United States
Consumer Product Safety Commission

CPSC Staff Assessment on Portable Electric Heaters

February 2023

Arthur Lee, Electrical Engineer
Evan Heimbach, Electrical Engineer
Division of Electrical Engineering
Directorate of Engineering Sciences

This report was prepared by the CPSC staff. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

Revision Changes

None

EXECUTIVE SUMMARY

According to the 2017–2019 Residential Fire Loss Estimates report, there were an estimated annual average of 1,400 fire service-attended fires, 50 deaths, and 120 injuries attributed to portable electric heaters. Staff conducted a search of the CPSRMS database for incidents related to portable electric heaters that occurred between January 1, 2011 to February 1, 2022. Staff also examined construction of, and components in, 27 new portable electric heater models.

The analysis of the incident data and samples revealed the following:

- Heater power cord sets with poor connections may lead to overheating of the connections.
- Poor internal connections may overheat and possibly ignite adjacent plastics.
- Some heaters are constructed with flammable plastic that may ignite and continue to burn.
- Heaters conforming to the appropriate voluntary standards may be less susceptible to the risk of fire.
- Extension cords used with heaters were often attributed as the cause for heater-related incidents.

The involvement of nearby combustibles was also cited in incident reports, but these reports typically did not contain sufficient information to conclude that the heater had actually ignited the nearby combustibles.

Based on this assessment, staff recommends the following, to reduce the risk of fires, deaths, and injuries from portable electric heaters:

- Improve connection reliability and minimize flame spread beyond the heater.
- Promote higher portable electric heater conformance to the performance and construction requirements of the appropriate voluntary standards.
- Provide enhanced consumer education on the risks of using an extension cord with an electric heater.

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

According to the U.S. Consumer Product Safety Commission's (CPSC's) 2017–2019 Residential Fire Loss Estimates report, there were an estimated annual average of 1,400 fire service-attended fires, 50 deaths, and 120 injuries attributed to portable electric heaters.[1]

Manufacturers can minimize fire risks for portable electric heaters by complying with the appropriate voluntary standards and maintaining quality control during production and by consumers' proper use of the heater. To comply with the voluntary standard requirements to address risk of fire, heaters incorporate safety features that include flammability-resistant plastics for specific areas, internal thermal switches, and other protective devices that are designed to shut off the heater or minimize the hazard if it becomes too hot or tips/falls over.

Engineering Sciences (ES) staff evaluated household portable electric heaters rated 2,000 watts or less.[2] This report documents staff's analysis and assessment of portable electric heaters.[3]

2.0 PRODUCT

Portable electric heaters are designed to be moved easily from one location to another to heat a space. Portable electric heaters are cord-and-plug connected with a maximum cord length of 8 feet.[4] Electric heaters can use different mechanisms to produce heat:

- Radiant--In a radiant heater, the heating element visibly glows or incandesces, heating objects, or people, rather than the air. The heat is instant, requiring little time for a user to feel the warmth.
- Convection–These products heat the air in a space and circulate the heated air, either through forced convection (fan-forced), or natural convection[5] (oil-filled). Types of heating elements in a fan-forced heater include nichrome wires,[6] sheathed heating elements, or ceramic/positive temperature coefficient heating elements.[7]

---

[1] Miller, D., *2017 – 2019 Residential Fire Loss Estimates*, U.S. National Estimates of Fires, Deaths, Injuries, and Property Loss from Unintentional Fires (October 2022); Division of Hazard Analysis; CPSC, Bethesda, MD.

[2] One heater was advertised as a 2,000 W heater, which UL 1278 classifies as a commercial/industrial heater, but staff measured a maximum input power of 1,500 W during testing.

[3] The views expressed in this report are those of the CPSC staff, and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

[4] UL 1278, Table 16.1 Acceptable types of cords limit cord lengths for types, specifically SRDT and SPT-3 power cord sets, to 6 feet. All other cord types are 8 feet.

[5] Natural convection is a method of heat transport generated only by density differences in the air temperature gradients and not by any external source, such as a fan.

[6] Nichrome wire is a resistive wire that is made from an alloy of nickel and chromium.

[7] A positive temperature coefficient heating element (PTC heating element) is an electrical resistance heater whose resistance increases with temperature.

3.0 STANDARDS FOR PORTABLE ELECTRIC HEATERS

Underwriter Laboratories (UL) is the standards developing organization for the American National Standards for portable heaters. There are three consensus voluntary safety standards that apply to portable electric heaters:

- *ANSI/UL 1278, Standard for Movable and Wall- or Ceiling-Hung Electric Room Heaters*
- *ANSI/UL 1042 – Standard for Electric Baseboard Heating Equipment*
- *UL 60335-2-30, Household and similar electrical appliances-Safety-Part 2-30:Particular requirements for room heaters*

Some relevant component standards for heaters include:

- *UL 60730-1, Automatic Electrical Controls - Part 1: General Requirements*
- *UL 60730-2-9, Automatic Electrical Controls - Part 2-9: Particular Requirements for Temperature Sensing Controls*
- *UL 817, Standard for Cord Sets and Power-Supply Cords*
- *UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*
- *UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluation*

4.0 RECALLS INVOLVING PORTABLE ELECTRIC HEATERS

CPSC has issued 61 recalls (1980 -2022) of portable electric heaters. The recalled heaters posed a risk of thermal burns and fire. Over 11 million heaters were involved in the 61 recalls. Table 4-1 lists the CPSC heater recalls.

Table 4-1. CPSC Recalls by Decade

Years	Recalls	Numbers
1980-1989	7	153,350
1990-1999	7	1,770,300
2000-2009	20	4,053,800
2010-2019	24	5,040,042
2020-2022*	3	964,500

* 3 year period

5.0 INCIDENT DATA REVIEW

Engineering staff analyzed incident data from the CPSC databases on portable electric heater incidents that occurred from 2011 to 2022. The following section summarizes this analysis.

5.1 Incidents

CPSC Epidemiology staff searched the CPSRMS database for incidents that occurred between January 1, 2011, and February 1, 2022, using the product code 348 (portable electric heaters) as the search criteria. The results are not a statistical estimate of portable electric heater incidents in the United States, but they provide a glimpse of the incident scenarios that have occurred so staff can identify potential gaps in the standards requirements to reduce the risks. The search produced 2,874 incident reports. Staff screened the searched results by reading the narratives and determined that 529 of the reports were out of scope because the heaters were either not likely the cause of the incident, the heater was not portable, or the heater was not electric. The remaining 2,345 incident reports contained 292 In-Depth-Investigation (IDI) reports, which provide the most detail on the product involved and the circumstances in the incident.

Staff categorized each of the 2,345 reports and recorded the following information: outcome (injury/death), hazard type, heater component involved, if an extension cord was used, heater type, type of residence, ignition source, and first item ignited.

In 78 percent of incidents reviewed no injuries occurred. The consumers were able to act to de-energize the heater when they noticed abnormal operation of the heater, such as smoke, fire, an electrical burning smell, or melting. There were 335 deaths (14.9%) associated with the reports. Table 5-1 lists the incidents by injury. Additional analysis of the in-scope deaths is conducted at the end of this section.

Table 5-1. Incidents by Severity of Outcome

Incidents Categorized by Outcome Severity	Count	Percent of Known
Death	335	14.9%
Smoke Inhalation (Injury)	78	3.5%
Burn (Injury)	81	3.6%
No Injuries	1,744	77.5%
Other	11	0.5%
Unknown (Narrative unreported)	96	

Staff reviewed the incident report narratives to identify the hazard. Eighty-seven percent of the incidents were classified as "fire." Table 5-2 lists the incidents by hazard.

Table 5-2. Incidents by Hazard

Incidents Categorized by Hazard	Count	Percent of Known
Fire	1,650	86.8%
Overheating (Smoke or burning smell)	168	8.8%
Burn (hot surface)	74	3.9%
Hyperthermia	6	0.3%
Shock/electrocution	3	0.2%
Unknown	444	

In more than half of the reports (63%), the individual submitting the report did not cite a specific component as the possible cause of the incident. The majority (34%) of the incidents in which a component was cited, were classified as "plug." These incidents mentioned that the plug may have been hot to the touch, melted, on fire, smoking, or that it charred the wall/receptacle. The other components mentioned were cord, wiring, and control panel. Table 5-3 lists the heater component that the narrative attributed as the cause of the incident.

There were instances where the heater was being used during the incident, but the heater did not appear to be the origin of the incident. These other products that were not part of a heater were noted, including receptacle outlet and extension cords. The incidents categorized as "receptacle," mentioned a receptacle with some form of damage, and the heater plug was not mentioned.

Table 5-3. Incidents by Component

Incidents Categorized by Component	Count	Percent of Known
Plug	218	34.2%
Cord	100	15.7%
Housing	53	8.3%
Heater Wiring	115	18.1%
Tip switch	35	5.5%
Control panel	66	10.4%

Incidents Categorized by Component	Count	Percent of Known
Fan	18	2.8%
Oil	32	5.0%
Non Heater Origin Incidents and Unknowns		
Receptacle	72	
Other non-heater component	154	
Unknown	1,482	

Table 5-4 lists the incidents according to whether an extension cord was used. Where extension cord use was not mentioned, or there was no mention of how the heater was plugged in (unknown), the incidents were classified as "receptacle." Otherwise, the incident was classified as "extension cord."

Table 5-4. Incidents involving Extension Cord Use

Incidents Where Extension Cord was Used	Count	Percent of Known
Receptacle	2080	88.7%
Extension Cord	265	11.3%

Table 5-5 lists the incidents by heater description type that was in the narratives. A large portion of the incident reports did not state the type or any description of the heater, accounting for 1,718 of the 2,345 incidents. The majority (88.7%) of known incidents had a description that the heater was a "radiant" type. The heater description in the narratives of "oil-filled" accounted for 174 of the incidents. These are typically convection type heaters. The incidents narratives may have used "desk" and "tower", these types of heaters can be either convection or radiant, no further descriptions were given.

Table 5-5. Incidents by Heater Description

Incidents Categorized by Heater Type	Count	Percent of Known
Radiant	263	41.9%
Convection	44	7.0%
Tower (either convection or radiant)	94	15.0%
Oil-Filled (typically convection)	174	27.8%
Desk (either convection or radiant)	52	8.3%
Unknown	1718	

Table 5-6 lists the incidents by structure. A large portion of the incidents (1,346) did not state the type of home structure. The majority (58.8%) of known incidents were in single-family homes. Heater incidents that occurred in mobile homes accounted for 14.3 percent of the known incidents.

Table 5-6. Incidents by Structure

Incidents Categorized by Structure	Count	Percent of Known
Single Family Home	587	58.8%
Townhouse/Row house	22	2.2%
Apartment/Condo	79	7.9%
Mobile home	143	14.3%
Trailer/RV	49	4.9%
Outside	5	0.5%
Outdoor Structure	28	2.8%
Business	86	8.6%
Unknown	1,346	
Total In-Scope Incidents	2,345	

Table 5-7 lists the incidents by ignition source. The majority (92.3%) of the incidents were classified as "heater," and the remainder of the incidents were classified as "multiple items." A heater igniting nearby combustibles was classified as "heater," since the heater provided the thermal energy to ignite the combustibles. Examples of incidents that were classified as "multiple items" were incidents that listed multiple appliances that may have contributed to the incident. When no appliance other than the heater, or nearby combustibles and a heater, were mentioned in the incidents, the default selection was "heater" as the ignition source.

Table 5-7. Incidents by Ignition Source

Incidents Categorized by Ignition Source	Count	Percent of Known
Heater	2,165	92.3%
Multiple items	180	7.7%
Total In-scope incidents	2,345	

Table 5-8 lists the incidents by item ignited. The majority (60.6%) of the incidents were classified as "heater" as the item that ignited. Not applicable category accounted for 23.5 percent. "Not applicable" included items, such as extension cords, that were used with the heaters and were a contributing factor in the incident.

Reports that mentioned "nearby combustibles" accounted for 15.9 percent of the reports. Reviewing these incident reports, staff observed that the reports were not a definitive assessment of the actual actions that may have taken place to cause the incident. "Nearby combustibles" suggests that the heater was too close to combustibles, which caused ignition of the nearby material; but these reports typically demonstrated full involvement of the room, and there is little evidence of the actual cause of fire. Nearby combustibles typically indicate that another item, such as a sofa, bed, or recliner, was near the heater when the incident occurred, such that it is unknown if the heater ignited combustibles through radiant heating, or the heater failed and ignited nearby combustibles.

Table 5-8. Incidents by Item Ignited

Incidents Categorized by Item Ignited	Count	Percent of Known
Heater	1,049	60.6%
Nearby combustibles	276	15.9%
Not applicable	407	23.5%
Unknown	613	
Total In-Scope incidents	2,345	

5.2 In-Depth Investigation Reports

Not all incidents contained detailed information but may have contained only a short narrative or description of the incident and product. The previous analysis was conducted on this information and screened concerning whether the incidents were in scope or not. To evaluate the possible errors in categorizing the incidents, a selection of in-scope incidents that contained IDI reports (292) had to meet two additional criteria–fire and death.

Staff screened the 292 IDI reports for being in-scope, being a fire incident and involving a death. There were 78 reports that met these criteria. The information in the 78 IDIs was reviewed, and 44 were identified where the heater may have been the likely cause of the incident. Twenty-four of the incident reports suggested the heater was unlikely the cause of the incident or the heater was "very old" as mentioned in the report or possibly had been modified. Of the 24, 11 incident reports suggested that the incidents may have originated from or at an extension cord that the heater was connected to. Four incident reports had insufficient information to determine if the heater was the cause of the incident. The remaining 214 IDI reports involved incidents of no injuries (194), smoke inhalation (10), burns (9), or unspecified minor injuries (1).

5.3 Selected Incident Cases and Analysis

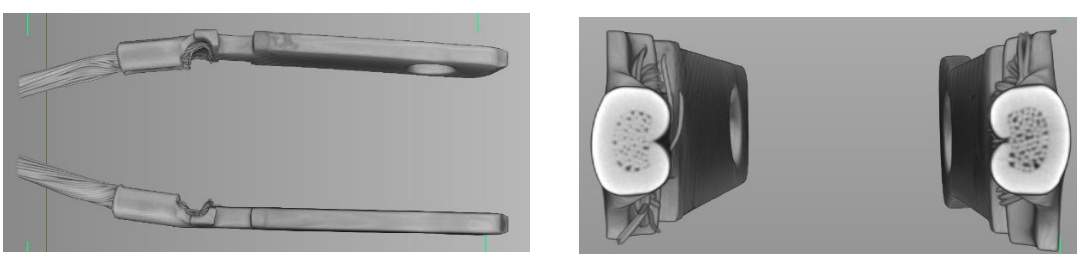
The incidents below are selected cases where an IDI was conducted and an analysis on the product was conducted.

Case A Analysis

An incident occurred with a portable electric heater that was purchased new about 6 months prior to the incident. The heater was located on a table and was plugged into a receptacle under the table. The 15A circuit breaker for the branch circuit from which the heater was supplied repeatedly tripped. The consumer changed the breaker from a 15A to a 20A circuit breaker, which also immediately tripped when the heater was used. The consumer later changed the circuit breaker from a 20A to a 30A, which he just bought. When the consumer turned on the 30A breaker, heavy smoke and flames emitted from the location where the heater was plugged into the receptacle within a few minutes, and after being unable to extinguish the fire, the homeowner called 911. No injuries were reported. This suggests an electrical fault that drew high current. Figure 5-1 shows the location of the heater in the laundry room after the incident.

Figure 5-1. Incident scene

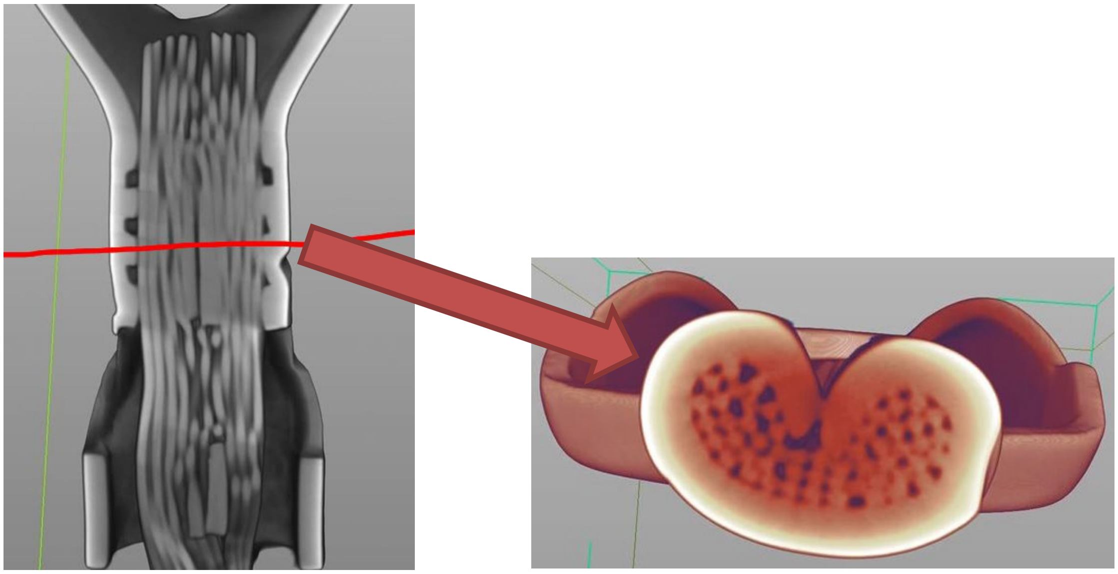
As part of the IDI CPSC field staff collected another heater of the same model that the consumer had purchased previously and was using in a bedroom without incident. This exemplar sample was provided to ES staff for assessment. Staff conducted an analysis of the heater, which was certified to UL 1278, including computed tomography (CT) images of the undamaged heater's plug. The attachment plug shows the wiring was attached in the attachment plug by crimps and welds (Figures 5-2 and 5-3), but there were voids between the conductor strands in the crimp barrels.



Welded wire strands to attachment plug

Voids in the crimps

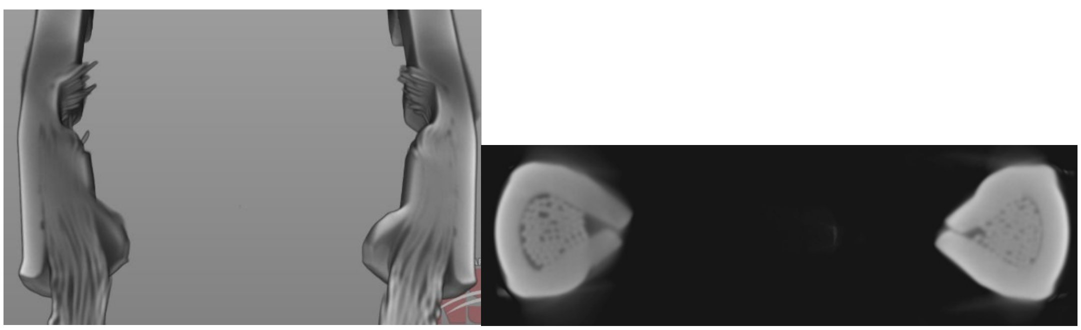
Figure 5-2. Attachment plug from undamaged heater



Voids in the crimps

Figure 5-3. Attachment plug from undamaged heater

Field staff also purchased a new exemplar heater sample of the same model incident heater for analysis. CT images of the heater's attachment plug show that the plug had improper crimping and voids within the crimp (Figure 5-4).



Improper crimping

Figure 5-4. Attachment plug from exemplar new heater

<u>Case B Analysis</u>

An incident occurred where a three-year-old male was found deceased in the morning with a melted portable electric heater in the same room. The portable electric heater was purchased approximately two months prior to the incident.

The night of the incident, the victim's mother put child to bed around 11:00 p.m., turned the heater on, and closed the bedroom door. About 15 minutes later, another resident in the house went to bed in a bedroom across the hallway from the victim's room. The resident heard the victim coughing, however, did not check on him. She smelled a smoke odor and thought it was the electrical equipment in her bedroom, so she opened the windows to her bedroom and went to sleep. The next morning, the parent went to check on the child and found him deceased in his bed. The cause of death was from smoke inhalation. The smoke alarm located in the home did not activate as the batteries had been removed the day before the incident.

CPSC staff conducted an analysis of the product, which was certified to UL 1278. The investigation of the incident scene photos revealed that the heater had overheated during the night, which generated an upper black smoke layer in the room (Figure 5-5). Figure 5-5 shows the fire had not spread beyond the incident heater itself.

Figure 5-5. Incident scene

Staff conducted an analysis of three additional incidents that had occurred with the same make and model heater. These incidents did not result in the heaters igniting or melting. The analysis of the incident heaters revealed that the connection to the heating elements had overheated (Figure 5-6). The overheating at the connections suggests that high resistance connections were occurring at the heating element connectors.

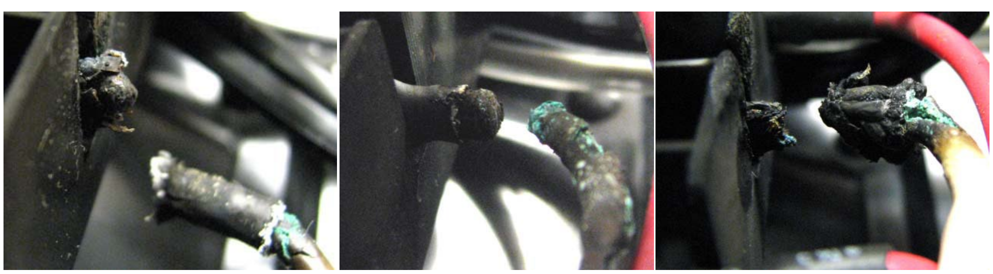
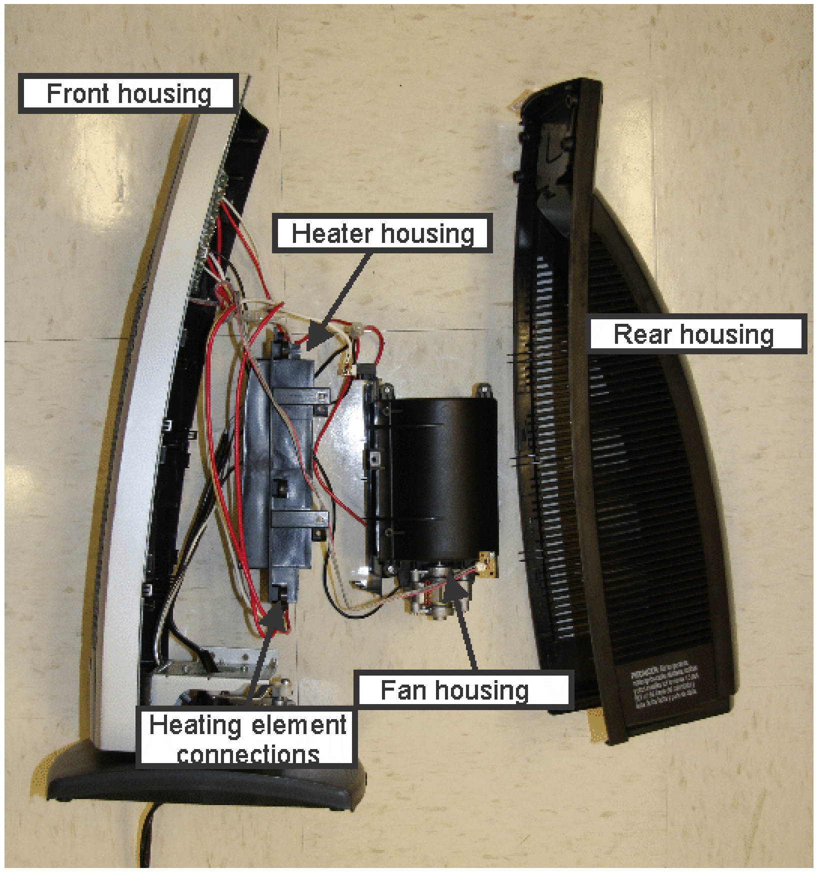


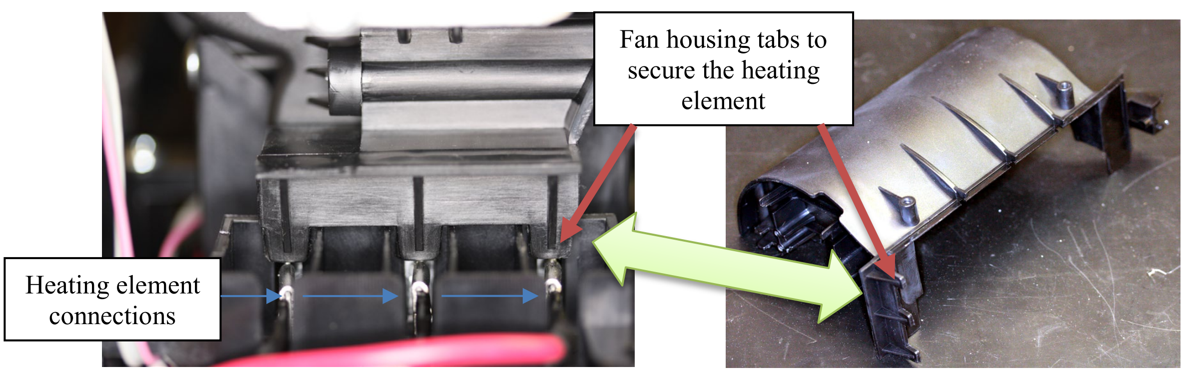
Figure 5-6. Melted connections at the heating element (three additional incident samples)

Staff analysis of heater internal construction revealed that a portion of the fan housing was used to secure the heater element connectors in place (Figure 5-7). As part of the fan housing, three plastic tabs were used to hold and secure the heating element in place (Figure 5-8).



Heater disassembled

Figure 5-7. Heater components on an exemplar sample



Heating element connections | Fan housing

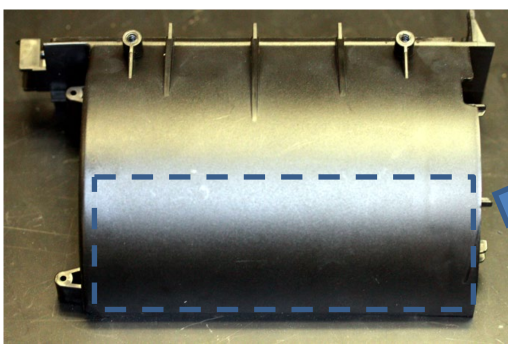
Figure 5-8. Fan housing near the heating element connections

The plastic fan housing was tested to determine the plastic's flammability. As a guide, UL 746C *Polymeric Materials – Use in Electrical Equipment Evaluation* and UL 94 *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances* were used. The plastic samples for the testing were cut from the right half of the fan housing, as shown in Figure 5-9. The burrs on the cut edges were removed before testing. The samples measured approximately 22 mm x 115 mm ±1 mm. The thicknesses of the plastic samples were measured in three different locations on each of the plastic samples. The thickness ranged from 1.970 mm to 2.014 mm. The average thickness was 1.987 mm.

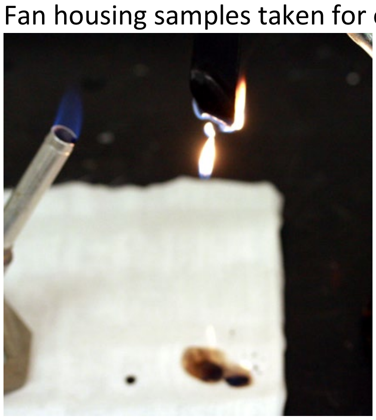
For the open flame test, utility-supplied natural (methane) gas was used to produce a 20 mm flame. Four layers of cotton cheesecloth were placed under the test area as an indicator of flaming drippings. The flame was applied to the plastic sample at approximately 10 mm above the top of the burner. The flame was applied for 10 seconds and then removed. When the flame contacted the plastic sample, the plastic ignited and began dripping flaming plastic onto the cotton cheesecloth. The after flame time was approximately 39 seconds (plastic sample self-extinguished 39 seconds after the flame was removed). During the test, the cotton cheesecloth ignited.

For the glow wire test, the wire was set at 750° C ± 1°C. Four layers of cotton cheese cloth were placed under the test area as a flaming dripping ignition indicator. The glow wire was applied to the plastic tests samples at 1 N pressure. Immediately when the wire contacted the plastic sample, the plastic ignited. The flames increased in size as the test progressed and began dripping flaming plastic onto the cotton cheesecloth (Figure 5-9). The cheesecloth ignited.

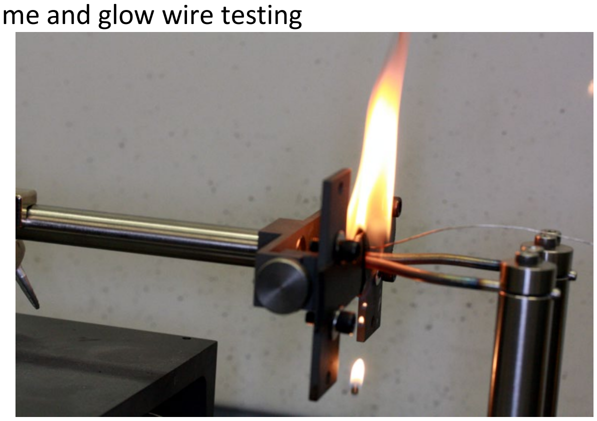
Analysis of the plastics within an exemplar heater revealed that the fan housing plastic used to hold down the heater connections can cause flaming dripping plastic if ignited.




Fan housing samples taken for open flame and glow wire testing



Open flame test



Glow wire test

Figure 5-9. Heater fan housing flammability testing on the exemplar sample

Staff conducted end-product flammability tests to examine what could happen if the heater had ignited at the fan housing. Two tests were conducted. The first test was in the CPSC large burn room. A second test was conducted in a small room to simulate conditions similar to the incident involving the death of the three-year-old male.

The first test was in the large open room, which contained a ventilation hood above the test item. The ventilation hood was on during the test to prevent the room from filling up with smoke. The heater's fan housing was ignited using an external flame source. The test sequence is shown in Figure 5-10. The sample ignited and burned rapidly, producing black smoke. The product burned with open flames for about 1 hour until the plastic fuel load had been used up.

The second test was in a closed room. The heater was placed in a 10 x 12 x 8-foot room with a 36-inch doorway that had been constructed within the large burn room. The sample was placed on a 5-foot-high stand that was positioned against one of the 10-foot-wide walls. The heater's fan housing was ignited using an external flame source, and the doorway was closed. The small room test resulted in the sample burning more slowly than the sample in the open burn room. Even though the sample burned slower, the sample still appears to have melted and resulted in a significant amount of smoke that fill the room.

0 minutes

Time 35.17 seconds after exposed to flame
5.17 seconds after source flame removed

1 minute after exposed to source flame

3 minutes after exposed to source flame

5 minutes after exposed to source flame

10 minutes after exposed to source flame

30 minutes after exposed to source flame

1 hour after exposed to source flame

Ignition of the fan housing in an open room

Sample ignition in a room

Figure 5-10. End-product flammability testing of exemplar by open flame ignition of the fan housing in a large open room and in a confined space.

The analysis suggests that ignition of the fan housing by a failed overheated heater connection could have resulted in a fire that completely consumed the heater (Figure 5-11).

Heater sample in open room after test

Heater sample in room after test

Figure 5-11. Heater samples after ignition of the fan housing

6.0 SAMPLES

Staff purchased 27 heater samples for evaluation and analysis. Staff selected the heaters to cover a variety of types, sizes and power ratings as shown in Figure 6-1. Additional details of the staff's examination are in the Appendix. Table 6-1 lists the heater samples tested.

Figure 6-1. Heater Samples

Table 6-1. Heater Type Samples

Sample Number	Shape	Max Watts	Temperature Controls	Fan
S1	Tower	1500	Digital	Y
S2	Tower	1500	Digital	Y
S3	Baseboard	1500	Mechanical	N
S4	Tower	1500	Digital	Y
S5	Tower	1500	Digital	Y
S6	Tower	1500	Digital	Y

Sample Number	Shape	Max Watts	Temperature Controls	Fan
S7	Tower	1500	Digital	Y
S8	Tower	1500	Digital	Y
S9	Desk	1500	Mechanical	N
S10	Desk	1500	Mechanical	Y
S11	Tower	1500	Digital	Y
S12	Tower	1500	Digital	Y
S13	Tower	1500	Digital	Y
S14	Tower	1500	Mechanical	N
S15	Desk	1500	Mechanical	N
S16	Radiator	1500	Mechanical	N
S17	Radiator	700	Mechanical	N
S18	Radiator	700	Mechanical	N
S19	Radiator	1500	Digital	N
S20	Radiator	1500	Mechanical	N
S21	Desk	1500	Mechanical	Y
S22	Panel	1500	Mechanical	N
S23	Desk	1500	Mechanical	Y
S24	Desk	1200	Mechanical	Y
S25	Desk	1000	Mechanical	Y
S26	Tower	2000*	Digital	Y
S27	Tower	1500	Digital	Y

*Labeled as 2,000 W, but staff measured only 1,500 W

Certification Status of Heater Samples

Staff examined the samples for markings that would indicate the products are third-party certified to the applicable standard, typically UL 1278. Twenty of the 27 heaters contained third party certification marks on the products. One of the samples only had a marking on the packaging. Six samples did not contain any third-party certification markings.

Staff looked up the markings' information on the online directories for the websites of the applicable labs. Staff was able to verify listings for 17 of the 21 products online. Three units had certification markings on the product, but the certification markings could not be verified as legitimate certifications to the claims. One unit had certification markings only on the packaging, but the certification markings could not be verified as legitimate certifications to the claims. It is possible a product could have been certified but was discontinued, and the on-line directory no longer lists the product. Table 6-2 lists the certification markings breakdown for the heater samples.

Table 6-2. Markings

Marking Certification	Count
Verified Certification Markings	17
Unverified Certification Markings	4
No markings on the packaging or product	6

Unverified Certification Markings	Markings[8]
Packaging	
Product	

6.1 Heater Sample Examination

Staff disassembled the heater samples to document the internal constructions and components used.

Eighteen heaters were forced-air convection heaters. The two types of fan impellers found in the samples were squirrel cage and radial blades, as shown in Figure 6-2. The squirrel cage impellers were constructed of either plastic or metal. All the radial blade impellers were plastic. For some models, two fans were used to accommodate the size of the heating element in the unit.

Squirrel cage impeller (S13) Dual fans (S7) Single radial blade (S24)

Figure 6-2. Fans

[8] UL and ETL are trademarks for Underwriters Laboratories and Intertek, respectively

Heaters contained either a mechanical or a digital selector switch for choosing the settings, as shown in Figure 6-3. Heater S27 did not contain any controls on the unit as it could only be controlled by the remote control provided with the unit.

Mechanical heat selector switch (S24)

Digital heat selector switch (S2)

Figure 6-3. Heat selector

All the heaters evaluated had some similar electrical components as follows:

- Heating element or assembly
- Temperature controls - regulating control (digital or mechanical)
- Temperature controls - limiting control
- Power cord

Staff traced and mapped out the circuits for all of the samples. Mechanical and thermo-mechanical safety control switches, such as the tip-over switch and thermal high limiters, are connected in series with the heating element, thus removing power when either device is activated. For example, as shown in Figure 6-4, S3 wire tracing was from one conductor of the power cord (PC) to the tip-over switch (TP) to the regulating thermostat (TS) to the fan heat selector switch (FS) to the heating element (HT) to the manual reset high limit (HLH) and finally to the other conductor of the power cord (PC). Heaters with digital controls may have used various temperature and tilting sensing devices that were controlled by the main circuit board. Appendix Table A-2. Wiring Connections contains additional information on the wiring of each product.

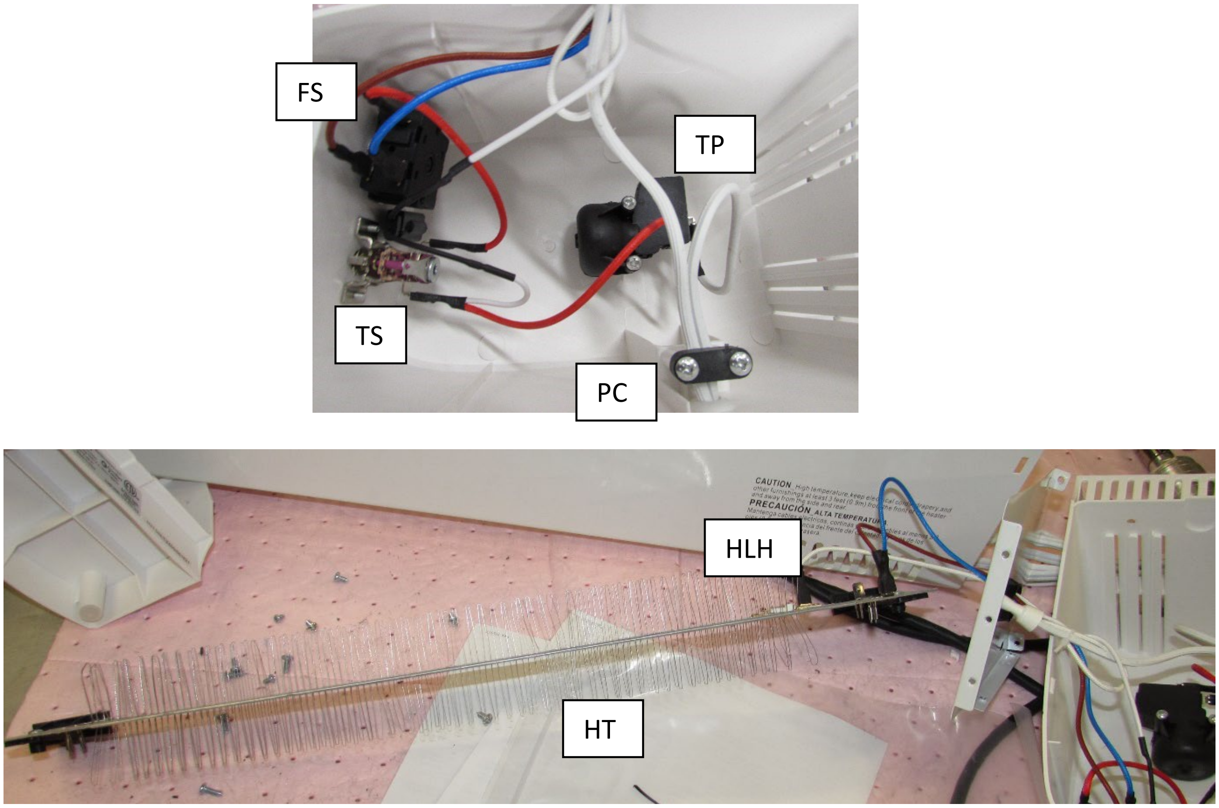


Figure 6-4. Wiring to components for S3

The heater models had either electronic or electromechanical temperature controls. An electromechanical temperature control uses a bi-metal switch to open and close the contacts as shown in Figure 6-5. When the temperature reaches the selected temperature, the bimetal component is heated and bends to make the moving contact part from the static contact, thus removing power to the heating element. When the temperature is lower than the set temperature for the bi-metal, the bi-metal bends back, and the two contacts close, energizing the heating element. For a regulating thermostat, the opening temperature to de-activate the heater can be adjusted manually by turning the dial, which adjusts the distance between the contacts.

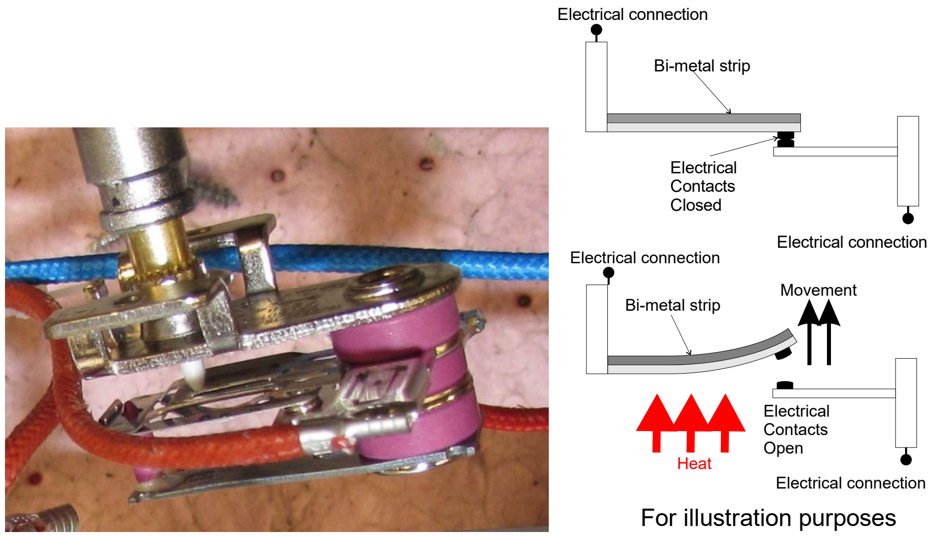


Figure 6-5. Mechanical temperature control

A digital thermostat uses a control board that regulates the temperature within the heater by using thermistors as temperature sensors. If the control board determines that the temperature is above the set point, the control board will open a relay to the heating element, thus de-energizing the heating element. One of the advantages of using a digital control is that multiple thermistors could be used to monitor the temperature at various locations in the heater, thus increasing the feedback to the controller, but the operation is dependent on proper programming to prevent overheating of the heater. Table 6-3 lists the regulating thermostats for the heater samples.

Table 6-3. Regulating Thermostats

Present	22
• Mechanical bi-metal	10
• Sensor/Thermistor w/relays	12
None	5

Timers and Remotes

Fifteen of the heaters had a timer feature. The timer feature allows the user to select the number of minutes the heater will be on before the timer shuts it off. Similarly, a sleep mode timer allows the user to program the heater to operate for a limited time.

Twelve heaters had remote controls; only heaters with digital controls had remotes. The remotes had features that could turn on/off the heater, change the set temperature, select fan speed, and/or oscillation of the unit within line of sight of the heater. Three units had the same remote appearance and button layout. One heater sample (S27) had no controls located on the unit, therefore could only be operated by a remote. Figure 6-6 shows sample remotes.

Figure 6-6. Samples of remotes from the heaters

Power Switch

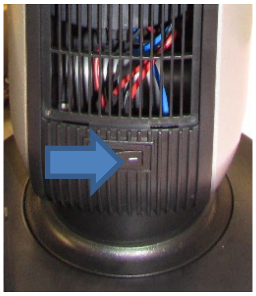
Twenty-six heater models had some type of a discrete power switch feature to turn the unit off completely. One heater (S21) did not contain an on/off power switch. S27 heater could only be operated and turned on and off with the remote; the unit did not have any controls on the product.

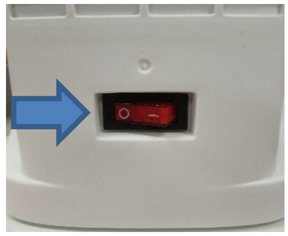
Table 6-4 lists the power switch types for the heater samples.

Table 6-4. Power Switch Types

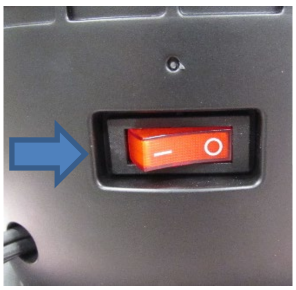
Power Switch Type	Count
Digital switch only	9
Mechanical incorporated with heat or fan select	10
Mechanical switch only	2
Digital switch with an additional mechanical switch	4
Remote	1
None	1

As shown in Figure 6-7, five heaters (S2, S5, S11, S13, S25) had the power switch located at the back of the heater, thus allowing the user to disable the unit and making it more difficult to unintentionally turn on the heater from the main control panel or the remote, if provided. One heater (S15) had the power switch at the front of the heater near the controls.


S2 – rear


S5 - rear


S11 – rear


S13- rear

S15 – front


S25 – rear

Figure 6-7. Separate power switches

Ten heaters had mechanical power switches incorporated into the heat select setting as shown in Figure 6-8. These switches were multiple function switches that turned the unit on and off and selected other functions, such as the heat output.

S14

S16


S24

Figure 6-8. Heat select power switches

Thirteen heaters had digital power switches incorporated in the controls on the heater as shown in Figure 6-9. These switches were multiple function switches that turned the unit on and off, selected the heat output, fan speed, and oscillation feature, if available.

S26 S2 S4

Figure 6-9. Digitally controlled power switches

Tip-Over Switch

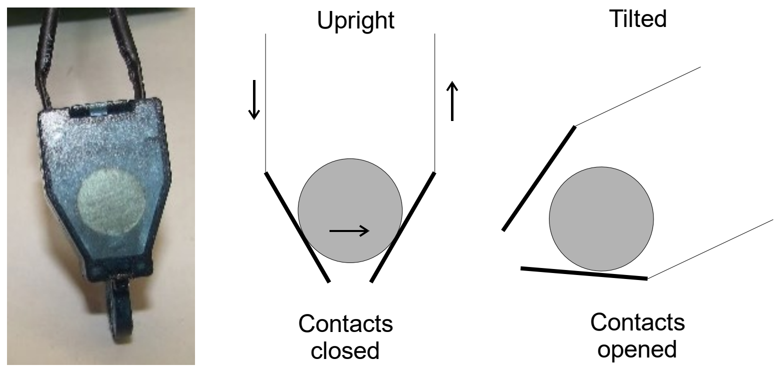
Twenty-five heater models contained tip-over switches to de-energize the heating elements when tipped over. Twenty heaters had a mechanical tip-over switch, and four heaters used a digital tip-over sensor. Two heaters did not contain any tip-over devices. The tip-over switches were either incorporated at the bottom of the heater base or within the heater as shown in Figure 6-10.

The tip-over switches at the bottom or under the heater base will be referred to as floor switches. These switches use a spring-loaded plunger to press a switch. If the unit is tilted, the tip-over switch activates. The two types of non-base switches were a V-metal disk or 360-degree ball switch. The V-metal disk uses a weighted metal disk that sits in a metal contact in the form of V. When the heater is upright, the metal disk makes electrical contact between the two sides of the metal contacts. When the heater is tilted, the V-disk moves out of the narrowest point of the V groove, thus breaking electrical contact and de-energizing the heater. The 360-degree ball switch contains a metal ball that sits in a cone against the actuator of a switch when the heater is upright. When the heater tips over, the ball moves from the base of the cone and releases the actuator of the switch to open the contacts for the switch.

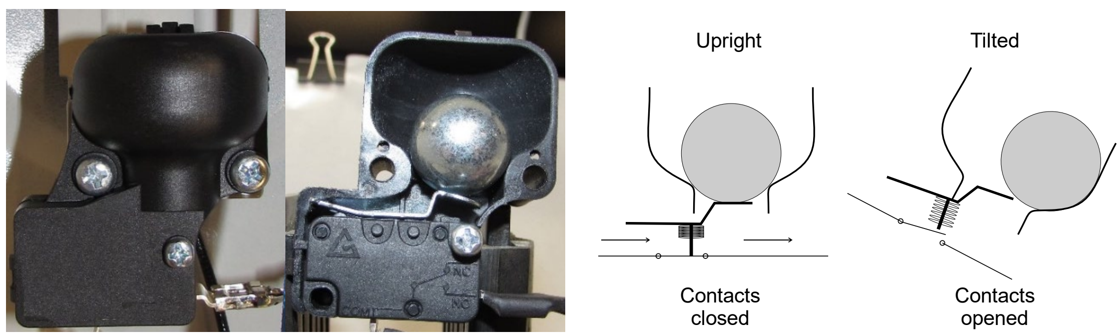
There were three heaters that incorporated digitally-controlled tip-over switches. The tip-over devices were incorporated on the circuit boards for the heaters and were not in series electrically with the incoming power but would remove power from the relay that controlled the heating element. Table 6-5 lists the tip-over switches for the heater samples.

Table 6-5. Tip-over Switch Types

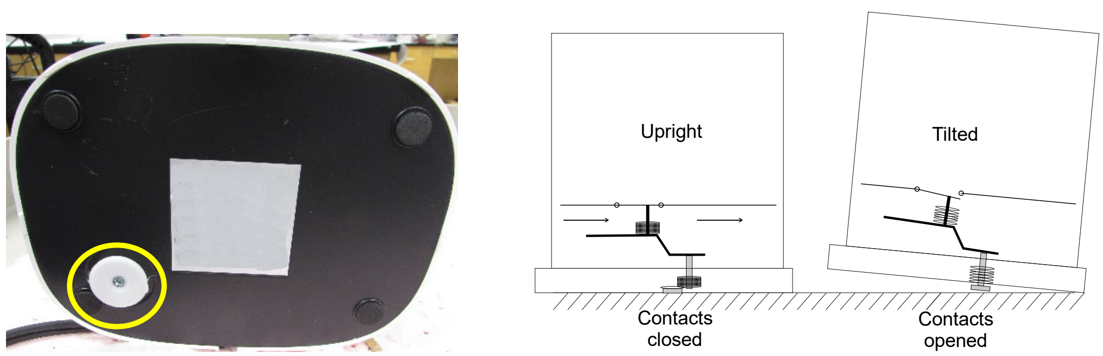
Tip-over switch type	Count
360 metal ball	14
Floor button	7
Digital	3
V metal disk	1
None	2



V groove and metal disk tip-over switch



360 metal ball tip-over switch



Floor tip-over switch

Figure 6-10. Tip-over switches

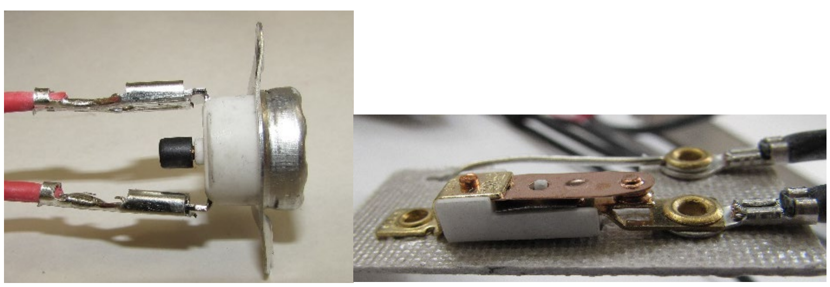
Temperature-Limiting Controls

There were two types of temperature-limiting controls that were found in the heater models, non-resettable and manually resettable as shown in Figure 6-11. Both of these device types are designed to de-energize the heater when they detect abnormally high temperatures within the heater. Eleven of the heater samples have manual reset only, high-limit devices. These devices, if activated, require user interaction to reset the safety device. Eight of the heaters have high limit with auto-reset devices. These devices, if activated, will automatically reset when the temperature drops below the set point. Five of the heaters contained two safety devices, a one-shot thermal fuse and an auto-reset high limit. Typically, an auto-reset high limit has an activation temperature that is lower than the one-shot thermal fuse activation temperature. Table 6-6 lists the temperature-limiting control switches for the heater models. Appendix Table A-3. Safety High-limit and One-shot Devices contains additional information.

Table 6-6. Temperature-Limiting Control Types

Safety Devices	Count
High limit manual reset only	11
High limit only (auto-reset)	8
one-shot thermal Fuse and high-limit (auto-reset)	5
High limit manual reset and high-limit (auto-reset)	1
one-shot thermal Fuse and high limit manual reset	1
Thermistor only	1

Automatic-reset High Limit Devices



Mechanical Electrical

Manual reset high limit devices

Auto reset and non-resettable limit controls

Figure 6-11. Samples of temperature-limiting controls

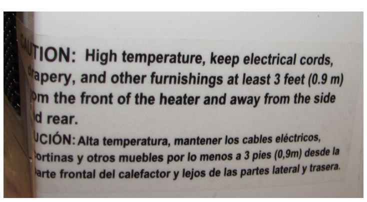
Warning Labels

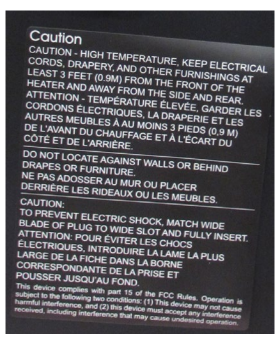
Twenty-one of the heaters had a “3-feet” warning label on the product (Figure 6-12). Eight of the 21 heaters with the labels also had the message in another language, Spanish or French. UL 1278 requires portable heaters be marked on a surface that is visible from the front of the heater with the following wording “CAUTION – High temperature, keep electrical cords, drapery, and other furnishings at least 3 feet (0.9 m) from the front of the heater and away from the side and rear” or similar. Six heaters did not contain any markings referencing 3-feet spacing from combustibles.

Nineteen heaters had safety warning cord tags. The cord tags varied in message and layout (text only or text and icons) (Figure 6-13). Some cord tags also displayed the message in another language besides English (Spanish, French, or German). UL 1278 requires portable heaters to display a cord tag located on the power cord with a list of safety instructions. Eight heaters did not contain any safety tag displayed on the power cord. One of these eight heaters had a cord tag, but the message was unrelated to safety.

Table 6-7. Warning Labels

“3-Feet” warning on the product	Count
English	21
None	6
Other additional language (Spanish or French)	8
Cord tag safety label	Count
Present	19
None	8





English and Spanish English and French English only

Figure 6-12. “3-feet” warning labels on the product

Text only Icons and text No warning

Figure 6-13. Power cord tag safety label

7.0 TESTING AND ANALYSES

Staff conducted the following assessments on the heaters and components to evaluate the operability of select components/features and flammability of the polymeric parts:

- Tip-over and Stability
- Power cord
- Internal wiring
- Abnormal Operation (variation of vertical wall test)
- Glow wire on plastic components
- Open flame on plastic components
- Open flame on end-product
- Nearby combustibles testing

7.1 TIP-OVER AND STABILITY TESTING

Staff assessed the activation angle of heaters with tip-over switches. Staff also conducted stability evaluation for the heater samples. The stability test is to evaluate movable heaters after being tipped in any direction to an angle of 10 degrees from horizontal (simulating someone bumping into the heater, or the heater placed on an unlevel surface). After being tilted 10 degrees, the heater should return to its at-rest upright position.

Tip-over

Staff subjected the 25 heaters with tip-over switches to a tip-over test to assess the efficacy of the tip-over switch. With the heater operating at its highest heat setting, the heater was tipped over in all four directions (front, back and sides) to 90 degrees. All the heaters shut-off in all four orientations.

Two heater samples (s1 and S8) did not have tip-over switches. Using UL 1278 Section 42.4 Tip-over Test as guide, staff conducted a tip-over test to evaluate the risk of fire when the heater has been tipped over. Terry cloth was placed on the flooring as a fire indicator. The heaters were set on the highest heat setting then tipped in all four directions. The heaters shut off when the heat output side was facing downward, and there was no indication of the terry cloth discoloring. The thermal devices shut off the unit. Even though the heaters did not shut off when tipped over on its back and sides, the terry cloth did not discolor or ignite.

After the heaters were tipped over (90 degrees), and the switch activated, staff returned the heaters to its intended at-rest upright position. Sixteen heaters re-energized after they had shut off when tilted. Nine models, all with digital controls, remained off when up righted. The digital controls required the heater to be reset to resume normal operation. Table 7-1 lists the results for the tip-over and inverted tests.

Table 7-1. Tip-over Test Results

Test Conducted	Count
Shut off when tipped over	25
Inverted and de-energized	24
Automatically energized after up righted	16

Inverted Test

There was a reported incident that stated a desk heater was still operating after it fell off the desk and was dangling from the cord. Even though the incident did not result in a fire, the heater samples were tested inverted 180 degrees from its upright position to evaluate the tip-over switch response. UL 1278 does not contain a performance test to evaluate inverted heaters.

Twenty-four heaters shut off when inverted 180 degrees. One sample (S27) did not shut off when the unit was inverted. Sample S27 contained a digitally controlled tip-over switch that only operated when the unit was tilted 90° but did not shut the heater off when inverted 180 degrees.

Stability

Staff slowly tilted the heaters to 10 degrees from horizontal. All the heaters returned to their vertical position when tilted 10 degrees from horizontal, meeting the requirement of UL 1278. Sample S17 was not tested because of limited samples.

The heater samples were tilted beyond the 10 degrees from horizontal to determine the tip angle where the heater would fall over (critical balance angle). The heaters were tested in all the orientations with "north" denoting the face or heat output as shown in Figure 7-2. The oil-filled heaters were oriented with the controls as "north." The baseboard heater was only tested on the north and south directions because the width would make it unlikely that it could tip-over in the east or west direction. Staff used a tension test stand (Figure 7-2) to slowly raise a platform from horizontal to measure the angle at which the unit would begin to fall over (critical balance angle).

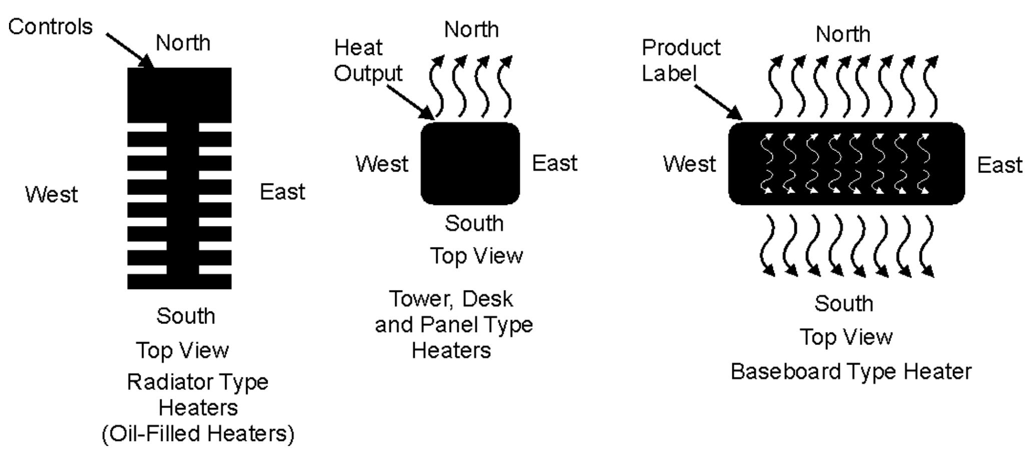


Figure 7-1. Heater orientation notation in the testing

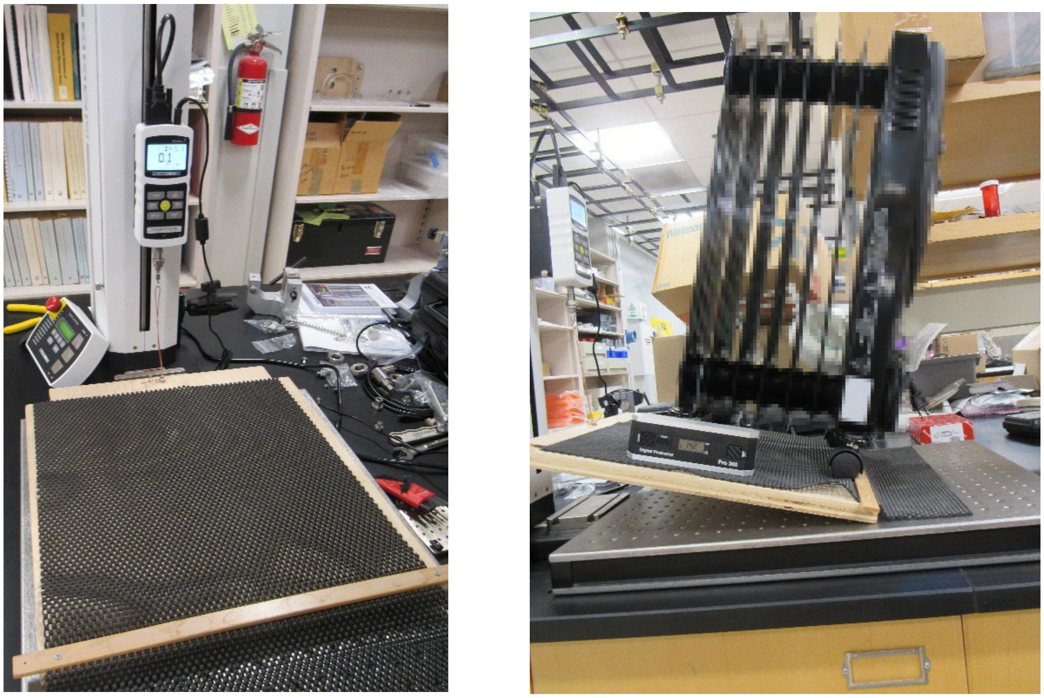


Figure 7-2. Critical balance angle

Staff recorded whether the tip switch activated before or after the critical balance angle as shown in Figure 7-3. Seven heaters had a lower tip-over switch activation angle than the critical balance angle for all the directions. These heater samples had a floor tip-over switch, thus soon after the heater base lifted from the floor, the tip-over switch activated. Fifteen had all directions where the tip-over switch activation angle was greater than the critical balance angle. The baseboard heater had tip over switch angles that were greater than the critical balance angles in the north and south directions. The other directions were not tested. Heater S15 had three of the four directions where the critical balance angle was greater than tip switch activation angle. S1, S8, S17 heaters were not tested.

Ideally, the heater tip switch should activate before the critical angle to minimize the likelihood of an energized tipped heater leaning against combustibles, such as a couch or bed. UL 1278 only requires the tip switch to activate before the critical balance angle if it was evaluated and determined that the tip switch is required to prevent a fire for the heater under evaluation. Table 7-2 summarizes the critical balance angle determination test results. Appendix Tables A-4 and A-5. Critical Balance Angles and Tip-over Switch Angles contain additional information on the testing.

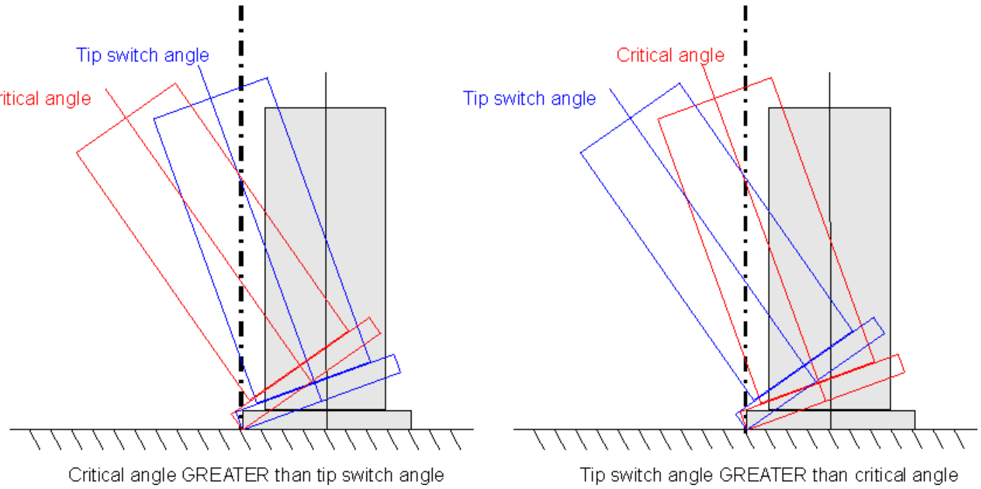


Figure 7-3. Critical balance angle and tip switch angle

Table 7-2. Tip-over Switch and Critical Balance Angle Test Results

Test Conducted	Count
Tip switch activation before critical balance angle (all directions)	7
Tip switch activation after critical balance angle (all directions)	15
Tip switch activation after critical balance angle (at least in one direction)	2

7.2 POWER CORD ANALYSIS

The power cords on all of the heater samples were permanently attached to the heaters, as required by UL 1278. Twenty-three power cords were marked as 16 AWG. Three cords were marked as 18 AWG, and one cord had no markings (measurements indicated it is an 18 AWG cord). The conductor sizes were estimated by counting the number of strands and averaging the diameter of 7 strands measured with a caliper in three different locations along the length of the wire strand. The measured conductor sizes were within the error tolerances of the marked wire sizes. Table 7-3 lists a summary of the power cord analysis.

UL 1278 requires that a power supply cord supplied with a household heater not intended for outdoor use (Table 16.1, row 1) must contain the -R suffix, which indicates that the cord meets the cord flexing requirements in accordance with the *Standard for Flexible Cords and Cables*, UL 62. Twelve of the heaters contained power cords that did not contain the -R suffix marking. Fifteen power cord sets contained the -R suffix marking . Appendix Table A-6. Power Cord Set Wire Size and Markings contains additional information on the power cord sets.

Table 7-3. Power Cord Sets

Description	Count
16 AWG	23
18 AWG or no markings	4
Suffix -R	15

Attachment plugs on the cord sets

All the cord sets except one (S26) contained nationally recognized third-party lab markings for the cord and the attachment plug. The power cord for S26 sample did not contain any markings to indicate the type of cord so it is unknown id it complies with UL 1278 - *Table 16.1, Acceptable types of cord*. All the attachment plugs were NEMA type 1-15P, which is a polarized two-conductor flat-blade plug. The attachment plugs were molded to the flexible cord as UL 1278 requires.

UL 1278, *Table 16.2 Cord wire size based on heater current rating* requires that crimps at the attachment plug be either soldered, welded, or brazed except for certain heater current ratings for specific cord wire sizes.[9] One third of the samples had not been soldered, welded or brazed.[10] Four plugs had poor soldering between the wire strands and crimp connector. Appendix Table A-7. Attachment Plug CT Observations contain the CT observations of attachment plugs.

X-rays and CT Images of the Attachment Plugs

All the attachment plugs on the heater cord sets were inspected, x-rayed, and computer tomography (CT) scanned. CT processing created detailed pictures of areas inside the attachment plug for inspection. The x-rays revealed if wire strands at the crimp to the plug blades were soldered, welded, or not and were verified with the CT scans.

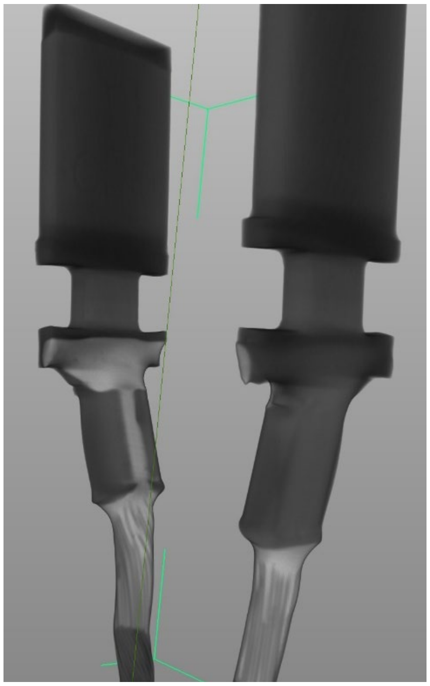
Three heater samples (S1, S8, S22) had attachment plugs with good, consistent crimps with soldering for both conductors. The solder fully filled any voids that may have been present between the wire strands before, within, and after the crimp barrel. The solder filled in the crimp barrel valleys. The crimp wings for the barrel were fully and evenly closed. Figures 7-4 to 7-6 show the power cord plugs with good crimping and soldering.

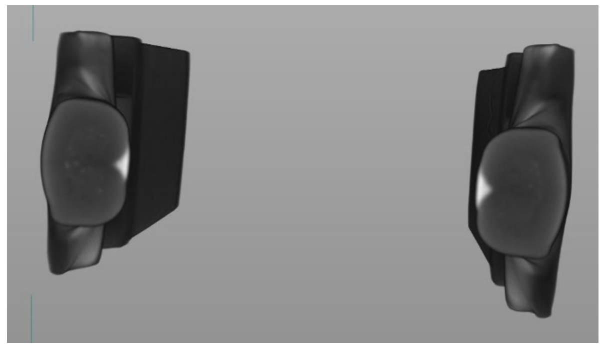
---

[9] Heaters are exempt from the requirment of either soldering, welding, or brazing the connection at the attachment plug if the heater is rated for less than 8A and uses 18 AWG cord wire, less than 10.4A and uses 16 AWG cord wire, or less than 14.4A and uses 14 AWG cord size.

[10] Heater samples S17 and S18 are rated at 700 W(5.8A) and uses 16 AWG cord size and contained solder at the attachment plugs. Heater sample S25 is rated at 1,000 W (8.3A) and uses 18 AWG cord size and did have soldering, welding, or brazing at the attachment plug. Heater sample S24 is rated at 1,200 W (10A) and uses 16 AWG cord size and contained solder at the attachment plug. No heater samples evaluated contained 14 AWG powr cord

- Solder fills the gaps between the wire strands above and below the crimp
- Any voids in the crimp are filled with solder
- The valley between the crimp wings is filled with solder
- Solder is bonded to the metal

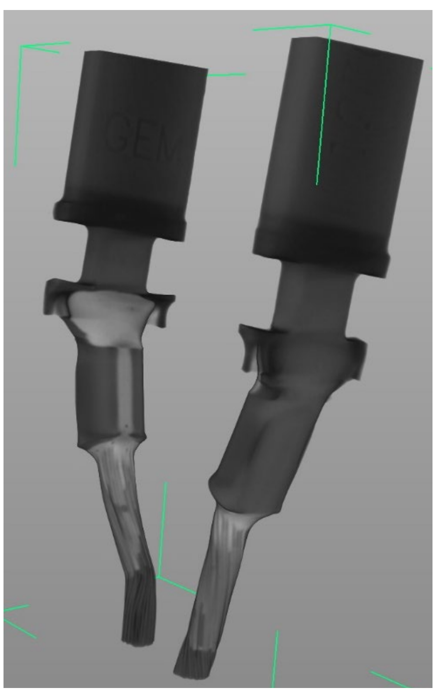


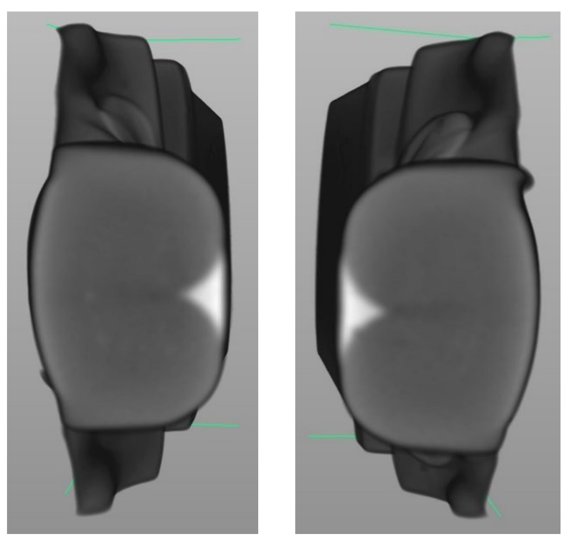


S1 – CT scan of attachment plug S8 – Cross section of crimps

Figure 7-4. S1 CT scan of the crimp connection (good crimping and soldering)

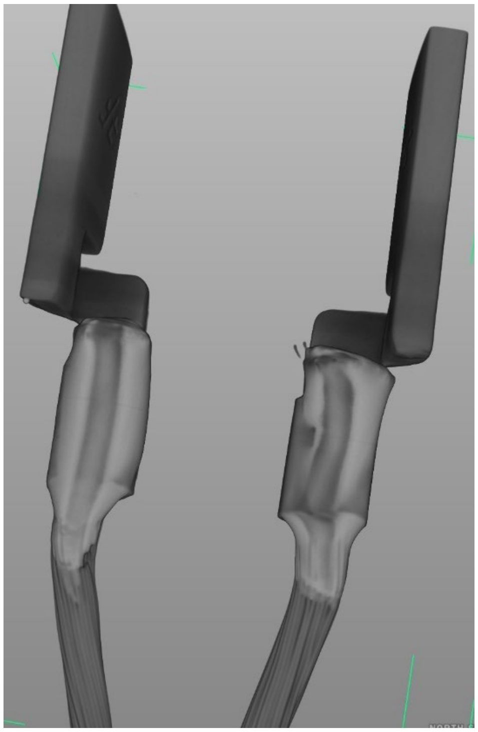
- Solder fills the gaps between the wire strands above and below the crimp
- Any voids in the crimp are filled with solder
- The valley between the crimp wings is filled with solder
- Solder is bonded to the metal



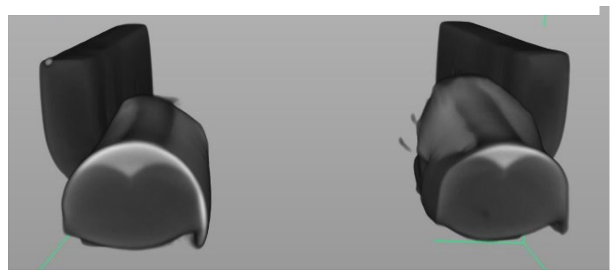


S8 – CT scan of attachment plug S8 – Cross section of crimps

Figure 7-5. S8 CT scan of the crimp connection (good crimping and soldering)



- Solder fills the gaps between the wire strands above and below the crimp
- Any voids in the crimp are filled with solder
- The valley between the crimp wings is filled with solder
- Solder is bonded to the metal



S22 – CT scan of attachment plug

S22 – Cross section of crimps

Figure 7-6. S22 CT scan of the crimp connection (good crimping and soldering)

X-ray inspections revealed that some of the soldering and welding may have been inferior for some of the power cord sets for the heaters. UL 1278 does not specify the quality of crimp connections, but rather uses a performance test to evaluate if the connection is adequate by not exceeding a specific temperature rise during a performance test.[11] Table 7-4 lists the observations of the CT images of the attachment plugs.

Almost three quarters of the attachment plug samples appeared to have voids between the wire strands within the crimp. The voids may be an indication that the crimp force may have been inadequate, thus all the wire strands were not uniformly compressed. A poor crimp can lead to a loose wire or wire strands that increases the resistance, which can overheat.

About half had asymmetric crimps where the crimp force was unevenly applied. The asymmetrical crimping may produce voids and/or damage wire strands. Asymmetric crimping may cause the wire strands to be not fully deformed to create maximum surface contact within the crimp barrel and/or over crimping to break or damage wire strands. Properly crimped connectors would closely pack the wire strands together in the connector. Improper crimping causes spacing between the wire strands resulting in higher contact resistance and heating, thus over time may lead to overheating and fire. However, proper soldering may potentially

---

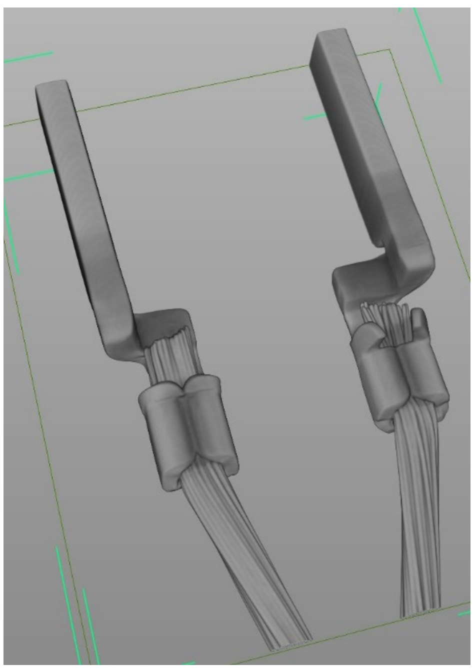
[11] UL 817, *Standard for Cord Sets and Power-Supply Cords, Section 12.2 Temperature test* requires that the connection of the conductors to the blades in a plug shall not have a temperature rise of more than 30° C under its rated current.

fill in the voids between the wire strands in some under crimping instances, thus improving the connection between the wire and the crimping terminal surfaces.

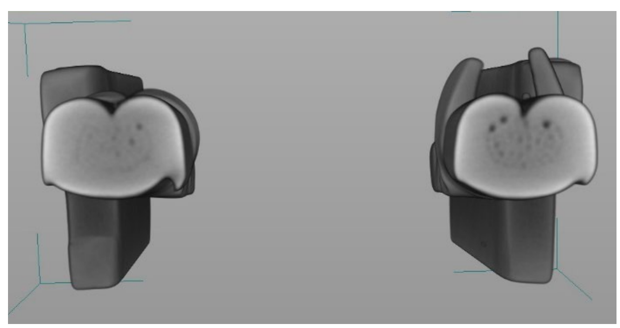
Table 7-4. CT Image Characteristics

CT Image observations	Count
Incorrect crimping tool	1
Poor soldering	4
Asymmetric	14
Voids in the crimp	20
No solder or weld	9
Long leads	2
Damaged crimp barrel/wings	1
Broken strands	2

Figures 7-7 to 7-14 show examples of poor crimps, lack of soldering, or poor soldering in the attachment plug.



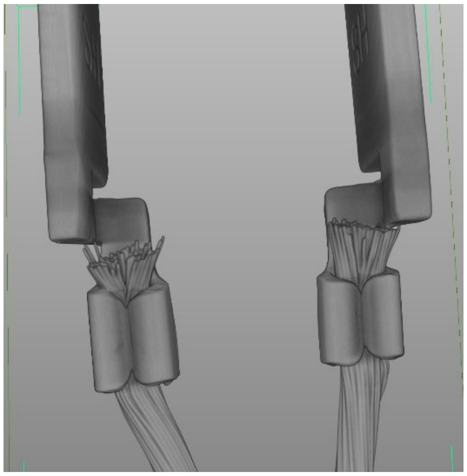
- No solder or weld
- Voids in the crimp
- Uneven crimp closure
- Damaged crimp wing



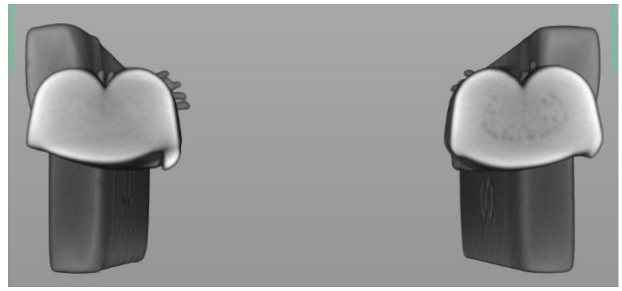
S9 – CT scan of attachment plug

S9 – Cross section of crimps

Figure 7-7. S9 CT scan of the crimp connection (no solder or welding)

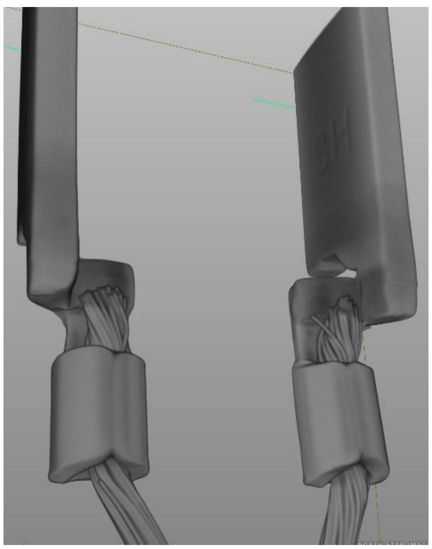


- No solder or weld
- Voids in the crimp

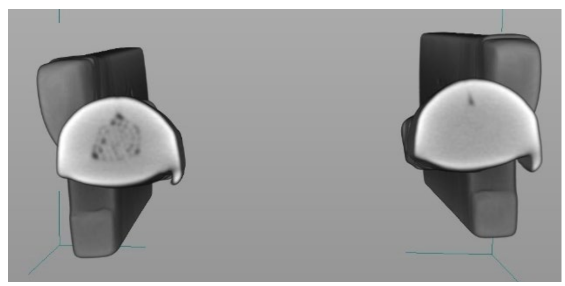


S23 – CT scan of attachment plug S23 – Cross section of crimps

Figure 7-8. S23 CT scan of the crimp connection (no solder or welding)

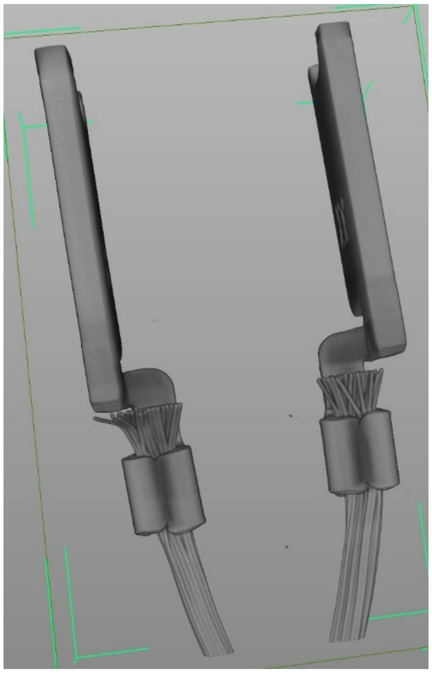


- No solder or weld
- Voids in the crimp
- Incorrect crimping

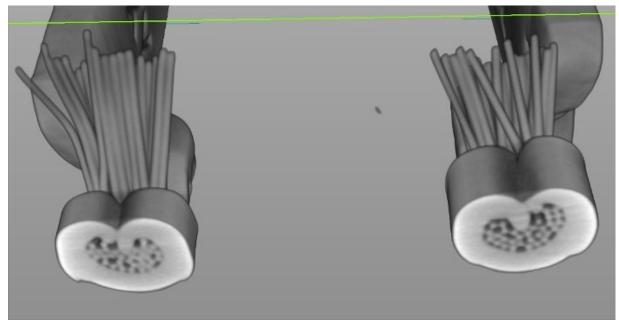


S25 – CT scan of attachment plug S25 – Cross section of crimps

Figure 7-9. S25 CT scan of the crimp connection (no solder or welding)

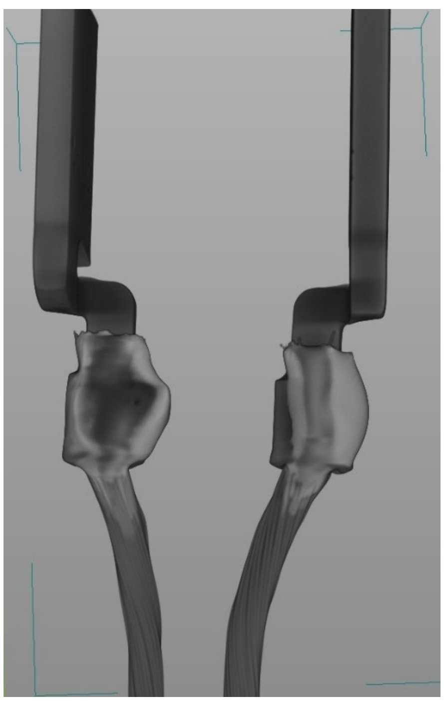


- No solder or weld
- Voids in the crimp
- Uneven crimping
- Incorrect crimping
- Long leads

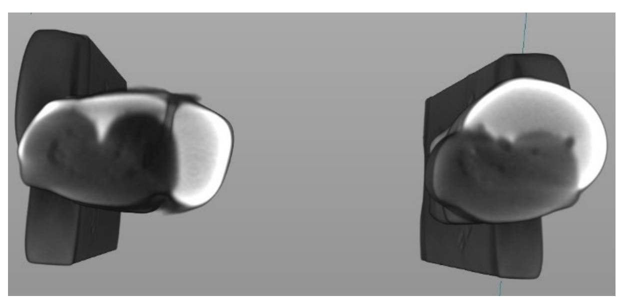


S27 – CT scan of attachment plug S27 – Cross section of crimps

Figure 7-10. S27 CT scan of the crimp connection (no solder or welding)

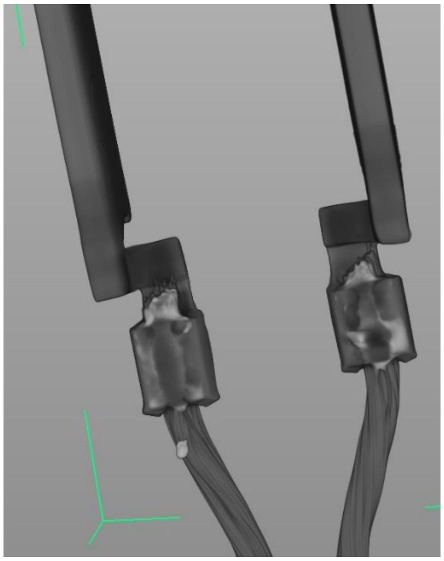


- Uneven soldering
- Voids in the crimp
- Solder does not fill in the crimp voids
- Uneven crimping

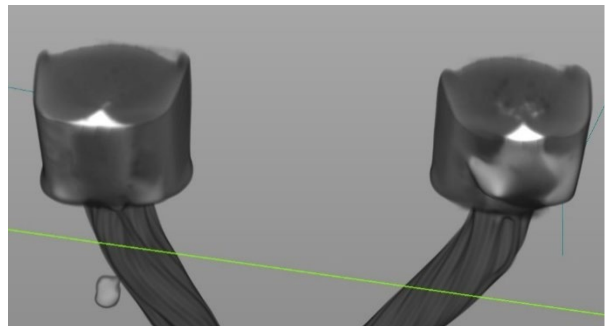


S4 – CT scan of attachment plug S4 – Cross section of crimps

Figure 7-11. S4 CT scan of the crimp connection (Asymmetrical crimping)

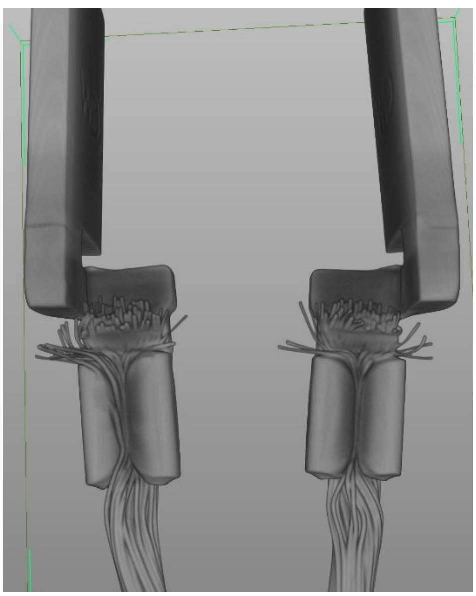


- Uneven soldering
- Voids in the crimp
- Solder does not fill in all the crimp voids
- Under crimping

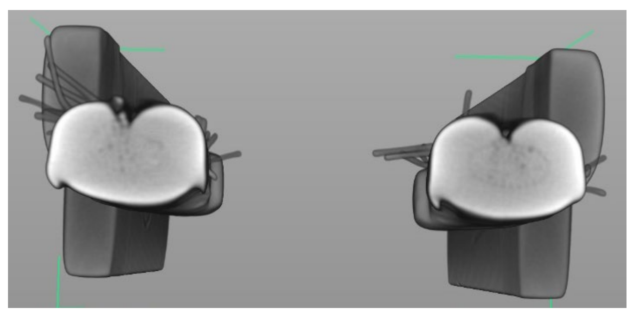


S16 – CT scan of attachment plug S16 – Cross section of crimps

Figure 7-12. S16 CT scan of the crimp connection (voids)



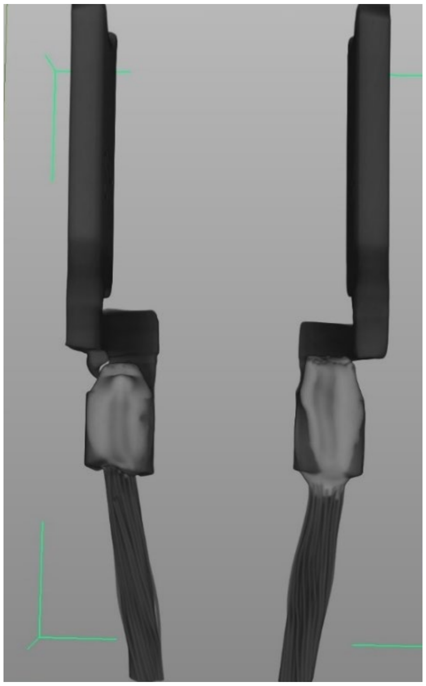
- All strands not welded
- Voids in the crimp
- Under crimping

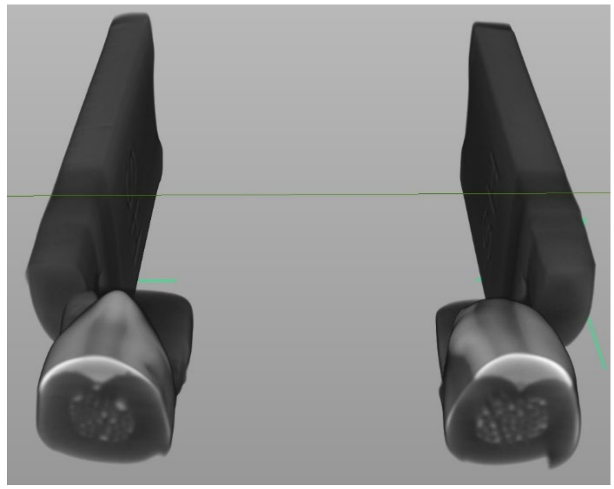


S20 – CT scan of attachment plug S20 – Cross section of crimps

Figure 7-13. S20 CT scan of the crimp connection (voids)

- Solder fills in the voids
- Under crimping
- Asymmetric crimps





S24 – CT scan of attachment plug S24 – Cross section of crimps

Figure 7-14. S24 CT scan of the crimp connection (voids)

Resistance Measurements of Plug Connections

The cold resistances of the crimp connections in the plug were estimated by taking two resistance measurements with a milliohm meter,[12] as shown in Figure 7-15. First, a fixed length of the cord with attachment plug was measured with the milliohm meter. After removing the plug, the same length of cord was measured with the milliohm meter as shown on the right side of Figure 7-15. By subtracting the resistance measurement of Length A of the cord-only from the resistance measurement of cord and plug, staff estimated the cold resistances of the plug connections.

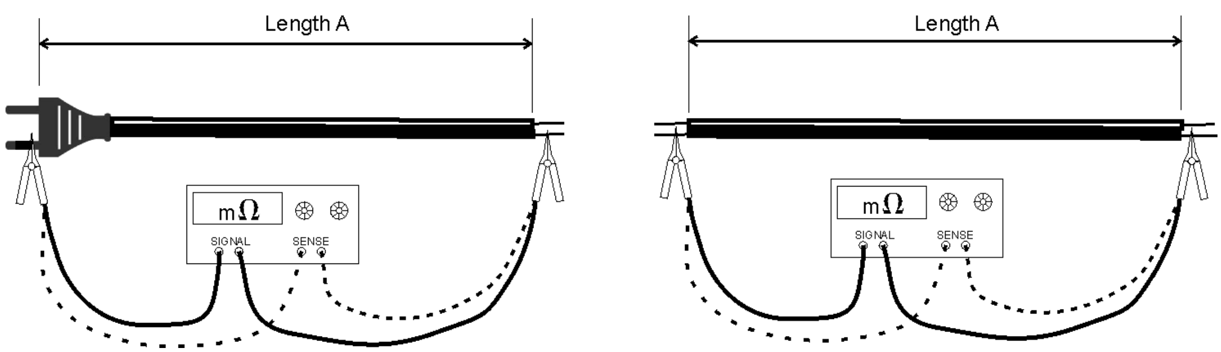


Figure 7-15. Attachment plug cold resistance measurement setup

[12] Cold resistance is the masured resistance when there is no voltage or current being applied. Resistance with the rated current through the connection may produce a different resistance measurement.

Four cord sets had a measured average cold resistance of less than 400% of the average neutral and hot wire only. As seen in the CT images, three of the samples had good solder and/or solder filled any voids in the crimps. The fourth sample showed voids and even though the solder appeared not fully bonded to the metal, it appears that it may have been sufficient to provide low resistance. Most of the samples (16) were in the range from 400% to 799%, thus posing the possibility of overheating. Three samples were over 1200%. The three samples that were over 1200% did not have any solder or welds at the crimp. Two of the samples had visible voids in the crimps as seen in CT images. Table 7-5 lists the measured resistance and the characteristics of the crimps. Appendix Table A-8. Milliohm Measurements contains the milliohm measurements of the attachment plugs.

Table 7-5. Resistance Measurements

Plug and Cord (percentage)[13]	Count	Voids	No solder or weld	Voids and no solder/welds	
< 400%	4	2	0	0	0%
400% to 799%	16	11	3	3	18.8%
800% to 1199%	4	2	3	2	50%
> 1200%	3	2	3	2	66.7%

<u>Thermal Imaging of Plugs under Electrical Load</u>

Thermal imaging of plugs under an electrical load test was conducted on selected cord sets (highest, average, and lowest change in resistance measured) from the heaters. The electrical load tests were to examine the heating of the attachment plug samples. The cord sets were 12 inches in length, except for S3 (11"), S4, S8 (8.5"), and S7, S9 (10.5"), and at the maximum rated current of the product (Test 1) and 22 A (Test 2) to determine if there is a detectable relationship between resistance in the attachment plug and temperature.[14]

An infrared (IR) camera was used to observe the relative temperatures on the attachment plugs and the cords as shown in Figure 7-16. A DC power supply and electronic load were connected to the power cord to energize the power cord and apply a resistive load as shown in Figure 7-17. The plug prongs were shorted with a piece of solid 12 AWG copper wire to provide a closed circuit from one conductor to the other conductor.

[13] Average (hot plug mΩ/ wire only mΩ)% + (neutral plug mΩ/wire only mΩ)%

[14] 22A is about 150% of 15A receptacle since 15A is the most common rceptacle in a home

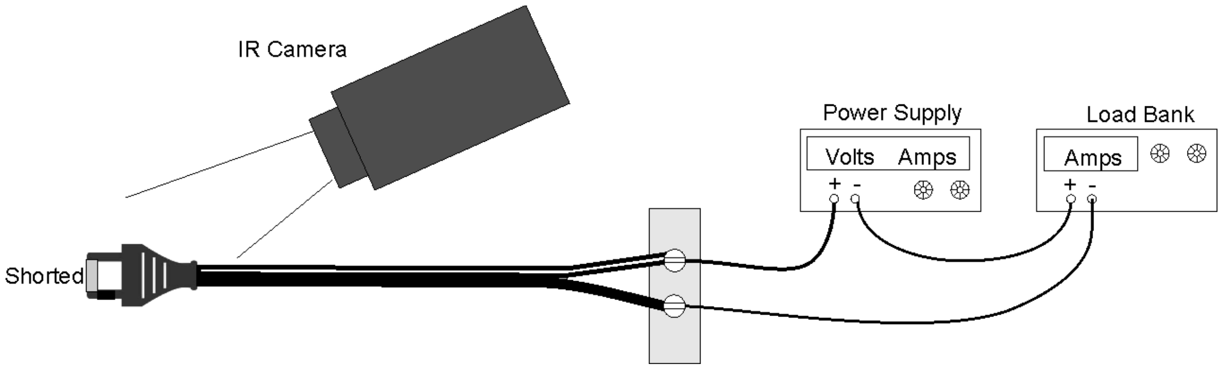
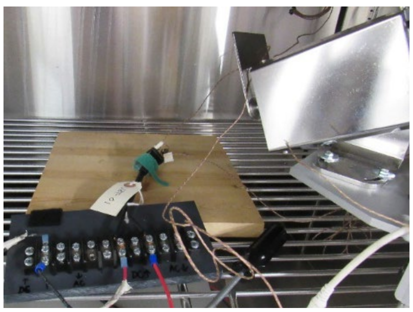


Figure 7-16. Attachment plug load test


Cord sample and IR camera

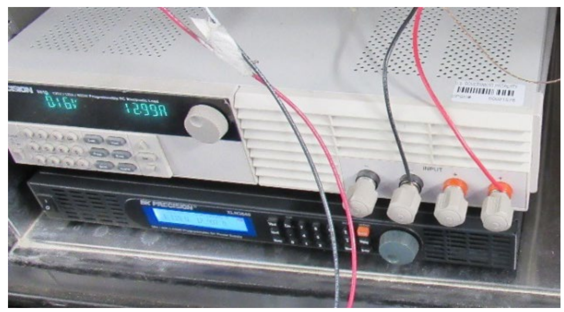

Power supply and load bank

Figure 7-17. Setup for load test

Table 7-6 summarizes the observed temperatures over ambient. At the heater current rating (Test 1), generally temperatures increased with plug resistance. Increasing the load current to 22 A increased the change temperatures as the percent resistance increased as shown in Figure 7-18. Between Test 1 and Test 2, the highest resistance plug had a 23.6°C increase in temperature when increased to 22 A and the lowest resistance plug had a 12.9° C increase in temperature. Figures 7-19 to 7-24 show IR images of power cord samples.

Table 7-6. Load Test Temperature Measurements

		Test 1		Test 2	
Sample Number	Hot/Neutral Average Resistance Percent Increase	Load Current (A)	Plug temp above ambient (°C)	Load Current (A)	Plug temp above ambient (°C)
S12	1932%	13	18.6	22	42.2
S7	1318%	13	12.6	22	26.8
S9	1262%	13	10.7	22	31.7
S21	1029%	13	12.3	22	27
S11	934%	13	10.9	22	24.4
S23	811%	13	12.2	22	25.1
S2	810%	13	11.4	22	23.5
S19	785%	13	7.7	22	23.3
S26	770%	17	27.1	22	37.8
S6	659%	13	9.1	22	21
S16	615%	13	10.3	22	25.4

		Test 1		Test 2	
Sample Number	Hot/Neutral Average Resistance Percent Increase	Load Current (A)	Plug temp above ambient (°C)	Load Current (A)	Plug temp above ambient (°C)
S27	612%	13	12.2	22	26.5
S3	600%	13	8.8	22	22.6
S20	575%	13	8.4	22	19.9
S25	575%	9	8.1	22	28.8
S18	565%	6	3.6	22	23.7
S5	528%	13	7.8	22	21.9
S24	502%	10	4.6	22	20.1
S13	501%	13	6.8	22	20.6
S8	475%	13	10.3	22	18.6
S10	444%	13	9.5	22	21
S17	444%	6	3.2	22	23.9
S4	428%	13	9.7	22	20.7
S22	397%	13	9	22	19.2
S14	393%	13	8.7	22	20.5
S1	367%	13	8.7	22	18.8
S15	354%	13	8.6	22	21.5

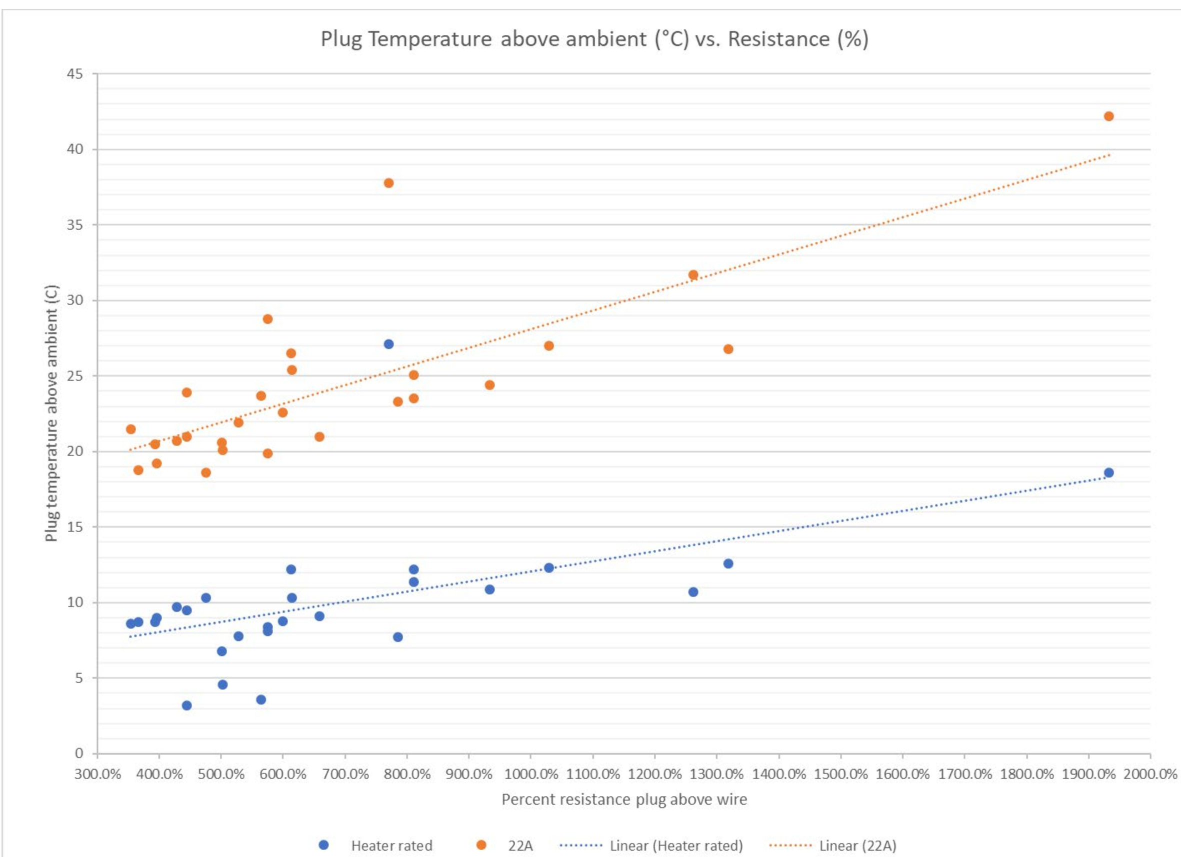
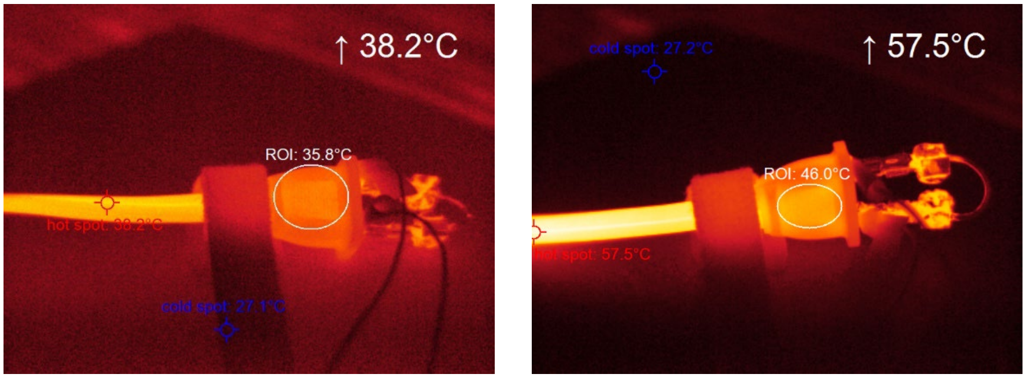


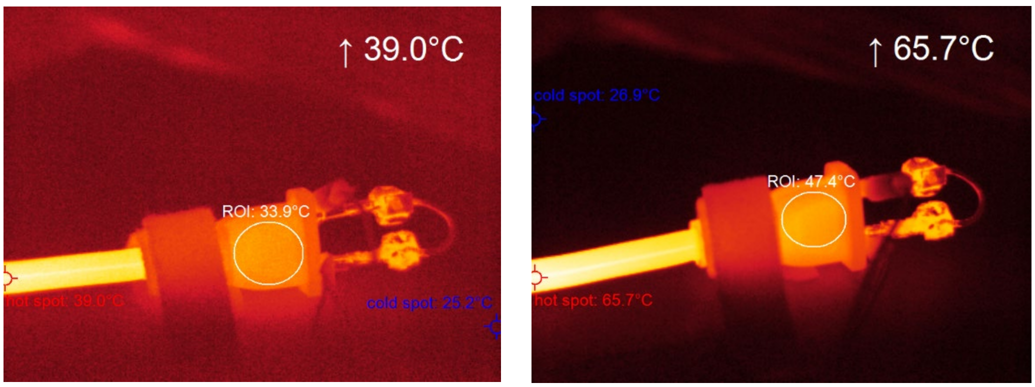
Figure 7-18. Temperature above Ambient vs. Resistance



S1 (13 A) Plug 35.8° C; Wire 38.2° C

S1 (22 A) Plug 46.0° C; Wire 57.5° C

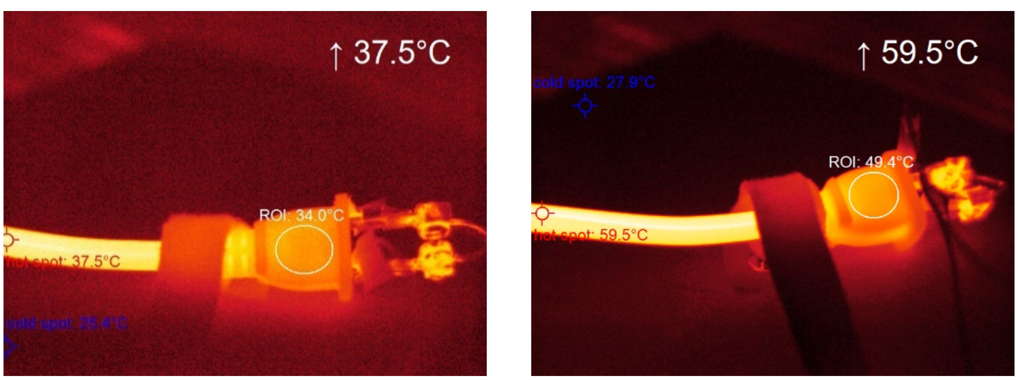
Figure 7-19. IR images for S1 at 13 A and 22 A



S14 (13 A) Plug 33.9° C; Wire 39.0° C

S14 (22 A) Plug 47.4° C; Wire 65.7° C

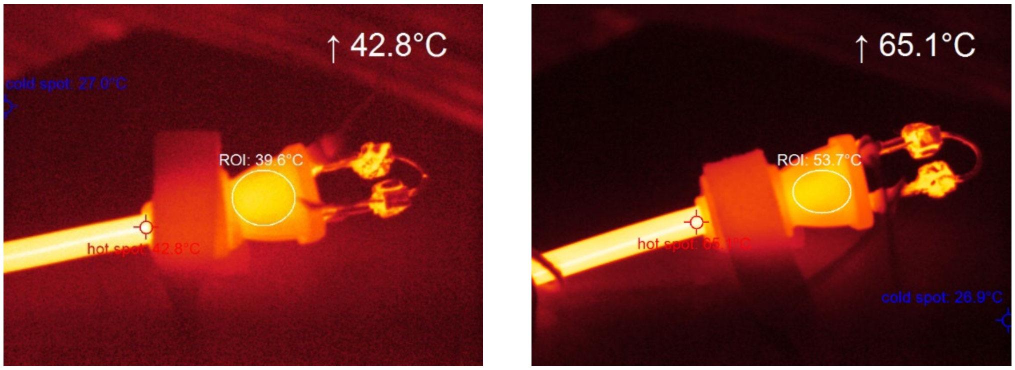
Figure 7-20. IR images for S14 at 13 A and 22 A



S15 (13 A) Plug 34.0° C; Wire 37.5° C

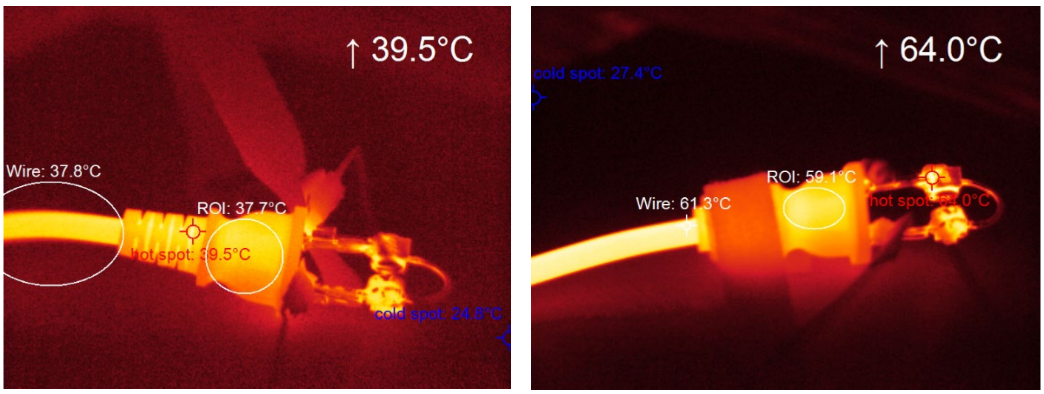
S15 (22 A) Plug 49.4° C; Wire 59.5° C

Figure 7-21. IR images for S15 at 13 A and 22 A



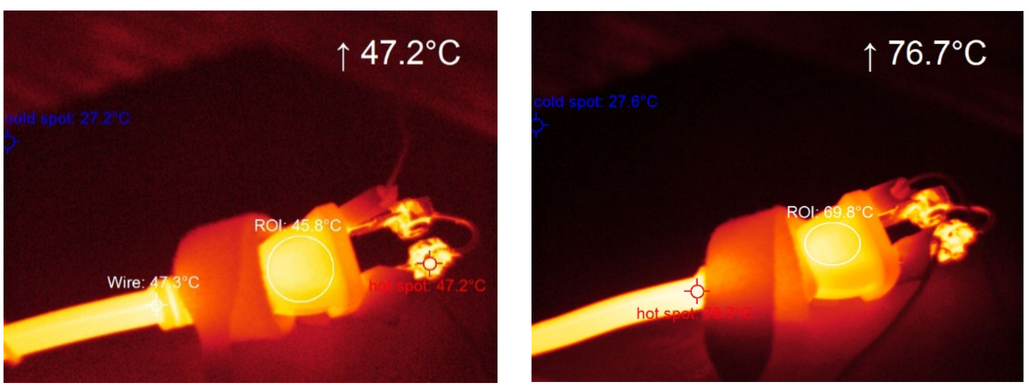
S7 (13 A) Plug 39.6° C; Wire 42.8° C S7 (26 A) Plug 53.7° C; Wire 65.1° C

Figure 7-22. IR images for S7 at 13 A and 22 A



S9 (13 A) Plug 39.5° C; Wire 37.8° C S9 (26 A) Plug 59.1° C; Wire 61.3° C

Figure 7-23. IR images for S9 at 13 A and 22 A

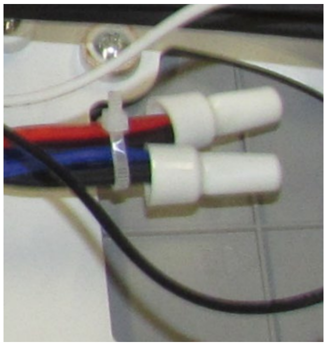


S12 (13 A) Plug 45.8° C; Wire 47.2° C S12 (22 A) Plug 69.8° C; Wire 76.7° C

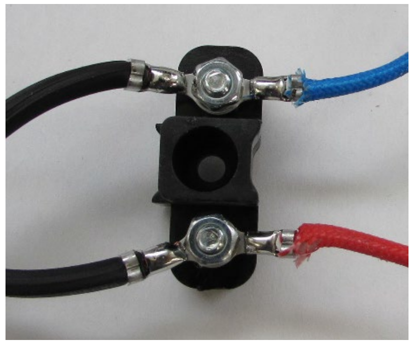
Figure 7-24. IR images for S12 at 13 A and 22 A

Power cord sets to internal wiring connection

Staff found that the type of connection between the power cord to the internal wiring was either a butt crimp connection, ring and block connection, spade connector, set screw block, soldered to printed circuit board, or barrel crimp connection as shown in Figure 7-25. These are all acceptable connections within the standard except configurations where the power cord set connection to the internal wiring was not soldered/welded/brazed as required.

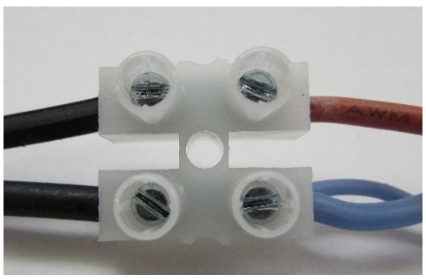


(a) Butt crimp connection

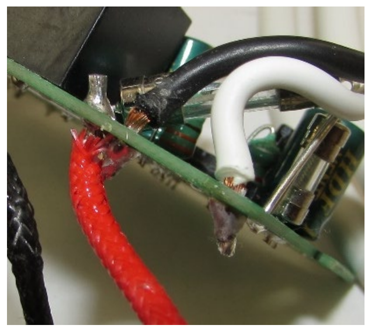


(b) Ring and block connection

(c) Spade connection



(d) Set Screw block connection



(e) PCB connection

(f) Barrel crimp connection

Figure 7-25. Power cord connection to internal wiring

Staff observed that the various heater samples examined had different design criteria for connections between opposite polarity. One of these design criteria was the distance between opposite polarities. The distance between the power cord connections was the greatest when one power cord conductor was connected to an electrical component such as a safety device and the other end was connected to a different component, such as the heating element or power switch. Connections of opposite polarity that are not in close proximity to each other offer a lower chance of electrically shorting if the connection fails.

The distance between the power cord connection conductors varied from 0.64 mm to >500 mm. The closer conductor connections were usually where the two conductors were secured parallel to each other as shown in Figure 7-26. The connections were insulated with shrink tubing and a fiberglass sleeve to prevent shorting. The power cord connections with maximum separation between opposite polarities occurred when the conductors were connected to separate components within the heater as shown in Figure 7-27.

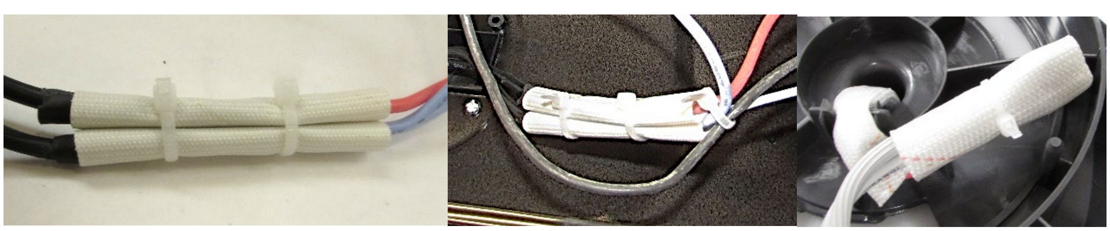
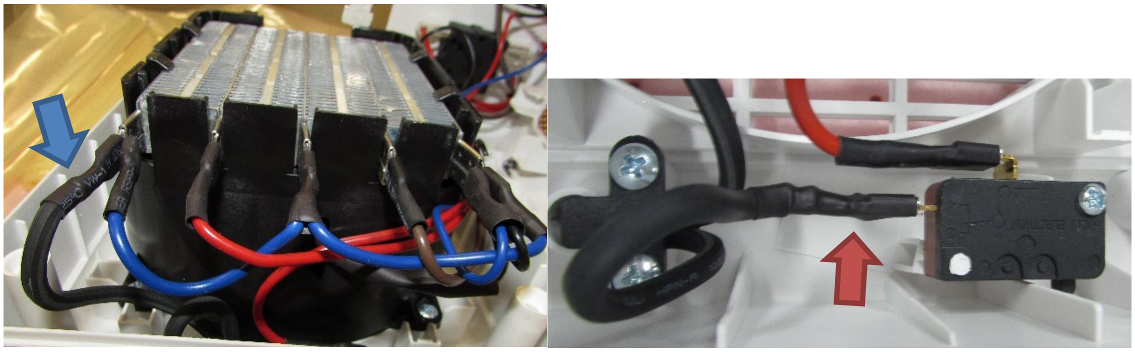
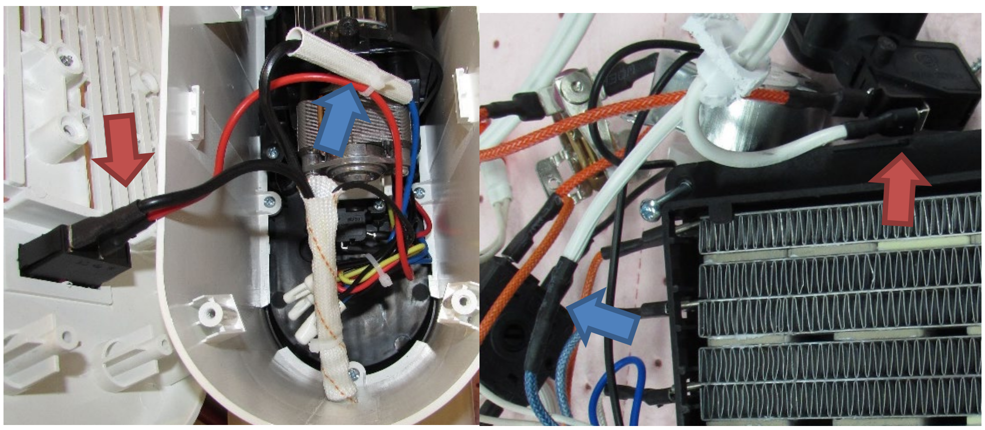


Figure 7-26. Power cord connections with minimum separation of conductors



(a) One conductor connected to the heating element and other connected to the tip-over switch



(b) One conductor connected to power switch and other connected to internal wire

Figure 7-27. Power cord connections with maximum separation of conductors

Some heater power cord samples contained pigtail connections from the power cord's first connection to the internal wiring as shown in Figure 7-28. These short wire connections (pigtail) are usually connected with a butt connector to the remainder of the internal wiring. This satisfies the UL 1278 requirement for soldering the first connection between the power cord and the internal wiring, but does not have the same robust construction for the remainder of the rated current carrying connections.

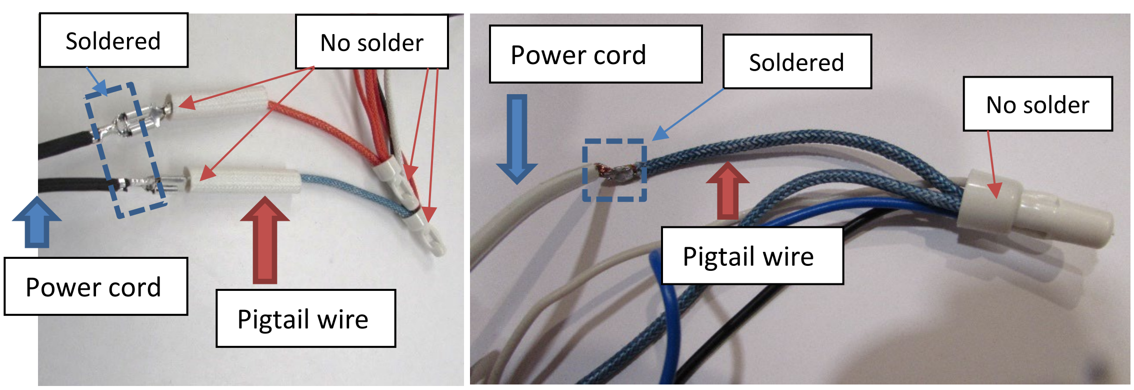


Figure 7-28. Power cord connections with pigtail wires

The connections of the power cord sets to the internal wiring were examined visually to determine if the crimps/connections were also soldered or welded. Improved contact through soldering or welding provides a lower resistance connection in the event of a poor crimp, but soldering provides the benefit of filling any voids in the crimp whereas welding does not.

Nineteen heaters had soldered connections between the power cord and the internal wiring, as indicated in Table 7-7. Staff observed that for some spade connections to the internal wiring, the power cord wire to spade connection were soldered, but the internal wiring to the spade connector was not soldered, which is not required by UL 1278. Appendix Table A-9 Power Cord Connection Type and Separation contains additional data on the power cord connections.

Table 7-7. Power Cord Connections

Power Cord Connections	Count
Soldered at cord side (both conductors)	19
Soldered at only one conductor	1
No solder	7
Distance Between Conductors of Opposite Polarity	**Count**
>500 mm	14
Greater than 10 mm and less than or equal to 50 mm	6
10 mm and less	6
Varied	1

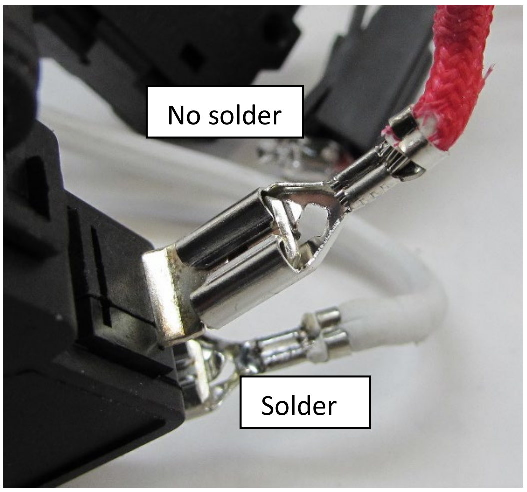
7.3 INTERNAL WIRING ANALYSIS

The internal wiring within the heater samples was examined. Staff counted the number of electrical connections that carry the rated current for each heater sample. For all of the heater samples, there was a minimum of four mechanical connections to a maximum of 14 connections to complete the electrical circuit through the various components, such as safety devices, fan speed selector, heat setting selector, and thermostat. The average number of connections was 11. A higher number of connections in a heater offers the potential of a higher risk of failure from an overheated connection, especially if the connections are poorly crimped, loose, and/or not soldered.

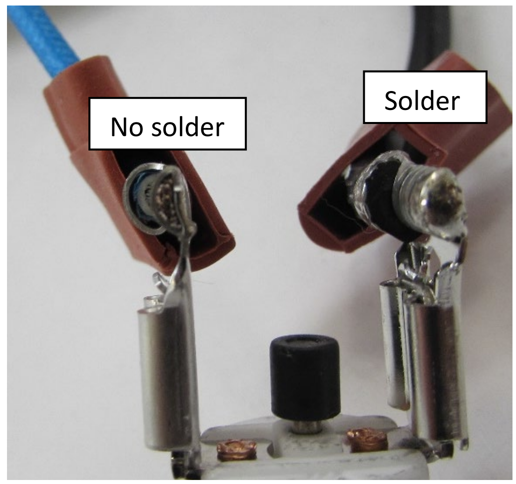
The internal wiring connections and crimp connections were examined for the heater samples. The following was observed in some of the heater samples:

- Poor crimping and loose wire strands (Figure 7-29)
- The internal wire connection side to the power cord was not soldered (Figure 7-30)
- Loose spade connections

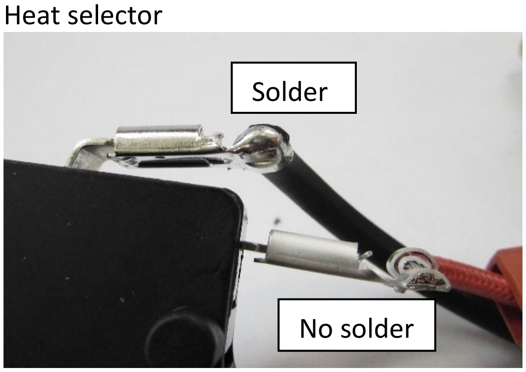
Figure 7-29. Poor crimp connection



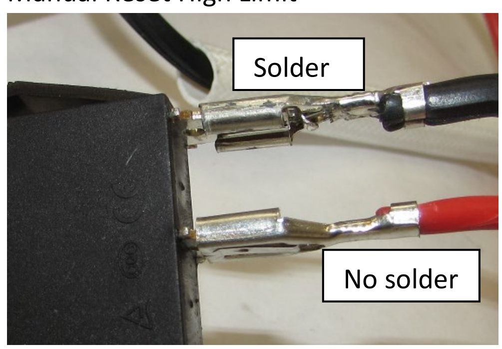
Heat selector



Manual Reset High Limit

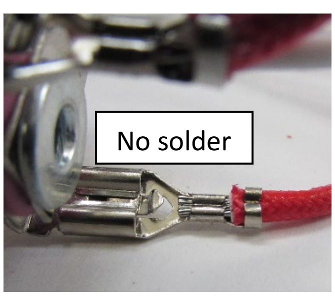


Tip-over switch

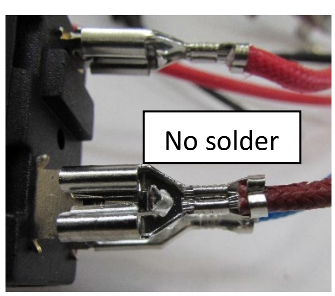


Power switch

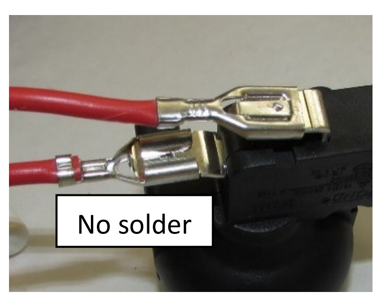
(b) No solder for internal connection after the power cord connection



Regulating thermostat



Heat selector



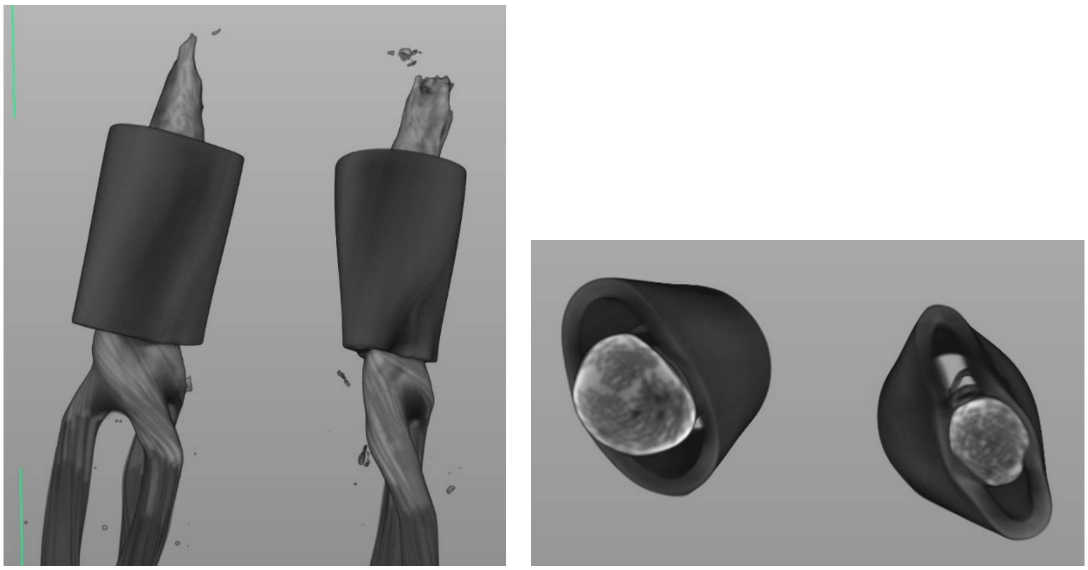
Tip-over switch

(c) Rated current connections not soldered

Figure 7-30. Internal connections (soldered or not soldered)

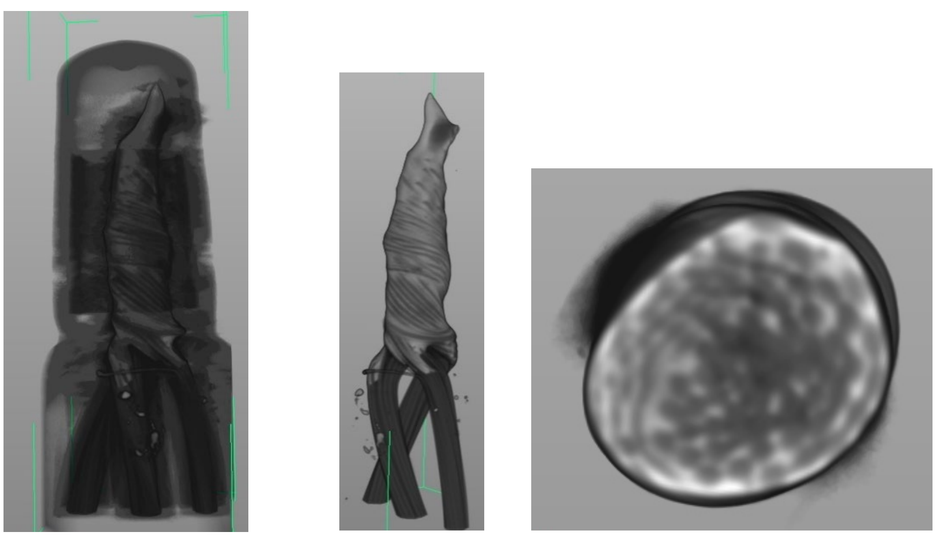
Butt Crimp Connectors Analysis

Butt crimp connectors are used for the internal wiring in some of the heater samples to join multiple conductors. Three heater samples contained butt connections where the connections were fully soldered as shown in Figures 7-31 to 7-33. These butt connections are examples of a high-quality connection.



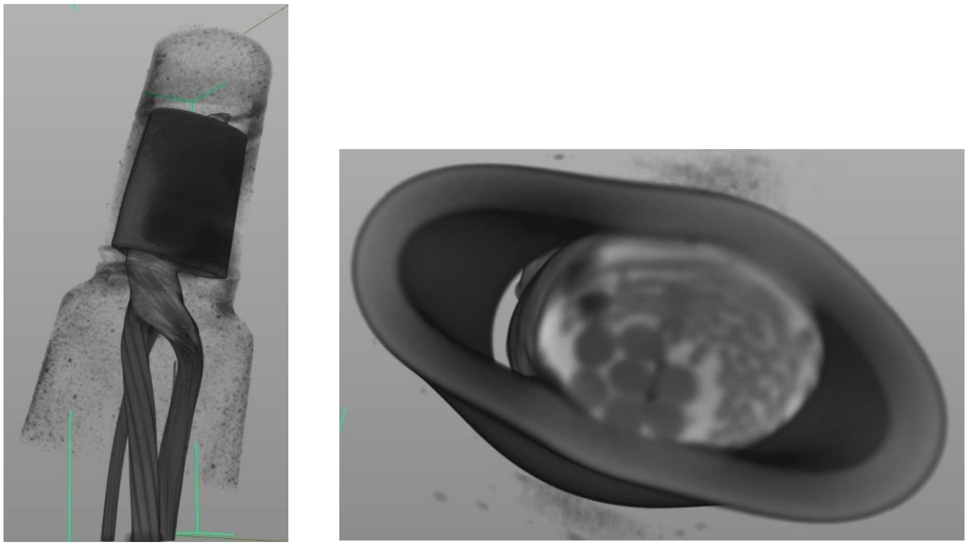
(a) CT of butt connections (b) Cross section of butt connections

Figure 7-31. S1 CT image of butt connections



(a) Butt connection (b) soldered (c) Cross section of butt connection

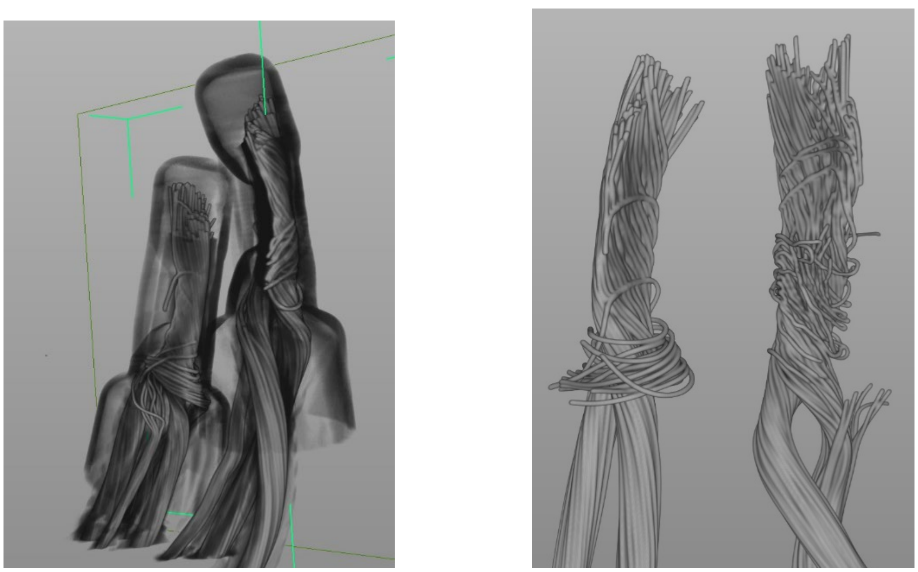
Figure 7-32. S8 CT image of butt connection



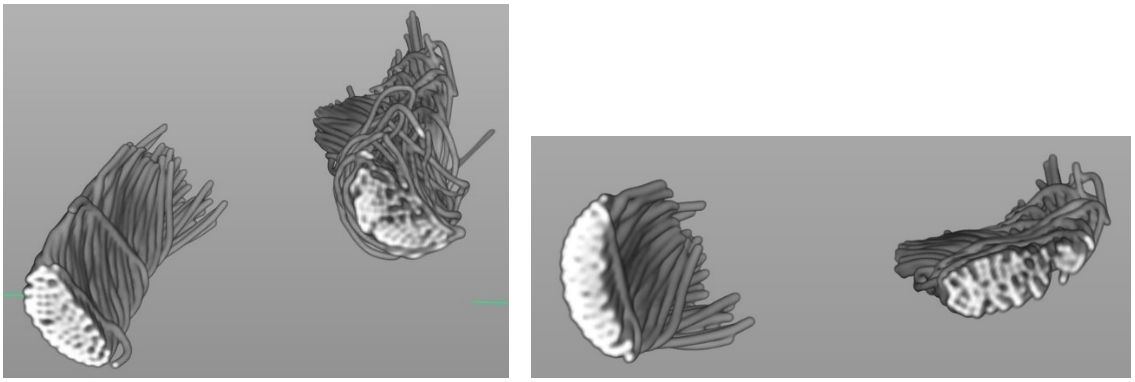
(a) Butt connection (b) soldered

Figure 7-33. S3 CT images of butt connection

There were six heaters samples that contained crimped butt connectors that were not soldered and showed evidence of voids between the wire strands as shown in Figures 7-34 to 7-39. A poorly crimped butt connection has the potential to overheat.

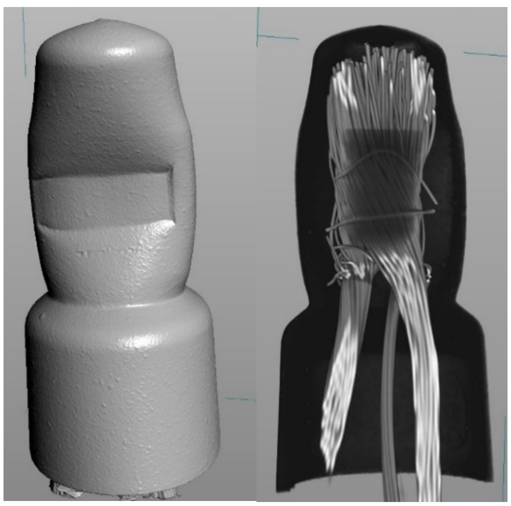


(a) Hot and neutral butt connectors (b) CT image of butt connection



(c) CT cross section of the hot and neutral butt connections

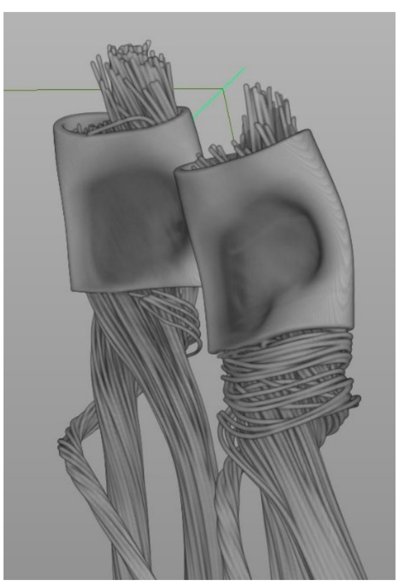
Figure 7-34. S14 CT image of butt connections



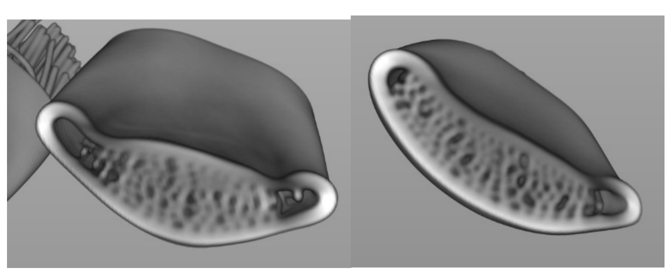
(a) CT image of butt connection

(b) Cross section of butt connector

Figure 7-35. S13 CT image of butt connections

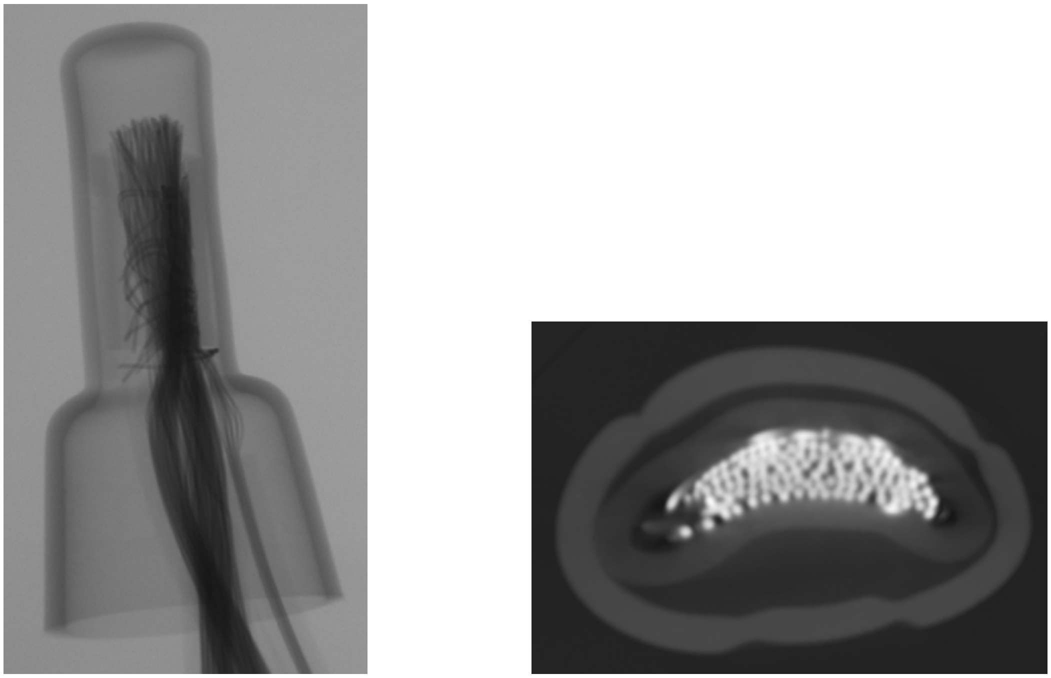


(a) CT image of butt connections



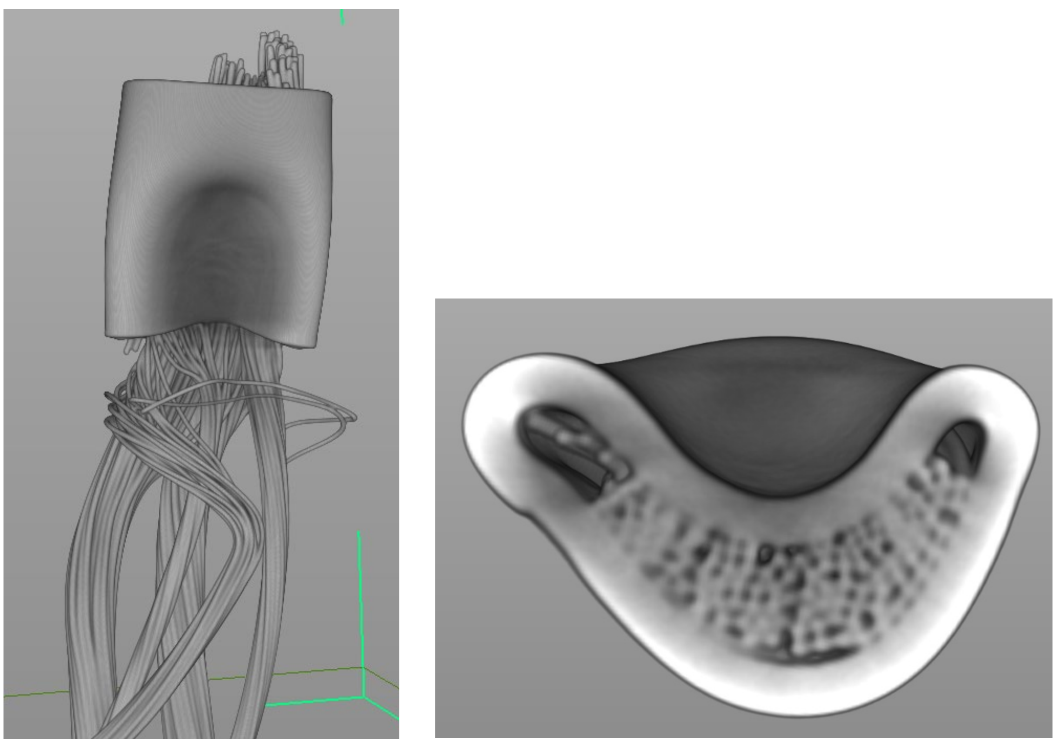
(b) Cross section of butt connectors

Figure 7-36. S22 CT image of butt connections



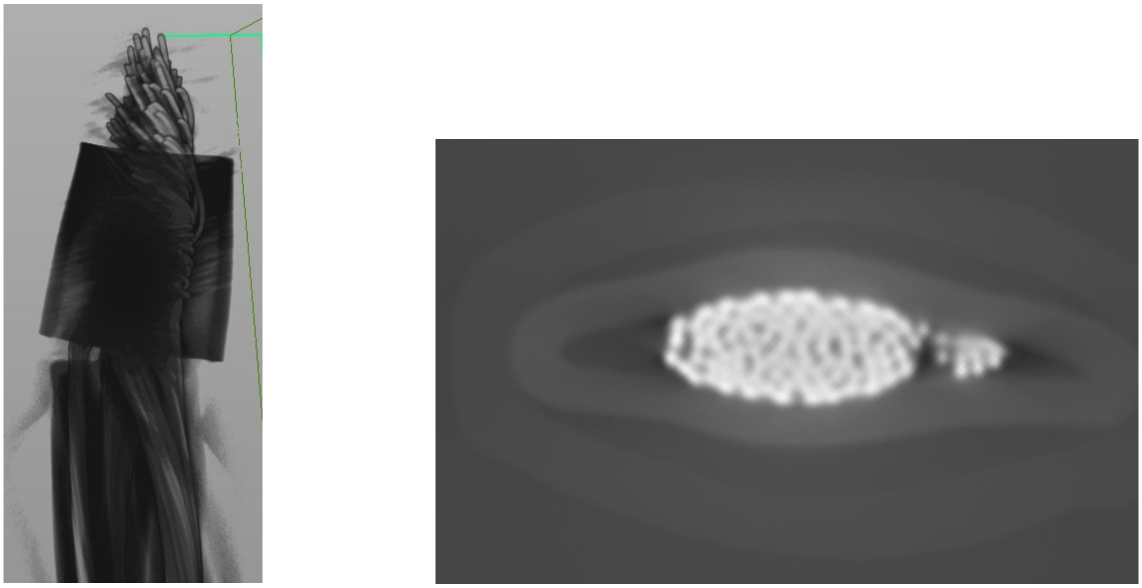
(a) X-ray image of butt connection (b) CT cross section of butt connector

Figure 7-37. S26 CT image of butt connections



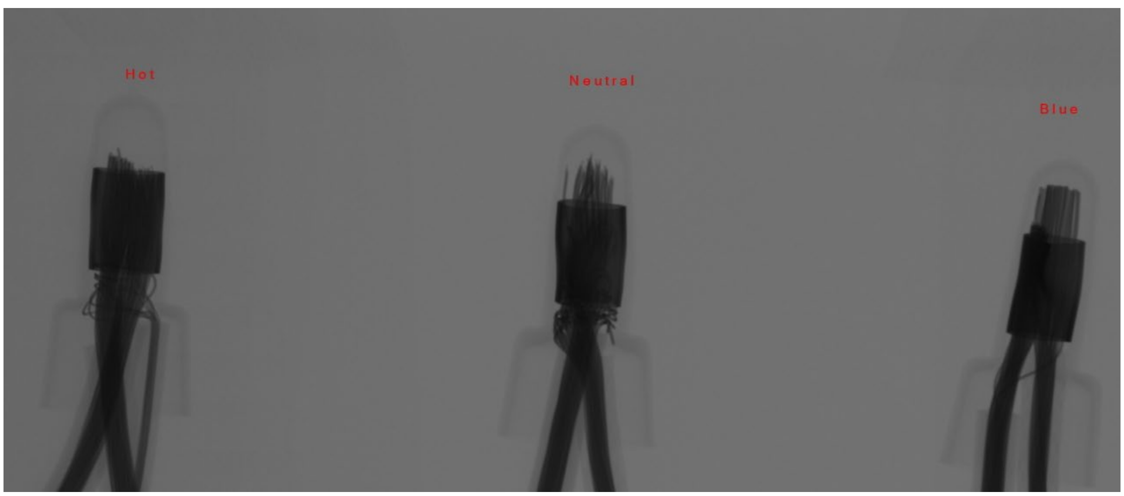
(a) CT image of butt connection (b) CT cross section of butt connector

Figure 7-38. S23 CT image of butt connections

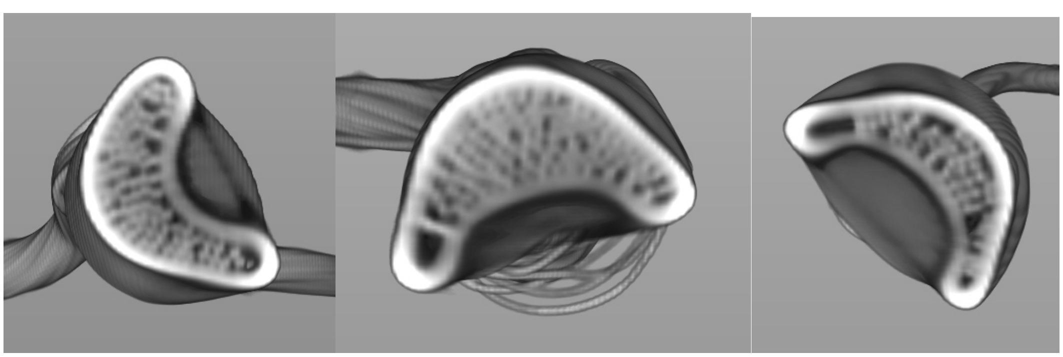


(a) CT image of butt connection (b) CT cross section of butt connector

Figure 7-39. S5 CT image of butt connections



(a) CT image of butt connection



(b) Cross section of butt connectors

Figure 7-40. S21 CT image of butt connections

Safety Device Connections

The heater samples had up to three different safety devices. Heaters with safety devices in series typically would be configured to de-energize the heating element or the entire heater if any of the safety devices activated or tripped. These safety devices typically carry the rated current of the heater.

Two-pole safety devices may use thermistors to monitor the temperatures in the heater. These heaters used control boards to monitor the various safety devices and the control board would trigger to remove power from the heating element or the entire unit if the signal exceeded the set point.

Five heater samples with mechanical tip-over devices had both connections soldered. Twelve heater samples did not have either tip-over device connection soldered. Five heater samples with one-shot devices (nondigital) had both connections soldered. Twelve heater samples did not have either one-shot device connection soldered. Four heaters with high-limit devices had both connections soldered. Twelve of the 22 heater samples did not have either high-limit device connection soldered. Six of the 27 heater samples had all the safety device connections soldered.

The rated current is carried through the safety devices, and the connections to these safety devices pose the same risk of poor connections with power cords. UL 1278 requires soldering/welding/brazing for heater power cord sets to improve the connection, thus decreasing the resistance and lowering the risk of overheating. UL 1278 does not require internal rated current connections to be soldered, except for the first connection between the power cord set to the internal wiring. Appendix Table A-10. Safety Devices Wiring Connections contain additional information on the connections for the safety devices. Table 7-8 lists the connections for the safety devices.

Table 7-8. Safety Device Connection (nondigital)

Tip-over Switch Connections	Count
Soldered at both connections	5
Solder at only connection	5
No solder	12
N/A	5
One-shot Device Connections	Count
Soldered at both connections	5
Solder at only connection	1
No solder	12
N/A	9
High-Limit Device Connections	Count
Soldered at both connections	4
Solder at only connection	1
No solder	12
N/A	10

Heating Element Connection Analysis

The majority of the heater samples (23) used spade connections to connect the wiring to the heating element. If the heater had multiple heat setting output, there were more than two connections to the heating element. Six of 27 heater samples had all the connections soldered. Two of the 27 heater samples had only some the heating element connections soldered. Nineteen of the 27 heater samples did not have any of the heating element connections soldered.

The rated current is carried through the heating element, and the connections to these safety devices pose the same risk of poor connections with power cords. UL 1278 does not require internal rated current connections for the heating element to be soldered. Appendix Table A-11. Heating Element Connections contain additional data on the heating element connections. Table 7-9 lists the connections for the heating elements.

Table 7-9. Heating Element Connection

Heating Element Connection	Count
Soldered at heating elements	6
Solder at only some heating element connections	2
No solder	19

Heaters require multiple connections to multiple components to complete the electrical circuit. Depending on the rated current of the heater, some connections may carry up to 12 A, thus presenting a risk of overheating and possibility of fire if a connection fails. UL 1278 only specifies soldering/welding/brazing of connections for the attachment plug for power cord sets and the first connection from the power cord to the heater's internal wiring. Only three of the 27 heater samples had soldered all the rated current connections in the heater and the power cord, thus providing a lower risk of fire from an overheated connection.

7.4 PLASTIC FLAMMABILITY

The plastics in the heater samples were evaluated for flammability using two UL standards as a guide, UL 746C Section 5.3 parts a and c and portions of UL 94 Section 8 *20 mm Vertical Burning Test; V-0, V-1, or V-2* to classify the plastic's flammability.[15] The Open Flame Test

[15] The UL 94 test procedures and classification criteria were used as a means of characterizing the performance of the plastic and not intended as a strict classification of the plastic's flammability. At least one variance from the procedures is that the samples were taken from the end-product whereas UL 94 classifications are based on specimens that are "…cut from sheet material, or are to be cast or injection, compression, transfer or pultrusion molded to the necessary form."

evaluated the response of plastic to an open flame. The Glow Wire Test simulated a high-resistance connection in direct contact with the plastic.

Glow Wire Test

One of each heater model was disassembled, and the plastic components were removed and weighed to compute the total amount of plastic for each model (Table 7-10).[16] Two plastic samples from each plastic component were cut for the Glow Wire Test. The size of the samples varied depending on the size and shape of the original plastic component.

Table 7-10. Total Plastic Weight for the Heater Samples

Sample Number	Total Plastic Weight (g)	Sample Number	Total Plastic Weight (g)
S1	1,274	S15	66
S2	1,628	S16	95
S3	435	S17	268.5
S4	1,389.5	S18	86.5
S5	935	S19	555
S6	1,698	S20	168.5
S7	1,065	S21	474.5
S8	1,774.5	S22	187.5
S9	622.5	S23	618.5
S10	488	S24	1,334
S11	2,753.5	S25	364.5
S12	1,348.5	S26	1,070
S13	1,338.5	S27	1,344
S14	710		

The temperature of the glow wire was set at 750°C and a pressure of 1N was applied on the plastic samples as specified in UL 746C. Cheesecloth was placed directly below to the sample as a fire indicator from any dripping plastics. If the sample ignited, it was monitored for 60 seconds, if it was still burning, the sample was manually extinguished. Figure 7-41 shows testing of plastic from sample S2.

[16] Knobs and plastic components too small to be tested were not included as the total weight

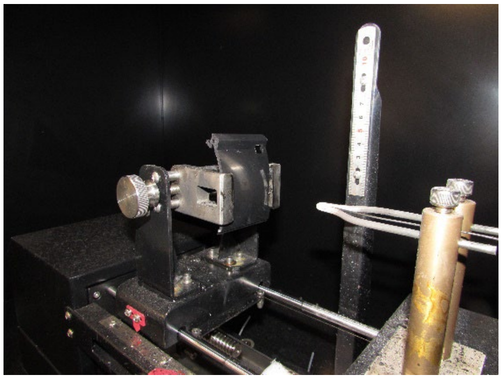
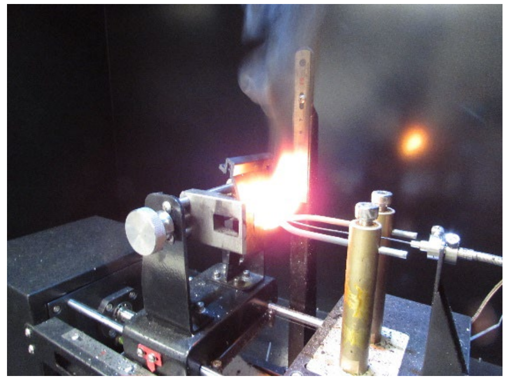



Figure 7-41. Plastic sample from S2 heater sample being tested in the Glow Wire Tester

In some cases, there were variations in performance between test sample 1 and test sample 2. The ignition times were consistent, but the extinguishment times varied between samples. This may be caused by the various thickness of the plastic samples. The ignition of the indicator cheesecloth below the sample also varied in some cases. For some plastic components, only one sample was tested due to limitations on the size of the plastic component.

Twenty heater samples contained some plastic component that ignited and burned for more than 60 seconds. Only one heater sample (S19) did not have any plastic ignite or burn for more than 30 seconds. The plastic flammability and its proximity to potential ignition sources, such as wiring, electrical components, and connections, significantly determines the fire risk, but heaters with less flammable plastic would provide smaller fuel loads in the event of overheating or a fire.

Nine heater samples (S2, S4, S5, S17, S23, S24, S25, S26, and S27) had plastics that ignited and dripped flaming plastics that ignited the cheesecloth below. Figure 7-42 shows open flame testing where the plastic sample ignited and continued to flame after 30 seconds and dripped flaming plastic onto the cheesecloth. Flaming dripping plastics promotes the possibility of flame spread within a product and to nearby combustibles. The results of the glow wire testing are shown in Appendix Table A-12.

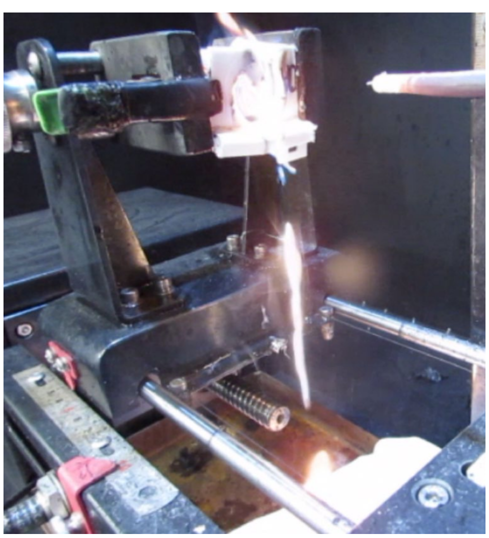


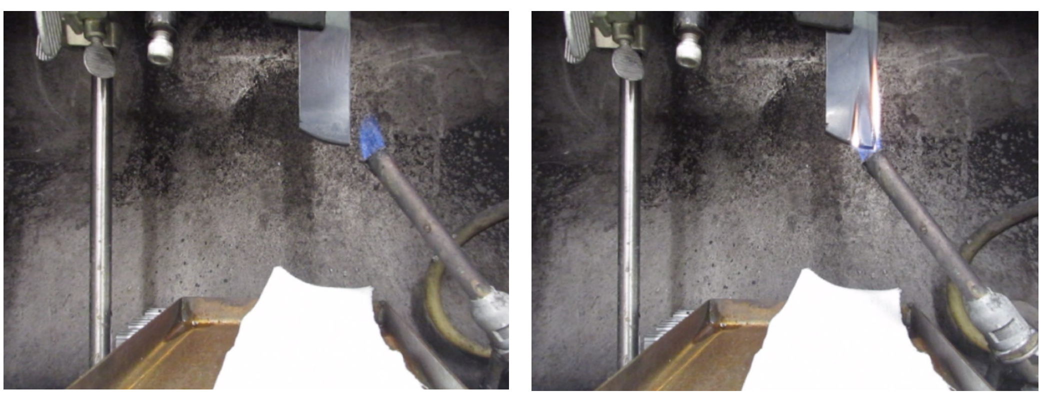

Figure 7-42. Plastic samples with flaming dripping plastic

Open Flame Testing

Similar to the glow wire test preparation, two samples from each plastic component were cut from the heater samples. The size of the sample varied depending on the size and shape of the original plastic component. Two plastic samples were tested if enough material was present.

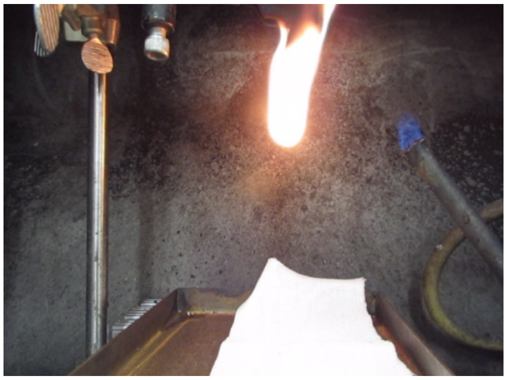
A 20-mm methane flame test was conducted on the plastic samples placed in a vertical orientation. The flame was set at 20-mm with the burner set at about 45-60° from horizontal depending on the shape of the test sample. Cheesecloth was placed directly below the sample as a fire indicator for dripping plastics. The open flame was brought into contact with the lower edge of the plastic sample for 30 seconds and then was withdrawn. If the plastic sample did not ignite or self-extinguished within 30 seconds after the withdrawal of the source flame, a second 30-second application of the flame was applied to the sample.

In some cases, the plastic sample self-extinguished immediately when the source flame was removed but caused ignition of the cheesecloth indicator when the source flame was applied during the first 30 seconds of testing. This was indicated in the data records, but not recorded as sustained flaming dripping ignition because it could not be determined if the source flame was causing by portions of the plastic melting and breaking away or it was actual flaming dripping plastic.[17] Once the source flame was removed, it was more obvious if the test resulted in flaming dripping plastic. Figure 7-43 shows open flame testing of a plastic.



(a) Open flame test (b) Open flame applied

[17] The size of the test sample varied because of the heater component which may have contributed in determining flaming dripping plastic in the first 30 seconds of the test.


(c) Open flame withdrawn (30s)

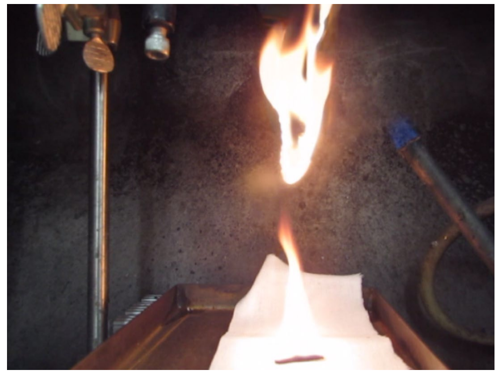

(d) Flaming dripping plastic

Figure 7-43. Plastic sample being tested with an open flame

Seventeen sample heaters had some plastic that continued to flame for more than 30 seconds after the source flame was removed. Twenty heater samples had ignition of the cheesecloth indicator from flaming dripping plastics during the testing. Nineteen heater samples had ignition of the cheesecloth from the plastic after the 30-second source flame was removed. While it is permissible to use non-V rated plastic in heaters, the use of flammable plastic in certain areas in the heater may pose a higher risk of fire if not properly spaced from potential ignition sources, such as connections. Appendix Table A-13. Results of Open Flame Test contain additional data from the open flame testing.

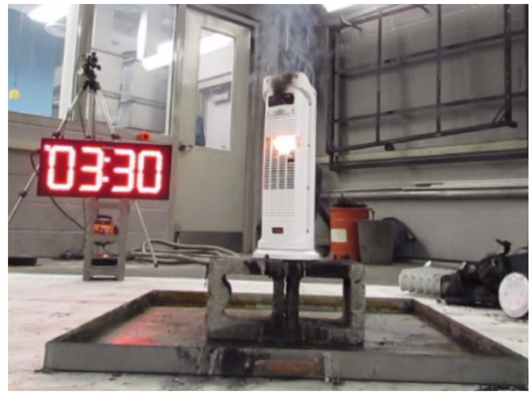
End-product Open Flame Ignition Testing

All of the heater models were subjected to an end-product open flame test. UL 1278 does not incorporate this type of performance test. The exploratory testing was to evaluate the heater burning progression if ignited. The heaters were not energized during the testing. Staff selected the points of flame impingement by selecting plastic components based on the Glow Wire and Open Flame Tests. Staff used a multipurpose butane lighter as the flame source. Some parts were located within the heater so small openings were cut to allow access to the selected plastic component. The open flame was applied for 30 seconds then withdrawn. If the plastic component did not ignite, after a 30-second wait period, the flame was reapplied for an additional 30 seconds.

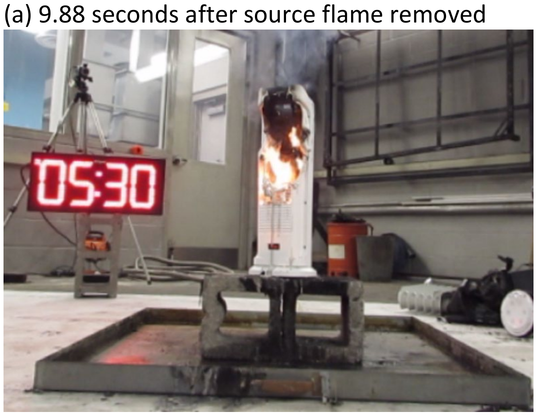
During the first round, eight heater models ignited at the selected plastic component location and caused the fire to spread to other parts of the heater. The heaters continued to burn until the test was terminated by manually extinguishing the fire. Figures 7-44 to 7-51 show the testing for the heater samples that ignited during the first series of testing.

For the second round, the 19 heater samples that did not ignite in the first round were subject to the flame being applied to a second plastic component. Three of these heaters were fully consumed. Figures 7-52 to 7-7-54 show the testing of the heater samples that ignited during the second round of testing.

(a) 9.88 seconds after source flame removed



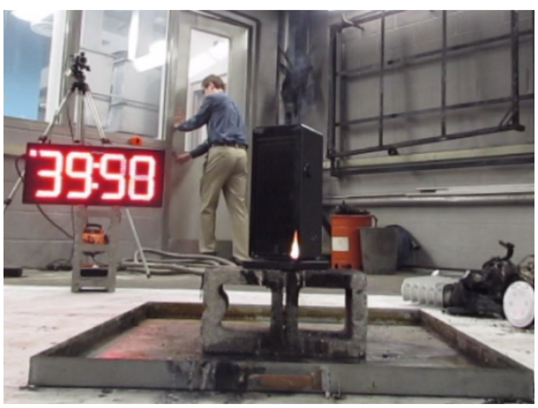
(b) 3min 30s from beginning of the test



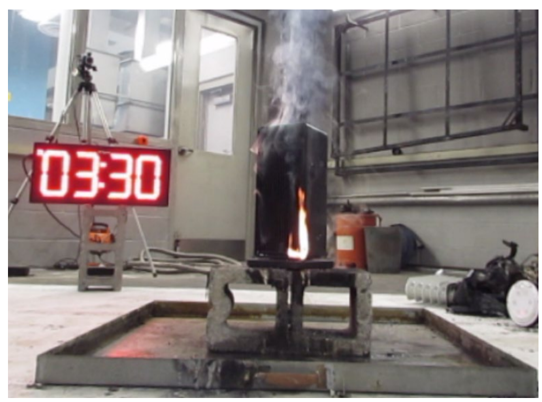
(c) 5min 30s seconds from beginning of the test

(d) 8min 30s from beginning of the test

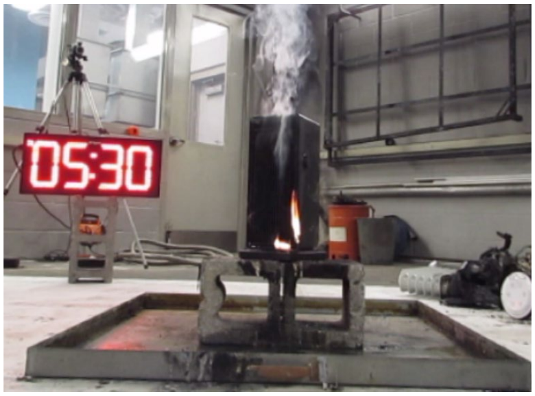
Figure 7-44. S5 1st ignition location at fan impeller



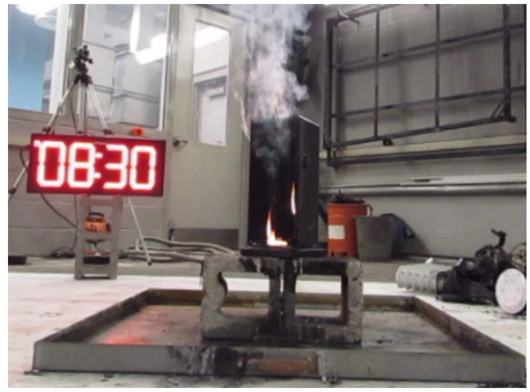
(a) 9.98 seconds after source flame removed



(b) 3min 30s from beginning of the test

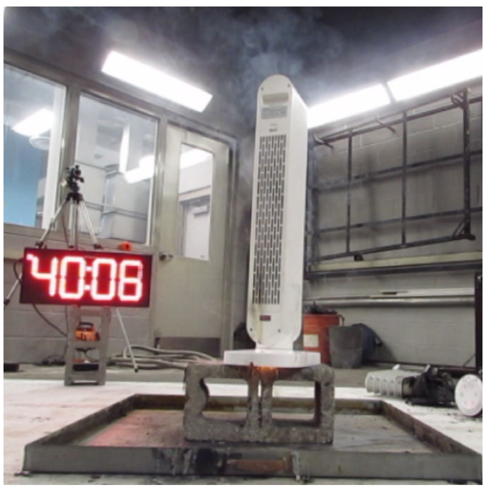


(c) 5min 30s seconds from beginning of the test

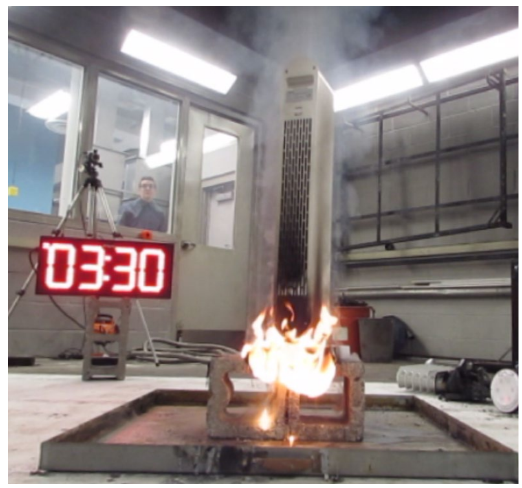


(d) 8min 30s from beginning of the test

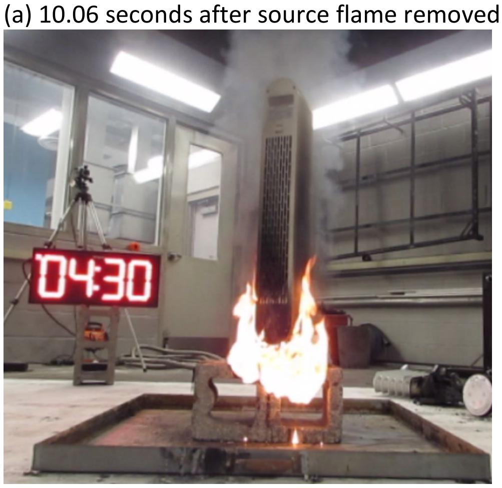
Figure 7-45. S6 1st ignition location at front trim



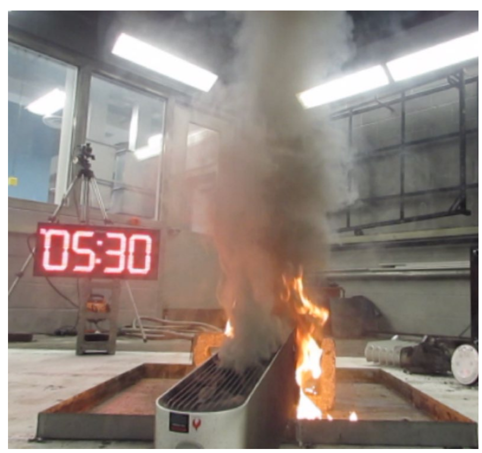
(a) 10.06 seconds after source flame removed



(b) 3min 30s from beginning of the test

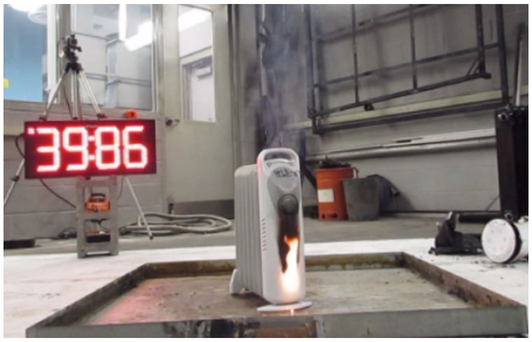


(c) 4min 30s seconds from beginning of the test



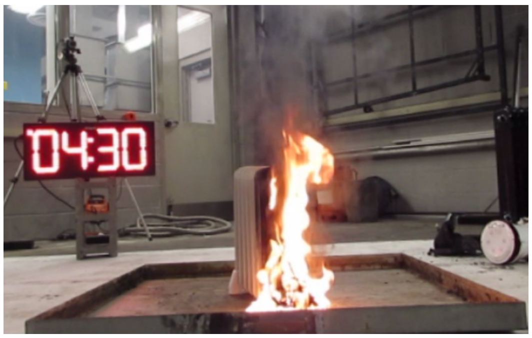
(d) 5min 30s from beginning of the test

Figure 7-46. S11 1st ignition location at the base



(a) 9.86 seconds after source flame removed

(b) 3min 30s from beginning of the test



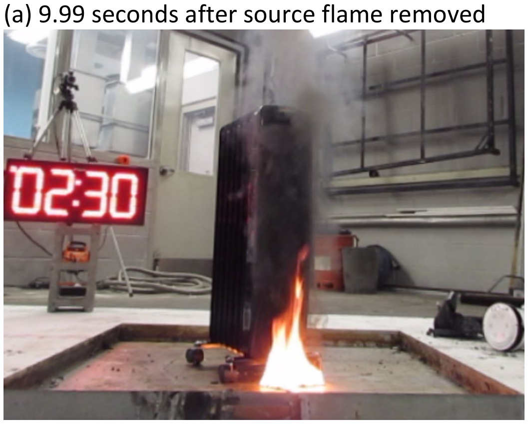
(c) 4min 30s seconds from beginning of the test

(d) 5min 30s from beginning of the test

Figure 7-47. S17 1st ignition location at the end housing

(a) 9.99 seconds after source flame removed

(b) 1min 30s from beginning of the test

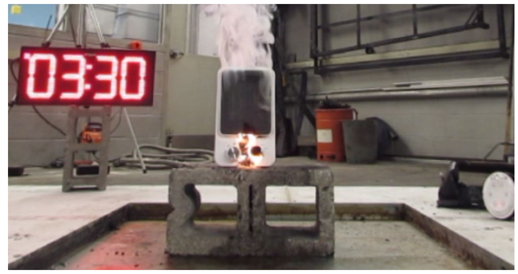


(c) 2min 30s seconds from beginning of the test

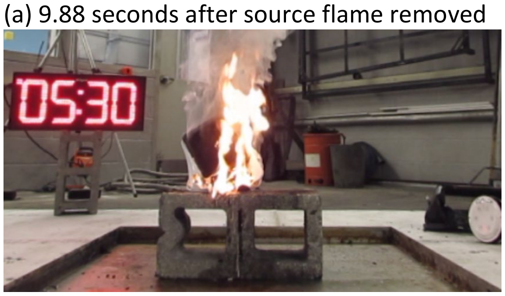
(d) 4min 30s from beginning of the test

Figure 7-48. S18 1st ignition location at the cord reel

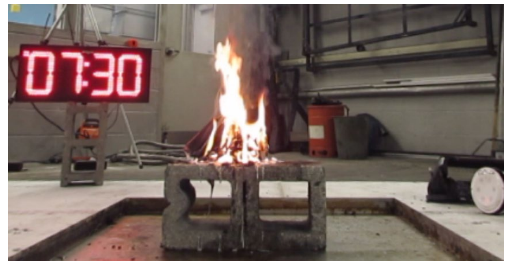
(a) 9.88 seconds after source flame removed



(b) 3min 30s from beginning of the test

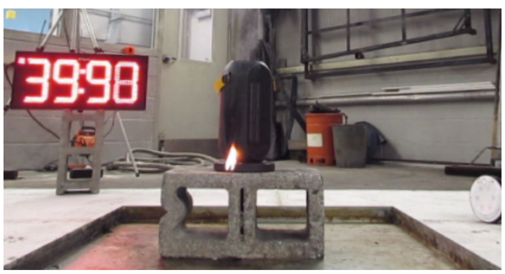


(c) 5min 30s seconds from beginning of the test

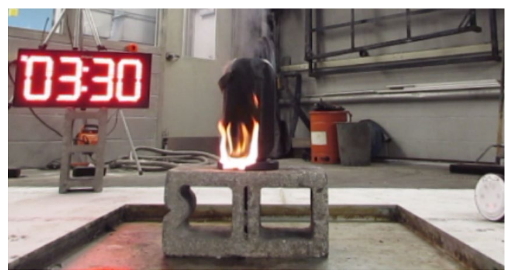


(d) 7min 30s from beginning of the test

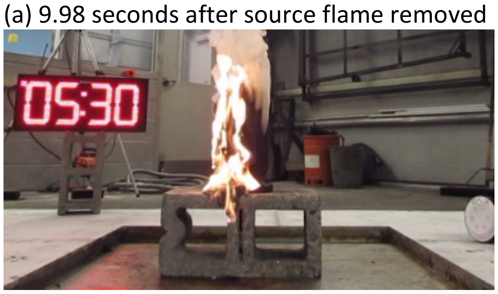
Figure 7-49. S23 1st ignition location at the front housing



(a) 9.98 seconds after source flame removed



(b) 3min 30s from beginning of the test

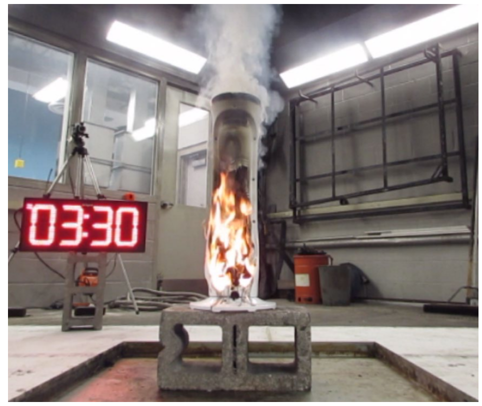


(c) 5min 30s seconds from beginning of the test

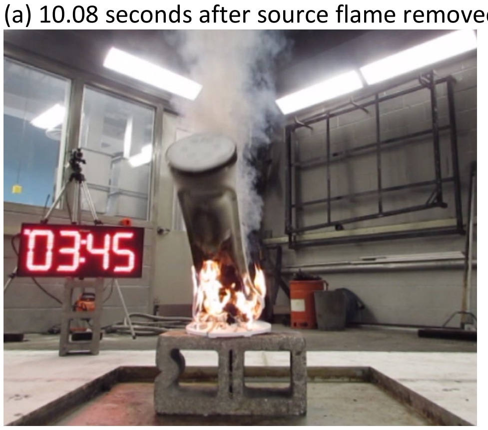
(d) 8min 30s from beginning of the test

Figure 7-50. S24 1st ignition location at the base

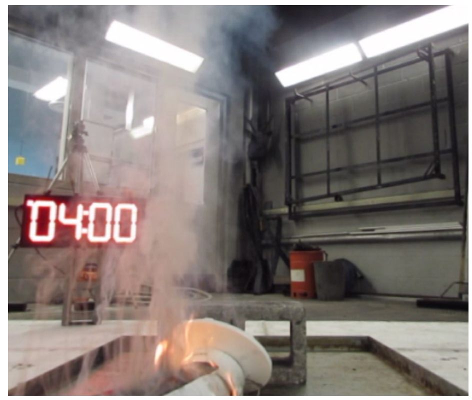
(a) 10.08 seconds after source flame removed



(b) 3min 30s from beginning of the test



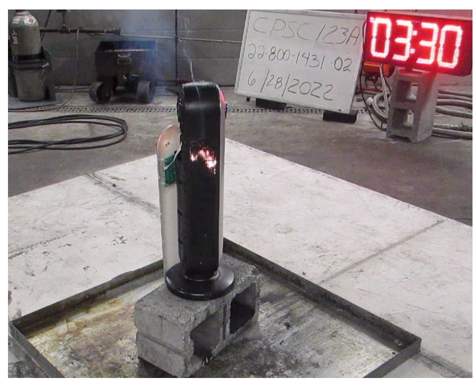
(c) 3min 45s seconds from beginning of the test



(d) 4min from beginning of the test

Figure 7-51. S26 1st ignition location at the rear housing

(a) 9.88 seconds after source flame removed



(b) 3min 30s from beginning of the test

(c) 5min 30s seconds from beginning of the test

(d) 6min 30s from beginning of the test

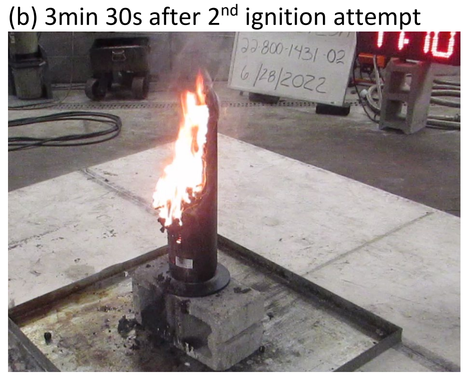
Figure 7-52. S2 2nd ignition location at the fan housing

S13 ignited at the second location (the fan impeller), but after about 2 minutes it appeared the flames extinguished. A third 30 second flame application was applied to the fan impeller, which caused the heater to ignite and be consumed.

(a) 10 seconds after 2nd source flame attempt

(b) 3min 30s after 2nd ignition attempt

(c) 5min 30s seconds after 2nd ignition attempt

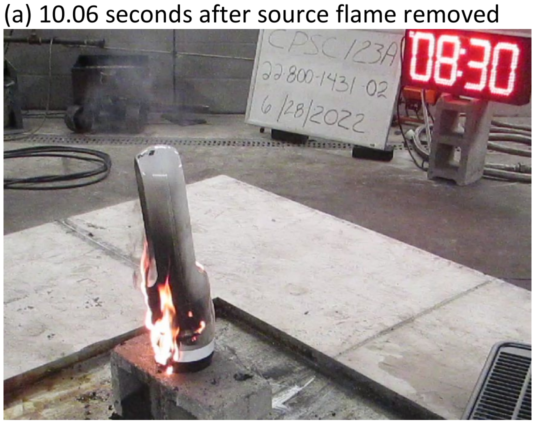


(d) 8min 30s from beginning of the test

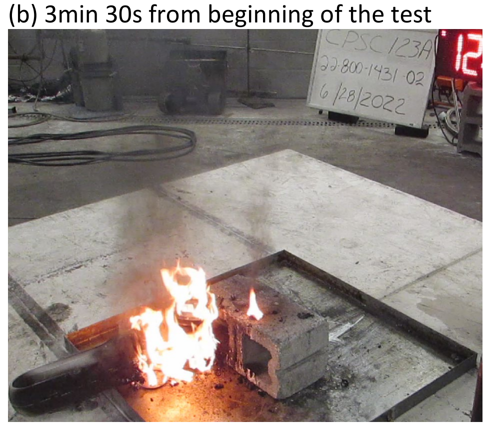
Figure 7-53. S13 2nd ignition location at the base

(a) 10.06 seconds after source flame removed

(b) 3min 30s from beginning of the test



(c) 8min 30s seconds from beginning of the test

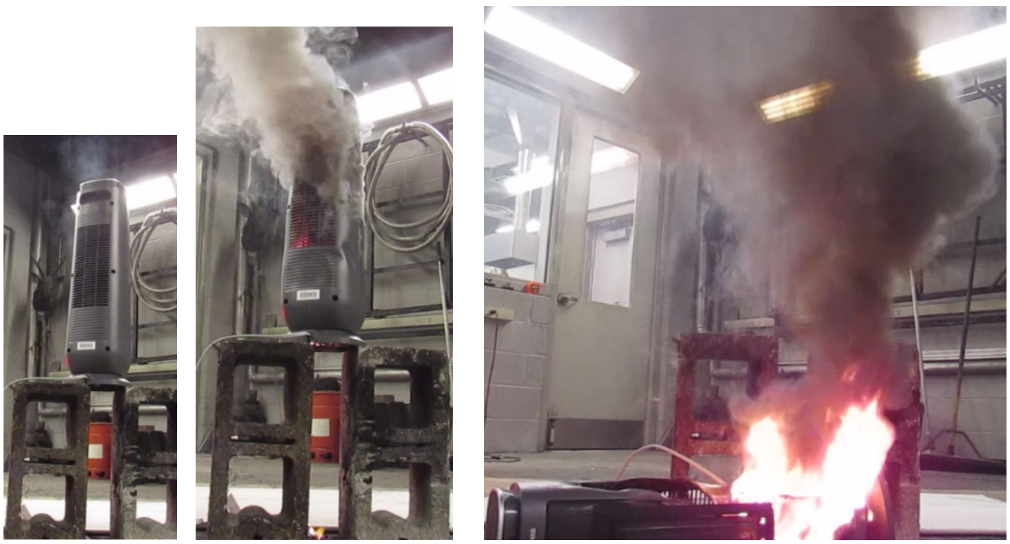


(d) 12min 01s from beginning of the test

Figure 7-54. S27 2nd ignition location at the lower ring housing

The data showed some inconsistencies in the testing and component testing that required retesting samples S05, S09, S12, S20, S21, and S25. A new sample was used for this series of tests. Four (S05, S09, S21, S21) of the 6 samples ignited. Two of the previous samples, S12 and S25, did not ignite. Figures 7-55 to 7-58 show the testing of the heater samples that ignited when a second sample was tested.

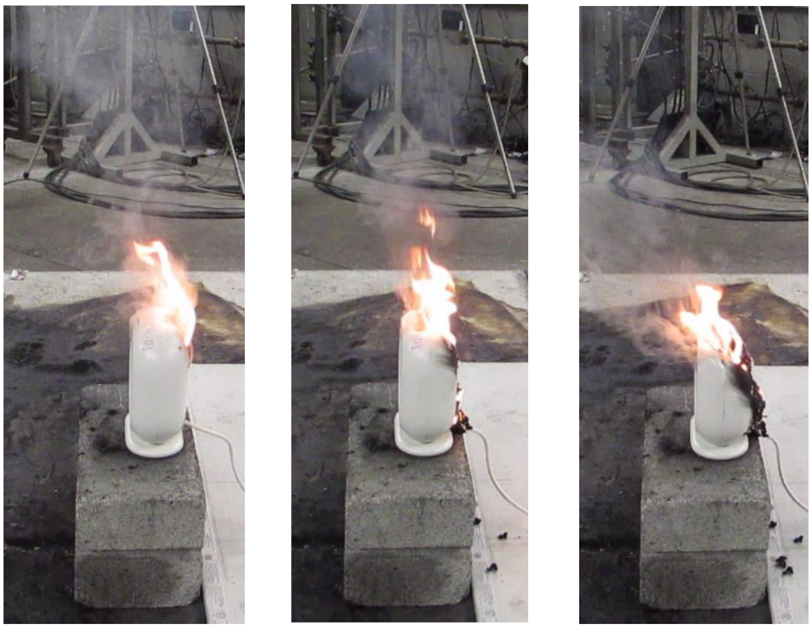
The source flame application for S05 second sample was at the motor housing base located at the bottom the heater. Ignition required a 30 s, 30 s, and 1 min source flame application with 30 s pause between applications. It appears because of the horizontal surface of the plastic; the plastic was not easily ignited until melting caused a vertical surface for the source flame to impinge.



(a) 3 minutes - (b) 5 minutes - (c) 6 min - after 3rd application of source flame

Figure 7-55. S05 2nd sample tested

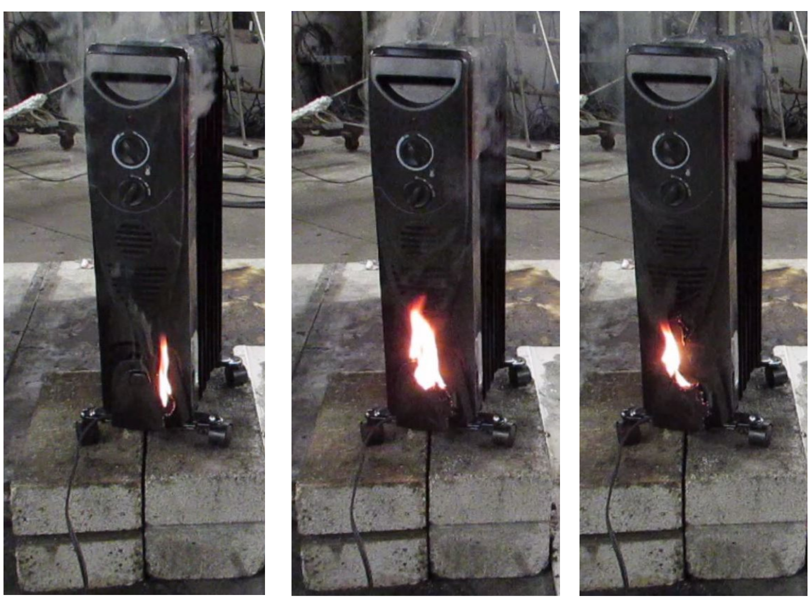
The source flame application for S09 second sample was on the fan housing at the rear of the heater. Ignition required a single a 30 s source flame application. It appears ignition of the fan housing along its vertical and horizontal surfaces allow ignition on the first attempt.



(a) 3 minutes - (b) 5 minutes - (c) 6 min - after 1st[d] application of source flame

Figure 7-56. S09 2nd sample tested

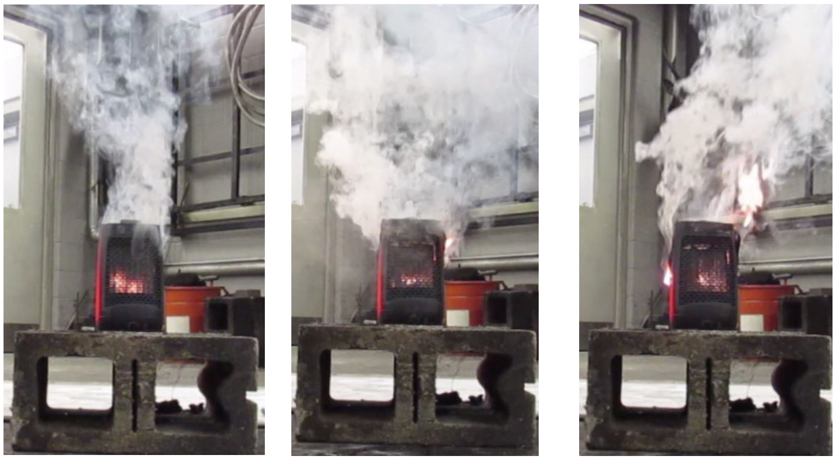
The source flame application for S20 second sample was at the cord reel. Ignition required a single 14 s source flame application. During the first round of testing there was no ignition of the cord reel perhaps due to the glossy smooth surface on its external side. An unfinished surface that was not glossy, similar as located in the internal side of the plastic, allowed easier ignition of the plastic component. The flames and burning was limited to only the cord reel and did not spread to the control panel plastic housing.



(a) 3 minutes - (b) 5 minutes - (c) 6 min - after 1st[d] application of source flame

Figure 7-57. S20 2nd sample tested

The source flame application for S21 second sample was at the fan housing. The first 30 s application did not result in an ignition. A second 30 s application at the fan housing resulted in ignition of the plastic.



(a) 3 minutes - (b) 5 minutes - (c) 6 min - after 2nd application of source flame

Figure 7-58. S21 2nd sample tested

The UL standards contain specific construction and performance requirements for the flammability ratings of plastics used in heaters fire, but they do not limit the total amount of plastic used in a heater. For the heater samples tested, the percentage of flammable plastics was calculated using the test data from the glow wire and 20 mm open flame testing. There may be a relationship between the percentage of flammable plastics to the progression of ignition as seen in Table 7-11. Heaters with a higher percentage of flammable plastics had a higher probability of flame progression and heaters with a low or zero percentage of flammable plastics had much lower chance of ignition. The middle portions had mixed results which may suggest further study is warranted. Appendix Table A-14. Full Heater Sample Ignition Test Results contains additional test data on the full heater open flame testing.

Table 7-11. Percent Weight Flammable Plastic and End-Product Flammability Testing

Sample Number	Percent flammable plastics to total plastic weight	Overall result (continuous ignition) (1st and 2nd attempt ignition of plastic components)
S03	0%	no
S15	0%	no
S16	0%	no
S19	0%	no
S22	0%	no
S10	3.79%	no
S08	6.17%	no
S01	9.65%	no
S11	9.71%	yes
S14	13.94%	no
S07	14.37%	no
S05	15.56%	yes*
S04	16.88%	yes
S20	17.80%	yes*
S09	19.20%	yes*
S13	24.47%	yes
S25	27.71%	no*
S18	32.37%	yes
S12	53.17%	no*
S06	56.18%	yes
S23	80.27%	yes
S21	82.72%	yes*
S26	90.33%	yes
S24	93.85%	yes
S02	100%	yes
S17	100%	yes
S27	100%	yes

* In addition to the Sample 02 tested, a second new sample (sub 03) was tested

7.5 HEAT OUTPUT DURING NORMAL OPERATION

Two tests were conducted to evaluate the temperature output of the heater samples. The first series of tests was to map the approximate temperatures across the face of the heater and at various distances away from the heater. The second series of tests was to evaluate response of combustibles close to the heater.

Temperature Mapping of the Heat Output

Staff conducted temperature mapping of the heaters using an array of Type K thermocouples to sense the temperatures on the front of the heaters as shown in Figure 7-59. . The thermocouples were connected to a data logger that sampled every five seconds. Thermocouples T1 through T5 were aligned along the long axis of the heating element as shown in Figure 7-60. The closest thermocouples in the array were placed 6 inches from the front face of the heater. The units were tested at their highest heat settings. The units were operated for a minimum of one hour to attain steady state temperatures, but the oil-filled heaters were operated for two hours because of the longer duration for the heaters to establish steady temperatures. Sample S17 was not tested due to limited samples.

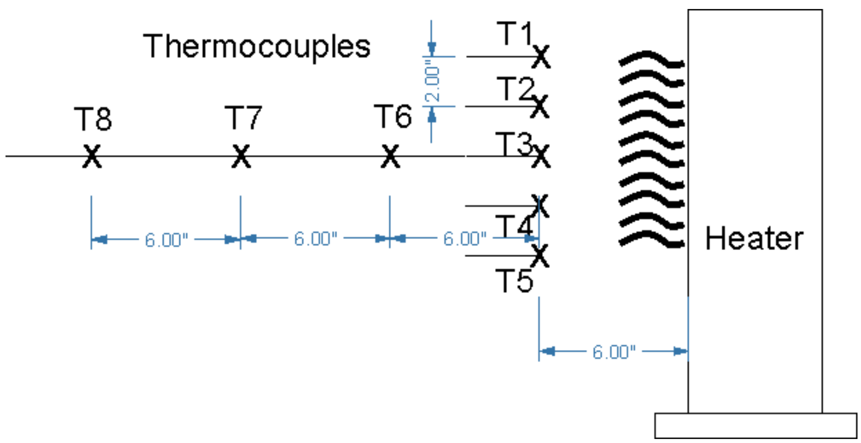


Figure 7-59. Thermocouple spacing and identification setup

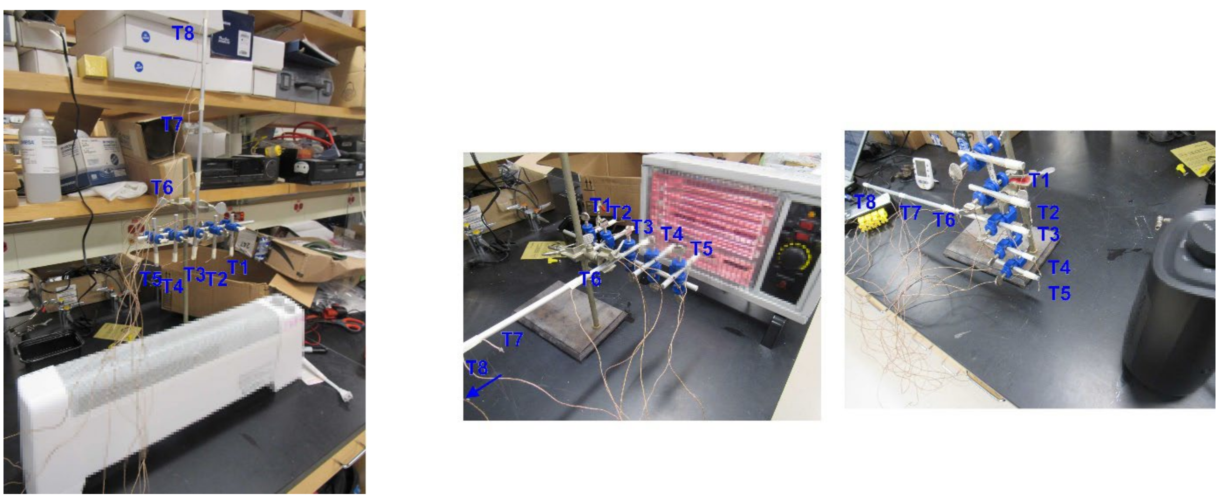


Figure 7-60. Orientations for thermocouple apparatus for various heaters

Results of Heater Temperature Measurements

Two of the heater samples (S13 and S14) shut off automatically. S13 shut off after 2 minutes of operation and S14 shut off after 12 minutes of operation. These heaters were digitally controlled and S13 and S14 measured a maximum of 101°C and 38°C, respectively.

After the temperature stabilized, the measurements were averaged. Table 7-12 lists the average measured temperatures for each of the thermocouples. Three heaters (S16, S18, S20) had the heating element cycle which resulted in the average measured temperature for Thermocouples 1 through 5 to not to exceed 30°C. Thirteen heaters had average temperatures below 100°C during the testing. Heater sample S21 had the highest average temperature of 149.5°C.

At six inches away from the heater samples tested, the measured temperatures would likely be insufficient to ignite nearby combustibles. The conditions for autoignition temperature of materials can vary depending on the conditions. For common combustible materials, such as cotton cloth and wood, the minimum ignition temperature is around 300°C. [18,19] For the heater samples tested, the maximum temperature measured around 6 inches from the heater produced a maximum temperature of about 150°C, thus a temperature of 150°C at 6 inches away has a low probability of igniting nearby combustibles (cotton and wood). Appendix Table A-15. Normal Operation Temperature Measurement Results contains additional test data on the measured temperatures.

Table 7-12. Temperature Measurements

		Average Temperature Measurements (°C)				
Sample Number	Cycle Time	1	2	3	4	5
S1	None	43.4	109.0	84.1	115.9	64.9
S2	None	47.0	37.6	64.7	45.6	44.9
S3	None	69.5	93.1	86.5	83.9	84.0
S4	None	35.4	50.7	52.2	50.4	76.6
S5	None	49.7	100.4	124.0	45.9	82.0
S6	None	40.5	75.8	92.3	74.5	86.7
S7	None	55.6	94.7	75.6	58.7	89.3
S8	None	69.3	73.9	123.8	41.0	61.6
S9	None	24.8	53.4	136.8	26.4	82.0
S10	None	42.2	94.1	104.7	25.3	47.3
S11	None	74.3	58.2	51.3	52.6	53.1
S12	None	37.8	94.9	98.3	42.9	75.8
S15	None	41.9	42.4	41.0	34.7	39.4
S16	3 Mins	25.2	25.2	25.0	24.9	25.3
S18	20 mins	28.0	27.7	27.2	26.4	27.3
S19	None	27.0	26.9	26.0	25.6	26.3
S20	15 mins	26.9	26.7	26.7	26.2	26.9

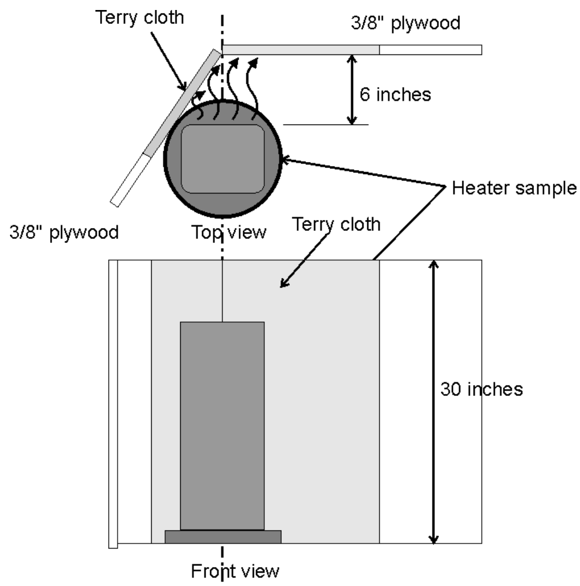
[18] Autoignition temperature is the minimum temperature required to ignite a dry material in air without a spark or flame being present.
[19] https://www.tayloredge.com/reference/Science/ignition.html

		Average Temperature Measurements (°C)				
Sample Number	Cycle Time	1	2	3	4	5
S21	None	24.3	42.2	149.5	24.0	49.5
S22	None	25.6	33.0	34.9	36.4	37.1
S23	None	65.0	77.9	106.6	48.9	83.7
S24	None	84.4	130.3	86.7	25.8	37.8
S25	None	23.2	25.6	75.3	35.6	67.2
S26	None	61.6	96.1	63.3	62.9	75.0
S27	None	22.9	23.3	24.0	25.0	23.6

Alcove Testing

The heater samples were tested in an alcove with the heater output impinging on terry cloth fabric draped over plywood to simulate a heater placed too close to combustibles as shown in Figure 7-61. None of the heater regulating and limiting controls were bypassed for these tests. The test cloth fabric sheets were 100% cotton terry cloth that was thermally aged in a conditioning oven for seven days at 150°C to simulate a heater that has been heating the fabric for an extended period of time. After thermal aging, the terry cloth sheets were moved to a conditioning chamber that maintained 20°C at 49% +/- 1% relative humidity until the test cloth was needed for testing.

The alcove consisted of two sheets of 3/8-inch plywood connected with hinges to allow the set-up to be customized to the physical characteristics of each heater. For each test, a new thermally-aged sheet of terry cloth was used unless there was enough unused portion of the terry cloth sheet from the previous test that could be used. Each heater was placed in the alcove with the front of the heater parallel to and 6 inches from the fixed wall of the alcove. The adjoining wall of the alcove was adjusted to allow the centerline of the heater to align with the intersection of the two plywood pieces and to be as close as the heater base allow. The test was conducted for 3 hours with the heater on its maximum heat setting. None of the heaters produced any smoking, flaming or charring of the terry cloth fabric.



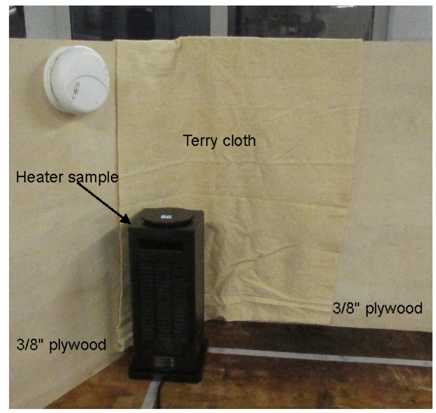


Figure 7-61. Nearby combustibles setup

8.0 COMPARISONS OF HEATERS BY CERTIFICATION STATUS

The following staff assessment of the portable electric heater samples relative to whether or not it was third-party certified focused on power cord wiring size, power cord connections, thermal devices, stability, tip-over devices, internal connections, flammability of plastics, thermal output., and markings.

Staff verified that 17 heater samples that were purchased had been third-party certified to UL 1278 as verified by searching for them on the listing lab's online certification directory. Six heater samples did not have any certification marks and for four samples staff could not verify the certification .

8.1 Power Cord Sets

UL 1278 Table 16.2 specifies that the heater attachment plug connections between the power cord and plug blades shall be both mechanically crimped and soldered, brazed, or welded. The soldering, brazing, or welding is intended to provide additional surface contact between the wire and the plug blades to minimize the contact resistance. All power cords except for S27 power cord had certification marks. Staff did not verify the power cords with certification markings to validate the certifications.

Table 8-1 indicates the certification statuses for the heater samples. Four certified heater samples did not contain any solder/brazing/welding at the attachment plugs. Five of the heater samples that were not certified or unverified had been soldered/brazed/welded at the attachment plug.

Table 8-1. Soldering, Brazing, or Welding in the Attachment Plug

Soldering, brazing, or welding connection in the attachment plug	Verified Certification	No or Unverified Certification
Yes	13	5
No	4	5

UL 1278 Paragraph 16.5 specifies household heaters not intended for outdoor use must have a power supply cord with a -R suffix designation marking which indicates it complies with the abrasion, mandrel pinching, mandrel crushing, and flexing test in UL 62 - *Standard for Flexible Cords and Cables*.

Table 8-2 indicates the cord markings on the sample. Three certified heater samples and eight certified/unverified heaters did not have a -R marked power cord. Two of the heater samples that were not certified or unverified to UL 1278 had a suffix -R power cord.

Table 8-2. Suffix -R on the Power Cord Set

R Designated Cord	Verified Certification	No certification or unverified
Yes	14	2
No	3	8

8.2 Stability

UL 1278 Section 51 includes test requirements to assess the physical ability of a heater to return to its intended at-rest position on a level surface after being tipped in any direction to a maximum angle of 10 degrees from horizontal.

All but one of the heater samples passed the stability test. Heater sample S19, which is certified, failed in two directions. It contains fold-out wheels. If the wheels were folded (worst condition), the heater was unstable in two directions. Heater S17 was not tested due to limited samples available.

8.3 Tip-Over

UL 1278 does not require a tip-over switch but rather Section 42.4 includes a performance test to evaluate the risk of fire when the heater is laying on its sides. For the test, the heater is overturned onto a softwood surface covered with a single layer of terry cloth for each orientation and cannot char or ignite the terry cloth indicator. Otherwise, the manufacturer may incorporate a tip-over switch as a method to de-energize the unit if the unit is tipped over. Only heater samples S1 and S8 did not have a tip-over switch.

UL 1278 Section 33 specifies that if a heater incorporates a tip-over switch as a means to reduce the risk of fire, the heater's tip-over switch must function before the heater has tipped beyond the angle of critical balance in any direction. The three heater samples without a tip-over switch were not subjected to this test. Of the 24 heater samples with tip-over switches, all of the certified heater samples, except for S15, and four of the non-certified/verified had a critical angle greater than the tip-over switch angle.[20] Heater sample S15 failed in one orientation where the critical angle was 2 degrees greater than the tip-over switch activation angle. Six of the non-certified/verified heater samples with tip-over switches functioned beyond the critical angle.

Table 8-3. Tip-over Switch Angle vs. Critical Angle

	Verified Certification	No certification or unverified
Observation	Count	Count
PASSED	13	4
FAILED	1	6

8.4 Internal Connections

UL 1278 Table 16.2 only requires soldering of the power cord supply connections to the internal wiring, but some of the heater samples had all of the full-current-carrying internal connections soldered. Five verified heater samples had soldered all the full-current-carrying connections. No uncertified/unverified heater samples had all the rated current connections soldered.

Table 8-4. Rated Current Connections Soldered

Observation	Verified Certification	No certification or unverified
All rated current internal connections soldered	5	0
All but one rated current internal connection soldered	2	1
Two or more rated current internal connections not soldered	10	9

Supply Connections to Internal Wiring

Thirteen of the certified heater samples had been soldered at the power cord crimp connections to the internal wiring. In some cases, there was solder at the power cord supply side of connection, but the other side of the connector to the internal wire lacked solder. Five of the noncertified/nonverified heater samples lacked solder/welding/brazing between the power cord set to the internal wiring.

Table 8-5. Power Supply Connections to the Internal Wiring

Soldered/Brazed/Welded	Verified Certification	No certification or unverified
Yes	14	5
No	3	5

[20] The critical angle is the maximum tilt angle where the heater will not self upright to its intended at-rest position.

Wire Connectors

UL 1278 paragraph 20.3.1 specifies that electrical connections, such as wire nuts, splicing wire connectors, quick-connect terminals, terminal connectors, multi-pin and other forms of wire connectors, must meet applicable UL standards.

Some of the heater samples used butt or barrel connectors, which UL 486A-486B *Wire Connectors* covers. UL 486A-486B paragraph 6.1.2 states that a connector intended for use with conductors of different sizes must have a clamping mechanism that adapts to conductors of different sizes without permanent removal or addition of parts. UL 486A-486B lists some examples of clamping mechanisms, which may be direct bearing screws, pressure plates, deformation of the connector barrel (crimping), a nut threaded onto a threaded split bolt; and element for insulation-piercing.

Staff x-rayed and CT-scanned the butt connectors. Half the certified heater samples with butt connections had no voids, and all the wire strands appeared to be bonded and were fully soldered. All the uncertified/unverified heater samples with butt connections contained voids and loose wire strands.

Table 8-6. Butt and Barrel Connectors used with Internal Wiring

Observation	Verified Certification	No certification or unverified
Adequate butt/barrel connections	3	0
Inadequate butt/barrel connections*	3	4

* CT images show voids between the wire strands, loose wire strands, and/or broken wires

8.5 Flammability of Polymeric Materials

UL 1278 Section 12 specifies the acceptability, including flammability, of a polymeric material used in heaters is to follow UL 746C, *Standard for Polymeric Materials – Use in Electrical Equipment Evaluations*.

UL 746C specifies that polymeric materials, such as the enclosure and parts of the enclosure, used in portable unattended household equipment, such as a portable electric heater, must meet *Table 4.1 Enclosure requirements*. The minimum flammability is V-rated with the note that V=V-0, V-1 or V-2 classed materials, or the enclosure complies with the 12 mm or 20 mm end-product flame tests as described in *Section 15*, *Flammability – 12 mm Flame* and *Section 16, Flammability – 20 mm (3/4-Inch) Flame*.

An exception notes that a polymeric enclosure material classified HB may be used in portable unattended household equipment that complies with the criteria specified in *Section 5, Portable Unattended Household Equipment – Alternate Path*.

The Alternate Path in Section 5 states that all electrical connections within the polymeric enclosure of portable unattended household equipment employing HB-rated enclosure material must meet the following:

- All polymeric materials located within 3 mm of electrical connections must be a minimum V-0, V-1, VTM-0, or VTM-1 flammability classification.
- a minimum SC-0, SC-1, SCTC-0, or SCTC-1 flammability classification, or
- a minimum Glow Wire Flammability Index (GWFI) of 750°C for the polymeric material.

The testing of the plastic components from the heater samples revealed some plastic components that were capable of sustaining ignition long enough to produce smoke and flames, but this is permitted by UL 746C for plastic components that do not pose a risk of ignition during normal or abnormal operations. During the end-product burn, 12 of the certified and four of the noncertified/nonverified heater samples did not sustain ignition. Five certified and six uncertified/verified heater samples sustained ignition, and the samples were consumed.

Table 8-7. Flammability of Plastics in the Heater Samples

Flammability Test Results	Verified Certification	No certification or unverified
Glow Wire Test		
Some plastic component ignited and flamed for more than 60 seconds	16	10
• Ignited cheesecloth below	4	4
No plastic component ignited or flamed for more than 30 seconds	1	0
20 mm Flame Test		
Some plastic component ignited and flamed for more than 30 seconds	11	9
Ignited cheesecloth below after the 30s source flame was removed	7	6
Full Scale Burn		
Sample self-extinguished or did not ignite	12	4
Sample ignited and was consumed	5	6

8.6 Safety Markings

Fifteen of the certified heater samples had the “3-foot” safety warning label on the product and a safety power cord tag. Two of the certified heaters lack the safety warning labels (3-foot and cord tag). Four of the noncertified/nonverified heater samples lacked the “3-foot” safety warning label on the product, and 6 of the noncertified/nonverified heater samples lacked the safety power cord tag.

Table 8-8. Rated Current Connections Soldered

Observation		Verified Certification	No certification or unverified
“3 foot” warning on the product	Present	15	6
	None	2	4

Cord tag, fire safety	Present	15	4
	None	2	6

9.0 CONCLUSIONS

According to the 2017 – 2019 Residential Fire Loss Estimates report there were an estimated annual average of 1,300 fire service attended fires, 50 deaths, and 120 injuries attributed to portable electric heaters. Staff conducted a search of incidents related to portable electric heaters in the CPSC CPSRMS database for the 11-year period from January 1, 2011, to February 1, 2022, yielding 2,345 reports. Staff screened the list of incidents to those related to a portable electric heater causing a fire, further refining the incidents to 1,430 to review for hazard patterns.

The data analysis revealed the following:

- Extension cords used with heaters were often attributed as the cause for heater-related incidents.
- Heater power cord sets with poor connections may lead to overheating of the connections.
- Poor internal connections may overheat and possibly ignite adjacent plastics.
- Some heaters are constructed with flammable plastics within the heater that may ignite and continue to burn.

Alcove testing of the heater samples did not result in fire from the different heaters tested. Some incident reports cited "nearby combustibles" as a factor. In reviewing these incident reports, staff observed that the reports were not a definitive assessment as the actual events that may have taken place to cause the incident. "Nearby combustibles" suggest that the heater was too close to combustibles which caused ignition of the nearby material, but these reports typically did not contain sufficient information to make a definitive conclusion that the heater had ignited the nearby combustibles. Staff's testing showed that for the normally operating heater samples tested, these heaters did not ignite terry cloth fabric 6 inches from the heaters. It is possible that a portion of the incident reports that are marked as "nearby combustibles" as the ignition source may have originated from a failed heater that has ignited and spread to nearby combustibles.

Staff examined the construction and components in 27 new portable electric heater samples. Seventeen heater samples had markings indicating third-party certification to the appropriate UL voluntary standards. Ten had either no certification markings or markings that could not be verified by checking the certification body's website. Some certified heater samples failed to meet various construction requirements, but uncertified heater samples had more construction variances and failures to meet requirements of the standards, including in the following areas:

- Soldering/welding/brazing at the attachment plug connection to the power cord
- Soldering/welding/brazing at the power cord set to the internal wiring
- A tip-over switch angle activation before angle of critical balance
- Input power cords rated for flexure, pinching, and crushing

Performance and construction quality between certified and uncertified heater samples varied suggesting that certified heaters may be less susceptible to fire risk in the following areas:

- Rated connections within the heater
- Butt connections for the internal wiring
- Power cord set failures
- Susceptibility to flame spread

Differences in tip-over and stability performance were not discernible between certified and uncertified heaters. All heater samples evaluated satisfied the tip-over and stability performance tests for UL 1278. UL 1278 only requires a tip-over switch for heaters that pose a risk of fire when tipped over onto a horizontal surface, however, the majority of the heater samples evaluated incorporated tip-over switches. Some tip-over switches did not meet the requirements of UL 1278 performance specification where the tip-over switch must function before the heater has tipped beyond the angle of critical balance in any direction. A heater that has fallen over but may be leaning against a couch or bed could still be operating if the tip switch activation angle is greater than the critical balance angle.

Based on this analysis, staff recommend the following to reduce the risk of fires, deaths and injuries for portable electric heaters:

- Improvements to connection reliability and minimizing flame spread beyond the heater
- Higher portable electric heater conformance to the performance and construction requirements for the appropriate voluntary standards
- Enhanced consumer education on the risk and dangers of using an extension cord with an electric heater

APPENDIX

Appendix - Test Data

Table A-1. Sample Features and Certifications

Sample Number	Category	Max Watts	Temperature Controls	Fan	Auto-off	Remote	Third Party Certification Markings on Packaging	Third Party Certification Markings on Product	Confirmed Third Party Certification
S1	Tower	1500	Digital	yes	Timer	yes	Yes	yes	yes
S2	Tower	1500	Digital	yes	Timer	yes	NONE	yes	yes
S3	Baseboard	1500	Mechanical	no	None	None	Yes	yes	yes
S4	Tower	1500	Digital	yes	Timer	yes	Yes	yes	yes
S5	Tower	1500	Digital	yes	Timer	yes	NONE	NONE	N/A
S6	Tower	1500	Digital	yes	Timer	yes	NONE	NONE	N/A
S7	Tower	1500	Digital	yes	Timer	yes	Yes	yes	yes
S8	Tower	1500	Digital	yes	Timer	None	Yes	yes	yes
S9	Desk	1500	Mechanical	yes	Timer	None	NONE	NONE	N/A
S10	Desk	1500	Mechanical	yes	Timer	None	Yes	yes	yes
S11	Tower	1500	Digital	yes	Timer	yes	Yes	yes	yes
S12	Tower	1500	Digital	yes	Timer	yes	NONE	yes	yes
S13	Tower	1500	Digital	yes	Timer	yes	NONE	NONE	N/A
S14	Tower	1500	Mechanical	no	None	None	Yes	yes	yes
S15	Desk	1500	Mechanical	no	None	None	Yes	yes	NO
S16	Radiator	1500	Mechanical	no	None	None	NONE	yes	yes
S17	Radiator	700	Mechanical	no	None	None	Yes	yes	yes
S18	Radiator	700	Mechanical	no	None	None	Yes	yes	yes
S19	Radiator	1500	Digital	no	Timer	yes	Yes	yes	yes
S20	Radiator	1500	Mechanical	no	None	None	Yes	yes	yes
S21	Desk	1500	Mechanical	yes	None	None	Yes	NONE	N/A
S22	Panel	1500	Mechanical	no	None	None	Yes	yes	yes
S23	Desk	1500	Mechanical	yes	None	None	Yes	yes	yes
S24	Desk	1200	Mechanical	yes	None	None	NONE	yes	NO
S25	Desk	1000	Mechanical	yes	None	None	NONE	NONE	N/A
S26	Tower	2000	Digital	yes	Timer	yes	NONE	NONE	N/A
S27	Tower	1500	Digital	yes	Timer	yes	Yes	yes	NO

Table A-2. Wiring Connections

Sample Number	Wiring order	Definitions	Component
S1	PG-PC-HLH-CB(TS)-HT-PC-PG	PC	Power cord conductor
S2	PG-PC-TP-PS-OS-HL-CB-HT-PC-PG	TP	Tip-over switch
S3	PG-PC-TP-TS-FS-HT-HLH-PC-PG	CB	Circuit board
S4	PG-PC-[CB(HLH-HT)-CB(TP)]-PC-PG	HT	Heating element
S5	PG-PC-TP-PS-CB-HT-HLH-PC-PG	OS	Temperature Limiting (One-Shot Fuse)
S6	PG-PC-[CB (OS-HLH)-CB (TP)-HT]-PC-PG	HL	Temperature Limiting (High Limit)
S7	PG-PC-TP-CB-HT-OS-PC-PG	TB	Terminal block
S8	PG-PC-HLH-CB(TS)-HT-PC-PG	FS	Fan/Heat select
S9	PG-PC-CB-TP/HL/HT-CB-PC-PG	FN	Fan
S10	PG-PC-TP-HLH-FS-HT-PC-PG	TS	Thermostat, regulating
S11	PG-PC-PS-TP-HLH-CB-HT-PC-PG	HLH	Temperature Limiting (High Limit with Hold)
S12	PG-PC-CB-HT-CB-OS-HL-TP-PC-PG	PS	Power switch
S13	PG-PC-TP-CB-HT-PC-PG	HS	Heat select
S14	PG-PC-TP/HLH/TS-FS-HT-PC-PG	PG	Plug prong
S15	PG-PC-TP-PS-TS-HLH-HT(FN)-PC-PG		
S16	PG-PC-OS-TP-TS-HS-HT-HL-PC-PG		
S17	PG-PC-TP-PS-TS-OS-HT-PC-PG		
S18	PG-PC-TB-OS-TP-FS-HT-TS-TB-PC-PG		
S19	PG-PC-OS-TP-HT-CB-PC-PG		
S20	PG-PC-TP-TS-FS-HL-HLH-HT-PC-PG		
S21	PG-PC-TP-FS-HT-OS-HL-PC-PG		
S22	PG-PC-TP-OS-TS-FS-HT-PC-PG		
S23	PG-PC-TP-TS-FS-HT-HLH-PC-PG		
S24	PG-PC-TP-HL-FS-HT-PC-PG		
S25	PG-PC-TP-OS-HT-HL-PS-PC-PG		
S26	PG-PC-TP-CB-HT-OS-PC-PG		
S27	PG-PC-CB-HL-OS-HT-CB-PC-PG		

Table A-3. Temperature Limiting Devices

Sample Number	Safety Devices
S1	High limit with hold
S2	Fuse and high limit
S3	High limit with hold
S4	High limit with hold
S5	High limit with hold
S6	Fuse and High limit with hold
S7	High limit with hold
S8	High limit with hold
S9	High limit
S10	High limit with hold
S11	High limit with hold
S12	Fuse and High limit
S13	Thermistor
S14	High limit with hold
S15	High limit with hold
S16	High limit
S17	High limit
S18	High limit
S19	High limit
S20	High limit with hold and High limit
S21	Fuse and High limit
S22	High limit
S23	High limit with hold
S24	High limit
S25	Fuse and bi-metal
S26	High limit
S27	Fuse and High limit

Table A-4. Tip-over Testing Results

			High Heat				Low Heat				Fan Only				
Sample number	Tip-over device	Tip-over Switch Type	F/B	S1/S2	Shut-off Inverted	Resets on upright	F/B	S1/S2	Shut-off Inverted	Resets on upright	F/B	S1/S2	Shut-off Inverted	Resets on upright	Notes
S1	no	n/a	Y/N	N/N	N	YES	Y/N	N/N	N	YES	N/N	N/N	N	YES	
S2	yes	button	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	
S3	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	N/A	---	---	---	No Fan
S4	yes	digital	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan Only
S5	yes	button	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Max 99°C
S6	yes	digital	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	
S7	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	
S8	no	n/a	Y/N	N/N	N	NO	Y/N	N/N	N	NO	N/A	---	---	---	No Fan Only
S9	yes	V disc	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	
S10	yes	button	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	
S11	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	N/A	---	---	---	No Fan Only
S12	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Max 99°C
S13	yes	button	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Max 95°C
S14	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan
S15	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan
S16	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	Oil, No Fan
S17	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	Oil, No Fan
S18	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	Oil, No Fan
S19	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	N/A	---	---	---	Oil, No Fan
S20	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	Oil, No Fan
S21	yes	button	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	
S22	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan
S23	yes	360 ball	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan Only
S24	yes	button	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	
S25	yes	button	Y/Y	Y/Y	Y	YES	Y/Y	Y/Y	Y	YES	N/A	---	---	---	No Fan Only
S26	yes	360 ball	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	Y/Y	Y/Y	Y	NO	
S27	yes	digital	Y/Y	Y/Y	N	NO	Y/Y	Y/Y	N	NO	N/N	N/N	N	---	No Control Panel

Table A-5. Critical Angles and Tip-over Switch Angles

			Maximum Critical Angle to Return Upright (from vertical)				Tip Switch Activation Angle (from vertical)				Tip Switch activation before Critical Balance Angle			
Sample Number	Safety Tip-over	Tip-over Type	North	East	West	South	North	East	West	South	North	East	West	South
S1	no	n/a	15	13.7	14.2	14.9	N/A	N/A	N/A	N/A	----	----	----	----
S2	yes	floor button	15.3	16	16.3	16.6	3.2	3.7	2	2.7	Pass	Pass	Pass	Pass
S3	yes	360 ball	29.4	Not tested	Not tested	29.2	56.6	Not tested	Not tested	55.5	Fail	N/A	N/A	Fail
S4	yes	digital	14.4	14.6	14.9	16.7	34	30	26	28	Fail	Fail	Fail	Fail
S5	yes	floor button	14.8	19.6	18.8	13.7	1.8	4.2	2.7	5.6	Pass	Pass	Pass	Pass
S6	yes	digital	19.8	20.5	21.2	21.9	48.3	45.3	46.1	46.8	Fail	Fail	Fail	Fail
S7	yes	360 ball	18	18.8	20.1	23.3	41.7	42.1	42.1	38.3	Fail	Fail	Fail	Fail
S8	no	n/a	13.4	13.7	14.7	22	N/A	N/A	N/A	N/A	----	----	----	----
S9	yes	V metal disc	19.4	24.2	32.5	13	68.5	90	90	68.2	Fail	Fail	Fail	Fail
S10	yes	floor button	19.3	28.9	27.5	19.9	1.4	2.6	6.3	16.3	Pass	Pass	Pass	Pass
S11	yes	360 ball	19.1	13.6	14.4	21	38.4	42	38.2	40.8	Fail	Fail	Fail	Fail
S12	yes	360 ball	19.8	21.1	21.2	24.6	43.7	41.3	43.2	44.3	Fail	Fail	Fail	Fail
S13	yes	floor button	21.2	21.7	19.6	19.1	3.2	4.4	4.6	4.5	Pass	Pass	Pass	Pass
S14	yes	360 metal ball	22.2	24.1	23.9	23	40.8	35.9	39.2	34.6	Fail	Fail	Fail	Fail
S15	yes	360 ball	27.4	50.3	40.5	31.5	50.9	48	48.3	38.1	Fail	Pass	Fail	Fail
S16	yes	360 ball	22.9	15.4	17	30.7	49.7	46.9	49.1	50.9	Fail	Fail	Fail	Fail
S17	Not tested													
S18	yes	360 ball	18.2	18.3	18.3	19.7	41.5	29.1	43.1	30.5	Fail	Fail	Fail	Fail
S19	yes	360 ball	15.1	16.8	17.2	17.5	52.1	51.5	46.6	50.3	Fail	Fail	Fail	Fail
S20	yes	360 ball	19.2	19.5	19.4	20.8	35.3	30.3	39.5	31	Fail	Fail	Fail	Fail
S21	yes	floor button	19.4	17.6	17.3	11.5	3.5	2.5	2.5	1.5	Pass	Pass	Pass	Pass
S22	yes	360 ball	15.9	29.5	28.8	14.5	38.7	42.1	41.8	37.1	Fail	Fail	Fail	Fail
S23	yes	360 ball	14.2	17.2	16.4	19.5	47.8	48.8	50	50.1	Fail	Fail	Fail	Fail
S24	yes	floor button	26.4	24.8	25.6	23.9	3.9	11.1	3	5	Pass	Pass	Pass	Pass
S25	yes	floor button	14.3	17.9	16.9	22.6	3	2	1.5	1.4	Pass	Pass	Pass	Pass
S26	yes	360 ball	15.2	16	18.9	19.5	40.3	39.4	40.1	44.7	Fail	Fail	Fail	Fail
S27	yes	digital	9.5	10.3	10.4	11	32.2	41.4	39.4	40.6	Fail	Fail	Fail	Fail

Table A-6. Power Cord Set Wire Size and Markings

Sample Number	Marking (AWG)	Third Party marking on cord	Cord type	Number of strands	Total conductor area (cmil)	Calculated wire size (AWG)
S1	16	Yes	HPN-R	65	2588.632	16
S2	16	Yes	SPT-2-R	42	2353.509	16
S3	16	Yes	HPN-R	65	2404.510	16
S4	16	Yes	HPN-R	65	2365.139	16
S5	16	Yes	HPN	65	2594.496	16
S6	16	Yes	HPN	65	2418.650	16
S7	16	Yes	HPN	65	2464.177	16
S8	16	Yes	HPN-R	65	2484.228	16
S9	16	Yes	VW-1	47	2809.944	15
S10	16	Yes	HPN-R	65	2609.183	16
S11	16	Yes	SPT-2-R	65	2238.064	16
S12	16	Yes	HPN	65	2246.244	16
S13	16	Yes	HPN-R	65	2379.163	16
S14	16	Yes	HPN-R	42	2380.534	16
S15	16	Yes	HPN-R	64	2009.601	17
S16	16	Yes	HPN-R	65	2149.063	16
S17	18	Yes	HPN-R	47	1475.801	18
S18	16	Yes	HPN-R	65	2591.563	16
S19	16	Yes	HPN-R	64	2235.939	16
S20	16	Yes	HPN-R	65	2544.869	16
S21	16	Yes	VW-1	43	2318.455	16
S22	16	Yes	VW-1	67	2371.968	16
S23	16	Yes	SPT-2-R	65	1749.241	17
S24	16	Yes	SPT-2	43	2577.929	16
S25	No markings	Yes	No markings	39	1912.950	17
S26	18	Yes	SVT	41	1434.130	18
S27	18	Yes	SJT	32	1803.430	17

Table A-7. Attachment Plug CT Observations

Sample Number	Conductors	Crimp connection at conductor (Solder, Weld, or None)	Notes
S1	A/B	Solder/solder	Good solder and crimp
S2	A/B	None/none	Asymmetric crimp, broken strands, no solder or weld
S3	A/B	Solder/solder	Asymmetric crimp, voids filled with solder
S4	A/B	Solder/solder	Solder filled voids, voids between wire strands, solder not bonded to terminal, open crimp
S5	A/B	Weld/weld	Asymmetric crimp, good weld
S6	A/B	Solder/solder	Asymmetric crimp, voids in crimp
S7	A/B	None/none	No solder or weld, good crimp
S8	A/B	Solder/solder	Good soldering above and below crimp barrel covers wire strands. No voids
S9	A/B	None/none	Asymmetric crimp, voids, damaged crimp barrel, no solder or weld, long leads
S10	A/B	Solder/solder	Asymmetric crimp, voids, good crimp
S11	A/B	Solder/solder	Open crimp barrel, solder not bonded to terminal
S12	A/B	None/none	Open crimp barrel, no solder or weld, voids
S13	A/B	Weld/weld	Asymmetric crimp, good crimp and weld
S14	A/B	Solder/solder	Asymmetric crimp, solder filled voids
S15	A/B	Solder/solder	Asymmetric crimp barrel, voids, open crimp barrel, solder not bonded to terminal
S16	A/B	Solder/solder	Voids, poor soldering; not bonded
S17	A/B	Solder/solder	Voids, solder filled voids, loose wire strand
S18	A/B	Solder/solder	Solder filled voids
S19	A/B	Solder/solder	Good soldering filled voids, open crimp
S20	A/B	Weld/weld	Asymmetric crimp, voids, poor crimp, open barrel, loose strands, poor weld
S21	A/B	None/none	No solder or weld, long wire leads, voids
S22	A/B	Solder/solder	Good soldering, filled voids, good solder coverage, good barrel closure
S23	A/B	None/none	No solder or weld, voids
S24	A/B	Solder/solder	Asymmetric crimp, solder filled voids, open crimp barrel
S25	A/B	None/none	Asymmetric crimp, voids, no solder or weld, incorrect crimping (triangle), broken strands
S26	A/B	None/none	Asymmetric crimp, voids, no solder or weld
S27	A/B	None/none	Voids, no solder or weld, asymmetric, long leads

Table A-8. Crimp Resistance Measurements

Sample Number	Neutral Prong (mΩ)	Hot Prong (mΩ)	Wire (mΩ)	Neutral increase (mΩ)	Hot increase (mΩ)	Sum Neutral and Hot	Neutral Percent Increase	Hot Percent Increase	Hot/Neutral Average Percent Increase	Solder/ Weld/ None	Notes
S1	3.51	3.39	0.94	2.57	2.45	5.02	373%	361%	367%	Solder	Good solder and crimp
S2	5.32	4.81	0.625	4.695	4.185	8.88	851%	770%	810%	None	Asymmetric crimp, broken strands
S3	3.3	2.88	0.515	2.785	2.365	5.15	641%	559%	600%	Solder	Asymmetric crimp, voids filled with solder
S4	3.23	3.54	0.79	2.44	2.75	5.19	409%	448%	428%	Solder	Solder filled voids, voids between wire strands, solder not bonded to terminal, open crimp
S5	3.42	3.86	0.69	2.73	3.17	5.9	496%	559%	528%	Weld	Asymmetric crimp, good weld
S6	3.48	3.24	0.51	2.97	2.73	5.7	682%	635%	659%	Solder	Asymmetric crimp, voids in crimp
S7	4.57	9.27	0.525	4.045	8.745	12.79	870%	1766%	1318%	None	Good crimp
S8	2.89	3.1	0.63	2.26	2.47	4.73	459%	492%	475%	Solder	Good soldering above and below crimp barrel covers wire strands. No voids
S9	6.69	4.54	0.445	6.245	4.095	10.34	1503%	1020%	1262%	None	Asymmetric crimp, voids, damaged crimp barrel, long leads
S10	4.04	3.82	0.885	3.155	2.935	6.09	456%	432%	444%	Solder	Asymmetric crimp, voids, good crimp
S11	3.82	5.33	0.49	3.33	4.84	8.17	780%	1088%	934%	Solder	Open crimp barrel, solder not bonded to terminal
S12	13.63	8.98	0.585	13.045	8.395	21.44	2330%	1535%	1932%	None	Open crimp barrel, voids
S13	3.81	3.8	0.76	3.05	3.04	6.09	501%	500%	501%	Weld	Asymmetric crimp, good crimp and weld
S14	3.28	3.64	0.88	2.4	2.76	5.16	373%	414%	393%	Solder	Asymmetric crimp, solder filled voids
S15	3.39	2.13	0.78	2.61	1.35	3.96	435%	273%	354%	Solder	Asymmetric crimp barrel, voids, open crimp barrel, solder not fully bonded
S16	4.53	5.8	0.84	3.69	4.96	8.65	539%	690%	615%	Solder	Voids, poor soldering; not bonded
S17	6.88	6.62	1.52	5.36	5.1	10.46	453%	436%	444%	Solder	Voids, solder filled voids, loose wire strand
S18	3.69	4.5	0.725	2.965	3.775	6.74	509%	621%	565%	Solder	Solder filled voids
S19	4.52	3.88	0.535	3.985	3.345	7.33	845%	725%	785%	Solder	Good soldering filled voids, open crimp
S20	4.12	2.84	0.605	3.515	2.235	5.75	681%	469%	575%	Weld	Asymmetric crimp, voids, poor crimp, open barrel, loose strands, poor weld

Sample Number	Neutral Prong (mΩ)	Hot Prong (mΩ)	Wire (mΩ)	Neutral increase (mΩ)	Hot increase (mΩ)	Sum Neutral and Hot	Neutral Percent Increase	Hot Percent Increase	Hot/Neutral Average Percent Increase	Solder/ Weld/ None	Notes
S21	6.96	8.68	0.76	6.2	7.92	14.12	916%	1142%	1029%	None	Long wire leads, voids
S22	4.32	4.05	1.055	3.265	2.995	6.26	409%	384%	397%	Solder	Good soldering, filled voids, good solder coverage, good barrel closure
S23	6.69	5.15	0.73	5.96	4.42	10.38	916%	705%	811%	None	Voids
S24	3.24	2.84	0.605	2.635	2.235	4.87	536%	469%	502%	Solder	Asymmetric crimp, solder filled voids, open crimp barrel
S25	7.93	6.85	1.285	6.645	5.565	12.21	617%	533%	575%	None	Asymmetric crimp, voids, incorrect crimping (triangle), broken strands
S26	5.39	7.16	0.815	4.575	6.345	10.92	661%	879%	770%	None	Asymmetric crimp, voids
S27	6.44	6.91	1.09	5.35	5.82	11.17	591%	634%	612%	None	Voids, asymmetric, long leads

Table A-9 Power Cord Connection Type and Separation

Sample Number	Power Cord Connection Type	Power Cord Connection Solder/Weld/None	Separation Measurement (mm)
S1	Butt crimps	Solder (both)	14.3
S2	Spades	Solder (both)	50
S3	Butt and spade	None (butt)/solder (spade)	250
S4	Barrel crimps	Solder (both)	2.18
S5	Spades	Solder (both)	>500
S6	Spades	Solder (both)	18.7
S7	Spades	Solder (both)	> 500
S8	Butt crimps	Solder (both)	>500
S9	Through holes on PCB	Solder (both)	10
S10	Spades	Solder (both)	>500
S11	Spades	Solder (both)	>500
S12	Spades	Solder (both)	>500
S13	Spades	Solder (both)	>500
S14	Spades	Solder (both)	9
S15	Spades	Solder (both)	>500
S16	Spades	Solder (both)	varied, min 10.6
S17	Sleeves and screw block	None	10.25
S18	Rings and screw block	Solder (both)	22
S19	Rings and screw block	Solder (both)	22
S20	Spades	Solder (both)	0.64
S21	Butt crimps	None	>500
S22	Butt crimps	None	8.3
S23	Barrel crimp and spade	Solder (both)	>500
S24	Butt crimp and spade	None (Butt or spade)	>500
S25	Spades	None	>500
S26	Spade and butt	None (butt or spade)	>500
S27	Spades	None	8.75

Table A-10. Safety Devices Wiring Connections

	Tip-over switch		One-shot device		High-Limit device	
Sample Number	Connector Type	Solder/Weld/None	Connector Type	Solder/Weld/None	Connector Type	Solder/Weld/None
S1	n/a	n/a	spade	solder	n/a	n/a
S2	spade	none	crimp	none	crimp	None
S3	spade	none	crimp/spade	none	n/a	n/a
S4	n/a	n/a	crimp	none	n/a	n/a
S5	spade	solder to power cord only	crimp	none	n/a	n/a
S6	n/a	n/a	crimp	none	crimp	None
S7	spade	Power cord solder, Circuit board-none	spade	PC-solder, CB-none	none	None
S8	n/a	n/a	spade	solder	n/a	n/a
S9	Low voltage connector	solder	n/a	n/a	Through hole to board	Solder
S10	spade	solder	crimp	solder	n/a	n/a
S11	spade	none	crimp	none	n/a	n/a
S12	spade	Power cord-solder, High limit-none	crimp	none	crimp	none
S13	spade	none	n/a	n/a	Through hole to board	solder
S14	spade	none	crimp	none	n/a	n/a
S15	spade	Power cord solder only	crimp	none	n/a	n/a
S16	spade	none	n/a	n/a	spade	none
S17	spade	none	n/a	n/a	spade	none
S18	spade	One-shot-solder only, Fan/heater select-none	n/a	n/a	spade	solder
S19	spade	solder	n/a	n/a	spade	solder to hot side only
S20	spade	solder	spade	solder	spade	solder
S21	spade	none	crimp	none	crimp	none
S22	spade	none	n/a	n/a	spade	none
S23	spade	solder	spade	solder	n/a	n/a
S24	spade	none	n/a	n/a	crimp	none
S25	spade	none	crimp	none	spade	none
S26	spade	none	n/a	n/a	crimp	none
S27	n/a	n/a	crimp	none	crimp	none

Table A-11. Heating Element Connections

	Heating Element	
Sample Number	Connector Type	Solder/Weld/None
S1	spade	solder
S2	spade	none
S3	spade	none
S4	spade	none
S5	spade	none
S6	spade	none
S7	spade	none
S8	spade	solder
S9	spade	none
S10	spade	some solder
S11	spade	none
S12	spade	none
S13	spade	none
S14	butt crimp	none
S15	spade	Power cord solder only
S16	ring	none
S17	ring	none
S18	spade	solder
S19	spade	solder
S20	ring	solder
S21	spade	none
S22	spade	none
S23	spade	solder
S24	spade	none
S25	spade	none
S26	spade	none
S27	spade	none

Table A-12. Glow Wire Test Results

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
S1	Rear housing	0.1	9.4	No	0.3	20.2	No
	Front housing	0.3	18.2	No	0.1	31.4	No
	Front logo	0.1	9.5	No	No Sample	~	~
	Base	0.3	32.3	No	0.3	31.1	No
	Oscillation ring	0.3	24.2	No	0.3	33.0	No
	Heater mount	No Ignition	~	~	No Sample	~	~
	Fan housing	8.2	33.3	No	No Ignition	~	No
	Fan impeller	No Ignition	~	~	No Ignition	~	~
	Base Cover	No Ignition	~	~	No Ignition	~	~
	Heater housing	1.7	29.9	No	0.6	30.8	No
S2	Base cover	1.5	>60	No	0.2	>60	No
	Base	0.3	12.0	No	1.1	31.0	No
	Side cover controls	0.8	30.9	No	0.5	13.9	No
	Rear housing	0.1	10.9	No	0.1	16.3	No
	Front housing	0.1	23.5	No	0.1	33.8	No
	Fan housing	0.1	31.3	YES	0.1	>60	Yes
	Fan impeller	0.1	>60	No	0.4	>60	No
S3	Control end housing	0.3	44.0	No	0.2	37.6	No
	End housing	0.3	>60	No	0.6	>60	No
S4	Base cover	0.2	30.0	No	0.2	>60	No
	Front housing	0.3	31.6	No	0.3	32.3	No
	Rear housing	0.1	31.0	No	0.5	49.0	No
	Motor base	1.5	>60	YES	1.6	>60	No
	Base	0.8	47.0	No	0.1	43.3	No
	Fan housing	1.1	31.4	No	1.2	30.5	No
	Heater housing	No Ignition	~	~	No Ignition	~	~
S5	Base cover	0.3	31.8	No	0.3	43.4	No
	Base	0.3	33.5	No	0.4	57.7	No
	Motor base	0.3	32.6	No	0.2	32.2	No

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
	Front housing	0.5	8.9	No	0.3	5.1	No
	Rear housing	0.8	5.3	No	0.5	7.8	No
	Fan holder	0.5	20.8	No	0.5	6.2	No
	Fan housing	0.1	>60	YES	0.4	>60	No
	Fan Impeller	0.3	>60	YES	0.1	>60	Yes
	Top control housing	No Ignition	~	~	0.3	2.0	No
	Heater housing	0.2	33.9	No	0.3	35.4	No
S6	Filter cover	0.3	32.3	No	0.5	34.0	No
	Base cover	0.4	35.8	No	1.1	23.9	No
	Front trim	0.1	>60	No	0.2	>60	No
	Front housing	1.6	6.7	No	No Ignition	~	~
	Base	0.5	20.8	No	0.3	45.2	No
	Rear housing	0.2	34.7	No	0.5	32.5	No
	Heater housing	1.0	29.0	No	1.0	32.8	No
	Fan holder	1.5	32.0	No	1.3	34.2	No
	Fan Impeller	0.3	>60	No	0.2	>60	No
	Fan housing	0.1	32.6	No	0.1	31.8	No
S7	Base cover	1.1	>60	No	0.4	19.8	No
	Base	0.6	29.3	No	0.1	23.4	No
	Filter cover	0.1	9.2	No	0.4	9.1	No
	Rear housing	0.5	20.0	No	2.6	15.7	No
	Front housing	0.1	19.2	No	0.5	9.9	No
	Top control housing	3.2	21.3	No	3.1	45.3	No
	Fan holder	1.4	18.5	No	1.4	20.0	No
	Fan Impeller	0.5	32.8	No	0.2	33.7	No
	Fan housing	0.3	31.3	No	0.3	40.4	No
	Heater housing	1.5	35.2	No	1.0	36.7	No
S8	Base cover	0.3	4.7	No	0.5	4.5	No
	Rear housing	0.3	31.9	No	0.3	30.8	No
	Fan housing	0.3	31.4	No	0.3	6.0	No
	Fan impeller	0.7	19.9	No	0.3	23.2	No

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
	Heater housing	1.0	33.5	No	0.7	30.6	No
	Front housing	1.0	32.5	No	0.5	33.6	No
	Filter cover	0.9	30.7	No	1.1	23.9	No
	Front bezel	0.5	32.1	No	0.3	38.5	No
	Base	6.0	28.3	No	4.5	30.1	No
	Control cover	0.9	37.7	No	No Ignition	~	~
	Motor mount	No Ignition	~	~	No Ignition	~	~
S9	Rear housing	1.0	>60	No	0.7	15.6	No
	Front housing	0.4	38.6	No	0.3	46.2	No
	Heater housing	1.0	14.2	No	0.9	26.8	No
	Fan	0.1	>60	No	0.1	>60	No
	Feet (base)	0.5	57.1	No	0.6	53.6	No
S10	Front housing	No Ignition	~	~	No Ignition	~	~
	Rear housing	No Ignition	~	~	No Ignition	~	~
	Heater housing	0.5	52.5	No	0.4	58.6	No
	Fan impeller	1.0	>60	No	0.6	>60	No
S11	Base	0.6	>60	No	0.5	>60	No
	Filter cover	1.3	28.4	No	0.7	41.8	No
	Front housing	0.5	34.2	No	0.9	35.4	No
	Side housing	0.6	37.3	No	0.2	40.2	No
	Rear housing	0.9	36.6	No	0.5	46.7	No
	Fan housing	0.6	32.4	No	0.5	38.5	No
	Motor housing	0.6	37.7	No	0.5	14.7	No
	Heater housing	0.4	35.9	No	0.6	35.5	No
S12	Rear housing	0.5	34.1	No	0.5	37.7	No
	Fan Housing	1.0	28.9	No	0.8	40.4	No
	Fan Impeller	0.7	26.3	No	0.5	35.6	No
	Heater shroud	0.5	58.7	No	0.6	38.8	No
	Motor mount	1.0	36.9	No	0.8	36.3	No
	Base cover	0.3	35.6	No	0.4	36.5	No
	Rear grill cover	0.2	>60	No	0.4	49.0	No

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
	Base	0.5	34.7	No	0.7	30.8	No
	Heater housing	1.2	33.5	No	0.3	39.6	No
	Side housing	0.3	37.6	No	0.3	34.3	No
	Top housing	0.8	>60	No	0.6	>60	No
S13	Base cover	0.4	41.7	No	0.4	53.6	No
	Base	0.6	37.7	No	0.7	45.0	No
	Rear housing	0.2	43.2	No	0.3	37.3	No
	Motor mount	0.5	8.3	No	0.4	7.5	No
	Front housing	0.3	41.2	No	0.6	35.2	No
	Heater housing	0.2	36.2	No	0.4	37.9	No
	Fan housing/impeller	0.1	>60	No	0.3	46.8	No
S14	Base	0.4	>60	No	0.2	>60	No
	Motor mount	0.5	>60	No	0.6	>60	No
	Lower ring housing	0.5	>60	No	0.6	56.0	No
	Top control housing	1.5	41.6	No	1.5	>60	No
	Top base	1.3	>60	No	1.0	53.5	No
S15	Leg supports	0.3	40.0	No	0.1	38.1	No
S16	Cord reel	0.4	43.6	No	0.3	40.4	No
	Control panel	0.8	43.6	No	0.5	40.3	No
S17	Led support	0.7	>60	No	0.6	>60	No
	End housing	0.3	>60	Yes	0.3	>60	Yes
S18	Cord reel	0.4	>60	No	0.5	>60	No
	Control panel	33.3	12.8	No	0.7	30.9	No
S19	Feet	2.8	12.6	No	1.6	21.8	No
	Control end cover	No Ignition	~	~	No Ignition	~	~
S20	Cord reel	0.3	>60	No	0.3	>60	No
	Do Not Cover	1.2	43.0	No	No Sample	~	~
	End vent	0.2	4.0	No	0.5	4.7	No
	End control cover	0.3	5.9	No	0.7	5.5	No
S21	Front grill	0.3	32.7	No	0.4	40.8	No
	Rear housing	0.3	33.4	No	0.2	35.8	No

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
	Front housing	0.4	33.6	No	0.2	34.3	No
	Heater housing	0.5	33.5	No	0.3	39.8	No
	Fan housing	0.8	>60	No	0.6	>60	No
	Fan Impeller	0.7	54.2 (consumed)	No	0.5	55.0 (consumed)	No
	Top control housing	0.7	25.4	No	0.3	>60	No
	Base	0.5	32.4	No	1.1	31.9	No
	Motor mount	0.3	36.5	No	0.7	54.8	No
S22	Feet	0.6	33.0	No	0.5	33.1	No
	Handle trim	0.5	32.9 (consumed)	No	No Sample		
	Handle	0.4	32.8	No	0.3	41.2	No
S23	Front housing	1.0	>60	YES	0.9	>60	Yes
	Rear housing	0.4	>60	YES	0.8	>60	Yes
	Heater housing	0.5	50.0	No	0.5	58.9	No
	Motor mount	1.2	31.5	No	0.8	32.6	No
	Fan housing	1.2	31.9	No	1.5	31.5	No
	Fan Impeller	0.6	32.7	No	0.6	33.7	No
	Base cover	1.0	43.9	No	1.0	34.1	No
	Grill trim	0.4	>60	No	0.5	>60	No
S24	Misc.	0.6	>60	No	No Sample	~	~
	Base cover	0.5	>60	No	0.3	>60	Yes
	Filter cover	0.1	>60	No	0.5	>60	No
	Rear housing	0.6	>60	No	0.6	>60	No
	Heater housing	0.4	33.6	No	1.6	31.3	No
	Front housing	0.6	>60	No	0.8	>60	No
	Fan housing	0.5	33.5	No	0.2	32.6	No
	Fan impeller	0.4	>60	No	0.4	>60	No
	Motor mount	0.3	>60	No	0.5	>60	No
	Base	0.5	>60	No	0.2	>60	No
	Top control cover	1.1	>60	No	1.2	>60	No
S25	Front housing	0.2	36.0	YES	0.6	40.0	Yes
	Rear housing	0.5	32.4	No	0.6	33.1	No

		Sample 1			Sample 2		
Sample Number	Part	Ignition time (s)	Extinguish time (s)	Ignition of indicator	Ignition time (s)	Extinguish time (s)	Ignition of indicator
	Fan Housing	0.5	35.3	No	0.2	32.5	No
	Fan Impeller	0.9	28.1	No	0.6	31.1	No
	Front grill trim/slats	1.0	34.8	No	1.1	35.1	No
	Heater housing	1.2	45.2	No	0.8	34.7	No
S26	Stabilizer base	0.8	>60	YES	0.9	>60	Yes
	Base cover	1.1	>60	YES	1.0	>60	Yes
	Rear housing	1.3	>60	YES	1.0	>60	Yes
	Front housing	1.8	>60	YES	1.3	>60	Yes
	Motor mount	0.7	>60	No	1.1	>60	No
	Fan housing	0.4	>60	No	0.6	>60	No
	Fan Impeller	0.8	31.2	No	0.6	31.8	No
	Heater housing	0.6	>60	No	0.3	>60	No
	Top control housing	0.4	>60	No	0.6	>60	No
	Front trim	0.5	>60	No	0.4	>60	No
	Motor mount	0.6	>60	No	0.3	>60	No
	Top housing	0.3	>60	YES	0.9	>60	Yes
	Control pad with handle	1.1	>60	YES	1.3	>60	Yes
S27	Base cover	0.6	>60	No	0.6	>60	No
	Base	0.5	>60	No	0.3	>60	No
	Ring base	0.6	>60	No	0.1	>60	No
	Base outer track ring	0.9	>60	No	0.6	>60	Yes
	Base motor cover	0.3	>60	YES	0.5	>60	No
	Lower housing ring base	0.3	>60	No	0.4	>60	No
	Fan housing	0.5	>60	YES	0.9	>60	No
	Rear housing	0.6	>60	No	0.5	>60	No
	Front housing	0.5	>60	No	0.5	>60	No
	Heater housing	0.5	>60	No	0.4	>60	No
	Fan impeller	0.2	>60	No	0.5	>60	No

Table A-13. Results of Open Flame Test

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
S1	Rear housing	1st	No	~	~	~	No	~	~	~
		2nd	No	~	~	~	No	~	~	~
	Front housing	1st	YES	5.07	~	~	YES	1.43	~	~
		2nd	YES	5.43	~	~	YES	1.38	~	~
	Front logo	1st	No	~	~	~	No Sample			
		2nd	No	~	~	~	N/A			
	Base	1st	YES	>30	~	~	No	~	~	~
		2nd	N/A				YES	1.47	~	~
	Oscillation ring	1st	No	~	~	~	No	~	~	~
		2nd	No	~	~	~	No	~	~	~
	Heater mount	1st	No	~	~	~	No Sample			
		2nd	No	~	~	~	N/A			
	Fan housing	1st	No	~	~	~	No	~	~	~
		2nd	No	~	~	~	No	~	~	~
	Fan impeller	1st	YES	9.66	~	~	YES	21.9	~	~
		2nd	No	~	~	~	YES	14.47	~	~
	Base Cover	1st	No	~	~	~	No	~	~	~
		2nd	No	~	~	~	YES	1.75	~	~
	Heater housing	1st	No	~	~	~	No	~	~	~
		2nd	YES	0.94	~	~	No	~	~	~
S2	Base cover	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Base	1st	YES	4.81	~	~	YES	23.85	~	~
		2nd	YES	1.75	~	~	YES	>30	~	~
	Side cover controls	1st	NO	~	~	~	YES	>30	~	~
		2nd	NO	~	~	~	N/A			
	Rear housing	1st	YES	>30	~	~	NO	~	~	~

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	N/A				NO	~	~	~
	Front housing	1st	YES	>30	~	~	YES	9.5	~	~
		2nd	N/A				YES	2.47	~	~
	Fan housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Fan impeller	1st	YES	>30	YES	YES	YES	10	YES	YES
		2nd	N/A				N/A			
S3	Control end housing	1st	YES	9.93	~	~	YES	5.35	~	~
		2nd	NO	~	~	~	YES	2	~	~
	End housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	1.78	~	~
S4	Base cover	1st	YES	1.25	~	~	YES	>30	~	~
		2nd	YES	>30	~	~	N/A			
	Front housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Rear housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Motor base	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Base	1st	YES	4.19	~	~	NO	~	~	~
		2nd	YES	4.12	~	~	YES	2.63	~	~
	Fan housing	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	2.62	~	~	NO	~	~	~
	Heater housing	1st	YES	2.91	~	~	YES	0.75	~	~
		2nd	YES	>30	~	~	YES	23.69	~	~
S5	Base cover	1st	YES	>30	~	~	YES	10.46	~	~
		2nd	N/A				NO	~	~	~

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Base	1st	YES	14.12	~	~	YES	11.25	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Motor base	1st	YES	4.85	~	~	YES	26.84	~	~
		2nd	YES	3.03	~	~	YES	7.19	~	~
	Front housing	1st	NO	~	YES(1)	YES	NO	~	YES(1)	~
		2nd	NO	~	YES(1)	YES	NO	~	YES(1)	YES
	Rear housing	1st	NO	~	YES(1)	YES	NO	~	YES(1)	~
		2nd	NO	~	YES(1)	YES	NO	~	YES(1)	YES
	Fan housing	1st	NO	~	YES(1)	NO	NO	~	YES(1)	YES
		2nd	NO	~	YES(1)	NO	NO	~	YES(1)	YES
	Fan housing	1st	YES	>30	~	YES	YES	>30	~	YES
		2nd	N/A				N/A			
	Fan Impeller	1st	YES	>30	~	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Top control housing	1st	NO	~	~	NO	YES	3.78	~	~
		2nd	YES	4.87	~	NO	YES	7.75	YES	NO
	Heater housing	1st	YES	2.41	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	4.4	~	~
S6	Filter cover	1st	YES	2	~	~	YES	1.34	~	~
		2nd	YES	3.72	~	~	NO	~	~	~
	Base cover	1st	YES	6.16	~	~	YES	7.4	~	~
		2nd	NO	~	~	~	YES	>30	~	~
	Front trim	1st	YES	>30	~	YES	YES	>30	~	YES
		2nd	N/A				N/A			
	Front housing	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	1.28	~	~	NO	~	~	~
	Base	1st	YES	>30	~	NO	YES	>30	~	~

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	N/A				N/A			
	Rear housing	1st	YES	>30	~	~	YES	>30	~	~
		2nd	N/A				N/A			
	Heater housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan Impeller	1st	YES	Consumed	~	NO	YES	Consumed	~	NO
		2nd	N/A				N/A			
	Fan housing	1st	YES	6	~	~	YES	0.94	~	~
		2nd	NO	~	~	~	NO	~	~	~
S7	Base cover	1st	YES	3.44	~	~	NO	~	~	~
		2nd	YES	2.88	~	~	NO	~	~	NO
	Base	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	3.5	~	~
	Filter cover	1st	NO	~	YES(1)	YES	NO	~	YES(1)	YES
		2nd	NO	~	YES(1)	YES	NO	~	YES(1)	YES
	Rear housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	5.72	~	~
	Top control housing	1st	YES	1.62	~	~	YES	3.47	~	~
		2nd	NO	~	~	~	YES	4.5	~	YES
	Fan housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan Impeller	1st	YES	Consumed	~	NO	YES	Consumed	~	~
		2nd	N/A				N/A			

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Fan housing	1st	YES	1.5	~	~	NO	~	~	~
		2nd	YES	2.09	~	~	YES	4.25	~	~
	Heater housing	1st	YES	0.94	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
S8	Base cover	1st	NO	~	YES(1)	YES	NO	~	YES(1)	YES
		2nd	NO	~	YES(1)	YES	NO	~	YES(1)	YES
	Rear housing	1st	YES	>30	~	~	NO	~	~	~
		2nd	N/A				NO	~	~	~
	Fan housing	1st	NO	~	YES(1)	NO	NO	~	YES(1)	YES
		2nd	NO	~	YES(1)	NO	NO	~	YES(1)	NO
	Fan impeller	1st	YES	Consumed	~	NO	YES	Consumed	YES	NO
		2nd	N/A				N/A			
	Heater housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front housing	1st	YES	4.37	NO	~	YES	5.13	~	~
		2nd	NO	~	~	~	YES	10.03	~	~
	Filter cover	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front bezel	1st	YES	0.78	NO	~	YES	23.22	~	~
		2nd	YES	>30	NO	~	YES	1.22	~	~
	Base	1st	NO	~	~	~	YES	0.72	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Control cover	1st	NO	~	~	~	YES	3.5	~	~
		2nd	NO	~	~	~	YES	0.84	~	~
	Motor mount	1st	YES	24	NO	~	YES	7.75	~	~
		2nd	YES	9.41	NO	~	YES	5.87	~	~
S9	Rear housing	1st	NO	~	~	~	YES	9.1	~	~

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	YES	22.38	~	~	NO	~	~	~
	Front housing	1st	YES	3.22	~	~	YES	5.81	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Heater housing	1st	YES	1.84	~	~	YES	2.87	~	~
		2nd	YES	2.1	~	~	YES	6.09	~	~
	Fan	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Feet (base)	1st	YES	17.75	~	~	YES	7.28	~	NO
		2nd	YES	1.62	~	~	YES	1.54	~	~
S10	Front housing	1st	YES	6.08	YES	YES	NO	~	~	~
		2nd	YES	5.69	YES	NO	NO	~	~	NO
	Rear housing	1st	YES	11.21	YES	NO	NO	~	~	~
		2nd	NO	~	YES(1)	YES	NO	~	YES(1)	YES
	Heater housing	1st	NO	~	~	~	YES	7	~	~
		2nd	NO		YES(1)	NO	NO	~	~	~
	Fan impeller	1st	YES	>30	~	~	Consumed	~	~	~
		2nd	N/A				N/A			
S11	Base	1st	YES	>30	~	~	YES	>30	~	NO
		2nd	N/A				N/A			
	Filter cover	1st	NO	~	~	~	YES	2.09	~	~
		2nd	YES	8.32	~	~	NO	~	~	~
	Front housing	1st	NO	~	~	~	YES	2.19	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Side housing	1st	YES	7.88	~	~	NO	~	~	~
		2nd	YES	6.56	~	~	NO	~	~	~
	Rear housing	1st	YES	2.38	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	10.56	~	YES

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Fan housing	1st	YES	23.88	~	~	NO	~	~	~
		2nd	YES	12.5	~	NO	NO	~	~	~
	Motor housing	1st	YES	10.5	~	~	YES	1.81	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Heater housing	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	3.44	~	~	NO	~	~	~
S12	Rear housing	1st	YES	9.07	~	~	YES	>30	~	~
		2nd	YES	>30	~	~	N/A			
	Fan Housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan Impeller	1st	NO	~	~	~	YES	3.57	~	~
		2nd	YES	6.18	~	~	YES	5.37	~	~
	Heater shroud	1st	YES	11.16	~	~	YES	21.25	~	~
		2nd	YES	20	~	~	YES	12.93	~	~
	Motor mount	1st	NO	~	~	~	YES	2.04	~	~
		2nd	NO	~	~	~	YES	>30	~	~
	Base cover	1st	YES	>30	~	~	YES	>30	~	~
		2nd	N/A				N/A			
	Rear grill cover	1st	YES	1.16	~	~	NO	~	~	~
		2nd	YES	5.22	~	~	YES	5.71	~	~
	Base	1st	NO	~	~	~	YES	15.75	~	~
		2nd	YES	2.38	~	~	NO	~	~	~
	Heater housing	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	6.44	~	~	NO	~	~	~
	Side housing	1st	YES	>30	~	~	YES	>30	~	~
		2nd	N/A				N/A			
	Top housing	1st	YES	7.85	YES	YES	YES	>30	~	YES

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	YES	>30	YES	YES	N/A			
S13	Base cover	1st	YES	2.22	~	NO	NO	~	~	~
		2nd	YES	>30	~	~	NO	~	~	~
	Base	1st	NO	~	~	~	YES	>30	~	~
		2nd	YES	28.85	~	~				
	Rear housing	1st	YES	2.9	~	~	NO	~	~	~
		2nd	YES	22.75	~	~	YES	13.66	~	~
	Motor mount	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front housing	1st	YES	8.41	~	~	YES	7.53	~	~
		2nd	YES	9	~	~	YES	14.12	~	~
	Heater housing	1st	YES	2.13	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan impeller	1st	YES	>30	~	~	YES	17.84	~	~
		2nd	N/A				YES	10	~	~
S14	Base	1st	YES	1.47	~	~	NO	~	~	~
		2nd	YES	2.81	~	~	YES	4.88	~	~
	Motor mount	1st	YES	6.31	~	~	YES	7.21	~	~
		2nd	YES	14.6	~	~	YES	8.97	~	~
	Lower ring housing	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	1.82	~	~	YES	2.78	~	~
	Top control housing	1st	YES	3.87	~	~	YES	4.75	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Top base	1st	YES	7.66	~	~	YES	4.6	~	~
		2nd	YES	Consumed	YES	YES	YES	20.97	~	~
S15	Leg supports	1st	YES	11.5	~	YES	YES	25	~	~
		2nd	YES	23.82	~	NO	YES	27.06	YES	NO

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
S16	Cord reel	1st	YES	3.53	~	~	YES	4	~	~
		2nd	YES	2.94	~	~	NO	~	~	~
	Control panel	1st	YES	3.84	~	~	YES	2.56	~	~
		2nd	YES	7.85	~	~	YES	7.03	~	~
S17	Led support	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	End housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
S18	Cord reel	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Control panel	1st	NO	~	~	~	YES	0.88	~	~
		2nd	YES	6.37	~	~	NO	~	~	~
S19	Feet	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Control end cover	1st	YES	15.94	~	NO	NO	~	~	~
		2nd	YES	2.94	~	~	NO	~	~	~
S20	Cord reel	1st	YES	>30	~	~	YES	>30	~	~
		2nd	N/A				N/A			
	Do Not Cover	1st	NO	~	YES(1)	YES	No sample			
		2nd	YES	8.09	YES	YES	N/A			
	End vent	1st	NO	~	YES(1)	YES	NO	~	YES(1)	NO
		2nd	NO	~	YES(1)	NO	NO	~	YES(1)	NO
	End control cover	1st	NO	~	YES(1)	YES	NO	~	YES(1)	YES
		2nd	NO	~	YES(1)	NO	NO	~	YES(1)	NO
S21	Front grill	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Rear housing	1st	YES	10.57	~	~	YES	0.85	~	~

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	YES	>30	~	~	YES	29.4	~	~
	Front housing	1st	YES	>30	~	~	YES	12.76	~	~
		2nd	N/A				YES	>30	~	~
	Heater housing	1st	NO	~	~	~	YES	4.03	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Fan Impeller	1st	YES	Consumed	YES	YES	YES	Consumed	YES	YES
		2nd	N/A				N/A			
	Top control housing	1st	YES	>30	~	~	NO	~	~	~
		2nd	N/A				YES	>30	~	~
	Base	1st	NO	~	~	~	YES	>30	~	~
		2nd	NO	~	~	~	N/A			
	Motor mount	1st	YES	12.91	~	~	YES	>30	~	~
		2nd	YES	>30	~	~	N/A			
S22	Feet	1st	YES	3.62	~	~	YES	21.09	~	~
		2nd	YES	1.44	~	~	YES	1.07	~	~
	Handle trim	1st	YES	19.9	~	~	No sample			
		2nd	NO	~	~	~	N/A			
	Handle	1st	YES	12.81	~	~	No sample			
		2nd	YES	7.62	~	~	N/A			
S23	Front housing	1st	YES	>30	YES	YES	Consumed	~	YES	YES
		2nd	N/A				N/A			
	Rear housing	1st	YES	Consumed	YES	YES	YES	Consumed	YES	YES
		2nd	N/A				N/A			
	Heater housing	1st	YES	Consumed	YES	YES	YES	Consumed	YES	YES
		2nd	N/A				N/A			

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Motor mount	1st	NO	~	~	~	YES	1.47	~	~
		2nd	NO	~	~	~	YES	>30	~	~
	Fan housing	1st	YES	0.75	~	~	NO	~	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Fan Impeller	1st	NO	~	~	~	NO	~	~	~
		2nd	YES	Consumed	YES	NO	YES	1.43	~	~
	Base cover	1st	YES	9.5	~	~	NO	~	~	~
		2nd	YES	7.4	~	NO	YES	>30	~	~
	Grill trim	1st	YES	18.87	~	~	YES	>30	~	~
		2nd	NO	~	~	~	N/A			
S24	Misc.	1st	YES	>30	~	~	No Sample			
		2nd	N/A				N/A			
	Base cover	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Filter cover	1st	YES	Consumed	~	YES	YES	Consumed	~	YES
		2nd	N/A				N/A			
	Rear housing	1st	YES	Consumed	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Heater housing	1st	NO	~	~	~	YES	4.13	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Fan housing	1st	YES	2.56	~	~	NO	~	~	~
		2nd	YES	14.28	~	~	YES	~	~	~
	Fan impeller	1st	YES	>30	YES	YES	YES	Consumed	YES	YES
		2nd	N/A				N/A			
	Motor mount	1st	YES	>30	YES	YES	YES	>30	YES	YES

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
		2nd	N/A				N/A			
	Base	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Top control cover	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
S25	Front housing	1st	NO	~	YES	YES	YES	2	YES	YES
		2nd	N/A				N/A			
	Rear housing	1st	YES	1.38	YES	YES	YES	1.87	YES	YES
		2nd	N/A				N/A			
	Fan Housing	1st	NO	~	~	~	NO	~	~	~
		2nd	NO	~	YES(1)	NO	NO	~	~	~
	Fan Impeller	1st	NO	~	~	~	YES	1	~	~
		2nd	NO	~	~	~	NO	~	~	~
	Front grill trim/slats	1st	YES	4	~	~	YES	>30	~	~
		2nd	YES	1.87	~	~	NO	~	~	~
	Heater housing	1st	YES	>30	~	~	YES	5.29	~	~
		2nd	YES	4.9	~	~	YES	7.03	~	~
S26	Stabilizer base	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Base cover	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Rear housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Front housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Motor mount	1st	YES	>30	YES	YES	NO	~	YES(1)	YES
		2nd	N/A				N/A			

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Fan housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Fan Impeller	1st	YES	7.4	~	~	NO	~	~	~
		2nd	NO	~	~	~	YES	1.69	~	~
	Heater housing	1st	YES	28.3	YES	YES	YES	7.91	YES	YES
		2nd	NO	~	~	~	YES	27.79	~	~
	Top control housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Front trim	1st	YES	>30	YES	YES	No sample			
		2nd	N/A				N/A			
	Motor mount	1st	YES	>30	~	YES	YES	>30	~	YES
		2nd	N/A				N/A			
	Top housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Control pad with handle	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
S27	Base cover	1st	YES	>30	~	YES	YES	>30	~	YES
		2nd	N/A				N/A			
	Base	1st	YES	Consumed	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Ring base	1st	YES	>30	~	YES	YES	>30	~	YES
		2nd	N/A				N/A			
	Base outer track ring	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Base motor cover	1st	YES	>30	YES	YES	YES	>30	~	~
		2nd	N/A				N/A			
		1st	YES	Consumed	YES	YES	YES	>30	YES	YES

		Sample 1					Sample 2			
Sample Number	Part	Test Trial	Ignition	Self-extinguish time (s)	Dripped	Ignition of indicator	Ignition	Self-extinguish time (s)	Dripped	ignition of indicator
	Lower housing ring base	2nd	N/A				N/A			
	Fan housing	1st	YES	Consumed	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Rear housing	1st	YES	>30	YES	YES	YES	22.89	YES	YES
		2nd	N/A				YES	>30	YES	YES
	Front housing	1st	YES	>30	YES	YES	YES	>30	YES	YES
		2nd	N/A				N/A			
	Heater housing	1st	YES	>30	YES	YES	YES	Consumed	YES	YES
		2nd	N/A				N/A			
	Fan impeller	1st	YES	>30	~	~	YES	>30	YES	YES
		2nd	N/A				N/A			

(1) The plastic sample dripped only during the first 30 seconds when the source flame was applied. When the source flame was applied to the plastic, it resulted in dripping plastic, which ignited the cheesecloth indicator material. Once the source flame was removed, the plastic sample immediately self-extinguished.

Table A-14. End-Product Heater Sample (Sub 02) Ignition Test Results

Sample Number	1st Ignition part application	1st Ignition attempt	2nd Ignition part application	2nd Ignition attempt	Overall Test Results (1st and 2nd attempts)
S1	Base	No	Fan Housing	No	No
S2	Base Cover	No	Fan Housing	YES	YES
S3	End Housing	No	Control end housing	No	No
S4	Fan Housing	No	Base cover	No	No
S5	Fan Impeller	YES	N/A	N/A	YES
S6	Front Trim	YES	N/A	N/A	YES
S7	Base Cover	No	Fan Impeller	No	No
S8	Rear Housing	No	Front Bezel	No	No
S9	Fan	No	Rear Housing	No	No
S10	Fan Impeller	No	Rear Housing	No	No
S11	Base	YES	N/A	N/A	YES
S12	Top housing	No	Side Housing	No	No
S13	Base	No	Fan Impeller	YES	YES
S14	Top base	No	Motor Mount	No	No
S15	Leg supports	No	Other Leg	No	No
S16	Cord Reel	No	Control Panel	No	No
S17	End Housing	YES	N/A	N/A	YES
S18	Cord Reel	YES	N/A	N/A	YES
S19	Control end cover	No	Feet	No	No
S20	Cord Reel	YES (self-extinguished after 3m 14 s)	End Control Cover	No	No
S21	Top Control Housing	No	Top Control Housing	No	No
S22	Feet	No	Handle (black	No	No
S23	Front Housing	YES	N/A	N/A	YES
S24	Base	YES	N/A	N/A	YES
S25	Front Grill Trim/Slats	No	Heater Housing	No	No
S26	Rear Housing	YES	N/A	N/A	YES
S27	Front Housing	No	Lower Housing Ring	YES	YES

Table A-15. Normal Operation Temperature Measurement Results

		Thermocouple 1		Thermocouple 2		Thermocouple 3		Thermocouple 4		Thermocouple 5		Thermocouple 6		Thermocouple 7		Thermocouple 8	
Sample Number	Heater Fan	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)	Max. (°C)	Avg. (°C)
S1	Fan	53.6	43.4	113.9	109.0	92.0	84.1	120.2	115.9	72.0	64.9	68.7	64.4	66.3	52.6	39.8	29.3
S2	Fan	53.0	47.0	38.7	37.6	69.9	64.7	46.4	45.6	46.1	44.9	55.1	51.9	48.6	47.7	39.6	37.3
S3	No fan	82.6	69.5	112.0	93.1	110.8	86.5	100.6	83.9	116.1	84.0	94.6	80.9	69.0	61.4	52.9	47.3
S4	Fan	44.2	35.4	57.7	50.7	66.0	52.2	65.5	50.4	87.4	76.6	67.0	61.9	55.3	44.0	28.4	24.0
S5	Fan	70.7	49.7	106.3	100.4	125.7	124.0	67.5	45.9	88.2	82.0	63.8	44.2	30.2	23.9	25.1	23.8
S6	Fan	45.7	40.5	77.5	75.8	93.3	92.3	76.8	74.5	87.8	86.7	79.3	77.4	43.7	40.4	33.7	32.1
S7	Fan	65.4	55.6	96.5	94.7	95.0	75.6	89.8	58.7	103.9	89.3	82.1	80.3	55.8	50.0	33.0	29.3
S8	Fan	72.6	69.3	77.3	73.9	125.4	123.8	53.6	41.0	63.8	61.6	93.2	88.5	47.6	35.4	26.0	23.6
S9	No fan	44.1	24.8	82.0	53.4	138.4	136.8	32.2	26.4	93.4	82.0	117.7	115.9	66.6	54.2	32.8	25.6
S10	Fan	92.8	42.2	128.4	94.1	118.5	104.7	29.6	25.3	66.5	47.3	40.4	27.0	24.4	23.1	23.7	23.3
S11	Fan	79.0	74.3	62.8	58.2	55.2	51.3	55.3	52.6	65.4	53.1	54.0	50.7	44.1	39.6	34.4	32.1
S12	Fan	39.6	37.8	110.1	94.9	107.3	98.3	53.0	42.9	86.2	75.8	66.5	50.7	37.7	31.7	26.6	24.3
S13	Fan	73.5	Note 1	71.0	Note 1	101.0	Note 1	81.7	Note 1	85.6	Note 1	48.5	Note 1	26.9	Note 1	25.5	Note 1
S14	No fan	34.6	31.3	36.6	32.9	37.8	33.7	38.7	34.6	37.5	33.4	26.4	25.2	26.4	24.8	24.8	24.2
S15	No fan	47.3	41.9	47.7	42.4	46.5	41.0	41.2	34.7	43.6	39.4	29.4	26.1	26.3	25.5	25.2	24.5
S16	No fan	26.3	25.2	26.5	25.2	26.0	25.0	25.9	24.9	26.3	25.3	24.0	23.4	24.1	23.7	24.1	23.5
S17 (Note 2)																	
S18	No fan	29.0	28.0	29.1	27.7	28.3	27.2	27.3	26.4	28.3	27.3	24.7	24.0	24.6	24.1	24.2	23.8
S19	No fan	28.1	27.0	27.9	26.9	27.2	26.0	26.7	25.6	27.6	26.3	24.2	23.5	24.3	23.7	23.9	23.4
S20	No fan	28.5	26.9	28.2	26.7	28.1	26.7	27.3	26.2	28.4	26.9	24.4	23.9	24.5	24.1	24.2	23.8
S21	Fan	26.9	24.3	59.7	42.2	151.9	149.5	25.3	24.0	63.7	49.5	111.1	97.8	49.5	27.0	33.7	23.3
S22	No fan	34.6	25.6	36.5	33.0	38.4	34.9	38.3	36.4	37.8	37.1	26.1	36.2	25.4	25.4	24.7	24.8
S23	Fan	72.8	65.0	89.1	77.9	109.7	106.6	57.7	48.9	86.6	83.7	71.1	65.1	30.9	23.9	24.8	23.8
S24	Fan	129.0	84.4	145.7	130.3	103.9	86.7	39.8	25.8	66.3	37.8	35.3	24.9	26.0	23.8	24.5	23.8
S25	Fan	25.6	23.2	32.2	25.6	105.3	75.3	39.2	35.6	71.5	67.2	91.9	84.8	36.0	26.6	27.7	24.3
S26	Fan	65.5	61.6	98.2	96.1	65.1	63.3	66.1	62.9	76.8	75.0	65.3	62.4	32.2	25.4	25.4	23.7
S27	Fan	24.6	22.9	28.4	23.3	29.4	24.0	30.0	25.0	27.8	23.6	35.6	34.5	35.8	34.8	35.1	33.9
NOTE 1 – The heater automatically shuts off after about 2 min. of operation, thus average temperature could not be calculated; NOTE 2 – No sample tested																	