Final Report: Ignition Potential of Common Fuels by Residential Electric Range Cooktops

Testing Facility: EKU Fire and Safety Laboratory
Submittal Date: June 30, 2012

Submitted by:
Corey Hanks – M.S. Student / Lab Coordinator
Donald Knoll – B.S. Student
Gregory Gorbett – Associate Professor

Eastern Kentucky University
Fire Protection and Safety Engineering Technology

Submitted to:
Jim Crawford
Michael Love
Daniel Madrzykowski

Institution of Fire Engineers (IFE), USA
Vision 20/20

Executive Summary

A study was conducted to analyze the competency of several types of electric cooktop ranges to evaluate the likelihood of them igniting a variety of common kitchen items. Three types of electric cooktop ranges were tested including a ceramic-glass cooktop range, an electric coil cooktop range, and an electric coil cooktop range with a Safe-T-element installed. The latest research was reviewed to select a representative sample of fuels commonly noted as the first fuel ignited. The eight selected fuels included cardboard (pizza box), a cotton dish towel, a roll of paper towels, a pan of canola oil, a pan of vegetable oil, a nylon short turn spatula (cooking utensil), a kitchen appliance (toaster), and a plastic storage container.

Each range was tested in the high, medium, and low thermostat settings on the large (8" diameter element) and the small (6" diameter element) resulting in a total of 48 tests per range type. A variety of data was collected for each test including video photography, infrared video photography, still photography, and thermocouple data. The heat sources were characterized using both thin skin calorimeters and heat flux transducers (radiometers).

The rate of temperature rise was found to be slowest with the Safe-T-Element, reaching its maximum temperatures 8-13 minutes slower than its ceramic-glass and electric coil counterparts. When the thermostat for the cooktops was placed on high, 85% of the time ignition occurred, regardless of the cooktop type. The high setting for all three ranges showed the maximum potential for ignition based on the total heat output produced by the 6-inch diameter and 8-inch diameter heating elements. 37.5% of the fuels tested on the ceramic-glass cooktop ignited at the medium setting, while only 18.75% and 6.25% of fuels ignited on the electric coil and Safe-T-element cooktops respectively. No ignition of any fuel occurred when the cooktop thermostats were placed on the low setting. In total, the electric coil cooktop resulted in ignition 39.5% of the time, Safe-T-element 35.4% of the time, and ceramic-glass cooktop resulted in ignition 31.25% of the time. Therefore, it can be concluded from these tests that all of the cooktops were similar in ignition competency for the provided fuels. Furthermore, it was found that when ignition did occur in similar fuels on different cooktops, that the Safe-T-element cooktop provided more time before ignition.

This study has validated a number of configurations of electric cooktop ranges in a variety of ignition scenarios. The competency of aforementioned cooktops as an ignition source given a number of common household fuels has been reported on in extensive detail within the body of this report.

Table of Contents

1.0 Introduction

The objective of this study was to evaluate the potential for ignition of commonly found household kitchen items using three different types of residential kitchen ranges. The three different types of kitchen ranges that were evaluated consist of a ceramic-glass cooktop range, an electric coil cooktop range, and an electric coil cooktop range with a Safe-T-element installed. Common residential kitchen items were selected as the fuels for this series of tests based on the statistics of first fuels ignited in kitchen range fires, including these eight common household fuel items (Ahrens, 2011):

1. Cardboard (Pizza box)
2. Dish Towel
3. Paper Towel
4. Canola Oil
5. Vegetable Oil
6. Cooking Utensil (Nylon Short Turner)
7. Kitchen Appliance (Toaster)
8. Storage Container

All eight fuels were tested using each of the ranges. The six-inch and eight-inch diameter heating elements were used for each range and both heating elements were used to test all eight fuels. Each test was conducted using the high, medium, and low settings for each heating element. This resulted in a test matrix of 48 ignition tests for each range.

Each test was documented using a systematic arrangement of thermocouples to record the temperature of the fuel (external and internal) and the heating element during the heating process. A thermal imaging camera and video camera also recorded each test.

2.0 Background

The following sections are included as a brief literature review of the statistics of cooking fires, common fuels associated with cooking fires, ignition scenario studies, and studies regarding the Safe-T-element. The statistics were reviewed to identify the most common fuels, ignition sources, and causes of cooking fires. This information was then used to help create the experimental setup for this study.

2.1 Cooking Fires

The U.S. continues to combat the loss and damage created every year by fire. In 2010, there were 1,331,500 fires reported in the United States. These fires result in 3,120 civilian deaths, 17,720 civilian injuries, and $11.6 billion in property damage. Although there has been a continued decrease in deaths annually by fire, the average for deaths on an annual basis reflects a consistent 3000 plus deaths yearly (Karter, 2011).

The majority of fire deaths occur in residential structure fires, 85% of civilian fire deaths in 2010 occurred in homes[1] (Karter, 2011). The leading cause of fires in residential structures since 1990 has been cooking. Between 2005-2009 it was found that unattended cooking was the greatest cause of cooking fires (Karter, 2011).

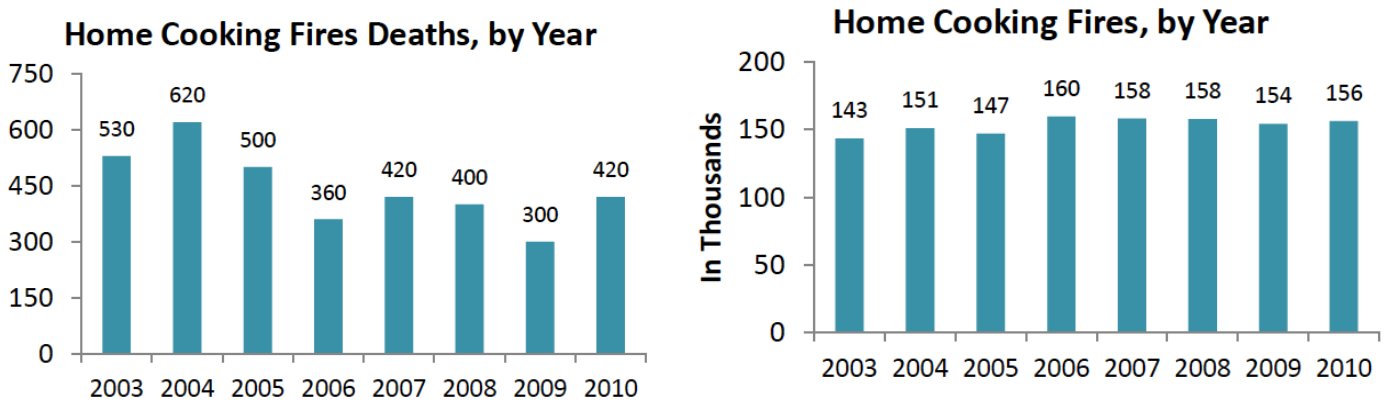


Figure 1: Statistics regarding home cooking fires (Karter, 2011)

To truly evaluate the cause of cooking fires, it is important to analyze these fires by evaluating the common ignition source(s), the material first ignited, and what elements or circumstances brought those elements together to cause the fire.

2.1.1 First Material Ignited in Cooking Fires

FEMA (2005) concluded that cooking materials, including food were the most common first material ignited in cooking fires. It was found that oil, fats, and grease are the first material ignited in 41% of cooking fires. Other foods, starch, and flour account for the second most common material ignited (21%), followed by plastics (10%) such as casings or cooking utensils (FEMA, 2005). A survey completed by CPSC between 1994 and 1996 found that the material being heated or cooked was the first material ignited in 71% of fires, followed by cabinets (5.2%) (Smith, Monticone, & Gillum, 1999). A similar problem was found in the United Kingdom, where a study found that 84.9% of fires with an electric range resulted from the ignition of material being heated or cooked, followed by the appliance being accidentally turned on (2.95%) (Hogg, 1963).

2.1.2 Common Ignition Sources in Cooking Fires

In 1998, the vast majority (72.1%) of cooking fires involve the range or cooktop, followed by the oven at 17.3% (Babrauskas, 2003). Between 2005-2009, the range or cooktop remained the greatest fire threat in cooking fires (58%). It is apparent the range or cooktop has been the consistent ignition source for cooking fires (Ahrens, 2011). It was also found that electric ranges have been shown to have a higher risk for cooking fires (Ahrens, 2011).

[1] According to NFPA, homes include one and two-family homes, apartments and other multi-family housing.

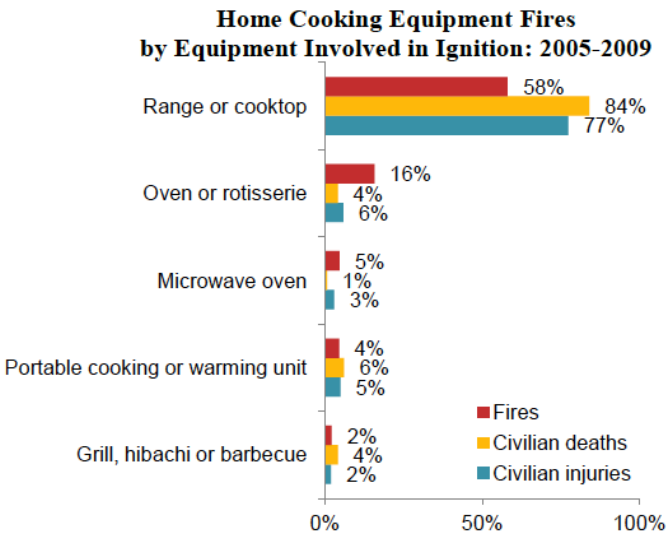


Figure 2: Home Cooking Equipment Fires (Ahrens, 2011)

2.1.3 Causes of Cooking Fires

A study completed in the UK revealed that that 97% of fires involving cooking equipment was caused by misuse (Hogg, 1963). A more recent study completed by CPSC (1999) found that the greatest action or event leading to cooking fires was (1) unattended cooktops [57.7%], (2) other misuse [11%], (3) mechanical/electrical failure [10%], (4) combustible material too close [9.3%], (5) accidentally turned on [5%].

There have been several studies completed to evaluate cooking fire ignition scenarios. However, the majority of these studies have been primarily focused on ignition properties of various oil and fat products. These studies are referenced when discussing the specific fuels used for this research in Section 3.2 of this report.

2.2 Electric Ranges

No detailed research studies could be found that evaluated electric ranges as ignition sources for fires. Several small studies had been completed to evaluate the ignition of corn oil when placed in a saucepan on an electric coil cooktop in comparison to a previous test with a gas burner (Fire Findings, 1997). The 1997 study evaluated the time to ignition and temperature of the oil at the time of ignition. The major findings of this study are that the electric range could easily ignite the oil as did the gas range burner had, and that it took 28 minutes for ignition with an oil temperature of 379^{o}C. In 2000, the same researchers evaluated the rate of temperature rise and whether the larger diameter heating elements would achieve higher temperatures prior to ignitioin. It was found that the larger diameter heating elements recorded a peak temperature of ~732^{o}C in five minutes, while the smaller heating elements reached ~500^{o}C in four minutes (Fire Findings, 2000).

2.3 Cooking Fire Mitigation Technology Studies: Safe-T-Element

A number of performance tests have been conducted on the Safe-T-element, which is an electronically controlled cast iron plate product designed to help prevent cooking fires. Testing was conducted by UL in 2005 to determine the ability of the device to actually prevent fires from occurring as well as to cook food effectively. The study included multiple types of utensils with 100mL of oil. Results indicated a significant reduction in the ignition of oil, but with significant increases in the time it took to cook water, pasta, fries, and bacon (Underwriters, 2005). Based on these results, enhancements were made to the Safe-T-element in order to try to reduce overall cook times. New studies were conducted in 2010 by the Canadian Standards Association (CSA) by OnSpex Consumer Produce Evaluation (Tech. Report Number 30013030). These studies were compared the overall cooking performance of the Safe-T-element as compared to that of an electric coil and glass-ceramic stovetop. Results indicated that the Safe-T-element was slower than a standard electric burner by approximately 10-20% for most cooking procedures. Overall, cook times were increased approximately 30 seconds to two minutes. However, compared to the glass-ceramic stove, the Safe-T-element was equivalent or faster in various cooking procedures.

Furthermore, testing of deep-fat frying foods demonstrated longer cook times for the Safe-T-element, taking approximately 50% longer than the electric coils and 25% longer than the glass-ceramic stovetop. Overall, the appearance and consistency of the cooked food from all three devices appeared similar (Onspex, 2010).

3.0 Methodology

The general methodology for this research was to select kitchen ranges of different cooktop technology to serve as the heat source for analyzing the potential ignition of a variety of common kitchen items. This section will discuss the heat sources and fuels selected for this research. Additional information can be found in Appendices A and F.

3.1 Heat Source

The objective of this study was to evaluate the potential for ignition of commonly found household kitchen items using three different types of residential kitchen ranges. The three different types of kitchen ranges that were evaluated consist of a glass-ceramic cooktop range, an electric coil cooktop range, and an electric coil cooktop range with a Safe-T-element. Thermocouple data and heat flux gauges were used to characterize the temperature and heat output for the six-inch and eight-inch elements for each range.

The model and manufacturer of the ranges used for this research was selected in an attempt to find an electric coil cooktop range and glass-ceramic cooktop range that was similar in element configurations and size, price, energy output, and manufacturer. The General Electric (GE) electric range was the most similar to these requirements and was selected for this research. Both the electrical coil cooktop range and ceramic-glass cooktop range have six- and eight-inch diameter elements.

3.1.1 Ranges

The following section will provide general information regarding the electric ranges selected and used for this study. Additional specifications for the ranges are listed in Appendix A.

The GE electric coil cooktop range has four heating elements two eight-inch diameter elements and two six-inch diameter elements. The model number for the electric coil cooktop range is GE JBP23DRWW. This model is a 30" free-standing electric range with approximate dimensions 46.88 inch by 29.88 inch x 27.75 inch (HxWxD). The six-inch diameter element has a maximum output of 1500 watts and the eight-inch diameter element has a maximum output of 2600 watts. Six of these ranges were purchased and used for this study, three were used without any modifications and the other three had a Safe-T-element installed over the electric coil (Figures 3-4).

The ceramic-glass cooktop range was also manufactured by GE and has two six-inch diameter heating elements and two eight-inch diameter heating elements. The model number for the ceramic-glass cooktop range is GE JBS55DMWW. This model is a 30" free-standing range with approximate dimensions 46.88 inch by 29.88 inch x 27.75 inch (HxWxD). The six-inch diameter element has a maximum output of 1500 watts and the eight-inch diameter element has a maximum output of 2000 watts respectively. Three of these ranges were purchased and used for this study (Figures 3-4).

Figure 3: (left) Electric Coil Cooktop Range - GE Model JBP23DRWW; (right) Electric Ceramic-Glass Cooktop Range - GE Model JBS55DMWW

The selection of these specific freestanding ranges was made because they satisfied most of the similarity requirements for this study. The dimensions, element size and configuration, manufacturer, and overall layout are identical. The one difference between the two ranges was the wattage output of the 8-inch diameter heating element. The two six-inch diameter elements are identical in wattage, but the maximum

output for the eight-inch diameter elements differed by 600 watts. Despite the difference in output for the eight-inch diameter heating element, these two ranges were still selected, because they were the closest matching set of ranges that were identified on the market. All test ranges operated on electric power supplies of 240 Volts.

In summary, the nine units being tested and compared to each other include (Figure 4):

- (3) Electric coil cooktop range manufactured by GE (Model: JBP23DRWW)
- (3) Electric ceramic-glass cooktop range manufactured by GE (Model: JBS55DMWW)
- (3) Electric coil cooktop range manufactured by GE (Model: JBP23DRWW) with a Safe-T element installed from Pioneering technology. Certified electricians installed these elements after being certified on the installation of the Safe-T-element by Pioneering technology.

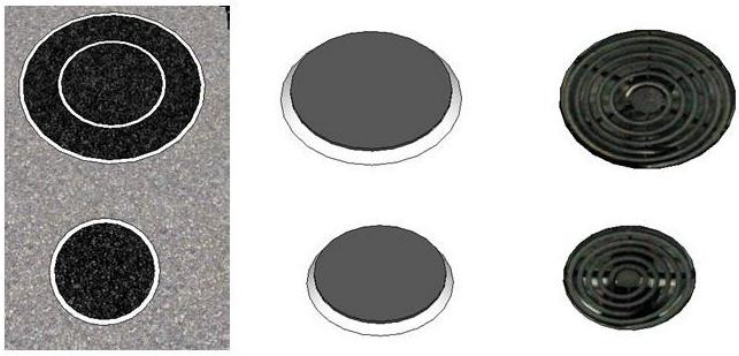


Figure 4: Three types of cooktop elements (left) ceramic-glass, (center) Safe-T-element over coil, (right) coil element

3.1.2 Safe-T-element

The Safe-T-element is manufactured by Pioneering technology from Ontario, Canada (http://www.pioneeringtech.com/safe-t-element). The product brochure for the Safe-T-element lists the following functions and details about their product (Figure 5):

> "Each Safe-T-element® is an electronically controlled solid cover plate that is installed on top of your existing stovetop burner. A patented control unit inside the stove controls the temperature of the plate cover allowing it to only reach a maximum of 350°C/662°F.
>
> When the plate reaches a temperature of 350°C/662°F, it automatically shuts the stove off and conversely as it cools to just below 350°C/662°F the stovetop is turned on again. In this way the burner plate maintains a temperature of 350°C/662°F, more than enough for efficient and effective cooking, while not allowing household materials to ignite" (Pioneering Technology, 2012).

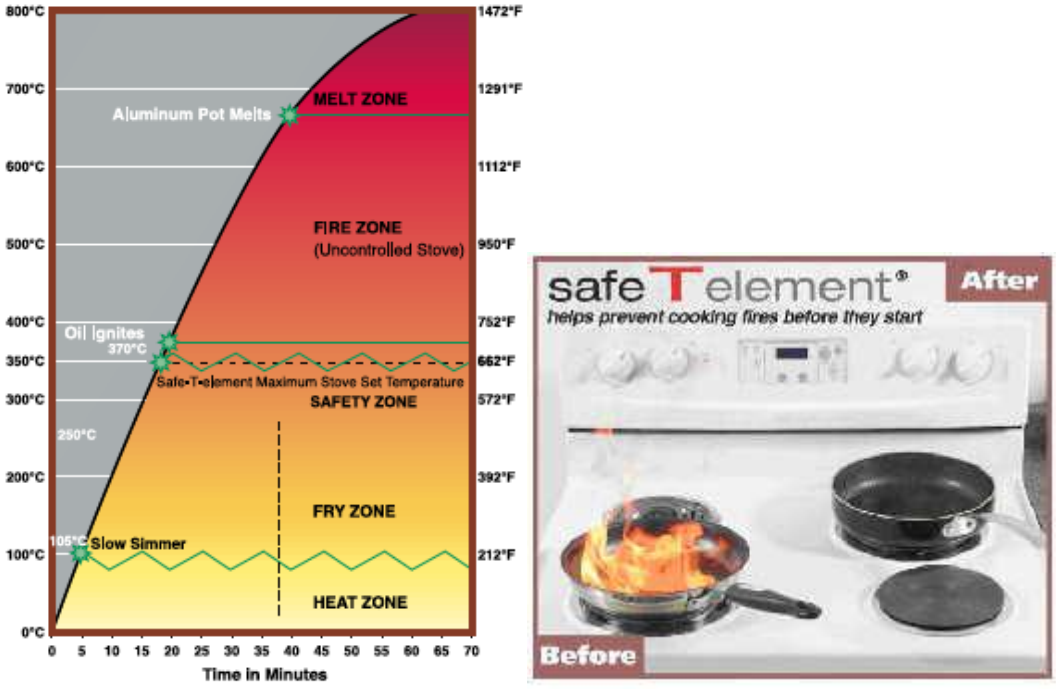


Figure 5: Time / Temperature Curve and Photograph of Safe-T-Element installed (source: product brochure for Safe-T-element)

The Safe-T-element can be pre-installed on new ranges or retrofitted on existing ranges. Two service technicians from Pioneering technology traveled to EKU to train two certified electricians on how to install the Safe-T-element to the electric coil cooktops. This included a hands-on course, classroom instruction, and an online exam. Both certified electricians sat through the course and completed the certification exam to become certified on installing the Safe-T-element. A Safe-T-element was installed onto the Electric coil cooktop range manufactured by GE (Model: JBP23DRWW) by these electricians. Both the six-inch diameter element and the eight-inch diameter element were installed.

3.2 Fuels

Common residential kitchen items were selected as the fuels for this series of tests based on the statistics of first fuels ignited in kitchen range fires, resulting in the selection of these eight common household fuel items (Ahrens, 2011):

1. Cardboard (Pizza box)
2. Dish Towel
3. Paper Towel
4. Canola Oil
5. Vegetable Oil
6. Cooking Utensil (Nylon Short Turner Spatula)
7. Kitchen Appliance (Toaster)
8. Storage Container

The solid fuels in this research included corrugated paper (cardboard), cotton (dish towel), paper (paper towel), polypropylene (plastic toaster), nylon (spatula), and polyethylene (storage container). The solid fuels were placed directly on the heating element. As such, literature was reviewed to identify hot surface ignition temperatures to best characterize the fuels. However, there are limited studies available for hot surface ignition of the selected fuels. Therefore, this report lists the available autoignition temperatures (AIT) for each fuel as a means to characterize the solid fuels.

The liquid fuels in this research included canola oil and vegetable oil. These fuels were placed in a one-quart, stainless steel saucepan (5.5 inch diameter) and then the pan was placed on the heating element. The appropriate ignition scenario for the liquid fuels is autoignition of the fuels, as there was no external ignition source present. Therefore, the AIT for each liquid fuel is listed below to characterize the liquid fuels.

The fuels are listed in this section according to the numerical order used above and will be the numerical order used to describe each test throughout the rest of this report. Additional information and photographs of the fuels can be found in Appendix F.

3.2.1 Corrugated Paper (Cardboard Pizza Box)

The cardboard material or corrugated paper was obtained from a commercial pizzeria (Little Caesars Pizza). Corrugated paper has been experimentally determined to have an ignition temperature of approximately 370^{o}C (Ohlemiller & Villa, 1991). The cardboard box was cut into six- and eight-inch diameter circles to fit directly on top of the six- and eight-inch elements. These cardboard box circles were placed directly on the element (Figure 6).

Figure 6: Orientation of corrugated paper (cardboard pizza box) fuel on heating element.

3.2.2 Cotton (Dish Towel)

The dish towel selected for this research was purchased from Walmart and is a Mainstays kitchen towel. It is fifteen inches wide and twenty-five inches long and is primarily constructed of cotton. Cotton has a reported AIT of approximately 250^{o}C (Babrauskas, 2003). The towel was folded over four times and centered directly on top of the element (Figure 7).

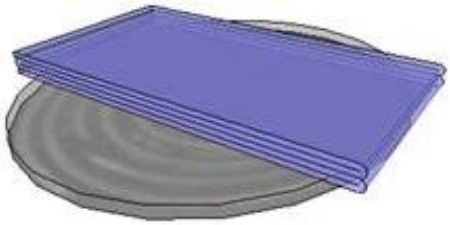


Figure 7: Orientation of dish towel on heating element

3.2.3 Paper (Paper Towel)

Sparkle brand paper towels were selected for the third fuel. Mowrer (2003) performed experiments to identify the minimum heat flux required for ignition of paper towels and found that paper towel was ignited at 30.6 kW/m^2. Babrauskas (2003) lists a range of measured AIT of various paper products between 123-240^{o}C. The full roll of paper towels, without any plastic covering, was centered horizontally on top of the element, lying flat extending across the heating element left to right in relation to the front of the range (Figure 8).

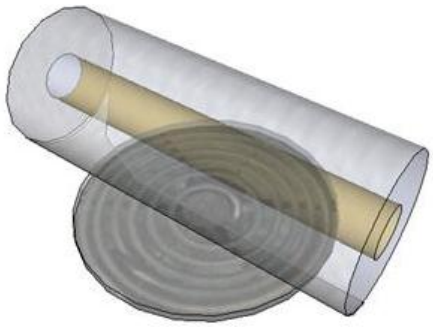


Figure 8: Orientation of paper towel roll on heating element

3.2.4 Canola oil

The fourth fuel used with this research was canola oil. Specifically, Land O' Lakes-all natural butter with canola oil was used. Babrauskas (2003) reports an AIT for canola oil ranging between 315-447^{o}C. A more recent study performed on the autoignition of cooking oils listed the AIT for canola oil as 424 ^{o}C (Buda-Ortins & Sunderland, 2010). A half-cup (~115 grams) of canola oil was placed into the stainless steel saucepan for each test (Figure 9).

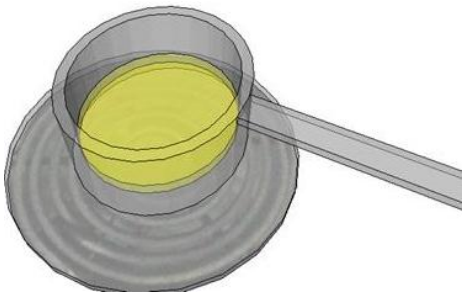


Figure 9: Orientation of saucepan on heating element

3.2.5 Vegetable oil

Vegetable oil was the fifth fuel used in this research. The vegetable oil was purchased at Walmart and was the "Great Value" brand. The AIT for vegetable oil is listed as 406°C (Buda-Ortins & Sunderland, 2010). A half-cup (~112 grams) of vegetable oil was placed into the saucepan for each test (Figure 9).

3.2.6 Nylon (Short Turner Spatula-Cooking Utensil)

The cooking utensil used for this study was a Farberware-professional short turner spatula. It is constructed from Nylon. Nylon has a recorded AIT of approximately 328-500°C (Babrauskas, 2003). Hot surface ignition temperatures for nylon based floor coverings have been reported as high as 660 °C (Babrauskas, 2003). The nylon spatula was placed directly on the heating element with the handle and base of the spatula in direct contact with the heating element (Figure 10).

Figure 10: Orientation of spatula on heating element

3.2.7 Polypropylene (Toaster-Kitchen Appliance)

The kitchen appliance selected for this research was a 2-slice toaster manufactured by Rival, Model 16041. The top and side panels of the appliance housing are constructed of plastic (polypropylene), while the base of the toaster and the internal mechanisms are constructed of metal. Babrauskas reports an AIT ranging between (325-440°C). The toaster was centered in the upright position directly on the burner (Figure 11).

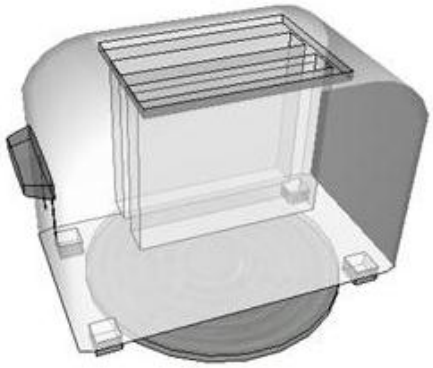


Figure 11: Orientation of toaster on heating element

3.2.8 Polyethylene (Food Storage Container)

The food storage container is a Takealongs® brand manufactured by Rubbermaid. The storage container has a square base approximately 5.5 inches in width and is constructed of low density polyethylene (LDPE) plastic. Babrauskas reports that polyethylene material has a recorded AIT between 349-457^{o}C (Babrauskas, 2003). The storage container was centered directly on the heating element (Figure 12).

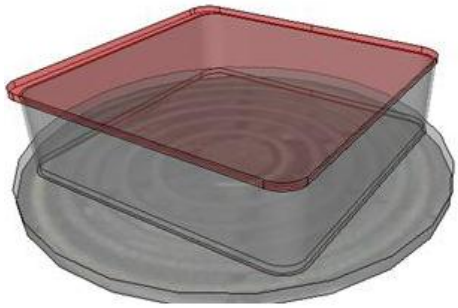


Figure 12: Orientation of food storage container on heating element

3.3 Experimental Design

The following discussion outlines the experimental design utilized for this research, including the test facility, instrumentation, and test matrix. All eight fuels were tested using each type of cooktop. The six-inch and eight-inch diameter heating elements were used for each range and both heating elements were used to test all eight fuels. Each test was conducted using the high, medium, and low settings for each heating element. This resulted in a test matrix of 48 ignition tests for each type of cooktop.

Each test was documented using a systematic arrangement of thermocouples to record the temperature of the fuel (external and internal) and the heating element during the heating process. A thermal imaging camera and video camera also recorded each test.

3.3.1 Test Facility

All tests were conducted utilizing Eastern Kentucky University's Ashland Fire and Safety Laboratory located in Richmond, KY. The testing took place in the sprinkler flow room that is constructed of concrete walls and bar joist ceiling. The room is constructed to enable small-scale tests and is equipped with a smoke ventilation system, as well as automatic and manual fire suppression systems. The ventilation system was only used to vent smoke after the tests were completed and was not in operation during any of the tests. A backdrop was used to increase the effectiveness of the video and photographs taken throughout the tests (Figure 13).

Figure 13: Experimental setup

3.3.2 Test Matrix

All eight fuels were tested using each type of cooktop. The six-inch and eight-inch diameter heating elements were used for each cooktop and both heating elements were used to test all eight fuels. Each test was conducted using the high, medium, and low settings for each heating element. This resulted in a test matrix of 48 ignition tests for each range. In order to organize this information each test was provided a unique alpha-numeric code as generated by the following setup: cooktop type | fuel | element diameter | thermostat setting. The acronyms used for the cooktop types include ceramic-glass (CG), electric coil (EC), and Safe-T-element (ST). The fuels will be listed in numerical order according to section 3.2 and repeated here: (1) cardboard (pizza box); (2) cotton (dish towel); (3) paper (paper towel); (4) canola oil; (5) vegetable oil; (6) nylon short turner spatula; (7) polypropylene (toaster); (8) polyethylene (storage container). The heating elements were listed according to their respective diameters, either given the number 6 or 8. Finally, the first letter of the thermostat setting was used to identify the setting: 'H' for High, 'M' for Medium, and 'L' for Low. Each value in the test identification heading is separated by a period, for example if the ceramic-glass cooktop was used for corrugated paper on the six-inch diameter heating element with a setting of high, the following test identification number was used ***CG.1.6.H***. Table 1 provides a complete listing of the tests completed with the ceramic-glass cooktop range. Table 2 provides a complete listing of the tests completed with the electrical

coil cooktop range. Table 3 provides a complete listing of the tests completed with the coil cooktop with the Safe-T-element installed.

Table 1: Ceramic-Glass Cooktop Range Test Matrix

Test Id	Cooktop Type	Fuel	Diameter	Setting
CG.1.6.L	Ceramic-Glass	Cardboard	6”	Low
CG.1.6.M	Ceramic-Glass	Cardboard	6”	Medium
CG.1.6.H	Ceramic-Glass	Cardboard	6”	High
CG.1.8.L	Ceramic-Glass	Cardboard	8”	Low
CG.1.8.M	Ceramic-Glass	Cardboard	8”	Medium
CG.1.8.H	Ceramic-Glass	Cardboard	8”	High
CG.2.6.L	Ceramic-Glass	Dish Towel	6”	Low
CG.2.6.M	Ceramic-Glass	Dish Towel	6”	Medium
CG.2.6.H	Ceramic-Glass	Dish Towel	6”	High
CG.2.8.L	Ceramic-Glass	Dish Towel	8”	Low
CG.2.8.M	Ceramic-Glass	Dish Towel	8”	Medium
CG.2.8.H	Ceramic-Glass	Dish Towel	8”	High
CG.3.6.L	Ceramic-Glass	Paper Towel	6”	Low
CG.3.6.M	Ceramic-Glass	Paper Towel	6”	Medium
CG.3.6.H	Ceramic-Glass	Paper Towel	6”	High
CG.3.8.L	Ceramic-Glass	Paper Towel	8”	Low
CG.3.8.M	Ceramic-Glass	Paper Towel	8”	Medium
CG.3.8.H	Ceramic-Glass	Paper Towel	8”	High
CG.4.6.L	Ceramic-Glass	Canola Oil	6”	Low
CG.4.6.M	Ceramic-Glass	Canola Oil	6”	Medium
CG.4.6.H	Ceramic-Glass	Canola Oil	6”	High
CG.4.8.L	Ceramic-Glass	Canola Oil	8”	Low
CG.4.8.M	Ceramic-Glass	Canola Oil	8”	Medium
CG.4.8.H	Ceramic-Glass	Canola Oil	8”	High
CG.5.6.L	Ceramic-Glass	Vegetable Oil	6”	Low
CG.5.6.M	Ceramic-Glass	Vegetable Oil	6”	Medium
CG.5.6.H	Ceramic-Glass	Vegetable Oil	6”	High
CG.5.8.L	Ceramic-Glass	Vegetable Oil	8”	Low
CG.5.8.M	Ceramic-Glass	Vegetable Oil	8”	Medium
CG.5.8.H	Ceramic-Glass	Vegetable Oil	8”	High
CG.6.6.L	Ceramic-Glass	Nylon spatula	6”	Low
CG.6.6.M	Ceramic-Glass	Nylon spatula	6”	Medium
CG.6.6.H	Ceramic-Glass	Nylon spatula	6”	High
CG.6.8.L	Ceramic-Glass	Nylon spatula	8”	Low
CG.6.8.M	Ceramic-Glass	Nylon spatula	8”	Medium
CG.6.8.H	Ceramic-Glass	Nylon spatula	8”	High
CG.7.6.L	Ceramic-Glass	Polypropylene	6”	Low
CG.7.6.M	Ceramic-Glass	Polypropylene	6”	Medium
CG.7.6.H	Ceramic-Glass	Polypropylene	6”	High
CG.7.8.L	Ceramic-Glass	Polypropylene	8”	Low
CG.7.8.M	Ceramic-Glass	Polypropylene	8”	Medium

CG.7.8.H	Ceramic-Glass	Polypropylene	8”	High
CG.8.6.L	Ceramic-Glass	Polyethylene	6”	Low
CG.8.6.M	Ceramic-Glass	Polyethylene	6”	Medium
CG.8.6.H	Ceramic-Glass	Polyethylene	6”	High
CG.8.8.L	Ceramic-Glass	Polyethylene	8”	Low
CG.8.8.M	Ceramic-Glass	Polyethylene	8”	Medium
CG.8.8.H	Ceramic-Glass	Polyethylene	8”	High

Table 2: Electric Coil Cooktop Test Matrix

Test Id	Cooktop Type	Fuel	Diameter	Setting
EC.1.6.L	Electric Coil	Cardboard	6”	Low
EC.1.6.M	Electric Coil	Cardboard	6”	Medium
EC.1.6.H	Electric Coil	Cardboard	6”	High
EC.1.8.L	Electric Coil	Cardboard	8”	Low
EC.1.8.M	Electric Coil	Cardboard	8”	Medium
EC.1.8.H	Electric Coil	Cardboard	8”	High
EC.2.6.L	Electric Coil	Dish Towel	6”	Low
EC.2.6.M	Electric Coil	Dish Towel	6”	Medium
EC.2.6.H	Electric Coil	Dish Towel	6”	High
EC.2.8.L	Electric Coil	Dish Towel	8”	Low
EC.2.8.M	Electric Coil	Dish Towel	8”	Medium
EC.2.8.H	Electric Coil	Dish Towel	8”	High
EC.3.6.L	Electric Coil	Paper Towel	6”	Low
EC.3.6.M	Electric Coil	Paper Towel	6”	Medium
EC.3.6.H	Electric Coil	Paper Towel	6”	High
EC.3.8.L	Electric Coil	Paper Towel	8”	Low
EC.3.8.M	Electric Coil	Paper Towel	8”	Medium
EC.3.8.H	Electric Coil	Paper Towel	8”	High
EC.4.6.L	Electric Coil	Canola Oil	6”	Low
EC.4.6.M	Electric Coil	Canola Oil	6”	Medium
EC.4.6.H	Electric Coil	Canola Oil	6”	High
EC.4.8.L	Electric Coil	Canola Oil	8”	Low
EC.4.8.M	Electric Coil	Canola Oil	8”	Medium
EC.4.8.H	Electric Coil	Canola Oil	8”	High
EC.5.6.L	Electric Coil	Vegetable Oil	6”	Low
EC.5.6.M	Electric Coil	Vegetable Oil	6”	Medium
EC.5.6.H	Electric Coil	Vegetable Oil	6”	High
EC.5.8.L	Electric Coil	Vegetable Oil	8”	Low
EC.5.8.M	Electric Coil	Vegetable Oil	8”	Medium
EC.5.8.H	Electric Coil	Vegetable Oil	8”	High
EC.6.6.L	Electric Coil	Nylon spatula	6”	Low
EC.6.6.M	Electric Coil	Nylon spatula	6”	Medium
EC.6.6.H	Electric Coil	Nylon spatula	6”	High
EC.6.8.L	Electric Coil	Nylon spatula	8”	Low
EC.6.8.M	Electric Coil	Nylon spatula	8”	Medium

EC.6.8.H	Electric Coil	Nylon spatula	8”	High
EC.7.6.L	Electric Coil	Polypropylene	6”	Low
EC.7.6.M	Electric Coil	Polypropylene	6”	Medium
EC.7.6.H	Electric Coil	Polypropylene	6”	High
EC.7.8.L	Electric Coil	Polypropylene	8”	Low
EC.7.8.M	Electric Coil	Polypropylene	8”	Medium
EC.7.8.H	Electric Coil	Polypropylene	8”	High
EC.8.6.L	Electric Coil	Polyethylene	6”	Low
EC.8.6.M	Electric Coil	Polyethylene	6”	Medium
EC.8.6.H	Electric Coil	Polyethylene	6”	High
EC.8.8.L	Electric Coil	Polyethylene	8”	Low
EC.8.8.M	Electric Coil	Polyethylene	8”	Medium
EC.8.8.H	Electric Coil	Polyethylene	8”	High

Table 3: Safe-T-element Coil Cooktop Test Matrix

Test Id	Cooktop Type	Fuel	Diameter	Setting
ST.1.6.L	Safe-T-element	Cardboard	6”	Low
ST.1.6.M	Safe-T-element	Cardboard	6”	Medium
ST.1.6.H	Safe-T-element	Cardboard	6”	High
ST.1.8.L	Safe-T-element	Cardboard	8”	Low
ST.1.8.M	Safe-T-element	Cardboard	8”	Medium
ST.1.8.H	Safe-T-element	Cardboard	8”	High
ST.2.6.L	Safe-T-element	Dish Towel	6”	Low
ST.2.6.M	Safe-T-element	Dish Towel	6”	Medium
ST.2.6.H	Safe-T-element	Dish Towel	6”	High
ST.2.8.L	Safe-T-element	Dish Towel	8”	Low
ST.2.8.M	Safe-T-element	Dish Towel	8”	Medium
ST.2.8.H	Safe-T-element	Dish Towel	8”	High
ST.3.6.L	Safe-T-element	Paper Towel	6”	Low
ST.3.6.M	Safe-T-element	Paper Towel	6”	Medium
ST.3.6.H	Safe-T-element	Paper Towel	6”	High
ST.3.8.L	Safe-T-element	Paper Towel	8”	Low
ST.3.8.M	Safe-T-element	Paper Towel	8”	Medium
ST.3.8.H	Safe-T-element	Paper Towel	8”	High
ST.4.6.L	Safe-T-element	Canola Oil	6”	Low
ST.4.6.M	Safe-T-element	Canola Oil	6”	Medium
ST.4.6.H	Safe-T-element	Canola Oil	6”	High
ST.4.8.L	Safe-T-element	Canola Oil	8”	Low
ST.4.8.M	Safe-T-element	Canola Oil	8”	Medium
ST.4.8.H	Safe-T-element	Canola Oil	8”	High
ST.5.6.L	Safe-T-element	Vegetable Oil	6”	Low
ST.5.6.M	Safe-T-element	Vegetable Oil	6”	Medium
ST.5.6.H	Safe-T-element	Vegetable Oil	6”	High
ST.5.8.L	Safe-T-element	Vegetable Oil	8”	Low
ST.5.8.M	Safe-T-element	Vegetable Oil	8”	Medium

ST.5.8.H	Safe-T-element	Vegetable Oil	8”	High
ST.6.6.L	Safe-T-element	Nylon spatula	6”	Low
ST.6.6.M	Safe-T-element	Nylon spatula	6”	Medium
ST.6.6.H	Safe-T-element	Nylon spatula	6”	High
ST.6.8.L	Safe-T-element	Nylon spatula	8”	Low
ST.6.8.M	Safe-T-element	Nylon spatula	8”	Medium
ST.6.8.H	Safe-T-element	Nylon spatula	8”	High
ST.7.6.L	Safe-T-element	Polypropylene	6”	Low
ST.7.6.M	Safe-T-element	Polypropylene	6”	Medium
ST.7.6.H	Safe-T-element	Polypropylene	6”	High
ST.7.8.L	Safe-T-element	Polypropylene	8”	Low
ST.7.8.M	Safe-T-element	Polypropylene	8”	Medium
ST.7.8.H	Safe-T-element	Polypropylene	8”	High
ST.8.6.L	Safe-T-element	Polyethylene	6”	Low
ST.8.6.M	Safe-T-element	Polyethylene	6”	Medium
ST.8.6.H	Safe-T-element	Polyethylene	6”	High
ST.8.8.L	Safe-T-element	Polyethylene	8”	Low
ST.8.8.M	Safe-T-element	Polyethylene	8”	Medium
ST.8.8.H	Safe-T-element	Polyethylene	8”	High

3.3.3 Instrumentation

Instrumentation typical to all tests is presented in this section. The specific thermocouple locations for each test varied based on the fuels evaluated and will be specifically addressed in the thermocouple section. In addition to the instrumentation recorded during the ignition tests, preliminary tests were completed in an attempt to characterize the heat output for each heating element, which included rate of rise temperature measurements and heat flux.

3.3.3.1 Thermocouple placement

Thermocouples were used to characterize the temperature between the heating element and the fuel, as well as within each fuel. All thermocouples were constructed of bare bead TCs that were 24Ga Type K with glass insulation. The first three thermocouples (TC0, TC1, and TC2) were located against the heating element beneath the fuel, with the nylon spatula being the only exception. The remaining thermocouples varied within the fuels dependent on the fuel configuration and are discussed in sections 3.3.3.1.1 – 3.3.3.1.8 (Figures 14-21).

3.3.3.1.1 Cardboard

The first three thermocouples were placed beneath the fuel and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed in the center of the cardboard box above the locations of TC0, TC1, and TC2. The last row of thermocouples (TC6-TC8) was placed on the top of the corrugated paper (Figure 14).

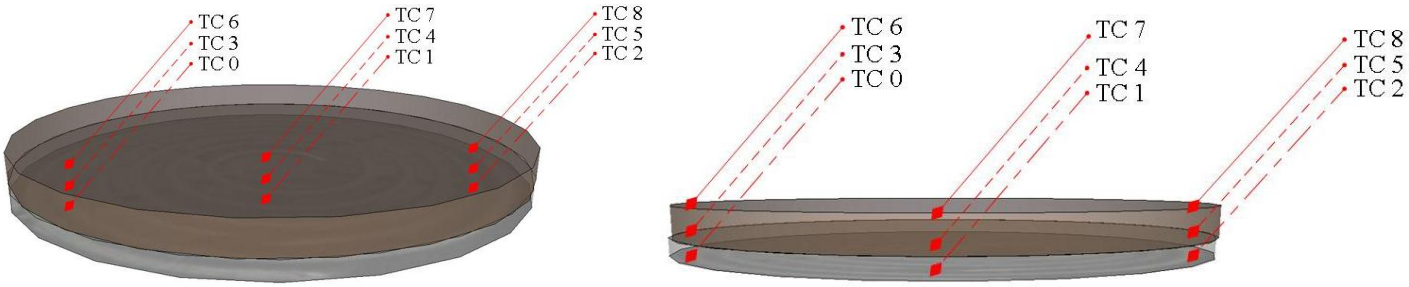


Figure 14: TC placement for corrugated paper (cardboard box): (left) isometric view; (right) elevation view

3.3.3.1.2 Dish Towel

The first three thermocouples were placed beneath the fuel and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed near the center of the dish towel above TC0, TC1, and TC2. The last row of thermocouples (TC6-TC8) was placed along the top of the dish towel (Figure 15).

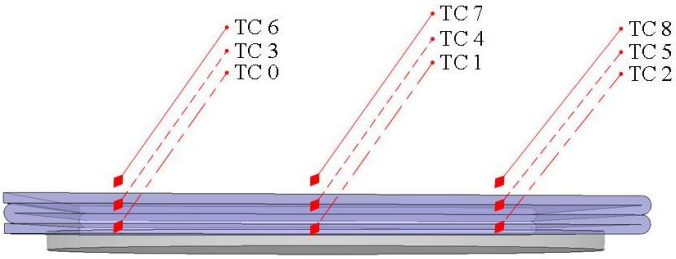


Figure 15: TC placement for dish towel (cotton)

3.3.3.1.3 Paper Towel

The first three thermocouples were placed beneath the fuel and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed in the center of the cardboard cylinder inside the paper towel roll. The last row of thermocouples (TC6-TC8) was placed along the top of the paper towel roll (Figure 16).

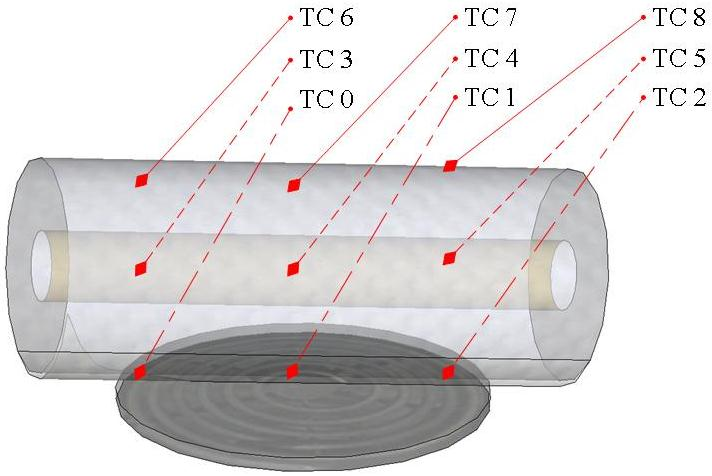


Figure 16: TC placement for paper towel roll

3.3.3.1.4 Canola Oil

The first three thermocouples were placed beneath the pan and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed near the center of the saucepan. The last row of thermocouples (TC6-TC8) was placed above the liquid level of the fuel (Figure 17).

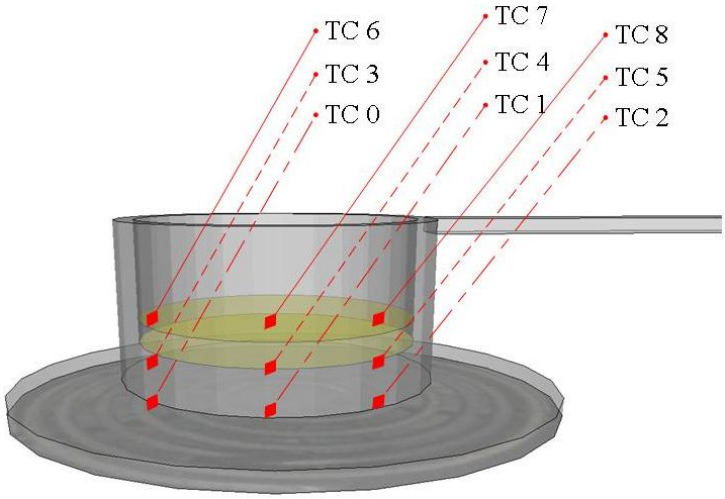


Figure 17: TC placement for canola oil and vegetable oil

3.3.3.1.5 Vegetable Oil

The first three thermocouples were placed beneath the pan and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed near the center of the saucepan. The last row of thermocouples (TC6-TC8) was placed above the liquid level of the fuel (Figure 17).

3.3.3.1.6 Nylon Spatula

The first thermocouple (TC0) was placed beneath the spatula end against the heating element. The second thermocouple (TC1) was placed along the top of the spatula above TC0. The third thermocouple (TC2) was placed beneath the handle end against the heating element. The fourth thermocouple (TC3) was placed along the top of the handle above TC2 (Figure 18).

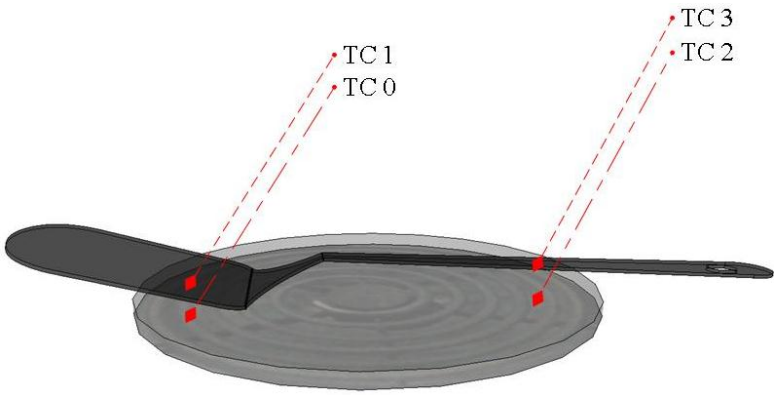


Figure 18: TC placement for nylon spatula

3.3.3.1.7 Toaster (Polypropylene)

The first three thermocouples were placed beneath the fuel and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed near the center of the toaster. The last row of thermocouples (TC6-TC8) was placed along the top of the toaster (Figure 19).

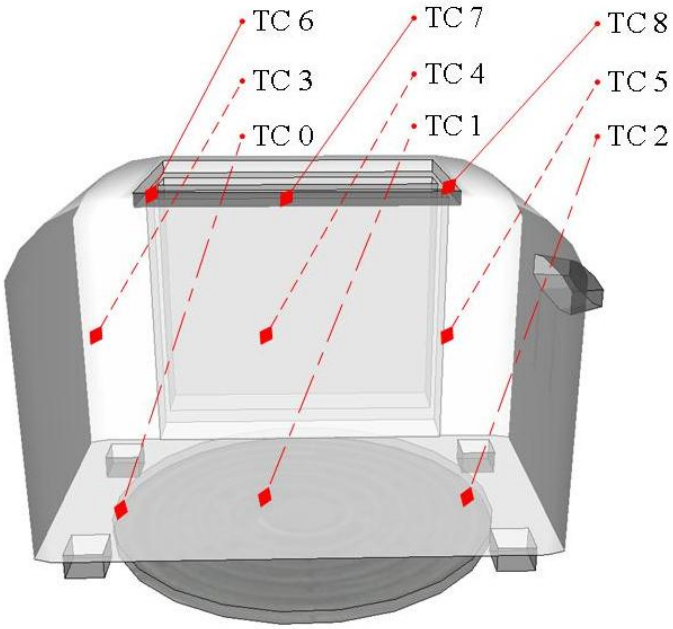


Figure 19: TC placement for toaster

3.3.3.1.8 Food Storage Container (Polyethylene)

The first three thermocouples were placed beneath the fuel and against the heating element (TC0, TC1, TC2). The next row of thermocouples (TC3-TC5) was placed in the center of the food storage container. The last row of thermocouples (TC6-TC8) was placed along the top of the food storage container (Figure 20).

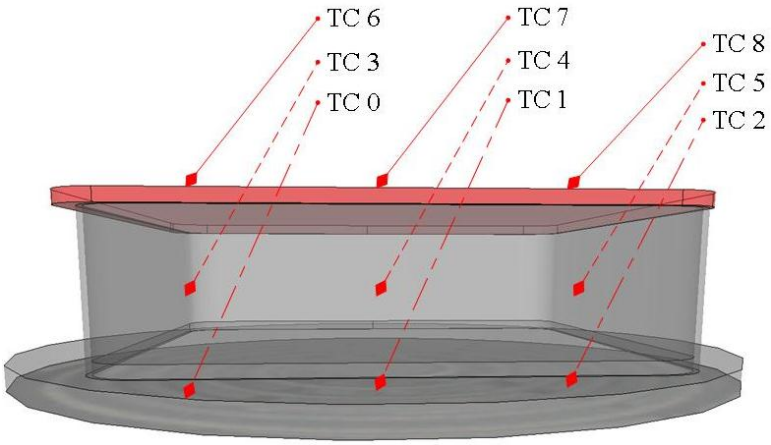


Figure 20: TC placement for food storage container

3.3.3.2 Heat Flux Transducer

Heat flux transducers (radiometers) were used to help characterize the heat flux emitted from the heating element. Each heating element was evaluated at low, medium, and high settings with a heat flux transducer placed approximately 0.75 inch above the heating element. Convective and radiant heat transfer was measured with a water cooled, Schmidt-Boelter type heat flux transducer. One limitation of this method to characterize the heat output is that the transducer is water-cooled and therefore does not take into account conductive heat transfer. This introduces significant uncertainty with this measurement, as conduction heat transfer is a significant portion of the total heat flux in this scenario due to the hot surface and direct contact with the fuels. Nevertheless, it is one of the methods used in this study employed to evaluate the heat output from the heating elements. Due to time constraints, this portion of the study will be published later as part of the MS thesis work of Corey Hanks and will not be presented in this report.

3.3.3.3 Thin-Skin Calorimeters (TSC)

The heat output for each heating element for all ranges was recorded for the high, medium, and low settings using three thin-skin calorimeters (TSC). Thin-skin calorimeters (TSC) were used to measure the incident heat flux on a surface as outlined in ASTM E459-05 (Alston, 2004). TSC data was collected for each cooktop and was to be calibrated with a constant heat flux from a cone calorimeter, which would enable a more accurate analysis of the heat output for the hot surface of each heating element. Due to time constraints, this portion of the study will be published later as part of the MS thesis work of Corey Hanks and will not be presented in this report.

3.3.3.4 Rate of Rise Temperature Measurements

The rate of temperature rise was recorded for each cooktop type, each heating element diameter, and thermostat setting. Three thermocouples were placed directly on each diameter heating element and each cooktop type, so the maximum temperatures and rate of temperature rise could be recorded (Figure 21). The results can be found in Appendix B.

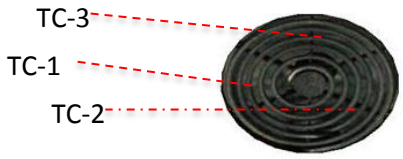


Figure 21: TC location for rate of rise temperature measurements

3.3.3.5 Videography and Photography

The events of each test were documented using video cameras. Two video cameras and an infrared (thermal imaging) camera were used for each test. All camera feeds were digitally recorded. One standard video camera and the Bullard IR T4MAX IR camera were placed in front of the cooktop and recorded each test. One standard video camera was placed directly above the range viewing the top of the fuel for each test (Figure 22). Additionally, photographs were taken before, during, and after each test.

Figure 22: Line of Sight for Test Videography

4.0 Results

This section details the ignition results of each cooktop and fuel. There are a total of 48 tests for each cooktop (8 fuels, 3 settings, 2 heating element diameters), resulting in a total of 144 tests completed for this study. The organization of this section includes a summary of results for each test separated by the cooktop and then the fuel evaluated. Ignition was for purposes of these test was the presence of flaming combustion. Additional data can be found in the appendices.

4.1 Rate of Temperature Rise Results

The cooktop with the Safe-T-element installed consistently had a slower rate of temperature rise as compared to the other cooktop types (Figures 23-24). The Safe-T-element took 13 minutes and 8 minutes more to reach its maximum temperature on the high thermostat setting with the respective 6-inch and 8-inch diameter heating elements. The maximum temperature varied. Table 4 provides the maximum temperatures achieved by each cooktop type. The values are provided as a range of temperatures based on the three-thermocouple locations (Figure 21). The full results of this analysis can be found in Appendix B.

Table 4: Maximum Temperature Ranges Achieved by Heating Elements

Diameter	Setting	Ceramic-Glass Temp (^{o}C)	Electric Coil Temp (^{o}C)	Safe-T-element Temp (^{o}C)
6”	High	451-664	542-731	467-652
	Medium	405-567	338-465	302-423
	Low	150-211	28-102	63-78
8”	High	482-645	564-743	523-689
	Medium	390-529	370-441	289-382
	Low	141-186	42-147	54-65

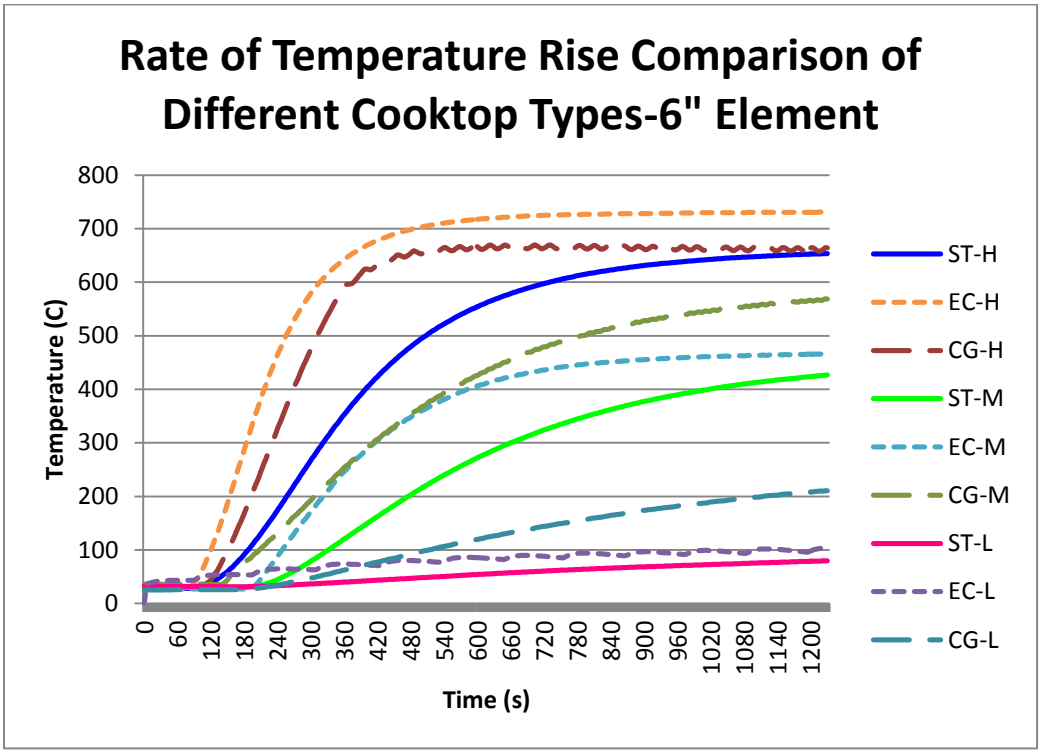


Figure 23: Rate of Temperature Rise-Cooktop Type Comparison (6" diameter heating element)

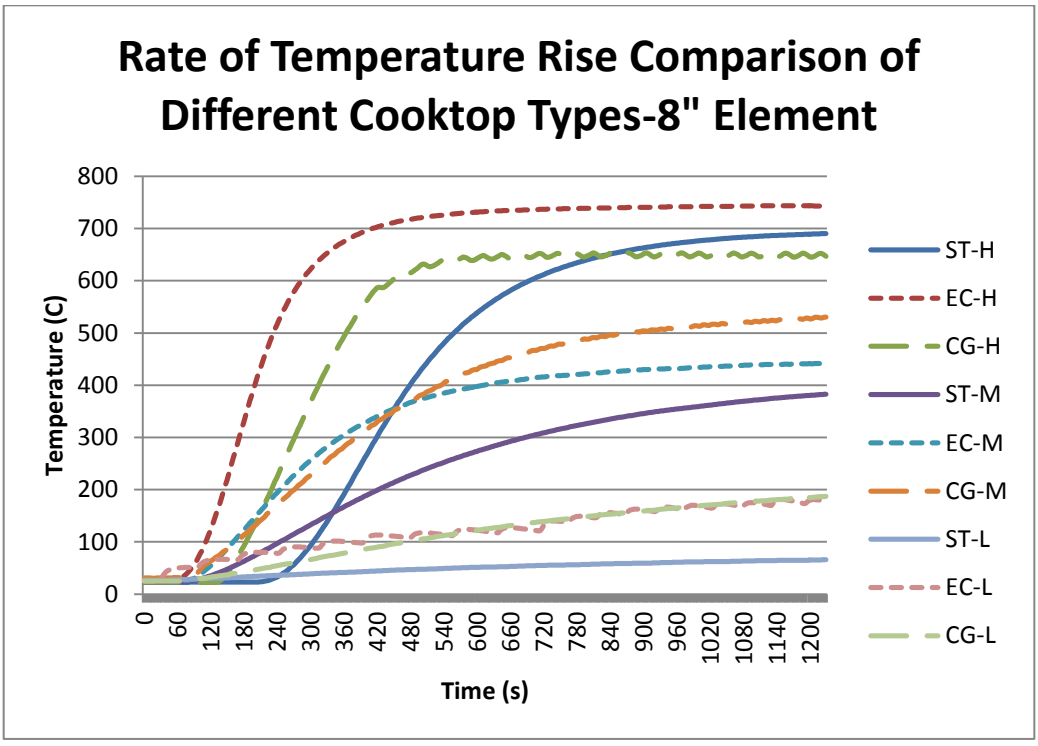


Figure 24: Rate of Temperature Rise-Cooktop Type Comparison (8" diameter heating element)

4.2 Ceramic-Glass Cooktop Range Results: Selected Observations

This section provides tables (Tables 5-12) that summarize the results for each ignition test, including the general conditions for the individual fuels that were evaluated with the ceramic-glass cooktop range. Below each table is a brief discussion regarding the selected observations witnessed during each test. The thermocouple data for each test can be found in Appendix C.

Table 5: Ignition Results of Ceramic-Glass cooktop and cardboard fuel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.6.L	Cardboard	6”	Low	25:00	No	
CG.1.6.M	Cardboard	6”	Medium	9:00	Yes	9:00
CG.1.6.H	Cardboard	6”	High	2:30	Yes	2:30
CG.1.8.L	Cardboard	8”	Low	25:00	No	
CG.1.8.M	Cardboard	8”	Medium	7:07	Yes	7:07
CG.1.8.H	Cardboard	8”	High	2:33	Yes	2:33

CG.1.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 30 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=364^{o}C, TC-1=318 ^{o}C, TC-2=300 ^{o}C.

CG.1.6.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the medium setting, resulted in flaming ignition in 9 minutes. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=315 ^{o}C, TC-1=304 ^{o}C, TC-2=357 ^{o}C.

CG.1.6.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

CG.1.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 33 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=518^{o}C, TC-1=488^{o}C, TC-2=378 ^{o}C.

CG.1.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the medium setting, resulted in flaming ignition in 7 minutes 7 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=427 ^{o}C, TC-1=388^{o}C, TC-2=387^{o}C.

CG.1.8.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 6: Ignition Results of Ceramic-Glass Cooktop and the dish towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.6.L	Dish Towel	6”	Low	25:00	No	
CG.2.6.M	Dish Towel	6”	Medium	12:09	Yes	12:09
CG.2.6.H	Dish Towel	6”	High	2:30	Yes	2:30
CG.2.8.L	Dish Towel	8”	Low	25:00	No	
CG.2.8.M	Dish Towel	8”	Medium	12:00	Yes	12:00
CG.2.8.H	Dish Towel	8”	High	3:26	Yes	3:26

CG.2.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 3 minutes 20 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=172^{o}C, TC-1=429 ^{o}C, TC-2=284^{o}C.

CG.2.6.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the medium setting, resulted in flaming ignition in 12 minutes 9 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=305^{o}C, TC-1=284^{o}C, TC-2=442^{o}C.

CG.2.6.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

CG.2.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel), using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 3 minutes 26 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=500^{o}C, TC-1=288 ^{o}C, TC-2=419^{o}C.

CG.2.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel), using the 8-inch diameter element, set to the medium setting, resulted in flaming ignition in 12 minutes. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=309^{o}C, TC-1=255^{o}C, TC-2=239^{o}C.

CG.2.8.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the cotton (dish towel) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 7: Ignition Results of Ceramic-Glass Cooktop and Paper Towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.6.L	Paper Towel	6”	Low	30:00	No	
CG.3.6.M	Paper Towel	6”	Medium	18:57	Yes	18:57
CG.3.6.H	Paper Towel	6”	High	2:36	Yes	2:36
CG.3.8.L	Paper Towel	8”	Low	35:00	No	
CG.3.8.M	Paper Towel	8”	Medium	10:24	Yes	10:24
CG.3.8.H	Paper Towel	8”	High	2:30	Yes	2:30

CG.3.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 36 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=432^{o}C, TC-1= 363^{o}C, TC-2=359^{o}C

CG.3.6.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the medium setting, resulted in flaming ignition in 18 minutes 57 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=526^{o}C, TC-1= 379^{o}C, TC-2=416^{o}C.

CG.3.6.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the low setting after a 30-minute test resulted in no flaming ignition.

CG.3.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 30 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=432^{o}C, TC-1= 363^{o}C, TC-2=359^{o}C.

CG.3.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 8 inch diameter element set to the medium setting, resulted in flaming ignition in 10 minutes 24 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=524^{o}C, TC-1= 477^{o}C, TC-2=461^{o}C.

G.3.8.L: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the paper (paper towel) using the 8-inch diameter element set to the low setting after a 30-minute test resulted in no flaming ignition. Smoldering combustion was noticed on the fuel’s surface.

Table 8:Ignition Results of Ceramic-Glass Cooktop and Canola Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.6.L	Canola Oil	6”	Low	No test	No	
CG.4.6.M	Canola Oil	6”	Medium	No test	No	
CG.4.6.H	Canola Oil	6”	High	20:00	No	
CG.4.8.L	Canola Oil	8”	Low	No test	No	
CG.4.8.M	Canola Oil	8”	Medium	No test	No	
CG.4.8.H	Canola Oil	8”	High	20:00	No	

CG.4.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the canola oil using the 6-inch diameter element set to the high setting after a 20-minute test resulted in no flaming ignition.

CG.4.6.M: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.4.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.4.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the canola oil using the 8-inch diameter element set to the high setting after a 20-minute test resulted in no flaming ignition.

CG.4.8.M: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.4.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 9: Ignition Results of Ceramic-Glass Cooktop and Vegetable Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.6.L	Vegetable Oil	6”	Low	No test	No	
CG.5.6.M	Vegetable Oil	6”	Medium	No test	No	
CG.5.6.H	Vegetable Oil	6”	High	25:00	No	
CG.5.8.L	Vegetable Oil	8”	Low	No test	No	
CG.5.8.M	Vegetable Oil	8”	Medium	No test	No	
CG.5.8.H	Vegetable Oil	8”	High	25:00	No	

CG.5.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the vegetable oil using the 6-inch diameter element set to the high setting after a 25-minute test resulted in no flaming ignition.

CG.5.6.M: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.5.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.5.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the canola oil using the 8-inch diameter element set to the high setting after a 25-minute test resulted in no flaming ignition.

CG.5.8.M: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.5.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 10: Ignition Results of Ceramic-Glass Cooktop and Nylon Spatula

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.6.L	Nylon spatula	6”	Low	No Test	No	
CG.6.6.M	Nylon spatula	6”	Medium	15:00	No	
CG.6.6.H	Nylon spatula	6”	High	8:34	Yes	8:34
CG.6.8.L	Nylon spatula	8”	Low	No Test	No	
CG.6.8.M	Nylon spatula	8”	Medium	15:00	No	
CG.6.8.H	Nylon spatula	8”	High	15:00	No	

CG.6.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 8 minutes 34 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=249^{o}C, TC-2= 172^{o}C.

CG.6.6.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

CG.6.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.6.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the high setting after a 15-minute test resulted in no flaming ignition.

CG.6.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the high setting after a 15-minute test resulted in no flaming ignition.

CG.6.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 11: Ignition Results of Ceramic-Glass Cooktop and Toaster

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.6.L	Toaster	6”	Low	No test	No	
CG.7.6.M	Toaster	6”	Medium	20:00	No	
CG.7.6.H	Toaster	6”	High	2:49	Yes	2:49
CG.7.8.L	Toaster	8”	Low	No test	No	
CG.7.8.M	Toaster	8”	Medium	20:00	No	
CG.7.8.H	Toaster	8”	High	7:48	Yes	7:48

CG.7.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 49 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=67^{o}C, TC-1=131^{o}C TC-2= 309^{o}C.

CG.7.6.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

CG.7.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.7.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 7 minutes 48 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=336^{o}C, TC-1=209^{o}C TC-2=23^{o}C.

CG.7.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

CG.7.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 12: Ignition Results of Ceramic-Glass Cooktop and Food Storage Container

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.6.L	Food Storage Container (Polyethylene)	6”	Low	No test	No	
CG.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	No test	No	
CG.8.6.H	Food Storage Container (Polyethylene)	6”	High	6:30	No	
CG.8.8.L	Food Storage Container (Polyethylene)	8”	Low	No test	No	
CG.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	6:30	No	
CG.8.8.H	Food Storage Container (Polyethylene)	8”	High	7:00	No	

CG.8.6.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the high setting after a 6 minute and 30 second test resulted in no flaming ignition. The test was stopped when all the fuel was consumed.

CG.8.6.M: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting. The test was stopped when all the fuel was consumed.

CG.8.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

CG.8.8.H: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the high setting after a 7-minute test resulted in no flaming ignition. The test was stopped when all the fuel was consumed.

CG.8.8.M: The test conducted using the Electric Ceramic-Glass Cooktop Appliance with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the high setting after a 6 minute and 30 second test resulted in no flaming ignition.

CG.8.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

4.3 Electric Coil Cooktop Range Results: Selected Observations

This section provides tables (Tables 13-20) that summarize the results for each ignition test, including the general conditions for the individual fuels that were evaluated with the electric coil cooktop. Below each

table is a brief discussion regarding the selected observations witnessed during each test. The thermocouple data for each test can be found in Appendix D.

Table 13: Ignition Results of Coil Cooktop and Cardboard

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.6.L	Cardboard	6”	Low	25:00	No	
EC.1.6.M	Cardboard	6”	Medium	6:30	No	
EC.1.6.H	Cardboard	6”	High	1:39	Yes	1:39
EC.1.8.L	Cardboard	8”	Low	25:00	No	
EC.1.8.M	Cardboard	8”	Medium	4:32	Yes	4:32
EC.1.8.H	Cardboard	8”	High	1:24	Yes	1:24

EC.1.6.H: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 1 minutes 39 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=448^{o}C, TC-1=289^{o}C, TC-2=318^{o}C.

EC.1.6.M: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the medium setting after a 6 minute and 30 second test resulted in no flaming ignition. The test was stopped after corrugated paper fuel mass was consumed.

EC.1.6.L: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

EC.1.8.H: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8 inch diameter element set to the high setting, resulted in flaming ignition in 1 minutes 24 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=407^{o}C, TC-1=292^{o}C, TC-2=265^{o}C.

EC.1.8.M: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the medium setting, resulted in flaming ignition in 4 minutes 32 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=272^{o}C, TC-1=231^{o}C, TC-2=153^{o}C.

EC.1.8.L: The test conducted using the Electric Coil Cooktop Appliance with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 14: Ignition Results of Coil Cooktop and Dish Towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.6.L	Dish Towel	6”	Low	25:00	No	
EC.2.6.M	Dish Towel	6”	Medium	6:15	Yes	6:15
EC.2.6.H	Dish Towel	6”	High	1:52	Yes	1:52
EC.2.8.L	Dish Towel	8”	Low	25:00	No	
EC.2.8.M	Dish Towel	8”	Medium	5:32	Yes	5:32
EC.2.8.H	Dish Towel	8”	High	1:20	Yes	1:20

EC.2.6.H: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 52 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=377^{o}C, TC-1=315^{o}C, TC-2=363^{o}C.

EC.2.6.M: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the medium setting, resulted in flaming ignition in 6 minutes 15 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=62^{o}C, TC-1=187^{o}C, TC-2=159^{o}C.

EC.2.6.L: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

EC.2.8.H: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel), using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 20 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=359^{o}C, TC-1=111^{o}C, TC-2=150^{o}C.

EC.2.8.M: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel), using the 8-inch diameter element, set to the medium setting, resulted in flaming ignition in 5 minutes and 32 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=246^{o}C, TC-1=387^{o}C, TC-2=341^{o}C.

EC.2.8.L: The test conducted using the Electric Coil Cooktop Appliance with the cotton (dish towel) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 15: Ignition Results of Coil Cooktop and Paper Towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.6.L	Paper Towel	6”	Low	25:00	No	
EC.3.6.M	Paper Towel	6”	Medium	15:00	No	
EC.3.6.H	Paper Towel	6”	High	1:29	Yes	1:29
EC.3.8.L	Paper Towel	8”	Low	35:00	No	
EC.3.8.M	Paper Towel	8”	Medium	15:00	No	
EC.3.8.H	Paper Towel	8”	High	1:36	Yes	1:36

EC.3.6.H: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 29 seconds.

EC.3.6.M: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition. The test was stopped after paper fuel mass was consumed and temperatures began to decrease in thermocouples.

EC.3.6.L: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

EC.3.8.H: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 36 seconds.

EC.3.8.M: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 8-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition. The test was stopped after paper fuel mass was consumed and temperatures began to decrease in thermocouples.

EC.3.8.L: The test conducted using the Electric Coil Cooktop Appliance with the paper (paper towel) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 16: Ignition Results of Coil Cooktop and Canola Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.6.L	Canola Oil	6”	Low	No test	No	
EC.4.6.M	Canola Oil	6”	Medium	20:00	No	
EC.4.6.H	Canola Oil	6”	High	11:38	Yes	11:38
EC.4.8.L	Canola Oil	8”	Low	No Test	No	
EC.4.8.M	Canola Oil	8”	Medium	20:00	No	
EC.4.8.H	Canola Oil	8”	High	11:42	Yes	11:42

EC.4.6.H: The test conducted using the Electric Coil Cooktop Appliance with the canola oil using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 11 minute 38 seconds. At the time of

ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=287°C, TC-4=280°C, TC-25=284°C.

EC.4.6.M: The test conducted using the Electric Coil Cooktop Appliance with the canola oil using the 6-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

EC.4.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

EC.4.8.H: The test conducted using the Electric Coil Cooktop Appliance with the canola oil using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 11 minute 42 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=294°C, TC-4=304°C, TC-5=302°C.

EC.4.8.M: The test conducted using the Electric Coil Cooktop Appliance with the canola oil using the 8-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

EC.4.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 17: Ignition Results of Coil Cooktop and Vegetable Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.6.L	Vegetable Oil	6”	Low	No test	No	
EC.5.6.M	Vegetable Oil	6”	Medium	25:00	No	
EC.5.6.H	Vegetable Oil	6”	High	9:24	Yes	9:24
EC.5.8.L	Vegetable Oil	8”	Low	No test	No	
EC.5.8.M	Vegetable Oil	8”	Medium	25:00	No	
EC.5.8.H	Vegetable Oil	8”	High	9:58	Yes	9:58

EC.5.6.H: The test conducted using the Electric Coil Cooktop Appliance with the vegetable oil using the 6 inch diameter element set to the high setting, resulted in flaming ignition in 9 minute 24 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=215°C, TC-4=291°C, TC-5=290°C.

EC.5.6.M: The test conducted using the Electric Coil Cooktop Appliance with the vegetable oil using the 6-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

EC.5.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

EC.5.8.H: The test conducted using the Electric Coil Cooktop Appliance with the vegetable oil using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 9 minutes 58 seconds. At the time of

ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=295°C, TC-4=298°C, TC-5=301°C.

EC.5.8.M: The test conducted using the Electric Coil Cooktop Appliance with the vegetable oil using the 8-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

EC.5.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 18: Ignition Results of Coil Cooktop and Nylon Spatula

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.6.L	Nylon spatula	6”	Low	No Test	No	
EC.6.6.M	Nylon spatula	6”	Medium	15:00	No	
EC.6.6.H	Nylon spatula	6”	High	2:39	Yes	2:39
EC.6.8.L	Nylon spatula	8”	Low	No Test	No	
EC.6.8.M	Nylon spatula	8”	Medium	15:00	No	
EC.6.8.H	Nylon spatula	8”	High	2:07	Yes	2:07

EC.6.6.H: The test conducted using the Electric Coil Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 39 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=377°C, TC-2=192°C.

EC.6.6.M: The test conducted using the Electric Coil Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

EC.6.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

EC.6.8.H: The test conducted using the Electric Coil Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 7 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=103°C, TC-2=273°C.

EC.6.8.M: The test conducted using the Electric Coil Cooktop Appliance with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

EC.6.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 19: Ignition Results of Coil Cooktop and Toaster

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.6.L	Toaster	6”	Low	No test	No	
EC.7.6.M	Toaster	6”	Medium	15:00	No	
EC.7.6.H	Toaster	6”	High	2:30	Yes	2:30
EC.7.8.L	Toaster	8”	Low	No test	No	
EC.7.8.M	Toaster	8”	Medium	15:00	No	
EC.7.8.H	Toaster	8”	High	2:00	Yes	2:00

EC.7.6.H: The test conducted using the Electric Coil Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 30 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=232^{o}C, TC-1=474^{o}C TC-2= 474^{o}C.

EC.7.6.M: The test conducted using the Electric Coil Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

EC.7.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

EC.7.8.H: The test conducted using the Electric Coil Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 2 minutes 0 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=350^{o}C, TC-1=345^{o}C TC-2=339^{o}C.

EC.7.8.M: The test conducted using the Electric Coil Cooktop Appliance with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

EC.7.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 20: Ignition Results of Coil Cooktop and Food Storage Container

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.6.L	Food Storage Container (Polyethylene)	6”	Low	12:00	No	
EC.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	12:00	No	
EC.8.6.H	Food Storage Container (Polyethylene)	6”	High	3:05	Yes	3:05

EC.8.8.L	Food Storage Container (Polyethylene)	8”	Low	12:00	No	
EC.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	12:00	No	
EC.8.8.H	Food Storage Container (Polyethylene)	8”	High	1:36	Yes	1:36

EC.8.6.H: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 3 minutes 5 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=307^{o}C, TC-1=416^{o}C TC-2=314^{o}C.

EC.8.6.M: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the medium setting after a 12-minute test resulted in no flaming ignition. The test was stopped after the fuel’s mass was consumed and the temperature recorded by the thermocouples started to decrease.

EC.8.6.L: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the low setting after a 12-minute test resulted in no flaming ignition. Test resulted in minor melting to the bottom of polyethylene food storage container.

EC.8.8.H: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 36 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=201^{o}C, TC-1=180^{o}C TC-2=261^{o}C.

EC.8.8.M: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the medium setting after a 12-minute test resulted in no flaming ignition. The test was stopped after the fuel’s mass was consumed and the temperature recorded by the thermocouples started to decrease.

EC.8.8.L: The test conducted using the Electric Coil Cooktop Appliance with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the low setting after a 12-minute test resulted in no flaming ignition. Test resulted in minor melting to the bottom of polyethylene food storage container.

4.4 Electric Coil Cooktop Range with Safe-T-Element Results: Selected Observations

This section provides tables (Tables 21-28) that summarize the results for each ignition test, including the general conditions for the individual fuels that were evaluated with the electric coil cooktop range with the Safe-T-element installed. Below each table is a brief discussion regarding the selected observations witnessed during each test. The thermocouple data for each test can be found in Appendix E.

Table 21: Ignition Results of Safe-T-Element Cooktop and Cardboard

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.6.L	Cardboard	6”	Low	20:00	No	
ST.1.6.M	Cardboard	6”	Medium	15:00	Yes	15:00
ST.1.6.H	Cardboard	6”	High	9:25	Yes	9:25
ST.1.8.L	Cardboard	8”	Low	20:00	No	
ST.1.8.M	Cardboard	8”	Medium	20:30	Yes	20:30
ST.1.8.H	Cardboard	8”	High	5:10	Yes	5:10

ST.1.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 9 minutes 25 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=560^{o}C, TC-1=437^{o}C, TC-2=292^{o}C.

ST.1.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition. The test was stopped after the fuel’s mass was consumed and thermocouple measurements decreased.

ST.1.6.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

ST.1.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 5 minutes 10 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=500^{o}C, TC-1=346^{o}C, TC-2=376^{o}C.

ST.1.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition. The test was stopped after the fuel’s mass was consumed and thermocouple measurements decreased.

ST.1.8.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the corrugated paper (cardboard pizza box) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 22: Ignition Results of Safe-T-Element Cooktop and Dish Towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.6.L	Dish Towel	6”	Low	25:00	No	
ST.2.6.M	Dish Towel	6”	Medium	25:00	No	
ST.2.6.H	Dish Towel	6”	High	5:46	Yes	5:46
ST.2.8.L	Dish Towel	8”	Low	25:00	No	
ST.2.8.M	Dish Towel	8”	Medium	25:00	No	
ST.2.8.H	Dish Towel	8”	High	6:55	Yes	6:55

ST.2.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 1 minute 52 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=360^{o}C, TC-1=372^{o}C, TC-2=330^{o}C.

ST.2.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel) using the 6-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.2.6.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

ST.2.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel), using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 6 minutes 55 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=500^{o}C, TC-1=371^{o}C, TC-2=354^{o}C.

ST.2.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel) using the 8-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.2.8.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the cotton (dish towel) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 23: Ignition Results of Safe-T-Element Cooktop and Paper Towel

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.6.L	Paper Towel	6”	Low	25:00	No	
ST.3.6.M	Paper Towel	6”	Medium	25:00	No	
ST.3.6.H	Paper Towel	6”	High	6:04	Yes	6:04
ST.3.8.L	Paper Towel	8”	Low	25:00	No	
ST.3.8.M	Paper Towel	8”	Medium	25:00	No	
ST.3.8.H	Paper Towel	8”	High	5:20	Yes	5:20

ST.3.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel), using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 6 minutes 4 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=535^{o}C, TC-1=374^{o}C, TC-2=27^{o}C. The low temperature recoded by TC-2 is most likely due to the fuel being consumed at this location prior to ignition.

ST.3.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel) using the 6-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition. The test was stopped after the bottom portion of the fuel’s mass was consumed and temperatures began to decrease.

ST.3.6.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel) using the 6-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

ST.3.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel), using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 5 minutes 20 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=554^{o}C, TC-1=417^{o}C, TC-2=203^{o}C.

ST.3.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel) using the 8-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition. The test was stopped after the bottom portion of the fuel’s mass was consumed and temperatures began to decrease.

ST.3.8.L: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the paper (paper towel) using the 8-inch diameter element set to the low setting after a 25-minute test resulted in no flaming ignition.

Table 24: Ignition Results of Safe-T-Element Cooktop and Canola Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.6.L	Canola Oil	6”	Low	No test	No	
ST.4.6.M	Canola Oil	6”	Medium	20:00	No	
ST.4.6.H	Canola Oil	6”	High	18:54	Yes	18:54
ST.4.8.L	Canola Oil	8”	Low	No test	No	
ST.4.8.M	Canola Oil	8”	Medium	20:00	No	
ST.4.8.H	Canola Oil	8”	High	17:54	Yes	17:54

ST.4.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the canola oil using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 18 minutes 54 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=300^{o}C, TC-4=301^{o}C, TC-5=303^{o}C.

ST.4.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the canola oil using the 6-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

ST.4.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

ST.4.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the canola oil using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 16 minutes 54 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-5=435^{o}C, TC-6=321^{o}C, TC-7=315^{o}C.

ST.4.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the canola oil using the 8-inch diameter element set to the medium setting after a 20-minute test resulted in no flaming ignition.

ST.4.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 25: Ignition Results of Safe-T-Element Cooktop and Vegetable Oil

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.6.L	Vegetable Oil	6”	Low	No test	No	
ST.5.6.M	Vegetable Oil	6”	Medium	25:00	No	
ST.5.6.H	Vegetable Oil	6”	High	22:00	Yes	22:00
ST.5.8.L	Vegetable Oil	8”	Low	No test	No	
ST.5.8.M	Vegetable Oil	8”	Medium	25:00	No	
ST.5.8.H	Vegetable Oil	8”	High	9:30	Yes	9:30

ST.5.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the vegetable oil using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 22 minute 0 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=335^{o}C, TC-4=320^{o}C, TC-5=305^{o}C.

ST.5.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the vegetable oil using the 6-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.5.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

ST.5.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the vegetable oil using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 9 minutes 30 seconds. At the time of ignition, the thermocouples located in the fuel recorded the following temperatures: TC-3=295^{o}C, TC-4=297^{o}C, TC-5=305^{o}C

ST.5.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the vegetable oil using the 8-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.5.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 26: Ignition Results of Safe-T-Element Cooktop and Nylon Spatula

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Ignition temp (^{o}C)	Time to Ignition (min:sec)
ST.6.6.L	Nylon spatula	6”	Low	No Test	No		
ST.6.6.M	Nylon spatula	6”	Medium	15:00	No		
ST.6.6.H	Nylon spatula	6”	High	4:45	Yes		4:45
ST.6.8.L	Nylon spatula	8”	Low	No Test	No		
ST.6.8.M	Nylon spatula	8”	Medium	15:00	No		
ST.6.8.H	Nylon spatula	8”	High	7:55	Yes		7:55

ST.6.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 4 minutes 45 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=366^{o}C, TC-2=217^{o}C.

ST.6.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the nylon (short turner spatula-cooking utensil) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

ST.6.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

ST.6.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 7 minutes 45 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=544^{o}C, TC-2=350^{o}C.

ST.6.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the nylon (short turner spatula-cooking utensil) using the 8-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition.

ST.6.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 27: Ignition Results of Safe-T-Element Cooktop and Toaster

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.6.L	Toaster	6”	Low	No test	No	
ST.7.6.M	Toaster	6”	Medium	25:00	No	
ST.7.6.H	Toaster	6”	High	6:20	Yes	6:20
ST.7.8.L	Toaster	8”	Low	No test	No	
ST.7.8.M	Toaster	8”	Medium	25:00	No	
ST.7.8.H	Toaster	8”	High	5:20	Yes	5:20

ST.7.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 6 minutes 20 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=306^{o}C, TC-1=68^{o}C TC-2= 197^{o}C.

ST.7.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the polypropylene (toaster-kitchen appliance) using the 6-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.7.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

ST.7.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 5 minutes 20 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=96^{o}C, TC-1=194^{o}C TC-2=203^{o}C.

ST.7.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with the polypropylene (toaster-kitchen appliance) using the 8-inch diameter element set to the medium setting after a 25-minute test resulted in no flaming ignition.

ST.7.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

Table 28: Ignition Results of Safe-T-Element Cooktop and Food Storage Container

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.6.L	Food Storage Container (Polyethylene)	6”	Low	No test	No	
ST.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	20:00	No	
ST.8.6.H	Food Storage Container (Polyethylene)	6”	High	6:26	Yes	6:26
ST.8.8.L	Food Storage Container (Polyethylene)	8”	Low	No test	No	
ST.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	6:30	No	
ST.8.8.H	Food Storage Container (Polyethylene)	8”	High	5:40	Yes	5:40

ST.8.6.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the high setting, resulted in flaming ignition in 6 minutes 26 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=358^{o}C, TC-1=369^{o}C TC-2=211^{o}C.

ST.8.6.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with Polyethylene (Food Storage Container) using the 6-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition. The test was stopped after the fuel mass was consumed and the temperature recorded by the thermocouples decreased.

ST.8.6.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

ST.8.8.H: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the high setting, resulted in flaming ignition in 5 minute 40 seconds. At the time of ignition, the thermocouples located between the element and the fuel recorded the following temperatures: TC-0=411^{o}C, TC-1=378^{o}C TC-2=350^{o}C.

ST.8.8.M: The test conducted using the Electric Coil Cooktop Appliance and the Safe-T Element with Polyethylene (Food Storage Container) using the 8-inch diameter element set to the medium setting after a 15-minute test resulted in no flaming ignition. The test was stopped after the fuel mass was consumed and the temperature recorded by the thermocouples decreased.

ST.8.8.L: No test conducted. The test was not conducted because the fuel did not show the potential of ignition on the next higher setting.

5.0 Discussion and Conclusions

The maximum temperatures were achieved with the 8-inch diameter heating element on the electric coil cooktop. The variation in maximum temperature of the 8-inch heating elements had much to do with the 600 wattage output differences between the two different cooktop types. Despite the differences in output, the electric coil cooktop 8-inch diameter heating element achieved temperatures 14% greater than that of the ceramic-glass cooktop. The more significant finding was that the Safe-T-element, which was installed over the electric coil cooktop, had a 7% decrease in maximum temperatures achieved with the 8-inch diameter heating element and a 14% decrease in maximum temperatures achieved with the 6-inch diameter as compared to the electric coil cooktop. The rate of temperature rise was found to be slowest with the Safe-T-Element, reaching its maximum temperatures 8-13 minutes slower than its ceramic-glass and electric coil counterparts.

A summary of the ignition results can be found in Table 29. The high thermostat setting for all three cooktop types tested at both the 6-inch and 8-inch diameter heating element resulted in the ignition of 41 of 48 tests (85%). Table 29 quickly illustrates, as logic would, that the potential for ignition is greatest when the cooktop is set to the high thermostat setting. 100% of the fuels tested were ignited by the electric coil and Safe-T-element cooktops, while only 56.25% of the fuels were ignited by the ceramic-glass cooktop. Although not all fuels ignited at the high thermostat setting, it was noted that the potential for ignition was possible due to the quick consumption of mass, smoldering combustion (cellulosic fuels), and increased volume of vaporization/pyrolysis products. The high setting for all three cooktop types showed the maximum potential for ignition based on the total heat output produced by the 6-inch diameter and 8-inch diameter heating elements.

The medium setting for all three cooktop types for both diameter heating elements resulted in few flaming combustion of the fuels. 37.5% of the fuels tested on the ceramic-glass cooktop ignited at the medium setting, while only 18.75% and 6.25% of fuels ignited on the electric coil and Safe-T-element cooktops respectively. Although only select fuels ignited on the different electric range types tested, it was noted that a majority of the fuels did demonstrate the potential of reaching flaming combustion through evidence of

smoldering combustion and significant loss of mass. The medium setting for all three ranges demonstrated moderate potential for ignition based on the total heat output produced by the 6-inch diameter and 8 inch diameter heating elements.

The low setting for all three cooktop types tested for both the 6-inch and the 8-inch diameter heating element resulted in no flaming ignition. All tests conducted using the three different electric range types for both the 6-inch and 8-inch diameter heating elements demonstrated no potential for ignition of any of the fuels tested. Based on the research conducted it can be concluded that the low setting for all three electric range types has minor-to-no potential for ignition of the fuels tested.

In total, the electric coil cooktop resulted in ignition 39.5% of the time, Safe-T-element 35.4% of the time, and ceramic-glass cooktop resulted in ignition 31.25% of the time. Therefore, it can be concluded from these tests that all of the cooktops were similar in ignition competency for the provided fuels, even Safe-T-element.

It is found that when ignition did occur in similar fuels on different cooktops, that the Safe-T-element cooktop provided more time before the fuel would ignite. This is consistent with the finding that the Safe-T-element had a slower rate of temperature rise. When evaluating the time to ignition, the percentage of difference was determined between the time to ignition between the Safe-T element and the electric coil cooktop, as well as between the Safe-T-element and the ceramic-glass cooktop. The Safe-T-element cooktop had an average increase in time to ignition of 94% (almost double the time to ignition) when comparing the 8-inch diameter element of the electric coil. A similar average increase to time of ignition (87% increase) was found between the 6-inch elements of the Safe-T-element and the electric coil. An average increase in time to ignition (~53%) was also found between the ceramic-glass and Safe-T-element for both 6-inch and 8-inch diameter elements.

Table 29: Summary of Ignition Results (Y=Yes, N=No for Ignition)

		Cardboard		Dish Towel		Paper Towel		Canola Oil		Vegetable Oil		Nylon Spatula		Toaster		Food Storage Container	
	Diameter	6”	8”	6”	8”	6”	8”	6”	8”	6”	8”	6”	8”	6”	8”	6”	8”
Ceramic-Glass	*High*	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	N	Y	Y	N	N
	Medium	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N
	Low	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Coil	*High*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Medium	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
	Low	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Safe-T-element	*High*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Medium	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Low	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

5.1 Future Testing

Further research in this area would enhance the knowledge of these findings and further develop the understanding of how kitchen ranges provide an ignition source to common household kitchen items. Due to the number of materials tested on the three different electric range types, no tests were conducted multiple times. Conducting multiple tests would further validate the findings. In addition, further testing needs to be conducted on the fuels identified relating to their orientation and placement of the fuels on the heating elements. The tests conducted here only evaluated one orientation of the fuel on the heating element. Additional tests need to be conducted to establish if a change in orientation of fuel results in different findings.

6.0 Acknowledgements

The authors and Eastern Kentucky University would like to thank the following contributors for their assistance with this project: Pioneering Technology provided the Safe-T-elements and training on their product, Professor Jeff Kimble (University of North Carolina Charlotte) for his assistance with the cone calorimeter, Andrew Barnott (undergraduate student at EKU) for his assistance with the tests and preparing much of the test data, Tom Lancaster (Graduate of EKU) for most of the diagrams and illustrations found within this report, Associate Professor Andrew Tinsley (EKU) for review of manuscript, Daniel Madrzykowski, and the Institute of Fire Engineers (IFE-USA) and Vision 20/20 for funding this project.

7.0 References

Ahrens, M. (2011). *Home Fires Involving Cooking Equipment.* NFPA: Quincy, MA.

ASTM E459-05 (2011). *Standard Test Method for Measuring Heat Transfer Rate Using a Thin-Skin Calorimeter.* ASTM International: West Conshohocken, PA.

Alston, J. (2004). *Room/Corner Fire Calibration Data: Marine Composite Screening Specimens.* Masters thesis, Worcester Polytechnic Institute: Worcester, MA.

Babrauskas, V. (2003). *Ignition Handbook.* Fire Science Publishers: Issaquah, WA.

Buda-Ortins, K., and Sunderland, P. (2010). *Auto-Ignition of Cooking Oils*. Department of Fire Protection Engineering. University of Maryland: College Park, MD.

FEMA (2005). *Structure Cooking Fire: Volume 5, Issue 6.* FEMA/USFA: Emmitsburg, MD. Retrieved June 20, 2012, from: http://www.usfa.fema.gov/downloads/pdf/statistics/v5i6.pdf

Fire Findings (1997). *Kitchen Fire: Electric Range Tests Produce Results Similar to 1993 Gas Range Experiment.* Volume 5, No. 3. Fire Findings: Benton Harbor, MI.

Fire Findings (2000). *New Range's Coils Heat Faster and Hotter.* Volume 8, No.2. Fire Findings: Benton Harbor, MI.

Karter, M. (2011). *Fire Loss in the U.S. During 2010.* NFPA: Quincy, MA.

Mowrer, F. (2003). *Ignition Characteristics of Various Fire Indicators Subjected to Radiant Heat Fluxes.* Fire and Materials, Interscience: San Francisco, CA.

Ohlemiller, T., and Villa, K. (1991). *Material Flammability Test Assessment for the Space Station Freedom,* Technical Report NISTIR 4591, National Institute of Standards and Technology: Gaithersburg, MD.

OnSpex Consumer Product Evaluation, "Cooking Performance Comparison," Tech. Report Number 30013030, Canadian Standards Association, February 2010.

Pioneering Technology. (2012). Safe-T-Element Product Brochure. Retrieved June 20, 2012, from: *http://www.pioneeringtech.com/sites/default/files/STE-sellsheet-web%20%281%29.pdf*

Underwriters Laboratories Inc., "Safe-T-element Special Investigation on Safe-T-Element," January 2005.

Appendix A – Specifications of Electric Ranges

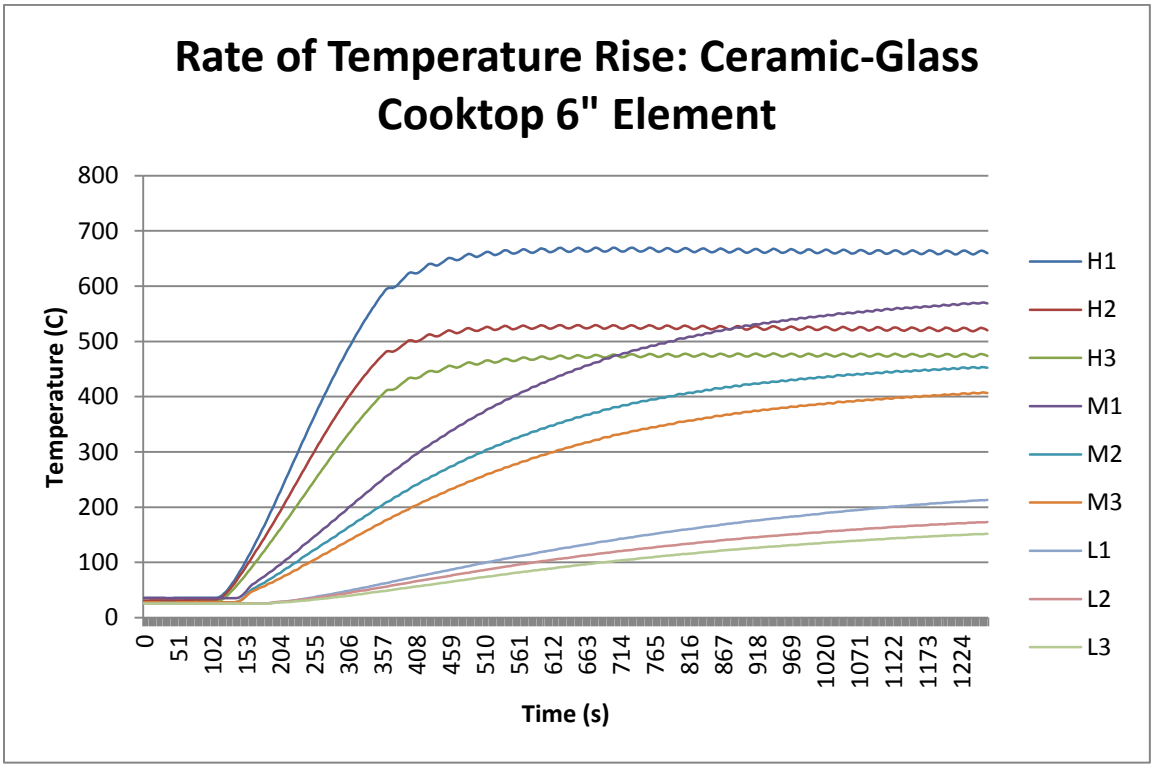
Specifications for the Electric Coil Cooktop Range: GE JBP23DRWW

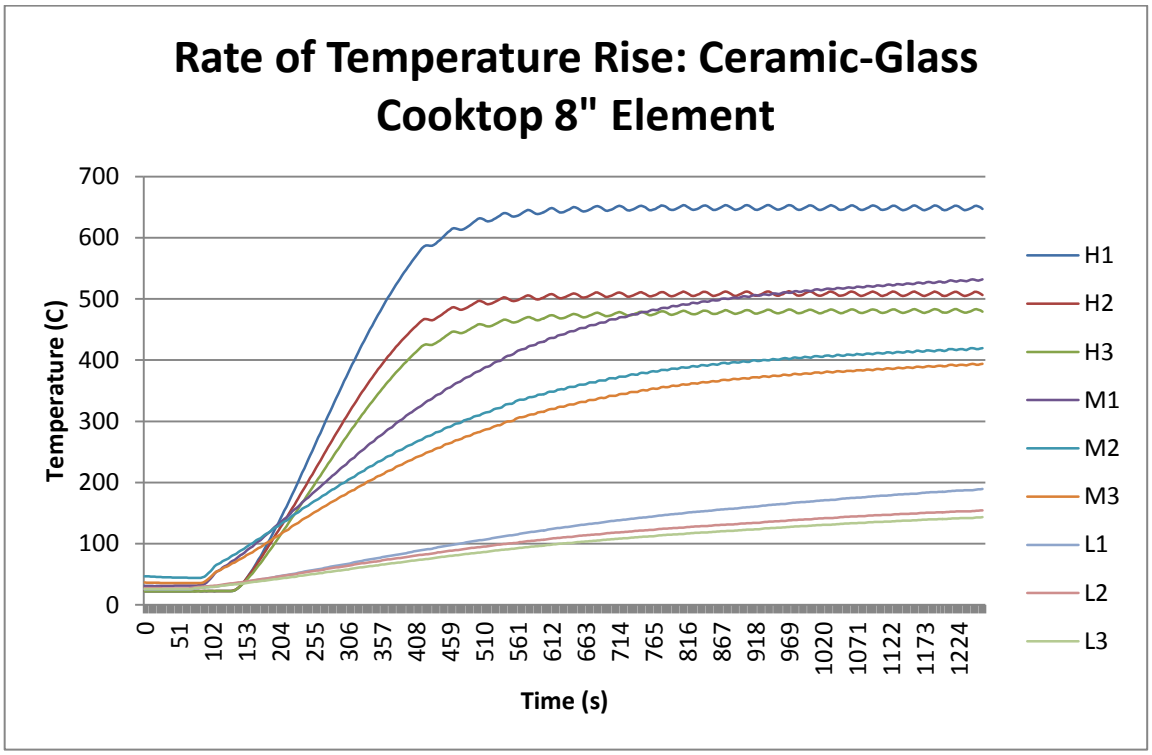
ADA Compliant	No	**ANSI Certified**	Yes
Amperage (amp)	40.0	**Appliance Thermostat**	Electro-Mechanical
Assembled Depth (in.)	27.75 in	**Assembled Height (in.)**	46.88 in
Assembled Width (in.)	29.88 in	**Baby UPC**	084691230052
Broiler Location	Oven	**Broiler Watt Range**	2480-3410
CASE DEPTH (In decimal format)	30.2	**CSA Listed**	No
Capacity of Oven (cu. ft.)	5.3	**Cleaning Type**	Self Cleaning
Clock	Yes	**Color of Cooktop**	White
Color/Finish	White	**Color/Finish Family**	White
Control Lockout	No	**Control Type**	Electronic
Convection	No	**Convection Type**	None
Cooktop Surface Type	Coil	**Cut-Out Depth (in.)**	27.75 in
Cut-Out Height (in.)	46.88 in	**Cut-Out Width (in.)**	29.88 in
Delay Bake Option (Time Bake)	Yes	**Digital Display**	Yes
Downdraft Exhaust	No	**ETL Listed**	No
ETL Safety Listed	No	**Element No.1 Size (In.)**	8.0
Element No.1 Type	Coil	**Element No.1 Wattage**	2600
Element No.2 Size (In.)	8.0	**Element No.2 Type**	Coil
Element No.2 Wattage	2600	**Element No.3 Size (In.)**	6.0
Element No.3 Type	Coil	**Element No.3 Wattage**	1500
Element No.4 Size (In.)	6.0	**Element No.4 Type**	Coil
Element No.4 Wattage	1500	**Energy Star Compliant**	No
ExcludedSellToStates	Ontario	**Food Temperature Probe**	No
Fuel Type	Electric	**Griddle**	No
Heating Element On Indicator Light	Yes	**Hidden Bake Element**	No
Hot Surface Indicator Light	No	**Item Package Type**	Cardboard Container
Item Package UOM	Pieces	**Manufacturer Warranty**	Limited 1-year entire appliance
NSF Listed	No	**Number of Elements**	4
Number of Glide/Rollout Racks	2	**Oven Light**	Yes
Oven Racks	2	**Oven Window**	Yes
Pan Presence Sensor	No	**Pan Size Sensor**	No
Power Cord Included	No	**Product Depth (in.)**	27.75 in
Product Height (in.)	46.88 in	**Product Weight (lb.)**	149 lb
Product Width (in.)	29.88 in	**Proofing Mode**	No
Range Type	Freestanding	**Returnable**	Non-Returnable
Sabbath Mode	Yes	**Self-Cleaning**	Yes
Sell Pack (Baby)	1	**Specific Color**	White
Surface Material	Other	**Voltage (volts)**	240.0 V
Warming Drawer	No		

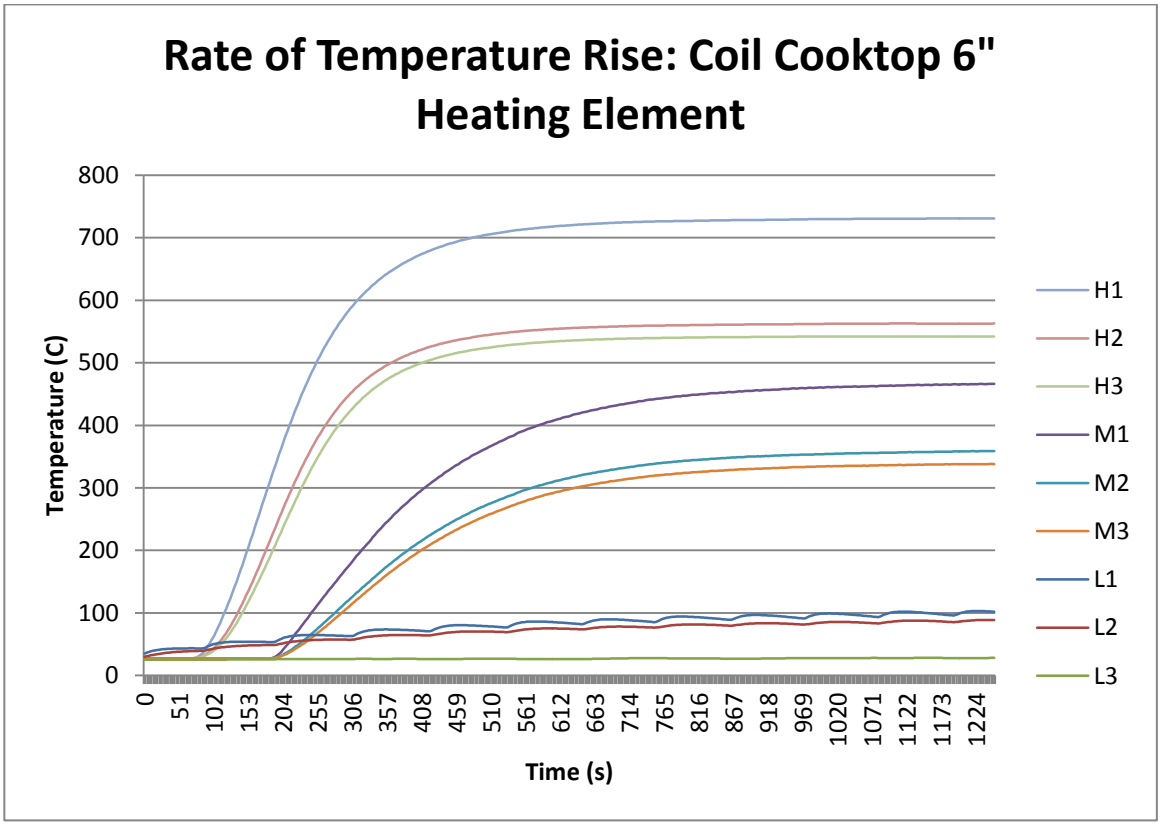
Specifications for the Electric Ceramic-Glass Cooktop Range: GE JBS55DMWW

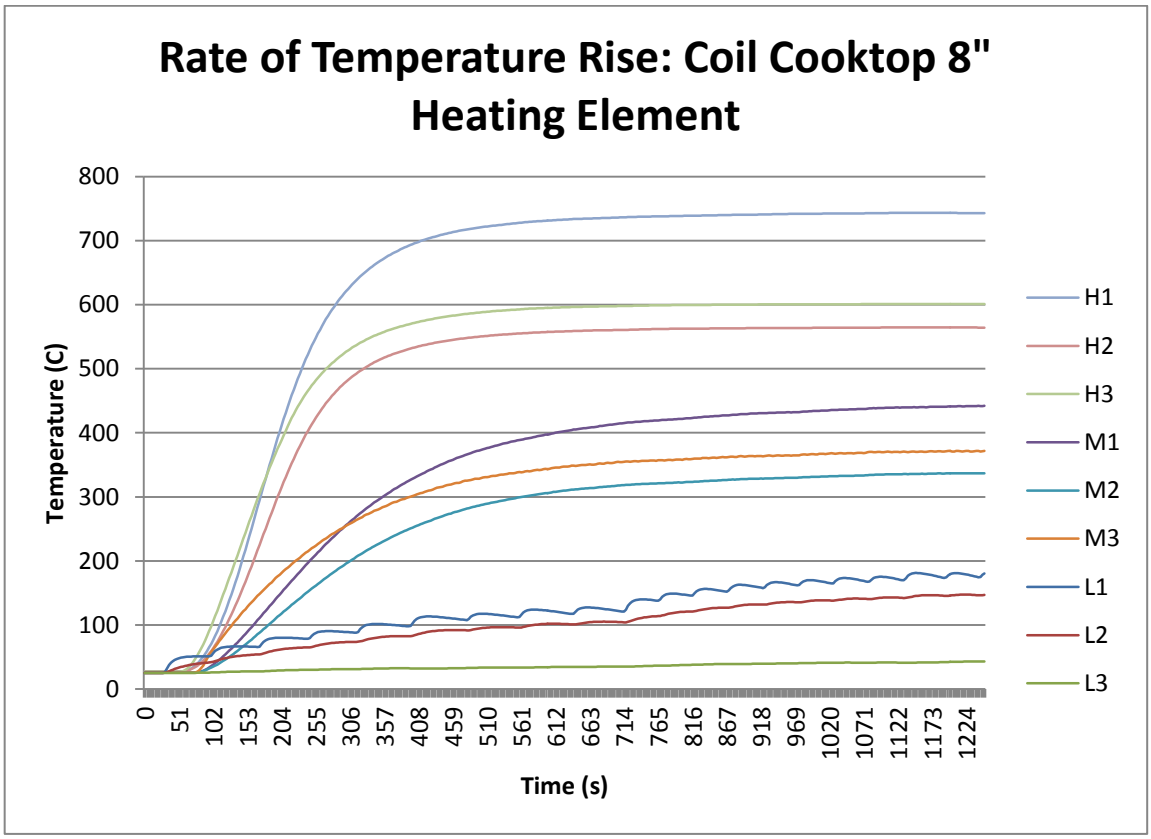
ADA Compliant	No	**ANSI Certified**	No
Amperage (amp)	40.0	**Assembled Depth (in.)**	27.75 in
Assembled Height (in.)	46.88 in	**Assembled Width (in.)**	29.88 in
Broiler Location	Oven	**Broiler Watt Range**	3410
CSA Listed	No	**Capacity of Oven (cu. ft.)**	5.3
Cleaning Type	Manual Clean	**Clock**	Yes
Color of Cooktop	White	**Color/Finish**	White
Color/Finish Family	White	**Control Lockout**	No
Control Type	Electro-Mechanical	**Convection**	No
Convection Type	None	**Cooktop Surface Type**	Smooth Surface
Cut-Out Depth (in.)	27.75 in	**Cut-Out Height (in.)**	46.88 in
Cut-Out Width (in.)	29.88 in	**Delay Bake Option (Time Bake)**	No
Digital Display	Yes	**Downdraft Exhaust**	No
ETL Listed	No	**ETL Safety Listed**	No
Element No.1 Size (In.)	8.0	**Element No.1 Type**	Radiant
Element No.1 Wattage	2000	**Element No.2 Size (In.)**	8.0
Element No.2 Type	Radiant	**Element No.2 Wattage**	2000
Element No.3 Size (In.)	6.0	**Element No.3 Type**	Radiant
Element No.3 Wattage	1500	**Element No.4 Size (In.)**	6.0
Element No.4 Type	Radiant	**Element No.4 Wattage**	1500
Energy Star Compliant	No	**Food Temperature Probe**	No
Fuel Type	Electric	**Griddle**	No
Heating Element On Indicator Light	Yes	**Hidden Bake Element**	No
Hot Surface Indicator Light	Yes	**Item Package Type**	Cardboard Container
Manufacturer Warranty	Limited 1-year entire appliance	**NSF Listed**	No
Number of Elements	4	**Number of Glide/Rollout Racks**	2
Oven Light	Yes	**Oven Racks**	2
Oven Window	Yes	**Pan Presence Sensor**	No
Pan Size Sensor	No	**Power Cord Included**	No
Product Depth (in.)	27.75 in	**Product Height (in.)**	46.88 in
Product Weight (lb.)	141 lb	**Product Width (in.)**	29.88 in
Proofing Mode	No	**Range Type**	Freestanding
Returnable	Non-Returnable	**Sabbath Mode**	Yes
Self-Cleaning	No	**Specific Color**	White
Voltage (volts)	240.0 V	**Warming Drawer**	No

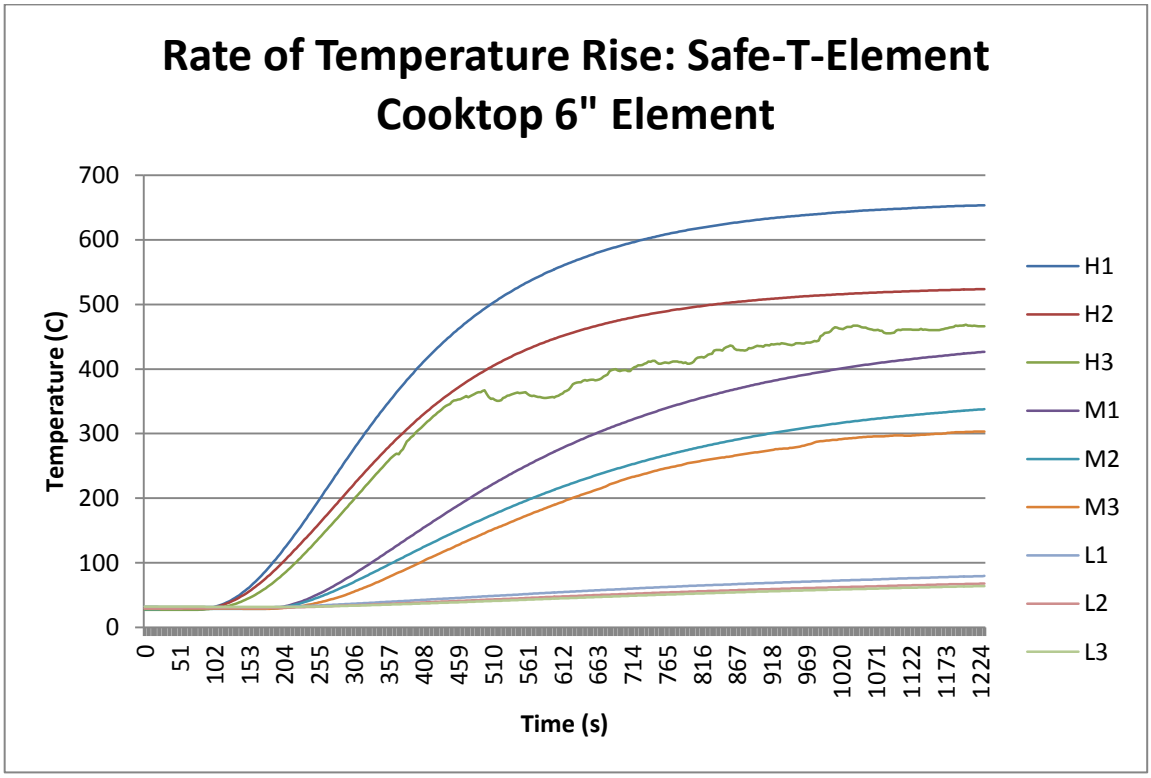
Appendix B – Rate of Temperature Rise Results

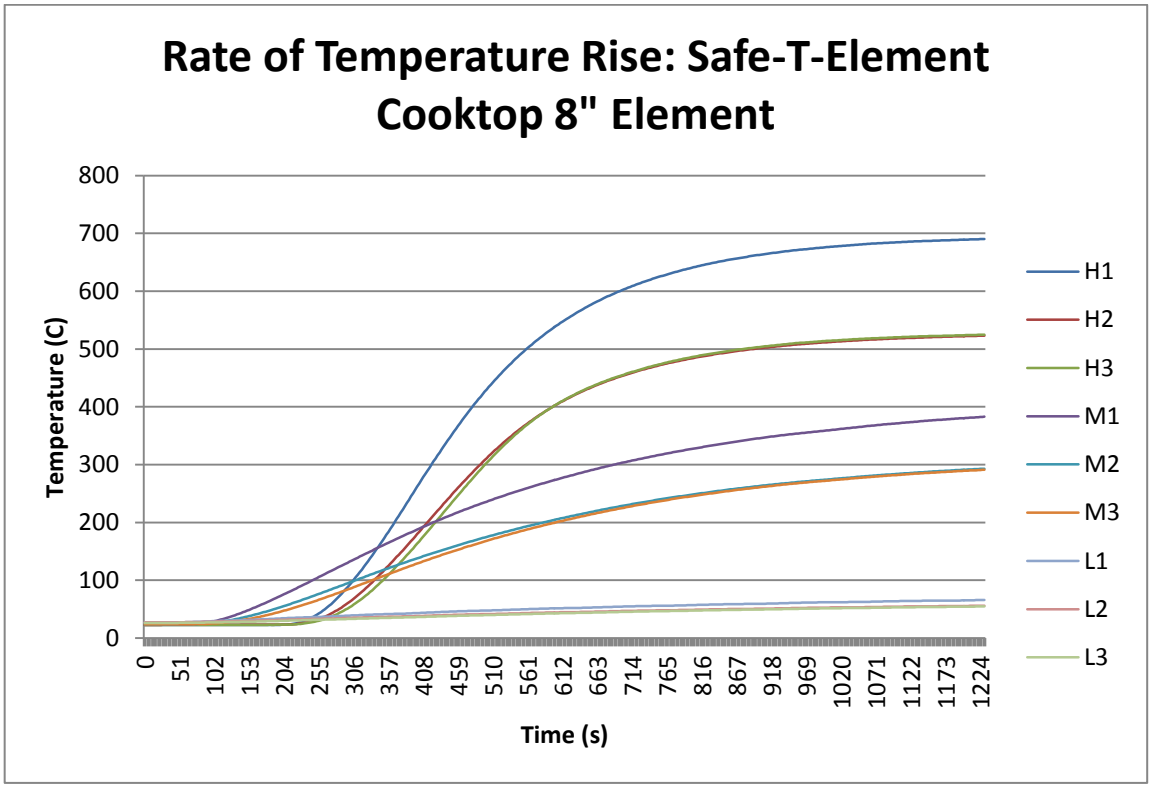


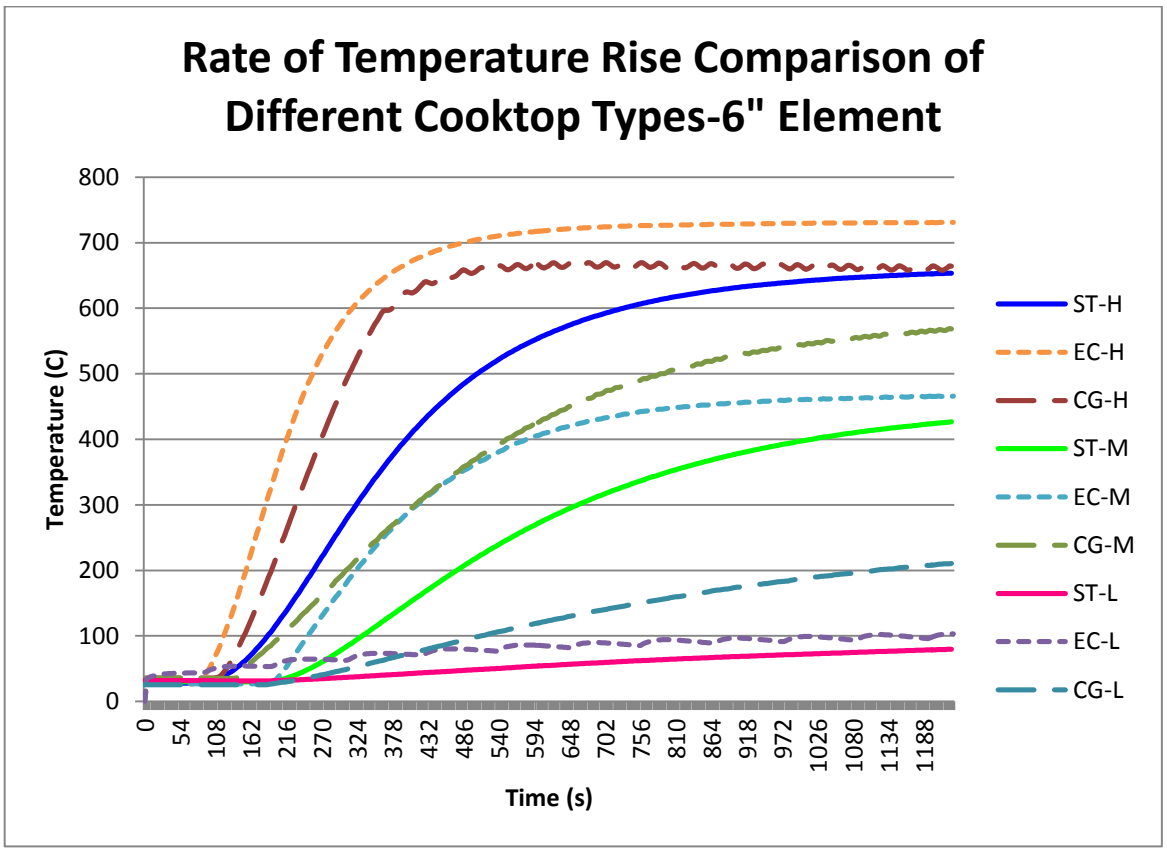


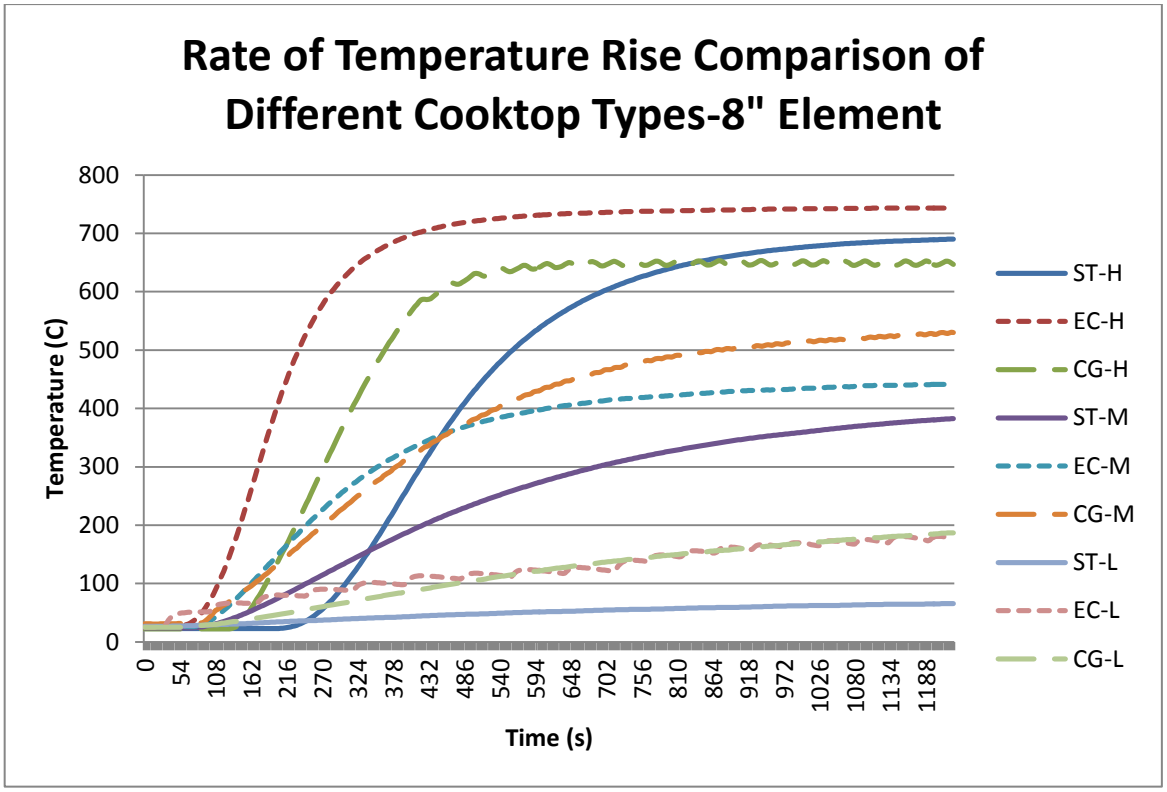

Rate of Temperature Rise: Coil Cooktop 6" Heating Element
Temperature (C)
800
700
600
500
400
300
200
100
0
0
51
102
153
204
255
306
357
408
459
510
561
612
663
714
765
816
867
918
969
1020
1071
1122
1173
1224
Time (s)
H1
H2
H3
M1
M2
M3
L1
L2
L3


Rate of Temperature Rise: Coil Cooktop 8" Heating Element
Temperature (C)
800
700
600
500
400
300
200
100
0
0
51
102
153
204
255
306
357
408
459
510
561
612
663
714
765
816
867
918
969
1020
1071
1122
1173
1224
Time (s)
H1
H2
H3
M1
M2
M3
L1
L2
L3


Rate of Temperature Rise: Safe-T-Element Cooktop 6" Element
Temperature (C)
700
600
500
400
300
200
100
0
0
51
102
153
204
255
306
357
408
459
510
561
612
663
714
765
816
867
918
969
1020
1071
1122
1173
1224
Time (s)
H1
H2
H3
M1
M2
M3
L1
L2
L3

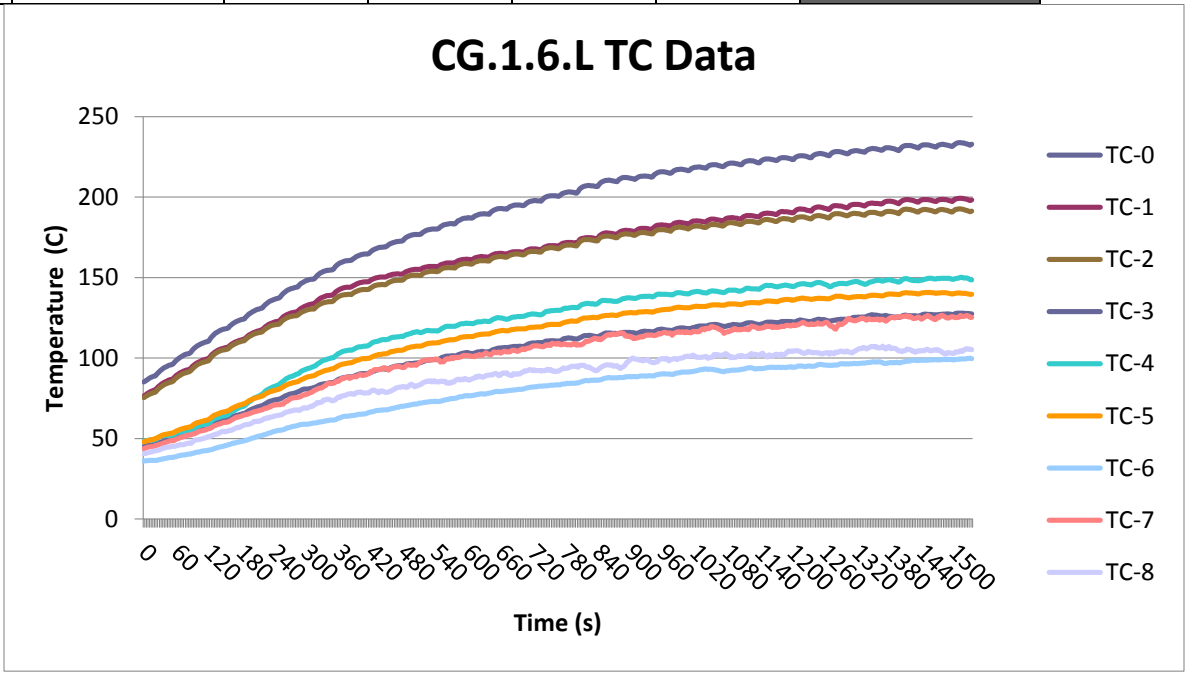

Rate of Temperature Rise: Safe-T-Element Cooktop 8" Element
Temperature (C)
800
700
600
500
400
300
200
100
0
0
51
102
153
204
255
306
357
408
459
510
561
612
663
714
765
816
867
918
969
1020
1071
1122
1173
1224
Time (s)
H1
H2
H3
M1
M2
M3
L1
L2
L3


Rate of Temperature Rise Comparison of Different Cooktop Types-6" Element
Temperature (C)
800
700
600
500
400
300
200
100
0
0
54
108
162
216
270
324
378
432
486
540
594
648
702
756
810
864
918
972
1026
1080
1134
1188
Time (s)
ST-H
EC-H
CG-H
ST-M
EC-M
CG-M
ST-L
EC-L
CG-L

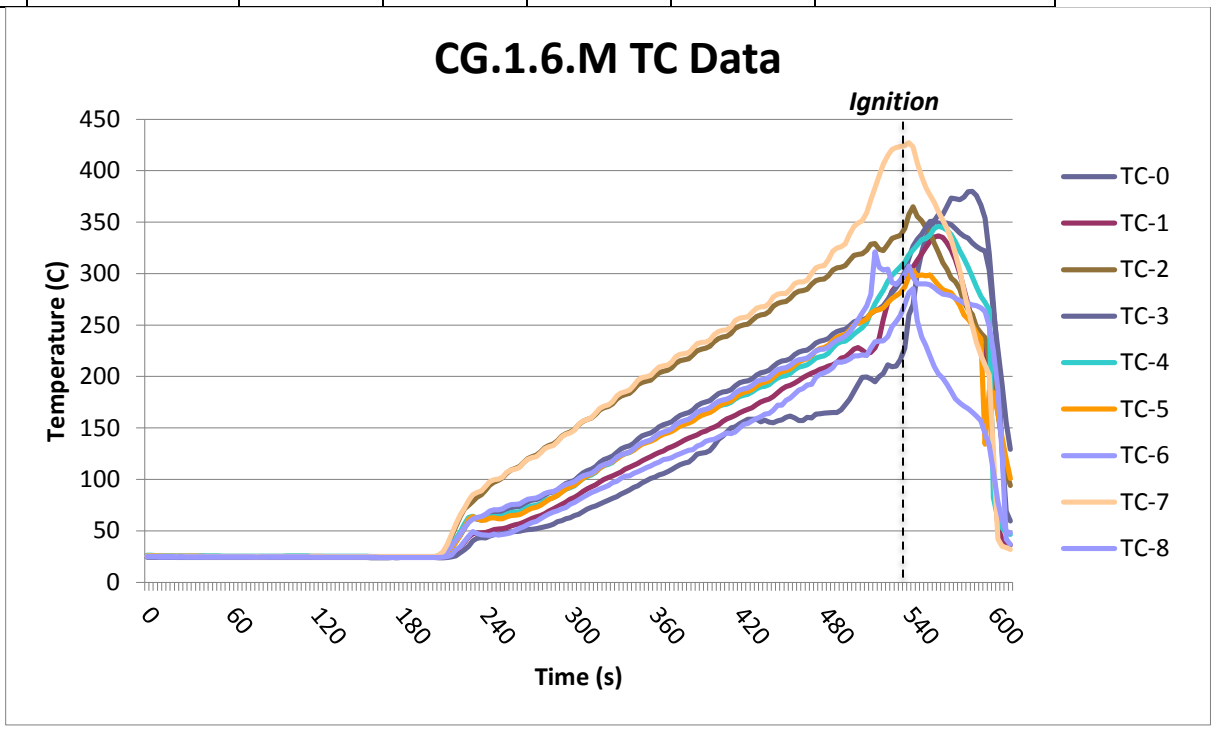

Rate of Temperature Rise Comparison of Different Cooktop Types-8" Element
Temperature (C)
800
700
600
500
400
300
200
100
0
0
54
108
162
216
270
324
378
432
486
540
594
648
702
756
810
864
918
972
1026
1080
1134
1188
Time (s)
ST-H
EC-H
CG-H
ST-M
EC-M
CG-M
ST-L
EC-L
CG-L

Appendix C – Ceramic-Glass Cooktop Range Results

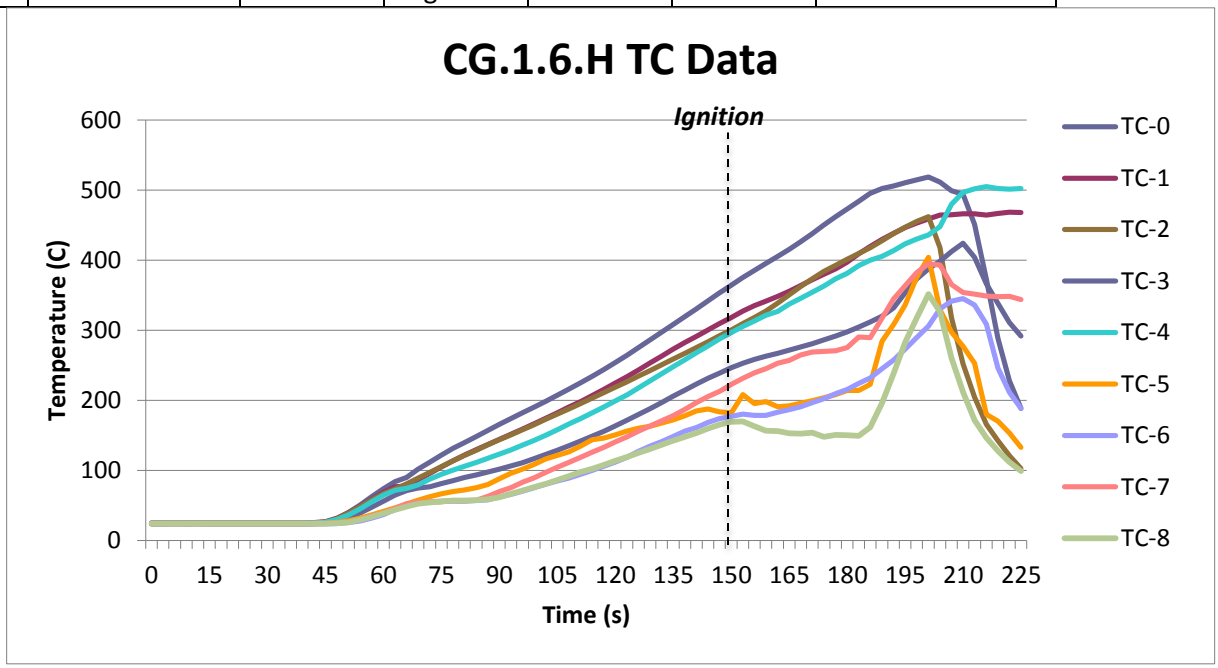
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.6.L	Cardboard	6”	Low	25:00	No	



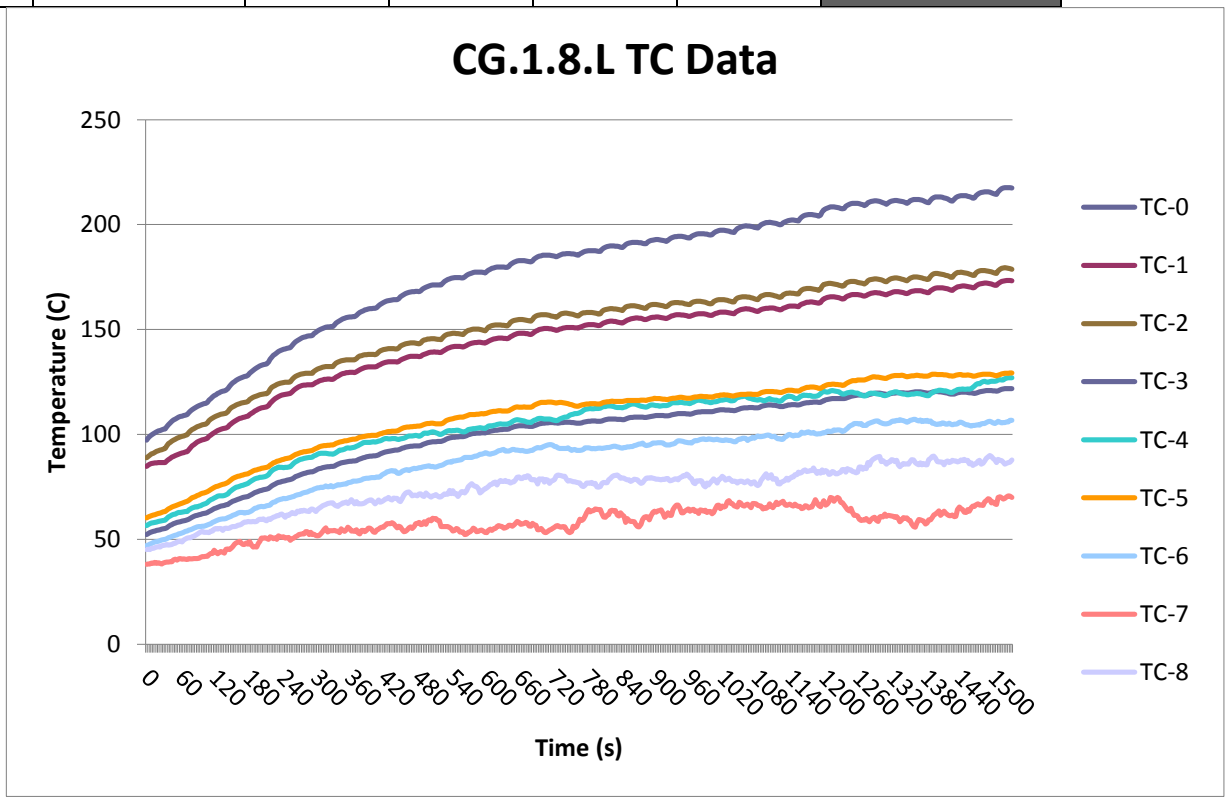
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.6.M	Cardboard	6”	Medium	9:00	Yes	9:00



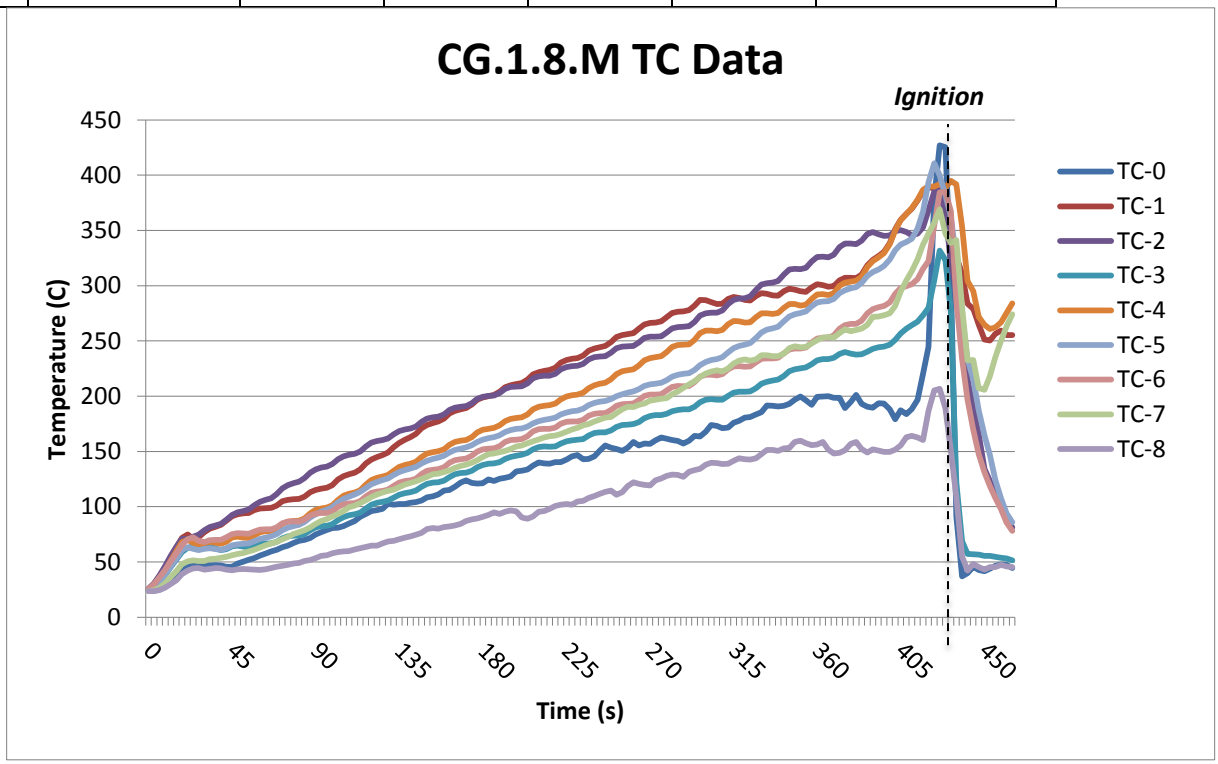
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.6.H	Cardboard	6”	High	2:30	Yes	2:30



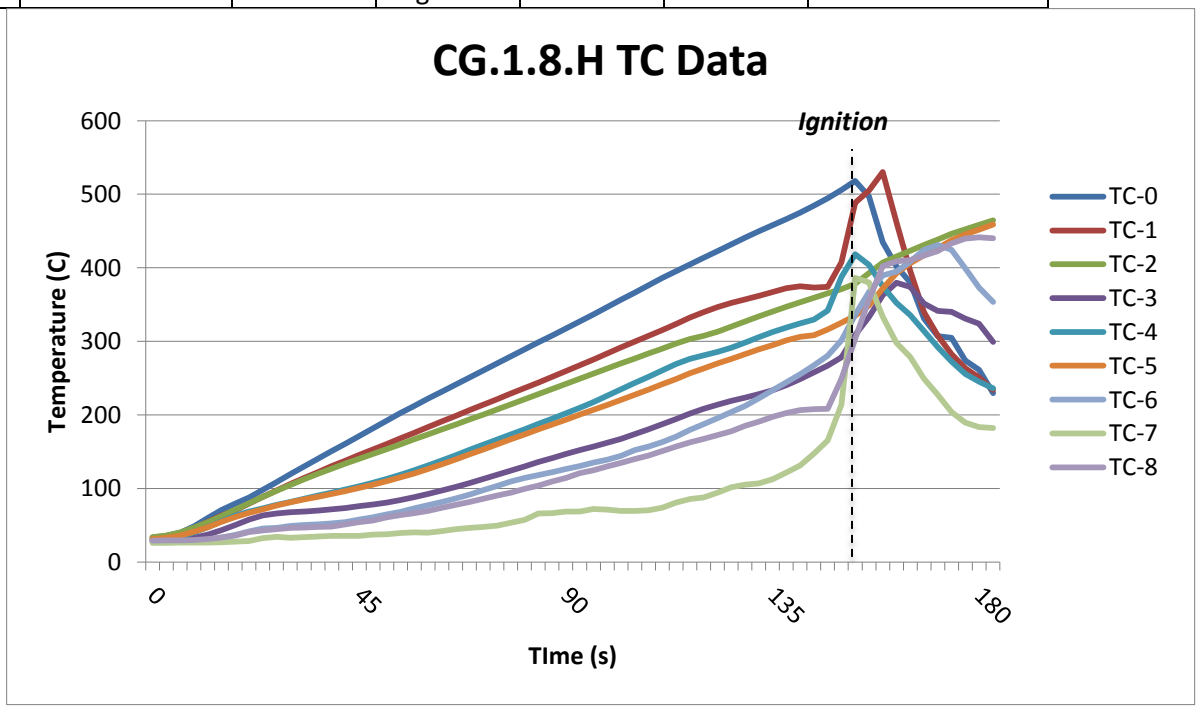
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.8.L	Cardboard	8”	Low	25:00	No	



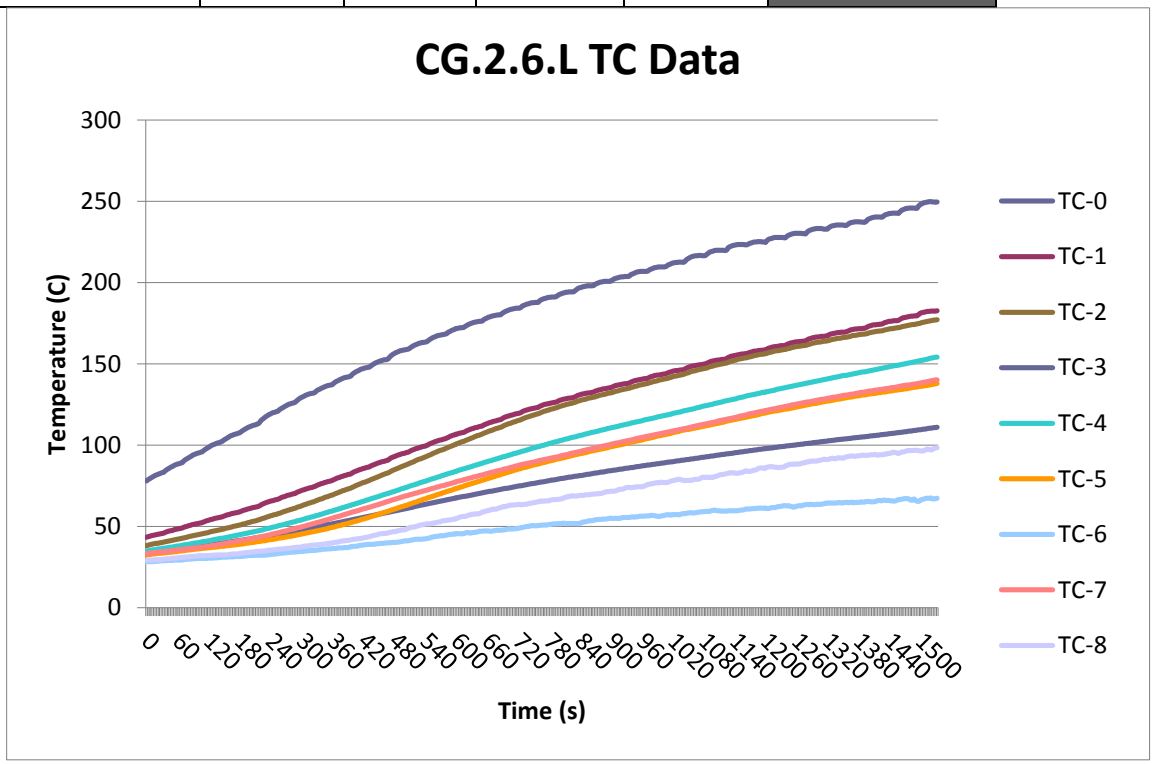
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.8.M	Cardboard	8”	Medium	7:07	Yes	7:07



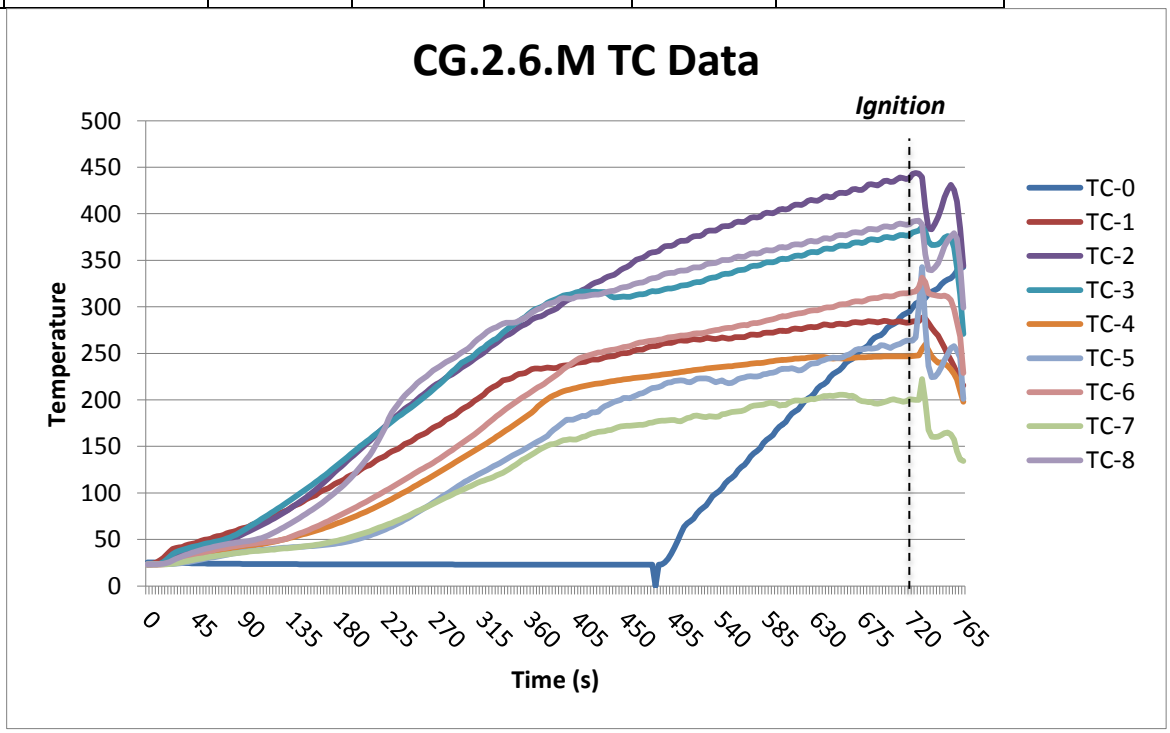
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.1.8.H	Cardboard	8”	High	2:33	Yes	2:33



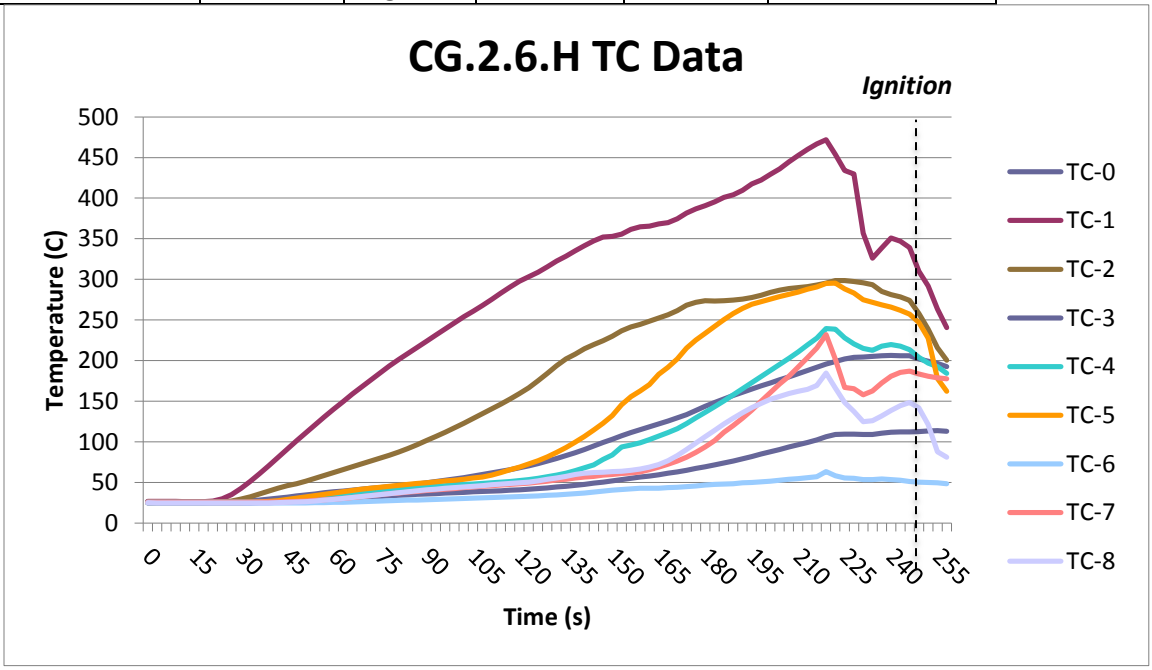
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.6.L	Dish Towel	6”	Low	25:00	No	



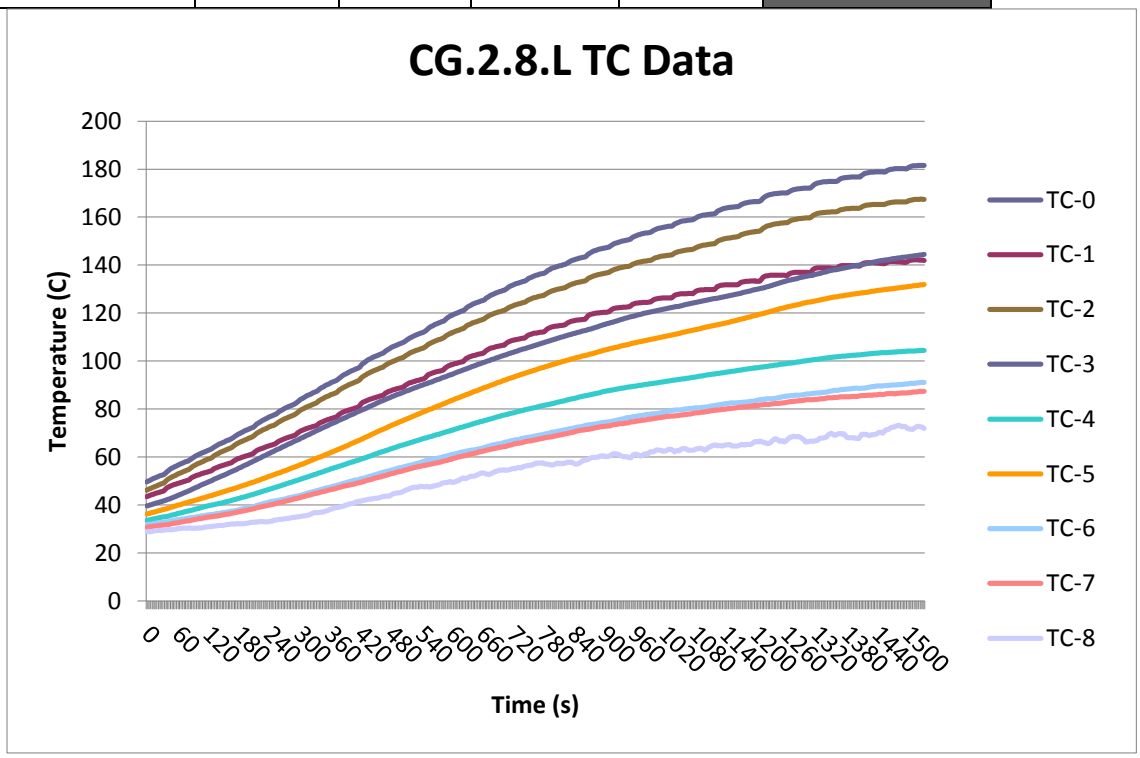
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.6.M	Dish Towel	6”	Medium	12:09	Yes	12:09



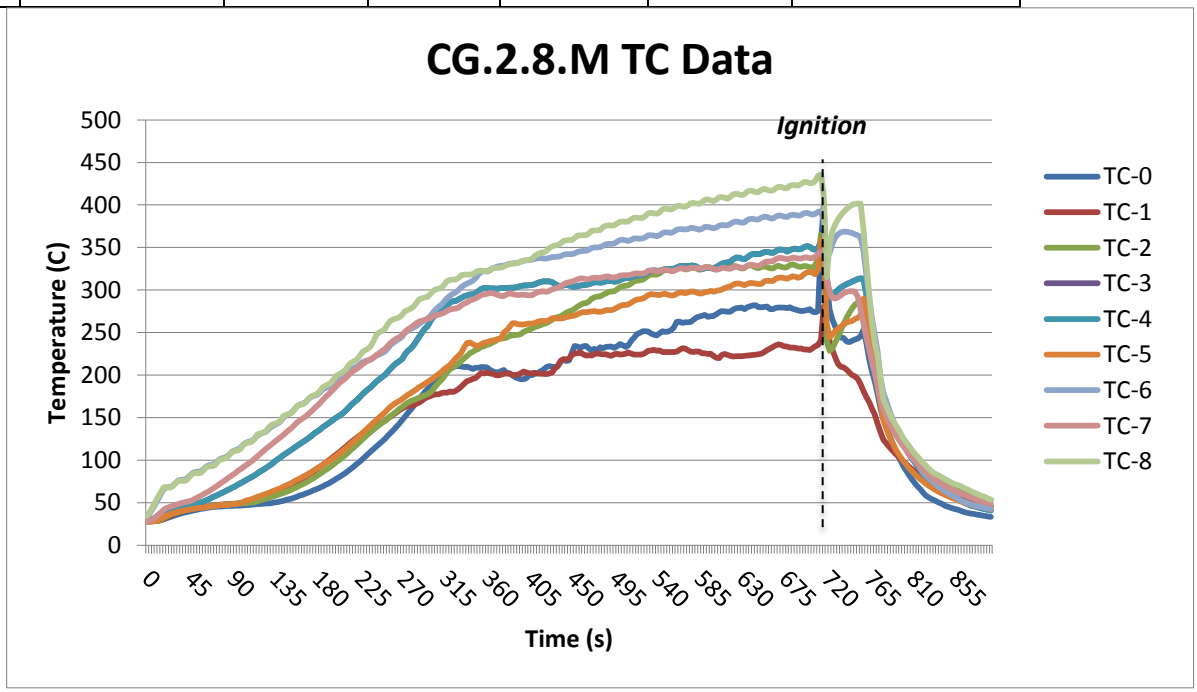
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.6.H	Dish Towel	6”	High	2:30	Yes	2:30



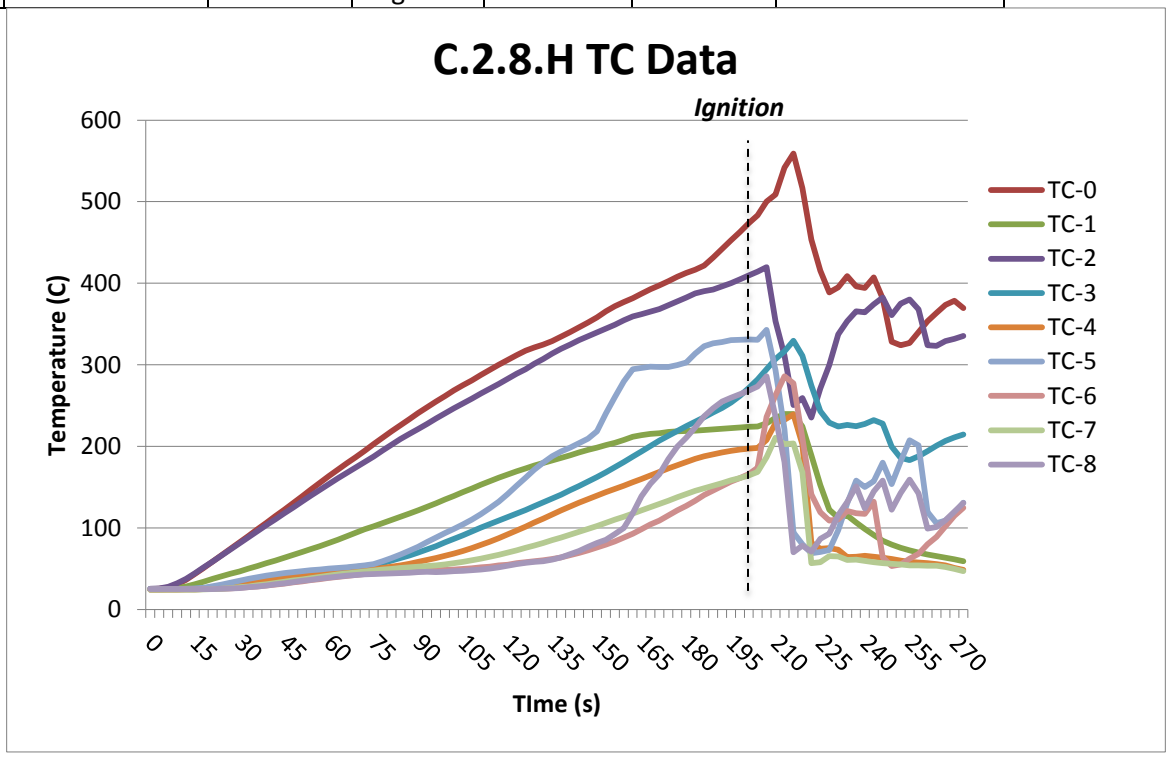
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.8.L	Dish Towel	8”	Low	25:00	No	



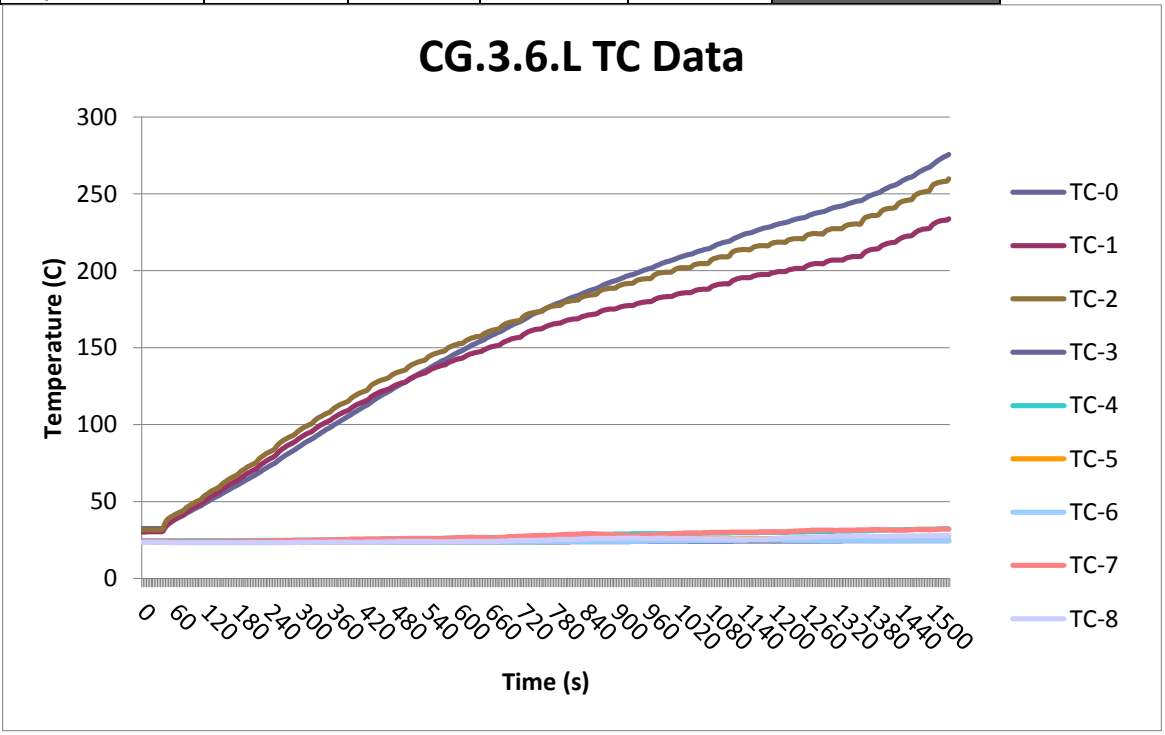
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.8.M	Dish Towel	8”	Medium	12:00	Yes	12:00



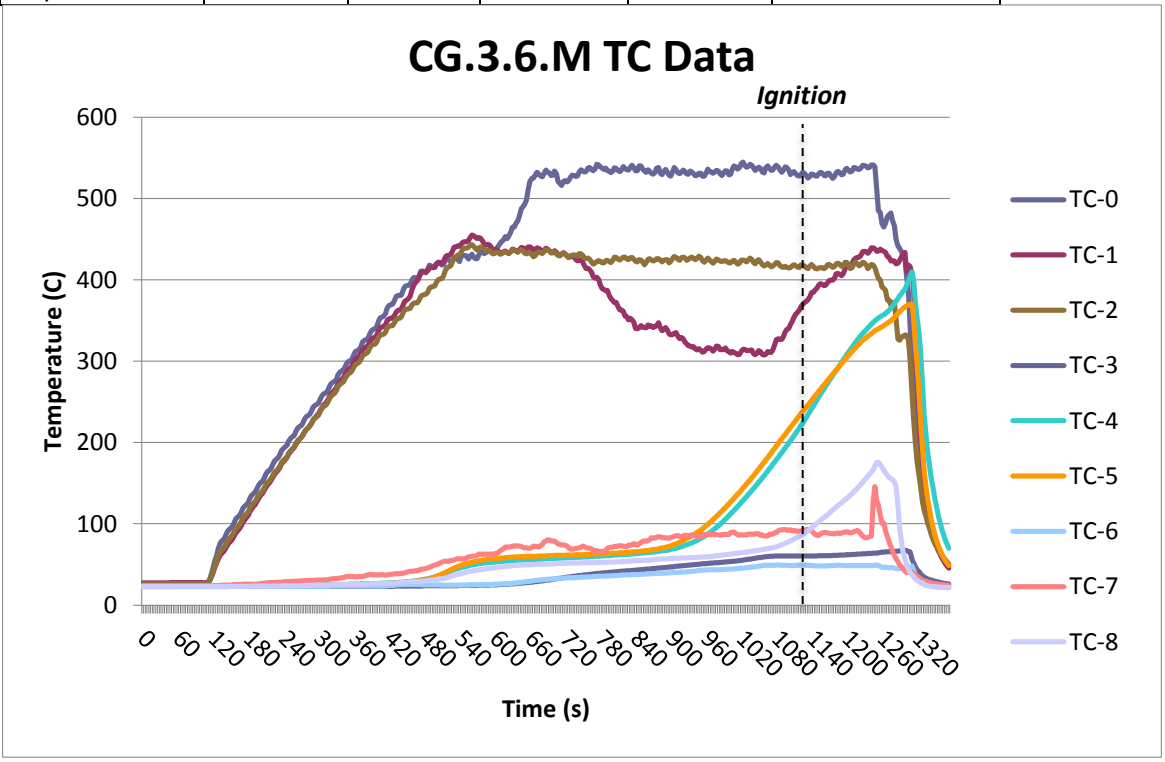
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.2.8.H	Dish Towel	8”	High	3:26	Yes	3:26



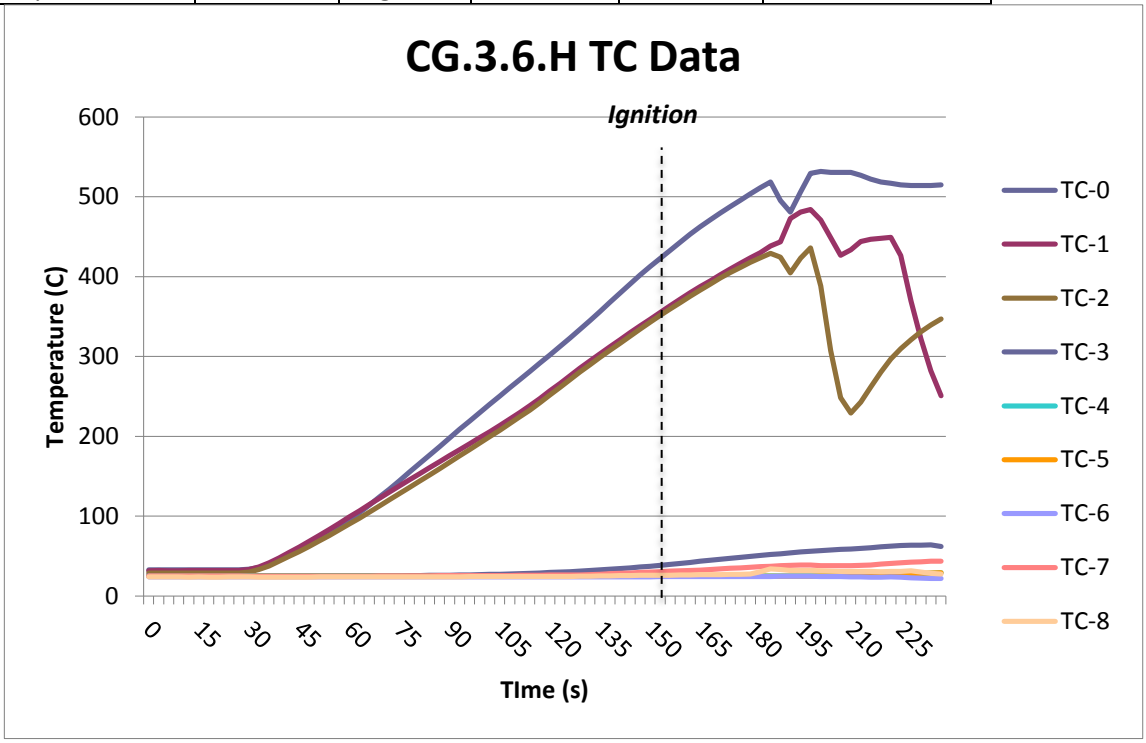
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.6.L	Paper Towel	6”	Low	30:00	No	



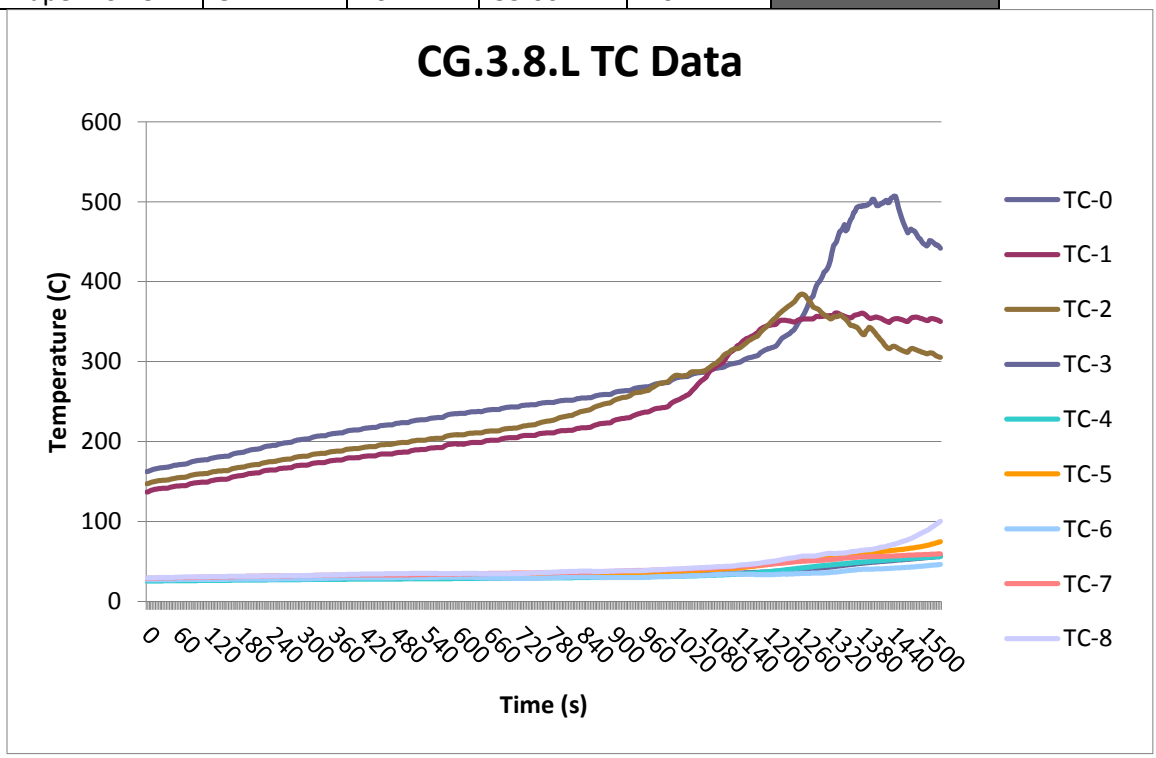
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.6.M	Paper Towel	6”	Medium	18:57	Yes	18:57



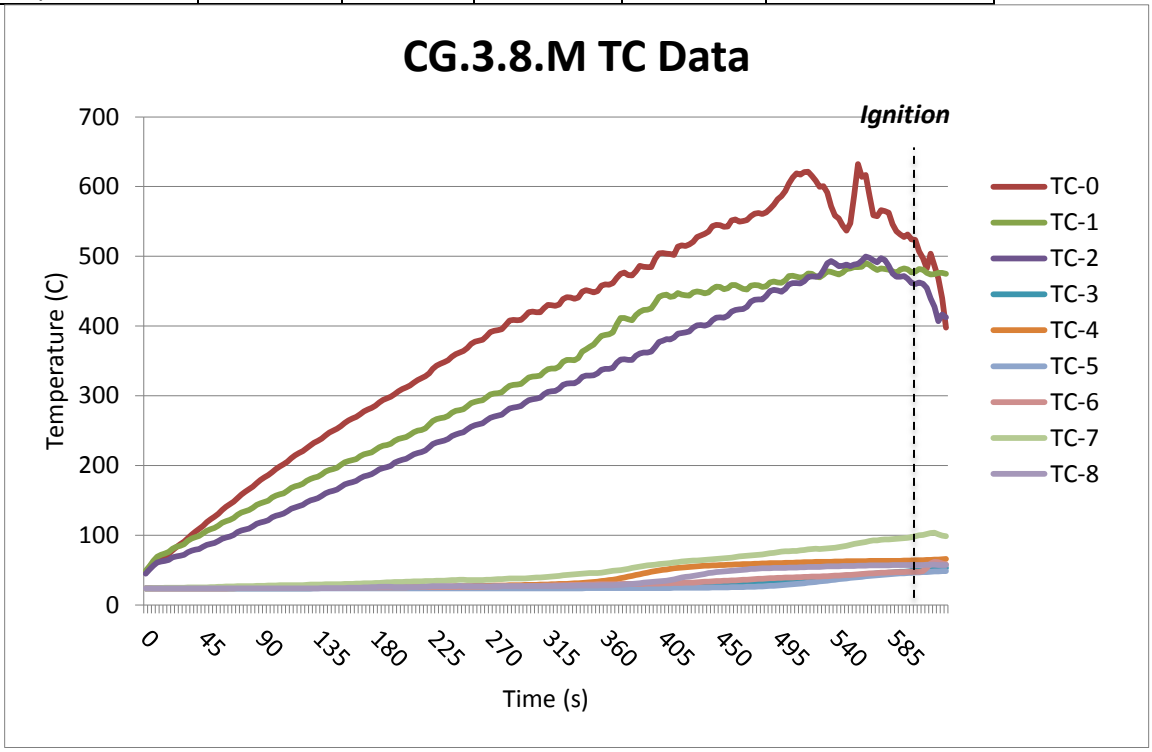
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.6.H	Paper Towel	6”	High	2:36	Yes	2:36



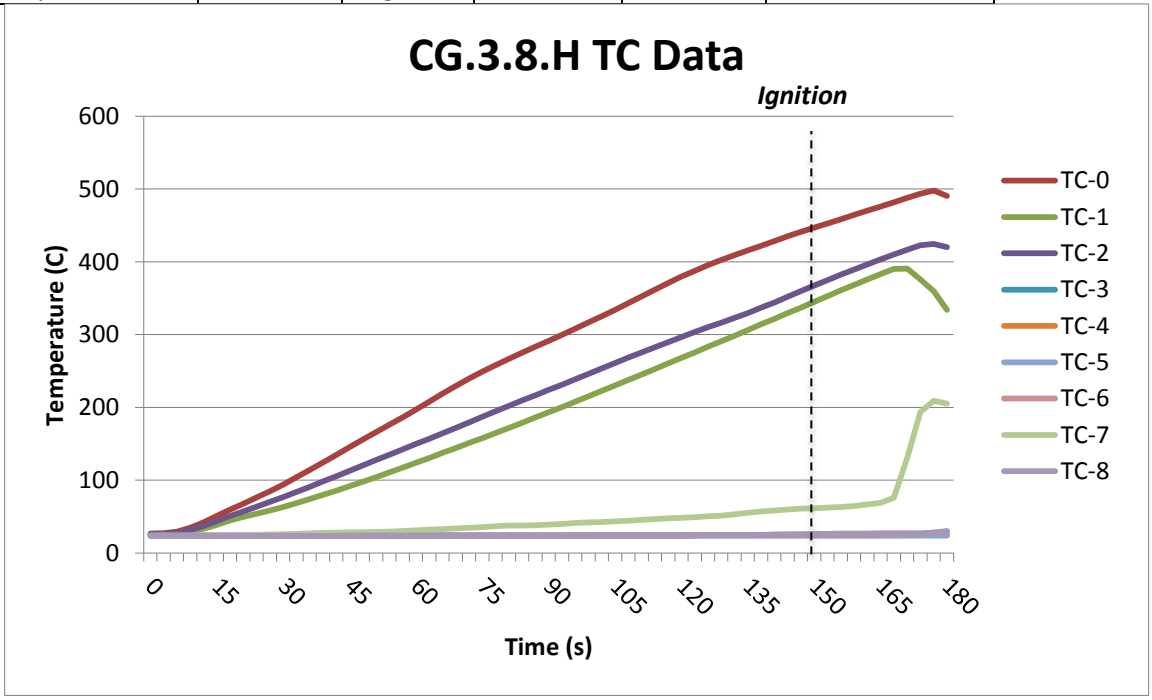
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.8.L	Paper Towel	8”	Low	35:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.8.M	Paper Towel	8”	Medium	10:24	Yes	10:24



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.3.8.H	Paper Towel	8”	High	2:30	Yes	2:30



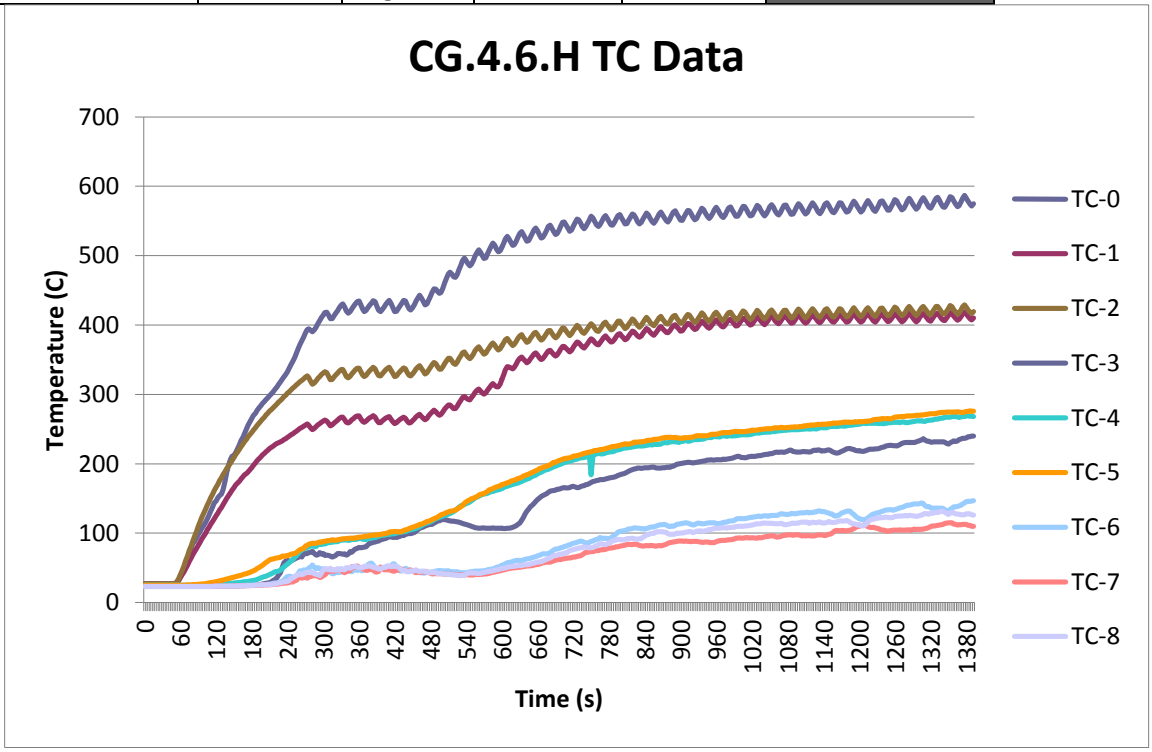
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.6.L	Canola Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.6.M	Canola Oil	6”	Medium	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.6.H	Canola Oil	6”	High	20:00	No	



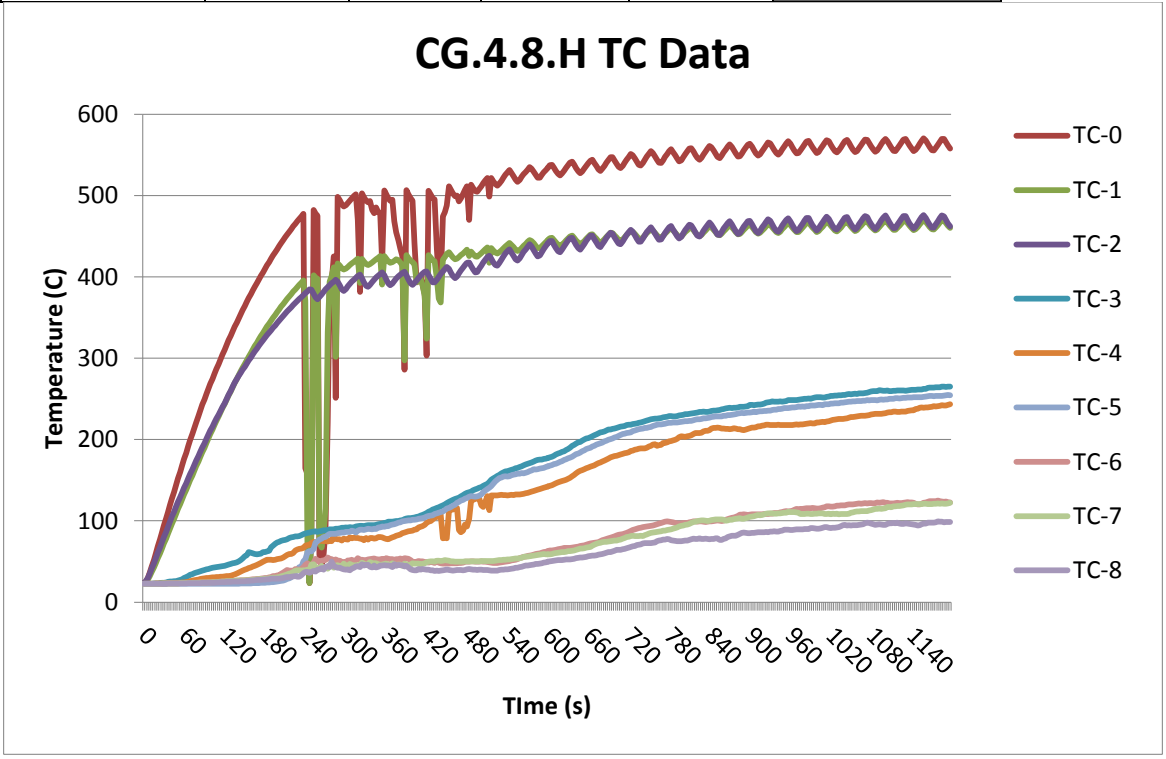
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.8.L	Canola Oil	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.8.M	Canola Oil	8”	Medium	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.4.8.H	Canola Oil	8”	High	20:00	No	



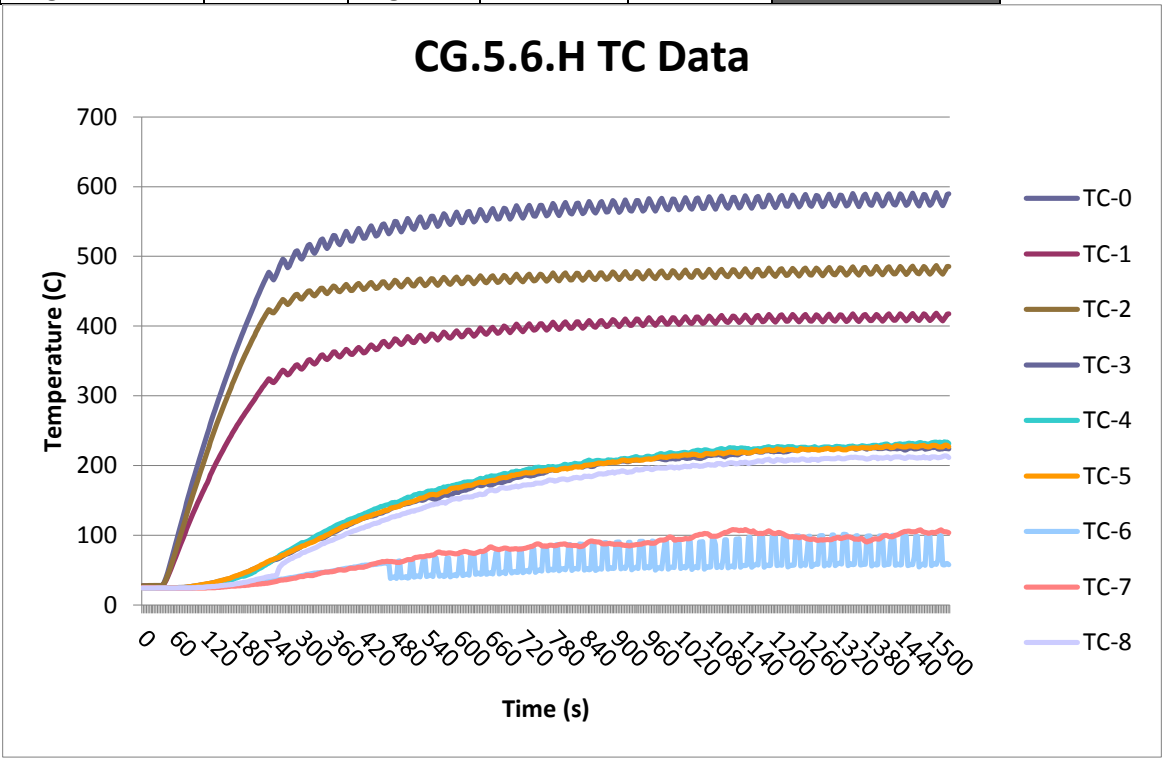
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.6.L	Vegetable Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.6.M	Vegetable Oil	6”	Medium	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.6.H	Vegetable Oil	6”	High	25:00	No	



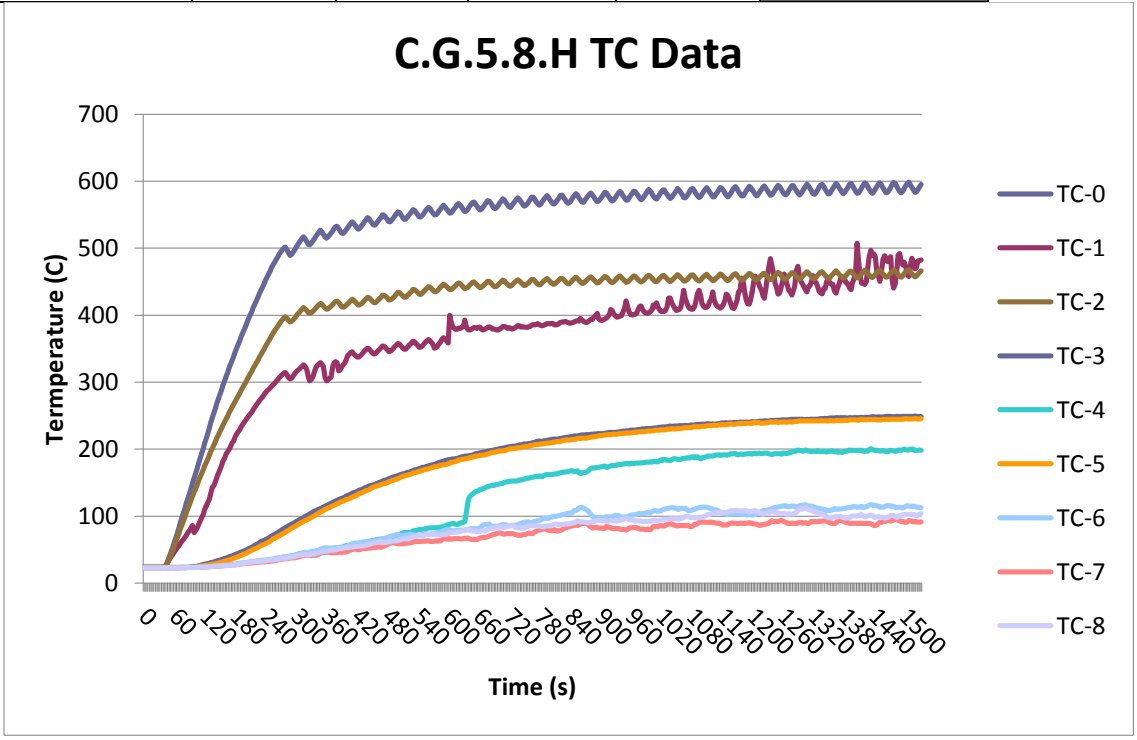
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.8.L	Vegetable Oil	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.8.M	Vegetable Oil	8”	Medium	No test	No	

No Test Conducted

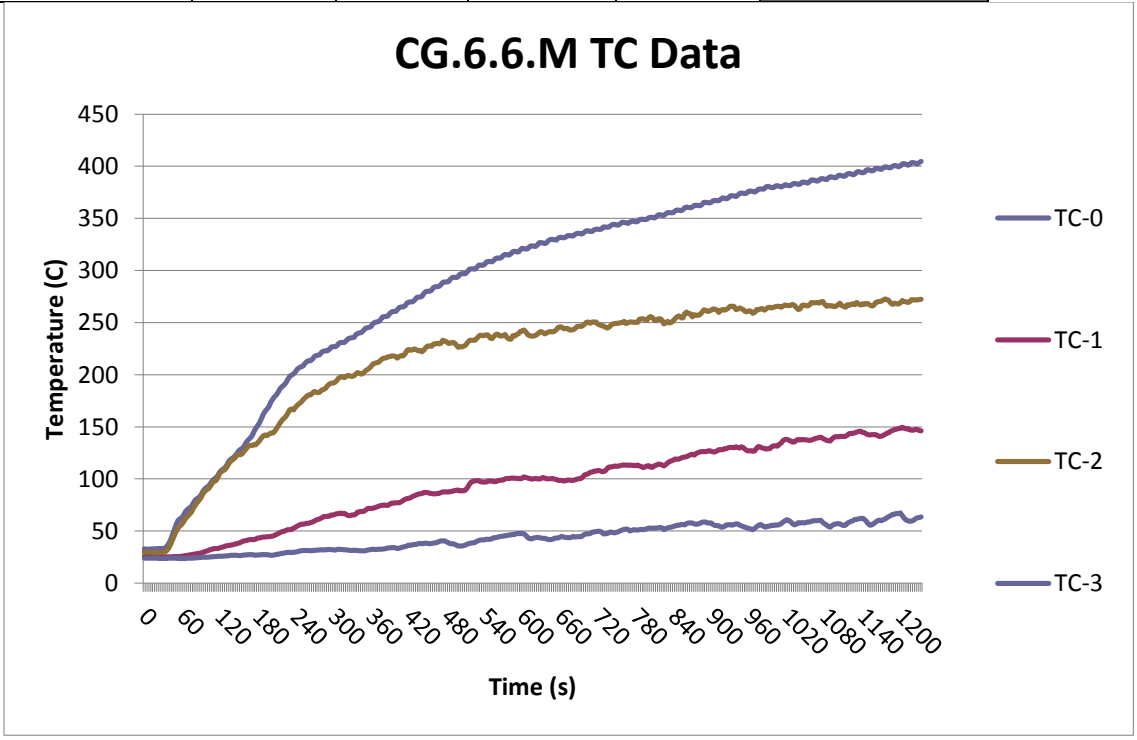
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.5.8.H	Vegetable Oil	8”	High	25:00	No	



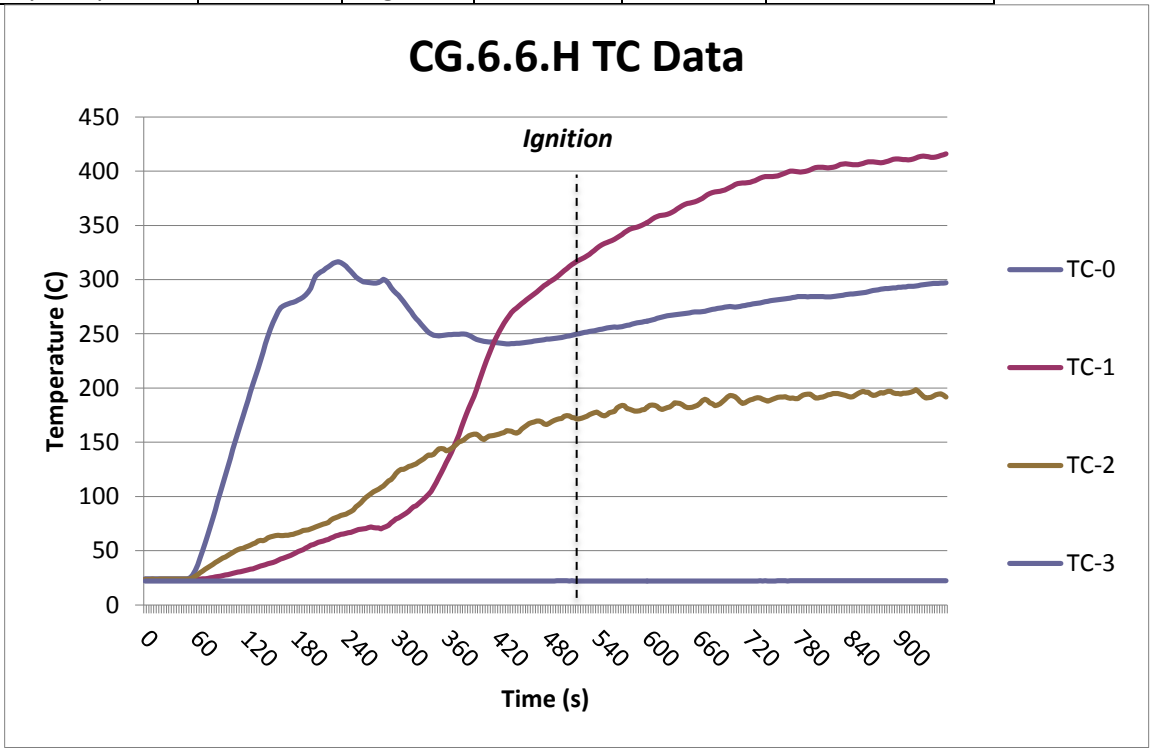
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.6.L	Nylon spatula	6”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.6.M	Nylon spatula	6”	Medium	15:00	No	



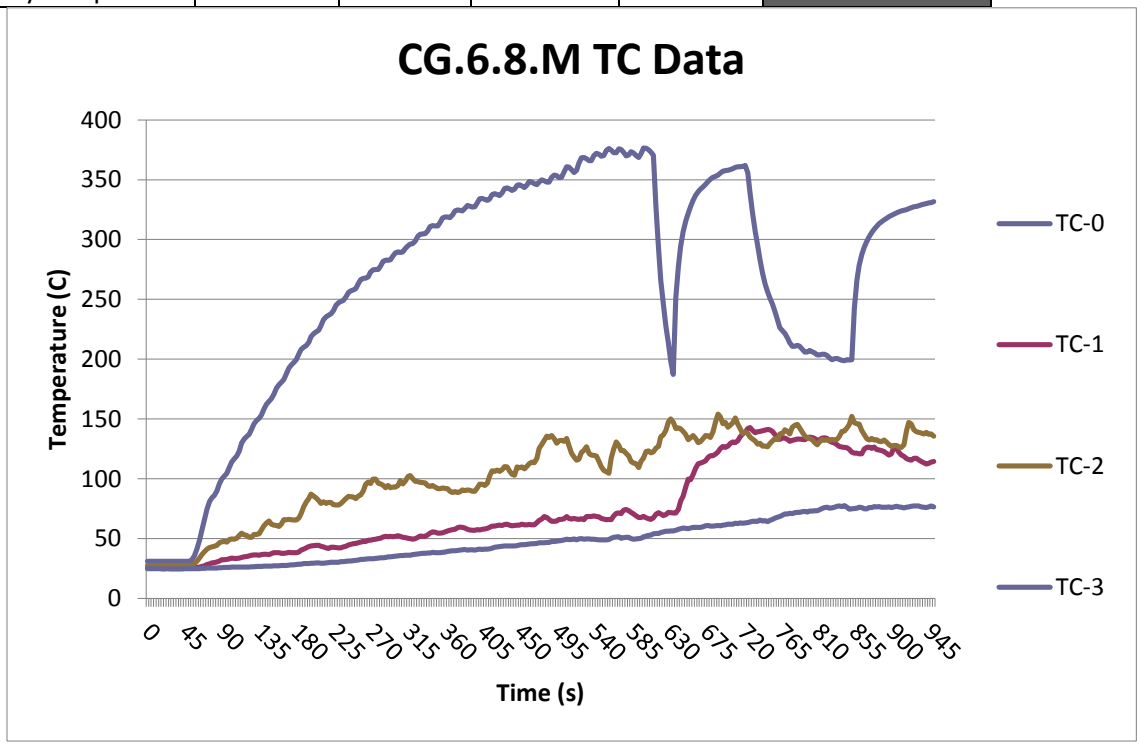
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.6.H	Nylon spatula	6”	High	8:34	Yes	8:34



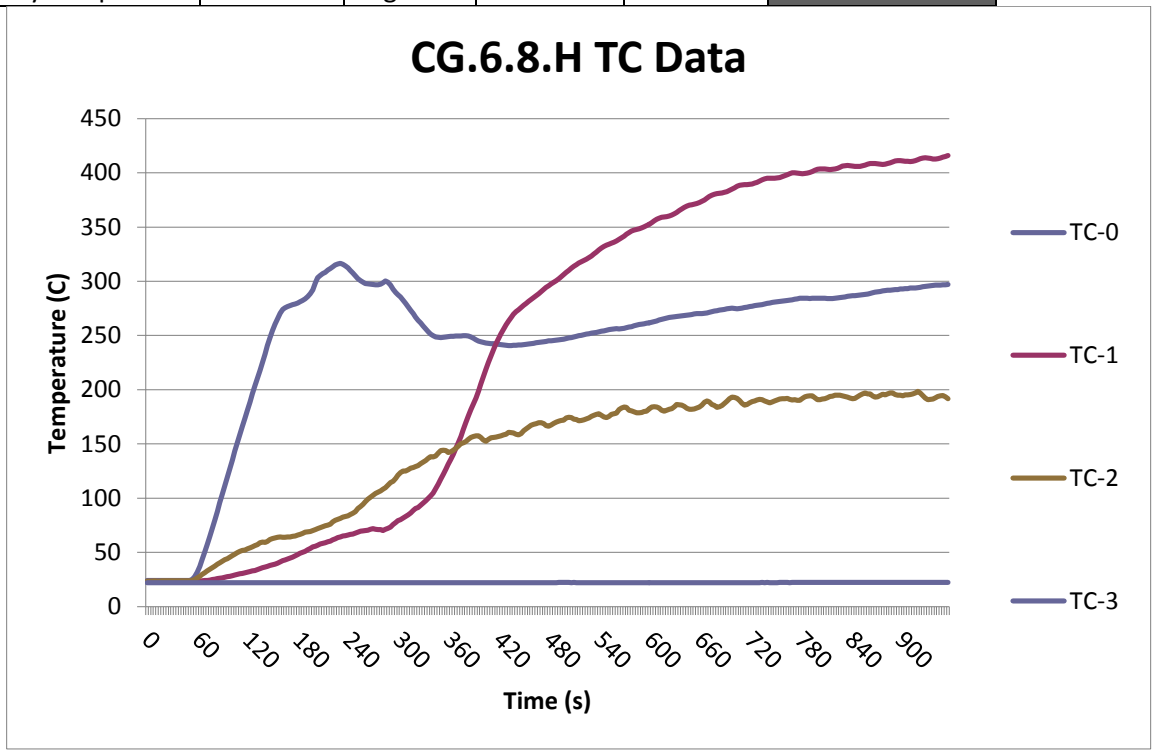
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.8.L	Nylon spatula	8”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.8.M	Nylon spatula	8”	Medium	15:00	No	



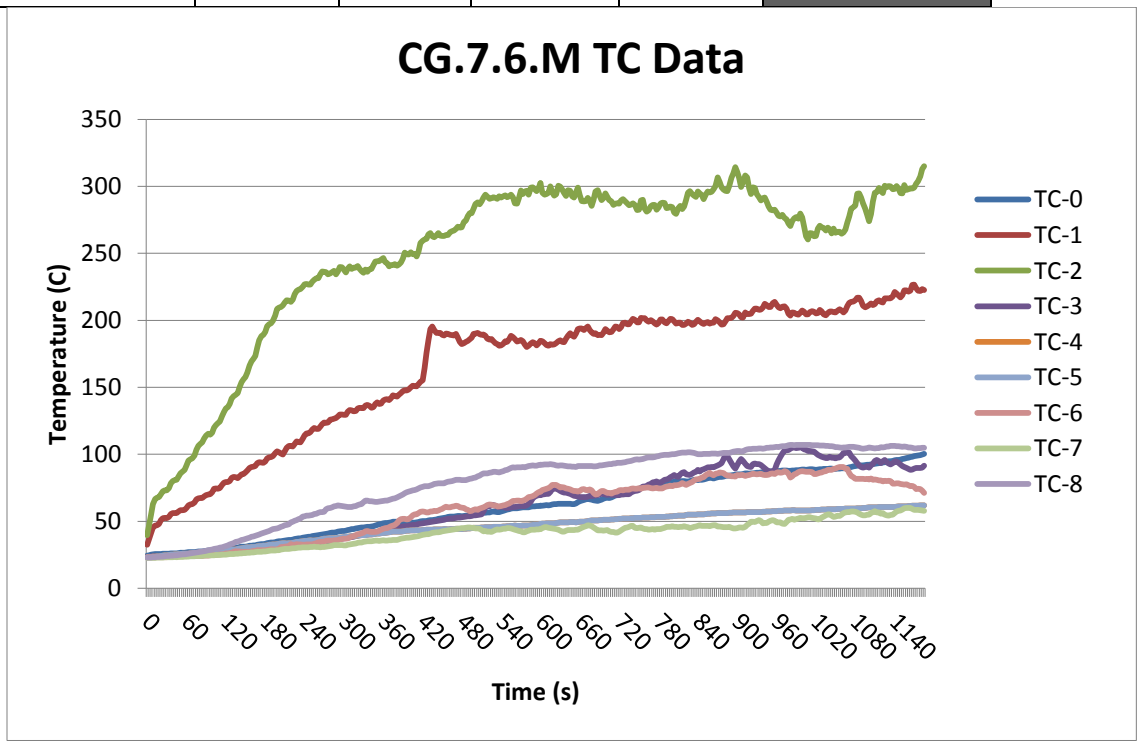
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.6.8.H	Nylon spatula	8”	High	15:00	No	



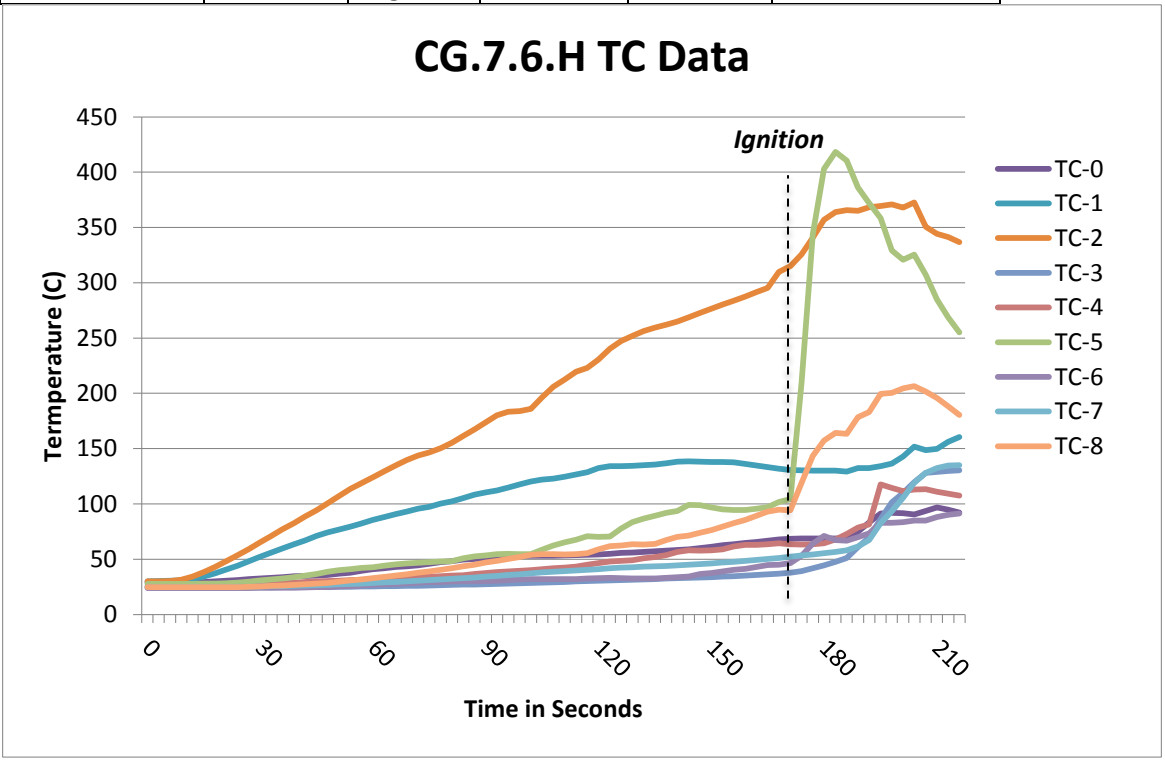
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.6.L	Toaster	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.6.M	Toaster	6”	Medium	20:00	No	



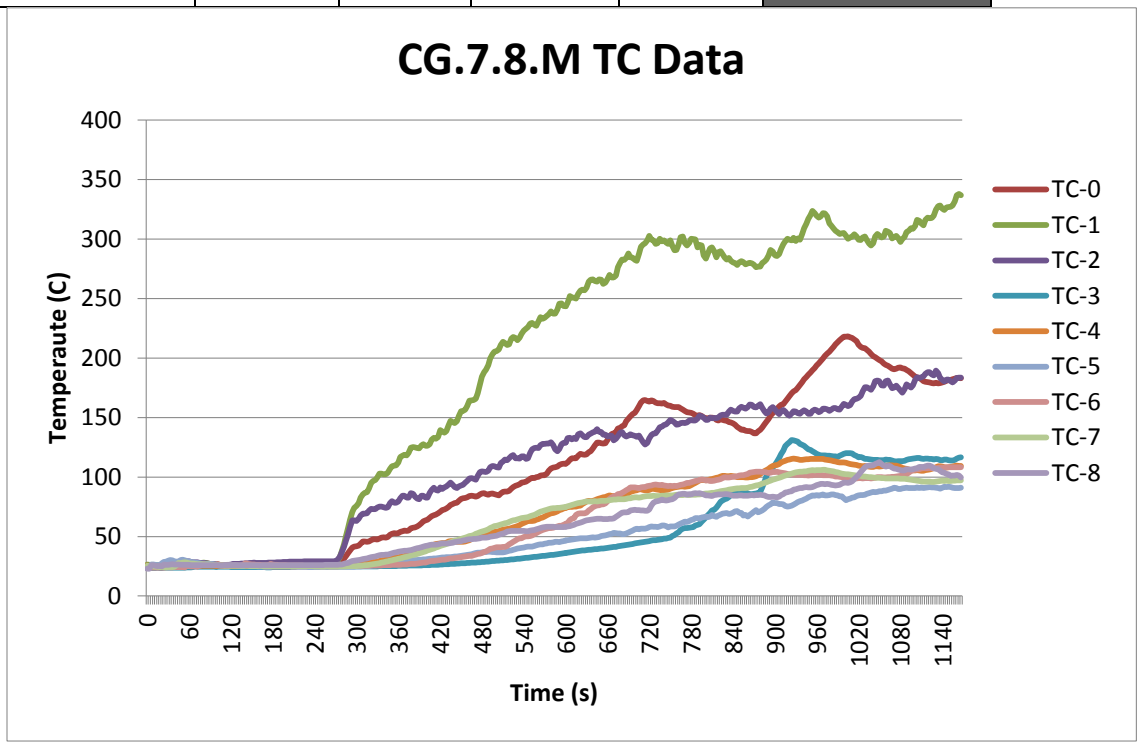
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.6.H	Toaster	6”	High	2:49	Yes	2:49



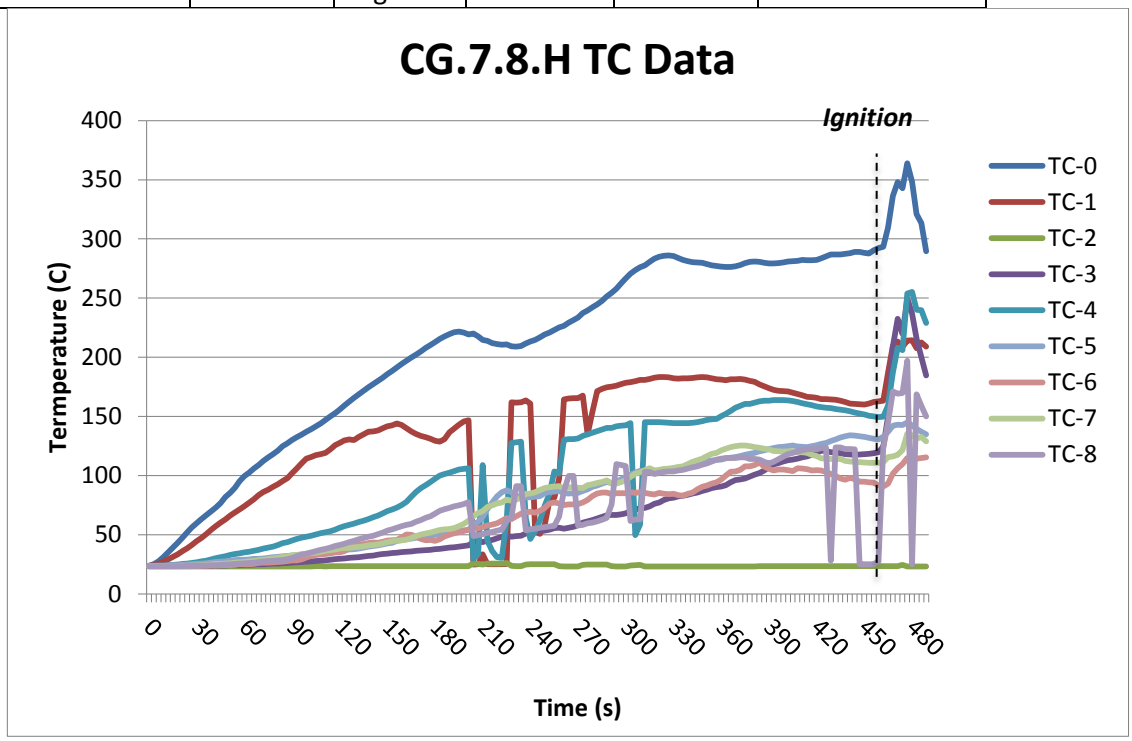
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.8.L	Toaster	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.8.M	Toaster	8”	Medium	20:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.7.8.H	Toaster	8”	High	7:48	Yes	7:48



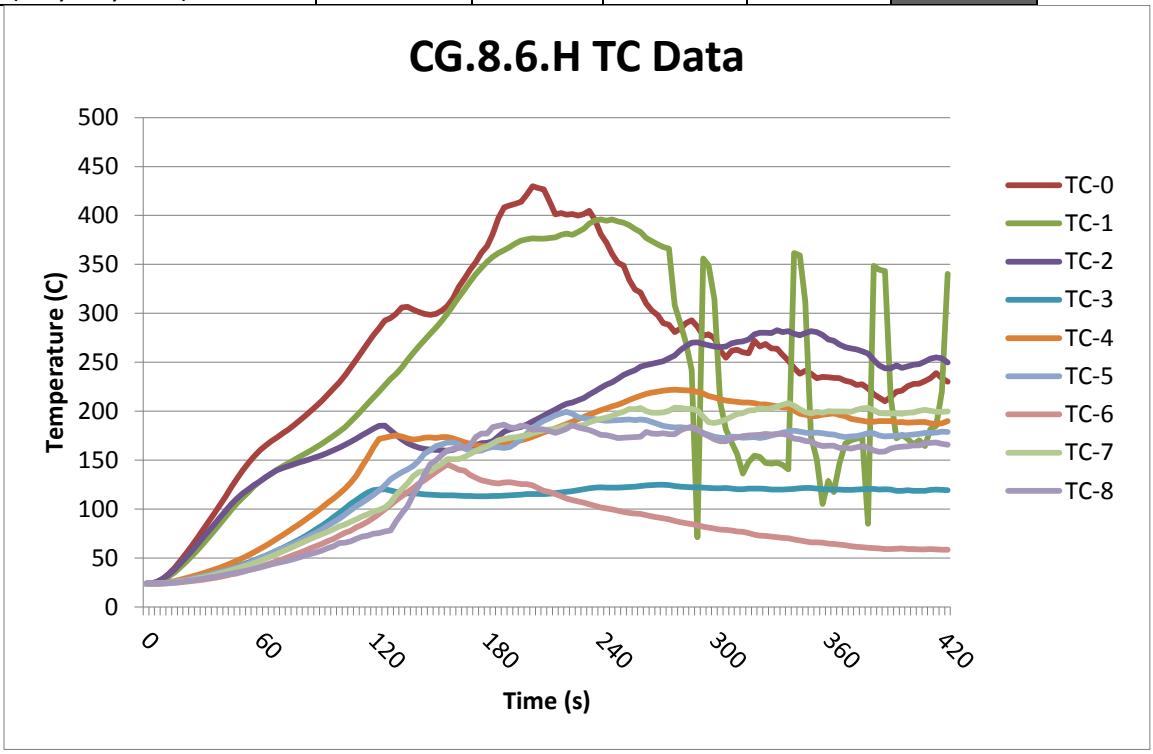
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.6.L	Food Storage Container (Polyethylene)	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	No test	No	

No Test Conducted

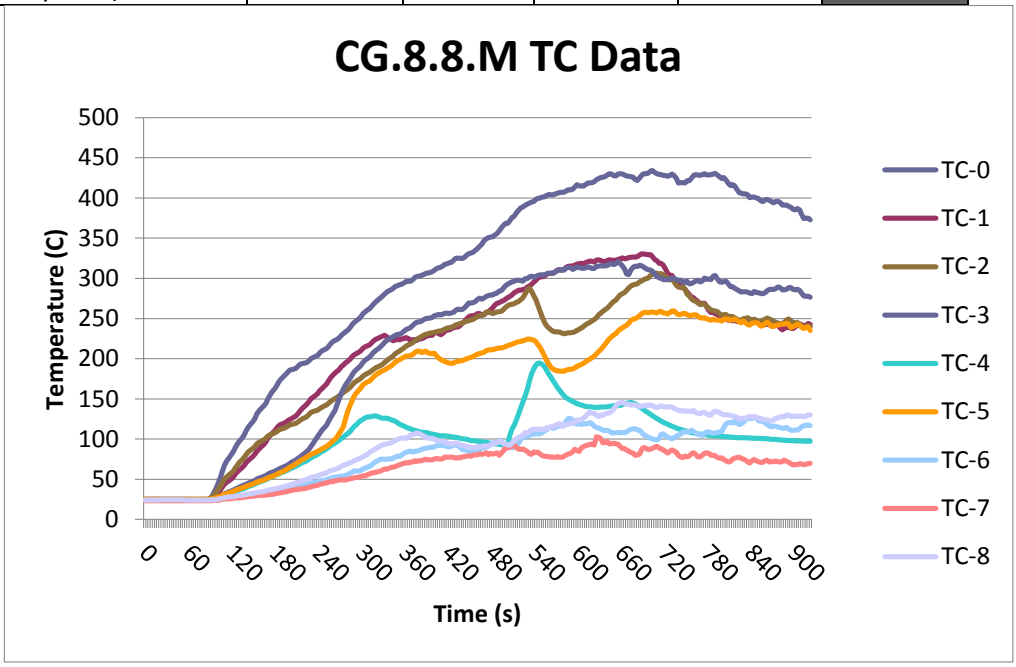
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.6.H	Food Storage Container (Polyethylene)	6”	High	6:30	No	



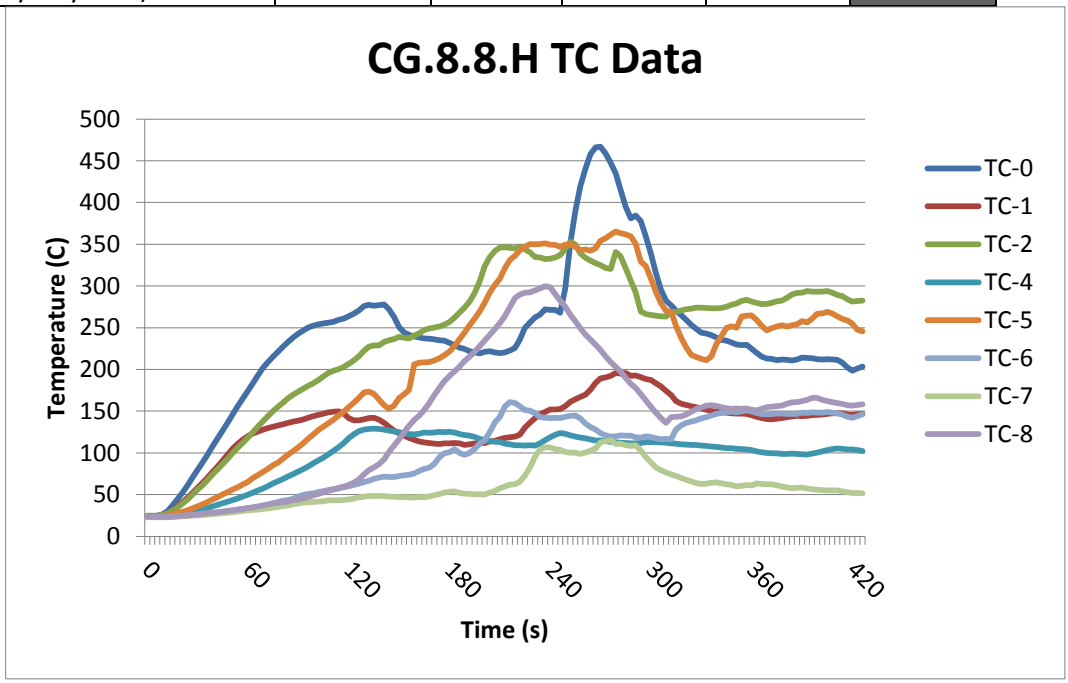
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.8.L	Food Storage Container (Polyethylene)	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	6:30	No	

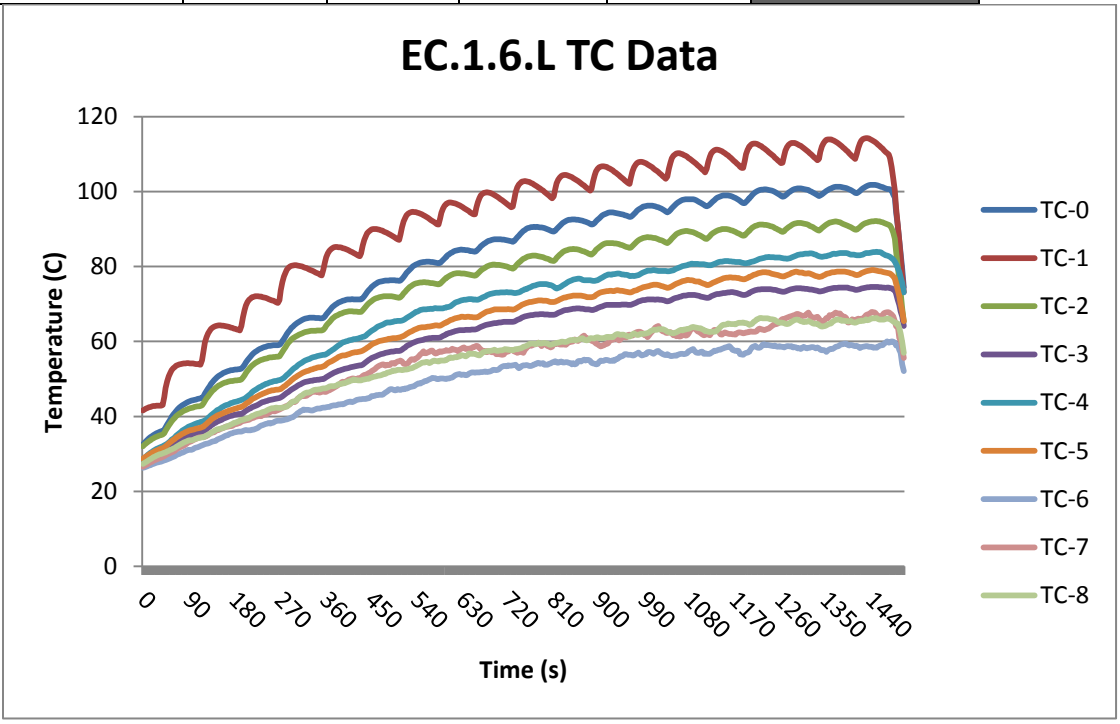


Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
CG.8.8.H	Food Storage Container (Polyethylene)	8”	High	7:00	No	

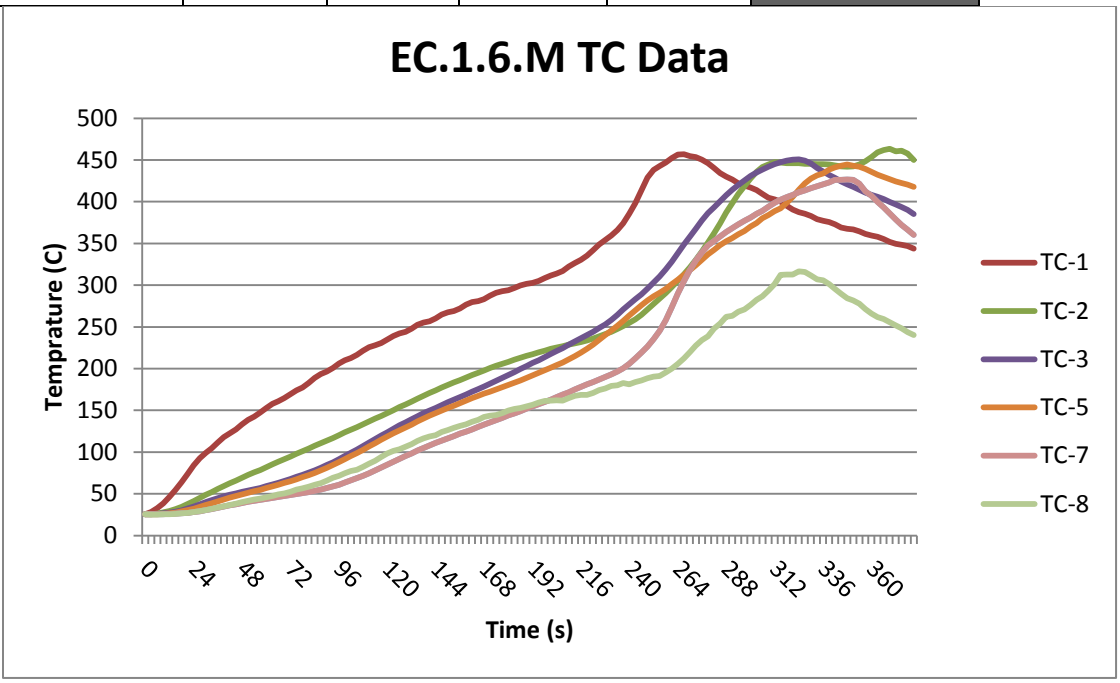


Appendix D – Electric Coil Cooktop Range Results

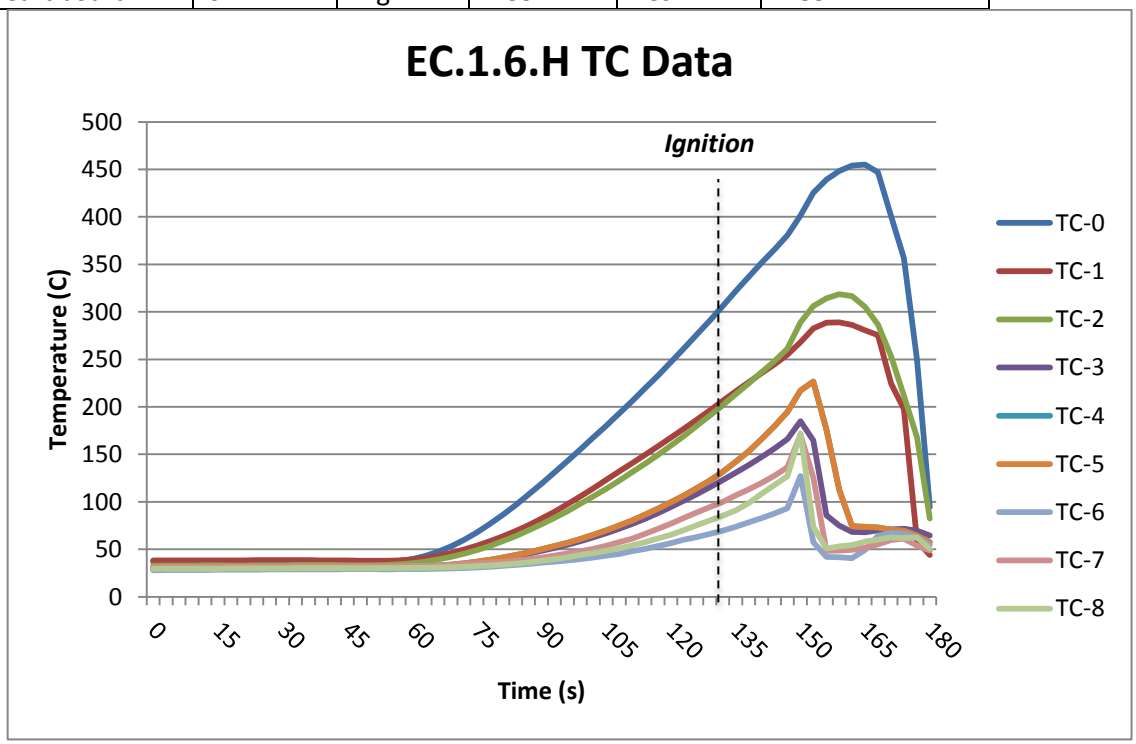
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.6.L	Cardboard	6”	Low	25:00	No	



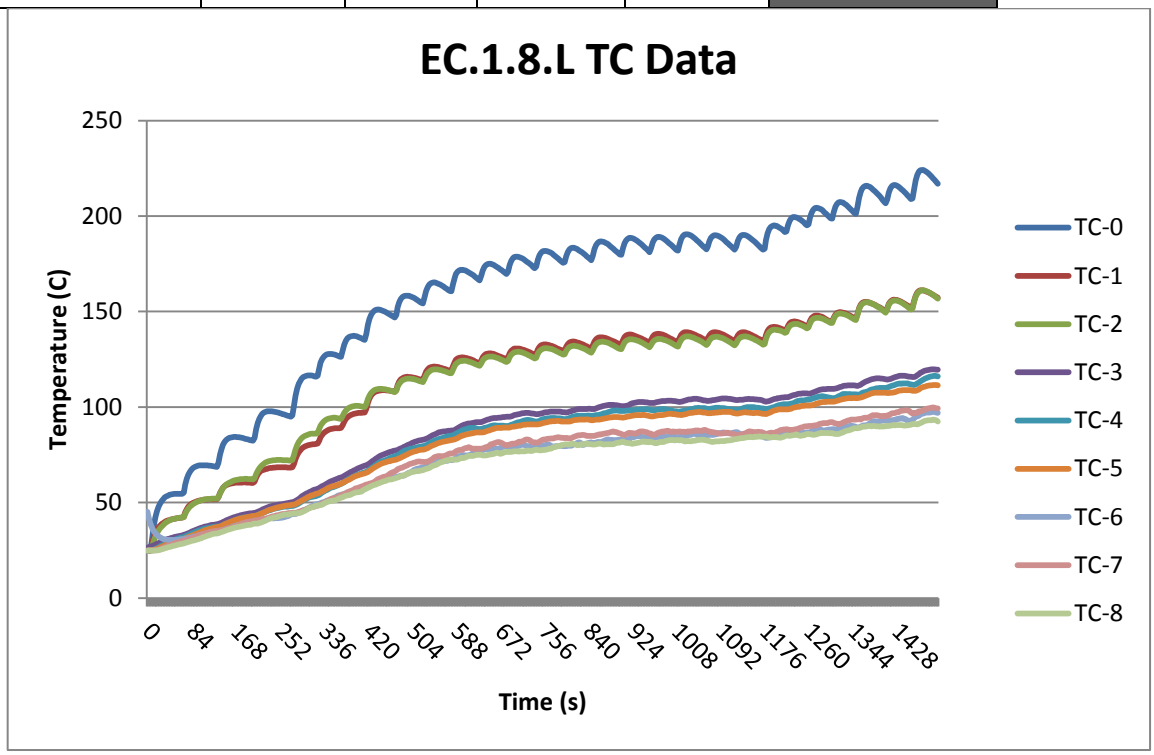
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.6.M	Cardboard	6”	Medium	6:30	No	



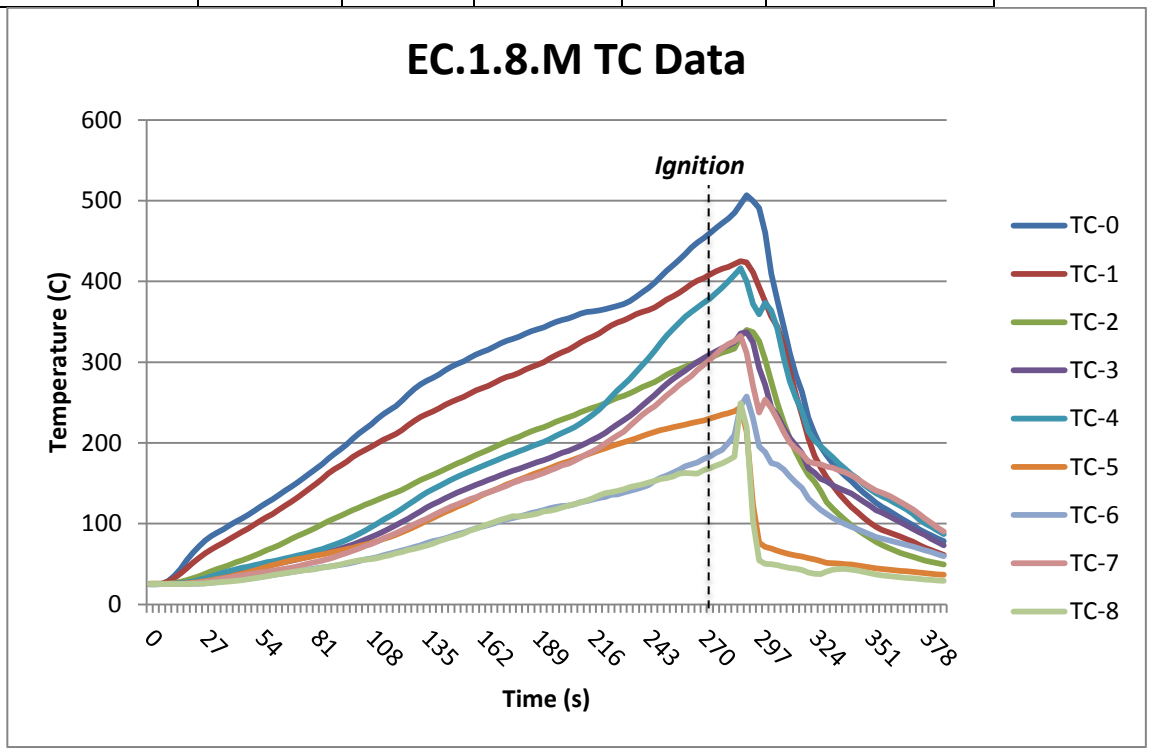
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.6.H	Cardboard	6”	High	1:39	Yes	1:39



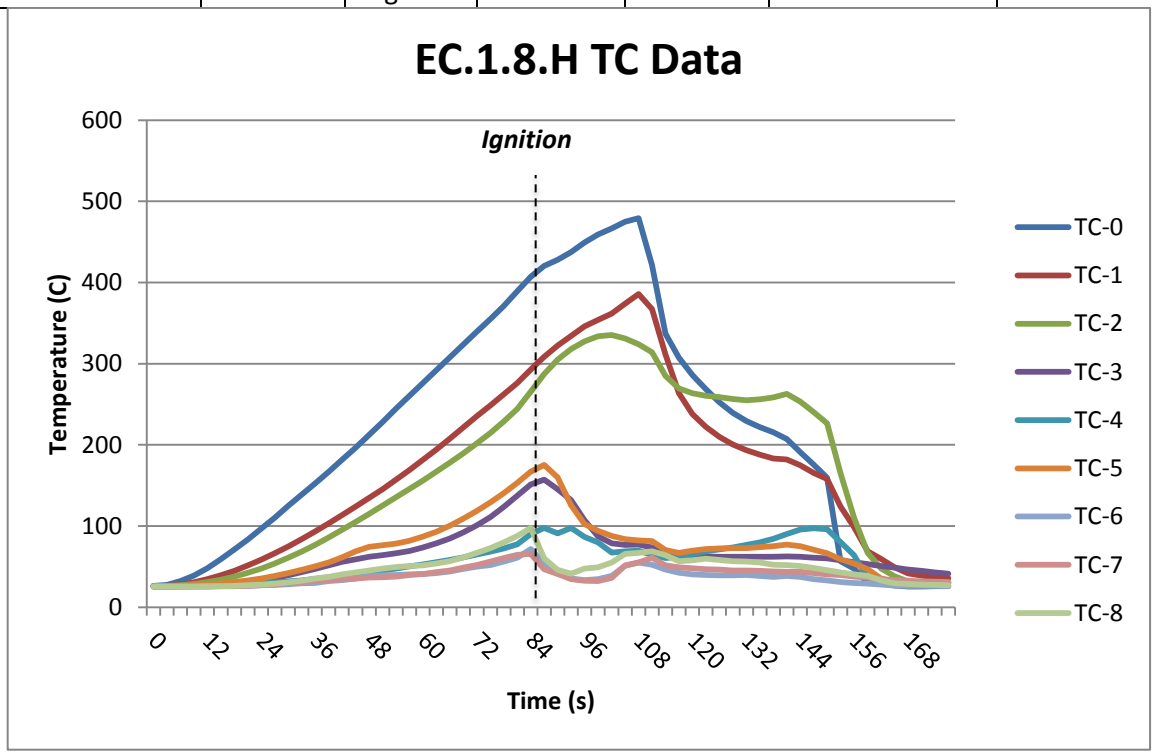
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.8.L	Cardboard	8”	Low	25:00	No	



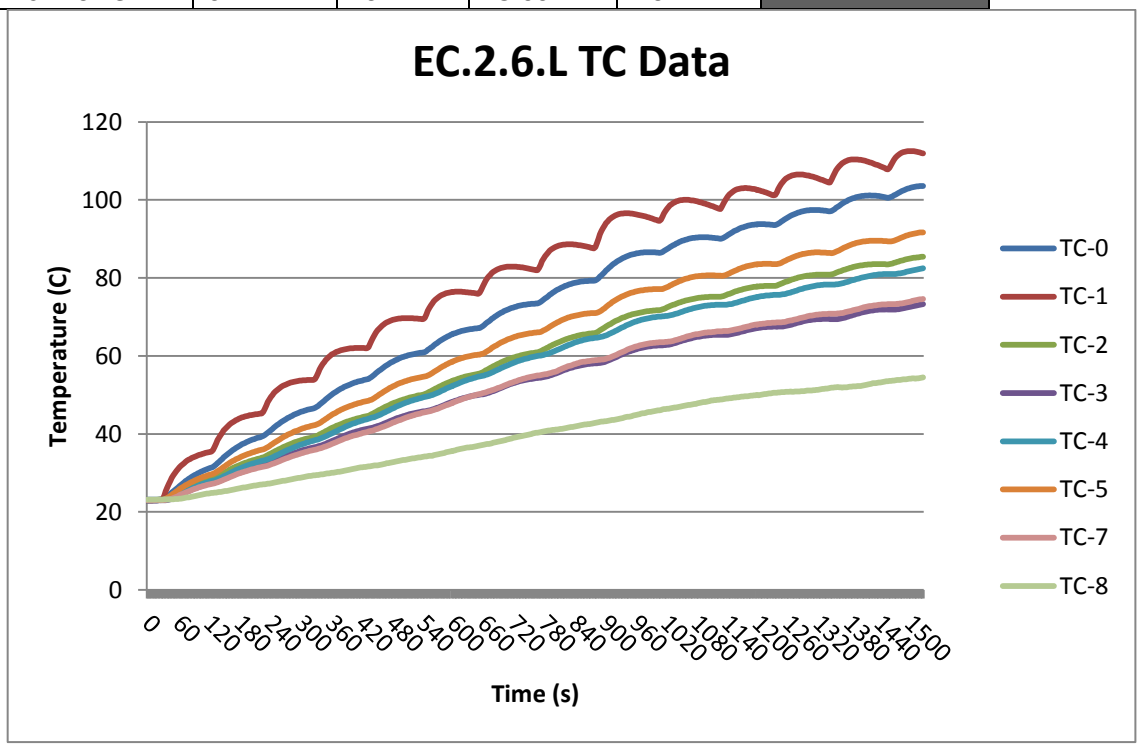
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.8.M	Cardboard	8”	Medium	4:32	Yes	4:32



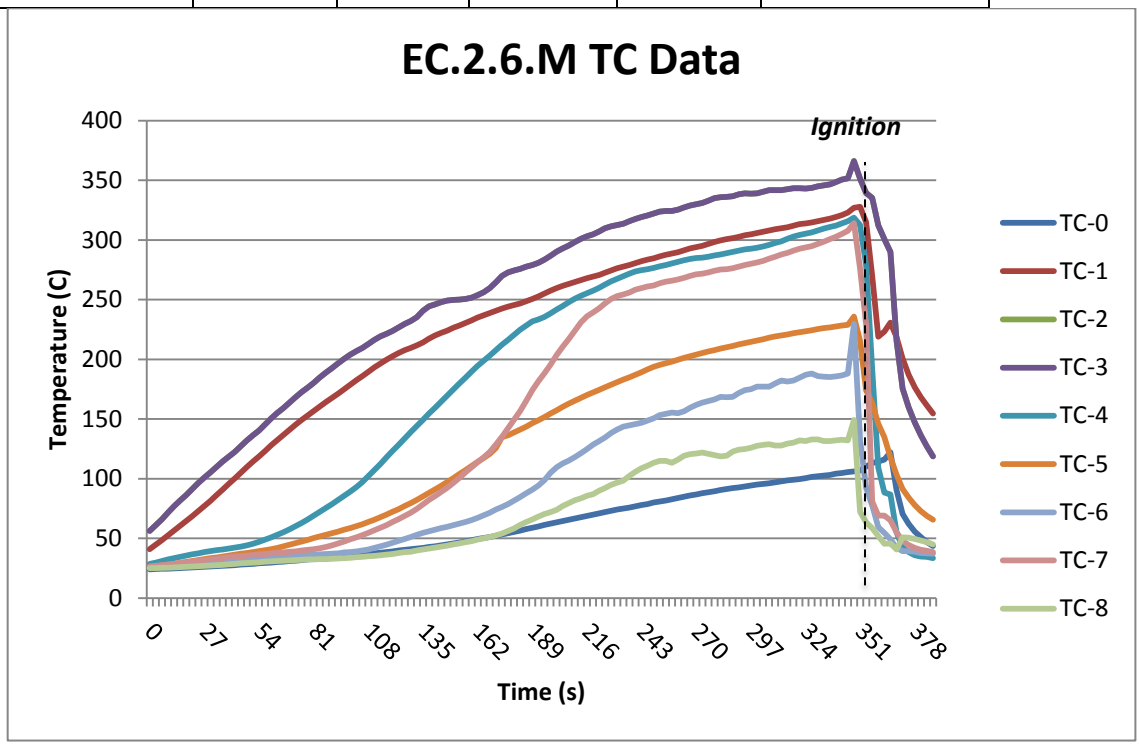
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.1.8.H	Cardboard	8”	High	1:24	Yes	1:24



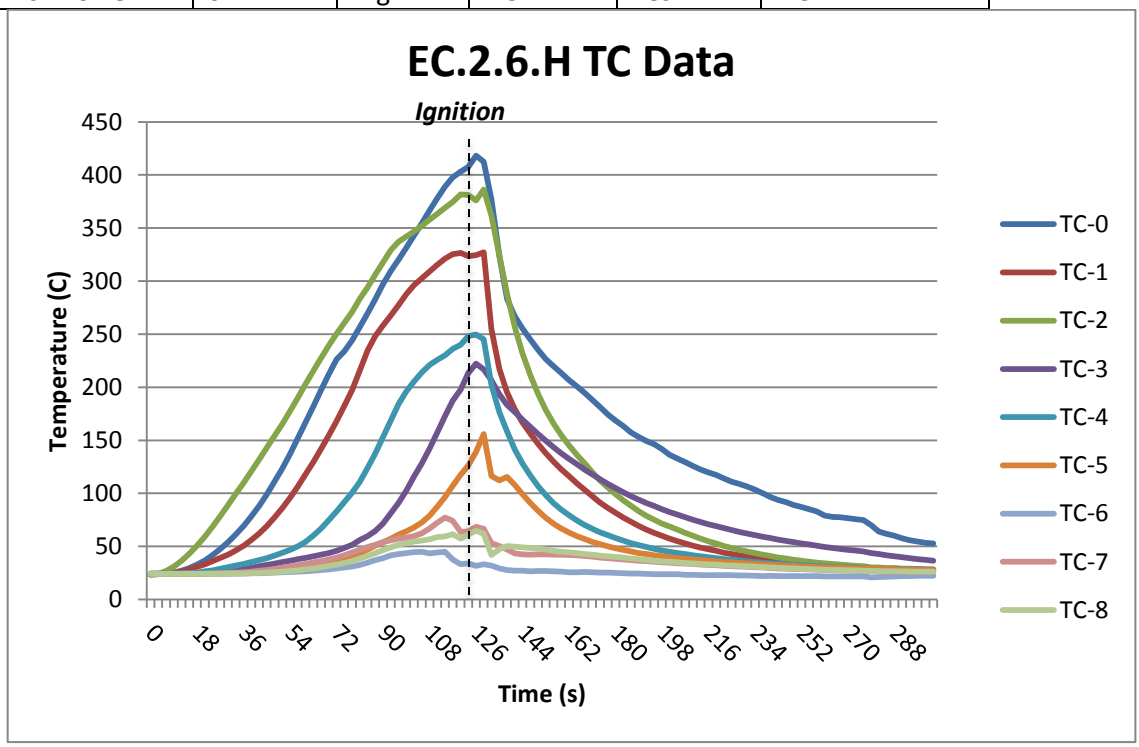
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.6.L	Dish Towel	6”	Low	25:00	No	



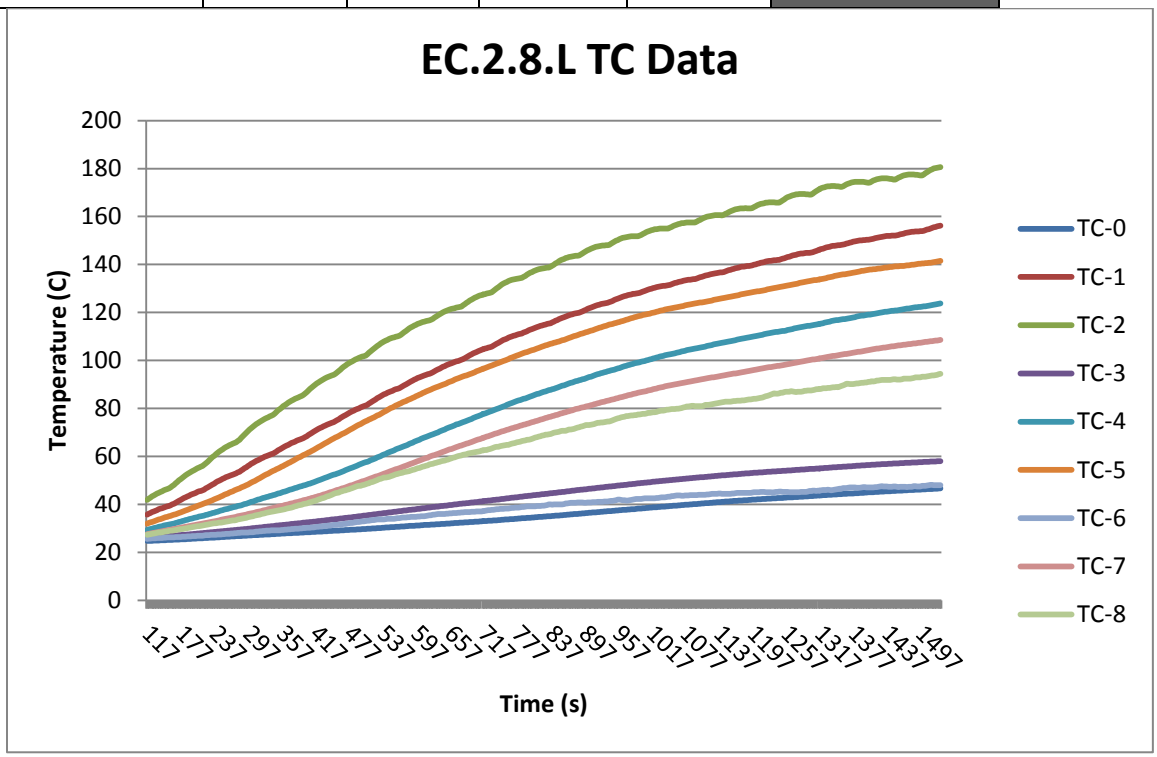
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.6.M	Dish Towel	6”	Medium	6:15	Yes	6:15



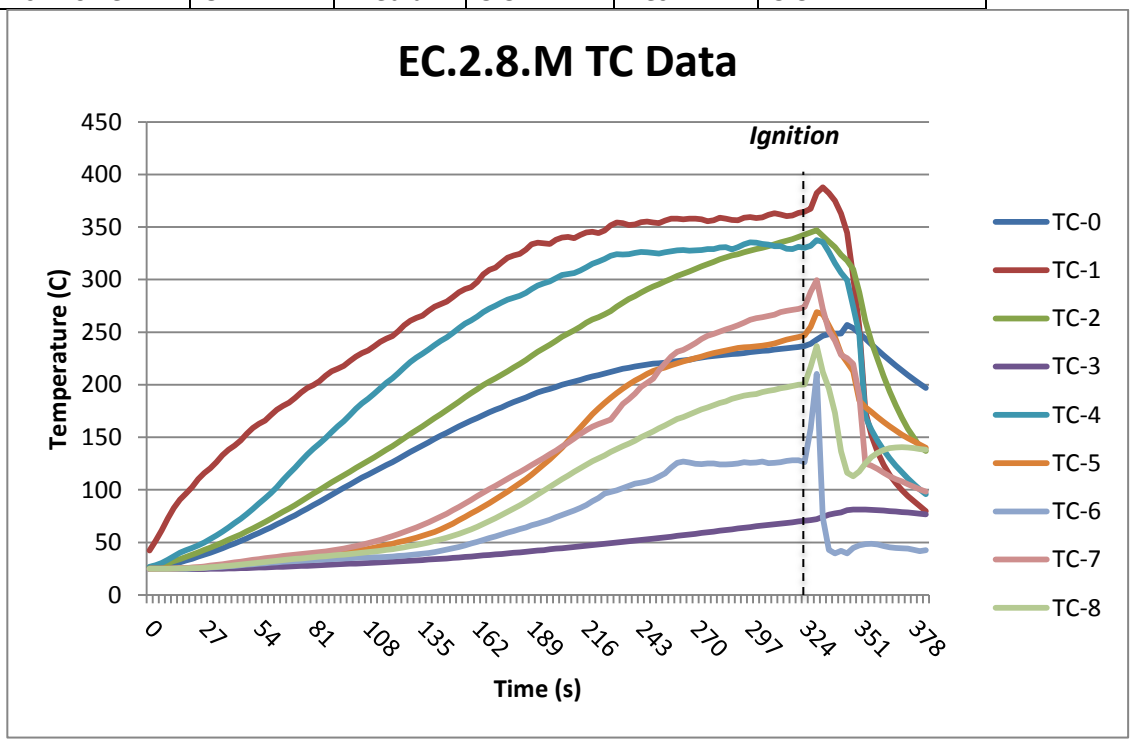
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.6.H	Dish Towel	6”	High	1:52	Yes	1:52



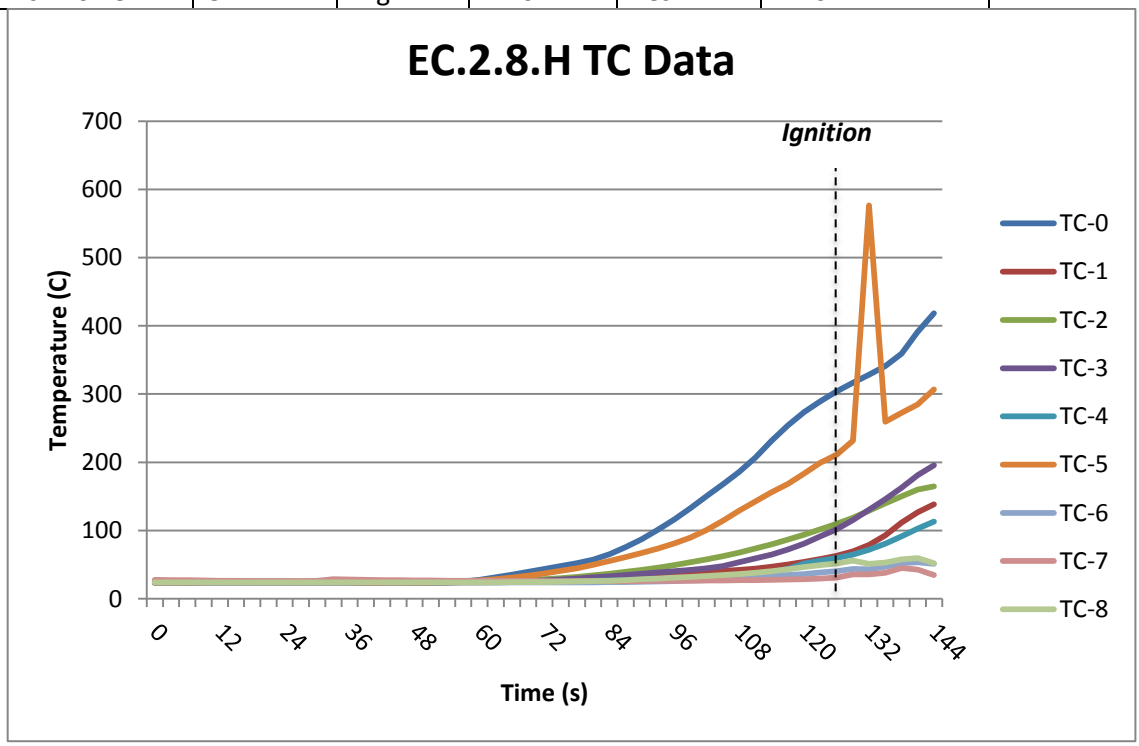
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.8.L	Dish Towel	8”	Low	25:00	No	



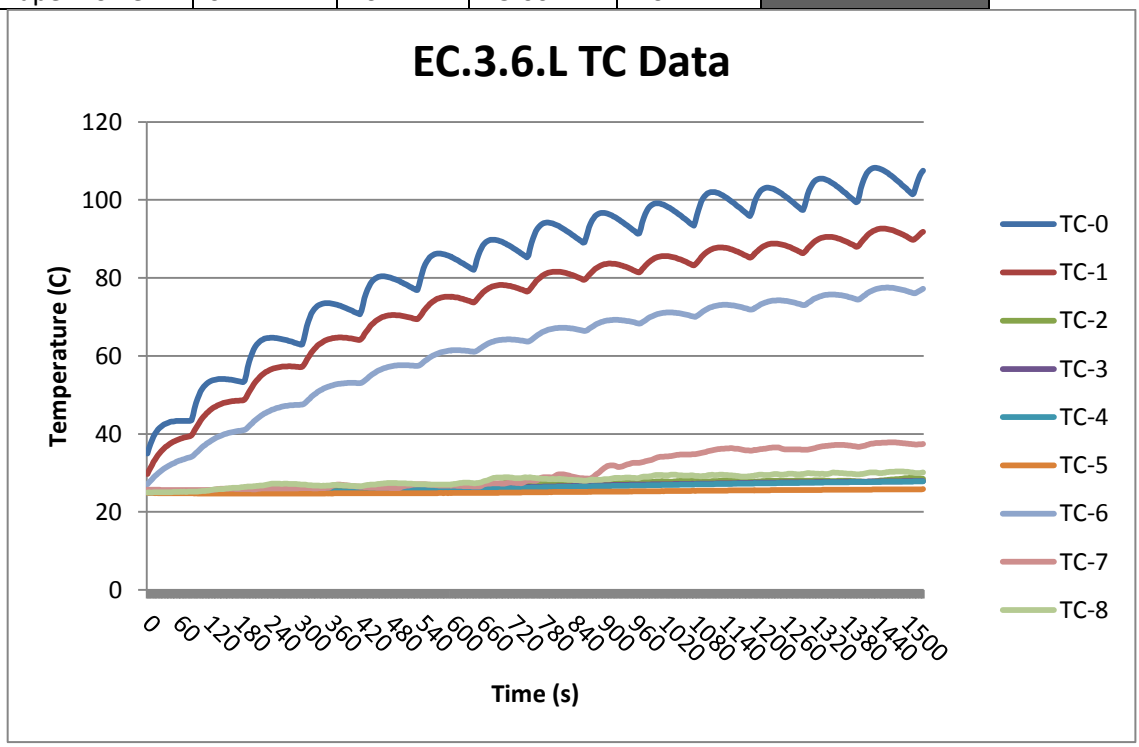
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.8.M	Dish Towel	8”	Medium	5:32	Yes	5:32



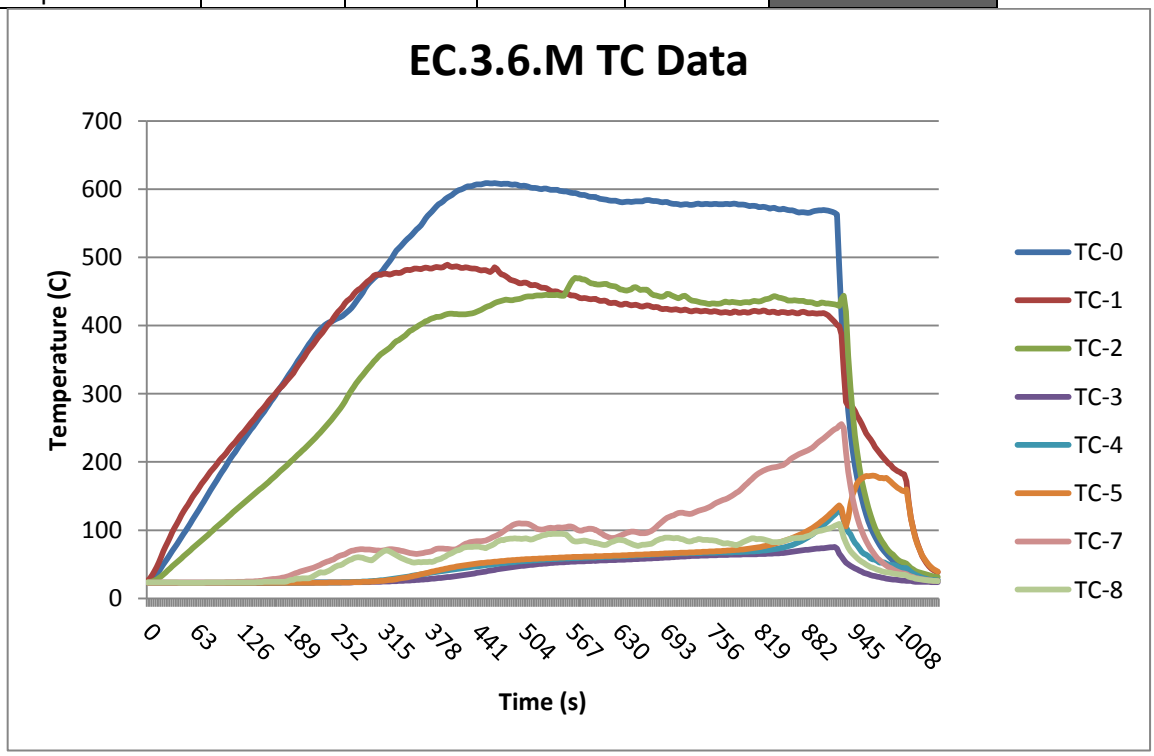
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.2.8.H	Dish Towel	8”	High	1:20	Yes	1:20



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.6.L	Paper Towel	6”	Low	25:00	No	



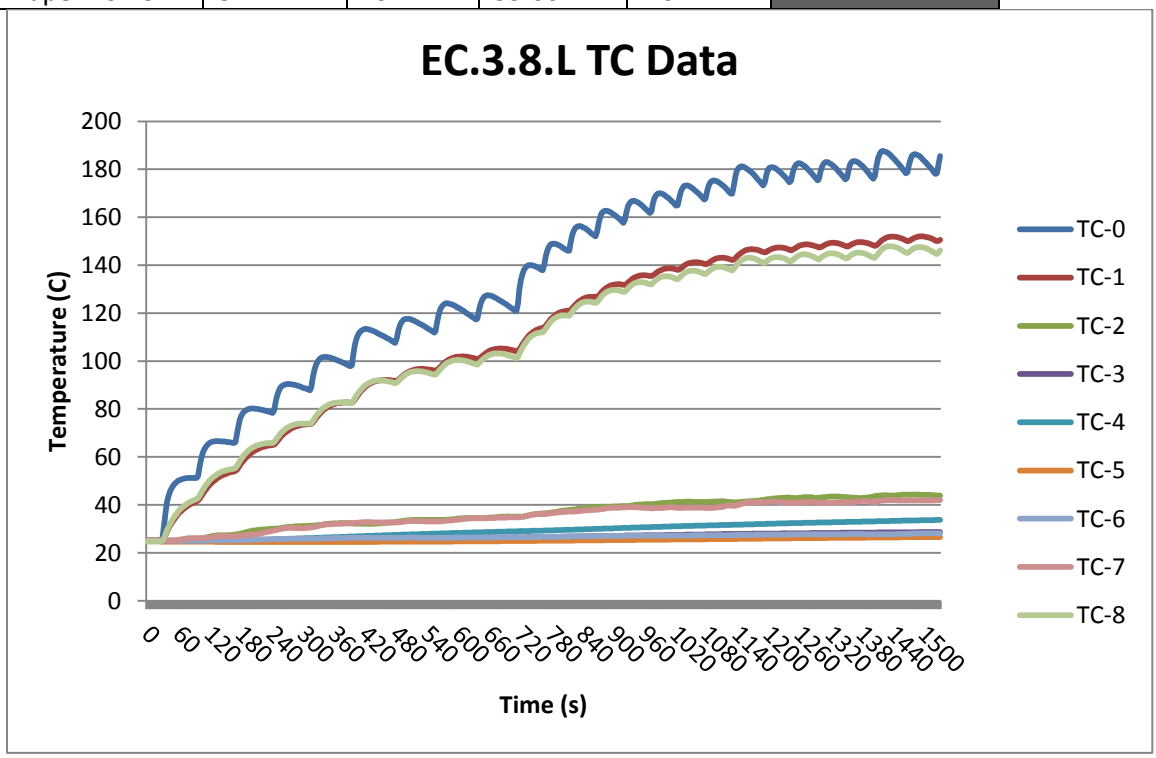
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.6.M	Paper Towel	6”	Medium	15:00	No	



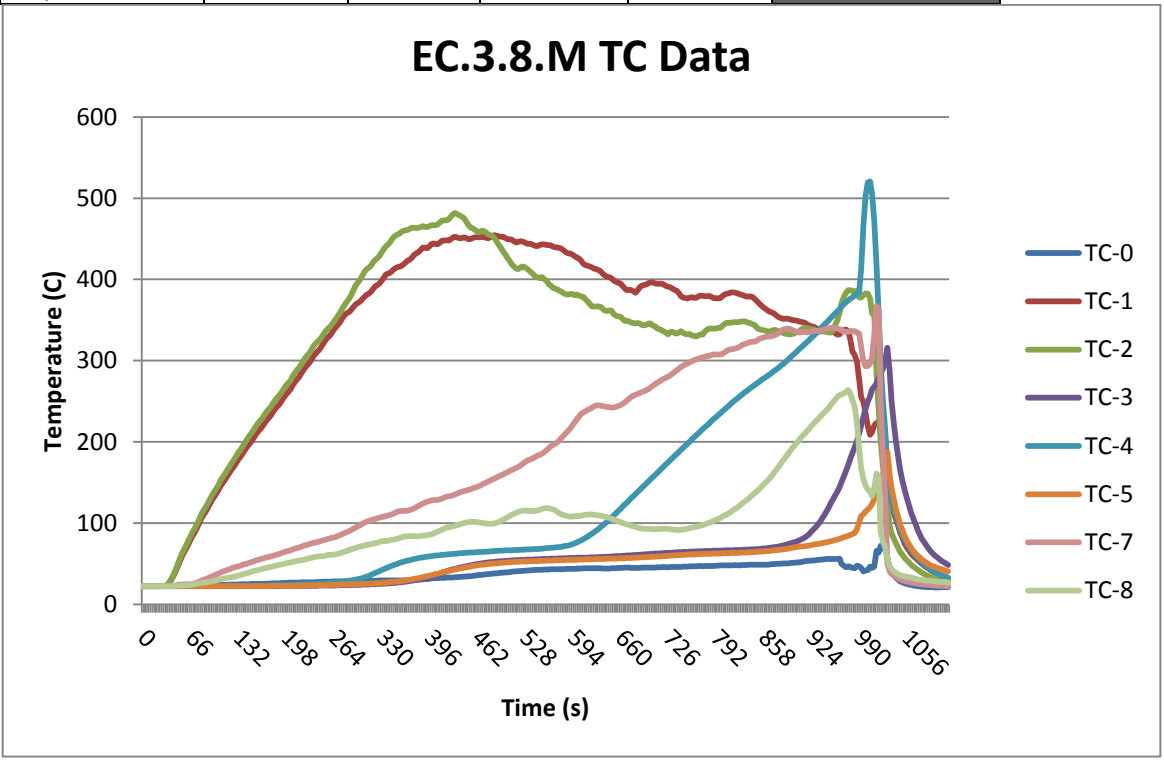
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.6.H	Paper Towel	6”	High	1:29	Yes	1:29

No Graph

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.8.L	Paper Towel	8”	Low	35:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.8.M	Paper Towel	8”	Medium	15:00	No	



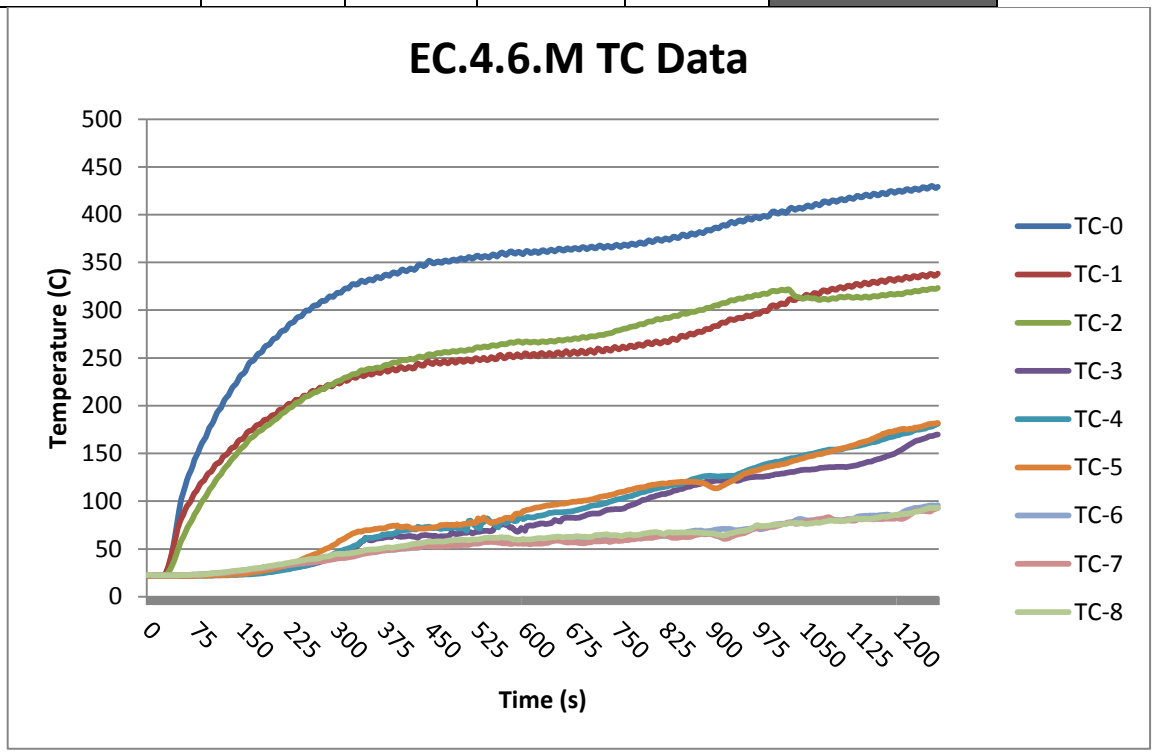
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.3.8.H	Paper Towel	8”	High	1:36	Yes	1:36

No Graph

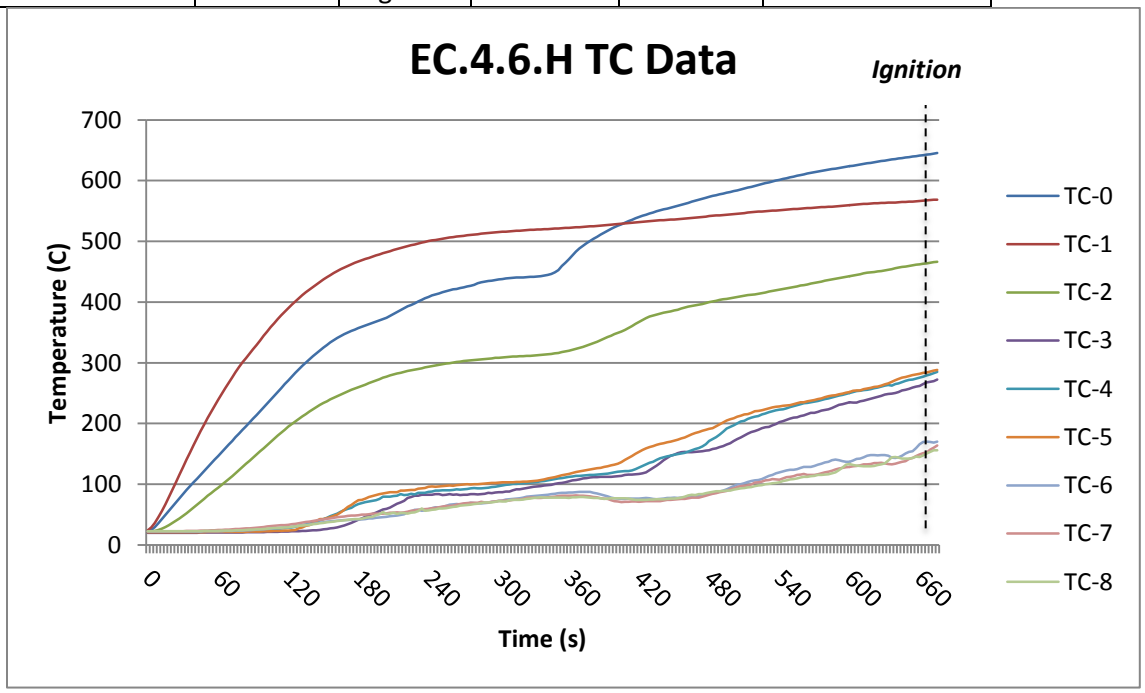
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.6.L	Canola Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.6.M	Canola Oil	6”	Medium	20:00	No	



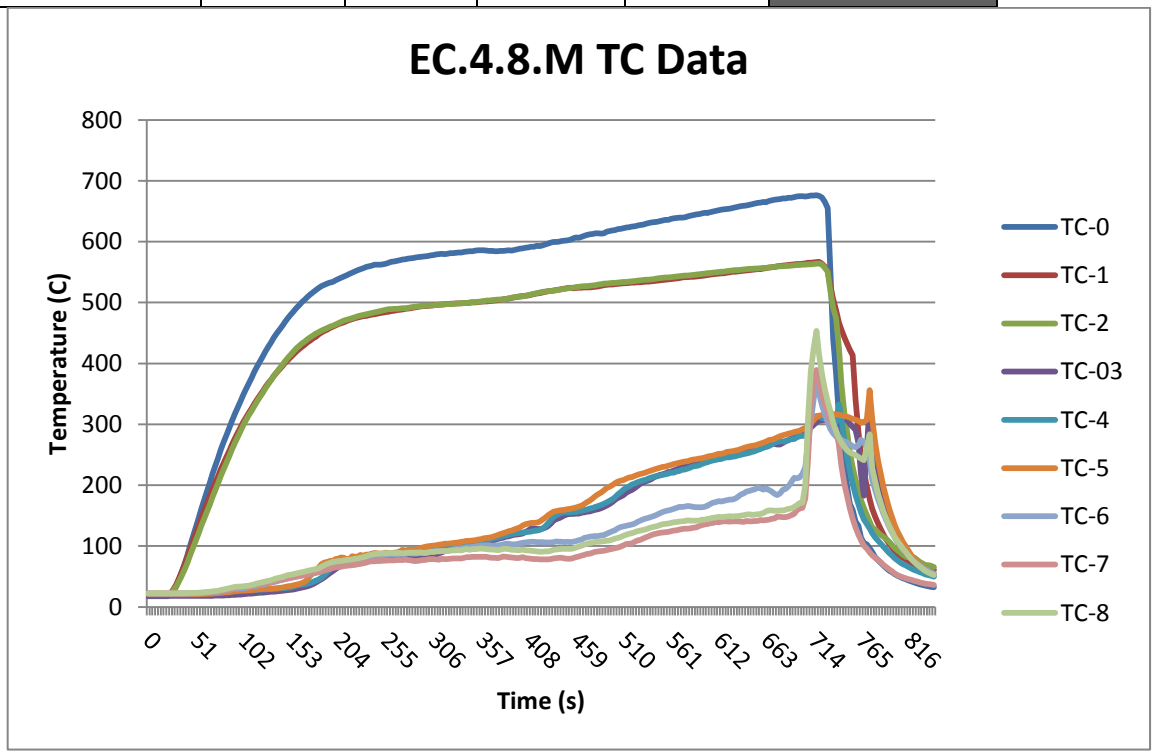
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.6.H	Canola Oil	6”	High	11:38	Yes	11:38



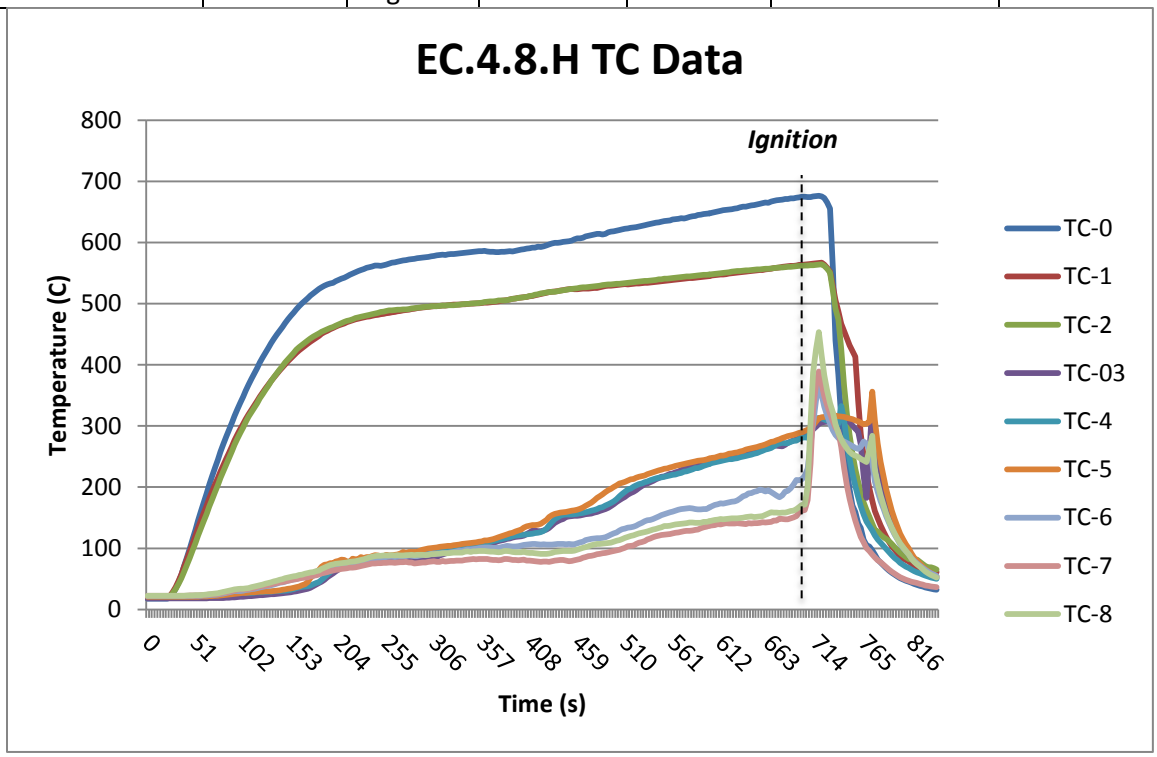
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.8.L	Canola Oil	8”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.8.M	Canola Oil	8”	Medium	20:00	No	



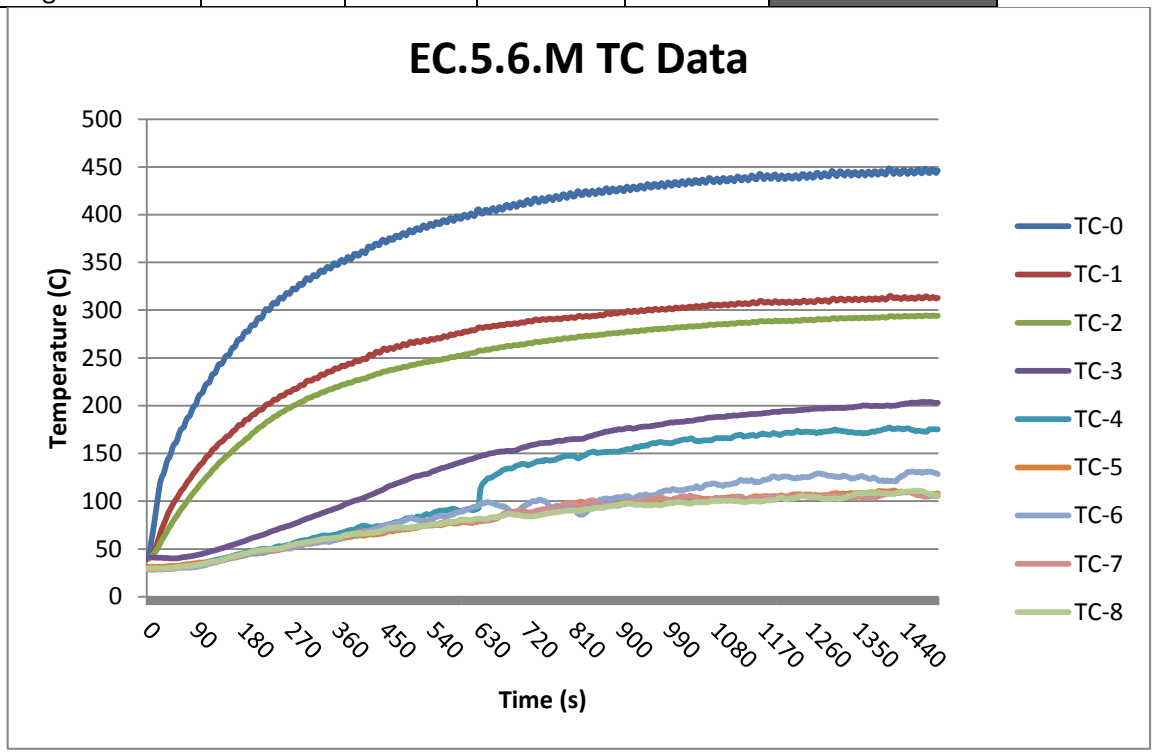
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.4.8.H	Canola Oil	8”	High	11:42	Yes	11:42



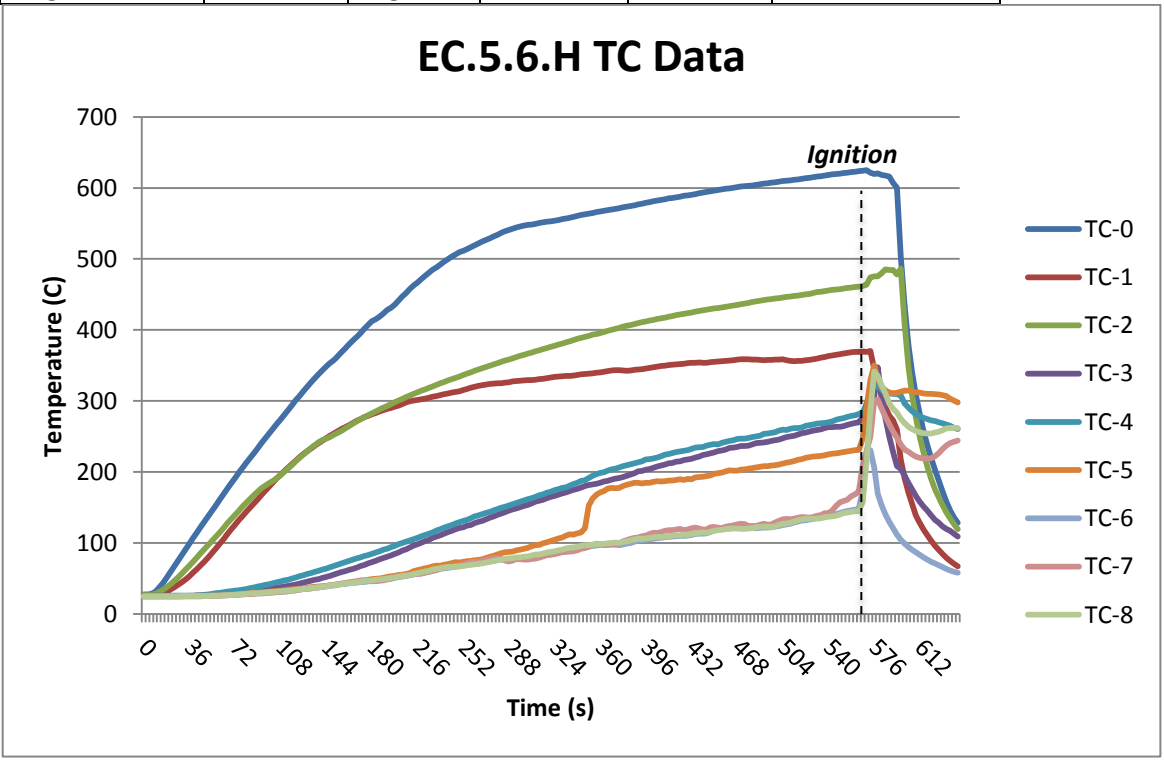
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.6.L	Vegetable Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.6.M	Vegetable Oil	6”	Medium	25:00	No	



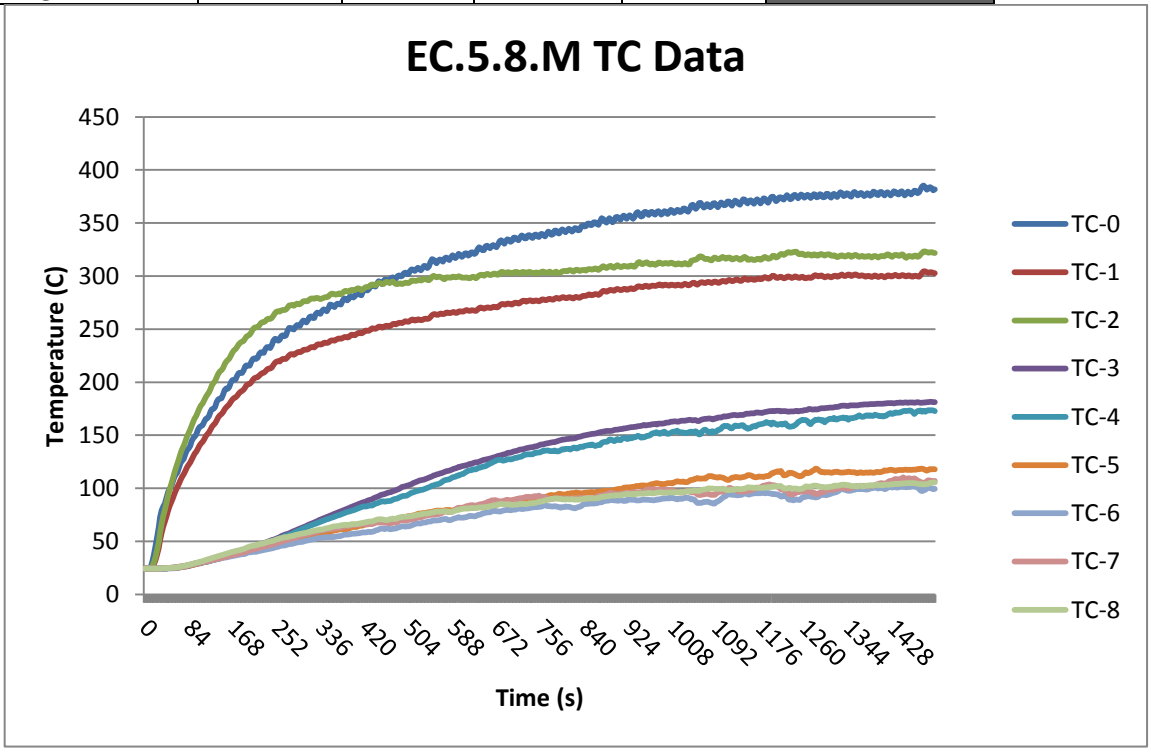
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.6.H	Vegetable Oil	6”	High	9:24	Yes	9:24



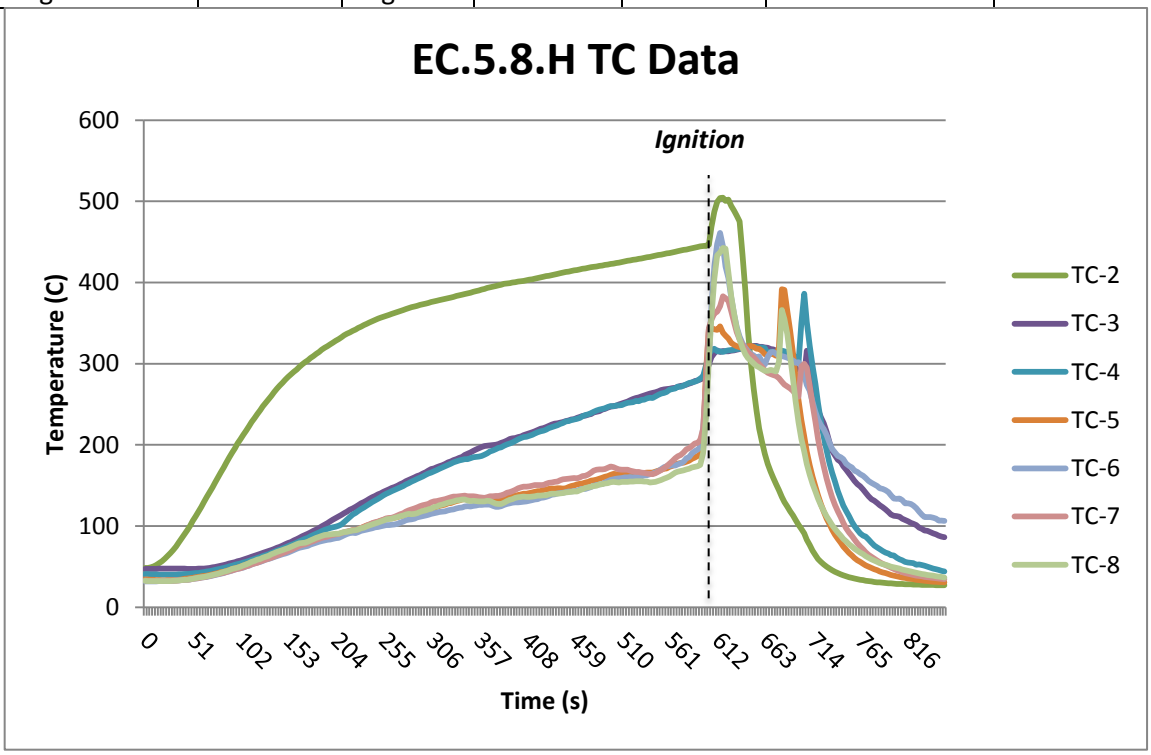
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.8.L	Vegetable Oil	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.8.M	Vegetable Oil	8”	Medium	25:00	No	



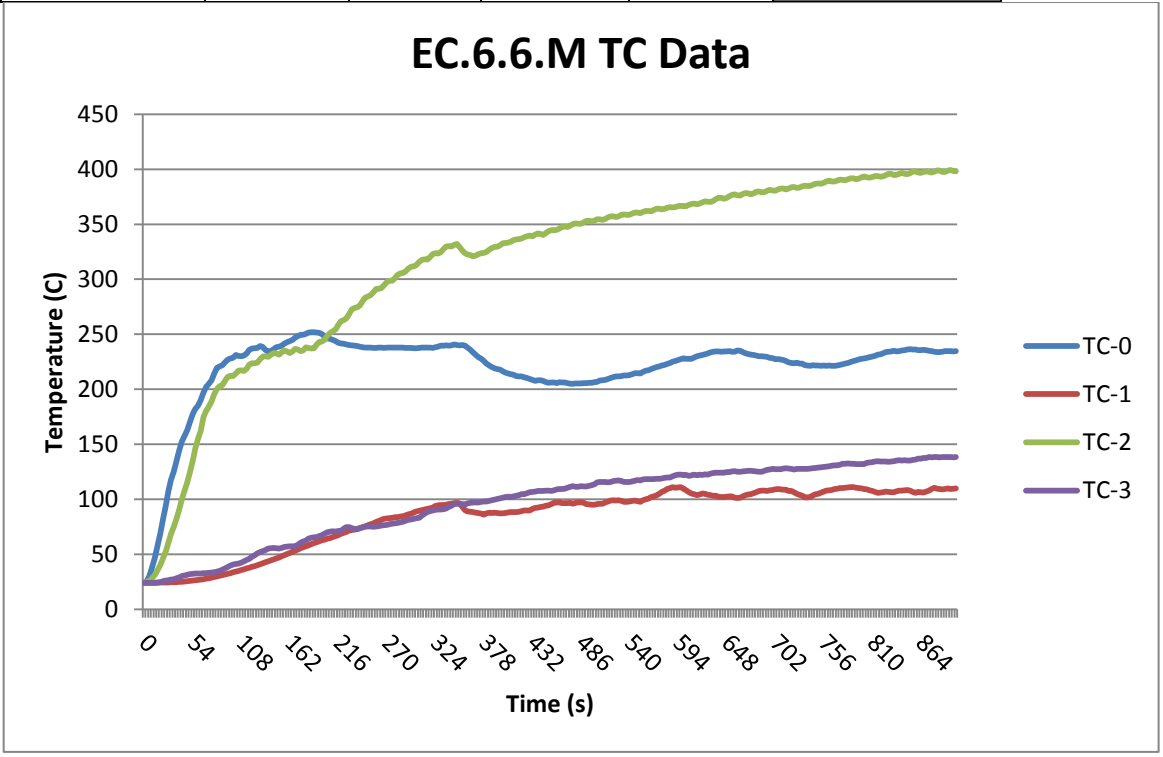
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.5.8.H	Vegetable Oil	8”	High	9:58	Yes	9:58



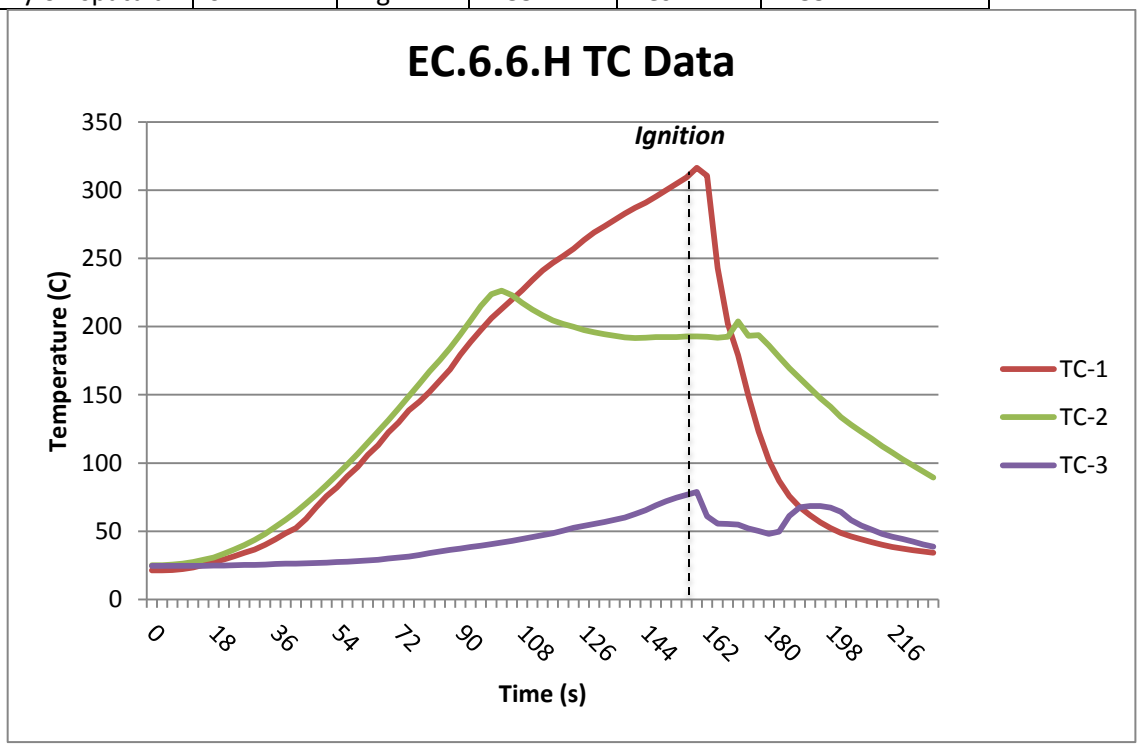
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.6.L	Nylon spatula	6”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.6.M	Nylon spatula	6”	Medium	15:00	No	



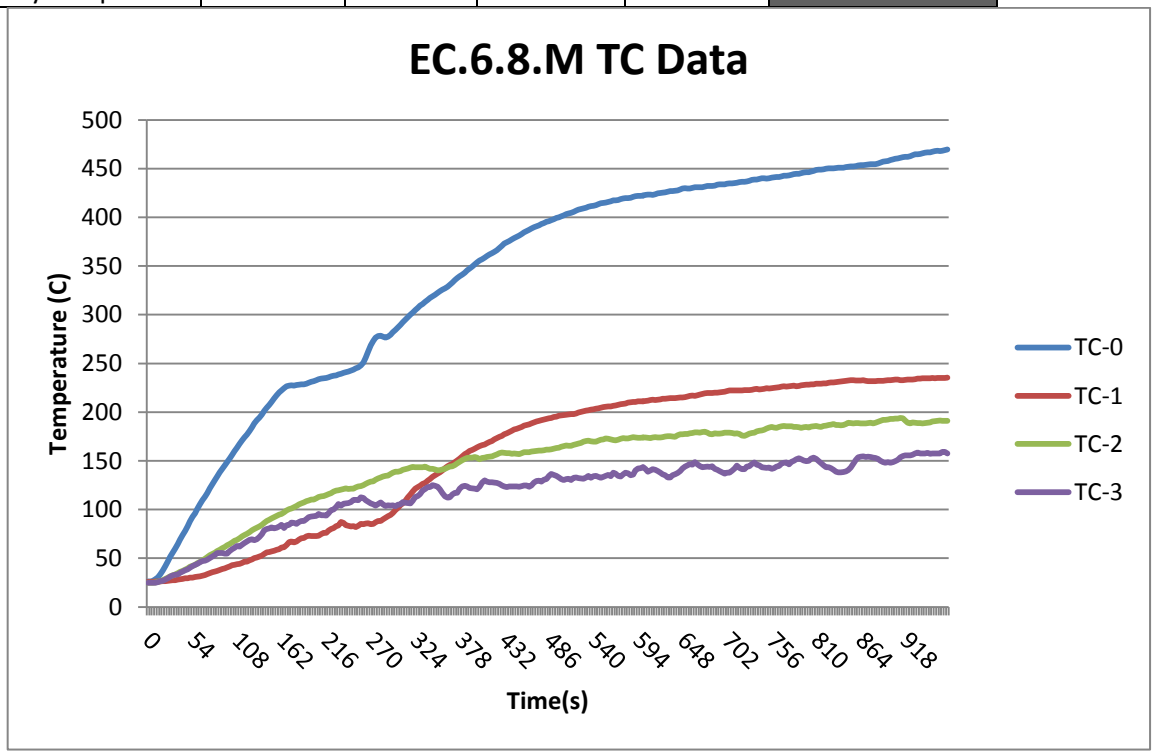
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.6.H	Nylon spatula	6”	High	2:39	Yes	2:39



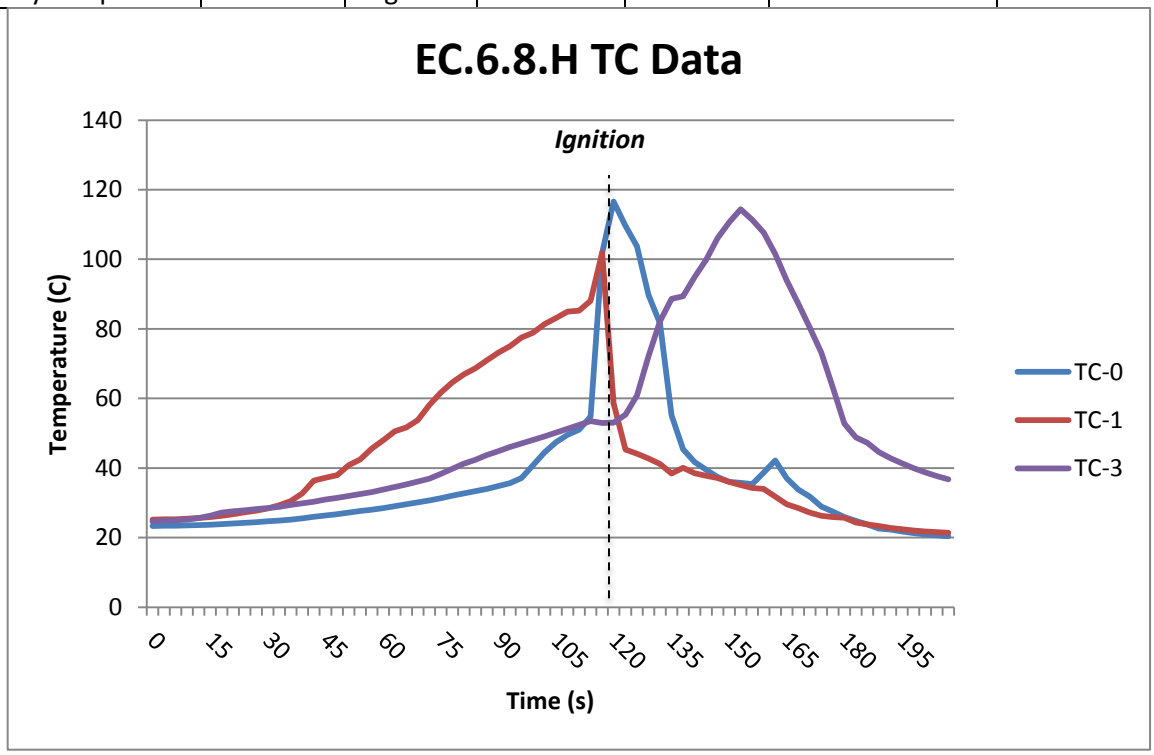
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.8.L	Nylon spatula	8”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.8.M	Nylon spatula	8”	Medium	15:00	No	



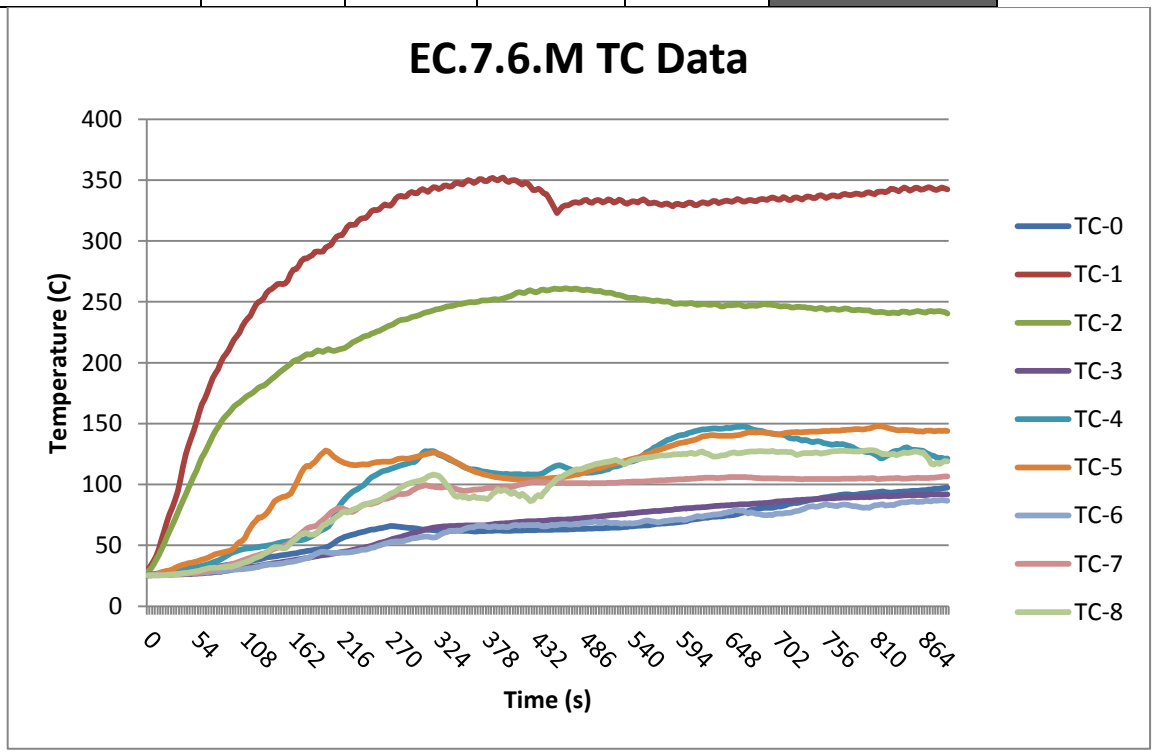
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.6.8.H	Nylon spatula	8”	High	2:07	Yes	2:07



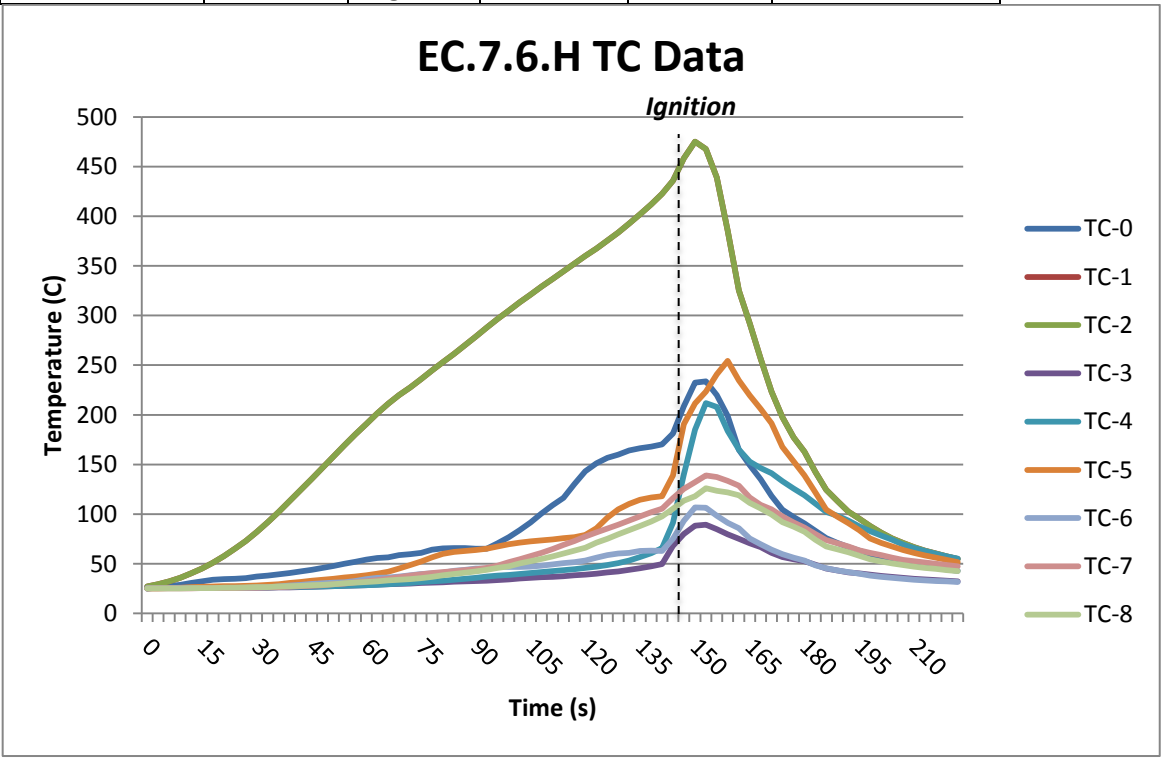
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.6.L	Toaster	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.6.M	Toaster	6”	Medium	15:00	No	



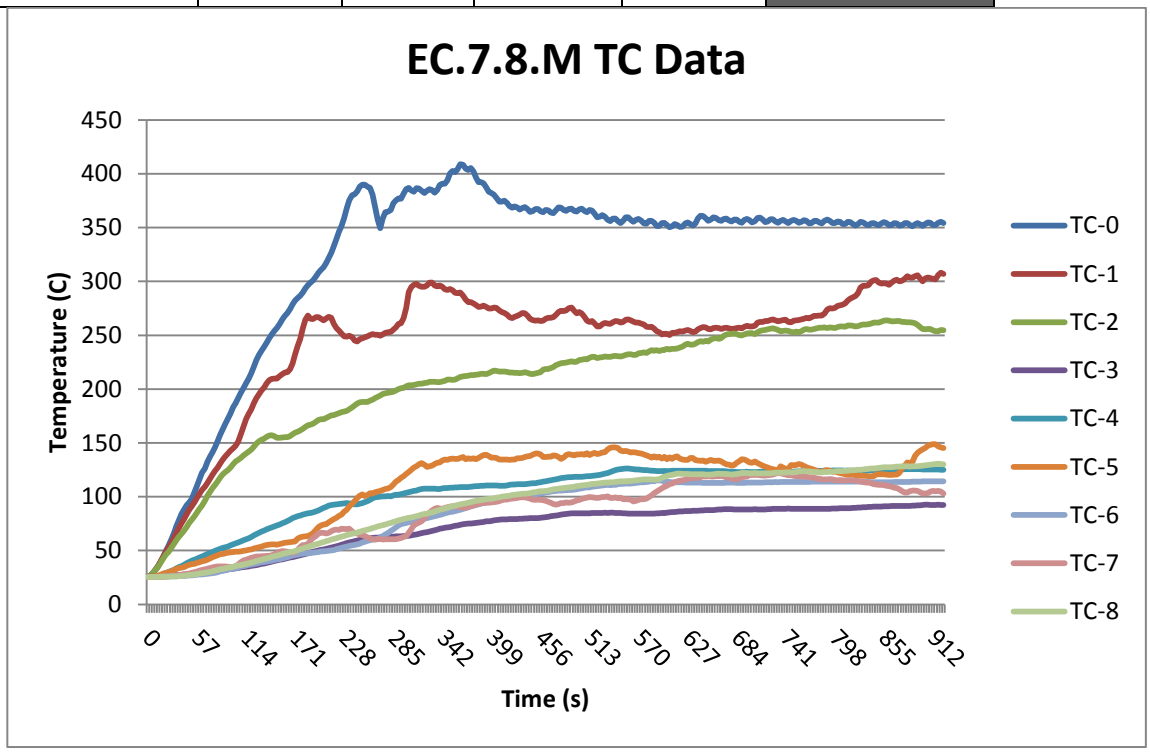
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.6.H	Toaster	6”	High	2:30	Yes	2:30



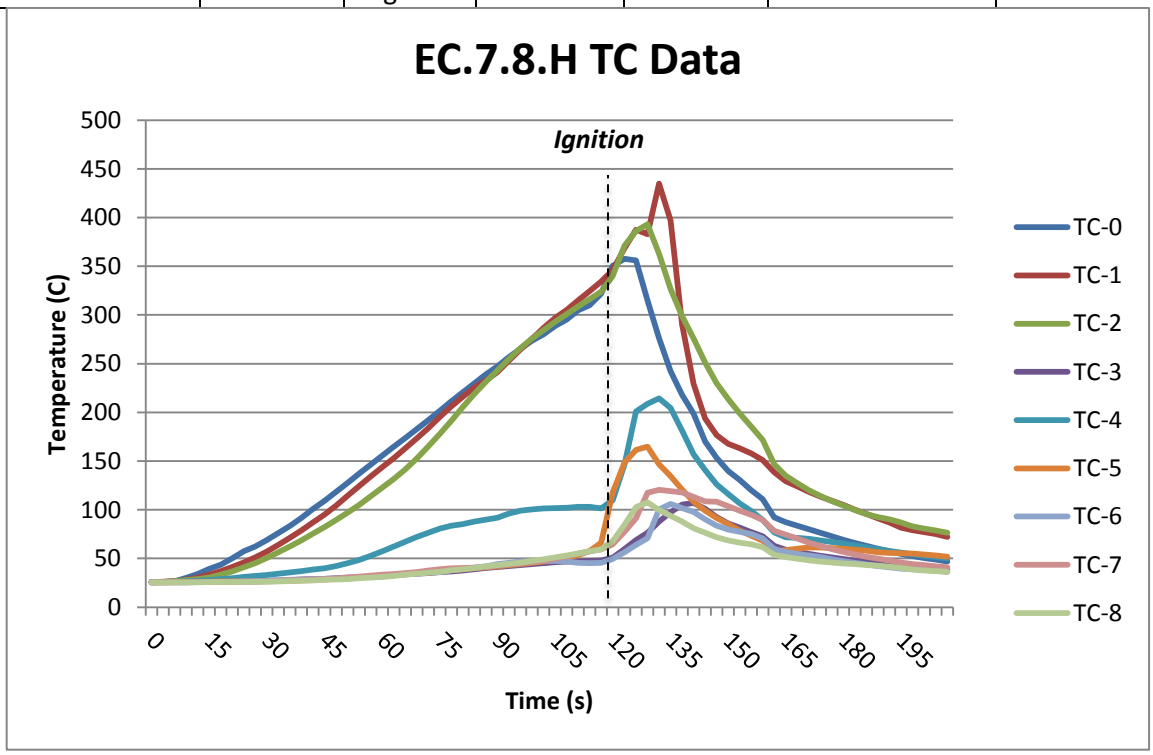
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.8.L	Toaster	8”	Low	No test	No	

No Test Conducted

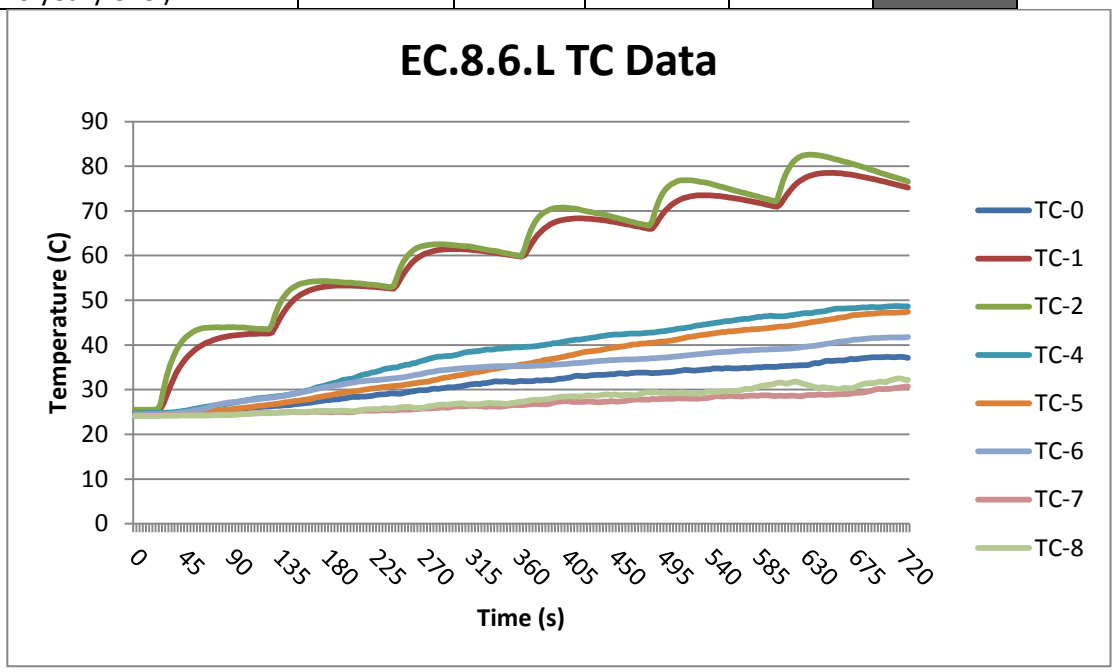
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.8.M	Toaster	8”	Medium	15:00	No	



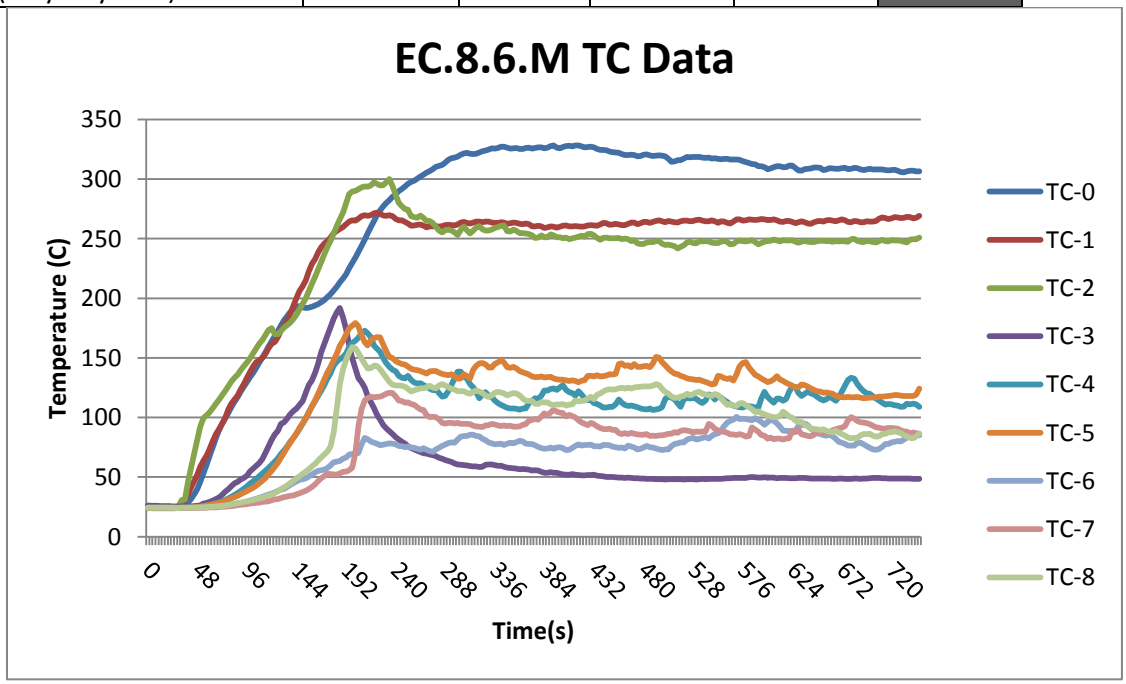
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.7.8.H	Toaster	8”	High	2:00	Yes	2:00



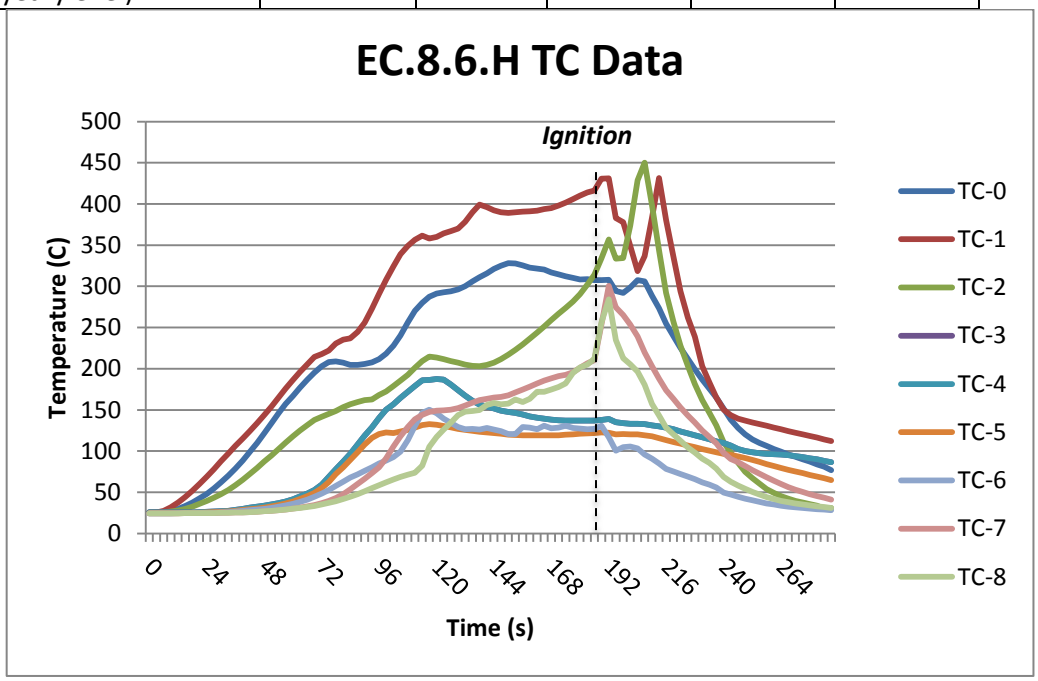
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.6.L	Food Storage Container (Polyethylene)	6”	Low	12:00	No	



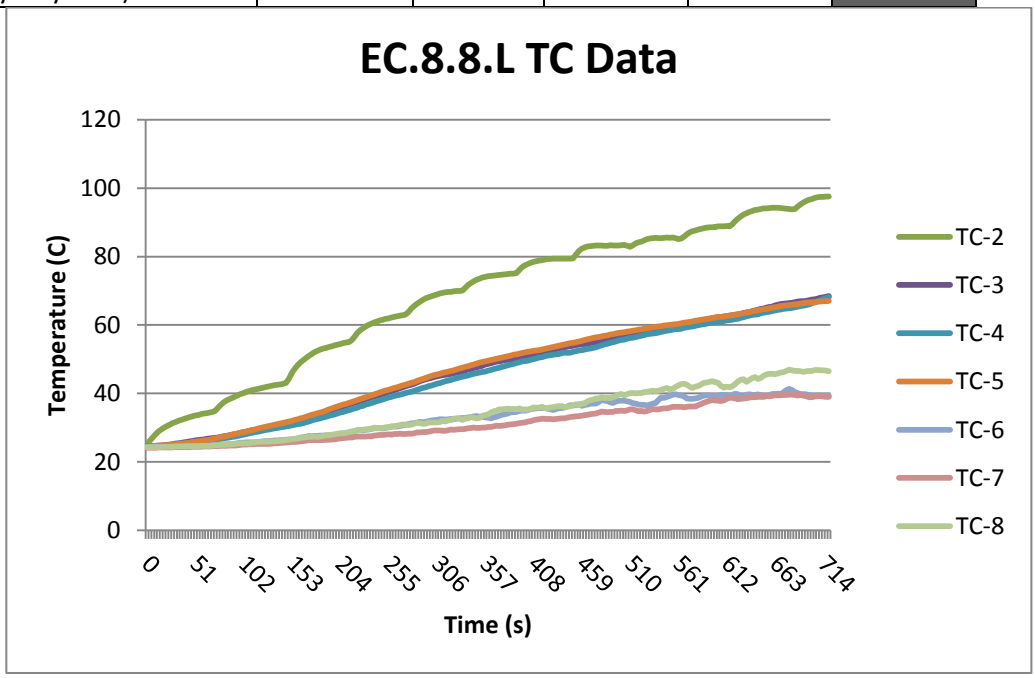
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	12:00	No	



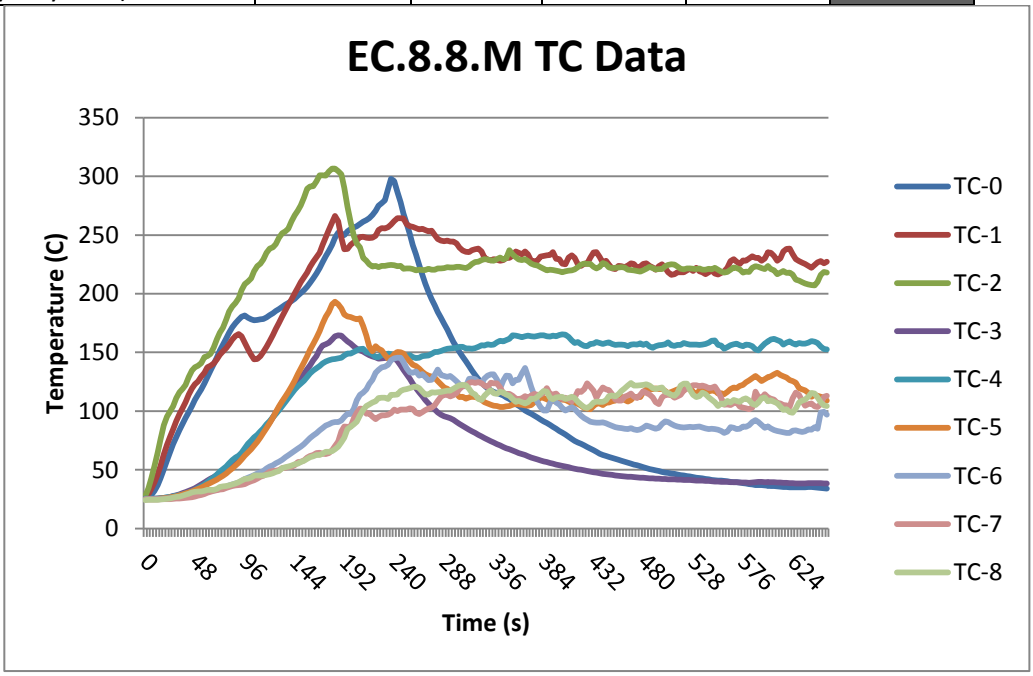
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.6.H	Food Storage Container (Polyethylene)	6”	High	3:05	Yes	3:05



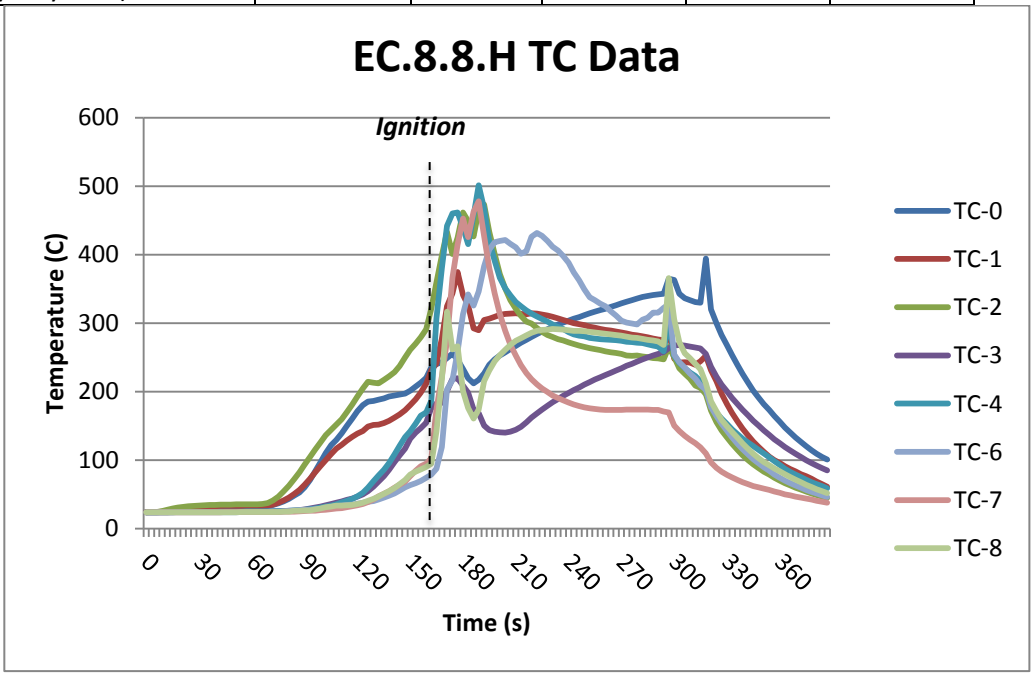
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.8.L	Food Storage Container (Polyethylene)	8”	Low	12:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	12:00	No	

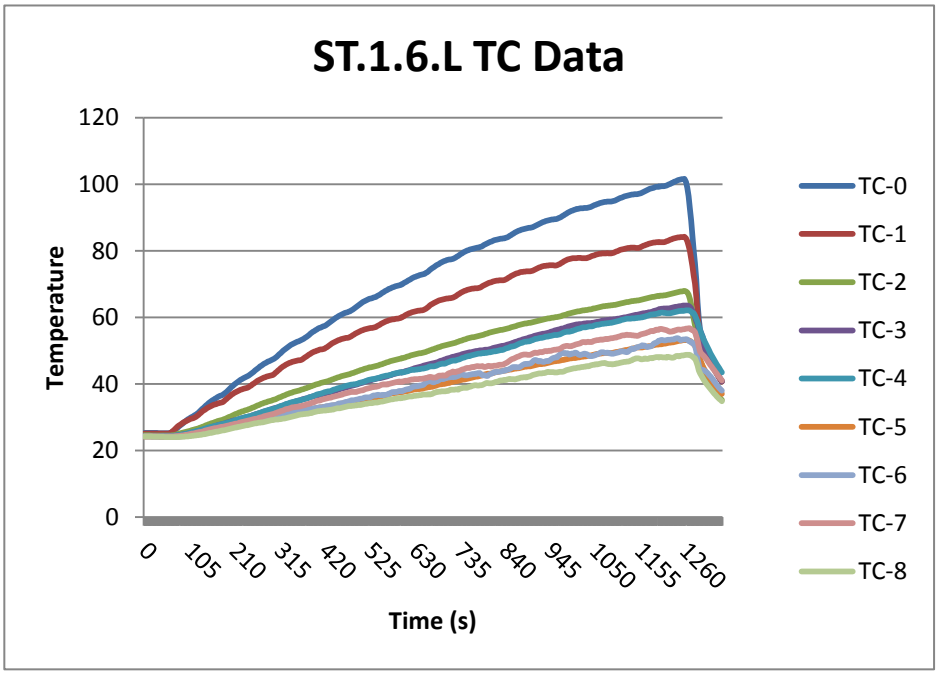


Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
EC.8.8.H	Food Storage Container (Polyethylene)	8”	High	1:36	Yes	1:36

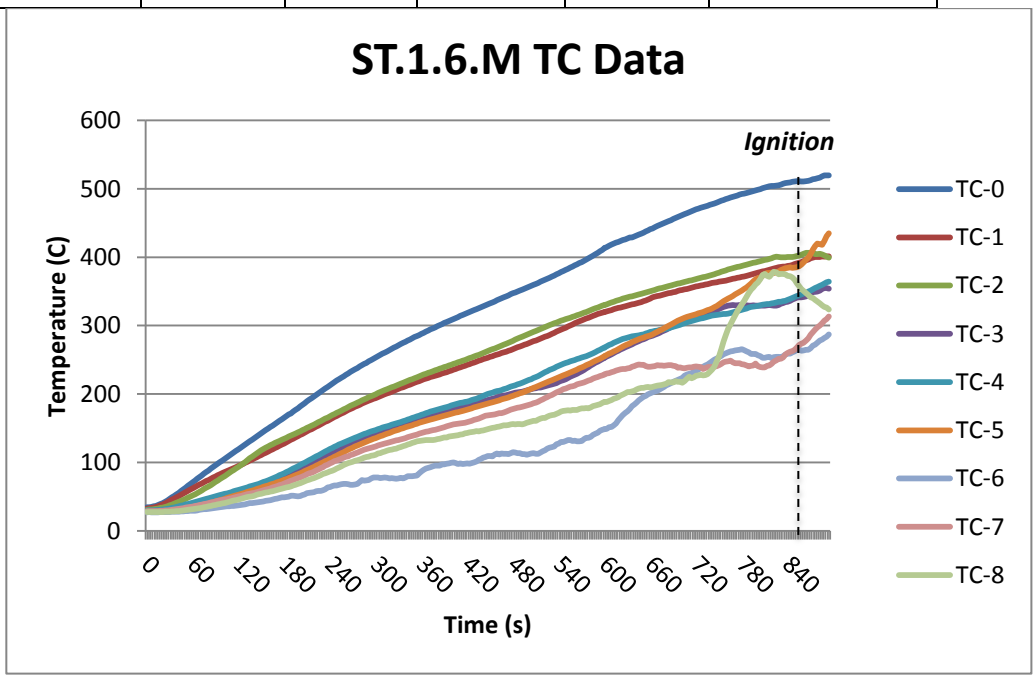


Appendix E – Electric Coil Cooktop Range with Safe-T-element Installed Results

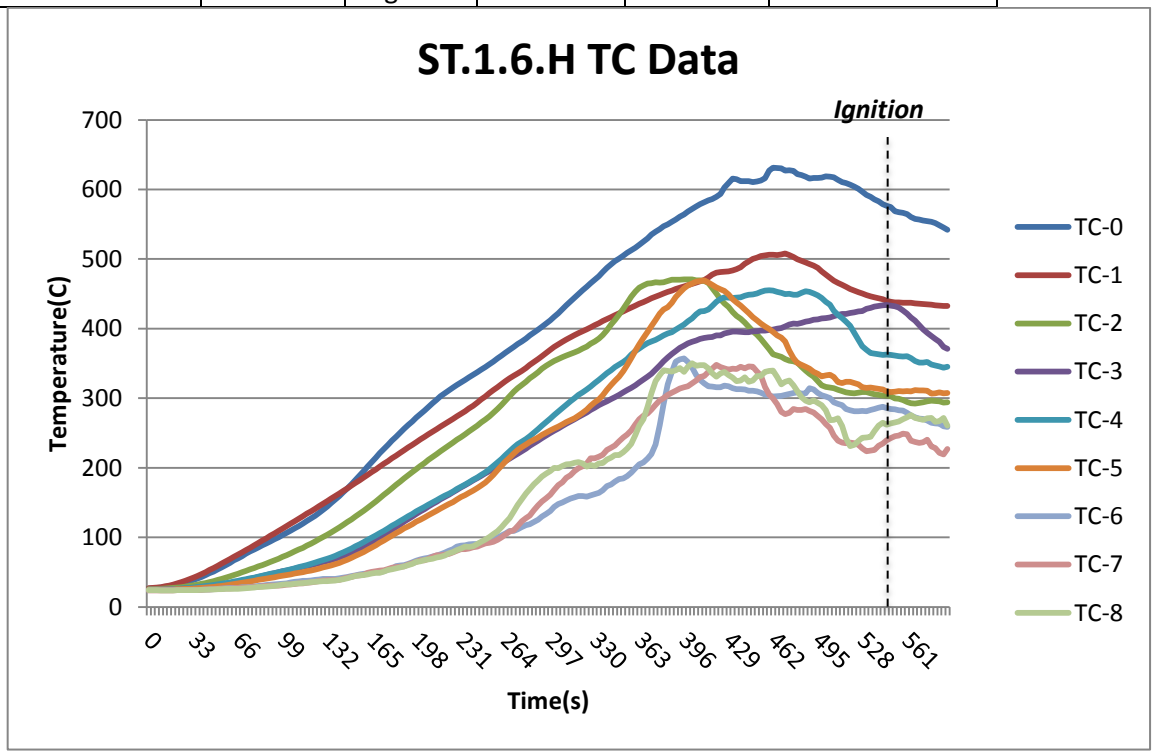
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.6.L	Cardboard	6”	Low	20:00	No	



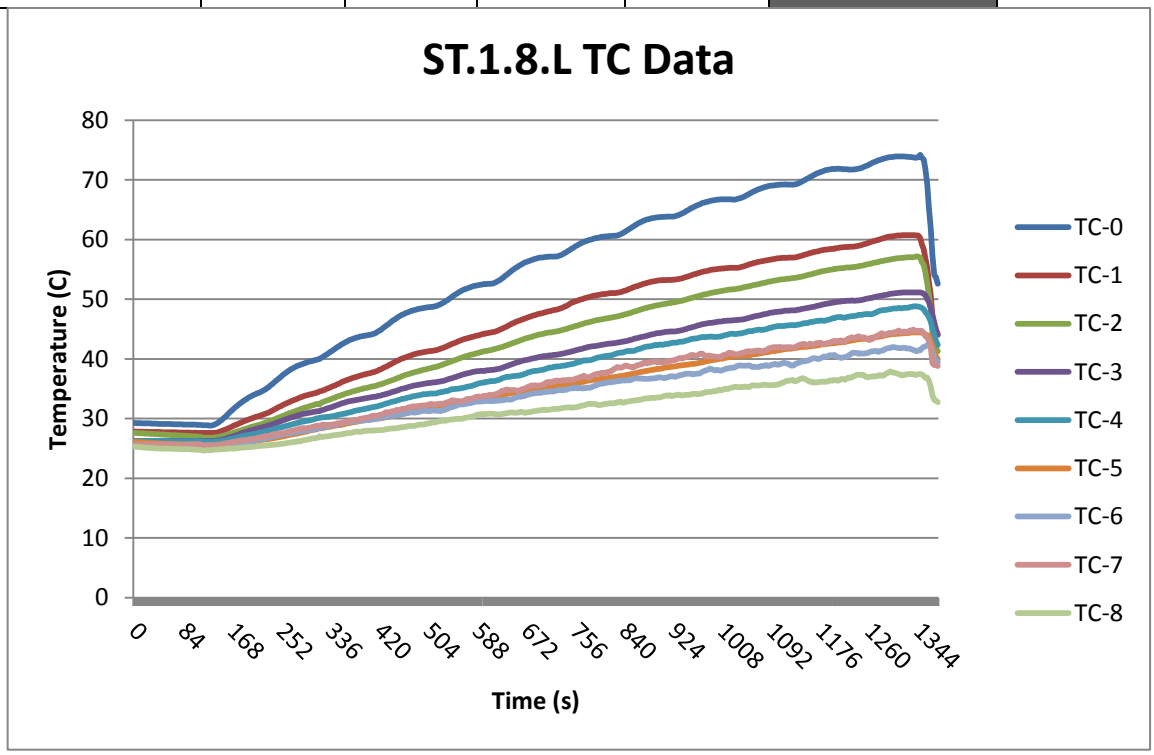
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.6.M	Cardboard	6”	Medium	15:00	Yes	15:00



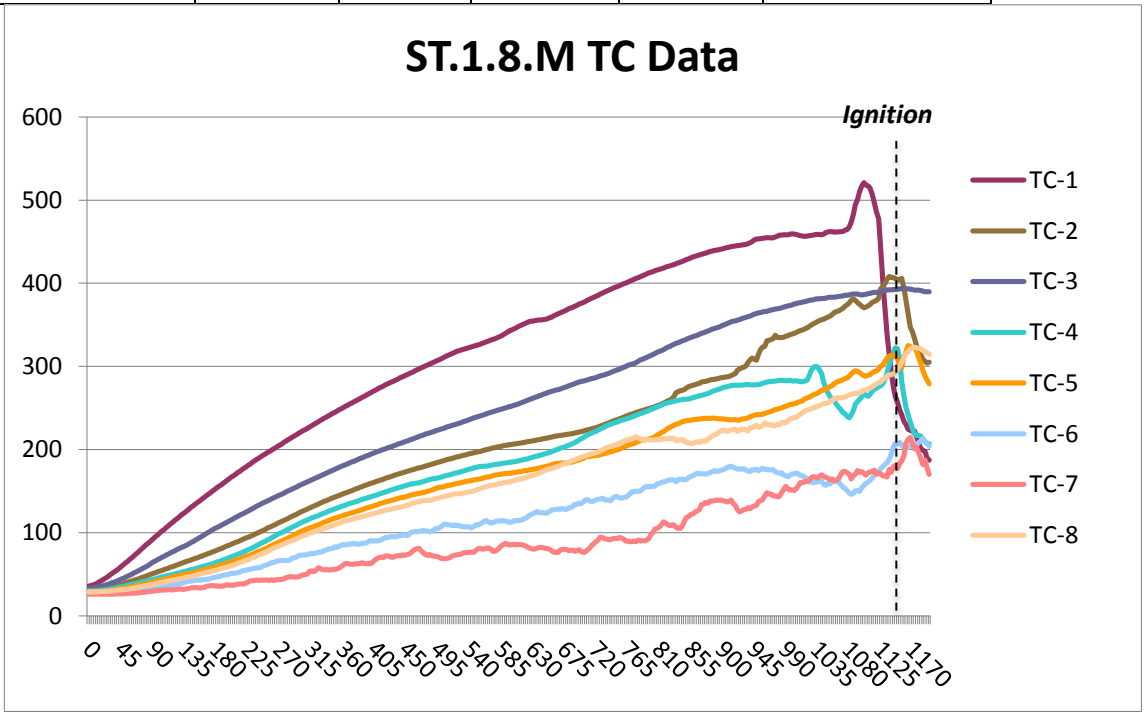
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.6.H	Cardboard	6”	High	9:25	Yes	9:25



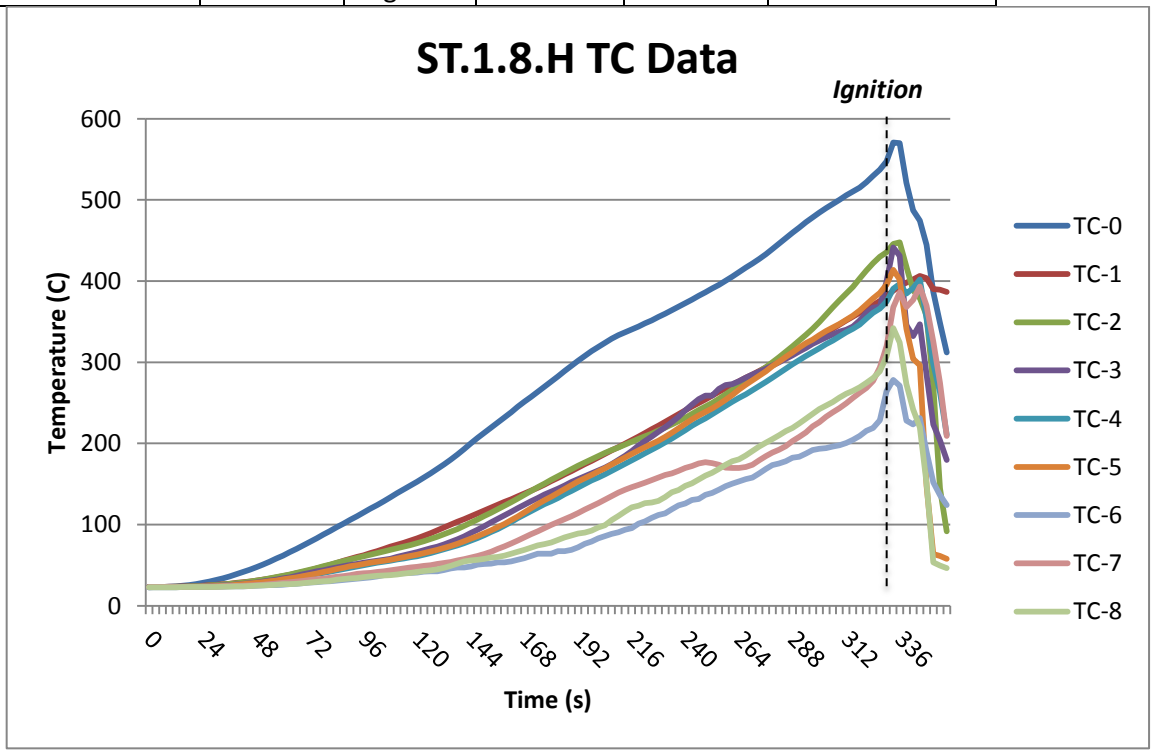
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.8.L	Cardboard	8”	Low	20:00	No	



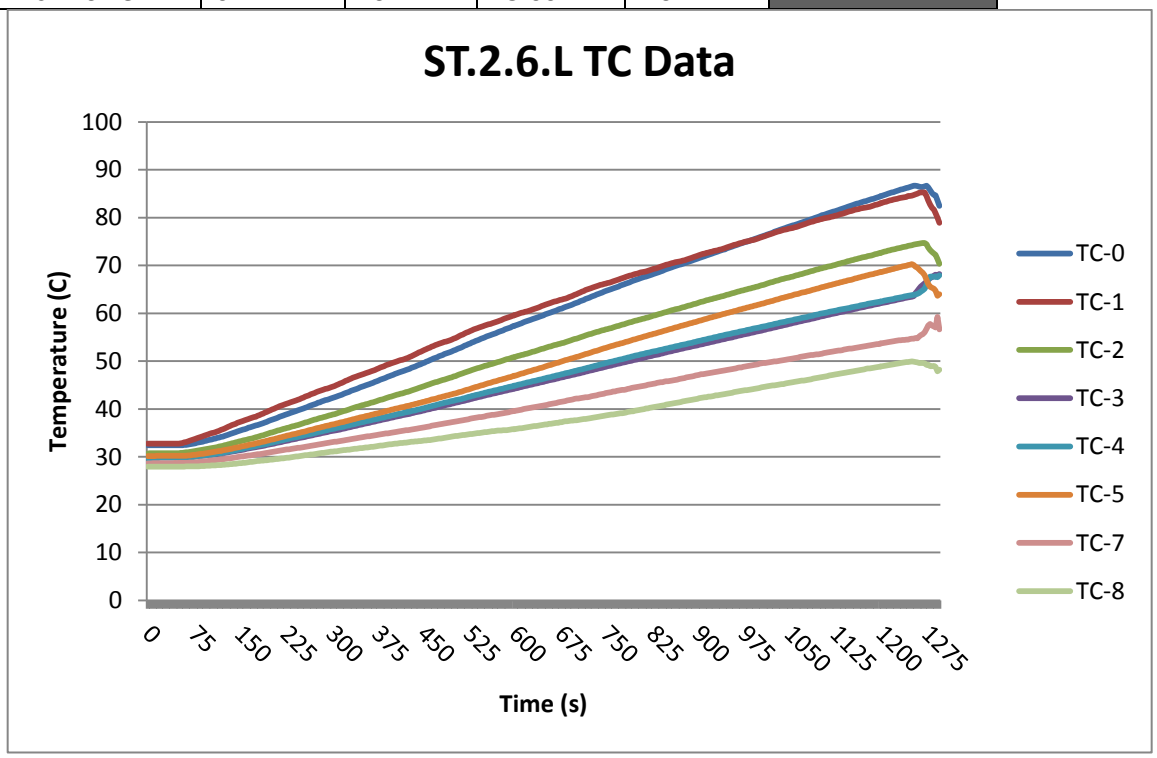
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.8.M	Cardboard	8”	Medium	20:30	Yes	20:30



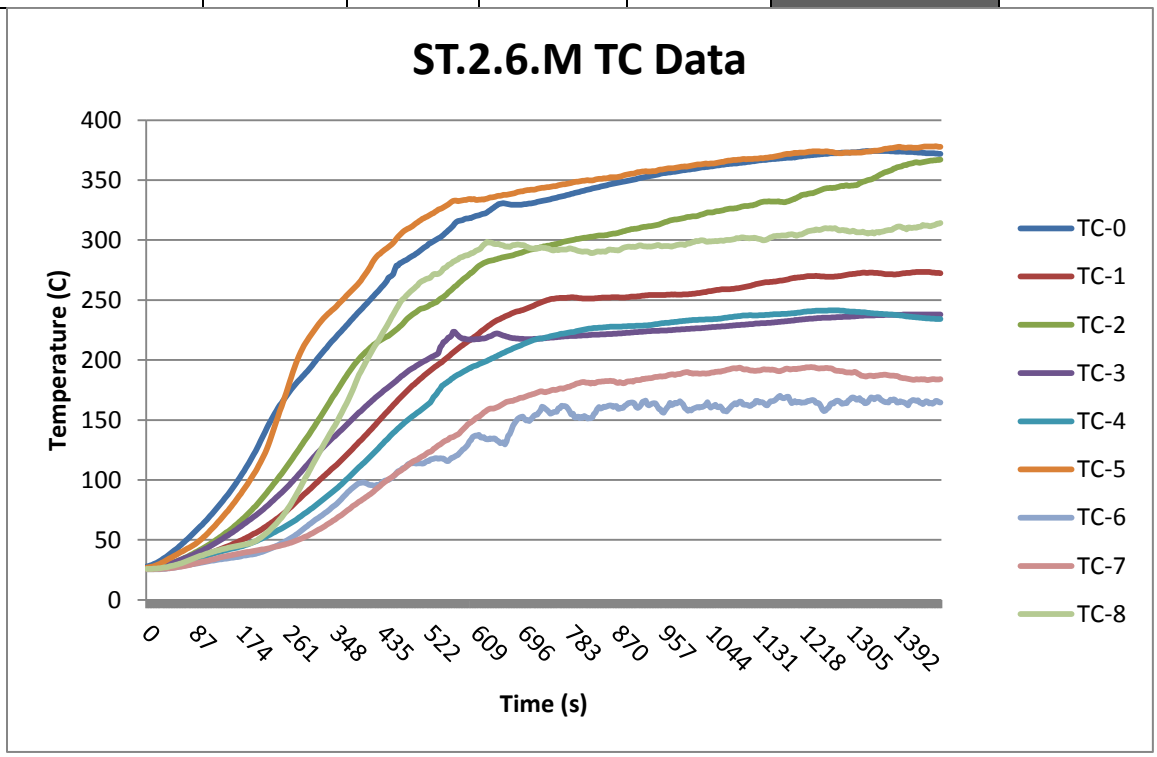
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.1.8.H	Cardboard	8”	High	5:10	Yes	5:10



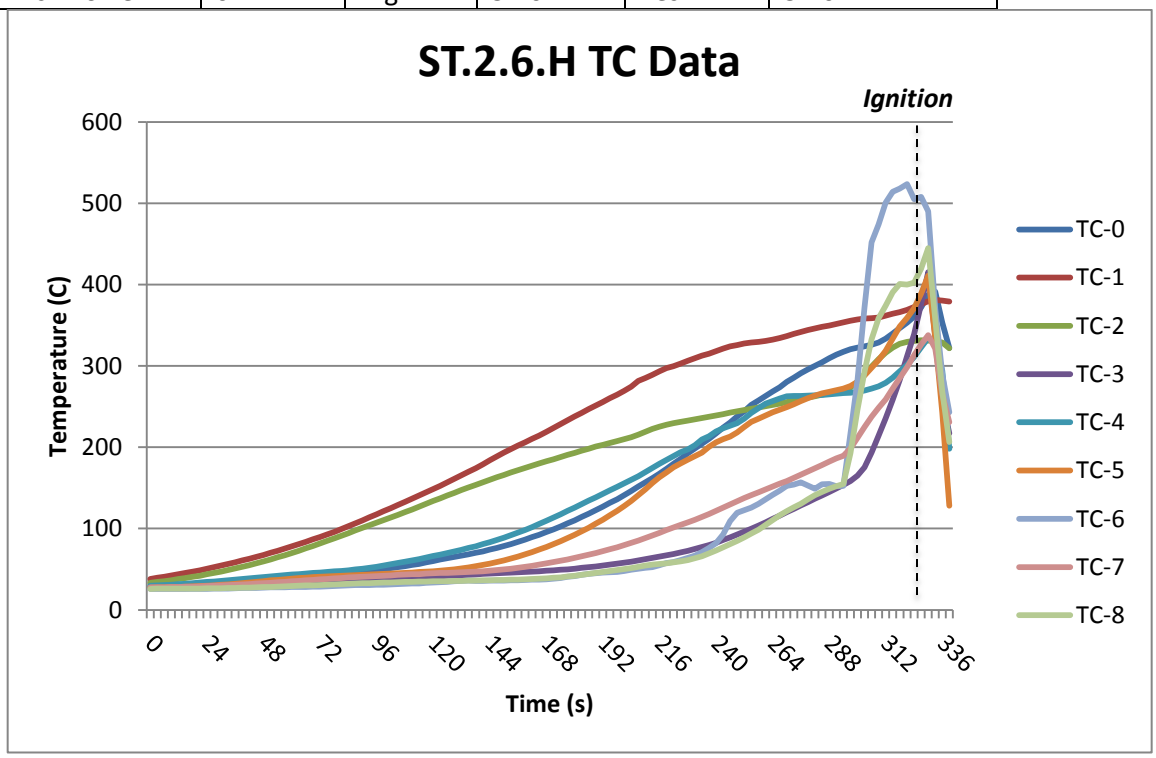
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.6.L	Dish Towel	6”	Low	25:00	No	



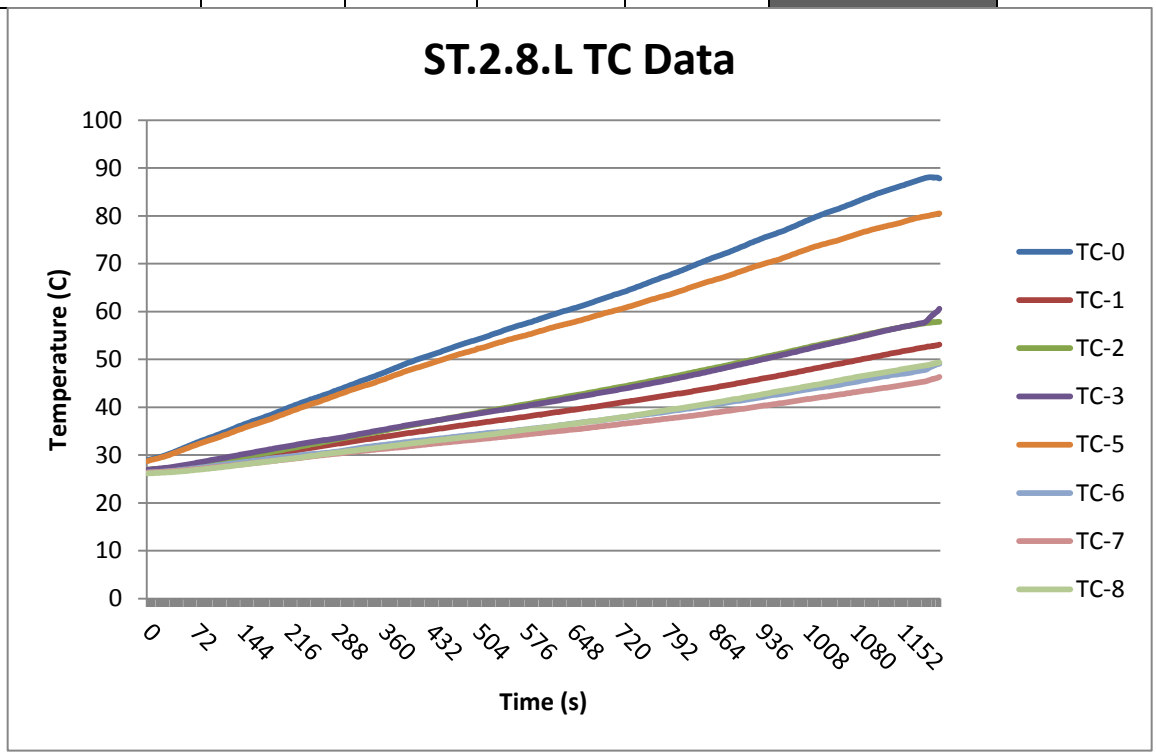
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.6.M	Dish Towel	6”	Medium	25:00	No	



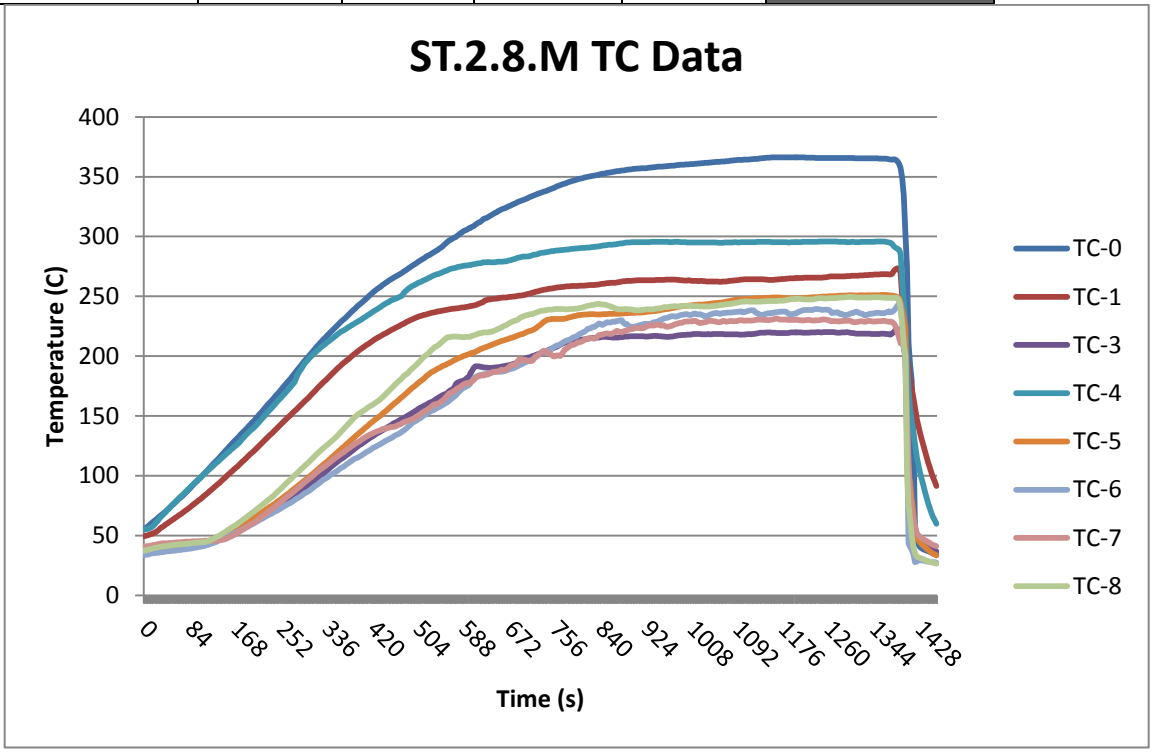
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.6.H	Dish Towel	6”	High	5:46	Yes	5:46



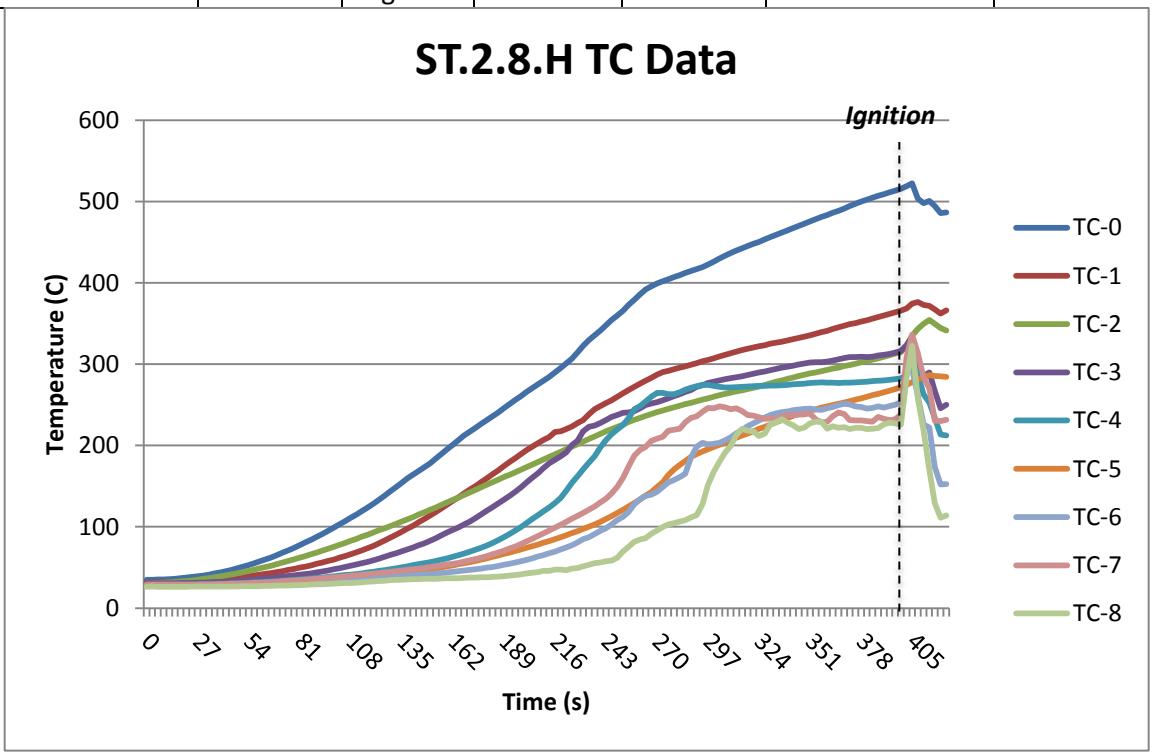
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.8.L	Dish Towel	8”	Low	25:00	No	



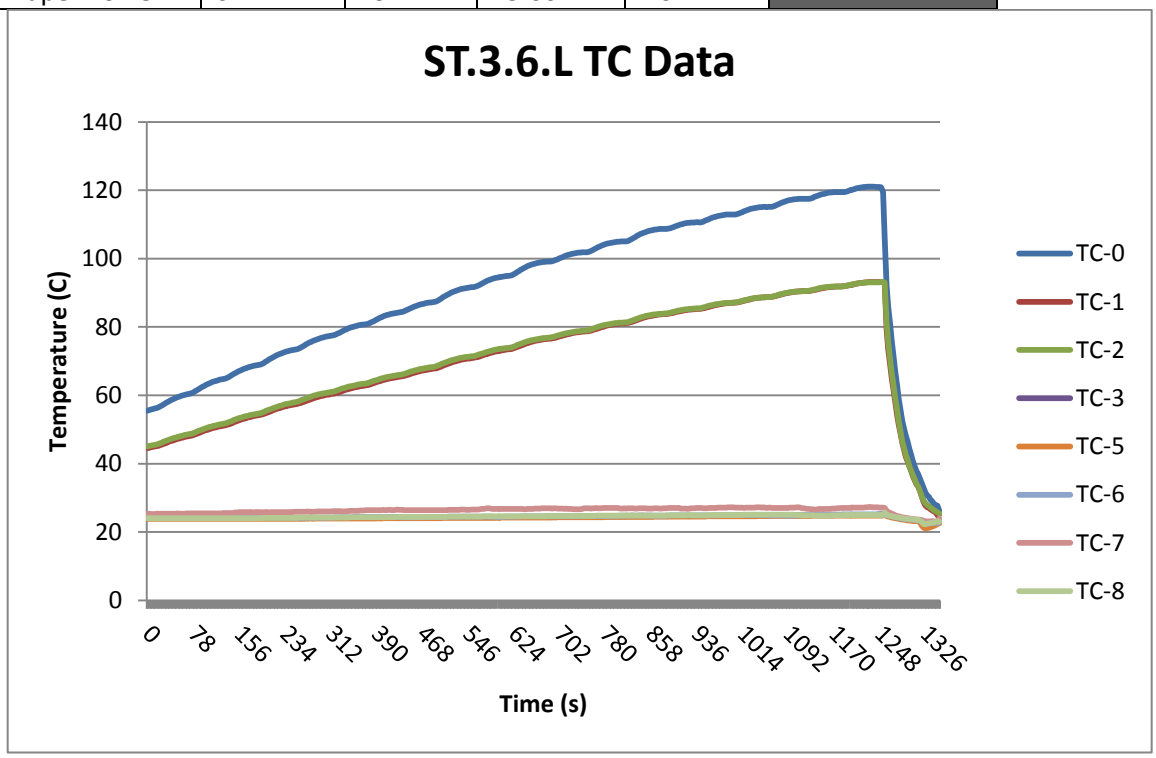
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.8.M	Dish Towel	8”	Medium	25:00	No	



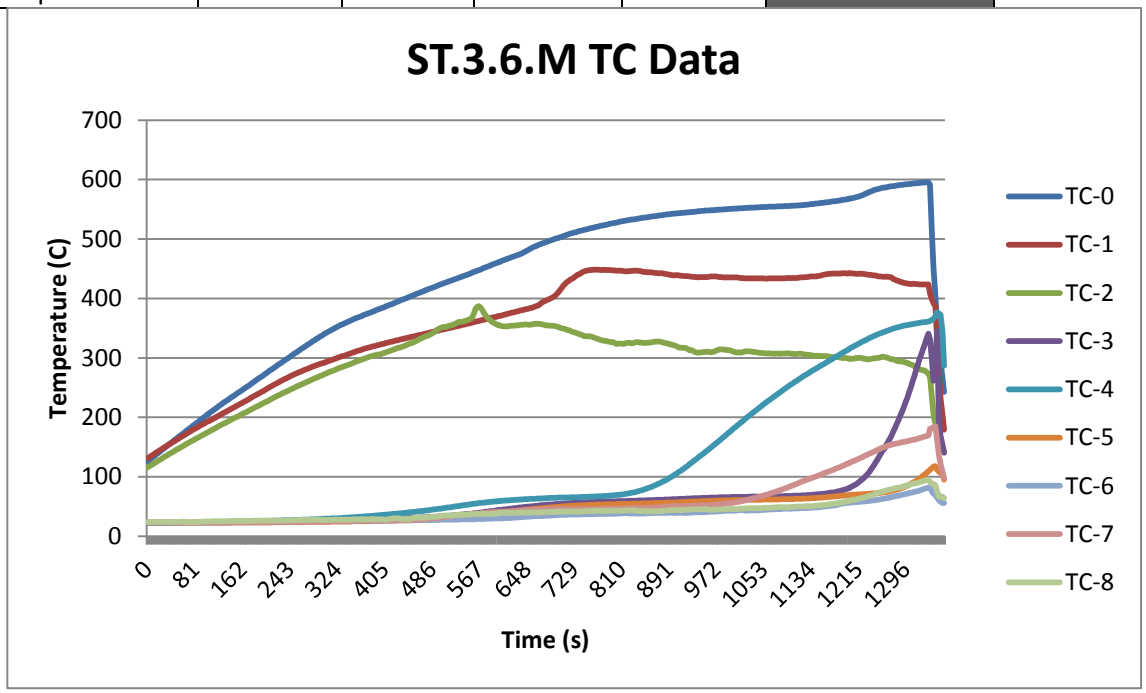
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.2.8.H	Dish Towel	8”	High	6:55	Yes	6:55



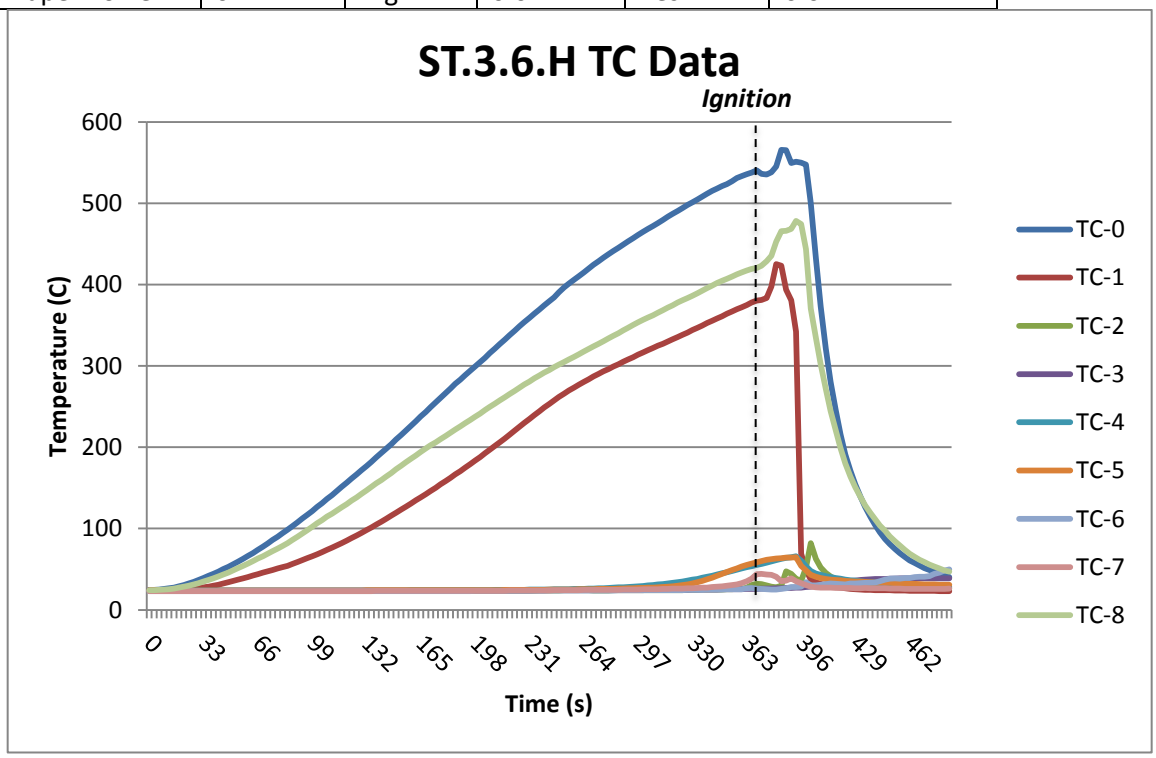
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.6.L	Paper Towel	6”	Low	25:00	No	



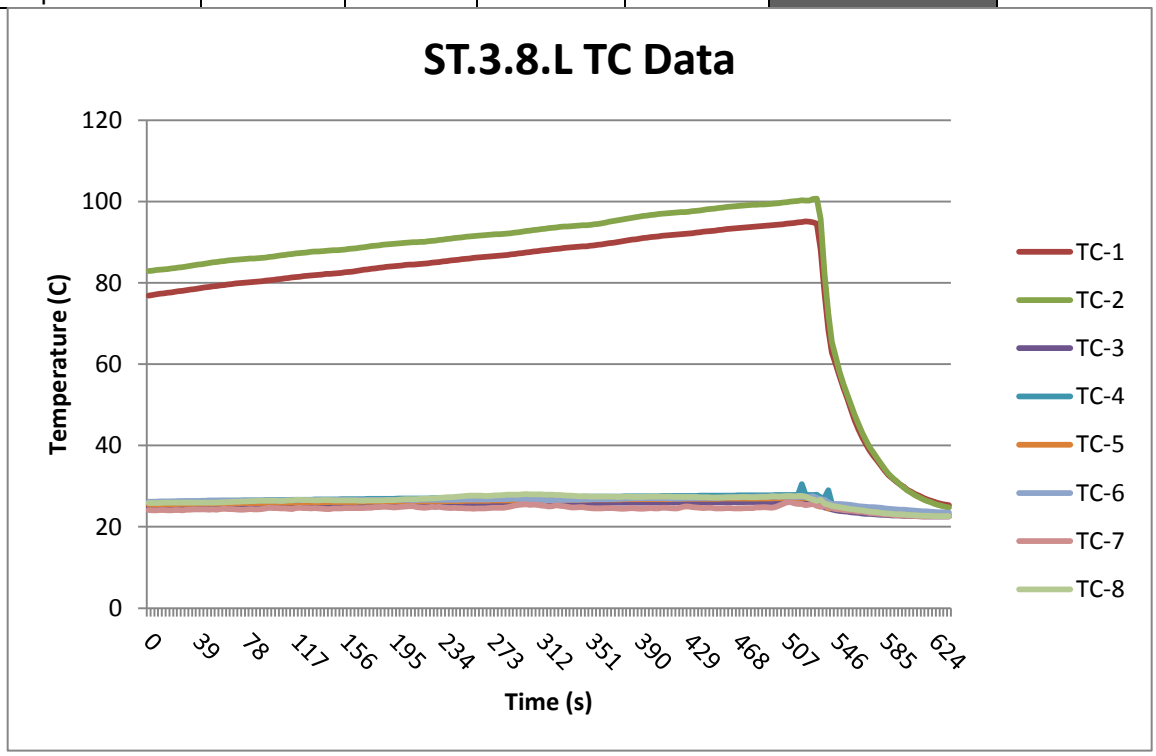
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.6.M	Paper Towel	6”	Medium	25:00	No	



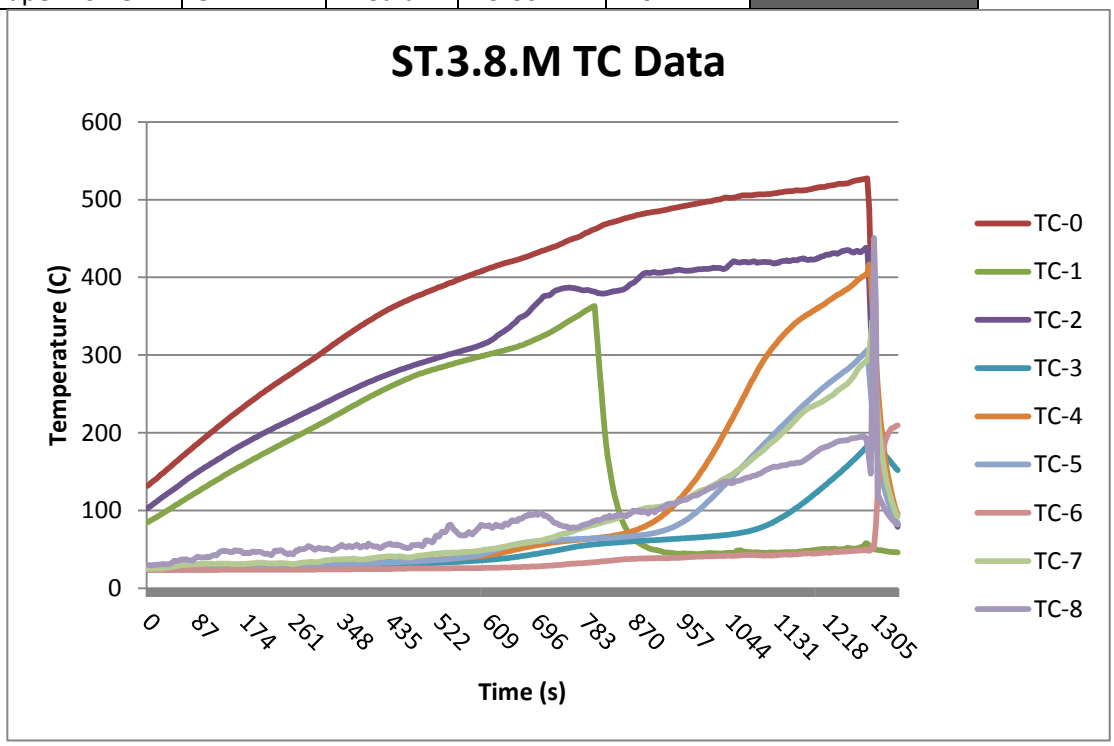
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.6.H	Paper Towel	6”	High	6:04	Yes	6:04



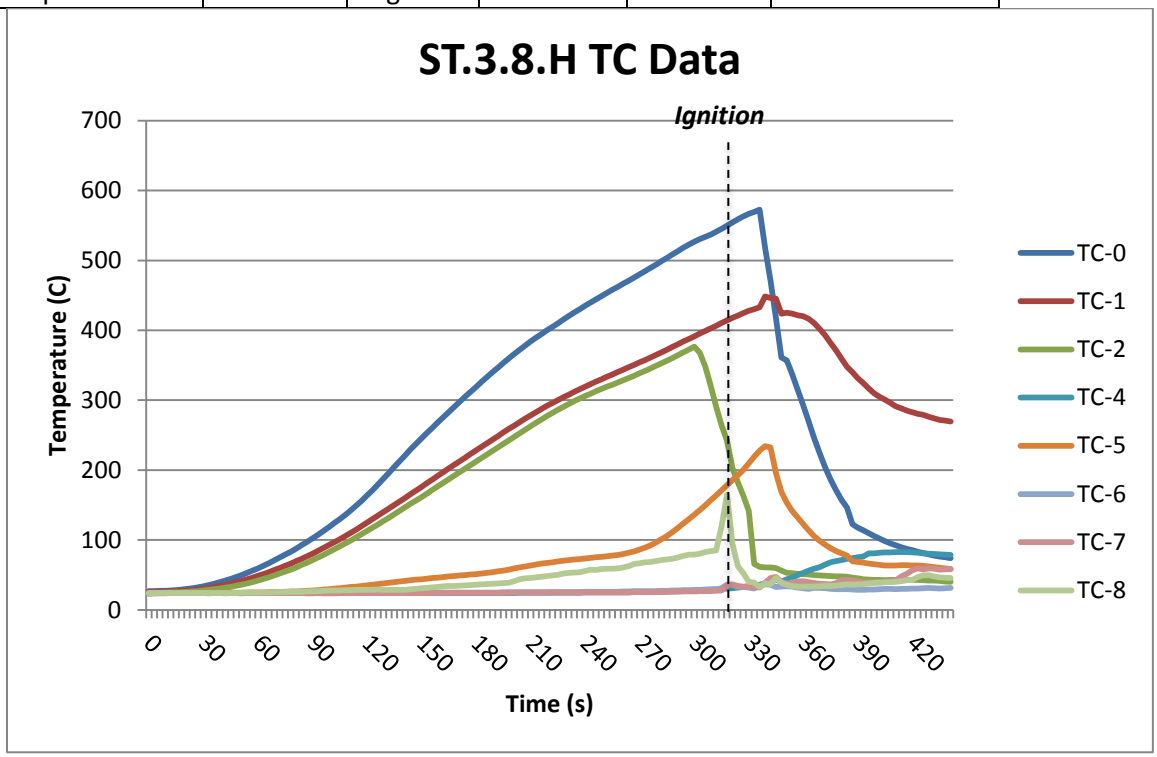
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.8.L	Paper Towel	8”	Low	25:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.8.M	Paper Towel	8”	Medium	25:00	No	



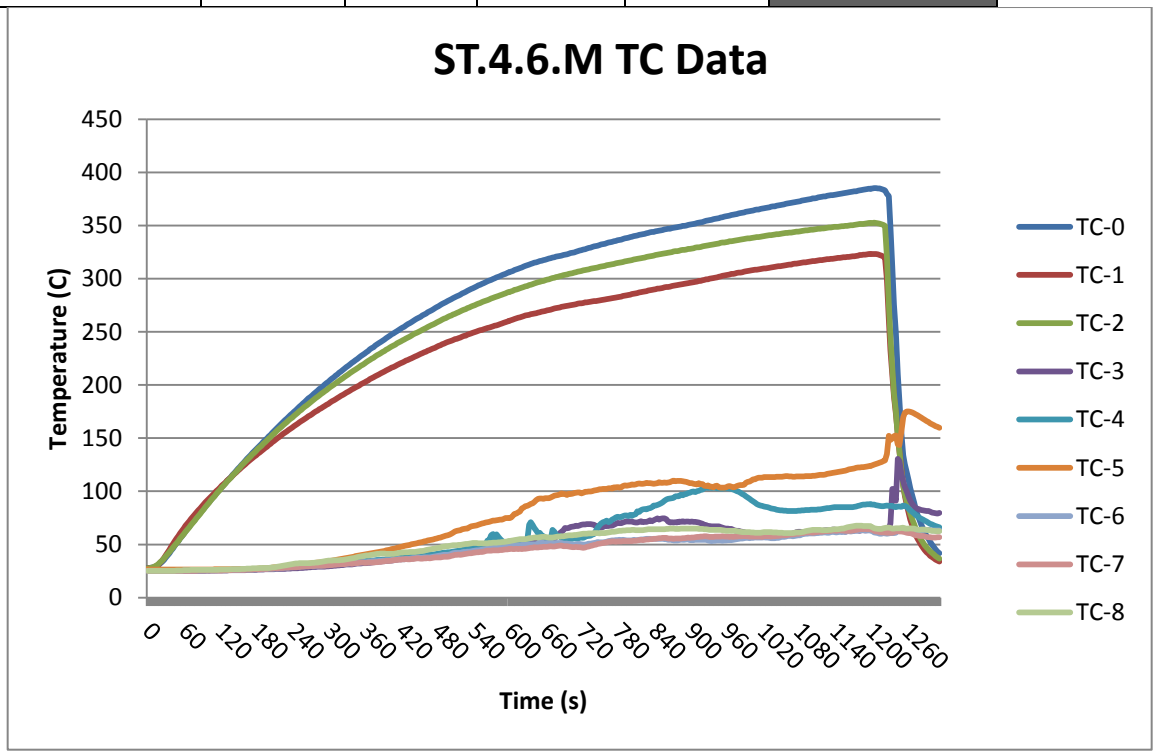
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.3.8.H	Paper Towel	8”	High	5:20	Yes	5:20



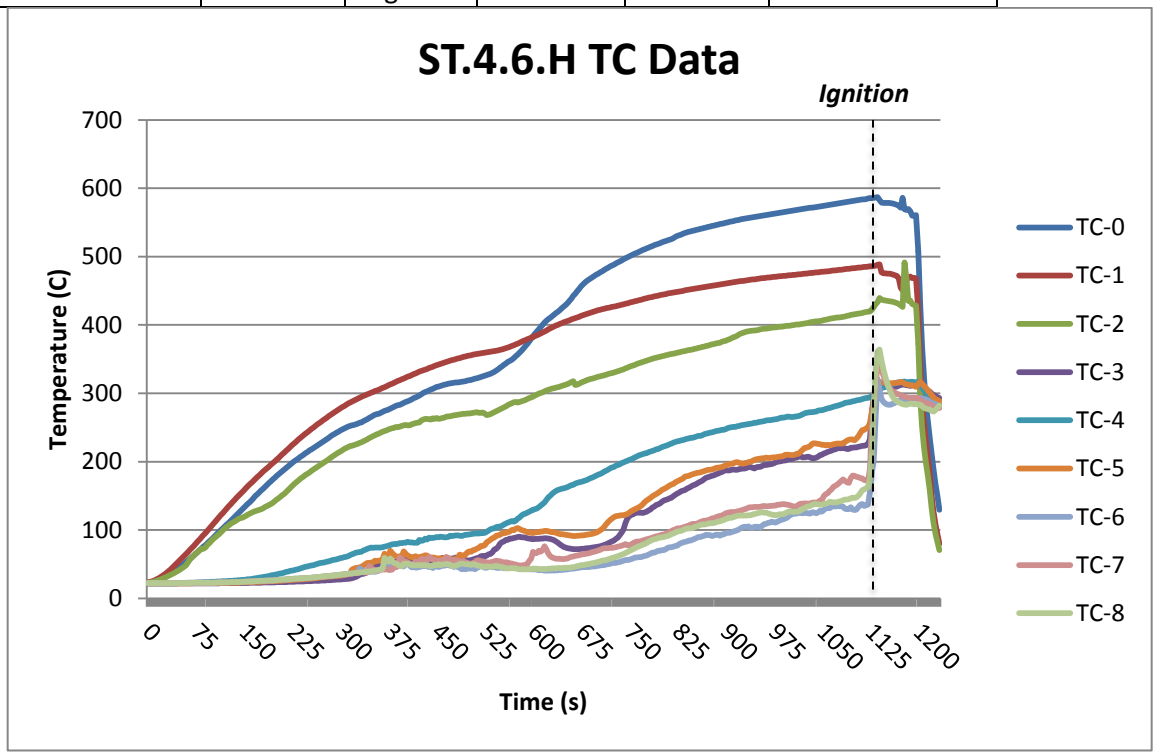
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.6.L	Canola Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.6.M	Canola Oil	6”	Medium	20:00	No	



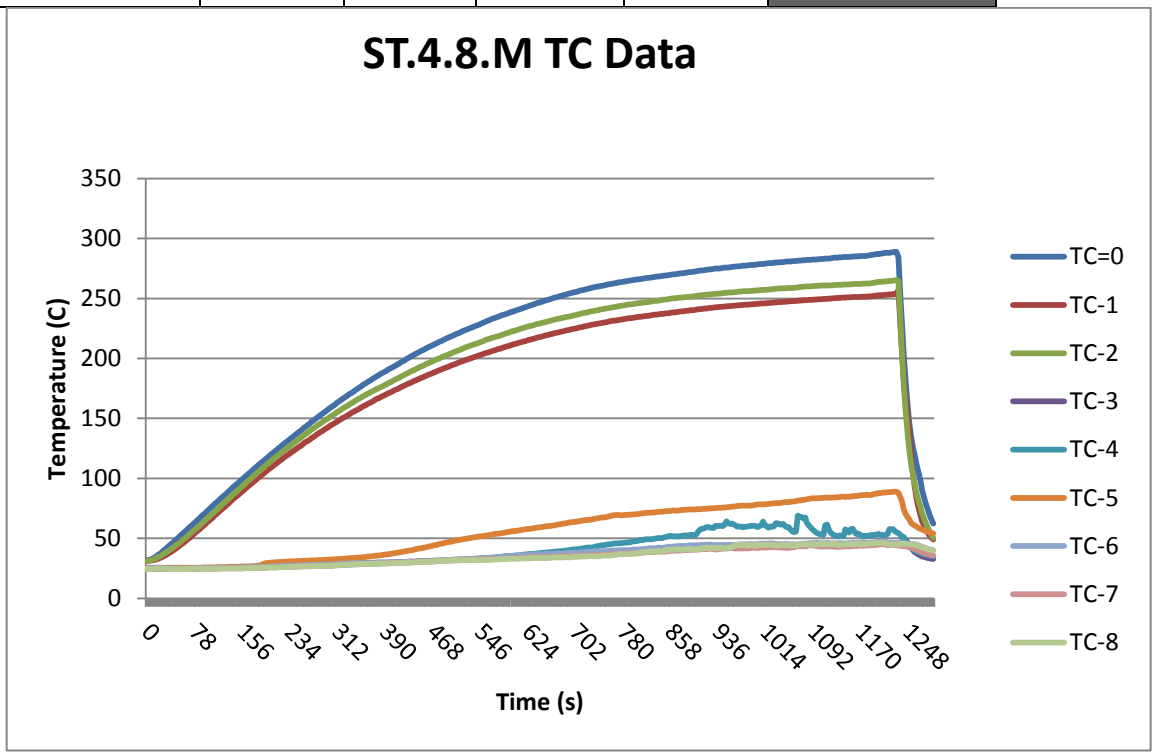
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.6.H	Canola Oil	6”	High	18:54	Yes	18:54



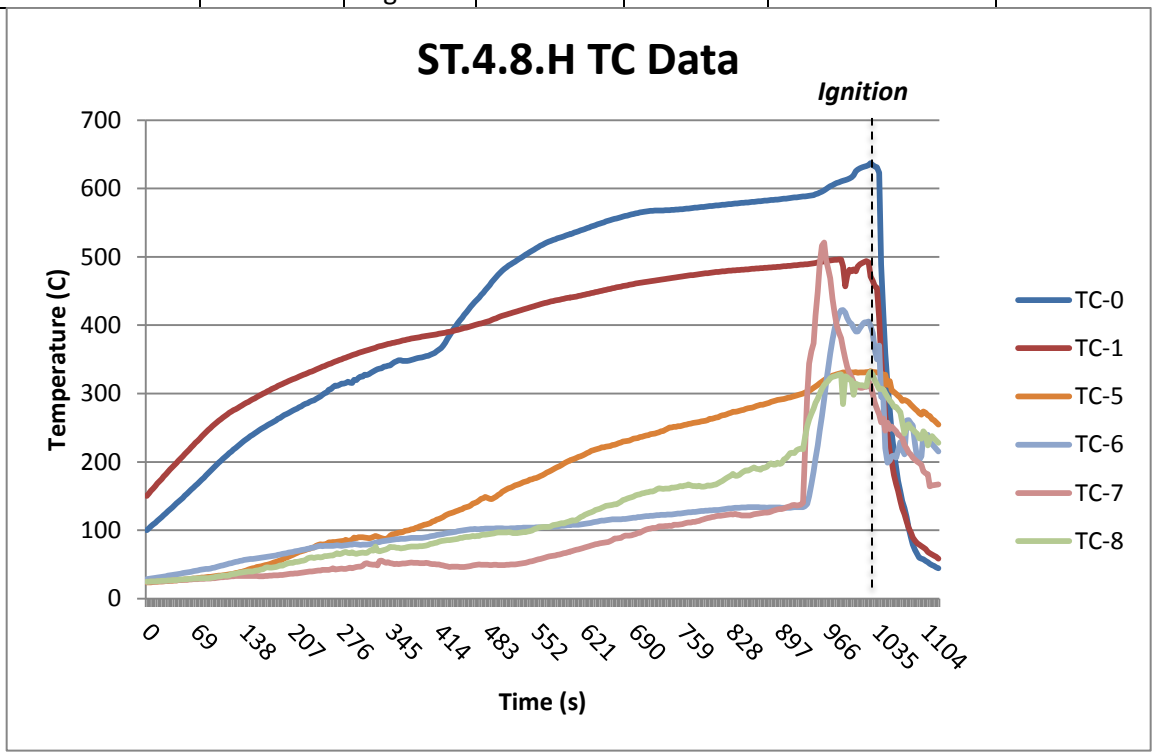
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.8.L	Canola Oil	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.8.M	Canola Oil	8”	Medium	20:00	No	



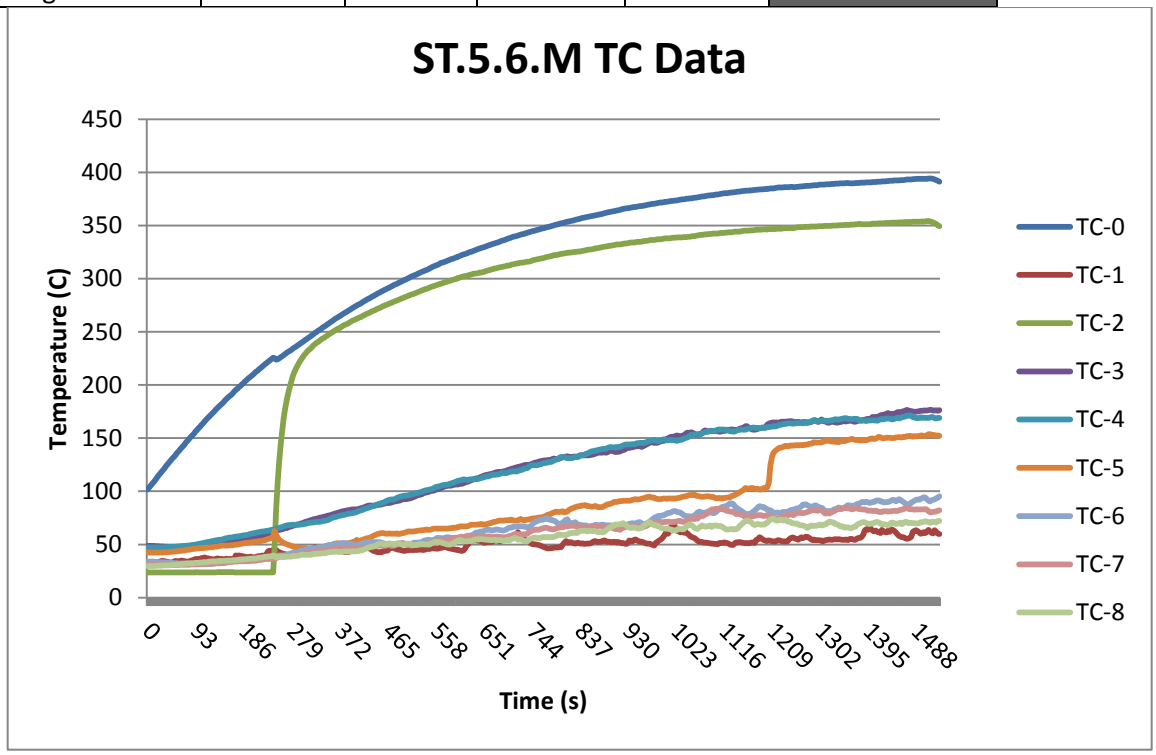
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.4.8.H	Canola Oil	8”	High	17:54	Yes	17:54



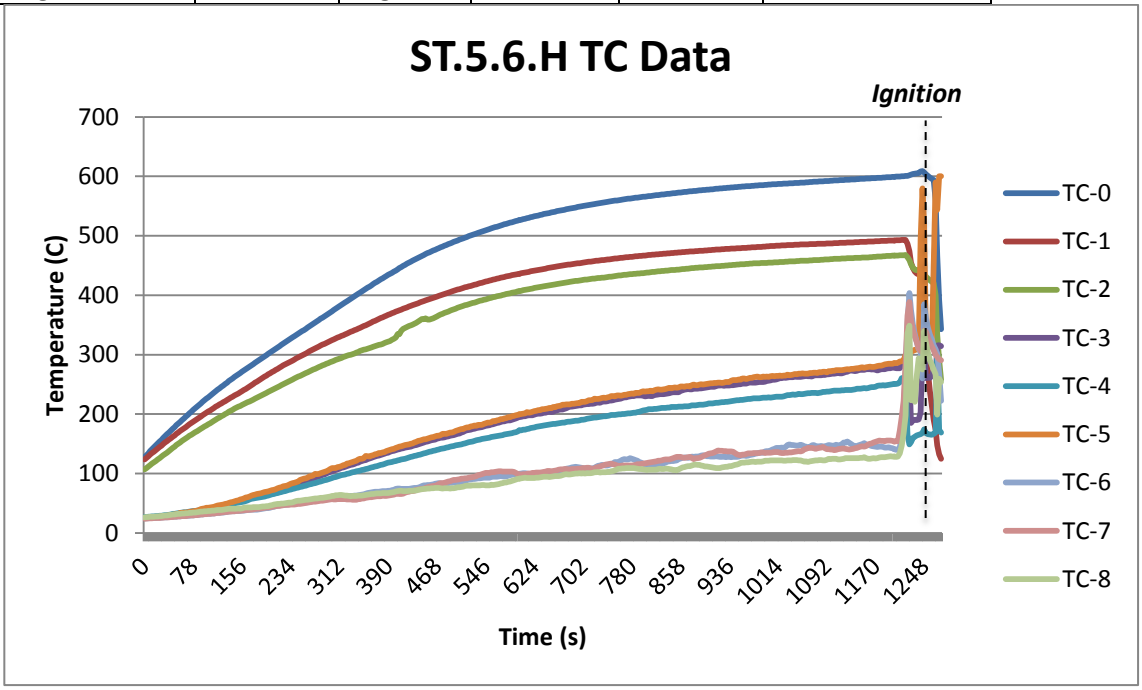
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.6.L	Vegetable Oil	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.6.M	Vegetable Oil	6”	Medium	25:00	No	



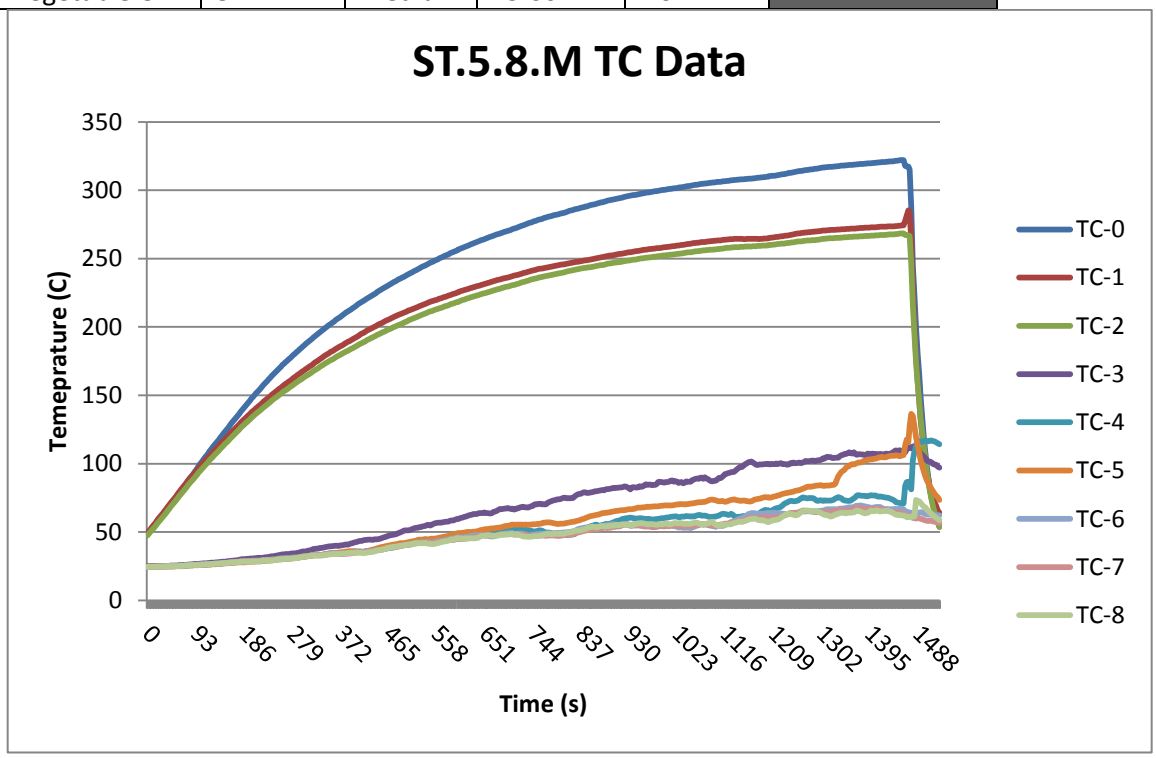
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.6.H	Vegetable Oil	6”	High	22:00	Yes	22:00



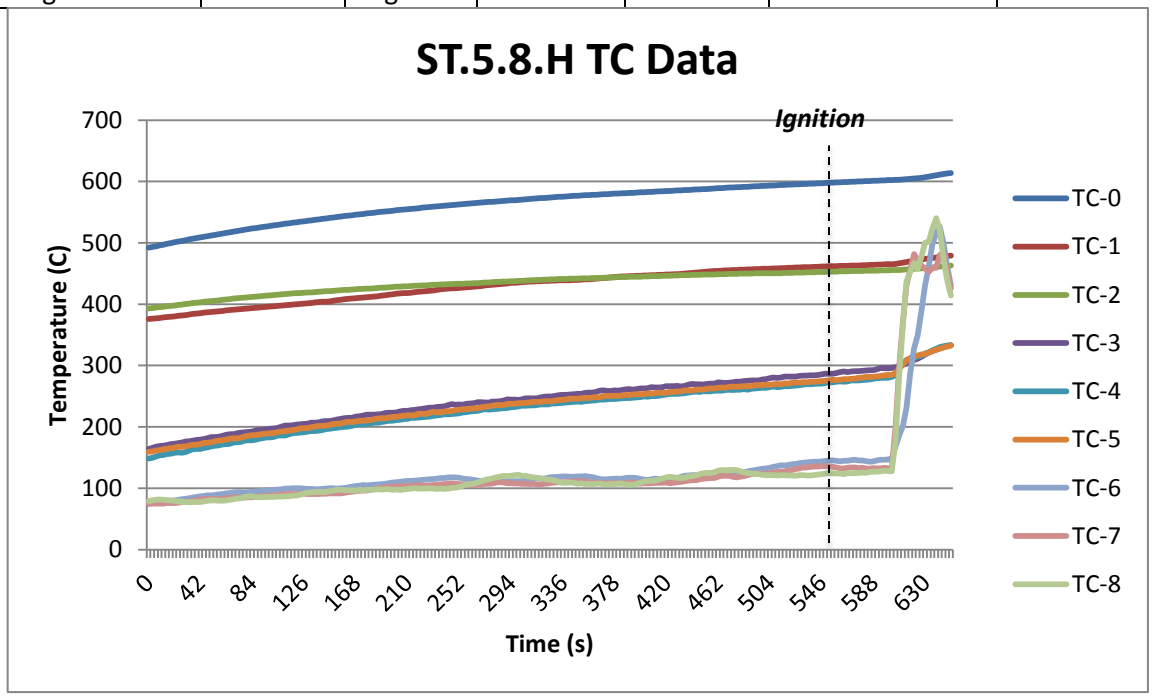
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.8.L	Vegetable Oil	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.8.M	Vegetable Oil	8”	Medium	25:00	No	



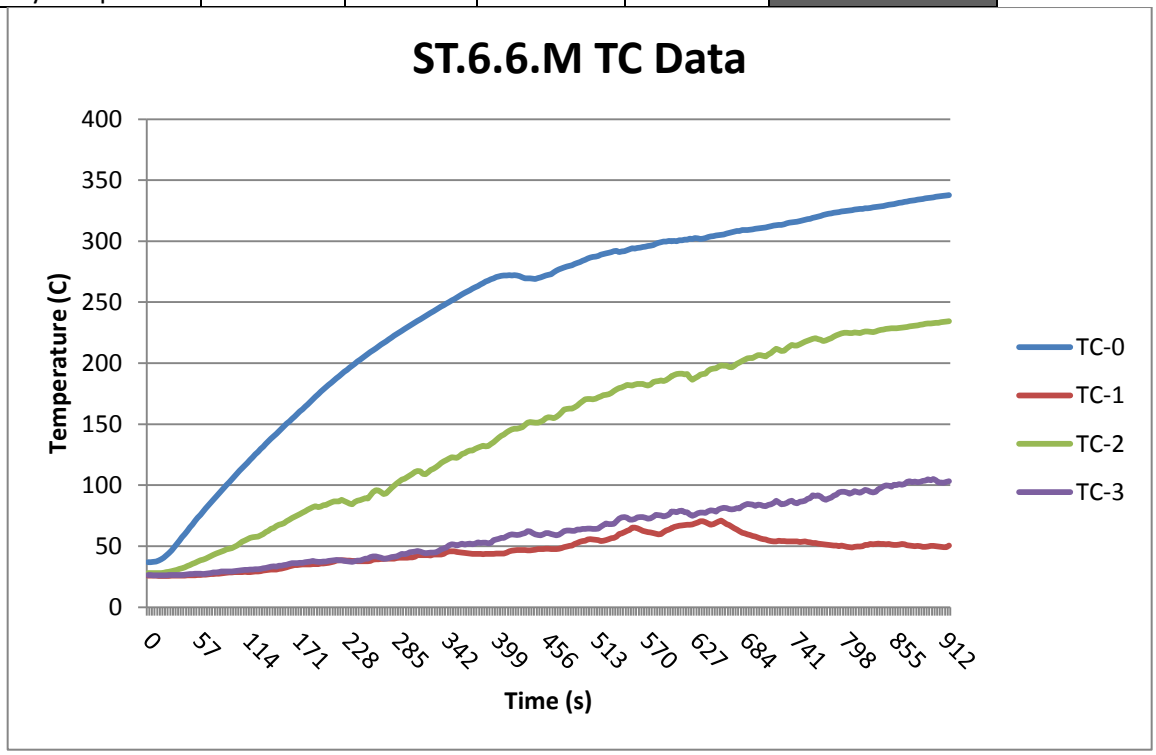
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.5.8.H	Vegetable Oil	8”	High	9:30	Yes	9:30



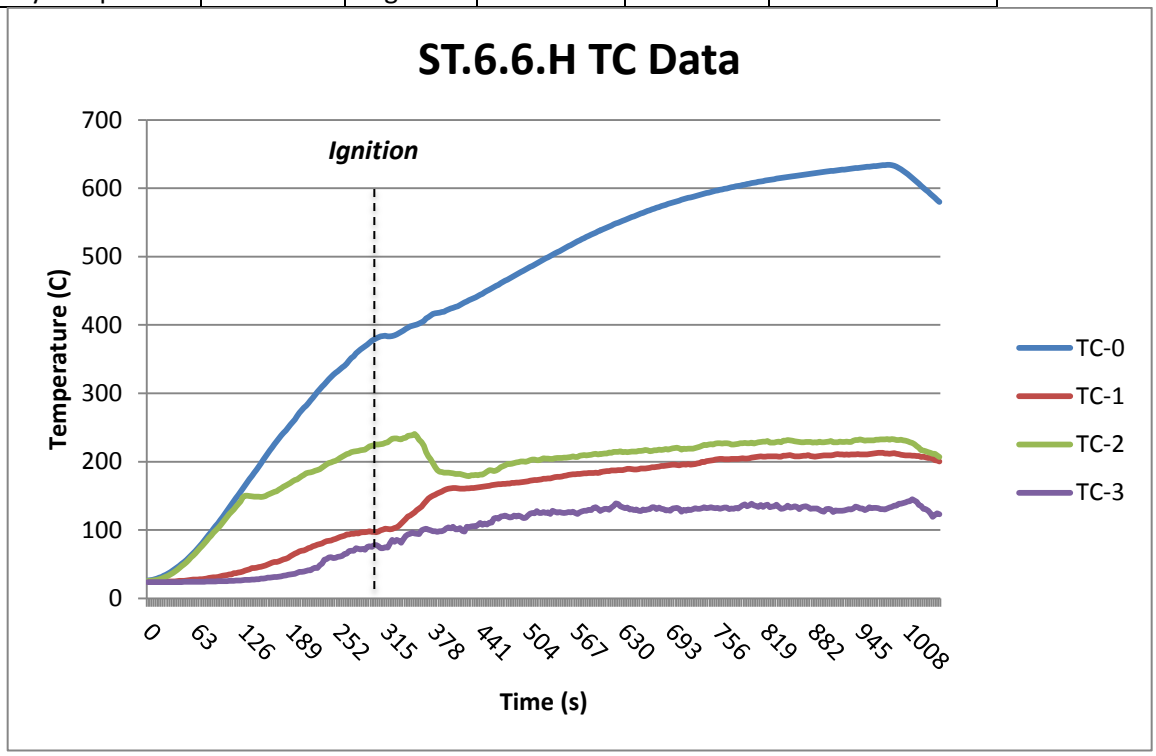
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.6.L	Nylon spatula	6”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.6.M	Nylon spatula	6”	Medium	15:00	No	



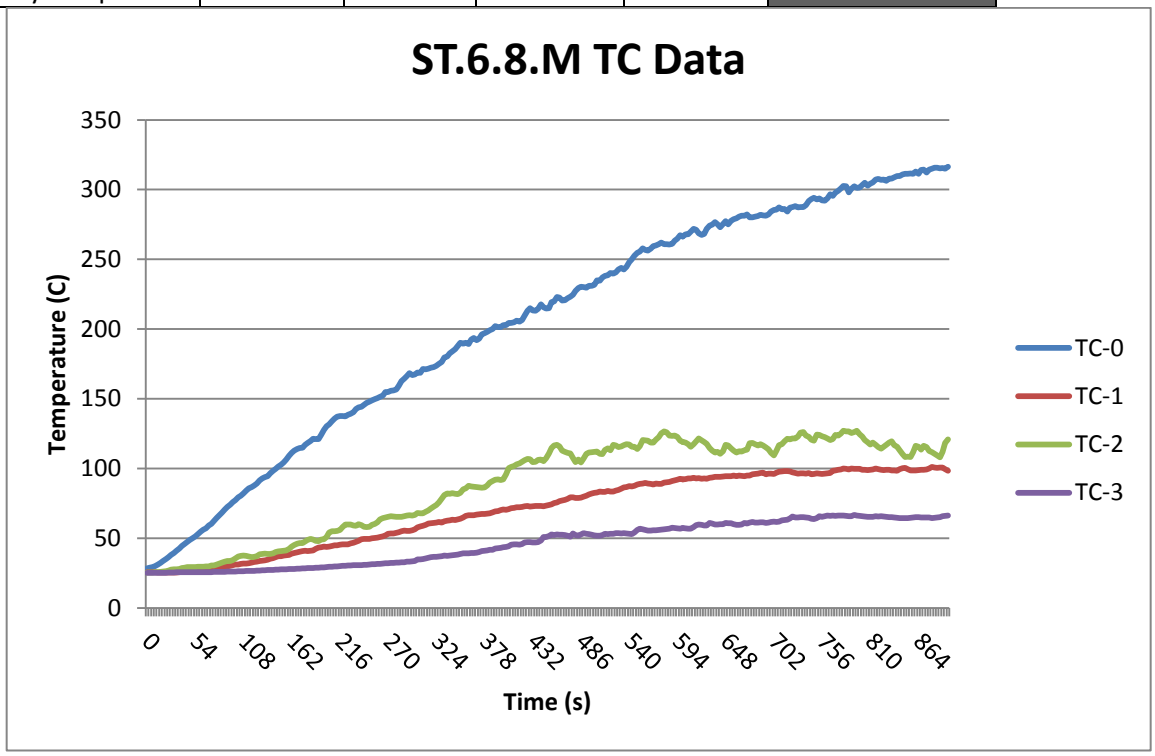
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.6.H	Nylon spatula	6”	High	4:45	Yes	4:45



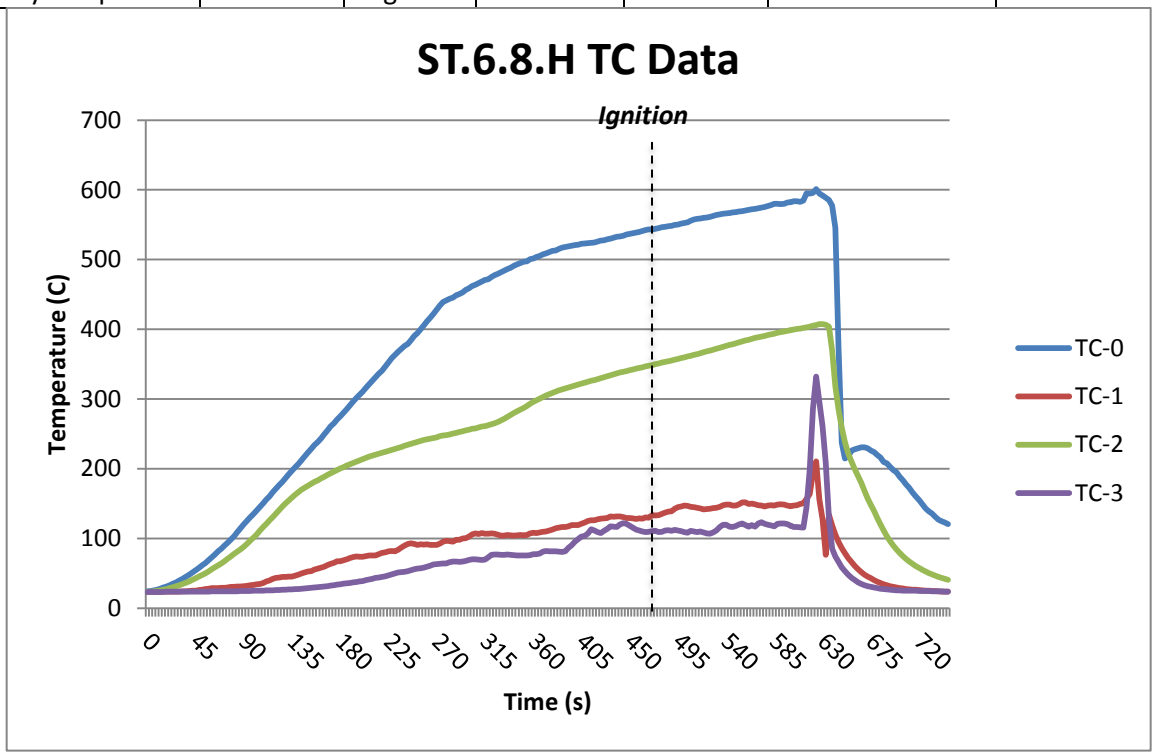
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.8.L	Nylon spatula	8”	Low	No Test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.8.M	Nylon spatula	8”	Medium	15:00	No	



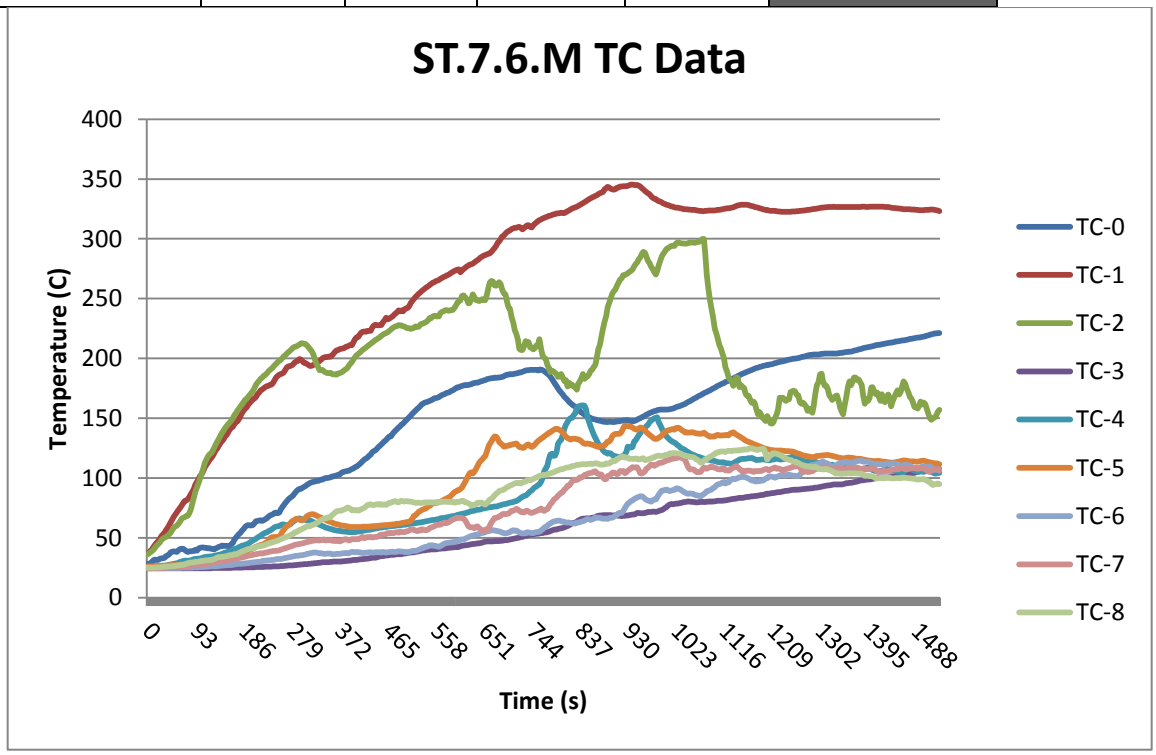
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.6.8.H	Nylon spatula	8”	High	7:55	Yes	7:55



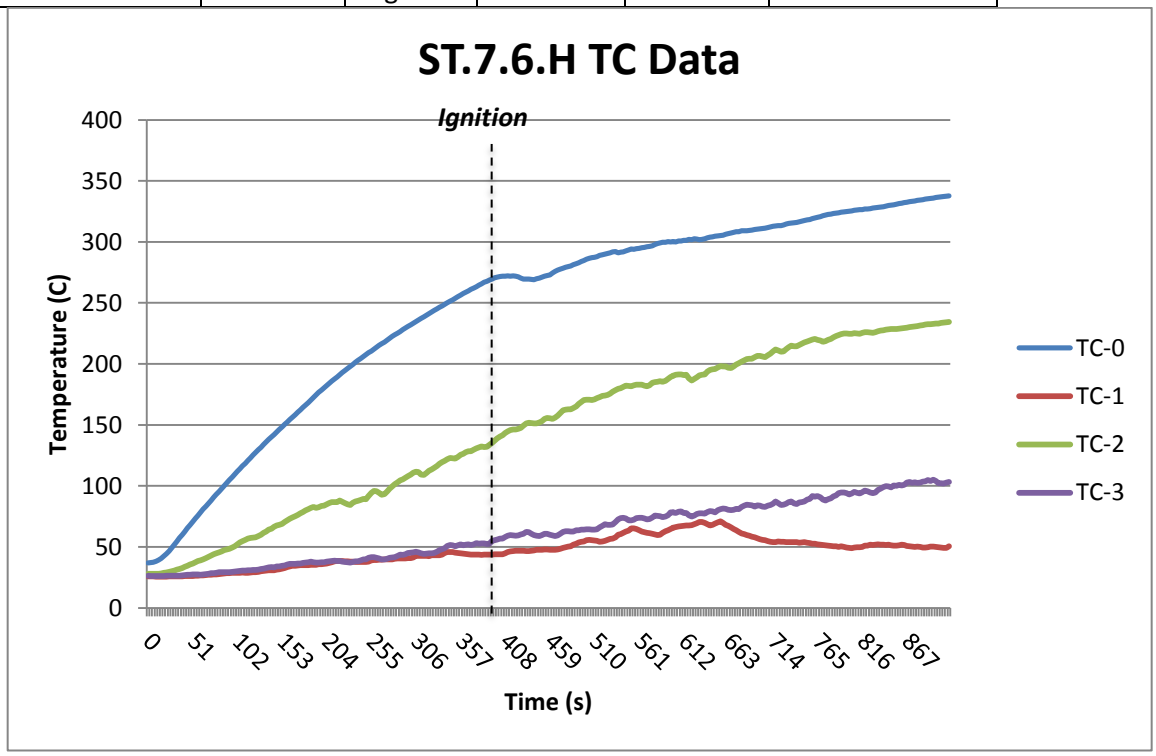
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.6.L	Toaster	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.6.M	Toaster	6”	Medium	25:00	No	



Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.6.H	Toaster	6”	High	6:20	Yes	6:20



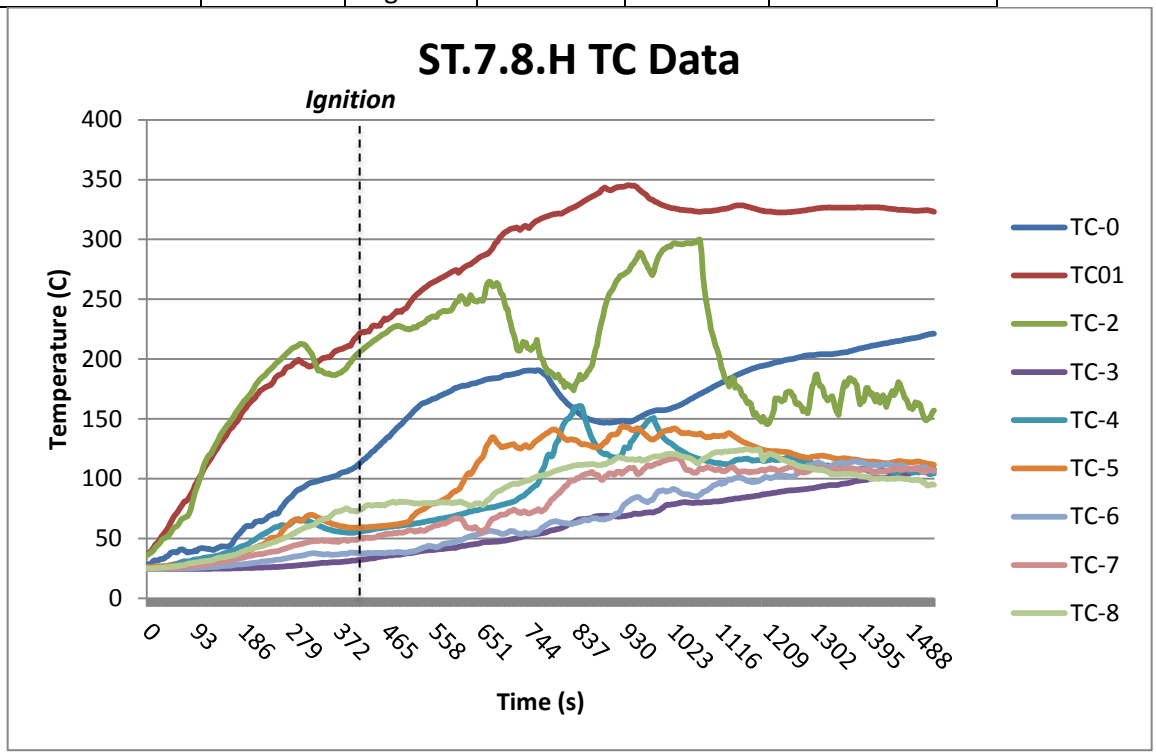
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.8.L	Toaster	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.8.M	Toaster	8”	Medium	25:00	No	

No Graph

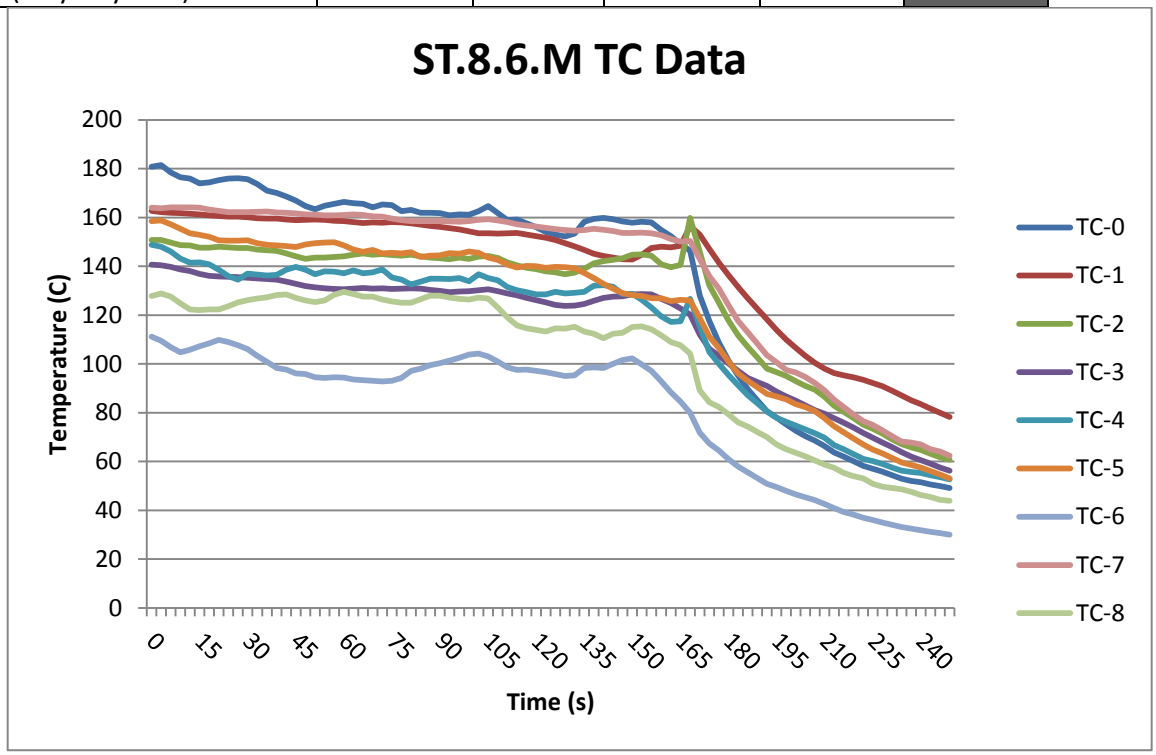
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.7.8.H	Toaster	8”	High	5:20	Yes	5:20



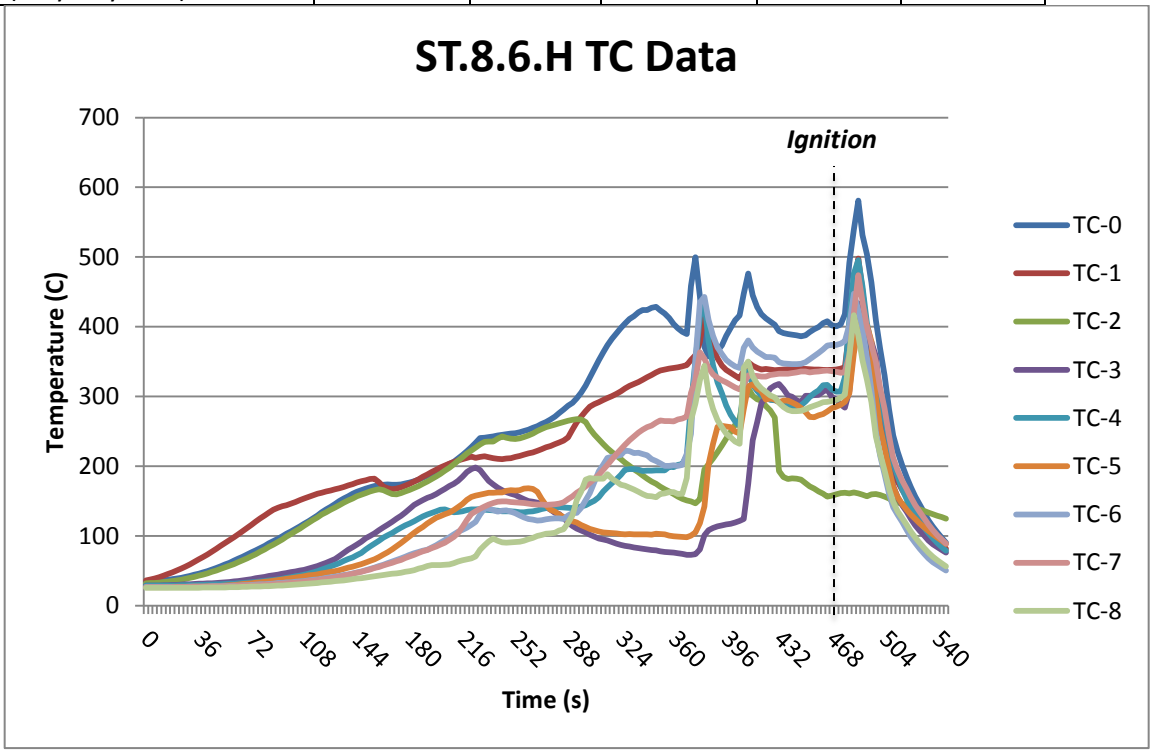
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.6.L	Food Storage Container (Polyethylene)	6”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.6.M	Food Storage Container (Polyethylene)	6”	Medium	20:00	No	



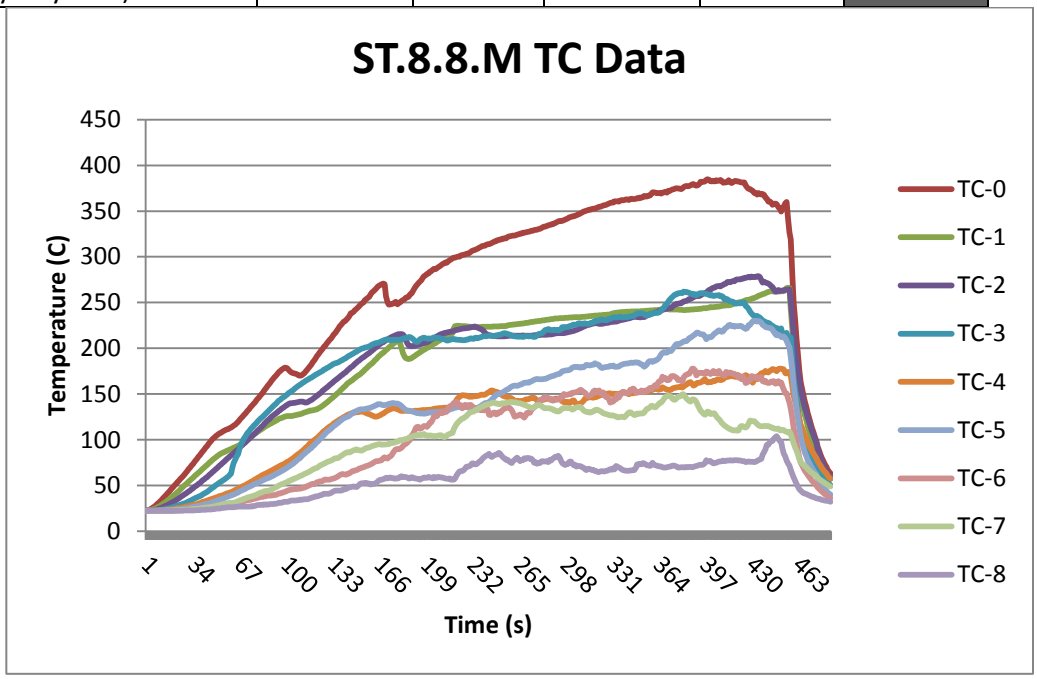
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.6.H	Food Storage Container (Polyethylene)	6”	High	6:26	Yes	6:26



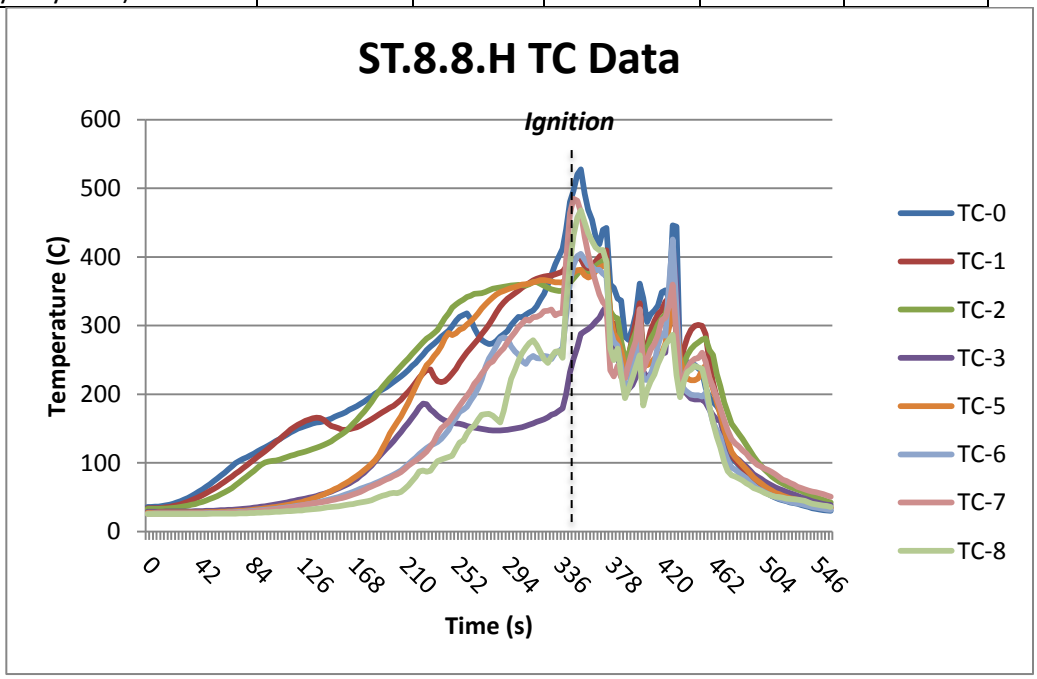
Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.8.L	Food Storage Container (Polyethylene)	8”	Low	No test	No	

No Test Conducted

Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.8.M	Food Storage Container (Polyethylene)	8”	Medium	6:30	No	

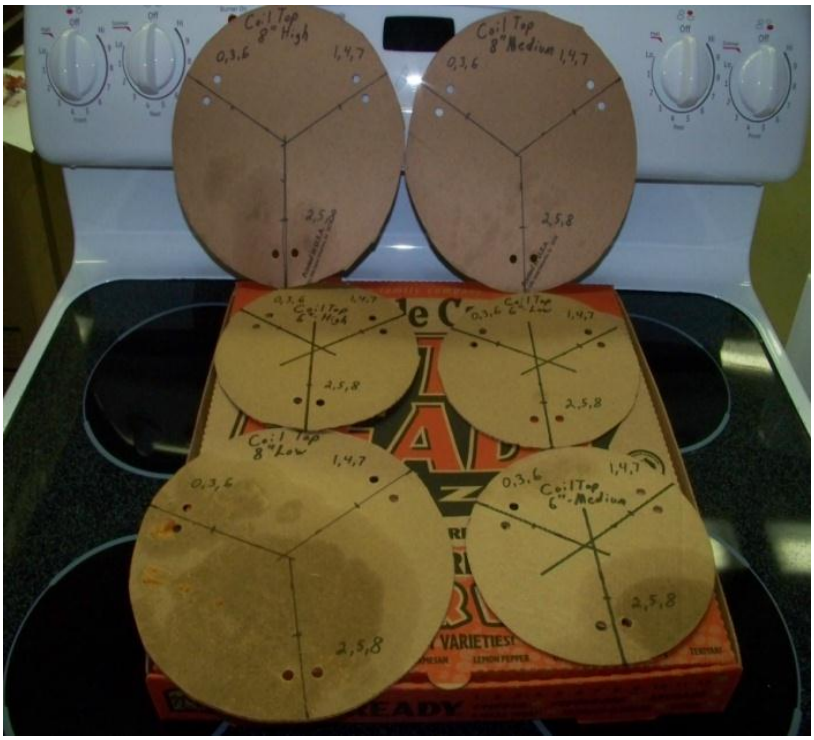


Test Id	Fuel	Diameter	Setting	Time (min:sec)	Ignition (Yes/No)	Time to Ignition (min:sec)
ST.8.8.H	Food Storage Container (Polyethylene)	8”	High	5:40	Yes	5:40



Appendix F – Photographs of Fuels

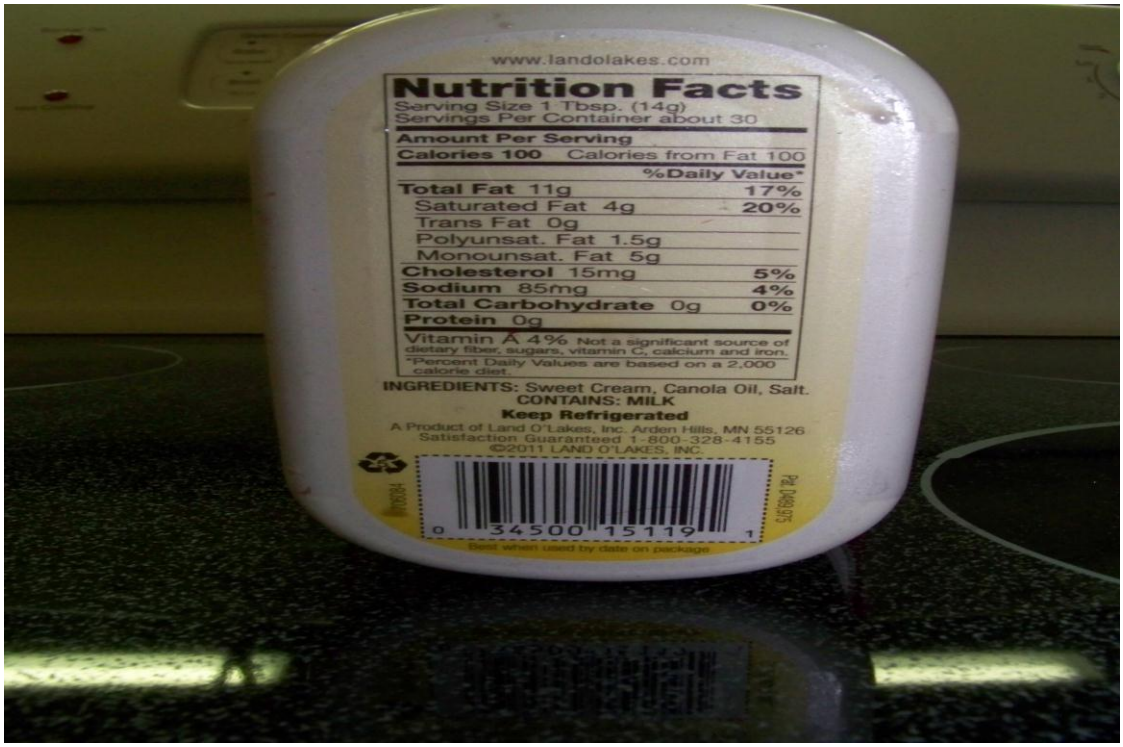
1. Cardboard (pizza box)



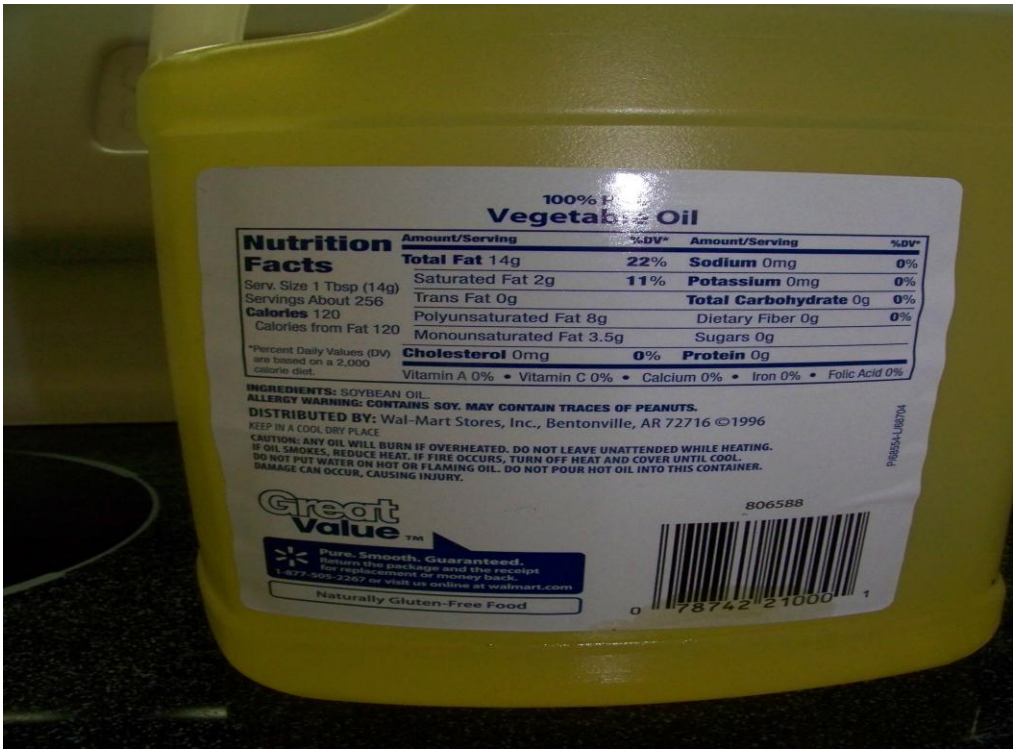
2. Dish Towel (Cotton)

3. Paper Towel (Paper)

4. Canola Oil (butter)

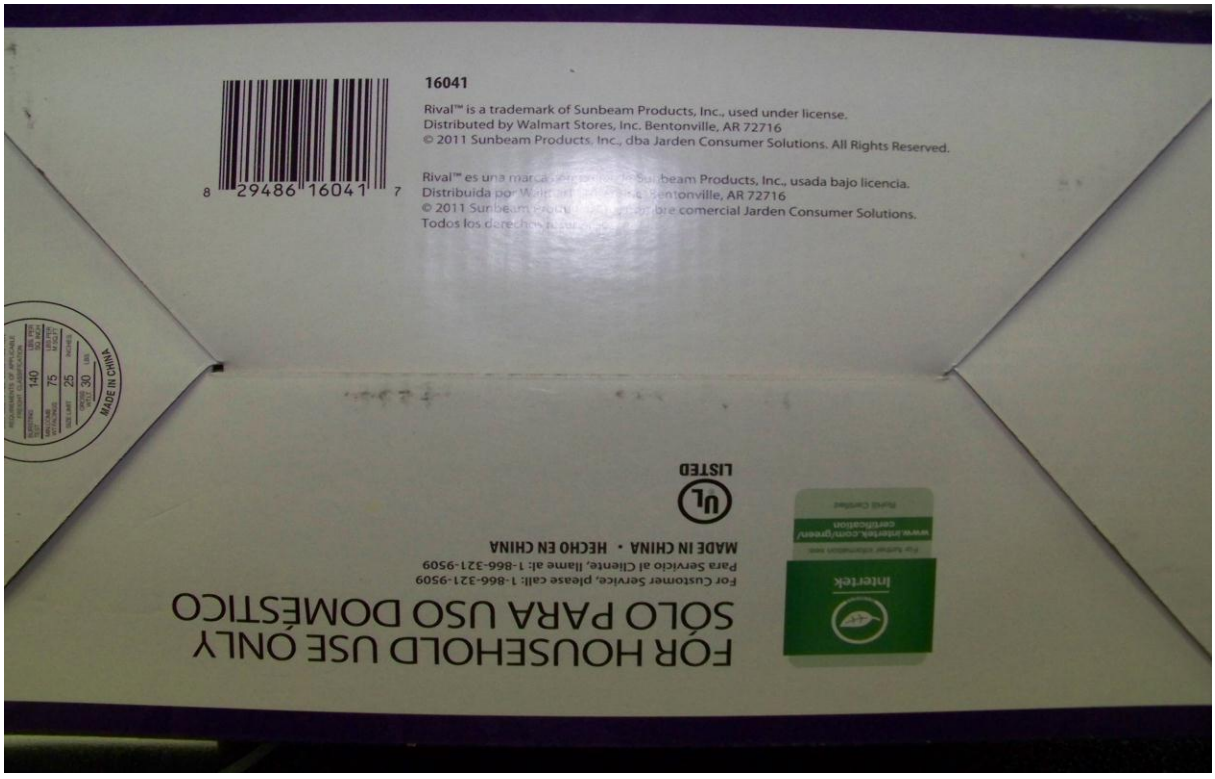


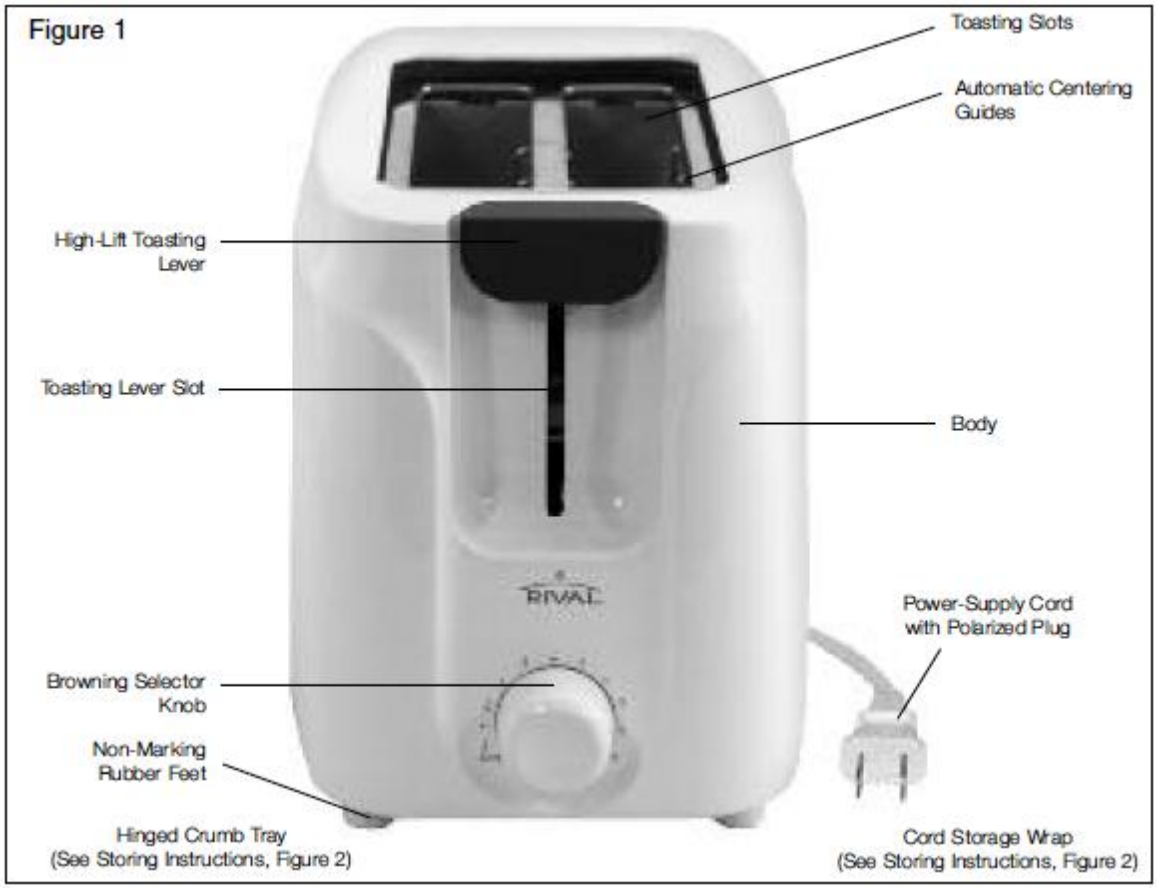
5. Vegetable Oil:



6. Kitchen Utensil (Nylon Short Turner Spatula)

7. Toaster – Appliance (Polypropylene)





source: Rival manual http://www.rivalproducts.com/manuals/MANUALS/16041_43_96048060.PDF

8. Food Storage Container (Polyethylene)