Technical, Practical and Manufacturing Feasibility of Technologies to Address Surface Cooking Fires

Final Report

Report to:

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Table of Contents

List of Figures

List of Tables

1. Background

Work has been sponsored over the past six years by the Consumer Product Safety Commission (CPSC) to study and develop technology to lessen the risk of surface cooking fires. In the early phases of this work, the CPSC used the resources of the National Institute of Standards and Technology (NIST) to determine if there were a common, measurable, pre-ignition indicator for the combustion of cooking materials on a range top. From this work, the most consistent, measurable, pre-ignition indicator was concluded to be pan temperature. Follow-on phases to this work led to the design and early development of a thermocouple-based control system to limit pot temperature to a level safely below a threshold, pre-ignition condition.

Separately, other technologies have been developed to address surface cooking fires. For example, a variety of US companies offer automatic fire extinguishing systems for residential cooking applications. In addition, gas-fired cooktops are made and sold in Japan that offer a temperature control function that will modulate or shut-off to prevent overcooking, burning and overheating of deep frying oil. Other technologies have been developed that were not intended to address surface cooking fires, but are intended to monitor and control pot temperature. For example, a European appliance manufacturer offers a cooking control system that remotely monitors pot temperature with an infra red sensor and controls the heat input rate accordingly. The patent literature is full of systems, approaches, technologies and concepts to address cooking fires.

US appliance manufacturers are deeply concerned about a) the potential effectiveness of these types of technologies to reduce the incidence of cooking fires and b) the potential impact of these technologies on the cooking performance, operability, reliability, durability, safety, and manufacturability of cooking products. Reliability is a significant issue to the industry. It includes the requirement that a safety device would address all fire incidents that it was intended to address throughout the life of the appliance. In all cases, the system would need to "fail-safe", in that the range would need to shut down in case the fire safety device were not working properly.

The CPSC requested the assistance of Arthur D. Little to conduct a study to evaluate the technical, practical and manufacturing feasibility of range modifications intended to address the ignition of cooking materials. The Association of Home Appliance Manufacturers provided additional support to expand this study to include technological solutions beyond the rangetop, such as fire suppression systems, to address the broad spectrum of surface cooking fires.

To focus the scope of this study, only surface cooking fires and surface cooking fire mitigation technologies were considered. Surface cooking fires include the ignition and combustion of materials on cooktops or rangetops. These materials are primarily cooking materials, but can be paper, trash, cabinetry, fuel, accelerants or unclassified items. The 1996 report entitled *Ten Community Study of the Behaviors and Profiles of People Involved in Residential Cooking Fires* (written by the Cooking Fires Task Force of the National Association of State Fire Marshals (NASFM) and AHAM member companies) concluded that behaviors associated with range-top cooking must be given special emphasis. The statistics compiled by the Fire Analysis and Research Division of the

National Fire Protection Agency mirror the results of the NASFM. The April 2000, NFPA report entitled *US Home Cooking Fire Patterns and Trends*, stated that 73% of home cooking fires originated from surface cooking. Therefore, we reviewed fire mitigation (or management) technologies that are intended to address surface cooking fires, independent of the origin of these fires. In addition, the statistics indicate that a significant number of fires are associated with unattended cooking fires, and the ignition of cooking materials. Therefore, we also reviewed technologies that specifically target unattended cooking and the ignition of cooking materials.

2. Objective

The objective of this study is to evaluate the technical, practical and manufacturing feasibility of technologies to address surface cooking fires. Specifically, feasibility is established by evaluating the potential for the technology to be designed in such a way as to 1) be effective in mitigating surface cooking fires; and 2) meet industry standards for: reliability, durability, cooking performance, safety, operability, and manufacturability.

3. Approach

The program involved three major activities (collect information, conduct evaluation, prepare report) that were further divided into the following seven specific tasks.

3.1 Identify Patents, Products, Technologies, Systems, and Concepts

We cast a broad net to identify the products, technologies, systems and concepts that have the potential to address surface cooking fires. Some of these technologies were available in the public domain, from the patent database, web-sites, technical literature, conference proceedings, and product brochures. In addition, we followed the 'inventor trail' from CPSC meeting and phone logs, AHAM files, Arthur D. Little files, and meetings with appliance manufacturers. Some concepts, particularly as they related to combinations of sensor technologies in control systems, were proposed at Arthur D. Little as part of the searching and technology classification process.

3.2 Structure Patents, Products into Technology Classes

In order to evaluate the feasibility of fire mitigation approaches, we structured the patents, products, concepts, technologies and systems into 22 technology classes. Both CPSC and AHAM reviewed these technology classes prior to our initiating the evaluation work. A number of the products, systems, or concepts that were grouped into these technology categories constituted a 'complete' approach to address surface cooking fires. Other patents or technologies could potentially be part of an approach that would address surface cooking fires, for example, a sensor technology, or an extinguishing agent, or a contact temperature sensor. In some technology classes, we grouped many products, patents and ancillary technologies. Other technology classes contained only one patent or one concept.

3.3 Identify, Review, and Develop Data to Support Technology Evaluation

We identified, reviewed, and developed data to support the technology evaluation process. We reviewed a large amount of literature, including:

- the reports covering the cooking fires work sponsored by the CPSC;
- the analyses conducted by the AHAM Cooking Fires Working Group and the memorandums covering the minutes of their meetings;
- fire statistics generated by the National Fire Protection Association (NFPA) and National Fire Incident Reporting System (NFIRS) and summarized by NFPA;
- studies conducted by the National Association of State Fire Marshals Cooking Task Force;
- AMCE Conference Proceedings;
- IEEE transactions;
- data on edible oils from a variety of sources.

- AHAM test reports covering work conducted as part of the 1986 Food Fire Test Program.

In addition, we reviewed videos illustrating grease fires and safe cooking techniques that AHAM made available to us.

To deepen our understanding of industry issues and concerns, we met with appliance manufacturers to discuss their product lines, product development process, technology needs, technology evaluations, relevant tests, concepts, related product development programs, product trends, industry concerns, and safety requirements. The specific elements of the discussions at these meetings are confidential, (as per our agreement with AHAM and CPSC) but we have incorporated the general information into our evaluations.

In addition to the literature reviews and meetings, we conducted some tests in our lab to obtain additional data on system performance and characteristics. We obtained the CPSC range prototypes and conducted limited testing on both the gas and electric units. We reviewed the Good Housekeeping report covering their tests of these units. We obtained a Rinnai Gas Table with a temperature controller and conducted numerous tests to understand its operation and performance. To supplement these tests, we reviewed the Rinnai User Manual, translated from Japanese by AHAM.

Finally, we utilized our understanding of the appliance industry, the standards process, the science of cooking products, and the product development process to support our analyses and evaluation work.

3.4 Develop Evaluation Criteria

Specific evaluation criteria and metrics were developed in the categories of cooking performance, operability, reliability/durability, manufacturability/installation/service, safety, and effectiveness in addressing surface cooking fires. These criteria and metrics were reviewed with representatives from CPSC and AHAM. It was agreed that as a starting point for the screening work, each criteria would have equal weighting relative to each other. These criteria were further grouped into two categories: 1) criteria that reflected the effectiveness of the technology to mitigate surface cooking fires and 2) criteria that reflected the potentially negative impact of the technology on the performance, operation reliability safety of the cooking system.

3.5 Screen Technology Classes by Evaluation Criteria

As an initial screen, we evaluated each technology class with respect to the agreed upon evaluation criteria and metrics. The evaluation scores for each technology class were tallied. A scatter plot of fire mitigation effectiveness versus impact on product value was generated for the set of technologies. Two additional ‘technology classes’ were evaluated as a process check: ‘do nothing’ (i.e. make no change to range/add no fire suppression technology), and ‘add smoke alarm only’.

Technologies that had comparatively low effectiveness or excessive negative impact on product value were eliminated from more detailed evaluation.

3.6 Select Technology Classes for Detailed Evaluation

The remaining technologies were screened for the potential to improve their effectiveness or decrease their impact on product value. Some technologies had inherent limitations. Others were found to have limitations in their current implementation, but had potential to be improved with additional research and development, or with the application of other known technologies. We selected 7 technologies for detailed evaluation.

3.7 Evaluate Selected Technology Classes

We collected additional information on the 7 technologies selected for evaluation. This activity included interviews with vendors, additional laboratory tests, and discussions with Arthur D. Little staff with relevant technology and/or industry experience. A draft report was prepared for review and comment by CPSC and AHAM representatives.

4. Results

4.1 Patents, Products, Technologies, Systems, Concepts

A complete list of the patents, products, technologies, systems, and concepts that we have identified that could potentially address surface cooking fires (or be part of a system to address surface cooking fires) is in Appendix A.

A number of these technologies were eliminated from additional consideration due to one or more of the following reasons:

- The technology had the potential to increase a safety risk to the homeowner (e.g. it required the user to extinguish the flame manually, or it required the homeowner to move closer to the flames in some way),
- The technology did not address a critical aspect of the surface cooking fire issue (e.g. it was not appropriate for grease fires of any kind)
- We were unsuccessful in obtaining additional information about the technology. (e.g. we some information on a web site, but received no response to phone calls, e-mails etc. for additional information)
- The technology or approach was obviously impractical or not feasible for residential application.

A list of the technologies that were eliminated from additional consideration (and the reasons for doing so) is included in Appendix B.

The remaining technologies were clustered into technology classes so that they could be more effectively evaluated. These classes are described in the following section.

4.2 Technology Classes

Table 4-1 lists the technology classes that we used to organize the hundreds of patents, products, technologies, systems and concepts identified in the first task.

Table 4-1 Fire Mitigation Technology Classes

Detect and Extinguish Fire
- Fusible Parts
- Non-optical Temperature Sensor
- Optical Temperature Sensor
- Smoke & Temperature Sensor

Detect a Fire – Provide Warning only
- Non-optical Temperature Sensor
- Optical T Sensor
- Smoke Sensor

Contain or Manage Fire
- Passive
- Active

Prevent Unattended Cooking- Warning and Control
- Motion Sensor Only
- Motion Sensor and Power level
- Motion Sensor and Temperature sensor
- Power level Sensor and Timer

Prevent Unattended Cooking- Warning Only
- Motion Sensor Only
- Motion Sensor and Power Level
- Power Level sensor and Timer

Prevent Food Ignition in Pan
- Electronic Signal Processing, Mode Selection, Pan-contact Temperature Sensor
- Electronic Signal Processing, Mode Selection, Non-contact Temperature Sensor
- Electronic Signal Processing, Auto-Control to Temperature Threshold, Pan-contact Temperature Sensor
- Electronic Signal Processing, Auto-Control to Temperature Threshold, Non-contact Temperature Sensor
- No Signal Processing, Mechanical Actuation

Boil Dry/Spill-over Sensor and Control

Each technology class is described and illustrated below.

Detect/Extinguish Fire -- Fusible Parts (Tech Class 1)

The first four technology classes involve detecting the presence of a fire and activating a fire extinguishing system. In the category of *Detect/Extinguish Fire – Fusible Parts*, the fire extinguishing technology is activated by a fusible link located above or near the cooktop that melts in response to a cooking fire. This system would respond to a surface cooking fire of any origin. When the fusible part melts due to the heat generated from the cooking fire, it triggers the release of fire extinguishing material onto the cooktop. This trigger can be mechanical or electrical. The fire extinguishing material can be liquid (generally a potassium-based, wet chemical formulated to extinguish grease fires) or powder (bicarbonate of soda or other dry mixture). The system can include the actuation of an alarm and/or heat source cut-off (either gas or electric power).

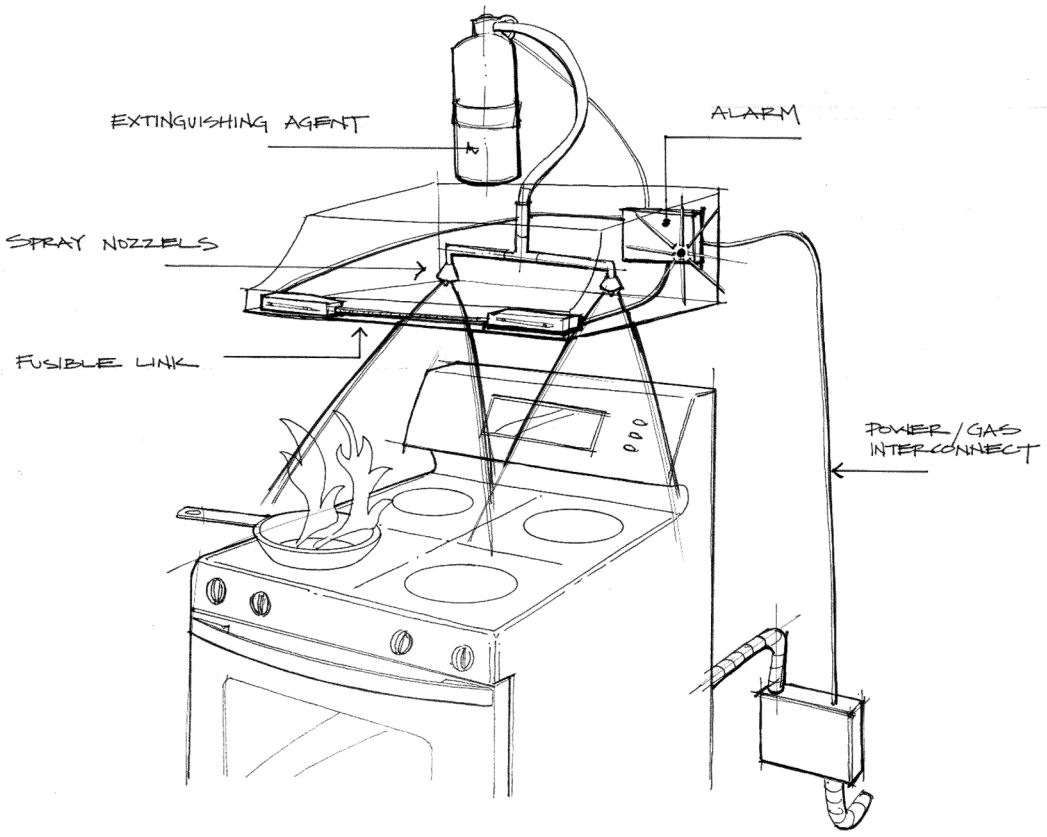


Figure 4-1: Detect/Extinguish Fire -- Fusible Parts

Detect/Extinguish Fire -- Non-optical Temperature Sensor (Tech Class 2)

This category differs from the one described above in the way the fire is detected. Instead of a fusible material, this technology utilizes a non-optical temperature sensor, such as a thermocouple, diode or thermistor, located near the cooktop (usually in hood) to detect fire. When the sensor response exceeds a threshold temperature, a release mechanism for the fire-extinguishing agent is actuated. As with the system described previously, a heat source cut-off mechanism or an alarm can be included in the system.

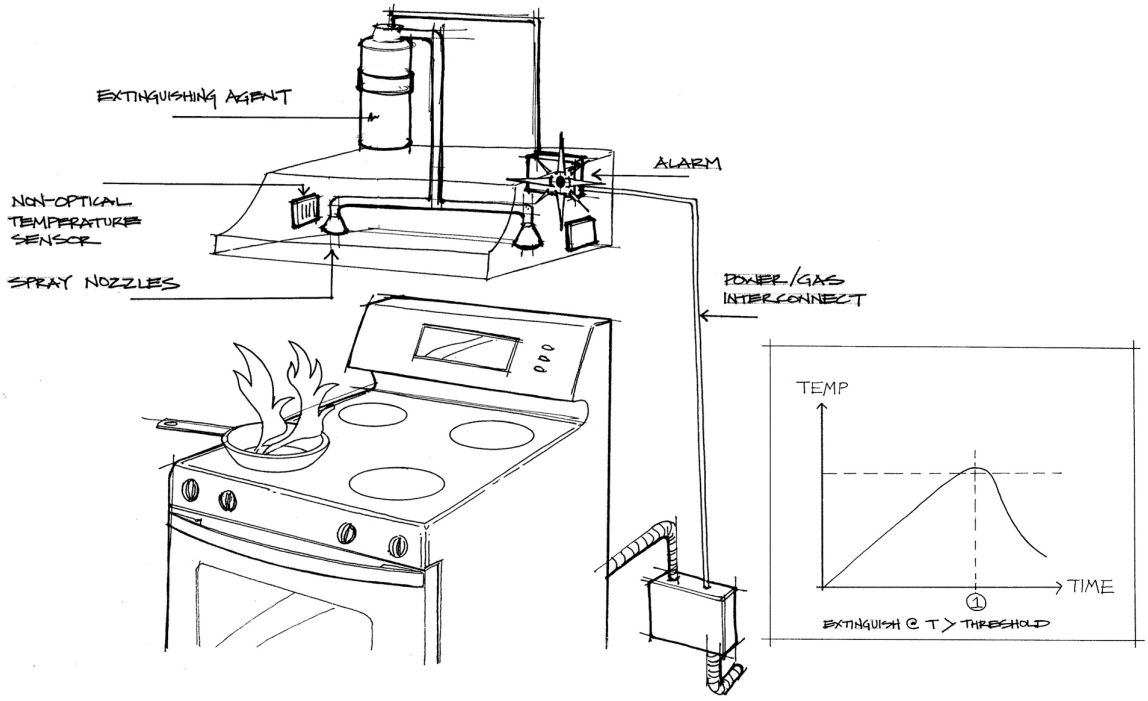


Figure 4-2: Detect/Extinguish Fire -- Non-optical T sensor

Detect/Extinguish Fire -- Optical Temperature Sensor (Tech Class 3)

In this fire extinguishing technology, an optical temperature sensor, such as an infra red (IR) sensor, is used to monitor the temperature surrounding or on top of the cooktop. When a temperature is sensed that exceeds a threshold, an alarm is sounded. At the same time, the system will actuate the release of the fire-extinguishing agent and can also turn off the cooktop heat source.

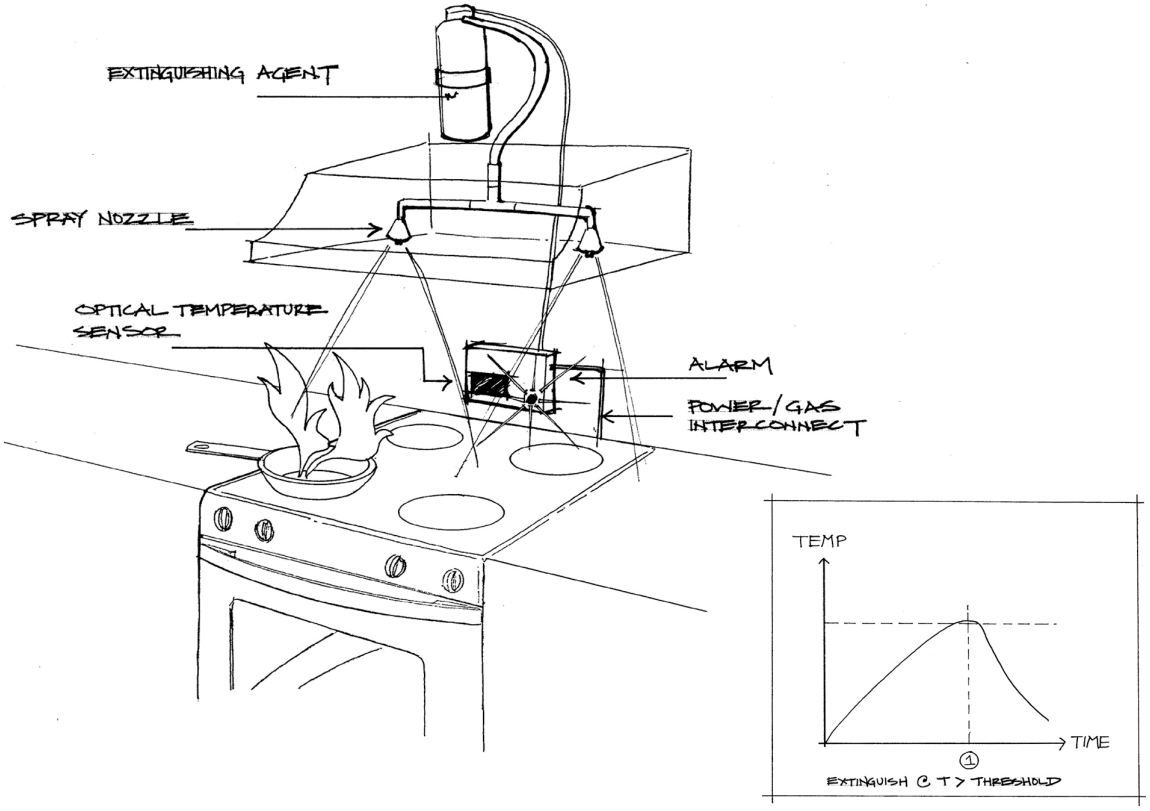


Figure 4-3: Detect/Extinguish Fire -- Optical T sensor

Detect/Extinguish Fire -- Smoke + Temperature Sensor (Tech Class 4)

This fire extinguishing system utilizes the combination of both smoke and temperature sensors to determine the presence of a surface cooking fire. First, the smoke sensor will detect a significant amount of smoke and sound the alarm. When the smoke is accompanied by a temperature exceeding a threshold level at the area surrounding the cooktop, it will turn off the heat source and either release fire extinguisher material and/or contact outside services (911 or fire department).

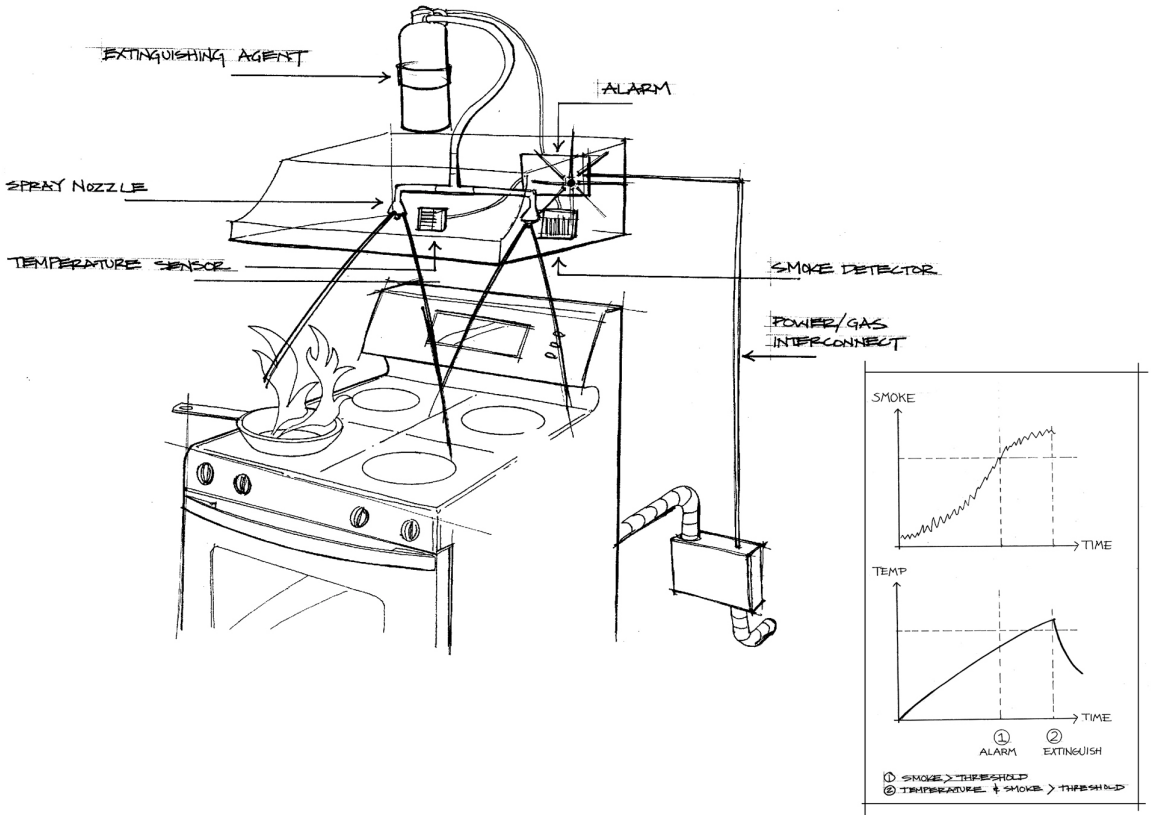


Figure 4-4: Detect/Extinguish Fire -- Smoke + T sensor

Detect Fire - Warning Only -- Non-optical Temperature Sensor (Tech Class 5)

This technology warns of the presence of fire, but does not actuate a fire extinguishing system. The presence of a fire is detected by a non-optical temperature sensor, such as a thermocouple, diode, or thermistor, located near the cooktop (usually in hood) to detect fire. When a threshold temperature is exceeded, an alarm will warn the user of a fire.

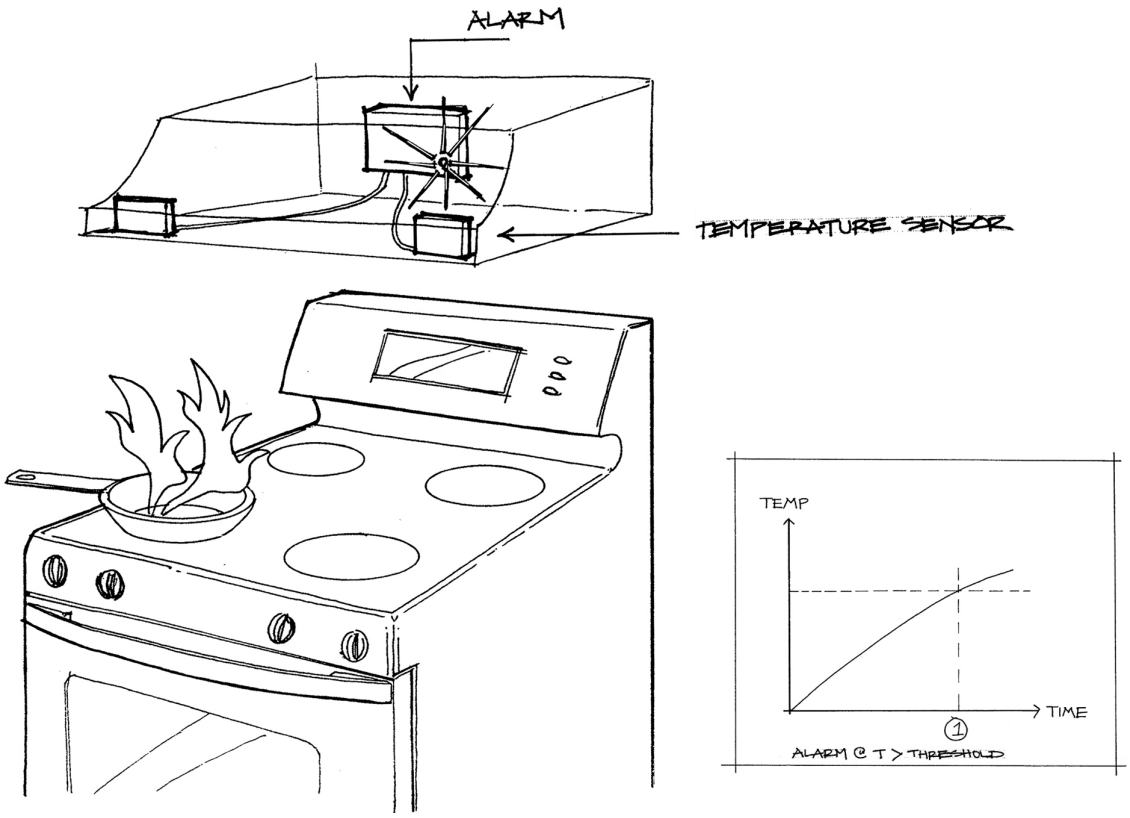


Figure 4-5: Detect Fire - Warning Only -- Non-optical T sensor

Detect Fire - Warning Only -- Optical Temperature Sensor (Tech Class 6)

Again, as with Technology Class 5, this is a warning system without a fire extinguishing system. In this case, an optical temperature sensor, such as and infra-red (IR) sensor, is used to monitor the temperature surrounding or on top of the cooktop. When the temperature exceeds a threshold, an alarm is actuated.

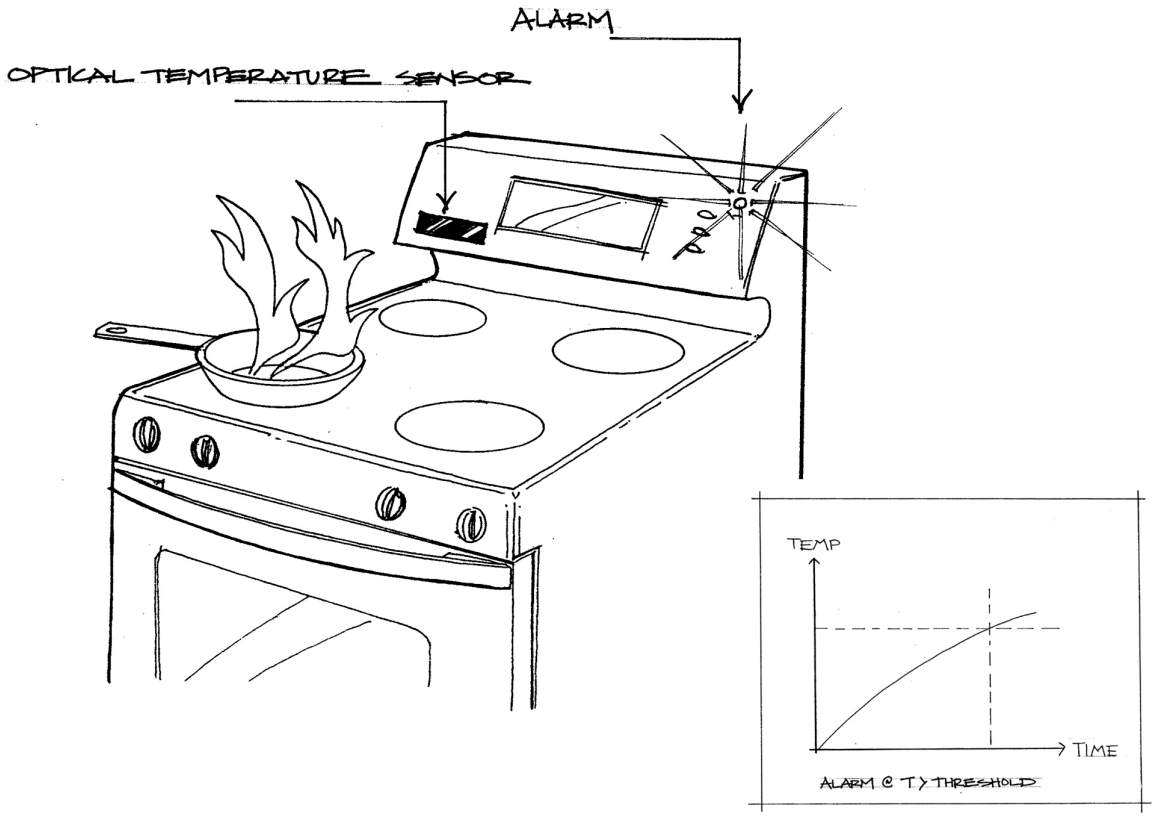


Figure 4-6: Detect Fire - Warning Only -- Optical T sensor

Detect Fire - Warning Only -- Smoke Sensor (Tech Class 7)

In this fire warning system, a smoke sensor located near the cooktop can detect the on-set of certain cooking fires, particularly those involving oil, grease, or fat that generate large amounts of smoke prior to igniting. The smoke sensor triggers an alarm when smoke levels exceed a threshold level.

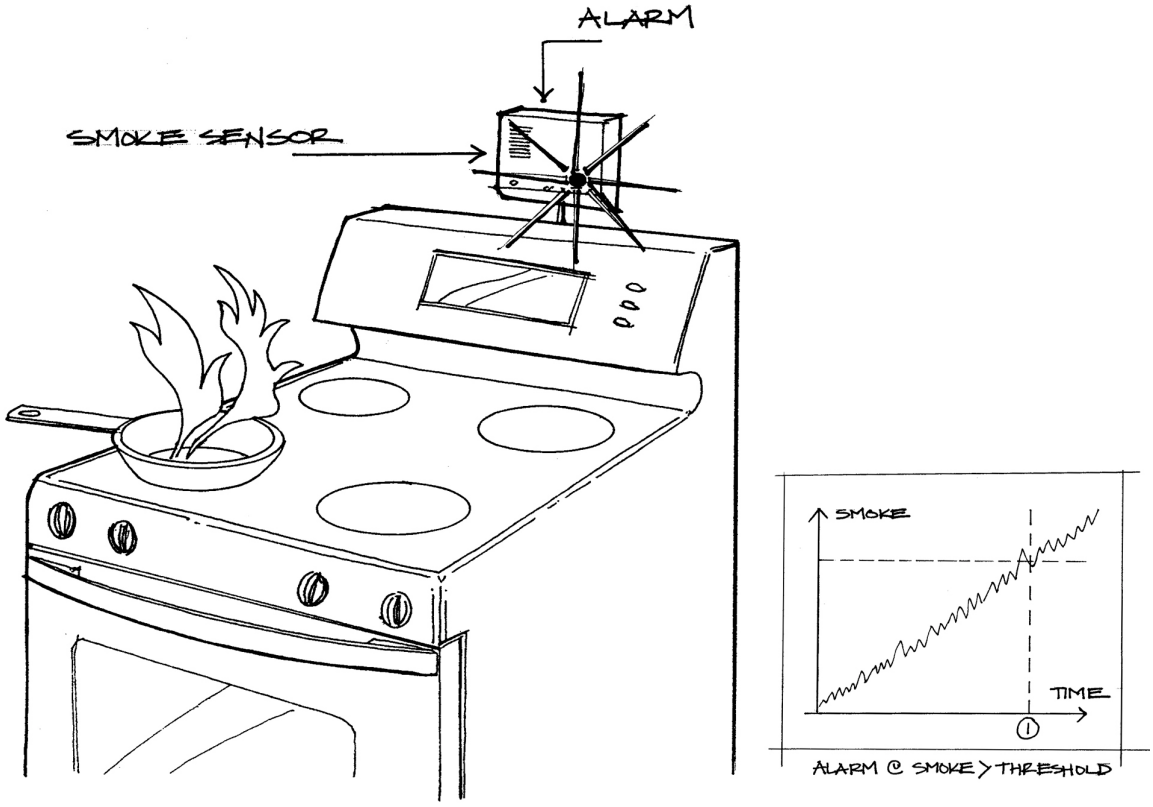


Figure 4-7: Detect Fire - Warning Only -- Smoke Sensor

Contain/Manage Fire Passive (Tech Class 8)

Three fire resistant panels are permanently attached to the sides and back of the cooktop. The panels are intended to contain a fire from spreading to any walls surrounding the cooktop or any flammable products or materials stored nearby the cooktop.

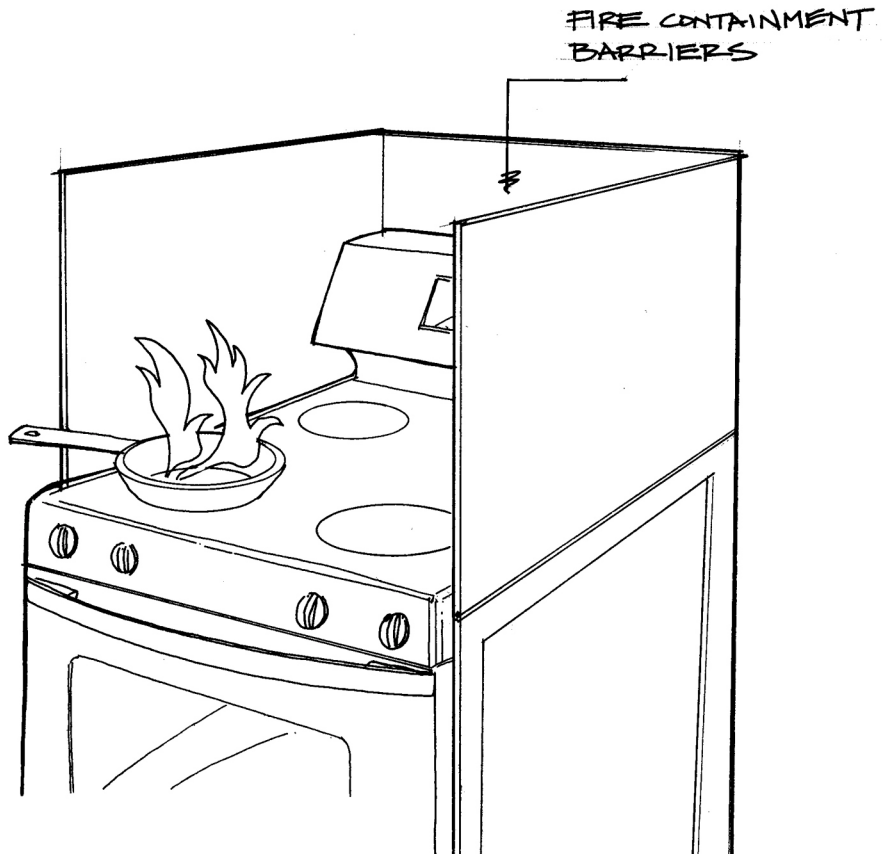


Figure 4-8: Contain/Manage Fire Passive

Contain/Manage Fire Active (Tech Class 9)

This concept defines an active system that completely surrounds the cooktop in case of fire. The system is activated when the temperature above the cooktop is higher than a threshold level. In one configuration, the fire resistant enclosure is in the form of a hood that drops to the cooking surface to contain the fire. A provision to turn off the heat source is also possible.

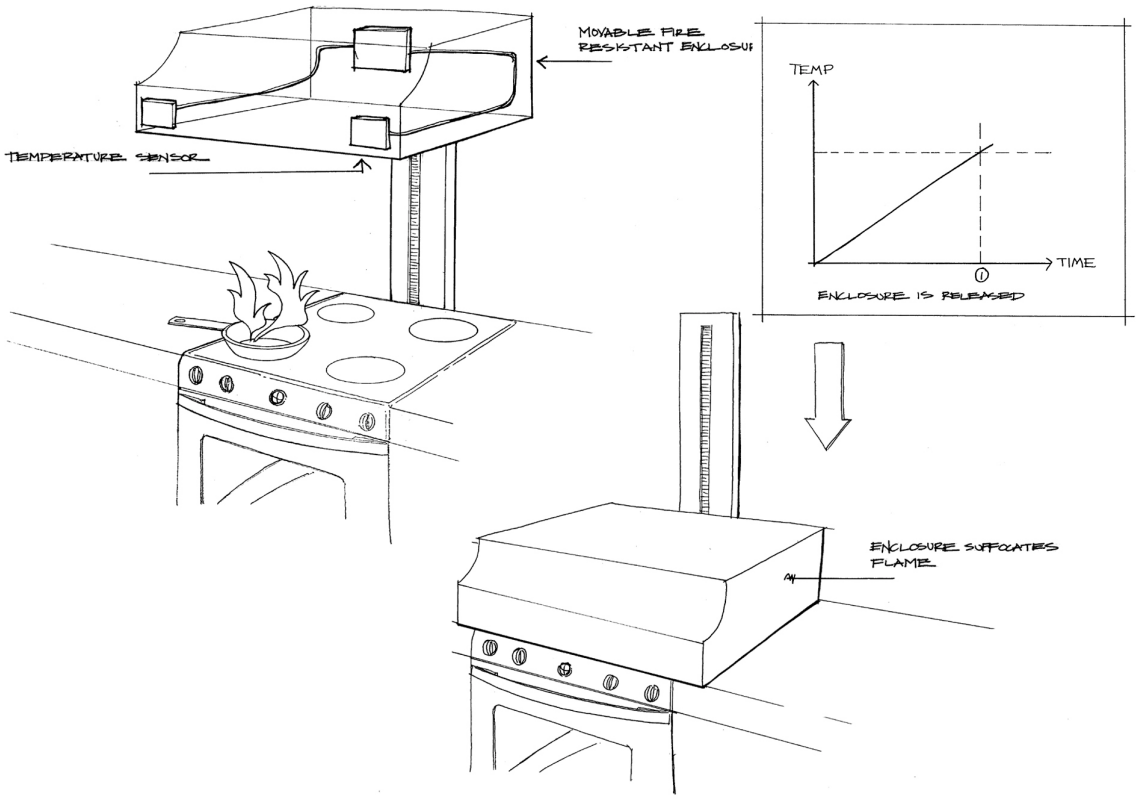


Figure 4-9: Contain/Manage Fire Active

Prevent Unattended Cooking -- Warning and Control -- Motion Sensor Only (Tech Class 10)

This technology is intended to require that a person be present while the cooktop is being used. This approach uses a motion sensor to detect the presence of a user near the cooktop. There are various possible locations for motion sensor, but many patents reference the sensor on the front panel of the cooktop. Slightly different types of algorithms are applied but in general, the system sounds an alarm if no person is detected near the cooktop after a set amount of time. The cook can return to the stove and reset the system without any effect on the cooking process. However, if no one responds to the warning alarm, the control will adjust the hob accordingly: e.g. reduce it or turn it off.

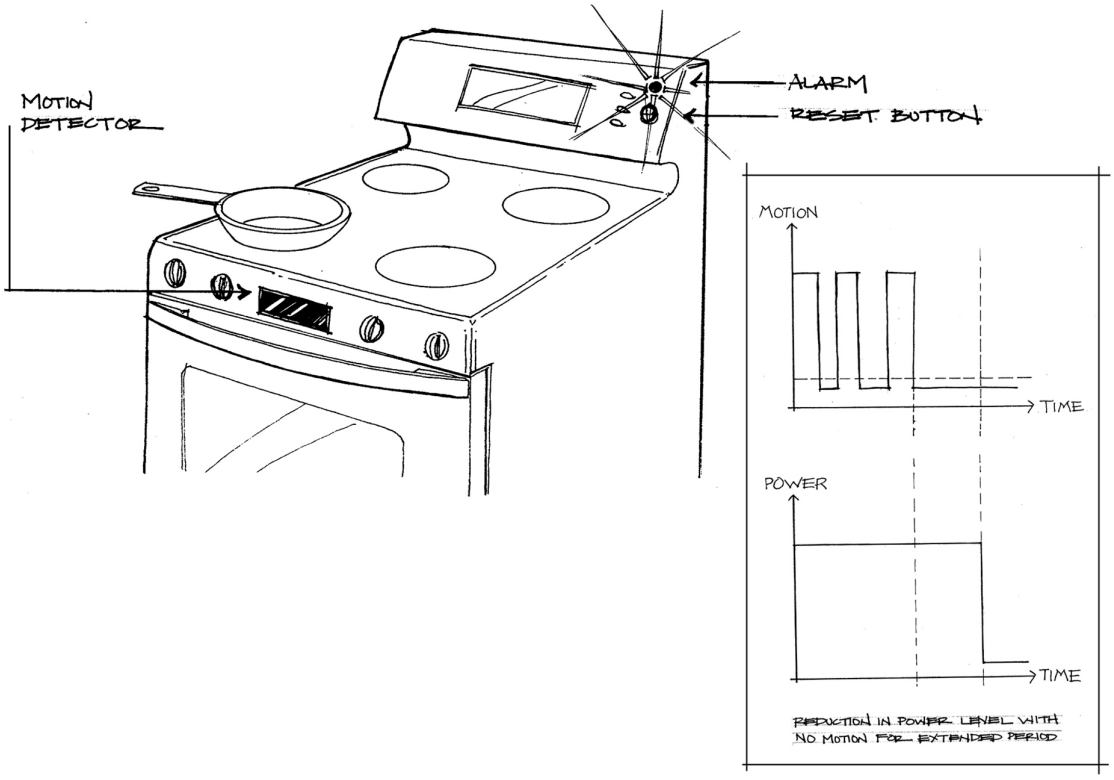


Figure 4-10: Prevent Unattended Cooking -- Warning and Control -- Motion sensor only

Prevent Unattended Cooking -- Warning and Control -- Motion + T Sensor (Tech Class 11)

Again, this technology is intended to require that a person attend to the cooking process. However, this technology couples a motion detector with a temperature sensor so that the person is not required to be present unless the pan temperature is nearing a potentially pre-ignition condition. A pan-contact temperature sensor monitors the temperature of the pan. When the pan-bottom temperature exceeds a threshold limit, the controller will decrease the heat input unless the motion detector senses the presence of the cook near the cooktop. If a person is detected, system might give a warning alarm to alert of the cook of a possible near fire condition.

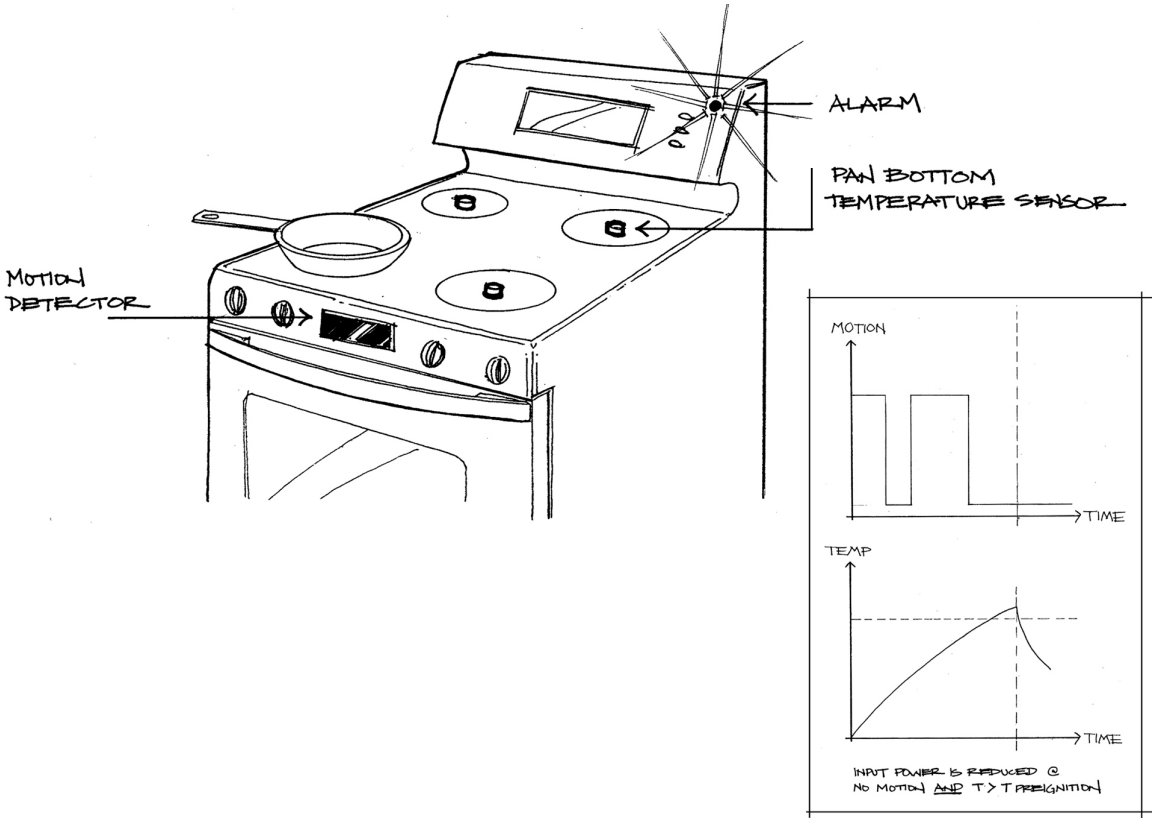


Figure 4-11: Prevent Unattended Cooking -- Warning and Control -- Motion + T sensor

Prevent Unattended Cooking -- Warning and Control -- Motion + Power Sensor (Tech Class 12)

This approach to prevent unattended cooking actuates only when the power level of the heat source surpasses a pre-set level (e.g. Medium-High). When the system actuates, the motion sensor monitors the presence of a user near the cooktop. When no user is detected after a pre-set duration, the alarm is sounded. If there is no response to the alarm (e.g. the user activates a re-set button) the controller will reduce the heat input to the burner or element.

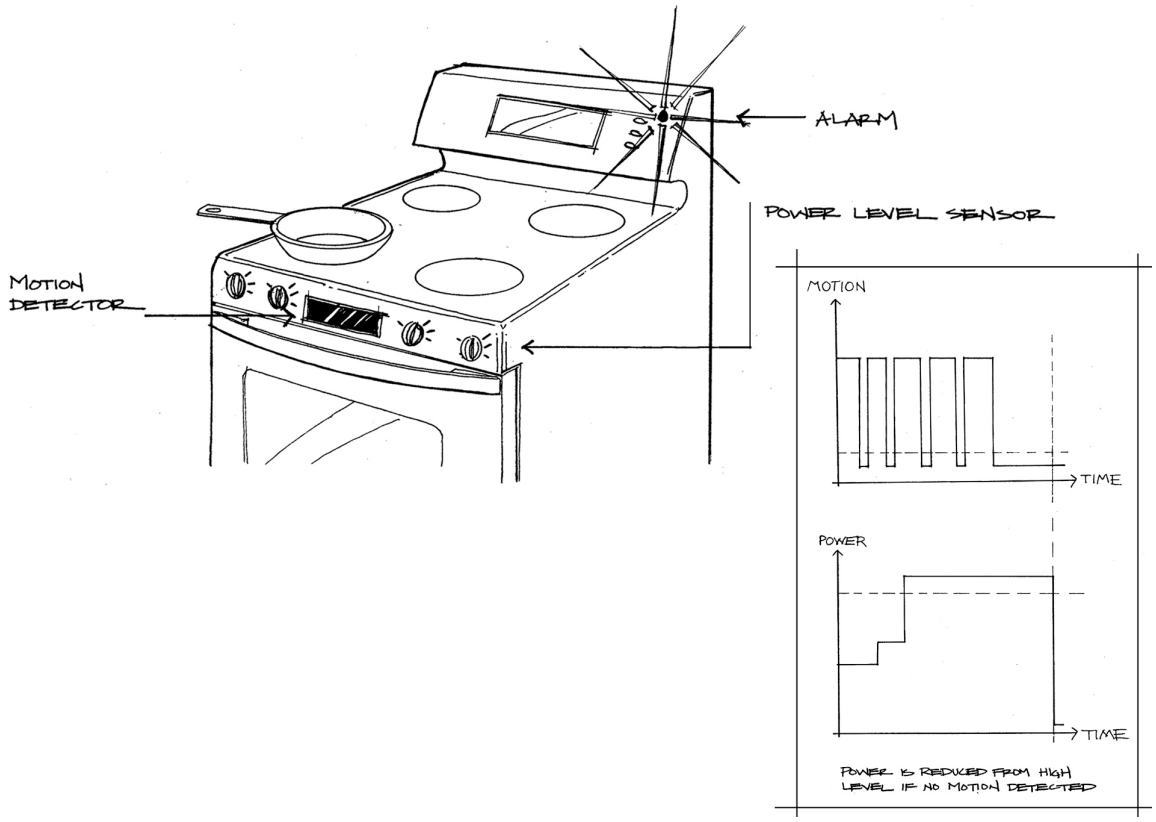


Figure 4-12: Prevent Unattended Cooking -- Warning and Control -- Motion + Power sensor

Prevent Unattended Cooking -- Warning and Control -- Power Level Sensor + Timer (Tech Class 13)

This approach to prevent unattended cooking has no motion detector. Instead, an alarm and control will activate based on the power level selected and a timer that is a function of the power level. Specifically, a time interval is associated with the power level of the element or burner (this could be implemented with relays, and may not require an electronic micro-controller). A timer will trigger an alarm to sound after the element or burner has been turned on. The user would press a re-set button to establish user presence near the cooktop. If the re-set button were not pushed, the control would turn off power to the element or gas to the burner. There are numerous possible variations of this approach. In one configuration, the control and alarm system actuates only above a minimum power level (i.e. activates only when element or burner is set higher than 'medium-low').

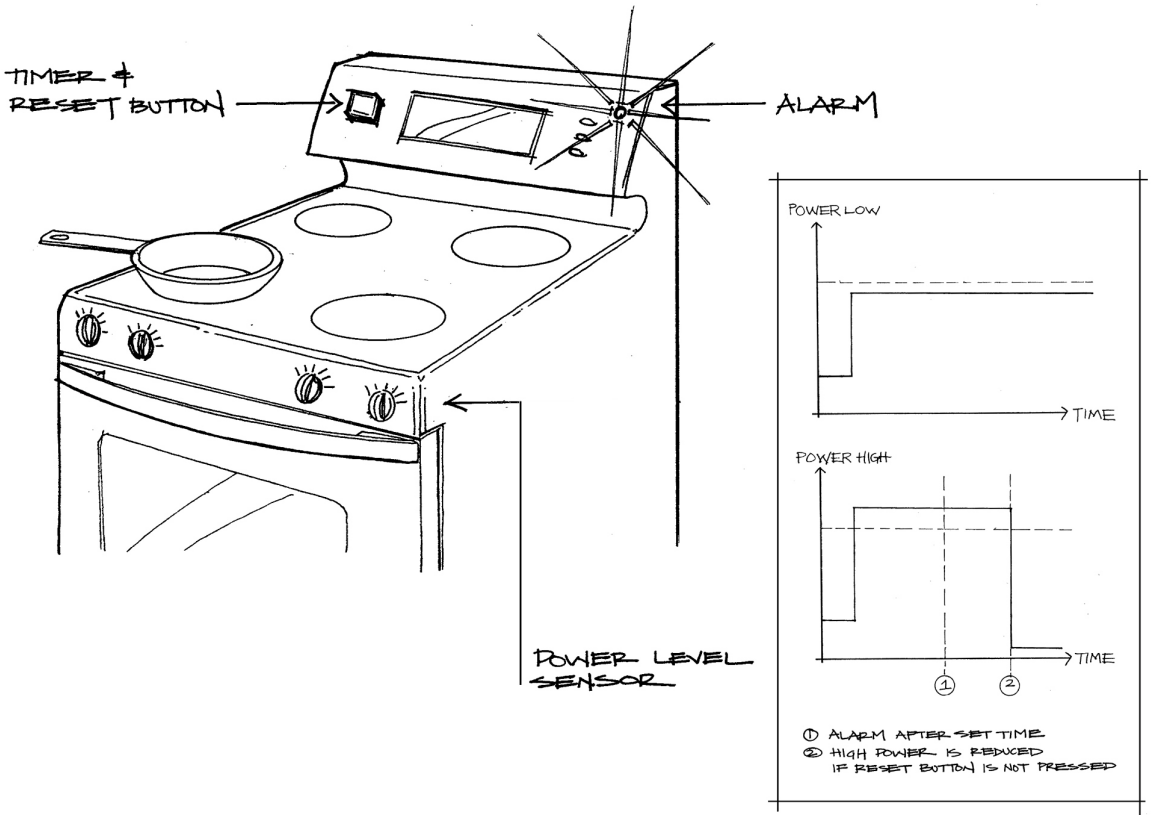


Figure 4-13: Prevent Unattended Cooking -- Warning and Control -- Power level sensor + timer

Prevent Unattended Cooking -- Warning Only -- Motion Sensor Only (Tech Class 14)

The next three technologies attempt to prevent unattended cooking through the use of a warning only. There is no follow-up control that would shut the unit down or reduce input in case no user is detected. In this case, a motion sensor detects the presence of a user near the cooktop. The location of the motion sensor may vary, but most patents show the sensor on the front panel of the cooktop. When the cooktop is operating, the sensor will monitor presence of user. If no user is detected after certain time period, an alarm will sound. The alarm will shut-off automatically if a person is detected nearby.

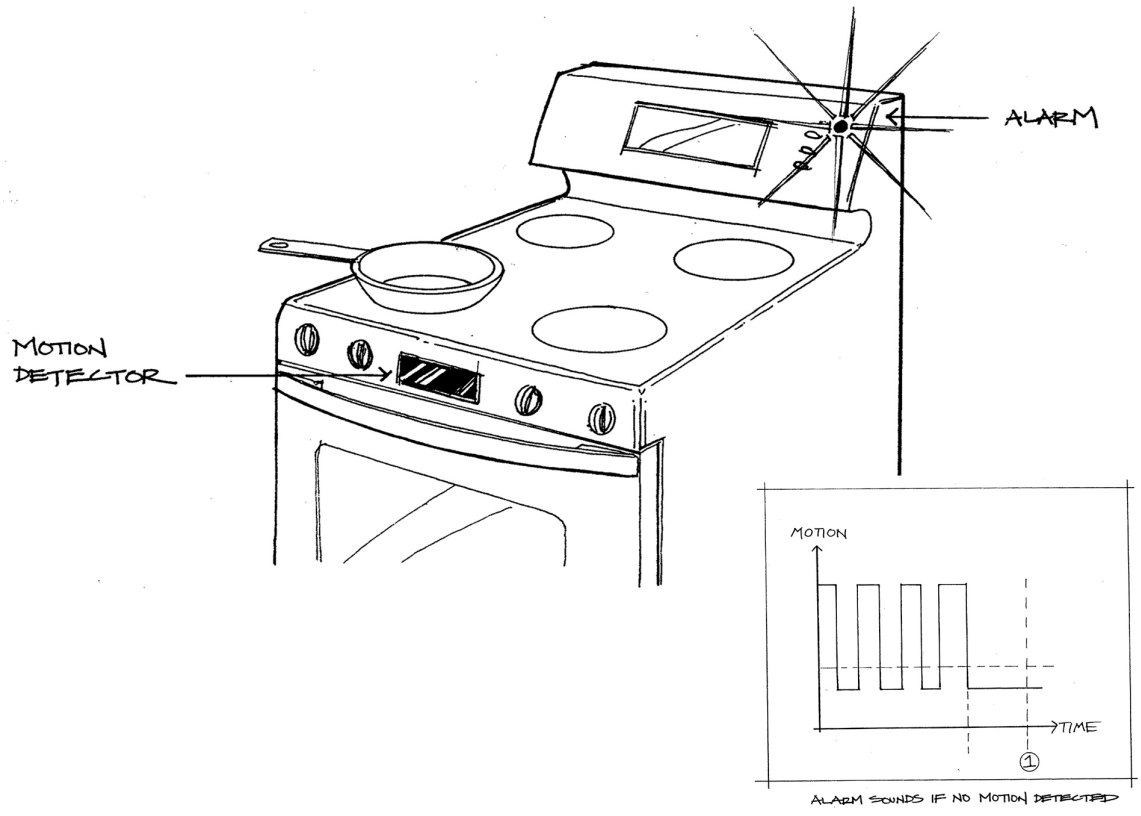


Figure 4-14: Prevent Unattended Cooking -- Warning Only -- Motion sensor only

Prevent Unattended Cooking -- Warning Only Motion + Power (Tech Class 15)

Again, this system attempts to prevent unattended cooking through a warning alarm, but no power level control. In this case, the safety system actuates only when a certain power level of the heat source has been surpassed (e.g. Medium-High level). When it actuates, the motion sensor detects the presence of a user near the cooktop. When no user is detected after a pre-set duration, an alarm sounds. The alarm shuts-off automatically once the motion sensor detects the user.

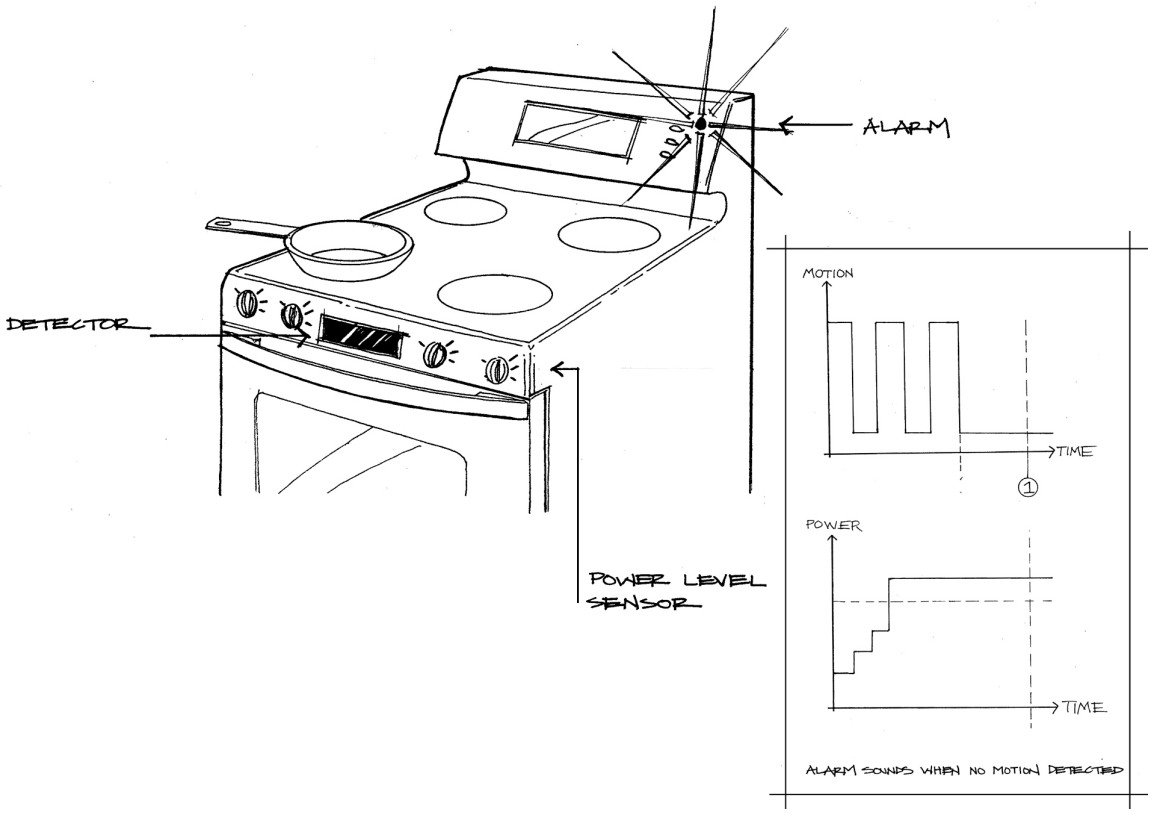


Figure 4-15: Prevent Unattended Cooking -- Warning Only Motion + Power

Prevent Unattended Cooking -- Warning Only -- Power Level Sensor + Timer (Tech Class 16)

This technology to prevent unattended cooking utilizes a power level sensor and a timer to warn the user to attend the cooking process. An alarm will activate based on the power level selected and a timer that is a function of the power level. Specifically, a time interval is associated with the power level of the element or burner (this could be implemented with relays, and may not require an electronic micro-controller). A timer will trigger an alarm to sound after the element or burner has been turned on. The user would press a re-set button to establish user presence near the cooktop. In one system configuration, the system is actuated only at a power level above a minimum threshold level.

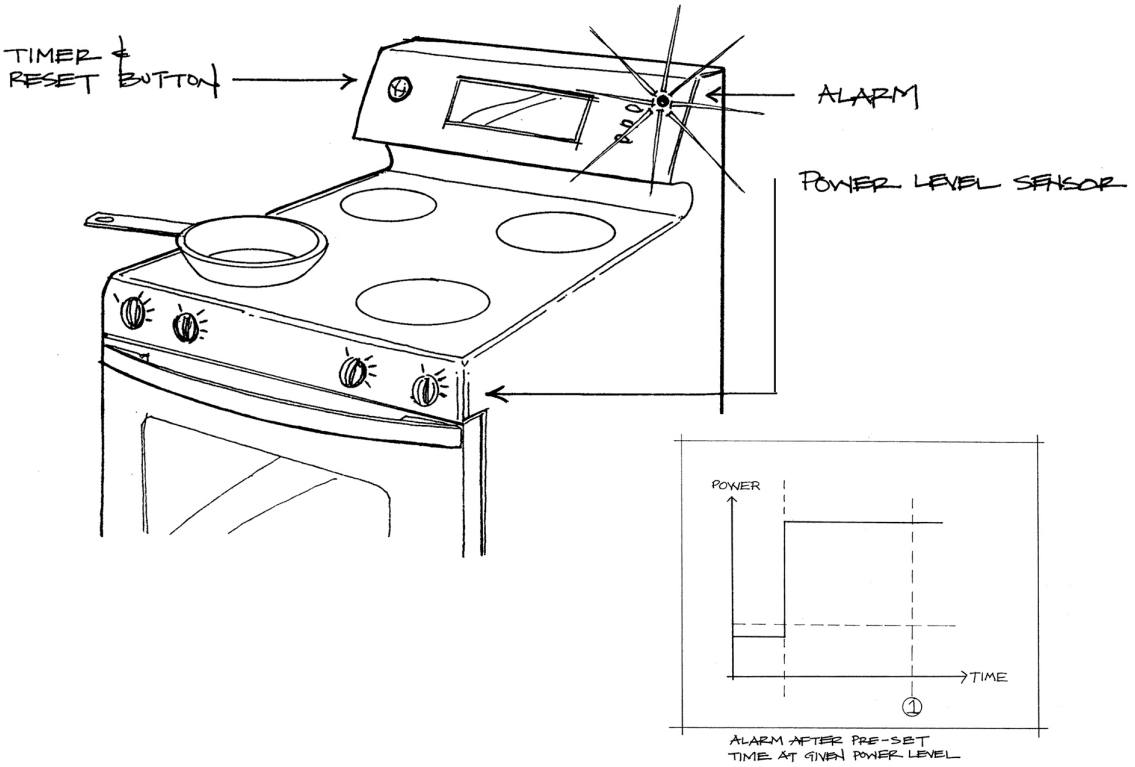


Figure 4-16: Prevent Unattended Cooking -- Warning Only -- Power level sensor + timer

Prevent Food Ignition in Pan -- Elec. Signal Processing, Select Mode or T -- T Sensor Contacts Pot (Tech Class 17)

The next five technologies are intended to prevent ignition of cooking materials in the pan. There are a number of approaches to control the heat input to the pan to avoid ignition. In this configuration, the safety system monitors the pan bottom temperature with a pan-contact temperature sensor (e.g. thermocouple). The controller is defined by a user-selected cooking mode (e.g. searing, boiling, frying) or a specified cooking temperature. A microprocessor control adjusts the heat input to the pot based on the cooking mode selected and the pan bottom temperature. This system prevents the temperature at the bottom of the pan from rising to a level that could cause ignition of cooking materials.

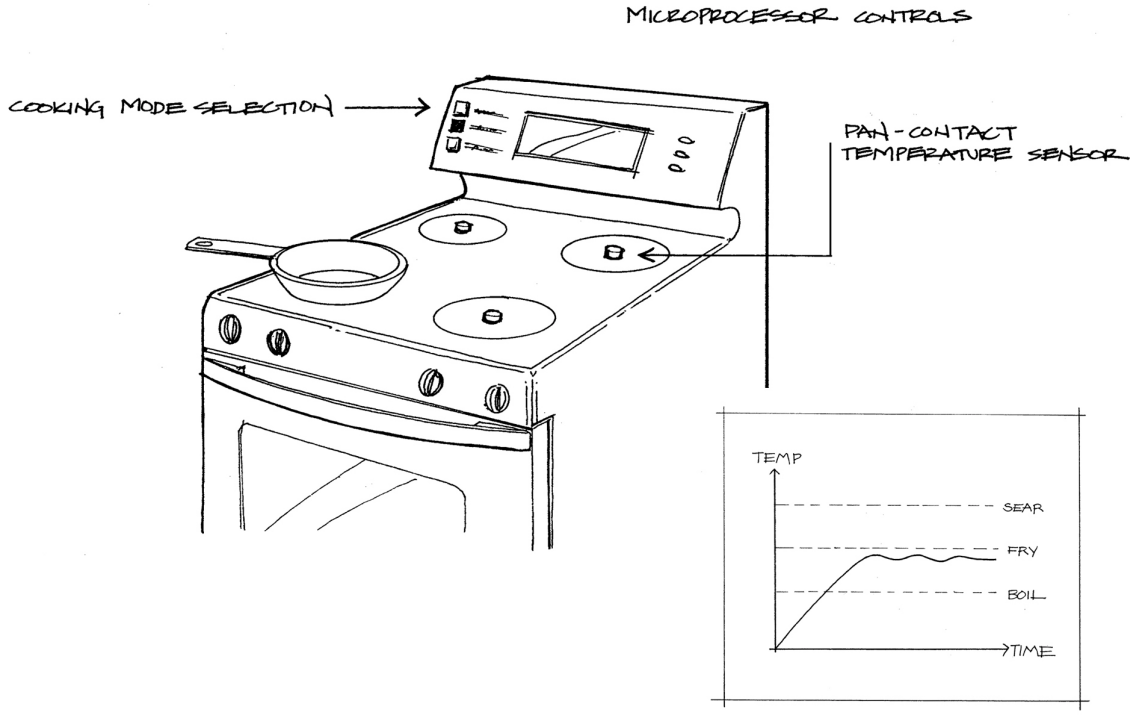


Figure 4-17: Prevent Food Ignition in Pan -- Elec. Signal Processing, Select Mode or T -- T sensor contacts pot

Prevent Food Ignition in Pan -- Elec. Signal Processing, Select Mode or T -- Non-contact T sensor (Tech Class 18)

In this configuration, the safety system monitors the pan bottom temperature with a non-contact temperature sensor (e.g. IR sensor). The controller is defined by a user-selected cooking mode (e.g. searing, boiling, frying) or a specified cooking temperature. A microprocessor control adjusts the heat input to the pot based on the cooking mode selected and the pan temperature. This system prevents the pan temperature from rising to a level that could cause ignition of cooking materials.

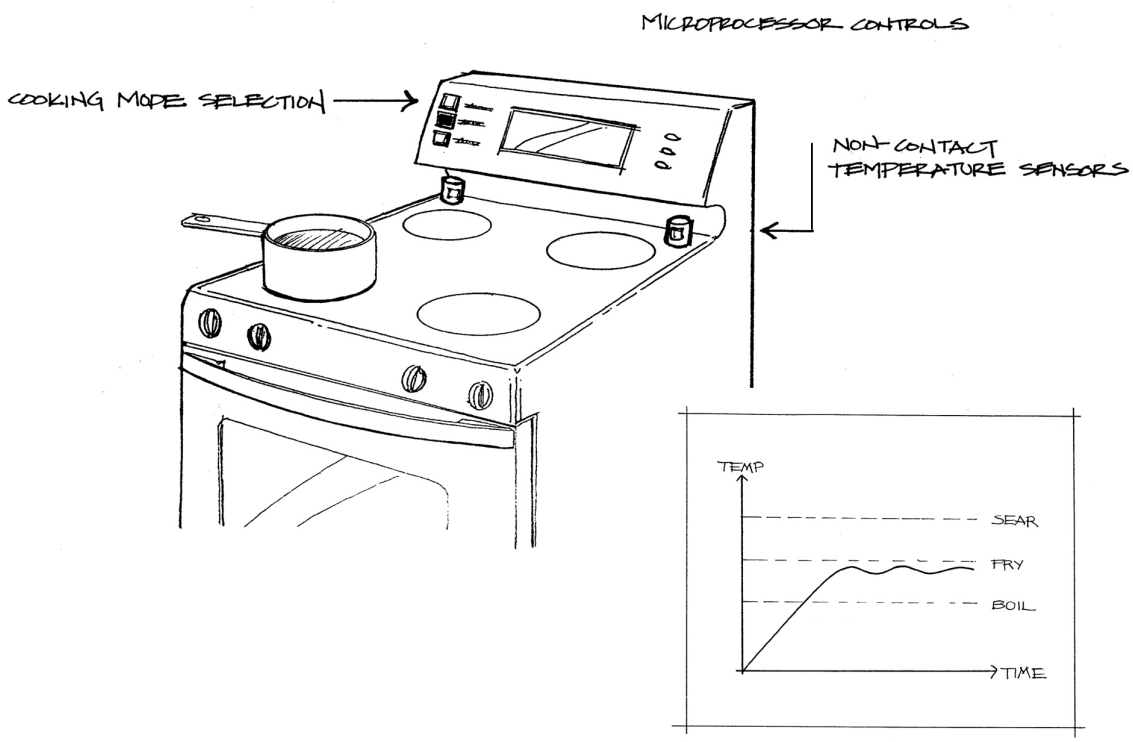


Figure 4-18: Prevent Food Ignition in Pan -- Elec. Signal Processing, Select Mode or T -- Non-contact T sensor

Prevent Food Ignition in Pan -- Elec. Signal Processing, Auto-activation -- T Sensor Contacts Pot (Tech Class 19)

In this configuration, the safety system monitors the pan bottom temperature with a pan-contact temperature sensor (e.g. thermocouple). The controller is configured to limit the temperature at the bottom of the pan to a threshold that is independent of the cooking mode. The threshold is selected to balance the requirements of various cooking modes and the limit to avoid ignition of cooking materials. A microprocessor control adjusts the heat input to the pot based on the pan bottom temperature. This system prevents the temperature at the bottom of the pan from rising to a level that could cause ignition of cooking materials.

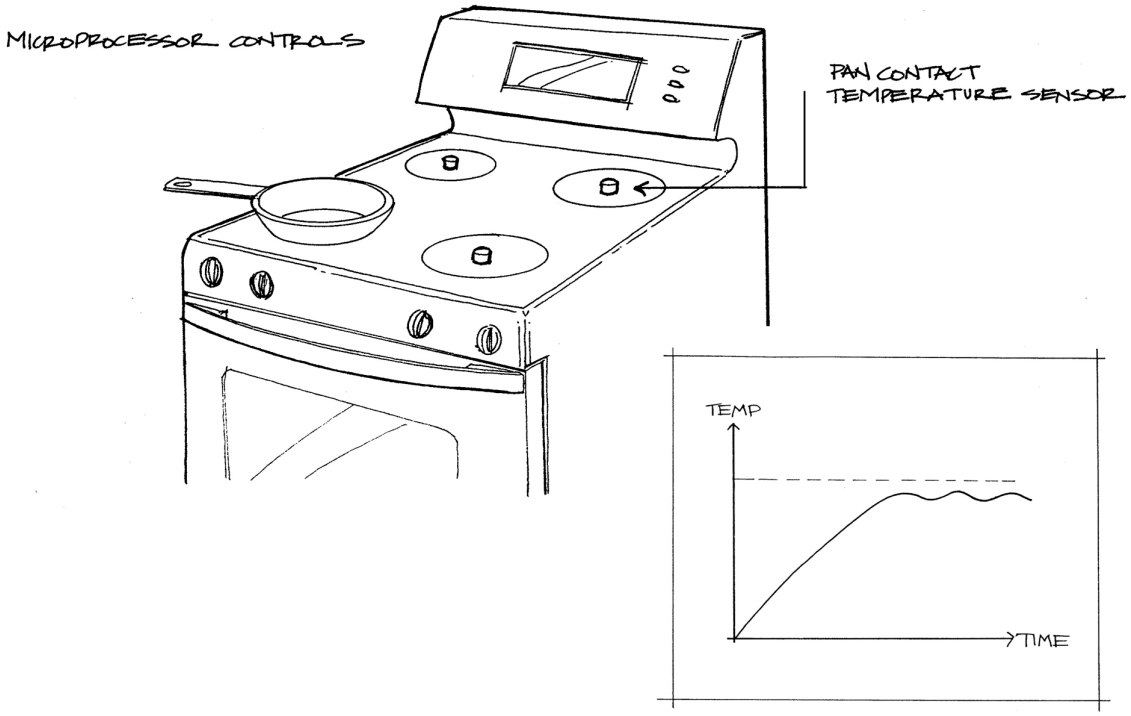


Figure 4-19: Prevent Food Ignition in Pan -- Elec. Signal Processing, Auto-activation -- T sensor contacts pot

Prevent Food Ignition in Pan -- Elec. Signal Processing, Auto-activation -- Non-Contact T Sensor (Tech Class 20)

In this configuration, the safety system monitors the pan temperature with a non-contact temperature sensor (e.g. IR sensor). The controller is configured to limit the pan to a threshold that is independent of the cooking mode. The threshold is selected to balance the requirements of various cooking modes and the temperature limit to avoid ignition of cooking materials. A microprocessor control adjusts the heat input to the pot based on the pan temperature. This system prevents the pan temperature from rising to a level that could cause ignition of cooking materials.

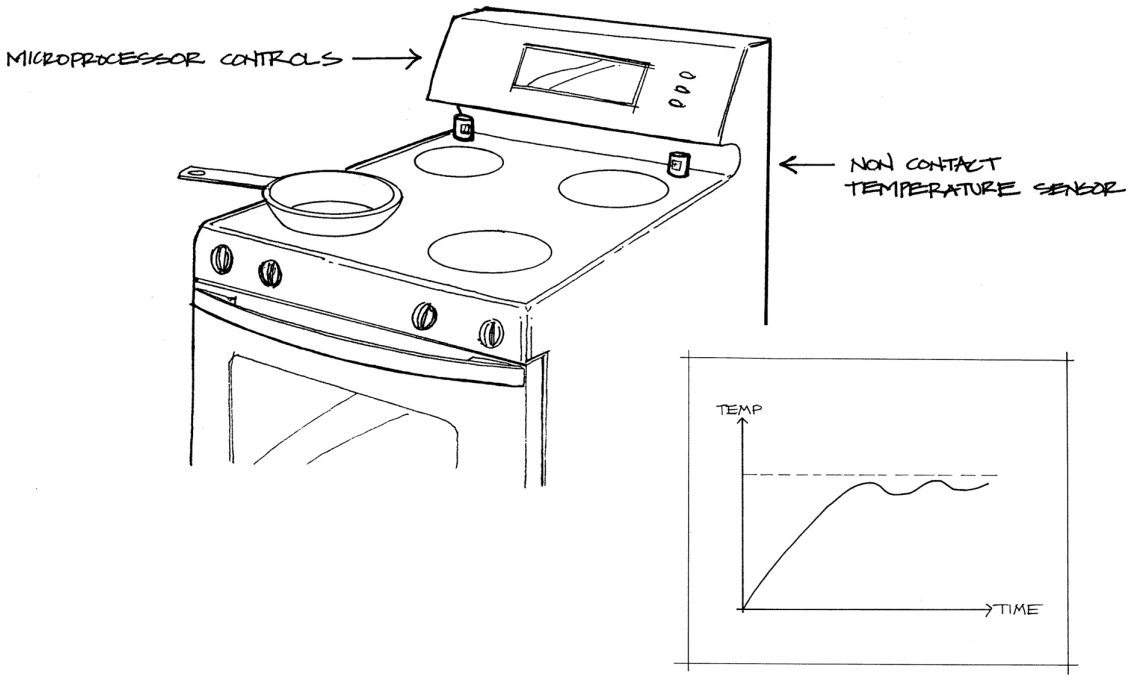


Figure 4-20: Prevent Food Ignition in Pan -- Elec. Signal Processing, Auto-activation -- Non-contact T sensor

Prevent Food Ignition in Pan -- No Signal Processing, Mechanical Actuation (Tech Class 21)

The safety system monitors the pan temperature with a pan-contact temperature sensor. The mode of actuation is mechanical instead of electrical. The temperature sensor used can be bi-metallic piece that will bend at certain pre-set temperature, a magnetized piece that changes properties at certain temperature, or an expandable liquid sensor. This type of technology has been used as either a heat-source regulating device or a one-time shut-off device.

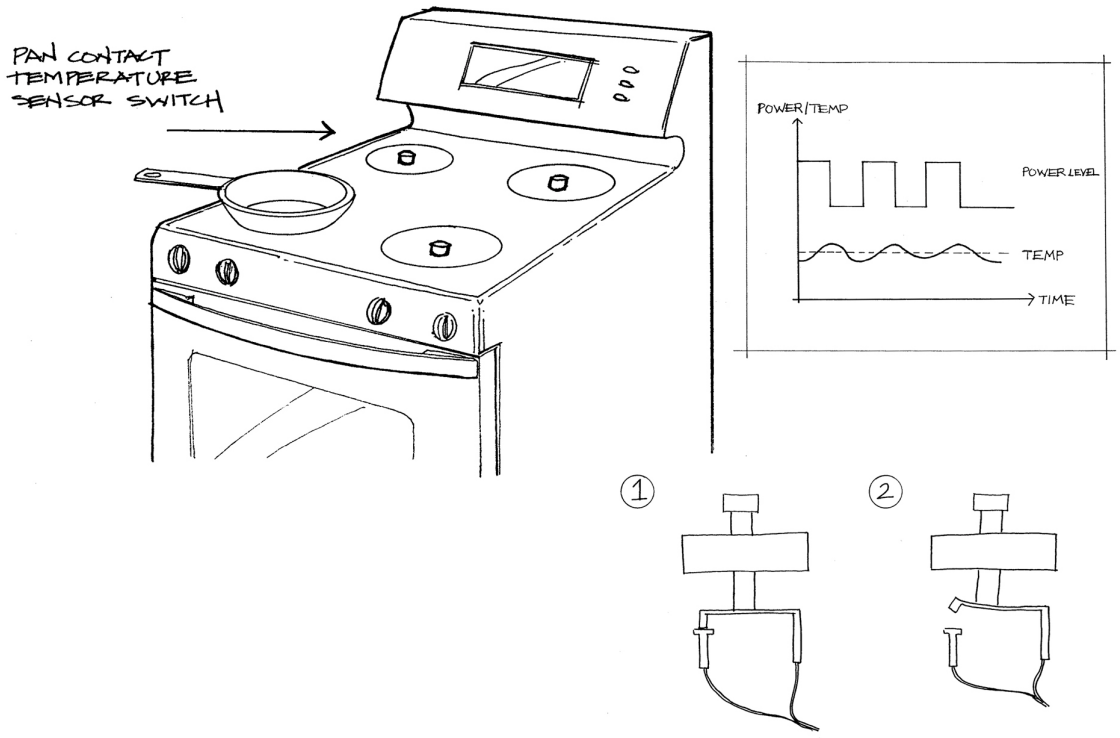


Figure 4-21: Prevent Food Ignition in Pan -- No Signal Processing, Mechanical actuation

Prevent Boil Dry/Spill Over –Temperature Sensor (Tech Class 22)

In this technology, the temperature of cooking utensil is monitored. The sensor technology can be a pan-contact thermocouple, or it could be an optical or non-optical temperature sensor. The basic element of this approach is the detection of a temperature signature for boil dry or spill over (e.g. sharp increase of temperature after a constant temperature reading). The controller is configured to shut-off the temperature to the element or gas burner after the boil-dry condition has been detected.

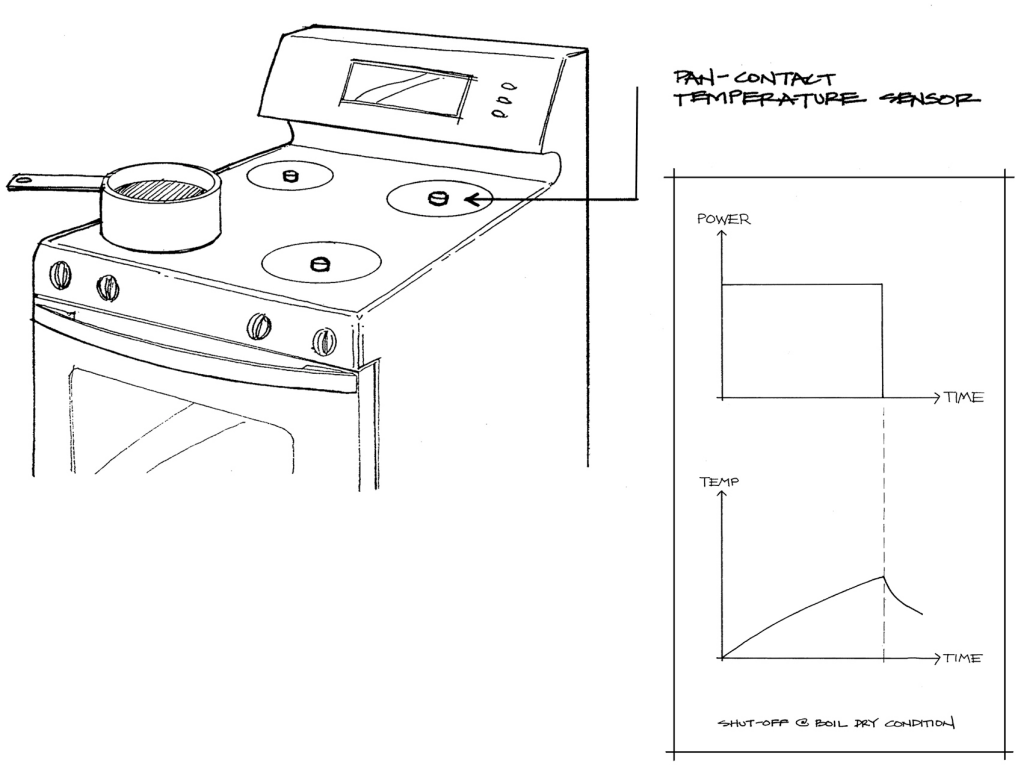


Figure 4-22: Prevent Boil Dry/Spill Over –T sensor

4.3 Screening Criteria

We developed screening criteria for these technologies based on two sets of considerations:

1) The potential impact of the technology on the cooking performance, operability, reliability/durability, safety, and manufacturability/installation/service of the cooktop or range; and
2) The potential effectiveness of the technology to mitigate surface cooking fires.

All the criteria and metrics used to screen, and ultimately evaluate, the surface-cooking, fire-mitigation technologies are listed below.

1. Cooking Performance:

- Effect on Cooking Process:
  - High: Works well with all surface cooking functions
  - Medium: One cooking function is eliminated or negatively affected
  - Low: More than one cooking function eliminated or negatively affected

- Effect on Cooking Time:
  - High: None
  - Medium: Some (Less than 10%)
  - Low: Significant (Equal or More than 10%)

2. Cooktop Operability

- Effect of System on Consumer Behavior While Operating the Cooktop
  - High: New user will not notice any difference in operating procedure compared with conventional cooktop
  - Medium: New user will notice difference(s) in procedure but it will be intuitive enough that he/she will not need a manual to operate
  - Low: New user will need to learn new skills through a product manual in order to operate cooktop

- Limits availability or efficacy of marketed cooktop features
  - High: New user will not notice any difference in product features
  - Medium: New user will notice difference(s) in product features
  - Low: Desirable product features are eliminated

- Safety System Maintenance:
  - High: System maintenance procedure is the same as a conventional cooktop
  - Medium: System maintenance requires few additional procedures/parts that do not require specialist's help
  - Low: System maintenance requires significant additional procedures/parts that might require specialist's help

- Cookware Applicability:
  - High: System works with any utensils, and at normal environment
  - Medium: Some restrictions on cookware or environment
  - Low: Specific set of applicable tools/utensils are needed

- Effect of Safety System on Cooktop Performance After Actuation of System:
  - High: Cooktop can perform normally as before safety actuation
  - Medium: Minor adjustment or cleaning necessary to return it to nominal operation
  - Low: Significant adjustment or cleaning or service call necessary

3. Reliability/Durability

- Can operate over product life w/o failure (safety factor of 2):
  (Considers normal cooktop cleaning (or non-cleaning) and maintenance)
  - High: Meets targets / Life data available/conducted
  - Medium: Looks good but no data
  - Low: Looks problematic, no data

- Can operate within reasonably foreseeable misuse conditions (durability)
  - High: Is robust/durability data available/conducted
  - Medium: Looks good but no data
  - Low: Looks problematic but no data

4. Safety

- Safety system components might pose added risk to consumer:
  - High: None
  - Medium: Some but easily and obviously modifiable
  - Low: Some and not easily or obviously modifiable

5. Manufacturability/Installation/Service:

- Applicability across product types and product models
  - High: Developed to be applicable to all cooktop systems
  - Medium: Can work for all models of one product type, e.g., sealed burners, open burner, open coil, glass ceramic, gas pilot, downdraft systems
  - Low: May require different design for functionally different models within a product type

- Components/system availability
  - High: All parts are on-the-shelf parts or have been manufactured for high volume low cost applications.
  - Medium: Most parts are available on-the-shelf or have been manufactured in high volume at low cost
  - Low: Most parts are new parts that need to be developed and manufactured or adapted from other industries

- Installation
  - High: No added effort than installing range
  - Medium: More time but no added people to install.
  - Low: Additional tradesmen and/or technicians required for installation

- Serviceability
  - High: Current staff can conduct routine maintenance with existing equipment.
  - Medium: Some training and/or new equipment is necessary.
  - Low: Specialized equipment and staff expertise or licensing is necessary.

6. Effectiveness in Mitigating Surface Cooking Fires

- Range of Fire Incident Coverage (Based on existing fire data)
  - High: Would address over 90% of surface cooking fires, based on the categories defined in NFPA study.
  - Medium: Would address between 40% - 90% of surface cooking fires
  - Low: Would address fewer than 40% of surface cooking fires

- Percent of new product sales covered by this technology
  - High: Would cover over 90% of new surface cooking products.
  - Medium: Would cover between 40% - 90% of new surface cooking products
  - Low: Would address fewer than 40% of new surface cooking products

- The degree of mitigation of fires addressed:
  - High: Prevents a fire from starting
  - Medium: Extinguishes/Manages a fire
  - Low: Warns of a Fire

- Ease of System Verification
  - High: Automatically verifies proper operation
  - Medium: User can verify operation with self test mode
  - Low: Verification of operation possible by service tech

- Potential for False Actuation:
  - High: "No" chance for false positive or false negative
  - Medium: Potential for false positive
  - Low: Potential for false negative

- Effect of Actuation on the Safety System:
  - High: Safety system does not require consumer reset (and this is safe)
  - Medium: Users have to manually reset the safety system (e.g. a press of a button)
  - Low: Service call or component replacement/recharging necessary for the safety system to return to its ready state

- Safety system's effect on cooktop's requirement to meet current safety standards (UL/ANSI); i.e. need to fail safe (cooking system shuts-down if safety system is not working):
  - High: In full compliance with standards
  - Medium: Can be easily and obviously modified to achieve compliance
  - Low: No obvious modification available to achieve compliance

4.4 Additional Considerations for Technology Evaluation

There were a number of additional considerations that formed the basis of the technology screening and evaluation work. These considerations are summarized in the following five sections.

4.4.1 Cooking Processes

We used criteria set forth by the ANSI Z21/UL 858 STP Cooking Fires Working Group to establish the cooking requirements of any range or cooktop coupled with a fire mitigation technology. Specifically, we used this group's list of cooking tests as a starting point for establishing the types of cooking processes that any cooking product would be required to provide. These cooking processes included:

- Blackening meat or fish in a skillet;
- Stir Frying Vegetables or Meat in a Wok;
- Boiling 1, 2, and 4 quarts of water in appropriately sized sauce pans;
- Heating and simmering sauces in 1 and 2 quart pans;
- Deep fat frying (repeatedly); and
- Canning (boiling and maintaining the boil of 8 quarts of water for 4-6 hours).

In addition, we added the following cooking processes to the list:

- Putting a kettle on to boil, (and leaving the kitchen); and
- Preparing a 'flambé', wherein the alcohol poured into a pan is burned off.

We used these cooking processes as a benchmark to evaluate whether fire mitigation technologies 'would work well with all surface cooking functions'.

A complete list of the definitions we have used for specific cooking processes is included in Appendix C.

4.4.2 Cooking Time

The effect of a fire mitigation technology on cooking time is an area of considerable concern for the industry. Market forces are continuously demanding cooking technologies that provide added convenience. In surface cooking, this market demand

translates into the need to reduce the time required to bring foods to their desired temperature (e.g. the time to boil, or the time to heat oil to the desired temperature).

There is general industry concern that a technology that limits the pan temperature to below a pre-ignition condition could have an adverse affect on cooking time. In addition, there is general concern that the temperature at the bottom of the pan may not accurately indicate the temperature of the cooking materials in the pan. Some of the tests conducted by Good Housekeeping on the CPSC cooking control prototype showed significant increases in cooking times for certain cooking functions. However, the existing data did not reveal the cause of the increased cooking times. In our meetings with appliance manufacturers, they did not identify any existing data on cooking process temperature or the measurements of pan temperatures under various cooking conditions.

In order to evaluate the potential efficacy of a pre-ignition threshold controller, we needed to determine the pan temperatures required for a set of standard cooking procedures and compare these temperatures to the thresholds used to avoid a pre-ignition condition. In a limited number of focused tests in our labs at Arthur D. Little, we examined:

1) the pan temperature associated with boiling, searing, and frying, and
2) the control temperature thresholds of the two CPSC prototypes (a Magic Chef gas range fitted with a prototype safety system, and a Hotpoint electric range fitted with a different prototype safety system), and a commercially available, Japanese residential cooker made by Rinnai with the SAFULL pan temperature control function intended to prevent overcooking, burning and overheating of deep frying oil. .

We compared these temperatures to the pre-ignition thresholds for oils identified in the literature (e.g. the CPSC studies, AHAM food test program, edible oil data, etc.)

In a series of experiments using a variety of pan types (stainless steel, aluminum, cast iron), we measured the temperatures of the pan bottom and pan contents during various cooking procedures. Pan bottom temperatures were measured at the center and edge of the pan, using K-type thermocouples drilled into the base of the pan. Pan contents temperature was measured using a third thermocouple placed into the liquid or pushed into the steak.

First, we confirmed the range of temperatures at which cooking oil would ignite in our setup, by heating oil on a burner with no safety system acting until ignition occurred. The results were consistent with the significant body of data available on oil ignition temperatures. The figure below shows the temperature ranges determined by us and those quoted by other sources. The results of analysis and ignition tests of used oil are described in Appendix G.

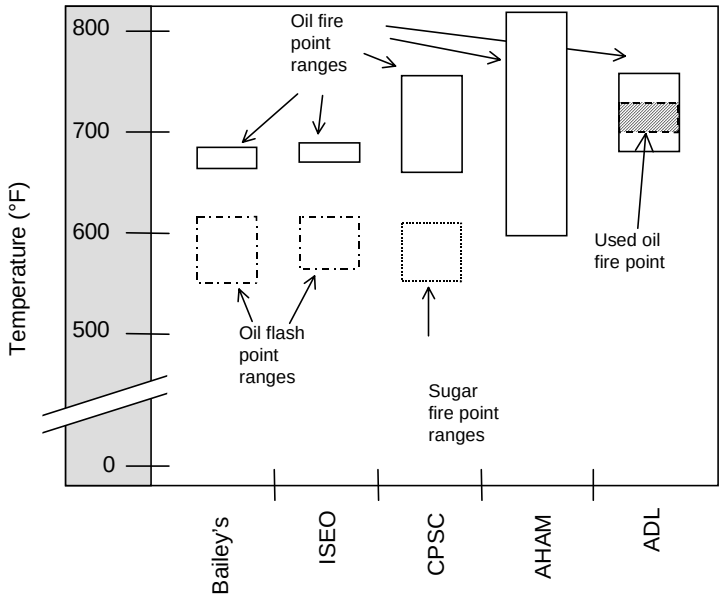


Figure 4-23: Food ignition temperatures.

Sources: Bailey's Industrial Oil and Fat Products; Institute of Shortening and Edible Oils (ISEO); CPSC Study (Phase III Report); AHAM "Food Fire" Test Program; ADL Tests. Fire point =Temperature at which spontaneous ignition can occur, Flash point = point at which external flame will cause ignition).

Next, we investigated the different temperature regimes for a variety of cooking procedures. We allowed different quantities of water to boil normally, with no safety system acting. Frying was simulated by heating oil on the Rinnai burner, using the setting that is designed to maintain the highest optimum temperature for frying food (390ºF). Steaks were pan-seared by an experienced cook, again with no safety system acting.

The figures below show the temperature ranges involved in the different processes. The first figure shows food temperatures. The second figure shows pan bottom temperatures.

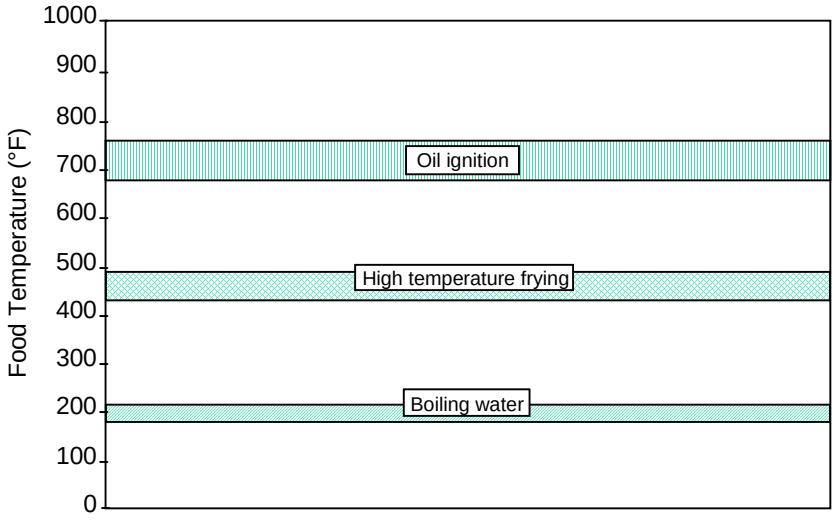


Figure 4-24: Temperature of pan contents during various cooking procedures

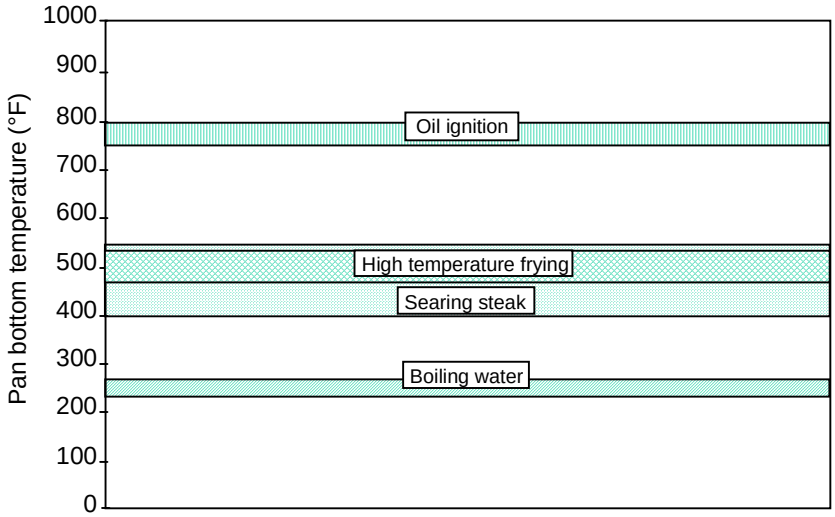


Figure 4-25: Temperature of pan bottom (at center of pan) during various cooking procedures

These figures indicate that the temperatures reached by both the food and pan bottom during normal cooking procedures are significantly lower than those experienced when ignition occurs. With an accurate, robust method of measuring pan temperature, it would in theory be possible to implement a threshold-based temperature control algorithm that should prevent ignition from occurring without affecting normal cooking. The issue is one of engineering design, not of fundamental principles.

However, the two prototype systems that we tested demonstrated the difficulty of designing an accurate pan bottom temperature sensor for this application. Both the electric and gas cooktops used spring-loaded thermocouple temperature probes that protruded above the electric ring or burner grate. When the pan was placed on the heating

element, the temperature probe was depressed but remained in contact with the pan bottom. The sensor on the gas stove used a shield around the probe to try to insulate it from the flame. As the graph below shows, we recorded large differences between the temperatures measured by the probes and those measured by the thermocouples we had embedded into the pan bases, particularly with the electric cooktop system.

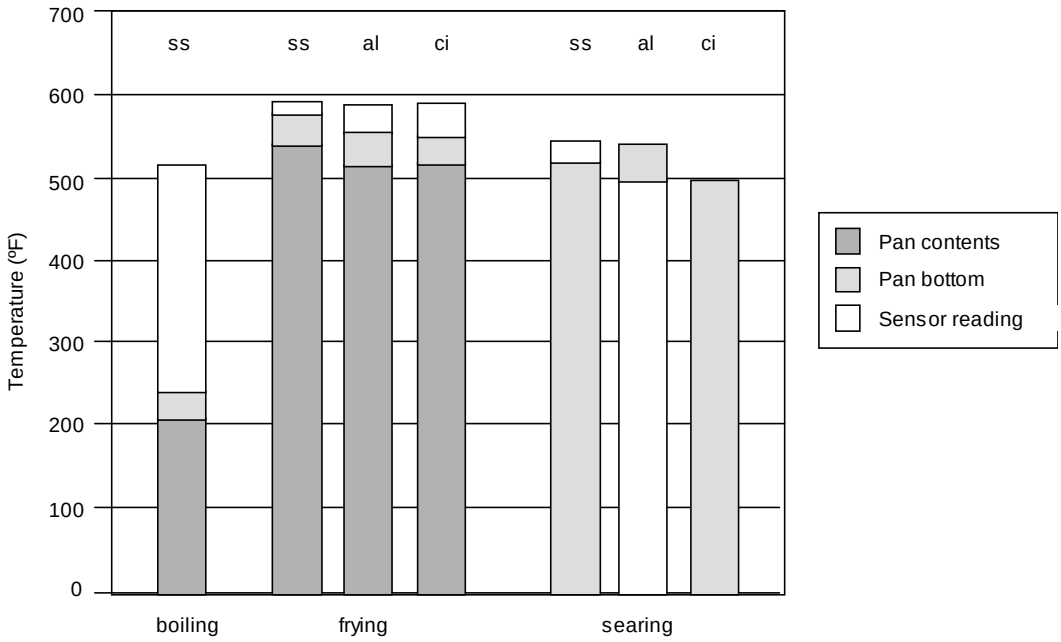


Figure 4-26: Differences between sensor readings and pan bottom & contents temperatures

Shielded, Centered Probe used in the CPSC gas-range prototype controller .
ss = stainless steel pan ; al = aluminum pan; ci = cast iron pan. Pan contents temperatures are not shown for searing.

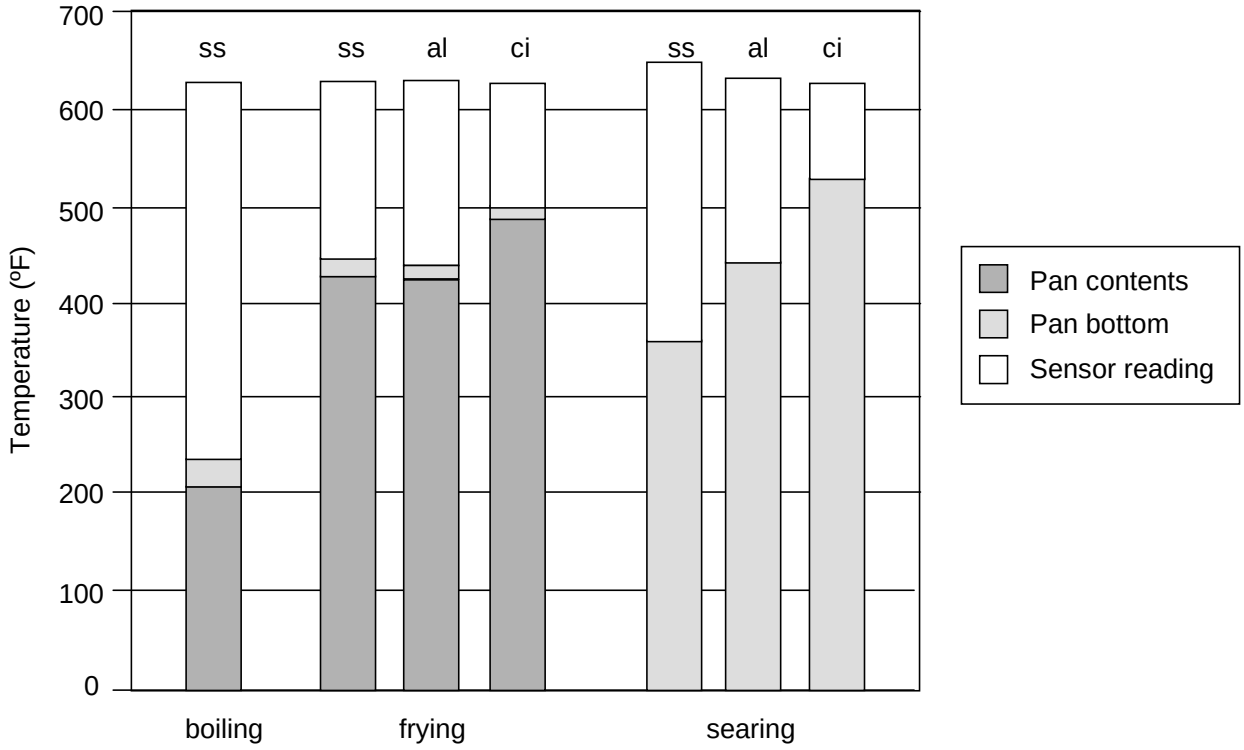


Figure 4-27: Differences between sensor readings and pan bottom & contents

Unshielded, through-coil probes (Temperature measured is maximum of the 3 probes) used on the CPSC prototype electric cooktop controller. ss = stainless steel pan ; al = aluminum pan; ci = cast iron pan. Pan contents temperatures are not shown for searing.

The safety systems were triggered when the measured temperatures exceeded a pre-set threshold. Because the probes were reading temperatures much higher than the pan bottom had actually reached, this limited the pan bottom temperature to a significantly lower threshold. As a result, in some cases, the pan did not get hot enough to produce good searing of the steak or even to allow a rolling boil.

This analysis provided some insights to the basis of the cooking performance of the current CPSC pre-ignition control prototypes. The tests and analysis also shed some light as to the engineering requirements for these types of safety systems.

See Appendix D for detailed plots of temperature measurements during the cooking tests.

4.4.3 Fire incident statistics used

We reviewed a variety of fire incident statistics in order to associate surface fire mitigation technologies with the fraction of fire incidents that potentially could be addressed by the technology. The fire statistics that we reviewed included:

Ten Community Study of the Behaviors and Profiles of People Involved in Residential Cooking Fires, Executive Summary, National Association of State Fire Marshals, Cooking Fires Task Force, AHAM Safe Cooking Campaign, July 1996 (Includes research conducted from 1995 through 1996).

US Home Cooking Fire Patterns and Trends, John Hall Jr., Fire Analysis and Research Division, National Fire Protection Association, April 2000 (and previous reports) The latest data contained in this study are from 1997.

Range Fires, Characteristics Reported in National Fire Data and a CPSC Special Study, Linda Smith et al, US Consumer Product Safety Commission, Hazard Analysis Division Directorate of Epidemiology and Health Sciences, January 1999.

The primary statistics that we used from these reports are as follows:

- Surface cooking represents between 73 – 83% of cooking fires, depending on the analysis;
- Depending on the analysis, between 58 – 85% of the surface cooking fires were unattended at the time of ignition.
- Cooking materials were ignited first in 72 – 77% of surface cooking fires.
- Half of homeowners who attempted to fight a cooking fire did the wrong thing.
- The cooking materials that do ignite are primarily greases, oils, meats, fish or starches.

We used these statistics in the following aspects of our evaluation work.

- The basis for focusing on surface cooking fires was confirmed. The significance of both unattended cooking and the ignition of cooking materials as factors in cooking fires was confirmed.
- We eliminated all patents, technologies, products or concepts that required a person to approach the fire or address it manually in any way. We eliminated these approaches because the statistics indicated that half of people who attempt to respond to a kitchen fire do the wrong thing. Fire marshals recommend leaving the area of the fire and calling the fire department. We wanted to be consistent with this recommendation.
- Fire extinguishing technologies that were not intended to address oil or grease fires were eliminated from consideration.
- We used the statistics to estimate the potential effectiveness of certain fire mitigation approaches. These numbers are only general estimates; they are useful for evaluating the relative impact of technologies. We averaged the varied numbers from the various reports as follows:
  - Requiring someone to attend to cooking was estimated, for the purpose of comparison, to mitigate 65 - 70% of surface cooking fires.
  - Preventing cooking materials from igniting was estimated, for the purpose of comparison, to mitigate 72% of gas surface cooking fires and 77% of electric surface cooking fires. The total effectiveness of a technology intended to prevent the ignition of cooking materials is also dependent on the applicability of the

technology to specific product types and the sales volume of the applicable product types. (Data used on product types is included in Section 4.4.5.)

4.4.4 Reliability/Durability

The ANSI Z21/UL 858 STP Cooking Fires Working Group outlined the reliability/durability requirements for any system that would be associated with a range or cooktop. We considered these requirements in our analysis of the various fire mitigation technologies. For the most part, there was insufficient data to determine conclusively whether the technologies could pass the defined tests. However, the group's guidelines for the requirements of any technology are listed below. Not all the requirements are pertinent to all the potential fire mitigation technologies. Reliability is clearly an important open item that would need to be addressed directly as part of a product development process for any new safety system.

- Perform as designed for twice its design life. It is recommended for safety components to have minimum of 100,000 cycles.
- Control components removed and installed 2,000 times without need for re-calibration – based on one disassembly operation for cleaning per week for 20 years with a 2x safety factor applied
- A burner needs to be cleaned thoroughly w/ washcloths and standard household cleaners for a total of 15,000 cycles (based on one cleaning per day over 20 years with 2x safety factor.
- Control components shall perform as designed after dragging 12" diameter. cast iron with heavy pattern/ribbed surface. The pan is assumed to be drawn across burner with a horizontal motion of 4-6 inches for a minimum of 50,000 times: This corresponds to pan movement for 2-3 times per day for 20 years with 2x safety factor.
- If a sensor is attached to a heating element where disassembly is allowed for cleaning, it should be removed and installed 2,000 times and reseated using 12" cast iron pan with a downward force (not impact) of TBD lbs
- Performance and reliability tests on used and new burner and components using: soil build-up, oxidation, water and grease, baked on or burnt on food materials -- use food mixture shown in ANSI Z21.1 or AHAM ER-1-1992 Section 8.6. Sensor should detect all required safety parameters without change in calibration.
- Depending on the type of sensor, performance and reliability tests at environmental condition of: Hood fan on high (250-300 CFM), in 85% humidity, 20% humidity and altitudes of 3000 feet
- For fire management system mounted on hood:
  a. Surface temperature at any point of the top building cabinet should not exceed 300C (572ºF)
  b. A fuse rated 3A connected between exposed dead-metal parts of cooking appliance and ground should not open
- For gas ranges, any components shall show no degradation when shut-down of range is applied. Any shut-down of gas valve shall allow safe restart without attention by service personnel.

4.4.5 Product Classes

We have used industry statistics and definitions of product classes in order to associate specific products with relevant fire mitigation technologies.

Gas and electric cooking products are classified into the following product categories:

- Free-standing Ranges – a stand-alone cooking product with cooktop and oven
- Drop-in (slide-in) Ranges – a cooking product with a cooktop and oven that is designed to be built into a cabinet/counter.
- Surface Cooking Units- a cooktop that is installed into a countertop.

Any of these product classes can be constructed in a downdraft configuration, meaning that a ventilation system is integral to the cooking product and no hood would be required/installed.

Gas units are further divided into the following product categories:

- Open Burners
  - With pilot
  - Electronic Ignition
- Sealed Burners

Electric units are further divided into the following product categories

- Smoothtop (glass ceramic)
- Open coil

In our analysis, we needed sales numbers (in percentages) associated with the following product categories. We have made estimates of these numbers based on AHAM data and information provided to us by manufacturers.

Overall sales percentages (and trends) are shown in the following graph:

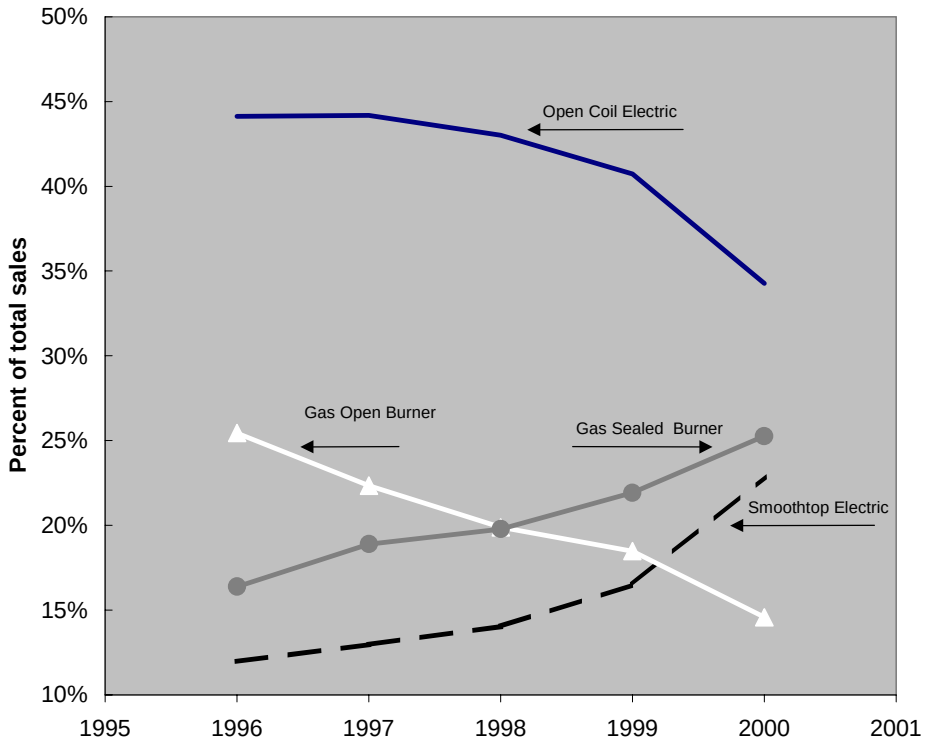


Figure 4-28: Trends in cooking product mix

- Percentage of products overall that currently have an electric connection (>90%)
- Percentage of surface cooking products that are installed in an island or peninsula configuration that would inhibit (or make more complex) the installation of an overhead hood. (<10%)
- Percentage of surface cooking products with downdraft ventilation (<10%)

4.5 Technology Screen

We evaluated each Technology Class listed in Section 4-2 in accordance with the Screening Criteria listed in Section 4-3. In the scoring process, a numerical score of 9 corresponded to a High score, 5 corresponded to a Medium score and 1 corresponded with a Low score. The scores of each technology are detailed in Appendix E. The basis of each score is detailed in Appendix F.

A graphical representation of the results of this screening process is shown in Figure 4 – 29. The technology scores are plotted on the axes of "Impact on Product Value" and "Effectiveness in Mitigating Surface Cooking Fires". A technology that is relatively more effective in mitigating surface cooking fires, with limited impact on other aspects of the product value, would be plotted in the upper right hand corner of the graph.

This screening process was effective in providing a comparison among a set of very different technologies. It helped to highlight a subset of technologies for further consideration.

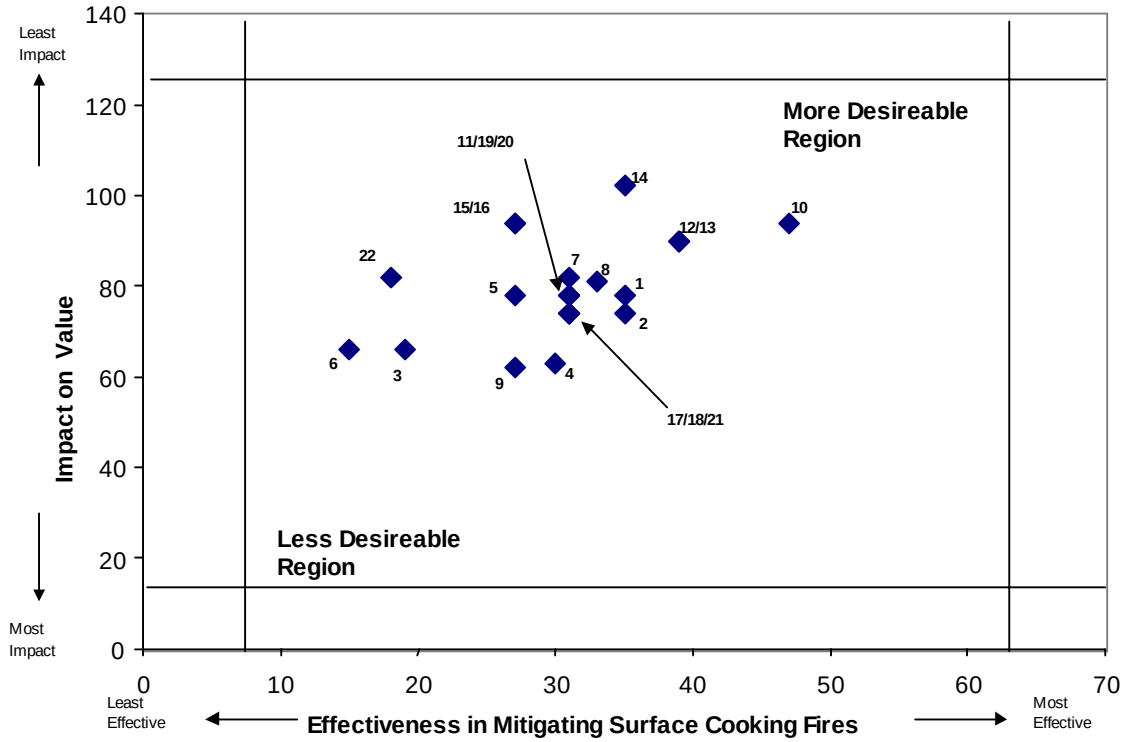


Figure 4-29: Technology Screening Results

The technologies that are clustered in the upper right hand corner of the graph are listed below:

1) Detect and Extinguish Fire: Fusible Link for Fire Detection (Tech Class 1)

   This technology scores relatively highly because it has minimal effect on consumer behavior, cooking performance or the operation of the cooktop. There are other areas in which the technology does not score highly, related to: ease of installation and service, the ability of the technology to 'fail-safe', and the impact of system actuation on the cooktop and the safety system itself. With regard to the effectiveness in mitigating fires, it is triggered by the presence of a fire, so some damage may already be done before the safety system actuates. It is not readily applicable to installations on islands or in association with cooktops with integral downdraft ventilation systems.

2) Detect and Extinguish Fire: Non-optical Temperature Sensor for Fire Detection (Tech Class 2)

This technology is a minor variant on the technology described above. It scored very similarly.

3) Prevent Unattended Cooking -- Warning and Control -- Motion sensor only (Tech Class 10)

This technology will have an impact on consumer behavior and available cooking processes. It scores highly in safety system effectiveness because it is intended to prevent a fire from igniting, it is applicable to most product classes, can be made to be 'fail safe'. The basic assumption here is that if a significant amount of fires occur when someone is out of the kitchen, then requiring the cook to remain in the kitchen will prevent these fires from occurring.

4) Prevent Unattended Cooking -- Warning Only -- Motion sensor only (Tech Class 14)

This technology scores similarly to the one above except that it is potentially less effective in preventing fires, but it may be less restrictive on consumer behavior as well.

5) Prevent Unattended Cooking -- Warning and Control -- Motion + Power sensor (Tech Class 12)

This approach has the same objective as the use of a motion sensor alone, but the addition of a power level sensor is an effort to allow some cooking processes to proceed unattended. One concern with the approach is that it will require a level of effort to implement on a gas system. In addition, because it allows some cooking to take place unattended, it may be less effective in mitigating fires than some other technology options.

6) Prevent Unattended Cooking -- Warning and Control -- Power level sensor + timer (Tech Class 13)

This approach scores exactly the same as Technology Class 12, with the timer, analogous to the motion detector, requiring the presence of the cook near the rangetop.

4.6 Selected Technologies

This screening task was to provide a guideline for eliminating some technologies from further consideration and selecting others for detailed evaluation. It was not intended to be used followed 'blindly'. We looked at technologies that did not score well and considered whether there was any opportunity for improvements in effectiveness or impact based on additional development work. We also looked at the set of technologies that were being selected to determine whether they represented a reasonable 'portfolio' of approaches for fire mitigation.

We added one more technology class to those listed above for more detailed evaluation. We added Technology Class 19 that would prevent food ignition in a pan by controlling pan temperature through a contact temperature sensor. The reasons for adding this technology are:

- A significant amount of work has been conducted on this approach to cooking fire mitigation. In addition, cooking products are manufactured and sold in Japan that use this approach. These factors warranted a more detailed evaluation of its potential in comparison with other technologies
- One of the reasons that this approach did not score highly in the technology screen is that it is unlikely that the approach is applicable to electric smoothtop systems. However, it may be a reasonable solution for coil or gas cooktops, and thus did not warrant being dismissed.
- After analyzing the reasons that the current prototypes did not perform well, we believed that there was some opportunity to improve the effectiveness and decrease the negative impact of the technology with additional development effort.

4.7 Technology Evaluation

4.7.1 Detect and Extinguish Surface Cooking Fires: Fusible Link or Temperature Sensor for Fire Detection

We have combined two technology classes (1 and 2) into one evaluation because of the similarities of the two approaches.

Description/Overview

As described in Section 4.2, this technology is a fully automated fire detection and extinguishing system for surface cooking fires. The system includes a fire extinguishing cylinder assembly that is located above or to the side of the ventilation hood, and extinguishing agent nozzles located under the hood. There are two approaches to detect the presence of a fire. In one option, a fusible link melts at sustained temperatures of 289 to 370ºF above ambient. This is a mechanical system that acts against a spring-loaded trigger for the fire extinguishing agent. An alternative detection approach is a temperature sensor. This approach requires an electronic controller to activate the extinguisher. In either case, the extinguishing agent is most generally a potassium-based wet-chemical, specifically formulated to extinguish grease fires. Sealed in the cylinder, the agent is good for 12 years.

When a discharge occurs, the system will cut the supply of gas with an electronic solenoid cut-off valve. Pressing a reset button on the solenoid valve restores gas flow. If the range needed to be moved for this process, it may need to be repositioned by a service technician to ensure the proper use of the anti-tip system. With an electric range, the system will cut the power to the range. Resetting the circuit breaker in the home's electrical panel restores power.

The cylinders are rechargeable. In case of a discharge, the homeowner would bring the cylinder to a local fire-protection equipment dealer or possibly the local fire station.

Cylinders that are installed in a residential application need to be hydro-statically tested every 12 years. Batteries for the electronics may need to be changes annually. If the system is installed in any sort of public building, it usually needs to be checked once a year by the local fire marshal or approved fire inspector.

Technology Development Status

Products or technologies triggered by a fusible link include:

- the Ansul Systems, manufactured by Reliable Fire Equipment, typically used in commercial cooking applications,
- The Safety Gourmet, manufactured by PEMALL, marketed for residential applications.
- The Guardian Systems (I) manufactured by 21st Century International Fire Equipment and Services Corporation, with over 45,000 units installed (primarily in military housing)
- 6 US patents covering various elements of extinguishing agents, extinguishing configurations, actuators, and detectors.

Additional products were considered but eliminated from this category, including:
Stove Top Fire Stop (because it is not approved for use with deep fat frying.)
Fire Breaker Fuel Neutralizer (because no information was available about this product).

Products or technologies triggered by a non-optical temperature sensor include:

- The Guardian System (III) manufactured by 21st Century International Fire Equipment and Services Corporation, this is an electronic control version of the Guardian I system.
- Five US patents covering temperature sensor technologies and configurations,
- One Japanese patent covering a full detection and extinguishing system

Potential Impact of Technology on Product Performance and Consumer Behavior

This approach will have no effect on cooking processes, cooking time, consumer behavior, cooktop features, or cookware applicability. There is a low risk for false actuation of the system, and the system components add little added risk to the homeowner.

The fire extinguishing systems are sold to fire equipment installers. There is, therefore, a third party involved in installing and servicing the systems.

Potential Effectiveness of Technology to Mitigate Cooking Fires

The technology will cover almost any type of surface cooking fire, whether it is attended, unattended, cooking materials, other materials etc. The technology is applicable to both

gas and electric ranges, although some additional components might be required in a gas range in order to allow for safe shut-off and re-start. There will be some situations in which hood installations are cumbersome, unsightly, or unacceptable. These installations include some percentage of island or peninsula locations, ranges with integral downdraft ventilation, and some installations with space constraints/cabinetry that does not allow for the installation of the fire extinguishing cylinder. These situations may represent approximately 10% of all range installations.

One significant issue with the technology is that, in its current configuration, it cannot guarantee fail-safe operation, as defined by the industry as inhibiting cooking function on the range if the safety system is not operating properly. There is no interconnect to ensure that the range is shut down if the pressure in the cylinders drops below a set level or if the extinguishing cylinder is not refilled. There is a pressure gauge on the cylinder to determine if the cylinder is operational. The electronics that control the system also have a self-diagnostic function that will flash an LED to let the user know that the system is operating correctly.

The homeowner is responsible for checking the pressure in the cylinders and having the units hydrostatically tested at appropriate intervals (recommended by the manufacturer for every 12 years). Some fire extinguishing manufacturers mail reminder cards to the homeowners at the appropriate intervals to have the systems checked. This approach has its limitations.

With regard to impact of the fire extinguishing system on the cooktop or on the safety system after actuation, these technologies are messy to clean-up. The fire extinguishing material goes all over the room, and there is significant effort required to recharge the system.

Development Needs and Issues

The primary development need for this technology is a means to ensure ‘fail-safe’ operation. This would mean that it would need to have some way to confirm that the tanks were charged and at the appropriate pressure. This implies that the system would need electronics and a self-diagnostic system.

Another issue relates to system life. The pressurized cylinders need periodic hydrostatic tests to ensure that they have no cracks or leaks. The pressure transducer integrated into the self-diagnostic might be sufficient to provide insurance of system integrity, but this would have to be confirmed. In addition, the system requires annual battery change. This requirement would be unacceptable to the industry since a battery failure could result in a service call. In order for the system to meet industry standards for reliability, life, and safety, it probably would need to be wired into the home electrical service. The need for an electrical connection adds the drawback that gas ranges could not be used in the event of a power failure.

4.7.2 Prevent Unattended Cooking -- Warning and Control
Motion sensor only (Tech Class 10)
Motion + Power sensor (Tech Class 12)
Warning Only, Motion Sensor only (Tech Class 14)

Description/Overview

These three approaches use a motion sensor to detect the presence of a person near an operating range. The systems use warnings or warnings and control to require the cooking process to be attended. These three related approaches will be evaluated as a set of technologies. Technology Class 10 uses a motion sensor to detect the presence of a person near the range; the lack of an attending person results in an alarm, followed by power modulation or shut-off if no one returns. Technology Class 12 uses a power level sensor in addition to a motion sensor so that the system is activated only if the heat input to the hobs is above a threshold level. The final Technology Class 14 is a warning system only. An alarm will sound if no one is detected near an operating range, but there is no control system to affect the power level.

These technologies are intended to work by changing consumer behavior. They will encourage or require the cook to be present near the range during the cooking process. In a way, this approach is similar to the way the automotive industry encourages the use of seatbelts. If we turn on a car and have not fastened our seat belt, a warning will sound. The warning bell is a reminder to follow safe behavior. These technologies are either exactly analogous to this approach (Tech Class 10, Warning Only), or they continue one further step. With the Warning and Control options, the power input to the range is either modulated or shut-off if the cook does not return to the range.

These technologies score highly in safety system effectiveness because they are intended to prevent a fire from igniting, are applicable to most product classes, and can be made to be ‘fail safe’. The basic operating assumption is that if a cook is attending the range, then the significant number of fires that are associated with unattended cooking can be prevented.

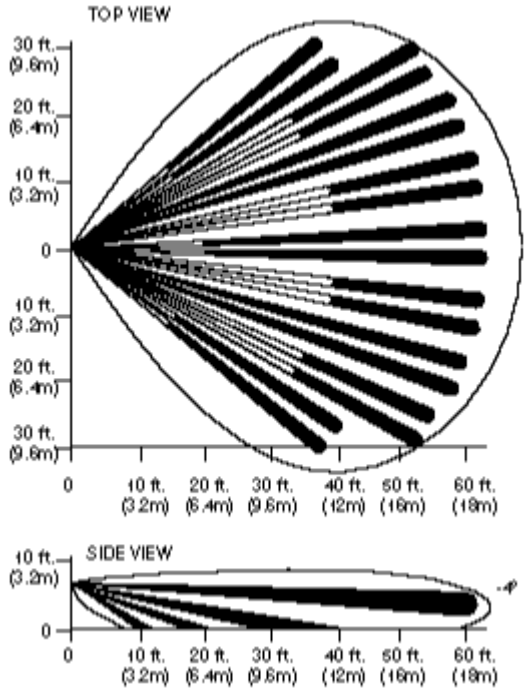
All these technologies involve the use of a motion sensor to detect the presence of a person near the range. A description of motion sensor technology is provided below.

Motion Detectors
Motion detectors can be grouped into two categories, passive and active. Passive sensors do not emit any energy, they only look or listen for changes to the environment. Active sensors emit a form of energy and then look for an echo of the transmitted energy.

Passive Sensors
Passive sensors use an infrared detector to detect differences in heat. These systems are often referred to as PIR (passive infrared). The systems usually consist of a plastic lens that focuses the IR energy onto one or more solid-state IR sensors. The lens allows the unit to have a wide field of view (FOV) and still only one or two sensing elements. The sensors are tuned to be most sensitive to the surface temperature of the human body,

around 93 °F, or as radiated infrared energy, between 9 and 10 micrometers. Thus, most sensors are most sensitive in the range of 8 to 12 micrometers. When these sensors detect a change of energy in the form of heat they become excited and output a signal. The microprocessor connected to the sensor then determines if the change occurred quickly enough and was large enough to trigger the system.

The sensors have a 5-year warranty. Since the sensor has no moving parts there is nothing that could be considered a wear item. Typical units have been in use for 10 – 15 yeas with no problems. The lens is the only exposed part that need to be inspected. If grease were to build up on its surface, it could reduce the transmittance of the IR source. The typical range of PIR sensors can be seen on the figure below.



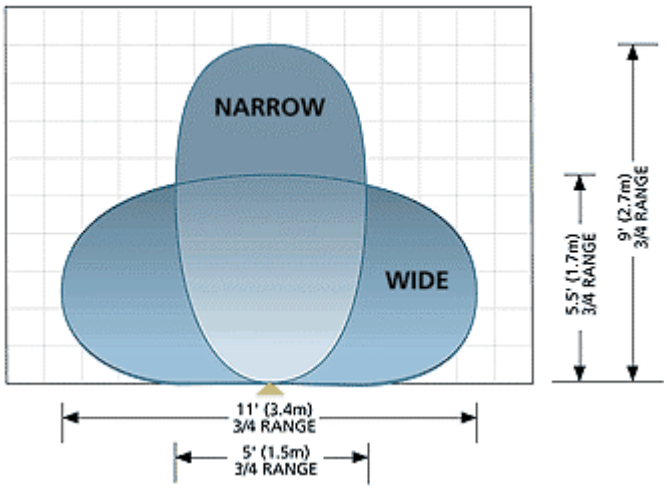
The field of view of the passive sensors is not very wide. As shown in the diagram, it could be possible to be standing a few feet from the range but be out of the view of the sensor.

Active Sensors

Active sensors use microwave, ultrasonic, or radio frequency energy to detect motion. In their simplest form, they are miniature radar systems. They emit a pulse of energy for a few milliseconds and then spend the next few milliseconds listening for its return. This process repeats several hundred times a second. When there is a moving target in the field of view (FOV) of the detector, the echo returned to the receiver will differ from the no-motion echo. A rapid enough change in the echo signifies detected motion. The microwave systems use a frequency within the K-band, 24.05 GHz – 24.25 GHz.

Ultrasonic systems use a frequency in the 40 kHz - 50 kHz range. The radio frequency systems operate at 6.5 Ghz. Like IR systems, ultrasonic systems also can be affected by the build-up of a layer of grease or oil on the sensor surface, but the higher operating frequencies of the microwave and RF detectors mean their signals are not significantly affected by the presence of grease on the surface of the device. More sophisticated systems also use the Doppler effect to measure the change in frequency in the return pulse. This method increases the sensitivity of the system.

The systems generally have a wide and narrow user selectable FOV setting. Rotating the antenna configures the selectable FOV for narrow or wide. The maximum range of the unit is determined by the power of the transmitter. The typical ranges and FOV of active systems can be seen below. Typical units have a 5-year warranty. Aside from the mechanical relays in the unit, the electronics package can last at least 10 years.



Technology Development Status

Systems that would prevent unattended cooking though warning and control using a motion sensor only are covered in 4 US patents.

There is one Japanese patent that refers to the use of a motion detector plus one additional input (either power level or heat sensor) to control heat input to the cooktop.

The warning only system is a concept. There are no patents for this approach.

We are not aware of any commercial products using these safety systems.

Motion detectors alone are common components in home security systems and automatic door openers.

Potential Impact of Technology on Product Performance and Consumer Behavior

This approach will have a significant effect on consumer behavior. We anticipate that a significant number of range users currently leave the kitchen during certain cooking functions, such as boiling water in a kettle, simmering sauces, simmering stews or soups, canning, or bringing a pot of water to a boil. The warning and control system (motion sensor only) requires attendance whenever the cooktop is operating, or the system modulates the heat input to the pot. The warning only system (motion sensor only) provides a reminder to attend to the cooking, but there is little consequence if the warning is not heeded (like the warning bell in a car to fasten the seat belt). The warning and control system that uses a power level sensor as well as the motion sensor would allow some low power input functions, such as simmering sauces, to proceed unattended.

If the user does attend to the cooking process, there would be no impact on cooking time. If, however, the user does not attend to the warnings, and the system modulates or shuts-off the heat input to the range, cooking times will obviously extend. None of these approaches would affect other cooktop features or cookware applicability. There is minimal system maintenance required.

The motion detector could be applied to any type of product. It would not add any installation requirement or significantly impact service to the cooking unit. However, there are some current limitations regarding applying a power level sensor to gas units. We know of no existing system that would provide an accurate power level sensor for gas-fired units. The development of such a sensor would be straight forward, but would take an effort.

Product life may be an issue in the use of motion sensors and their associated electronics. As indicated above, the motion sensors have a five-year warranty, but typically last 10 or more in the field. These motion sensors are in many homes now as part of security systems. However, there is no data that suggests that the motion detectors can provide a 20-year product life with a safety factor of 2. There is no obvious reason that the motion sensor electronics should have a shorter life than the electronic controls currently in cooking appliances, but this potential for life would need to be tested.

Potential Effectiveness of Technology to Mitigate Cooking Fires

If all the unattended cooking fires could have been avoided by having a person attending to the range, these technologies would eliminate between 65 and 70% of all surface cooking fires. Unlike a fire extinguishing approach, these systems are intended to prevent a fire from starting. The fire would be avoided rather than extinguished.

In the systems defined by the referenced patents, the operation of the safety system could be verified manually, but not automatically. A self-check could potentially be built into the electronics, however. The technology as envisioned would be 'fail-safe', because the range would not operate without the circuit in place and operating.

One significant issue with the motion sensor technology is that, in its current configuration, there is potential for false actuation. For example, a large pet or child could trigger the motion sensor. The range operation would be enabled even if no one were attending to the cooking process.

Development Needs and Issues

The primary development need for this technology would be to obtain some consumer feedback on the acceptability of the general approach. This technology is intended to change consumer behavior. It is important to understand how consumers would respond to this requirement. Would a warning be effective or would it be ignored? Would consumers be significantly hindered by the inability to leave the room for extended periods of time during certain cooking processes? Would people develop approaches to 'trick' the systems? The industry will not accept any system that could bypass the operation of the safety system.

Beyond this broad consumer issue, there are questions of sensor and electronics reliability and life that need to be confirmed. Finally, an approach to detecting the power level setting on a gas range would need to be developed. We can envision a number of simple approaches to detecting knob position. The technical approaches could be similar to the ignition switches currently on gas ranges and cooktops. In this case, the knob position may need to be calibrated to the nominal heat input to the burner.

Overall, the engineering issues are straightforward to address. The consumer issues are much less clear.

4.7.3 Prevent Unattended Cooking -- Warning and Control Power level sensor + timer (Tech Class 13)

Description/Overview

A simple timer and power level sensor could achieve the same objective as motion sensor coupled with a power level sensor. In the configuration of Technology Class 13, a timer would sound a warning at pre-determined intervals (potentially related to power input level). The cook would need to press a manual re-set button to indicate his/her presence near the range. With the timer, the unit would provide an alarm even if the cook were nearby. Some range users could perceive this requirement as a nuisance.

As with the previous three technologies, the timer and power level sensor is intended to have an impact on consumer behavior. It will require the cook to be present near the range during the cooking process. If the cook does not activate a re-set button, the power input to the range is either modulated or shut-off.

This system scores highly in safety system effectiveness because is intended to prevent a fire from igniting, is applicable to most product classes, and can be made to be 'fail safe'. The basic assumption here is that attended cooking will reduce surface cooking fires.

Technology Development Status

There is one US and one Japanese patent that describe the combination of a timer and a power level sensor to require a user to stay close to an operating range.

We are not aware of any commercial products using this system.

Potential Impact of Technology on Product Performance and Consumer Behavior

This approach will have a significant effect on consumer behavior for the same reasons outlined in Section 4.7.2. The level of behavior modification required would depend on the timer interval settings for the various power levels. These timer intervals would need to be defined in a way that balanced safety and operational considerations at each power level. Short timer intervals may be necessary at high power levels to prevent overheating of small volumes of material, but this would require frequent resetting of the timer by the cook. Further analysis of tests characterizing ignition times of various foods or amounts of oil (such as the study by the AHAM cooking fires working group in 1986), would be needed to develop suitable timer interval settings. The impact of the system on cooking product performance is minimal, for the same reasons as described in Section 4.7.2.

A simple timer and power level sensor may have longer life than the motion sensor, but this system would have more consumer impact. With the timer, the unit would provide an alarm even if the range user were nearby. The user would need to actuate a re-set button on a regular basis.

Potential Effectiveness of Technology to Mitigate Cooking Fires

If all the unattended cooking fires could have been avoided by having a user attend to the range, these technologies would eliminate between 65 and 70% of all surface cooking fires. Unlike a fire extinguishing approach, these systems are intended to prevent a fire from starting. The fire would be avoided rather than extinguished.

In the systems defined by the body of patents, the operation of the safety system can be verified manually, but not automatically. The technology would 'fail-safe', because the range would not operate without the circuit in place and operating. It is possible that an electro-mechanical implementation could be designed (i.e. no electronic control board required). However, with electronics, a self-check could potentially be built into the system.

This system is unlikely to be 'tricked' or result in false actuation.

Development Needs and Issues

As with the motion detector systems, the primary development need for this technology would be to obtain some consumer feedback on the acceptability of the general approach. This technology would be implemented to change consumer behavior. It is important to understand how consumers would respond to this requirement.
Technically, the approach would be straightforward to implement.

4.7.4 Prevent food ignition in the pan – electrical signal processing, auto-activation – T sensor contacts pot

Description/Overview

These systems work on the basis of limiting the temperature at the bottom of the pan so that the ignition temperature of the pan contents is never reached. This process is automatic and requires no intervention from the user. There are two critical aspects of the technology: 1) the pan contact temperature sensor; and 2) the algorithms used to differentiated standard cooking conditions from pre-ignition conditions.

Technology Development Status

Two prototype systems exist, both developed on behalf of the CPSC. One is for an electric cooktop, the other for a gas cooktop.

- CPSC gas system: This measures temperature using a spring loaded thermocouple, partly shielded from the flame, which makes contact with the pan base slightly to one side of the burner. When the thermocouple reading reaches 590ºF, the burner switches to a low setting. When the temperature drops below 590ºF again, the burner switches back to its original firing rate (previously set using the knob on the range).

- CPSC electric system: This uses three thermocouples, spaced roughly equally around a circle, about 2 inches from the center of the electric ring. The thermocouples, which are spring-loaded, poke up between the gaps in the element and need to be carefully positioned so as not to contact the element. The control algorithm uses only the maximum of the three temperature readings. When this reaches 330ºC (626ºF), the element starts to cycle on and off (1 sec on, 6 sec off). If the temperature reaches above 360ºC (680ºF) for more than 2 seconds, the element shuts off completely.

In addition, spring-loaded, pan contact temperature sensors are common on 'gas tables': i.e. two-burner, gas-fired, countertop cooktop units sold in Japan. (The controls on the Japanese units incorporate a mode switch to select the appropriate algorithm, for frying, boiling, etc.)

Potential Impact of Technology on Product Performance and Consumer Behavior

This technology should not require changes to consumer behavior, but it could impact cooking processes and/or cooking time. Ideally, as described in Section 4.4.2, there is a significant gap between the pan temperature associated with pre-ignition conditions, and the pan temperatures required for standard cooking processes. If the pan contact sensor is well insulated from the burner or electric element, and if it has good contact with the bottom of the pan, it will reflect the actual pan bottom temperature and can be used in straightforward way in a cooktop controller. The engineering implementation of the pan contact sensor will strongly affect the efficacy of this approach. If the contact sensor does not contact the pan well, or if it is not well shielded or insulated from the burner itself, the sensor output would not accurately reflect the pan bottom temperature. If the sensor indicates a temperature higher than the actual pan bottom temperature, the controller would cause the element or burner to modulate prematurely, thus increasing cooking time or affecting a cooking process. There is much work that would need to be done to develop a reliable and durable pan contact sensor that has the performance characteristics needed for a controller that does not impact cooking time or cooking quality.

The effectiveness of the system depends on good contact between the pot and the sensor. Pan type and quality will affect the accuracy of the pan bottom temperature measurement. We anticipate that a system could be made to be compatible with most pan types. However, we expect that cooking times for glass or ceramic cookware could be extended because of the larger thermal gradient in those materials.

Reliability and life are significant issues. The gas tables with spring-loaded temperature sensors have been selling in Japan for 10 years. Two companies provided general data on sensor life. Rinnai has indicated that the average life of the sensors is expected to be five years. The also indicated that the product improvement cycle is short and the manufacturer keeps spare parts in stock for about five years. Paloma informed us that the average life of the sensor is expected to be eight years.

This life would probably not be acceptable to the US market that expects 15 – 20 year life from range components. Designing a pan-contact sensor that can meet the reliability and durability specifications outlined in Section 4.4.6 will be a significant challenge.

The industry has had experience many years ago with pan contact temperature sensors used in mechanical control circuits that were intended to provide fine temperature control to the cooking process. As we understand from discussions with appliance manufacturers and controls suppliers, the most frequent failures modes associated with the old 'Burner with a Brain' or 'Thermal-Eye' products included:

- The system would respond differently when an aluminum pot was used vs. a cast iron pot.
- Gas turndown was insufficient to meet the lowest temperature requirements.
- Electric elements of the time had high thermal inertia.
- There was inconsistent contact area between the pot and resistance coils.
- The sensing element was under constant abuse.

The first three issues are not as relevant for this safety application because fine temperature control is not required for the pre-ignition controller. The last two considerations, which are reliability and durability issues, are still relevant and would need to be addressed for this approach to be commercialized. The system must operate in a difficult environment in which grease or dirt can become baked onto the sensor. The system would need to operate under these conditions.

Potential Effectiveness of Technology to Mitigate Cooking Fires

This approach has the potential to address up to 75% of surface cooking fires. There has been some discussion about the statistics that indicate that cooking materials are an ignition factor in 72-77% of surface cooking fires. The question was posed whether the cooking materials that ignite are potentially *outside* of the pot, i.e. in the burner well or in the cooktop rough-in box. It has been hypothesized that a safety system that controlled pan temperature would not affect the ignition of oil or grease that had accumulated around and in the cooktop itself.

We conducted some very preliminary tests to investigate this hypothesis. We measured cooktop temperatures around the burner bowl, rough-in box, and cooktop surface during standard cooking functions and during conditions in which pan contents reached pre-ignition temperatures. We did not find any cooktop surface temperatures (in the burner bowl, under the burner, in the rough-in box etc.) that neared *flash* point of oils when the pan was at pre-ignition temperatures. We strongly agree that grease and oil around the cooktop would exacerbate a fire.

This approach is potentially applicable to gas units and open coil electric units. The Japanese units that use a pan contact sensor are generally open burners, with a hole in the

center of the burner for the sensor. Obviously a different configuration would be needed for a sealed gas burner.

The implementation of this control approach in electric smoothtops is not currently feasible. The temperature below the glass ceramic cannot be used to indicate pan temperature accurately. Control suppliers are reluctant to provide additional information about the potential for the current pan detection sensors to be used as pot temperature sensors. It appears that the thermal inertia in the glass ceramic is too great for the sensor to provide a reasonable indication of pan temperature.

There are two additional important issues for 'effectiveness' that would need to be addressed. One is the potential for the system missing a pre-ignition condition due to the sensor being dirty or damaged. The second issues is designing a way for the system to 'fail safe.' It is not obvious how to implement a self-check that would prevent the range from operating if the sensor was not reading pan temperatures accurately.

Development needs and issues

Currently, the prototype systems do not meet all the requirements for commercial implementation.

The system used in the gas cooktop was the more successful. The algorithm used appeared to successfully limit pan bottom temperature indefinitely to below the oil ignition temperature, did not require any action from the user, and did not appear to adversely affect cooking. However it was not robust and would be easily damaged in the field. The current implementation was excessively noisy.

The electric system did succeed in preventing ignition in our tests, but the system was less satisfactory. Both boiling water and searing steak were adversely affected. In addition, the sensors could be easily damaged. The problem with the prototype is that the temperature sensors appear to be sensing as much of the element temperature as the pan temperature.

In both cases, the algorithm used was, in principle, valid for the task (although this would need to be confirmed for all cooking functions). However, extensive testing would be required to ensure that the exact parameters chosen (temperature thresholds, cycling times, reduced heat input rates etc.) were suitable for the widest range of cooktops, pan types and cooking functions.

In sum, the sensor design would have to be improved significantly, so that the pan bottom temperature measurements were more accurate and the sensor was much more robust. Some self-check or self-calibration could be needed to implement a fail-safe system.

Given the product development cycles in the industry, this effort probably would require a minimum of 2-3 years of development time and significant investment by both the appliance manufacturers and their vendors.

If this were successful, the resulting system would have a high probability of preventing most surface cooking fires without requiring modification of consumer behavior or affecting cooktop function.

4.8 Results Summary

This section summarizes our evaluation regarding the technical, practical and manufacturing feasibility of the selected technologies to address surface cooking fires. All the technologies reviewed in detail have the potential to mitigate a significant percentage of surface cooking fires. Their commercial feasibility varies by technology.

Detect and Extinguish Surface Cooking Fires, Fusible Link or Temperature Sensor for Fire Detection

There are commercially available systems that detect and extinguish surface cooking fires. They currently do not meet all the industry requirements for technical feasibility because they are not configured to 'fail safe'. However, the sensing and electronics necessary to detect the pressure in the extinguishing agent cylinders and to interconnect the system to the range is technically possible with a focused development effort.

There are some practical issues to resolve regarding high volume commercialization of this type of technology. These systems are currently manufactured, distributed, installed and serviced through 'third-parties' to the appliance industry. The appliance business and the fire extinguishing business are currently very different businesses, with different requirements for installers and service personnel. In order to commercialize a mass-produced solution for the industry, significant coordination could be required.

These systems are currently manufactured in volumes of a few to ten thousand units per year. The technical, manufacturing, installation, service, and support infrastructure would need to be greatly expanded to provide products for the entire range market.

Prevent Unattended Cooking, Warning and Control – Motion Sensors

This technology is very early in the development process. At this stage, however, the general approach appears to be technically feasible. The reliability and life of the motion sensors and electronics would need to be addressed. A power level sensor for a gas burner would need to be developed. It is expected, however, that a focused, two-year development effort could produce a manufacturable product.

The practical aspects of this solution, however, are not so straight forward. This approach requires significant changes to consumer behavior. It is not clear that the requirements imposed by the systems as described would be acceptable to consumers. The system that couples a motion sensor with a power level sensor may mitigate some of the consumer resistance. It would be critical to conduct some consumer feedback work to understand their response. The safe cooking products will enter the market only if consumers purchase them; the products must be acceptable to the consumers.

Prevent Unattended Cooking – Warning and Control, Power Level Sensor and Timer

The feasibility of this approach is very similar to the motion sensor systems. The approach is technically feasible and could be manufactured using conventional techniques. The consumer response to the approach needs to be tested.

Prevent Food Ignition in the Pan – Contact Temperature Sensor

The current sensor approach is not technically feasible due to lack of reliability and durability. The Japanese sensor technology is a reasonable starting point for a development effort, but it is currently applied only to open-burner gas systems, a product class that is rapidly decreasing in US market share. In addition, some type of self-check algorithm would need to be developed to implement a fail-safe system.

The benefit of this approach is that it would impose significantly less constraint on consumer behavior than any of the systems that require attended cooking. It is potentially less problematic to implement than the fire extinguishing systems. However, it would take an extensive development effort of 2-3 years to develop the contact temperature sensor and robust cooking algorithms.

This approach is currently not feasible for glass ceramic (smoothtop) cooktops. In these systems, pot temperature need to be inferred from glass temperature or from the temperature in the region below the glass. The variations in contact between pots and the glass ceramic surface make the temperature difference between the glass and the pot too variable. The thermal inertia of the glass ceramic is a problem as well to have appropriate response time to avoid a potential cooking fire.

References

No	Title		Prepared By	Prepared For
1	Development for Ctrl Sys. For Preventing Food Ignition on Gas Ranges	A TC based cooking fire solution developed for gas ranges using 1 off-centered semi-shielded.	Energy International Inc.	CPSC
2	Study of Tech .for Detecting Pre-ignition Conditions of Cooking Related Fires Assoc. w/ Elec. Ranges Phase I Report	CPSC work to determine pre-ignition condition for food related cooking firescusing multiple sensors such as: smoke, temperatures, cooking alcohols and hydrocarbons.	Erik L. Johnsson NIST	CPSC
3	Study of Tech .for Detecting Pre-ignition Conditions of Cooking Related Fires Assoc. w/ Elec. Ranges Phase IV Report	Review on the CPSC three unshielded TC cooking fire solution for electric coil cooking element. Describe designs and coking tests results	Han Lim CPSC	CPSC
4	Study of Tech .for Detecting Pre-ignition Conditions of Cooking Related Fires Assoc. w/ Elec. Ranges Final Report	Summary of NIST/CPSC work on technical solutions for food-related cooking fires: Determination of pre-ignition conditions, development & test of prototype TC based solution -- conclusion pre-fire detection system is physically feasible and merits further exploration	Erik L. Johnsson NIST	CPSC
5	Practical Work w/ an electric-coil range equipped w/ an experimental TC-based preignition control system	Result review of the GHI cooking tests on the EI/CPSC TC based cooking fire prevention solution for electric coil heating element	Sharon Franke Good Housekeeping Institute	CPSC
6	Range Fires Characteristic Reported in National Fire Data and a CPSC Special Study	Report on statistical data obtained from NFPA/NFRIS on home fires especially cooking fires w/ breakdown of specific causes and types of cooking equipments involved	Linda Smith CPSC	CPSC
7	Response to Peer Reviewers Comments on Range Fires Project Technical Reports	Editorial comments of the first draft for the final report on the Study of Tech. for Detecting Pre-ignition Conditions of Cooking Related Fires Assoc. w/ Elec. Ranges	Andrew Trotta CPSC	CPSC

No	Title	Summary	Prepared By	Prepared For
1	Nov 1998 Working Group Meeting (Minutes)	Defining sources of cooking fire, Define potential solutions, review previous TC devices	Wayne Morris	Cooking Fires Issues Task Group
2	Feb 1999 Task Group #4 on Non-Technological Options	Task group reviewed AHAM's "Recipe for Safer Cooking Campaign." Discuss other non-technical solution for cooking fire prevention: how to increase public awareness on cooking fire, and how can building codes be improved to address cooking fire incidents (sprinkler systems)	Wayne Morris	Working Group on Careless Cooking Fire
3	March 1999 Working Group Meeting (Minutes)	Range manufacturers agree TC pan feedback mech. Shows greatest promise for solution. Discuss cooking test result on CPSC elec. prototype. Discuss predicted system cost. Discuss other solutions from industry (Cherry + TRC)	Wayne Morris	Cooking Fires Issues Task Group
4	Aug 2000 Work Assignments for Task Group	Cooking fires joint task group are determining the types of testing that a cooktop that has cooking fire systems has to pass in order for it to be a viable technological option	Wayne Morris	Cooking Fires Joint Task Group
5	Aug 1999 Report of Cooking Fires Working Group	Review of residential fire data from NFPA, CPSC phone survey, and NASFM/AHAM 1997 report. Review on CPSC TC system on coil element cooktop and subsequent cooking tests by GHI. Discuss Additional cost of safety system to cooktop	AHAM	
6	Ten Community Study of the Behaviors & Profiles of People Involved in Residential Cooking Fires (July 1998)	A detailed research to learn the sources of cooking fire based on equipment and user's behavior. Used a survey form distributed to fire dept. of 10 community over 6 months period.	NASFM/AHAM	
7	US Home Cooking Fire Patterns and Trends through 1996	Report of statistical home fire data gathered from NFPA. Study is conducted for fire data from 1980 to 1996. Has some data on sources of fire -- kitchen being the leading area of origin.	Nat'l Fire Protection Assoc.	AHAM
8	US Home Cooking Fire Patterns and Trends (April 00)	Report of statistical home fire data gathered from NFPA. Similar information as previous entry with the addition of a more detailed data eceived from 1993 to 1997	Nat'l Fire Protection Assoc.	AHAM
9	Bailey's Industrial Oil & Fat Products	Information on cooking oils properties: smoke, flash and fire point	Y.H. Hui	
10	Table of Fats & Oils used in food	Information on cooking oils properties: smoke, flash and fire point	Economic Res. Serv. Of the US Dept of agriculture	
11	Food, Fats & Oils	Information on cooking oils properties: smoke, flash and fire point	Inst. Of Shortening & Edible Oils	
12	Cost Analysis of CPSC Range Control Prototype	Cost analysis of CPSC three TC solution for electric coil heating element	AHAM	CPSC
13	Kitchen range -- Fire safety device/system for surface elements/burners: ist for design criterias	List of acceptance criteria of fire safety device/system and list of several fire systems developed or in development	AHAM (member?)	
14	NFPA-NFIRS Fire Data	Review on how NFPA & NFIRS collect their fire data	UL	STP members

No.	Company	Product/Title	Comments	Type
1	Cherry Sensors and Control.	Standard Comfort Module	Controllers for ceramic top electric cooktop.	Paper brochure
2	Cherry Sensors and Control	Design Freedom (We make cooktops smarter)	Controllers for ceramic top electric cooktop. Describe various sensors that can be included with the controllers including a temperature sensor for cooking vessel	Paper brochure
3	Siemens	Cooking Sensors (Pan temp - IR)	Ceramic elec. Hob w/ IR pop-up cooking vessel T sensor	Web printout
4	Rinnai	Smart Hob RB-3EMB	Gas cooktop w/ contact T sensor for pan bottom	Web printout
5	Fire Line	Ansul Fire Suppression System	Hood installed extinguisher	Web printout
6	Firemelt	DoubleFire Hood System	Hood installed extinguisher	Web printout
7	PEM ALL Fire exting. Corp.	Fire Suppression System (Detect/Suppress/Alarm)	Hood installed extinguisher	Web printout
8	Miele	Miele cooktop	Auto switch-off/heat-up/spill-detect	Web printout
9	Gaggenau	Gaggenau cooktop	Cook-settings and Auto quick-boil	Web printout
10	Twenty First Century	The Guardian System	Hood installed extinguisher	Web printout
11	Cabinova AB Swesen	Stove Alarm for Electrical Stoves	Wall mounted alarm	Web printout
12	Cabinova AB Swesen	Stove Alarm and Stove Cutout for Electrical Stoves	Wall mounted alarm + Stove power cutout device	Web printout
13	Figaro	Gas sensors General Information	Thin film metal oxide semiconductor gas sensors	Paper brochure
14	GRI	Simmer Sentry	Tsensor + acoustic sensor directly in contact w/ food	Paper brochure
15	Robertshaw	Gas Thermal Eye with Flame Set	Tsensor for bottom of cooking vessel	Paper brochure
16	Ecowatt Schweitz AG	Nouveau Cooking (Conduspeed cooktop)	Ceramic cooktop w/ T sensor	Web printout
17	National Fireproofing Co.	Fire Breaker Fuel Neutralizer	Manual fire extinguisher material (powder in bottle)	Web printout
18	Williams Pyro Inc.	Stovetop FireStop	Hood installed (magnet) extinguisher - No pressurized tank	Web printout
19	Bosch	NST 615F Sensor Cooker	Ceramic elec. Hob w/ IR pop-up cooking vessel T sensor	Product Brochure
20	Paloma	Gas cooktops	Gas cooktop w/ contact T sensor for pan bottom	Product Brochure
21	National	Gas cooktops	Gas cooktop w/ contact T sensor for pan bottom	Product Brochure
22	Purpose	Safull Gas cooktop	Gas cooktop w/ contact T sensor for pan bottom	Product Brochure
23	Siemens	Chimney hood w/ smog sensor	ultrasound sensor detect amount of smog/smoke and adjust it's intake - has radio contact btw cooker and hood	Web printout
24	Siemens	Cookers, Microwave Ovens and Cooker Hoods	General brochure of Siemens entire kitchen appliances	Product Brochure
25	Encon	Euro burners	Solid disc heating element w/ temperature limiter	Paper brochure
26	Rinnai	Gas cooktop RT-L5500GFT	Gas cooktop w/ contact T sensor for pan bottom	Care Manual

No.	Title	Description	Authors	Company	Journal	Date
1	Applications of Thermopile Infra-red Sensor to the Home Appliance	Using IR T sensor to measure external pot temperature on a gas range. Use to determine boiling point and boil dry condition by analyzing Temp. gradient	KoonSeok Lee, Sung Myun Baek, Jeong Hyeon Lim	LG Electronics Inc.	AMCE Proceedings	Oct-98
2	Advanced Cookware Sensing System for Vitroceramic Cooktops	Gold alloy tracks for pot sensing. Has transmitter & receiver track - detection by measuring amount of electromagnetic damping on track. Detect vitroceramic T around heat zone (thus cooking pot) by measuring specific resistance of the gold alloy track	Mike Schwert	Cherry Elec. Products	AMCE Proceedings	Sep-99
3	Functional Fantasies: Designing Dream Kitchens that Cooks	A comment by a restaurant & food industry consultant on the need for consumer input and consideration in the development of cooking equipments; form should follow function, etc.	Jan Weimer	Rest. & Food Indust. Consultant	AMCE Proceedings	Sep-99
4	Accurate and Reliable Gas Sensors for the Mass Market	Paper on the development of an accurate and reliable gas sensors that can be cheap enough to be manufactured for the mass market. The technology is based on Micro Electro Mechanical systems (MEMS). The company is in the process of developing a smaller less expensive NDIR gas sensor	Brian R. Kinkade	Ion Optics. Inc	AMCE Proceedings	Sep-00
5	New Micro-machined Water Sensor for Home Appliance Applications	Description of a new micromachined water vapor sensor that was developed using the MEMS (microelectromechanicas systems) technique.	Ralph Fenner, Meindert Kleefstra, etc.	Hygrometrix, Inc.	AMCE Proceedings	Sep-00
6	Optical Fire & Security Technology: Sensor Principle & Detection Intelligence	A discussion on optical sensor technology for fire detection. Basic physics of sensor mechanism is well understood, but actual design of cost effective detectors reliable under an extreme range of environment is still a highly demanding task	P. Reyser, G Pfister	Cerberus Ltd.	IEEE	1991
7	Fire Detection - The Least of Our Problems	A short discussion on limitations of various current fire detection technologies such as their sensitivity levels to different types of fire and their tendencies to cause false alarms	Andrew Morgan	Siemens Building Technologies Ltd	-	
8	Fire Detection w/ Combined Ultrasonic-Microwave Doppler Sensor	A description of a new development of a fire detection system that combined two sensors: ultrasound and microwave Doppler sensor to reduce the incidence of flase alarms	H. Ruser, V. Magori	Siemens AG	IEEE Ultrasonic Symposium	1998
9	SiC Thin-Film Thermistors	Thermistor using RF-sputtered SiC film developed specifically for cooking appliance Has been applied to detect Tpan bottom for gas cooktop. Thermistor is connected to a controller that adjust gas valve for burner - shows rapid thermal response	Takeshi Nagai, Masahiko Itoh	Matsushita Housing Products	IEEE Transactions on Industry Applications	1990
10	Temperature Control for Food in Pots on Cooking Hobs	Paper describing the technology applied on the development of Bosch's sensor cooktop. The temperature sensor used is a thermopile optical sensor.	Uwe Has, Dimitar Wassilew	Bosch, Siemens, DIAS Angewandte Sensorik	IEEE Transactions on Industry Applications	1999
11	Automated Cooking and Frying control using a gas sensor microarray	A discussion on a new development effort on a gas sensor microarray that is specifically to determine the doneness level of steak cooking. The sensor is located on the undersidse of the pan lid.	S. Ehrmann, J. Jungst, J. Goschnick	Institut fur Instrumentelle Analytik Hermann-..	Sensors and Actuators	2000
12	Japanese Industrial Standard: Gas burning cooking appliances for domestic use (JIS S 2103) 1991	Japanese standards for domestic gas cooker. Important info: there is a standard that contends all gas cooktop should limit the temperature of cooking oil in the cooking vessel to be below a certain level	Japanese Standards Association	Japanese Standards Association	-	1991
13	NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, 1998 Edition	US standards for fire protection systems for commercial cooking appliances including in-hood fire extinguishing system instalation	NFPA	NFPA	-	1996

Appendix A: Complete List of Technologies

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DESCRIPTION OF CURRENT TECHNOLOGIES 111 IN TOTAL

BOIL-OVER/BOIL-DRY ONLY

No	Patent Number	Description	Company	
1	US 4665292	Cook modes (warm-simmer-boil) and regular Hi-Med-Lo settings available. Use pre-set Tthres then estimate time to completion & manipulate HS & set alarm on when time reached	General Electric Company	
2	US 6118105	Auto detect for boil, boil-over, boil-dry. T sensor for vessel bottom & cooktop, & power level indica. Temp signal plateu = boil, temp signal increase after plateau, boil dry, etc.	General Electric Company	USE TEMPERATURE SENSOR
3	US 4465228	Preventing boil over incidents by monitoring pan bottom temperature and usind a pre-selected decrease in temperature gradient as food boiling point	Matsushita Elec. Ind Co., Ltd	
4	US 5947370	Cook modes (warm-simmer-boil) and regular Hi-Med-Lo settings available. Compare realtime data with stored empirical data w/ fuzzy logic to determine cooking state	Arthur D. Little, Inc.	
5	Simmer Sentry	Tsensor + acoustic sensor directly in contact w/ food. The sensor sticks out of the back panel of the cooktop and its sensor tip is immersed in the cooking liquid	GRI	
6	US 4633230	A temperature sensor is attached at the end of a 2 bar link arm that can be ad-justed to contact the cooking container. The temperature sensor will convert the measured cooking vessel temperature into electrical signal that will signal alarm in cases of boil over or boil dry.	None	
7	US 5079407	Moisture sensor above pot (in hood/on top of pot) measure vapor and activate alarm (audible/ visual) and manipulate heat source when boiling is detected	Whirpool	USE MOISTURE SENSOR

FIRE EXTINGUSIHING/CONTAINMENT/ALARM

No	Patent	Description	Company	
1	US 4580638	A flexible incombustible curtain automatically drops over and contained cooking unit once fire is detected, then gas fire extinguisher released inside the partitioned area to avoid messy cleanup	Mon/Arc, Inc.	
2	US 6105677	Can(s) of particulate extinguishing mat'l inverted above range (in hood). Cap has fusible mat'l that melt at Temp ~ 220 F, releasing particulates that fall on cooktop by gravity	None	
3	US 3889754	Dry fire extinguish powder avoid splatter of grease. Auto deploy - fusible parts that lets go a spring actuated puncture for CO2 canister which allow pressurized deployment of extinguisher	None	USING FUSIBLE PARTS AS DETECTOR AND ACTUATOR
4	US 5490566	Panel w/ heat fusible parts, filled w/ extinguisher powder. Located above range in hood/as ceiling panels (Firemelt powder)	Firemelt Inc.	
5	US 4813487	Fusible part actuated fire extinguishing agent to stove and actuated spring loaded solenoid switch to turn off stove.	None	
6	US 6032663	A fusible part (nylon cord webbing extended above stove) is used as fire detection device. Once flame melt the webbing, this releases the gas valve/electric switch which was held in tension so burner is off	None	
7	Ansul System	In hood fire detection and suppression system. Fire detection and suppression actuator is a fusible links which will cause cartridge to propel gas into Ansulex liquid agent tank	Reliable Fire Equipment	
8	The Safety Gourmet	Waiting for Brochure	PEMALL	
9A	US 4773485	Pressurized extinguishing canister connected to valve networks within hood above stove. Actuator are cables in tension connected w/ fusible parts	21st Century Int'l Fire Equipment & Services	
9B	The Guardian I (US 4773485)	Fire detection-suppression system - concealed in hood or in kitchen cabinet above range When fire detected, **using fusible parts** (within hood), auto shuts off fuel supply to stove (gas & electric), while releasing extinguisher. Optional: audible alarm & pull stations	Twenty First Century	
10	JP 8107942	Nozzles connected to pressurized water source capable of delivering fine water mist/fog to suffocate and cool fire/stove. Using fusible parts to activate nozzles	NOHMI BOSAI LTD	
11	Fire Line	Hood installed extinguisher using fusible link	Ansul Fire Suppression System	
12	Firemelt hood system	Hood installed extinguisher using fusible parts and a new powder extinguisher that suppse to work well with grease fire too.	Firemelt	
13	US 3653443	Thermostat in hood detect fire. Circuit connected to thermo. activate removable fluid extinguisher tank in hood and cuts off electric/gas valve to range and turns on alarm	Mon/Arc, Inc.	
14	US 5351760	T sensor - 1st temp. threshold - fan turns on, 2nd temp threshold - alarm turns on, 3rd temp threshold - range shuts off, beyond 3rd temp threshold fusible link melt and dispense	None	
15	US 5868205	Fire extinguishing agent container above the cook range at the back of the range hood w/ a bimetal-actuating device. Actuated when ambient temp. reached certain temp	Fail Safe Safety Systems, Inc.	USE NON-OPTICAL TEMP. OR FIRE SENSOR
16	US 6029751	TC or metallic alloy element responds to high threshold T. It sends signals to release fire suppressor & turns alarm on & turns off electrical/gas supply. When Tsensor cools off, suppressor valve auto-closes	None	
17	JP 7132151	Fire detected by sensor then gas valve is cut-off, then liquid fire extinguisher is pressure released. Finally alarm is activated to warn user	None	
18A	US 6044913	Heat sensor (diodes/thermistor) detect fire, activate fire extingusher release and activates audible alarm which activates gas/electricity shut-off to heat source (sensor+alarm battery operated)	21st Century Int'l Fire Equipment & Services Corp.	
18B	The Guardian III (US 6044913)	Fire detection-suppression system - concealed in hood or in kitchen cabinet above range When fire detected, **using heat sensors (diodes)** within hood, auto shuts off fuel supply to stove (gas & electric), while releasing extinguisher. Optional: audible alarm & pull stations	Twenty First Century	
19	JP 58050096	IR sensor is used to detect fire above cooktop (on wall behind cooktop). Then from inside the rangehood, fire extinguisher will be released	MATSUSHITA ELECTRIC	

20	JP 58152575	Flame sensor behind the cooktop, at a level just above the cooking vessel, activated a spray nozzle that releases fire extinguisher from behind the cooktop onto the pot/pan on cooktop, and then cut-off gas valve. Sensor is IR	DAIKIN KOGYO KK	USE OPTICAL TEMPE-RATURE OR FIRE SENSOR
21	Stove Alarm and/or cut-off US 5196830	An auxiliary system using an IR temperature sensor, mounted above the cooktop on the wall behind it. Reacts to heat (if T of cookstove > Tthres) it will turn on an alarm and some version has an electric cut-off switch that cuts the power the the electric stove. Claim that user can adjust sensor's sensitivity (photo conductive cell)	Cabinova Sweden	
22	Safety system for cooktops and ovens	Preliminary stage. Detection of critical level smoke alarm prior to combustion (photo-electric). Then audible alarm, if not reset by user after time delay (eg. 45 sec) gas supply to appliance cuts-off. Else, combo of smoke and T level will disconnect power supply immediately. If flame occurs, immediate power disconnect & provision of auxiliary output - extinguisher on, or contact outside services-911, etc.	Technology Research Corporation	USE SMOKE SENSORS
23	JP 4093529	A photoelectric sensor (light projector and receiver) is installed in downdraft cooking vent/hood. When smoke level in the vent is > pre-set value sensor will send signal to turn on alarm and turn off heater	Matsushita Electric Ind. Corp	
24	JP 2182274	Range hood act as a fire enclosure/containment unit. Tsensor detect ambient T around cook table then activate a buzzer and then drops down to cover entire surface cooking unit -- automatically activated with sensors to detect fire and activate release	None	FIRE CONTAINMENT, NO EXTINGUISHER AGENT
25	JP 11221297	Extinguish stove fire and prevent fire from expanding into hood duct. Nozzle that sprays water droplet is situated inside the duct of a range hood to spray into duct an onto stove surface. Sensor means unclear.	BUNKA SHUTTER CO LTD	OTHER OR UNKNOWN FIRE DETERMINATION METHOD
26	JP 2045073	Water sprayed from surrounding pipe frame to cool and suppress fire. After flame has subsided, a metal plate covers pot automatically. Sensor means unclear.	None	
27	Stovetop FireStop	Hood installed (magnet) extinguisher - No pressurized tank. There is an explosive material inside the powder ectinguisher canister that will explode when it fuse mechanism experience a threshold environmental temperature	Williams Pyro Inc.	
28	US 4483314	Pull out blanket from drawer underneath the burner/heat source. Used to manually smother fire	None	MANUAL FIRE EXTINGUISH AND COOKING FIRE DETERMINATION METHOD
29	JP 10201871	Manual fire extinguishing sheet. Fire extingusih agent is suspended in a flexible & fusible encasing from polyethylene film. When fire occurs drape sheet on stove to melt film and delivers extinguisher	None	
30	JP 9206393	Kitchen mat with incombustible material to smother fire manually	DUSKIN CO LTD	
31	JP 9117329	Incombustible back panel for wall cover. A passive wall attached on the wall behind the cooktop to reduce the spread of cooking fire.	MATSUSHITA ELEC. WORKS LTD	
32	JP 1015068	Range hood act as a fire enclosure/containment unit. Drops down to cover entire cooking unit -- manually activated	None	
33	Fire Breaker Fuel Neutralizer	Manual fire extinguisher material (powder in bottle). User has to squirt the plastic bottle containin the powder extinguisher on the source of fire.	National Fireproofing Co.	

PREIGNITION OF FOOD/OTHER

No	Patent Number	Description	Company	
1	US 5717188	Motion sensor (spec. area covearge) determine if user is present. If not depending on 2nd sensor (power level, heat sensor, etc.). No user detected, 1st alarm then some heat source manipulation	None	MOTION SENSOR & OTHER SENSOR (POWER/TEMP) TO
2	US 5380985	Motion sensor detect if person is near stove (specified area coverage). If not will turn off electric heater after a specified pre-determined time	None	USES MOTION SENSOR ONLY
3	US 6130413	Motion sensor determine user presence. The 1st time user not detected after pre-set period, stove disabled temporarily for a pre-set period. When user enters it is auto-enabled. The 2nd time user leave,stove is disabled permanently until user manually reset it. Add on to old stove	None	
	US 4775913	Motion sensor determine user presence. For the 1st time user not detected after pre-set period, stove disabled temporarily for a pre-set period. When user enters it is auto-enabled. The 2nd time user leave,stove is disabled permanently until user manually reset it. Integrated	None	
4	WO 00/53975	Motion detector determined user's presence near stove for a pre-set time. If no user is around controller sent a signal by which to manipulate (off) electric heater	None	
5	US 5457302	Can use cooking modes: broil (manual) and the rest is automated Determine cook mode auto. (when not in broil mode) by the time required to increase temp.	Sanyo Electric Co., Ltd.	MEASURE PAN BOTTOM TEMP W/ CONTACT SENSOR PROCESS SIGNAL W/ MICROPRO-CESSOR TO DETERMINE COOKING STATE AND ACTION OF COOKTOP HAS TO SELECT COOKING MODE/COOKING VESSEL TEMP TO ACTIVATE
6	US 4493981 **ELECTRIC** Incl. US 4639578 for sensor failure	Cook modes boil mode (warm-simmer-boil) and fry mode, and regular Hi-Med-Lo settings available. Detect boil dry condition when in boil mode - When rate of increase of Tpot exceeds a predetermined reference rate, or the sensed Tpot exceeds a predetermined threshold temperature. If Tsensor fail - indicator signal user & it becomes conventional cooker	General Electric Company	
7	US 4493980 **ELECTRIC** Incl. US 4639578 for sensor failure	Cook modes boil mode (warm-simmer-boil) and fry mode, and regular Hi-Med-Lo settings available. Each mode is associated w/ a min SS temp and a SS power level. Ctrler compares Tpot & current power setting to selected mode settings and adjust to reach the Tthres quickly w/ minimum overshoot. If Tsensor fail - same as above	General Electric Company	
8	JP 63061820	Cooking T (To) is set by switch. Once it is achieved (Tpan bottom), flame is reduced. Microprocessor then set Tthres = To + DeltaT (pre-set in prog.). If after flame reduction Tpan > Tthres, turn off burner. For cooking with small food content	OSAKA GAS CO LTD	
9	JP 62010510	User selected switch. If on: If Tpan bottom > Tthres, burner switches on and off to maintain Tthres When switch is off: If Tpan bottom > Tthres, burner switches off and remains so. Gas valve is latching solenoid valve - if switch is on & Tpan = Tthres, resistance in wire reduce & valve open	Matsushita Electric Ind Co LTD	
10	JP 5052336	User select cook modes: boil or fry. If boil is selected, burner will terminate when Tpan bottom = T of food scorching (referenced). If fry selected, burner terminate when Tpb = T of oil ignition	HARMAN CO LTD	

11	JP 6193880	Contact T sensor for pan bottom on a gas fired cooktop. There seem to be a T limit of 270 C for cut off. There is also a controlling algorithm to allow a better handling of temperature increase to the user-selected cooking temperature	RINNAI CORP	SYSTEM
12	US 5243172	Cook-top with automatic controls - The cooktop is equipped w/ a pot detector (weight sensor) and Tsensor means. It also incorporate a timer. When no pot is detected or Tvessel is > Tselect, heating element can be reduced/turned off. Timer will keep element from shuting off for temporary pot removal due to shaking or flipping food content. (no sensor design but logic algorithm only)	U.S. Philips Corp.	
13	US 3665159	Heating System Control - a Thermistor is used as Tsensor for the cooking vessel. Its signal is used to control vessel T and to speed up the T rise to user selected Tvessel while avoiding overshoot of Tselect due to heat capacity of system. This achieved by constantly comparing current Tvessel and Tselect and adjusting the power of the electrical heating element	Whirlpool Corp.	
14	RT-L5500GFT-R with 7 safety functions	TC based T sensor for pan bottom Temp. For frying oil, select 3 preset temps, and controller maintain burner. Boil ctrl, once boiling is detected alarm on - turn down burner - wait 5 min then turn off burner. Can detect stew cooking is boil dry or when cooking vessel is empty - auto-off. If food content T = Tgrease-fire, burner auto-off then alarm on. When boil-over happens and spill over food turns off burner, gas valve auto-off. Burner auto off when on for more than 2 hrs.	Rinnai	
15	Conduspeed cooktop	Ceramic cooktop w/ integrated temperature sensor. Cook can select the cooking temperature. Claims tat Tsensor can be used to detect boil-over, boil-dry, and contaminated pot/pan surface (which will affect heat transfer to pot/pan), and can be applied to prevent oil/grease fire problems. Also claims quick and even heating due to its coper aloy construction -- and the ceramic plate can cool in 30 seconds.	Ecowatt Schweitz AG	
16	US 5294779 **ELECTRIC**	A sensor at the center of an electric hot plate, will contact cooking vessel and detect vessel presence and vessel bottom's temp (indicator only?) Will cut-off electrical supply to hot-plate when sense max. T is reached by a fuse connected to vessel bottom which melt at that T	SEB S.A. Selongey, France	MEASURE PAN BOTTOM TEMP W/ CONTACT SENSOR PROCESS SIGNAL W/ MICROPRO-CESSOR TO DETERMINE COOKING STATE AND ACTION OF COOKTOP AUTOMATIC ACTIVATION OF SAFETY SYSTEM
17	US 4723067 **ELECTRIC**	A sensor at the center of an electric hot plate, will contact cooking vessel and detect vessel temp. A separate temperature cut-out device made of temperature limiting rod is embedded beneath the hotplate for precision cut-off when Thot plate > Tthreshold	E.G.O. Elektro-Gerate Blanc U Fisher	
18	US 4492336	T sensor for pan bottom temp. T rise gradient at initial state of heating for a certain time is used as correction value for pan type, T rise gradient after certain T has been reached is used as correction value for amount of food. They are converted into preset T values for operating T for T sensor. Once the T operation is reached, heating is maintained. A Tcut-off also calculated from the operating T.	Matsushita Electric Ind Co LTD	
19	JP 8014573	A load sensor determine if there is pan/not on top of burner.When there is pan, a Tsensor which measure pan bottom T, will determine if Tbottom > Tthreshold A, if No, combustion is continued, if Yes, empty boil/over-heating detected -> turn off flame. If no pan detected, & Tsensor measure Tbottom > Tthreshold B, pan is temporarily removed/shaken -> reduce to weak flame	TOKYO GAS CO LTD	
20	JP 7012335	Tsensor detect pan bottom Temp. When Tpan bottom > Tthreshold for a pre-determined time period. Cut off gas valve. If Tpan bottom > Tthreshold temporarily (< pre-determined time) then nothing is done Reduce nuisance burner turn-off due to shaking of pan or temporary pan lifting (flipping pancake)	RINNAI CORP	
21	JP 5044939	Tpan bottom measured every 0.32s. (Tmax-Tmin) between 4 consecutive T measurement is calculated. Oil fire is prevented by comparing (Tmax-Tmin) with a reference value and by the time it takes for T to rise from 220 to 240 deg C	RINNAI CORP	
22	JP 8233278	Thermistor detect Tpan bottom & connected to valve coil of safety valve through intermediate switch. At pre-set Tthres thermistor operates the switch and turns off heat	Osaka Gas Co Ltd	
23	JP 4236012	Cooking mode is auto judged by bottom pot temperature/moisture sensor (liquid cooking/ frying). Prevent over-cook (boil/simmer) or fire (frying) by temperature rise pattern of pan/pot bottom	Matsushita Electric Ind Co LTD	
24	JP 61105025	Use electromotive force of TC for pan bottom. If this becomes larger than V drop of an electric resistance, signal is processed to output a pulse for heat source. If beyond Tthres, gas valve turns off	Matsushita Electric Ind. Corp	
25	JP 9148062 **ELECTRIC**	Pan/pot bottom T is measured by a T sensor below ceramic heat resistant slab for electric stovetop. When abnormal T is detected, heat source is manipulated (stop, heat retaining, or low)	Matsushita Electric Ind. Corp	
26	JP 4020718	In addition to overheat preventive function (Tpan bottom based), A contact sensor is installed to detect pot/pan on burner tripod/grill. If no pot is detected, alarm is on after a pre-set period	Harman Co Ltd	
27	Ctrl Sys. For Preventing Food Ignition on Gas R	A TC-based T sensor for pot bottom to determine the arrival of pre-ignition cond. T threshold of 590F was selected. When Tpan > 590F, burner is reduced to 40% output When Tpan < 590F burner up to full (selected) output. Specifically for gas burner	Energy International Inc.	
28	CPSC Prototype Detect preignition w/ Elec. Ranges	A TC-based T sensors (3) for pot bottom to determine the arrival of pre-ignition cond. Heater is cycled (1s on and 6s off) when Tpan is between 330-360 C, and when Tpan is larger than 360 C, heater turns off. Specifically for electric cooktop	CPSC	
29	Applications of Thermopile Infrar Sensor to the Home Appliance	Using IR T sensor to measure external pot temperature on a gas range. Use to determine boiling point and boil dry condition by analyzing Temp. gradient	LG Electronics Inc.	MEASURE PAN TEMP W/ NON-CONTACT SENSOR SELECT T OR COOKING MODE
30	NST 615F Cookir Hob	Thermopile IR sensor is used to detect the side wall T of pan/pot. Pot side has enamel strip w/ known emissivity (0.9). Sensor connects to controller which adjust heat source depending on selected T set-points for specific cooking modes. Heat source is cycled	Bosch, Siemens, DIAS Angewandte Sensorik	
31	JP 4080525	Fire prevention by the comparing the temperature gradient of the pan with pre-set conditions. If gradient < preset value A then actual T is compared to preset Ta, if less, continue. If more stop	NORITZ CORP	
32	US 3781506	Non-contact T sensor for cooking vessel, specifically for **induction** electric cooktop.	General Electric Co. Schenectady	

33	US 4994652 ELECTRIC	Use cook mode switch. 2 T sensors are used, dependent on type off cooking selected: for roasting T contact (T dependent resistor) on the underside of ceramic plate and for other, through pot wall using contact and/or IR sensor. Signal fed to controller that'll manipulate heat source depending on mode	Fissler GmbH Germany	MEASURE PAN TEMP w/ W/ CONTACT OR NON-CONTACT T SENSOR
34	JP 11118153	A design for a reliable temperature sensitive metal and a magnet that can actuate gas valve in case of fire. At pre-set Tthres, device will close valve	Paloma Ind Ltd	MEASURE PAN BOTTOM T NO SIGNAL PROCESSING USE ELECTROMAGNETIC SENSOR CONTACT T SENSOR
35	JP 3236520	Gas valve is opened w/ spring force. TC (for Tpan) is in contact w/ an electromagnet attached to on/off gas valve switch. When Tpan > Tthres TC produce electricity which attracted the electromagnet and compress the spring on the gas valve and closes it.	Matsushita Electric Ind Co LTD	
36	JP 3236519	Electromagnet is the T sensor for pan bottom. As Tpan increases to Tthres, sensor loses its property and releases the spring loaded gas valve and turns burner off	Matsushita Electric Ind Co LTD	
37	JP 8254320	TC for pan bottom generate electricity to a coil w/ electromagnet. This electromagnetic force kept gas valve (attached to T sensitive metal) open. When cooker gets hot, T sensitive metal loses its magnetic permeability and valve is closed. Else when thermoelec. Force of TC has lowered, valve also closes	Paloma Ind Ltd	
38	JP 11094245	TC for pan bottom is combined with a bimetal switch and a temperature fuse. These sensors are all combined in series to create a safety valve circuit to connect TC with the solenoid safety valve	RINNAI CORP	MEASURE PAN BOTTOM T NO SIGNAL PROCESSING USE BIMETAL SENSOR CONTACT T SENSOR
39	JP 11094258	Tsensor using bimetal switch is connected in series w/ a TC (pilot) & safety valve constituting an electrical closed circuit. It is also connected to a T fuse to turn off gas @ Tthres. No need for dry-cell	Hitachi Hometec Ltd	
40	US 4217481	Electric cooktop with 2 cooking zones: boiling & roasting. Each hot plate has a Tsensor. For boiling zone, the temperature range is between 40-140 deg for boiling & warming. For roasting, temperature range is between 80-270 deg C. Sensor uses expansion liquid & capillary tube to connect thermostat	None	MEASURE PAN BOTTOM T NO SIGNAL PROCESSING USE EXPANSIBLE LIQUID SENSOR CONTACT T SENSOR
41	US 2786930	Cooktop element or burner has a T sensor made of expansible thermosensitive material (fluid) connected with a capillary tube to a mechanical power/gas controller to control the tem-ture of the cooking vessel which is in contact with the Tsensor	Robertshaw	
42	Thermal Eye or Burner-w/-a-Brain	Tsensor using expandible thermosensitive liquid within a capillary tube. Used to control the temperature of cooking vessel.	Robertshaw Ctrls	
43	US 5945017	Tpan is used to determine near fire condition, it is bypassed if motion sensor detect person near stove within a pre-set period. It resets again after person is detected. If no motion detected, burner turns off	None	MOTION+Tpan SENSOR & MICROPROCESSOR TO ACTUATE CONTACT T SENSOR
44	JP 6265158	Tpan bottom = Tthres, controller counts set time, if during set period no motion (person) is detected, heater off. If yes, controller reset counting and continue, if set period is passed, heater lowered/off.	TOSHIBA CORP	
45	JP 7083442	User select button for frying function - actuate safety circuit. If no T change is determined from the IR motion sensor at the front of stove, burner will turn off after a specified time (~10 min)	TOKYO GAS	
46	US 5796346	To prevent fire from foreign object (eg. grease) that touches heating element to accidentally burns. When power level/heater above a threshold value, timer (and possibly alarm) will turn on. Depending on the measure power level, a a corresponding pre-set time will start to be counted down by the timer. If by the time the timer ends the count down the user does not provide action (e.g. press reset button), burner will turn off automatically	None	TIMER AND POWER LEVEL
47	JP 6050551	Pre-set time periods for auto-power off is determined by heat source power levels When no switching operation is performed by user during pre-set period since the last time a switching operation is carried on during the on times of heating element, burner turns off to prevent user from forgetting to turn off cooktop after use.	Toshiba Corp	
48	US 5416301	The cooking appliance automatically turns off the heater a predetermined time after a last pressed switch, i.e., automatic power off function. A caution lamp indicates that the heater will automatically be turned off a minute prior to the automatic power off function.	Matsushita Electric Ind. Corp	TIMER ONLY
49	JP 61038338	The IR smoke detector will detect a threshold amount of smoke, then set a timer on. After a pre-set time (eg. 10min) has elapsed from the timer, check again, if smoke generation increase/not reducing, shut-off valve, if not reset timer and repeat procedure	NIPPON DENSO CO LTD	SMOKE SENSOR
50	JP 4093529	A photoelectric sensor (light projector and receiver) is installed in downdraft cooking vent/hood. When smoke level in the vent is > pre-set value sensor will send signal to turn on alarm and turn off heater	Matsushita Electric Ind. Corp	
51	US 5611327	Smart range w/ multiple sensors & functions. For fire safety of cooktop, a nearness sensor check for authorized user and/or utensils. If unauthorized person/utensil is around/used, burner is locked - for authorization, transmitter has to be carried by person/embedded in utensils The pot support grid has a weight measuring device. If no weight is sensed then burner turns off. Timer is used for individual burner to turn it off automatically. Have bypass functions for when pot is temporarily lifted or pot is left on grid after finishing w/ cooking (lock burner off)	None	VARIOUS SENSORS
52	US 5608378	Power level (elec) or flame (gas) sensors. If sensor detect heat source is on, a warning indicator located next to exit door/audible alarm turns on when door is opened -- prevent unattended/accidental on	None	
53	JP 5018539	An odor sensor is used to determine what kind of food is cooked and also to determine if food is over-heating. It is connected to controller that can manipulate heat source	Sharp Corp	
54	JP 5018539	Auto detect of food type using odor sensor. Use food type info. for auto. cooking and use odor data to determine food fire and manipulate burner (shut-off) when that happens	Sharp Corp	
55	JP 8086445	A contact/touch sensor (combined with Tpan bottom sensor) is used to determine if pan/pot is on top of burner. When pan is not on burner, burner flame is either reduced or off so no cloth/sleeve catch fire	Tokyo Gas Co Ltd	
56	JP 9056601	Tsensor at suction passage below burner through its circumference and in smoke duct below burner system. When abnormal heat is detected, alarm turns on and gas valve is turned off	Yamaoka Kinzoku Kogyo KK	

57	JP 4006325	An energy (Temp) sensor is installed within a downdraft duct behind burner. When food overheat (oil) The energy sensor detected pre-set radiation energy from cooktop, turn off burner and stop blower	Matsushita Electric Ind. Corp	
58	JP 7171061	T sensor is directly inserted to pan/pot content. T sensor is attached to an alarm system that can generate synthesized voice to alert cooker of cooking fire danger when Tfood/oil ~ Tthres (eg. 200 C)	None	

SENSORS/ACTUATORS

No	Patent Number	**Description**	**Company**	
1	US 4710611	A T sensor for pan bottom T, located at the center of an electric heat plate cooking hob. Tsensor could be a thermistor/liquid based. Conical sensor housing shape meant to reduce dirt from entering sensor	AB Electrolux Sweden	
2	US 3668372	Detailed design on how to mount the capillary type Tsensor using the capillary tube itself as the spring device that will maintain the contact of sensor head with cooking vessel bottom	Robertshaw	CONTACT TEMPERATURE SENSOR FOR COOKING VESSEL
3	SiC Thin-Film Thermistors	Thermistor using RF-sputtered SiC film developed specifically for cooking appliance Has been applied to detect Tpan bottom for gas cooktop. Thermistor is connected to a controller that adjust gas valve for burner - shows rapid thermal response	Matsushita Housing Products	
4	US 5919385	Specifically for hob w/ halogen lamp as heat source and a ceramic cooktop which absorbs ~40% of halogen radiation. The Tsensor engages the bottom part of the ceramic cooktop	U.S. Phillips Corporation	
5	US 5397873	For Elec heater w/ glass ceramic cooktop. T sensor form PTC (positive T coeff. sensing element). It is attached to the underside of ceramic cooktop and measure T of cooking area (not pot bottom directly)	Emerson Electric Co.	
6	US 6075463	A wireless Tsensor consisting of an antenna, piezo-electric crystal and reflector is integrated to the bottom of the pot/pan. The sensor transmit wirelessly to the receiver beneath the ceramic top	AKO-Werke GmbH & Co. KG Wangen, Germany	NON-CONTACT TEMPERATURE SENSOR FOR COOKING VESSEL
7	US 5750963	Temperature sensor for cooking hob by using a field sensor that will measure the decay of the ma DC field which is a function of cooking vessel and food content. The signal from the field sensor will then be used to control the electric heat source to a user pre-determined temperature	AB Electrolux Sweden	
8	Advanced Cook-ware Sensing Sys for Vitroceramic	Gold alloy tracks for pot sensing. Has transmitter & receiver track - detection by measuring amount of electromagnetic damping on track. Detect vitroceramic T around heat zone (thus cooking pot) by measuring specific resistance of the gold alloy track	Cherry Elec. Products	
9	US 5283412	A device to measure pan or content temperature during induction heating independent of cooking vessel diameter/surface configuration (heat conductor w/ current measurement)	Compagnie Europeenne Pour l'Equipment Menager	
10	JP 00090365	A conductive thin plate is formed of copper foil printed in the thermoplastic resin film polyester film a notch is installed in copper foil. When flame is directly brought into contact with the thermoplastic resin film the thermoplastic resin film is contracted part of the notch in copper foil breaks and it does not conduct	NIPPON SIGNAL CO LTD	FLAME/FIRE SENSOR
11	Fire Detection w/ Combo Ultrasonic μwave Doppler Sensor	A combined ultrasonic-microwave doppler sensor is developed for a sensitive and fast fire alarm that is robust against false alarm.	Siemens AG	FLAME/FIRE SENSOR
12	Micro-machined Water Sensor for Home Appliance	A new micro-machined relative humidity sensor was developed. Output signal is linearly proportional to relative humidity from 0%-100% RH. Claims: low cost and reliable sensor can be applied to cooking ranges of different types (electrics and gas)	Institut fur Instrumentelle Analytik Hermann-..	HUMIDITY SENSOR
13	Conference pape	Automated Cooking and Frying control using a gas sensor microarray A discussion on a new development effort on a gas sensor microarray that is specifically to determine the doneness level of steak cooking. The sensor is located on the underside of the pan lid.	Institut fur Instrumentelle Analytik	GAS/ODOR SENSOR

Appendix B: Technologies Eliminated in Initial Screen

TECHNOLOGIES ELIMINATED FROM CONSIDERATION FOR VARIOUS REASONS: 29

No	Technology	Description	Company	Explanation
1	JP 4080525	Fire prevention by the comparing the temperature gradient of the pan with pre-set conditions. If gradient < preset value A then actual T is compared to preset Ta, if less, continue. If more stop	NORITZ CORP	Find patent's figure later and realize it is for oven
2	JP 5018539	An odor sensor is used to determine what kind of food is cooked and also to determine if food is over-heating. It is connected to controller that can manipulate heat source	Sharp Corp	Find patent's figure later and realize it is for oven
3	JP 8086445	A contact/touch sensor (combined with Tpan bottom sensor) is used to determine if pan/pot is on top of burner. When pan is not on burner, burner flame is either reduced or off so no cloth/sleeve catch fire	Tokyo Gas Co Ltd	Address only small % of cooking fire
4	JP 4093529	A photoelectric sensor (light projector and receiver) is installed in downdraft cooking vent/hood. When smoke level in the vent is > pre-set value sensor will send signal to turn on alarm and turn off heater	Matsushita Electric Ind. Corp	Optical sensor easily soiled by grease & not accessible for daily cleaning
5	US 5283412	A device to measure pan or content temperature during induction heating independent of cooking vessel diameter/surface configuration (heat conductor w/ current measurement)	Compagnie Europeenne Pour l'Equipment Menager	Only work for induction type cooking hob - very small % in market
6	JP 9056601	Tsensor at suction passage below burner through its circumference and in smoke duct below burner system. When abnormal heat is detected, alarm turns on and gas valve is turned off	Yamaoka Kinzoku Kogyo KK	Detection threshold might easily be compromised - dirt/boil-over
7	JP 4006325	An energy (Temp) sensor is installed within a downdraft duct behind burner. When food overheat (oil) The energy sensor detected pre-set radiation energy from cooktop, turn off burner and stop blower	Matsushita Electric Ind. Corp	Sensor easily soiled by grease & not accessible for daily cleaning
8	JP 7171061	T sensor is directly inserted to pan/pot content. T sensor is attached to an alarm system that can generate synthesized voice to alert cooker of cooking fire danger when Tfood/oil ~ Tthres (eg. 200 C)	None	User have to install/uninstall sensor everytime used - nuisance
9	US 5608378	Power level (elec) or flame (gas) sensors. If sensor detect heat source is on, a warning indicator located next to exit door/audible alarm turns on when door is opened -- prevent unattended/accidental on	None	Does not seem to be very effective High likelyhood of false alarms
10	US 5942816	Modified fuse for electric cooktop with build-in timer. Each heat element ctrl knob has 1 fuse. The modified fuse will turn off heat element to reset after a pre-determined period of time (pre-set or user-selected)	None	Timer period selection is arbritrary or dependent on user - not desireable to let user define safety limits
11	US 4577181	A contact sensor for electric heater to detect pan/pot presence above heater detailed sensor drawing	Fissler GmbH Germany	Only address fires from non-food mat'l small % of cooktop fire source
12	US 3781506	Non-contact T sensor for cooking vessel, specifically for induction electric cooktop.	General Electric Co. Schenectady	Not many induction cooktop in the market today
13	JP 5018539	Auto detect of food type using odor sensor. Use food type info. for auto. cooking and use odor data to determine food fire and manipulate burner (shut-off) when that happens	Sharp Corp	Find patent's figure later and realize it is for oven
14	US 4483314	Pull out blanket from drawer underneath the burner/heat source. Used to manually smother fire	None	User has to manually smother fire -- harmful
15	JP 10201871	Manual fire extinguishing sheet. Fire extingusih agent is suspended in a flexible & fusible encasing from polyethylene film. When fire occurs drape sheet on stove to melt film and delivers extinguisher	None	User has to manually smother fire -- harmful
16	JP 8107942	Nozzles connected to pressurized water source capable of delivering fine water mist/fog to suffocate and cool fire/stove. Using fusible parts to activate nozzles	NOHMI BOSAI LTD	Water is not recommended to turn off grease fire
17	JP 9117329	Incombustible back panel for wall cover	MATSUSHITA ELEC. WORKS LTD	Only contain fire from burning back wall
18	JP 9206393	Kitchen mat with incombustible material to smother fire manually	DUSKIN CO LTD	User has to manually smother fire -- harmful
19	JP 11221297	Extinguish stove fire and prevent fire from expanding into hood duct. Nozzle that sprays water droplet is situated inside the duct of a range hood to spray into duct an onto stove surface	BUNKA SHUTTER CO LTD	Water is not recommended to turn off grease fire
20	JP 2045073	Water sprayed from surrounding pipe frame to cool and suppress fire. After flame has subsided, a metal plate covers pot automatically	None	Water is not recommended to turn off grease fire
21	JP 1015068	Range hood act as a fire enclosure/containment unit. Drops down to cover entire cooking unit -- manually activated	None	Has to manually activate sys. Harmful to user
22	US 4633230	A temperature sensor is attached at the end of a 2 bar link arm that can be ad-justed to contact the cooking container. The temperature sensor will convert the measured cooking vessel temperature into electrical signal that will signal alarm in cases of boil over or boil dry.	None	Very cumbersome setup. Will affect cook's performance to have this arm sticking out on the way. Can be harmful if it obstruct cook's movement and cause spills etc.
23	Conference paper	Automated Cooking and Frying control using a gas sensor microarray A discussion on a new development effort on a gas sensor microarray that is specifically to determine the doneness level of steak cooking. The sensor is located on the underside of the pan lid.	Institut fur Instrumentelle Analytik	Sensor can only judge the doneness of meat during steak frying only. Still at early stages of development
24	Conference paper	Fire Detection w/ Combined Ultrasonic-Microwave Doppler Sensor A description of a new development of a fire detection system that combined two sensors: ultrasound and microwave Doppler sensor to reduce the incidence of false alarms	Siemens AG	Sensor is still at early stage and looks to be too expensive an addition to cooktop or hood
25	Fire Breaker Fuel Neutralizer	Manual fire extinguisher material (powder in bottle)	National Fireproofing Co.	User has to manually spray the product on the fire -- considered unsafe proximity
26	Stovetop FireStop	Hood installed (magnet) extinguisher - No pressurized tank	Williams Pyro Inc.	Product not applicable for grease fire since it is released w/ large pressure that can splatter the grease and fire to surrounding
27	Simmer Sentry	Tsensor + acoustic sensor directly in contact w/ food. The sensor sticks out of the back panel of the cooktop and its sensor tip is immersed in the cooking liquid	GRI	Only to detect the presence of boiling in liquid cooking. Also the protruding sensor is not practical in real cooking scenario
28	Fire Line	Hood installed extinguisher using fusible link	Ansul Fire Suppression System	System is applicable for commercial kitchens
29	Firemelt hood system	Hood installed extinguisher using fusible parts and a new powder extinguisher that suppse to work well with grease fire too.	Firemelt	No clear description of product and company did not return contacts

COOKING METHODS DEFINITIONS

1. **Sauté:**
   To sauté is to cook a food quickly in a small amount of fat over a relatively high direct heat. First, heat the pan over a medium flame, then add your fat. Once the fat begins to ripple, add your ingredient. It is very important not to crowd the pan or the liquid released from the food will actually cause steaming rather than sautéing.
2. **Searing:**
   To sear means to cook food over a very high, dry heat to seal a surface--and seal in juices. This is usually done in a skillet or under a broiler. The high heat caramelizes the naturally occurring sugars present in the food and produces a flavorful crust. Browning becomes apparent when the food's surface reaches approximately 310 F.
3. **Stir-fry:**
   To stir-fry means to cook food quickly, stirring constantly over extremely high heat in a small amount of fat. This technique is traditionally performed in a wok. Since the heat is intense, it's best to use a fat with a high smoke point, such as peanut, canola, corn or safflower oil, or lard. The wok must be very hot before the fat is added or the fat and food will stick.
4. **Blackened**
   Meat or fish is cooked in a cast-iron skillet that's been heated until almost red hot. The food is customarily rubbed with a cajun spice mixture before being cooked. The extra hot skillet combined with the seasoning rub gives food an extra crispy crust.
5. **Browning**
   To cook quickly over high heat, causing the surface of the food to turn brown while the interior stays moist. This method not only gives food an appetizing color, but also a rich flavor. Browning is usually done on top of the stove, but may also be achieved under a broiling unit.
6. **Caramelize**
   To heat sugar until it liquefies and becomes a clear syrup ranging in color from golden to dark brown (from 320 degrees to 350 degrees F on a candy thermometer).
7. **Blanching:**
   The term "blanching" refers to the technique of plunging a food, usually a vegetable or fruit, into boiling water until either its color has set or the food has softened slightly. This takes anywhere from a few seconds to several minutes, depending on what is being blanched.
8. **Parboiling:**
   It is a technique that is similar to blanching, but takes a bit longer. Parboiled food is actually partially cooked.
9. **Melting Chocolate:**
   Chocolate scorches easily, melt slowly over low heat. Place the chocolate in a double boiler over simmering water, remove from heat when halfway melted, and stir until smooth. 4 ounces of chocolate takes about 3 min.

10. Simmering:

To cook food gently in liquid at a temperature (about 185 degrees F) low enough that tiny bubbles just begin to break the surface. Cooking time varies from short (less than 10 minutes) to long (more than 1 hr)

11. Canning:

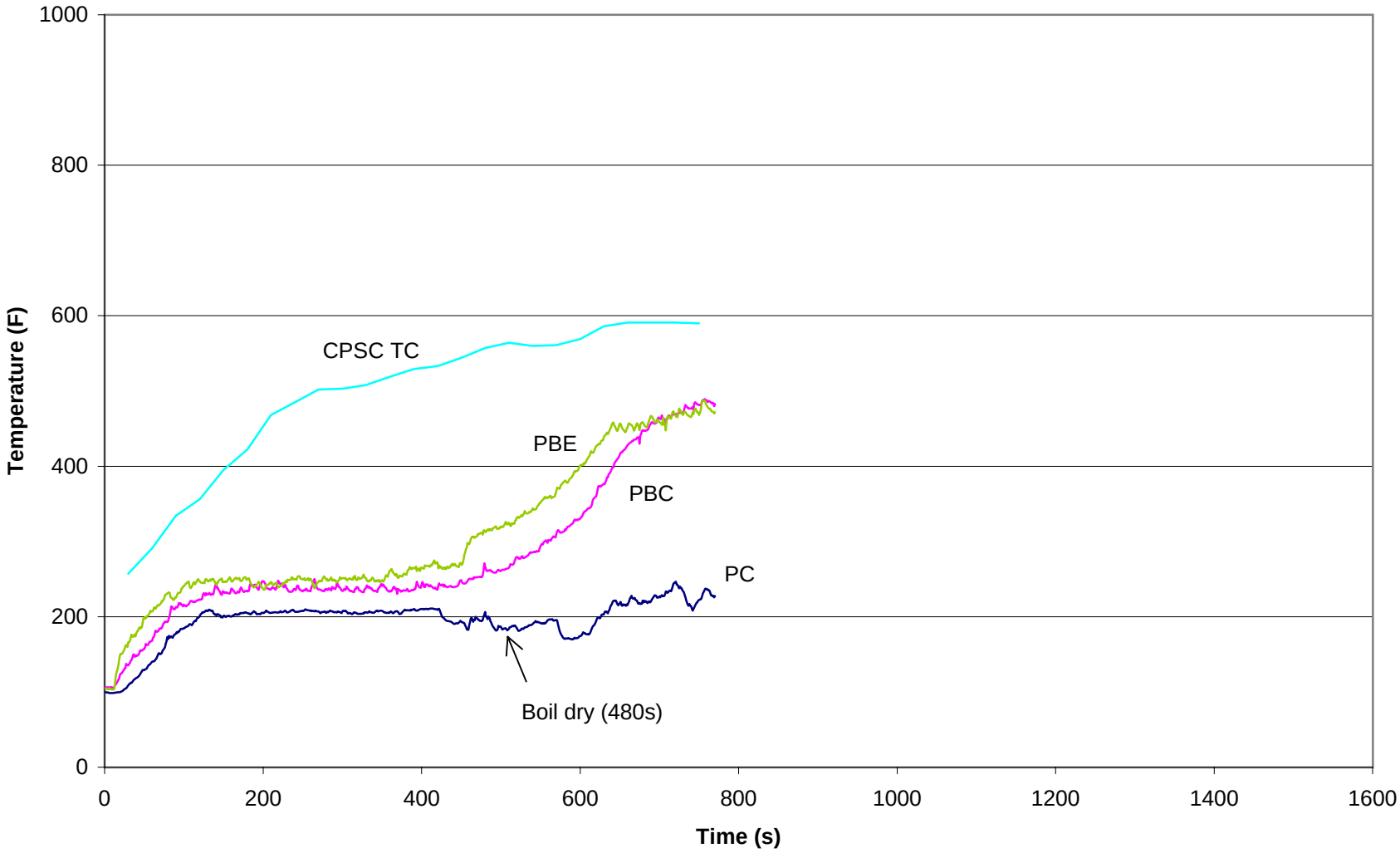
Boiling-Water Canners: These canners are made of aluminum or porcelain-covered steel. They have removable perforated racks and fitted lids. The canner must be deep enough so that at least 1 inch of briskly boiling water will be over the tops of jars during processing. To ensure uniform processing of all jars with an electric range, the canner should be no more than 4 inches wider in diameter than the element on which it is heated. Cooking time is between 10-45 min depending on type of canner used and type/amount of food canned. Boiling canner has a large diameter (found one w/ 16.5" diameter). Pressure canner w/ diameter of 12.25" to 15.25".

12. Braising

A cooking method by which food (usually meat or vegetables) is first browned in fat, then cooked, tightly covered, in a small amount of liquid at low heat for a lengthy period of time (Can be > 1hr). The long, slow cooking develops flavor and tenderizes foods by gently breaking down their fibers. Braising can be done on top of the range or in the oven. A tight-fitting lid is very important to prevent the liquid from evaporating.

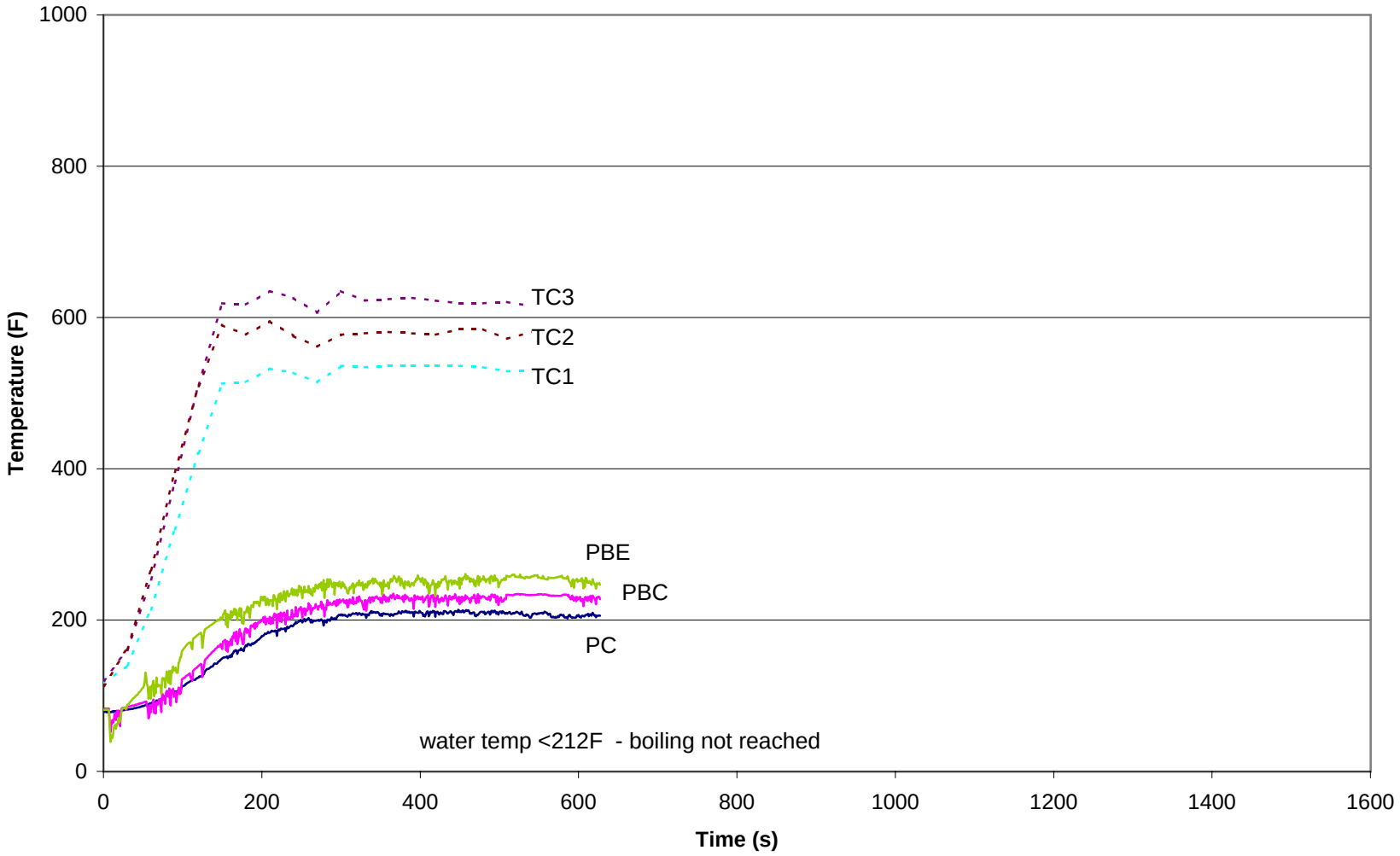
Appendix D: Temperature Measurements from ADL Cooking Tests

100ml Water Test in Stainless Steel Pan on CPSC Gas Range



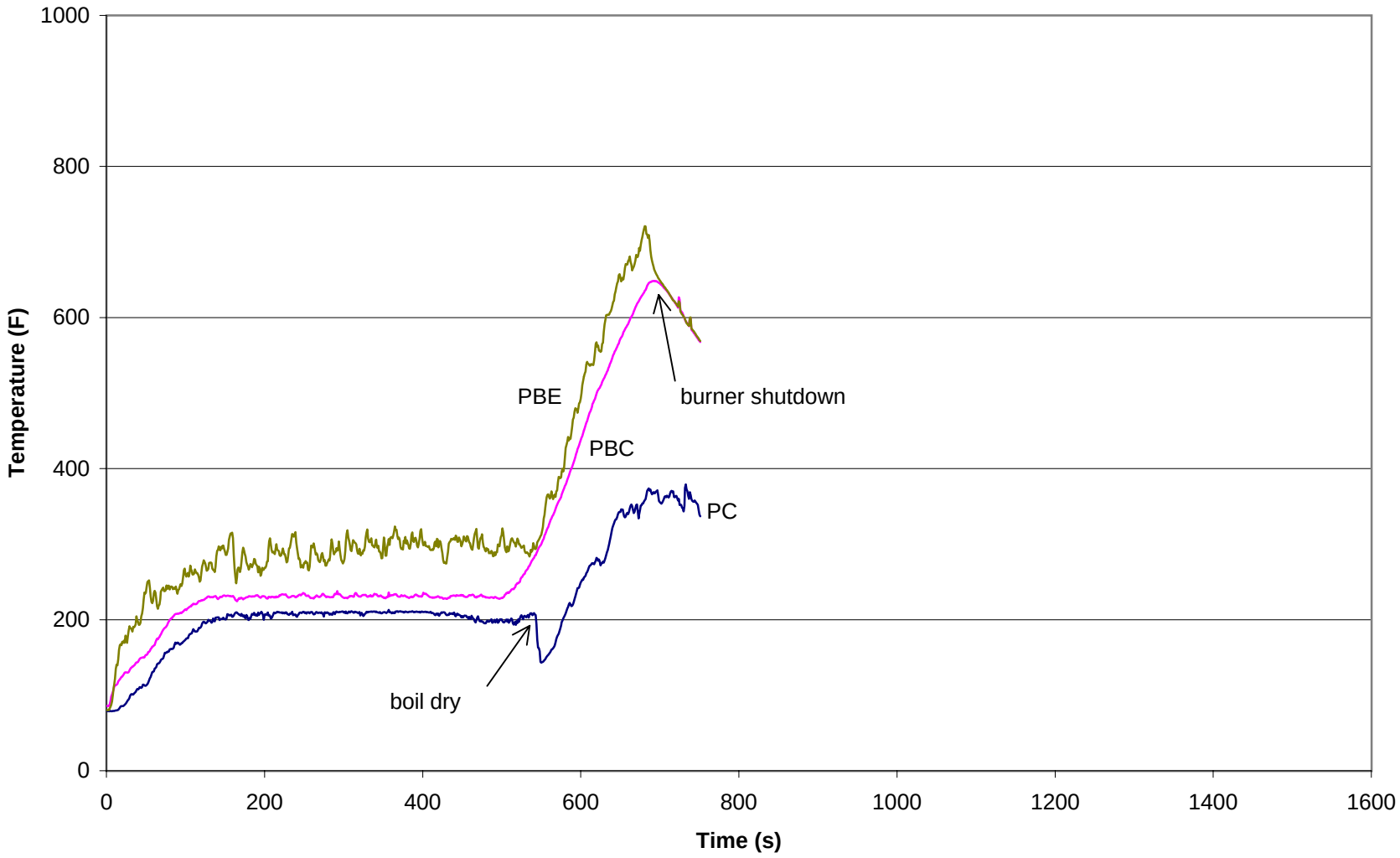
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

100ml Water Boil Test in Stainless Steel Pan on CPSC Electric Range



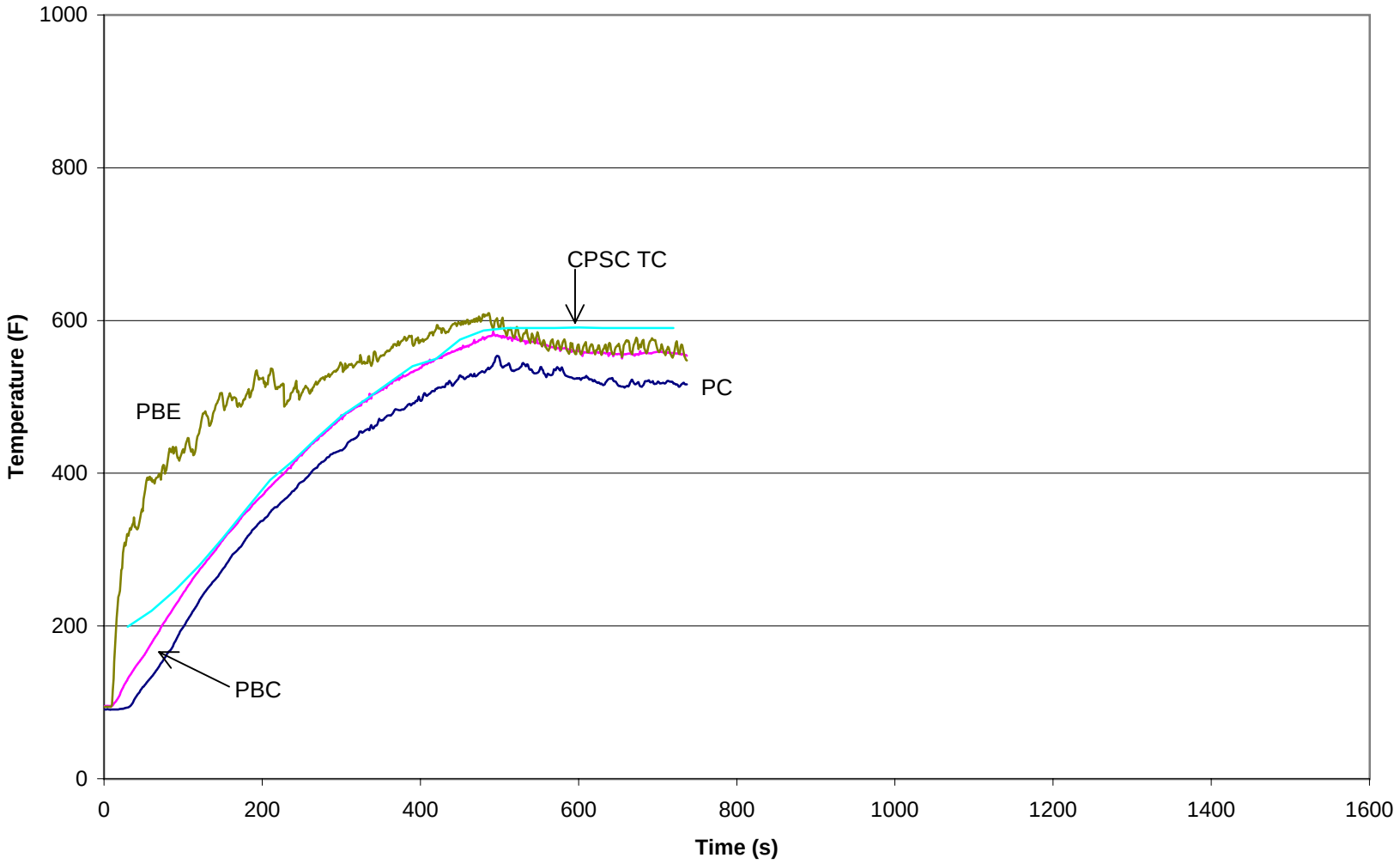
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

100ml Water Boil Test in Stainless Steel Pan on Rinnai Range



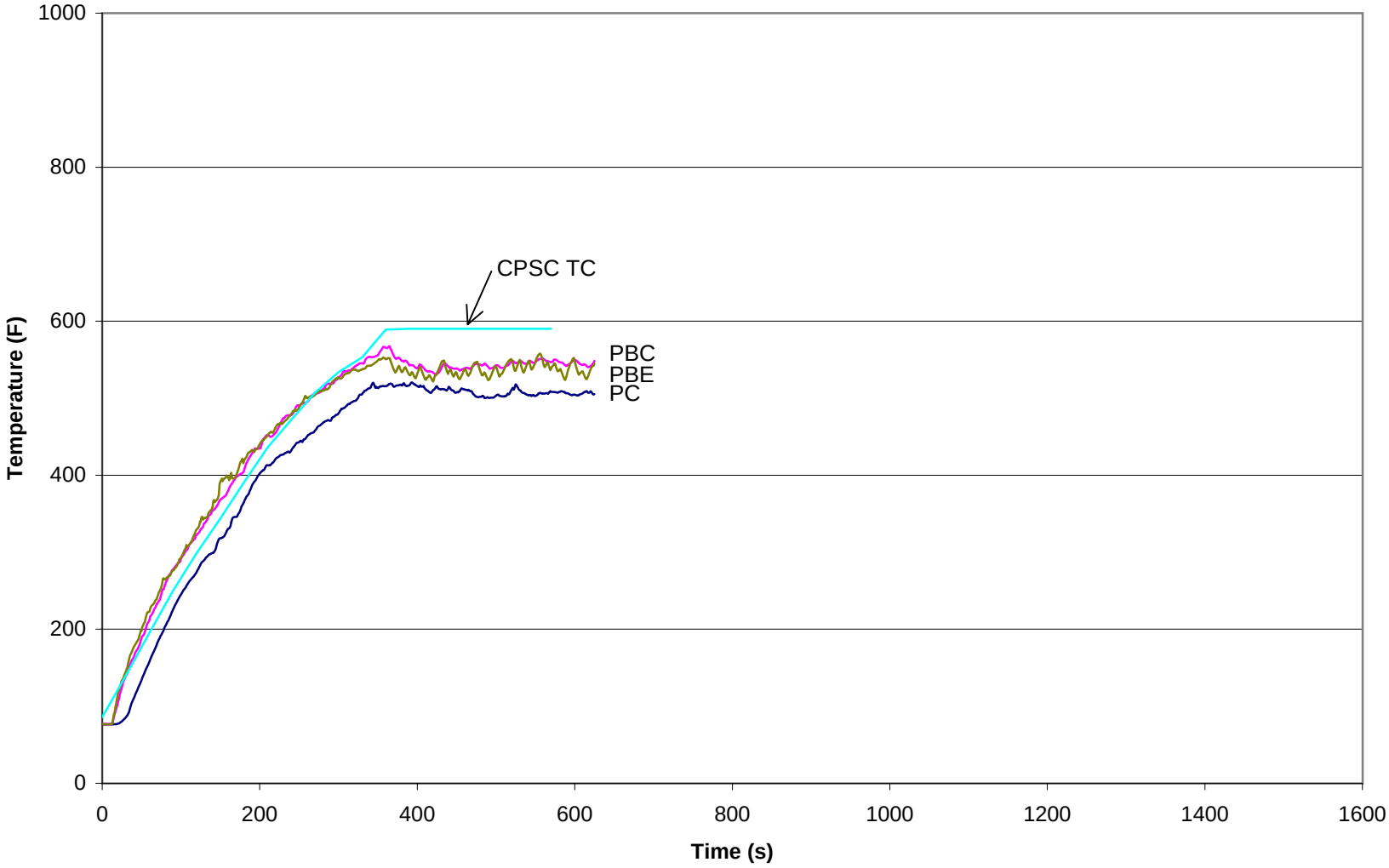
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

100ml Oil Test in Stainless Steel Pan on CPSC Gas Range



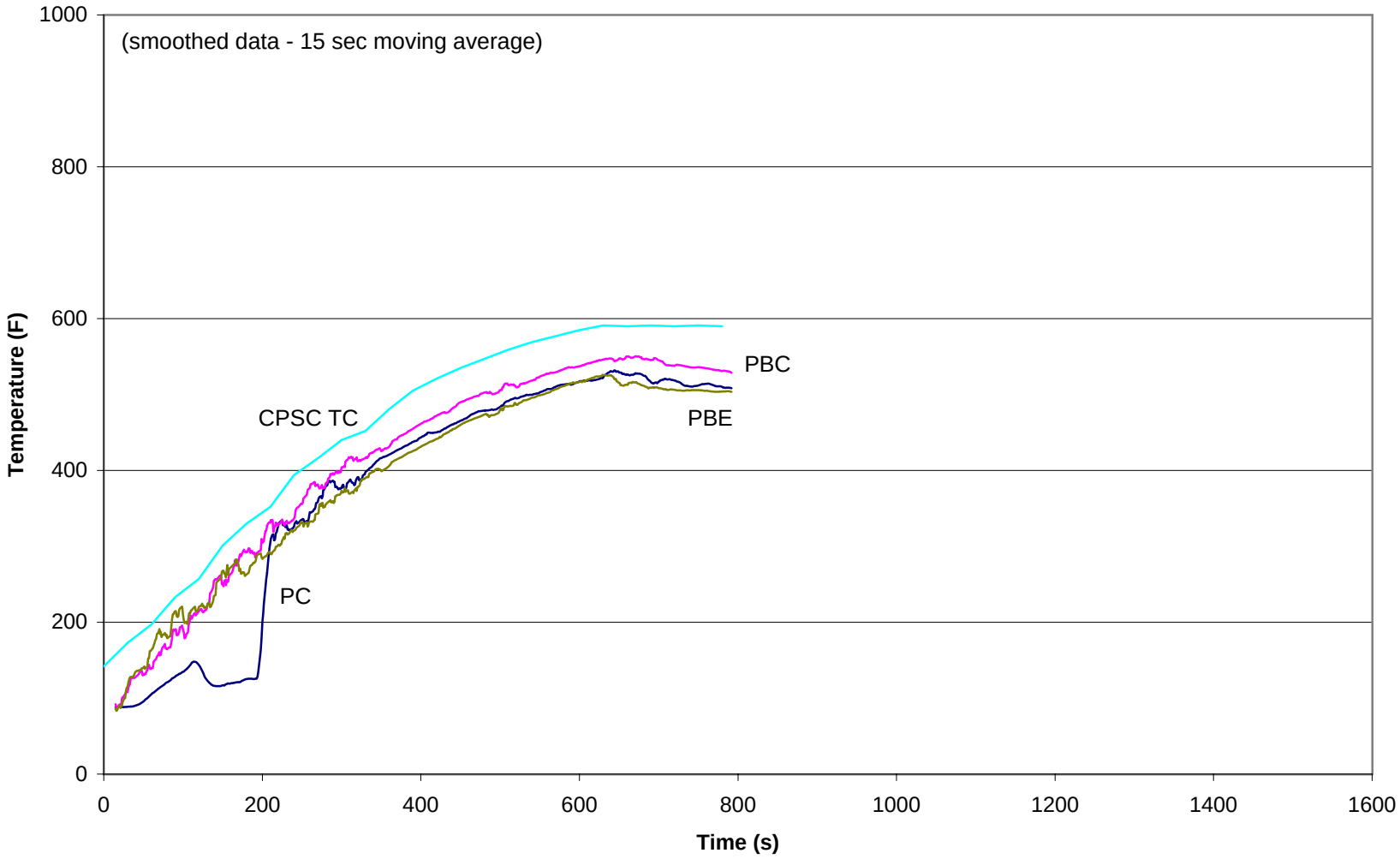
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

100ml Oil Test in Aluminum Pan on CPSC Gas Range



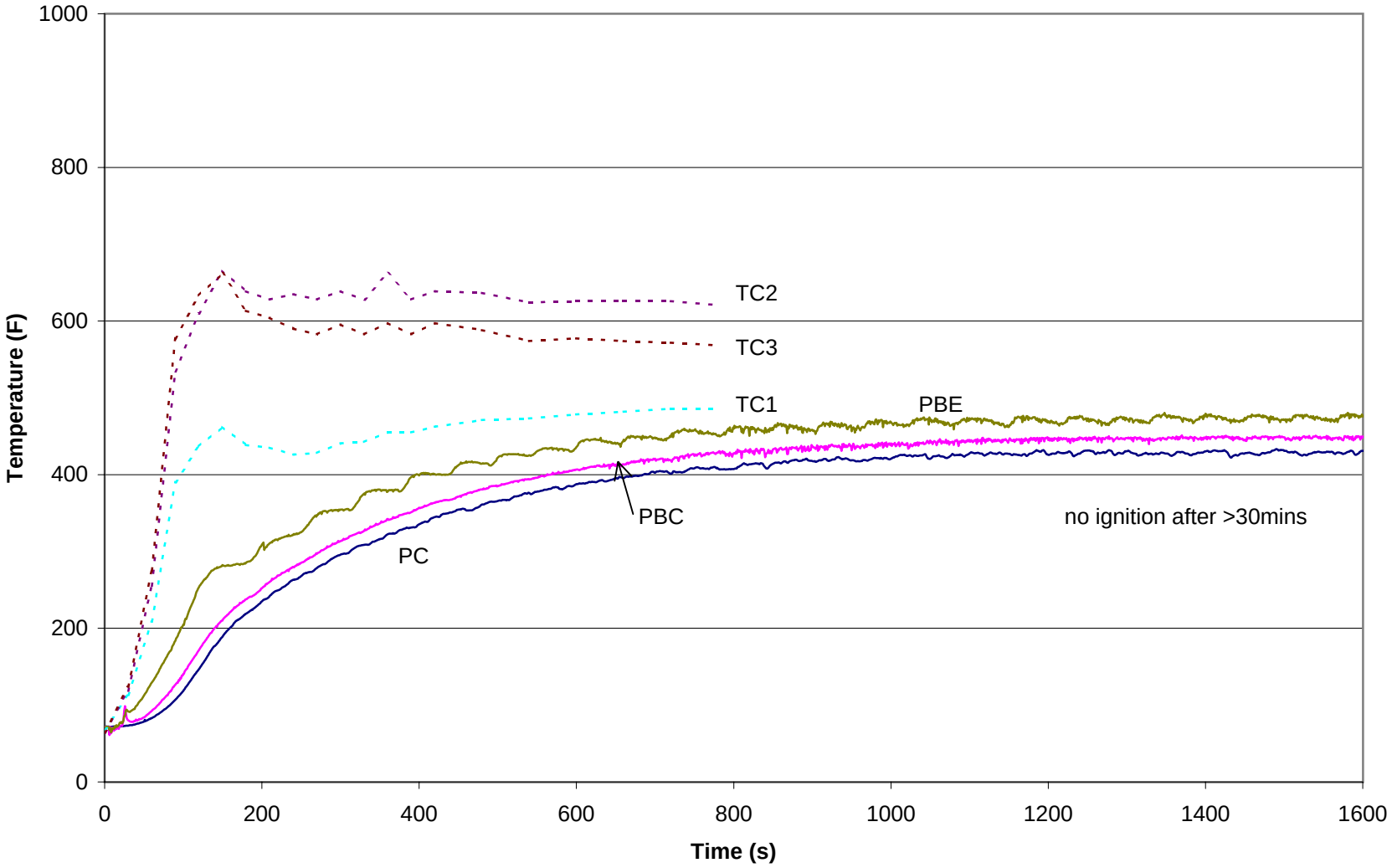
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

100ml Oil Test in Cast Iron Pan on CPSC Gas Range



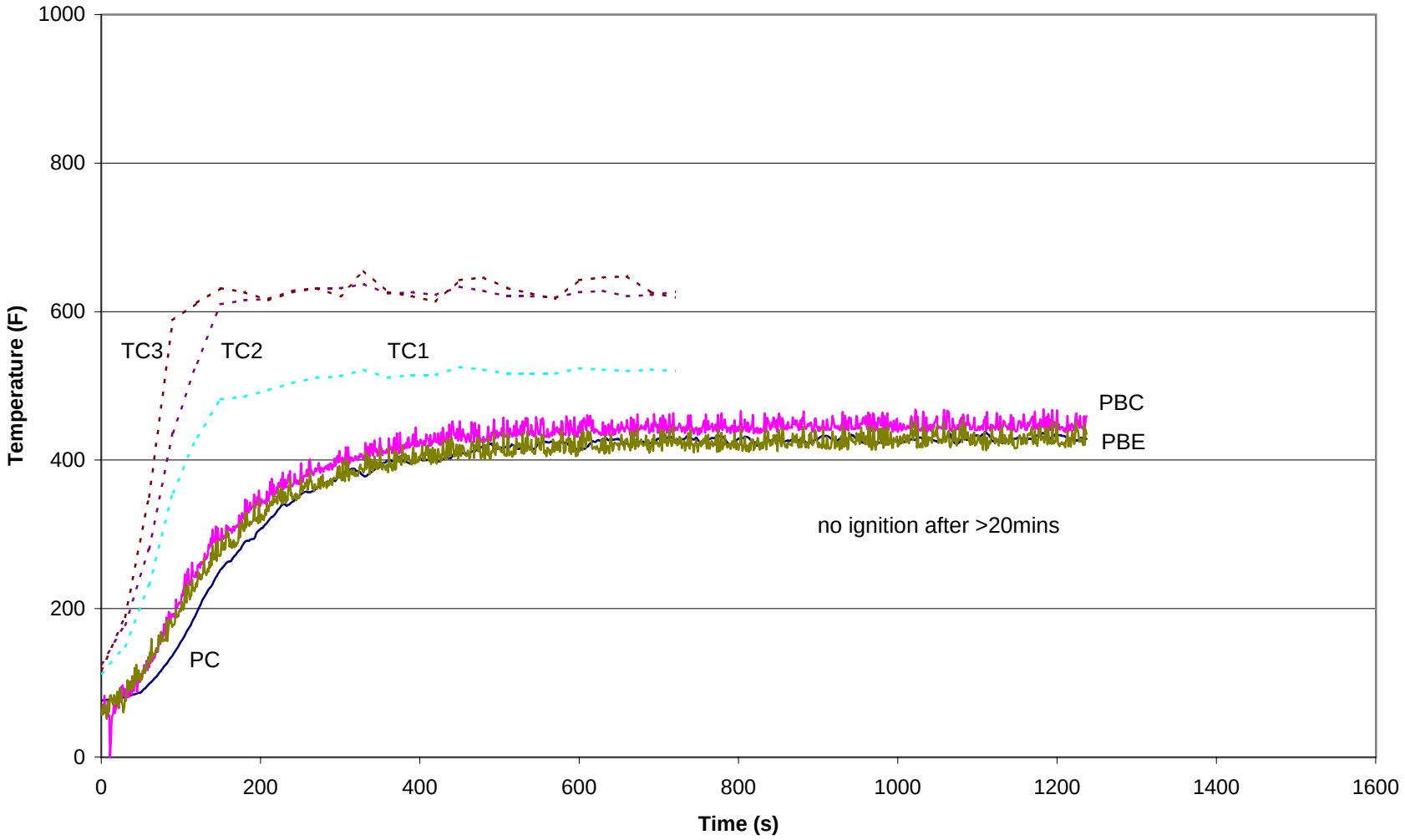
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

100ml Oil Test in Stainless Steel Pan on CPSC Electric Range



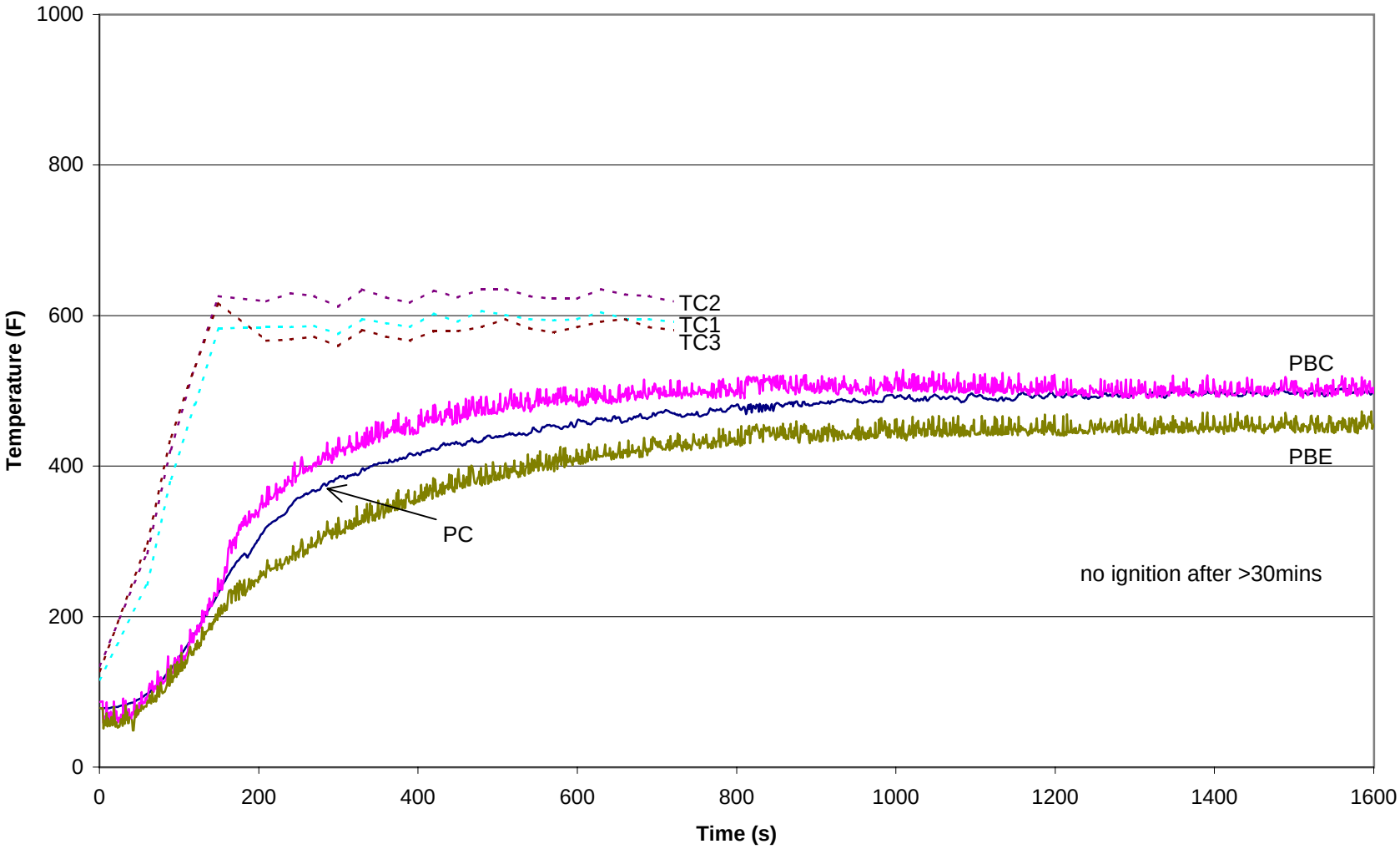
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

100ml Oil Test in Aluminim Pan on CPSC Electric Range



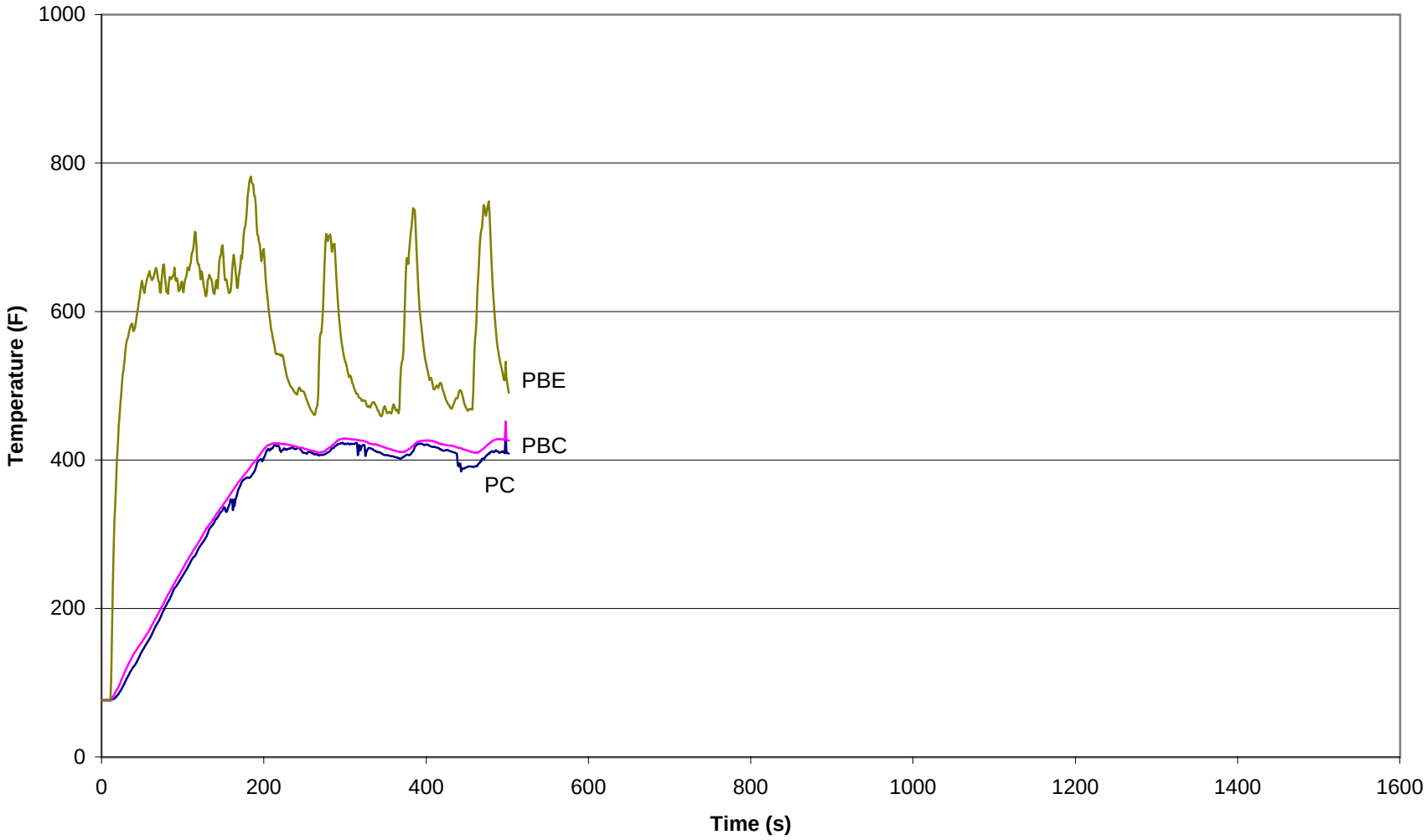
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

100ml Oil Test in Cast Iron Pan on CPSC Electric Range



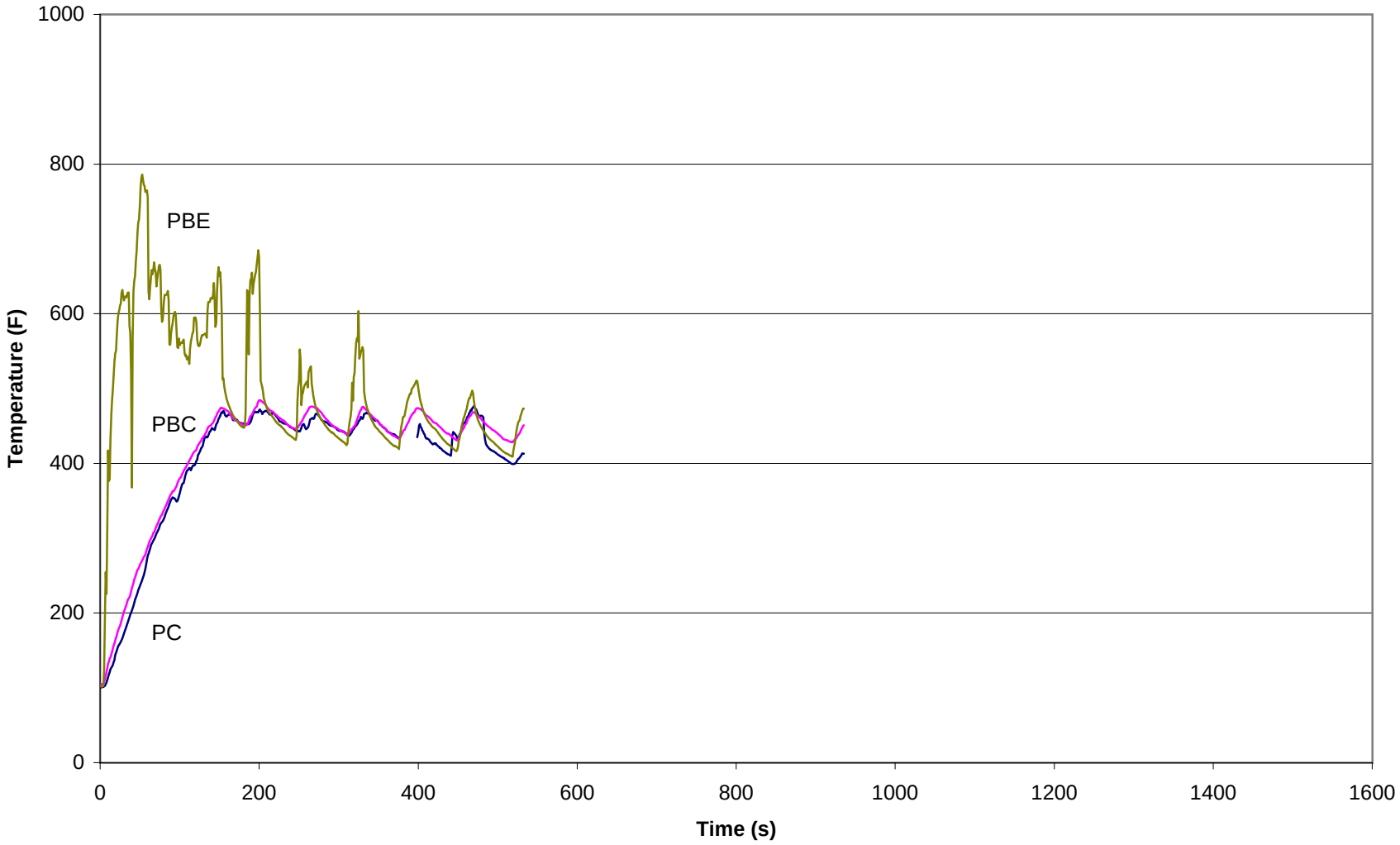
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

100ml Oil Test in Stainless Steel Pan on Rinnai Range



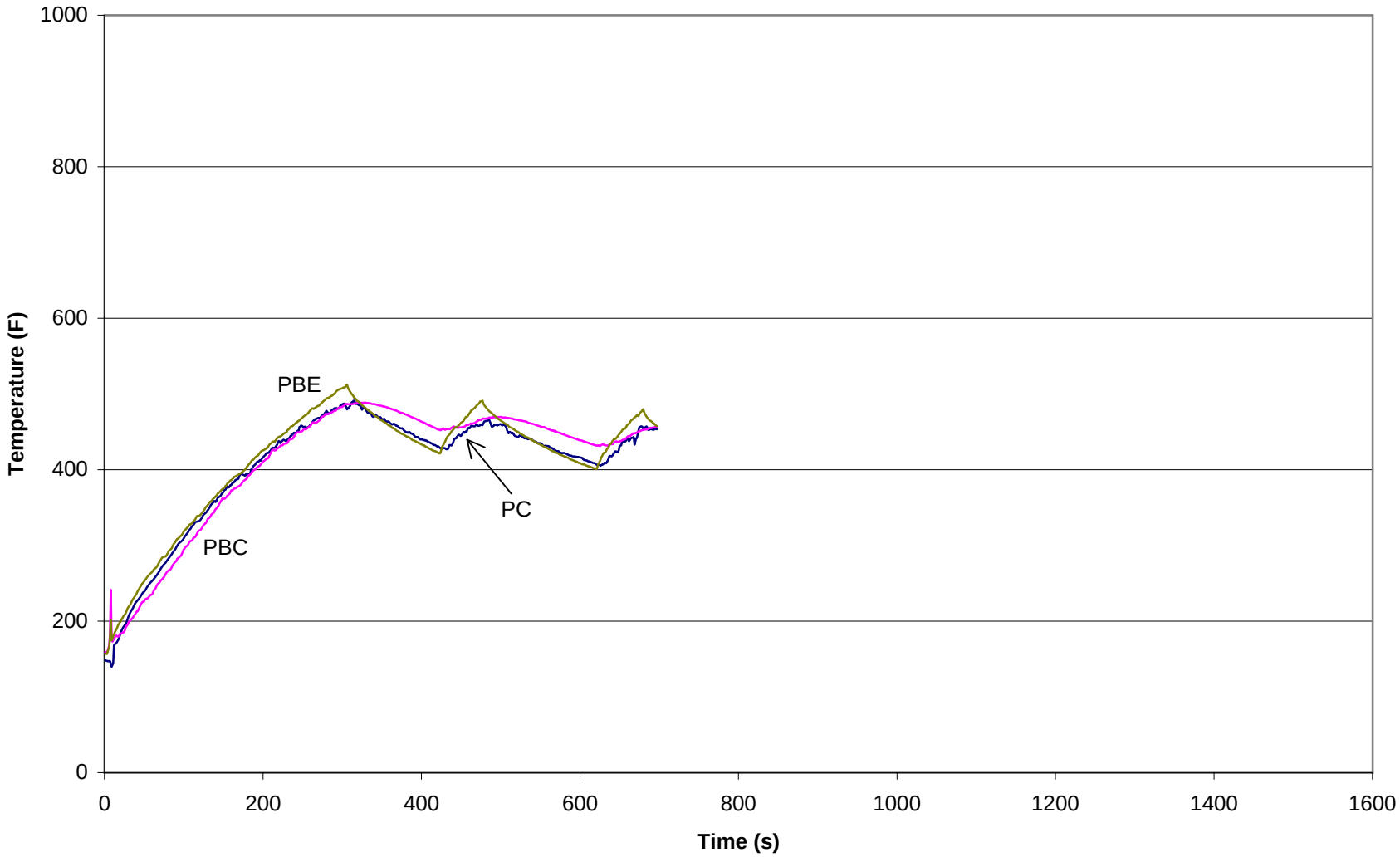
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

100ml Oil Test in Aluminum Pan on Rinnai Range



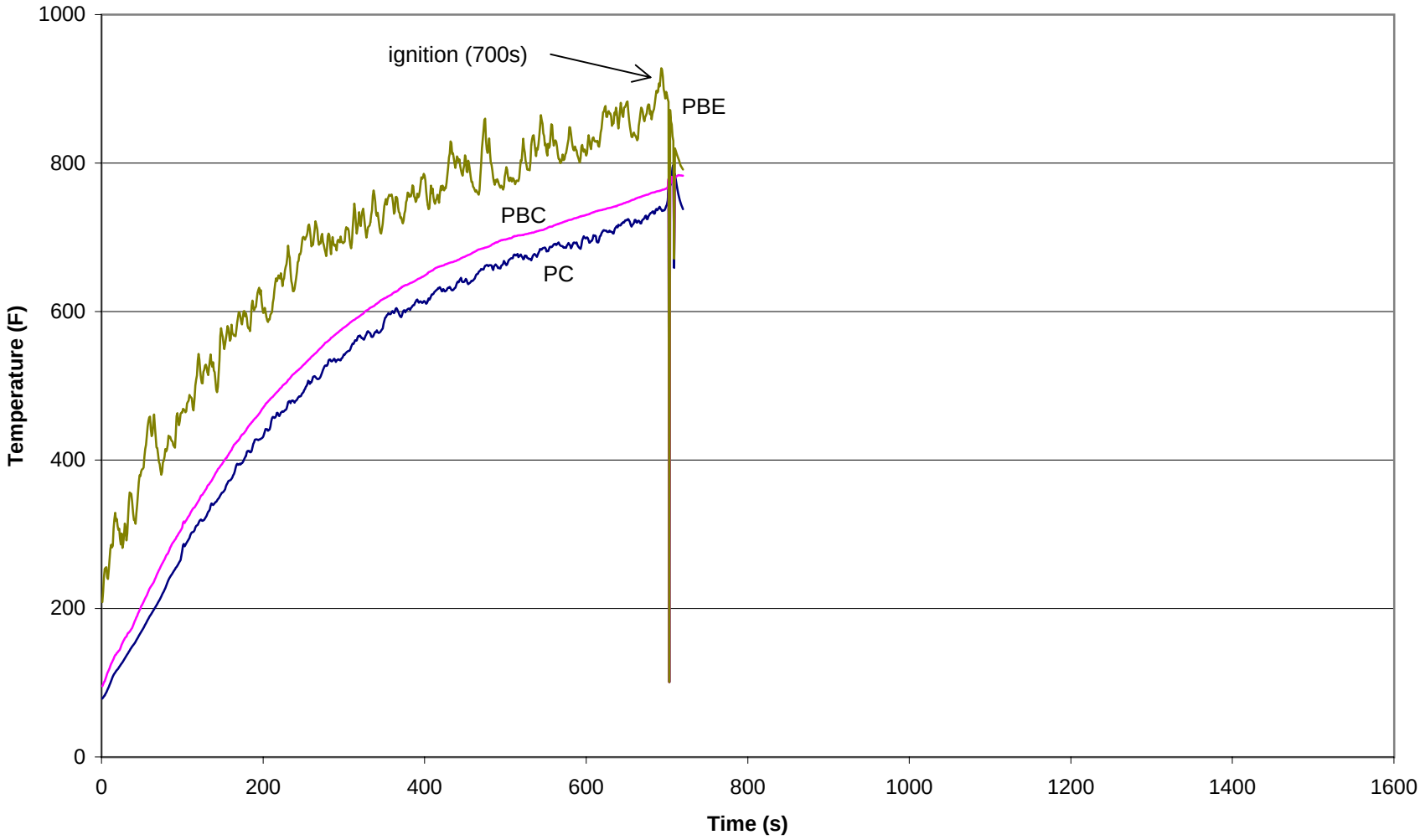
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

100ml Oil Test in Cast Iron Pan on Rinnai Range



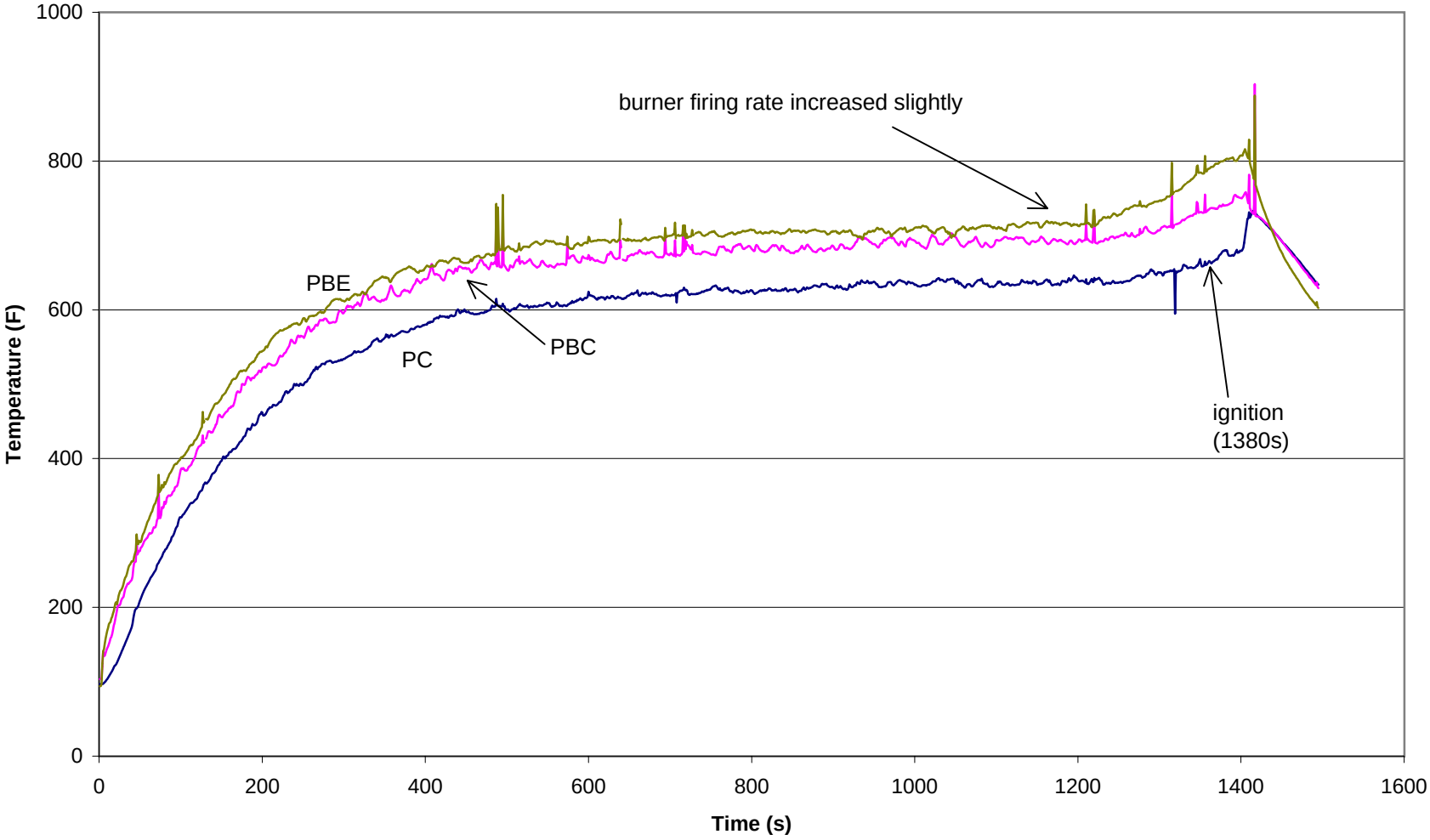
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Oil Ignition Test on Rinnai Uncontrolled Burner in Stainless Steel Pan



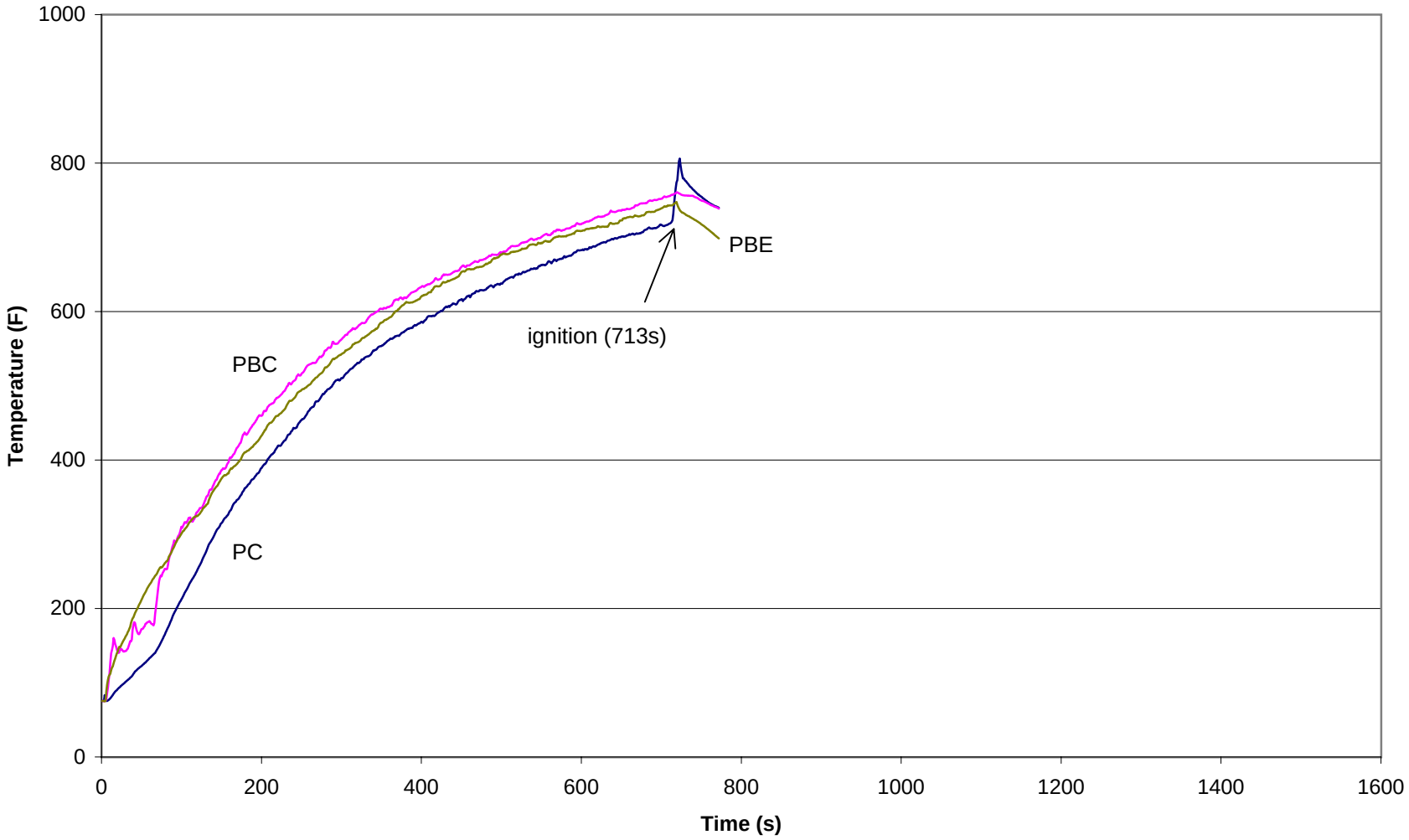
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Oil Ignition Test on Rinnai Uncontrolled Burner in Aluminum Pan



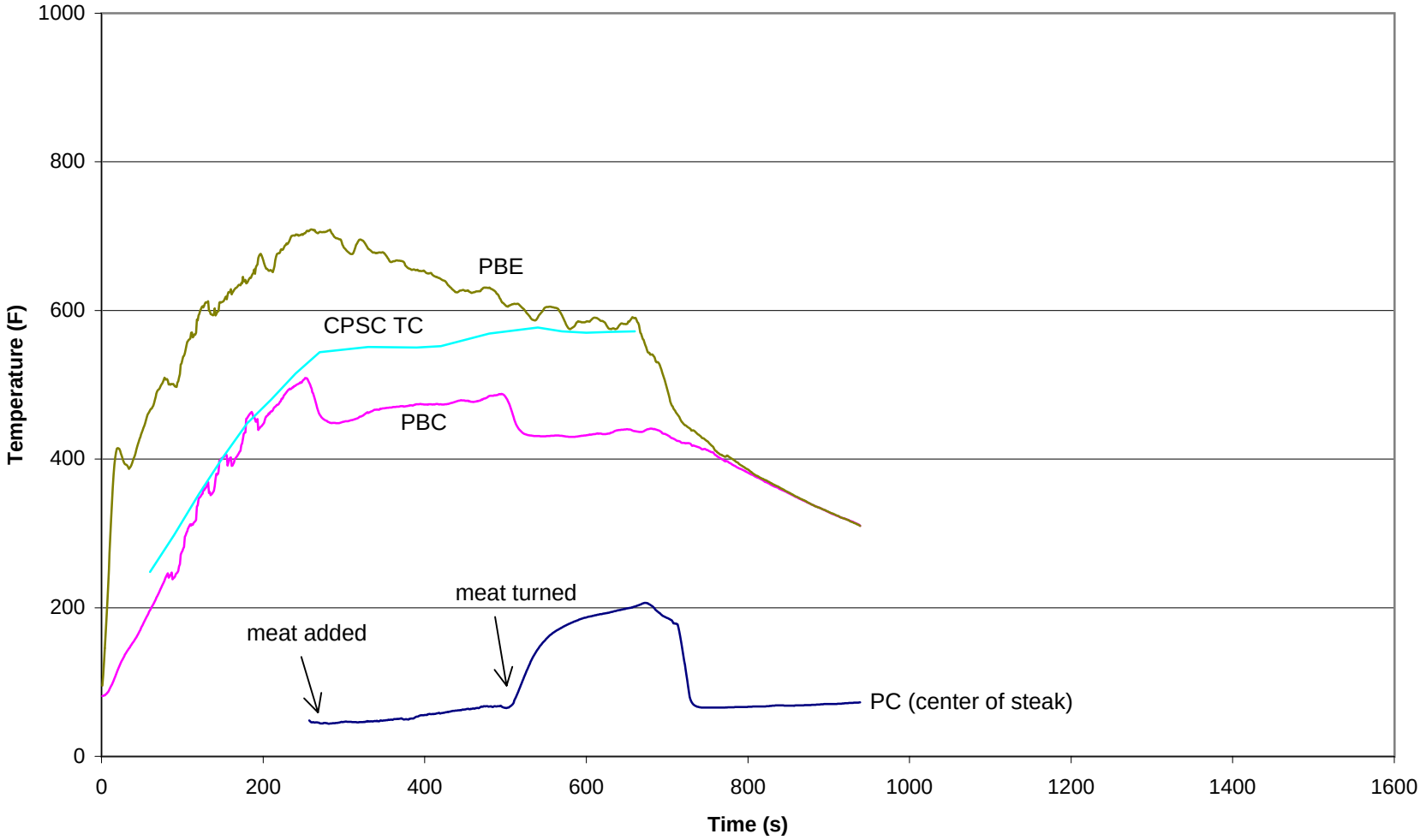
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Oil Ignition Test on Rinnai Uncontrolled Burner in Cast Iron Pan



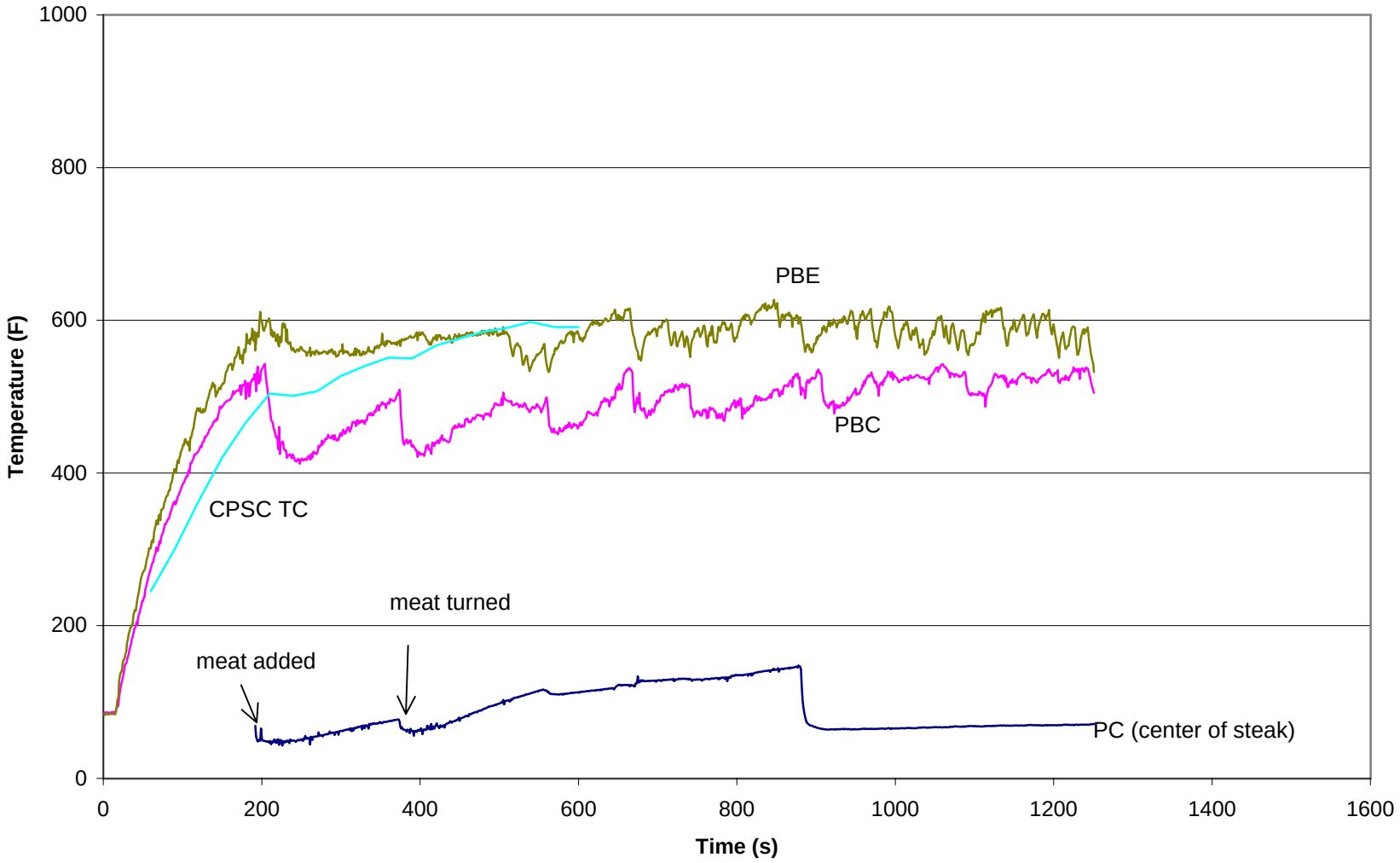
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Searing Steak in Stainless Steel Pan on CPSC Gas Range



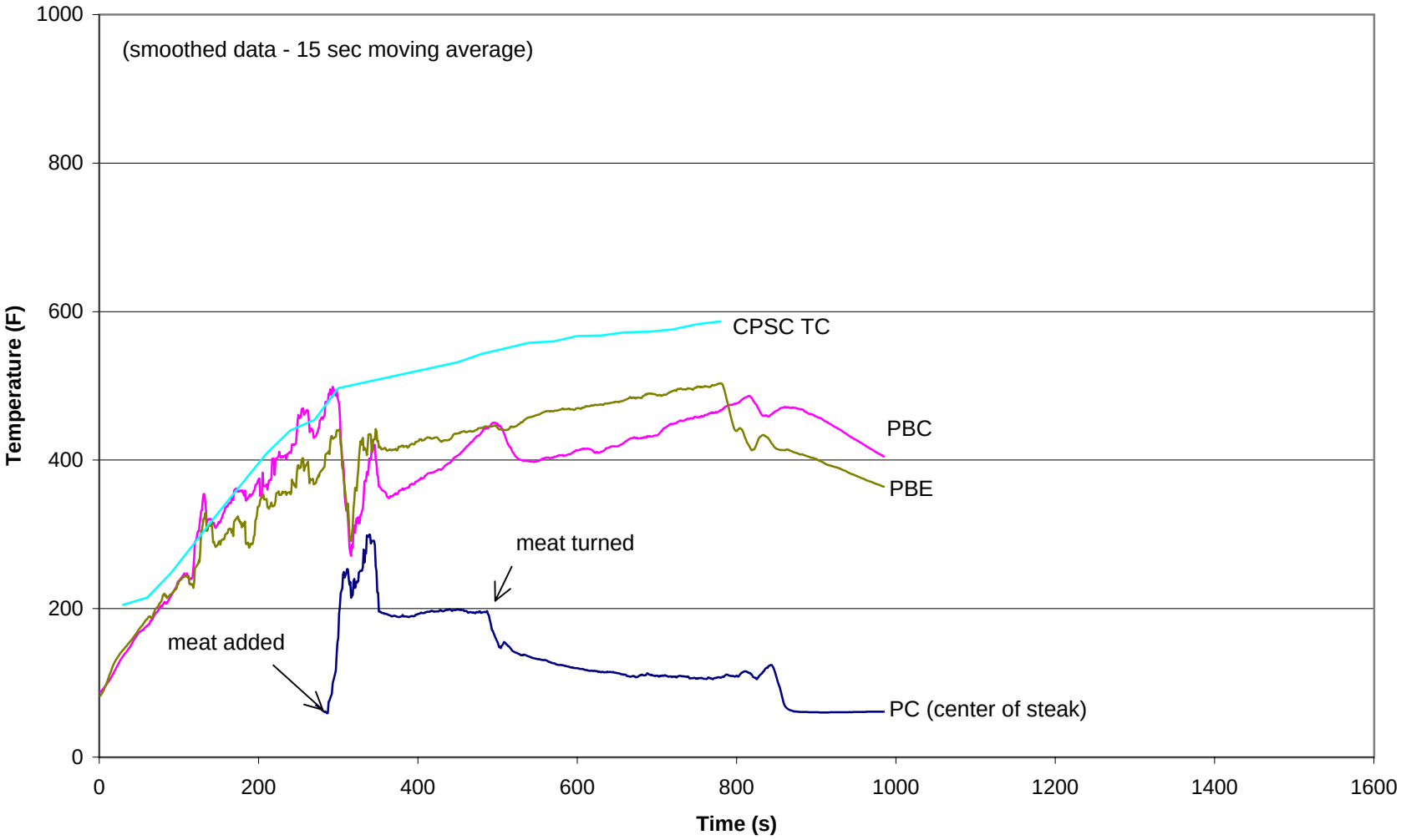
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

Searing Steak in Aluminum Pan on CPSC Gas Range



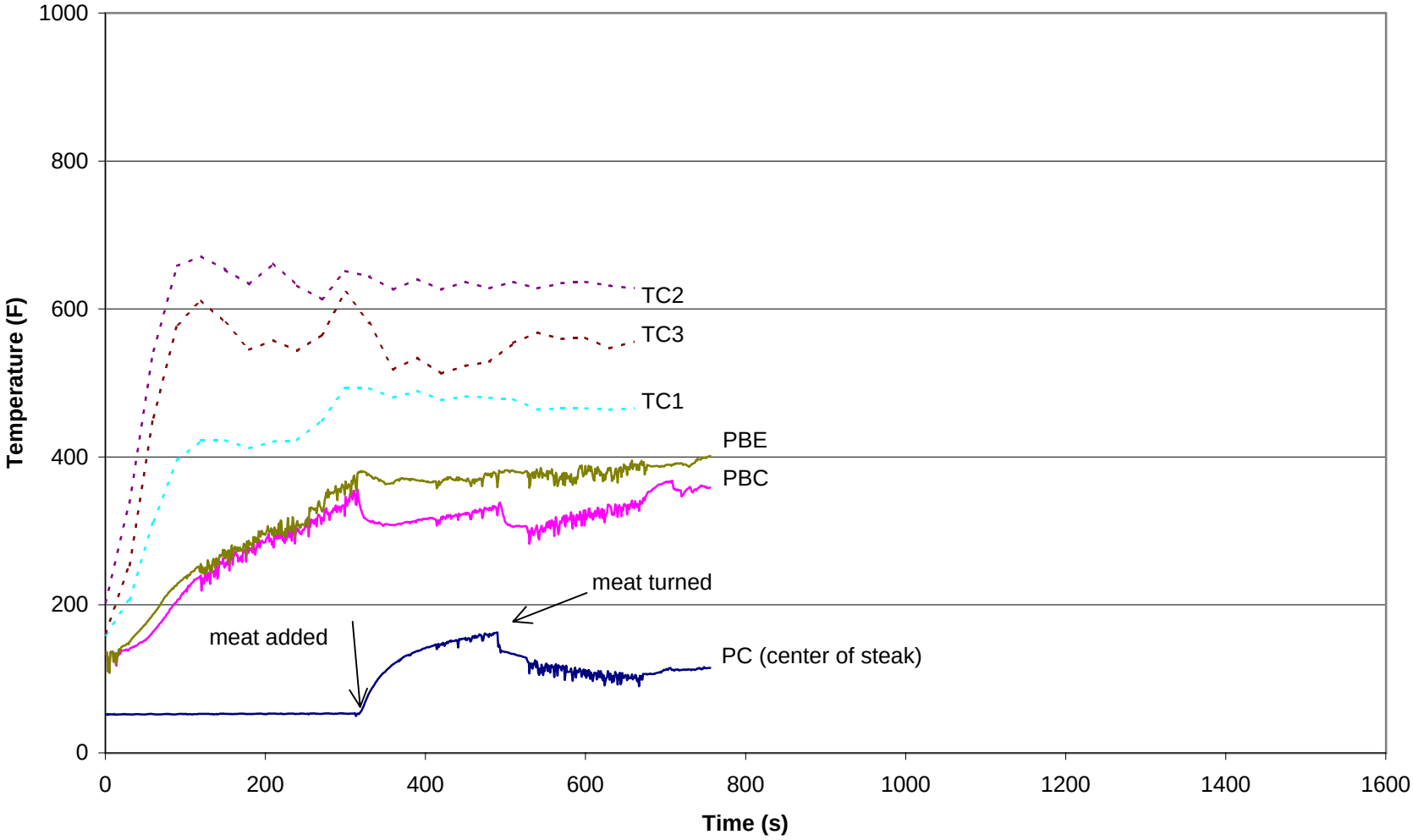
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

Searing Steak in Cast Iron Pan on CPSC Gas Range



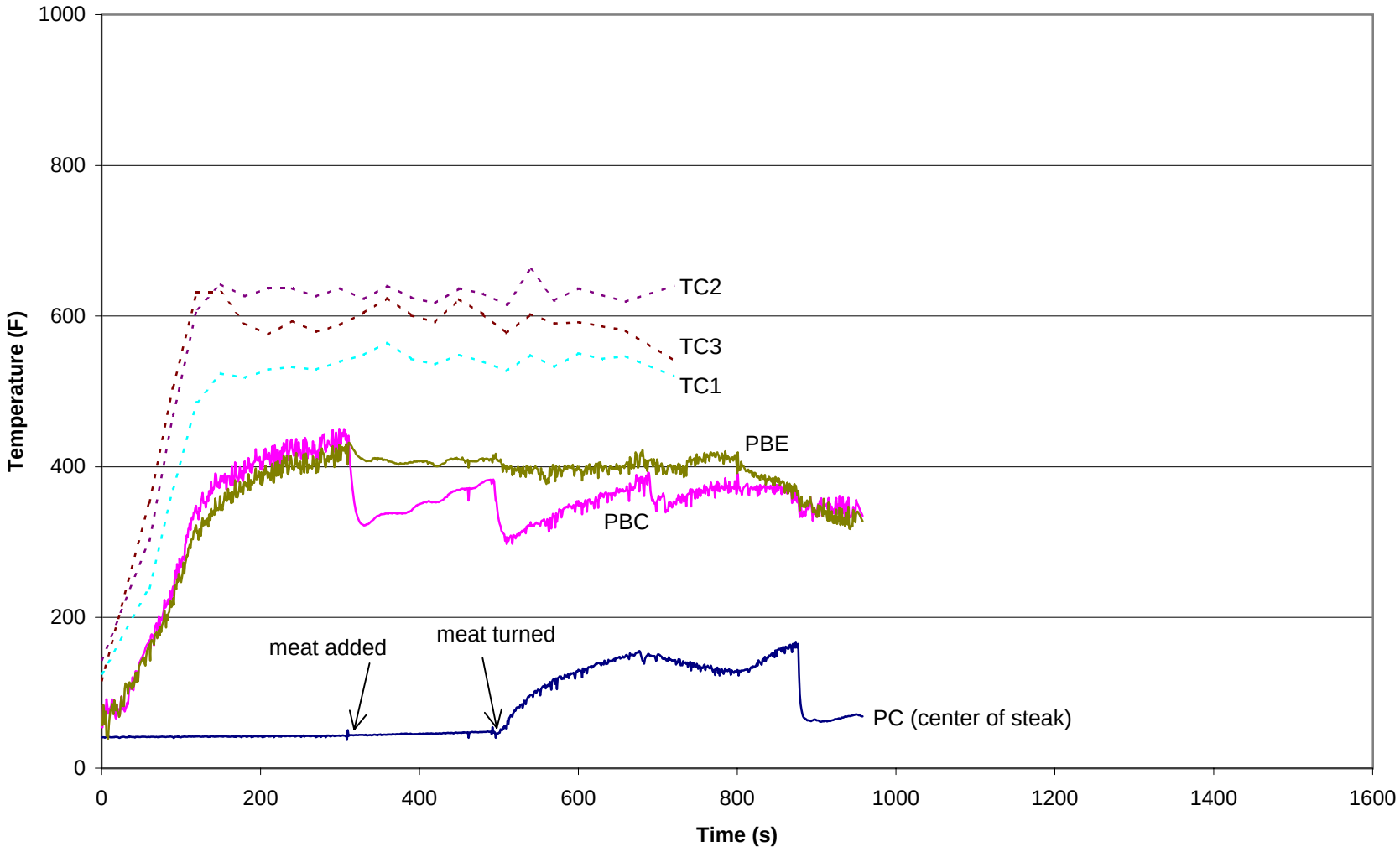
PC = pan contents PBC = pan bottom center PBE = pan bottom edge CPSC TC = built-in thermocouple

Searing Steak in Stainless Steel Pan on CPSC Electric Range



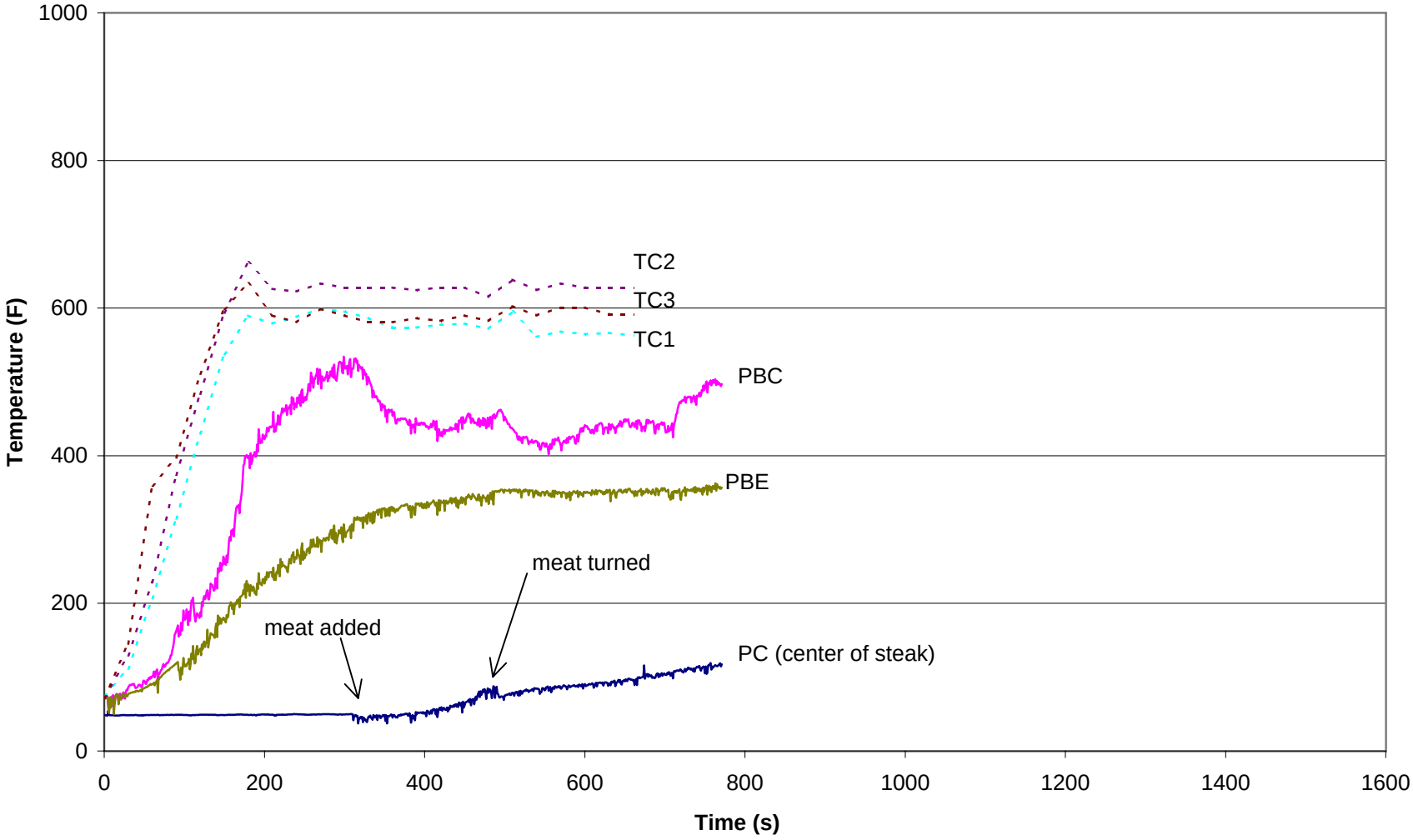
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

Searing Steak in Aluminum Pan on CPSC Electric Range



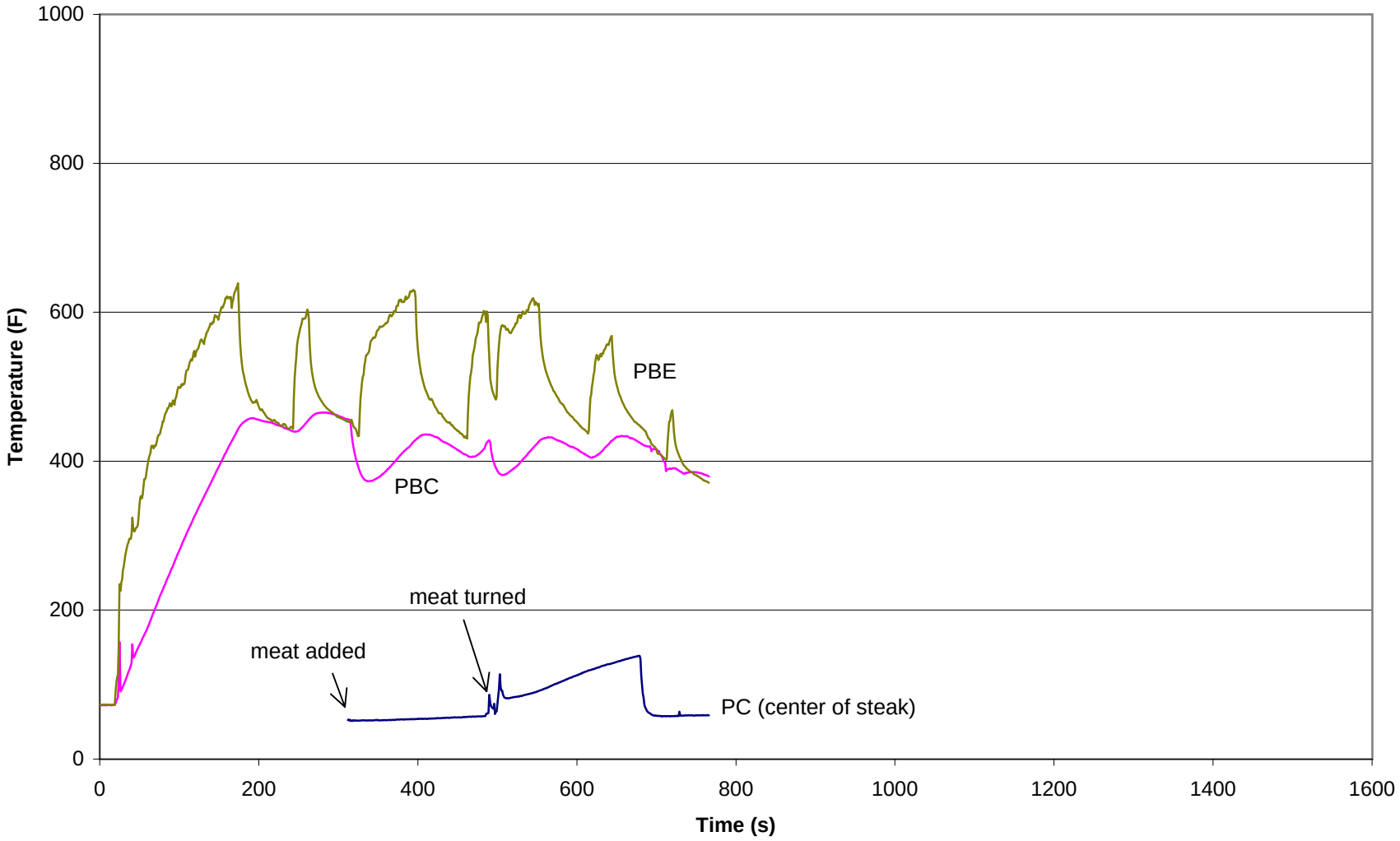
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

Searing Steak in Cast Iron Pan on CPSC Electric Range



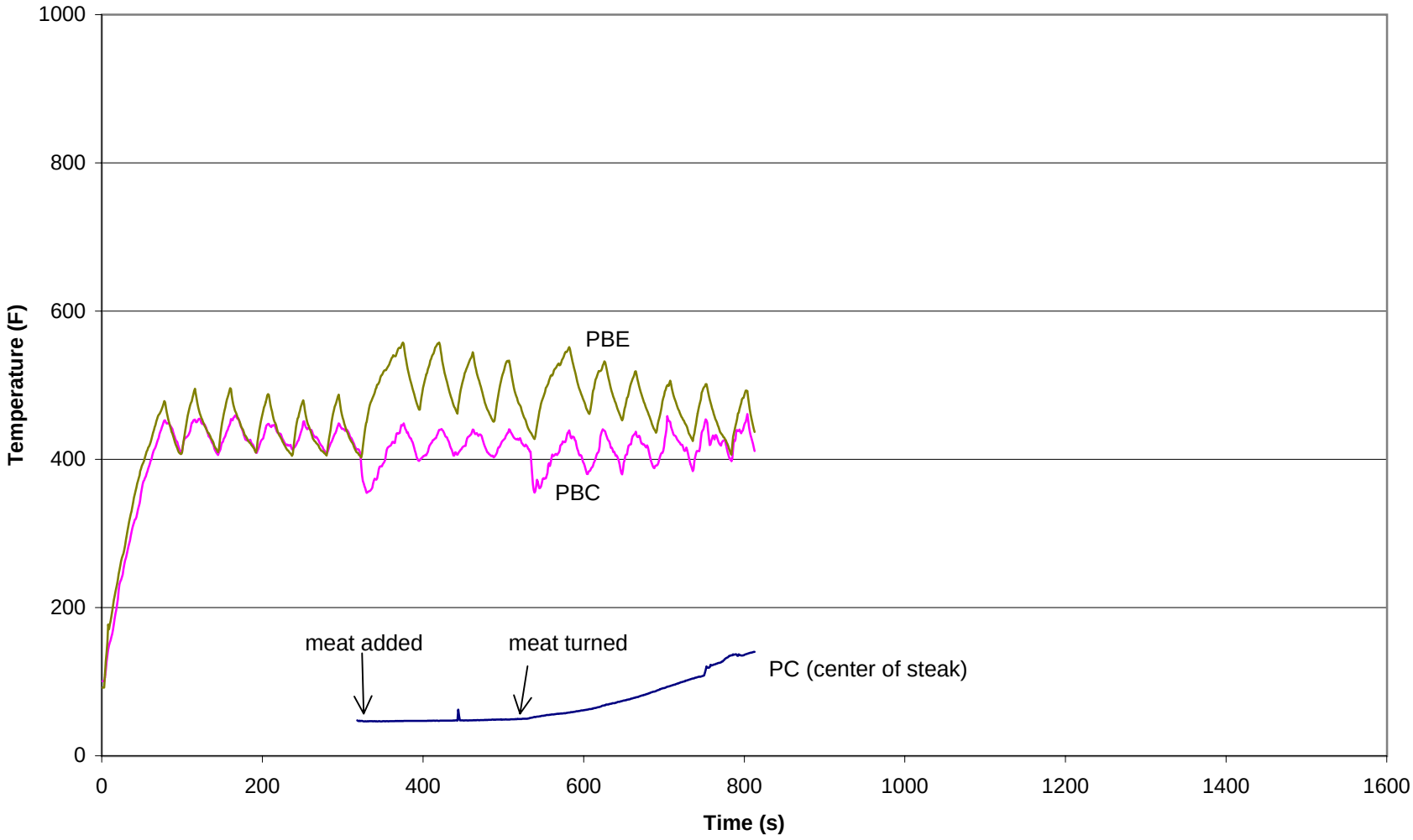
PC = pan contents PBC = pan bottom center PBE = pan bottom edge TC1, TC2 and TC3 = built-in thermocouples

Searing Steak in Stainless Steel Pan on Rinnai Range



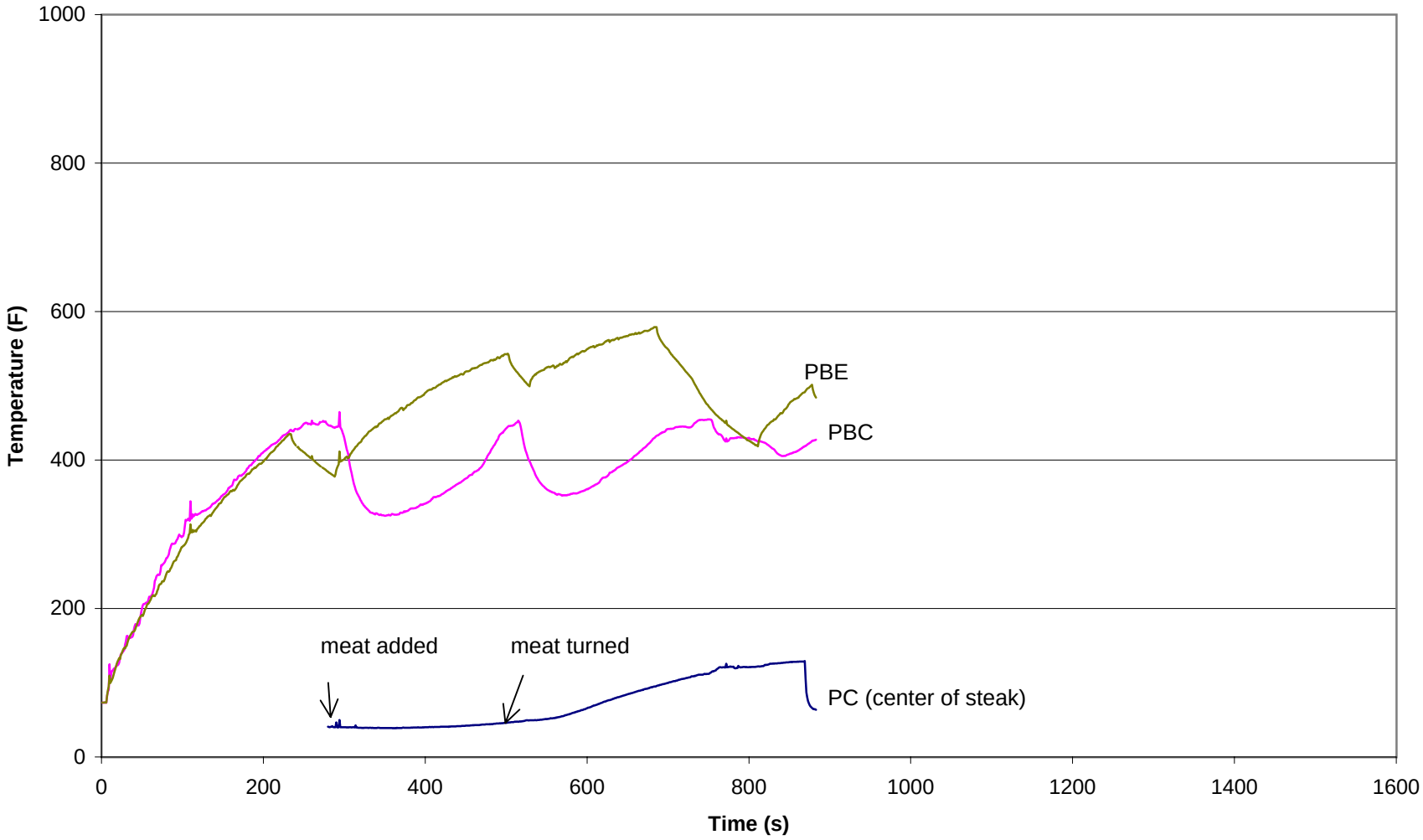
PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Searing Steak in Aluminum Pan on Rinnai Range



PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Searing Steak in Cast Iron Pan on Rinnai Range



PC = pan contents PBC = pan bottom center PBE = pan bottom edge

Appendix E: Technology Screening Scores

No	Classification of Technologies	Partial Score Efficacy of Technology as Cooking Fire Deterrent	Partial Score Others Consumer Impact/Value	Partial Scores Added	Ranking	Stage of technology
		Effectiveness	Consumer Impact			
1	**Detect/Extinguish Fire Fusible Parts**	**35**	**78**	113	**7**	Patent and product in the market
2	**Detect/Extinguish Fire Non-optical T sensor**	**35**	**74**	109	**8**	Patent and product in the market
3	**Detect/Extinguish Fire Optical T sensor**	**19**	**66**	85	**14**	Patent and product in the market
4	**Detect/Extinguish Fire Smoke + T sensor**	**27**	**62**	89	**12**	Concept in development by TRC
5	**Detect Fire - Warning Only Non-optical T sensor**	**27**	**78**	105	**10**	Concept
6	**Detect Fire - Warning Only Optical T sensor**	**15**	**66**	81	**13**	Patent and product in the market
7	**Detect Fire - Warning Only Smoke**	**31**	**82**	113	**8**	Patent and product in the market
8	**Contain/Manage Fire -- Passive**	**33**	**81**	114	**6**	Concept
9	**Contain/Manage Fire -- Active**	**30**	**63**	93	**12**	Patent
10	**Prevent Unattended Cooking Warning and Control Motion sensor only**	**47**	**94**	141	**1**	Patent
11	**Prevent Unattended Cooking Warning and Control Motion + T sensor**	**31**	**78**	109	**8**	Patent
12	**Prevent Unattended Cooking Warning and Control Motion + Power sensor**	**39**	**90**	129	**3**	Patent
13	**Prevent Unattended Cooking Warning and Control Power level sensor + timer**	**39**	**90**	129	**3**	Patent
14	**Prevent Unattended Cooking Warning Only Motion sensor only**	**35**	**102**	137	**2**	Concept
15	**Prevent Unattended Cooking Warning Only Motion + Power**	**27**	**94**	121	**4**	Concept
16	**Prevent Unattended Cooking Warning Only Power level sensor + timer**	**27**	**94**	121	**4**	Concept
17	**Prevent Food Ignition in Pan, Elec. Signal Processing Select Mode or T, T sensor contacts pot**	**31**	**74**	105	**8**	Patent and product in the market
18	**Prevent Food Ignition in Pan, Elec. Signal Processing Select Mode or T Non-contact T sensor**	**31**	**74**	105	**8**	Patent and product in the market
19	**Prevent Food Ignition in Pan, Elec. Signal Processing Auto-activation T sensor contacts pot**	**31**	**78**	109	**7**	Patent, product in market, and tech. in development by CPSC
20	**Prevent Food Ignition in Pan, Elec. Signal Processing Auto-activation Non-contact T sensor**	**31**	**78**	109	**7**	Concept
21	**Prevent Food Ignition in Pan, No Signal Processing Mechanical actuation**	**31**	**74**	105	**10**	Patent
22	**Prevent Boil Dry/Spill Over -- T sensor**	**18**	**82**	100	**11**	Patent
23	**No Cooktop Fire Prevention Technology (Do Nothing)**	**9**	**117**	126	**5**	None

NOTE: - Technologies highlighted in Red are technologies that fall inside the Preferred Region
- Technologies highlighted in Blue are technologies that fall at the border of the Preferred Region

Appendix F: Basis for Technology Screening Scores

1. **DETECT/EXTINGUISH FIRE -- FUSIBLE PARTS**
   - **Effect on Cooking Process**: None, system only actuates after a fire has occurred
   - **Effect on Cooking Time**: None, system only actuates after a fire has occurred
   - **Effect of System on Consumer Behavior While Operating the Cooktop**: None, system only actuates after a fire has occurred
   - **Limits availability or efficacy of marketed cooktop features**: None
   - **Ease of System Verification**: If pressurized extinguisher is used, a pressure indicator is installed so user can verify manually. Fusible part is just a material with a certain melting point – unlikely to change this property within its operating condition
   - **Safety System Maintenance**: User require significant additional procedures/parts (e.g. extinguisher material refilling) that might require specialist's help. Need to clean up additional part within the hood.
   - **Cookware Applicability**: All cookware can be used with cooktop at any normal environment
   - **Range of Fire Incident Coverage (Based on existing fire data):** Will address all fire incident since it will actuate whenever fire is detected
   - **Percent of new product sales covered by this technology:** Less than 90% since downdraft installation or island installation does not require or cannot have hood installed
   - **The degree of mitigation of fires addressed:** Extinguish or manage a fire
   - **Effect of Safety System on Cooktop Performance After Actuation of System:** Cooktop will need significant cleaning and adjustment since fire has occurred and extinguisher material has been released
   - **Effect of Actuation on the Safety System:** Service call or component replacement/recharging (fire extinguisher material) is necessary to return system to its ready state
   - **Potential for False Actuation:** None, a significantly high temperature (more than normal cooking condition) is needed to melt the fusible parts
   - **Can operate over product life w/o failure (safety factor of 2):** Looks good but no data. Similar applications has been implemented for sometime in commercial kitchen.
   - **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data. System is out of reach of user during normal cooking operation.
   - **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will still able to work even though safety system is not on/operating
   - **Safety system components might pose added risk to consumer:** None is expected
   - **Applicability across product types and product models:** Can work for all models for one product type (for vented or non-vented hood, and under cabinet hood or free standing ones), but cannot work for downdraft or island installations where no hood is available
   - **Components/system availability:** Most part are available off-the-shelves or have been manufactured in high volume at low cost
   - **Installation:** Need specialist help to install
   - **Serviceability:** Need specialist help to service (extinguisher tank)

2. **DETECT/EXTINGUISH FIRE -- NON-OPTICAL T SENSOR**
   - **Effect on Cooking Process:** None, system only actuates after a fire has occurred
   - **Effect on Cooking Time:** None, system only actuates after a fire has occurred
   - **Effect of System on Consumer Behavior While Operating the Cooktop:** None, system only actuates after a fire has occurred
   - **Limits availability or efficacy of marketed cooktop features:** None
   - **Ease of System Verification:** Some systems available in the market automatically verifies system readiness. Still need user to manualy verifies pressure level of extinguisher canister.
   - **Safety System Maintenance:** User maintenance requires significant additional procedures to make sure that temperature sensor is cleaned and fire extinguisher is fully charged
   - **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
   - **Range of Fire Incident Coverage (Based on existing fire data):** Will address all fire incident since it will actuate whenever fire is detected
   - **Percent of new product sales covered by this technology:** Less than 90% since downdraft installation and island installation does not require or cannot have hood installed
   - **The degree of mitigation of fires addressed:** Extinguish or manage a fire after it has occurred

- **Effect of Safety System on Cooktop Performance After Actuation of System:** Need significant cleaning and adjustment after actuation since extinguisher material has been released on cooktop surface and fire had occurred
- **Effect of Actuation on the Safety System:** Service call and component replacement necessary to refill the extinguisher material
- **Potential for False Actuation:** No chance of false alarm since a significantly higher temperature than normal cooking condition needs to be detected by the temperature sensor for the system to actuates
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good, but no data. Product has been developed and sold in the market for some time.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data. System is out of reach of user during normal cooking operation.
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will continue working even though the safety system is not on/operating
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models for one product type (for vented or non-vented hood, and under cabinet hood or free standing ones), but will not work for non-hood installation such as downdraft or island installation
- **Components/system availability:** Most parts have been developed but has not been manufactured in high volume at low cost.
- **Installation:** Needs additional tradesmen/technicians to install system
- **Serviceability:** Servicing the the electronics and temperature sensors require specialized equipment and staff expertise or licensing. Need specialist's help to refill extinguisher canister.

3. DETECT/EXTINGUISH FIRE -- OPTICAL T SENSOR

- **Effect on Cooking Process:** None, safety system only actuates when a fire had already occurred
- **Effect on Cooking Time:** None, safety system only actuates when a fire had already occurred
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Needs service technician's help to verify system's operation
- **Safety System Maintenance:** Needs significant additional procedure to clean the optical sensor, change battery, recharge the extinguisher material
- **Cookware Applicability:** Dependent on location of of sensor, it can mistake gas flame from burner or radiant heating element as fire condition. Cooking using small pot/pans where a radiant heat source is not fully shielded from the view of the sensor might affect system.
- **Range of Fire Incident Coverage (Based on existing fire data):** Will address between 40-90% of the cooking fire incidents -- due to the fact that this system currently not applicable for gas ranges.
- **Percent of new product sales covered by this technology:** Less than 90% . It will not work for gas cooktop since heat from burner will be mistaken as cooking fire, probably the same with radiating electric heat element
- **The degree of mitigation of fires addressed:** Will extinguish or contain fire
- **Effect of Safety System on Cooktop Performance After Actuation of System**: Since fire has occurred and system will release fire extinguisher on cooktop surface, significant cleaning and adjustement will be necessary to operate cooktop again
- **Effect of Actuation on the Safety System:** User will need to recharge/refill the fire extinguisher before it can operate again
- **Potential for False Actuation:** Potential for false positive when sensor is not properly cleaned and might miss a fire incident. Potential for false negative when optical sensors, which are not part of daily cooktop clean up, are not properly cleaned and is obstructed by airborne food or grease particles.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic but no data. Sensor optical window, which are not part of daily cooktop clean up, can easily get covered up with airborne cooking oils/particles and needs calibration. Extinguisher needs to be recharged
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data. Sensor is away from user's reach

- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop wills still work even though the safety system is not operating/off
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models of one product type for electric cooktops (for vented or non-vented hood, and under cabinet hood or free standing ones), but will not be applicable for gas cooktop since the open fire from the burner can be mistaken as cooking fire
- **Components/system availability:** Needs to be developed and manufactured or adapted from other industries
- **Installation**: Need additional tradesmen or technician to install
- **Serviceability**: Need special equipment and staff expertise or licensing to perform servicing

4. DETECT/EXTINGUISH FIRE -- SMOKE + T SENSOR

- **Effect on Cooking Process:** Will negatively affect high temperature cooking with high particulate emission such as searing or stir frying.
- **Effect on Cooking Time:** None
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User will intuitively figure out that cooktop will sound alarm whenever excessive amount of smoke is produced increasingly during cooking
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification**: Need a specialist's help to verify the operation of the safety system
- **Safety System Maintenance:** Need additional procedures to clean the smoke detector and temperature sensor, and to recharge the extinguisher tank (check tank pressure etc.)
- **Cookware Applicability:** Works for all types of cookware at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Will detect more than 90% of cooking fire incidents since it will actuate whenever fire is occuring.
- **Percent of new product sales covered by this technology:** Will cover less than 90% of new product sales since non-hood installations (downdraft and island cooktop) need different approach
- **The degree of mitigation of fires addressed:** Will extinguish fire when it happens
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Will need significant cleaning and adjustment since a fire has occurred when safety system actuated
- **Effect of Actuation on the Safety System:** Will need service technician help to return safety system to readiness (recharge the extinguisher tank, etc.)
- **Potential for False Actuation:** Potential of false positive during high particulate cooking (searing) where the smoke sensor might trigger the alarm unnecessarily
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic but no data -- smoke sensor might get soiled and covered up by airborne cooking or grease particles and needs replacement.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data -- smoke sensor can get soiled and covered up by airborne cooking or grease particles
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will still operate even though the safety system is off
- **Safety system components might pose added risk to consumer**: None is expected
- **Applicability across product types and product models**: Can work for all models for one product type (for vented or non-vented hood, and under cabinet hood or free standing ones), need different solution for non-hood instalation such as downdraft or island installations.
- **Components/system availability**: Most parts have been manufactured but not in high volume and low costs, some need to be adapted from other industry.
- **Installation:** Need additional tradesmen to install the alarm, extinguisher and heat sensor
- **Serviceability:** Specialized equipment and/or staff expertise or licensing is necessary

5. DETECT FIRE - WARNING ONLY -- NON-OPTICAL T SENSOR

- **Effect on Cooking Process:** None, does not affect the operation of the cooktop
- **Effect on Cooking Time:** None, does not affect the operation of the cooktop
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None, alarm will only activate when temperature sensor measured a relatively high ambient temperature

- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Verification of operation needs the help of service technician
- **Safety System Maintenance:** Need to clean temperature sensors from cooking soil/grease build-up.
- **Cookware Applicability:** Works for all types of cookware at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Will detect more than 90% of cooking fire incidents since it will actuate whenever a fire is occuring.
- **Percent of new product sales covered by this technology:** Will cover less than 90% of new product sales since non-hood installations (downdraft and island cooktop) need different approach
- **The degree of mitigation of fires addressed:** Will only warn of the presence of cooking fire
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Since there is high probability that fire has commenced when the system is triggered, the cooktop can be damaged from the high heat due to no provision to quickly extinguish the fire once it is detected. Even if the user act quickly and extinguish the flame w/ a portable fire extinguisher, clean up might be necessary.
- **Effect of Actuation on the Safety System:** User might have to reset the alarm once the fire has been controled. Since there is high probability that fire has commenced when the system is triggered, the sensor can be damaged from the high heat due to no provision to quickly extinguish the fire once it is detected
- **Potential for False Actuation**: No chance of false alarm since a significantly higher temperature than normal cooking condition needs to be detected by the temperature sensor for the system to actuates
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good, but no data
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good since it will be out of the way of the user during normal cooking operation, but no data
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will still be operable despite the safety system is not on/operating
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models for one product type, but need other approach on island installation or others where there is no wall or hood space to locate the sensor/alarm.
- **Components/system availability:** Need to be adapted from other industries
- **Installation:** Need additional tradesmen to install the alarm and heat sensor
- **Serviceability:** Specialized equipment and/or staff expertise or licensing is necessary

6. DETECT FIRE - WARNING ONLY -- OPTICAL T SENSOR

- **Effect on Cooking Process:** None, safety system only actuates when a fire had already occurred
- **Effect on Cooking Time:** None, safety system only actuates when a fire had already occurred
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Needs service technician's help to verify system's operation
- **Safety System Maintenance:** Needs significant additional procedure to clean the optical sensor, change battery, etc.
- **Cookware Applicability:** Dependent on location of of sensor, it can mistake gas flame from burner or radiant heating element as fire condition. Cooking using small pot/pans where a radiant heat source is not fully shielded from the view of the sensor might affect system.
- **Range of Fire Incident Coverage (Based on existing fire data):** Will be between 40-90% of cooking fire incident -- due to the fact that this system currently not applicable for gas ranges.
- **Percent of new product sales covered by this technology:** Will not work for gas cooktop since heat from burner will be mistaken as cooking fire, probably the same with radiating electric heat element
- **The degree of mitigation of fires addressed:** Warning only
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Since there is high probability that fire has commenced when the system is triggered, the cooktop can be damaged from the high heat due to no provision to quickly extinguish the fire once it is detected. Even if the user act quickly and extinguish the flame w/ a portable fire extinguisher, clean up might be necessary.
- **Effect of Actuation on the Safety System:** User might have to reset the alarm once the fire has been controled. Since there is high probability that fire has commenced when the system is triggered, the sensor can be damaged from the high heat due to no provision to quickly extinguish the fire once it is detected

- **Potential for False Actuation:** Potential for false negative when sensor is not properly cleaned and might miss a fire incident. Sensor location is not in area that will be part of daily clean up.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic but no data. Sensor optical window can easily get covered up with airborne cooking oils/particles and needs calibration
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data. Sensor is away from user's reach
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop wills still work even though the safety system is not operating/off
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models for one electric product type, but need other approach on island installation or others where there is no wall or hood space to locate the sensor/alarm. Probably not be applicable for gas cooktop since the open fire from the burner can be mistaken as cooking fire.
- **Components/system availability:** Needs to be developed and manufactured or adapted from other industries
- **Installation:** Need additional tradesmen or technician to install
- **Serviceability:** Need special equipment and staff expertise or licensing to perform servicing

7. DETECT FIRE - WARNING ONLY -- SMOKE SENSOR

- **Effect on Cooking Process:** None can cook at any temperature
- **Effect on Cooking Time:** Will negatively affect high temperature cooking with high particulate emission (searing or frying) since alarm most likely will turn on often and cause nuisance as cook needs to constantly reset/turn it off during cooking time.
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User will need to read manual to figure out that cooktop will sound alarm whenever excessive amount of smoke is produced increasingly during cooking
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Will need a service technician to verify sensor operation working at factory set level
- **Safety System Maintenance:** User's maintenance might require specialist's help to clean the smoke sensor and make sure it is working at proper calibration level. For new houses where smoke sensor power is connected to main electrical wiring , any servicing will require specialist help.
- **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Probably will detect less than 40% of cooking fire incident since it will only warn user that there is excessive smoke generated during cooking. And there is a danger of user being desensitized to the noise if smoke alarm produced too many false alarms during high heat cooking.
- **Percent of new product sales covered by this technology:** More than 90% -- sensor can be located near any type of cooktop.
- **The degree of mitigation of fires addressed:** It will warn that a possible fire is about to happen
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, as long as user is around to take preventive measure and stop the fire from actually occurring
- **Effect of Actuation on the Safety System:** User needs to manually reset the alarm to off when he/she has addressed the source of the smoke. Most likely alarm will turn on much earlier before a fire actualy occurred. Therefore, if addressed promptly, no damage should be done on the sensor or alarm
- **Potential for False Actuation:** False positive, smoke detector will turn on although no pre-ignition condition is present (during searing or frying)
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic but no data -- sensor might get soiled and covered up by airborne cooking or grease particles
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic but no data -- sensor might get soiled and covered up by airborne cooking or grease particles
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will continue on working if smoke sensor is not operating
- **Safety system components might pose added risk to consumer:** None
- **Applicability across product types and product models:** Will work for all models

- **Components/system availability:** All parts are on the shelves parts
- **Installation:** Needs additional tradesmen to install (especially for new houses where power source of alarm is from the main electric line)
- **Serviceability:** Needs additional tradesmen to service (especially for new houses where power source of alarm is from the main electric line)

8. CONTAIN/MANAGE FIRE – PASSIVE (THREE SIDE-WALLED COOKTOP)

- **Effect on Cooking Process:** None
- **Effect on Cooking Time:** None
- **Effect of System on Consumer Behavior While Operating the Cooktop:** Have to always adjust pot handle a certain way. Access to heat source on the back is limited; cannot use it for active cooking where user needs to constantly manipulate the foodstuff in the vessel.
- **Limits availability or efficacy of marketed cooktop features:** Yes, cannot smoothly transfer foodstuff or cooking vessel from surrounding tabletop to the cooktop or vice-versa (e.g. during deep frying). Almost impossible to use the back burners when the front ones are also used.
- **Ease of System Verification:** Nothing to verify, it is just a permanently mounted fire-resistant wall.
- **Safety System Maintenance:** Only needs to clean extra surface of the three side walls.
- **Cookware Applicability:** cannot use larger cooking vessels or those with long handles.
- **Range of Fire Incident Coverage (Based on existing fire data):** Not applicable since system only contain fire to the back and sides of the cooktop but does not contain the top or front side. If left continued unextinguished by user, fire will eventually spread throughout the kitchen.
- **Percent of new product sales covered by this technology:** Almost everything except island versions.
- **The degree of mitigation of fires addressed:** Not applicable: does not warn, prevent, extinguish or contain fire continuously
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Not applicable, since if fire did occur and user did not extinguish it manually, cooktop will continue to burn and fire will spread
- **Effect of Actuation on the Safety System:** Fire-resistant wall surface will just need some cleaning (though the rest of the cooktop/kitchen can be ruined by fire)
- **Potential for False Actuation:** None, nothing actuates
- **Can Operate Over product life w/o failure (safety factor of 2):** Side walls will have the same product life as the rest of the cooktop, even longer
- **Can operate within reasonably foreseeable misuse conditions (durability):** Side walls most likely are made from a strong fire resistant material that can endure reasonably foreseeable misuse conditions
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will continue working normally if side walls were taken down by user
- **Safety system components might pose added risk to consumer:** Long cooking vessel handle will jut out of the front and can risk user accidentally shoving the hot pot and content off of cooktop. When front burners are on, can risk burn of user's arm when reaching the food/cooking vessels at the back burners.
- **Applicability across product types and product models:** Almost everything except island versions
- **Components/system availability:** Easily available parts off-the-shelves
- **Installation:** Need additional installation effort/procedures for the side walls
- **Serviceability:** No new training or new equipment is necessary for servicing the walls

9. CONTAIN/MANAGE FIRE – ACTIVE

- **Effect on Cooking Process:** None, only actuates when fire has already occuring
- **Effect on Cooking Time:** None, only actuates when fire has already occuring
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None, only actuates when fire has already occuring
- **Limits availability or efficacy of marketed cooktop features:** None, only actuates when fire has already occuring
- **Ease of System Verification:** Need professional help to verify system operability
- **Safety System Maintenance:** Requires significant additional maintenance procedure and specialist's help with the drop hood, release mechanism and temperature sensor
- **Cookware Applicability:** All cookware can be used with cooktop at any normal environment

- **Range of Fire Incident Coverage (Based on existing fire data):** All cooktop fire (over 90%) will be addressed by this fire containment system since it actuates after the detection of fire
- **Percent of new product sales covered by this technology:** Less then 90% since island cooktop installation and under cabinet installation probably not be possible with the drop hood
- T**he degree of mitigation of fires addressed:** It extinguishes fire once it has commenced
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Will require significant cleaning and adjustment after actuation since fire have started already and the hood has been dropped on top of the cooktop.
- **Effect of Actuation on the Safety System:** Needs specialist help for adjustment of drop hood back to its position and resetting the actuation and release mechanism
- **Potential for False Actuation:** None, since temperature sensor has to register a relatively high temperature to actuate
- **Can Operate Over product life w/o failure (safety factor of 2):** Drop hood release mechanism has no data and looks problematic due to the hood is being released using gravity pull. Unknown impact force, hood might get damaged when it impacted the cooktop surface.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic but no data. Safety system is out of reach of user during cooktop operation, but drop hood is released using gravity pull. Unknown impact force, hood might get damaged when it impacted the cooktop surface.
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** If the drop hood release mechanism is not working properly there is no indication that cooktop will not continue operating
- **Safety system components might pose added risk to consumer:** The falling hood can catch or pinch user's body parts (finger, arm) if they did not clear out of the way. Can be modified by having an alarm that will alert user of hood actuation moments before it actually does.
- **Applicability across product types and product models:** Each cooktop model may require different design for functionally different models within a product type since they come in different dimensions. The enclosing hood must have the appropriate dimension for each one of them. Non hood installation such as island and downdraft versions need different solution.
- **Components/system availability:** Need to develop all of the system's components
- **Installation**: Needs special tradesmen/specialist to install system
- **Serviceability:** Needs additional training and new equipment to service system

10. PREVENT UNATTENDED COOKING -- WARNING AND CONTROL -- MOTION SENSOR ONLY

- **Effect on Cooking Process:** User cannot simmer/boil some food and then leaves the room
- **Effect on Cooking Time:** As long as user is around the cooktop there is none.
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User will need to read the manual to learn that burner will manipulate heat when he/she leaves cooktop area. Simmering will need attendance.
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** User can verify easily if system is on or off by turning the burner and leaving the room and see what happens.
- **Safety System Maintenance:** Cleaning the sensor surface is not more than wiping off the front sensor window cover which is part of the regular daily cooktop cleaning
- **Cookware Applicability:** Any utensil at any environment will work
- **Range of Fire Incident Coverage (Based on existing fire data):** Will at least address unattended cooking (~53.5% of fire incident from NFIRS+NFPA data from 1994-1996)
- **Percent of new product sales covered by this technology:** Should be able to cover more than 90% of new product sales
- **The degree of mitigation of fires addressed:** Will prevent a fire due to unattended cooking from starting
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, fire will not even start so cooktop should be ready to work normally again after safety actuation
- **Effect of Actuation on the Safety System:** Depending on the algorithm used. On some, safety system should be ready to work normally again once user presence is detected. On others, user has to reset the system manually.

- **Potential for False Actuation:** Potential for false positive when user is leaving a pot of food to simmer. Potential for false negative, where sensor might mistaken pets, curtains or small children, can be eliminated using appropriate sensor data analyzing algorithm.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good, but no data.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will not work if no signal from motion sensor is detected
- **Safety system components might pose added risk to consumer:** None was expected
- **Applicability across product types and product models:** Developed to be applicable for all cooktop systems
- **Components/system availability:** Most parts are available off the shelf or has been manufactured at high volume at low cost
- **Installation:** No added effort than installing conventional range
- **Serviceability:** Some training or new equipment is necessary for servicing the sensor

11. PREVENT UNATTENDED COOKING -- WARNING AND CONTROL -- MOTION + T SENSOR

- **Effect on Cooking Process:** Should be none since high temperature cooking is still possible as long as the cook is near the cooktop. And simmering should still be possible since cooktop should only manipulate heat source when food temperature is significantly higher than simmering/boiling temperature.
- **Effect on Cooking Time:** Should be none if user is around during high temperature cooking. Simmer/boiling will not be affected since it's temperature is well below food ignition temperature
- **Effect of System on Consumer Behavior While Operating the Cooktop:** Consumers need to read manual to figure out that cooktop will alarm and manipulate burner when it is left alone while cooking vessel temperature is relatively high.
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need specialist help to verify the operation of safety system
- **Safety System Maintenance:** Need additional procedures to clean the temperature sensors regularly from grease of food soil buildup. Cleaning the motion sensor surface is not more than wiping off the front sensor wondow cover which is part of the regular daily cooktop cleaning.
- **Cookware Applicability:** Some cookware materials or shape can compromise safety system performance since the sensor will need to be in contact to the cooking vessel (e.g. glass/ceramic ware, cookware with concave bottom)
- **Range of Fire Incident Coverage (Based on existing fire data):** Should cover at least more than 50% of the cooking fire incidents due to unattended cooking.
- **Percent of new product sales covered by this technology:** Multiple designs applicable for gas and solid or coil electric elemet cooktops. Has some design for smooth top Ceran (gold alloy track) but the application might be more difficult for a reliable means to gauge pot content temperature.
- **The degree of mitigation of fires addressed:** Will prevent cooking fire from occurring
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, since it prevents any fire from occurring, no extra cleaning or adjustment is necessary after each actuation
- **Effect of Actuation on the Safety System:** None, system is always on during cooktop operation
- **Potential for False Actuation:** Potential for false negative if temperature sensor and cooktop did not have good contact due to surface dirt or misalignment
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic, no data. Sensor is unprotected
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data. Sensor is out in the open and have high likelihood to be impacted by cooking wares
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop might still work if safety system is off
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models of one product type
- **Components/system availability:** Most parts are new parts that need to be developed and manufactured
- **Installation:** No different than conventional range
- **Serviceability:** Current staff needs some training and/or new equipment to test/service the sensor

12. **PREVENT UNATTENDED COOKING -- WARNING AND CONTROL -- MOTION + POWER SENSOR**
    - **Effect on Cooking Process:** As long as user is around the cooktop there is none. User can simmer some food and then leaves the room since it should be at lowest heat setting below which the system should actuate. Need to be around when boiling hot water – usually at higher heat settings
    - **Effect on Cooking Time:** As long as user is around the cooktop there is none. If user simmers some food and leaves the room, then it should be at lowest heat setting below which the system should actuate.
    - **Effect of System on Consumer Behavior While Operating the Cooktop:** User will need to read the manual to learn that burner will manipulate heat when he/she leaves cooktop area.
    - **Limits availability or efficacy of marketed cooktop features:** None
    - **Ease of System Verification:** User can verify easily if system is on or off by turning the burner on at certain power level and leaving the room to see what happens.
    - **Safety System Maintenance:** Cleaning the sensor surface is not more than wiping of the front casing/cover which is part of the regular daily cooktop cleaning. Power level sensor will most likely be located away from soil from cooking.
    - **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
    - **Range of Fire Incident Coverage (Based on existing fire data):** If working properly, will at least address unattended cooking (~53.5% of fire incident from NFIRS+NFPA data from 1994-1996)
    - **Percent of new product sales covered by this technology:** Will work fine with electric cooktop, but need some development for he power sensor for gas burner.
    - **The degree of mitigation of fires addressed:** Will prevent fire from occurring if working properly
    - **Effect of Safety System on Cooktop Performance After Actuation of System:** None, fire will not even start so cooktop should be ready to work normally again after safety actuation
    - **Effect of Actuation on the Safety System:** Cooktop should reactivate automatically when user's presence is detected
    - **Potential for False Actuation:** Potential for false negative if food/oil is already hot when burner was turned on. Potential for false negative, where sensor might mistaken pets, curtains or small children, can be eliminated using appropriate sensor data analyzing algorithm.
    - **Can Operate Over product life w/o failure (safety factor of 2):** Looks good, but no data.
    - **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data
    - **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will not work if no signal from motion sensor or power level sensor is detected
    - **Safety system components might pose added risk to consumer:** None was expected
    - **Applicability across product types and product models:** Will need more development to apply for gas cooktop – specifically for the power level sensor. No patent found that specifically address this type of technology on gas cooktop, although it does not seem difficult to do.
    - **Components/system availability:** Most parts are available off the shelf or has been manufactured at high volume at low cost
    - **Installation:** No added effort than installing conventional range
    - **Serviceability:** Some training or new equipment is necessary for servicing the sensor

13. **PREVENT UNATTENDED COOKING -- WARNING AND CONTROL -- POWER LEVEL SENSOR + TIMER**
    - **Effect on Cooking Process:** All cooking procedures can be done on the cooktop as long as user maintains cooking operation – simmer is possible as long as power level is kept at a minimum. Continuous searing might be affected as heat source might continually turns on and off which might affect temperature of cooking vessel.
    - **Effect on Cooking Time:** As long as it is attended, cooking time will be no different
    - **Effect of System on Consumer Behavior While Operating the Cooktop:** User will need to read manual to learn that constant supervision and user input is necessary to keep cooktop from manipulating heat source automatically
    - **Limits availability or efficacy of marketed cooktop features:** None
    - **Ease of System Verification:** User can easily verify by turning power level on high and wait to see if cooktop will turn on signal and then manipulate the heat source output

- **Safety System Maintenance:** user maintenance procedure is the same as conventional cooktop. Power level sensor will most likely located away from grease and food build-up under the cooktop surface.
- **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Depending on the timer duration and limiting power level selected, there is probability that system might address 60% of fire incident
- **Percent of new product sales covered by this technology:** Power level sensor for gas burner needs more development.
- **The degree of mitigation of fires addressed:** To prevent pre-ignition condition
- **Effect of Safety System on Cooktop Performance After Actuation of System:** If system works as intended, then no fire will ever occur so no cleaning or adjustment is necessary after system actuation
- **Effect of Actuation on the Safety System:** User needs to reset system by pressing a button or turning a control knob
- **Potential for False Actuation:** Potential for false negative if food/oil was already hot when burner was turned on.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good but no data
- **Can operate within reasonably foreseeable misuse conditions (durability):** looks good but no data
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Burner will not turn on when no signal from power level sensor is received.
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Will need more development to apply for gas cooktop – specifically for the power level sensor. No patent found that specifically address this type of technology on gas cooktop, although it does not seem difficult to do.
- **Components/system availability:** Most components are off the shelves or have been manufactured at high volume and low cost
- **Installation:** No added effort than installing range
- **Serviceability:** Some training or new equipment is necessary for servicing the sensor

14. PREVENT UNATTENDED COOKING -- WARNING ONLY -- MOTION SENSOR ONLY

- **Effect on Cooking Process:** None, nothing affected the burner operation
- **Effect on Cooking Time:** None, nothing affected the burner operation
- **Effect of System on Consumer Behavior While Operating the Cooktop:** user need to read manual to learn that to stop alarm, he/she needs to be present near the cooktop even during simmer cooking
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** User can verify easily if system is on or off by turning the burner and leaving the room and see what happens.
- **Safety System Maintenance:** Cleaning the motion sensor surface is not more than wiping off the front casing/cover which is part of the regular daily cooktop cleaning.
- **Cookware Applicability:** Any utensil at any environment will work
- **Range of Fire Incident Coverage (Based on existing fire data):** Probably will catch less than 40% of cooking fire incident since it only warns user that nobody is near the cooktop. If cook is far enough from the kitchen not to hear the warning then it is useless.
- **Percent of new product sales covered by this technology:** Should be able to cover more than 90% of new product sales
- **The degree of mitigation of fires addressed:** Only warns user of possible cooking fire
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None as long as user hears the alarm and return to kitchen. Cooktop should perform normally since no control is applied to cooktop
- **Effect of Actuation on the Safety System:** Depends on algorithm selected, alarm will turn off when user presence is detected again or user still needs to reset system by manipulating a button or a knob.
- **Potential for False Actuation:** Potential for false positive when user simmers food on pot and leaves it alone. Potential for false negative, where sensor might mistaken pets, curtains or small children, can be eliminated using appropriate sensor data analyzing algorithm.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good, but no data.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good, but no data.

- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Alarm will continually turn on if cooktop is operated and no signal from motion sensor is detected
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Developed to be applicable for all cooktop systems
- **Components/system availability:** Most parts are available off the shelf or has been manufactured at high volume at low cost
- **Installation:** No added effort than installing conventional range
- **Serviceability:** Some training or new equipment is necessary for servicing the sensor

15. PREVENT UNATTENDED COOKING -- WARNING ONLY MOTION + POWER

- **Effect on Cooking Process:** None, nothing affected the burner operation
- **Effect on Cooking Time:** None, nothing affected the burner operation
- **Effect of System on Consumer Behavior While Operating the Cooktop:** user need to read manual to learn that to stop alarm, he/she needs to be present near the cooktop
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** User can verify easily if system is on or off by turning the heat source to high power level and leaving the room to see what happens.
- **Safety System Maintenance:** Cleaning the motion sensor surface is not more than wiping off the front sensor window cover which is part of the regular daily cooktop cleaning. Power level sensor will most likely be located away from grease and food build-up under the cooktop surface.
- **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Probably will catch less than 40% of cooking fire incident since it will only warn user that cooking is unattended and heat source is set at dangerous level. If user is far enough from the kitchen not to hear the alarm, then the system is useless.
- **Percent of new product sales covered by this technology:** Less than 90% since it needs more development work for gas cooktop power sensor.
- **The degree of mitigation of fires addressed:** Only warn of possible pre-ignition condition
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, provided user act on the alarm, no extra cleaning or adjustment is necessary. Alarm will turn on before fire is occuring.
- **Effect of Actuation on the Safety System:** User might have to reset the mechanism once system alarm is on.
- **Potential for False Actuation:** Potential for false negative depending on the selection of limiting power level. Food/oil can still get really hot with lower power setting. And user might put a pot with an already hot food content. Potential of false negative if the motion sensor is not calibrated to detect only adult user – mistaken pets or children as responsive adults.
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good but no data
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but no data
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will not operate when no signal from either motion or power level sensor is received
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Will need more development to apply for gas cooktop – specifically for the power level sensor. No patent found that specifically address this type of technology on gas cooktop, although it does not seem difficult to do.
- **Components/system availability:** Most parts are available off the shelf or has been manufactured at high volume at low cost
- **Installation:** No added effort than installing conventional range
- **Serviceability:** Some training or new equipment is necessary for servicing the sensor

16. PREVENT UNATTENDED COOKING -- WARNING ONLY -- POWER LEVEL SENSOR + TIMER

- **Effect on Cooking Process:** None, nothing affected the burner operation
- **Effect on Cooking Time:** None, nothing affected the burner operation

- **Effect of System on Consumer Behavior While Operating the Cooktop**: user need to read manual to learn that to he/she needs to be present near the cooktop to either stop or avoid the actuation of alarm by occasionally turning the knob or pressing a reset button
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** User can easily verify system operation by setting the power level to high and see if the alarm will turn on after a pre-determined time has elapsed.
- **Safety System Maintenance:** User maintenance procedure is the same as conventional cooktop. Power level sensor will most likely located away from grease and food build-up under the cooktop surface.
- **Cookware Applicability:** All cookware can be used with cooktop at any normal environment
- **Range of Fire Incident Coverage (Based on existing fire data):** Probably will catch less than 40% of cooking fire incident since it only warns user that burner has been on for a certain time. If user is far enough from the kitchen not to hear the alarm, then the system is useless.
- **Percent of new product sales covered by this technology:** Will work fine with electric cooktop, but needs more development work for gas burner power sensor.
- **The degree of mitigation of fires addressed:** Only gives warning of possible cooking fire pre-ignition condition
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, no special clean-up was necessary if alarm works as intended: it alerts user to check on cooktop and fire did not occur.
- **Effect of Actuation on the Safety System:** User has to reset manually to turn off alarm.
- **Potential for False Actuation:** Potential for false negative depending on the selection of limiting power level. Food/oil can still get really hot with lower power setting. And user might put a pot with an already hot food content
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks good but not data. It is just a simple timer and alarm.
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks good but not data. It is just a simple timer and alarm.
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will not work if no signal of heat source power level was received
- **Safety system components might pose added risk to consumer:** Nothing is expected
- **Applicability across product types and product models:** Will need more development to apply for gas cooktop – specifically for the power level sensor. No patent found that specifically address this type of technology on gas cooktop, although it does not seem difficult to do.
- **Components/system availability:** Most parts are available off the shelf or has been manufactured at high volume at low cost
- **Installation:** No added effort than installing conventional range
- **Serviceability:** Some training or new equipment is necessary for servicing the sensor

17. PREVENT FOOD IGNITION IN PAN -- ELEC. SIGNAL PROCESSING, SELECT MODE OR T -- T SENSOR CONTACTS POT

- **Effect on Cooking Process:** All cooking process is possible as long as T range determined is high enough for high temperature cooking (searing)
- **Effect on Cooking Time:** Likely to affect cooking time by less than 10%
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User need to read the manual to use the new mode selecting control knob or buttons without the need to read manual
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need special equipment or specialist's help to determine systems operability
- **Safety System Maintenance:** Need additional procedure to clean the temperature sensor from grease or food soil build-up
- **Cookware Applicability:** Some cookware materials or shape can compromise safety system performance. (e.g. glass/ceramic ware, cookware with concave bottom)
- **Range of Fire Incident Coverage (Based on existing fire data):** Likely will address more than 40% of fire incident since it prevents pre-ignition condition from occurring during most of the cooking processes

- **Percent of new product sales covered by this technology:** Multiple designs applicable for gas and solid or coil electric elemet cooktops. Has some design for smooth top Ceran (gold alloy track) but the application might be more difficult for a reliable means to gauge pot content temperature.
- **The degree of mitigation of fires addressed:** Will prevent fire from occurring
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, no adjustment or cleanup necessary after safety system actuation since it prevents fire from ever occurring
- **Effect of Actuation on the Safety System:** Since cooktop will continuously manipulate heat to keep foodstuff at proper temperature, no reset is necessary after each actuation
- **Potential for False Actuation:** Potential for false negative if temperature sensor and cooktop did not have good contact due to surface dirt or misalignment
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic, no data. Sensor is unprotected
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data. Sensor is out in the open and have high likelihood to be impacted by cooking wares
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Depending on the algorithm selected. On some system, where cooking modes need to be selected, cooktop will still work even though the safety system is not on/operating , on others cooktop will not work since user has to input foodstuff temperature for the cooktop for maintain when turning on the control knob.
- **Safety system components might pose added risk to consumer**: None is expected
- **Applicability across product types and product models:** Can work for all models of one product type
- **Components/system availability:** Most parts are new parts that need to be developed and manufactured
- **Installation:** No different than conventional range
- **Serviceability:** Current staff needs some training and/or new equipment to test/service the sensor

18. PREVENT FOOD IGNITION IN PAN -- ELEC. SIGNAL PROCESSING, SELECT MODE OR T -- NON-CONTACT T SENSOR

- **Effect on Cooking Process:** All cooking process is possible as long as T range determined is high enough for high temperature cooking (searing)
- **Effect on Cooking Time:** Likely to affect cooking time by less than 10%
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User need to read the manual to use the new mode selecting control knob or buttons without the need to read manual
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need special equipment or specialist's help to determine systems operability
- **Safety System Maintenance:** Need additional procedure to clean the temperature sensor from grease or food soil build-up
- **Cookware Applicability:** Need special cookware for system to work properly (Known emissivity)
- **Range of Fire Incident Coverage (Based on existing fire data):** Likely will address more than 40% of fire incident since it prevents pre-ignition condition from occurring for most of the cooking process
- **Percent of new product sales covered by this technology:** Can be installed to any new cooktop though more work needs to be done for the gas fired cooktop to make sure that radiation from flame will not be mistaken as pot high temperature.
- **The degree of mitigation of fires addressed:** Prevent fire from even occurring
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, fire should never even occur
- **Effect of Actuation on the Safety System:** None, no cleaning or adjustment is necessary every time safety system actuates
- **Potential for False Actuation:** Potential for false negative, if sensor is dirty and did not register the actual cooking pot temperature
- **Can Operate Over product life w/o failure (safety factor of 2):** No data, looks problematic – sensor window might get soiled w/ grease and food that might require replacement. Some model requires sensor to move up and down from cooktop's surface; this might get soiled and jammed.
- **Can operate within reasonably foreseeable misuse conditions (durability):** No data, looks good. Sensor is located away from the pot and pans traffic during cooking. Chance of impact with cooking pot/pan is minimal

- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop can still operate even though the safety system might not be working (e.g. Bosch's in the market model becomes conventional cooktop when system is not working).
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work on all models of the same type
- **Components/system availability:** Most parts need development
- **Installation:** No different than conventional cooktop
- **Serviceability:** Needs new training and some new equipment

19. PREVENT FOOD IGNITION IN PAN -- ELEC. SIGNAL PROCESSING, AUTO-ACTIVATION -- T SENSOR CONTACTS POT

- **Effect on Cooking Process:** High temperature cooking (searing) is negatively affected
- **Effect on Cooking Time:** Probably affected cooking time by less than 10%
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None, since user will not even be aware that safety system is actuating
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need service technicians to verify system operation.
- **Safety System Maintenance:** User maintenance requires few additional procedures to clean up the temperature sensor regularly from grease or food soil build-up
- **Cookware Applicability:** Some cookware materials or shape can compromise safety system performance. (e.g. glass/ceramic ware, cookware with concave bottom)
- **Range of Fire Incident Coverage (Based on existing fire data):** Will address more than 40% of cooking fire incident since it will avoid the occurrence of overheated foodstuff or cookware
- **Percent of new product sales covered by this technology:** Multiple designs applicable for gas and solid or coil electric element cooktops. Has some design for smooth top Ceran (gold alloy track) but the application might be more difficult for a reliable means to gauge pot content temperature.
- **The degree of mitigation of fires addressed:** Will prevent cooking fire from occurring
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, no adjustment or cleanup necessary after safety system actuation since it prevents fire from ever occurring
- **Effect of Actuation on the Safety System:** None, system will actuates and resets automatically.
- **Potential for False Actuation:** Potential for false negative if temperature sensor and cooktop did not have good contact due to surface dirt or misalignment
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic, no data. Sensor is unprotected
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data. Sensor is out in the open and have high likelihood to be impacted by cooking wares
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop will still work even though the safety system is not on/operating
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models of one product type
- **Components/system availability:** Most parts are new parts that need to be developed and manufactured
- **Installation:** No different than conventional range
- **Serviceability:** Current staff needs some training and/or new equipment to test/service the sensor

20. PREVENT FOOD IGNITION IN PAN -- ELEC. SIGNAL PROCESSING, AUTO-ACTIVATION -- NON-CONTACT T SENSOR

- **Effect on Cooking Process:** Will affect quality on high temperature cooking such as searing
- **Effect on Cooking Time:** Might affect cooking time by less than 10%
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None, cook will not notice that system is actuating
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need specialist's help or special equipment
- **Safety System Maintenance:** User maintenance requires few additional procedures to clean up the temperature sensor regularly from grease or food soil build-up
- **Cookware Applicability:** Need special cookware for system to work properly (Known emissivity)

- **Range of Fire Incident Coverage (Based on existing fire data):** Likely will address more than 40% of fire incident since it prevents pre-ignition condition from occurring for most of the cooking process
- **Percent of new product sales covered by this technology:** Can be installed to any new cooktop though more work needs to be done for the gas fired cooktop to make sure that radiation from flame will not be mistaken as pot high temperature.
- **The degree of mitigation of fires addressed:** Prevent cooking fire from occurring
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, system will prevent fire from occurring. Therefore, no additional cleaning or adjustment is necessary after each actuation
- **Effect of Actuation on the Safety System:** None, system automatically resets itself.
- **Potential for False Actuation:** Potential for false negative, if sensor is dirty or illegal cookware with unknown emissivity is used.
- **Can Operate Over product life w/o failure (safety factor of 2):** No data, looks problematic – sensor window might get soiled w/ grease and food that might require replacement. Some model requires sensor to move up and down from cooktop's surface; this might get soiled and jammed.
- **Can operate within reasonably foreseeable misuse conditions (durability):** No data, looks good. Sensor is located away from the pot and pans traffic during cooking. Chance of impact with cooking pot/pan is minimal
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop might still be able to work even though safety system is off
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work on all models of the same type
- **Components/system availability:** Most parts need development
- **Installation:** No different than conventional cooktop
- **Serviceability:** Needs new training and some new equipment

21. PREVENT FOOD IGNITION IN PAN -- NO SIGNAL PROCESSING, MECHANICAL ACTUATION

- **Effect on Cooking Process:** High temperature cooking (searing) is negatively affected
- **Effect on Cooking Time:** Most likely will affect more than 10 percent of cooking time. Most mechanical actuation devices (bimetal strip or expansible liquid sensors) will react slower to temperature fluctuation which might cause it to delay the on/off cycle time and thus prolong cooking time.
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None, since cooktop will constantly manipulate heat source to maintain temperature settings selected. Or it will maintain a limiting high temperature automatically regardless of the heat setting selected
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Need service technicians to verify system operation.
- **Safety System Maintenance:** User maintenance requires few additional procedures to clean up the temperature sensor regularly from grease or food soil build-up
- **Cookware Applicability:** Some cookware materials or shape can compromise safety system performance since the sensor will need to be in contact to the cooking vessel (e.g. glass/ceramic ware, cookware with concave bottom)
- **Range of Fire Incident Coverage (Based on existing fire data):** Will address more than 40% of cooking fire incident since it will avoid the occurrence of overheated foodstuff or cookware
- **Percent of new product sales covered by this technology:** Will be difficult to apply on smooth top cooktop (Ceran) so will probably cover between 40-90% of new product sales
- **The degree of mitigation of fires addressed:** Prevent cooking fire
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, no adjustment or cleanup necessary after safety system actuation since it prevents fire from ever occurring
- **Effect of Actuation on the Safety System:** Since cooktop will continuously manipulate heat to keep foodstuff at proper temperature, no reset is necessary after each actuation
- **Potential for False Actuation:** Potential for false negative if temperature sensor and cooktop did not have good contact due to surface dirt or misalignment
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic, no data. Sensor is unprotected
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data. Sensor is out in the open and have high likelihood to be impacted by cooking wares

- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Depending on the mechanical design; on some cooktop can still work when safety system is off. On other designs cooktop cannot be turned on when the sensor is broken.
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models of one product type except on smooth top cooktop (Ceran)
- **Components/system availability:** Most parts are new parts that need to be developed and manufactured
- **Installation:** No different than conventional range
- **Serviceability:** Current staff needs some training and/or new equipment to test/service the sensor

22. PREVENT BOIL DRY/SPILL OVER -- T SENSOR

- **Effect on Cooking Process:** Will not affect any cooking process since user needs to select boil cooking mode for system to actuate
- **Effect on Cooking Time:** Will not affect cooking time since user needs to select boil cooking mode for system to actuate and this only actuates after boil is detected. For other cooking process no manipulation is imposed on the heat source therefore, no change in cooking time.
- **Effect of System on Consumer Behavior While Operating the Cooktop:** User will intuitively figure out how to use cooktop. System control have knob setting or switch button specifically for boil cooking
- **Limits availability or efficacy of marketed cooktop features**: None
- **Ease of System Verification:** Need service technicians to verify system operation.
- **Safety System Maintenance:** User maintenance requires few additional procedures to clean up the temperature sensor regularly from grease or food soil build-up
- **Cookware Applicability:** Some cookware materials or shape can compromise safety system performance since the sensor will need to be in contact to the cooking vessel (e.g. glass/ceramic ware, cookware with concave bottom)
- **Range of Fire Incident Coverage (Based on existing fire data):** Will address less than 40% of cooking fire incident since it only address fire due to boil dry condition.
- **Percent of new product sales covered by this technology:** Will be difficult to apply on smooth top cooktop (Ceran) so will probably cover between 40-90% of new product sales
- **The degree of mitigation of fires addressed:** Prevent only boil dry incident.
- **Effect of Safety System on Cooktop Performance After Actuation of System:** None, cooktop is performing normally as the system actuates continuously.
- **Effect of Actuation on the Safety System:** None, system resets automatically whenever boil mode is selected
- **Potential for False Actuation:** Potential for false negative if temperature sensor and cooktop did not have good contact due to surface dirt or misalignment
- **Can Operate Over product life w/o failure (safety factor of 2):** Looks problematic, no data. Sensor is unprotected
- **Can operate within reasonably foreseeable misuse conditions (durability):** Looks problematic, but no data. Sensor is out in the open and have high likelihood to be impacted by cooking wares
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** Cooktop might still work if safety system is off
- **Safety system components might pose added risk to consumer:** None is expected
- **Applicability across product types and product models:** Can work for all models of one product type, except Ceran™ cooktop
- **Components/system availability:** Most parts are new parts that need to be developed and manufactured
- **Installation:** No different than conventional range
- **Serviceability:** Current staff needs some training and/or new equipment to test/service the sensor

23. NO COOKTOP FIRE PREVENTION TECHNOLOGY (DO NOTHING)

- **Effect on Cooking Process:** None
- **Effect on Cooking Time:** None
- **Effect of System on Consumer Behavior While Operating the Cooktop:** None
- **Limits availability or efficacy of marketed cooktop features:** None
- **Ease of System Verification:** Not Applicable
- **Safety System Maintenance:** None, regular cooktop maintenance only is needed.

- **Cookware Applicability:** Work for all types of cookware.
- **Range of Fire Incident Coverage (Based on existing fire data):** Not Applicable
- **Percent of new product sales covered by this technology:** Not Applicable
- **The degree of mitigation of fires addressed:** Not Applicable
- **Effect of Safety System on Cooktop Performance After Actuation of System:** Cooktop will be burned down
- **Effect of Actuation on the Safety System:** Not Applicable
- **Potential for False Actuation:** Not applicable since fire will never be detected
- **Can Operate Over product life w/o failure (safety factor of 2):** No additional part installed that might have any effect to current cooktop product life
- **Can operate within reasonably foreseeable misuse conditions (durability):** No additional part installed that might have any effect to current cooktop durability
- **Safety system's effect on cooktop's conformity with current safety standards (UL/ANSI) Need to fail safe (cooking system shut-down):** No additional part installed that might have any effect to current cooktop safety standards
- **Safety system components might pose added risk to consumer**: No additional part installed that might pose added risk
- **Applicability across product types and product models:** No additional part installed.
- **Components/system availability**: No additional part needs to be installed or developed
- **Installation:** No additional part installed.
- **Serviceability:** No additional part installed that might have any effect to current cooktop service routine

Most of the oil ignition tests described in the experimental section of this report were carried out with unused oil. It is known that during cooking, the concentration of free fatty acids in the oil increases and that this increase is associated with a drop in the ignition temperature of the oil. Therefore it is important to consider whether the temperature thresholds discussed in section 4 are appropriate for used oil as well as fresh oil.

The graph below shows the change in smoke, flash and fire (ignition) points of oil with increasing free fatty acid (FFA) content. Typical FFA concentrations for unused frying oil are between 0.05 and 0.08% or less [Reference: Bailey's Industrial Oil and Fat Products, Volume 1, page 214]. From the graph, it can be seen that the FFA concentration must rise to around 2% before any significant change in ignition temperature occurs.

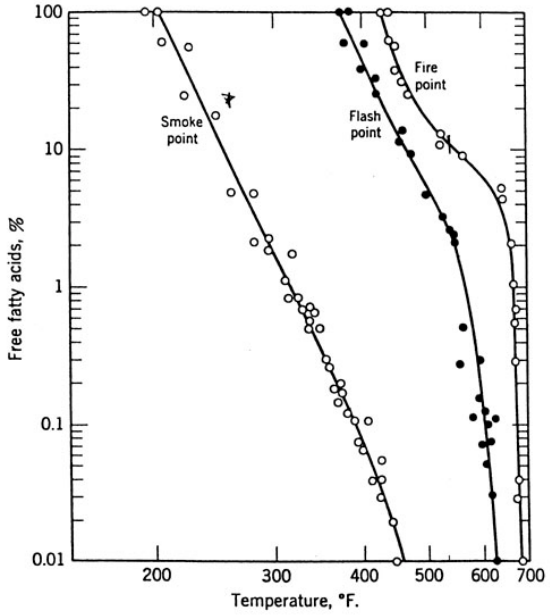


Figure G1: Smoke, fire and flash points of miscellaneous crude and refined fats and oils, as functions of the content of free fatty acids. [from: Bailey's Industrial Oil and Fat Products, Volume 1, page 212].

Data is available in the literature relating time at temperature of cooking oil to the increase in free fatty acid content in the oil. For example, for canola oil held at 190C (374F), and used to fry batches of french fries for four minutes three times every eight hours:

	0 hrs	32 hrs	64hrs
FFA, %	0.01	0.46	0.96

[Reference: U.S. Patent 6,201,145 *Non-hydrogenated canola oil for food applications,* Fan;Zhegong; Assigned to Cargill Inc.]

For partially hydrogenated soybean oil (commonly used for commercial frying), held at 360F for 15hrs and used to fry pork and chicken continuously, the final FFA content was 0.69%. This oil was considered to be unacceptable for further use.
[Reference: U.S. Patent 6,187,355 *Recovery of used frying oils,* Akoh, te al. Assigned to the Georgia Research Foundation, Inc.]

In addition, the USDA requires that meat and poultry products including such products as corn dogs and pork rinds be fried in oil containing no more that 2% FFA.
[Reference: Libra Technologies Inc., 101 Liberty St., Metuchen, NJ 08840]

The tests described above relate to commercial frying situations, in which the level of oil use is significantly more severe than would be experienced in the home. They indicate that even with heavy commercial levels of oil reuse, the increase in FFA content is not sufficient to significantly lower the ignition temperature of the oil.

In order to verify these data, ADL carried out ignition tests on used oil. In these tests, approximately 750ml of canola oil was heated to 360F or above and used to fry ten batches of frozen french fries. In between each batch, the oil temperature was allowed to drop to around 300F. After the tenth batch, three 100ml samples of the used oil were then heated until ignition in a stainless steel frying pan. The resulting oil ignition temperatures, and the ignition temperatures for unused oil from the earlier tests are given in the table below.

Test conditions			**Ignition temperature (F)**
Oil type	**Pan type**	**Range**	
used	stainless steel	Rinnai	700, 730, 735
fresh	stainless steel	Rinnai	750
fresh	cast iron	Rinnai	730
fresh	aluminum	Rinnai	680
fresh	stainless steel	electric	760
fresh	cast iron	electric	740
fresh	aluminum	electric	760

These test results are consistent with the findings in the literature and show that the ignition temperatures in the used oil tests lay within the range of ignition temperatures noted for fresh oil.