

First Wall Qualification Mockup (FWQM) Testing at Sandia

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- **Requirements for Testing**
- **Test Setup and Procedures**
- **Results from first round of testing**
- **Plans for round 2**
- **Summary**

Requirements for Testing FW Panels

- **Baseline design heat flux**
 - Normal Operation 0.25 MW/m² 400 sec, 20,000 cycles
 - Peak normal operation 0.5 MW/m² 400 sec, 10,000 cycles
 - MARFE conditions 1.4 MW/m², 10 sec, 1,000 cycles
- **Testing was required to demonstrate the cyclic thermal stress resistance of the Be tile to Cu alloy heat sink in the FW**
 - 12,000 cycles at 0.625 MW/m² (all of peak cycles plus 10% of half power cycles) 180 sec on and 60 sec off
 - 1,000 cycles at 1.75 MW/m² 10 sec on and 84 sec off
 - Heat flux multiplied by 1.25 for safety factor on normal conditions
- **FWQM testing qualifies the joining process in each party**
- **Semi-Prototypes will be tested to qualify manufacturing.**

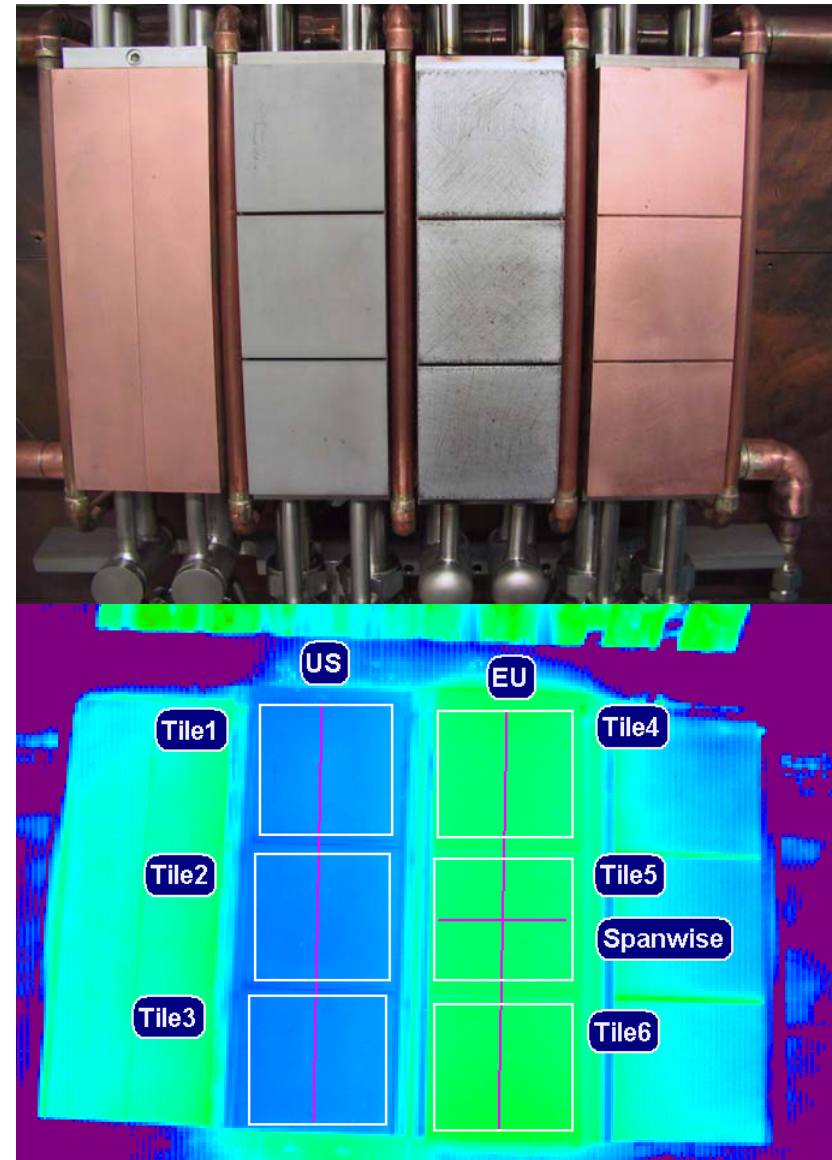
Test Conditions on US Facility

- Our electron beam can be magnetically switched between two samples for cyclic testing.
- Efficient switching requires equal on and off cycles
- Stress analysis was used to find heat flux and cycle time that
 - Matched the strain cycle during the ITER baseline requirements
 - Matched the operating temperature swing at the Be to Cu interface
 - Coolant flow was adjusted to simulate nuclear heating
- Resulting US test Conditions
 - 0.875 MW/m² for 48 sec on and 48 sec off with 1 m/s coolant flow
 - MARFE 1.4 MW/m² for 20 sec on 20 sec off with 4 m/s flow
 - Accuracy on heat flux +/- 5% required

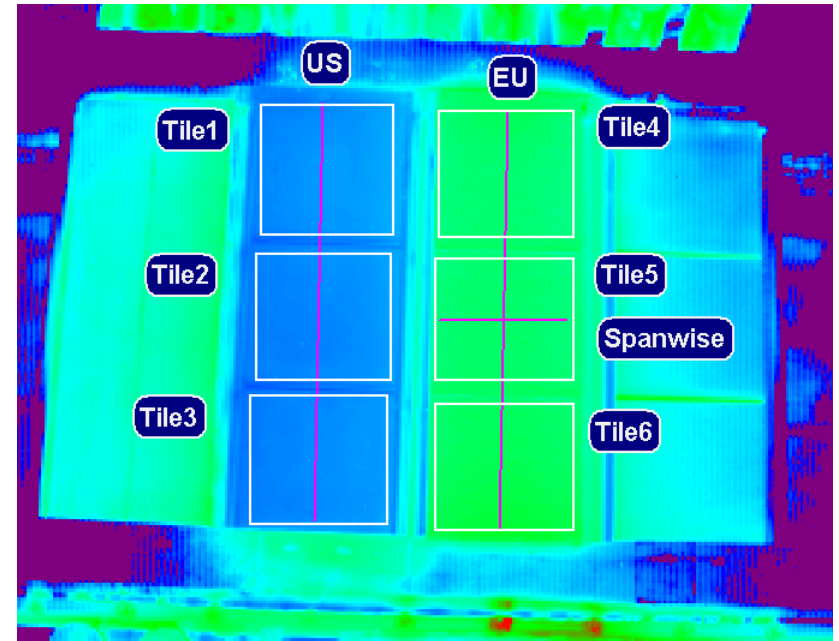
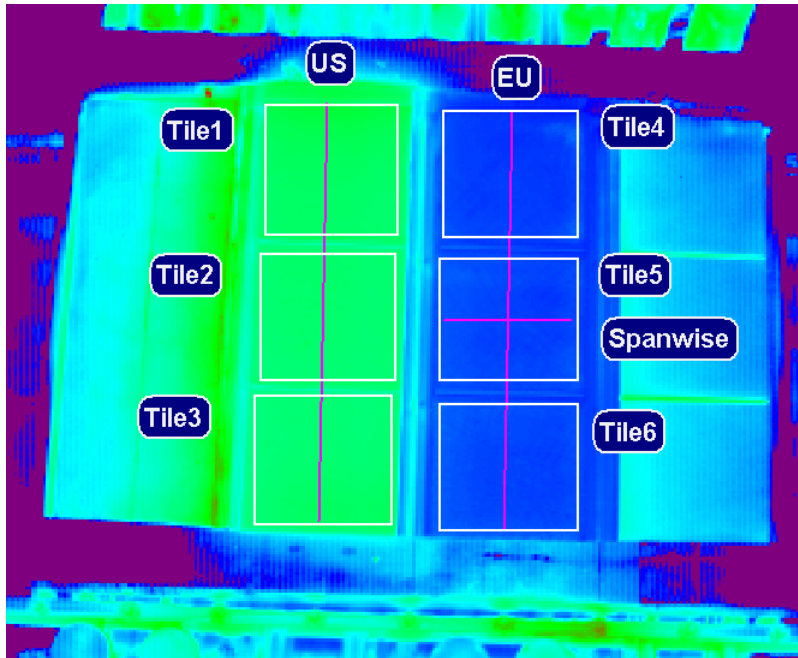
Test Setup and Procedures

- Only US and EU FWQM were available for the first set of tests
- Two copper mockups were used to fill the remaining spaces
- Our electron beam (40kV, ~0.5 A) is magnetically swept over each target.
- The sweep pattern is switched from one FWQM to the other
- Emissivity is calibrated by applying heat without cooling (constant T)
- Absorbed power is calibrated with long pulses (~300 s) with higher coolant flow

US EU



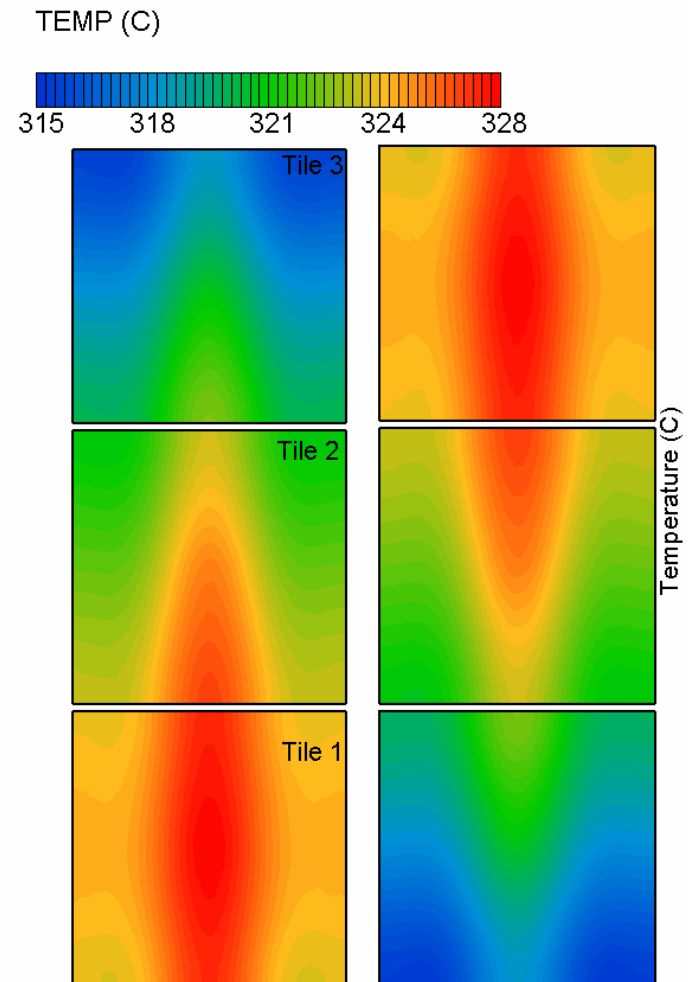
IR Camera Images



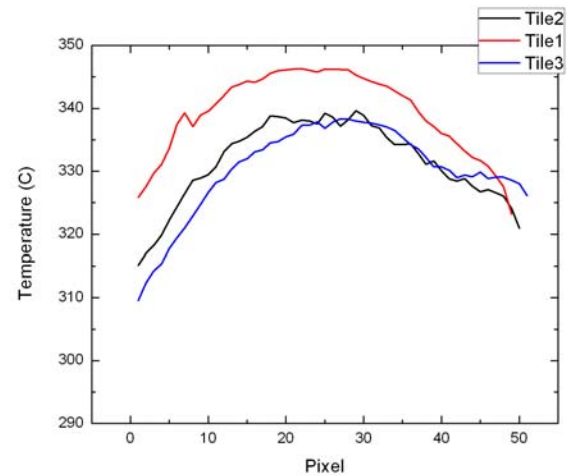
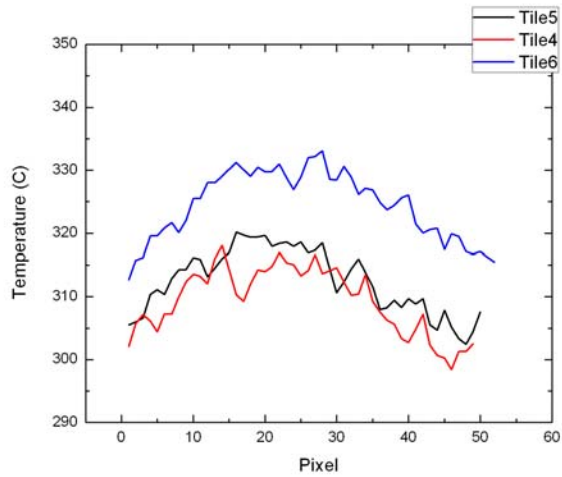
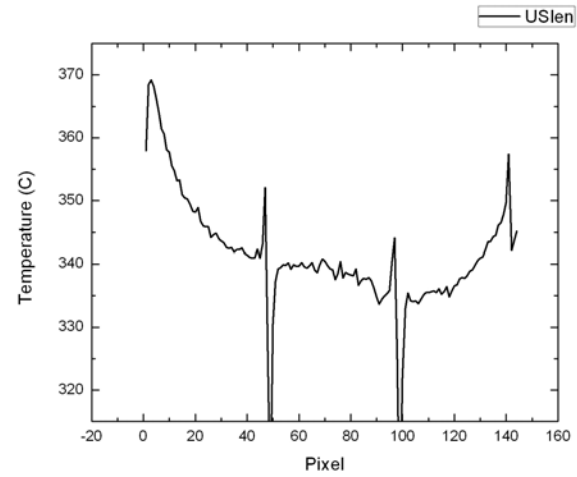
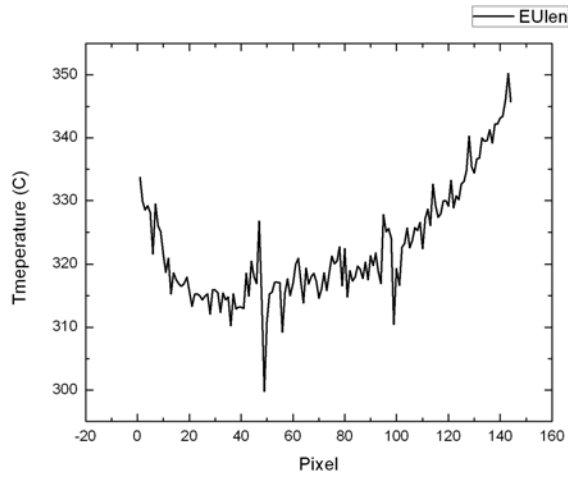
These images also identify the tiles that are shown in the beam power uniformity slides later.

Heat Flux Uniformity

- The beam sweep pattern on each FWQM was adjusted during absorbed power calibration to achieve a uniform temperature ($\pm 5\%$) across the tiles
- The temperature along the length of a mockup is calculated to rise ~ 20 C with 0.875 MW/m². This was matched to within 5%.
- The sweep pattern is saved for use during the cyclic testing.

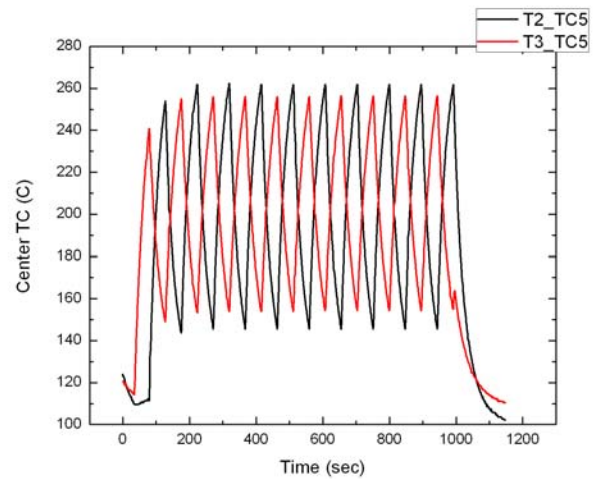
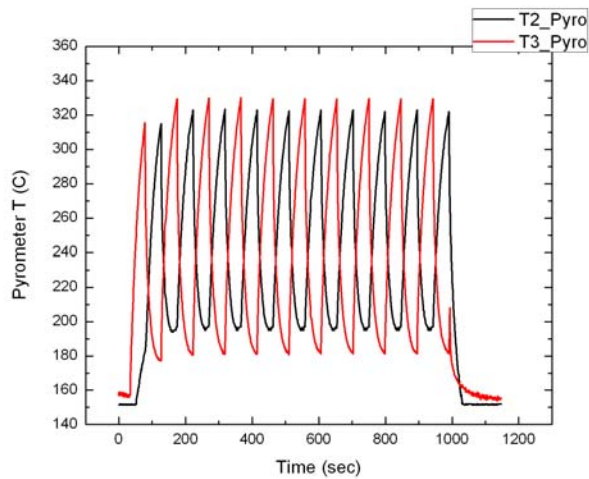
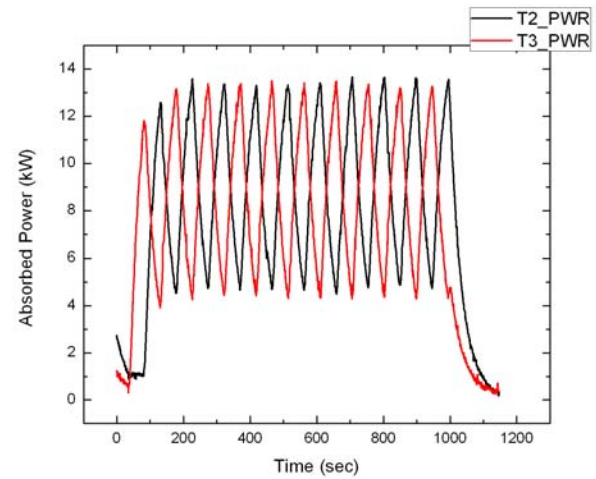
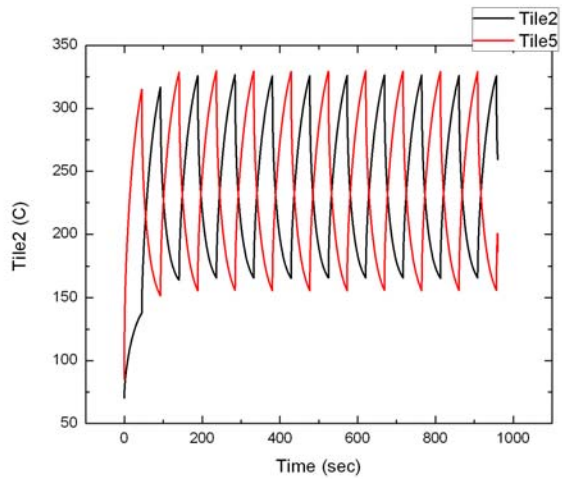


Temperature Profiles During Power Cal.

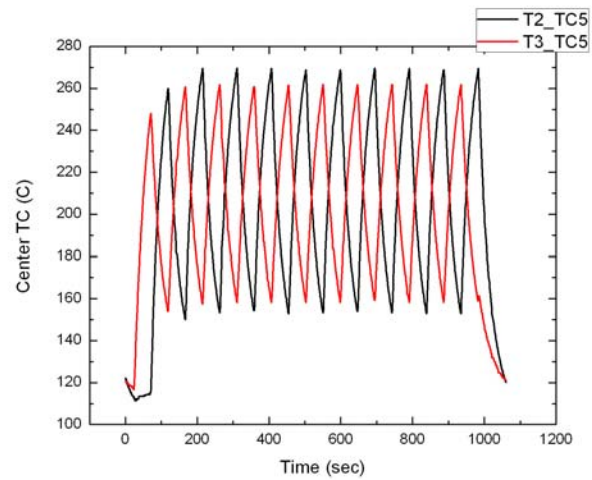
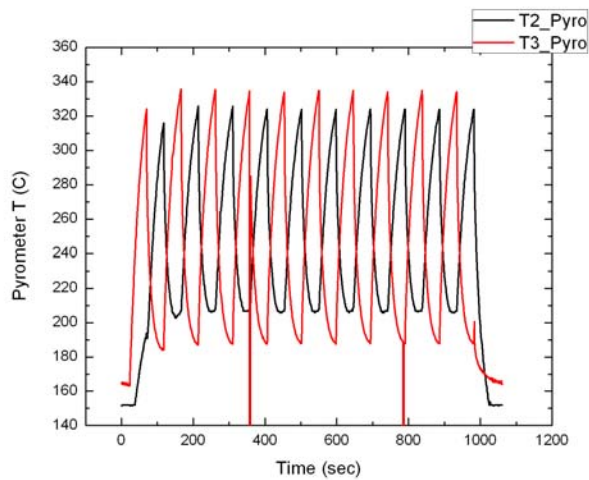
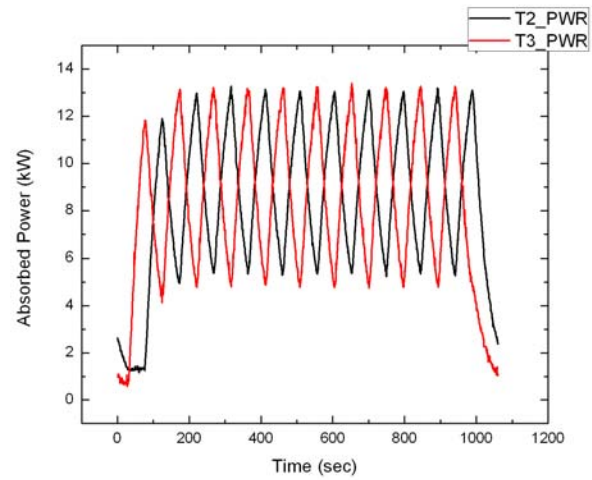
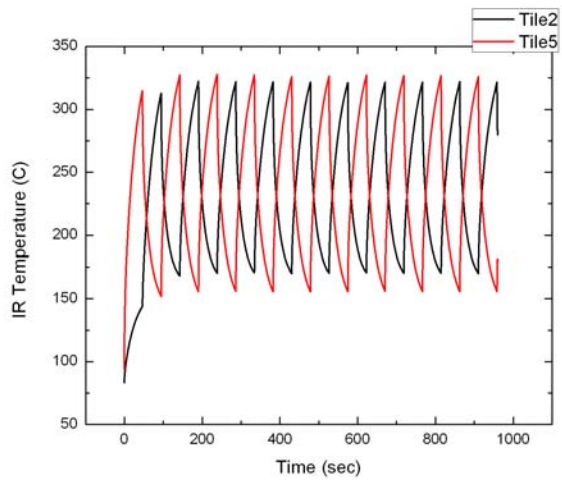


Examples of Data From Testing

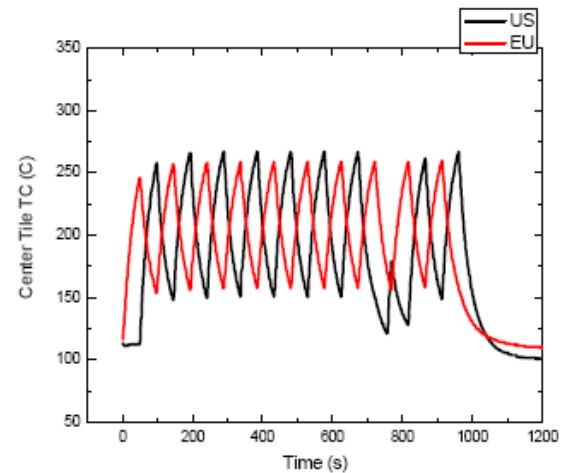
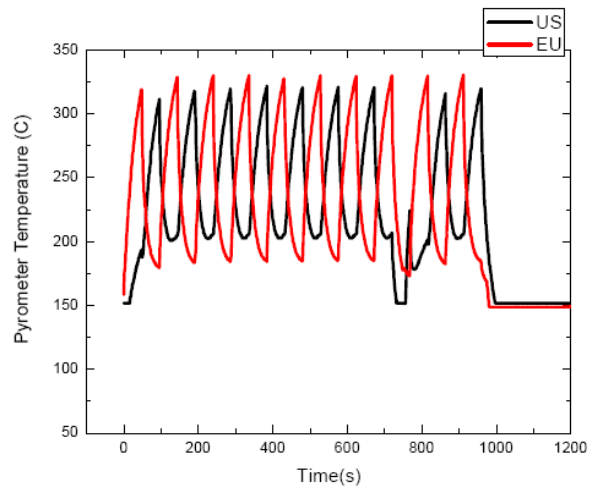
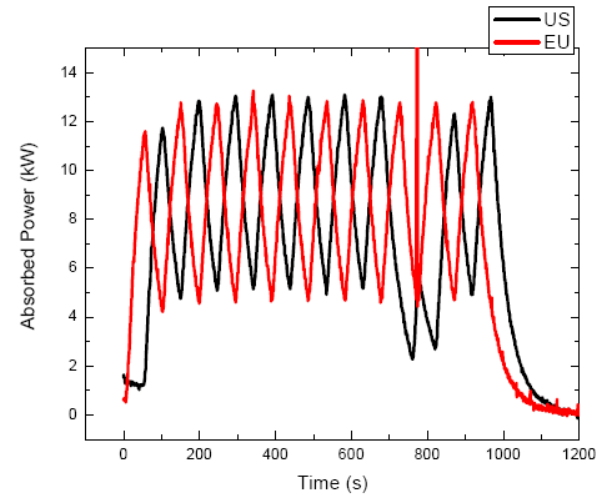
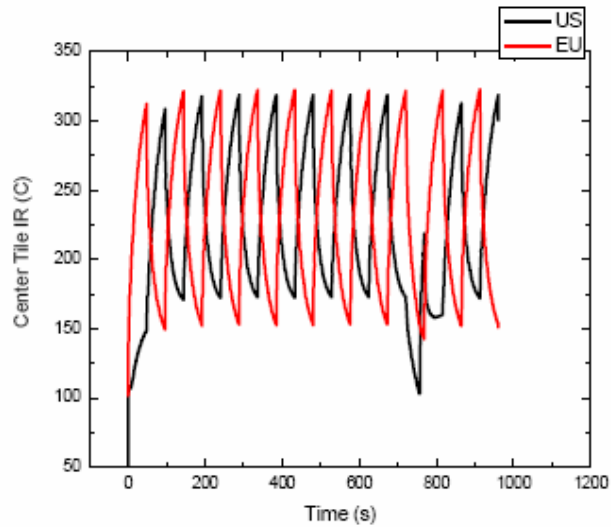
Cycle 1003



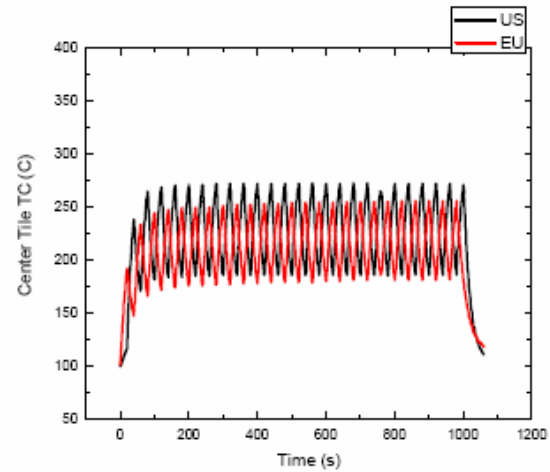
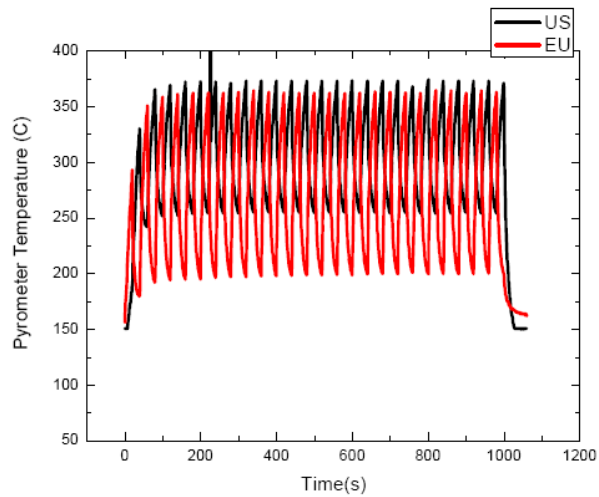
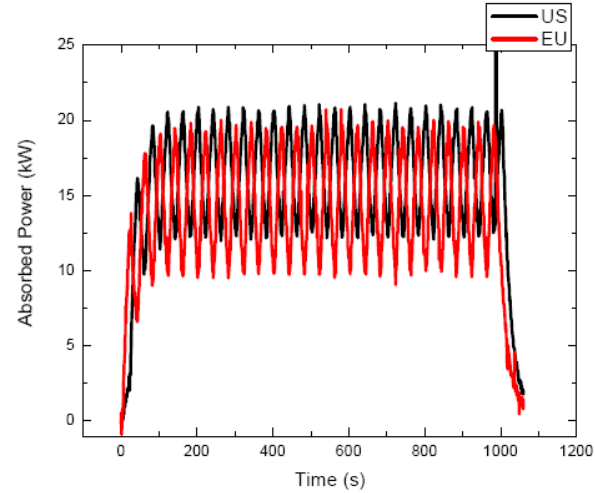
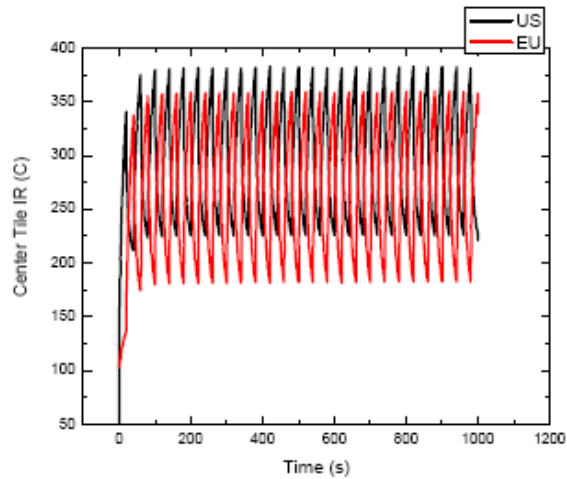
Cycle 6000



Cycle 12,000



End of MARFE Testing



Testing Results

- **The first phase of testing (12,000 cycles at 0.875 MW/m² and 1,000 cycles at 1.4 MW/m²) was completed on July 17, 2008.**
- **Neither the EU nor the US FWQM showed any signs of tile failure.**
- **Both FWQM passed the required test.**
- **Both the US and EU have completed one of the two required tests.**
- **The second test is underway on a radiant heat facility in the Czech Republic (over 7,000 cycles)**

Plans for the Second Round of Testing

- **The second round of FWQM testing in the US will have four FWQM (China, Japan, Korea, and Russia)**
- **We will use both e-guns for this test.**
- **The Chinese mockup will not arrive until mid-October 2008**
- **Testing will start about the beginning of November and end in late February or early March 2009.**

Summary

- **Round 1 of FWQM testing has been completed at Sandia**
- **All of the ITER requirements were met**
- **Both the EU and US FWQM passed the test**
- **The second part of the testing is about half completed at the EU test facility**
- **A second round of testing will start in November 2008 with four mockups**
- **First Wall Qualification will be completed by Spring 2009**