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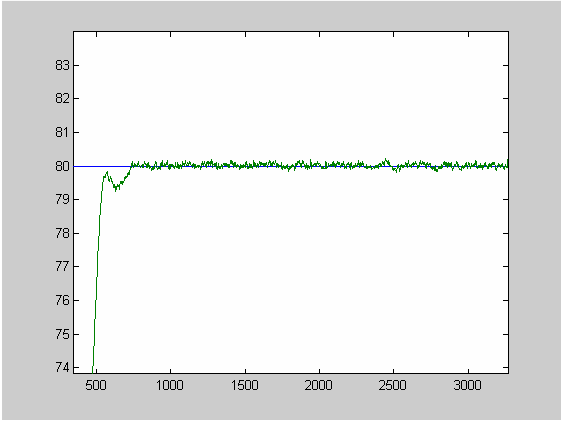
Product Group:	Digestion
Product:	BDS - Seal
Section:	Service & Technical
Type:	Reference Papers
Valid Until:	Always

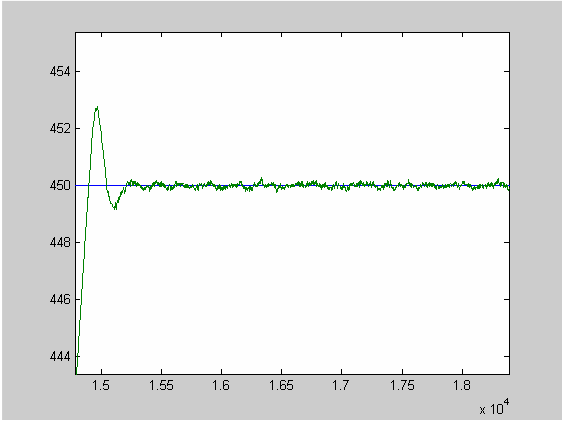
Subject:	Temperature Accuracy and Precision of the BD50s Block Digestion System

The following data shows the accuracy and precision of the BD50s Block Digestion System across its operating temperature range (ambient to 450 °C). The temperature specification for the BD50s is to maintain a consistent temperature across the block (within +/- 2 °C). Note the performance of the block has been optimised for the situation when it is fully loaded with a full set of digestion tubes and samples. It will perform slightly differently when not loaded with any digestion tubes due to the difference in thermal mass.

1. Temperature Precision at Different Temperatures



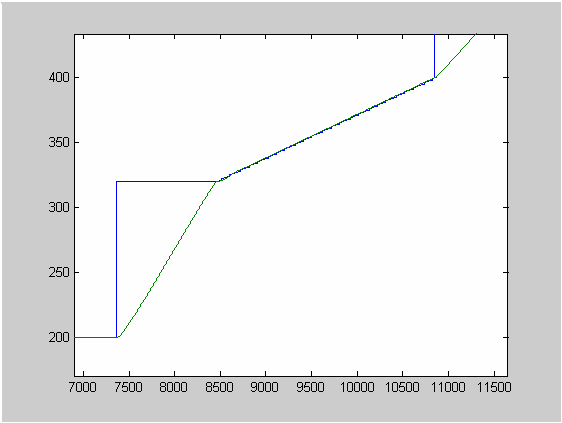
The above graphs shows heating a fully loaded block to 80°C. The block very quickly heats to 79.5°C and then takes a few minutes to reach final temperature. Once the block reaches the setpoint temperature, it maintains it within +/- 0.2°C.

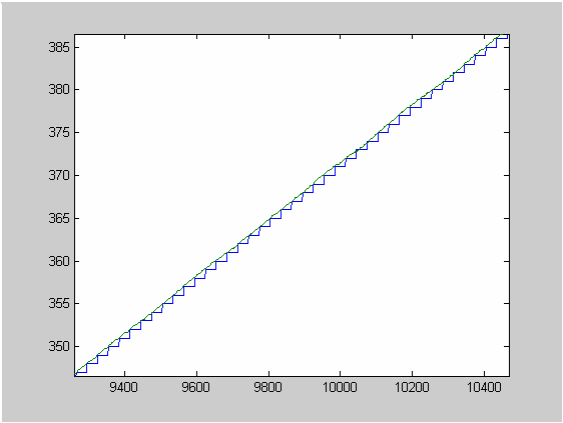


Heating an unloaded block to 450°C shows a similar performance though in this case there is an overshoot in the setpoint temperature of the block caused by reduced thermal mass of not having digestion tubes in place. As above, once the block reaches the setpoint temperature, it maintains the setpoint temperature within +/-0.2°C.

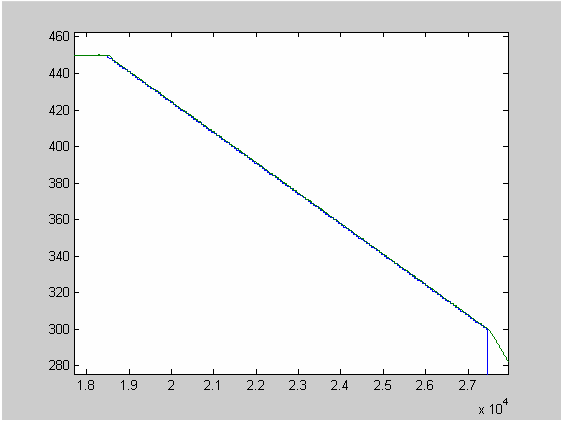
2. Precision of Temperature Ramping

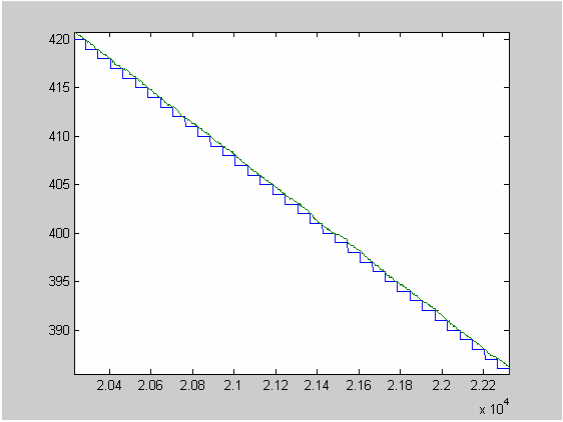
Positive Ramp at 5 degrees per minute.





Negative Ramp at 1 degree per minute.





The results from testing show that the control system controls the block temperature to within +/- 0.2°C. This is a full order of magnitude better than the specified +/- 2°C.

Rise time is as fast as allowed by the thermal mass of the BD50s block, and is much faster than the BD50 Block Digestion System, which used a gain scheduling approach to reduce power as the block reaches a set point. There was no significant phase-delay measured in the ramp rates.

3. Accuracy of Block Temperature

3.1 Calibration Accuracy

Using the thermocouple simulator the block was calibrated for 2 points (user calibration) and 5 points (factory calibration).

The calibration values were:

Number of Points	Gain	Offset
2	0.6788	-121.56
5	0.6766	-120.715

After calibration, the full range of temperature from 0 to 400°C was reported correctly to +/- 1°C, regardless of the number of calibration points. The readings did not drift over a test period of 24 hours.

3.2 Absolute Accuracy

In section 1, it has been shown that the control accuracy is to within 0.2°C. However this assumes the thermocouple is measuring the actual block temperature. To check the thermocouple reading against the actual block temperature, several vial reservoirs were coated in heat-sink compound, and a welded tip thermocouple was inserted into the heat-sink. The block was heated to certain temperatures according to the thermocouple and soaked for 20 minutes. The actual block temperature was measured as an average across 5 tubes spread across the block surface.

Controller Temperature Reading	Average Block Temperature
22 degrees	22.7 degrees
80 degrees	79.2 degrees
200 degrees	200.6 degrees

These readings show the measured temperature matches the actual block temperature to within 1° C.

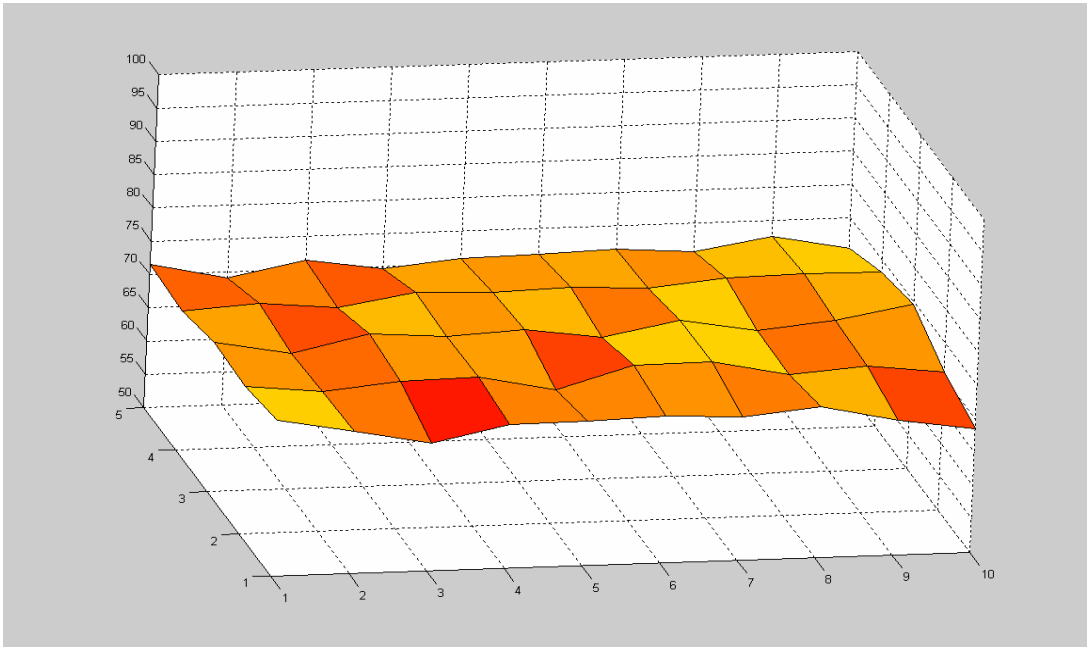
It should be noted that these measurements are an average of 5 vial positions. All positions were within 2°C of each other. Also the measurements were made near the bottom of the vials (1/3rd from the bottom), the temperatures at the top of the vials are typically 1-2°C cooler. Therefore the specified +/- 2°C has been achieved, but will depend greatly on where and how the block is measured.

4. Sample Temperature

A BD50s Block Digestion System was fully loaded with 50 digestion tubes of water. The tubes were surrounded with a draft shield and the block was heated to 80°C. When the block reached 80°C, the water samples had only reached a temperature of 41°C, indicating the delay in heat transfer from block to sample.

The BD50s block was allowed to soak at 80°C degrees for 1 hour. After this time, the temperature of the samples had essentially equilibrated. The average water temperature was 71.7°C.

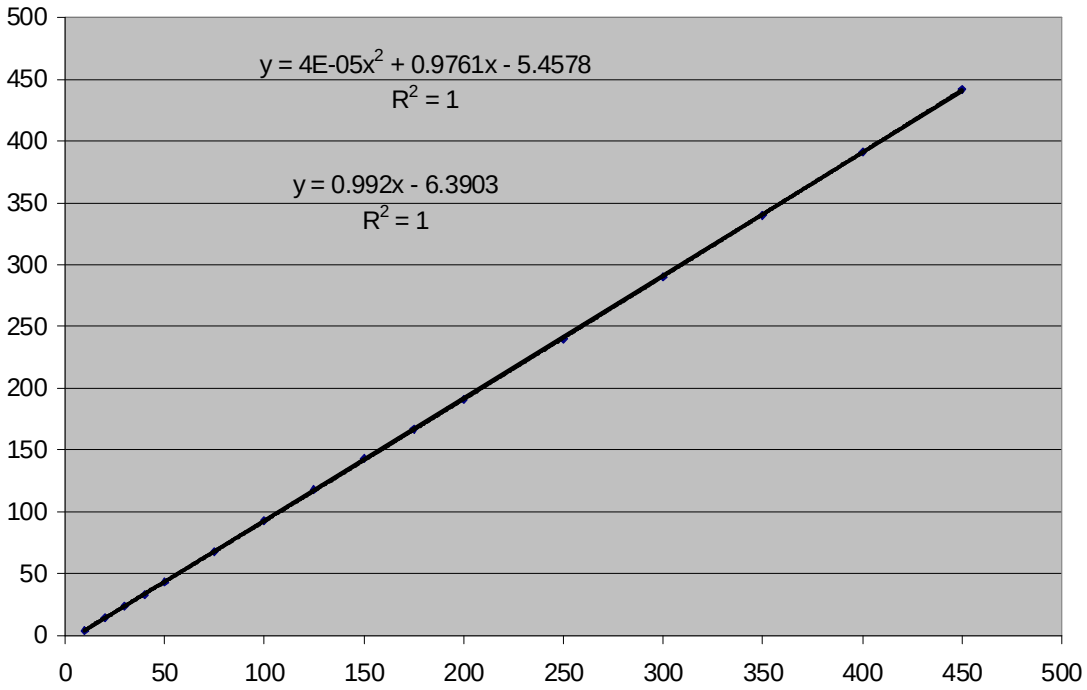
The hottest measurement was 74.6°C and the lowest was 68.5°C with a std dev of 1.25°C. The distribution of temperature is shown on the surface plot below…



This plot shows the temperature of each sample versus its position in the block and shows there are no localised hot or cold spots.

5. Temperature Linearity

The design of the BD50s includes a thermocouple transmitter that performs some electrical linearization on the thermocouple signal. The firmware can then scale and shift this linear signal into an accurate temperature reading.



The graph shows the actual block temperature versus temperature reported by the controller.

The results show the output of the transmitter is very linear across the operating range of the block and requires zero/gain compensation (linear).

6. Summary

The BD50s controller is capable of controlling the temperature of the BD50s block to within 0.2°C.

The variation in temperature across the BD50s block at a specific temperature is within +/- 1°C.

The BD50s block is linear in temperature acorss the range of ambient to 450°C.

For technical assistance contact your service distributor or Aim Lab at support@aimlab.com or phone +61 7 3105 5002.
For sales assistance contact Aim Lab at aimlab@aimlab.com or phone +61 7 3105 5005.