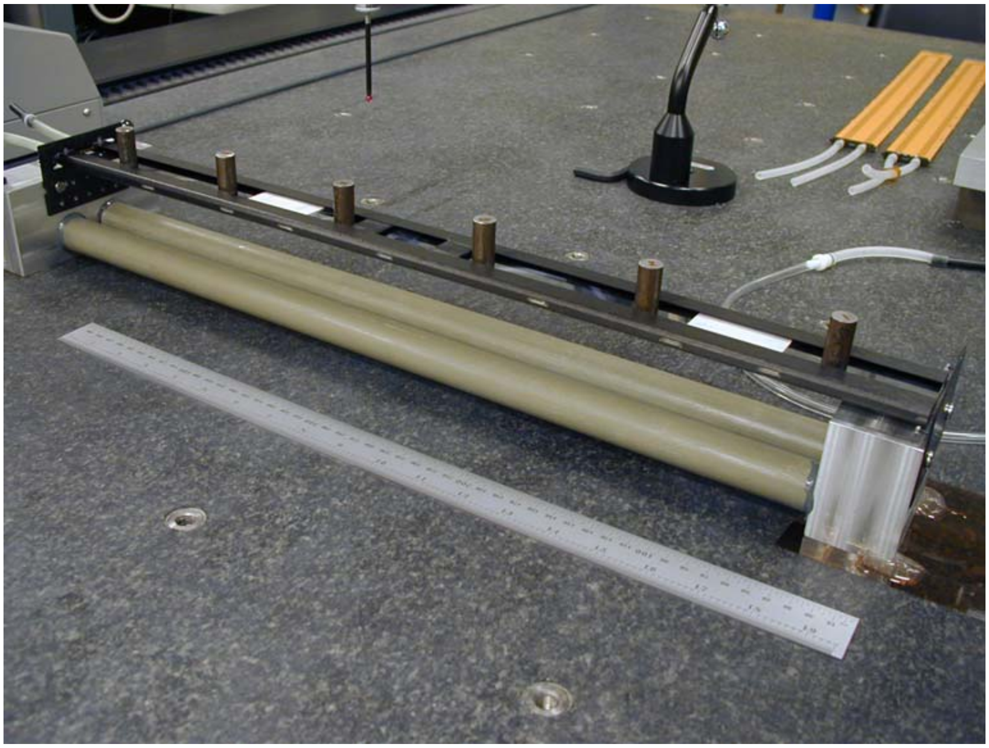

Figure 1 – The creep test setup

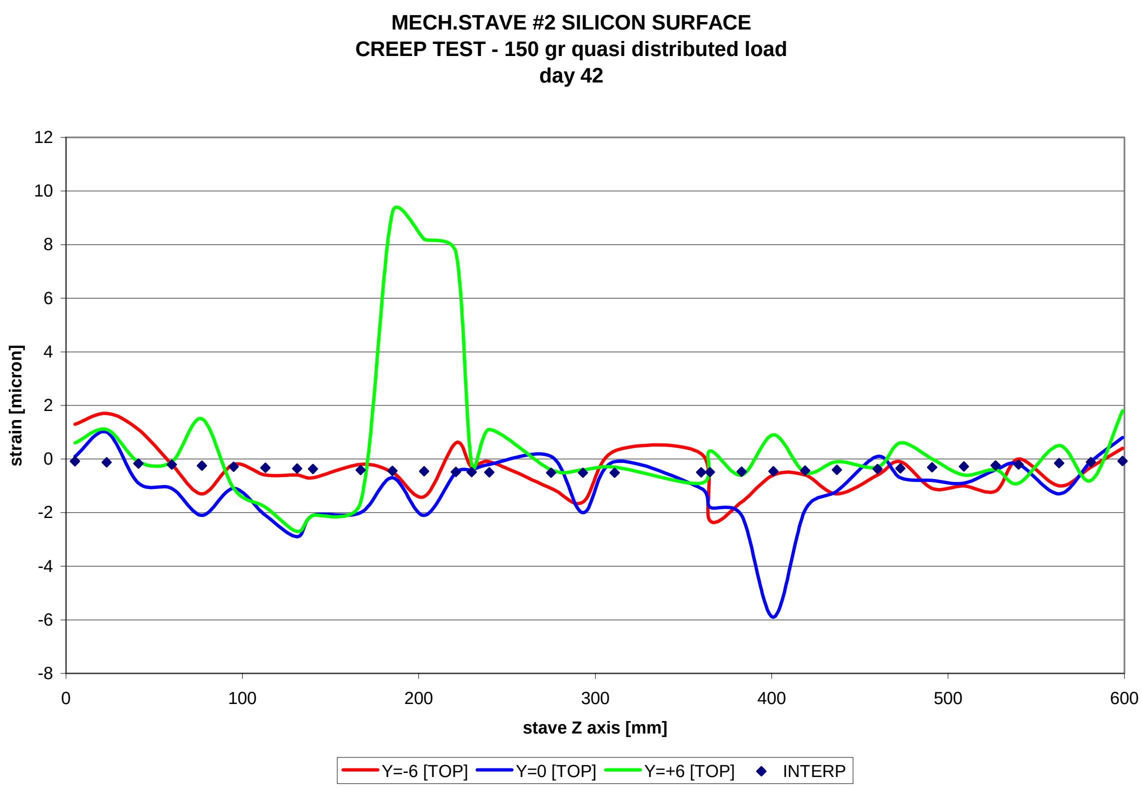

Figure 2 – Typical data chart. The solid lines represents measured data on the sensor surface (the blue line is on the sensor center line while the red and green are 6 mm off from the center). The dotted line corresponds to the fourth order polynomial that best fits all the points measured on the sensor. Small particles of dust seem to be the cause of the two relatively large peaks at ~200mm (green line) and at ~400mm (blue line).

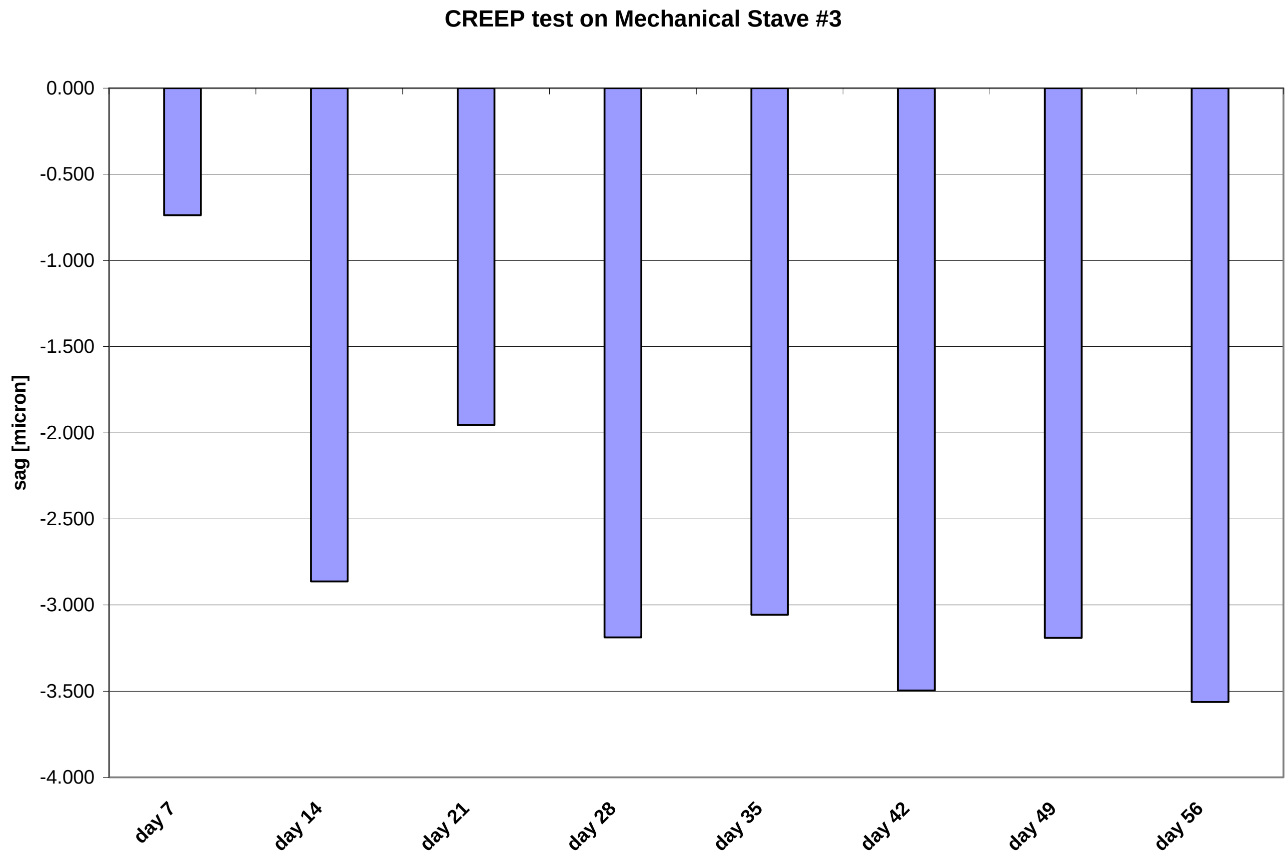

Figure 3 – Sag due to creep on ***mechanical stave #3****. Strains are computed from the first day deflection profile; data have been fitted by a fourth order polynomial and the maximum deflection obtained from the interpolated curve has been charted versus time (days). The stave exhibits some creep behaviour in the first 4 weeks. It is not clear if after this period the stave strain settled and the creep came to a stop.*

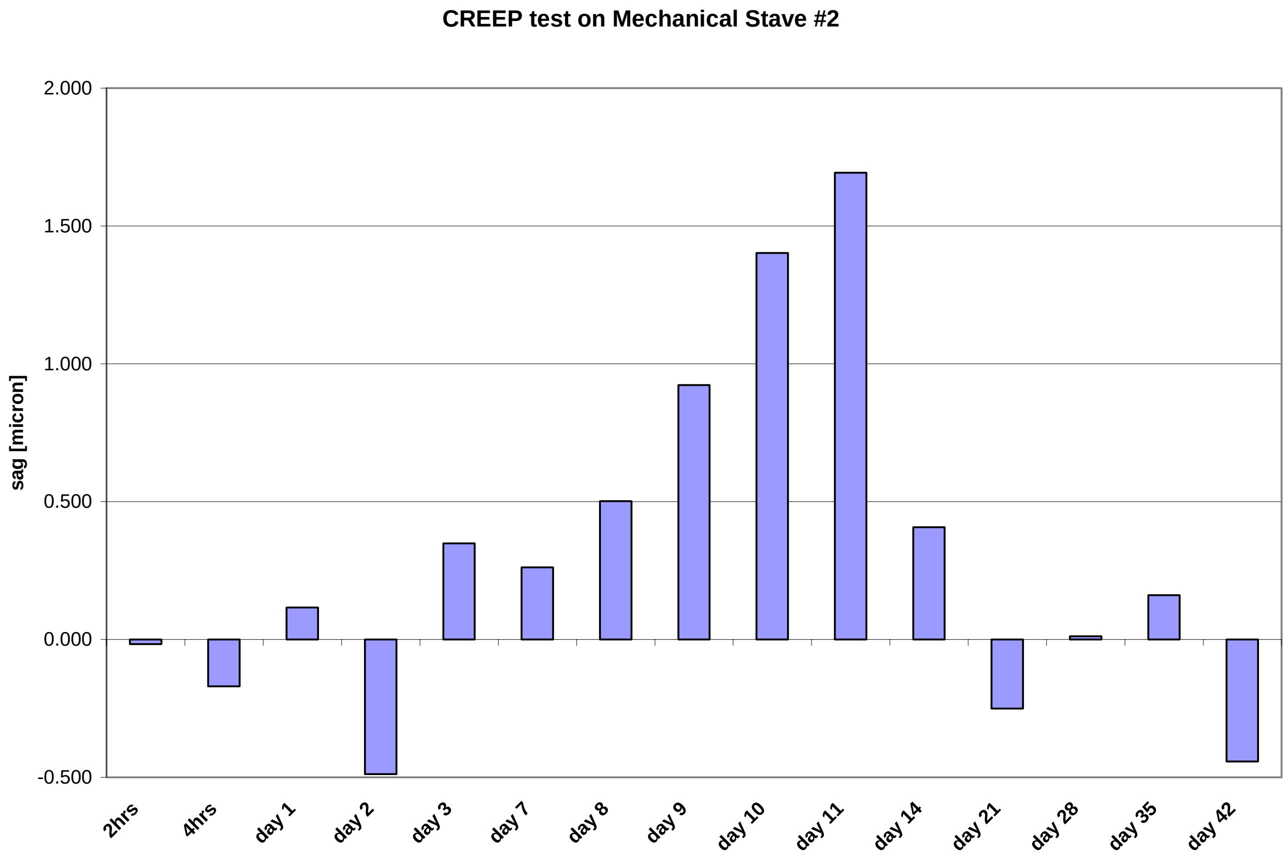

Figure 4 – Sag due to creep on the ***mechanical stave #2****. Strains are computed from the first day deflection profile; data have been fitted by a fourth order polynomial and the maximum deflection obtained from the interpolated curve has been charted versus time (days). The data seems to be dominated by measurement error and no creep behaviour is visible.*

3. Summary

The creep behaviour of the D0 RunIIb final design stave has been successfully tested. At room temperature, the stave response to the long term loading was good and it did not reveal any substantial creep mechanism. The result is even more encouraging if we think that the stave operating temperature will be -15°C and that the creep rate decreases exponentially with lower temperature.

It seems reasonable to consider the stave structurally stable over the period of time it will be in service for the design load and operating temperature.

4. Reference

1. G.Lanfranco, *Deflection Test Results on D0 RunIIb Stave,* Sept. 9th 2003, Fermilab technical memo TM-2300