Butane Fueled Table Top Cooking Appliances
Staff Project Report

Prepared by
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Directorate for Laboratory Sciences
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UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

Butane Fueled Table Top Cooking Appliances

Introduction: The U.S. Consumer Product Safety Commission (CPSC) established this project to evaluate the operational safety characteristics of typical portable butane fueled table top stoves. The project evaluated incident and injury data, and tested a sample of stoves. The results from the evaluation and testing were used to develop recommendations to revise U.S. voluntary standards.

Product Description: The product is a portable single burner butane cooking appliance. The stoves are typically used in restaurants for buffets, aboard boats, and for cooking demonstrations. Figure 1 shows a new stove with the fuel compartment door open and a fuel canister in place. Their typical size is 13x11½x3½ inches (330x290x90 mm). A combined grate and drip pan surrounds the burner and supports the cookware. There is a fuel compartment with a lid to the right of the burner. The fuel is contained in an 8 oz (227 gm) aerosol canister that is regulated by the Department of Transportation. The fuel canister's nozzle fits into the regulator, is sealed with an O-ring, and held in place either mechanically or magnetically. The control knob is on the right front of the stove, directly in front of the regulator. A locking lever to the left of the knob inserts the fuel can into the regulator. There is an over-pressure protection device on the regulator. The gas flows from the regulator through a primary nozzle integral with the burner. A piezo-electric spark at the burner ports is used to ignite the butane/air mixture. Turning the control valve fully on activates this spark. Older stove designs are stored with the combined grate and drip pan upside down. These stoves have an interlock to prevent the fuel can from being locked into the regulator if the combined grate and drip pan is in the storage position. Newer stove designs store the combined grate and drip pan right side up.

Fig. 1. Typical Table Top Butane Cooking Appliance

The Korean Gas Safety Corporation provided "Comparison of Korean and Japanese Standards on Portable Cookers attached to Liquefied Petroleum Gas Cylinder" and "Comparison of Korean and Japanese Standards on Gas Cylinders for Portable Gas Cookers". See the attached April 11, 2001 facsimile transmission from the Korean Gas Safety Corporation. The CPSC staff was unable to get copies of the Korean and Japanese standards from our normal sources, and these comparisons are the only available information on these standards in English.

Laboratory Testing, (Tab D): The laboratory test plan was developed to evaluate the mechanisms of overheating identified in the injury and incident data. Testing was performed in three stages: fuel canister, over-pressure protection, and operating tests in three conditions. First, all fuel canisters were tested in a 131°F hot water bath in accordance with Department of Transportation requirements specified in 49 CFR 173.306(a)(3)(v). Can failure would be obvious and leaks would show as bubbles. This was followed by testing the over-pressure protection feature with compressed air through a modified fuel canister on one stove of each of the four models tested. Pressure was read directly from the attached pressure gauge. The individual stoves used to test the over-pressure protection were not used in the operating tests. Operating tests were conducted on four stove models in three conditions described below. Temperatures were recorded from six points during each test. First the staff conducted a normal use test where the stove was operated with a large frying pan to provide a baseline for further testing. The next test replaced the frying pan with a large griddle that extended over the fuel compartment. Finally, the frying pan was used with the combined grate and drip pan inverted. (With the two stoves that store the pan support inverted, the pan support rested on the interlock, so the stove could operate.) This last test was done with all four stoves.

All the fuel canisters passed the hot water bath test without any leaks. It was possible to hear the butane boiling inside the canister, as the canister was immersed in the hot water. The pressure to activate the over-pressure protection for the four stoves ranged from 65 psig to 79 psig (0.45 Mpa to 0.54 MPa). This is consistent with requirements in both the Korean standard (0.49 MPa to 0.686 MPa (71.1 psig to 98.6 psig)) and the Japanese standard (0.4 MPa to 0.6 MPa (58 psig to 87 psig)).

There were no gas fires in the fuel compartment during the testing. The fuel canisters were cooled internally during use by the butane changing phase, and they were generally cooler than the ambient temperature. The regulator temperature was the most representative measure of stove performance recorded, because the over-pressure protection device is part of the regulator. Maximum regulator temperatures during the normal tests ranged from 34°C to 71°C (88°F to 160°F). With the griddle extending over the fuel compartment, regulator temperatures ranged from 75°C to 118°C (162°F to 244°F), and with the grate inverted from 74°C to 109°C (165°F to 228°F). In all three test series, the highest temperatures came from a model having a plate under the fuel canister to provide better low temperature performance. The over-pressure protection did not activate during the normal tests of the four stove models. It activated in three of the griddle tests, and all but two of the inverted grate tests. One inverted grate test, involving one sample of one model, was terminated because wiring for the igniter caught fire under the grate.

Injury Data and Hazard Patterns, (Tab A): The attached memo from the Division of Hazard Analysis, describes the injury and incident data from the CPSC databases from January 1, 1995 through August 21, 2001. There were 14 incidents with 24 injuries. There were four instances of the stoves being used with the drip pan inverted, and four where two stoves were used side by side. Twelve incidents with 21 injuries were associated with fires. Two incidents with three injures were associated with sudden pressure release where fire was not reported The injuries were due to hot food and broken dishes.

All of the 14 noted investigations describe failures within the fuel compartment. In all but three the fuel can's rim vent release activated. This can feature is required by the Department of Transportation (DOT) to make shipment safer and preclude can explosions. This indicated excessive heat in the fuel compartment.

Initial review of the 14 investigation indicated that there were two probable mechanisms of over heating in the investigations. One mechanism was using large pans that extended over the fuel compartment. This could restrict airflow and thus heat up the fuel canister. The second was using the stove with the combined grate and drip pan inverted. The older design stoves are packaged and shipped with the grate and drip pans stored inverted over the burner to reduce the overall height. Most stoves with this design have a warning on the grate that is visible in the stored position that it must be turned over before use. However, explicit statements in the IDIs, burn patterns on cookware, and explicit statements in attached reports about people not having the product's instructions and not having been told how to use the product strongly indicated that an inverted grate may have been central to some of the incidents.

Market Information, (Tab B): The Directorate for Economic Analysis reported that most stoves are imported from Korea, and the remainder from Japan. They identified six firms importing 19 models. Imports from Korea averaged 50,000 a year for the four year period 1995-98. There was an over seven fold increase in 1999 to over 365,000. Some stoves were marketed as emergency equipment in the event of year 2000 infrastructure failures. Sales in 2000, the most recent available year, remained high, over 260,000 units. Retail prices at the time of the report ranged from less than $40 to over $100. These stoves are currently available in Gaithersburg, MD for about $25.

Recalls and Product Safety Assessments: There has been one recall. This was due to a manufacturing defect that prevented the over-pressure protection device on the regulator from working.

Voluntary Standards, (Tab C): Underwriter's Laboratories, Subject 1291 "Outline of Investigation for Commercial Butane-Fueled Portable Cook Stoves", and ANSI, Z21.72, "Portable Type Gas Camp Stoves" appear to be the most relevant standards published in the United States. UL Subject 1291 is primarily concerned with heat radiating from the stove and carbon monoxide. The scope includes outdoor and restaurant use. ANSI Z21.72 was developed for stoves using other gases and recently was amended to include butane stoves. The scope is limited to outdoor use. The American Boat & Yacht Council (ABYC), Standard A-30, "Cooking Appliances with Integral LPG Cylinders" adds requirements for LPG cooking appliances used aboard boats.

Conclusions and Recommendations: Based on testing and reviews of the standards and incidents reported to CPSC, the CPSC staff has three areas of concern with Butane Fueled Table Top Cooking Appliances: (a) The U.S. Voluntary Standards do not require over-pressure protection. (b) Consumers use the stoves configured as they come out of the box, even if the grate is inverted. (c) The standards specify only outdoor and commercial use in the scope.

Accordingly, staff has developed the following voluntary standards recommendations:

(a) The standards should incorporate performance criteria for over-pressure protection similar to those in the Korean and Japanese standards.

(b) The standards should incorporate a requirement that the stoves be useable as they come out of the box. Alternatively, the standards could require an interlock that ensures the combined grate and drip pan is in the correct position before the fuel will flow.

(c) The scope of the standards needs to be expanded to include uses beyond commercial and outdoor use..

Attachments:
A: Injury Data and Hazard Patterns
B: Market Information
C: Review of Voluntary Standards
D: Laboratory Testing Data

TAB A

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: January 10, 2002

TO : William L. Rowe
Project Manager, Table Top Cooking Appliances
Division of Mechanical Engineering, Directorate for Laboratory Sciences

THROUGH: Susan W. Ahmed, Ph.D.
Associate Executive Director
Directorate for Epidemiology

Russell H. Roegner, Ph.D.
Division Director, Division of Hazard Analysis
Directorate for Epidemiology

FROM : Jean Mah
Division of Hazard Analysis, Directorate for Epidemiology

SUBJECT : Hazard Sketch for Butane Table Top Cooking Appliances

This memorandum summarizes incident data contained in the CPSC databases since 1995 that involve butane table top cooking appliances and hazards from fire and sudden pressure release. The Table Top Cooking Appliances project was concerned with a particular design, which utilizes a disposable 8 oz. butane canister that fits horizontally into a compartment at one side of the burner and plugs directly into the controls. Incidents that were investigated by CPSC staff and confirmed to involve this specific design are described and analyzed in greater detail.

Incidents documented in this hazard sketch were compiled from the following CPSC databases:

- Injury or Potential Injury Incident (IPII) File
- Death Certificate (DCRT) File
- National Electronic Injury Surveillance System (NEISS)
- In-Depth Investigation (INDP) File

See Appendix for the codes and keywords used in the database searches.

Incident Data

As stated above, the Butane Table Top Cooking Appliances project was interested in a particular product design. However, other designs of butane cooking appliances exist, including a design that uses a one pound butane cylinder. In that design the cylinder remains upright, and the burner attaches to the top of the cylinder. In reviewing all the incident data related to butane cooking appliances, CPSC staff was not

always able to determine from the product description and hazard scenario provided whether the table top design of interest was involved. Therefore, the incident data associated with the product design of interest are presented separately from the incident data associated with butane cooking appliances where the design could not be determined.

Table 1: Incidents by Design Type and Data Source, 1995 - 2001					
	INDP	**IPII**	**NEISS**	**DCRT**	**Totals**
Design of Interest	14	0	0	0	14
Design Not Specified	0	5	6	1	12
Totals	**14**	**5**	**6**	**1**	**26**

Note: Results reflect databases as of Sept. 2001.
Note: Incidents reported in more than one data base are included only once.

Table 2: Injuries and Deaths by Design Type and Data Source, 1995 - 2001					
	INDP	**IPII**	**NEISS**	**DCRT**	**Totals**
Design of Interest	24	0	0	0	24
Design Not Specified	0	2	6	1	9
Totals	**24**	**2**	**6**	**1**	**33**

Note: Results reflect databases as of Sept. 2001.
Note: Incidents reported in more than one data base are included only once.

One report of a death was found in the DCRT file.

The incident data relating to butane cooking appliances included both non-occupational and occupational scenarios. In some cases, employees operated the appliances, but customers who were waiting to be served were injured as a result of the incident. From analysis of the in-depth investigations (IDIs) that were performed for both types of incidents, no substantial differences were detected in the product designs or hazard scenarios based on whether a professional or consumer purchased and operated the appliances.

Butane Table Top Stoves

The following section discusses only those incidents that were followed up by IDIs and confirmed to involve the product design of interest to the project. Products having this design will be referred to as "table top stoves" for the remainder of the memorandum. Fourteen incidents since 1995 were investigated and found to involve table top stoves. Table top stoves mainly consist of a fuel compartment for an 8-oz. butane canister, a control panel, burner, and a grate for supporting cookware. The butane canister must be aligned correctly with the stove's gas regulator and securely connected to avoid fuel leakage. An odorant is added to butane fuel to facilitate the detection of leaks, which are sometimes also identified by a hissing noise originating from the top of

the canister. The controls include a canister-locking lever and an ignition control knob. The user must install the butane canister and set the locking lever before the ignition control will produce a flame in the burner area.

Virtually every table top stove investigated was found to include a safety feature that inhibited the butane canister from locking into place unless the ignition control knob was in the "off" position. Once the butane canister was properly installed, if an over-pressurization of butane was sensed, a mechanism would extinguish the burner flame and disengage the fuel canister, ceasing the flow of gas.

Another aspect of the table top stove is a removable grate with raised supports and an integral drip pan. Since the supports protrude from the stove surface, the drip pan can be inverted for more compact packaging and shipping. Again, most of the 14 investigated stoves were shipped with the drip pan inverted. In one IDI it was unknown whether the stove was shipped with the drip pan inverted.[1] Although most of the table top stoves that came with inverted drip pans included a safety feature that would not allow the butane canister to lock into place if the drip pan were inverted, this feature could not be documented for all of them.

Table 3 presents the butane table top stove investigations by the documented hazard. The two types of hazards associated with the incidents were fires and sudden pressure release. Twenty-four injuries and no deaths were documented in the 14 IDIs.

Table 3: Butane Table Top Stove IDIs by Hazard Type, 1995 - 2001

Hazard	Investigations	Injuries
Fire/Flame	12	21
Sudden Pressure Release (Without Fire/Flame)	2	3
Totals	**14**	**24**

Note: Results reflect databases as of Sept. 2001.

The table top stoves in the investigations were purchased from retail outlets, such as grocery stores, department stores, and marine supply stores, as well as from wholesale restaurant suppliers. One product was obtained from a store that rented party equipment. Over half of the incidents involved stoves that were less than one year-old.

Seven table top stove incidents occurred indoors in restaurants, residences, or cabins of boats. Four incidents occurred outdoors under party tents, on a back porch, or on the deck of a boat. In another boat incident, it was unknown whether the stove was operated indoors or outdoors, two incidents occurred in unknown settings.

The scenarios found in the IDIs can generally be described as follows: The user installed the butane canister and ignited the burner, and the stove had been in use for at

[1] 010124HEP9006

least five minutes. At some point during the cooking process, the user noticed an explosion, followed by flames shooting out of the stove, usually in an upward direction and as high as six feet. Less typically, an explosion occurred without the user seeing any flames.

The longest time a table top stove was in use just prior to fire or an explosion was one hour and a half. In that incident, one butane canister was used, exhausted, and replaced with a second canister. The user experienced difficulty in locking the canister into place, but eventually ignited the stove. Five minutes after the new canister had been loaded and in use, an explosion and fire occurred.[2] Another incident involved a stove that had operated for one hour,[3] and the remaining incidents occurred after half an hour or less of use. Information regarding whether users heard or smelled gas escaping prior to the incidents was unavailable in all but three IDIs. In two of the incidents, users said they did not hear or smell gas escaping,[4] while in one incident the users thought they smelled gas.[5]

Of the 21 victims injured due to fire scenarios, 12 were female and 9 were male, including a 7 year-old boy. Common injuries were burns to the face, neck, shoulders, hands, and legs. Often the user of the stove was standing over the stove when the incident occurred and flames shot upward. Victims who suffered 1st and 2nd degree burns were usually treated at hospitals and released, while one victim who suffered 3rd degree burns was hospitalized. Another hospitalized victim received burns to over 20 percent of his body.[6] One victim underwent re-constructive plastic surgery[7]. As the result of a single incident, one victim received a skin graft and the other was referred to a burn and plastic surgery center for follow-up treatment.[8] A few victims received minor burns or other injuries as a result of the fire incidents but did not seek treatment.

In the two sudden pressure release (without flames) incidents, injuries were caused by hot food and broken dishes being projected into the surrounding area, and were less severe than the fire-related injuries. In one IDI, a female received heat blisters to her face from the sauce being heated on the stove, while in the second IDI, a male received deep lacerations to his arm from flying debris. His wife received minor bruises but was not treated.

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[2] 980302CMC8127
[3] 001030CNE5836
[4] 001030CNE5836, 991018CWE6002
[5] 001213CNE5961
[6] 000919HCC2841
[7] 990810CCN0294
[8] 991221HEP9005

Selected characteristics of the 14 investigations are presented in Table 4 below.

Table 4: Characteristics of Investigations	
Total Investigations: 14	
Characteristic	**Investigations**
Incident Occurred During 1st Use of Incident Table Top Stove	7
Incident Occurred During 1st Use of Incident Butane Canister	8
User Claimed Experience in Use of Table Top Stove	3

In three incidents, users initially had trouble installing the butane canisters and setting the locking levers on the stoves.[9] In two of these incidents, it was later found that the stoves were operating with the drip pans inverted.[10] Inverted drip pans were also involved in two additional incidents.[11] A user in one such incident commented that since the stove was shipped with the drip pan inverted, he assumed that this was also the proper position for cooking. He stated that he had set-up the drip pan in both the upright and inverted positions and decided that the inverted position was more stable. Another user had apparently operated the stove on a previous occasion with the drip pan inverted without incident. During this previous use, the stove operated for a half an hour, and the user noted that he had to let the butane canister cool off for a considerable amount of time before he could remove it from the stove.

There were four IDIs in which two or more stoves were operated side-by-side during the incident.[12] Some instruction manuals for the stoves recommend against this practice as it increases the amount of heat exposure to the butane canister. However, one manufacturer advertised a doublewide rack, to be used as a single cooking surface, facilitating the use of two stoves side-by-side.[13]

Table top stoves were used to cook omelets, fry meats, sauté vegetables, boil water for pasta and wieners, heat soups and sauces, and make coffee. The types of cookware used with the stoves included metal frying pans and woks, metal pots, ceramic bowls, and coffeepots. Although exact measurements of the cookware were unavailable in most IDIs, cookware as wide as 12 inches in diameter was recorded. Although oil was likely used in preparing food in several of the IDIs, there were two IDIs where grease may have been a more prominent factor. One user was cooking pork and sausage in a frying pan when flames engulfed him, causing extensive burns to over 20 percent of his

[9] 980302CMC8127, 001030CNE5836, 000215CCC3161
[10] 000215CCC3161, 001030CNE5836
[11] 000915CNE5757, 990108CCC0205
[12] 990810CCN0294, 001030CNE5836, 980302CMC8127, 990806CNE5248
[13] 990108CCC0205

body.[14] Another user apparently cooked meat directly on the burner grate in addition to cooking vegetables in a pot on the burner. [15]

Other circumstances recorded in the IDIs may have affected how the users operated the stove. One consumer claimed that no separate set of instructions was included with the product package and found the instructive labeling on the product itself confusing.[16] Two IDIs involved households where it was noted that familiarity with English was poor, which may have interfered with proper usage of the product.[17]

Butane Cooking Appliances With Unspecified Product Design

The only reported death involved a fire in a butane cooking appliance of unspecified design. The victim was an 84 year-old male, whose clothes reportedly caught fire from the stove, resulting in 3rd degree burns to 34 percent of his body.

Injuries consisted of 1st, 2nd and 3rd degree burns to body parts including the face, neck, shoulders, arms, wrists, hands, and legs. Five injuries were the result of incidents where flames were unexpectedly emitted from butane containers being used with cooking appliances. One of the five injured in these scenarios was a 4 year-old male who suffered burns to his chest and arms and was subsequently airlifted to a hospital specializing in burn treatment. Three other victims were burned in scenarios where they attempted to connect butane fuel to a cooking appliance. Two of these victims were burned when butane leaked onto one victim's clothing as she tried to replace the old fuel container with a new one. A nearby candle ignited the escaping gas and the fuel on her clothing, resulting in 2nd degree burns to 12 percent of her body. The victim's daughter also received burns that required treatment at an emergency room.

Four butane cooking appliance incidents did not result in any injuries. Two incidents were fires that occurred while the appliances were in use. A third fire occurred while the victim tried to connect butane fuel to the appliance. The fourth incident involved a complaint from a consumer that a potential fire hazard existed because the butane cooking appliance did not have a regulator.

[14] 000919HCC2841
[15] 010124HEP9006
[16] 000215CCC3161
[17] 001213CNE5961, 010124HEP9006

APPENDIX

The queries below were submitted through the EPIR application. Query results were manually reviewed to include fire/flame and sudden pressure release hazards and to exclude out-of-scope cases and duplicates.

In-Depth Investigation (INDP) File

Date of Queries: 9/21/01

Incident dates: 1/1/95 – 8/21/01
(time between assignment and completion of IDI is usually 4-6 weeks)
Product Codes: 131, 3233, 3248-3249
Narrative contains: TABLE, BUTANE, or TOP

Incident dates: 1/1/95 – 8/21/01
Product Codes: 131, 3233, 3248-3249
Narrative contains: PORT or GAS

Incident dates: 1/1/95 – 8/21/01
Product Codes: 204, 221, 224

Incident dates: 1/1/95 – 8/21/01
Product Codes: 250, 257, 273
Narrative contains: PORT, BUTANE, or GAS

Incident dates: 1/1/95 – 8/21/01
Product Codes: 260
Narrative contains: PORT or BUTANE

Incident dates: 1/1/95 – 8/21/01
Product Codes: 981
Narrative contains: GRILL, RANGE, or BURNER

Incident dates: 1/1/95 – 8/21/01
Product Codes: 981
Narrative contains: STOVE

INDP reports used in hazard sketch: *980302CMC8127, 990108CCC0205, 990806CNE5248, 990806CNE5250, 990810CCN0294. 990810CCN0295, 991018CWE6002, 991221HEP9005, 000215CCC3161, 000915CNE5757, 000919HCC2841, 001030CNE5836, 001213CNE5961, 010124HEP9006*

Injury or Potential Injury Incident (IPII) File

Date of queries: 9/21/01

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 131, 3233, 3248-3249
Narrative contains: TABLE, BUTANE, or TOP

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 131, 3233, 3248-3249
Narrative contains: PORT or GAS

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 204, 221, 224
Narrative contains: BUTANE or GAS

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 250, 257, 273
Narrative contains: BUTANE, GAS, or PORT

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 260
Narrative contains: BUTANE or PORT

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 981
Narrative contains: GRILL, RANGE, or BURNER

Incident entered on or prior to: 9/20/01
Incident dates: 1/1/95 – 9/20/01
Product codes: 981
Narrative contains: STOVE

IPII reports used in hazard sketch: *F9590034A, F9610163A, F9680019B, H9810195A, H9980194A*

Death Certificates (DCRT) File

Date of queries: 9/21/01

Date of death: 1/1/95 – 9/20/01
Deaths entered on or prior to: 9/20/01
Product codes: 131, 3233, 3248-3249
Narrative contains: BUTANE

Date of death: 1/1/95 – 9/20/01
Deaths entered on or prior to: 9/20/01
Product codes: 204, 221, 224
Narrative contains: BUTANE

Date of death: 1/1/95 – 9/20/01
Deaths entered on or prior to: 9/20/01
Product codes: 250, 257, 273
Narrative contains: BUTANE

Date of death: 1/1/95 – 9/20/01
Deaths entered on or prior to: 9/20/01
Product codes: 260, 981
Narrative contains: BUTANE

DCRT report used in hazard sketch: *9520008954*

National Electronic Injury Surveillance System (NEISS)

Date of queries: 9/24/01

Treatment dates: 1/1/95 – 9/23/01
Product codes: 131, 3233, 3248-3249
Narrative contains: BUTANE

Treatment dates: 1/1/95 – 9/23/01
Product codes: 204, 221, 224
Narrative contains: BUTANE

Treatment dates: 1/1/95 – 9/23/01
Product codes: 250, 257, 273
Narrative contains: BUTANE

Treatment dates: 1/1/95 – 9/23/01
Product codes: 260, 981
Narrative contains: BUTANE

NEISS reports (NEK) used in hazard sketch: *960118497, 970222724, 970613532, 990813906, 990900522, 00738518*

TAB B

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 7, 2003

TO : William Rowe
Directorate for Laboratory Sciences

THROUGH: Gregory Rodgers GR
Acting Associate Executive Director
Directorate for Economic Analysis

FROM : Robert Franklin RF
Economist
Directorate for Economic Analysis

SUBJECT : Portable Butane Stoves

You requested some information on the market for portable butane stoves and the different models available. This memorandum provides a description of the product and some information on the number of portable butane stoves imported in the US annually. This memorandum is substantially the same as the one dated December 28, 2001, except that information intended for official use only has been deleted.

Portable butane stoves are generally single-burner stoves that are fueled by disposable 8-ounce canisters of butane that are inserted into a compartment in the stove. Depending on the actual heat setting, a stove may operate for 1 to 5 hours on a single canister. Most portable butane stoves come with a hard plastic carrying case.

Portable butane stoves are often used in commercial food service operations for activities such as cooking food at the diners' tables and by caterers for preparing food on their clients' premises. Households may use portable butane stoves for activities such as cooking while camping, picnicking, and boating. Portable butane stoves may also be used as a backup cooking appliance in case of power failures. There is no readily available information regarding the proportions of butane stoves used in commercial applications or in household applications.

Most portable butane stoves appear to be imported from Korea.[1] Portable butane stoves are classified under the Harmonized Tariff Schedule (HTS) code 7321.11.1030 (portable cooking appliances and plate warmers for gas fuel or for both gas and other fuels). Imports from Korea for this code are given in the Table below. The data below represent the upper level for imports of portable butane stoves since the HTS code includes other types of portable stoves, such as

[1] One manufacturer is a large and diversified Japan-based manufacturer. I have not been able to determine where its stoves are actually manufactured.

backpacking and camping stoves. The data show a significant increase in imports for 1999 and after.

Imports of Portable Butane Stoves (from Korea)

Year	Quantity	Total Customs Value	Average Customs Value
1995	41,036	$ 492,129	$11.99
1996	61,336	$ 65,6930	$10.71
1997	36,544	$ 41,7486	$11.42
1998	64,552	$ 45,5595	$ 7.06
1999	365,857	$2,800,975	$ 7.66
2000	260,510	$2,385,474	$ 9.16

Source: U.S. International Trade Commission

Retail prices for portable butane stoves range from less than $40 to more than $100, depending upon the model and supplier. Wholesale prices depend upon the quantity ordered by the dealer, but are around $18 per unit for quantities of 100 or more.[2] The 8-ounce butane fuel canisters retail for about $3.00 per can.

There are several substitutes for these portable stoves. One substitute is a portable butane stove that, instead of inserting butane cartridge in the stove, is fueled by adding butane to a reservoir using the same type of cartridge used for refilling butane cigarette lighters. These stoves are can retail for less than $20 to more than $50. They are usually smaller and lighter in weight and are designed for uses such as backpacking. There are several types of stoves that are similar to the butane stoves in that they are single or double burner stoves designed for countertop use, but that use propane or electricity instead of butane canisters.

At least two manufacturers are members of the North American Association of Food Equipment Manufacturers. This is a trade association that caters to the restaurant and institutional food service industry.

[2] Based on data from one wholesaler.

TAB C

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: December 26, 2001

TO : Andrew G. Stadnik, Associate Executive Director, Directorate for Laboratory Sciences

THROUGH: James Hyatt, P. E. Director Mechanical Engineering Division

FROM : William Rowe, Mechanical Engineering Division

SUBJECT : Voluntary Standards for Butane Fueled Table Top Cooking Appliances

Underwriter's Laboratories (UL) Subject 2191 "Outline of Investigation for Commercial Butane-Fueled Portable Cook Stoves", and American National Standards Institute (ANSI) Z21.72 "Portable Type Gas Camp Stoves" are the most nearly applicable voluntary standards for these stoves published in the United States. The American Boat & Yacht Council (ABYC) "Standard A-30, Cooking Appliances with Integral LPG Cylinders" adds requirements for outdoor LPG cooking appliances if they are use aboard boats.

The scope of UL Subject 2191 states the stoves are intended solely for use outdoors as camping equipment or for use indoors in commercial restaurants where food is prepared at individual tables. UL 2191 does not require a overpressure relief valve or related safety shutoff device. The safety provisions are primarily concerned with minimizing carbon monoxide emissions and the potential for fire due to heat radiating from the stove.

ANSI Z21.72 was developed for stoves using other gases and recently was amended to include butane stoves. This standard is for outdoor use only. There are no requirements for safety shutoff devices or interlocks to prevent the stoves from being used with the grate inverted.

ABYC A-30 is being revised. The 1993 edition summarizes parts of the UL and ANSI standards and includes provisions applicable to boats, but it does not add safety features to the stoves beyond the UL or ANSI requirements. ABYC A-30 references UL and ANSI as organizations, but does not cite UL Subject 1291 or ANSI Z21.72.

The CPSC data show the stoves are sold by retailers and purchased by consumers for use in homes and boats. These uses are not covered by UL or ANSI. UL, ANSI, and ABYC do not currently have performance criteria for the over pressure protection, require the stoves be useable as they come out of the box, or reflect marketing practices and consumer use.

The Korean Gas Safety Corporation provided a comparison of the Korean and Japanese standards for these stoves. See facsimile transmission dated April 11, 2001, attached. CPSC was unable to obtain copies of the Korean and Japanese standards from our normal sources, and this comparison, provided by the Korean Gas Safety Corporation, is the only available information on these standards.

Attachment

KGS Korea Gas Safety Corporation

332-1 Daeya-Dong, Siheung-City, Gyeonggi-Province, 429-712 REPUBLIC OF KOREA
TEL: 82 31 310 1160, FAX: 82 31 312 5526, E-mail: kdjang@kgs.or.kr

TO : Mr. William Rowe
Mechanical Engineer, Directoraye for Laboratory Science
U.S. Consumer Product Safety Commission
10901 Darnestown Road, Gaithersburg, MD 20878
USA
FAX: 1 301 413 4107 TEL: 1 301 413 0173 E-mail: WRowe@cpsc.gov
7107

FROM : In-Bom LEE
DATE : April 11, 2001
SUBJECT : **Standards for Portable Butane Stove and Fuel Canisters**

Dear Mr. Rowe,

Regarding your request, I am sending a copy of the English comparison of the Korean and Japanese Standards. However, as you well indicated in your mail, I am afraid that the comparison table may lead you to misunderstanding due to inaccurate translation in spite of good intention. In this context, I highly recommend you to use the English version just for personal reference.

Our standards for portable butane stove are much similar to Japanese standards i.e. JIS S 2147 and JIS S 2148. I think you can contact the Japanese counterpart and may get the Japanese standards in English.

As the work file of the comparison table is completed using Korean word processor, I am sending them by fax separately.

Sincerely yours,

Inbom Lee

In-Bom LEE
Manager
International Relations Department
Korea Gas Safety Corporation

(ATTACHMENT)

Comparison of Korean and Japanese Standards on Portable Cookers attached to Liquefied Petroleum Gas Cylinder

Sector	Test Items	Korea (MOCIE Notification, KS B 8105)	Japan (JIS S 2147)
1. Performance	1) Ambient temperature in temperature rise test	▷Indicate the difference(Δt) with test room temperature.	▷The temperature of the test room shall be 35℃.
	2) Temperature applied to temperature rise test	▷Not available	▷Surface temperature of the gas-passing part of gas choking valve body other than the device plug : 85℃ max. or not more than the temperature.
		▷Surface temperature of the cylinder shall be less than 40℃ after more than 1 hour lapse of time since ignition with the pan of the opening diameter of 320 mm on top of the appliance.	▷Not available
	3) Cylinder pressure	▷Not more than 0.49 mPa(5kg/㎠)	▷Less than 0.4 mPa
	4) Working pressure of pressure sensative safety device	▷Operates in the range of 0.49 mPa(5kg.㎠) to 0.686 mPa(7kg/㎠)	▷Operates in the range of 0.4 mPa to 0.6 mPa
2. Structure and Dimensions	1) Tilting/overturning test	▷The appliance shall not overturn or move at less than 20 degrees.	▷The appliance shall not overturn or move at less than 10 degrees.

Sector	Test Items	Korea (MOCIE Notification, KS B 8100)	Japan (JIS S 2147)
	2) Structure of cylinder junction part	▷Not availble	▷For the appliance of which the structure emits gas in attaching and detaching of a cylinder after closing the device plug, the internal capacity excluding the part from the device plug until the flame hole where the emitted gas stray shall be less than 1 cc.
		▷The structure shall not facilitate the attachment of any spare cylinder.	▷Not available
		▷The appliance shall be equipped with a cylinder connection guide, and have the structure which facilitates the junction of a cylinder only when the center of the guide and that of the groove of a cylinder fit together and shall not allow gas leakage.	▷In connecting a cylinder to the appliance, the cylinder shall not be equipped easily if not put on the right position.
		▷In connecting a cylinder to an appliance, spring shall not be used as pushing force and the area of the pushing part shall be more than two thirds(2/3) of the area of the lower disk of the cylinder.	▷The the cylinder and appliance shall not be connected if the cylinder is not moved to the shaft direction of the cylinder valve, and spring shall not be used as pushing force to connect the cylinder and appliance.

<table>
<tr><th>Sector</th><th>Test Items</th><th>Korea (MOCIE Notification, KS B 8116)</th><th>Japan (JIS S 2147)</th></tr>
<tr><td></td><td>3) Resistance test on electrically insulated part</td><td>▷Resistance value of electric insulation : more than 1MΩ</td><td>▷Resistance value of electric insulation : more than 50MΩ</td></tr>
<tr><td></td><td>4) Use of the appliance</td><td>▷The appliance shall not have the structure that facilitates 2 purposes simultaneously.</td><td>▷Not available</td></tr>
<tr><td>3. Materials</td><td>1) Corrosion resistance test</td><td>▷Rating number : 6~9.8</td><td>▷Rating number : 9~9.8</td></tr>
<tr><td></td><td>2) Material of main burner</td><td>▷The thickness and the permitted limit of error for materials used in the main burner shall be in accordance with the following :
<table>
<tr><th>Material</th><th>Thickness</th><th>Permitted Limit of Error</th></tr>
<tr><td>Cast iron and aluminum alloy</td><td>3 mm</td><td>-1 mm</td></tr>
<tr><td>Aluminum</td><td>1 mm</td><td>-0.2 mm</td></tr>
<tr><td>Stainless or aluminum coated steel</td><td>0.3 mm</td><td>-0.1 mm</td></tr>
<tr><td>steel or zinc coated steel</td><td>0.5 mm</td><td>-0.1 mm</td></tr>
<tr><td>Copper or copper alloy</td><td>1 mm</td><td>-0.3 mm</td></tr>
</table></td><td>▷Not available</td></tr>
</table>

Sector	Test Items	Korea (MOCIE Notification, KS B 8190)	Japan (JIS S 2147)
4. Testing Method	1) Tilting/overturning test	▷Tilting-overturning tester level : less than 20 degrees	▷Tilting-overturning tester level : less than 10 degrees
	2) Misuse prevention test for juice receiver, etc.	▷The appliance shall have such a structure that the cylinder must not be connected or the gas passage must not be opened if the trivet is placed upside down.	▷The test pan must stand stable on the juice receiver placed upside down or of which the trivet is removed.
	3) Cylinder misuse prevention test	▷Not availble	1) In the test, the cylinder with the maximum length of stem specified in the "Dimensions of Cylinder and Cylinder Valve(JIS S 2148)" shall be used. 2) Carry out the attaching operation of a cylinder which is not in place by forcing 150 N of power on the central part of the cylinder setting lever and check if the connection is possible. 3) After carrying out the test items specified in 1), check if the airtightness of gas passage, ignition performance, operation performance of pressure sensative safety device and attaching/detaching of the cylinder and appliance are in accordance with the requirements under ordinary conditions of use.

Sector	Test Items	Korea (MOCIE Notification, KS B 8106)	Japan (JIS S 2147)
	4) Loading test	A. Trivet : apply a static load of less than 49.0 N(5kg/㎠) for 5 minutes. B. Appliance : apply a static load of less than 49.0 N(5kg/㎠) for 5 minutes.	A. Trivet : apply a static load of less than 50.0 N for 5 minutes. B. Appliance : apply a static load of less than 50.0 N for 5 minutes.
	5) Pressure resistance test of gas passage	▷Apply the pressure of 1.28 MPa(13kg/㎠) for one minute.	▷Apply the pressure of 1.3MPa for one minute.
	6) Gas consumption test	▷Carry out the test with the pan filled with water more than a half(1/2) of the depth of the pan. ▷Not available.	▷Carry out the test with the pan filled with water more than a third(1/3) of the depth of the pan. ▷Water quantity required to measure the thermal efficiency of appliance of which the gas consumption is exceeding 300g/h : 5.6 kg.
	7) Working performance test of pressure sensative safety device	▷Apply the air pressure of 49 kPa(0.5 kg/㎠) per second.	▷Apply the air pressure of 5 kPa per second.

(ATTACHMENT)

Comparison of Korean and Japanese Standards on Gas Cylinders for Portable Gas Cookers

Sector	Test Items		Korea (MOCIE Law & Notification, KS B 6616)	Japan (JIS S 2148)
1. Performance	1) Airtightness		▷No leakage	▷No leakage
	2) Pressure resistance	Deformation	▷No leakage or deformation after 30 minutes of lapse of time under the pressure of 1.274 MPa(13kg/cm²)	▷No leakage or deformation after 30 minutes of lapse of time under the pressure of 1.3 MPa
		Rupture	▷No rupture from any parts of the cylinder compressed to 1.474 MPa(15kg/cm²)	▷No rupture from any parts of the cylinder compressed to 1.5 MPa
	3) Gas resistance	Packings for cylinder valve	▷Rate of mass change less than 20%, no brittling or softening or change impedimental to use	▷Rate of mass change less than 20%, no deterioration or change impedimental in use
	4) Ozone resistance		▷Not available	▷No crack under ozone density of 50 pphm
	5) Strength of stem spring		▷800 g or over, 2000 g or under	▷12 N or over, 20 N or under(stem operating load)
	6) Repeated-use		▷Confirm to the standards on airtightness and strength of spring	▷No leakage
	7) Accuracy of filled gas quantity with respect to marked gas quantity		▷Not available	▷+1 % - 2 %
	8) Initial partial pressure of air		▷Not available	▷Not more than 25 kPa under 25℃
	9) Flow quantity of valves		▷Not available	▷More than 8 ℓ/minute of flow rate under the 1st pressure of 0.2 MPa
2. Filled Gas	1) Components		▷Maximum filling pressure shall be not more than 5 kgf/cm² under 35℃	▷C_4H_{10} : more than 95 wt% ▷Other hydrocarbons : less than 5 wt%

Sector	Test Items		Korea (MOCIE Notification) KS B 0816	Japan JIS S 2140
	2) Weight		▷Not less than 220g and not more than 260g	▷Not less than 220g and not more than 250g(Marked gas quantity)
	3) Odor		▷The gas filled in the cylinder shall be odoriferous	▷The gas filled in the cylinder shall be odoriferous
3. Dimensions	1) Dimensions of the parts of cylinders and cylinder valves	Total height	▷185.0+1.5(185.0~186.5) mm	▷185.0±0.8(184.2~185.8) mm
		Outer diameter of can-shell	▷65.9±0.3(65.6~66.2) mm	▷66.7±0.7(66.0~67.4) mm
		Outer diameter of lower part of can	▷68.3±0.4(67.9~68.7) mm	▷Upper part : 66.7±0.7(66.0~67.4) mm ▷Lower part : 68.5±0.5(68.0~69.0) mm
		Outer diameter of stem	▷4.0+0.05 mm -0 mm	▷4.0+0.05 mm -0 mm
		Length of stem	▷6.7+1.0(6.7~7.7) mm	▷7.2±0.5(6.7~7.7) mm ▷Height of stem : 5.5±0.5(5.0~6.0) mm
		Diameter of boss	▷10.7±0.2(10.5~10.9) mm	▷10.5~10.8 mm
		Inner diameter of mounting cup	▷24.6±0.3(24.3~24.9) mm	▷Not available
		Notch	▷Not available	▷10.3±0.3(10.0~10.6) mm
	2) Compressing stroke of cylinder valve		▷More than 1.7 mm	▷More than 1.7 mm and less than 4.0 mm
	3) Initial injection stroke of cylinder valve		▷Less than 1.5 mm	▷More than 0.2 mm and less than 1.0 mm
4. Material	1) Cylinder body		▷Materials specified in KS D 3506 or metallic material of corrosion resistance equal to or superior to this	▷Materials specified in JIS G 3303 or metallic material of corrosion resistance equal to or superior to this
	2) Stem		▷Not available	▷Materials specified in JIS H 3250 or metallic material of corrosion resistance and heat resistance equal to or superior to this
	3) Packings		▷Materials which have gas resistance	▷Materials which have gas resistance and ozone resistance

Sector	Test Items		Korea (MOCIE Notification, KS B 8106)	Japan (JIS B 2148)
5. Test Methods	1) Vibration test		▷Fix a cylinder under the packaged condition horizontly on the vibration tester, vibrate upwards, downwards, left, and right at 600 vibrations/minute and 5mm in total amplitude for 30 minutes, and examine the airtightness and shall have no leakage	▷Fix a cylinder under the packaged condition horizontly on the vibration tester, vibrate upwards, downwards, left, and right at 600 vibrations/minute and 5mm in total amplitude for 30 minutes, and examine the airtightness and shall have no leakage
	2) Shock test		▷Examine the presence of deformation or damage to airtightness after dropping the filled cylinder at height of 30 cm to wooden surface	▷Not available
	3) Gas resistance test		▷Calculate the rate of change of mass and examine the presence of deformation or brittling impedimental to use after the gas resistance test of cylinder valve pakings	▷Calculate the rate of change of mass and examine the presence of deterioration or deformation impedimental to use after the gas resistance test of cylinder valve pakings
	4) Ozone resistance test		▷Not available	▷Examine the presence of crack of cylinder valve packings after testing them for 96 hours under 50 pphm of ozone density and 40±2℃ of temperature
	5) Airtightness test		▷Sample Inspection : Pressurize the cylinder at more than 5 kg/㎠ for 30 seconds and examine for gas leakage ▷Total Inspection : Immerse the gas filled cylinder in water at the temperature of 46~50℃ and examine for gas leakage from each part of the cylinder	▷Sample Inspection : Immerse the cylinder in water at 48~50℃ for 30 minutes and examine for gas leakage from each part of the cylinder ▷Total Inspection : Immerse the gas filled cylinder in water at 55±2℃ for 110 seconds and examine for gas leakage from each part of the cylinder
	6) Pressure resistance test	Deformation	▷Pressurized the cylinder at 1.274 MPa(13 kg/㎠) for 30 seconds and examine for leakage or deformation of each part of the cylinder	▷Pressurized the cylinder at 1.3 MPa for 30 seconds and examine for deformation of each part of the cylinder
		Rupture	▷Examine for rupture of each part of the cylinder after pressurization to 1.474 MPa(15 kg/㎠)	▷Examine for rupture of each part of the cylinder after pressurization to 1.5 MPa
	7) Strength test of the stem spring		▷Measure the loads applied to the tip of the stem when pushed from more than 1.0 mm to the compressing stroke of the cylinder valve	▷Measure the loads applied to the tip of the stem when pushed from 1.5 mm to the compressing stroke of the cylinder valve

Sector	Test Items	Korea (MOCIE Notification KGS [illegible])	Japan (JIS [illegible])
	8) Repeated service test	▷Carry out pushing the stem to the compressing stroke of the cylinder valve 100 times at the rate of once per second and examine for gas leakage and strength of stem spring	▷Carry out pushing the stem to the compressing stroke of the cylinder valve 100 times at the rate of once per second and examine for gas leakage
	9) Test on the gas composition	▷The analysis of the composition of the gas shall be carried out in accordance with the gas chromatography of KS M 2077	▷The analysis of the composition of the gas shall be in accordance with the gas chromatography of JIS K 2301
	10) Test on the mass of gas	▷The mass of the gas shall be calculated by measuring the mass of the cylinder filled with gas and the mass of the cylinder after the gas has been purged	▷The mass of the gas shall be calculated by measuring the mass of the cylinder filled with gas and the mass of the cylinder after the gas has been purged
	11) Odorizing test	▷The test on the odorization of the gas shall be carried out in accordance with the test method stipulated in the test regulation for Liquefied Petroleum Gas	▷The test on the odorization of the gas shall be carried out in accordance with appendix
	12) Tests on compressing stroke of cylinder valve	▷The dimension of the stem fully pressed shall be measured using a dial gauge	▷The dimension of the stem fully pressed shall be measured using a dial gauge
	13) Initial injection stroke dimension of cylinder valve	▷The dimension when the stem is gradually pushed and bubbles are produced intermittantly, shall be measured using a dial gauge	▷The dimension when the stem is gradually pushed and bubbles are produced intermittantly, shall be measured using a dial gauge
	14) Initial partial pressure of air	▷Not available	▷Immerse the cylinder filled with gas in water at 25±1℃ for 30 minutes and measure the initial internal pressure, release the gas for 10 seconds and immerse the cylinder in water at 25±1℃ for 30 minutes and measure the pressure, and calculate the initial partial pressure of air according to the equation
	15) Flow rate of valve	▷Not available	▷Using the test equipment, push the stem for 1.5 mm and compress the pressure of 0.2 MPa at the upper part of cylinder and measure the flow rate of air

Sector	Test Items	Korea (MOCIE Notification No. 2000-8186)	Japan (JIS S 2140)
6. Inspection and Marking	1) Inspection	▷Lots are formed according to the numbers of products manufactured and the inspection is carried out by taking samples in each lot. - Periodical inspection : Periodical inspection is carried out every month for the items of compressing dimensions of cylinder nozzles, repeated use test, vibration test, shock test - Product inspection : Production inspection is carried out at every production time for the items of structure inspection, visual inspection, airtightness test, pressure resistance test(deformation and rupture), marking requirements	▷Type inspection : The type inspection shall be carried out for every item. ▷Product inspection : The product inspection shall be carried out for the items of airtightness, pressure resistance, dimensions and marking. (sample inspection)
	2) Marking requirements	▷Name or abbreviation of cylinder manufacturer ▷Name of the gas filled ▷Internal volume of the cylinder ▷Information relating to the mounting and preserving method of the cylinder ▷Manufacturing number or lot number ▷Information relating to the method of use ▷Warning notice ▷Other necessary information	▷Name of the cylinder ▷Information relating to the mounting method of the cylinder ▷Information relating to the preserving method of the cylinder ▷Information relating to the handling of the cylinder ▷Information relating to the gas filled ▷Name of the company shich filled the gas or its abbreviation ▷Name of the company as sales agent ▷Year and month of manufacturer or its abbreviation ▷Manufacturing number or lot number

TAB P

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: December 1, 2001

TO : Andrew G. Stadnik, Associate Executive Director, Directorate for Laboratory Sciences

THROUGH: James Hyatt, P.E., Director, Mechanical Engineering Division

FROM : William Rowe, Mechanical Engineering Division

SUBJECT : Results of Single Burner Butane Stove Testing

Background: The goal of the Fiscal Year 2001 (FY01) Table Top Cooking Appliances Project was to make recommendations for voluntary standards. A series of tests was conducted on typical butane fueled table top cooking appliances (hereafter referred to as stoves) with three objectives: (1), become familiar with the performance and operating characteristics of the stoves. (2), duplicate the operating conditions found in the CPSC investigations. (3), provide data for standards development. A test plan (Appendix A) was developed to address these objectives.

Samples Tested:
Figure 1 shows the four stoves, termed A, B, C, and D that were tested. Incidents involving A and B are found in the CPSC data. For these two models, the manufacturer is the same, the mechanisms appear identical, and the only visible difference is the importer. The combined grate and drip pan is stored inverted over the burner when these stoves are shipped or stored, and this appeared to be a factor in some incidents. Stove C has a sheet metal fuel compartment lid that conforms to the top of the fuel canister. This lowers the integral grate, so the stove canister is stored with the grate right side up, as it will be used. Stoves A, B, and C were made in Korea. Stove D was made in Japan. Stove D is generally similar to C, with the addition of a metal plate to conduct heat to the fuel canister. This facilitates stove operation in cool temperatures.

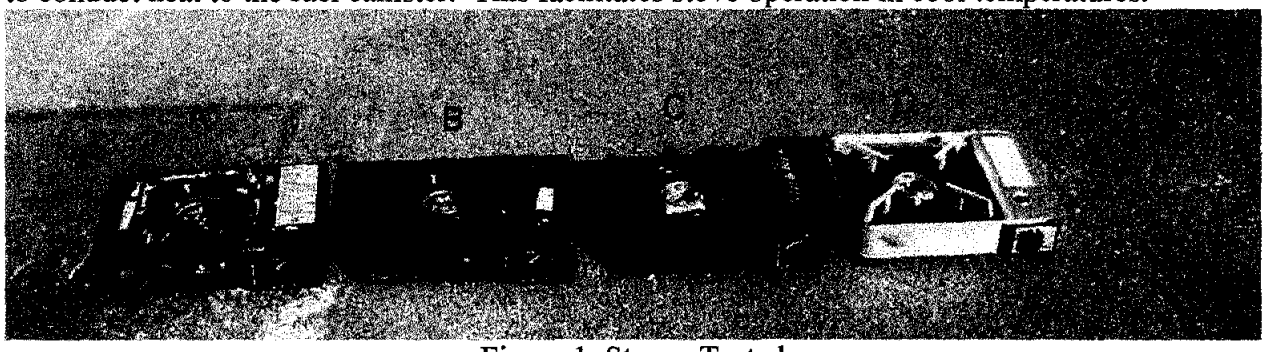

Figure 1. Stoves Tested

The Department of Transportation (DOT) regulates the disposable fuel canisters in 49 CFR 178.33. Each canister contains 8-oz (227 g) of butane and attaches to the stove regulator through

an O-ring seal. All fuel canisters are physically interchangeable, and were used in these tests without regard to brand.

Testing and Results:
The CPSC Laboratory developed the hot water bath tests and gas regulator over pressure protection tests based on DOT requirements. DOT does not specify how the hot water bath requirement is to be evaluated. The hot water bath and gas regulator over pressure protection tests were conducted before the simulated use tests to eliminate weak fuel canisters and stoves with possibly defective regulators. The individual stove tests were scheduled to minimize repeated instrumentation of the stoves and the associated set up errors.

Hot Water Bath
All fuel canisters were immersed in water at 131° (55°C) as specified by DOT, 49 CFR Part. 173.306 (a)(3)(v). The canisters were placed in a capped perforated schedule 40 steel pipe. Figure 2 shows the equipment used and a fuel canister prior to testing. The tests were conducted outside for safety. Each canister was tested for 5 minutes. These tests were conducted to reduce the chance of a canister failing during stove operation, since each canister contains enough fuel to produce over 160 ft^3 (4.5 m^3) of flammable fuel-air mixture. All canisters passed the hot water test without leaking.

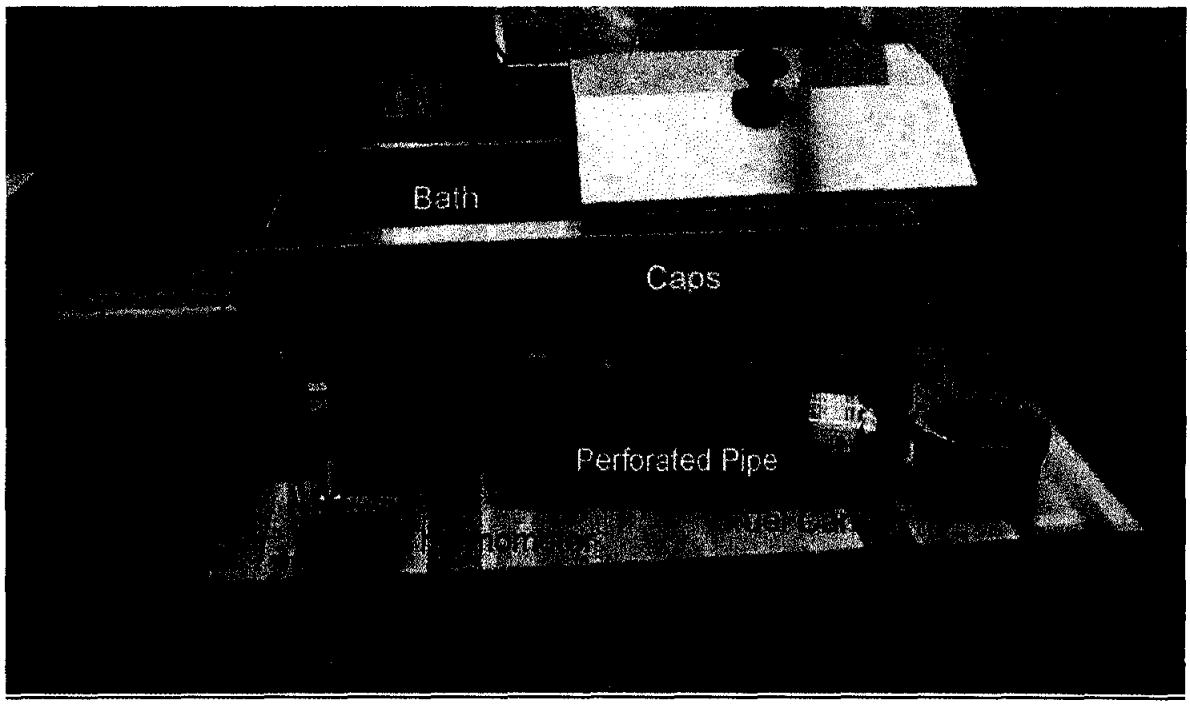

Figure 2. Hot Water Bath Test Equipment

Gas Regulator Over Pressure Protection
Each stove is equipped with an over pressure protection device integrated into the regulator. Figure 3 shows a regulator that was removed for study. The CPSC laboratory developed a test to evaluate the over pressure protection device. One stove of each model tested was connected to compressed air, and the pressure required to activate the over pressure protection was recorded.

Figure 4 shows stove D being tested. This test consisted of monitoring the trip pressure of the over pressure protection device as the pressure to the test canister was slowly increased. The test results are shown in Table 1. Stoves used in these tests were not used in the operating tests.

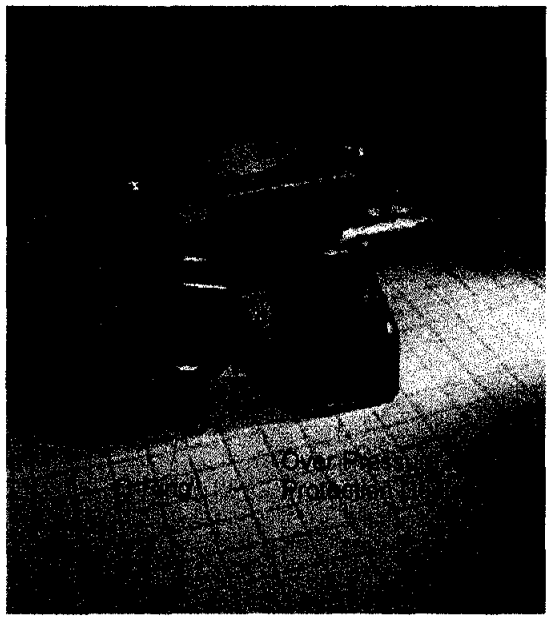

Figure 3. Regulator

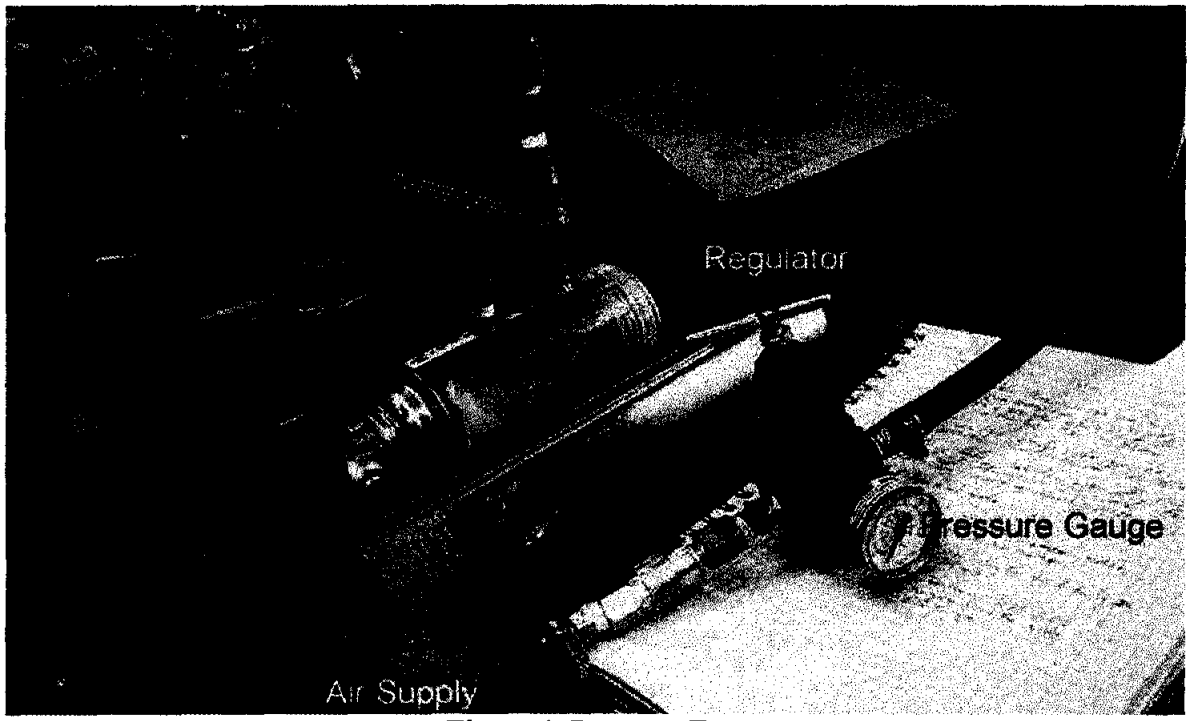

Figure 4. Pressure Test

Stove	Average psig	Average MPa
A	78	0.537
B	74	0.510
C	79	0.545
D	65	0.448

Table 1. Pressure (psig) to Activate Over Pressure Protection

Stove Temperature

The stoves were tested in the CPSC Laboratory Sciences' burn room in Building G. The temperatures were recorded with six J-type thermocouples. There were two thermocouples on the combined drip pan and stove grate. They indicated if the stove was operating. The third was on the fuel compartment wall next to the burner. This indicated the heat being transferred toward the fuel canister and the regulator. The fourth was on the bottom of the fuel canister. Overheating the fuel canister was the apparent cause of the incidents investigated by CPSC. The fifth thermocouple was on the side of the regulator away from the burner. This indicated conditions inside the regulator. The sixth measured room temperature. Figure 5 is the instrumentation schematic, and Figure 6 is an image of an instrumented stove. The six thermocouples were connected by plugs to thermocouple wire to an EXP 16 interface board located in the adjacent control room. The board was connected to the parallel port of a PC. Data were recorded using Labtech Control, Version 10.1. These data were saved as a .prn file and subsequently analyzed using Excel.

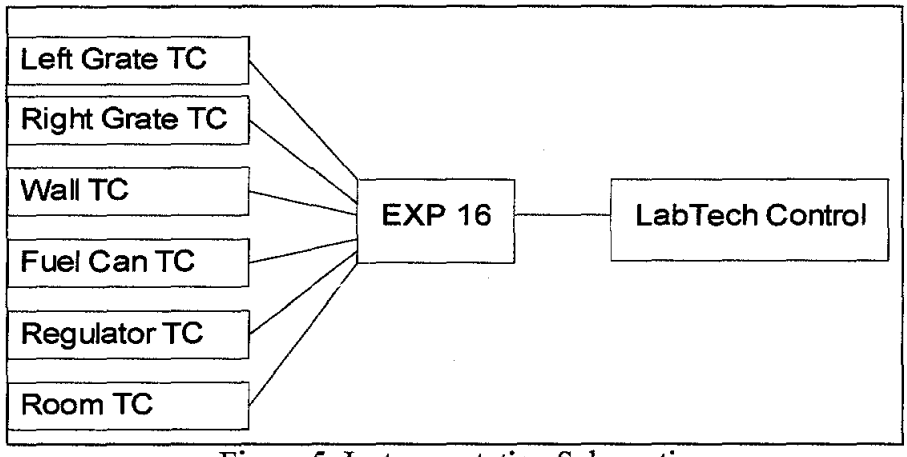

Figure 5. Instrumentation Schematic

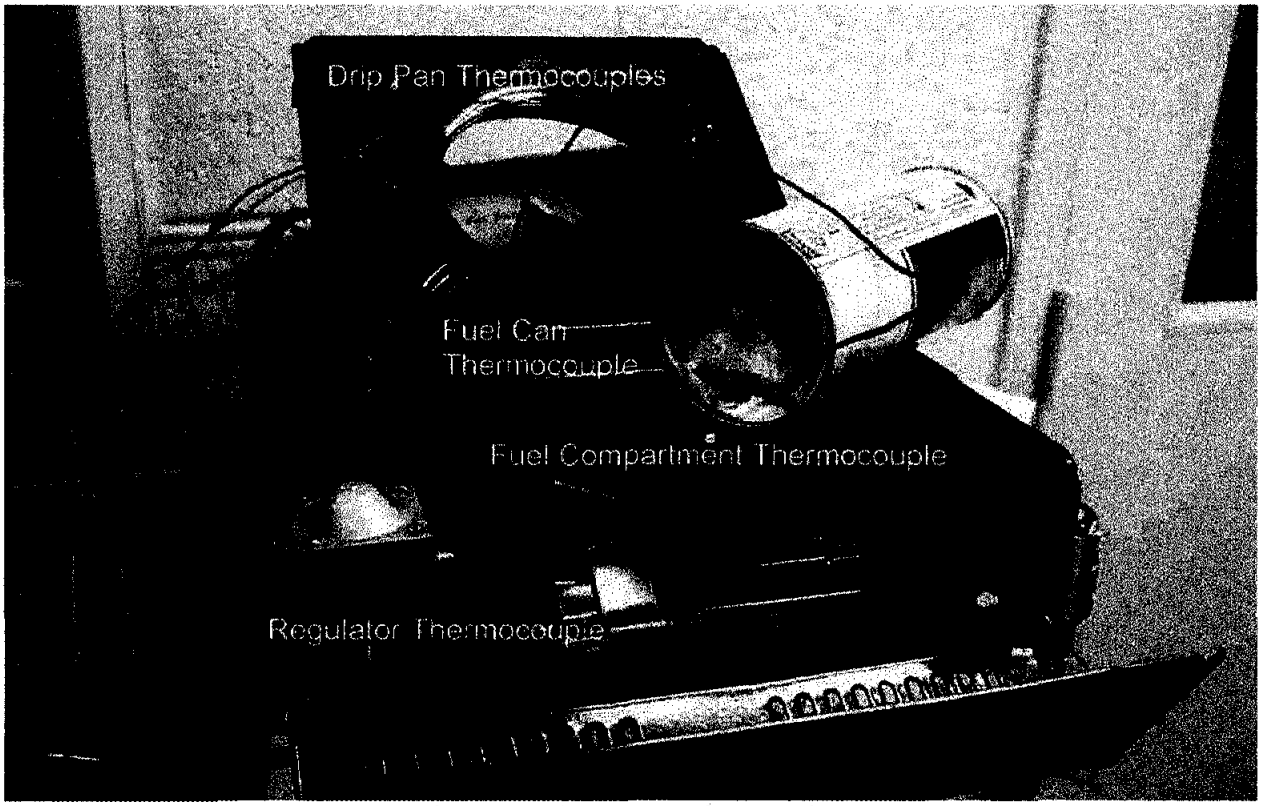

Figure 6. Thermocouple Location

Tests were run with an empty frying pan on the grate to simulate proper usage, termed Normal; with a griddle extending over the fuel compartment, termed Griddle; and with the grate inverted, termed Inverted. The grate rested on the interlock of stoves A and B. Figure 7 shows stove A with a bare burner, stove B with the empty pan, stove C with griddle, and stove D with the grate inverted.

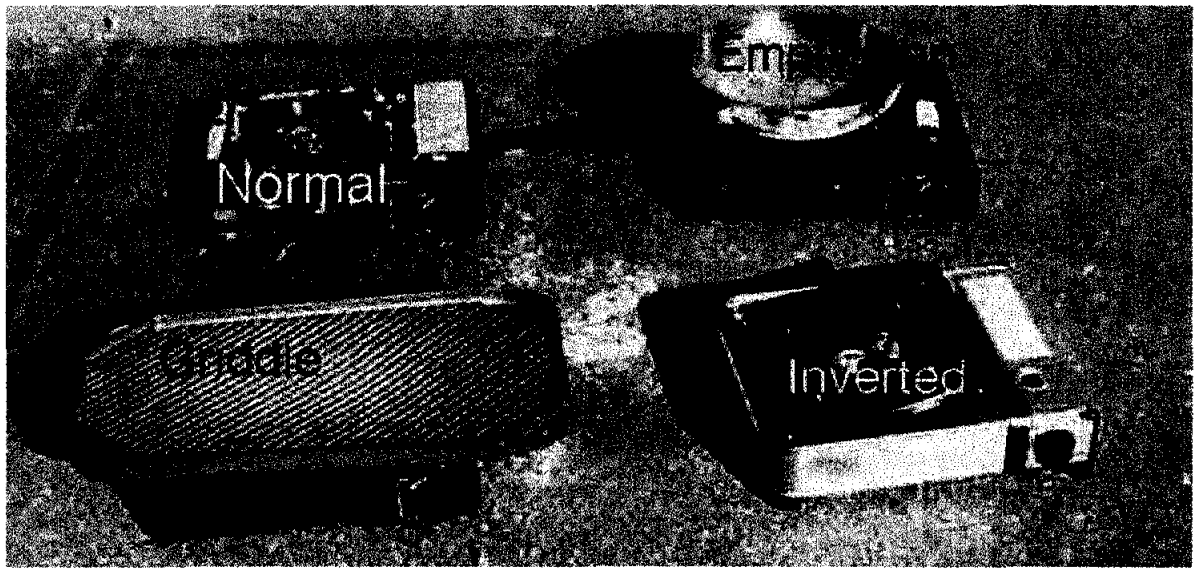

Figure 7. Test Conditions

Test Results are summarized in Table 2, Summary of Test Data. None of the tests resulted in a gas leak or gas fire. Nine of the 24 tests shown in Table 2 resulted in the gas regulator over pressure protection shutting the stove down. The regulator temperature is the best available information on conditions at the regulator.

Figure 8 - Temperatures from Parts of the Stove During Typical Normal Test, graphs the six temperatures of stove B with a frying pan. The stove was operated until the fuel was exhausted. The highest temperatures were at the left and right grate thermocouples that were nearest to the flame. Considerably lower, but next highest was the fuel compartment wall. That temperature indicates energy available to heat the regulator and fuel canister. The room temperature was nearly constant. The fuel canister temperature was cooler than the room temperature because the butane was changing phase, from liquid to gaseous, as the fuel is used. Then, at about 45 minutes into the test the temperature suddenly increased, as the liquid butane was exhausted. Almost immediately the grate temperatures dropped because the fuel was exhausted.

DISCUSSION:

Regulator Temperature

Figures 9, 10, and 11 show the regulator temperatures for the four stoves in the Normal, Griddle, and Inverted operating conditions. The same time and temperature ranges are used for the three graphs to simplify comparison between conditions. The time scales differ so more points are shown. The lowest temperatures were observed in the Normal condition. The Griddle conditions had the next highest temperatures, and the Inverted condition was hottest.

Over Pressure Protection

The over pressure protection did not activate during any of the normal tests. The griddle tests activated the over pressure once with stove C and both times with stove D. The inverted grate tests activated the over pressure protection in all but two of the eight tests. Stove C did not shut down during the cooler (72°C) of the two runs. In one test the insulation on the wiring for the piezo-electric igniter of stove D caught fire. It was impossible to separate the effects of the burning insulation from the heat from the burner, and the test was terminated.

Duplicating Investigated Failures

The lab tests ended when the temperatures became constant, the over pressure device activated, or the fuel was exhausted. We were not able to induce a fire in the fuel compartment by deflecting the flame with a griddle or the grate and thus heating the fuel canister and the regulator.

Stove	Condition	File	Date & Time	Grate Max		Wall Max		Regulator		Safety Activated?	Comment
				Temp °C	Time min	Temp °C	Time min	Temp °C	Time min		
A	Normal	Stove9	8/01/01 1257	242	15.17	74	48	52	62.33	No	
A	Griddle	Stove10	8/02/01 1614	257	16.17	91	24.5	75	27.67	No	Fuel Exhausted
A	Griddle	Stove28	9/18/01 1626	255	16	84	35.5	84	37.33	No	
A	Griddle	Stove31	9/20/01 1058	236	37.83	87	63.5	75	76.83	No	
A	Inverted	Stove11	8/03/01 1359	628	8.83	94	25.33	80	27	Yes~30 min	
A	Inverted	Stove12	8/07/01 1602	648	16.33	82	16.5	74	16.83	Yes~17 min	
B	Normal	Stove13	8/09/01 1345	247	18.33	94	40.5	69	46	No	
B	Normal	Stove29	9/19/01 1406	267	45.17	85	70	67	87.17	No	
B	Griddle	Stove17	8/10/01 1311	237	44	96	44.33	87	43	No	
B	Griddle	Stove34	10/03/01 1016	244	24.83	73	33.17	66	33.83	No	
B	Inverted	Stove18	8/18/01 1313	417	22.33	163	22.33	94	23.83	Yes~19 min	
B	Inverted	Stove32	9/20/01 1246	453	18.17	142	18.33	75	20	Yes~18 min	
C	Normal	Stove35	10/03/01 1316	240	24.33	73	24.33	34	19.5	No	
C	Normal	Stove36	10/03/01 1517	274	20.5	101	46.33	42	42	No	
C	Griddle	Stove39	10/05/01 1500	299	38.67	137	40	86	42.33	Yes~40 min	
C	Griddle	Stove40	10/12/01 1333	269	24.83	121	35.83	80	40.67	No	
C	Inverted	Stove42	10/15/01 1347	438	48.33	180	52.17	74	51.33	Yes~50 min	
C	Inverted	Stove43	10/15/01 1550	417	25.5	167	56.67	72	60	No	
D	Normal	Stove19	8/21/01 1520	332	37.17	140	46.5	71	47.5	No	
D	Normal	Stove22	8/24/01 0841	377	32.5	142	61.17	66	60.33	No	
D	Griddle	Stove23	8/24/01 1404	402	11.17	194	11.33	115	11.5	Yes~12 min	
D	Griddle	Stove25	8/31/01 1037	401	11.17	206	11.5	118	11.5	Yes~11 min	
D	Inverted	Stove26	9/12/01 1006	400	7.83	248	7.83	106	7.5	No	Insulation Fire
D	Inverted	Stove27	9/12/01 1520	377	5.5	294	5.5	109	5.17	Yes~6 min	

Table 2. Summary of Test Data

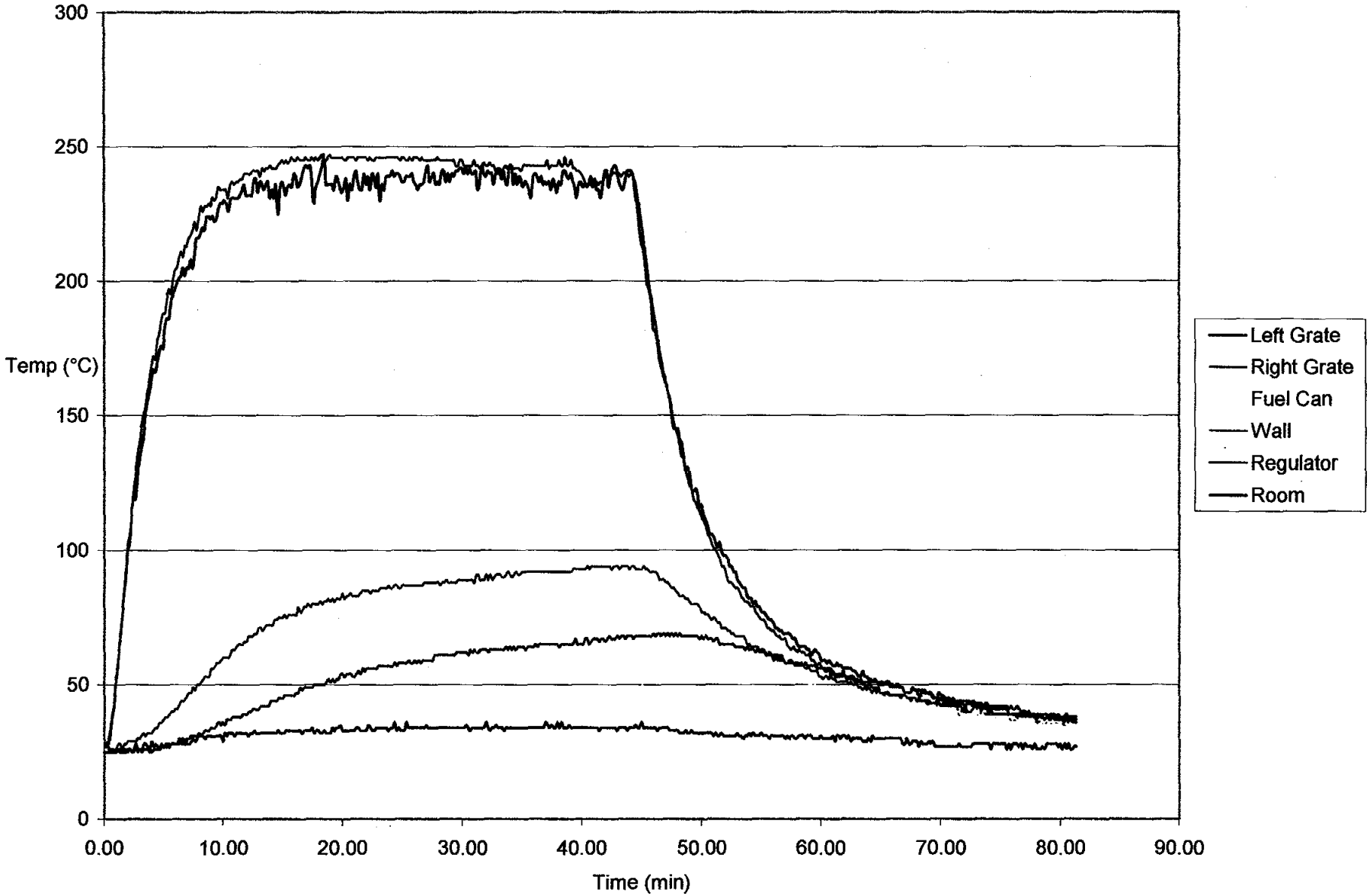

Figure 8 Temperatures from Parts of the Stove During Typical Normal Test

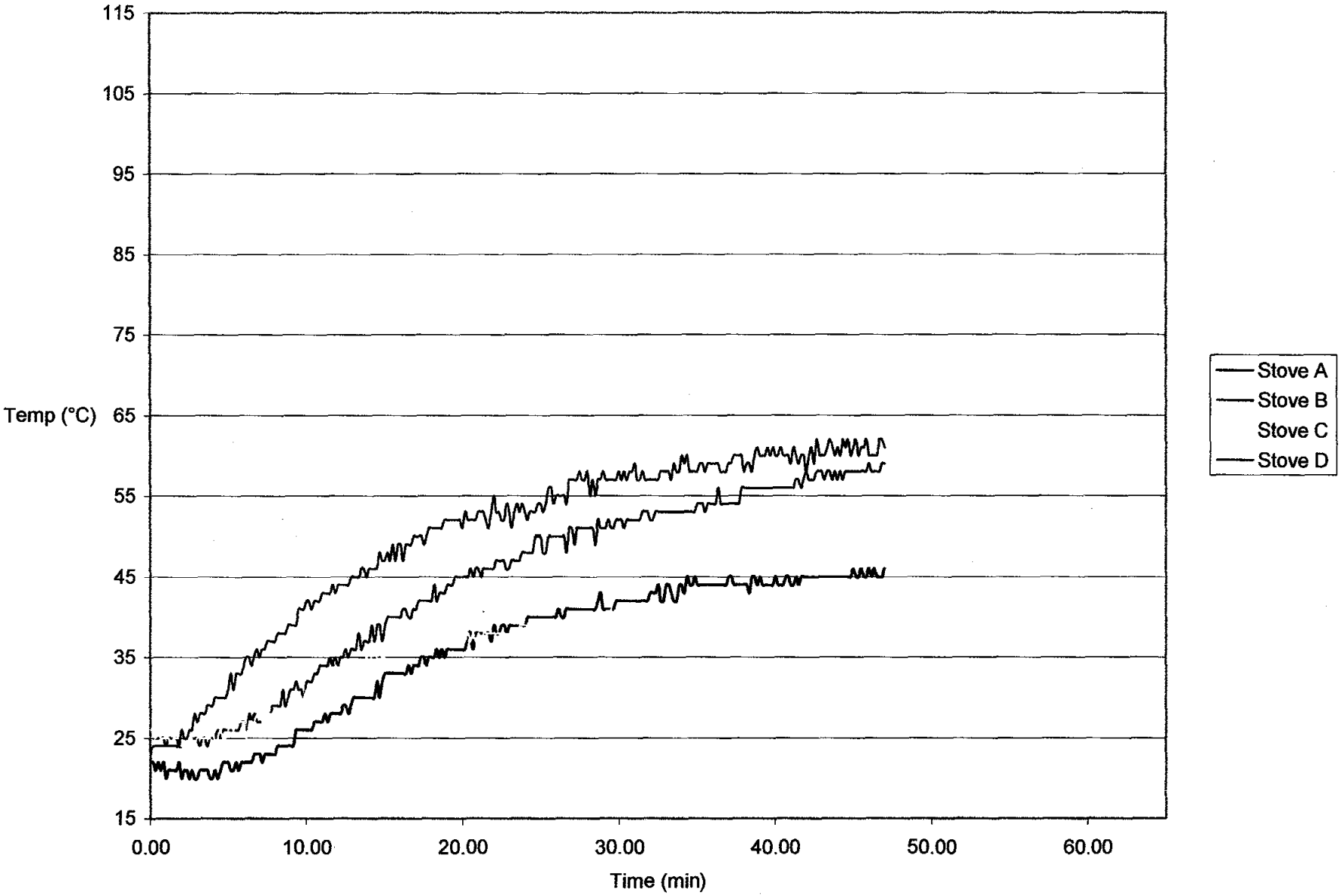

Figure 9 Typical Regulator Temperatures During Normal Tests

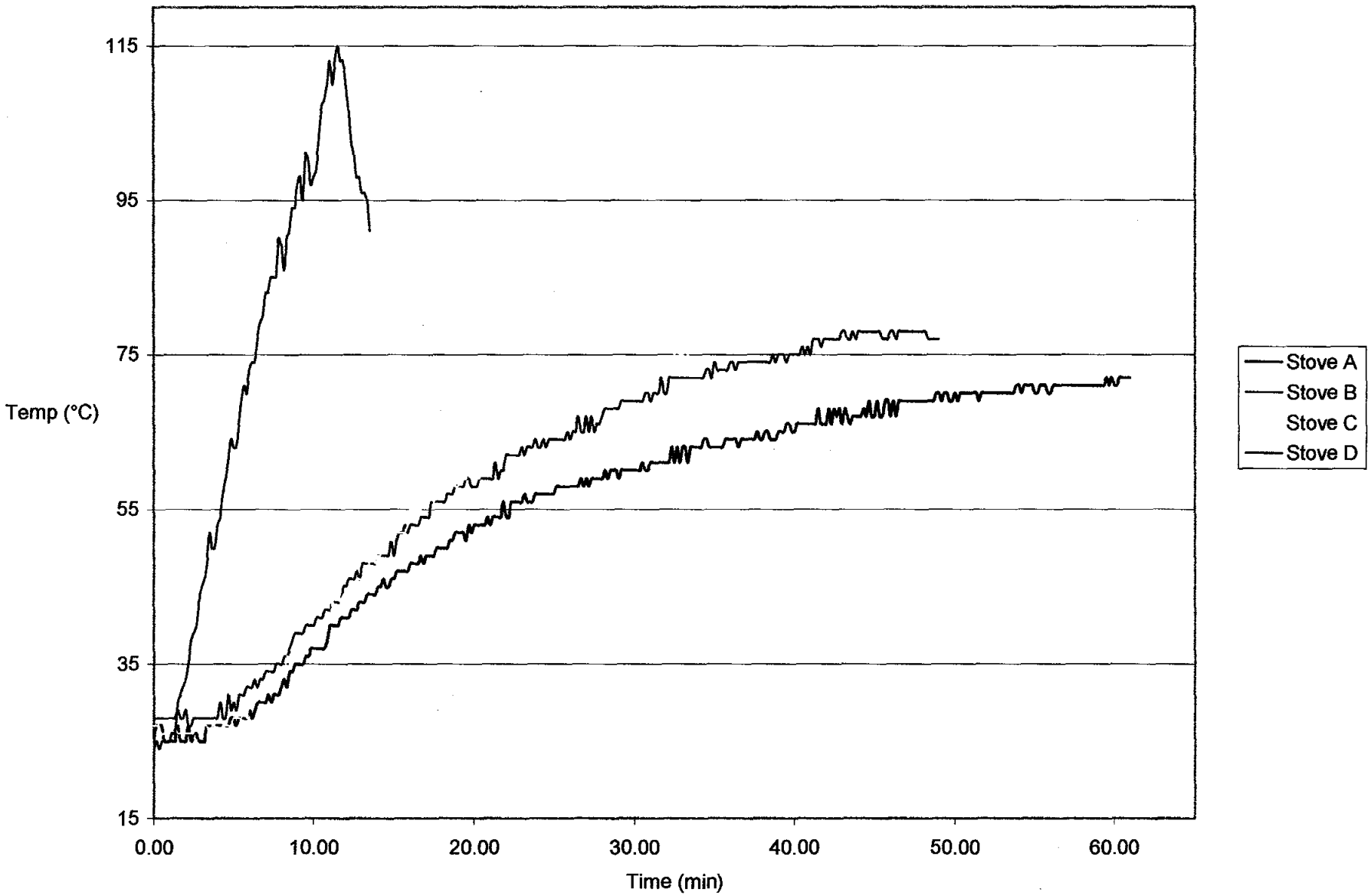

Figure 10 Typical Regulator Temperatures During Griddle Tests

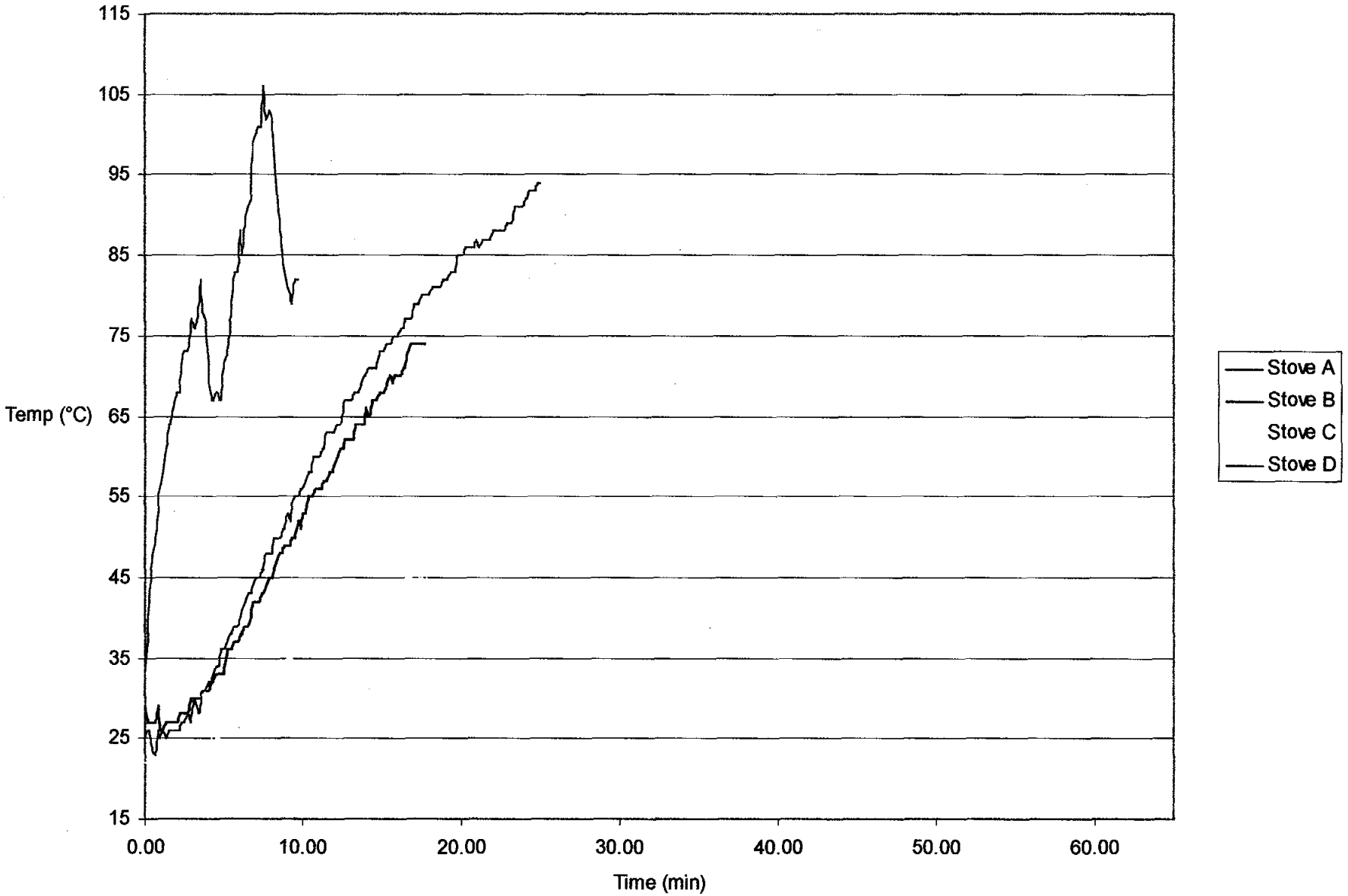

Figure 11 Typical Regulator Temperatures During Typical Inverted Tests

Appendix A

Table Top Cooking Appliances Test Plan

July 31, 2001

1. **Background:** The available incident data and samples show the fires are caused by accidental heating of the butane fuel canister resulting in venting followed by ignition of the contents. Some of the incidents appear to be due to the burner flames being directed against the fuel canister by an inverted drip pan. Others may have been due to ignition of fuel leaks at the nozzle. The incident stoves all had an interlock to prevent operation if the drip pan was inverted and an over pressure cut off that should have prevented all of the incidents. The interlock prevents the fuel canister from locking in place if the grate is inverted. A tab on the mechanism contacts the grate as the fuel canister moves into place, however it is possible to lock the fuel canister in place, and then set the grate on top of the tap. The fuel canisters are DOT-2P/2Q containers regulated by the Department of Transportation
2. **Samples:** All of the stoves have a similar configuration. The testing will examine the stove performance envelope related to the incidents. The Directorate for Laboratory Sciences currently has official CPSC sample stoves from six importers. Two stoves with an innovative drip pan will be purchased. Fuel canisters will first come from existing CPSC samples, and then will be purchased locally.
3. **Fuel Canister Test:**
   - **3.1** Submerge all fuel canisters in water at 131°F for 1 minute prior to use. Problematic fuel canisters will leak prior to being exposed to an ignition source. Canisters will be inside a perforated schedule 40 steel pipe nipple.
4. **Over Pressure Cutoff:** Determine the pressure necessary to activate the over pressure protection built into the regulator. A pressure gauge and a compressed air fitting will be attached to an empty fuel canister.
5. **Operating Tests**
   - **5.1 Baseline:** The stove is operated according the manufacturer's instructions with a 9½ inch frying pan. Data from these tests will provide a base line for comparison with other test conditions.
     - **5.1.1Temperature Recorded:**
       - **5.1.1.1 Grate:** Two thermocouples each 1½ inches from the left and right edges of the grate on the underside.
       - **5.1.1.2 Regulator:** One thermocouple on the regulator.
       - **5.1.1.3 Fuel Compartment Wall:** One thermocouple on inside wall of the fuel compartment closest to the burner
       - **5.1.1.4 Fuel Canister:** One thermocouple on the bottom of the can.
       - **5.1.1.5 Ambient:** One thermocouple measuring room temperature
   - **5.2 Inverted Grate:** The stove is operated as in the baseline test except the grate is upside down. The grate thermocouples are moved to the surface toward the burner with the cooking drip pan upside-down.
   - **5.3 Over Size Cookware:** The stove is operated as in the baseline test except a griddle extends over the fuel compartment cover.
6. **Test Duration:** Tests in this phase will be conducted until the over pressure protection activates, or the temperatures are steady for 5 minutes or declining . Duration will be less than two hours which is the typical amount of fuel in a canister.
7. **Test Matrix:**
   - **6.1 Operating Tests:**

Test	T Under Drip Pan	T Regulator	T Fuel Compartment Wall	T Fuel Canister
Baseline	X	X	X	X
Griddle	X	X	X	X
Inverted Grate	X	X	X	X