LCLS-II SXU Lifetime Test

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Abstract

A lifetime test was performed on SXU-021. For the test, the gap was repeatedly cycled and was set 60,000 times in total. Many measurements were made during the test. This note summarizes the results of the measurements.

1 Introduction[1]

A lifetime test was performed on SXU-021. The gap was repeatedly cycled and set, and many measurements were made to look for changes over time. The results from the measurements are documented in this note.

The undulator was cycled in a manner which simulates the way the undulator is used in practice. The gap sequence used in the test is shown in figure 1. Each cycle consists of sub-cycles in which the gap is set 100 times. The cycle starts with three sub-cycles between 7.2 mm and 12 mm with 6 gap settings in each sub-cycle. The gap is set every 2 mm except for the 7.2 mm setting. After that, there are two sub-cycles between 7.2 mm and 18 mm with 12 gap settings in each sub-cycle. Then there is one sub-cycle between 7.2 mm and 24 mm with 18 gap settings, followed by one sub-cycle between 7.2 mm and 30 mm with 24 gap settings. Finally, the gap goes from 7.2 mm to 170 mm and back to 31 mm with 16 gap settings. The idea is that most of the gap settings in the tunnel will be at small gaps in the 7.2 mm to 22 mm operating range of the undulator, while occasionally going beyond this range and even fully opening to 170 mm as will be done for testing or to turn off an undulator. This sequence of sub-cycles was repeated 600 times for the test. In total, the gap was set 60,000 times. This corresponds in the tunnel to setting the gap 16 times a day for 10 years. We believe this is a significant fraction of the life of an SXR undulator.

During the 600 cycles, magnetic measurements were made after 60, 200, 350, 500, and 600 cycles. Touch probe measurements of the poles were made at the start and end of the test.

The result of the test is that no changes to the undulator were observed. In addition, no mechanical problems (such as making noise due to lubrication wearing off) were observed.

[1]Work supported in part by the DOE Contract DE-AC02-76SF00515. This work was performed in support of the LCLS project at SLAC.

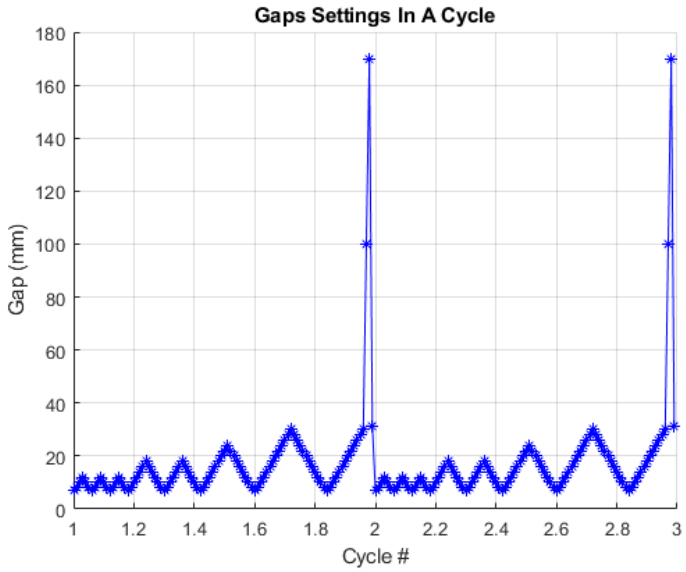

Figure 1: Two cycles of the sequence used to set the gap in the lifetime test.

2 Touch Probe Analysis

Touch probe measurements of the undulator poles were made at the start and at the end of the lifetime test. Figure 2 shows the difference in the measurements for all the undulator poles. There is a spread in the measurements of the gap change. There is no significant systematic gap change, however.

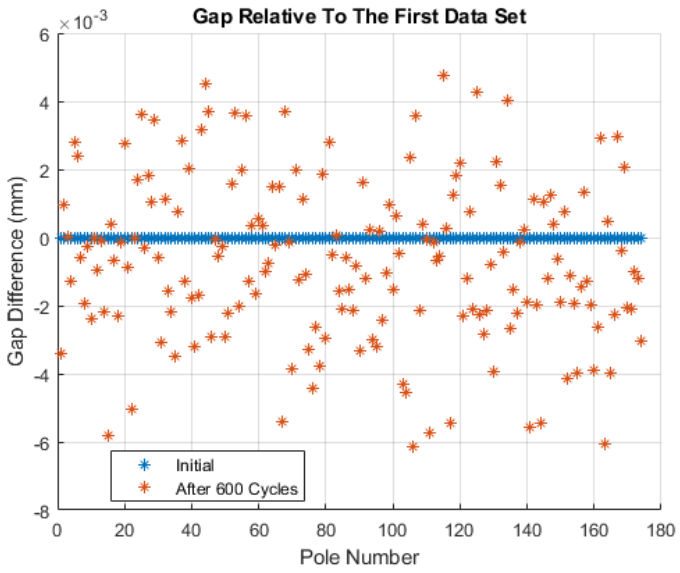

Figure 2: Difference in the undulator gap after the lifetime test compared to at the start of the lifetime test.

3 Magnetic Measurements

In order to look for local changes in the undulator field during the cycling, we compared the peak fields at 10 mm gap. Figure 3 shows the difference in the peak fields in the core of the undulator relative to the initial measurement. The difference is divided by the peak field value in order to get the normalized relative change. One can see that the gap is not set perfectly each time. There is a small taper and offset in each dataset giving relative field differences at the 10^{-4} level. We will see that this has an impact on the K value, but it is much less than the tolerance. Since the variations are smooth, we see from the figure that no pole or local set of poles has moved significantly during the lifetime test.

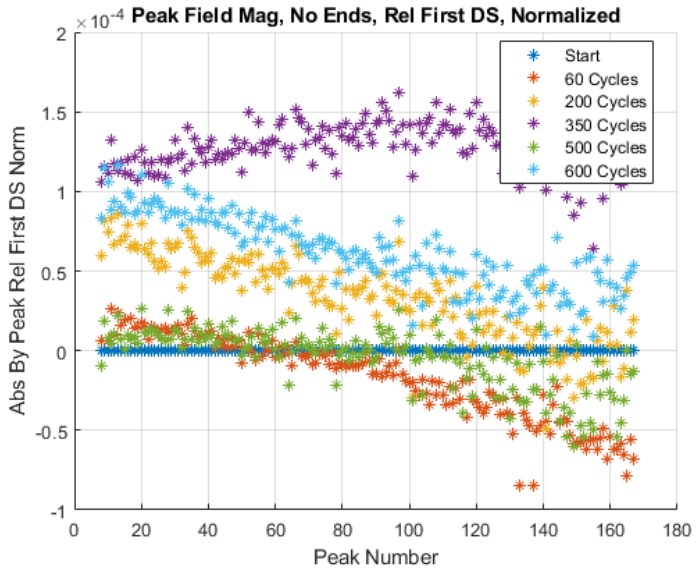

Figure 3: Change in peak field at 10 mm gap relative to the initial measurement. The change is divided by the peak field giving the normalized change.

The primary quantity of interest for the performance of the undulator is the K value. The measured K value relative to the initial measurements as a function of gap is plotted in figure 4. All values agree with the initial measurements well within the tolerance limit. The temperature of each measurement is shown in figure 5. The temperature varies by about 0.1 deg C between the measurements. When the K values are corrected to 20.0 deg C, we have the results shown in figure 6. All K values, except after 350 cycles, agree more closely after the temperature correction. All changes in K relative to the initial measurements are well within the tolerance limits.

The phase errors are sensitive to distortions of the gap (taper, bow, etc.). The phase errors are shown in figure 7. The phase errors are very stable, differing by fractions of a degree during the lifetime test. This indicates that the shape of the gap remained stable.

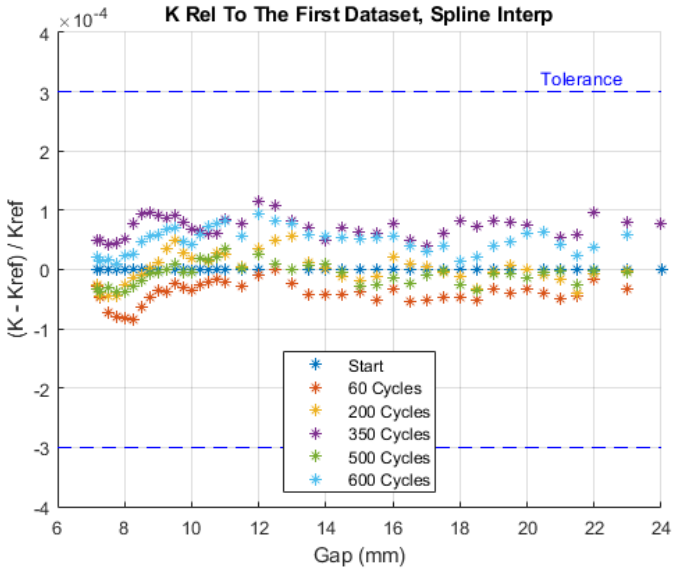

Figure 4: Measured K value as a function of gap.

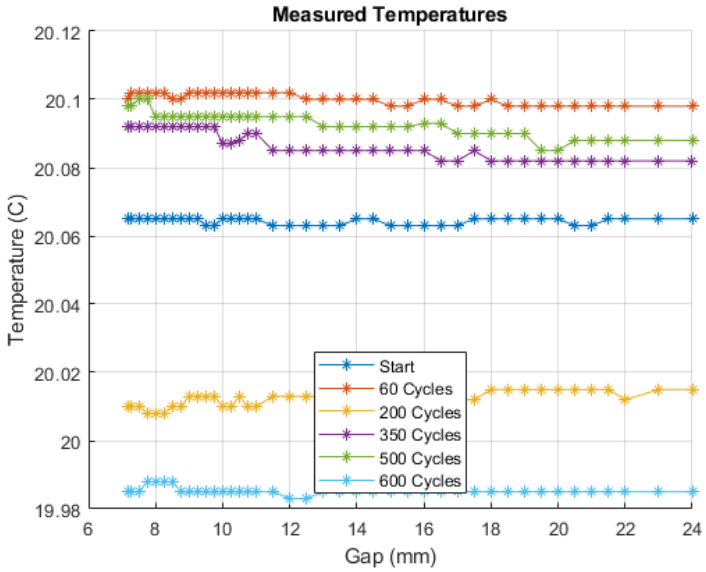

Figure 5: Measured undulator temperature during the magnetic measurements.

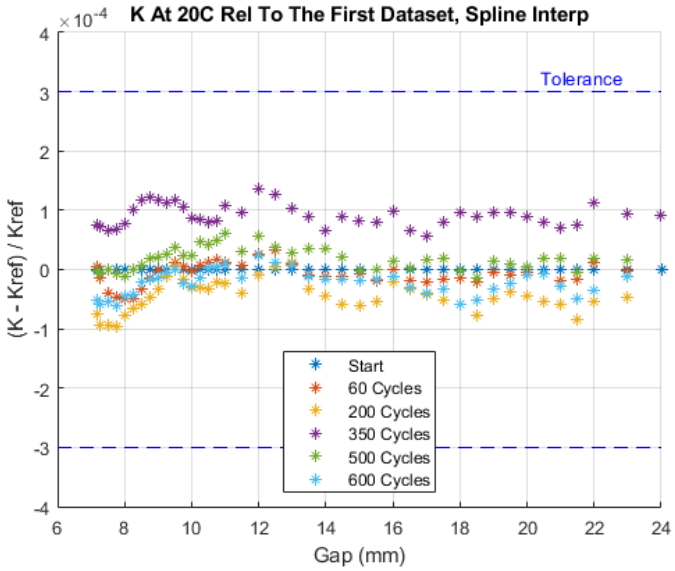

Figure 6: K values corrected to 20.0 deg C as a function of gap.

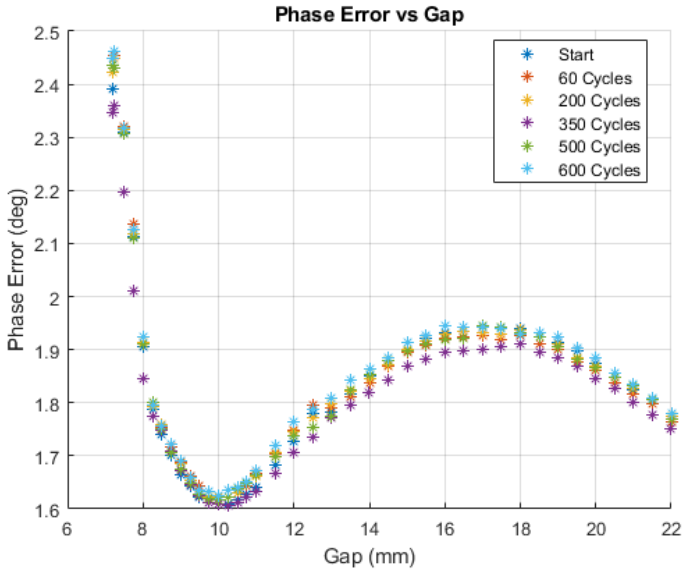

Figure 7: Phase errors as a function of gap.

4 Summary

A lifetime test was performed on SXU-021. The conclusion of the test is that the SXR undulators are stable with use. The gap of SXU-021 was cycled 600 times with 60,000 gap settings and there were no significant changes in the K value or phase errors. No mechanical problems were observed.

Acknowledgements

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