EXPERIMENTAL STUDY OF THE TEMPERATURE PROFILE OF A GAUSSIAN TYPE HEAT DISTRIBUTION

A Paper
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

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In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Program:
Industrial Engineering & Management

April 2020

Fargo, North Dakota

North Dakota State University
Graduate School

Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

In research aimed at studying the laser microwelding of thermoplastic materials, two theoretical heat flow models were studied by Dr. Grewell. In the surface temperature profile based on the Gaussian type distributed heat source model, two peak temperatures were predicted.

The purpose of the current project was to develop a controlled test environment to study the surface temperature profile of a thermoplastic material using a Gaussian type heat source and to validate the prediction of the inflection point in the plastic sample.

One of the key results of the initial experimentation was the lack of a Gaussian distribution of the infrared lamp used as a heat source. This limitation was addressed by first employing a thermal camera and then later a laser system. The observation of two peak temperatures was not substantiated with the experimentations conducted in this study.

ACKNOWLEDGEMENTS

I would like to thank my wife, Katie, for standing beside me every step of this journey, for her unwavering support and for loving me and believing in me.

I also want to give thanks to Dr. David Grewell for helping me develop this project. His help and guidance were integral to my success.

A very special thanks to Dr. Chrysafis Vogiatzis for his involvement during crucial times. His choice to invest in me and care even while being away was invaluable to me.

I also want to thank Dr. Jordi Estevadeordal and Al Habib for their assistance with the experimentation set up and the use of laser system. Their expertise and input while conducting experiments helped me significantly.

I also would like to thank Emma Anderson and Timothy Straus for partnering with me and helping run the experiments.

I would also like to thank Dr. Paulo Flores and Austin Eide for their generosity in sharing the thermal camera and for being flexible and accommodating with their schedules.

DEDICATION

To my loving wife Katie

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CJC.....Cold Junction Compensation.

IR.....Infrared.

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1. INTRODUCTION

1.1. Literature Review

In 2002, Grewell studied the laser microwelding of polystyrene and polycarbonate materials. In this study, two theoretical heat flow models were used to analyze the temperature distribution. The two models were Rosenthal's point heat source model (Rosenthal, 1946) and the Gaussian distributed heat source model. It was observed that at relatively low travel speeds of the laser beam the predicted temperature distributions of both the models were comparable. However, at higher travel speeds of the laser beam the two models were significantly different.

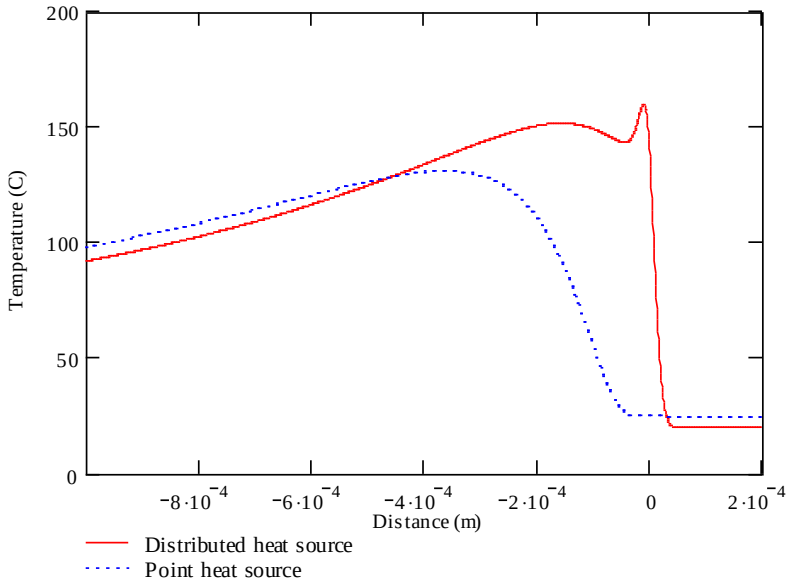

Figure 1.1. Predicted Surface Temperature at Higher Travel Speeds (Grewell, 2002)

One of the key findings in this study was that at relatively high travel speeds (>100 mm/s) of the laser beam, the distributed heat source model predicted a location within the plastic that experienced two peak temperatures, see Figure 1.1. It was believed that the initial peak was caused by the direct heating from the heat source and that the second peak was caused by heat conduction from the center of the heat source.

To further test this observation an FEA model was simulated in the study. The generated FEA model also predicted the similar result of two peak temperatures with slight variability in the peak temperature values. See figure 1.2.

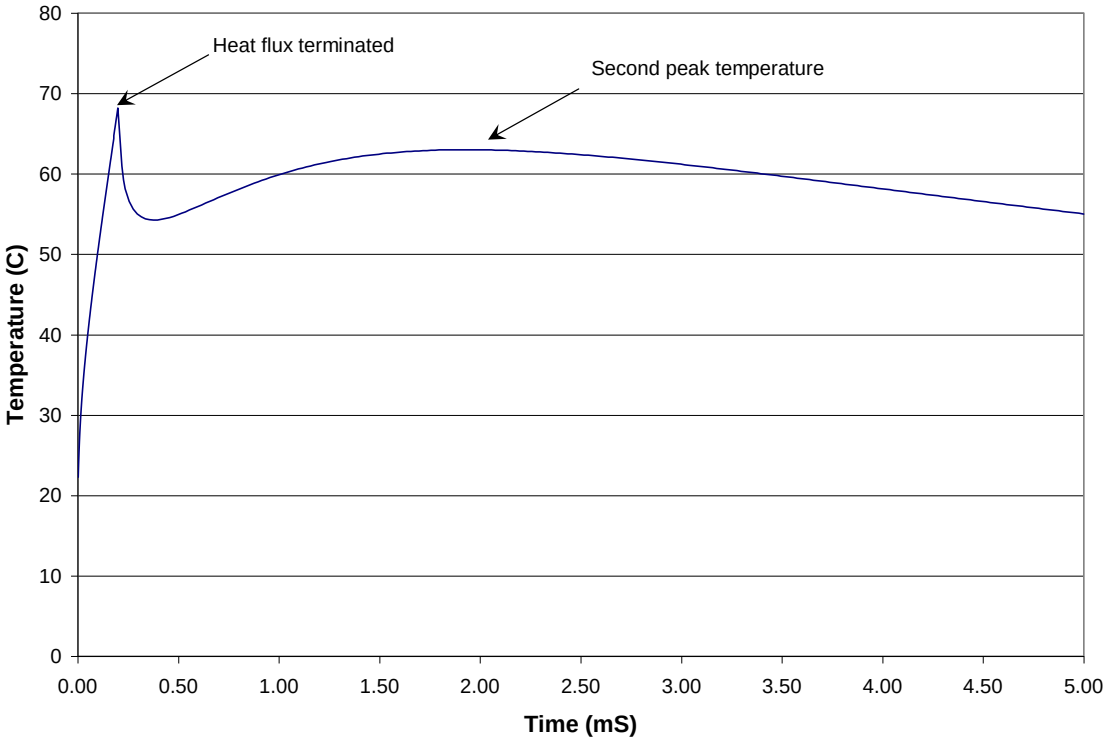

Figure 1.2. FEA Predicted Temperature History for 2-D Model with Gaussian Heat Flux (Grewell, 2002)

It was noted that the results from the FEA model did not provide sufficient data to substantiate the prediction of dual peak temperatures. Further experimental studies were recommended to collect data and corroborate the prediction.

1.2. Objective

The objective of this work was to develop an experimental setup to help facilitate the study of the surface temperature profile of a thermoplastic material when heated using a Gaussian distributed heat source. The other objective was to utilize the developed experimental

test setup to collect data to substantiate the observation of two peak temperatures in the plastic sample.

The experimental test setup consisted of:

- Thermoplastic test samples
- Gaussian type heat source
- Temperature measuring instrument
- Data acquisition system
- Data processing system

The experimental procedure involved heating the test sample with the heat source for a determined amount of time. Using thermocouples (initial experiments) and a data acquisition system, the surface temperatures of the sample were recorded during the course of heating and cooling. The collected data was later processed using a data processing system.

During the initial experiments, limitations of certain components were observed. To address these limitations further research was conducted, and suitable alternative components were acquired. The following section details the limitations and the modifications made to improve the experimental setup during the course of experimentation.

2. EXPERIMENTAL PROCEDURES

The initial setup consisted of polycarbonate test samples, an infrared lamp (Smith-Victor TL2), thermocouples for measuring the surface temperature, and a data acquisition system connected to a laptop via ethernet. The data was processed using Microsoft Excel.

The initial data collected using the thermocouples was not accurate because of poor surface contact with the test sample. This limitation was rectified by melting the thermocouples in place with a soldering iron. This modification ensured good surface contact of the thermocouples with the test surface.

The infrared lamp had a relatively slow response time to reach its full intensity. This greatly reduced the heating time in which the experiment result required a pulse heat input. To rectify this limitation, a shutter system was designed and implemented. The shutter system consisted of a metal sheet connected to a stepper motor which allowed the sheet to be rotated exposing the opening of the lamp. The stepper motor was controlled using a microcontroller which facilitated the regulation of the time of exposure. Implementing the shutter system allowed the lamp to be turned on and reach its full intensity before exposing the test surface to the lamp.

In addition, the infrared lamp did not have a power regulation switch which limited the control of the heat intensity of the lamp. This was rectified by utilizing a potentiometer to control the power (intensity) of the lamp.

The heat distribution of the infrared lamp was not focused which led to a larger heated zone on the test sample. To rectify this limitation an aperture was developed to reduce the size of the focal spot size. The aperture consisted of a metal sheet with holes of varying diameters. It was further found that the heat distribution was not Gaussian and had a distribution similar to the

geometry of the filament of the lamp (this was confirmed in later experiments using an infrared thermal camera, see appendix for results). Thus, the IR lamp experimental setup was abandoned.

The second experimental setup employed a laser system instead of an infrared lamp which allowed the heat source to be precisely focused and pulsed. Initially the temperature measuring system (thermocouples) and the data acquisition system were the same systems employed in the first setup. The data was also processed using the same data processing tool.

Because of the intensity of the laser system the test zone surface melted which resulted in the thermocouples detaching from the test surface during experimentation. This was rectified by employing a thermal camera to measure the surface temperature of the test samples as well as reducing the pulse duration of the laser.

Thus, the final experimental setup consisted of a thermal camera (ICI 9640 P-Series) and a laser system. The recorded data was then processed using the MATLAB software. The required MATLAB code was developed to process the data. A series of experiments were conducted using the third experimental setup.

The details and results of all the experimental setups are discussed in the following sections.

2.1. Test Samples

Two sheets of dimensions 6” x 6” x 1/2” and 12” x 12” x 1/2” of polycarbonate material were acquired for experimental testing. Polycarbonate material was selected to match the sample material similar to the material used in the TTIr micro welding research but with a higher melt temperature to prevent the effects of phase changes in the heat flow.

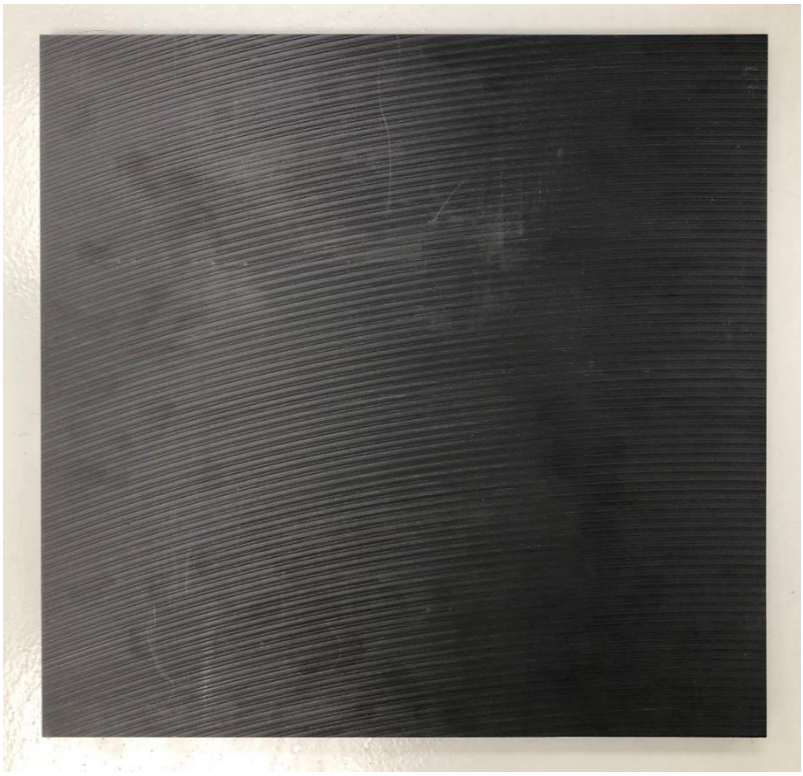

Figure 2.1. Photograph of Polycarbonate Test Sample
Figure Note: The Circular Pattern on the Sample Surface is the Machining Tool Marks Generated During Production

Table 1. Mechanical and Thermal Properties of Polycarbonate Material

Property	Value
Trade name	McMASTER-CARR
Temperature range	-40ºF to 180ºF
Tensile strength	9100-9500psi
Impact strength	2ft.-lbs./in.
Hardness	Rockwell M70
Specifications met	UL 94HB

2.2. Experimental Setup 1

2.2.1. Heat Source

2.2.1.1. Infrared lamp

The IR lamp was:

- Trade name: Smith-Victor

- Model: TL2

Figure 2.2. Photograph of Infrared Lamp

2.2.1.2. Potentiometer

A potentiometer was acquired to help modulate the light intensity of the lamp.

Figure 2.3. Photograph of Dimmer Switch

2.2.2. Data Acquisition System

The data acquisition system for measuring thermocouple measurements specifications were:

- Trade name: OMEGA
- Model: OM-NET-TC
- Software: TracerDAQ
- Eight 24-bit differential thermocouple inputs with thermocouple channel-to-host isolation
- 4 samples/sec channel maximum sample rate
- 2 integrated cold junction compensation (CJC) sensors
- Open thermocouple detection
- 8 digital I/O isolated from thermocouple inputs and host
- 10/100 ethernet interface
- Digital outputs have ±24 mA drive capability and are configurable as thermocouple alarms

Figure 2.4. Photograph of Data Acquisition System

2.2.3. Thermocouple System

A thermocouple system was assembled to measure the surface temperature of the test sample. The assembled system was comprised of K type thermocouples and connectors which were placed at the measurement points on the test sample surface.

2.2.3.1. First part: large gauge insulated thermocouple wire

- Trade name: OMEGA
- Model: TT-K-24-25
- Gauge: 24 AWG
- Type: K

Figure 2.5. Photograph of 24 AWG Insulated Thermocouple Wire

2.2.3.2. Second part: high temperature miniature connectors

- Trade name: OMEGA
- Male connector: HFMPW-K-M
- Female connector: HFMPW-K-F
- Calibration: Type K

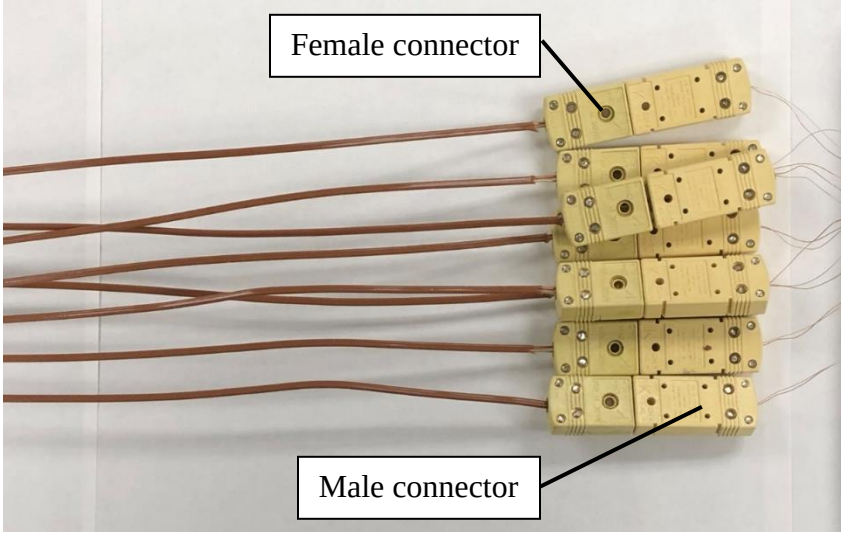

Figure 2.6. Photograph of Connectors

2.2.3.3. Third part: fine gauge insulated thermocouple wire

- Trade name: OMEGA
- Model: TFCY-005-100 / TFAL-005-100
- Diameter: 0.005”
- Type: K

Figure 2.7. Photograph of Fine Gauge Insulated Thermocouple Wire

2.2.4. Experimental Setup

In the initial experimental setup TracerDAQ software was used to record the temperature data. One end of each thermocouple was melted in place with a soldering iron at eight measurement points on the test sample surface. The heat source was focused at the first measurement point. The data acquisition system recorded data at the rate of 4 samples/sec for each of the eight thermocouple channels. The data was saved in Microsoft Excel CSV format. The temperature measurements were recorded in ^{o}F.

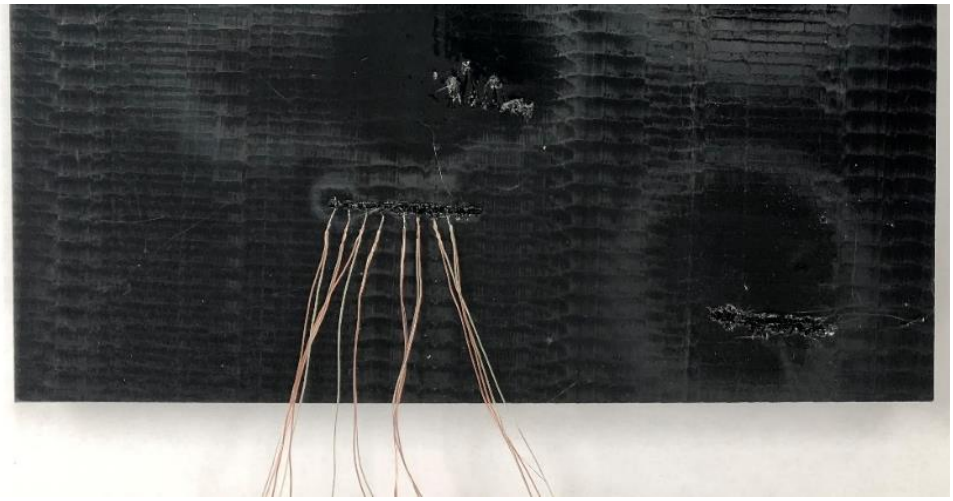

Figure 2.8. Photograph of Thermocouples Placed 3mm Apart

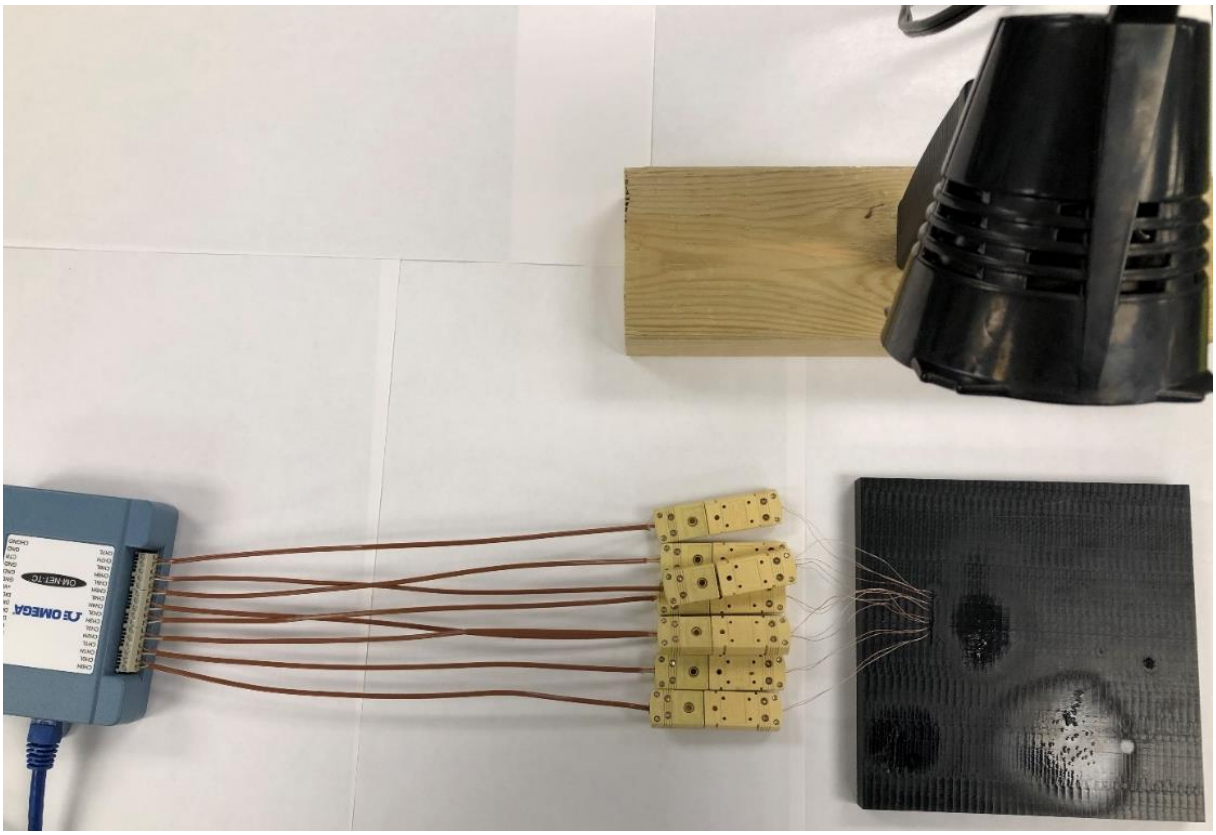

Figure 2.9. Photograph of Experimental Setup 1

2.2.5. Experimental Procedure and Parameters

The heat source was turned on until the desired temperature was observed at the first measurement point and then the heat source was turned off. The data at each temperature measurement point was recorded during this procedure and later was processed in Microsoft Excel. During experimentation, the effects of the following parameters were studied.

- Temperature at each measurement point
- Duration of heat source exposure (5s, 120s)
- Intensity of heat source (450W, 600W)

2.3. Experimental Setup 2

2.3.1. Heat Source

The details of the laser used in later experiments were:

- Trade name: Quantel laser
- Model: CFR
- Type: Nd:YAG laser
- Peak wavelength: 1064 nm
- Frequency: 15 Hz
- Maximum energy: 100 mJ
- Pulse duration: <13 ns
- Power supply: ICE 450

Figure 2.10. Photograph of Laser System

2.3.2. Experimental Setup

The second set of experiments had the same thermocouple setup however a laser system was used as a heat source. The data in this setup was recorded using the TracerDAQ software and the same data acquisition system used in setup 1. The temperature measurements were recorded in ^{o}F. The data was recorded in Microsoft Excel CSV format.

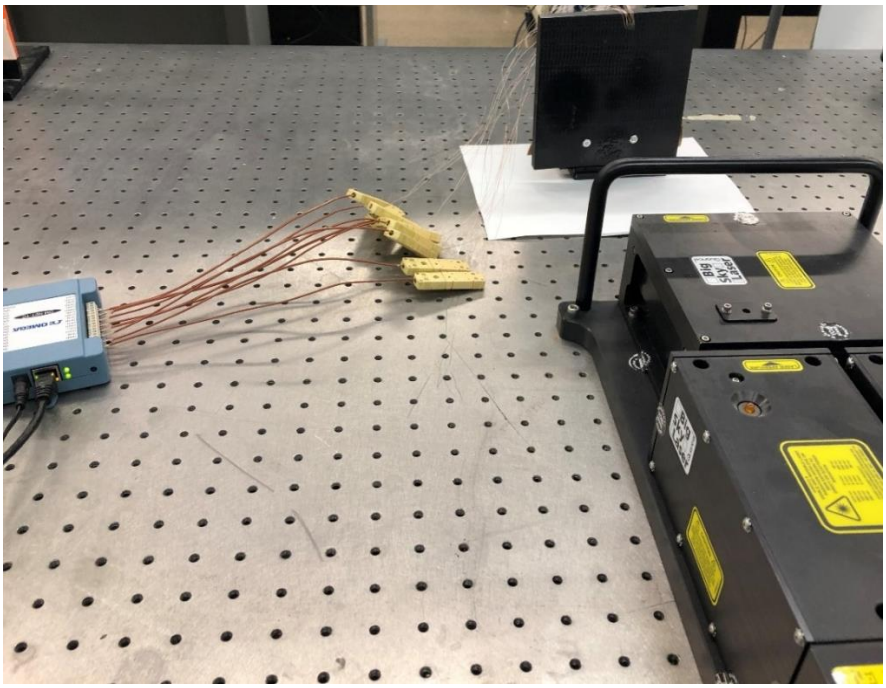

Figure 2.11. Photograph of Experimental Setup 2

2.3.3. Experimental Procedure and Parameters

The test sample surface was positioned such that the laser focal point was aligned with the first thermocouple. The laser was turned on until the desired temperature was observed at the first measurement point and then the laser was turned off. During experimentation, the effects of the following parameters were studied.

- Temperature at the first measurement point
- Duration of heat source exposure (0.5s, 3s)
- Intensity of the laser (<100mJ, 100mJ)

2.4. Experimental Setup 3

2.4.1. Thermal Camera

The thermal imaging system that was used is detailed:

- Trade name: ICI
- Model: 9640 P-Series
- Pixel resolution: 640 x 480
- Maximum frame rate: 30 Hz
- Temperature range: -40^{o}C to 140^{o}C
- Accuracy: +/- 1^{o}C
- Power and connectivity: USB 2.0
- Software: IR Flash

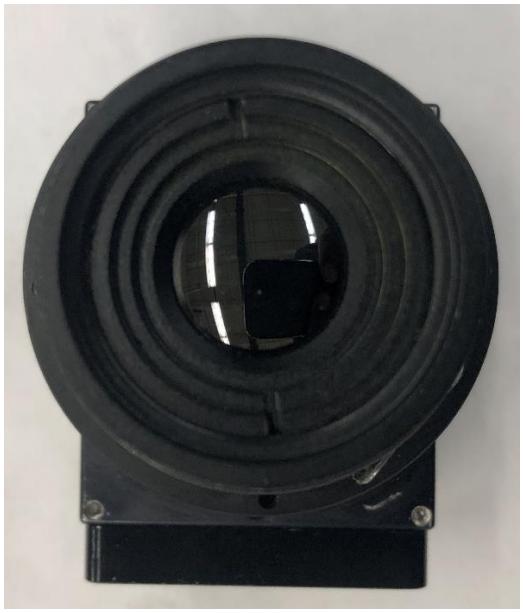

Figure 2.12. Photograph of the Front of the Thermal Camera

Figure 2.13. Photograph of the Back of the Thermal Camera

2.4.2. Experimental Setup

In the third set of experiments, the thermocouples and the data acquisition system were eliminated and instead a thermal camera was employed to capture the surface temperature profile. The test sample was mounted perpendicular to the laser system in order for the laser beam to focus on the test sample. The thermal camera was then positioned and focused to capture the heated area of the sample. It is important to note that there was a slight angle between the sample and the camera as the camera and the laser could not be coaxial. The data from the thermal camera was recorded using the IR Flash software installed on the laptop.

2.4.3. Experimental Procedure and Parameters

The thermal camera was adjusted to capture a clear image of the test spot. The laser was activated for 0.5 seconds. During this time period data from the thermal camera was captured and was later processed in MATLAB software. During experimentation, the effects of the following parameters were studied.

- Distance of the test sample from the laser system which effect the focal spot diameter (6”, 7”, 8”, 9”, 10”)
- Duration of test sample exposure to the laser system (0.5s, 3s)

Figure 2.14. Photograph of Experimental Setup 3

2.5. Personal Protection Equipment

For personal safety reasons, eye protection glasses were acquired for all experiments as detailed below:

- Trade name: Lightobject
- Model: LSR-G808EP5
- Range: 808/904/1064nm

Figure 2.15. Photograph of Eye Protection Glasses

3. EXPERIMENTAL RESULTS

3.1. Experimental Setup 1 Results

To visualize the surface temperature profile of each measurement point, the recorded temperature measurements of each of the eight thermocouple channels were simultaneously graphed as a function of time. The axes of the generated graph are as follows.

- X-axis: time (mm:ss.s)
- Y-axis: temperature (^{o}F)

The resulting data was examined for a second peak temperature in any of the eight thermocouple measurements. Only the following two graphs suggest a second peak temperature of the 33 tests that were conducted. Because the results could not be repeated, no conclusive results were observed. The additional results of the experimental setup 1 are provided in the appendix.

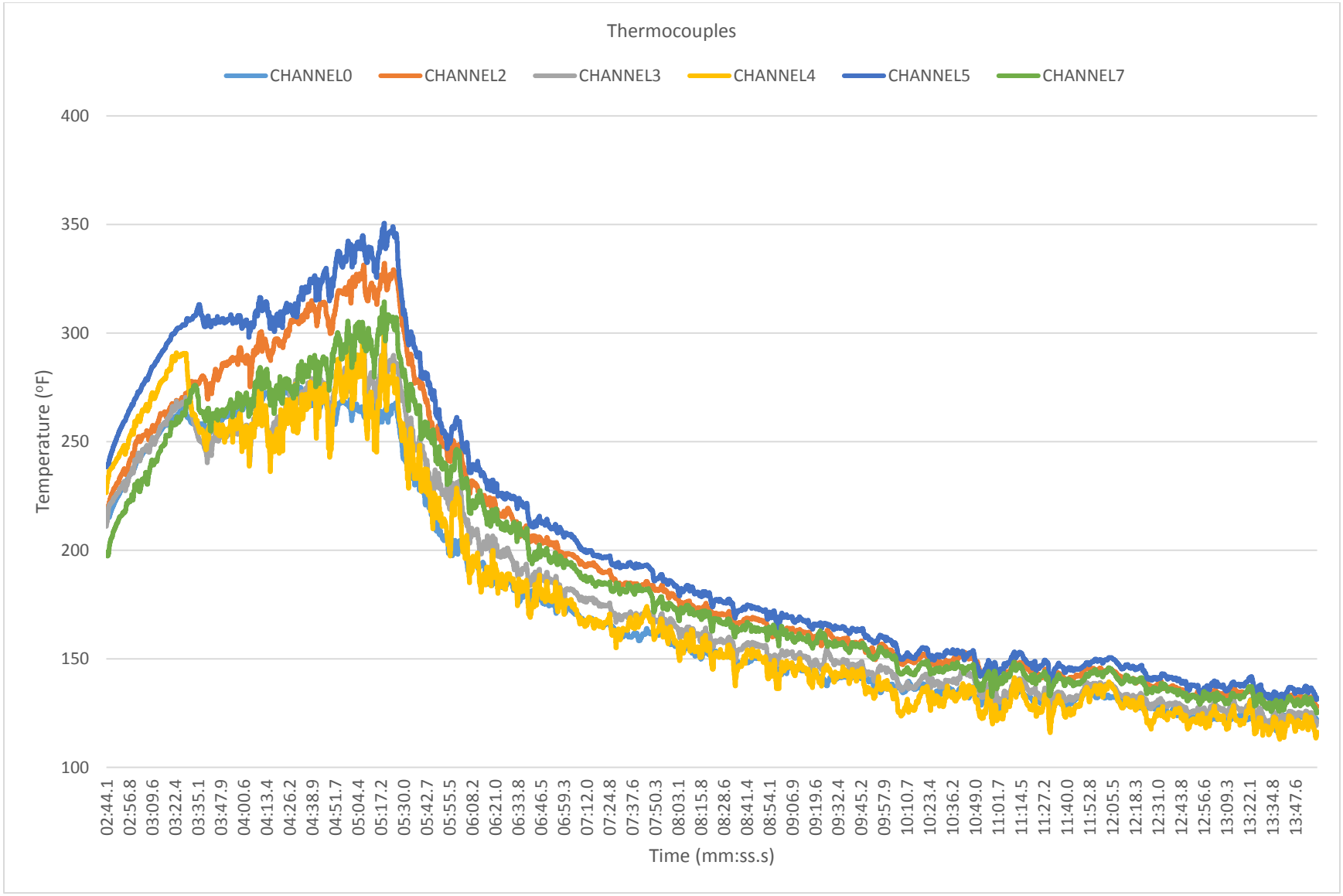

Figure 3.1. Graph of Setup 1 Test Two – Low Temperature Long Duration Exposure

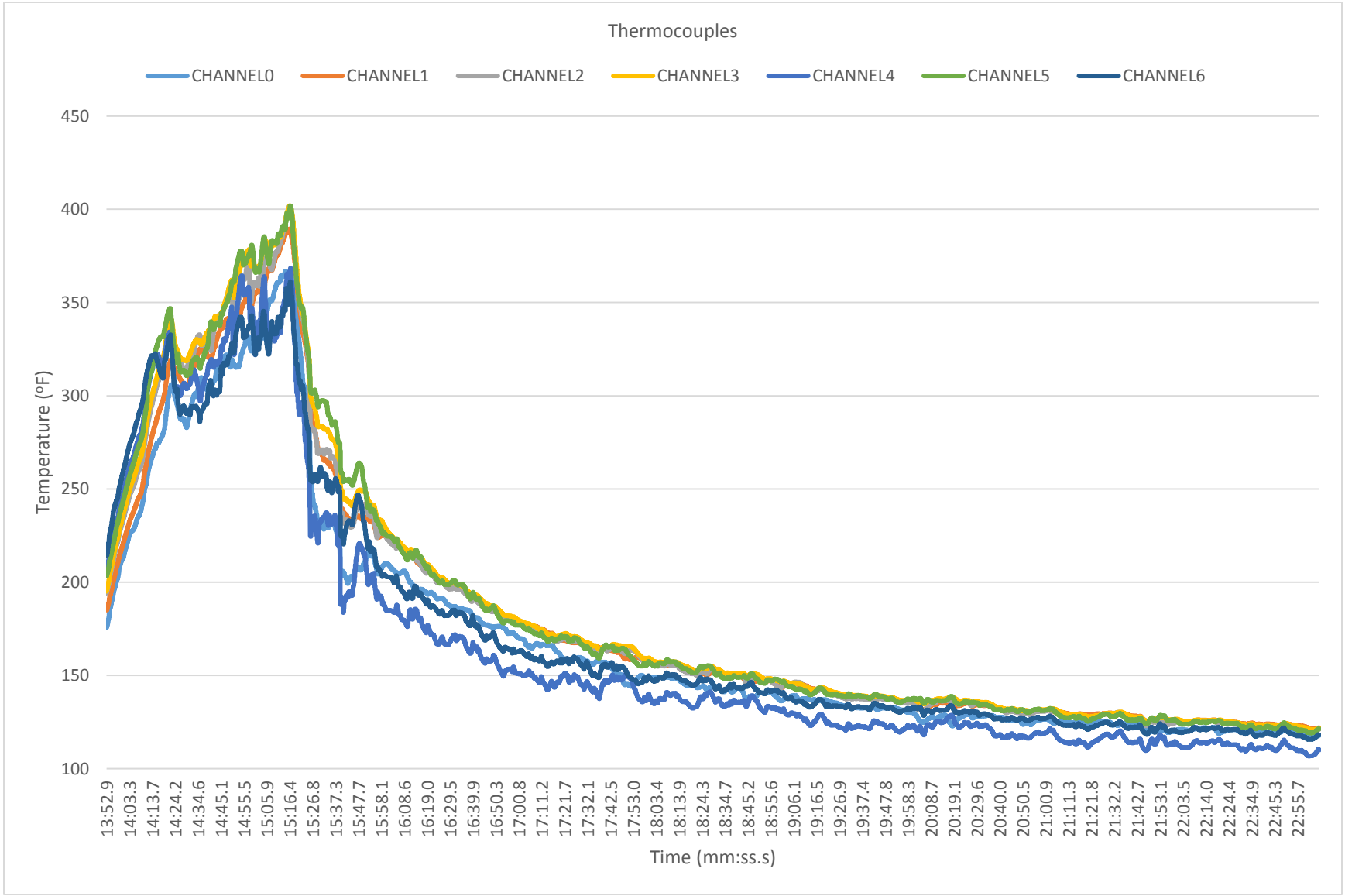

Figure 3.2. Graph of Setup 1 Test Nine – High Temperature Long Duration Exposure

3.2. Experimental Setup 2 Results

The recorded temperature measurements of each of the eight thermocouple channels were simultaneously graphed over as a function of time.

The axes of the generated graph are as follows.

- X-axis: time (mm:ss.s)
- Y-axis: temperature (^{o}F)

The resulting temperature histories were examined for a second peak temperature in any of the eight channels. Only the following profile suggested second peak temperature of the 11 experiments that were conducted. Because the results could not be repeated, no conclusive results were observed. The additional results of the experimental setup 2 are provided in the appendix.

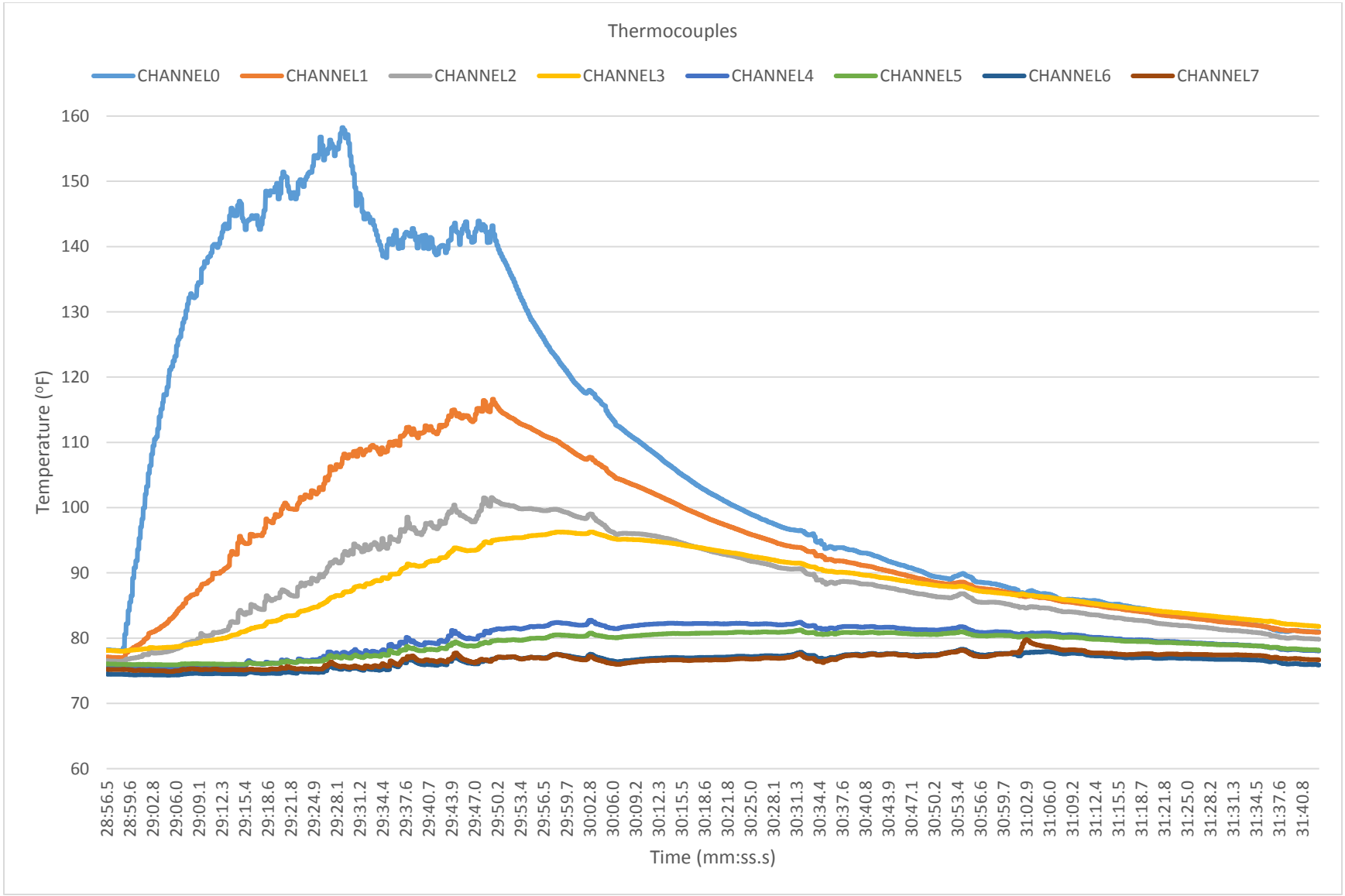

Figure 3.3. Graph of Setup 2 Test Six – Low Temperature Long Duration Exposure

3.3. Experimental Setup 3 Results

In experimental setup 3 data was captured using the IR Flash software. The thermal camera recorded the images in two different formats, CSV and TIFF. The recorded data was then processed in MATLAB.

3.3.1. TIFF Format Processing Procedure

The MATLAB code used to process the raw TIFF files was as follows:

```
% To uncomment Ctrl+t
% To comment Ctrl+r
clear all
close all
clc
frameSize=% Input desired frame size between 0 to 100;
path = ' % Input the file path here';
im = imread(strcat(path,'Image_00000016.tif'));
r = im(:,:,1);
r(r<150)=0;
r = imbinarize(r);
cc=bwconncomp(r);
pp = regionprops(r);
y_center = fix(pp.Centroid(2));
x_center = fix(pp.Centroid(1));

prompt = {'Enter the number of first photo you want to analyze','Enter the number of last
photo you want to analyze','Enter photos overall name'};
dlg_title = 'Input';
num_lines = 1;
def = {'00000001','00000001','Image_'};
photo_no = inputdlg(prompt,dlg_title,num_lines,def);
mmm=str2double(photo_no{1});
nnn=str2double(photo_no{2});
for k=mmm:nnn
file = strcat(path,photo_no{3}, num2str(k,'%08.f'), '.tif');
im = imread(file);
r = im(:,:,1);
%=====================================

r = r((y_center-frameSize):(y_center+frameSize),(x_center-
frameSize):(x_center+frameSize));

%=====================================
```

```
r_height = size(r,1);
r_width = size(r,2);
x = linspace(1,r_width,r_width);
r_middle = fix(r_height/2);
cross = r(r_middle,:);

% figure,
fig = plot(x, cross);
output_jpg = strcat(path,photo_no{3}, num2str(k,'%08.f'), '.jpg');
saveas(fig,output_jpg)
end
```

The MATLAB code accomplished the following steps:

- In the first step it read the raw temperature data of the test surface from the TIFF image file. Each pixel of the TIFF image contained a temperature measurement in an unsigned 8-bit integer number format.

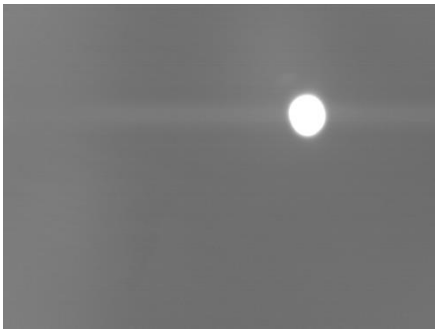

Figure 3.4. Raw TIFF Image File

- In the second step it truncated the raw data into a squared array with a specified size. The heated zone became the center of the squared array.

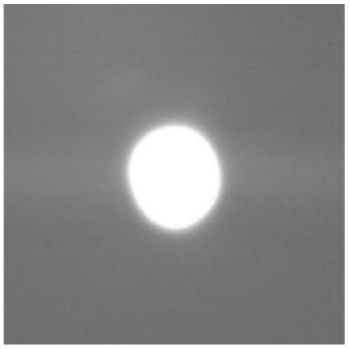

Figure 3.5. Squared Image File

- In the final step the horizontal center line data of the squared array was plotted. Y-axis represented the temperature of the test surface. X-axis represented the pixel position along the horizontal direction. This resulted in plotting of the temperature profile of the test surface.

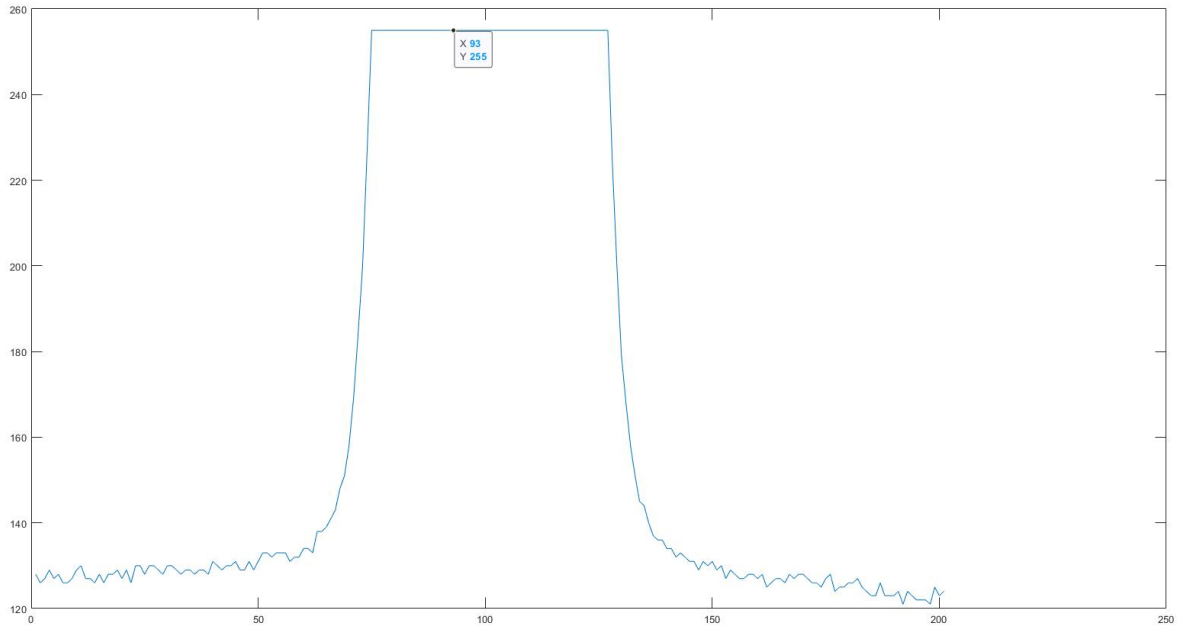

Figure 3.6. Temperature Profile of the Test Surface

The major limitation of the TIFF format was that the measurement data peaked at 255. Because of this limitation the temperature profiles of the test surface were prematurely truncated therefore the data could not be used. To overcome this limitation the data was captured in Microsoft Excel CSV format.

3.3.2. CSV Format Processing Procedure

The MATLAB code used to process the raw TIFF files was as follows:

```
% To uncomment Ctrl+t
% To comment Ctrl+r
clear all
close all
clc
frameSize= % Input desired frame size between 0 to 100;
```

```
extension_format = '.csv';
path = % Input the file path here ';
r = readmatrix(strcat(path,'Image_00000008',extension_format));

r(r<90)=0;
r = imbinarize(r);
cc=bwconncomp(r);
pp = regionprops(r);
y_center = fix(pp.Centroid(2));
x_center = fix(pp.Centroid(1));
%%

prompt = {'Enter the number of first photo you want to analyze','Enter the number of last
photo you want to analyze','Enter photos overall name'};
dlg_title = 'Input';
num_lines = 1;
def = {'00000013','00000013','Image_'};
photo_no = inputdlg(prompt,dlg_title,num_lines,def);
mmm=str2double(photo_no{1});
nnn=str2double(photo_no{2});
for k=mmm:nnn
file = strcat(path,photo_no{3}, num2str(k,'%08.f'), extension_format);
r = readmatrix(file);

%=======================================
% To use when the frame of picture changes
% % r_bw= imbinarize(r,0.1);
% % % imshow(r_bw)
% % stats = regionprops(r_bw,'BoundingBox');
% % r = imcrop(r,stats.BoundingBox);
% figure, imshow(r)
%=======================================
r = r((y_center-frameSize):(y_center+frameSize),(x_center-
frameSize):(x_center+frameSize)); %Test4

%=======================================
r_height = size(r,1);
r_width = size(r,2);
% r_Center = [x_center, y_center];
x = linspace(1,r_width,r_width);
r_middle = fix(r_height/2);
cross = r(r_middle,:);
cross2 = r(:,r_middle);
cross3=diag(r);
rf = flip(r,2);
cross4=diag(rf);
```

```
% figure,
fig = plot(x, cross);
hold on
fig = plot(x, cross2);
hold on
fig = plot(x, cross3);
hold on
fig = plot(x, cross4);
% axis auto
output_jpg = strcat(path,photo_no{3}, num2str(k,'%08.f'), '.jpg');
saveas(fig,output_jpg)
end
```

The MATLAB code accomplished the following steps:

- Step 1: read CSV file.
- Step 2: binary format using a specified threshold.

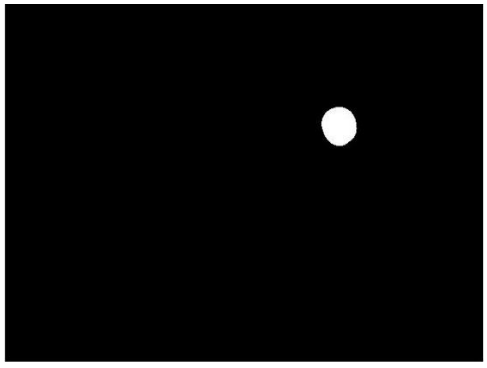

Figure 3.7. Binary Format of the CSV File

- Step 3: calculate center of the heat zone. Generate a square array of specified size with the heat zone centered.
- Step 4: multiple cross sections passing through the center of the array were plotted as a function of distance.
- Y-axis of the graph represented the temperature in ^{o}C. X-axis represented the size of the square array. This resulted in the plotting of the temperature profile of the test surface in multiple directions.

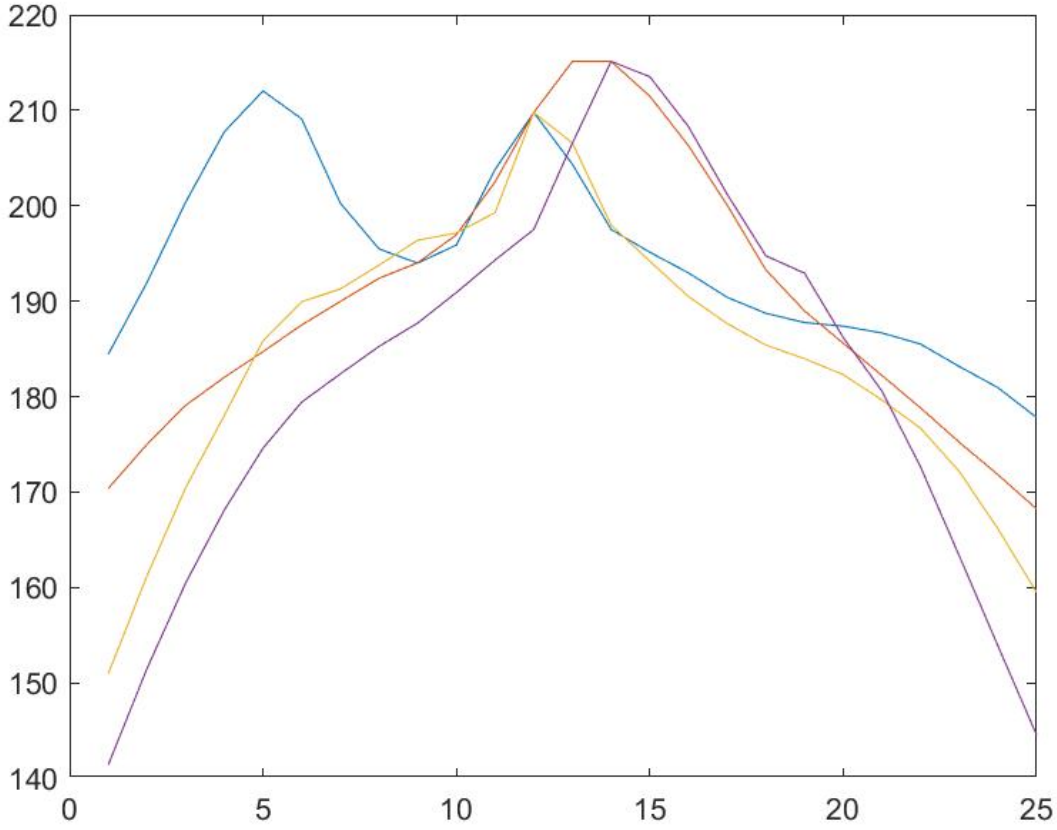

Figure 3.8. Sample Figure of the Temperature Profile of the Test Surface

The following graphs were investigated for the second peak temperature. However, no conclusive results were observed. The additional results of the experimental setup 3 are provided in the appendix.

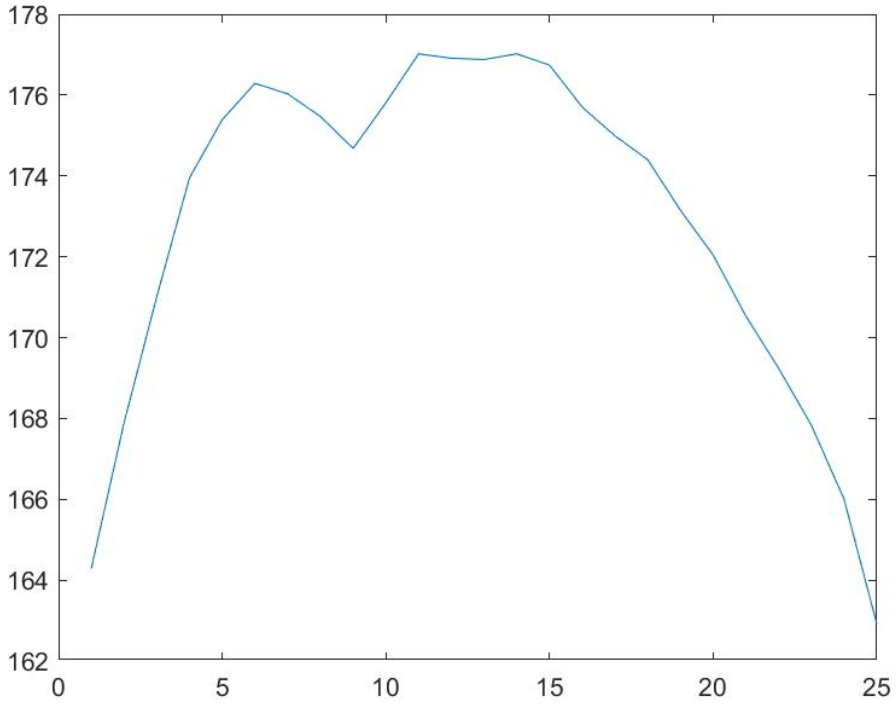

Figure 3.9. Graph of Setup 3 Replication 1 Test Fifteen – Single Cross Section

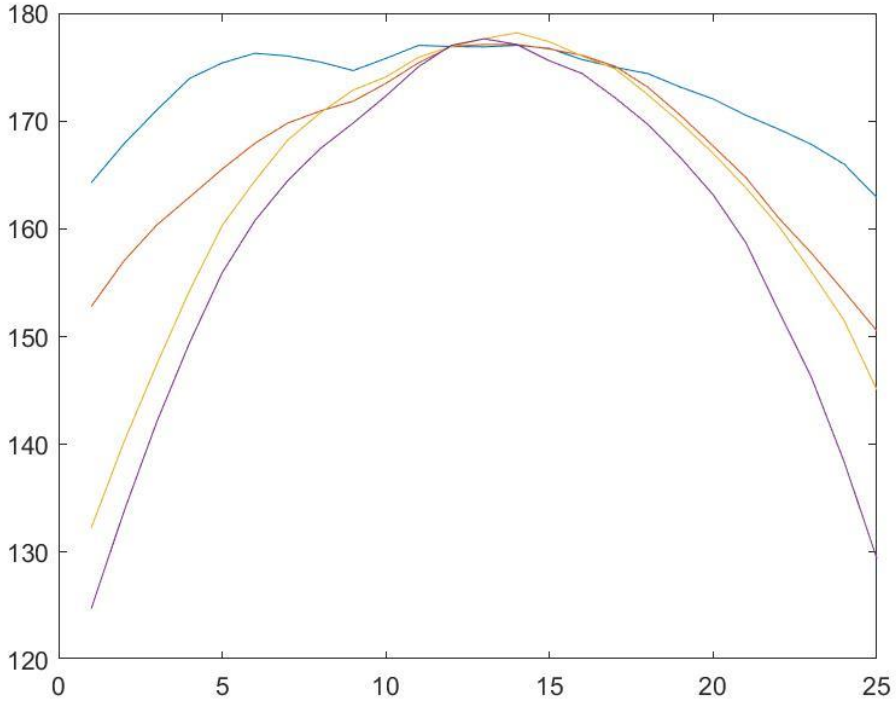

Figure 3.10. Graph of Setup 3 Replication 1 Test Fifteen – Multiple Cross Sections

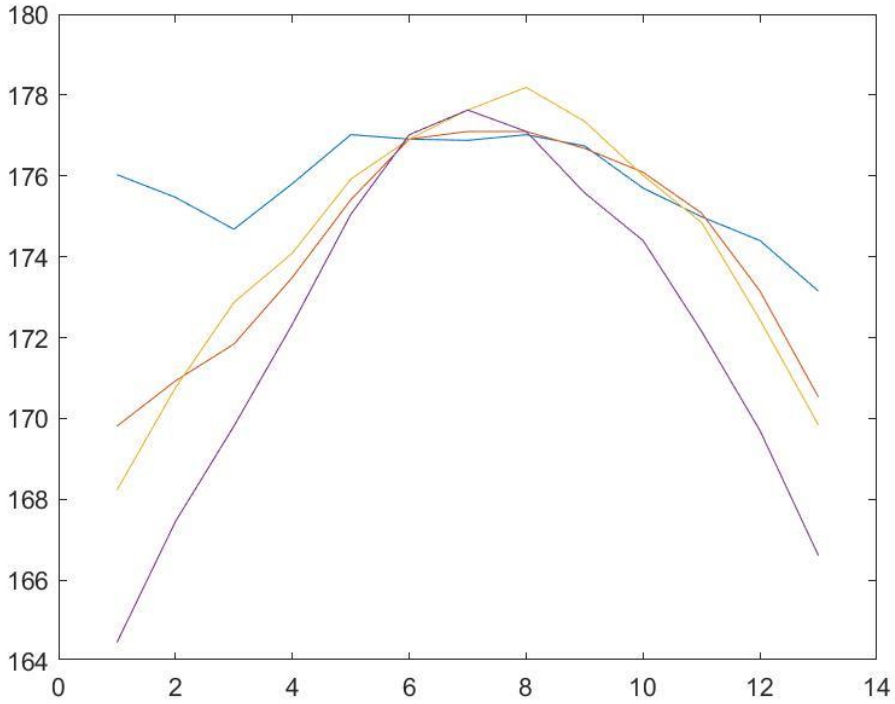

Figure 3.11. Magnified Section of Graph of Setup 3 Replication 1 Test Fifteen – Multiple Cross Sections

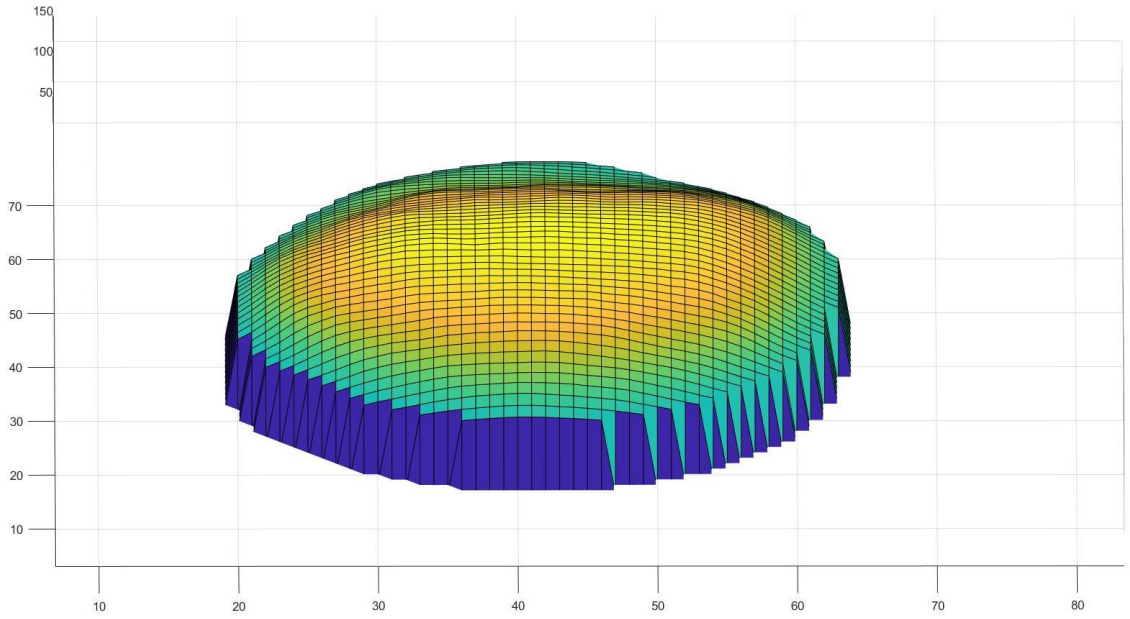

Figure 3.12. 3-D Plot of Setup 3 Replication 1 Test Fifteen

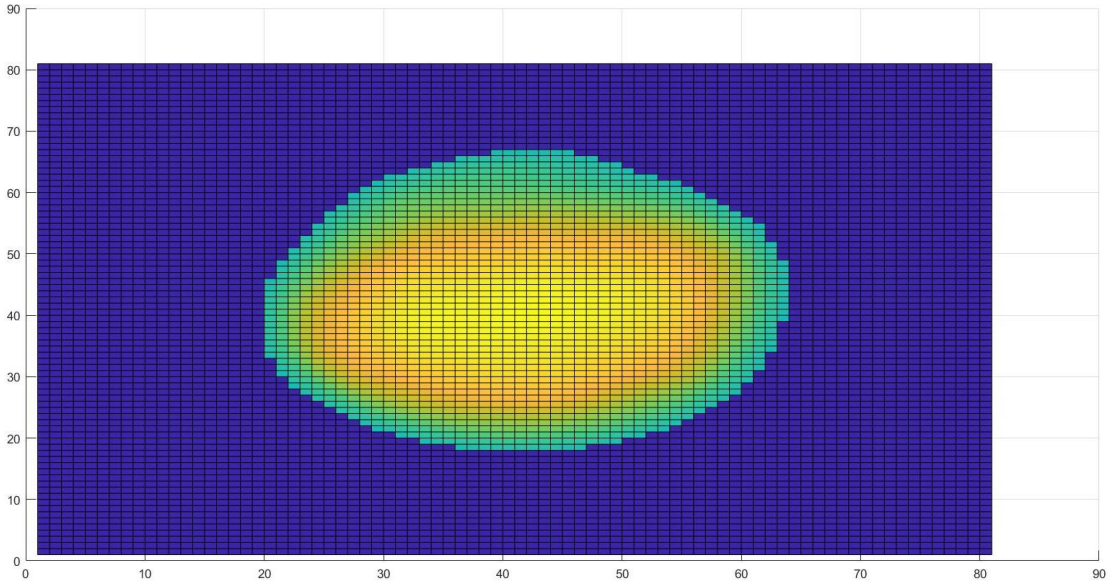

Figure 3.13. Contour Plot of Setup 3 Replication 1 Test Fifteen

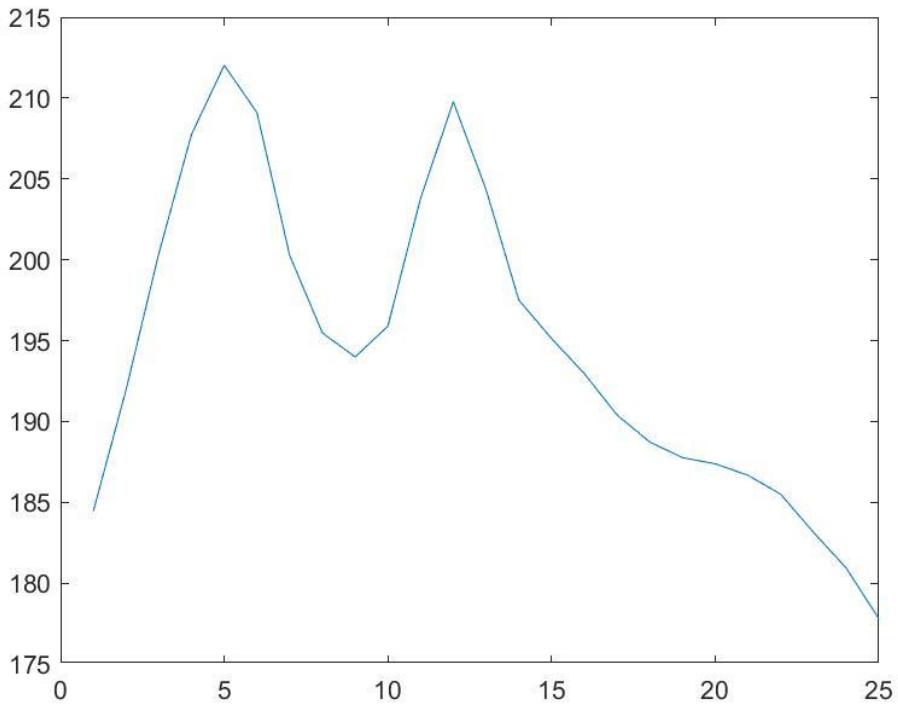

Figure 3.14. Graph of Setup 3 Replication 1 Test Sixteen – Single Cross Section

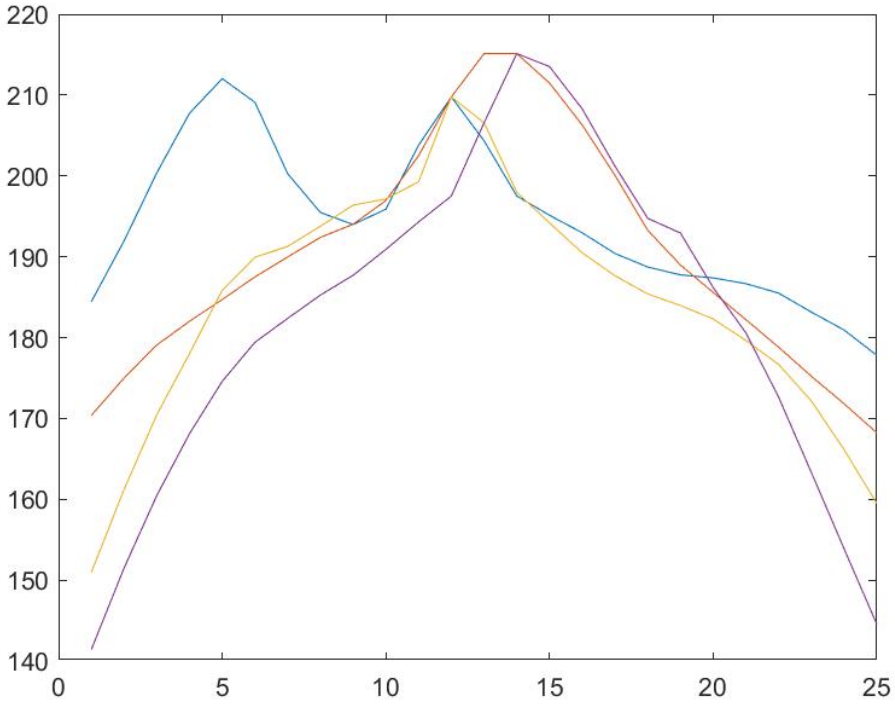

Figure 3.15. Graph of Setup 3 Replication 1 Test Sixteen – Multiple Cross Sections

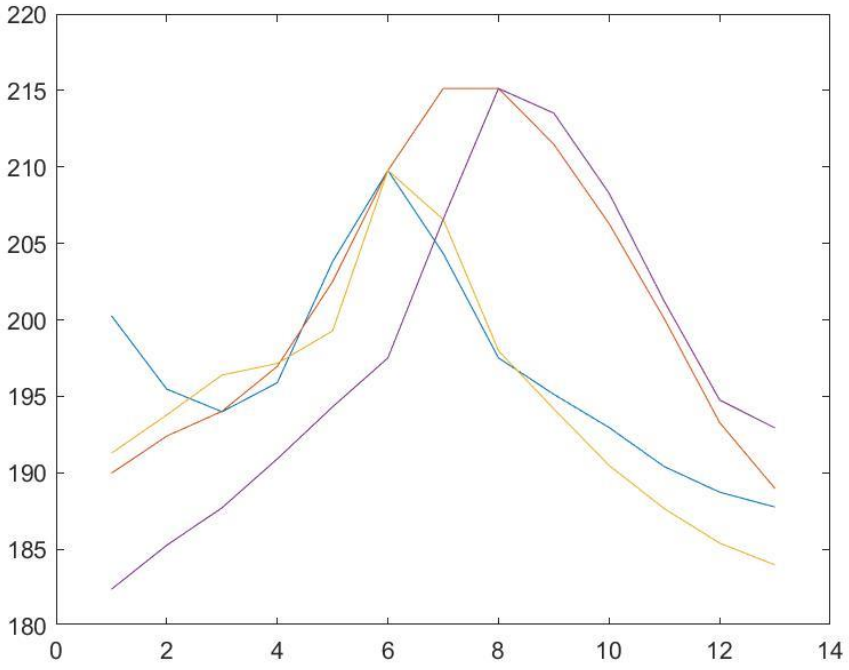

Figure 3.16. Magnified Section of Graph of Setup 3 Replication 1 Test Sixteen – Multiple Cross Sections

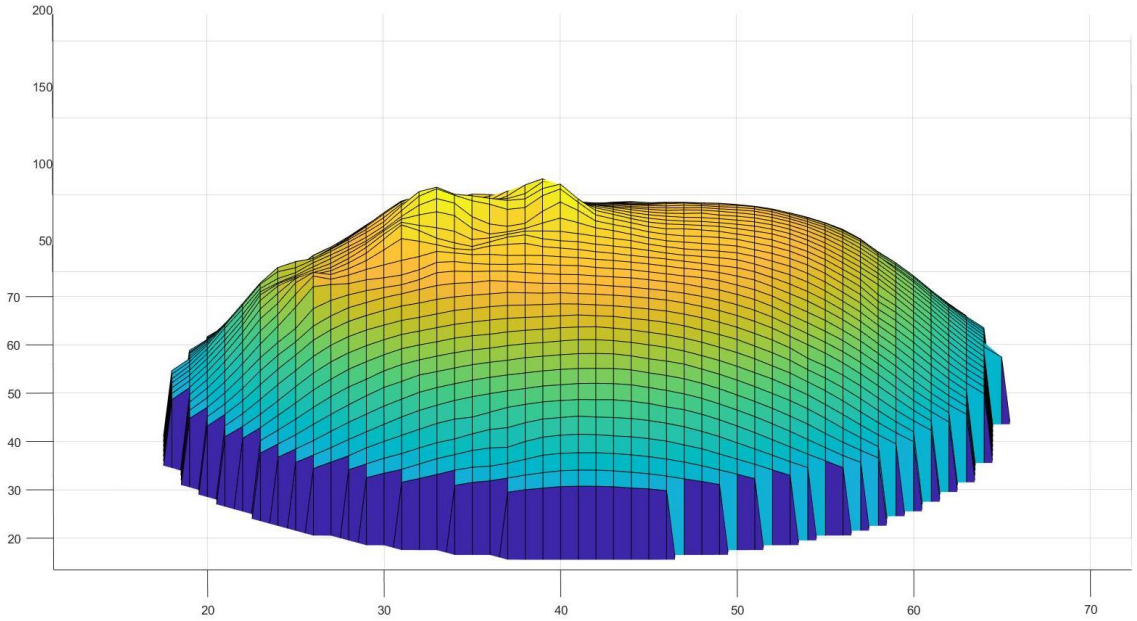

Figure 3.17. 3-D Plot of Setup 3 Replication 1 Test Sixteen

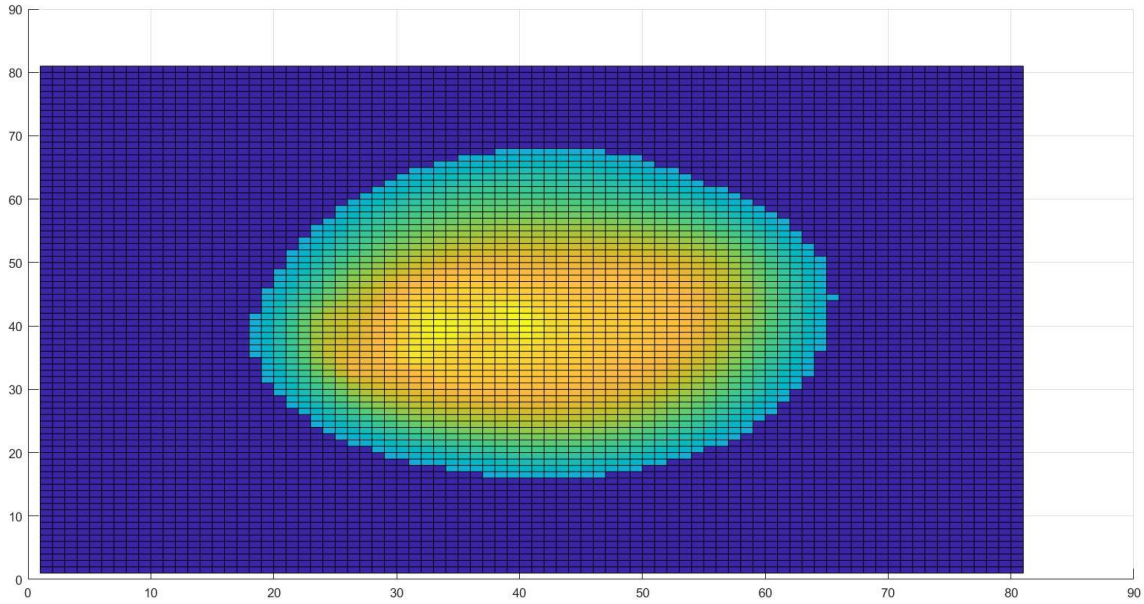

Figure 3.18. Contour Plot of Setup 3 Replication 1 Test Sixteen

4. CONCLUSIONS AND RECOMMENDATIONS

In the initial experiment no conclusive results were observed which led to further investigation of the test setup in order to correct the test setup. This investigation identified that the heat source (IR lamp) in the experimentation was a potential limitation. When the temperature profile of the lamp was studied using a thermal camera it was observed to be a non-Gaussian type heat source. In order to rectify this limitation, the second experimental setup was designed which replaced the lamp with a laser system which is a Gaussian type heat source.

In experimental setup 2 two limitations were observed/considered.

- Because the exact location where the second peak temperature might be observed was unknown and because eight discrete measurement points were selected there was the possibility of missing the location of the point of interest.
- The thermocouples were melted in place with a soldering iron on the test surface, this resulted in the alteration of the test sample surface. Because of this alteration of the surface, there was a possibility of distortion of the heat flow in the surface material.

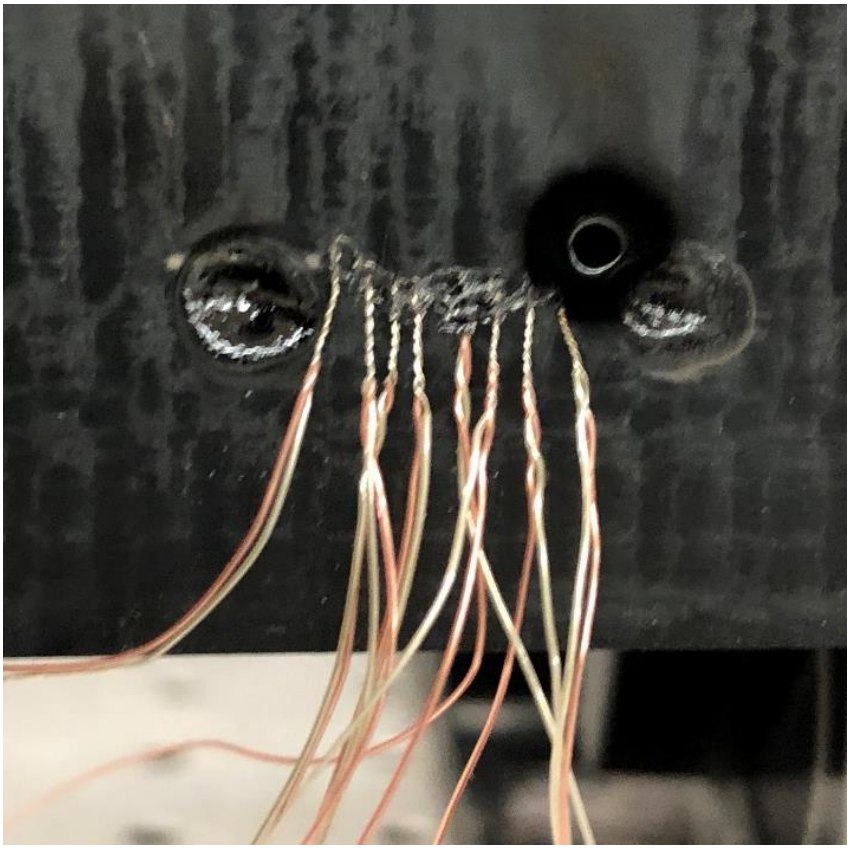

Figure 4.1. Photograph of the Thermocouples Melted in Place on the Test Surface

In order to overcome these limitations, the third experimental setup was designed which replaced the thermocouples with a thermal camera.

Although no conclusive results were observed in any of the experimental setups, it was determined to design a third experimental setup consisting of:

- Thermal camera with a laser system.
- Use a thermal camera with a higher frame rate (>10 Hz).
- Use a single shot pulse from the laser system to heat the sample surface (<0.2 second duration).
- Of the 60 tests that were conducted, two of the test results suggested a second peak temperature. Because these results could not be repeated, no conclusive results were observed.

REFERENCES

Grewell, D. (2002). *Laser microwelding of polystyrene and and polycarbonate*. (Master's Thesis). Retrieved from https://etd.ohiolink.edu/

Rosenthal, D. (1946). *The theory of moving source of heat and its application to metal treatment*. Transaction, ASME 43(11):849-866.

APPENDIX. SUPPLEMENTARY FIGURES

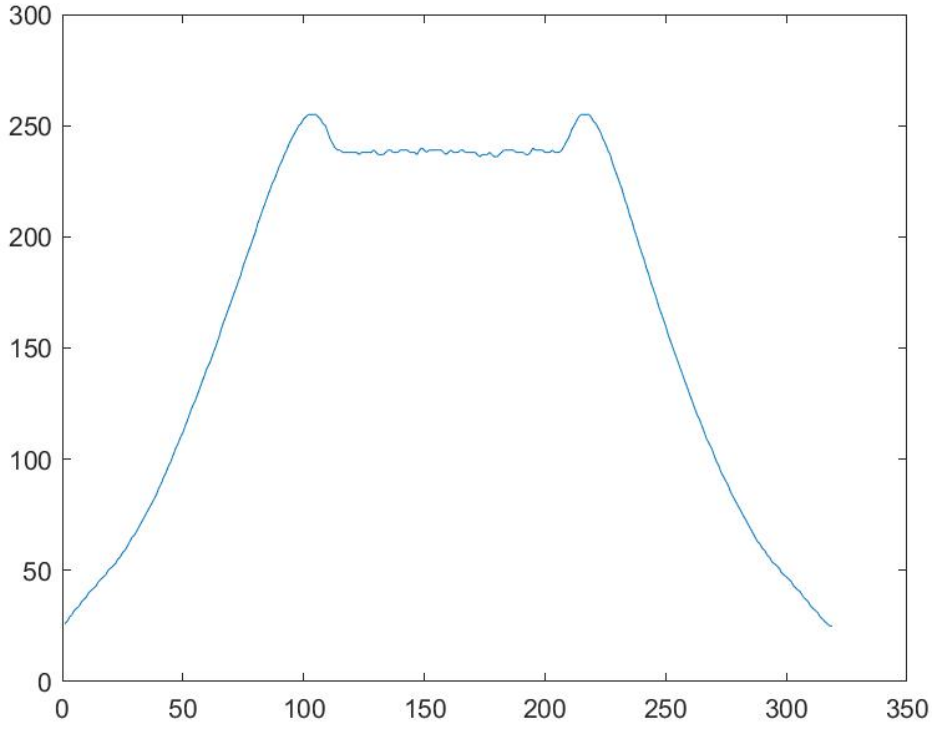

Figure A.1. Temperature Profile of the Infrared Lamp at Timestamp 1

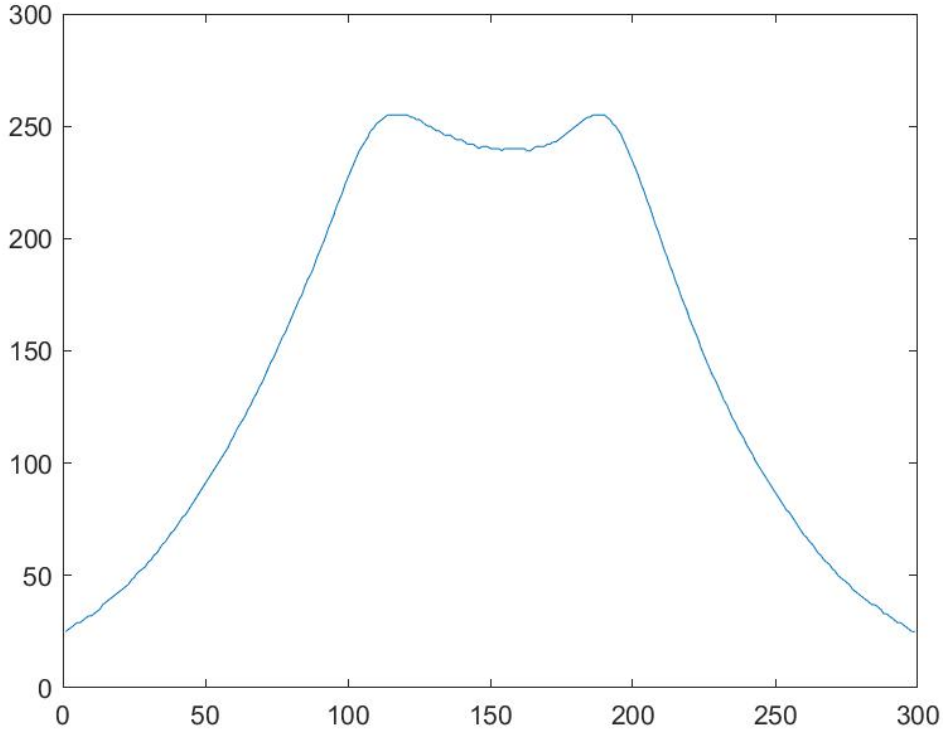

Figure A.2. Temperature Profile of the Infrared Lamp at Timestamp 2

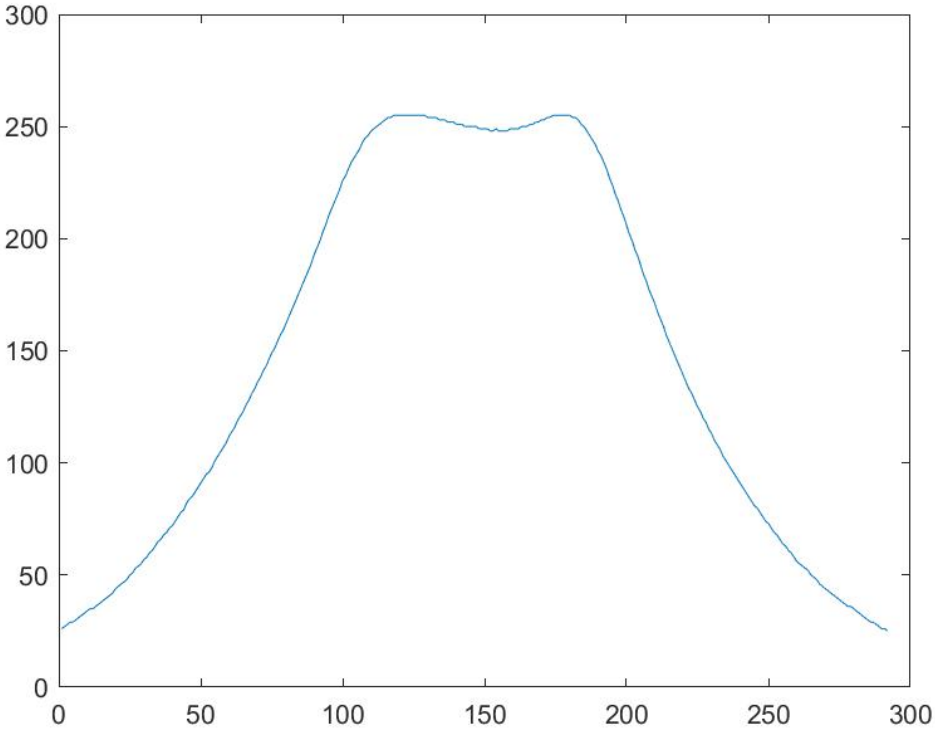

Figure A.3. Temperature Profile of the Infrared Lamp at Timestamp 3

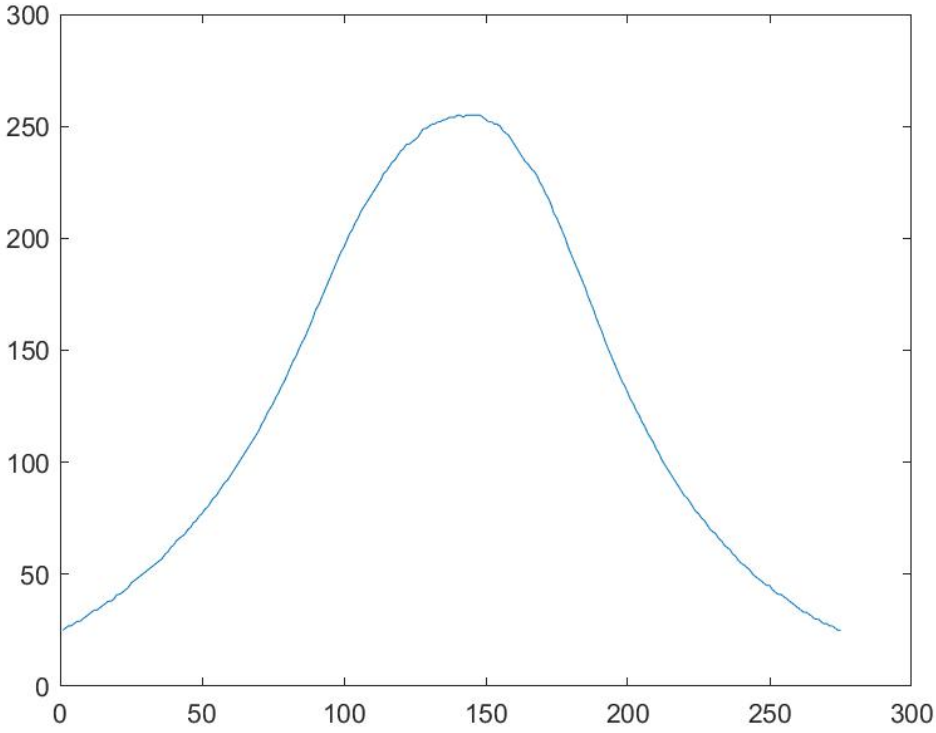

Figure A.4. Temperature Profile of the Infrared Lamp at Timestamp 4

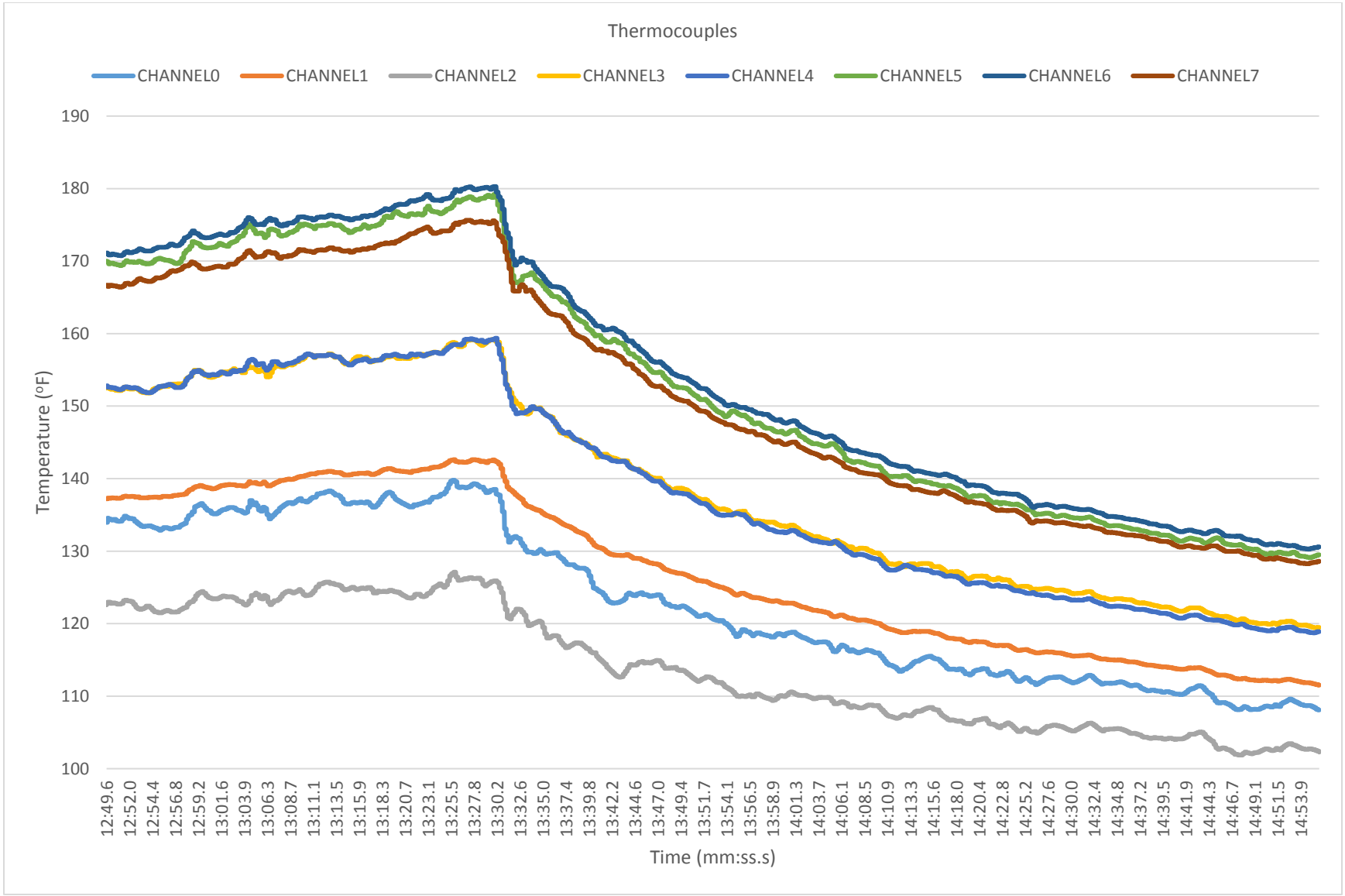

Figure A.5. Graph of Setup 1 Mock Test 1

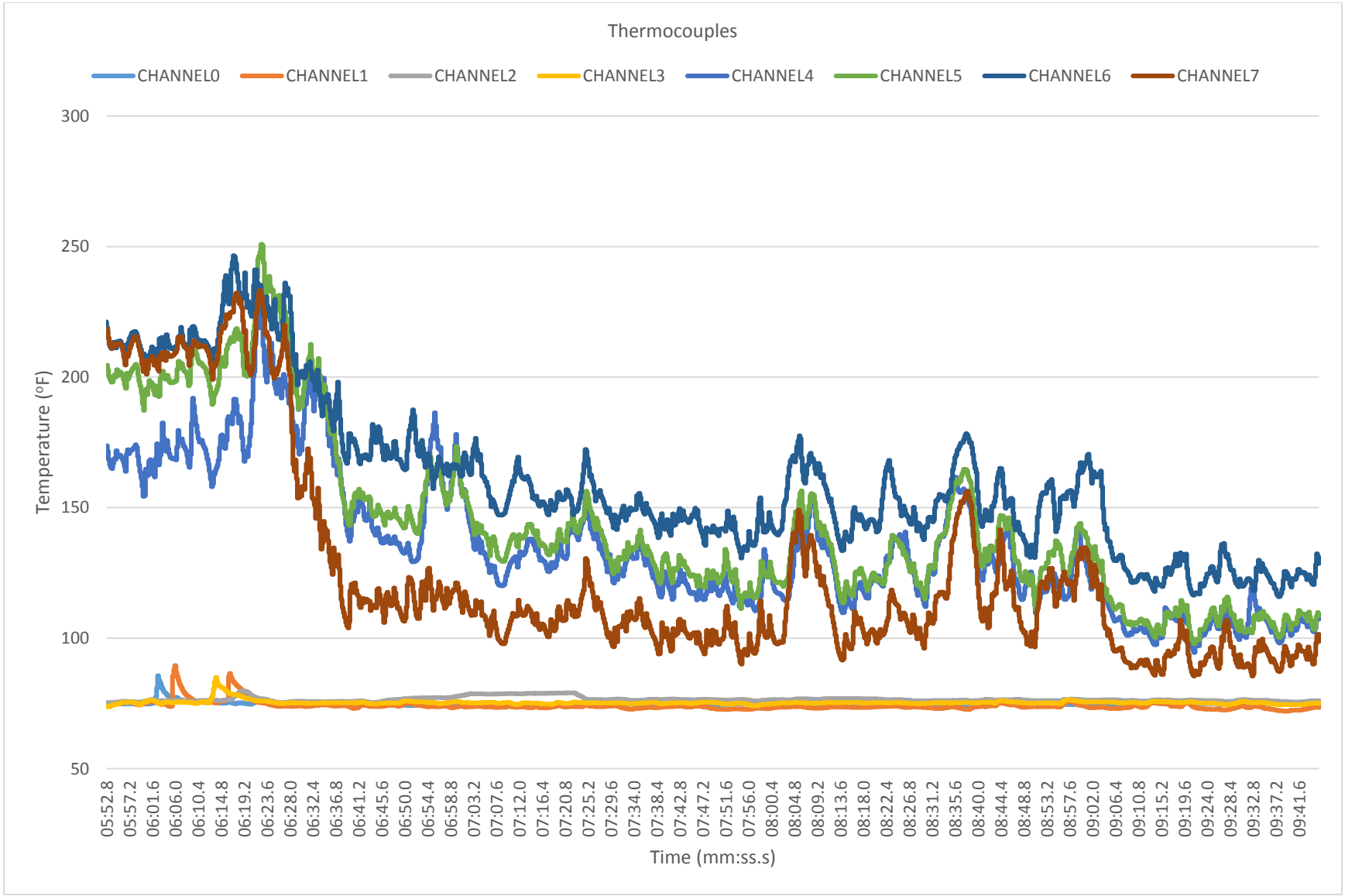

Figure A.6. Graph of Setup 1 Mock Test 2

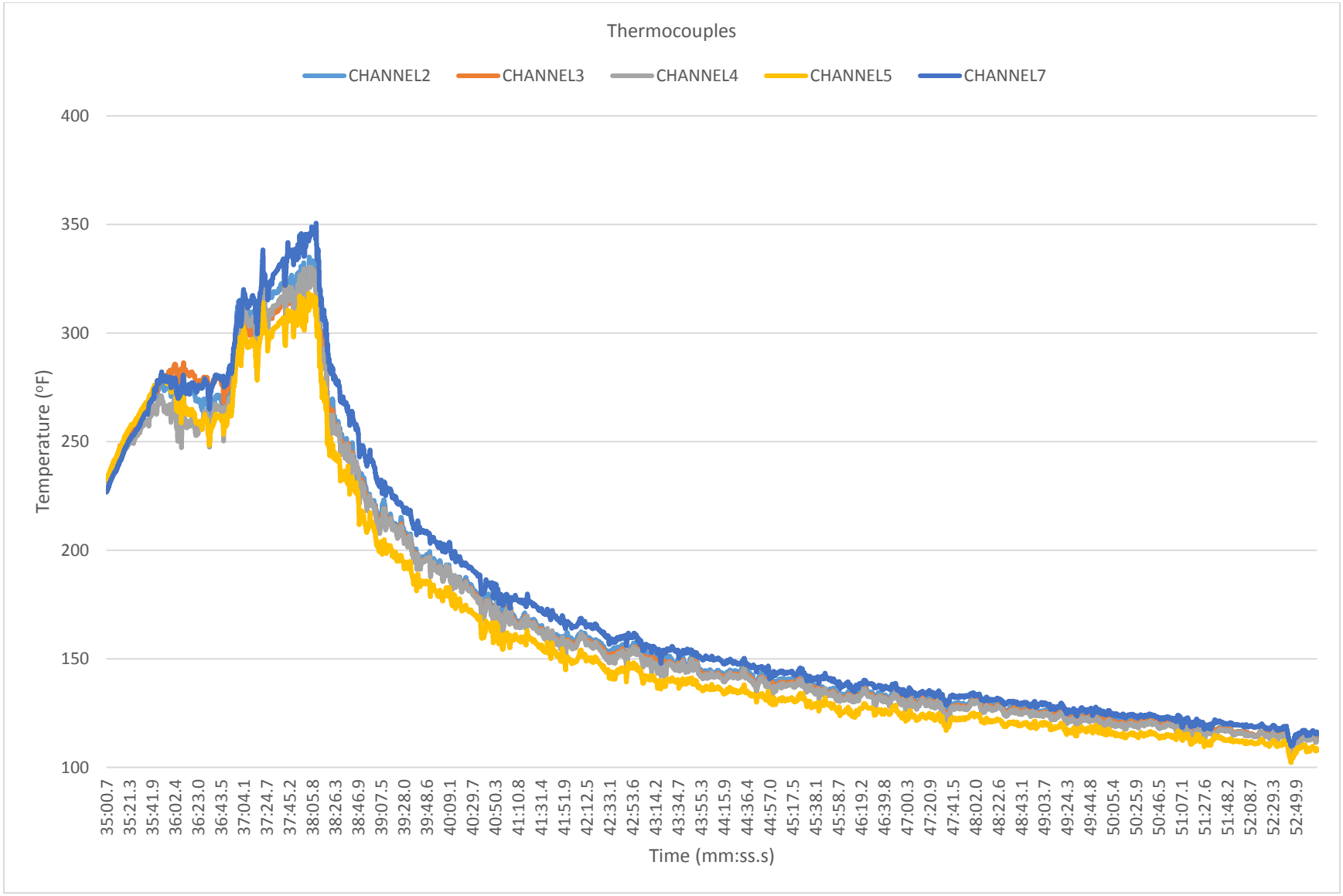

Figure A.7. Graph of Setup 1 Test 1 – Low Temperature Long Duration Exposure

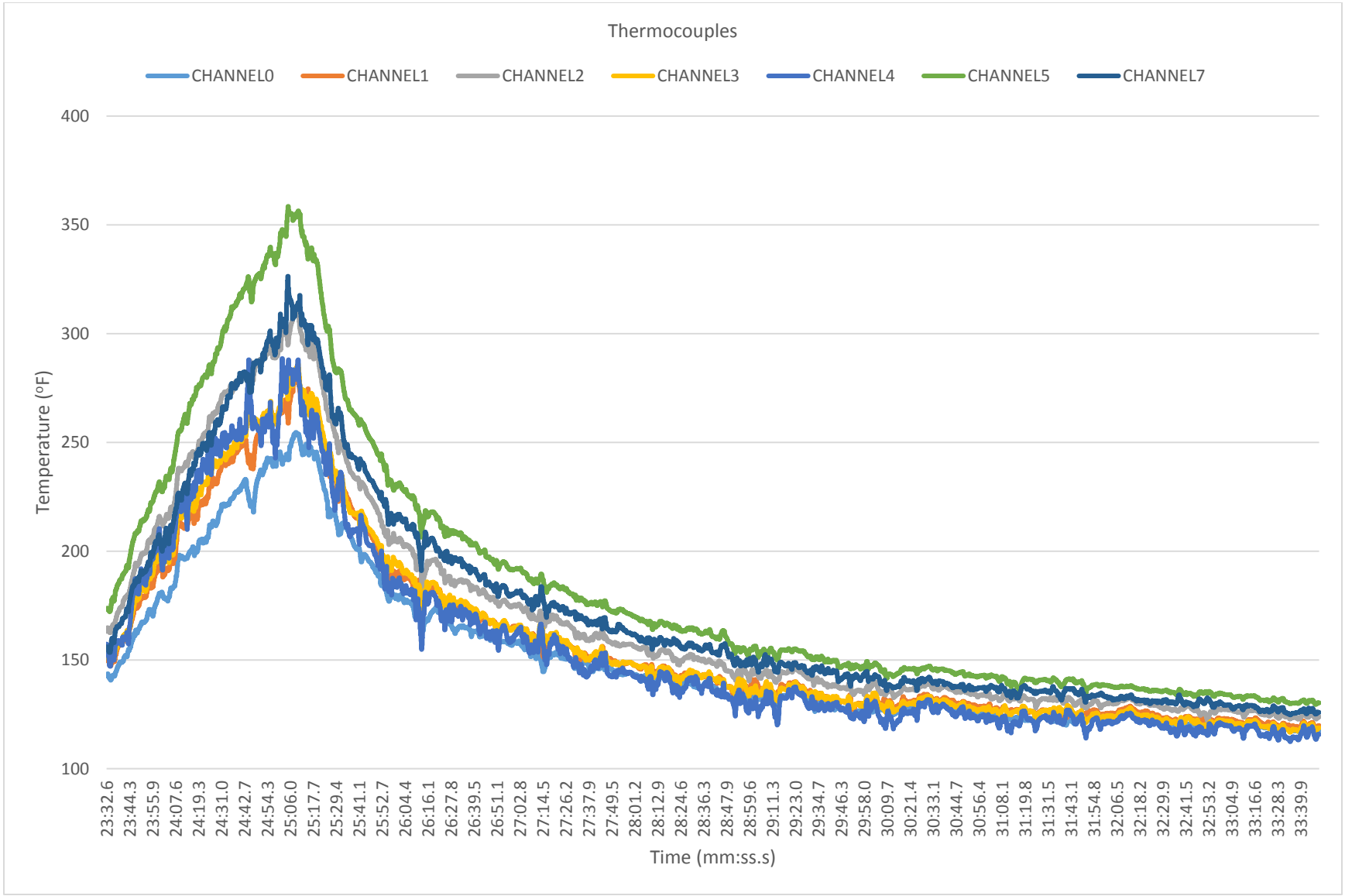

Figure A.8. Graph of Setup 1 Test 3 – Low Temperature Long Duration Exposure

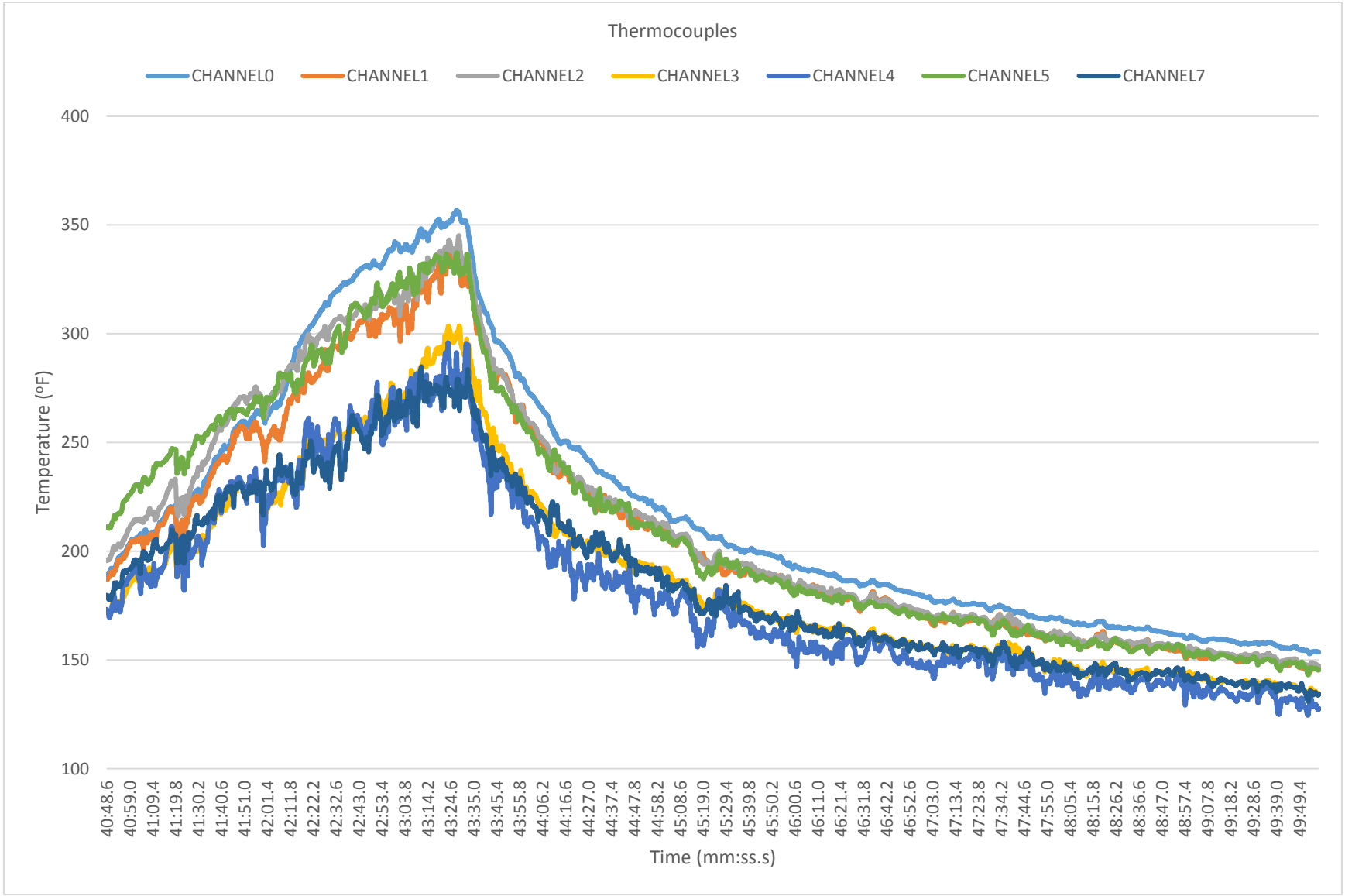

Figure A.9. Graph of Setup 1 Test 4 – Low Temperature Long Duration Exposure

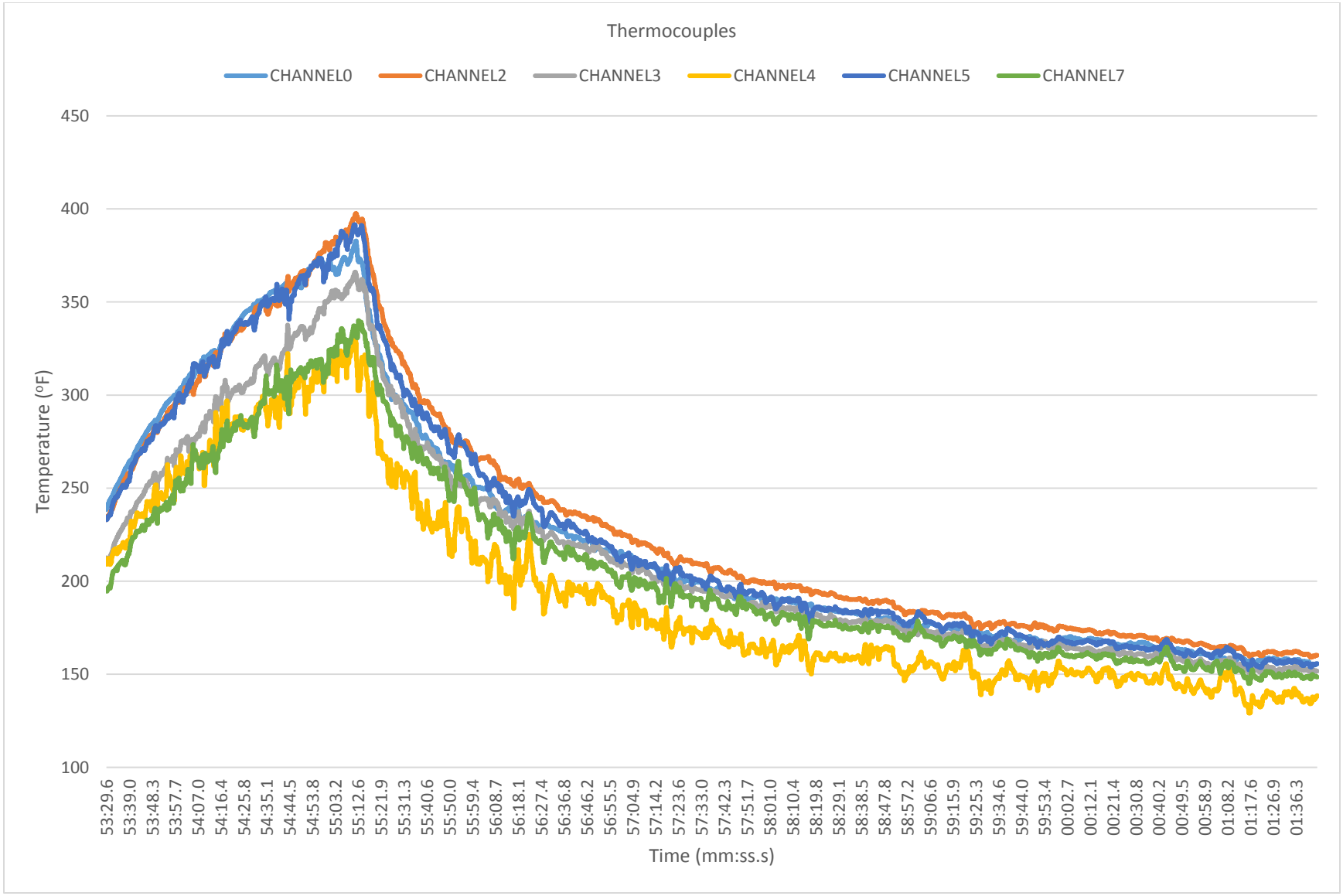

Figure A.10. Graph of Setup 1 Test 5 – High Temperature Long Duration Exposure

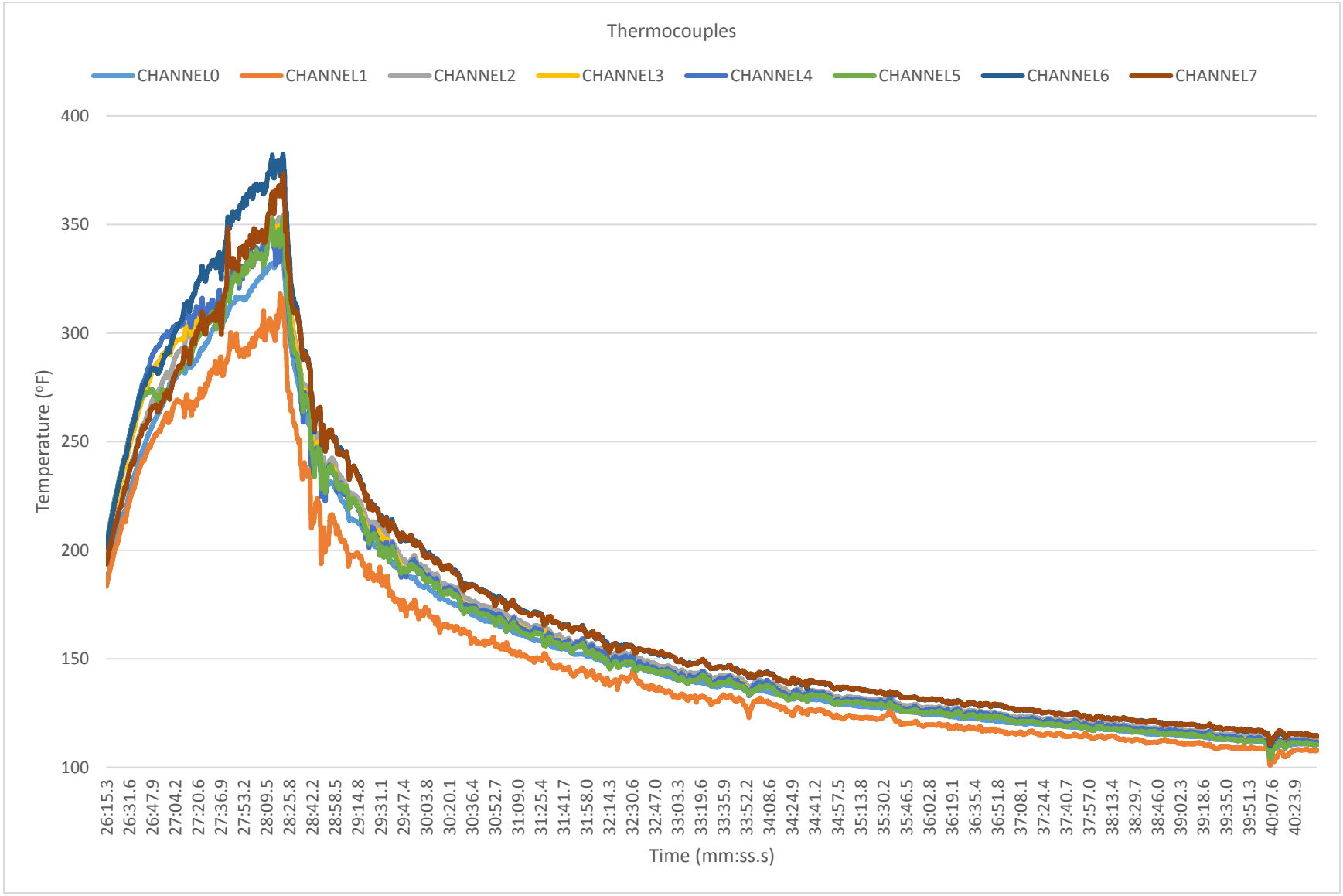

Figure A.11. Graph of Setup 1 Test 6 – High Temperature Long Duration Exposure

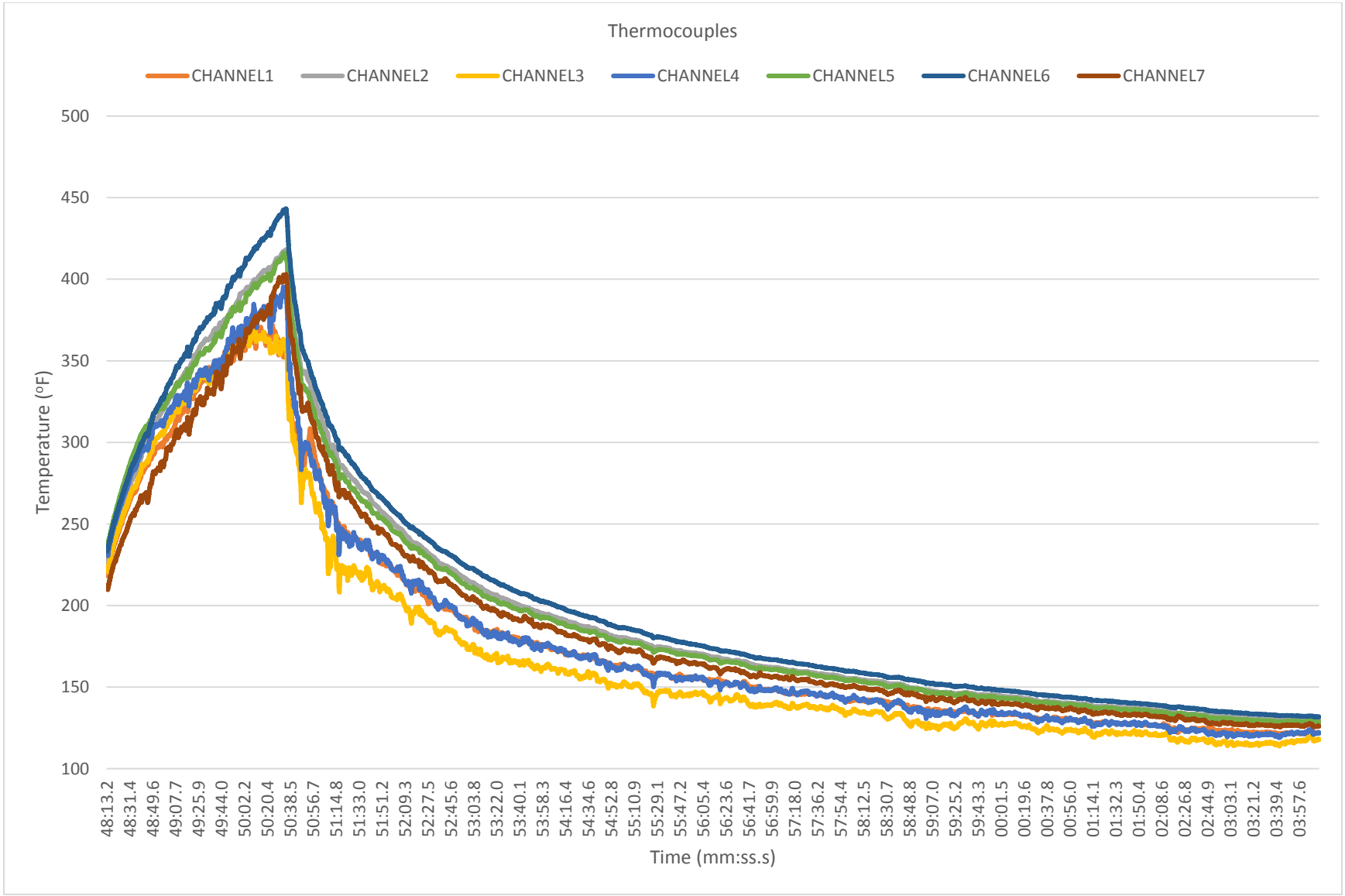

Figure A.12. Graph of Setup 1 Test 7 – High Temperature Long Duration Exposure

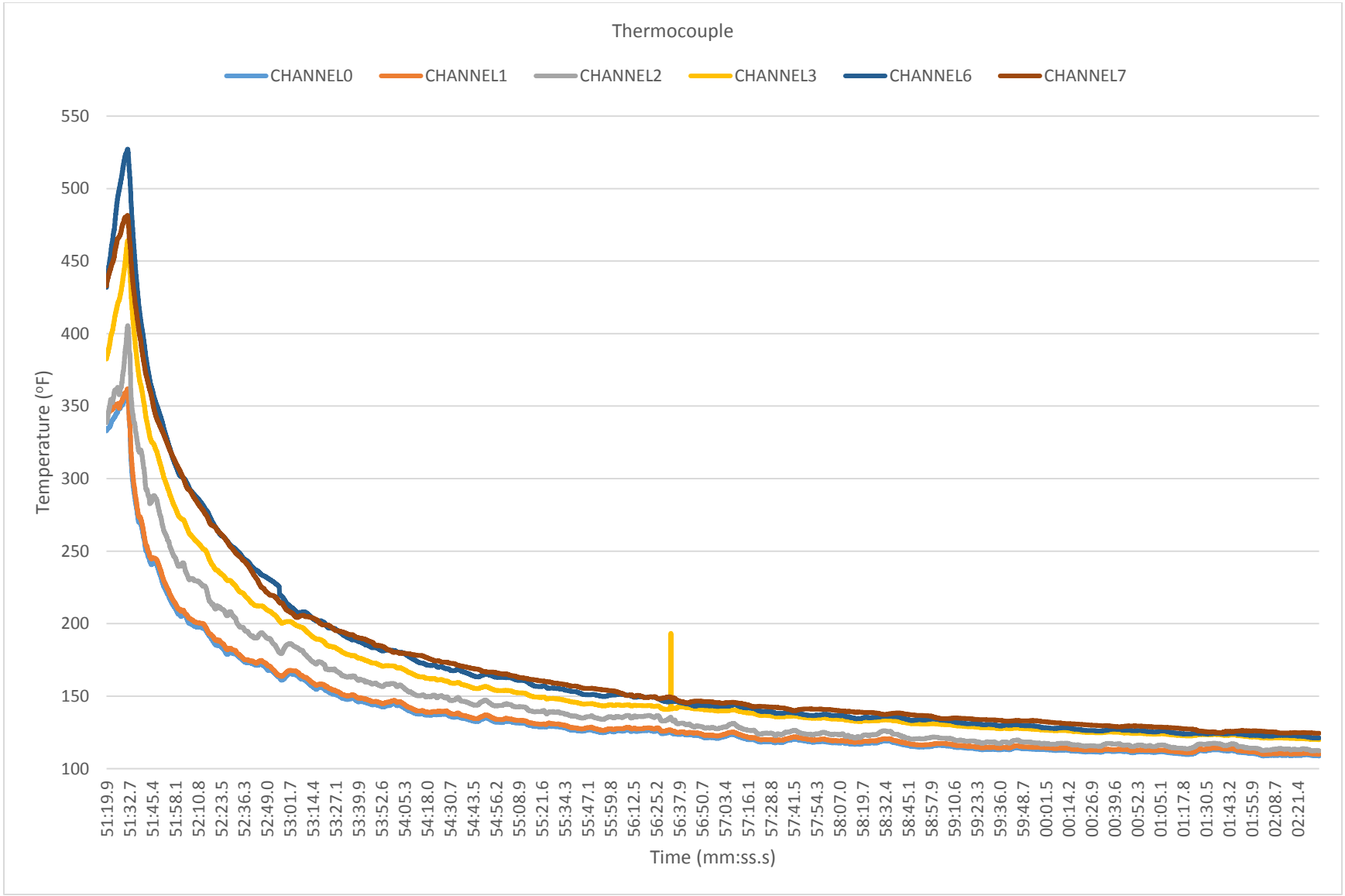

Figure A.13. Graph of Setup 1 Test 8 – High Temperature Long Duration Exposure

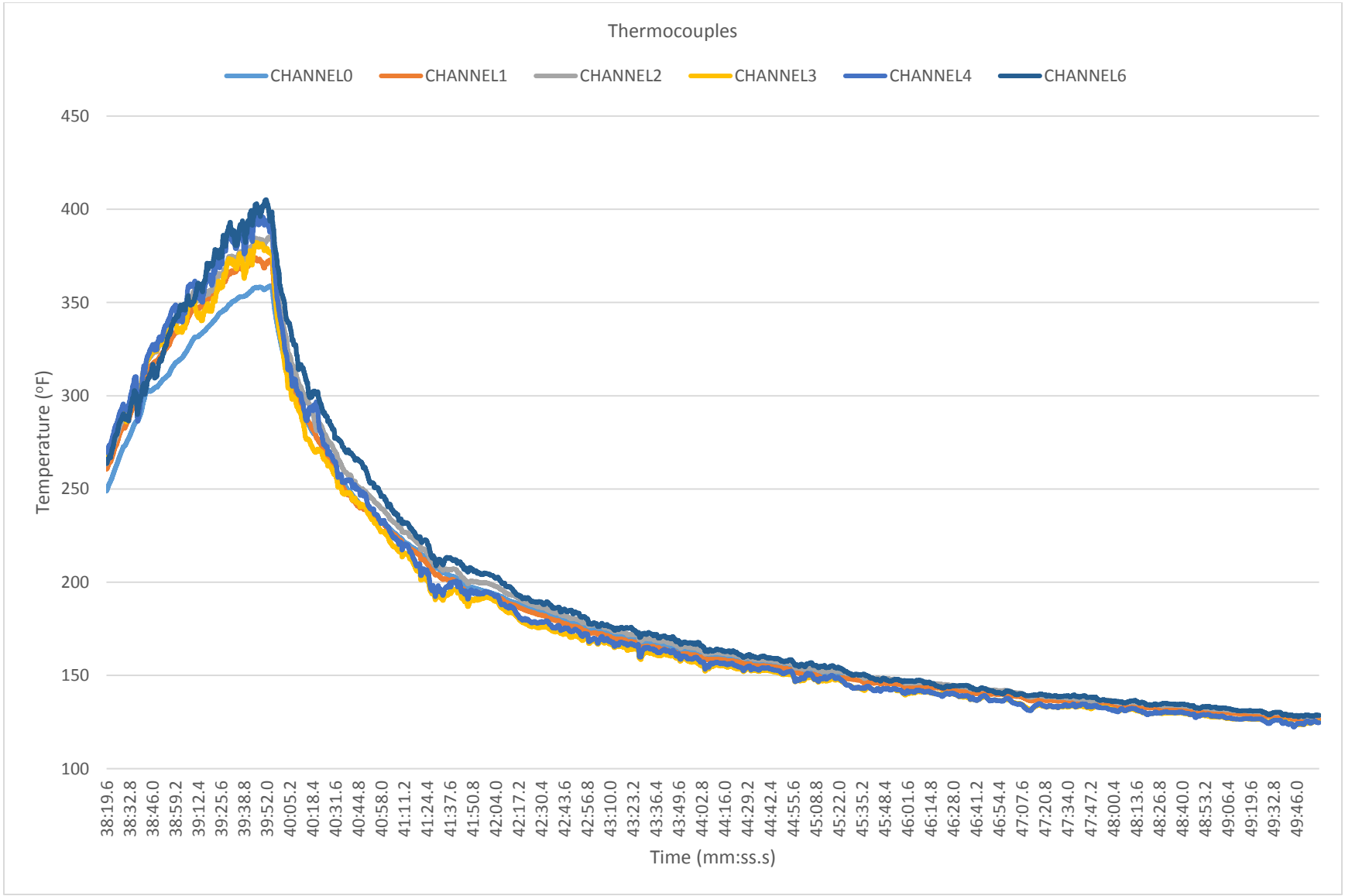

Figure A.14. Graph of Setup 1 Test 10 – High Temperature Long Duration Exposure

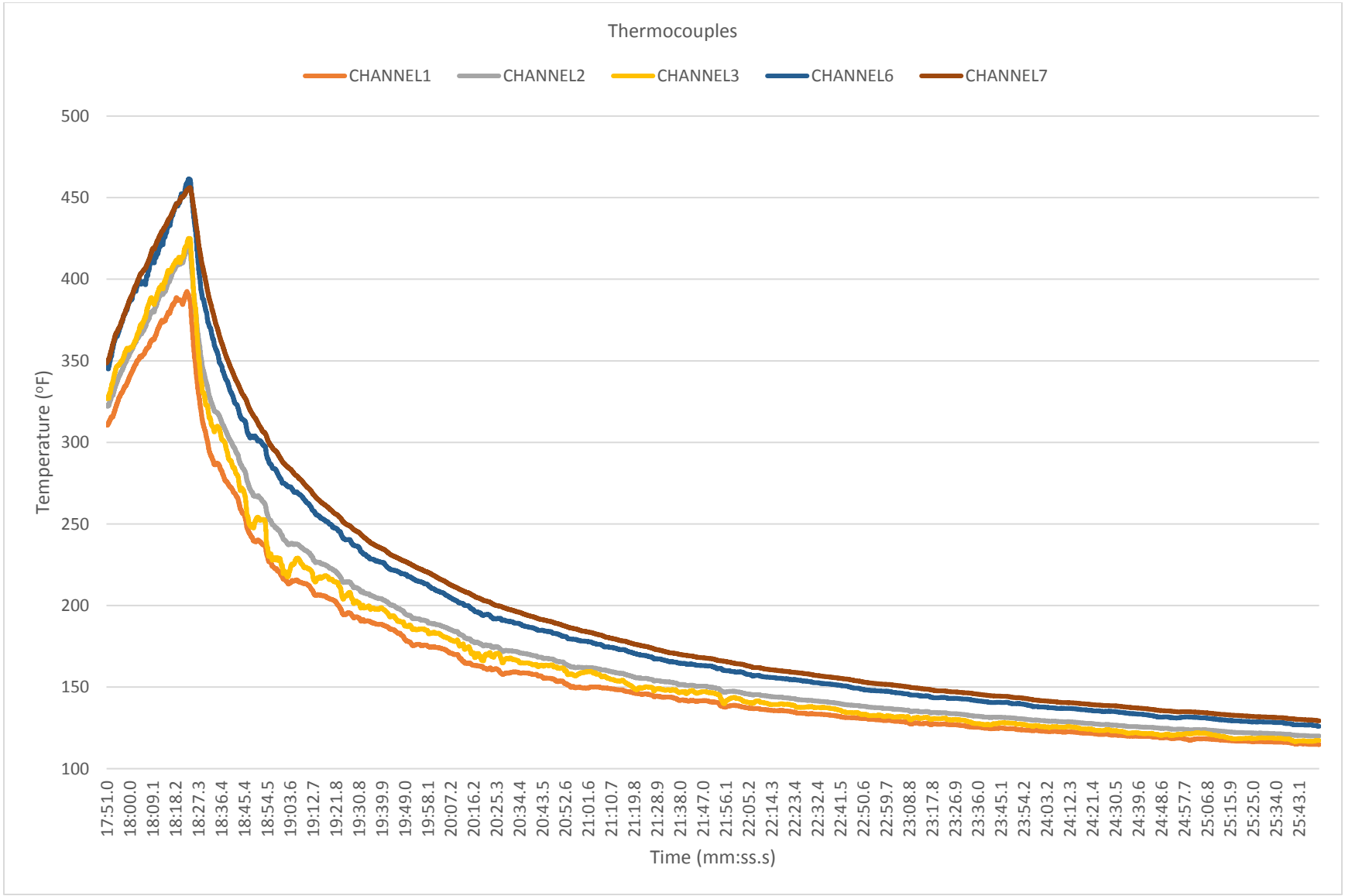

Figure A.15. Graph of Setup 1 Test 11 – High Temperature Long Duration Exposure

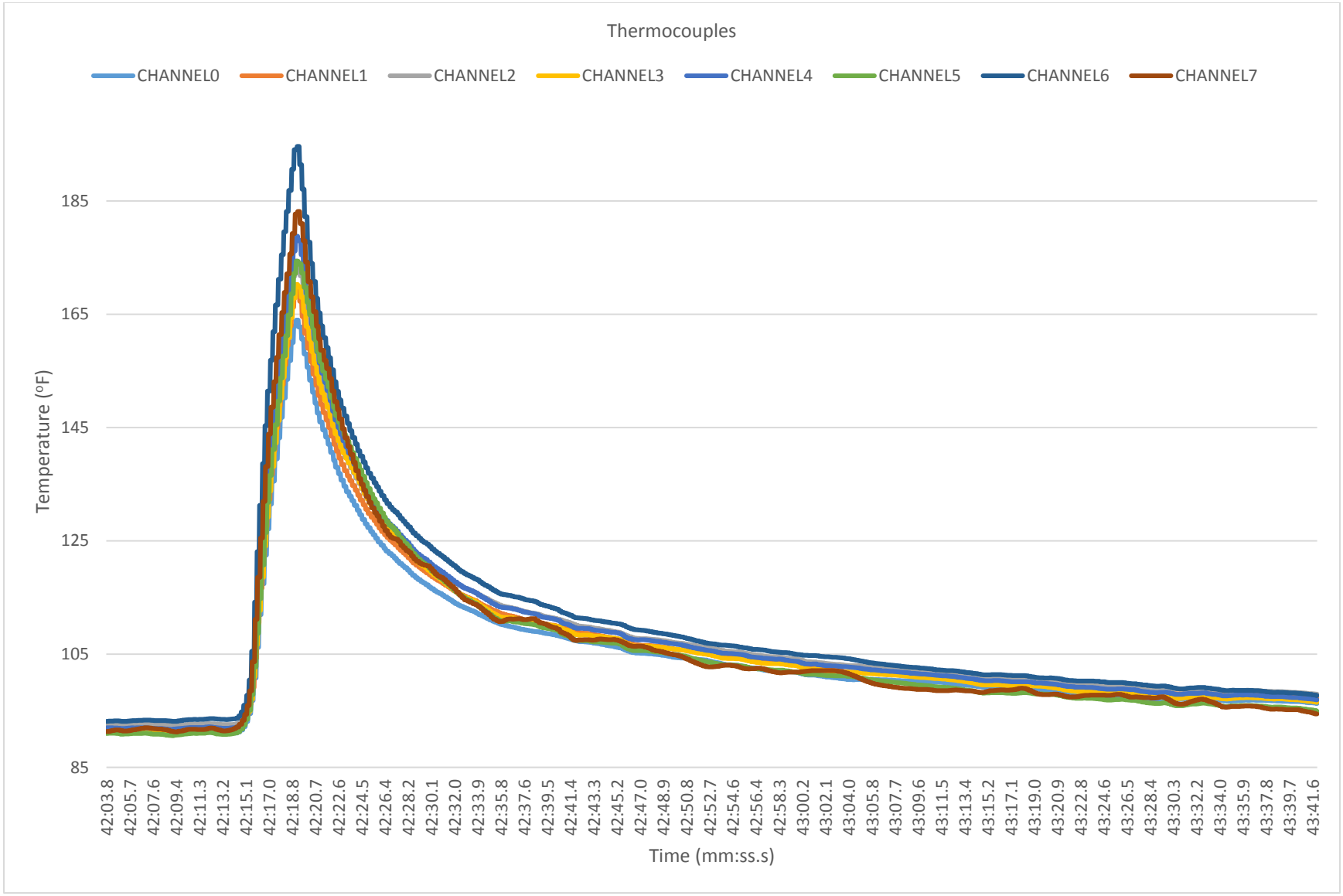

Figure A.16. Graph of Setup 1 Test 12 – Low Temperature Short Duration Exposure

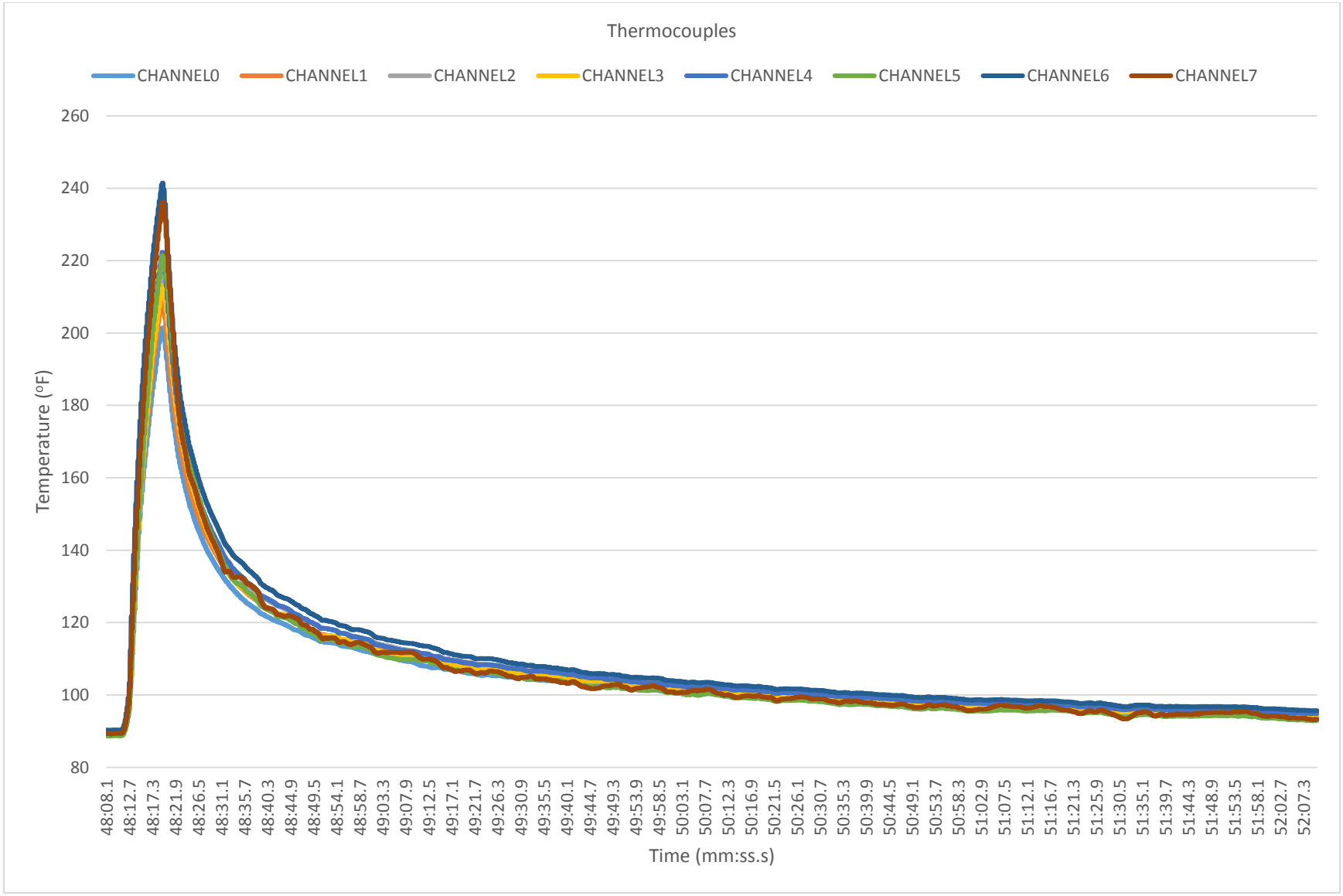

Figure A.17. Graph of Setup 1 Test 13 – Low Temperature Short Duration Exposure

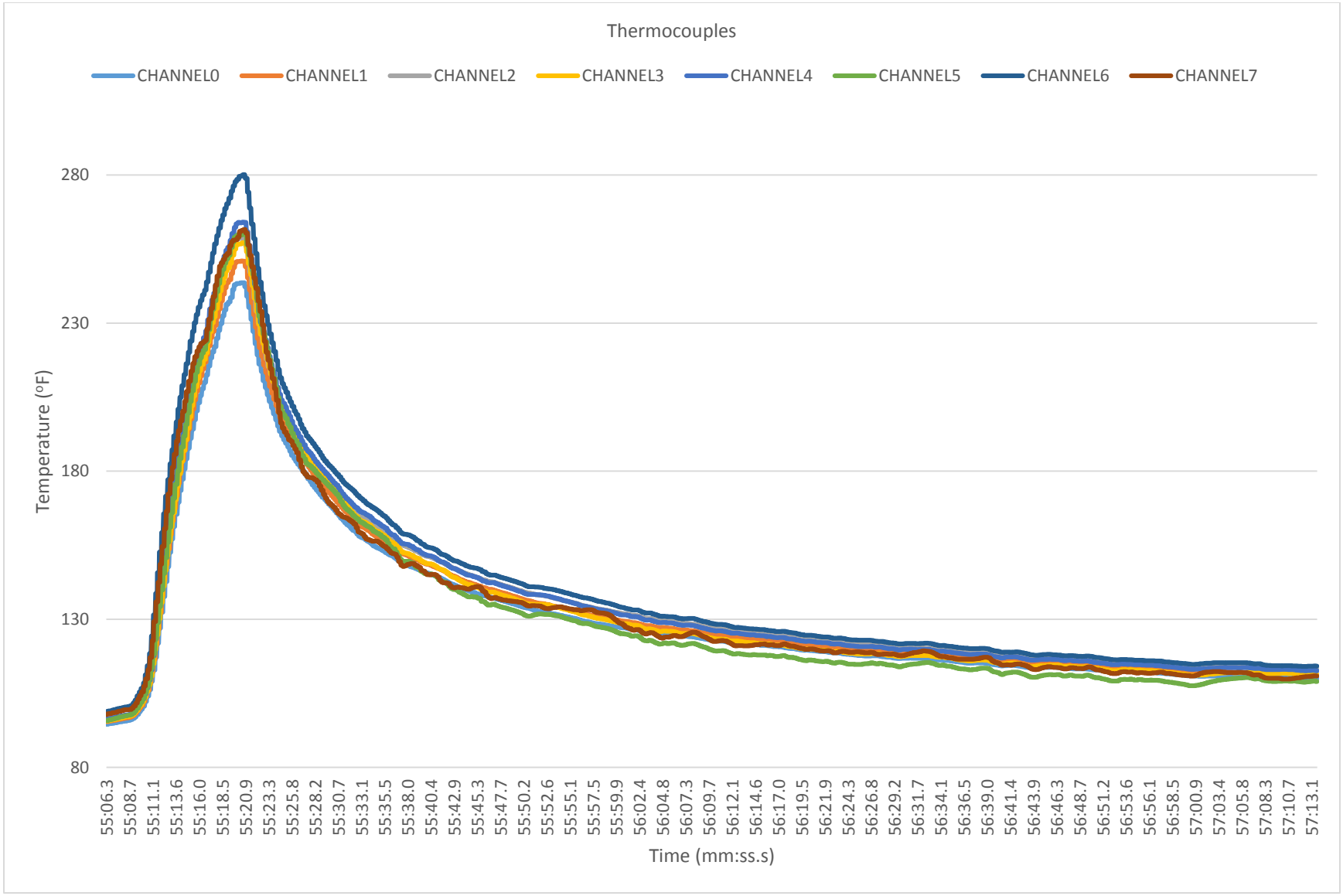

Figure A.18. Graph of Setup 1 Test 14 – Low Temperature Short Duration Exposure

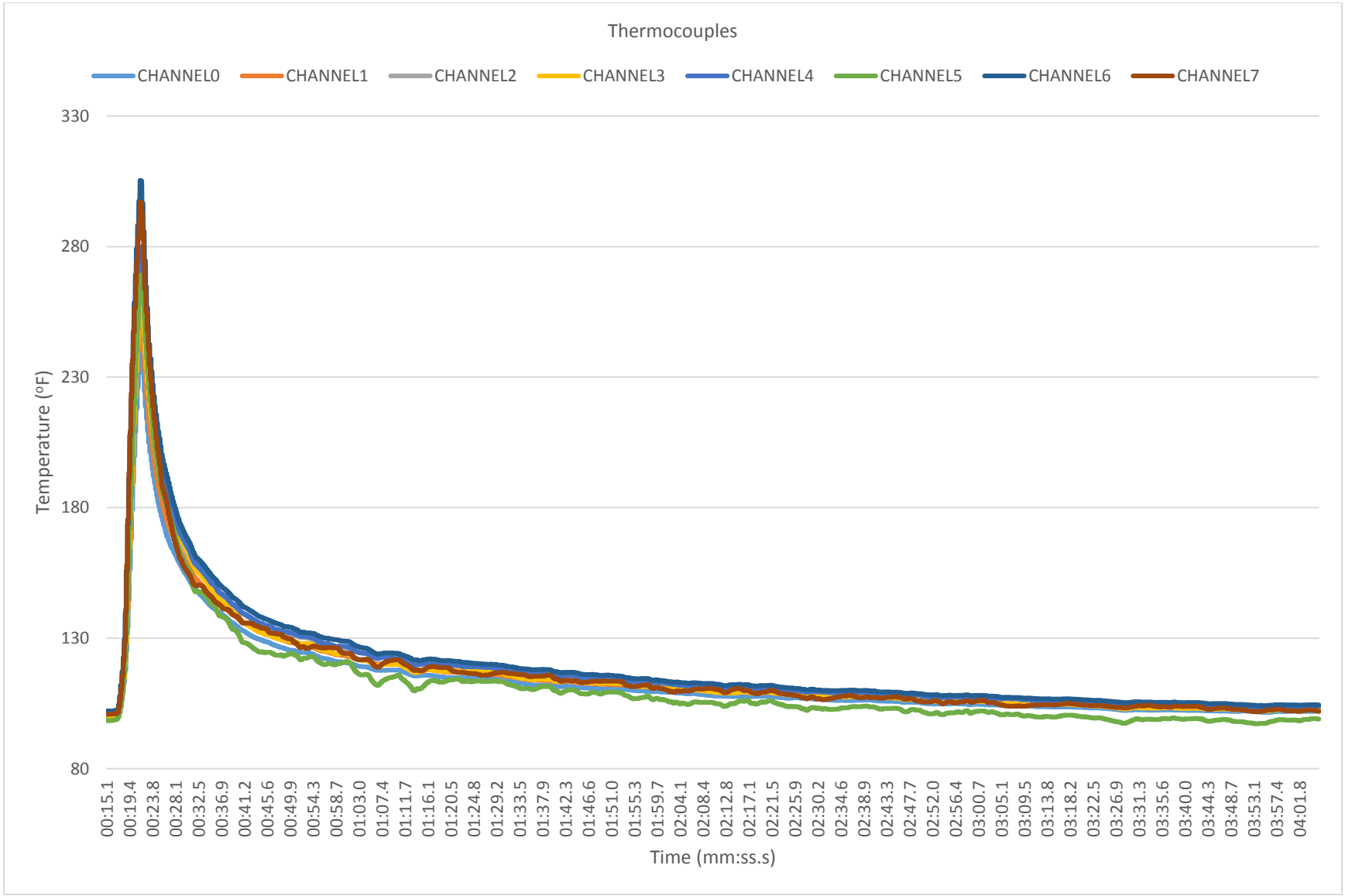

Figure A.19. Graph of Setup 1 Test 15 – Low Temperature Short Duration Exposure

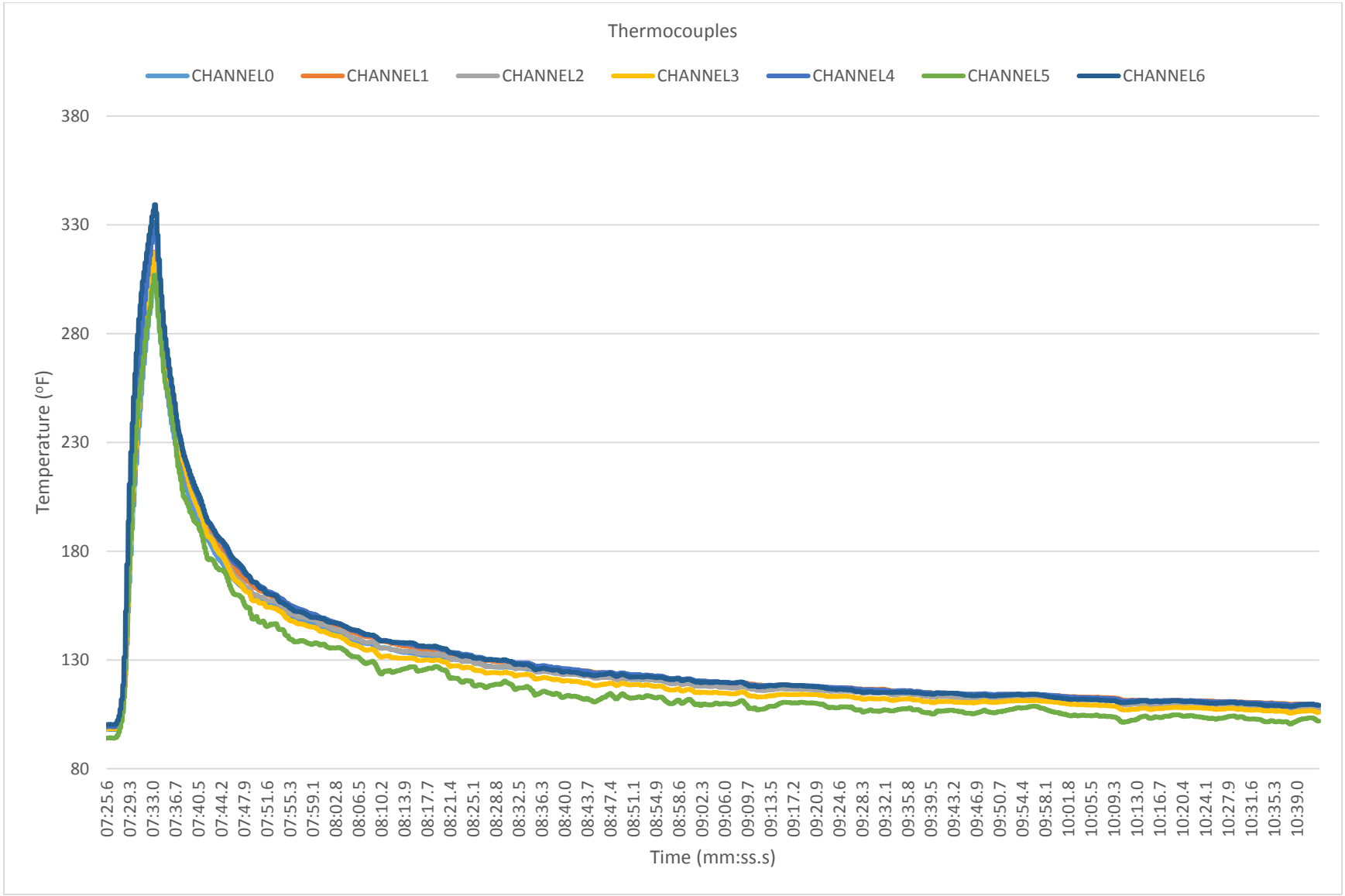

Figure A.20. Graph of Setup 1 Test 16 – High Temperature Short Duration Exposure

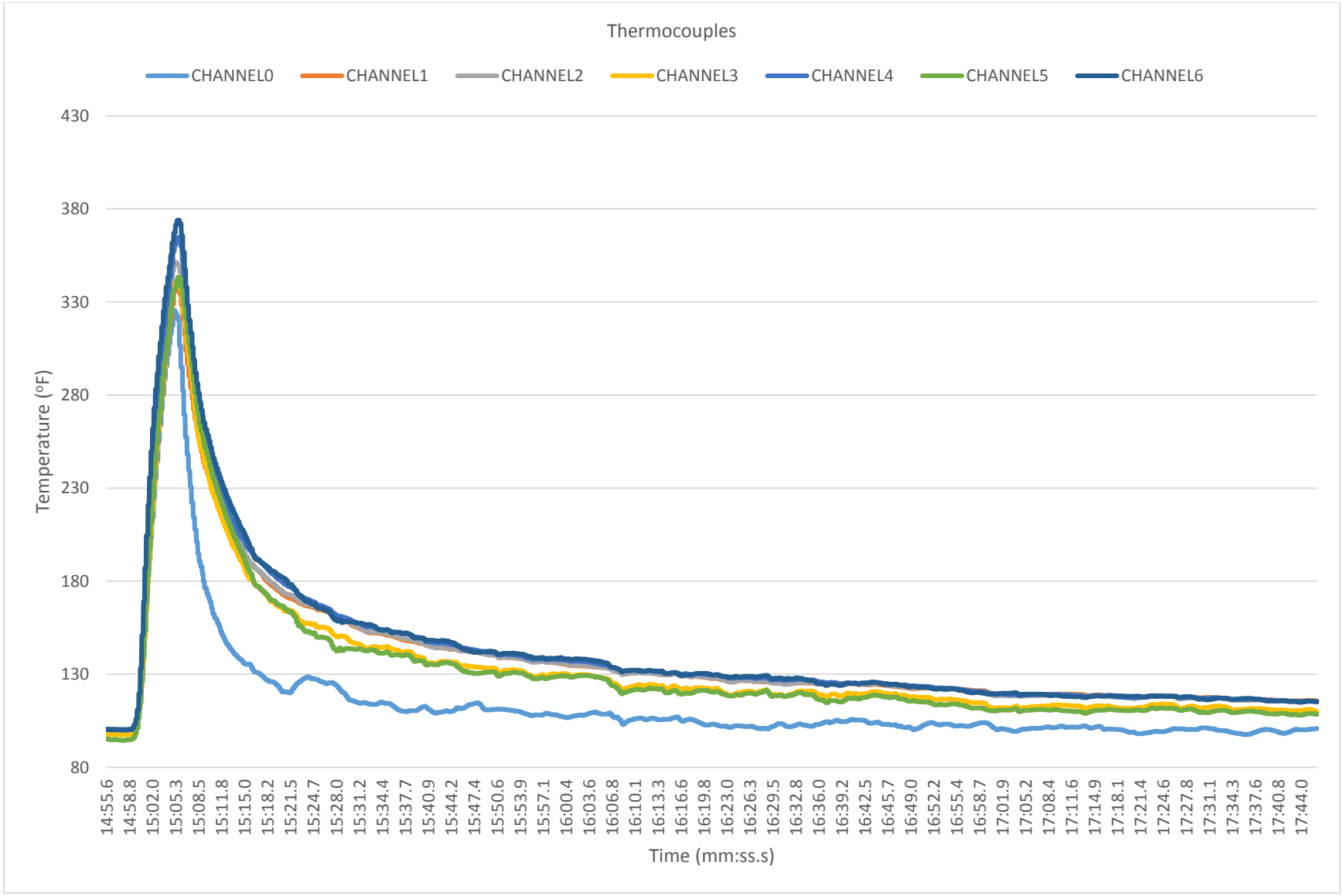

Figure A.21. Graph of Setup 1 Test 17 – High Temperature Short Duration Exposure

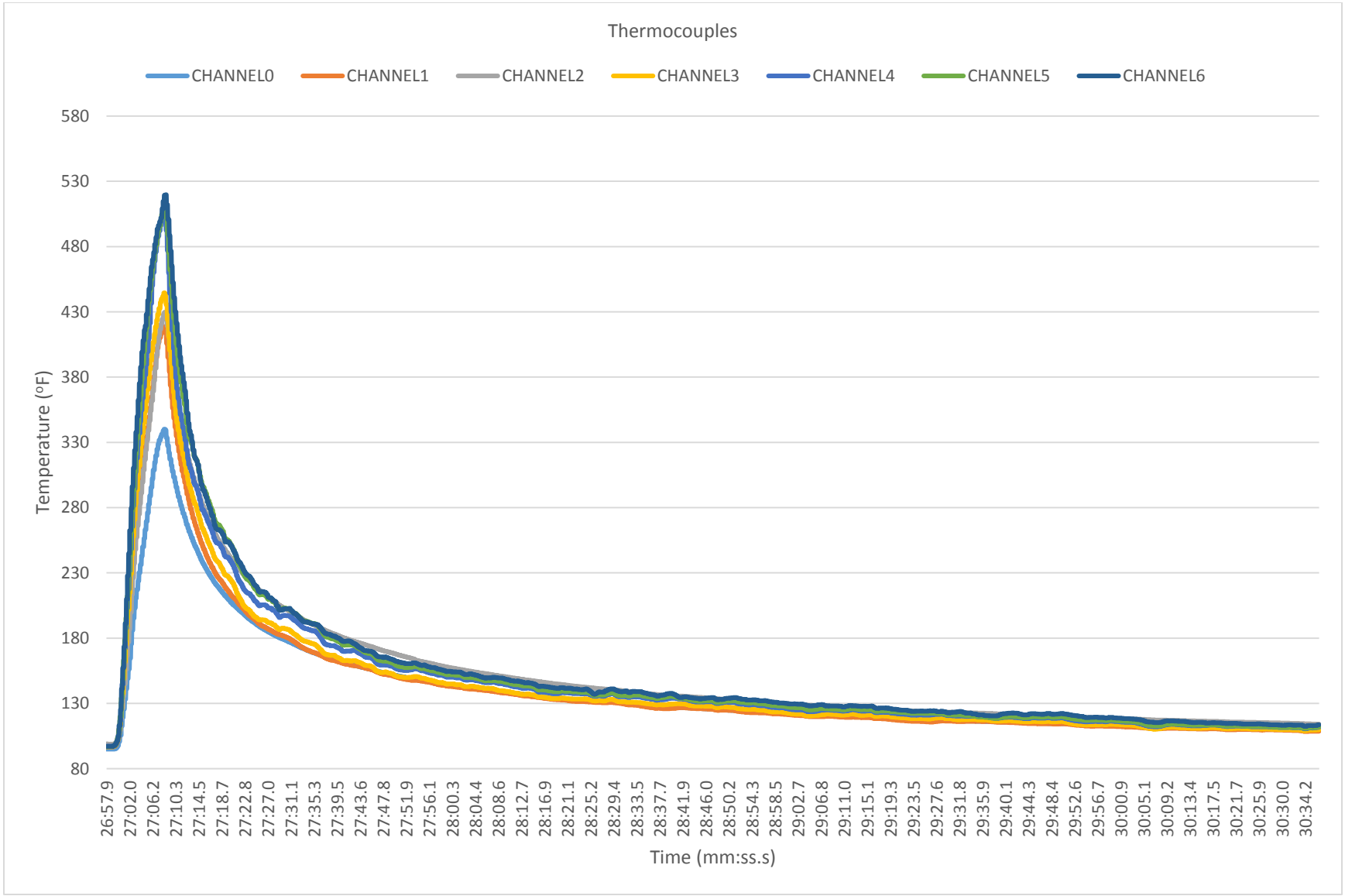

Figure A.22. Graph of Setup 1 Test 18 – High Temperature Short Duration Exposure

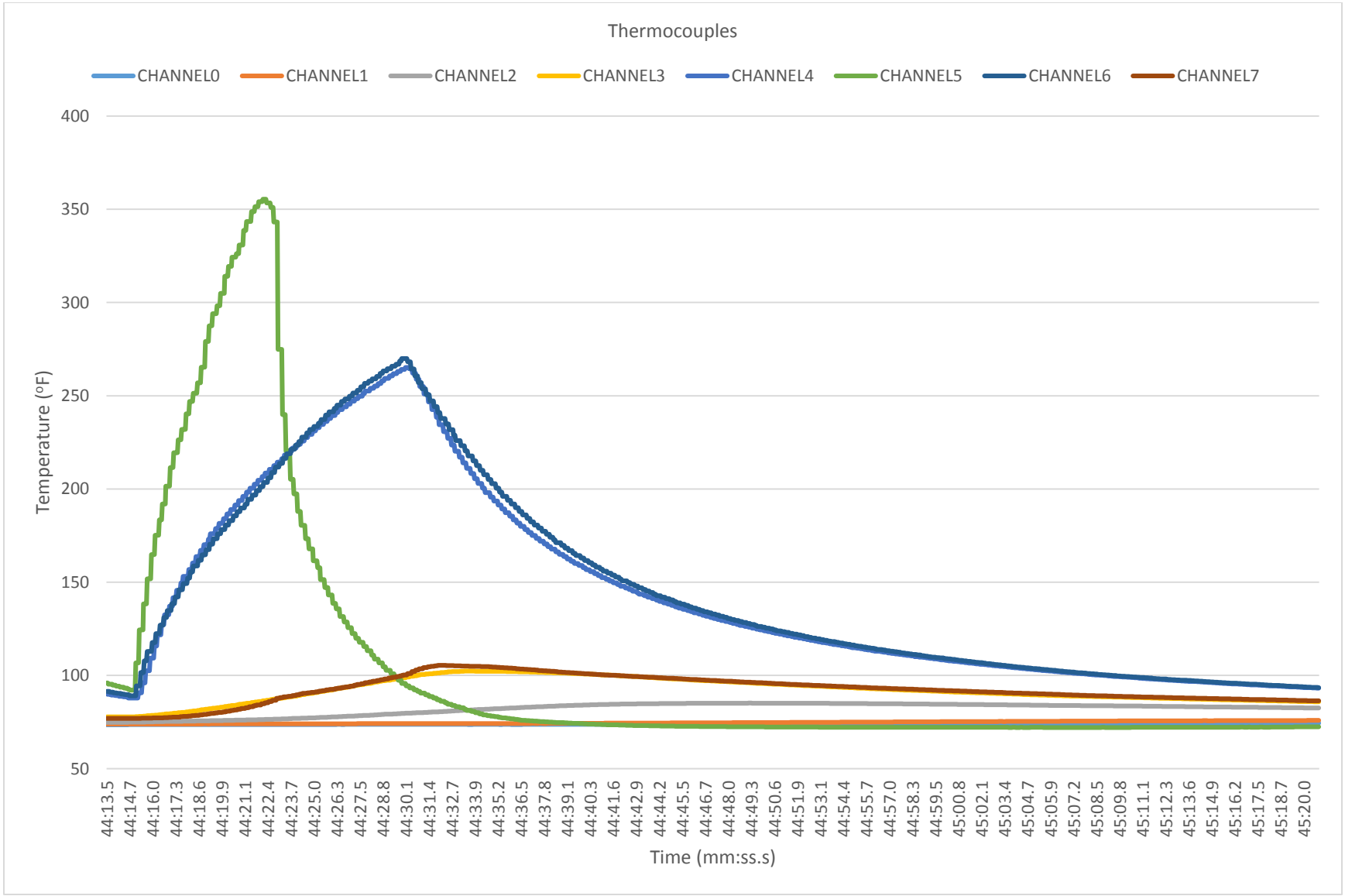

Figure A.23. Graph of Setup 2 Mock Test 1

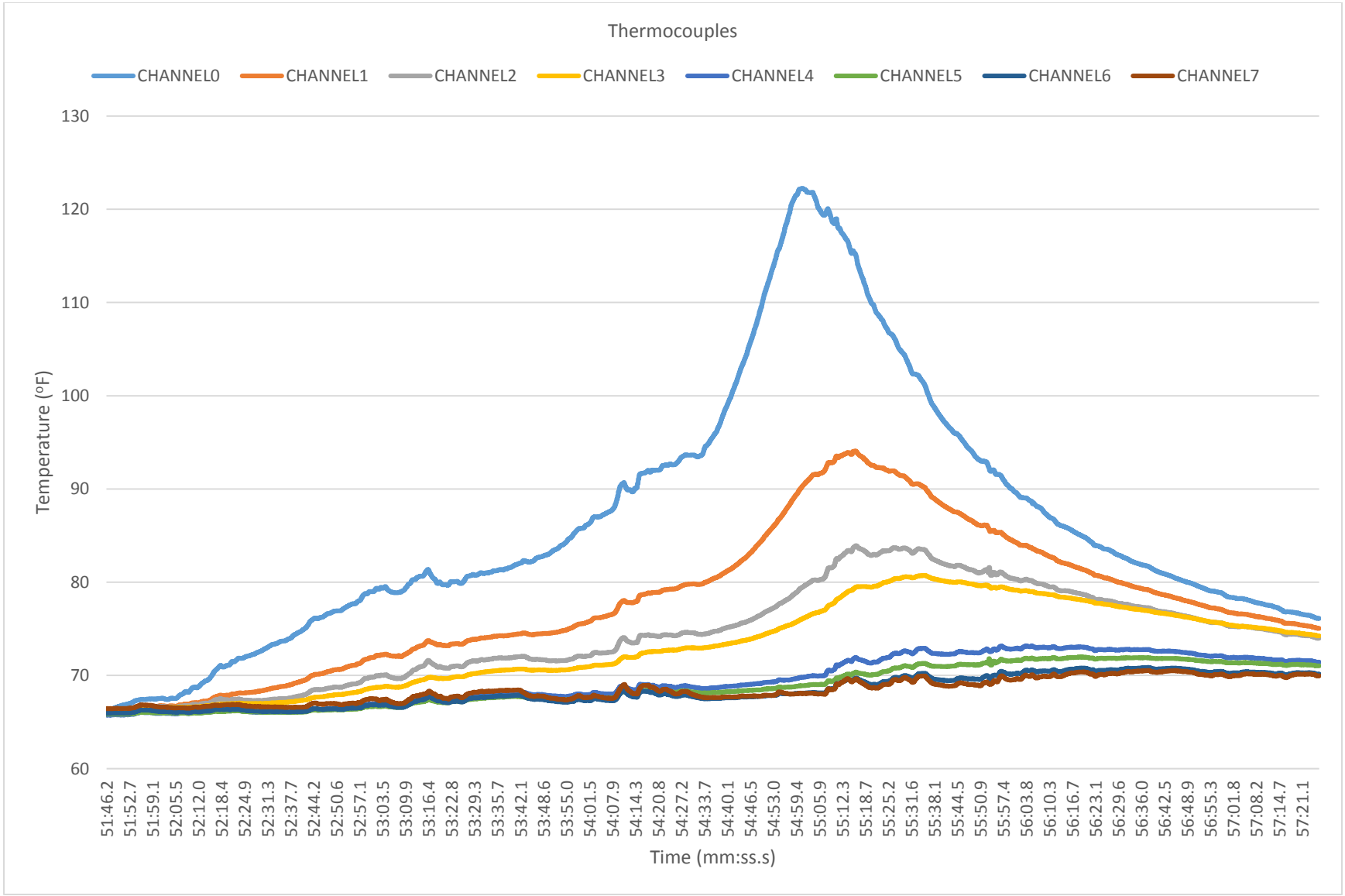

Figure A.24. Graph of Setup 2 Test 1 – Low Temperature Long Duration Exposure

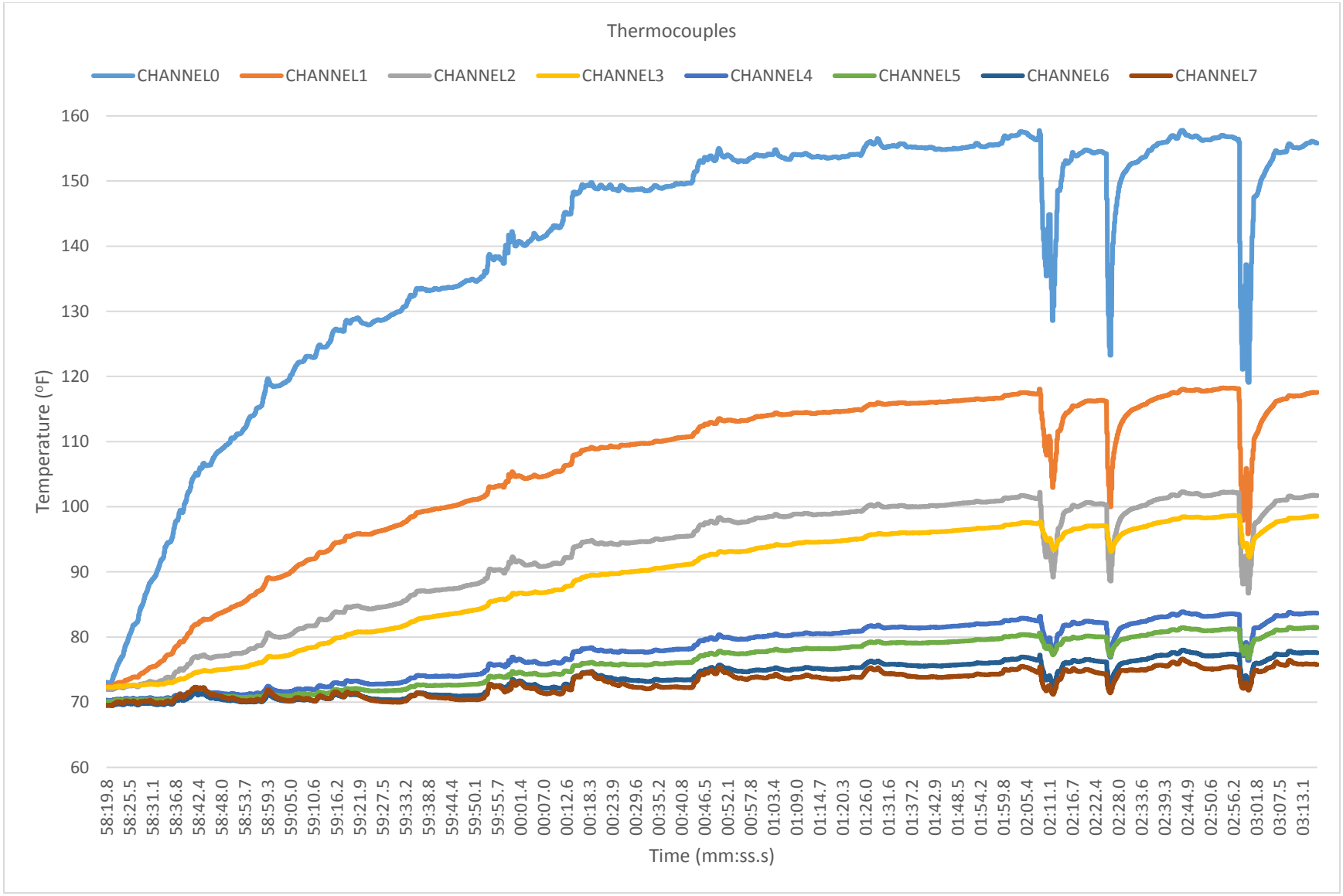

Figure A.25. Graph of Setup 2 Test 2 – Low Temperature Long Duration Exposure

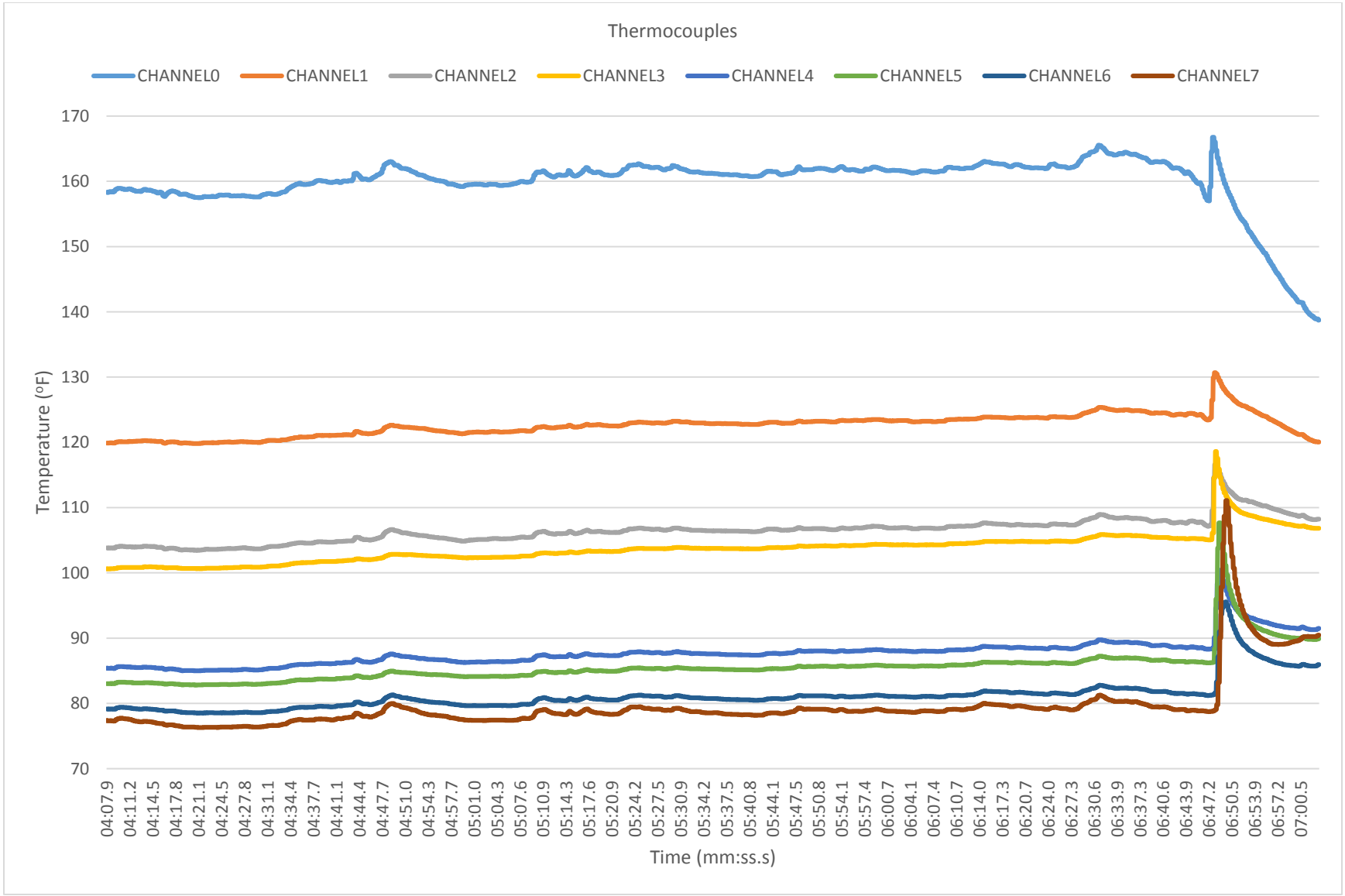

Figure A.26. Graph of Setup 2 Test 3 – Low Temperature Long Duration Exposure

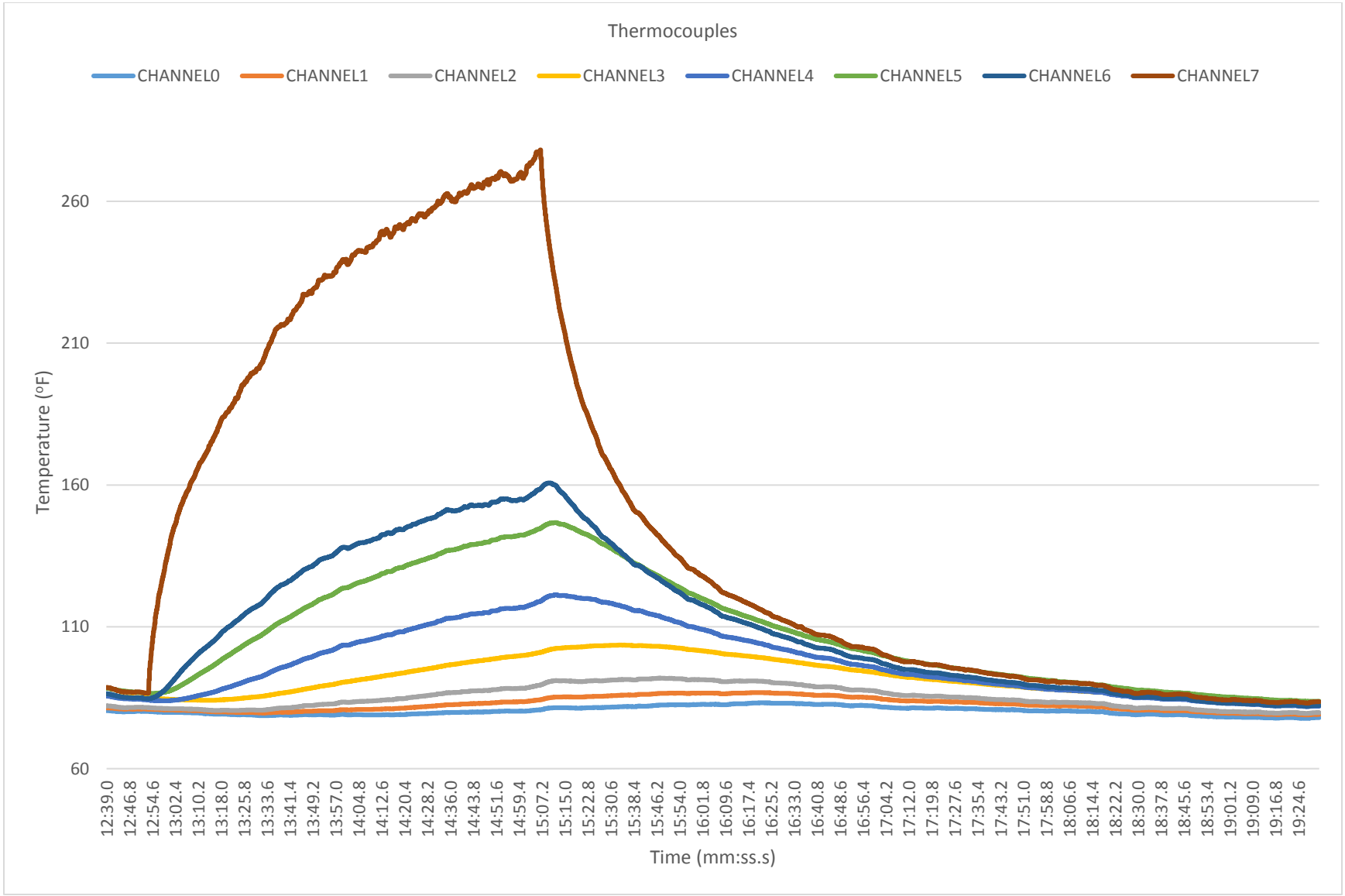

Figure A.27. Graph of Setup 2 Test 4 – High Temperature Long Duration Exposure

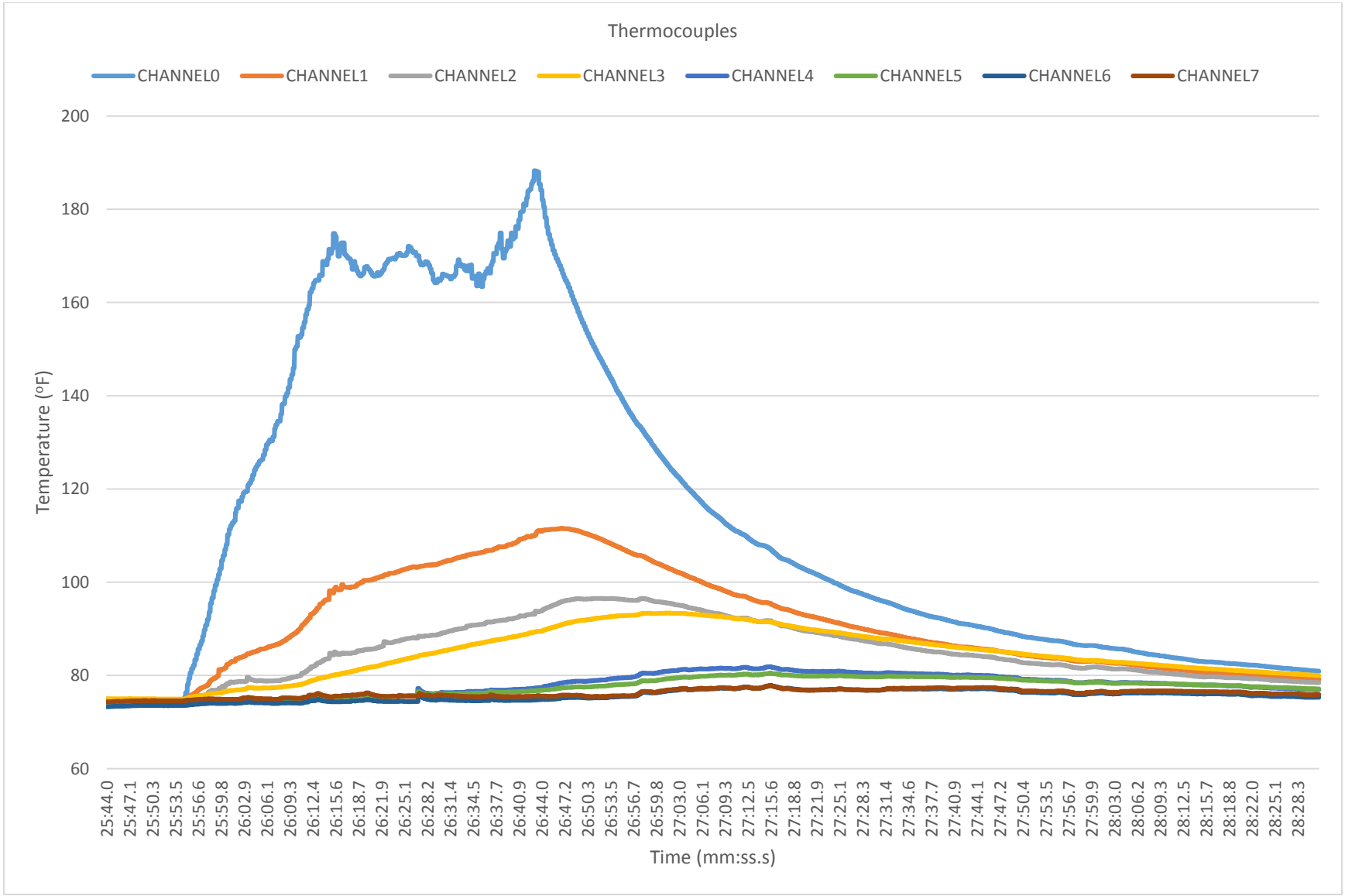

Figure A.28. Graph of Setup 2 Test 5 – High Temperature Long Duration Exposure

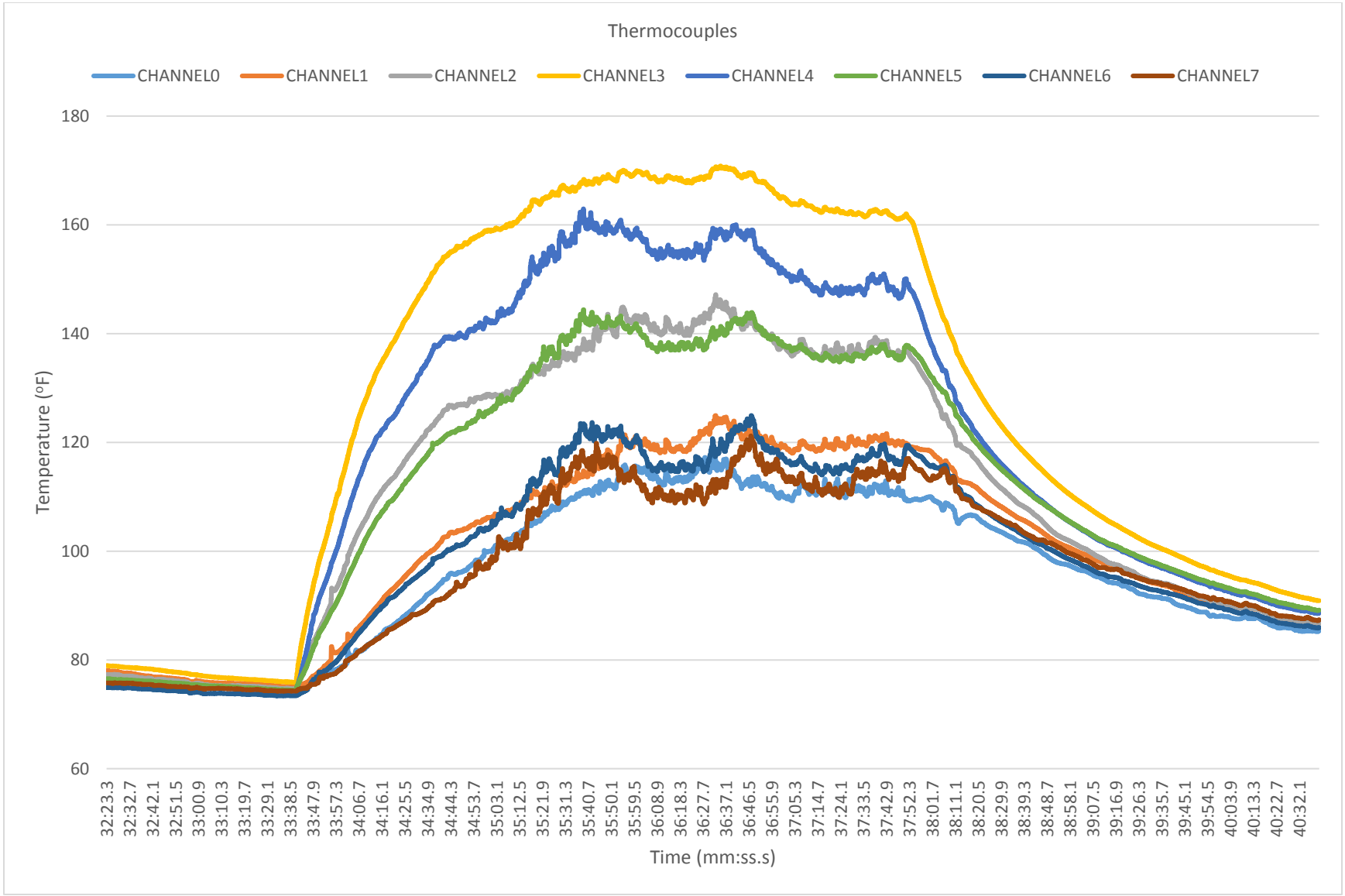

Figure A.29. Graph of Setup 2 Test 7 – Low Temperature Long Duration Exposure

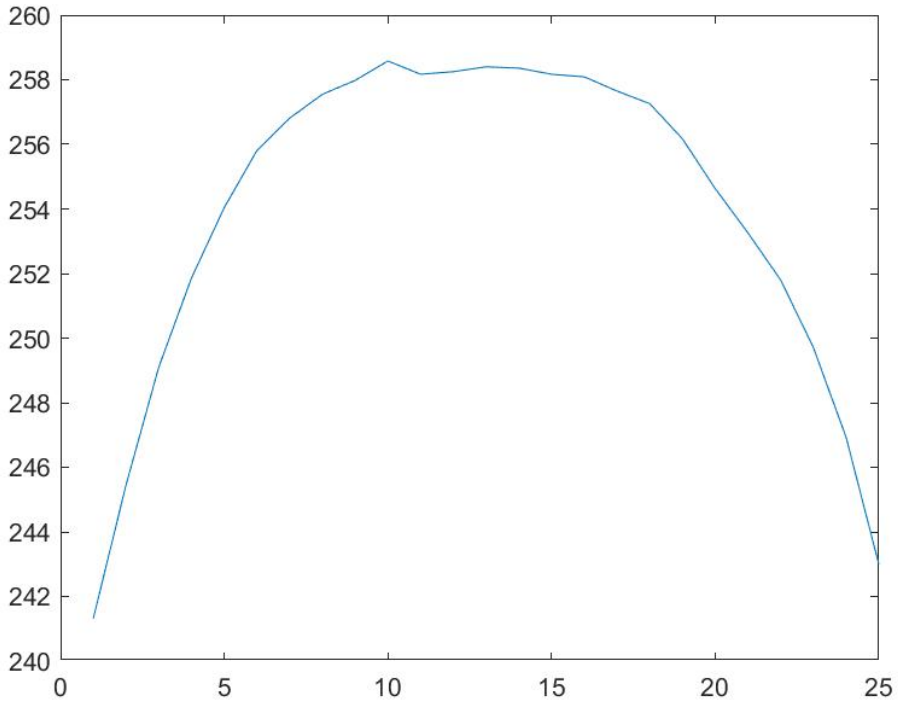

Figure A.30. Graph of Setup 3 Replication 1 Test 1 – Single Cross Section

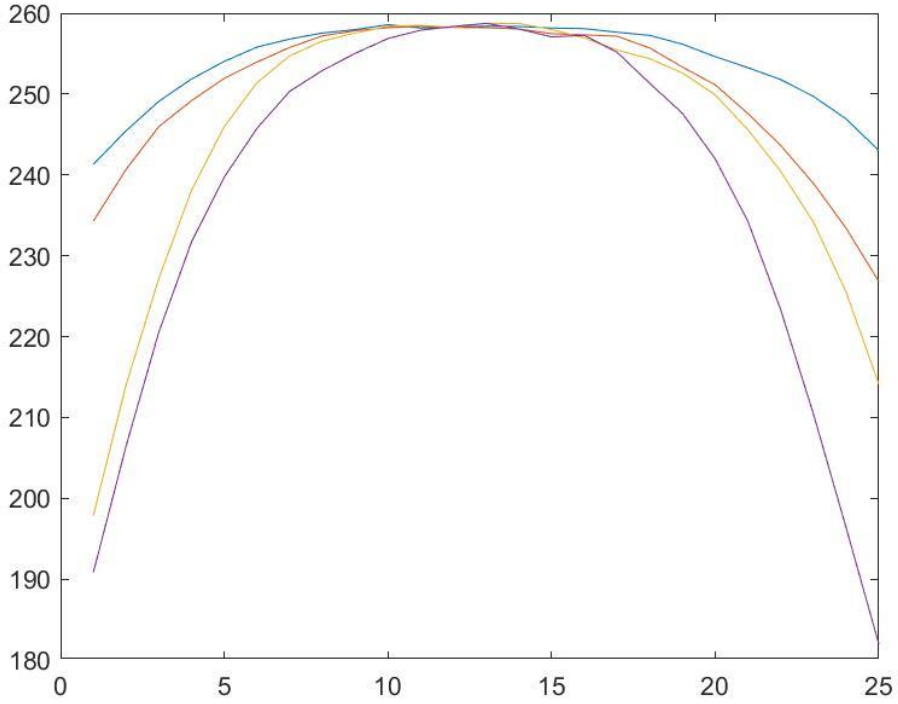

Figure A.31. Graph of Setup 3 Replication 1 Test 1 – Multiple Cross Sections

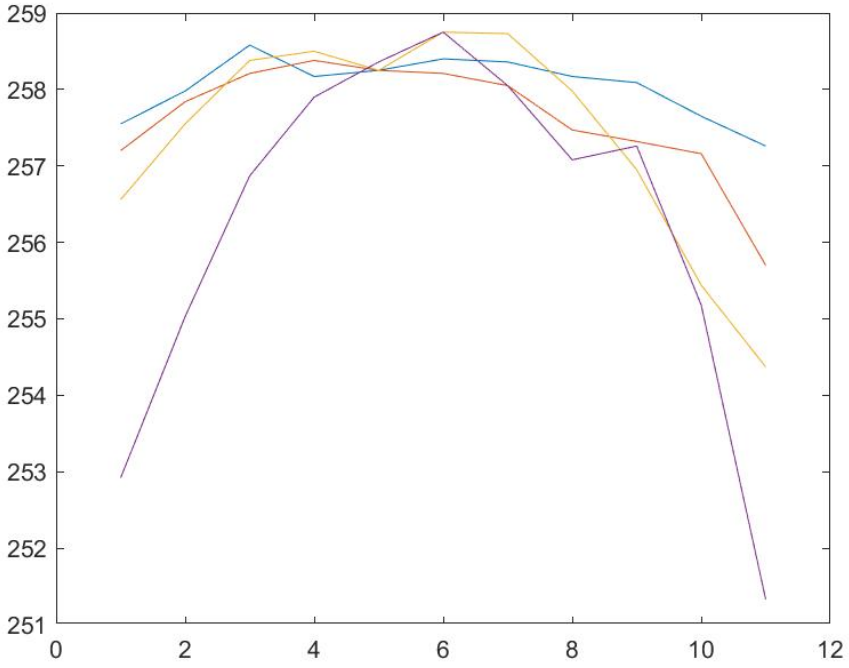

Figure A.32. Magnified Section of Graph of Setup 3 Replication 1 Test 1 – Multiple Cross Sections

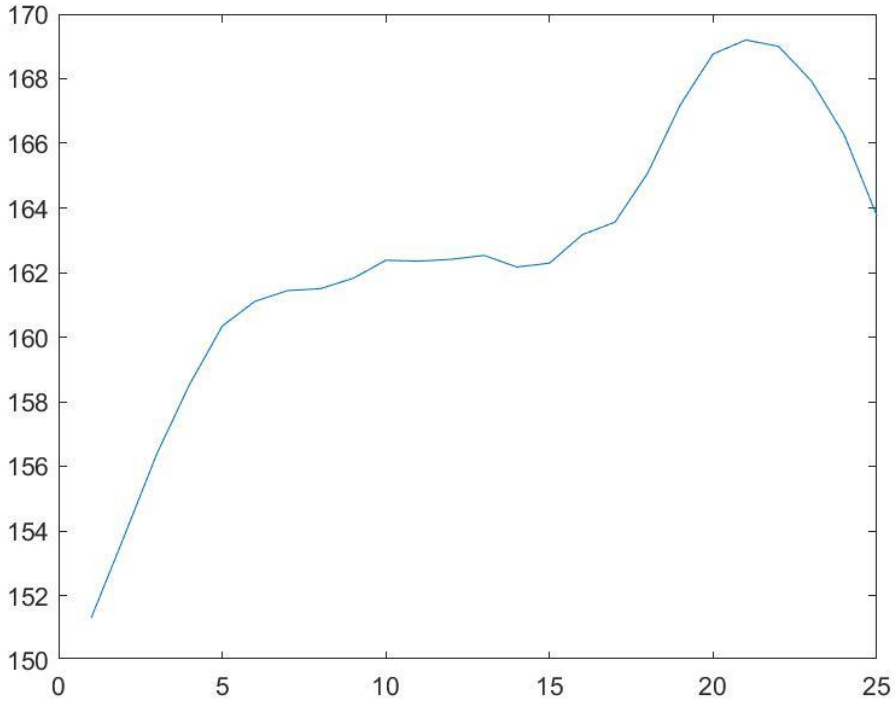

Figure A.33. Graph of Setup 3 Replication 1 Test 2 – Single Cross Section

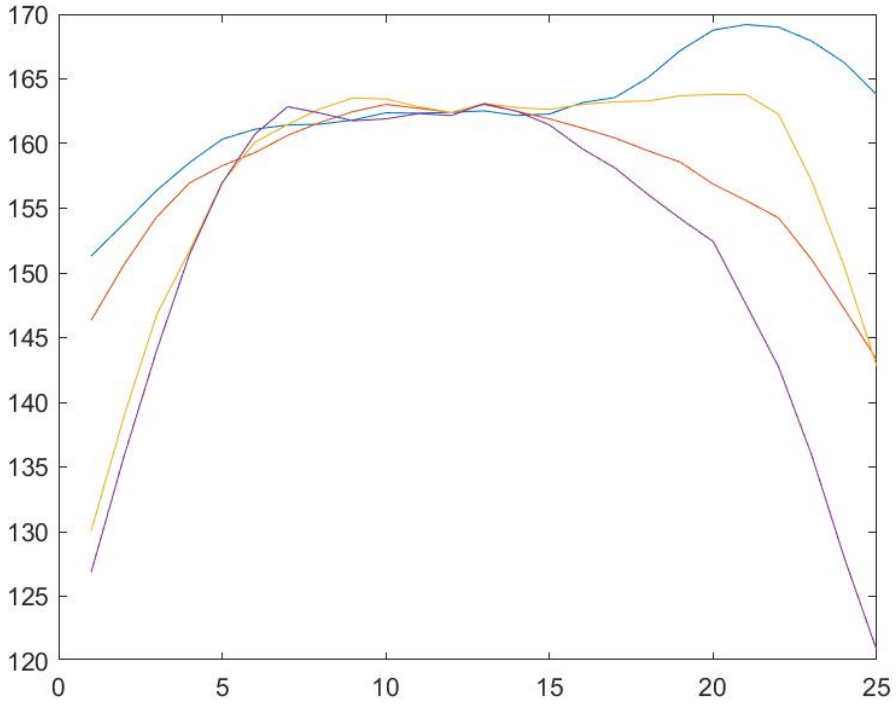

Figure A.34. Graph of Setup 3 Replication 1 Test 2 – Multiple Cross Sections

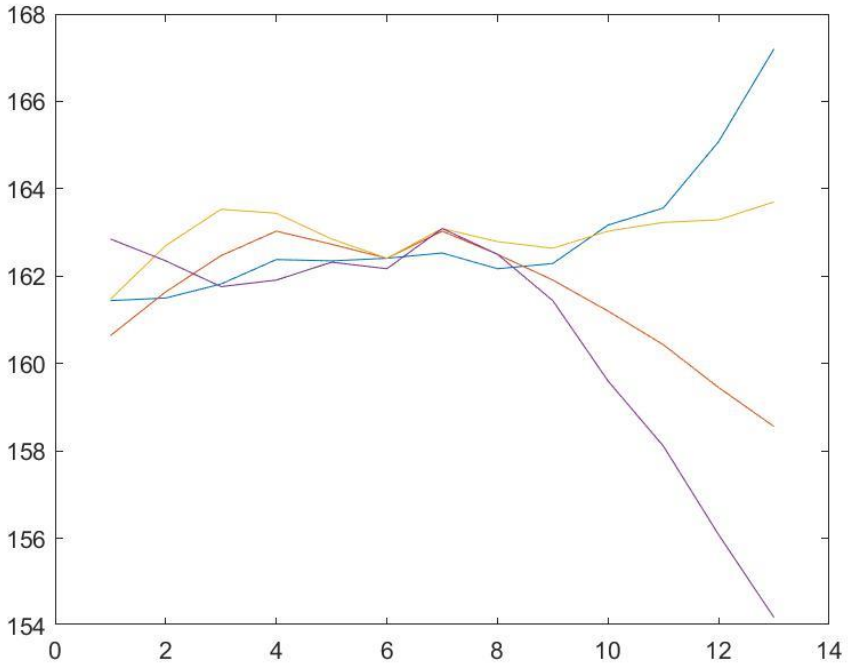

Figure A.35. Magnified Section of Graph of Setup 3 Replication 1 Test 2 – Multiple Cross Sections

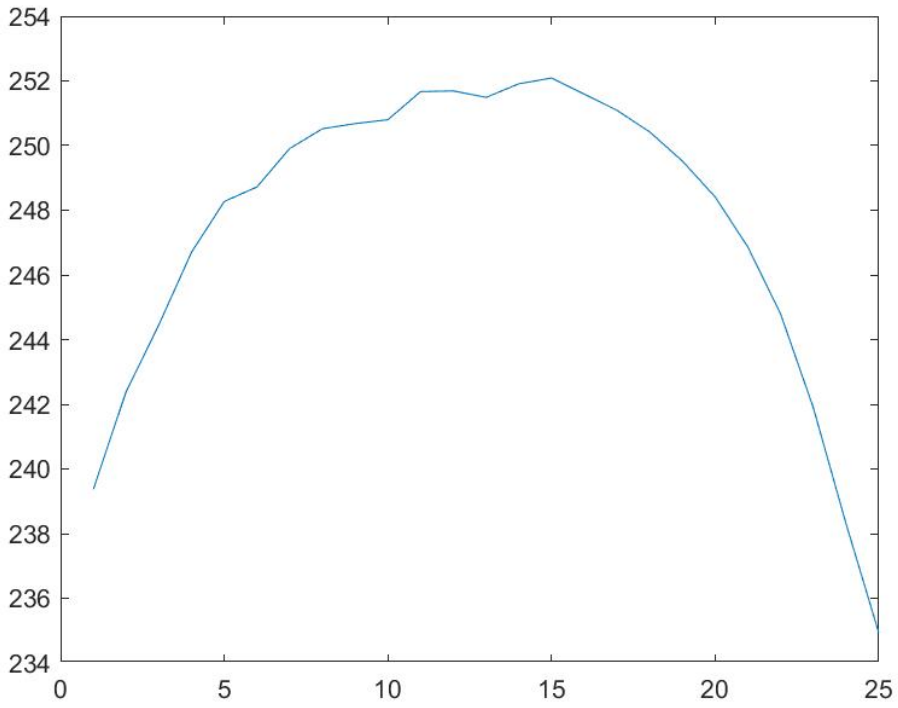

Figure A.36. Graph of Setup 3 Replication 1 Test 3 – Single Cross Section

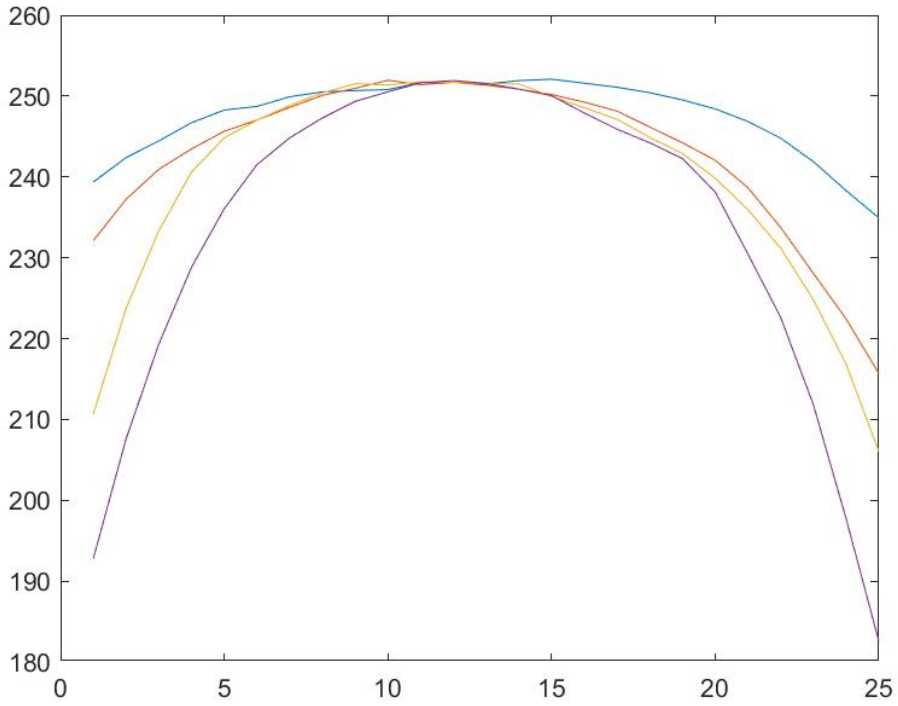

Figure A.37. Graph of Setup 3 Replication 1 Test 3 – Multiple Cross Sections

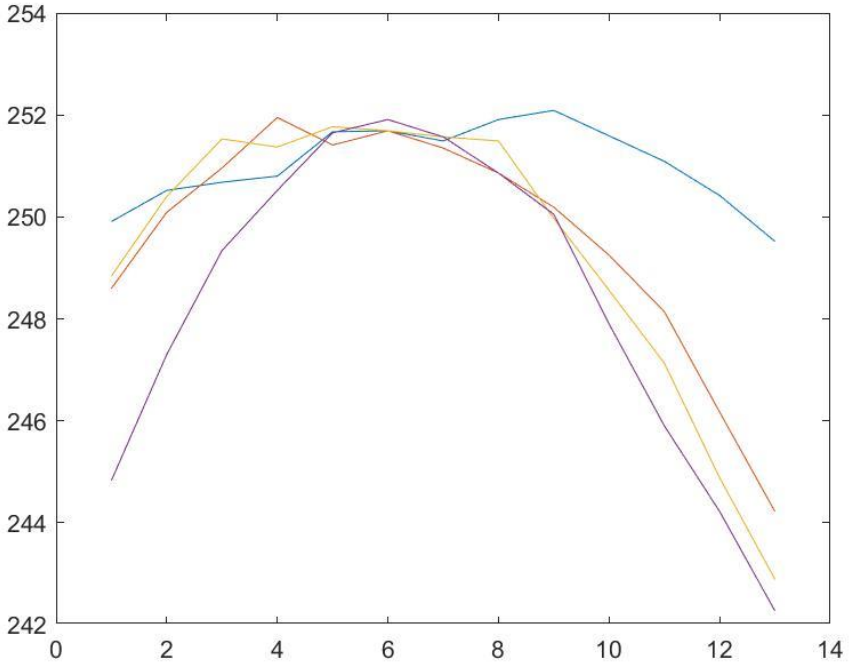

Figure A.38. Magnified Section of Graph of Setup 3 Replication 1 Test 3 – Multiple Cross Sections

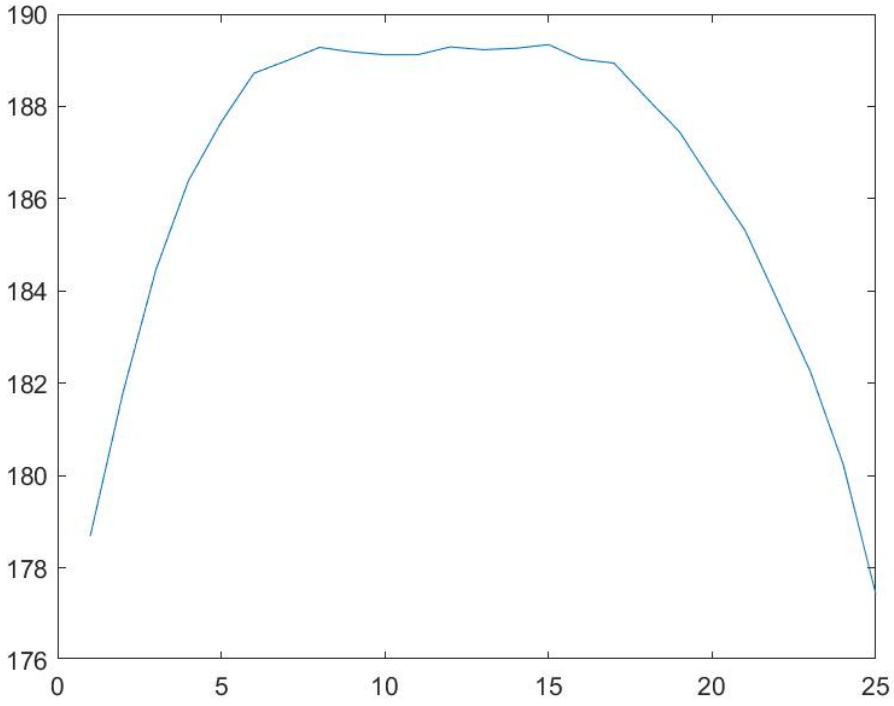

Figure A.39. Graph of Setup 3 Replication 1 Test 4 – Single Cross Section

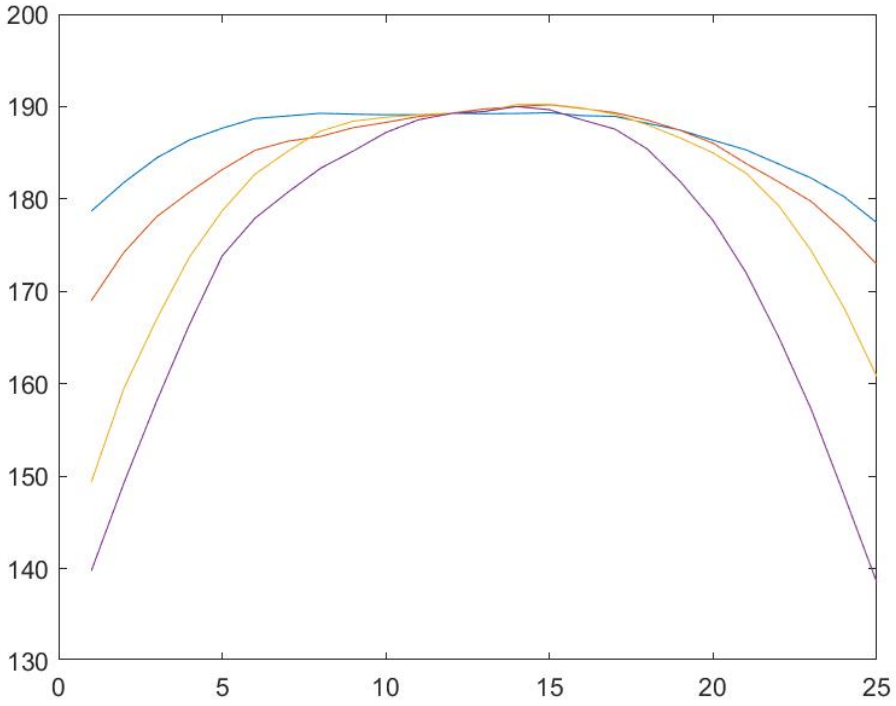

Figure A.40. Graph of Setup 3 Replication 1 Test 4 – Multiple Cross Sections

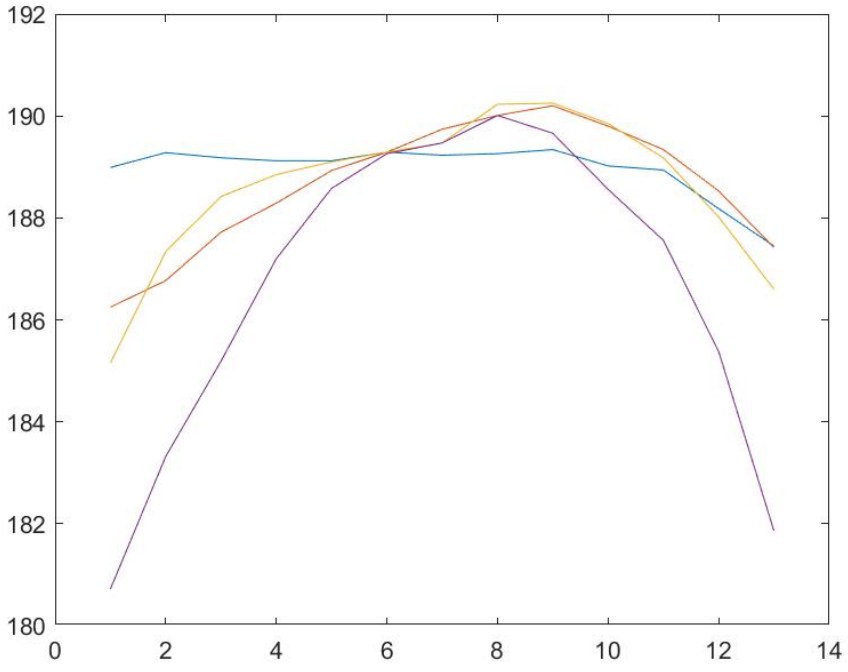

Figure A.41. Magnified Section of Graph of Setup 3 Replication 1 Test 4 – Multiple Cross Sections

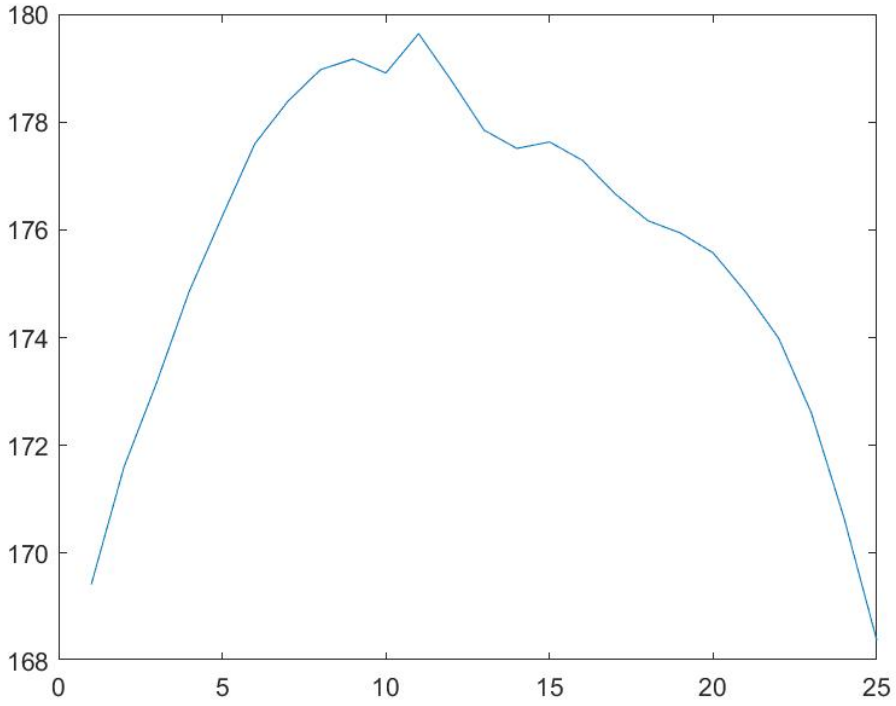

Figure A.42. Graph of Setup 3 Replication 1 Test 5 – Single Cross Section

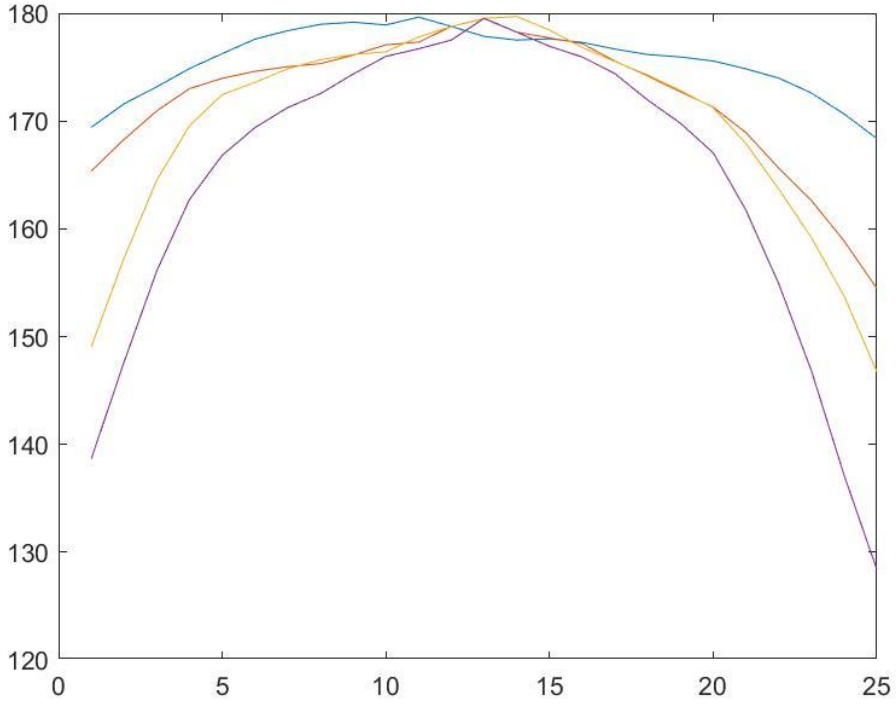

Figure A.43. Graph of Setup 3 Replication 1 Test 5 – Multiple Cross Sections

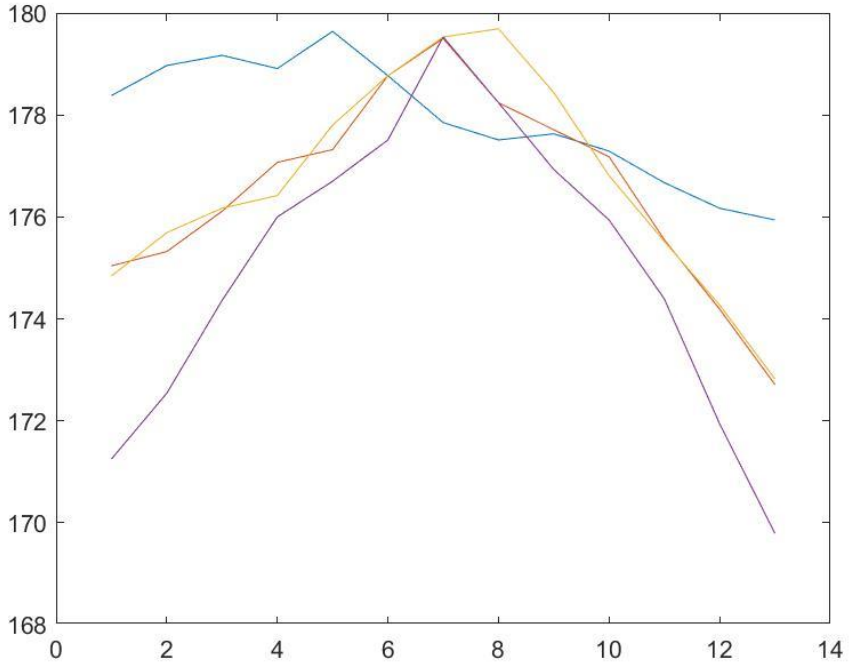

Figure A.44. Magnified Section of Graph of Setup 3 Replication 1 Test 5 – Multiple Cross Sections

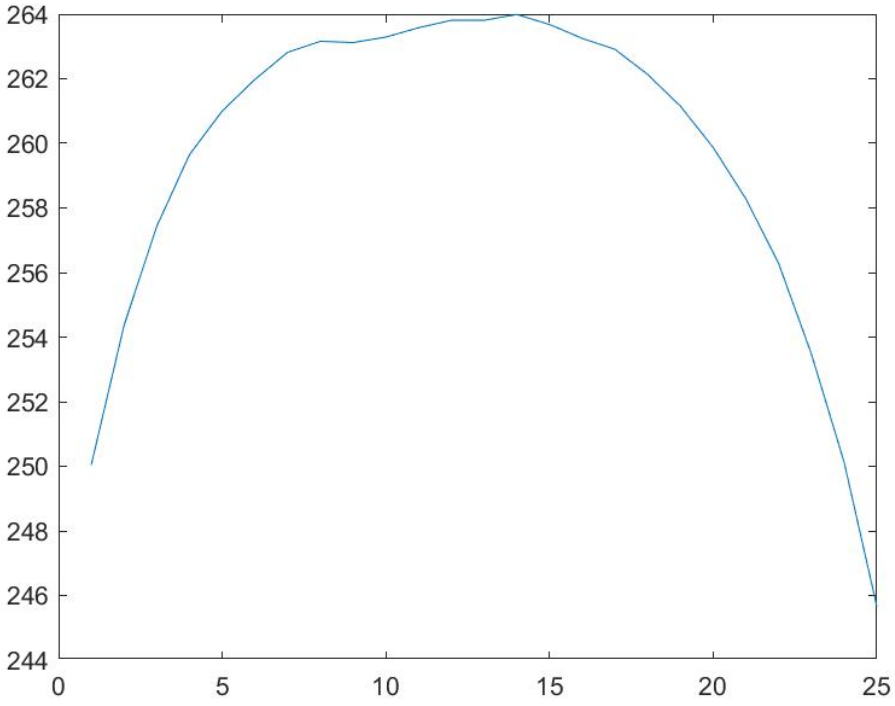

Figure A.45. Graph of Setup 3 Replication 1 Test 6 – Single Cross Section

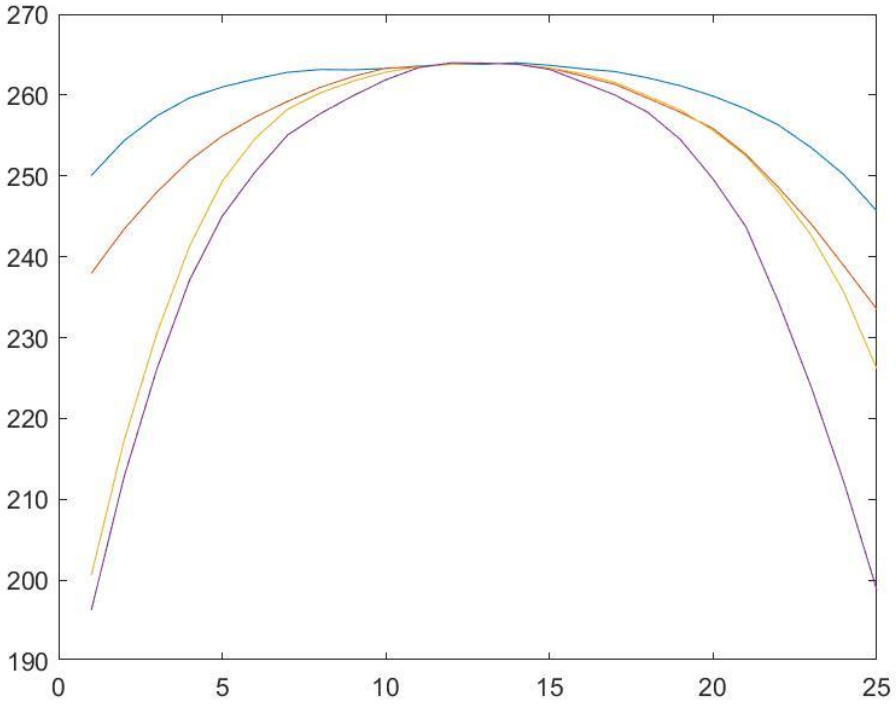

Figure A.46. Graph of Setup 3 Replication 1 Test 6 – Multiple Cross Sections

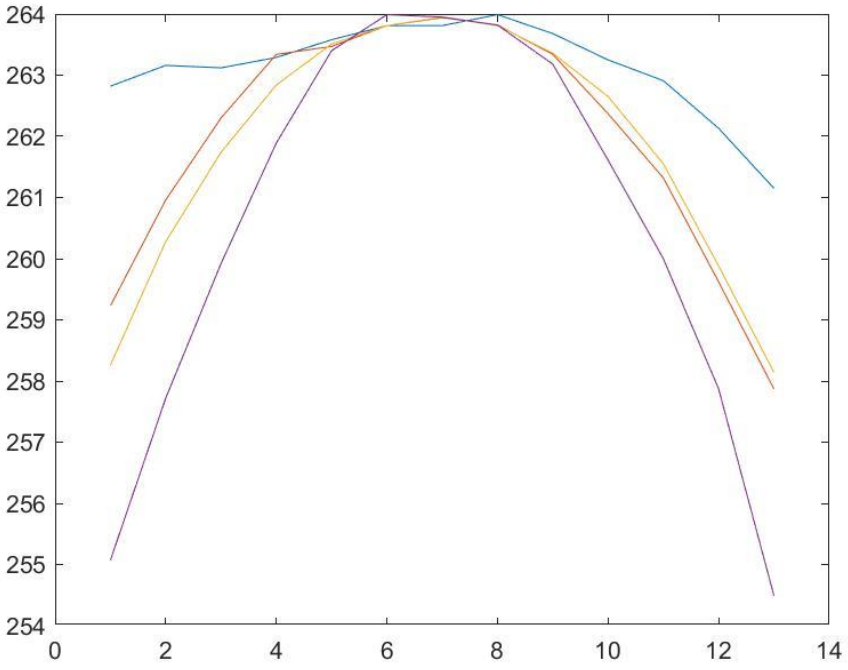

Figure A.47. Magnified Section of Graph of Setup 3 Replication 1 Test 6 – Multiple Cross Sections

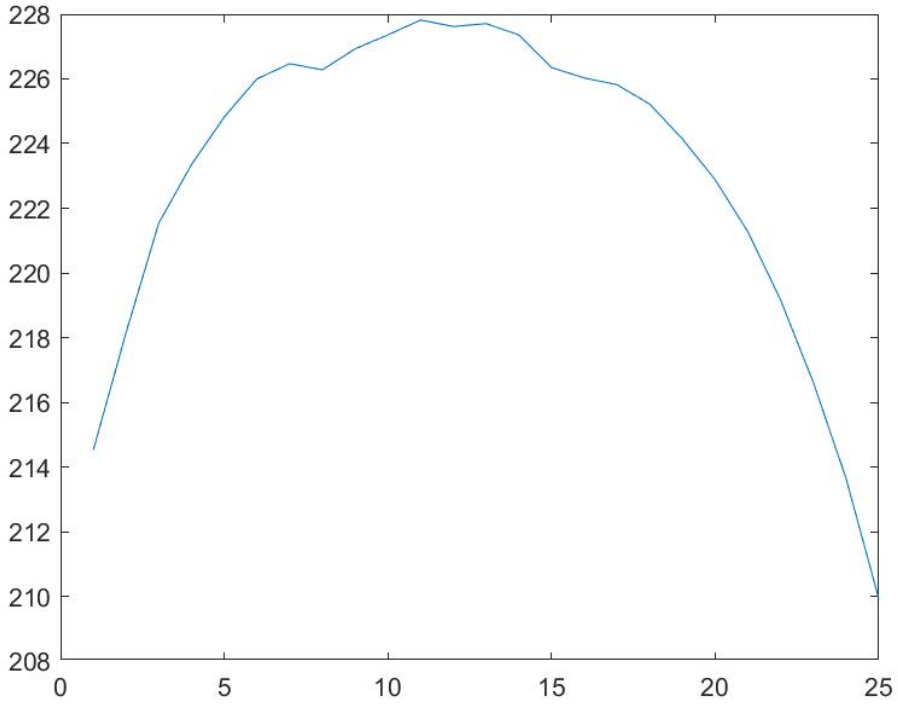

Figure A.48. Graph of Setup 3 Replication 1 Test 7 – Single Cross Section

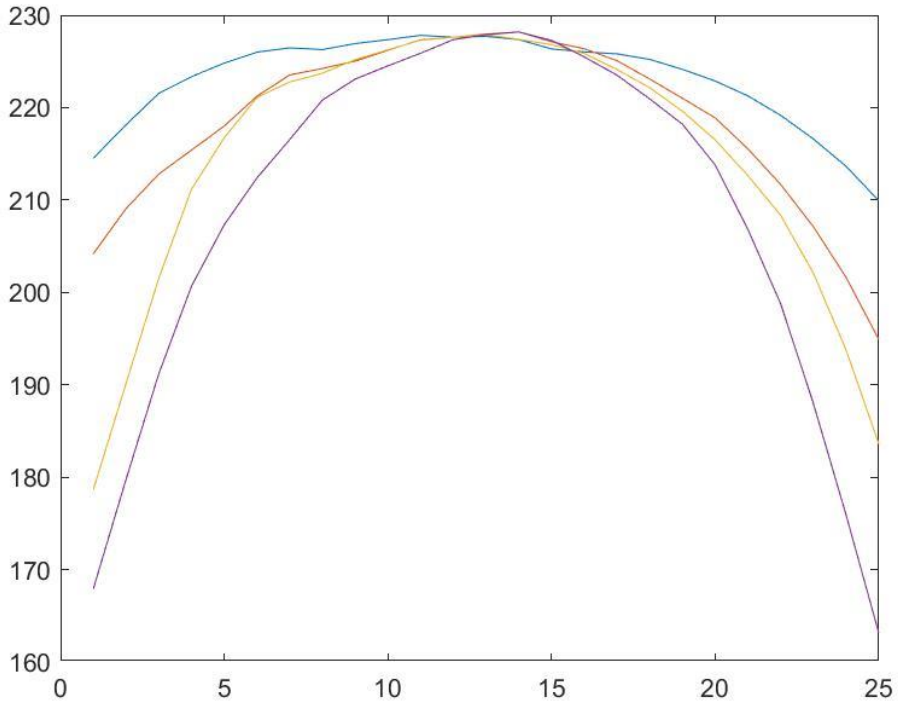

Figure A.49. Graph of Setup 3 Replication 1 Test 7 – Multiple Cross Sections

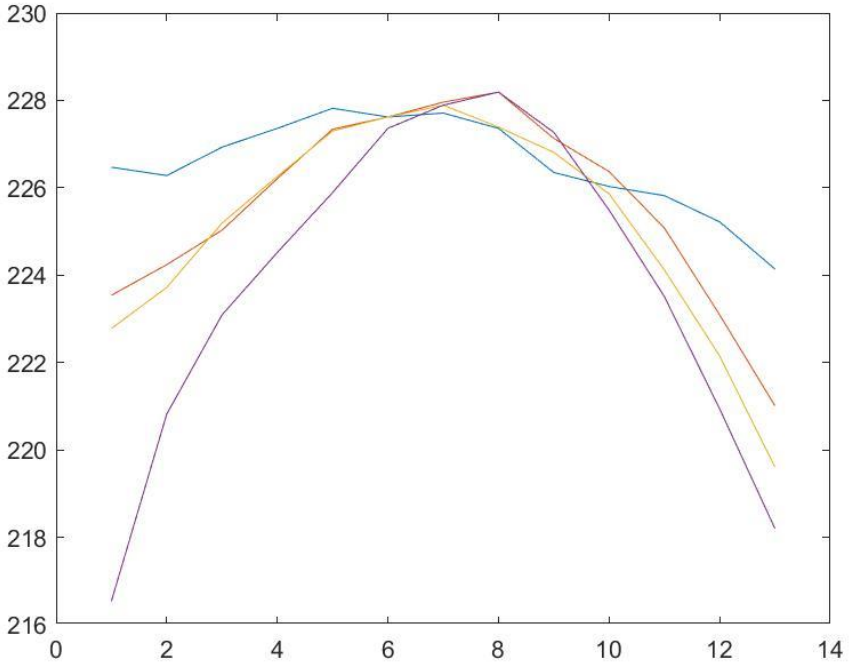

Figure A.50. Magnified Section of Graph of Setup 3 Replication 1 Test 7 – Multiple Cross Sections

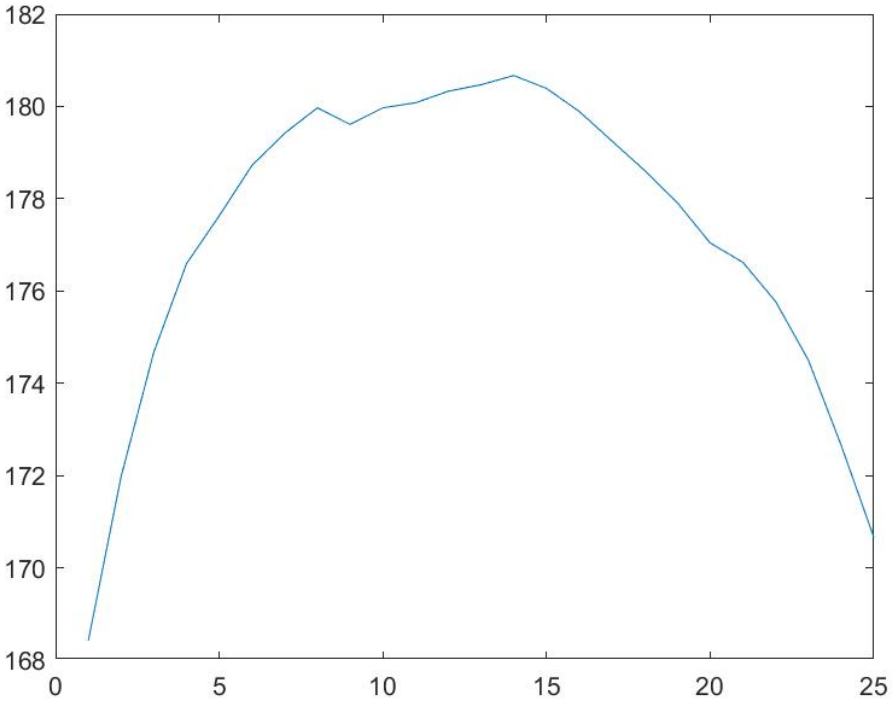

Figure A.51. Graph of Setup 3 Replication 1 Test 8 – Single Cross Section

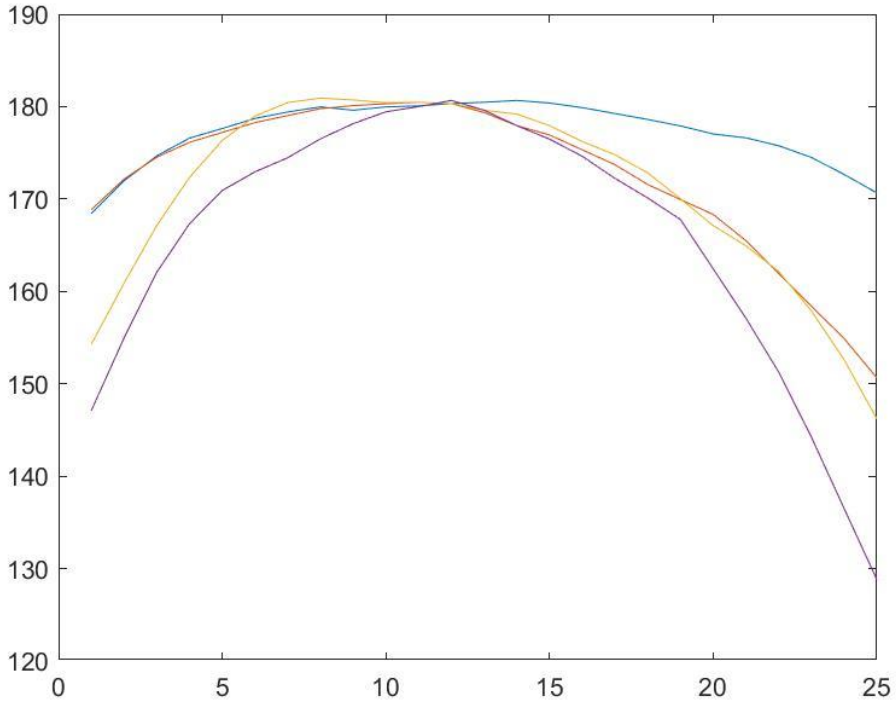

Figure A.52. Graph of Setup 3 Replication 1 Test 8 – Multiple Cross Sections

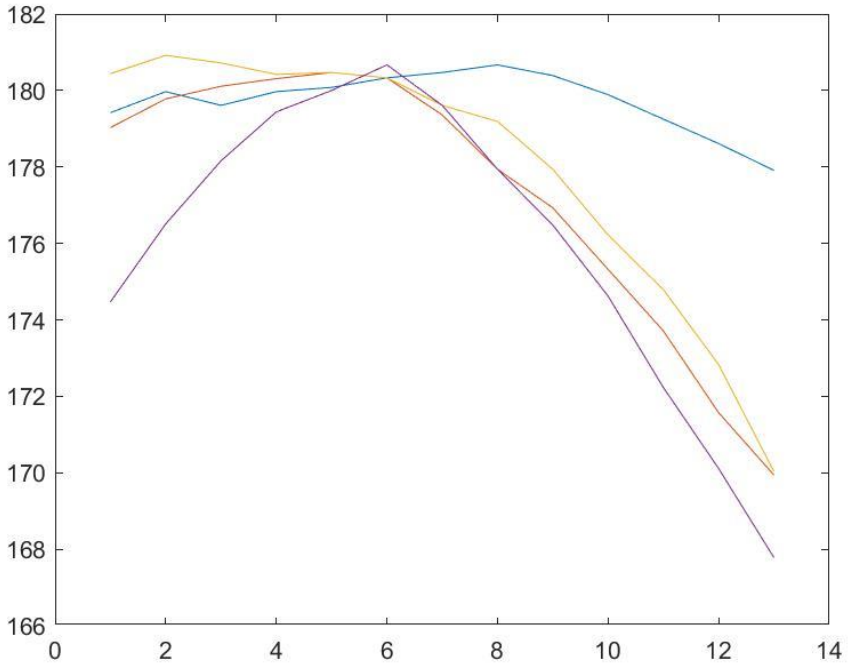

Figure A.53. Magnified Section of Graph of Setup 3 Replication 1 Test 8 – Multiple Cross Sections

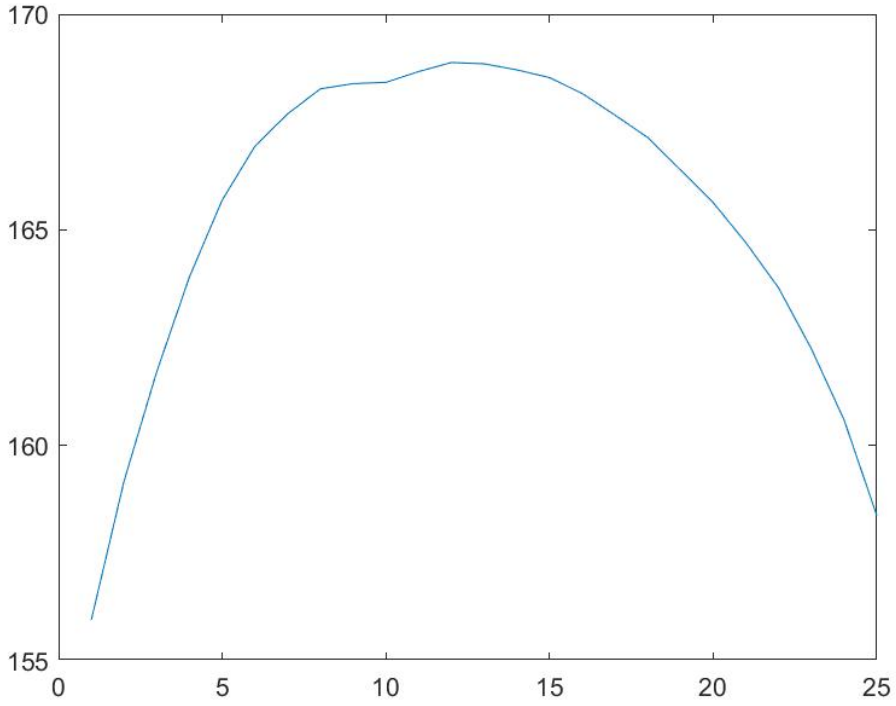

Figure A.54. Graph of Setup 3 Replication 1 Test 9 – Single Cross Section

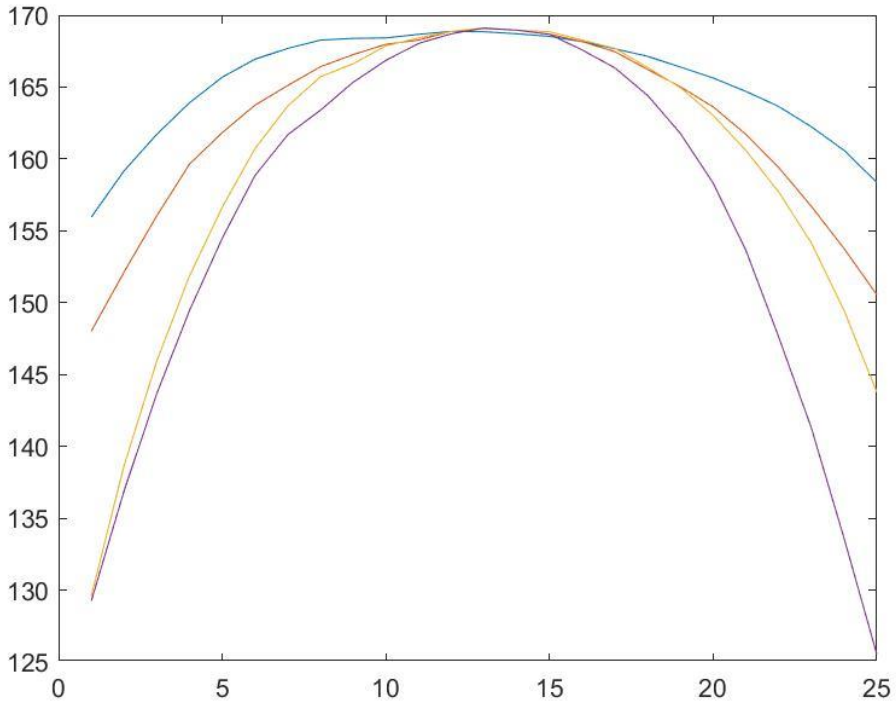

Figure A.55. Graph of Setup 3 Replication 1 Test 9 – Multiple Cross Sections

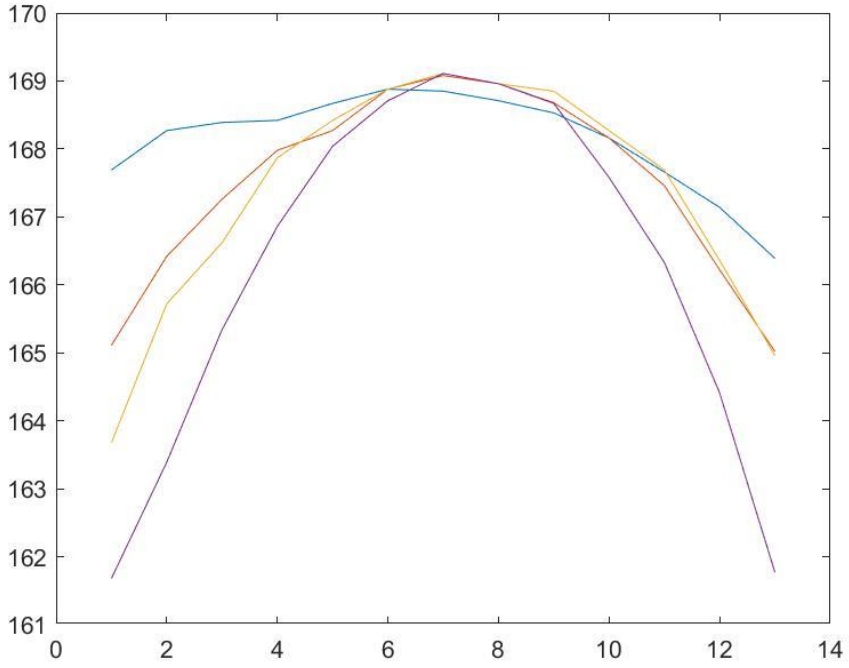

Figure A.56. Magnified Section of Graph of Setup 3 Replication 1 Test 9 – Multiple Cross Sections

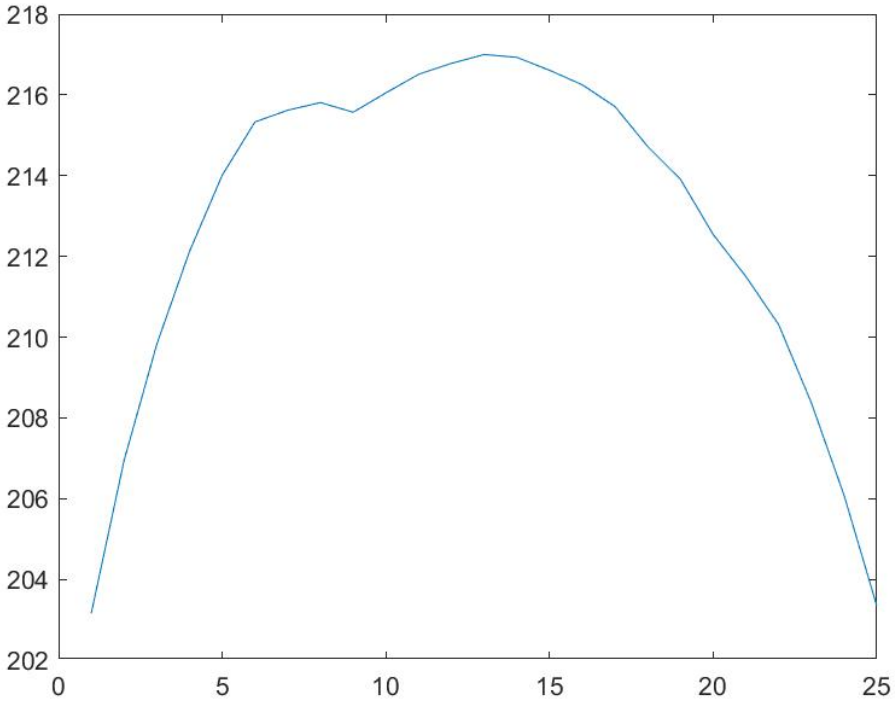

Figure A.57. Graph of Setup 3 Replication 1 Test 10 – Single Cross Section

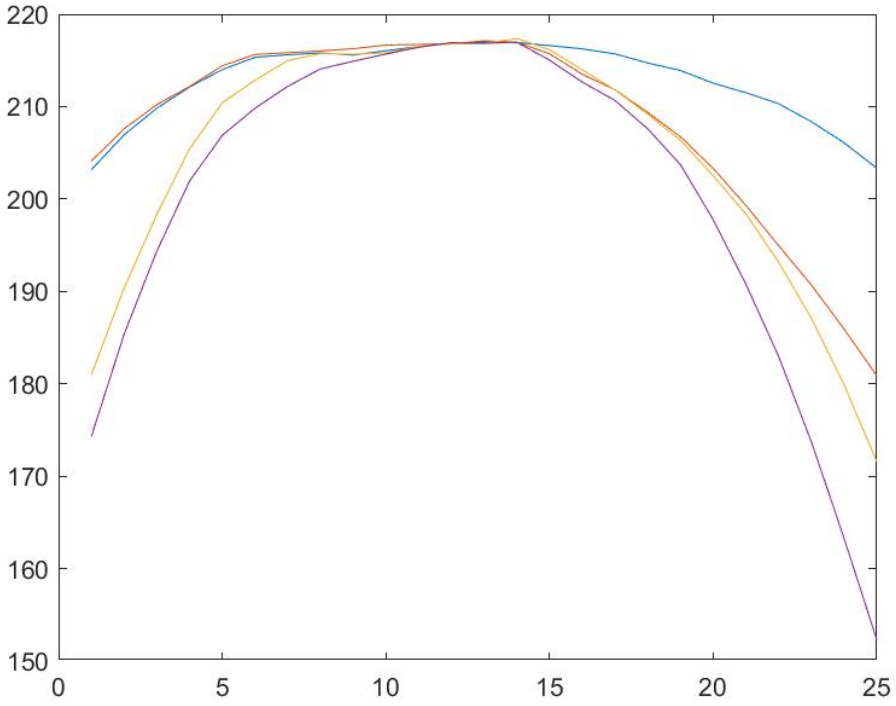

Figure A.58. Graph of Setup 3 Replication 1 Test 10 – Multiple Cross Sections

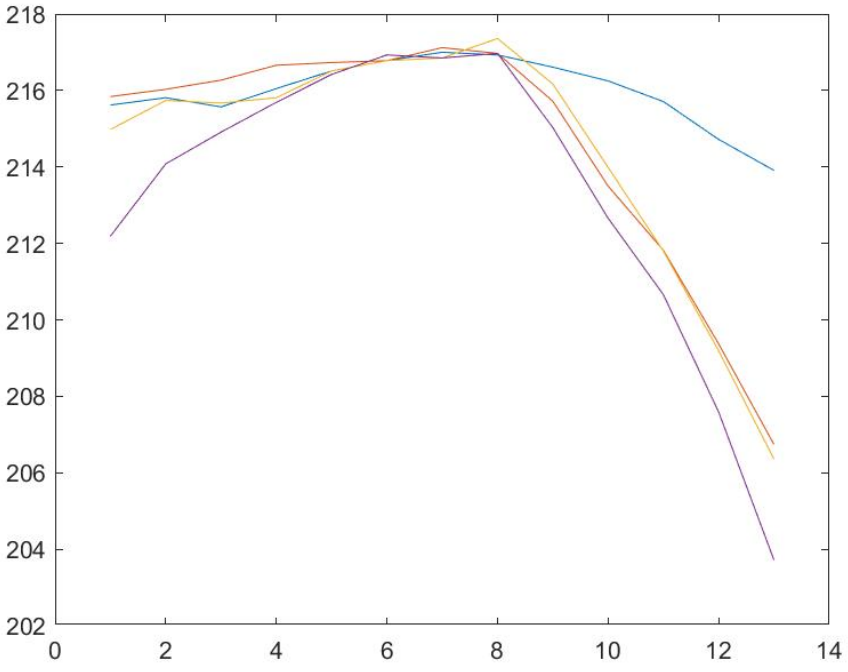

Figure A.59. Magnified Section of Graph of Setup 3 Replication 1 Test 10 – Multiple Cross Sections

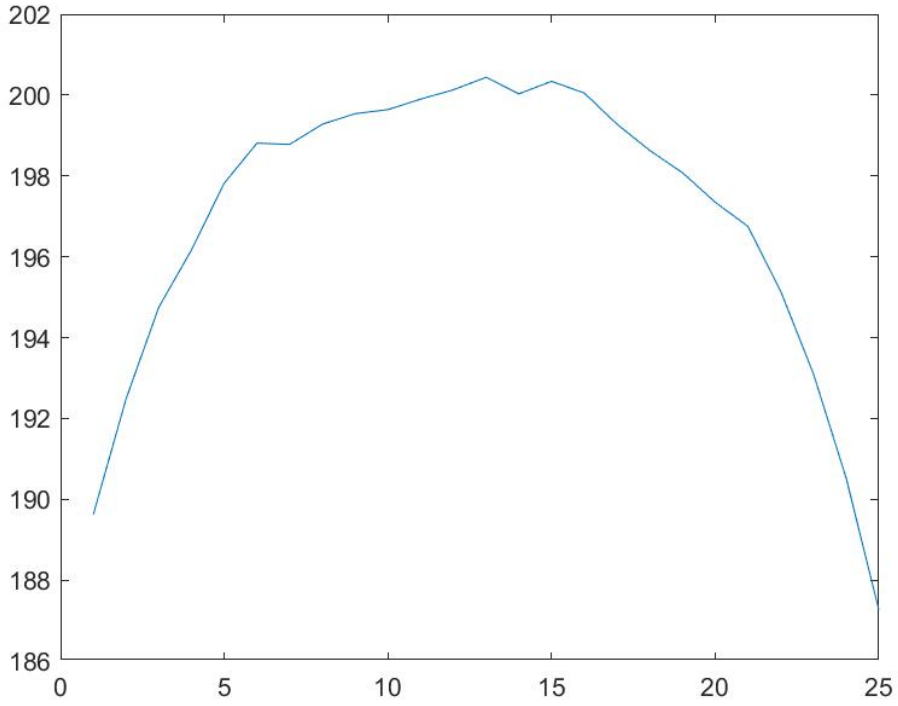

Figure A.60. Graph of Setup 3 Replication 1 Test 11 – Single Cross Section

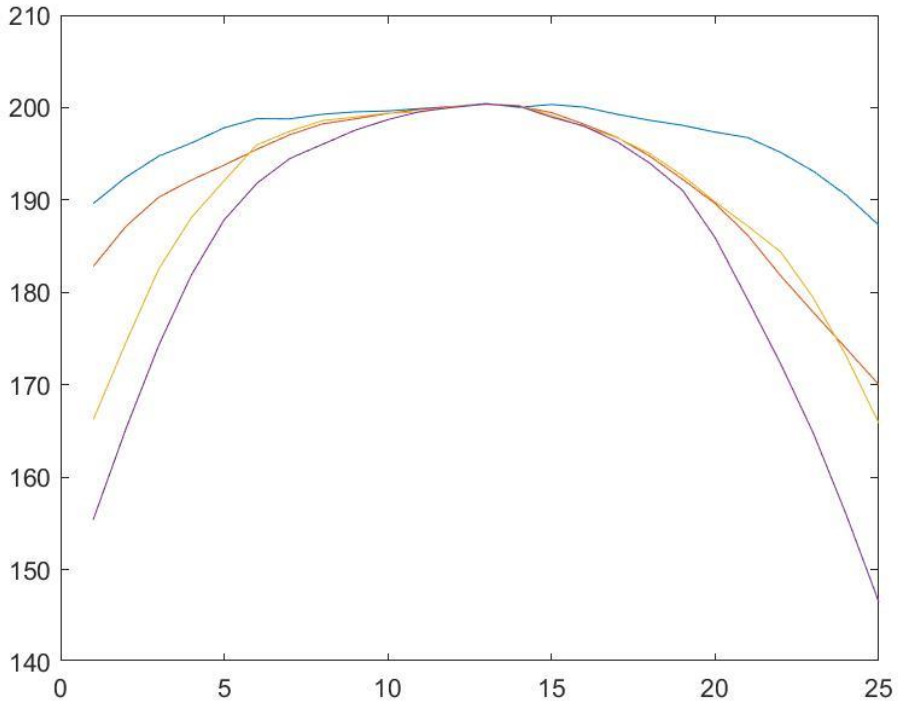

Figure A.61. Graph of Setup 3 Replication 1 Test 11 – Multiple Cross Sections

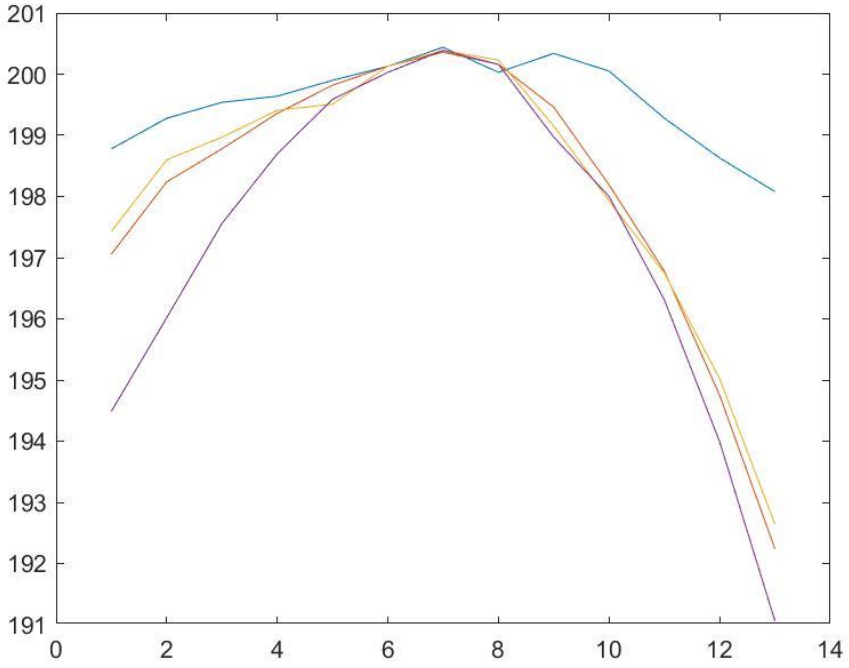

Figure A.62. Magnified Section of Graph of Setup 3 Replication 1 Test 11 – Multiple Cross Sections

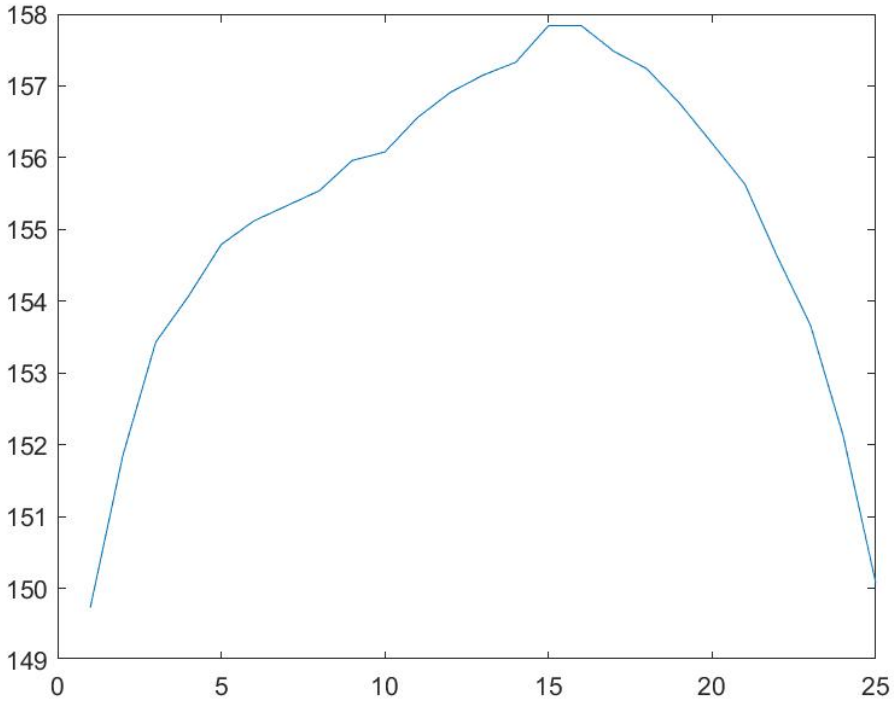

Figure A.63. Graph of Setup 3 Replication 1 Test 12 – Single Cross Section

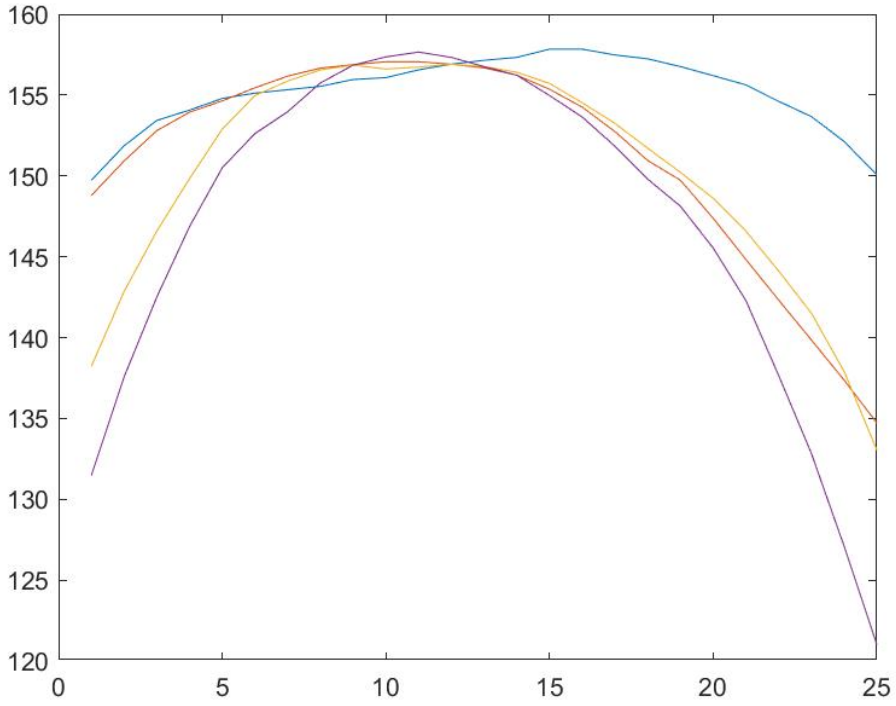

Figure A.64. Graph of Setup 3 Replication 1 Test 12 – Multiple Cross Sections

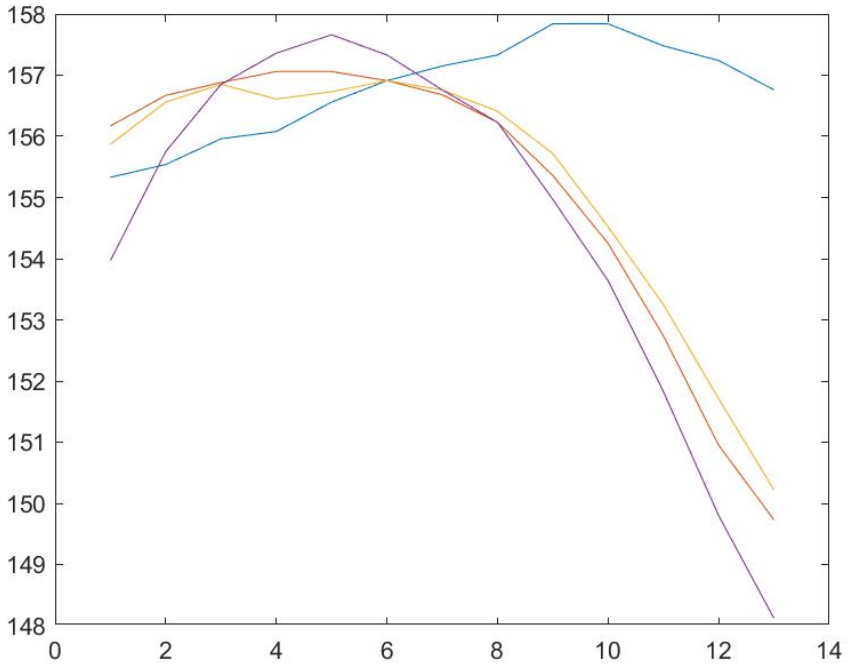

Figure A.65. Magnified Section of Setup 3 Graph of Replication 1 Test 12 – Multiple Cross Sections

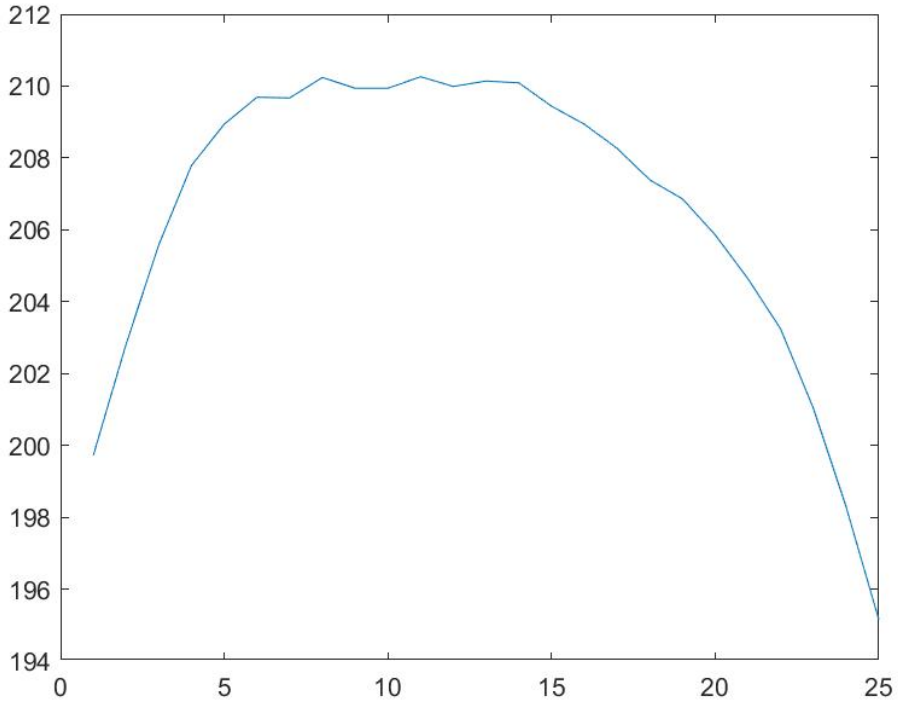

Figure A.66. Graph of Setup 3 Replication 1 Test 13 – Single Cross Section

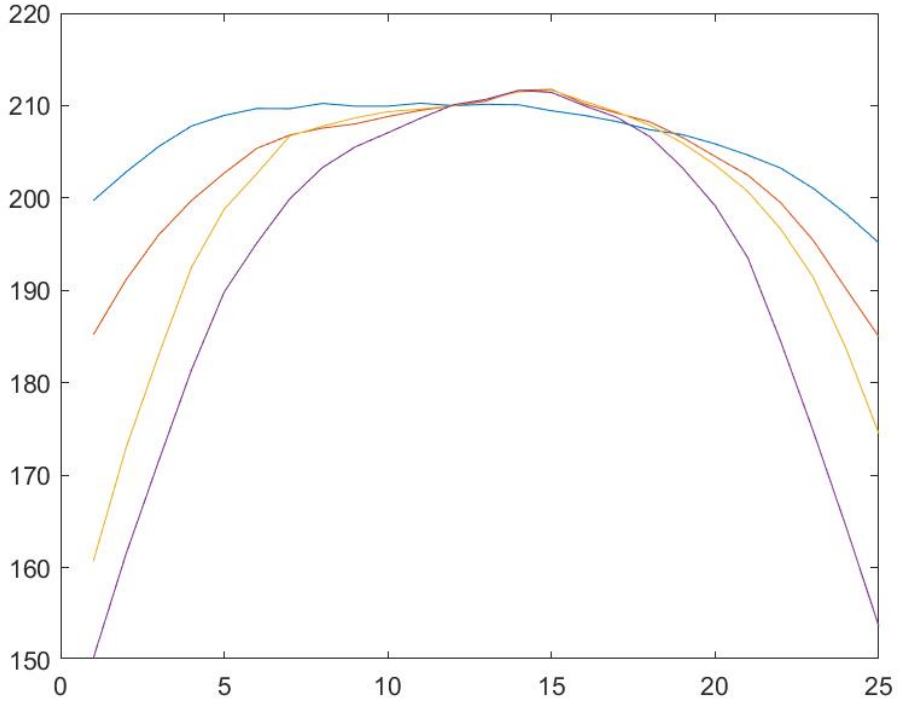

Figure A.67. Graph of Setup 3 Replication 1 Test 13 – Multiple Cross Sections

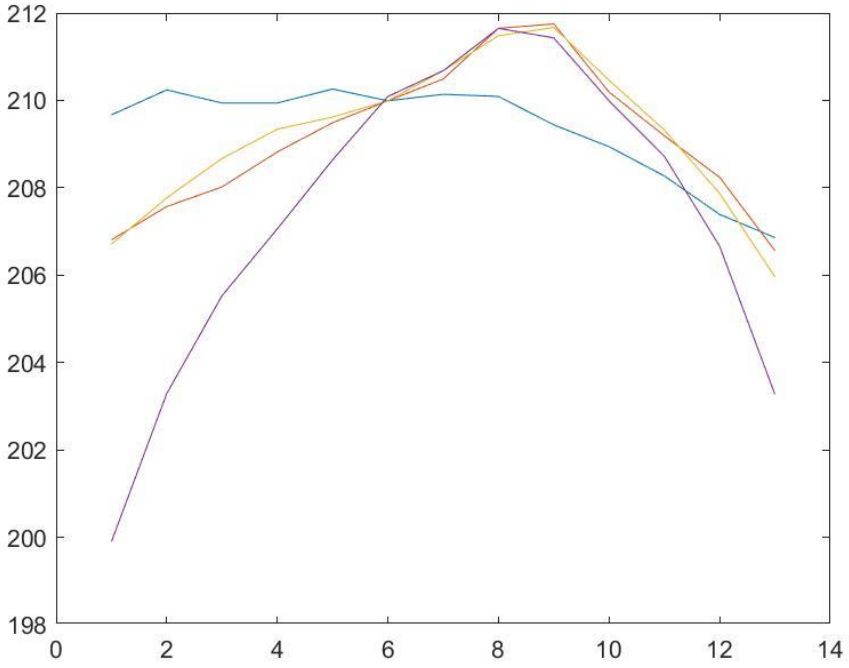

Figure A.68. Magnified Section of Graph of Setup 3 Replication 1 Test 13 – Multiple Cross Sections

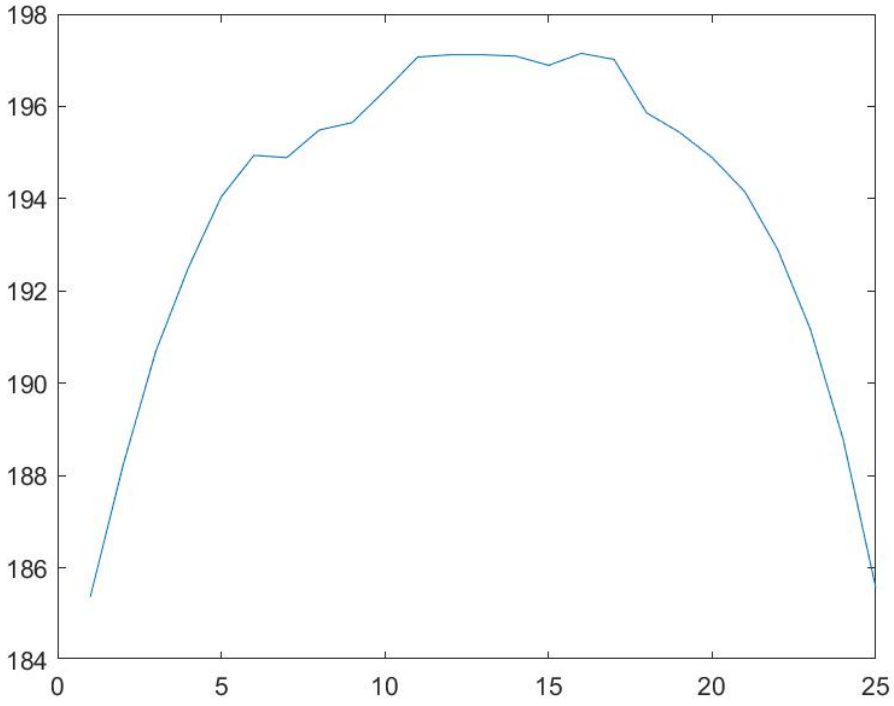

Figure A.69. Graph of Setup 3 Replication 1 Test 14 – Single Cross Section

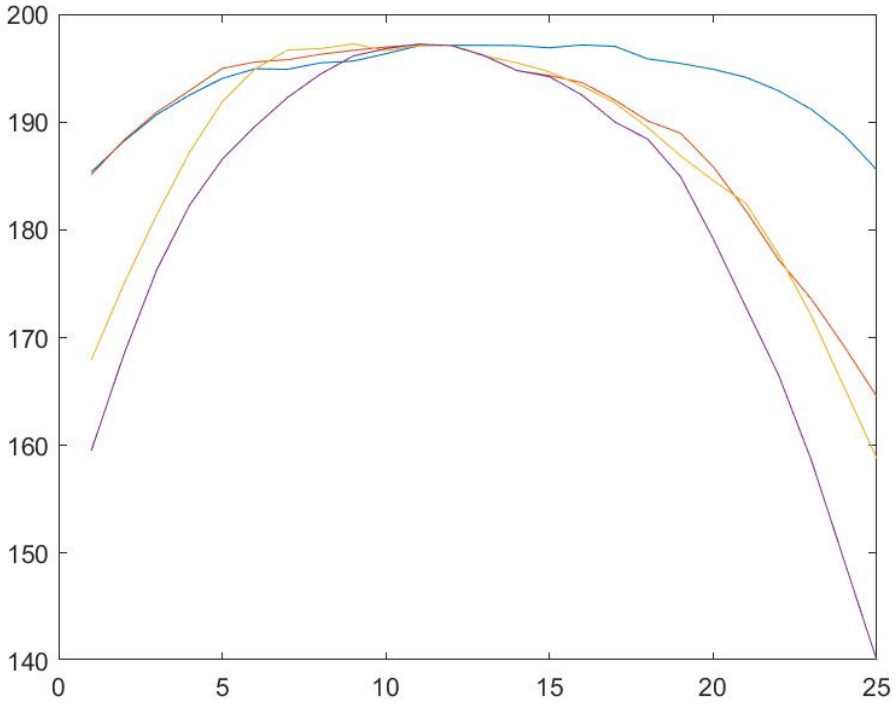

Figure A.70. Graph of Setup 3 Replication 1 Test 14 – Multiple Cross Sections

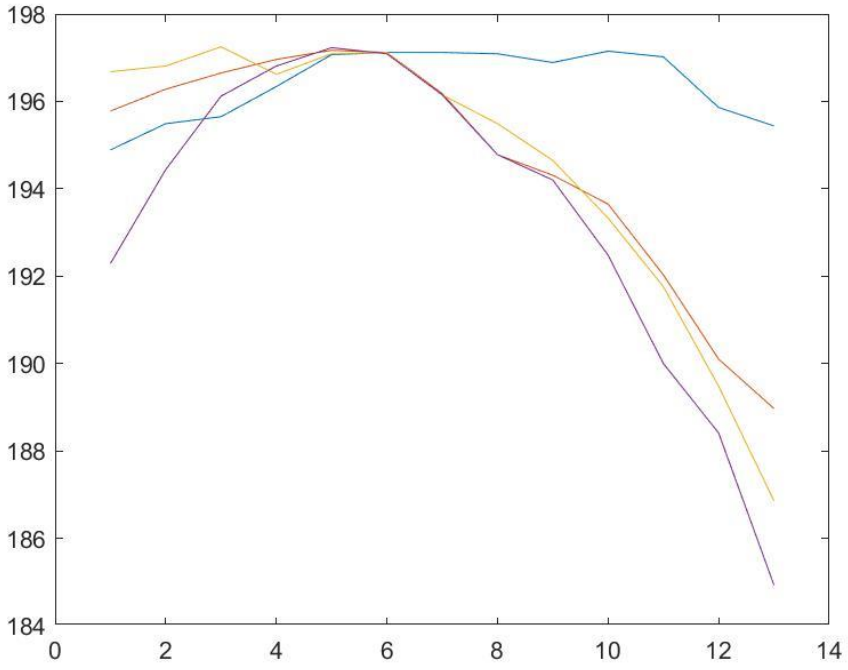

Figure A.71. Magnified Section of Graph of Setup 3 Replication 1 Test 14 – Multiple Cross Sections

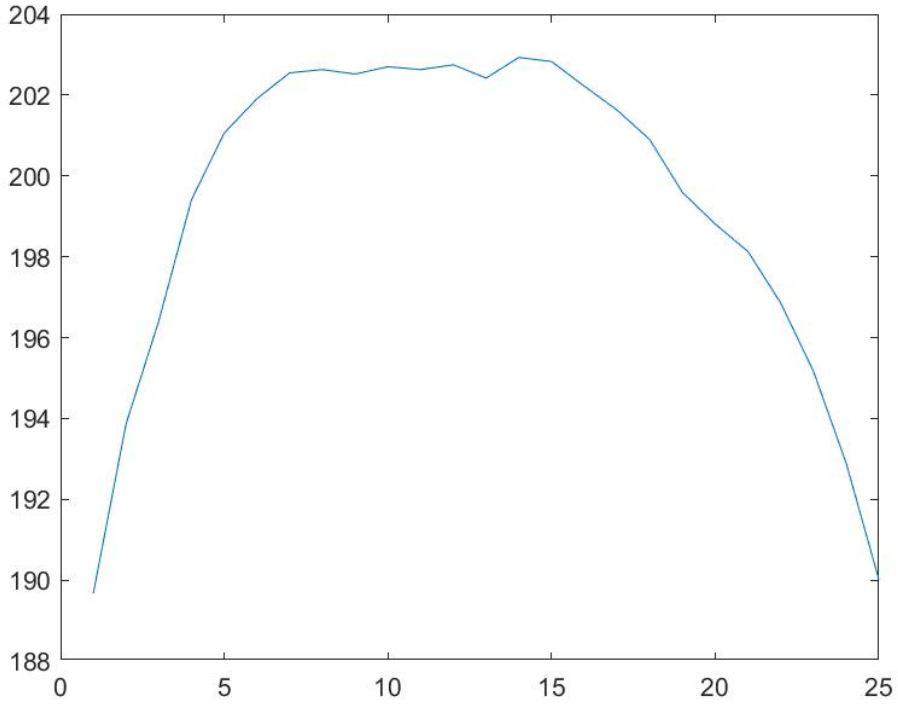

Figure A.72. Graph of Setup 3 Replication 1 Test 17 – Single Cross Section

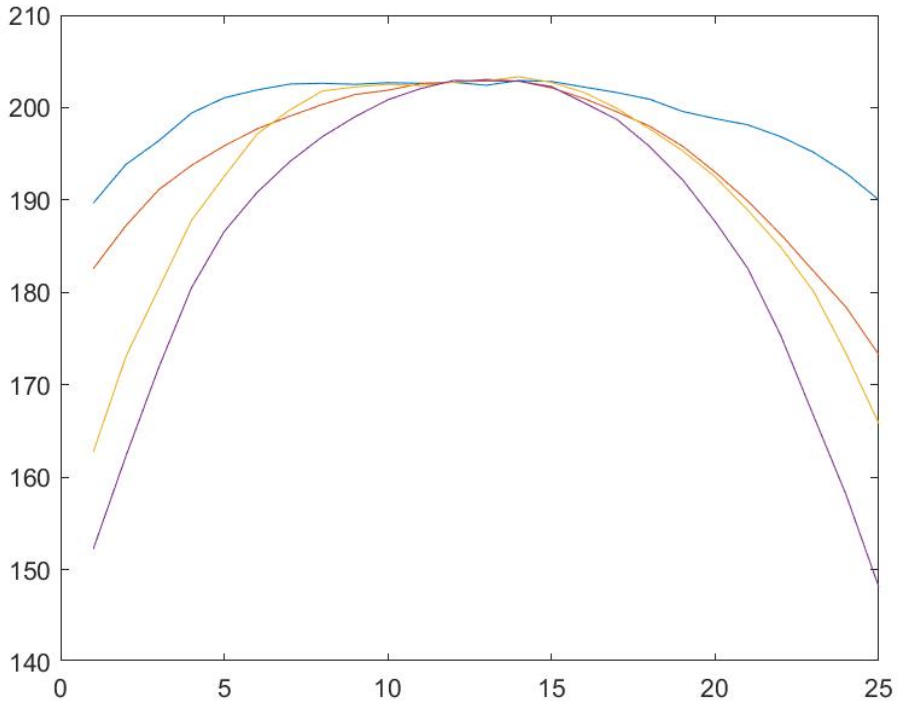

Figure A.73. Graph of Setup 3 Replication 1 Test 17 – Multiple Cross Sections

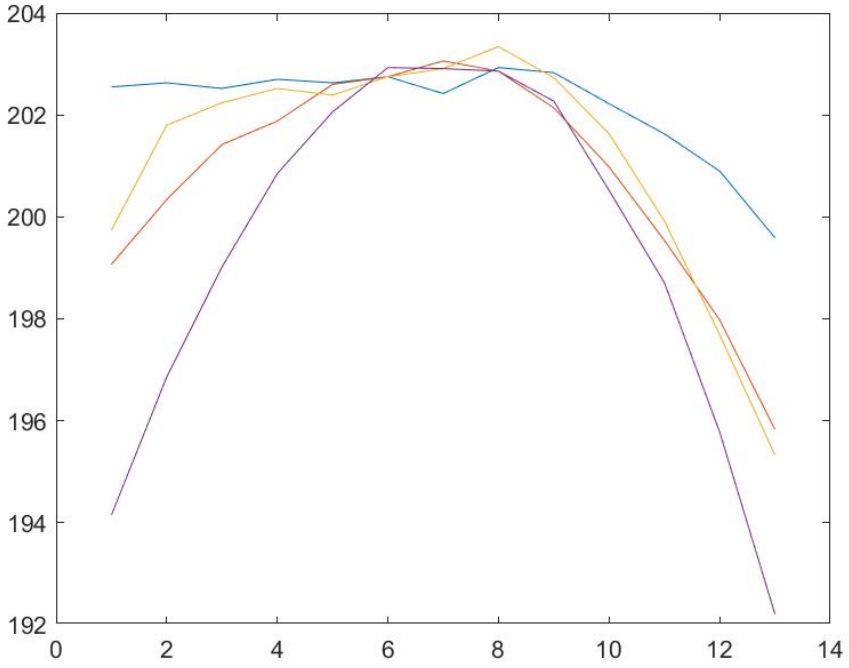

Figure A.74. Magnified Section of Graph of Setup 3 Replication 1 Test 17 – Multiple Cross Sections

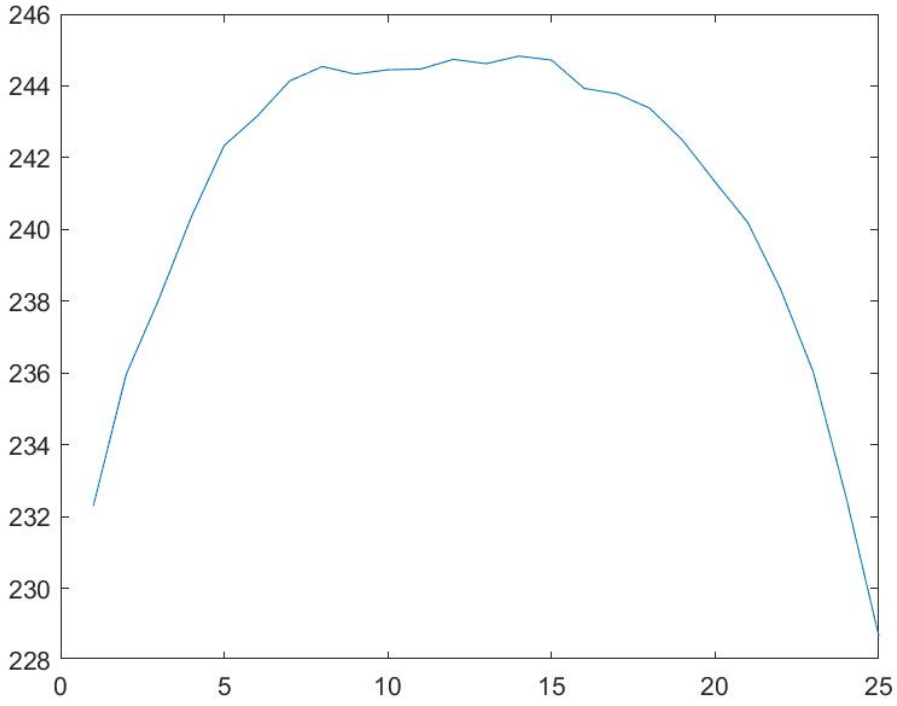

Figure A.75. Graph of Setup 3 Replication 1 Test 18 – Single Cross Section

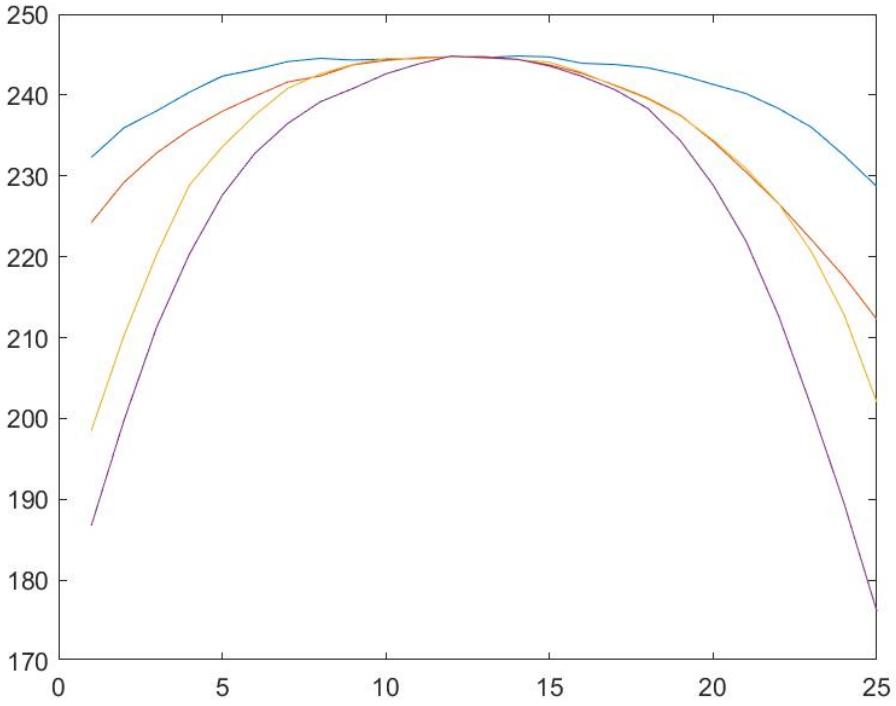

Figure A.76. Graph of Setup 3 Replication 1 Test 18 – Multiple Cross Sections

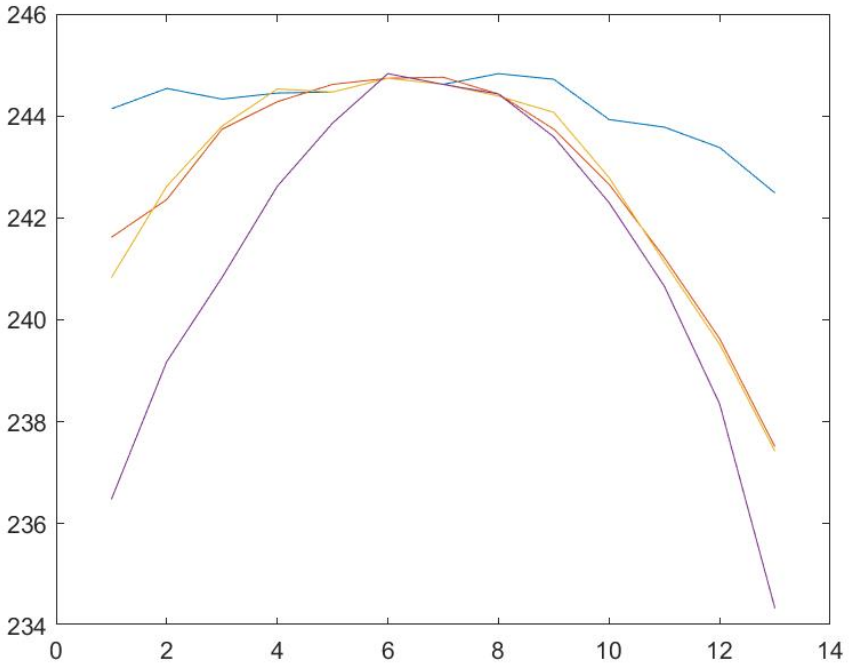

Figure A.77. Magnified Section of Graph of Setup 3 Replication 1 Test 18 – Multiple Cross Sections

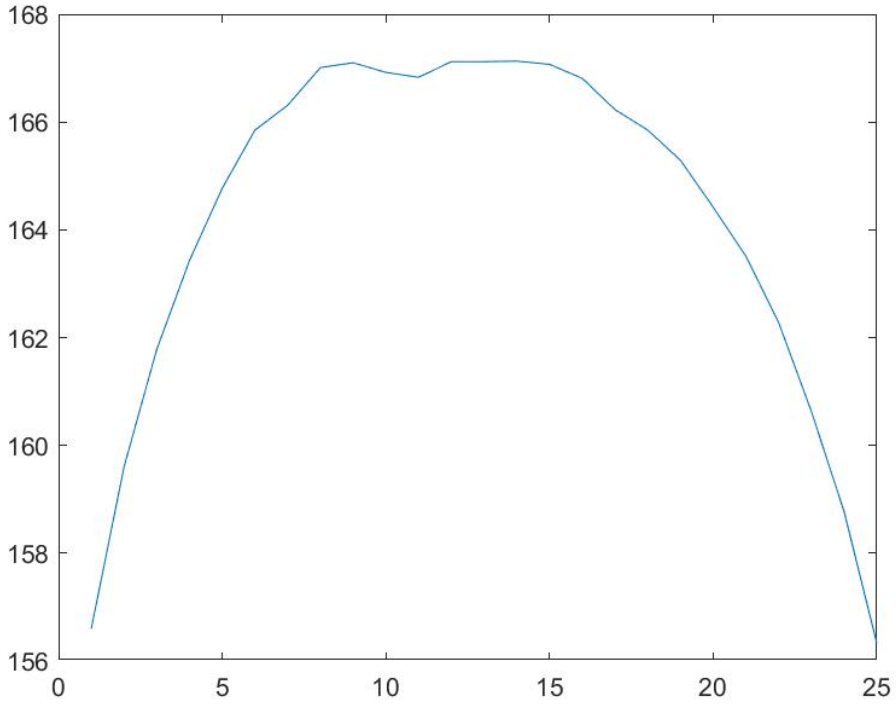

Figure A.78. Graph of Setup 3 Replication 1 Test 19 – Single Cross Section

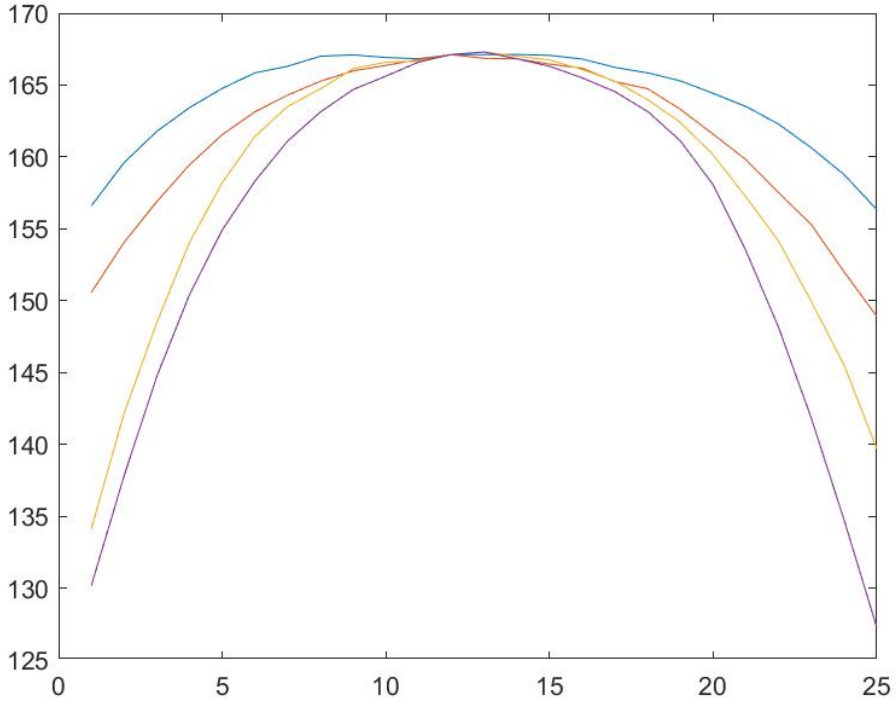

Figure A.79. Graph of Setup 3 Replication 1 Test 19 – Multiple Cross Sections

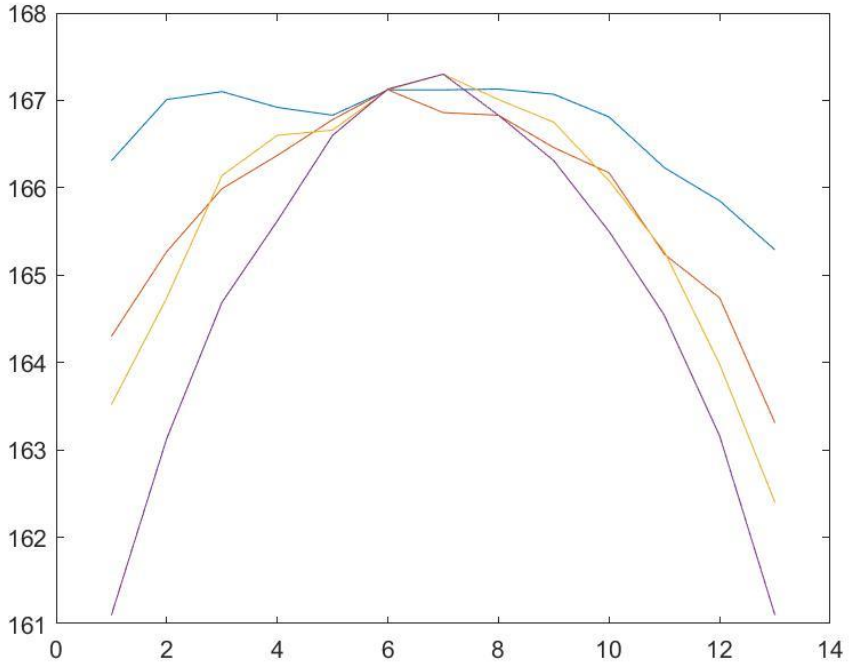

Figure A.80. Magnified Section of Graph of Setup 3 Replication 1 Test 19 – Multiple Cross Sections

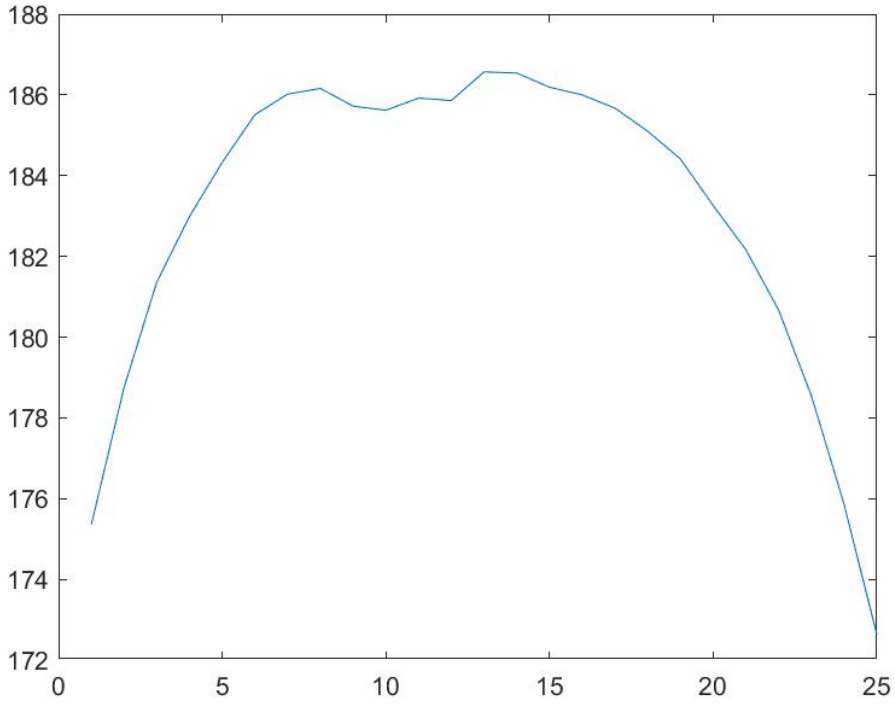

Figure A.81. Graph of Setup 3 Replication 1 Test 20 – Single Cross Section

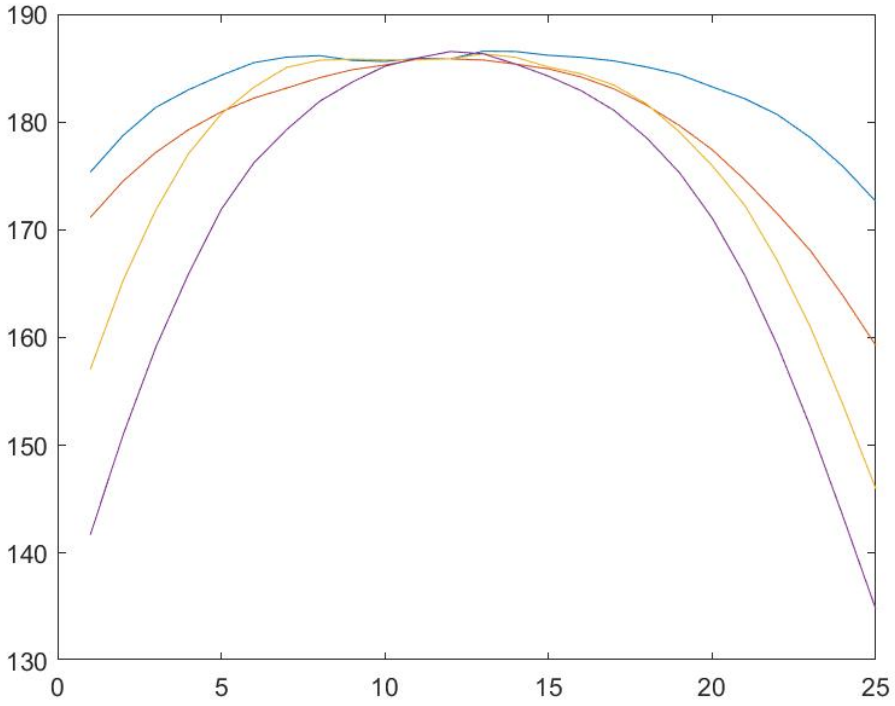

Figure A.82. Graph of Setup 3 Replication 1 Test 20 – Multiple Cross Sections

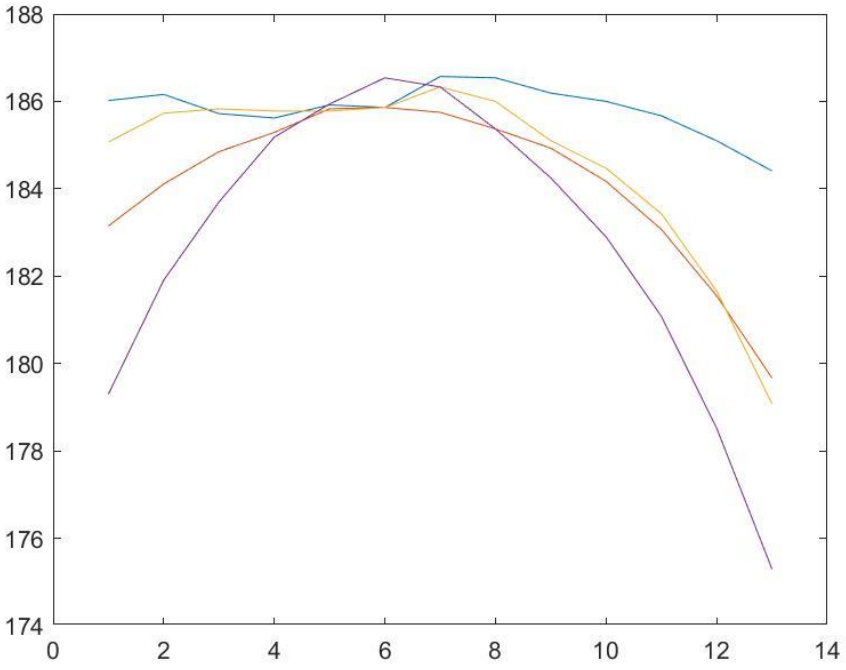

Figure A.83. Magnified Section of Graph of Setup 3 Replication 1 Test 20 – Multiple Cross Sections

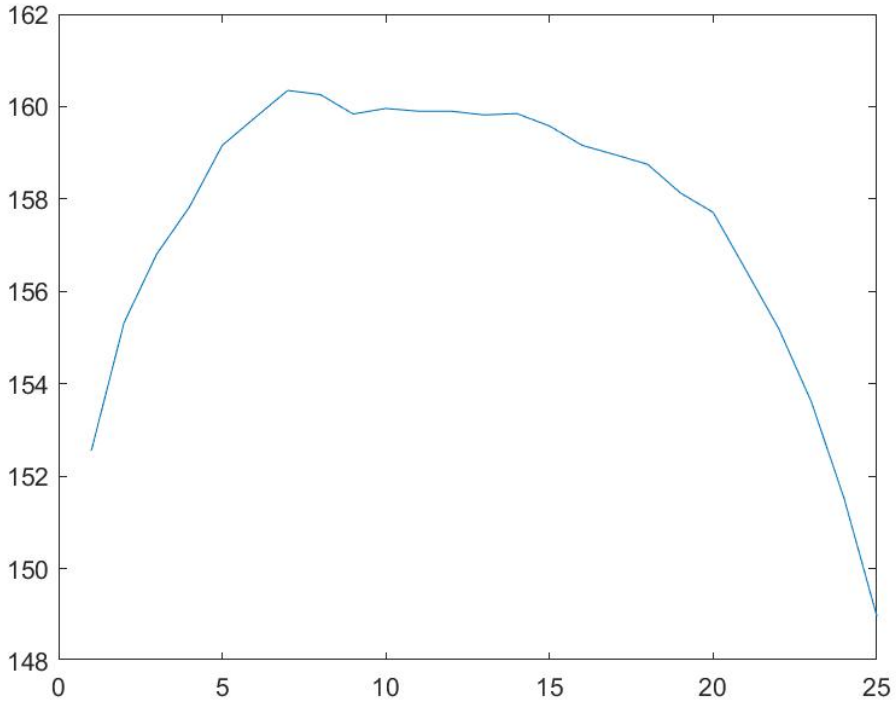

Figure A.84. Graph of Setup 3 Replication 1 Test 21 – Single Cross Section

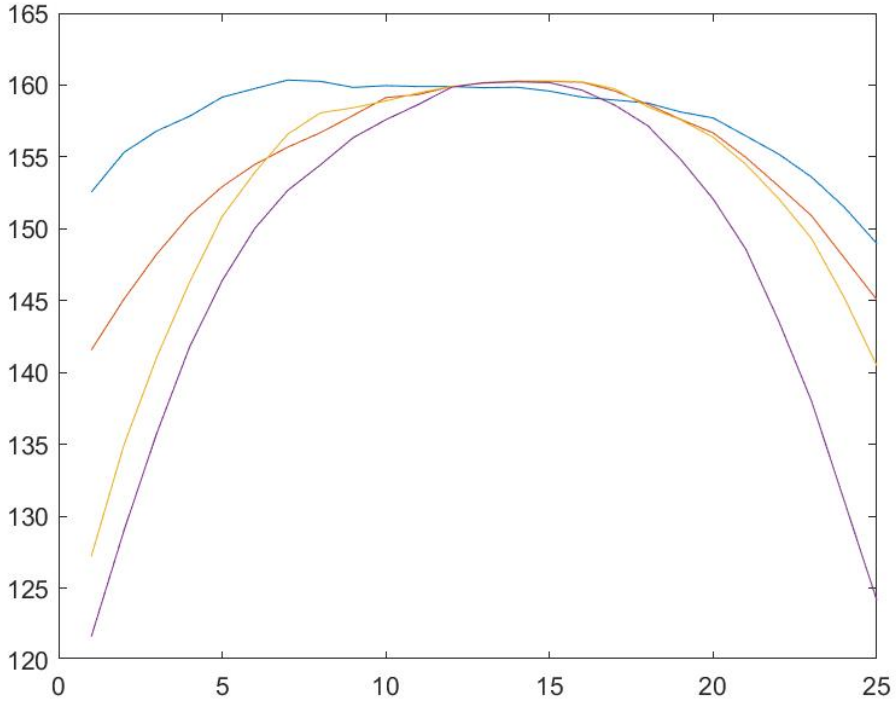

Figure A.85. Graph of Setup 3 Replication 1 Test 21 – Multiple Cross Sections

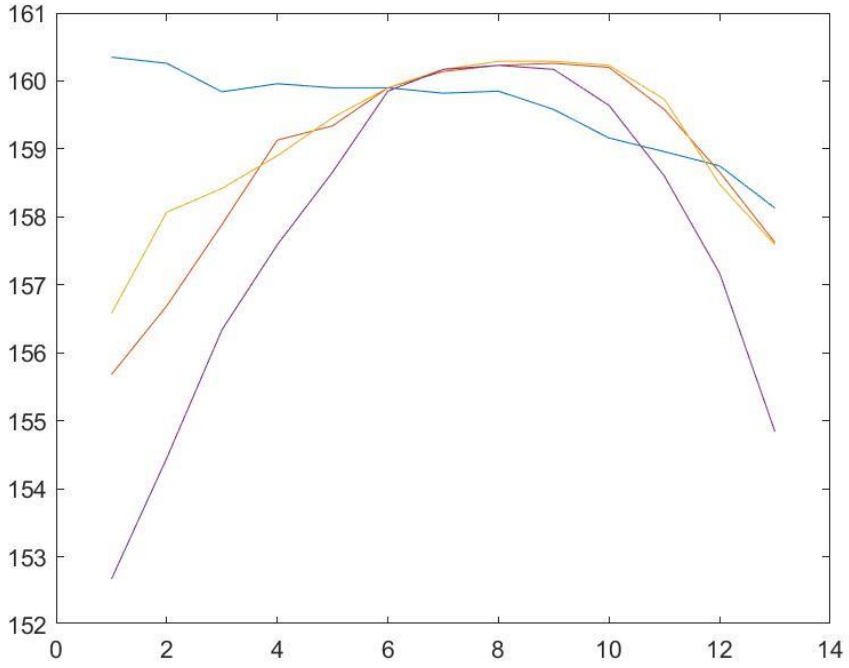

Figure A.86. Magnified Section of Graph of Setup 3 Replication 1 Test 21 – Multiple Cross Sections

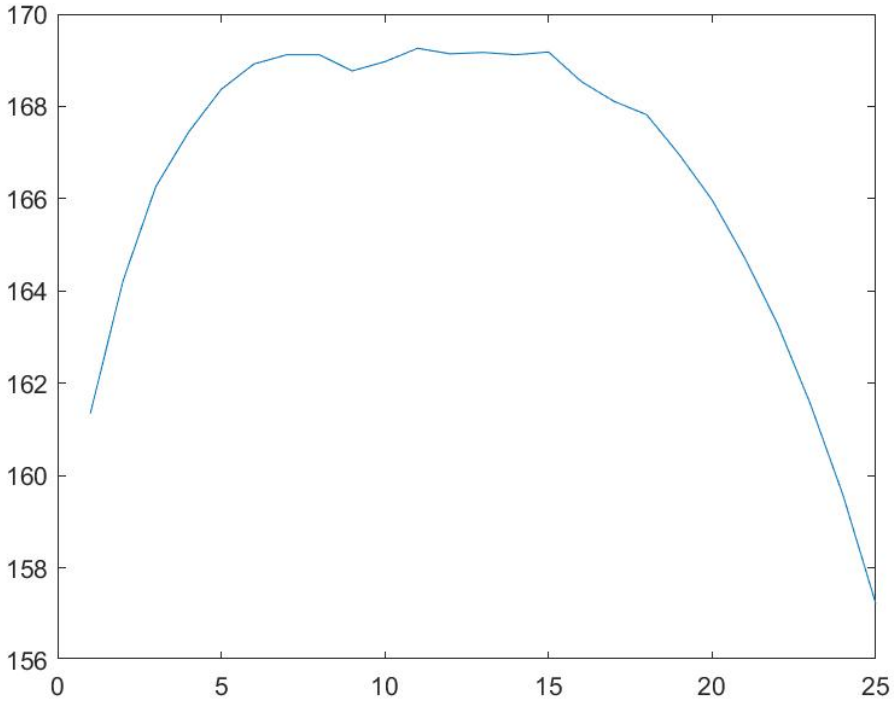

Figure A.87. Graph of Setup 3 Replication 1 Test 22 – Single Cross Section

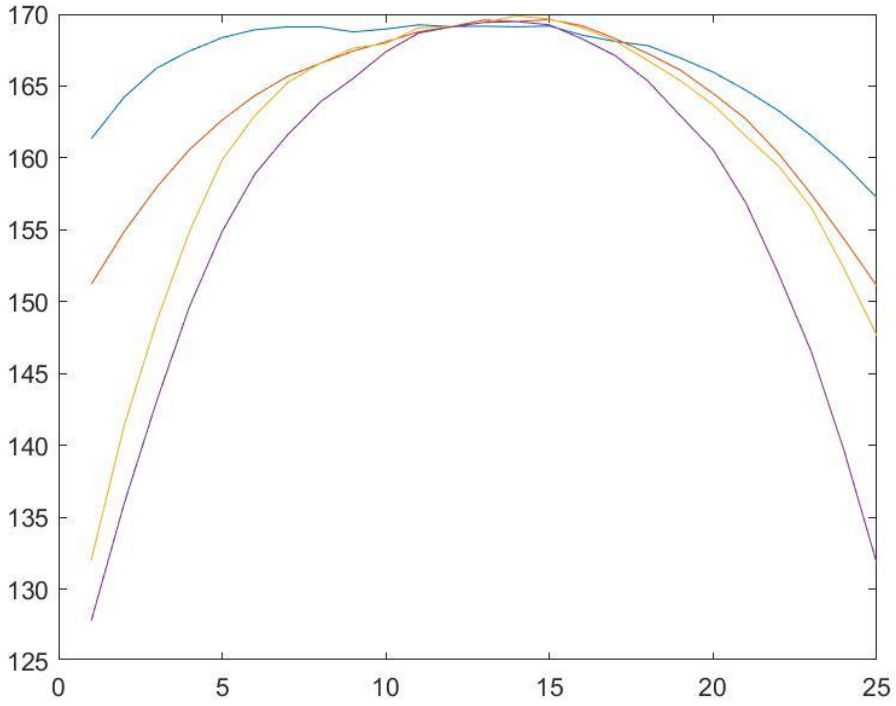

Figure A.88. Graph of Setup 3 Replication 1 Test 22 – Multiple Cross Sections

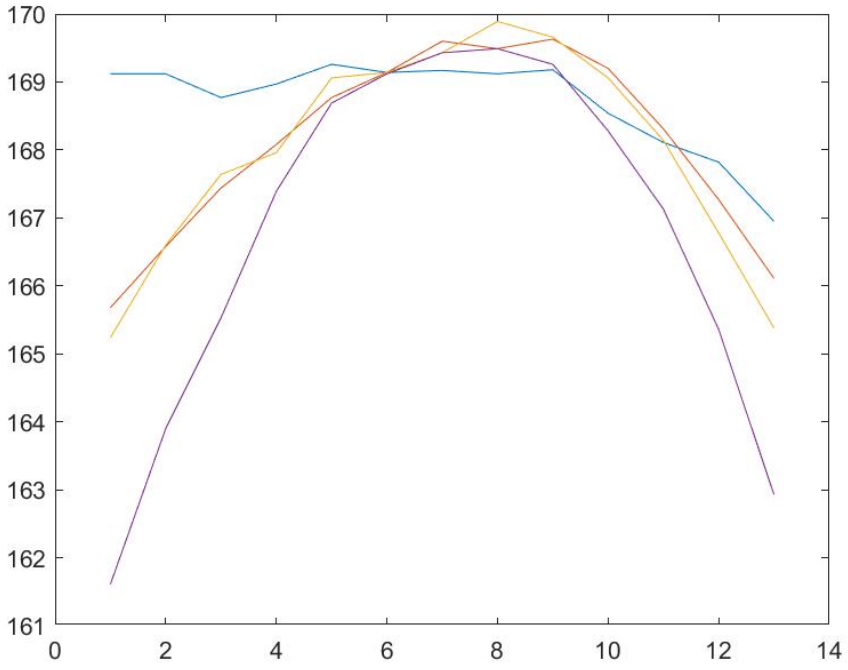

Figure A.89. Magnified Section of Graph of Setup 3 Replication 1 Test 22 – Multiple Cross Sections

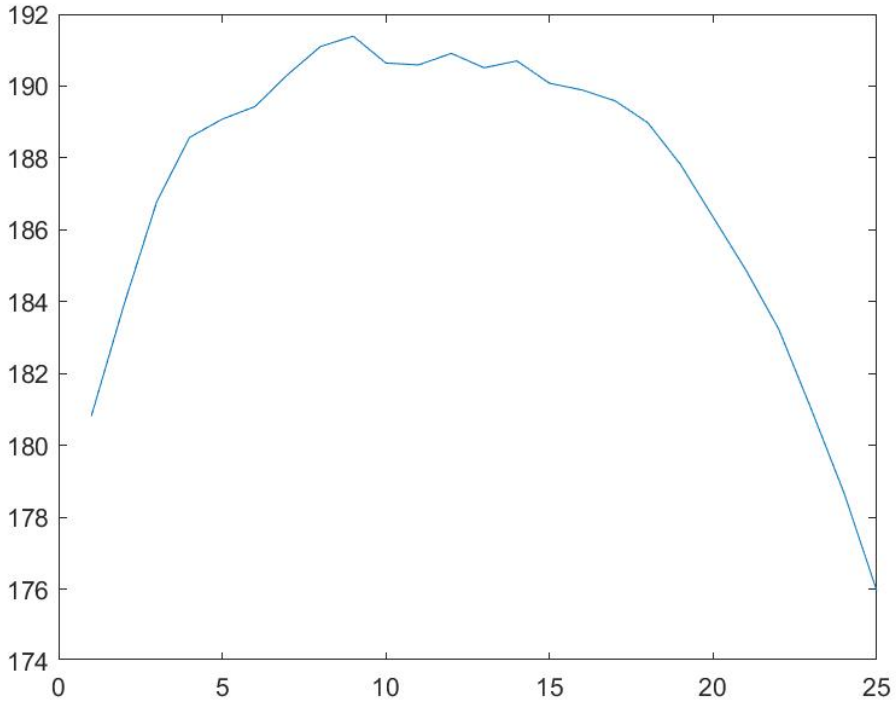

Figure A.90. Graph of Setup 3 Replication 1 Test 23 – Single Cross Section

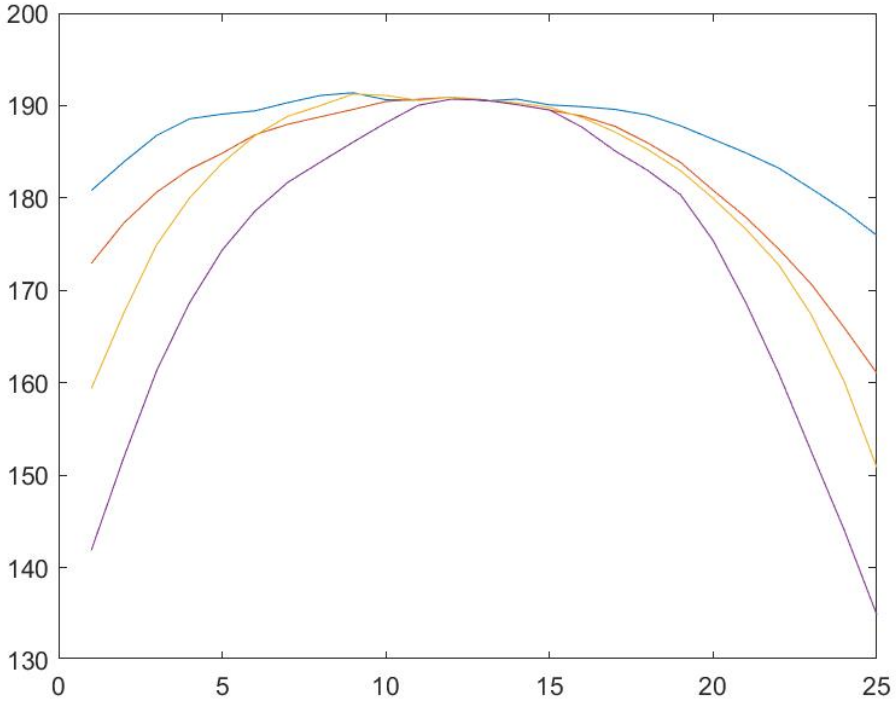

Figure A.91. Graph of Setup 3 Replication 1 Test 23 – Multiple Cross Sections

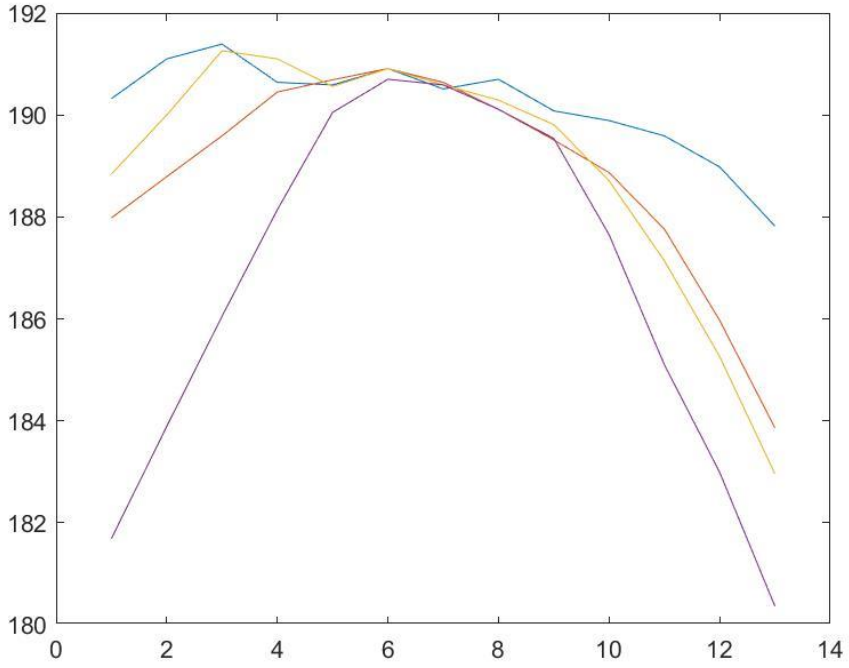

Figure A.92. Magnified Section of Graph of Setup 3 Replication 1 Test 23 – Multiple Cross Sections

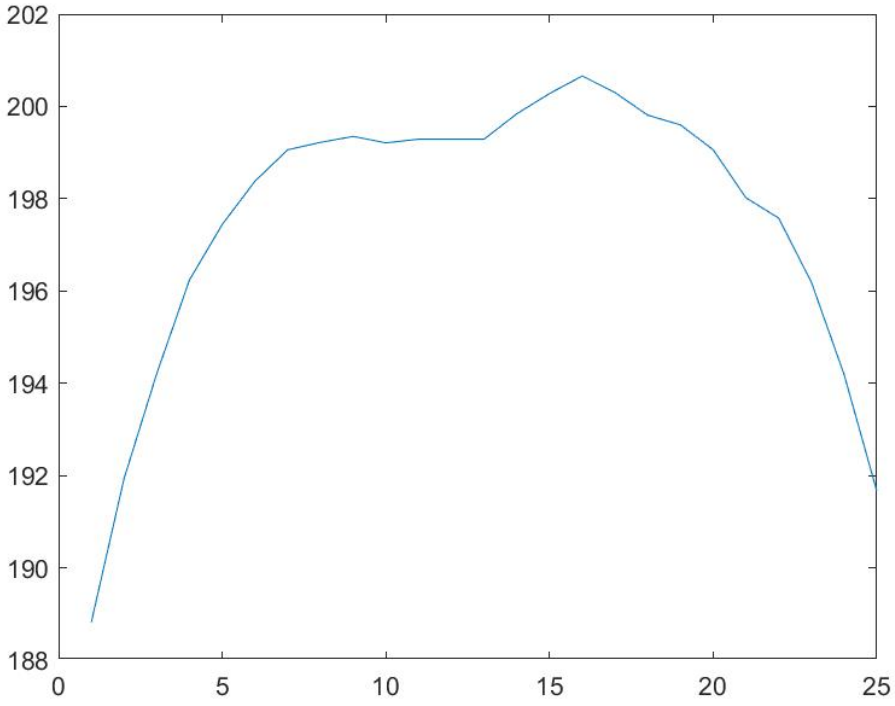

Figure A.93. Graph of Setup 3 Replication 1 Test 24 – Single Cross Section

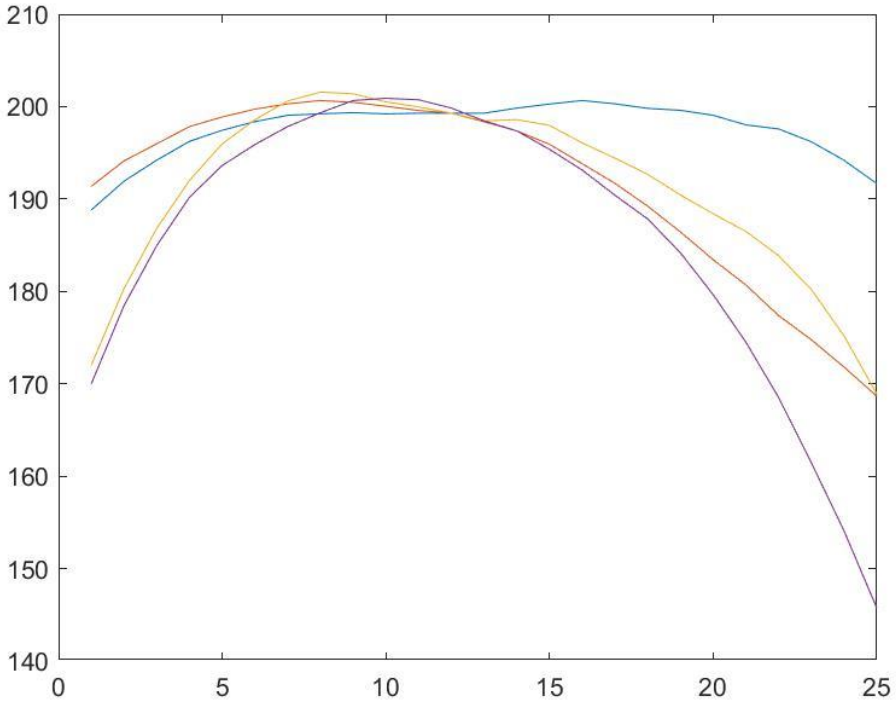

Figure A.94. Graph of Setup 3 Replication 1 Test 24 – Multiple Cross Sections

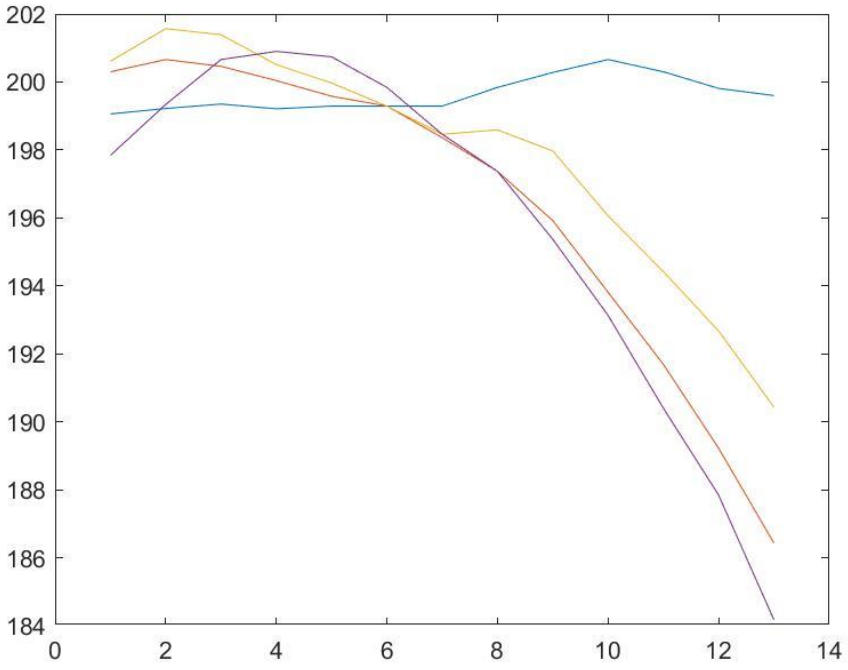

Figure A.95. Magnified Section of Graph of Setup 3 Replication 1 Test 24 – Multiple Cross Sections

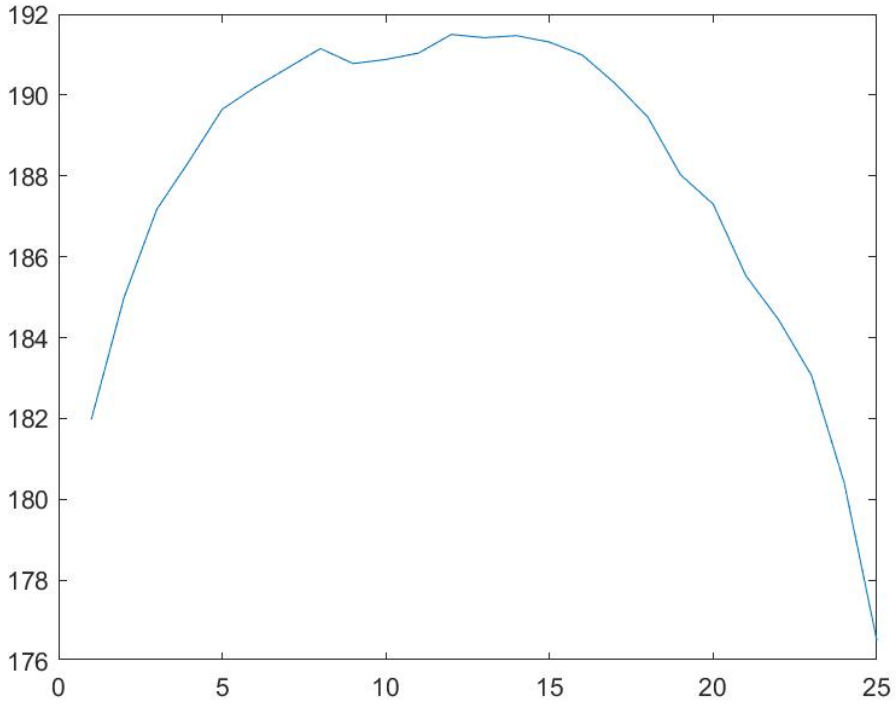

Figure A.96. Graph of Setup 3 Replication 1 Test 25 – Single Cross Section

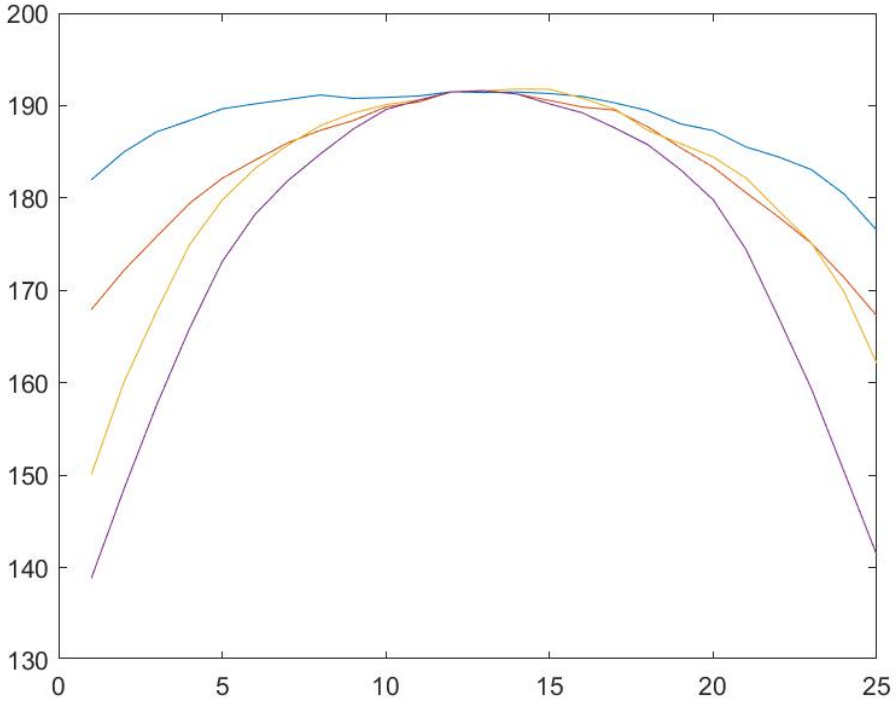

Figure A.97. Graph of Setup 3 Replication 1 Test 25 – Multiple Cross Sections

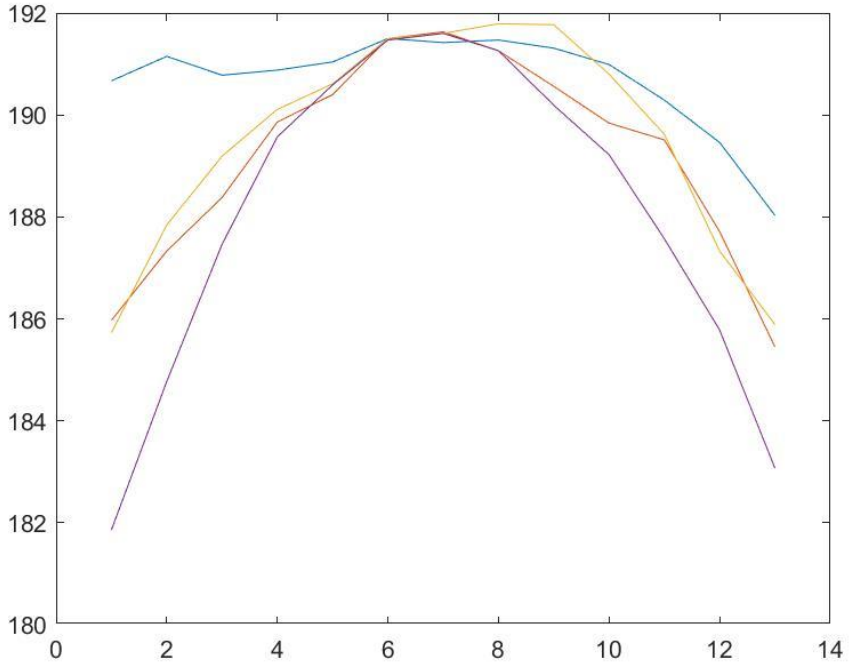

Figure A.98. Magnified Section of Graph of Setup 3 Replication 1 Test 25 – Multiple Cross Sections

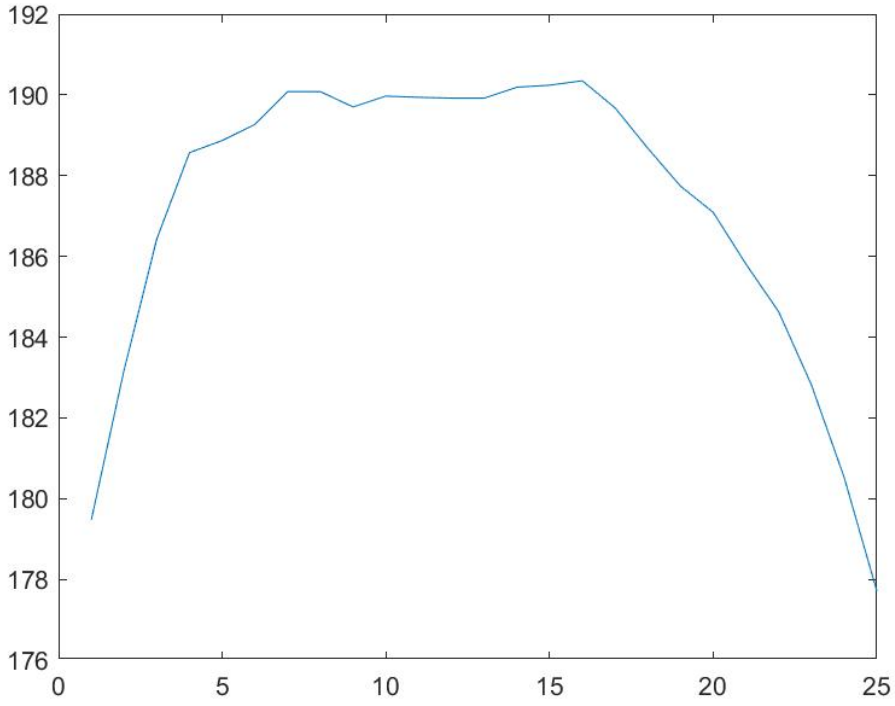

Figure A.99. Graph of Setup 3 Replication 1 Test 26 – Single Cross Section

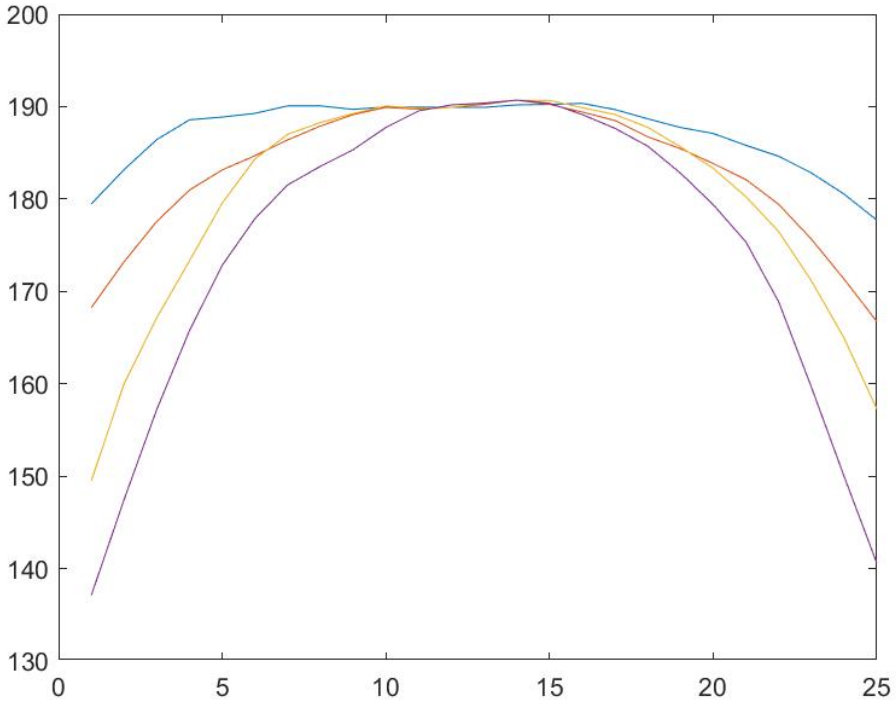

Figure A.100. Graph of Setup 3 Replication 1 Test 26 – Multiple Cross Sections

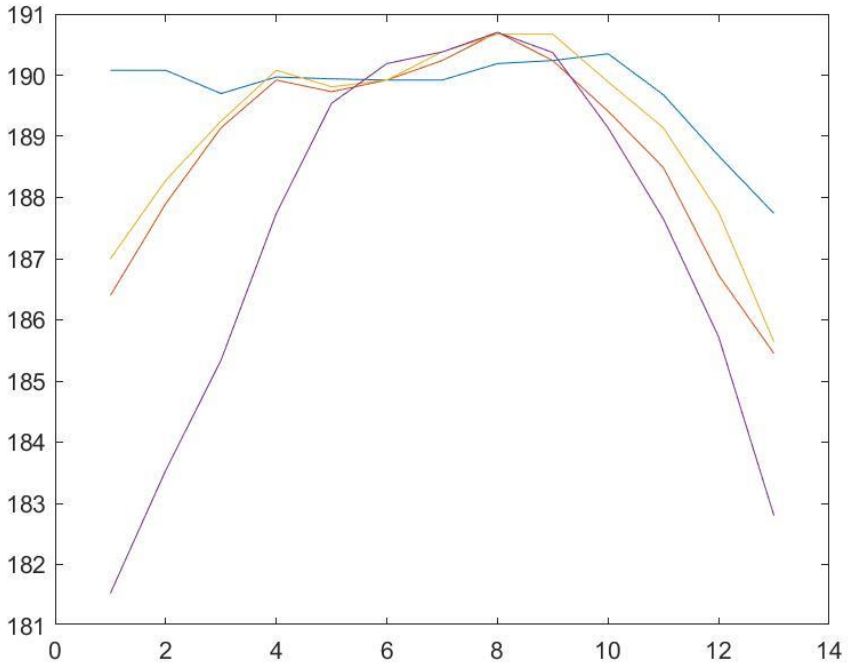

Figure A.101. Magnified Section of Graph of Setup 3 Replication 1 Test 26 – Multiple Cross Sections

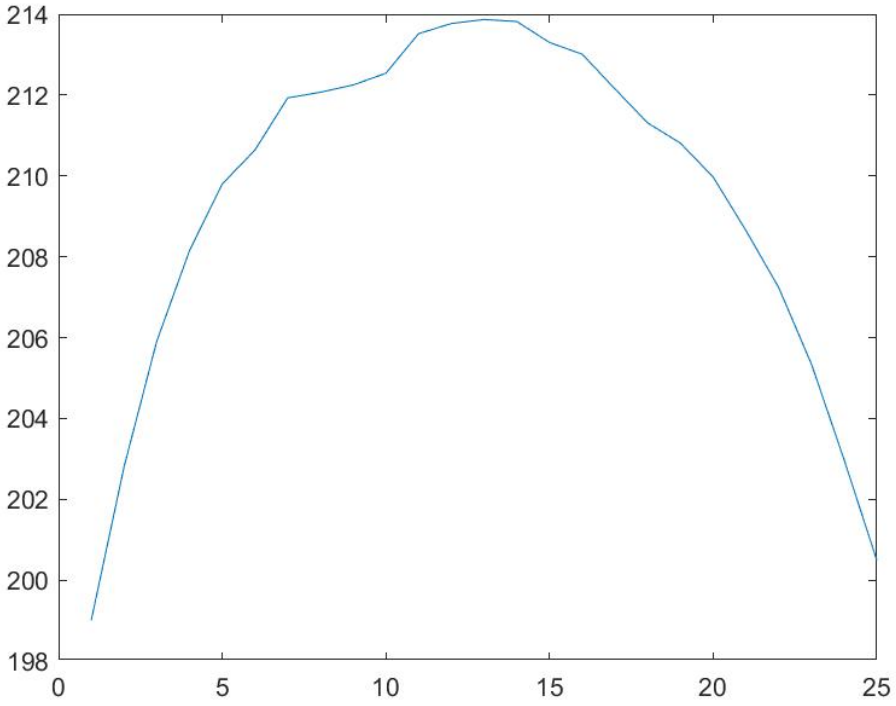

Figure A.102. Graph of Setup 3 Replication 1 Test 27 – Single Cross Section

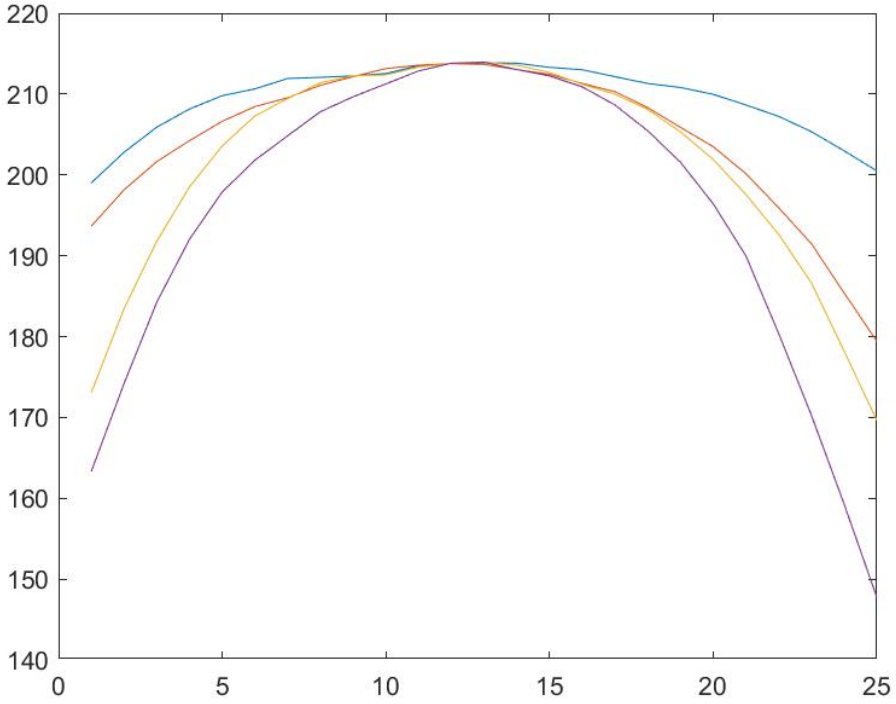

Figure A.103. Graph of Setup 3 Replication 1 Test 27 – Multiple Cross Sections

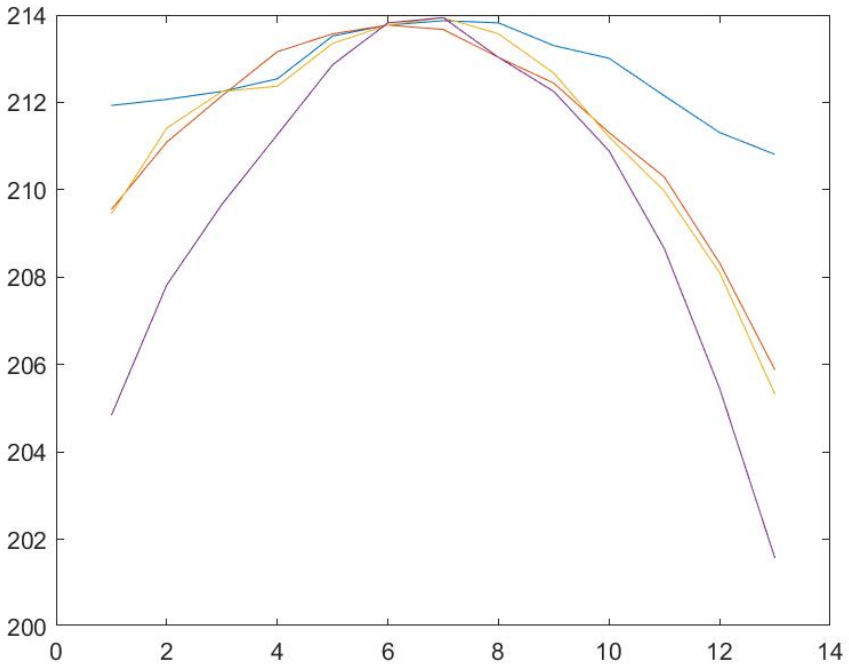

Figure A.104. Magnified Section of Graph of Setup 3 Replication 1 Test 27 – Multiple Cross Sections

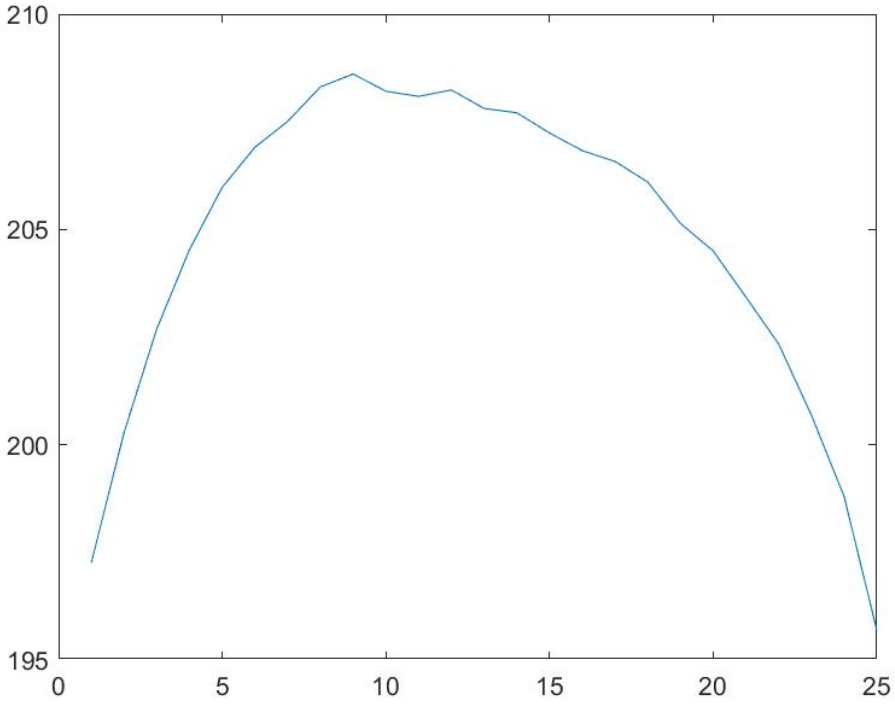

Figure A.105. Graph of Setup 3 Replication 1 Test 28 – Single Cross Section

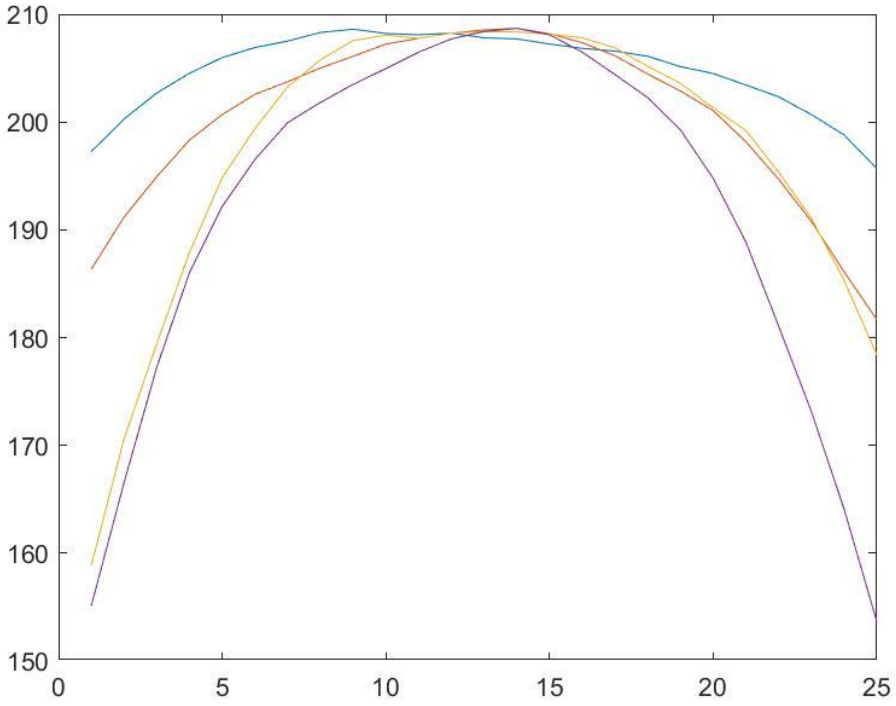

Figure A.106. Graph of Setup 3 Replication 1 Test 28 – Multiple Cross Sections

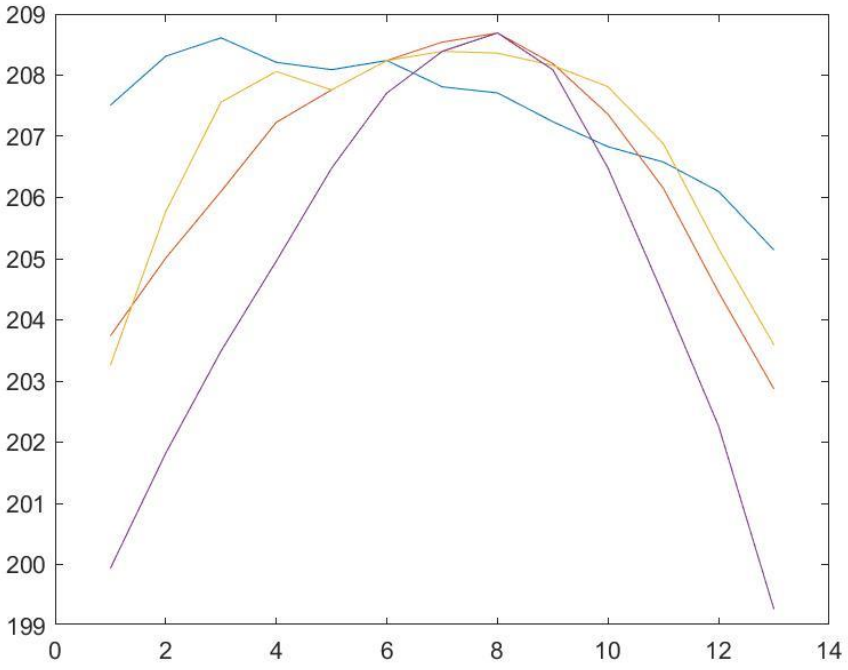

Figure A.107. Magnified Section of Graph of Setup 3 Replication 1 Test 28 – Multiple Cross Sections

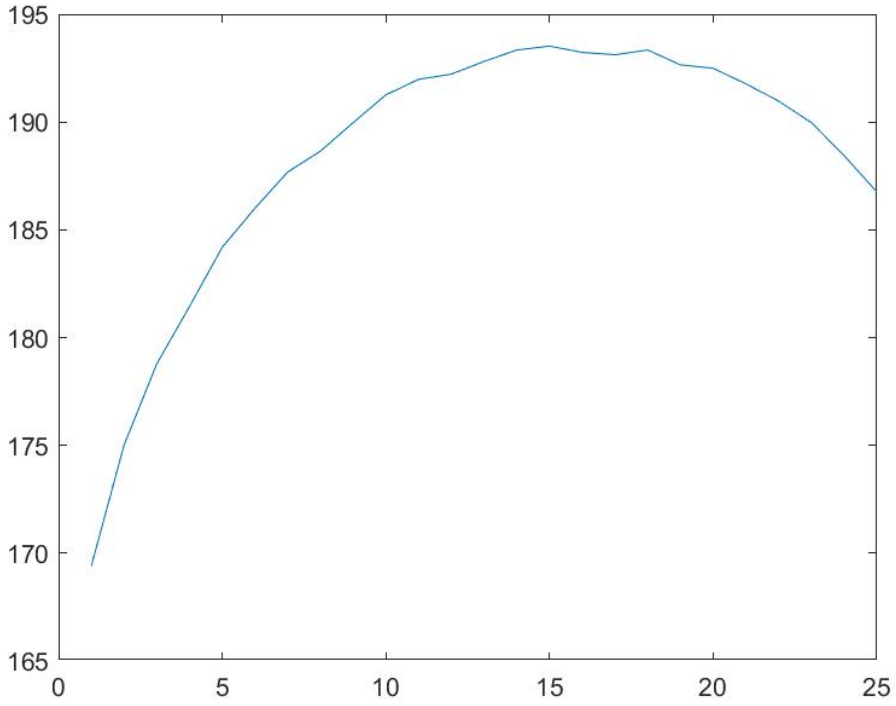

Figure A.108. Graph of Setup 3 Replication 1 Test 29 – Single Cross Section

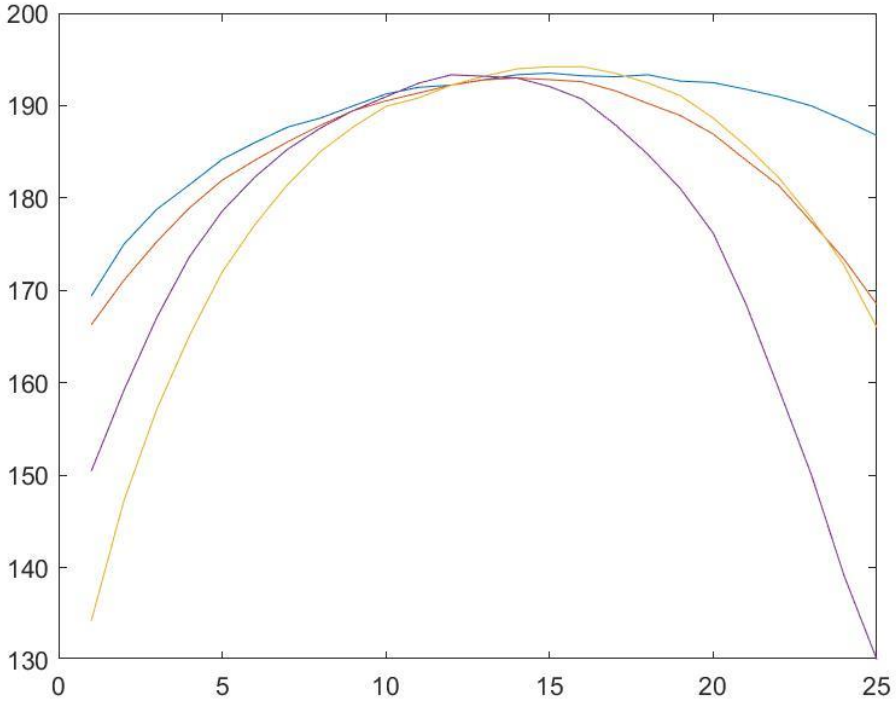

Figure A.109. Graph of Setup 3 Replication 1 Test 29 – Multiple Cross Sections

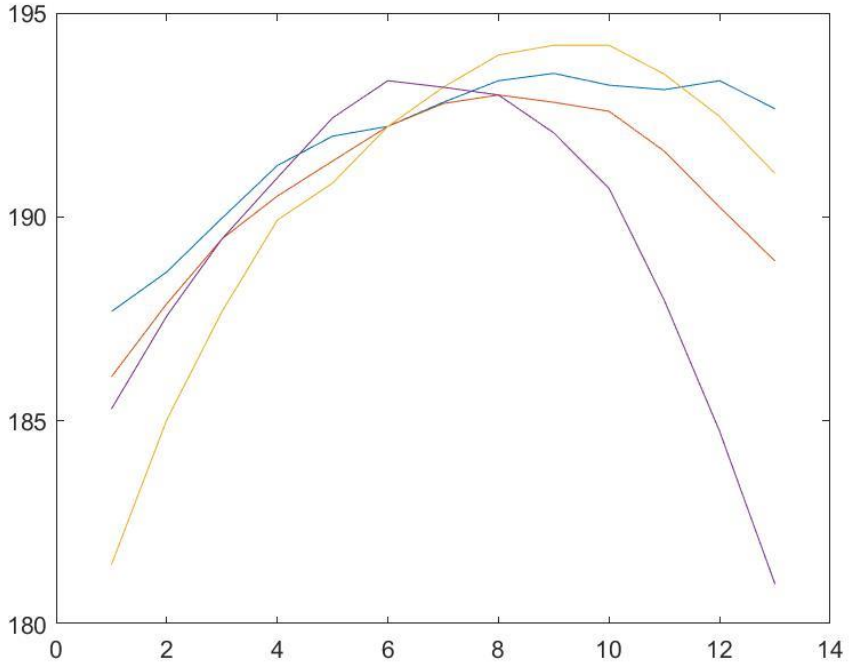

Figure A.110. Magnified Section of Graph of Setup 3 Replication 1 Test 29 – Multiple Cross Sections

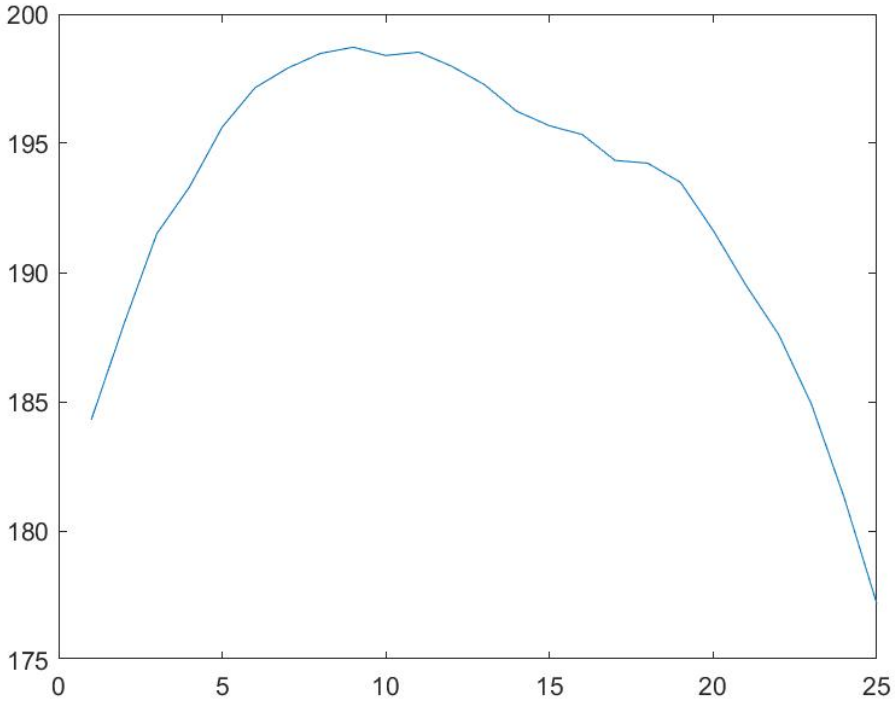

Figure A.111. Graph of Setup 3 Replication 1 Test 30 – Single Cross Section

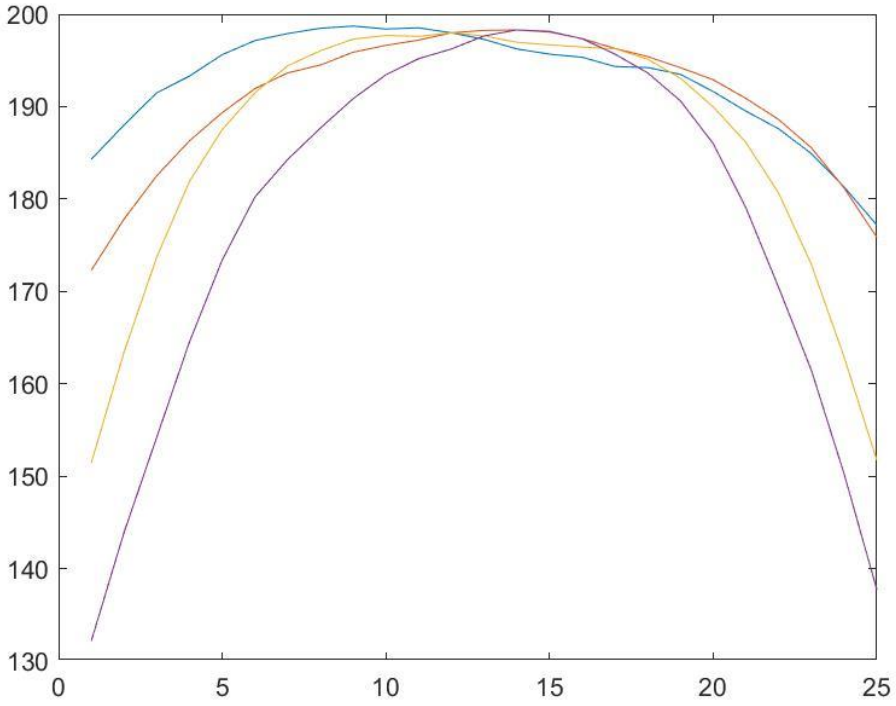

Figure A.112. Graph of Setup 3 Replication 1 Test 30 – Multiple Cross Sections

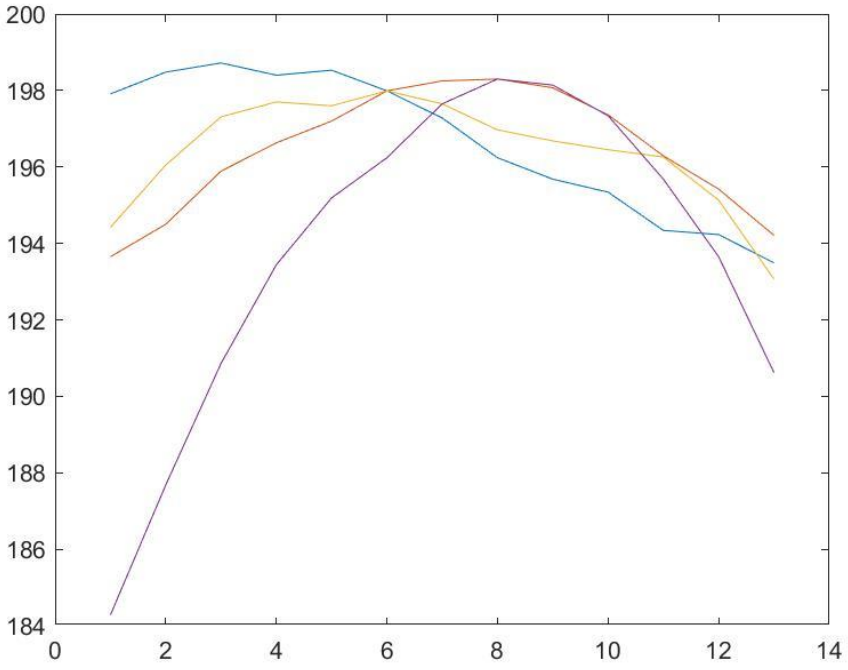

Figure A.113. Magnified Section of Graph of Setup 3 Replication 1 Test 30 – Multiple Cross Sections

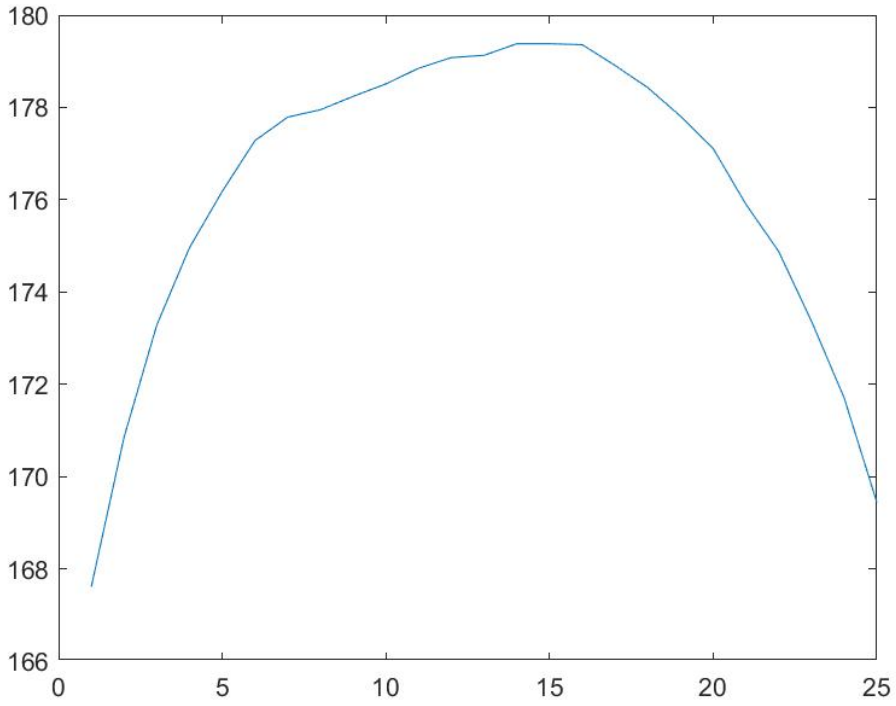

Figure A.114. Graph of Setup 3 Replication 2 Test 1 – Single Cross Section

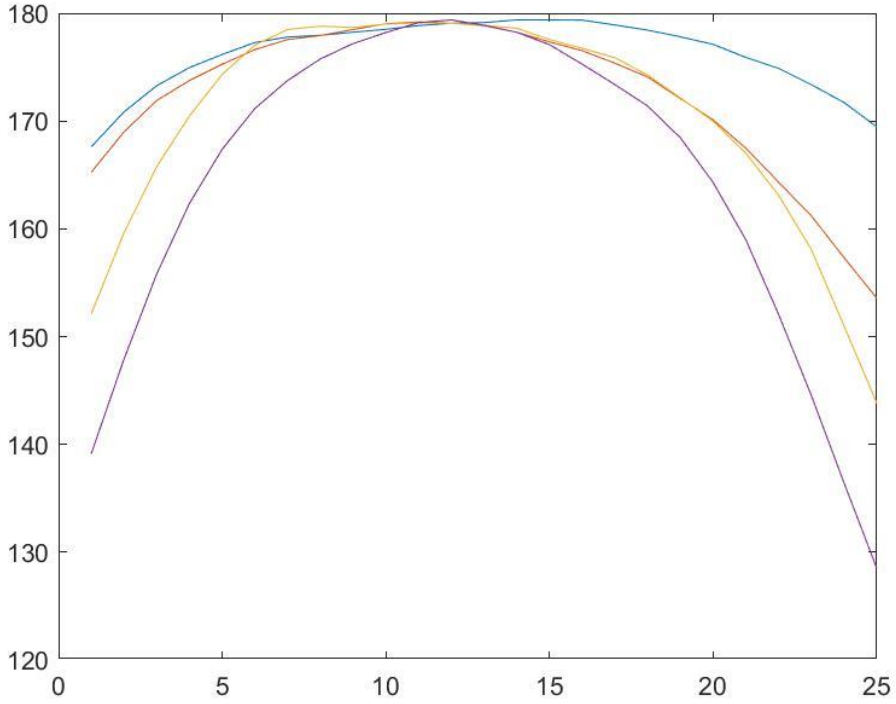

Figure A.115. Graph of Setup 3 Replication 2 Test 1 – Multiple Cross Sections

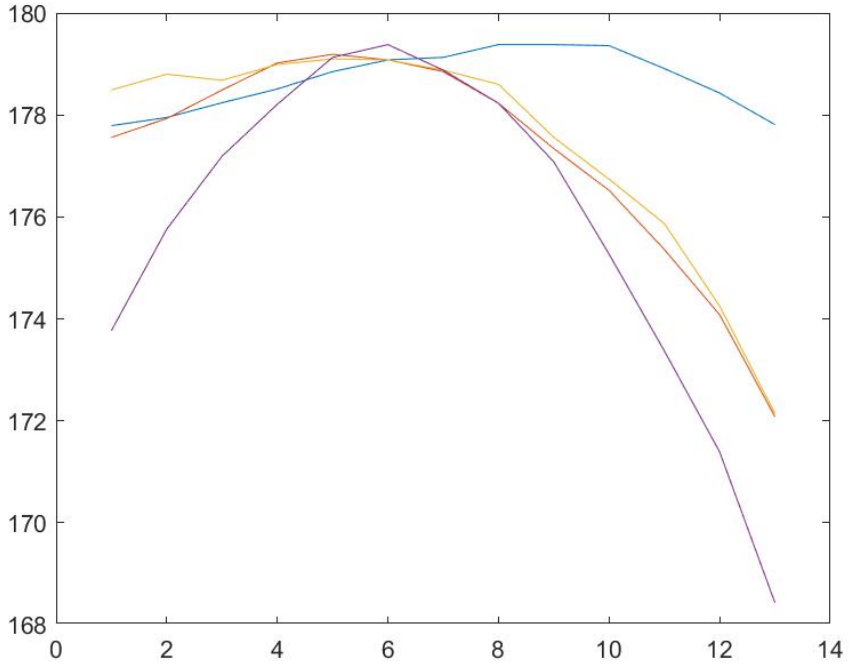

Figure A.116. Magnified Section of Graph of Setup 3 Replication 2 Test 1 – Multiple Cross Sections

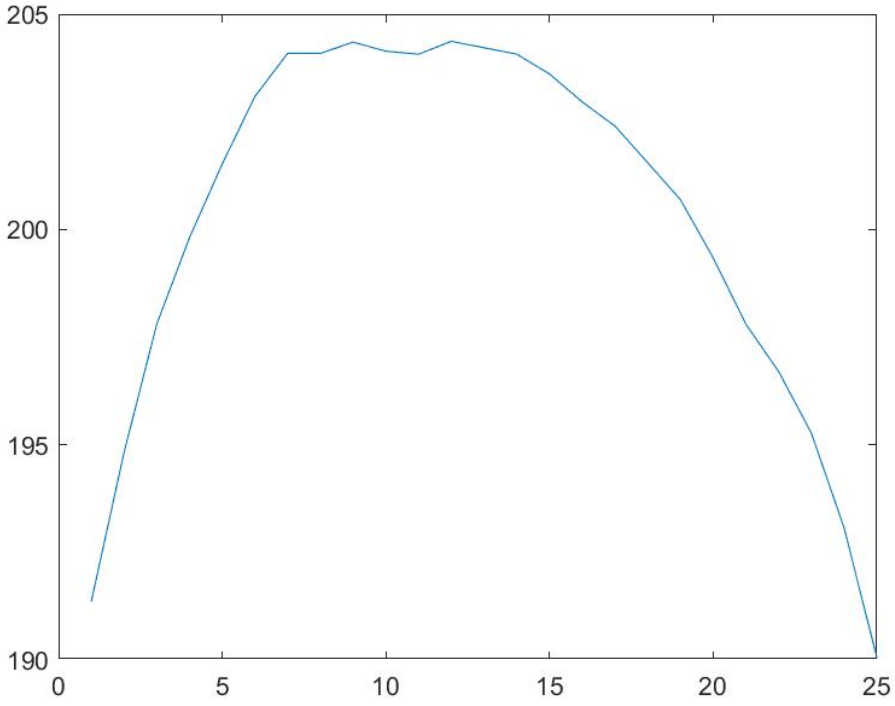

Figure A.117. Graph of Setup 3 Replication 2 Test 2 – Single Cross Section

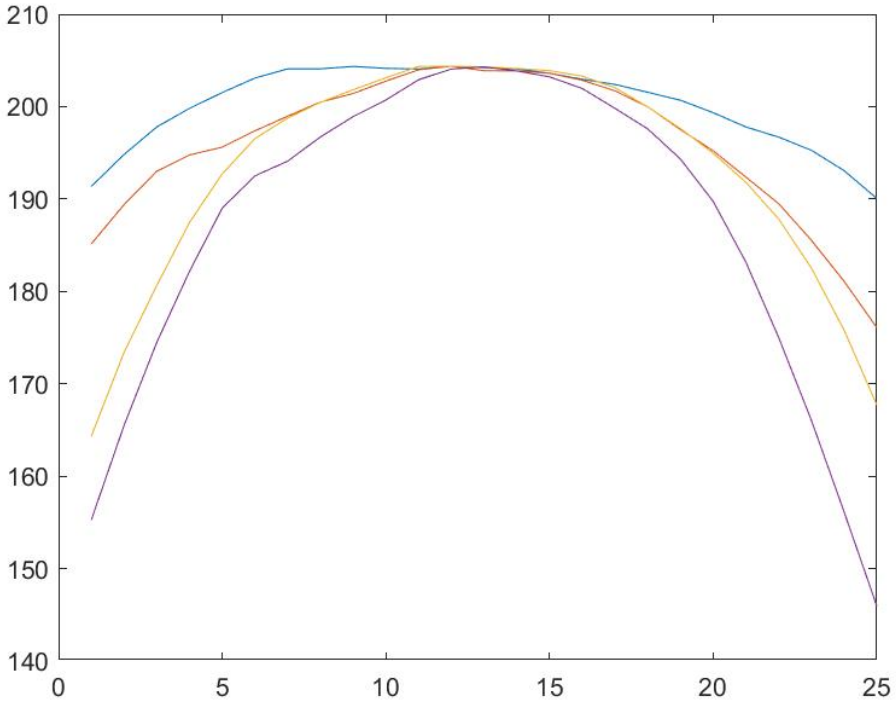

Figure A.118. Graph of Setup 3 Replication 2 Test 2 – Multiple Cross Sections

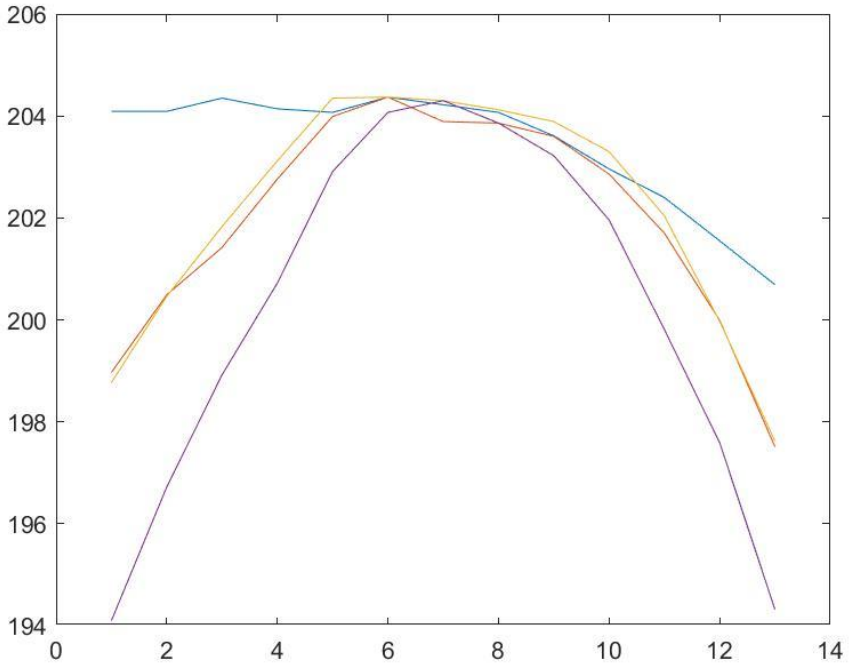

Figure A.119. Magnified Section of Graph of Setup 3 Replication 2 Test 2 – Multiple Cross Sections

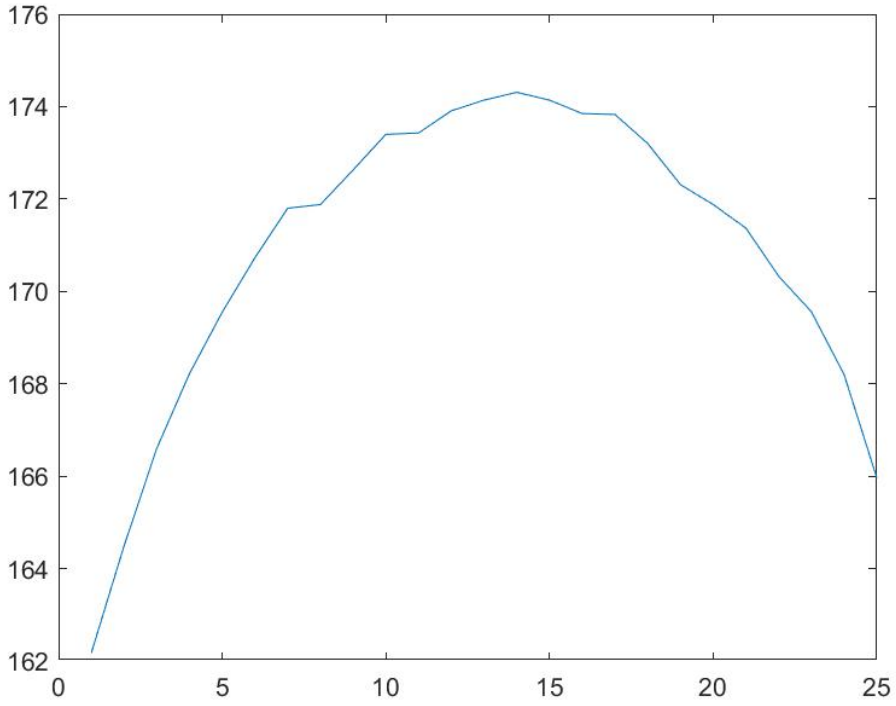

Figure A.120. Graph of Setup 3 Replication 2 Test 3 – Single Cross Section

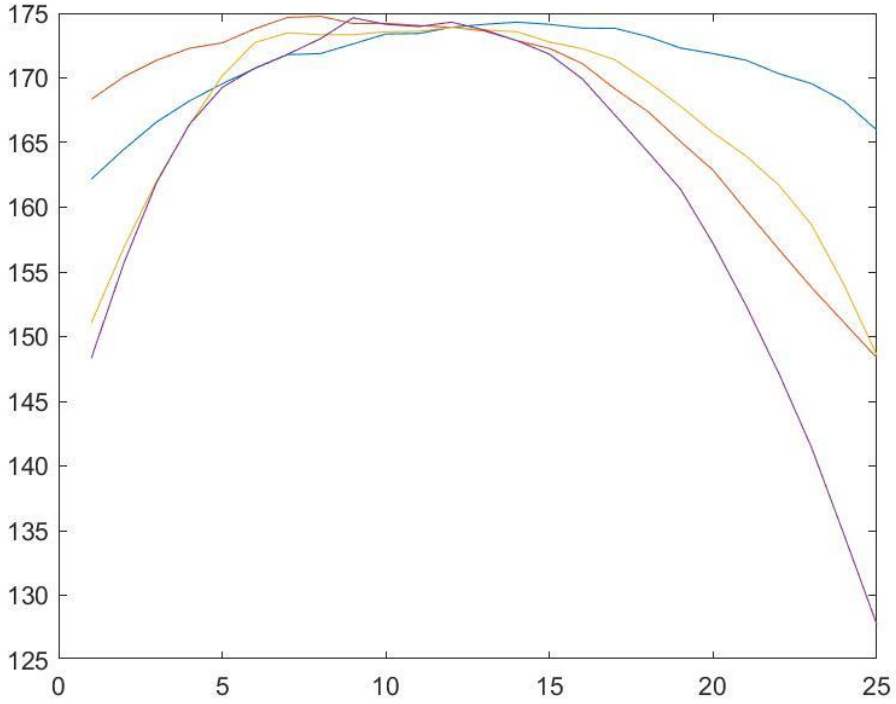

Figure A.121. Graph of Setup 3 Replication 2 Test 3 – Multiple Cross Sections

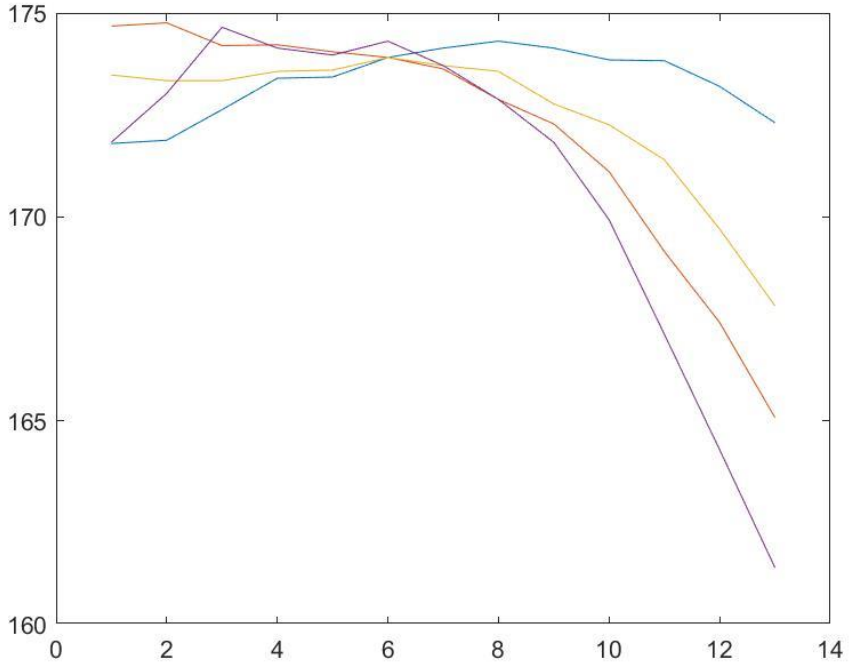

Figure A.122. Magnified Section of Graph of Setup 3 Replication 2 Test 3 – Multiple Cross Sections

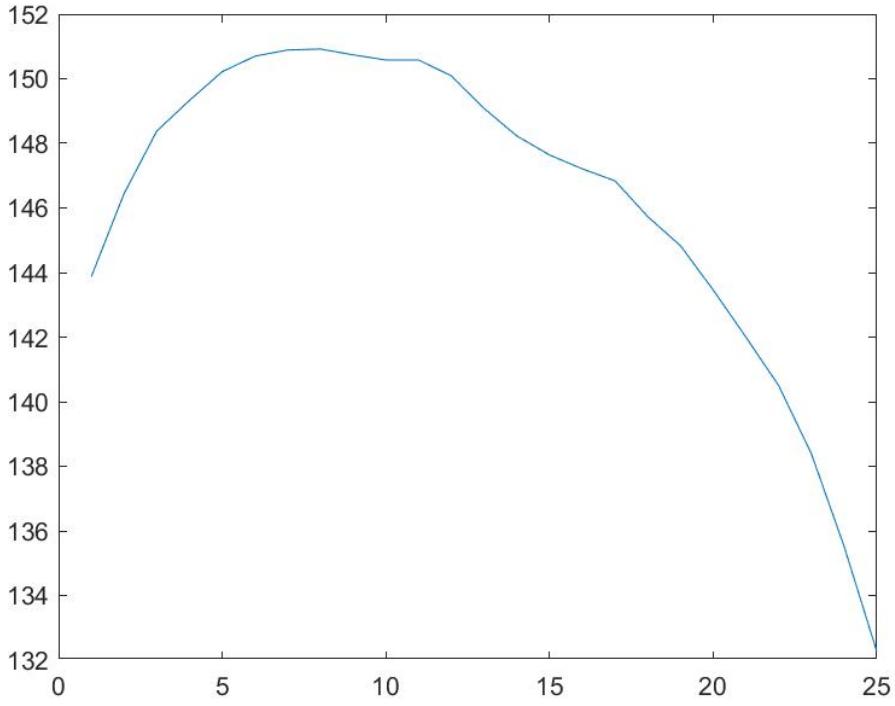

Figure A.123. Graph of Setup 3 Replication 2 Test 4 – Single Cross Section

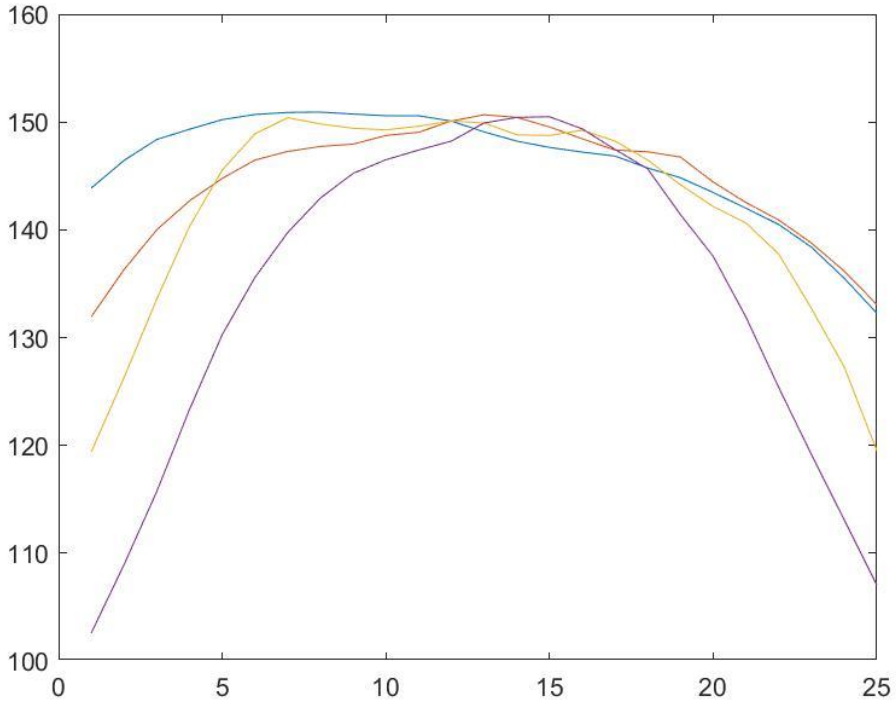

Figure A.124. Graph of Setup 3 Replication 2 Test 4 – Multiple Cross Sections

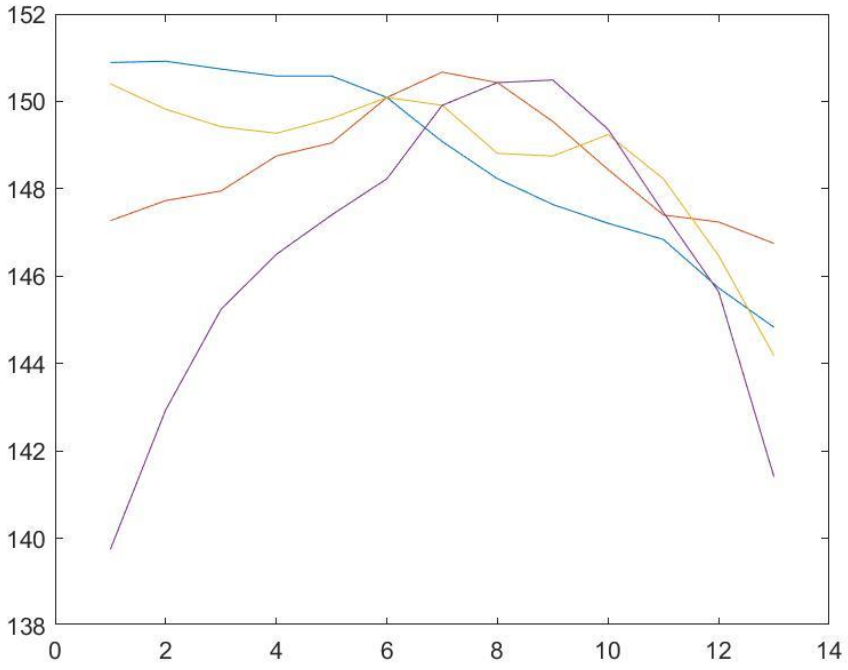

Figure A.125. Magnified Section of Graph of Setup 3 Replication 2 Test 4 – Multiple Cross Sections

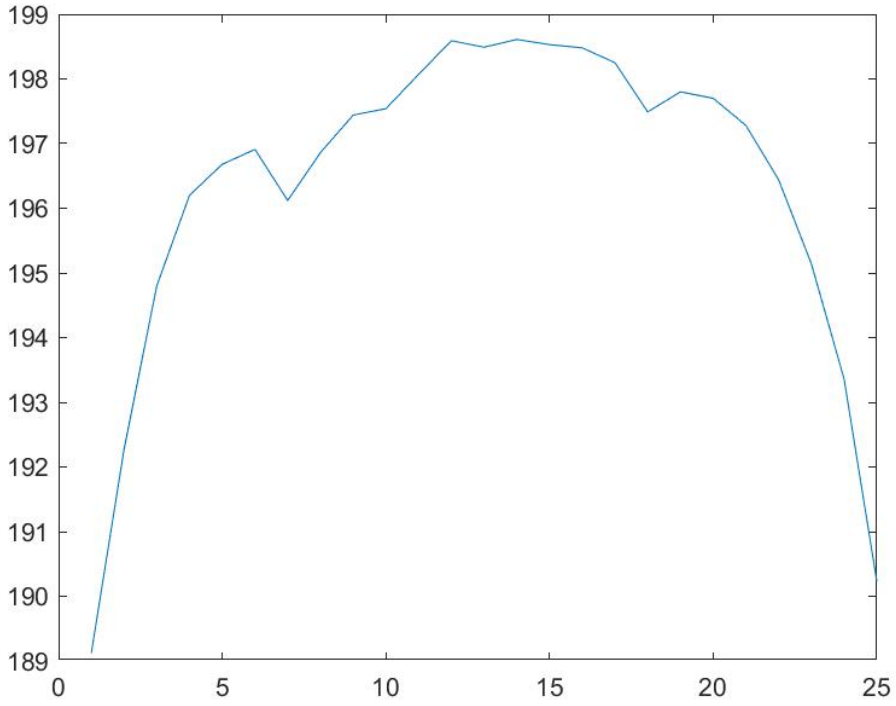

Figure A.126. Graph of Setup 3 Replication 2 Test 5 – Single Cross Section

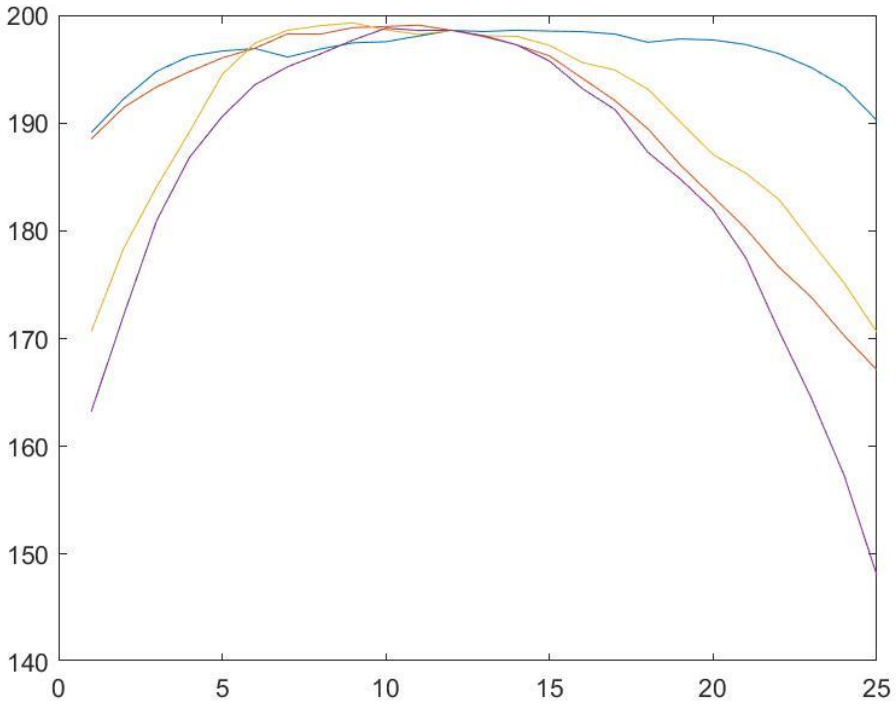

Figure A.127. Graph of Setup 3 Replication 2 Test 5 – Multiple Cross Sections

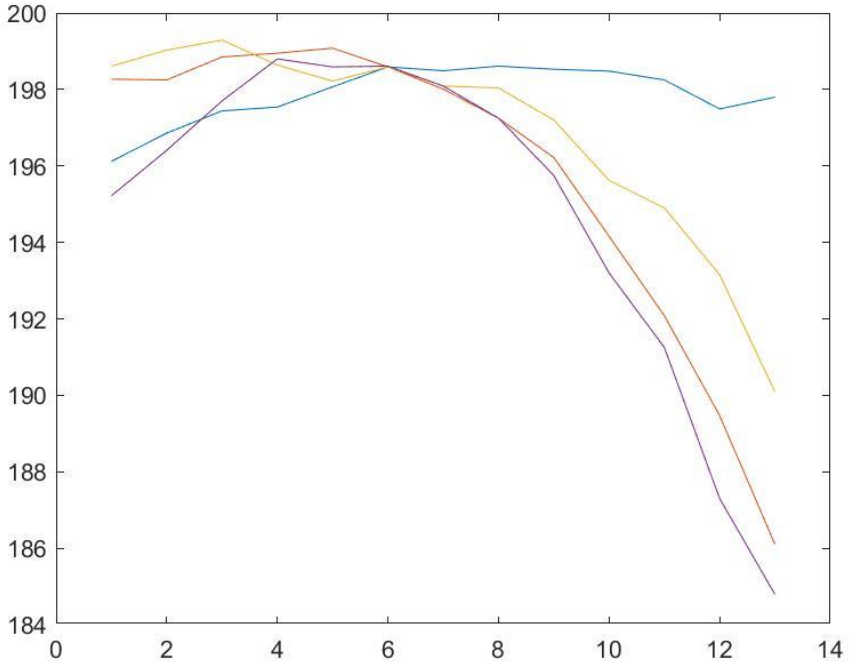

Figure A.128. Magnified Section of Graph of Setup 3 Replication 2 Test 5 – Multiple Cross Sections

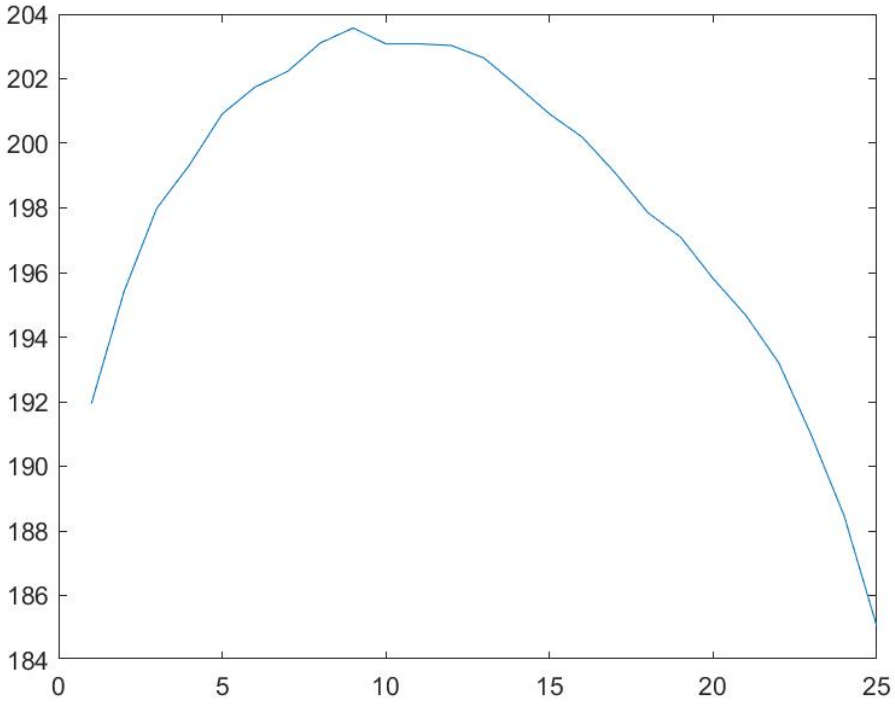

Figure A.129. Graph of Setup 3 Replication 2 Test 6 – Single Cross Section

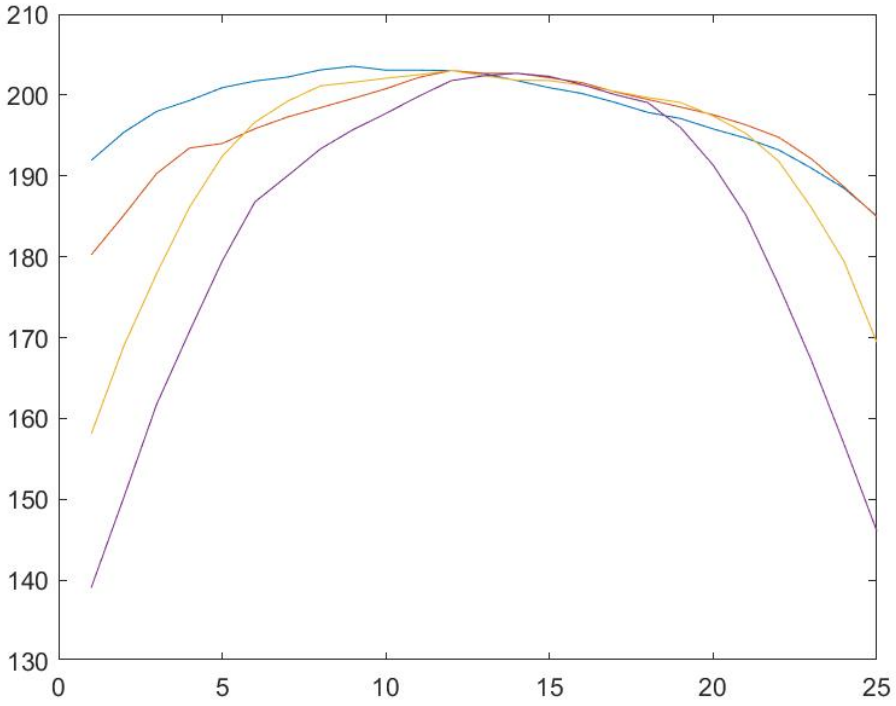

Figure A.130. Graph of Setup 3 Replication 2 Test 6 – Multiple Cross Sections

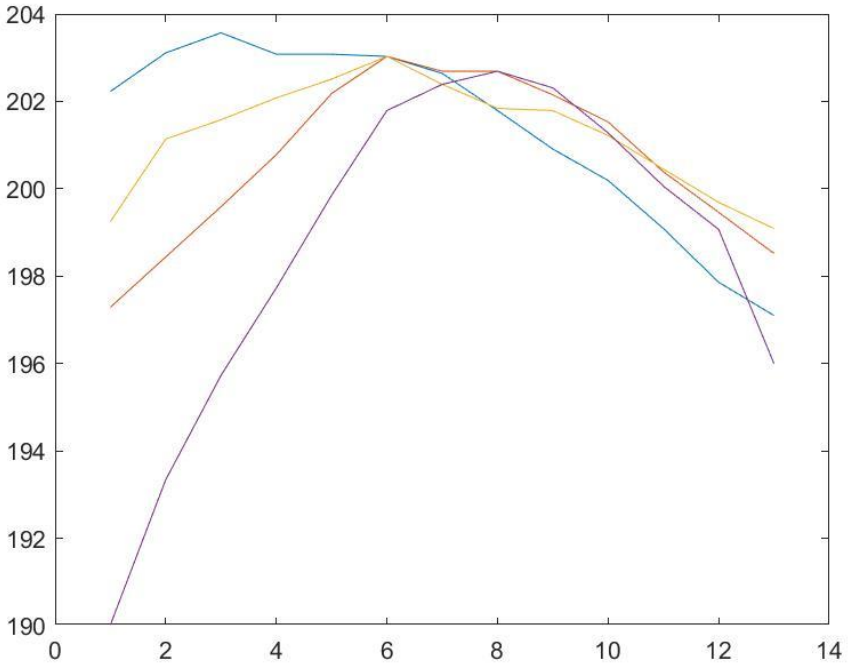

Figure A.131. Magnified Section of Graph of Setup 3 Replication 2 Test 6 – Multiple Cross Sections

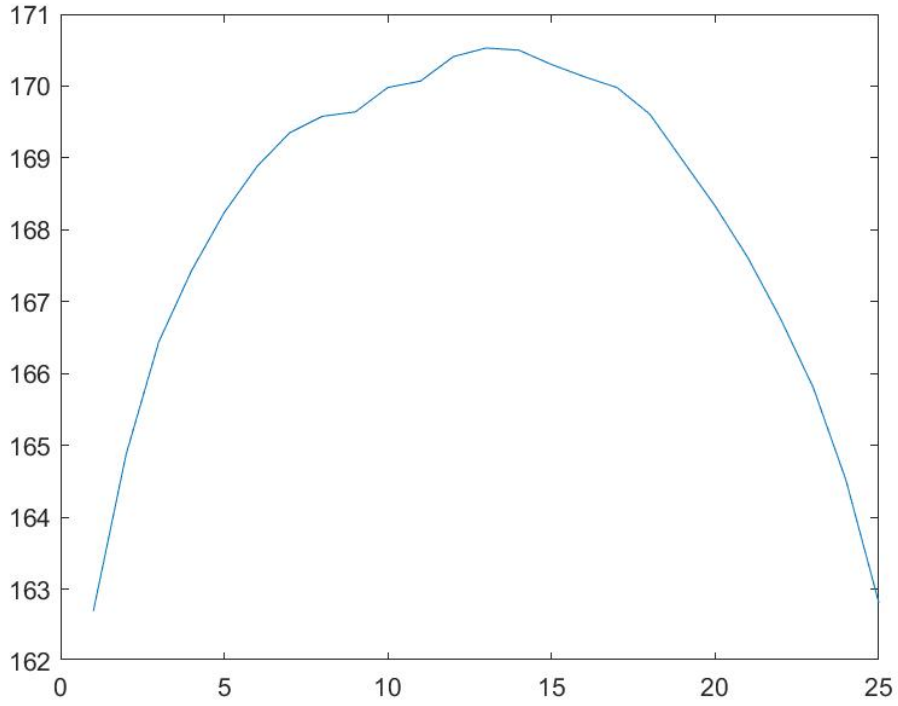

Figure A.132. Graph of Setup 3 Replication 2 Test 7 – Single Cross Section

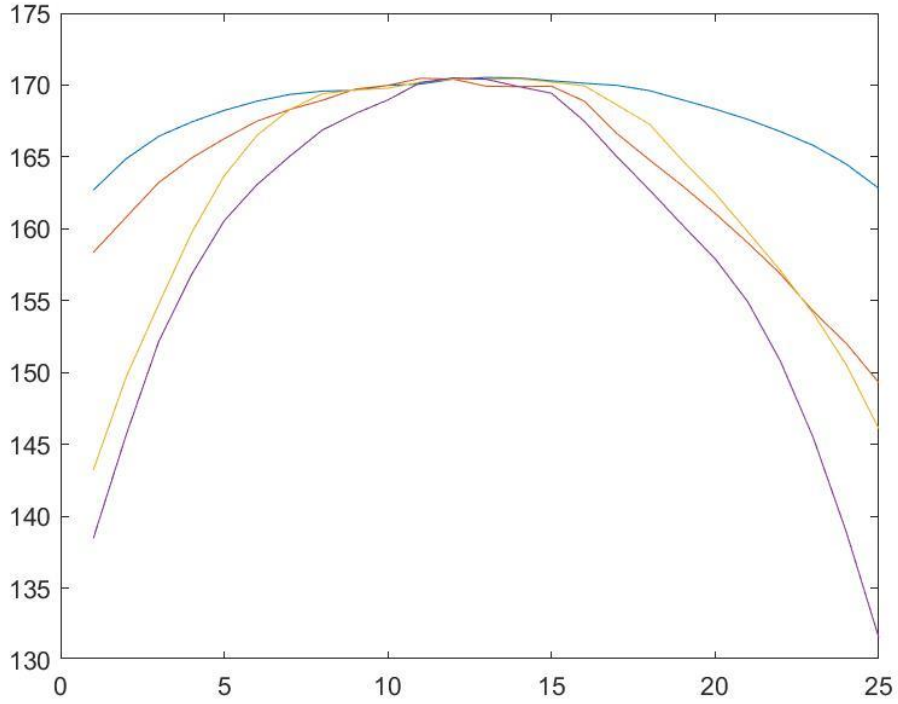

Figure A.133. Graph of Setup 3 Replication 2 Test 7 – Multiple Cross Sections

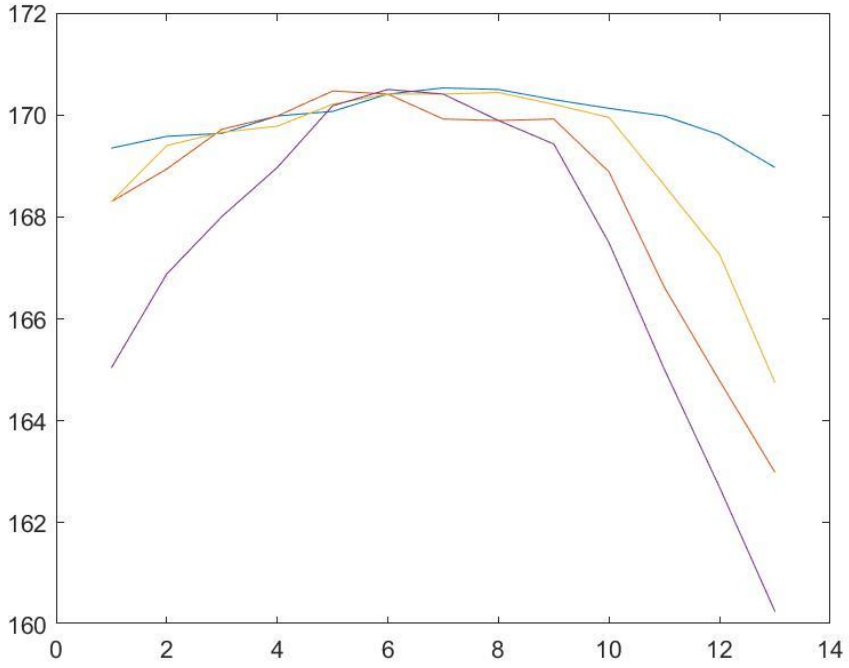

Figure A.134. Magnified Section of Graph of Setup 3 Replication 2 Test 7 – Multiple Cross Sections

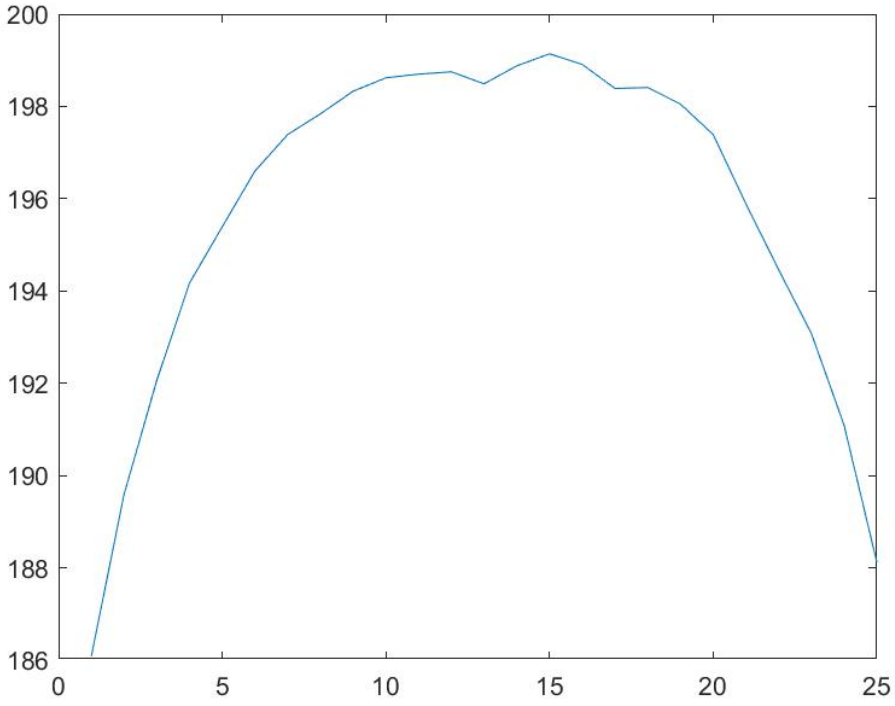

Figure A.135. Graph of Setup 3 Replication 2 Test 8 – Single Cross Section

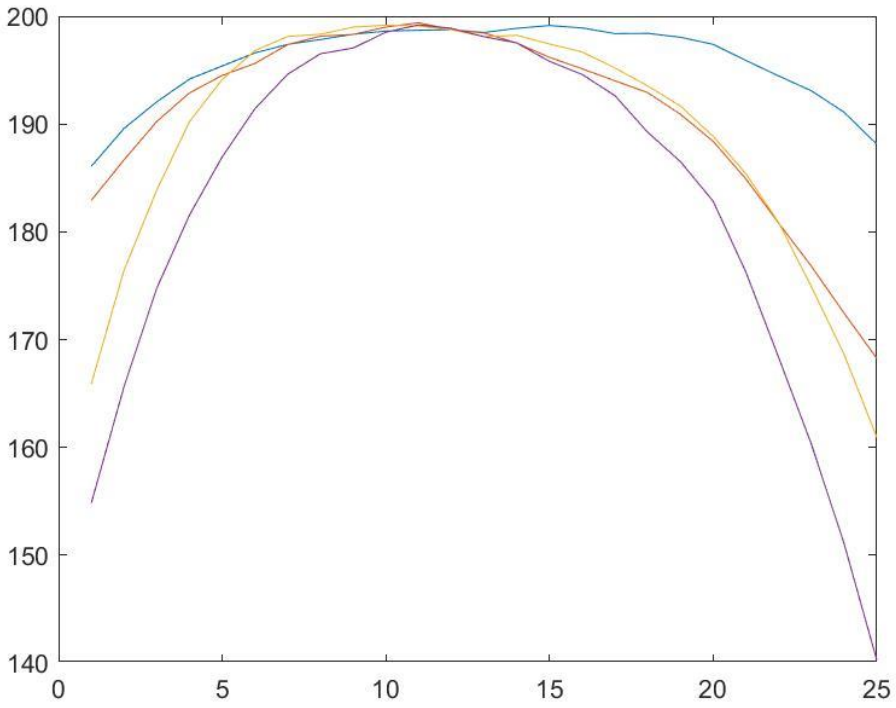

Figure A.136. Graph of Setup 3 Replication 2 Test 8 – Multiple Cross Sections

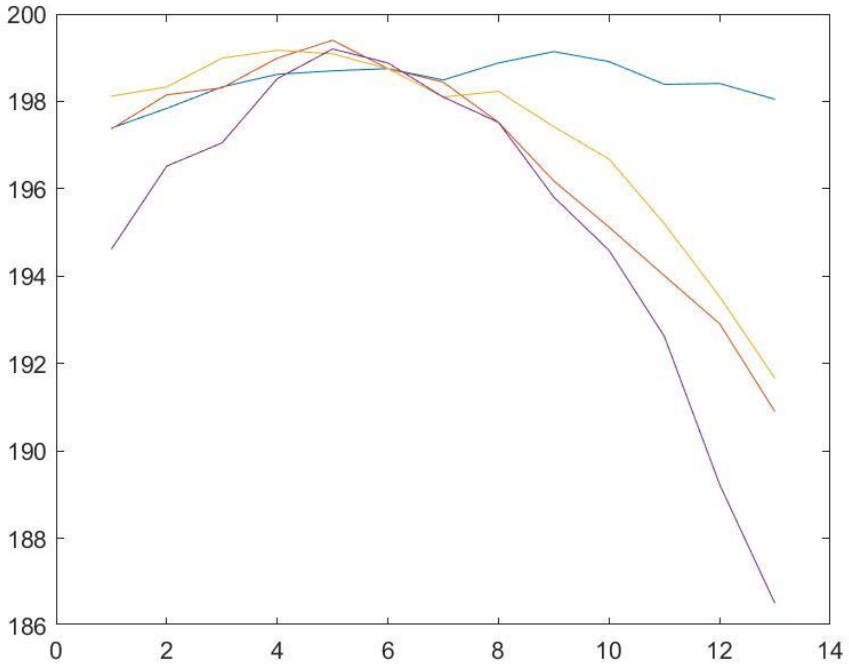

Figure A.137. Magnified Section of Graph of Setup 3 Replication 2 Test 8 – Multiple Cross Sections

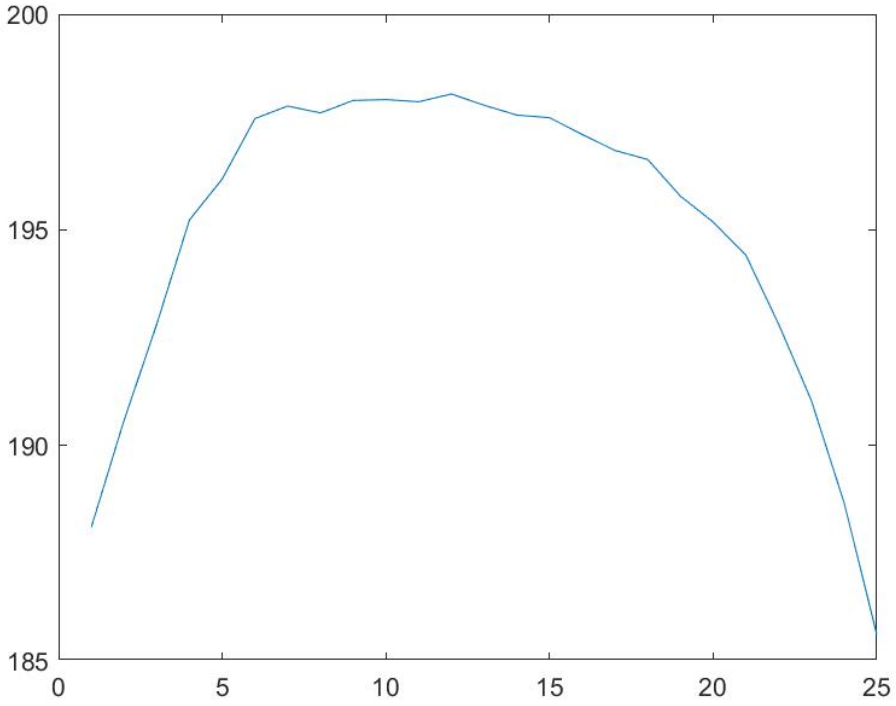

Figure A.138. Graph of Setup 3 Replication 2 Test 9 – Single Cross Section

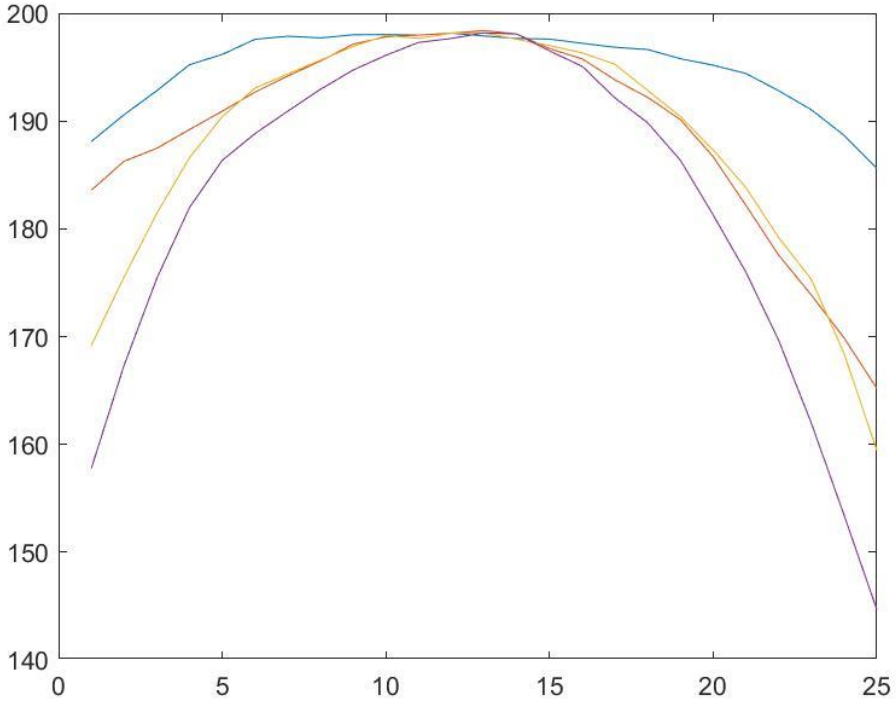

Figure A.139. Graph of Setup 3 Replication 2 Test 9 – Multiple Cross Sections

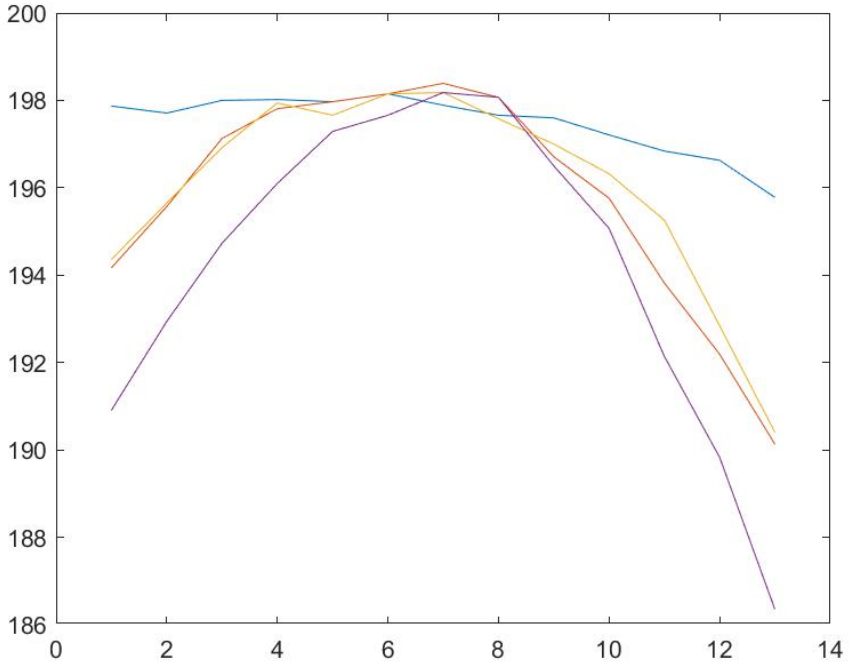

Figure A.140. Magnified Section of Graph of Setup 3 Replication 2 Test 9 – Multiple Cross Sections

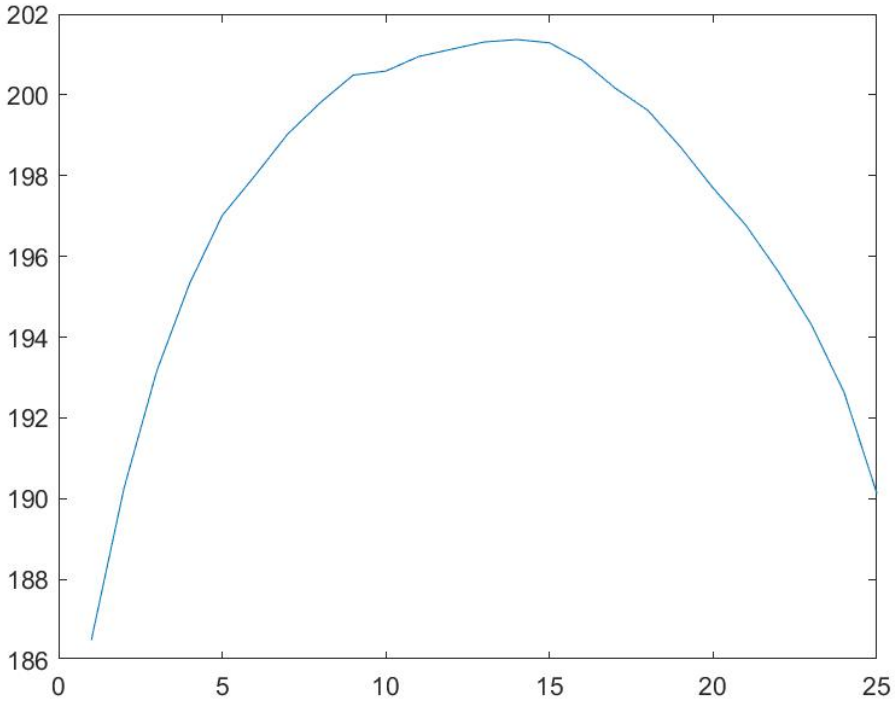

Figure A.141. Graph of Setup 3 Replication 2 Test 10 – Single Cross Section

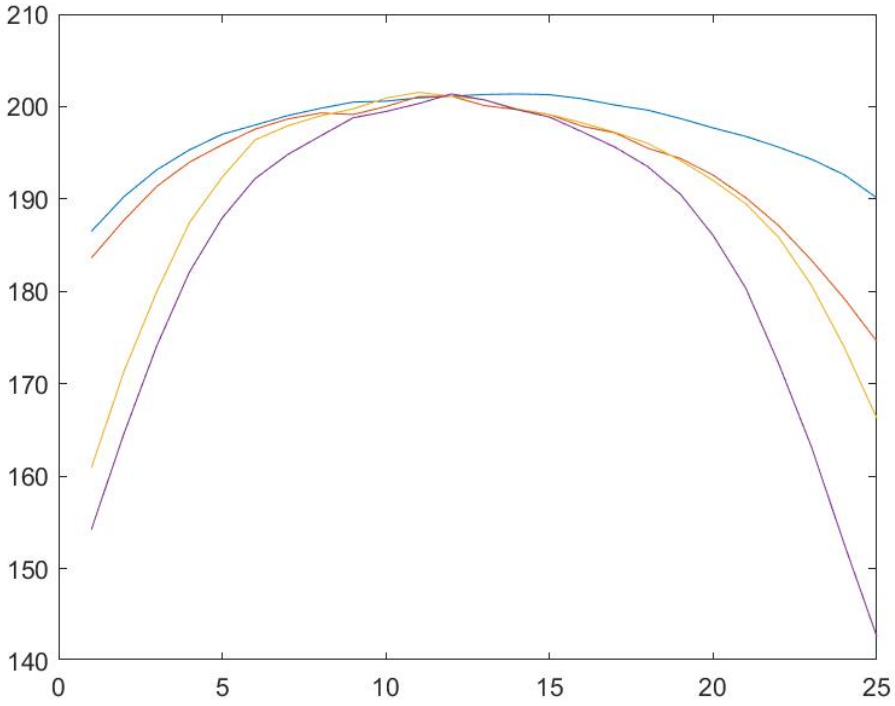

Figure A.142. Graph of Setup 3 Replication 2 Test 10 – Multiple Cross Sections

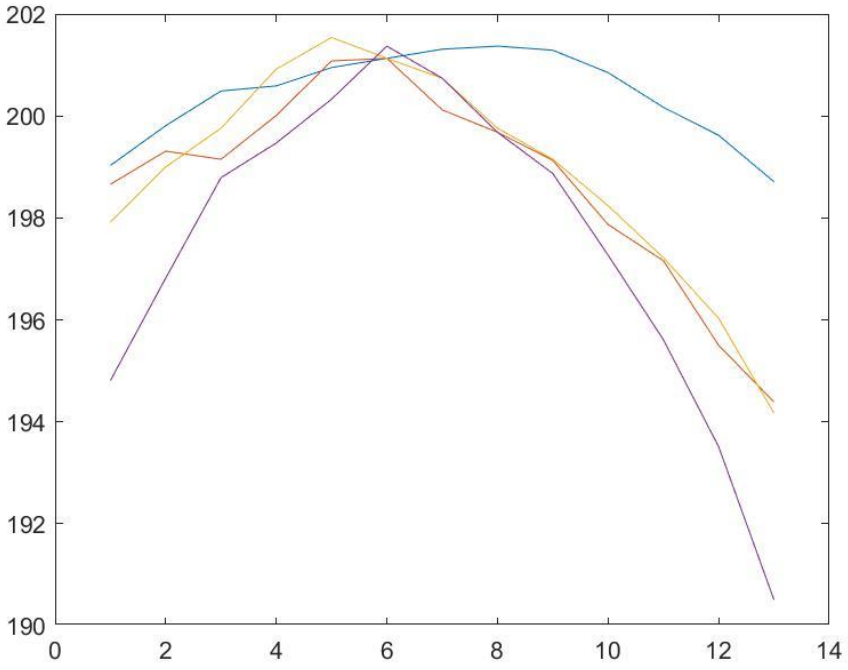

Figure A.143. Magnified Section of Graph of Setup 3 Replication 2 Test 10 – Multiple Cross Sections

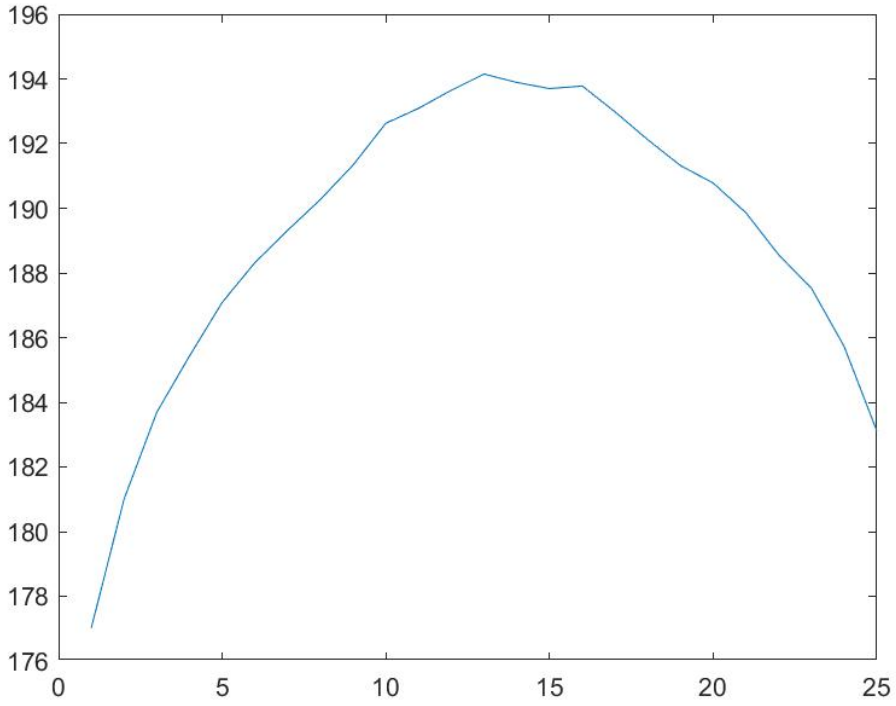

Figure A.144. Graph of Setup 3 Replication 2 Test 11 – Single Cross Section

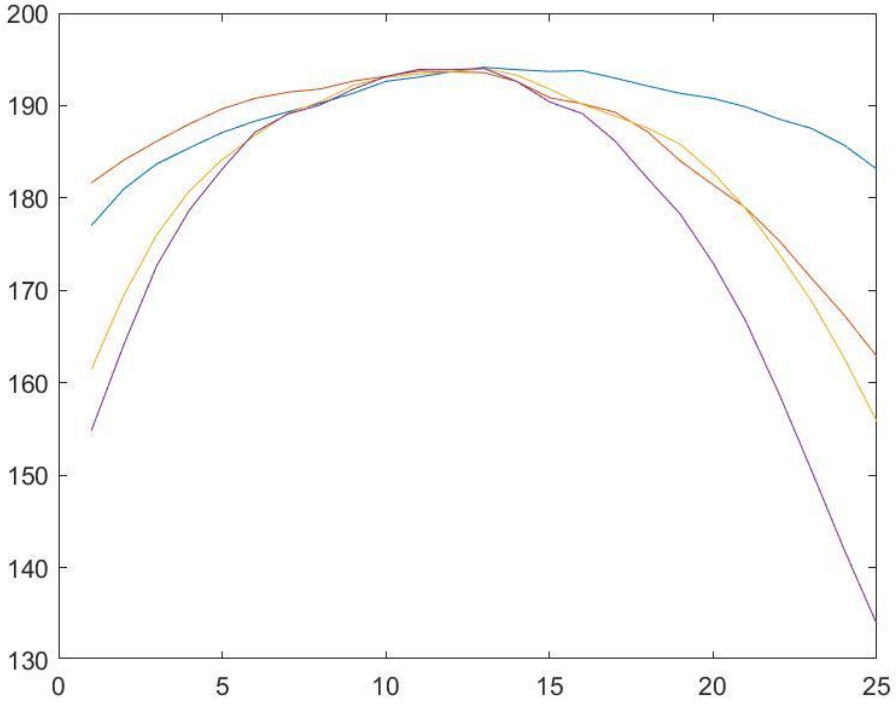

Figure A.145. Graph of Setup 3 Replication 2 Test 11 – Multiple Cross Sections

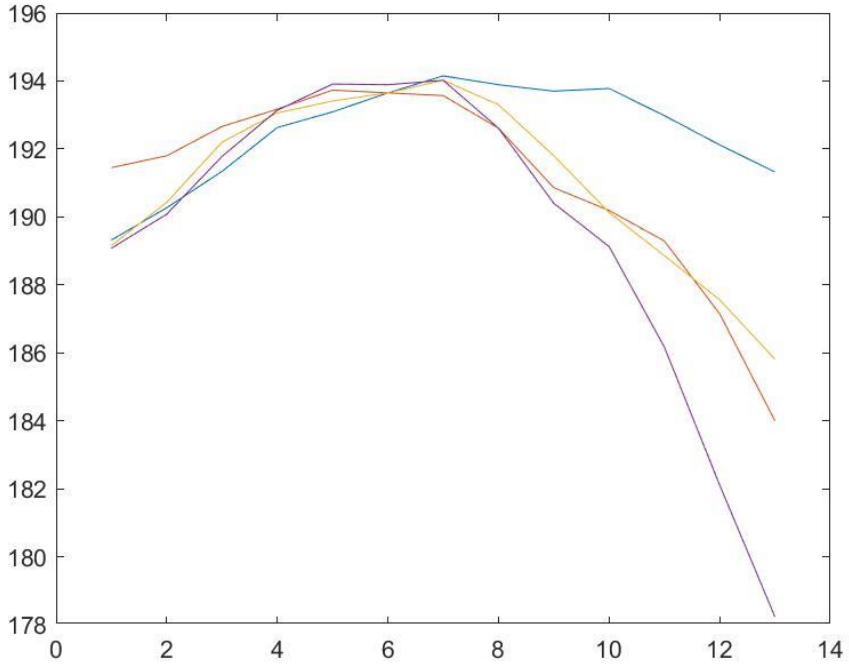

Figure A.146. Magnified Section of Graph of Setup 3 Replication 2 Test 11 – Multiple Cross Sections

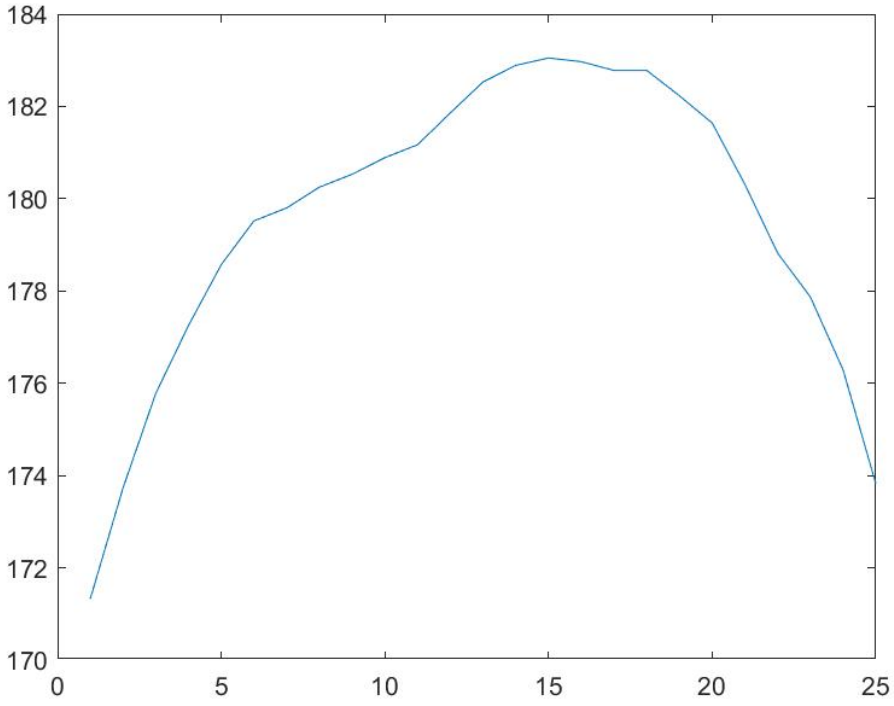

Figure A.147. Graph of Setup 3 Replication 2 Test 12 – Single Cross Section

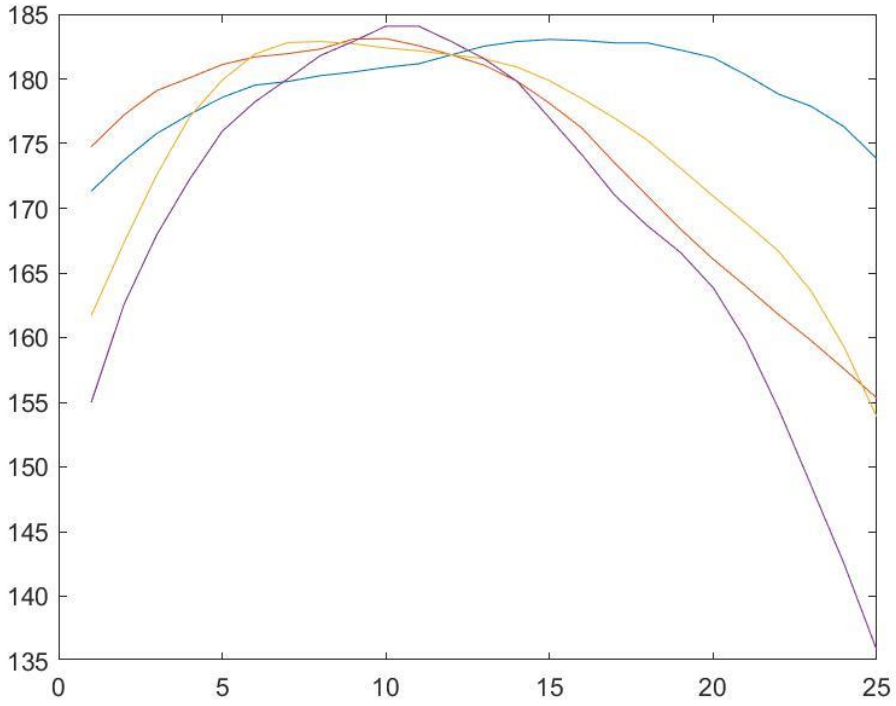

Figure A.148. Graph of Setup 3 Replication 2 Test 12 – Multiple Cross Sections

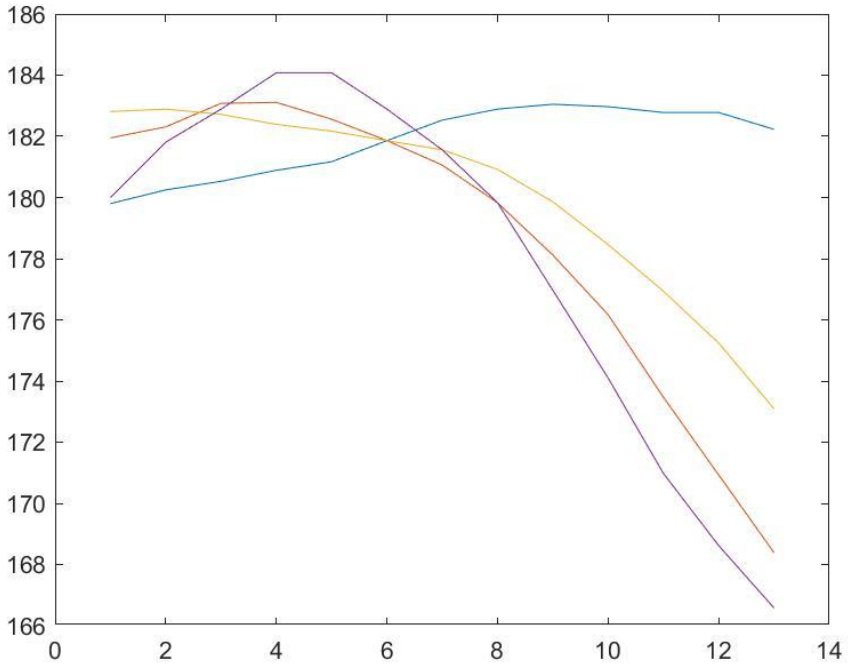

Figure A.149. Magnified Section of Graph of Setup 3 Replication 2 Test 12 – Multiple Cross Sections

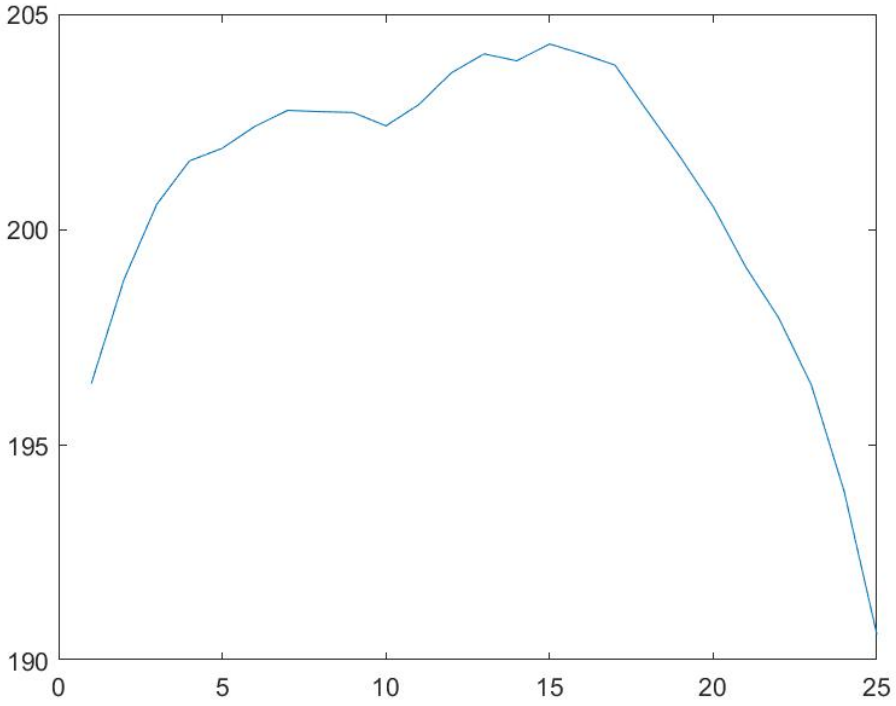

Figure A.150. Graph of Setup 3 Replication 2 Test 13 – Single Cross Section

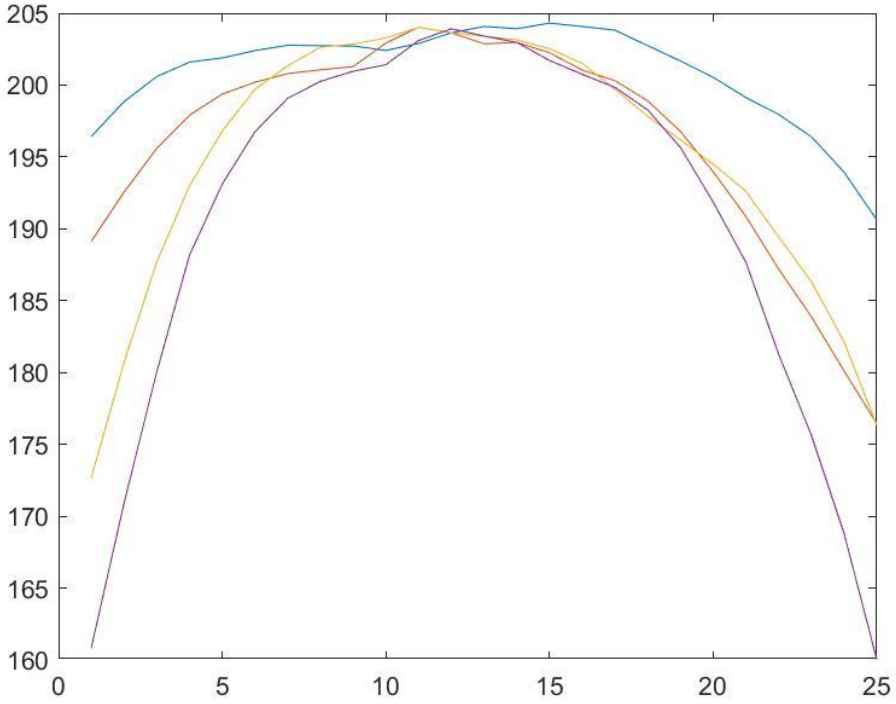

Figure A.151. Graph of Setup 3 Replication 2 Test 13 – Multiple Cross Sections

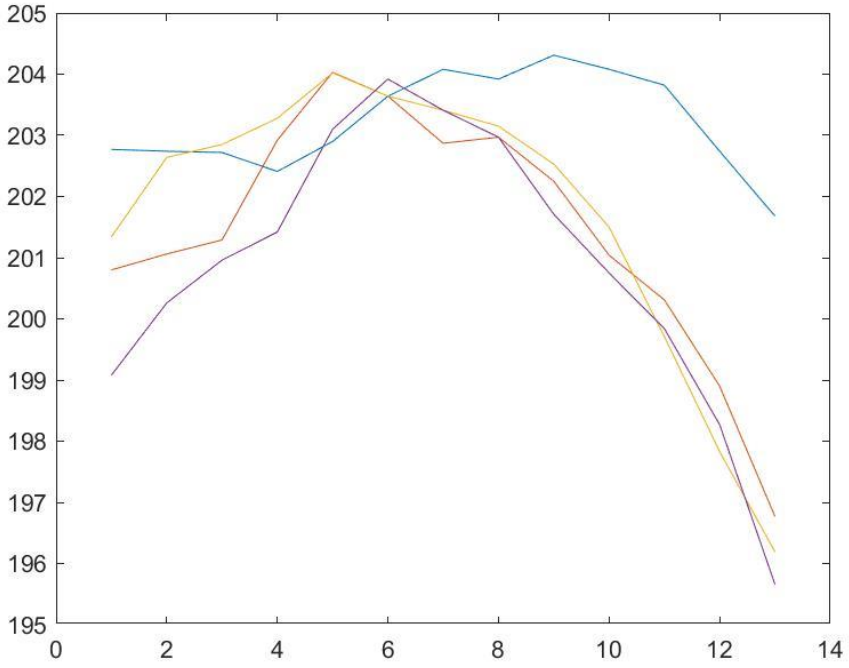

Figure A.152. Magnified Section of Graph of Setup 3 Replication 2 Test 13 – Multiple Cross Sections

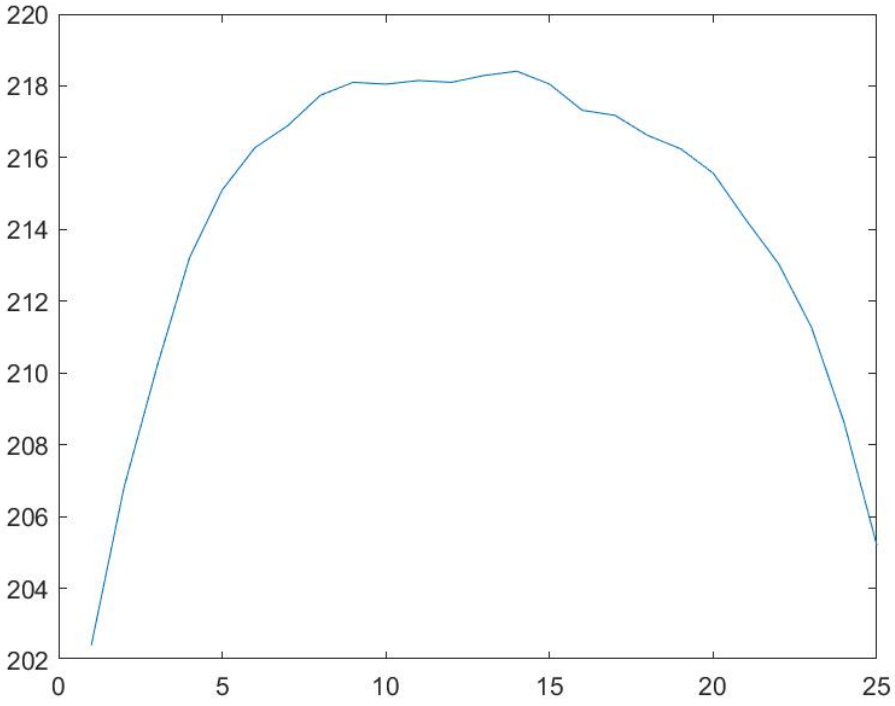

Figure A.153. Graph of Setup 3 Replication 2 Test 14 – Single Cross Section

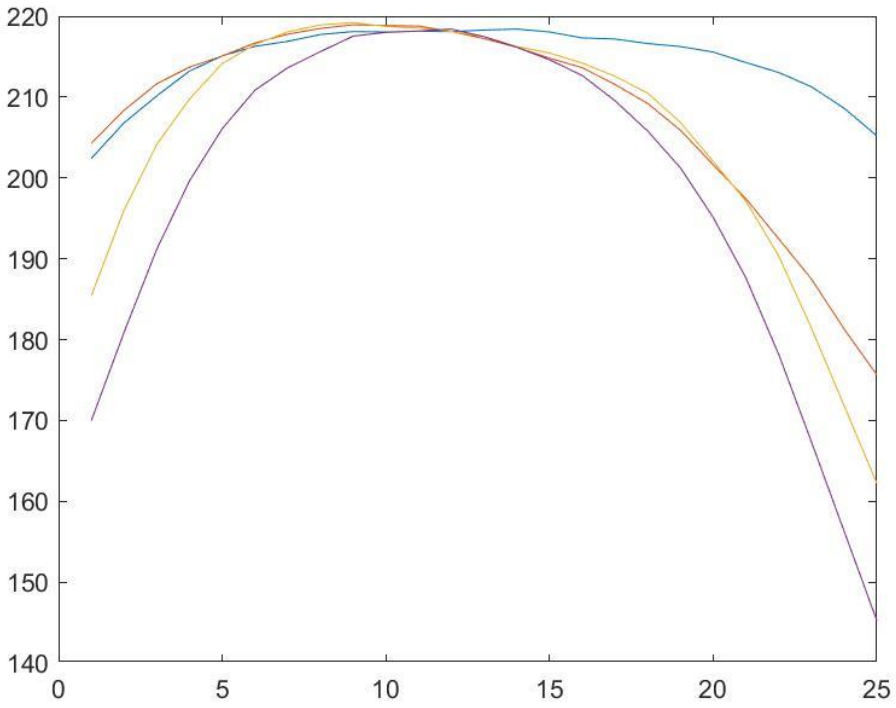

Figure A.154. Graph of Setup 3 Replication 2 Test 14 – Multiple Cross Sections

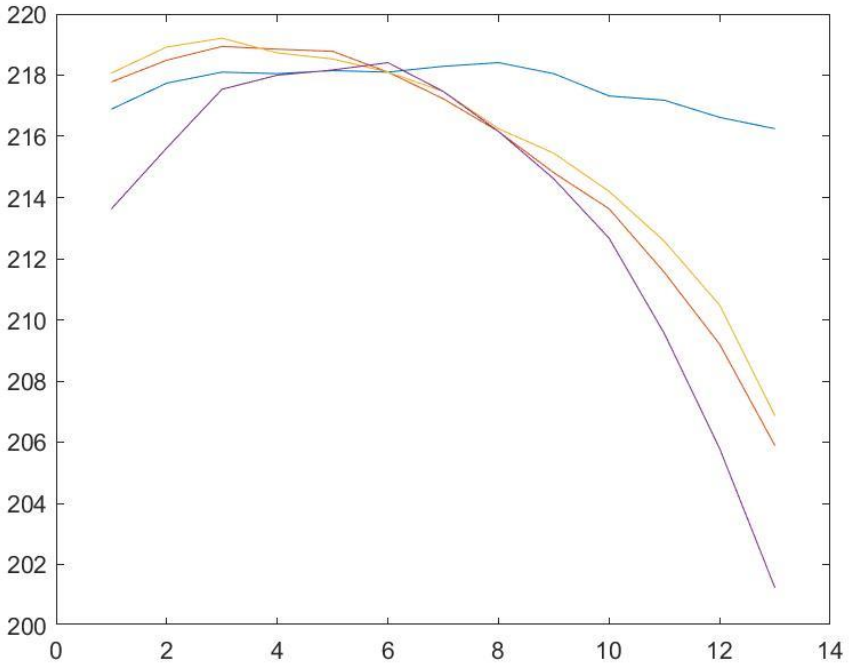

Figure A.155. Magnified Section of Graph of Setup 3 Replication 2 Test 14 – Multiple Cross Sections

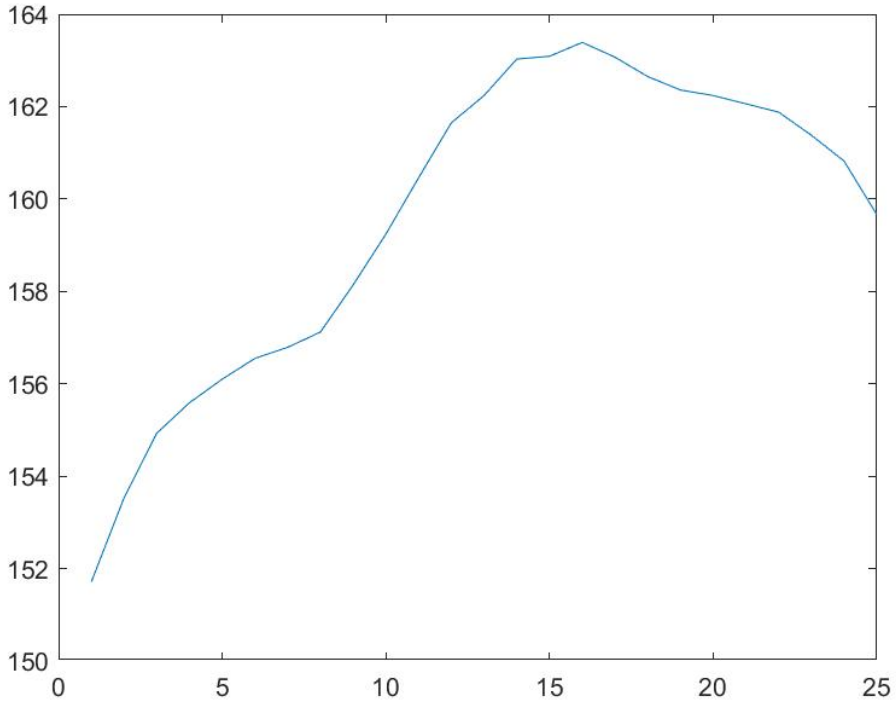

Figure A.156. Graph of Setup 3 Replication 2 Test 15 – Single Cross Section

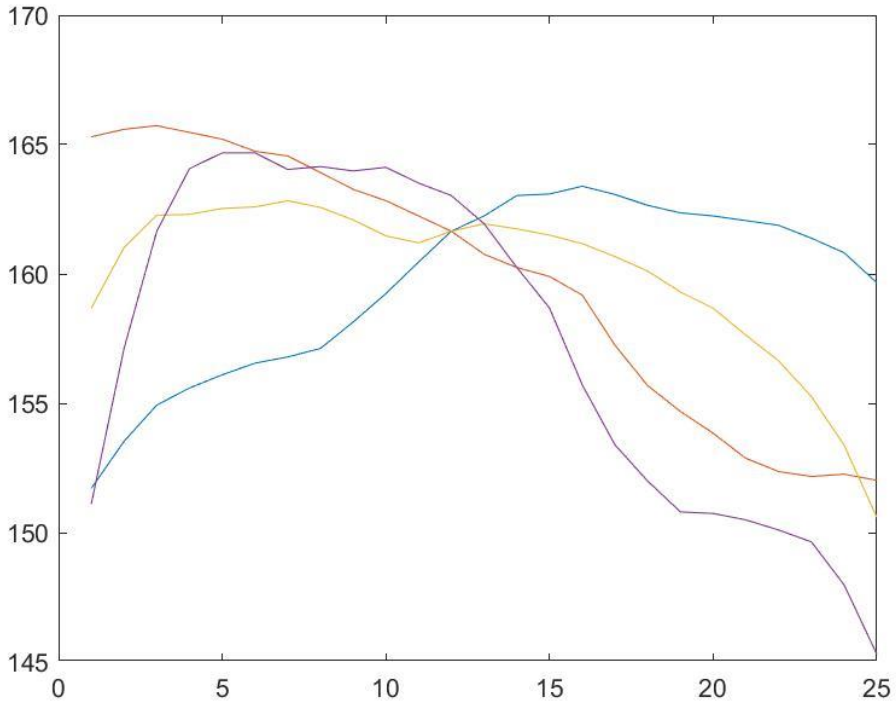

Figure A.157. Graph of Setup 3 Replication 2 Test 15 – Multiple Cross Sections

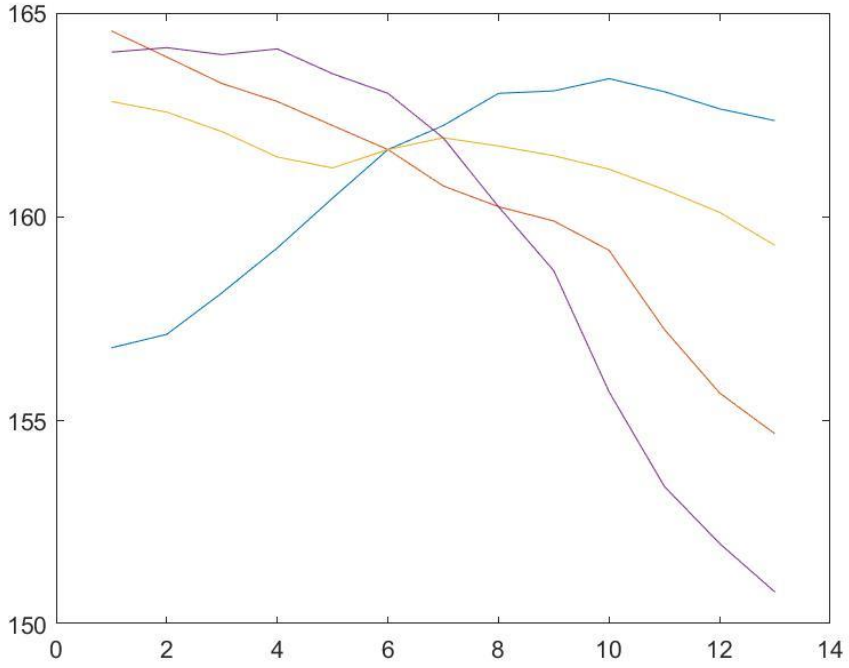

Figure A.158. Magnified Section of Graph of Setup 3 Replication 2 Test 15 – Multiple Cross Sections

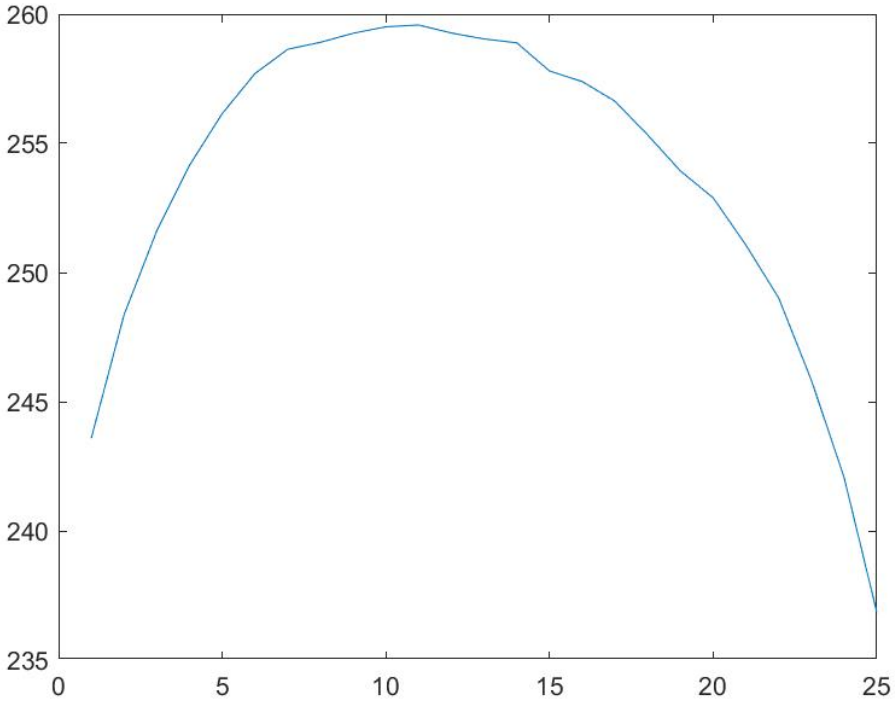

Figure A.159. Graph of Setup 3 Replication 2 Test 16 – Single Cross Section

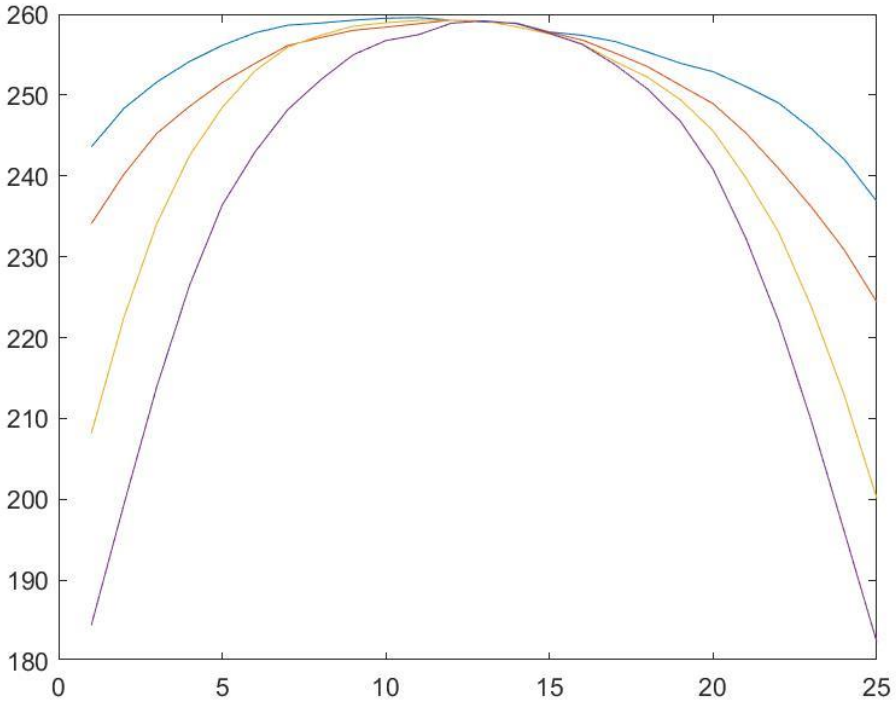

Figure A.160. Graph of Setup 3 Replication 2 Test 16 – Multiple Cross Sections

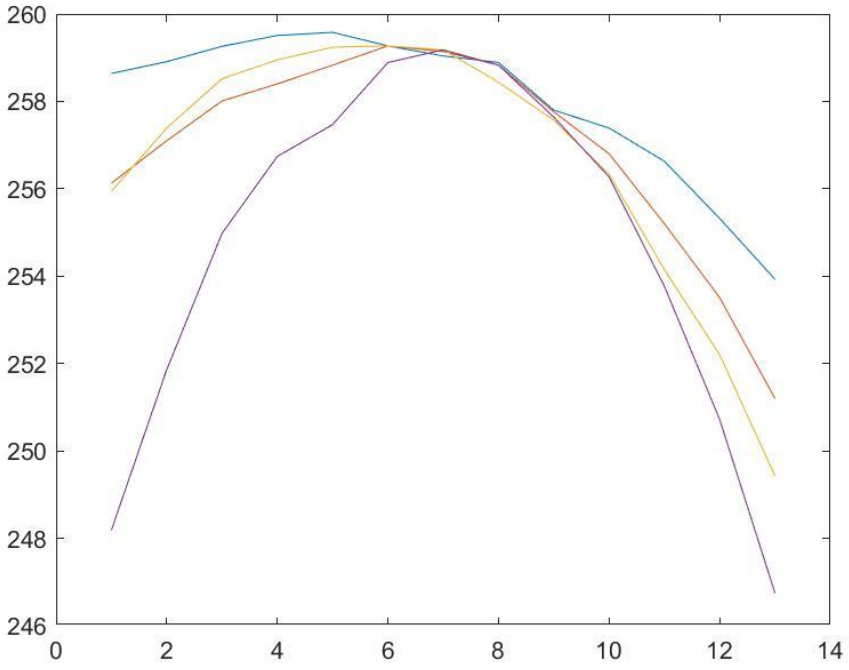

Figure A.161. Magnified Section of Graph of Setup 3 Replication 2 Test 16 – Multiple Cross Sections

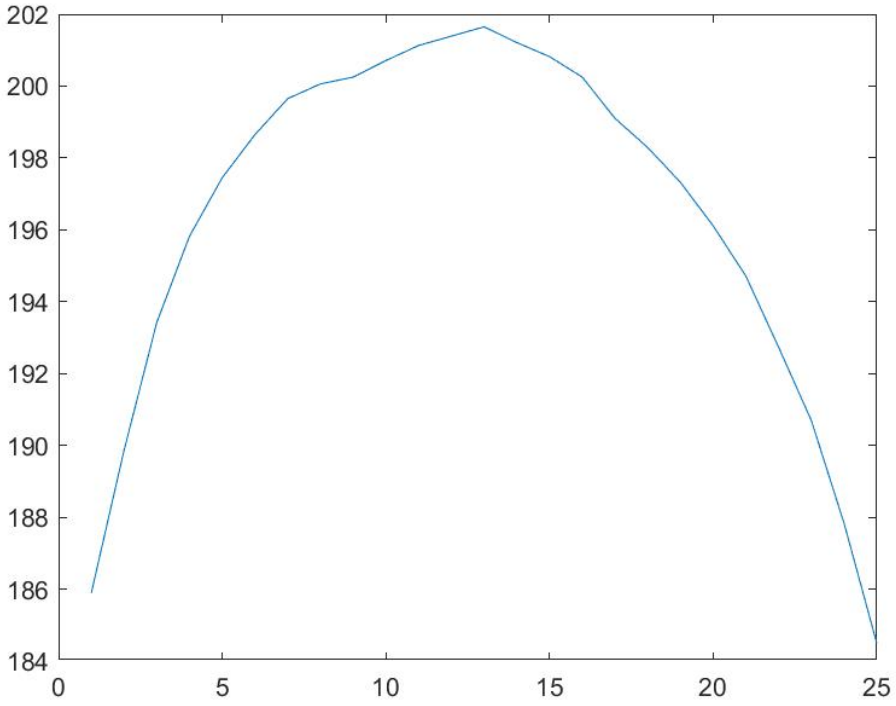

Figure A.162. Graph of Setup 3 Replication 2 Test 17 – Single Cross Section

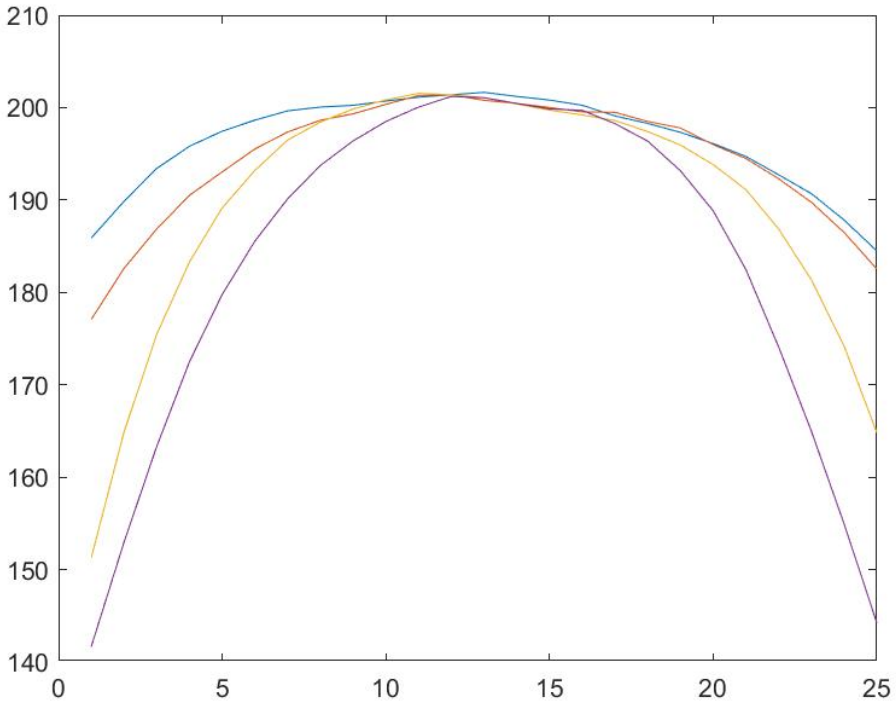

Figure A.163. Graph of Setup 3 Replication 2 Test 17 – Multiple Cross Sections

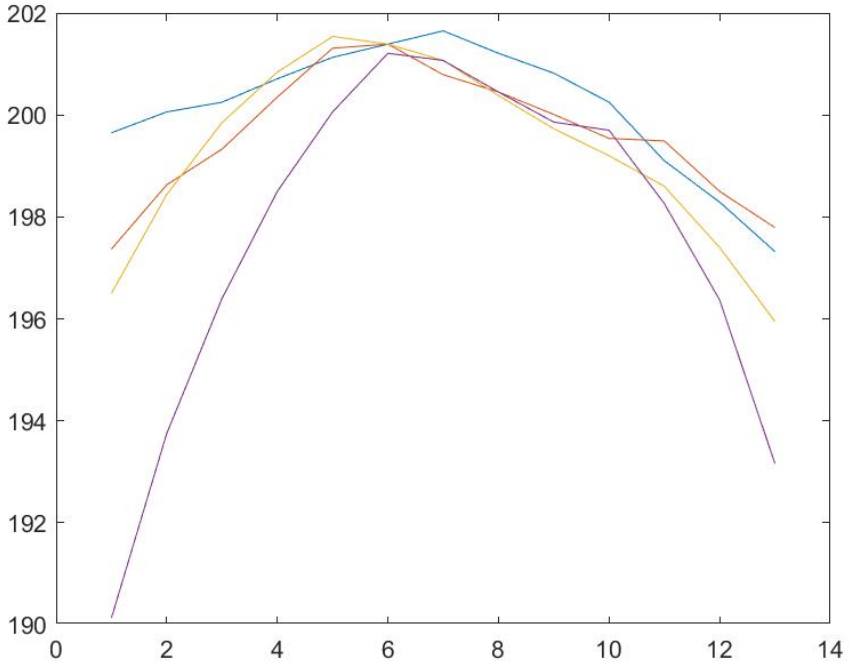

Figure A.164. Magnified Section of Graph of Setup 3 Replication 2 Test 17 – Multiple Cross Sections

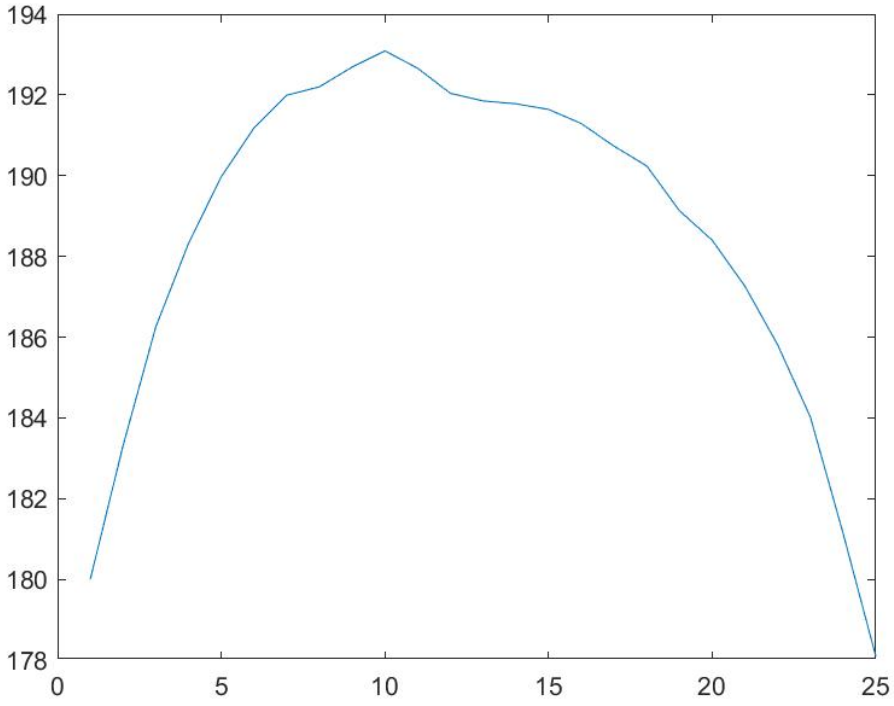

Figure A.165. Graph of Setup 3 Replication 2 Test 18 – Single Cross Section

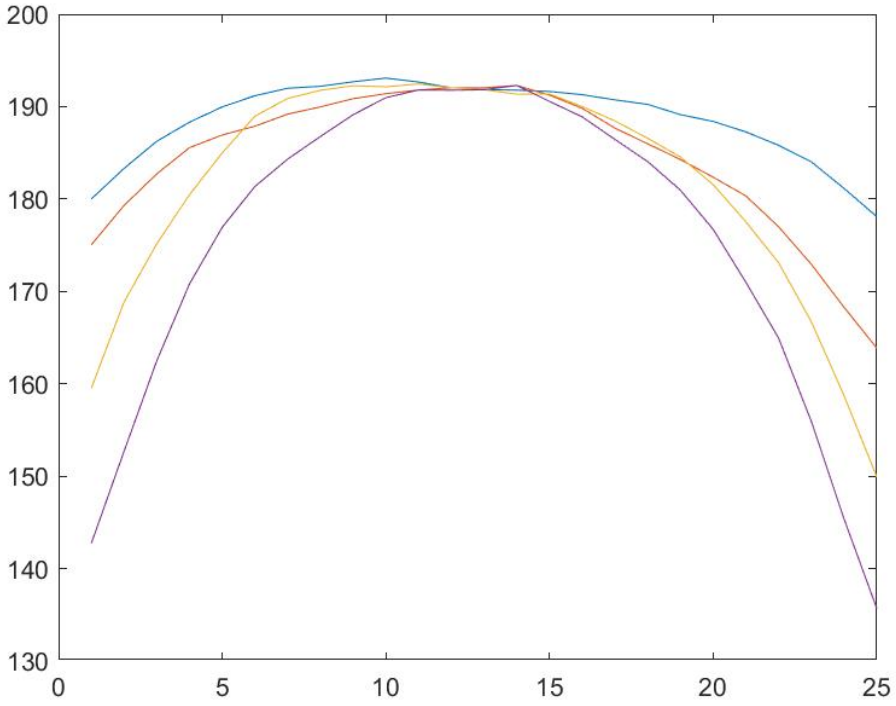

Figure A.166. Graph of Setup 3 Replication 2 Test 18 – Multiple Cross Sections

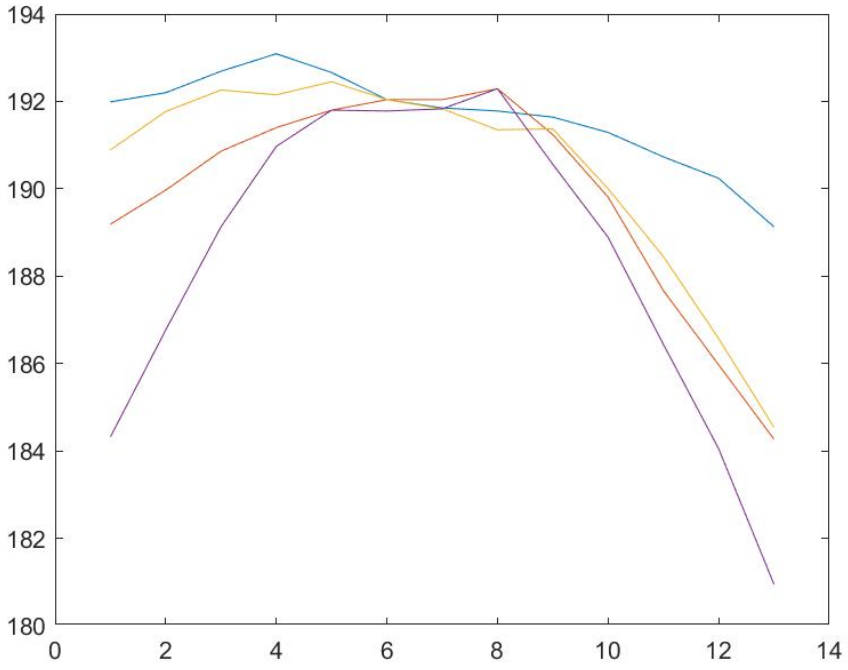

Figure A.167. Magnified Section of Graph of Setup 3 Replication 2 Test 18 – Multiple Cross Sections

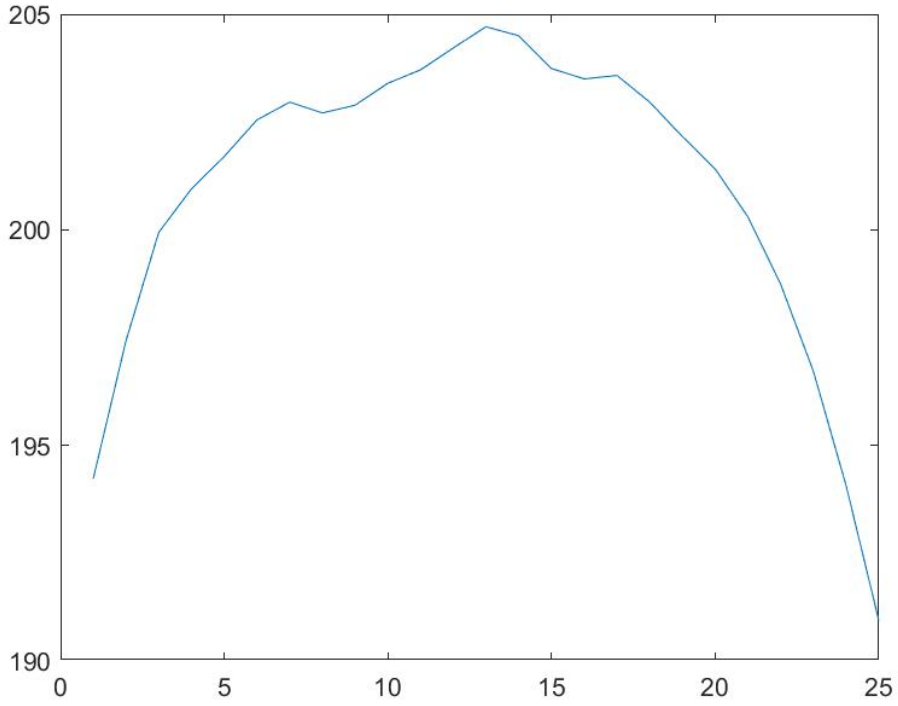

Figure A.168. Graph of Setup 3 Replication 2 Test 19 – Single Cross Section

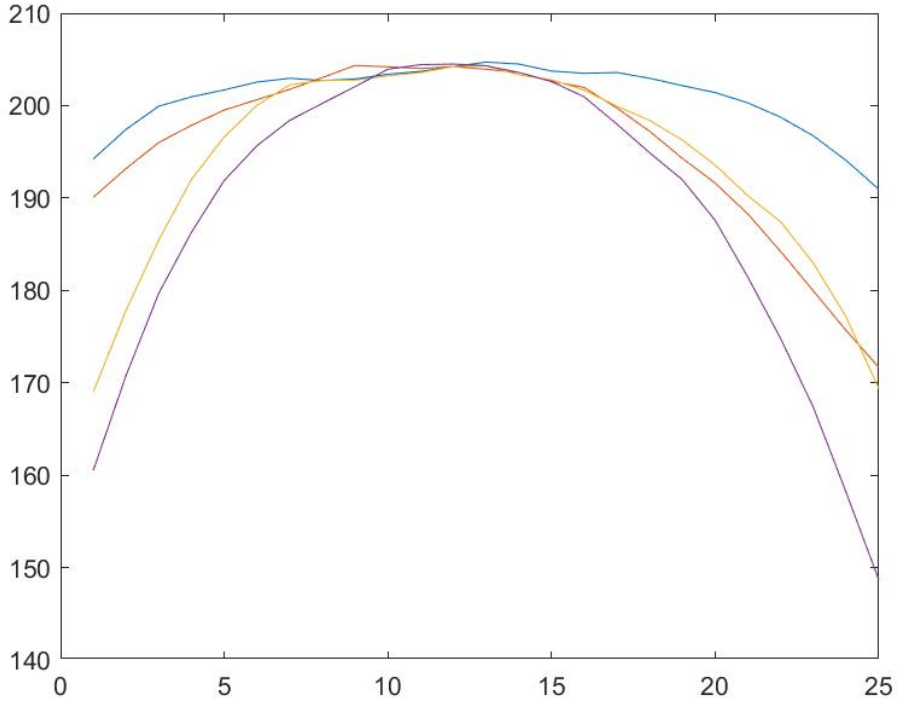

Figure A.169. Graph of Setup 3 Replication 2 Test 19 – Multiple Cross Sections

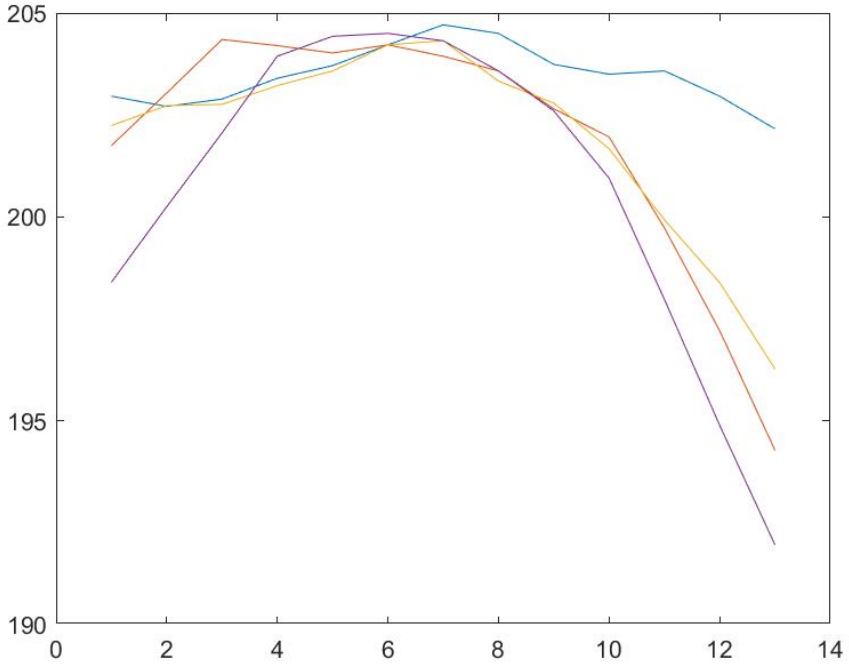

Figure A.170. Magnified Section of Graph of Setup 3 Replication 2 Test 19 – Multiple Cross Sections

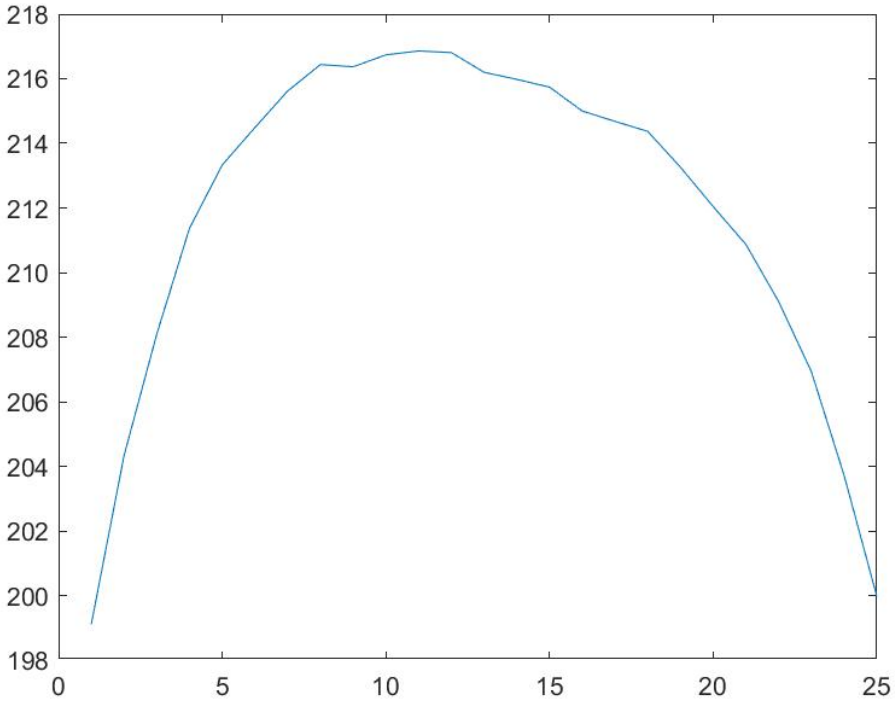

Figure A.171. Graph of Setup 3 Replication 2 Test 20 – Single Cross Section

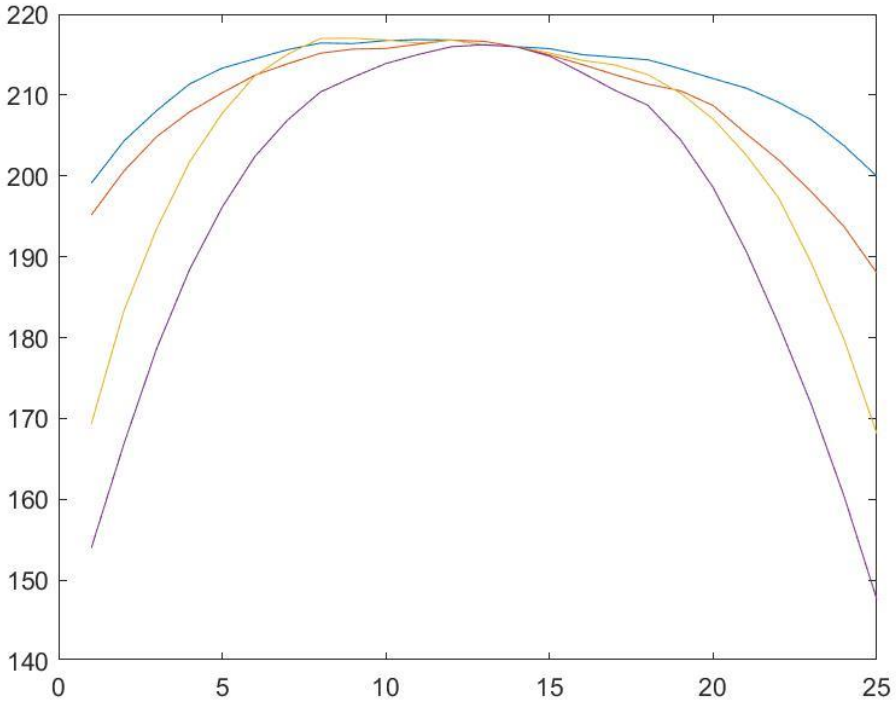

Figure A.172. Graph of Setup 3 Replication 2 Test 20 – Multiple Cross Sections

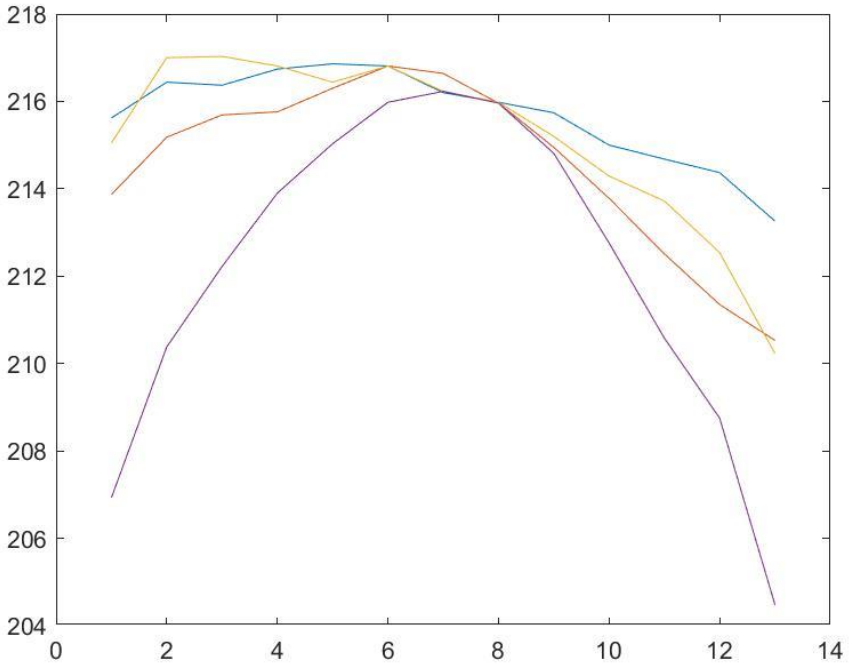

Figure A.173. Magnified Section of Graph of Setup 3 Replication 2 Test 20 – Multiple Cross Sections

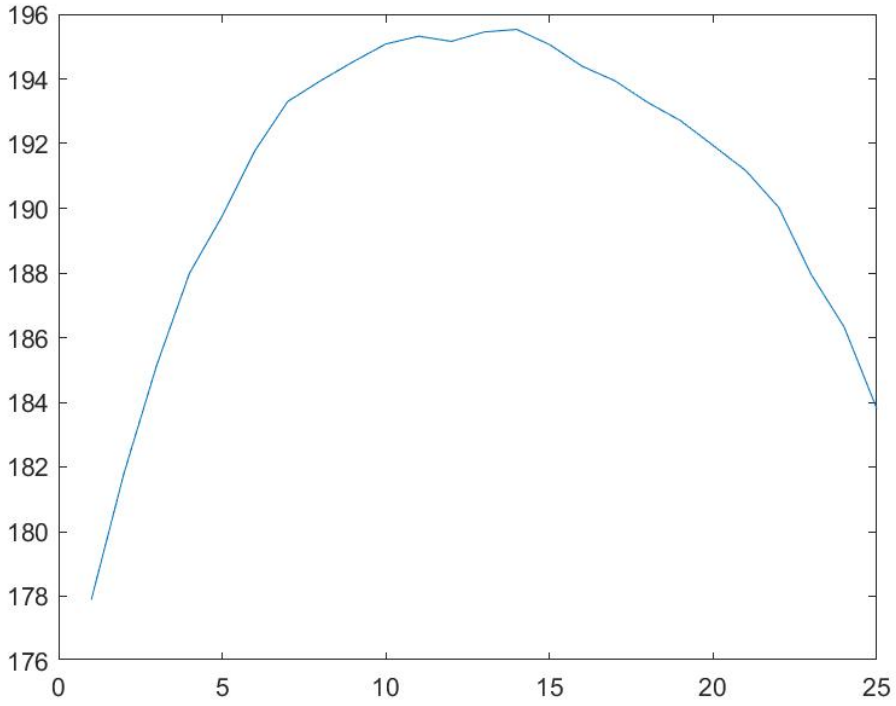

Figure A.174. Graph of Setup 3 Replication 2 Test 21 – Single Cross Section

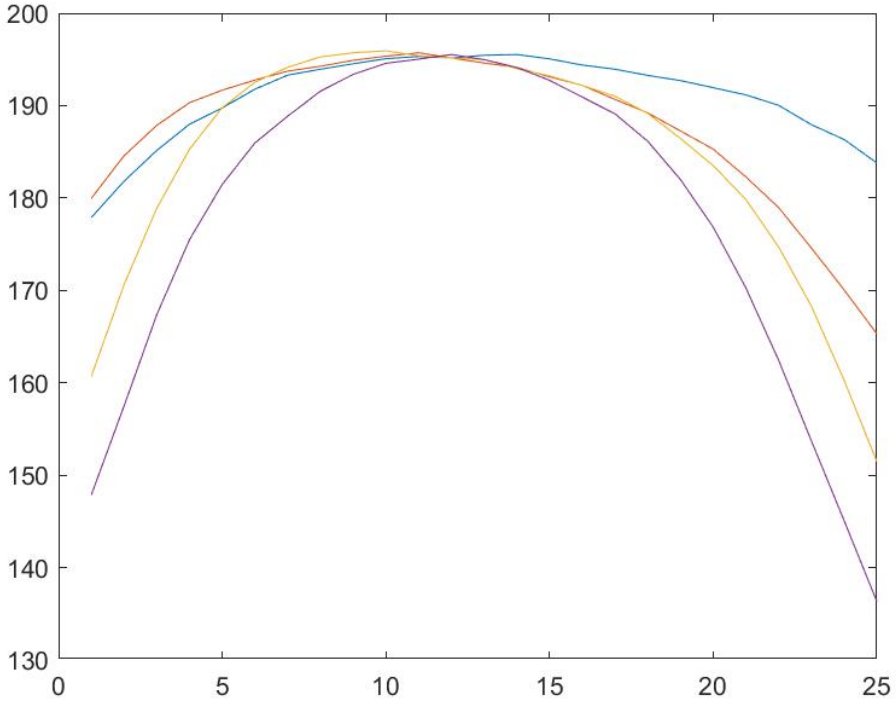

Figure A.175. Graph of Setup 3 Replication 2 Test 21 – Multiple Cross Sections

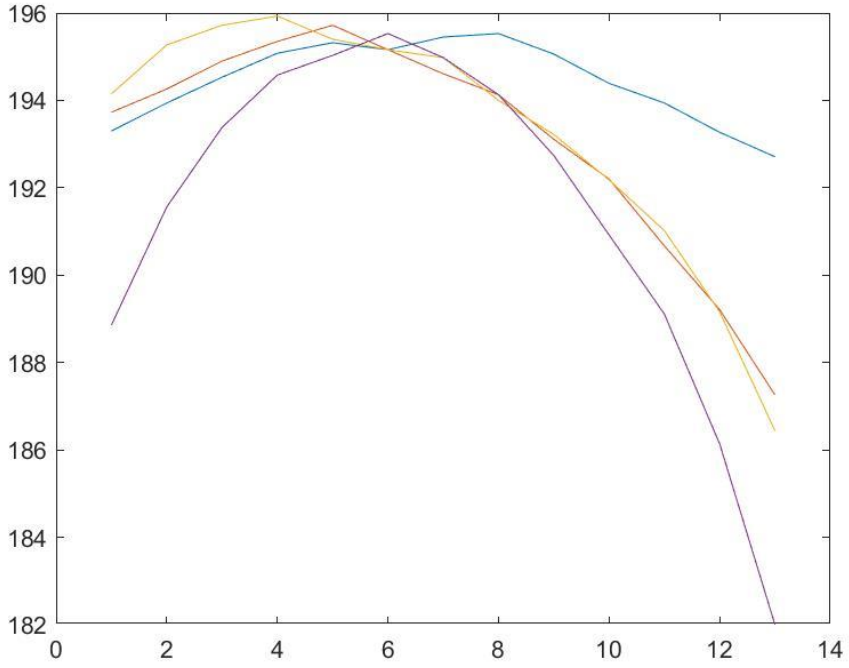

Figure A.176. Magnified Section of Graph of Setup 3 Replication 2 Test 21 – Multiple Cross Sections

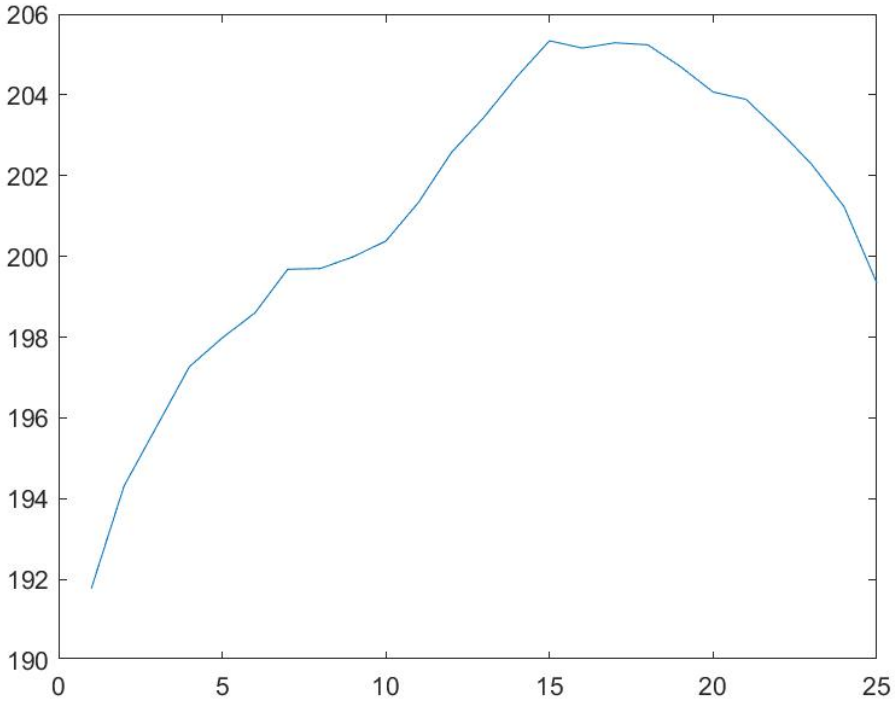

Figure A.177. Graph of Setup 3 Replication 2 Test 22 – Single Cross Section

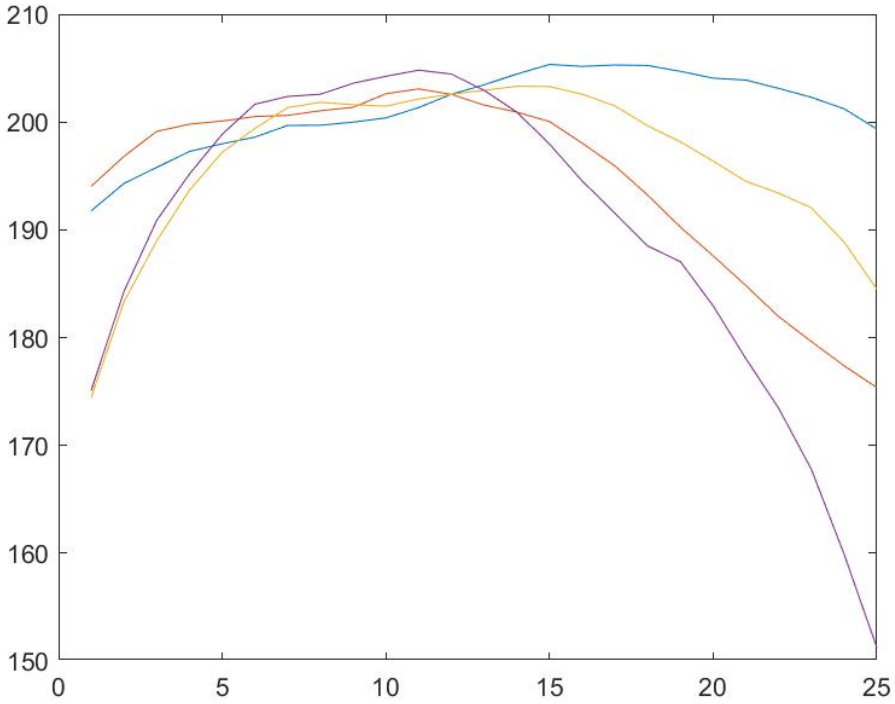

Figure A.178. Graph of Setup 3 Replication 2 Test 22 – Multiple Cross Sections

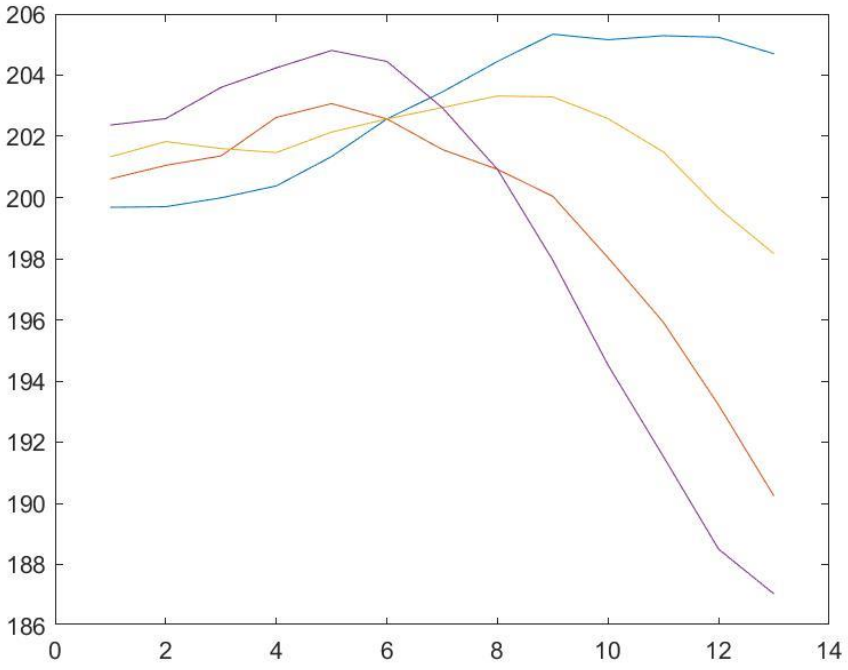

Figure A.179. Magnified Section of Graph of Setup 3 Replication 2 Test 22 – Multiple Cross Sections

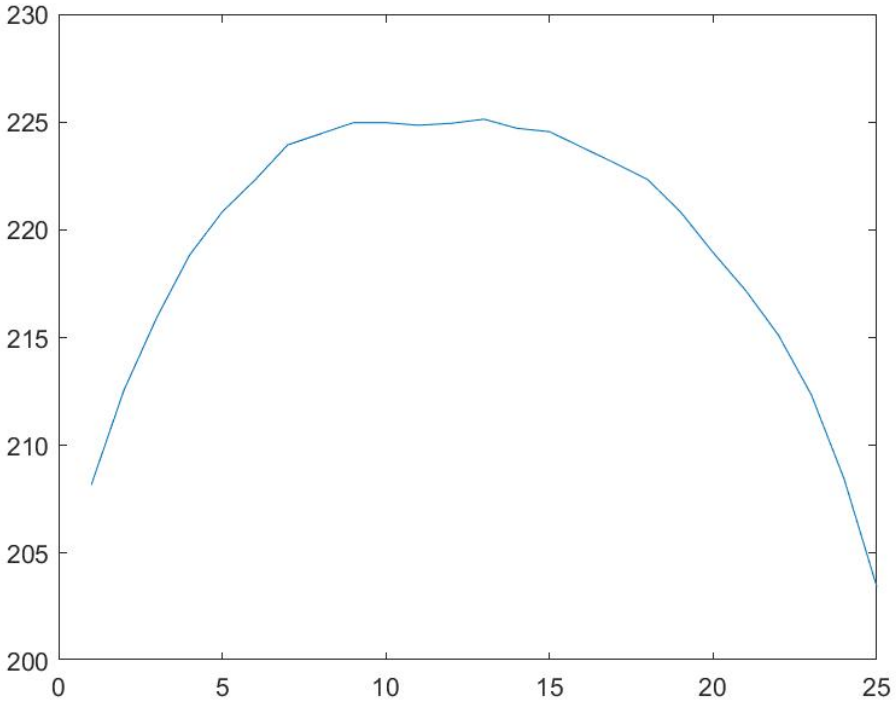

Figure A.180. Graph of Setup 3 Replication 2 Test 23 – Single Cross Section

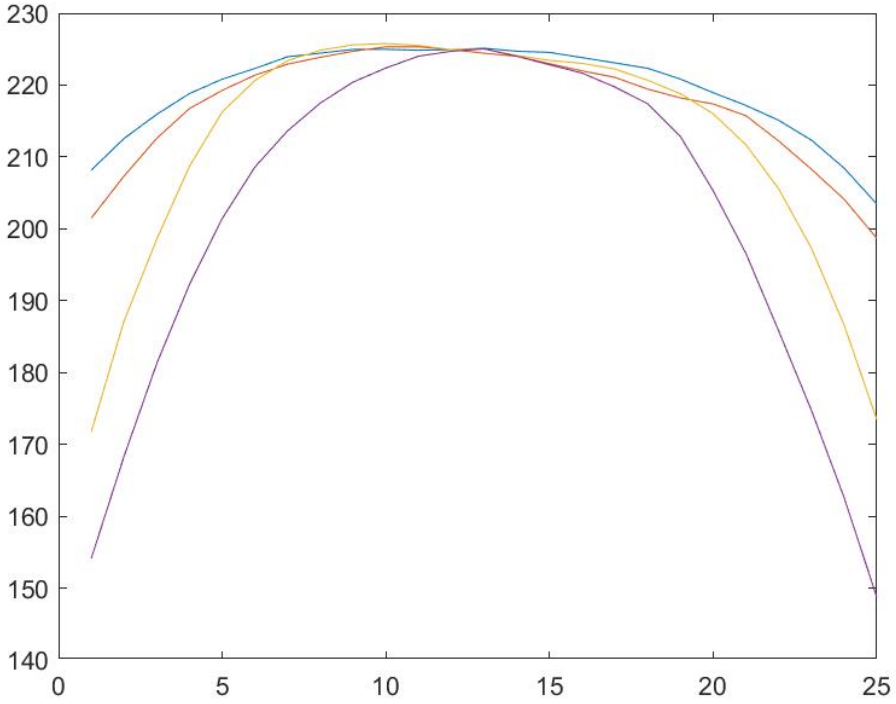

Figure A.181. Graph of Setup 3 Replication 2 Test 23 – Multiple Cross Sections

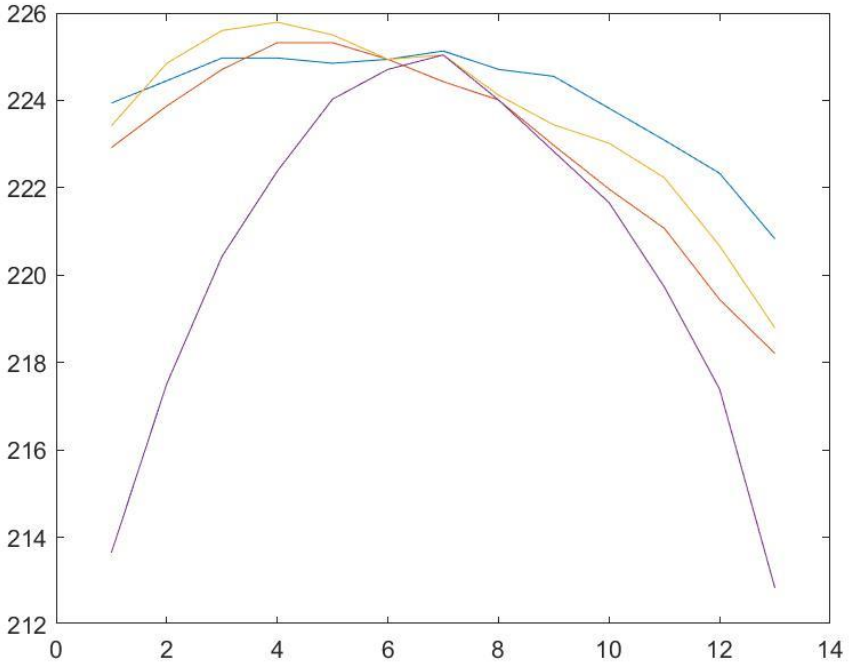

Figure A.182. Magnified Section of Graph of Setup 3 Replication 2 Test 23 – Multiple Cross Sections

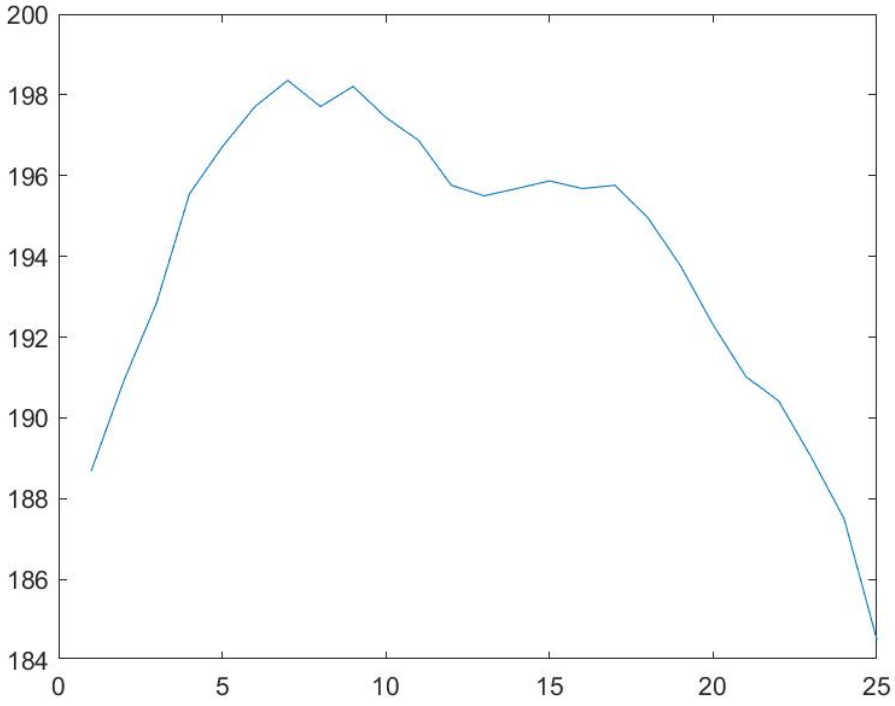

Figure A.183. Graph of Setup 3 Replication 2 Test 24 – Single Cross Section

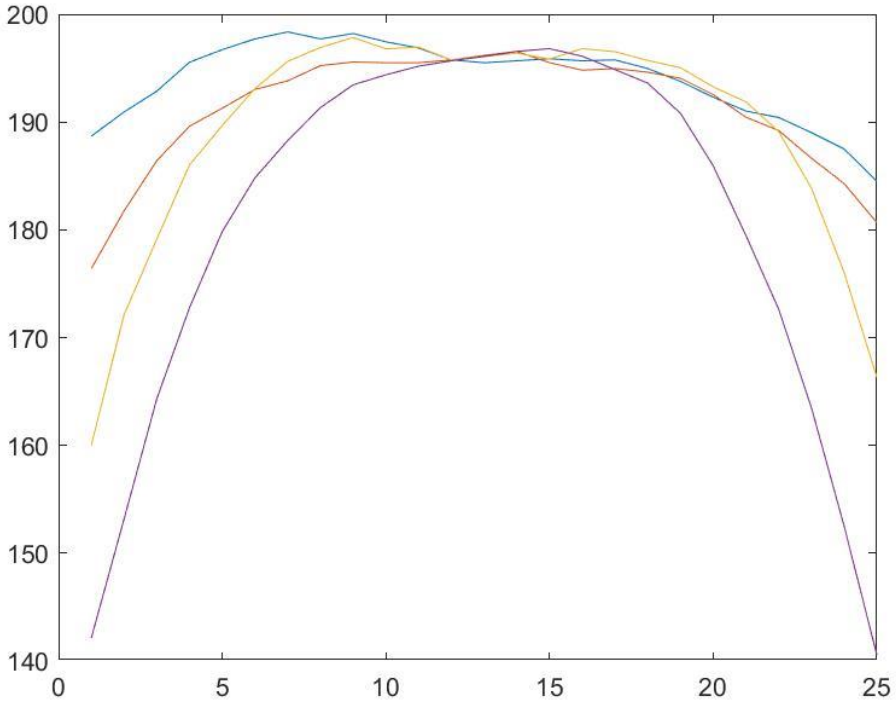

Figure A.184. Graph of Setup 3 Replication 2 Test 24 – Multiple Cross Sections

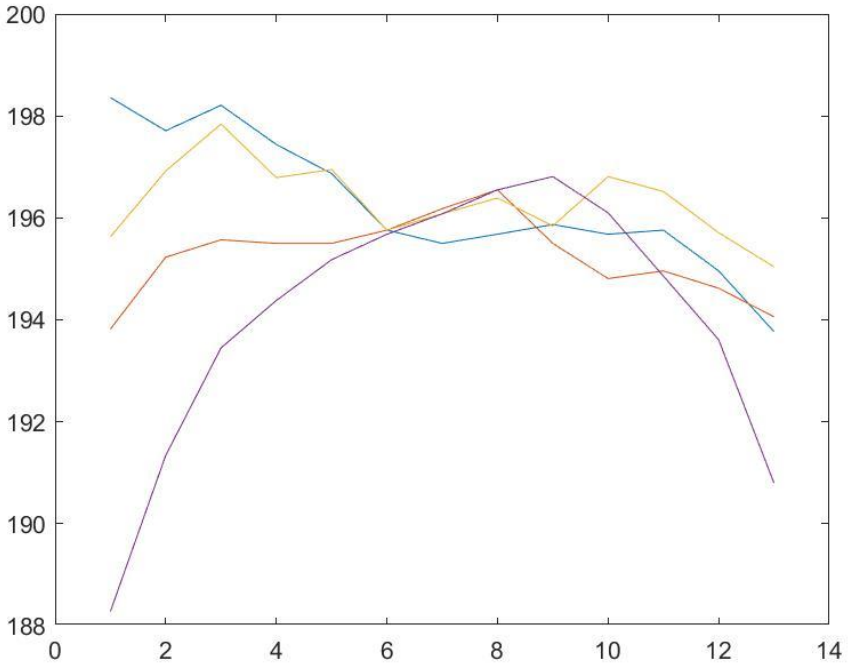

Figure A.185. Magnified Section of Graph of Setup 3 Replication 2 Test 24 – Multiple Cross Sections

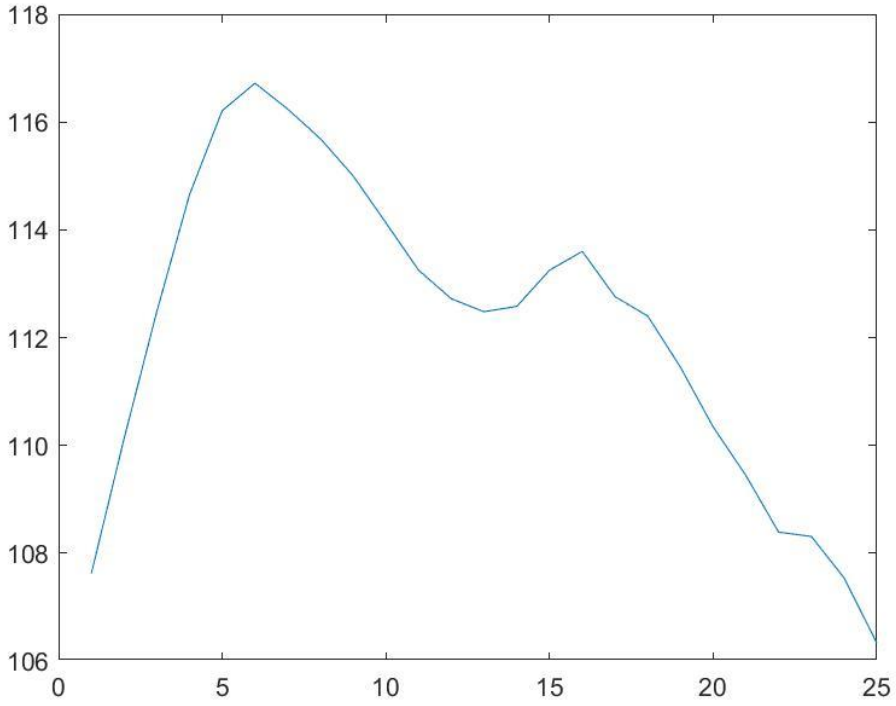

Figure A.186. Graph of Setup 3 Replication 2 Test 25 – Single Cross Section

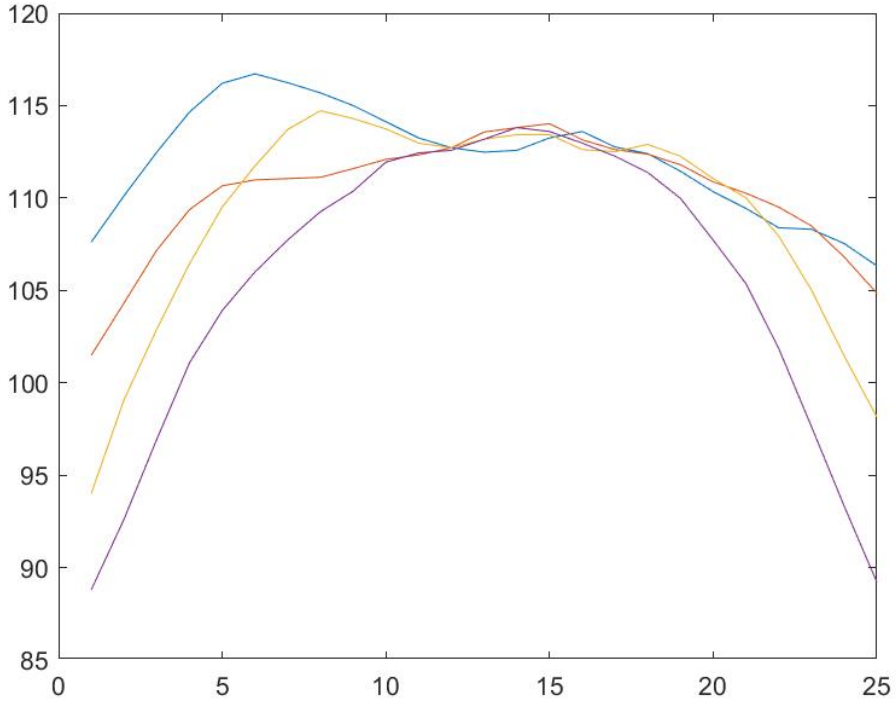

Figure A.187. Graph of Setup 3 Replication 2 Test 25 – Multiple Cross Sections

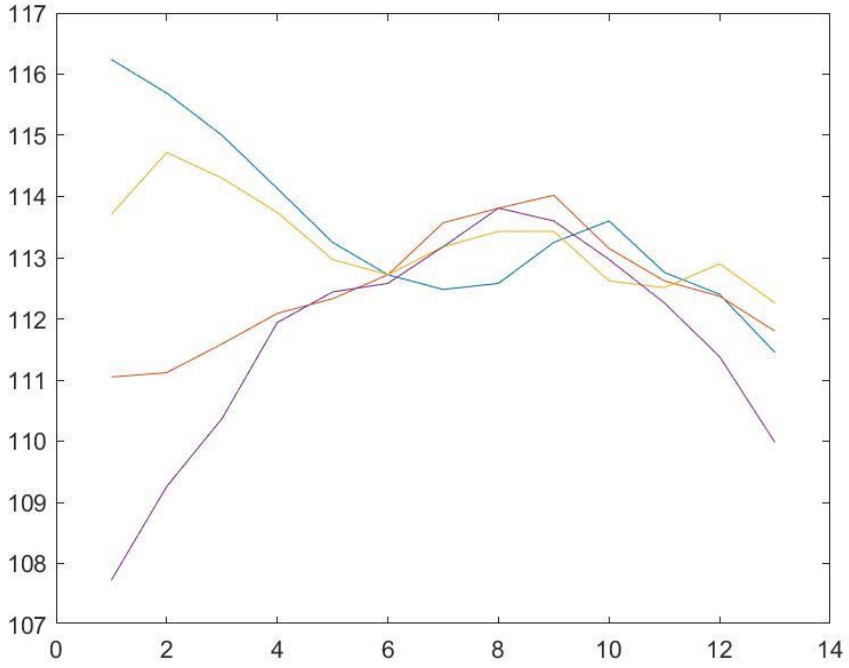

Figure A.188. Magnified Section of Graph of Setup 3 Replication 2 Test 25 – Multiple Cross Sections

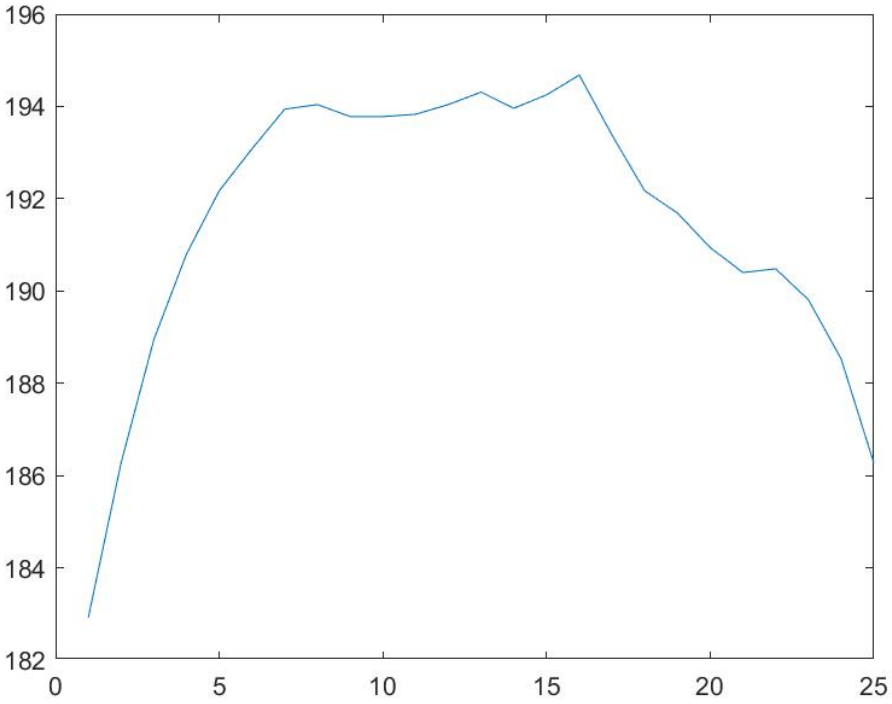

Figure A.189. Graph of Setup 3 Replication 2 Test 26 – Single Cross Section

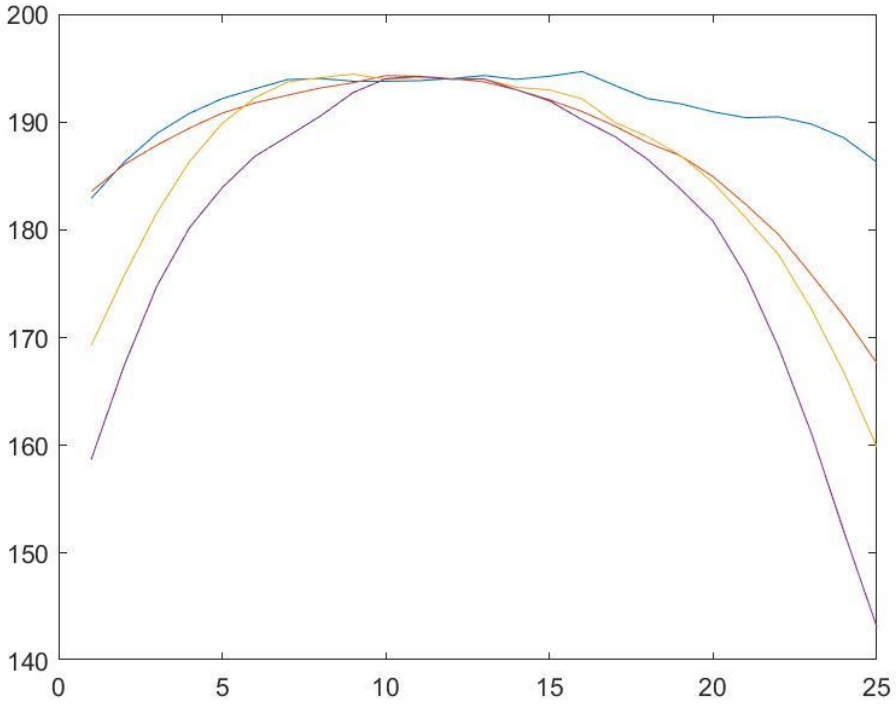

Figure A.190. Graph of Setup 3 Replication 2 Test 26 – Multiple Cross Sections

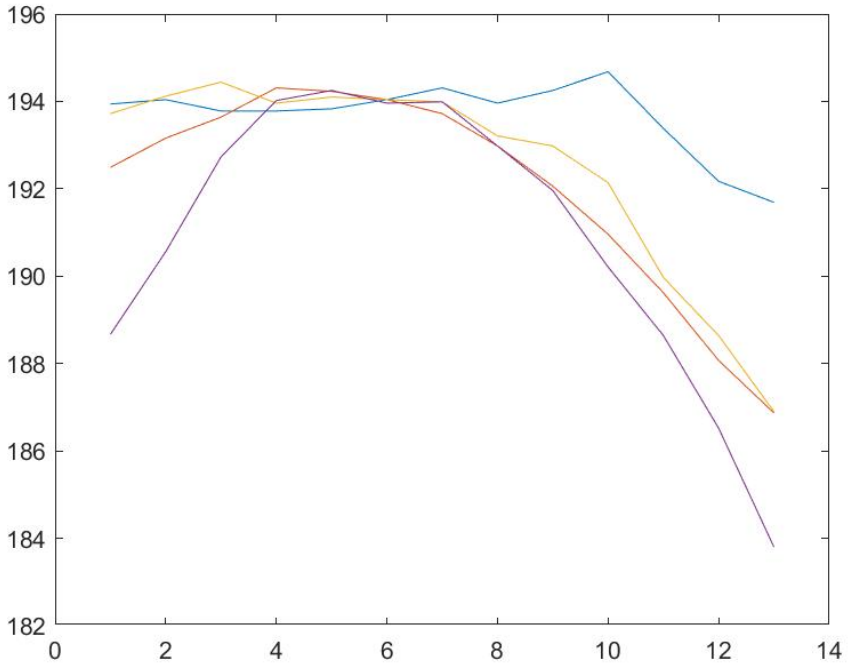

Figure A.191. Magnified Section of Graph of Setup 3 Replication 2 Test 26 – Multiple Cross Sections

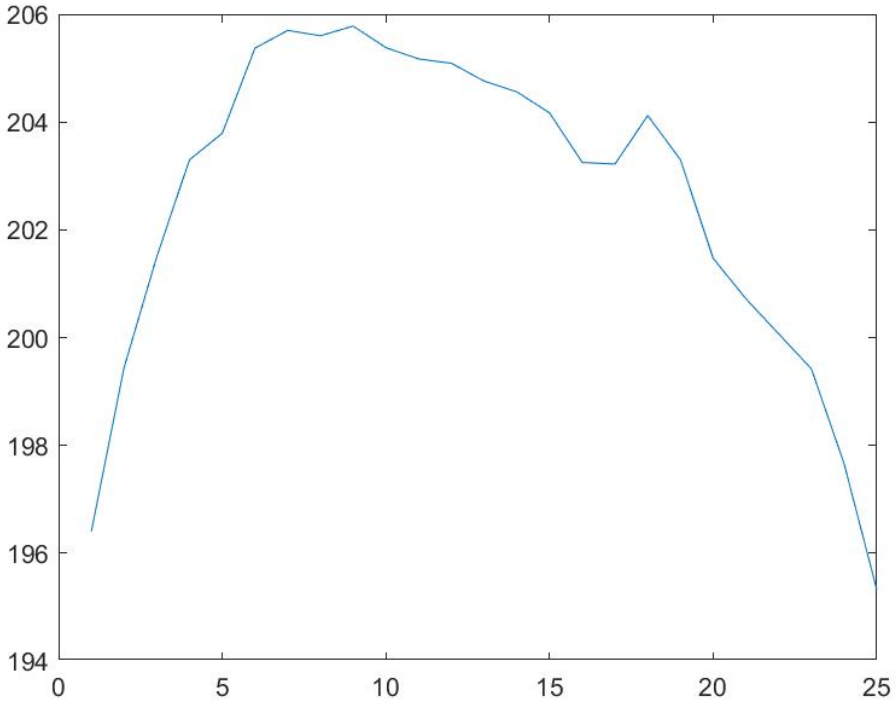

Figure A.192. Graph of Setup 3 Replication 2 Test 27 – Single Cross Section

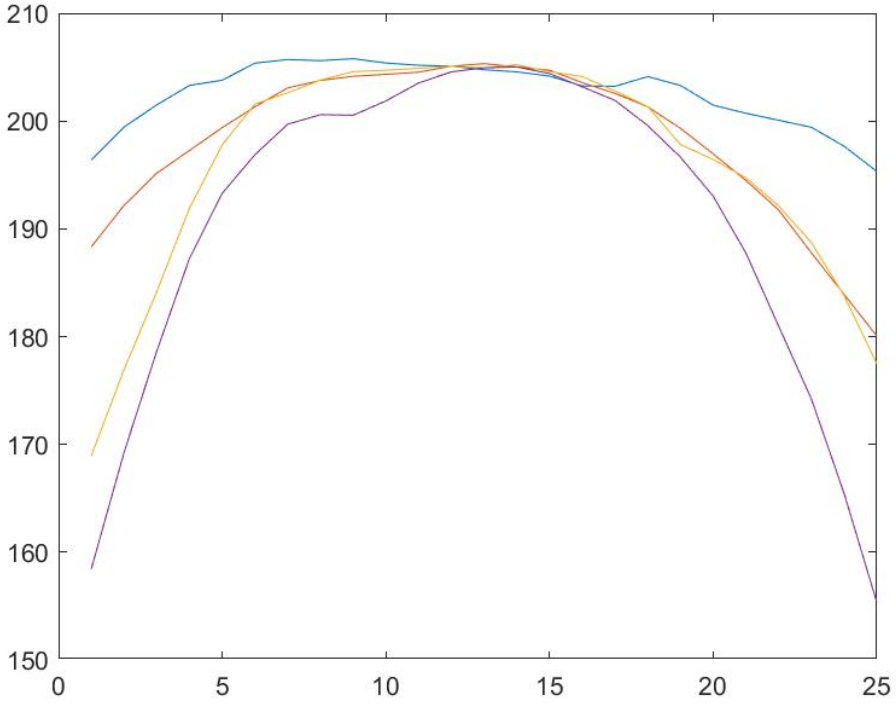

Figure A.193. Graph of Setup 3 Replication 2 Test 27 – Multiple Cross Sections

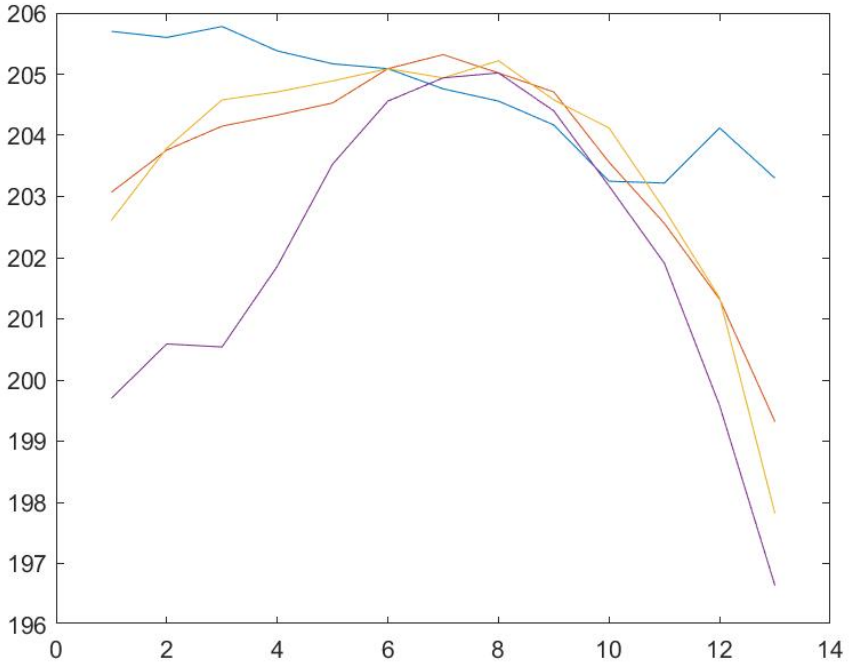

Figure A.194. Magnified Section of Graph of Setup 3 Replication 2 Test 27 – Multiple Cross Sections

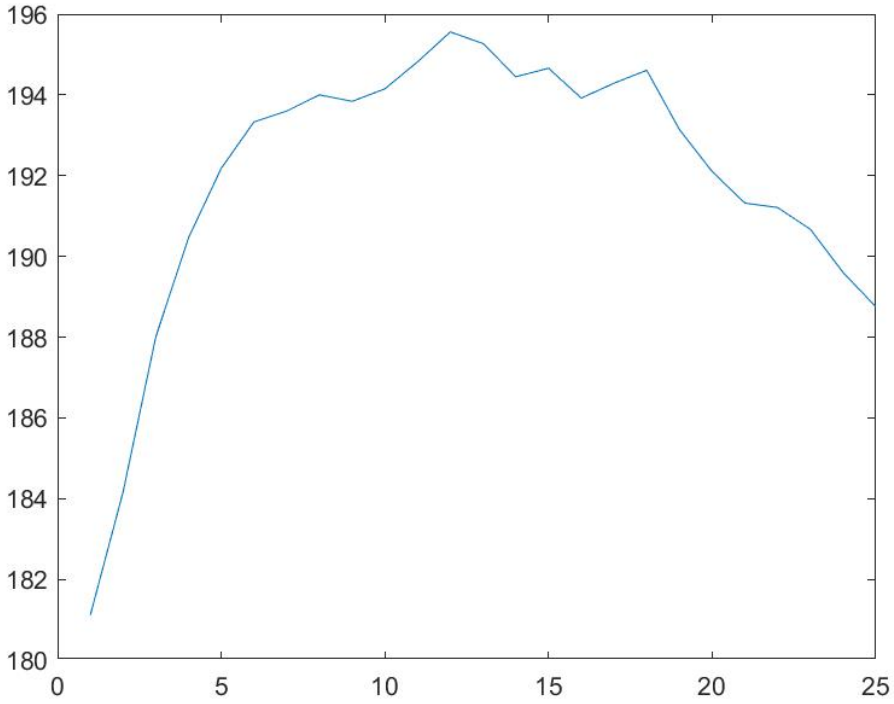

Figure A.195. Graph of Setup 3 Replication 2 Test 28 – Single Cross Section

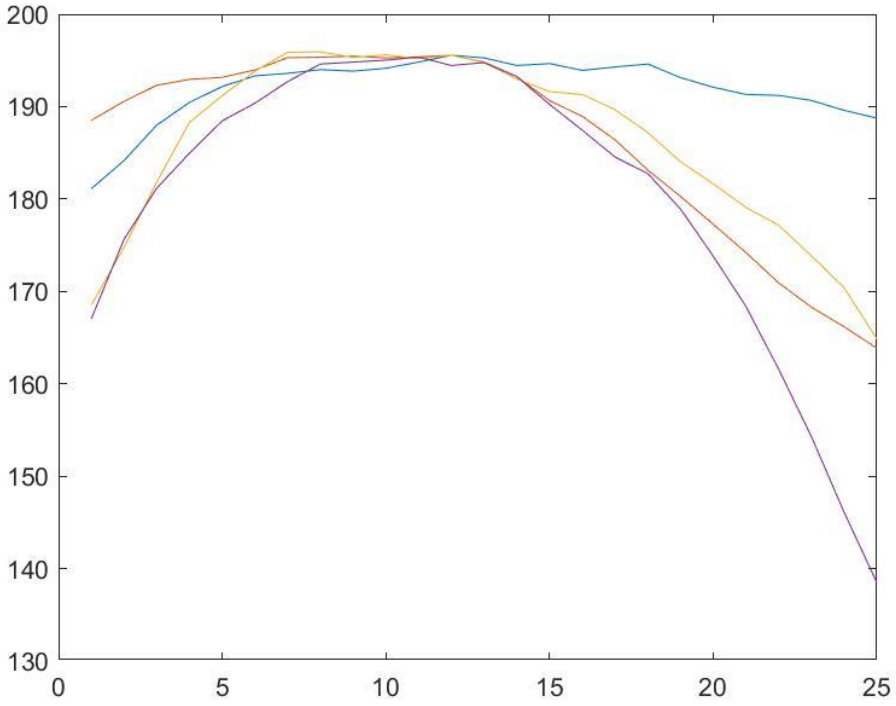

Figure A.196. Graph of Setup 3 Replication 2 Test 28 – Multiple Cross Sections

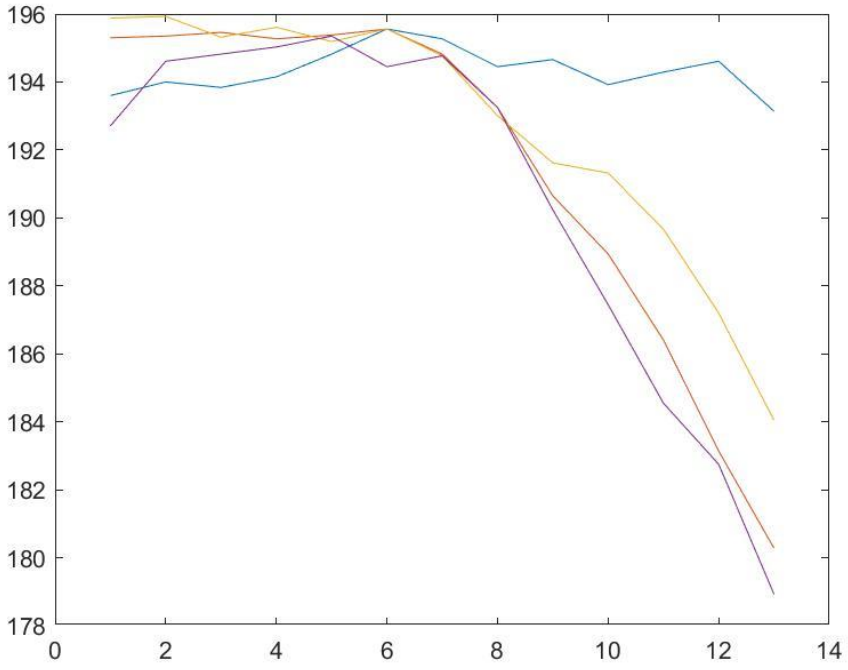

Figure A.197. Magnified Section of Graph of Setup 3 Replication 2 Test 28 – Multiple Cross Sections

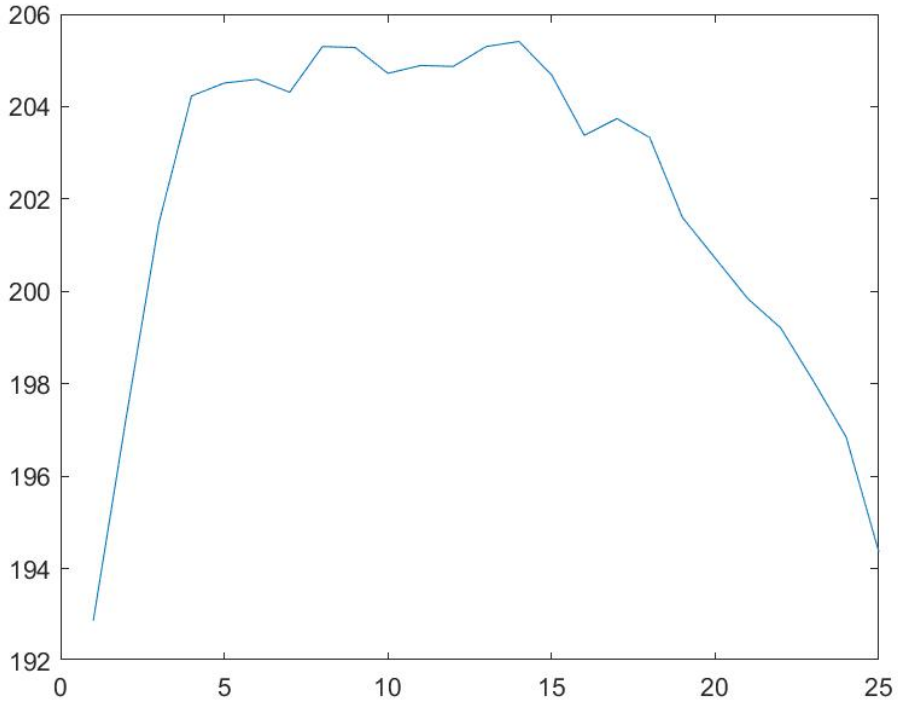

Figure A.198. Graph of Setup 3 Replication 2 Test 29 – Single Cross Section

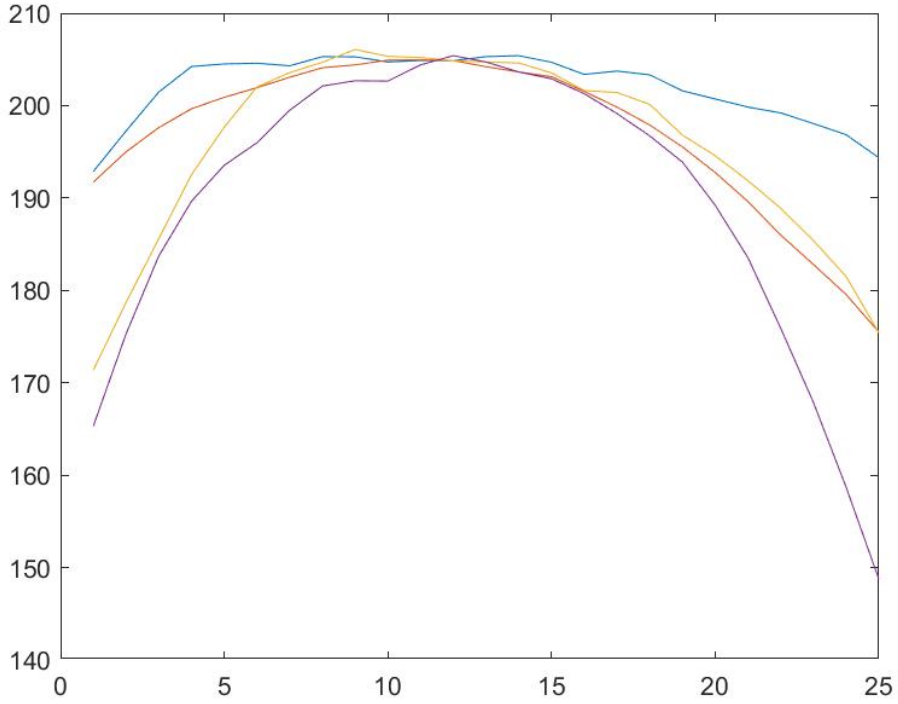

Figure A.199. Graph of Setup 3 Replication 2 Test 29 – Multiple Cross Sections

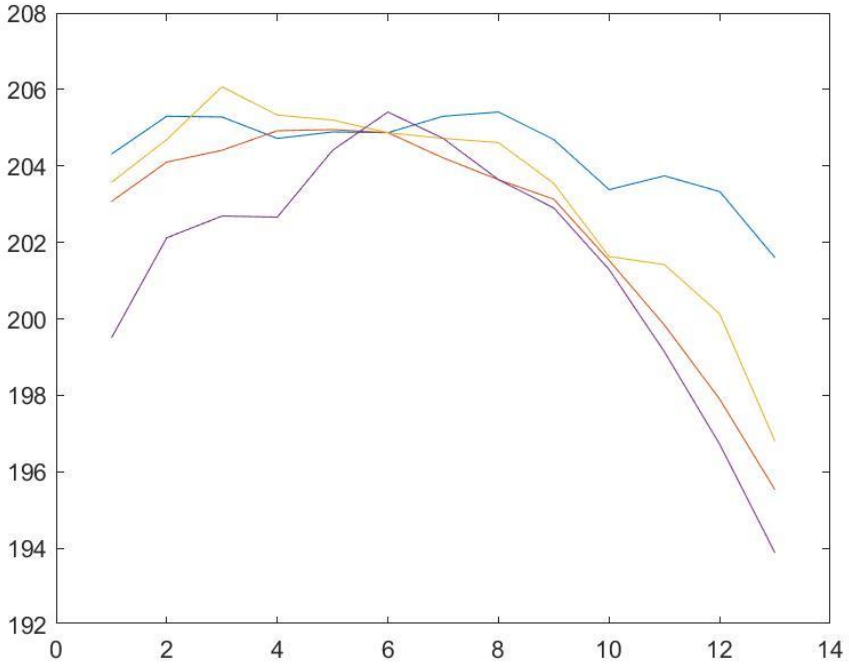

Figure A.200. Magnified Section of Graph of Setup 3 Replication 2 Test 29 – Multiple Cross Sections

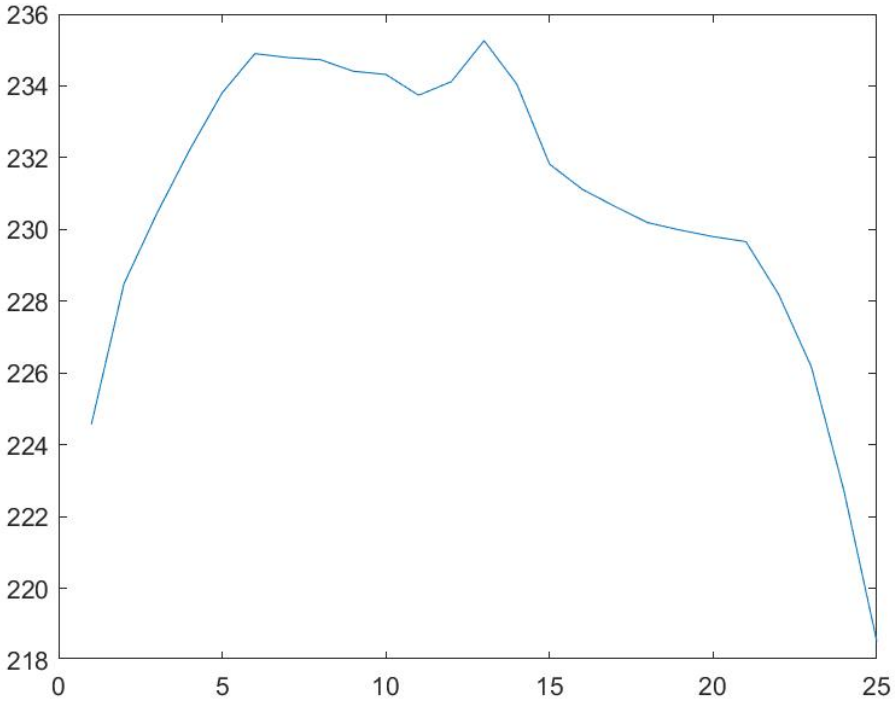

Figure A.201. Graph of Setup 3 Replication 2 Test 30 – Single Cross Section

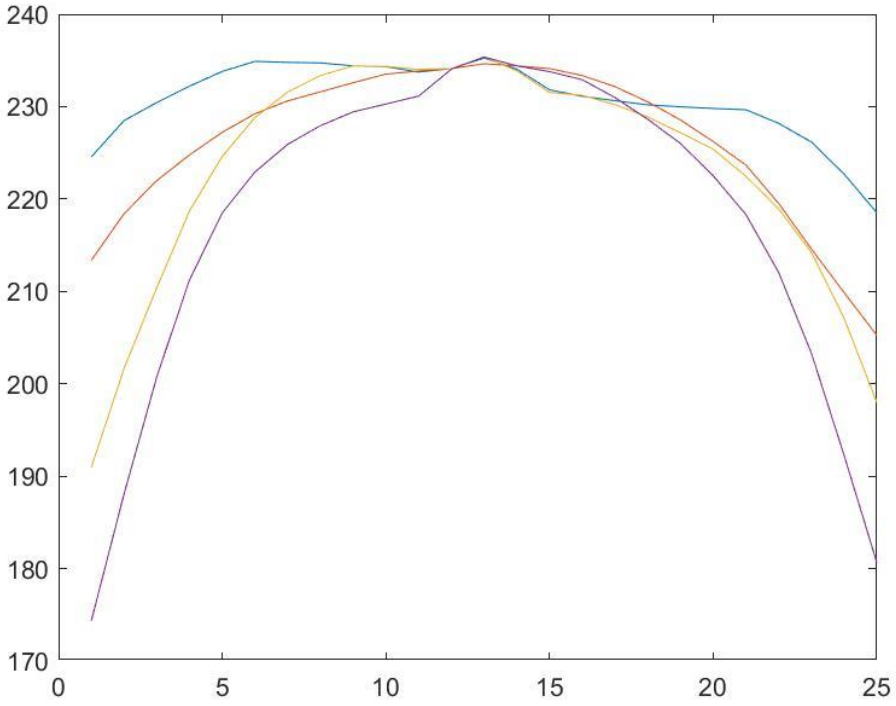

Figure A.202. Graph of Setup 3 Replication 2 Test 30 – Multiple Cross Sections

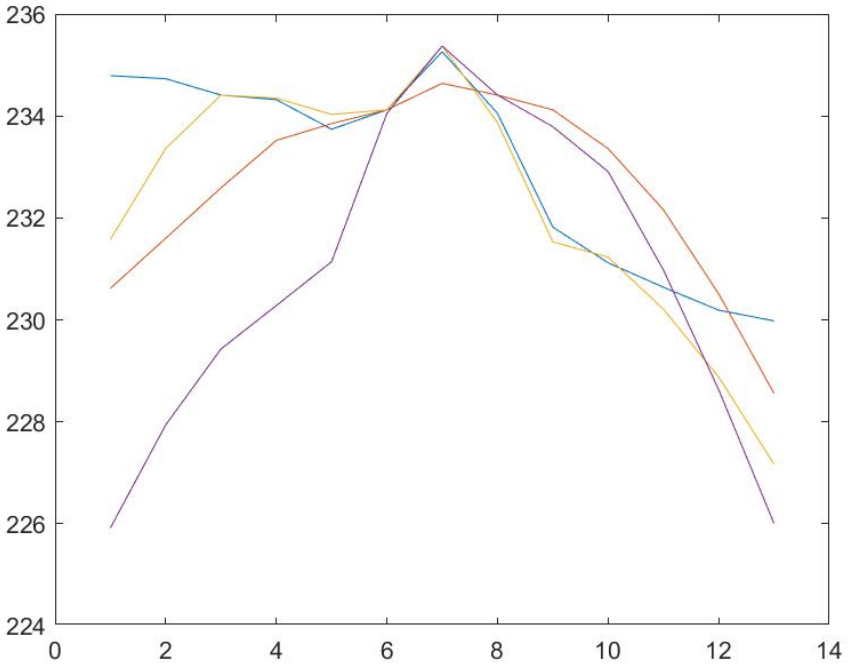

Figure A.203. Magnified Section of Graph of Setup 3 Replication 2 Test 30 – Multiple Cross Sections